AECOM

Executive Summary

Assessment of Extreme Rainfall Events in 2021

Report to Ad Hoc Committee and Board of GLWA

Great Lakes Water Authority

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			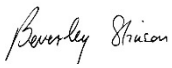
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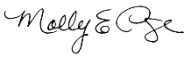
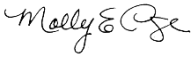
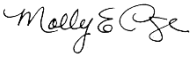
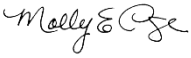
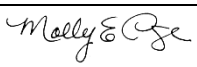
Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	18 November 2021	Phase 1 Interim Report Released for Independent Panel Review		Molly Page	Vice President, US West Water
1	3 December 2021	Phase 1 Interim Report		Molly Page	Vice President, US West Water
2	29 April 2022	Draft Final Report		Molly Page	Vice President, US West Water
3	6 June 2022	Final Report		Molly Page	Vice President, US West Water
4	20 June 2022	Final Report		Molly Page	Vice President, US West Water

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EXECUTIVE SUMMARY

In 2021, Southeast Michigan experienced two extreme rainfall events, on June 25-26 (the "June 25/26 Rainfall Event") and July 16 (the "July 16 Rainfall Event, collectively the June 25/26 Rainfall Event and July 16 Rainfall Event, are called the "June/July 2021 Rainfall Events.") The June 25/26 Rainfall Event resulted in widespread surface flooding and reported basement backups (i.e., water-in-basement) across Dearborn in the west, the southern portion of the City of Detroit, and the Grosse Pointe communities in the east. Although more localized, the July 16 Rainfall Event resulted in hundreds of basement backups. For both the June/July 2021 Rainfall Events, the preparation and response of the Great Lakes Water Authority (GLWA) was scrutinized. Particularly for the June 25/26 Rainfall Event, as it was reported that failures of some of GLWA's stormwater Pumping Station (PS) had occurred.

GLWA engaged the engineering consulting firms of Wade Trim and Brown and Caldwell on June 28 to conduct an internal investigation into the June 25/26 Rainfall Event. That investigation was later expanded to include an investigation of the July 16 Rainfall Event as well. Recognizing the need to be transparent and respond to concerns of the member communities and their residents, the Board of Directors (BoD) of GLWA engaged the engineering firms of AECOM Technical Services, Inc. (AECOM) and Applied Science, Inc. (ASI) on July 28 to conduct an independent investigation of the June/July 2021 Rainfall Events. The AECOM team was led by an Independent Panel of experts from industry and academia who directed the investigation. On December 3, 2021, the Independent Panel presented its initial findings to the BoD. That report presented the factual account of both rainfall events, GLWA's state of readiness and their operational response. The findings of both the internal and external investigations were essentially the same; therefore, the BoD directed the investigations to collaborate and develop a single Final Report. This report includes the results of the investigations; factual accounts of what occurred; and provides conclusions and recommendations to improve the reliability of the stormwater infrastructure and chart a course for future improvements.

The investigation of the June 25/26 Rainfall Event yielded several observations and conclusions. A summary of these actions is provided in Table ES-1:

Table ES-1: Observations and Conclusions for the June 25/26 Rainfall Event

Charge	Observation/Conclusion
Characterization of Rainfall Event and Extent of Flooding	• The June 25/26 Rainfall Event was a large, high-intensity storm that covered much of the GLWA wastewater service area but was most intense in a band from Inkster in the west, across the southern portions of Dearborn, the city of Detroit, and the Grosse Pointe communities generally intensifying farther to the east. • The most intense areas of rainfall received more than 6 inches of rain with some areas receiving over 8 inches of rainfall over a 24-hour period. Based on historical rainfall records, this equates to a rainfall return period of 200 years to over 1000 years. • While areas to the north and west received significant rainfall with return periods between 5 and 10 years, the rainfall event across the southern portions of the service area, particularly in the east, produced combined sewer flow rates that far exceeded the designed capacity of the wastewater system. As such, extensive surface flooding and basement backups are considered inevitable. • The City of Detroit received thousands of reported water-in-basement complaints following the June 25/26 Rainfall Event. Complaints were concentrated in areas with the highest rainfall intensities in the west bordering Dearborn and on the east side. Extensive hydraulic modeling was performed, and results of high flood risk generally coincided with the location of basement flooding complaints in Detroit. Similarly, surface flooding analyses for Detroit coincided well with observed high-water marks.

Charge	Observation/Conclusion

Operational readiness	• Following the 2016 rainfalls events, GLWA implemented several measures to improve the reliability and performance of the wastewater system. Operators were deployed to the PS and CSO facilities prior to the June 25/26 Rainfall Event in accordance with measures implemented after rainfall events in 2016. Electrical technicians floated between Freud PS and Connors Creek PS due to their proximity.
	• Wastewater operations historically evaluate their readiness level based on predicted daily rainfall. In the case of the June 25/26 Rainfall Event, the actual rainfall far exceeded weather forecasts creating a false sense of readiness. This assessment of readiness was communicated to the BoD in response to an inquiry by the BoD prior to the June 25/26 Rainfall Event.
	• At the Freud PS, electrical power supply was compromised.
	  ○ Prior to the June 25/26 Rainfall Event, GLWA was a DTE customer, but GLWA's power supply to this PS was provided by Detroit's PLD distribution system. Since 2014, DTE has been working with its customers, including GLWA, to convert the power supply from PLD's distribution system to DTE's distribution system.
	  ○ In 2017, PLD abandoned one of the three independent electrical feeds and spliced one electrical feed to power transformers 1 and 3 at the PS.
	  ○ On June 22, 2021, a utility contractor accidentally hit the utility service #1 distribution line (Ludden Feeder No. 208) feeding primary transformers 1 and 3 (removing them from service). The energy supplier attempted a repair of the utility service #1 but was unable to complete the repairs before the June 25/26 Rainfall Event. With two of three transformers out of service, the PS's peak pumping capacity was only approximately 43% of the overall capacity during the event (three of seven duty storm pumps available). This was considered sufficient for the forecasted rainfall.
	  ○ Consistent with SOP, the hit line was communicated to the SCC supervisor. The supervisor did not communicate the damaged line to GLWA executive leadership nor the BoD.
	  ○ With only one primary transformer available, there was enough electrical capacity to operate three storm pumps and two sanitary pumps.
	• At the Connors Creek PS, all storm pump systems, except Storm Pump 5, checked out available prior to the June 25/26 Rainfall Event.
	• At the Bluehill PS:
	  ○ Under normal conditions, the PS is operated remotely by the operators at the SCC. Operators visit the PS to perform routine preventive maintenance duties. During storm events, staff operators are dispatched if the automated systems indicate a fault at the PS.
	  ○ All equipment was available for service; however, Storm Pump #4 was marked for emergency use only.
	  ○ At the time of the June 25/26 Rainfall Event, electrical power was supplied through PLD's distribution system and provided via two separate 24kV utility services to provide a level of utility redundancy. The PS has two GLWA-operated primary transformers, each sized to power any three of the four storm pumps. Therefore, the capacity of the primary transformers prevents full electrical redundancy. One of the power sources is backed up by three 1,825 kW emergency generators. There are no provisions to connect the emergency generators to back up utility service 2.
	  ○ According to the current O&M manual, hydraulic restrictions downstream of the PS limit operation to only three of four pumps. The investigation noted that four pumps did operate briefly, so further investigation is recommended.

Charge	Observation/Conclusion

System response	• At the Freud PS:
	  ○ Power issues related to only one transformer being available resulted in only two pumps operating consistently. Attempting to start a third pump tripped out the operating two pumps. High normal wet well levels were exceeded before 11 p.m. and continued to rise. Operators were eventually able to start three pumps and, with five pumps then operating at Connors Creek PS (see below), wet well levels gradually subsided.
	• At the Connors Creek PS:
	  ○ The elevation and configuration of the storm pumps requires the operation of a vacuum priming system prior to starting the storm pumps. This system has historically been complex to operate; vacuum priming takes 15 to 20 minutes per pump, and the seal water capacity allows only two storm pumps to be started simultaneously. The stormwater pumping system response does not keep pace with rapid increases in wet well levels, due to the time required for priming prior to starting pumps.
	  ○ For the June 25/26 Rainfall Event, the rate of rise of wet well levels was fast and the operators could not start additional pumps fast enough to respond.
	  ○ Operators were able to initially start two pumps, but a leak from the vacuum priming system sprayed on an electrical panel causing a loss of house power, including the lighting system. Electrical supply to the PS was not impacted and the two pumps continued to operate, but additional pumps could not be started. The wet well elevation before midnight was already above 86 feet (i.e., the maximum recordable level).
	  ○ Electricians dispatched to the Freud PS were recalled to Connors Creek PS to perform repairs, but street flooding and lack of lighting or ability to access the site (security gates operate on house power) hampered these efforts. This delay is estimated at 15 to 30 minutes with the wet well level remaining above 86 feet. When house power was restored, five pumps were able to operate and began to reduce wet well levels and shortly after 2 a.m., dropped to within recordable range.
	• At the Bluehill PS:
	  ○ Experienced power quality issues from PLD's distribution system. Voltages plus/minus 10% of rated voltage will cause a pump not to start. The PS operated with two of the four available storm pumps during the peak of the June 25/26 Rainfall Event and the wet well level reached the maximum recordable level (approximately 86 feet).
	• Local System Response:
	  ○ Detailed reviews of the response of member communities was beyond the scope of this investigation; however, the investigation found:
	  ▪ Peak flow measurements of discharges suggest that most communities were at or below their contracted discharges limits within the exception of the Cities of Grosse Pointe Park and Grosse Pointe, which significantly exceeded their contract limits.
	  ▪ SEMSD operated for extended periods beyond their contract capacity, Dearborn, Grosse Pointe Farms and the flow in other districts were impacted by the surcharged condition of the GLWA system during the height of the storm.
	  ▪ Accounts of local system response are included in the ASI report (Appendix A9)

Charge	Observation/Conclusion
System Response if Everything had worked as intended	• The intensity of the rainfall far exceeded the designed capacity of the wastewater system and, as a result, some level of both surface flooding and basement backups was unavoidable. • Modeling suggests an additional 336 MG (or 26%) of total flow could have been pumped had everything operated as intended and wet well levels at the Connors and Freud PS would have been approximately 7 feet lower. • An analysis of risk of basement backups did not show an appreciable reduction in risk if everything had worked as intended. • Surface flooding would have been reduced, but not eliminated. For example, the areas that experienced surface flooding greater than 2 feet could have been reduced by approximately 110 acres. • GLWA customer contract limit exceedances that occurred during the June 25/26 Rainfall Event did not significantly affect basement backup flooding. • The above suggests that conveyance capacity in the collection system, not pumping, was the primary cause of flood risk and additional pumping capacity would not appreciably reduce the risk of surface flooding and basement backups. Rather, a strategic assessment of conveyance improvements, inlet controls and in-system storage is warranted.

Notes:
BoD = Board of Directors
DTE = DTE Energy
kV = kilovolt
kW = kilowatt
MG = million gallons
O&M = operations and maintenance
PLD = Public Lighting Department
PS = Pumping Station
SCC = Systems Control Center
SEMSD = Southeast Macomb Sanitary District
SOP = Standard Operating Procedure

The investigation of the July 16 Rainfall Event yielded several observations and conclusions. A summary of these conclusions is provided in Table ES-2:

Table ES-2: Observations and Conclusions for the July 16 Rainfall Event

Charge	Observation/Conclusion
Characterization of Rainfall Event and Extent of Flooding	• While smaller than the June 25/26 Rainfall Event, the July 16 Rainfall Event was still a large, high-intensity storm that covered much of the GLWA wastewater service area. The storm was most concentrated in the southeast portions of Dearborn, the city of Detroit, and the Grosse Pointe communities and generally intensified farther to the east. • Maximum accumulated depth of 4.7 inches over 12 hours was observed, representing a rainfall return period of 100 years to 300 years. • Areas to the north generally experienced less than 5-year rainfall, while Dearborn and the south-central part of Detroit saw rainfall in the 10 to 50 year range. Because the storm exceeded the designed capacity of the wastewater system, localized surface flooding and risk of basement backups could be expected. Areas experiencing greater than 100 year intensities would certainly incur flooding and basement backups based on local hydraulic conditions. • The City of Detroit received hundreds of water-in-basement complaints following the July 16 Rainfall Event; however, the number of complaints was far fewer than the June 25/26 Rainfall Event. Complaints in Detroit were concentrated in the east and south, including the neighborhoods of Jefferson Chalmers and Cornerstone Village.

Charge	Observation/Conclusion

Operational readiness	• Operators were deployed to the PS and CSO facilities prior to the July 16 Rainfall Event.
	• At the Freud PS, three storm pumps were not available (one with warranty issues and two with electrical issues) leaving five pumps available for service.
	• At the Connors Creek PS, all storm pump systems, except Storm Pump 1, checked out available prior to the July 16 Rainfall Event.
	• At the Bluehill PS:
	  ○ Under normal conditions, the PS is operated remotely by the operators at the SCC. Operators visit the PS to perform routine preventive maintenance duties.
	  ○ The Bluehill PS was staffed prior to the July 16 Rainfall Event.
	  ○ Based on the operator logbook, all systems appear to have been available at the time, however, Storm Pump #4 was marked for emergency use only.

System response	• At the Freud PS:
	  ○ External power quality issues were observed but did not significantly impact operations. Repairs to the main electrical feed lines to the Freud PS were completed prior to the July 16 Rainfall Event.
	  ○ Four storm pumps were operated continuously over the event and a fifth pump was started and ran for approximately 2 hours from 2 p.m. to 4 p.m.
	  ○ Wet well levels peaked slightly above the maximum normal wet well elevation, but quickly subsided and wet well levels continued to drop during the normal pump shutdown process.
	• At the Connors Creek PS:
	  ○ The investigation did not reveal any equipment issues and up to six storm pumps were operated simultaneously during the event.
	  ○ Water levels in the wet well remained well below the normal maximum wet well elevation.
	• The Bluehill PS experienced power quality issues that did not allow all available pumps to operate or delayed their operation as operators attempted to supplement with on-site generators:
	  ○ Throughout most of the July 16 Rainfall Event only one pump operated, and wet well levels surpassed the normal high water level between approximately 10:30 a.m. and 2:00 p.m. During this time, wet well levels remained above the maximum recordable level of about 86 feet.
	  ○ By 2 p.m., operators were able to first start one small pump and then an additional large pump resulting in water levels in the wet well quickly dropping within range.
	  ○ Operational issues continued, but wet well levels remained within normal limits.
	  ○ While detailed analysis and modeling of DWSD's local collection system was beyond the scope of this investigation, it is reasonable to anticipate that surcharging of the local collection system would have occurred.
	• Modeling results did not indicate any areas in Detroit with significant surface flooding during the July 16, 2021 Rainfall Event.
	• 350 basement backup complaints provided by GLWA were reviewed and none of those reported significant surface flooding.
	• Surface flooding in Dearborn and areas of the Grosse Pointe communities could not be simulated because those sewer systems are not included in sufficient detail in the model.
	• The GLWA PC SWMM model was used to assess the risk of basement backup and over 6900 acres was estimated as having significant flood risk.
	• There are reports of basement flooding in locations in Detroit where the model results show low probability of basement backups. These instances of basement backups may have been caused by issues in the local and/or property owners sewer systems not included in the PC SWMM model.

Charge	Observation/Conclusion
System Response if Everything had worked as intended	• The intensity of the rainfall exceeded the designed capacity of the wastewater system in some areas and, in those areas, basement backups were reported. • The Connors Creek and Freud PSs operated as intended and no surface flooding was observed. Despite this, numerous basement backups were reported in the Jefferson Chalmers area, suggesting local conveyance issues/restrictions may be present. • Power quality issues at the Bluehill PS delayed the necessary starting of storm pumps, which resulted in high water levels in the PS and likely surcharge of the local upstream collection system. It is not known whether local basement flooding complaints could have been reduced if the system has operated as intended.

Notes:
CSO = Combined Sewer Overflow
DWSD = Detroit Water and Sewerage Department
GLWA = Great Lakes Water Authority
PS = Pumping Station
SCC = Systems Control Center

A summary of the following recommendations is provided in Table ES-3 and detailed in Section 4. Recommendations are structured in short-/medium-/long-term timeframes with short-term recommendations generally focused on measures to improve availability and reliability of existing infrastructure, medium term measures to retrofit and improve infrastructure performance, and long-term measures to investigate and develop policies and direction to maximize level of service. Many measures can be undertaken by GLWA internally; a preliminary cost estimate is provided for recommended capital works. It should be noted that significant detail has been omitted from this table; therefore, the reader is encouraged to review the appropriate report section (Section 4.1.2) to better understand each recommendation.

Table ES-3: Summary of Recommendations and Estimated Capital Cost

Category (Subheading)	Summary	Preliminary Cost Estimate
Short Term (approximately 12 to 18 months)		
General (4.1.1)	Take measures to reduce basement backups. Maintain a level of service of at least 14 of 16 storm pumps at Connors Creek and Freud PS and at least 3 of 4 storm pumps at Bluehill PS. Be ready for extreme storms at all times not just when predicted.	
PS (4.1.2)	Conduct tests on vacuum priming system and pump starting at Connors Creek PS to improve system reliability and to provide operator training opportunities. Develop, improve and document operational measures. Regularly use Connors Creek PS in wet weather and maintain the vacuum priming systems after a large storm events to improve system readiness and enhance operator training.	
Electrical Systems (4.1.3)	Transfer power sources to DTE. Provide capability for emergency generators to be connected to any section of the switchgear to enable generators to power any group of pumps. Develop protocols to operate generators at no-load prior to expected events to enable the pumps to be quickly switched to generator power if there is an outage.	
Mechanical Systems (4.1.4)	Make improvements to seal water and vacuum priming systems. Keep the Connors Creek storage gates and relief gates at the CSO Basins in good working order.	

Category (Subheading)	Summary	Preliminary Cost Estimate
Medium Term (approximately 2 to 5 years)		
General (4.2.1)	Define level of service objectives with respect to flooding and water quality and implications of water quality requirements. Investigate how those objectives have been achieved previously.	
PS (4.2.2)	Implement modifications to the “Freud Pump Station Improvements – DRAFT” report prepared by Arcadis/Brown and Caldwell for GLWA project number CS-120 in August 2020	
Electrical Systems (4.2.3)	Provide for a policy for redundant PS power sources and perform studies to understand existing and potential power source redundancy.	
Mechanical Systems (4.2.4)	Implement intake flow conditioning devices at Connors Creek PS and Freud PS wet wells based on testing and recommendations from the February 2018 Clemson Engineering Hydraulics, Inc. study. Also, replace two storm pumps with vertically suspended pumps at Connors Creek PS. Expand and improve the Connors Creek PS seal water system.	$16M for IFC devices $19.5M for VS3i pumps
Operational Measures (4.2.5)	Operate and inspect IFC devices. Regularly clean the Connors Creek Storm wet well and IFC devices.	
Additional Investigation/Studies (4.2.6)	Review existing studies with consideration of flooding and water quality objectives. Conduct additional studies to understand flooding and water quality level of service and optimize system operations using “real-time” data. Consider different operating procedures for extreme storms that maximizes conveyance but may increase CSOs.	
Long Term (more than 5 years)		
General (4.3.1)	Consider implementing comprehensive policies and practices that address the frequency and extent of flood losses.	
PS (4.3.2)	Make additional PS modifications at the Connors Creek PS based on performance of medium-term recommendations, including replacing the remaining six storm pumps and constructing access and screening improvements in lieu of building a new pumping station.	
Regional Coordination		
General (4.4)	Foster regional coordination. Various recommendations generally intended to reduce future flood damages and requiring regional coordination to implement.	

Notes:
CSO = Combined Sewer Overflow
DTE = DTE Energy
IFC = intake flow conditioning
PS = Pumping Station

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