Twin Lakes Temporary Drawdown

Twin Lake, St. Croix County, Wisconsin

Warren Township, Wisconsin

SEH No. WARTW 155197

September 10, 2020

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September 10, 2020

RE: Warren Township, St. Croix County, WI
Twin Lakes Temporary Drawdown
Model Report
SEH No. WARTW 155197 14.00

Attn: Town Manager
Mr. Gene Hanson
Town of Warren
St. Croix County, WI

We have enclosed a summary letter report detailing the analysis and results of the Twin Lakes Temporary Drawdown Analysis completed by SEH.

As you are aware the high water issues surrounding Twin Lakes are a complex issue not only in developing a good understanding of the cause but also in the development of feasible solutions to water level management. This is not an issue limited solely to Twin Lakes, but is also a problem with numerous landlocked "seepage lakes" across Wisconsin and eastern Minnesota. Unfortunately our report does not provide a silver bullet to lake level management, but points to a bigger picture solution that may include a number of different strategies to mitigate the human effects of high water levels and the resulting flooding of public and private properties around the lakes.

If you have any questions or comments regarding the details of this report or the analyses completed by SEH, please feel free to reach out to me directly at bwoznak@sehinc.com or by phone at 651.470-7678.

Sincerely,

Brad T Woznak

Brad Woznak, PE, PH, CFM

btw
Enclosure
c: Chad Posta, Twin Lakes Committee Chair

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Twin Lakes Temporary Drawdown Study

St. Croix County, Wisconsin

Prepared for Warren Township, Wisconsin

1.0 Purpose of the Study

The purpose of this study is to develop feasible means for managing lake water levels in Twin Lakes (east and west basins). To do this, it is crucial that an understanding of the hydrology and hydrologic mechanisms underlying the lake levels is developed. SEH developed a high level water-budget, model based on available data, to evaluate existing lake levels and also to assess potential pumping scenarios. The study includes an investigation and summary of the permitting and design obstacles surrounding the most feasible water level management solution, including alternatives and next steps.

2.0 Background Data

2.1 Vertical Datum

All vertical geometry data, water surface profile elevations, and lake-boundary elevations used in the updated modeling are referred to the NAVD88 vertical datum.

2.2 Lake Volume / Stage-Storage Curve

The lake volume curve was created utilizing a bathymetric map obtained from the DNR produced in 1994 overlaid on the current St. Croix county digital elevation model (DEM). The bathymetric map indicated the lake bottom depth of 953.38' and the water surface elevation (WSEL) of 965.38' at the time the map was created. The depth contours were used to develop a stage-storage relationship for the lakes by calculating the volume at each depth in the lake by utilizing the surface areas and depths of each contour line. The lake volume above the WSEL in 1994 (965.38') was developed using the St. Croix county 1-meter DEM and the same process of multiplying elevation contour surface areas by their "depth" in relation to the bottom of the lake. From this data, a volume/stage-storage curve was created to calculate the volume at elevation between 953.38' and 1030.92' (Figure 1). The stage-storage curve will be used to relate the water-budget model results into lake level elevations.

2.3 Historical Lake Level

Twin Lakes lacks a thorough long term record of past lake levels. Based on information available to SEH, it appears that the levels were measured in 1974 (959'), 2008 (965.5'), 2009 (964.8'), 2018 (967.7') and in 2019. In 2019 the lake level was measured 36 times from June 3rd to October 15th, the lowest and highest levels recorded were 969.12' and 970.02', respectively. Since 2019 provided the most comprehensive dataset, and could be considered a wet weather year, SEH used the 2019 data to develop a calibrated lake level response and budget model.

2.4 Historical Groundwater Elevation

Based on our review of available information, it appears that minimal groundwater elevation data exists for Twin Lakes. A past SEH groundwater/surface water interaction study included the installation of piezometers near the lake, which have been submerged by rising lake levels. Therefore, static groundwater levels were analyzed from available recorded well logs for wells drilled near the lake over the past 60 years. This data was utilized along with the Wisconsin DNR (WDNR) well locator tool to investigate general groundwater patterns near Twin Lakes. One drawback of this method is well construction reports are not known for recording static groundwater depth with great precision and the wells could be tapping into different groundwater layers. For this reason, SEH did not rely heavily on the reported groundwater elevations, but the data did depict a rising trend in the static groundwater levels over the past 60 years (Figure 2). Wells near the lake that were drilled within the last 20 years have static groundwater levels near that of the current lake levels. This finding matches anecdotal reports from the WDNR on rising groundwater levels in the surrounding areas.

2.5 Waste Water Treatment Plant (WWTP) Inflow

The Roberts WWTP provided data for the daily effluent discharge volume into Twin Lakes. For the water level budget modeling, this effluent volume was added directly into the lake for each day during the analysis period.

3.0 2019 Water-Budget Model – Twin Lakes

A water-budget model was created to account for all inflows and outflows to the lake and estimate the total lake volume at each day. The total modeled lake volume was then converted to a lake level for each day using the lake stage-storage curve discussed earlier. Calibration of the water-budget model is an important step in the process to help ensure the overall validity of the results. Model calibration was performed by comparing the modeled lake levels to actual measured lake levels. The water-budget model was adjusted until the modeled lake levels match the measured lake levels as closely as possible. The water-budget calibration was performed on the summer of 2019 data because it appeared to be the only summer with consistent lake level measurements with which to calibrate the model to. It was determined that the hydrologic conditions associated with the summer of 2019 would result in development of a conservative pumping rate with which to manage the lake levels.

3.1 Inflow Data Summary

3.1.1 Precipitation/Direct Contribution

Precipitation/direct contributions include all of the precipitation that falls directly onto the lake surface. This portion of the water-budget model accounted for 71% of the total lake inflow in the summer of 2019. During our modeling period of June to mid-October, rainfall was the only precipitation type experienced (snow not reported). The portion of lake inflow due to precipitation was determined by multiplying the total lake surface area by the daily precipitation to get a total precipitation volume for each day (Figure 3). The rainfall data used in the model was downloaded from the National Weather Station for the Roberts WWTP.

3.1.2 Rainfall Runoff

Rainfall runoff is comprised of all the rain that falls within the watershed tributary to Twin Lakes and drains to the lake, excluding the rainfall that falls directly onto the lake. This portion of the water-budget accounted for 17% of the total lake inflow in the summer of 2019. Estimating rainfall runoff involves a hydrologic calculation that factors in the rain depth, rain intensity, drainage area size, land use, and land slope. The Soil Conservation Service methodology was used to perform the hydrologic calculation for this project. To quantify the rainfall runoff volume for each rainfall event, a runoff volume curve was created by estimating the runoff volume associated with a given rainfall depth based on a set of pre-defined storm events modeled by SEH.

The runoff calculations were performed using HydroCAD, which is a computer program that utilizes the TR-55 based hydrologic calculations to analyze storm water runoff. The TR-55 method is utilized to estimate the peak discharge rate, runoff hydrographs, and storage routing for reservoirs for primarily small watersheds. The MSE 3 rainfall distribution was used with storm event depths from the NOAA Atlas 14 dataset. The rainfall distribution describes the timing and intensity of a particular rain event.

3.1.3 WWTP Contributions

Daily WWTP discharge volumes to the lake were provided by the Roberts WWTP. The WWTP effluent accounted for approximately 12% of the overall inflow to Twin Lakes in the summer of 2019.

3.2 Outflow Data Summary

3.2.1 Evaporation

Evaporation it is the process of liquid water converting to a gas form and can play a significant role in lake levels for landlocked lakes or those with insignificant outlets. The Linacre equation was used to estimate the daily evaporation volumes for Twin Lakes during the summer of 2019. The Modified Linacre equation utilizes the altitude, latitude, air temperatures, and dew point temperatures to calculate evaporation. Temperature data was taken from the National Weather Service Station at the Roberts WWTP.

3.2.2 Net Groundwater Interaction

Similar to the findings of the previous groundwater/ surface water interaction study, it was determined that estimating the groundwater seepage to or from the lakes is an extremely complex undertaking and outside the scope of this study. The groundwater seepage was approximated using the lake level calibration data by fitting the water-budget model to the calibrated data and treating the groundwater seepage component as an unknown variable. The net groundwater interaction rate was then estimated by starting at an assumed infiltration rate and iteratively reducing the rate until the water budget model best matched the observed water surface elevations.

3.3 Summary of Model Output

The water-budget model was used to estimate the water surface elevation from the inflow/outflow data and the lake stage-storage curve described in section 2.2. For each day from June 3rd, 2019 to October 15th, 2019, the overall change in lake volume was determined by subtracting the total outflows from the total inflows. The total inflows include the direct precipitation, the rainfall runoff, and the WWTP discharge. The total outflows include the estimated evaporation and groundwater seepage. The daily lake volume change is then added to the preceding lake volume to calculate the total lake volume for each day of the time period analyzed. The daily total lake volume can be converted to the daily lake level from the stage-storage curve. The field measured lake levels depict a lake level increase of 0.8-feet from June 3rd to October 15th in 2019. The calibrated water-budget model estimated the lake increase of 0.9-feet over the same time period (Figure 4).

3.4 Modeled Drawdown Pumping Scenarios

A main goal of the project is to develop pumping scenarios to meet different lake level management goals. Scenarios analyzed include:

1. Developing a pumping rate to maintain a consistent water surface elevation throughout the summer,

2. Pumping rates to lower the lake levels by 3-inches each month, and

3. Reducing the impact of WWTP inflows on the lake levels by pumping out the equivalent of half of the total WWTP inflow volumes throughout the summer (Figure 5).

These scenarios were selected to help to guide management and implementation decisions through understanding the magnitude of pumping solutions for managing the lake levels during a wet weather season.

Table 1. Drawdown pumping data.

Drawdown Pumping Scenarios				
Scenario	Gallons/Day	Pump Rate (GPM)	Total Volume Pumped (G)	Goal
1	347,000	240	52,344,000	Consistent Lake Level
2	673,000	468	101,660,000	Lower level 3"/month
3	varies	varies	7,001,000	50% of WWTP Inflow Pumped

3.4.1 Consistent Lake Level

The goal of this scenario is to remove, through pumping, an adequate volume of lake water to maintain consistent lake levels consistent from June 3rd to October 15th (2019). During this time period, the lake level increased approximately 0.8-feet. The water-budget model estimated a total volume of 52,344,000 gallons (160.6 ac-ft) are necessary to be pumped from the lakes during the modeled time frame to keep lake levels consistent. This would require 347,000 gallons to be pumped per day at a rate of 240 gallons per minute (GPM).

3.4.2 Lowering Lake Level

The goal in this scenario was to lower the lake level by 3-inches per month during the modeled time frame. This rate was chosen as it is the fastest recommended rate to lower lake levels without adversely impacting the shoreline slope stability, structural integrity of existing structure foundations near the lake, or the natural ecosystem function within the lake. An estimated total pumping volume of 101,660,000 gallons (312.0 ac-ft) over the modeled period are required to result in lowering the lake levels by 3-inches per month. This is equivalent to pumping approximately 673,000 gallons per day at a rate of 470 GPM.

3.4.3 Reducing WWTP Inflow

SEH also investigated the lake level effects associated with reducing WWTP inflows by 50-percent (or pumping from the lakes an equivalent volume) over the modeled time frame. This volume was estimated from the WWTP flow data to be 7,001,000 gallons (21.5 ac-ft) over the course of the 4.5 month modeled time frame. Reducing the WWTP inflows by 50-percent result in an approximate 0.2-foot decrease over the 4.5 month time period of the model compared with an increase of 0.7-feet associated with the expected existing system discharge over the same time period.

4.0 Water Level Management

The pumping solutions analyzed for the 2019 time period, show that approximately 50 million gallons (greater than 150 acre-feet) of water would need to be pumped from the lake onto adjacent agricultural lands or into holding ponds to maintain the lake level, let alone lower it.

The University of Wisconsin, College of Agricultural and Life Sciences, estimates that an average field of feed corn requires 0.32" of sprinkler irrigation every 4-5 days during the summer in Wisconsin. Assuming this irrigation rate is maintained over the entire modeled period, it would take approximately 223 acres of feed corn to land apply the requisite 160.6 ac-ft of water required to maintain lake levels and 433 acres to land apply the 312 ac-ft to reduce the lake levels. A typical quarter-section field planted with a pivoting sprinkler is approximately 130 acre, meaning that it would require at least 2 fields irrigating all summer, despite any other precipitation events, to maintain the lake level and 3-4 fields to reduce the lake levels. To meet the demands of the irrigation system, the actual pump size required for a single pivot sprinkler system is approximately 1550 GPM per field.

Despite the access to crop land in the area that may use the water for irrigation, it is likely infeasible to assume that the lake could be managed using the water for crop irrigation. During dry summers when irrigation is most necessary, pumping large volumes from the lake could dramatically reduce the lake levels. Historic documents provided by the WDNR state that prior to the inclusion of the WWTP, the lakes would often dry up during the summers leaving only a marshy basin. On wet summers, such as 2019, farmers are often already dealing with an excess of water on their fields and may not be willing to pump the water necessary to manage the levels. The water would also require larger pumps with a screening system to remove sediment and algae from the water to prevent plugging of expensive irrigation equipment. For these reasons, it was determined that it would be infeasible to manage the lake level through the land application of lake water.

A 50-percent reduction in WWTP inflows to the lake does not result in significantly lower lake levels because the total WWTP inflows account for a fairly insignificant volume (12-percent) of the lake inflows over the modeled time frame. While the 2019 period was wetter than average, 42 inches of rainfall versus an average amount closer to 32 inches for the area. A review of historic rainfall data does show a trend of increasing average annual rainfall depths; the average rainfall over the last 45 years is 32.5 inches, over the last 10 years is 34 inches, and over the last 5 years is 37.5 inches (Figure 6).

Even though our analysis was completed on 2019 rainfall data, which was a wetter-than-average year, we believe it appropriately represents the typical magnitude of inflow and outflow contributions to Twin Lakes. A 2009 USGS study (Juckem) found results similar to the findings of this study, finding that precipitation represents 80-85 percent of inflow volume to the lakes (SEH study estimated 71-percent), 10-percent of inflow volume attributed to WWTP discharge (SEH study estimated at 12-percent), while the USGS study assumed rainfall runoff to be negligible. This is one area of discrepancy between SEH results and the USGS study, as the SEH study estimated that approximately 17-percent of total inflow to the lake may be attributed to rainfall runoff. Regardless of which study is correct, the resulting volumes necessary and feasible solutions available to manage lake water levels likely would not very substantially.

Since it was deemed infeasible to utilize the surrounding agricultural fields or storage ponds as feasible receiving areas for any lake water management solution, additional receiving bodies / areas were preliminarily investigated. The most desirable solution to any landlocked basin is to provide an outlet system that can be drained via gravity or if deemed infeasible, pumping system to the nearest gravity conveyance system (natural outlet). Unfortunately due to the surrounding topography, existing development, and infrastructure, excavation of a gravity outfall for the Twin Lakes system does not appear to be a feasible option (significant costs would be incurred to construct such a system). The nearest gravity conveyance system with which the Twin Lakes water could be pumped to appears to be the Kinnickinnic River system. The Kinnickinnic river is classified by the WDNR as an Outstanding Resource Water and is considered by the public as a prized trout stream, discharge to the Kinnickinnic River, while technically feasible may be quickly ruled out as an option due to anticipated public opposition and associated permitting costs for approval to discharge to, even assuming the wastewater is treated prior to discharge.

In preliminary discussions with the WDNR surrounding potential permitting challenges associated with a pumping solution, SEH learned that the WDNR currently has 5 other similar permit applications for other seepage lakes in this region of Wisconsin alone and are working on assembling a taskforce to streamline the permitting process.

Even with a streamlined permitting process, discharging to a river such as the Kinnickinnic would result in additional scrutiny. While we are not recommending discharge to the Kinnickinnic at this time, the WDNR was able to provide general requirements for discharge from the WWTP or Twin Lakes to such a resource. Some requirements include the treatment of effluent such that the nutrient and/or pollutant levels associated with the effluent are lower than the background loading levels within the receiving water. Typically this includes total suspended solids (TSS), nitrogen, phosphorus, temperature, chloride, biological oxygen demand (BOD), ammonia, metals, and others (DNR did not provide a comprehensive list as specifics would have to be identified during the permitting process). Discharging to an ORW such as the Kinnickinnic becomes even more challenging due to very low nutrient and pollutant levels and temperature concerns. A first step to understanding the potential challenges of such an undertaking and level of treatment required would be to establish a longer-term sampling program to establish baseline conditions for the proposed receiving body of water.

It is our understanding that the new CLEARAS wastewater treatment system being added to the Roberts WWTP has the potential to treat discharge to much higher levels of water quality which may improve the options for where the treated water can be discharged. Additional investigation into the potential receiving waters, required treatment levels for discharge, and initial water quality results of the effluent water from the CLEARAS system will be necessary to determine if water treated from the Roberts WWTP can be discharged to other receiving waters. This would be a next step to determining potential outlet options by utilizing the WWTP to treat water pumped from Twin Lakes prior to discharge in an attempt to meet any treatment standards required by the WDNR.

Aquatic invasive species (AIS) being transported from Twin Lakes is also another area of concern for discharge, which will also require a monitoring program to identify and quantify any potential AIS in the Twin Lakes system. It is likely that any AIS would need to be removed from the effluent discharge prior to being introduced to the receiving body of water, unless it could be demonstrated that any AIS is already present in the receiving system.

A water appropriations permit would likely also be necessary to allow for construction of any type of outlet which proposes to transport water from one watershed to another. Additionally, drawing down the Twin Lakes levels could also result in wetland impacts to any surrounding wetlands which may require mitigation.

5.0 Conclusions & Recommendations

Based on information provided by the township, the water surface elevation in Twin Lakes in August 2020 was 971.3 feet. Over the past 12 years, the water levels in Twin Lakes has increased 5.8 feet (at a rate of approximately 0.48' feet per year). While it is difficult to determine how the climate may change and/or lake levels fluctuate into the future, it is likely that the rate of rise will slow as the lake water elevation rises and flooded surface area increases. Even in saying that though, it would be prudent to have a plan of action and mitigation activities in place that assume the lakes will continue to rise at a rate equal to that already experienced. Mitigation activities should include this "what if the lake continues to rise" so that activities can be planned and implemented ahead of time versus reacting after the fact or continually raising roads a few inches at a time to stay ahead of rising waters. Assuming Twin Lakes continue to rise at or near that experienced recently, high water levels will impact other at-risk infrastructure surrounding the lake. The following table provides an estimate of the time frame in which valuable at-risk infrastructure could be inundated by high water levels in Twin Lakes (Figure 7). Of utmost importance is the fact that if the current rate of rise of Twin Lakes continues into the future, the Roberts WWTP could be at risk of inundation by 2026 if no mitigation activities are implemented.

Table 2. Future inundation estimates of at-risk infrastructure.

Infrastructure at Risk	Estimated Elevation of Initial Inundation	Estimated Year of Inundation
112th Street	970.0'	Currently inundated (by 1.3 ft)
107th Street	972.0'	2022
Roberts WWTP	974.0'	2026

Based on our analysis, two potential alternative options could potentially be considered further for the lake level management of Twin Lakes:

1. No Pumping

    a. Lake levels will continue to fluctuate with climactic variations, resulting in extended periods of high water during wet cycles and lower water levels under drought conditions.

    b. With this option, it may be desirable to pursue other mitigation strategies and funding such as acquisition of at risk properties and elevation and or structural or non-structural protection of critical infrastructure to minimize the impacts of high water years.

    c. This option was suggested by the WDNR because it may be lower cost, cheaper to implement, and result in the least environmental disruption. Additional funding for this option may be available from the WDNR through the Municipal Flood Control Grant.

2. Pursue a pumping option

a. Establish the long term desired lake water level management goals and an associated pumping rate necessary to meet those goals along with available funding constraints for construction and the long-term operation and maintenance.

b. Perform an in-depth engineering analysis to officially review and further screen potential receiving waters and options. Including costs, permitting requirements, and public input.

References

1. Juckem, P.F., 2009, Simulation of the groundwater-flow system in Pierce, Polk, and St. Croix Counties, Wisconsin: U.S. Geological Survey Scientific Investigations Report 2009–5056, 53 p. (https://pubs.usgs.gov/sir/2009/5056/pdf/sir2009-5056.pdf)

Figures

Figure 1. Lake Volume Curve

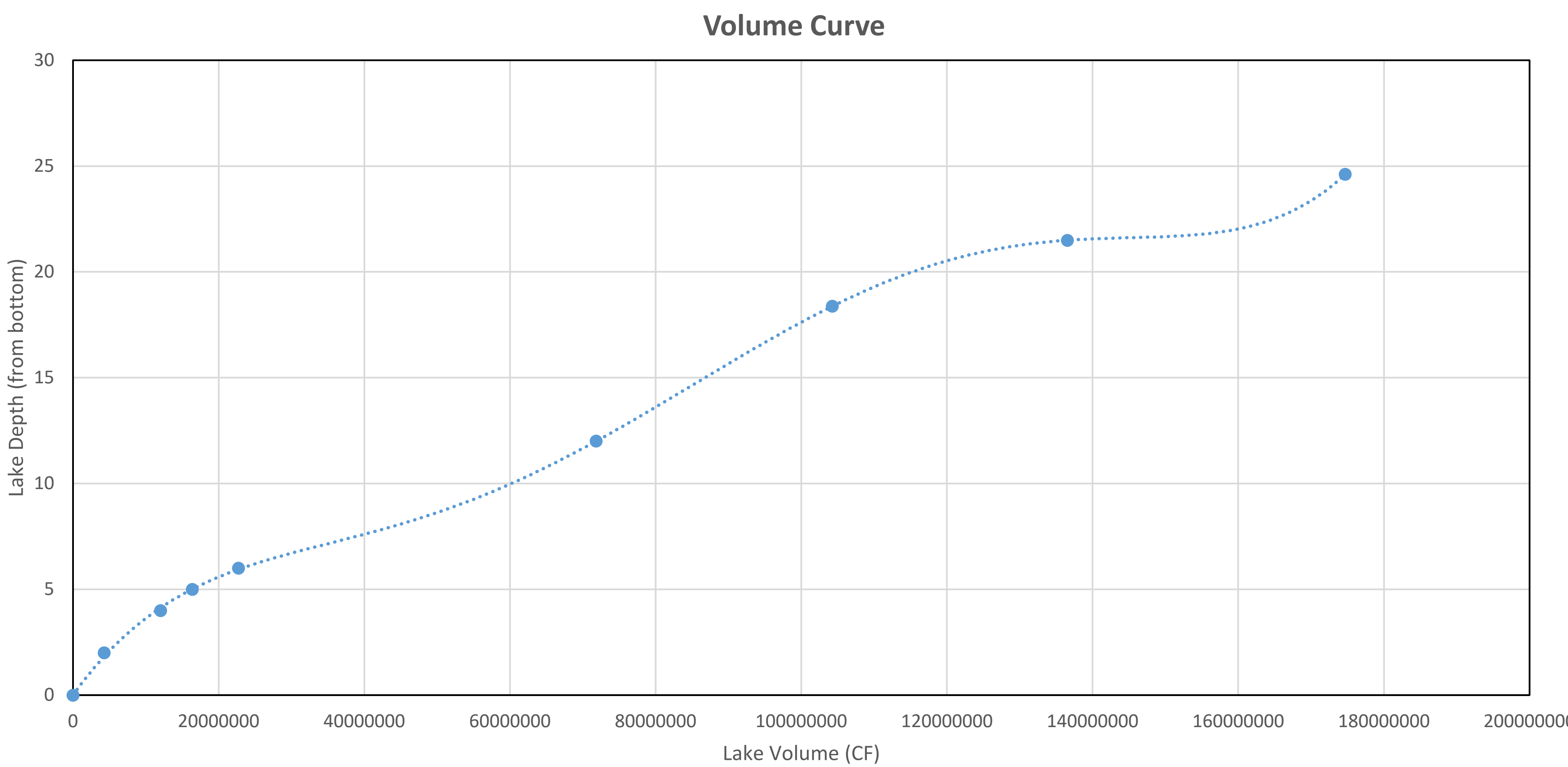
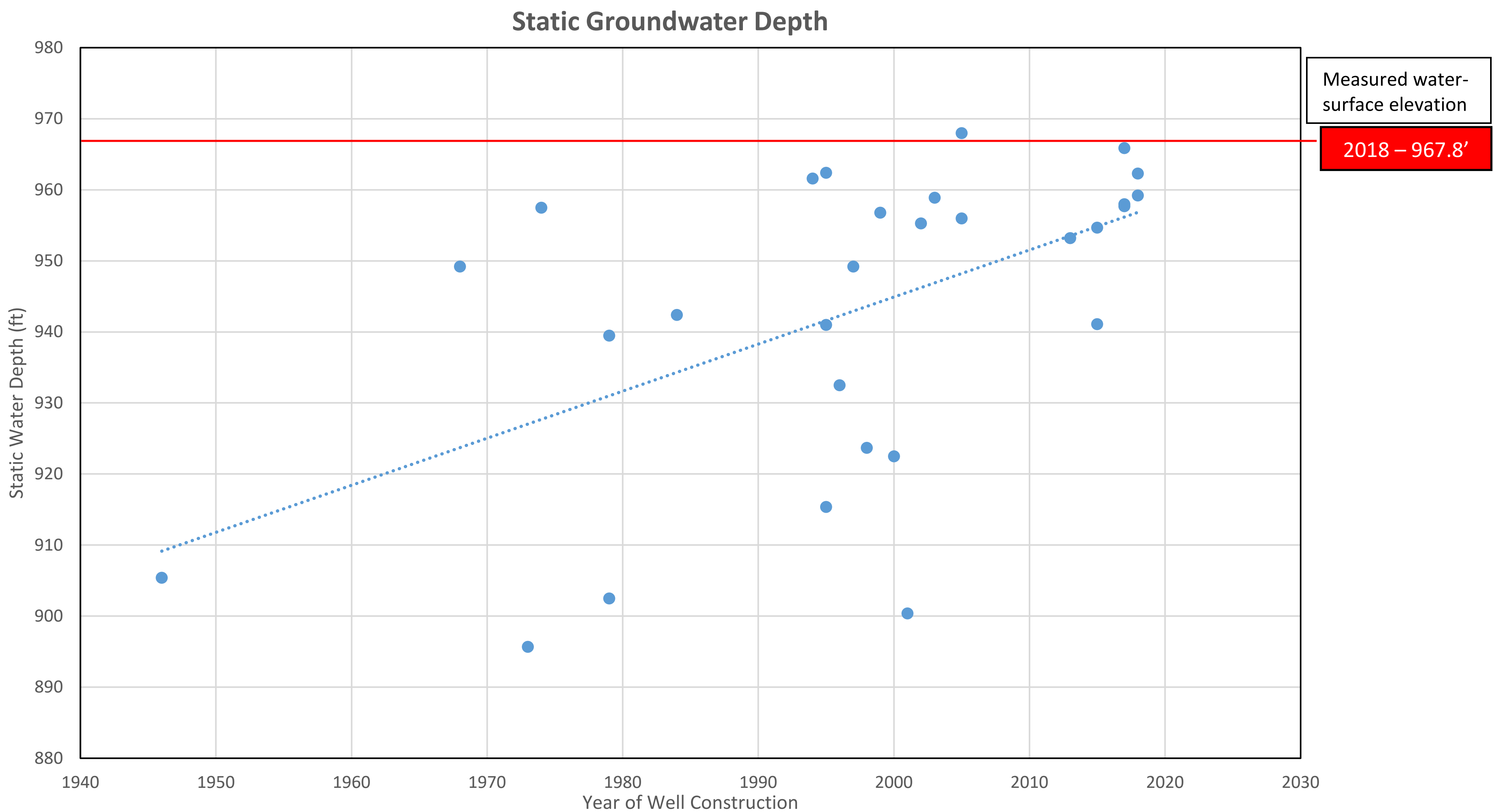
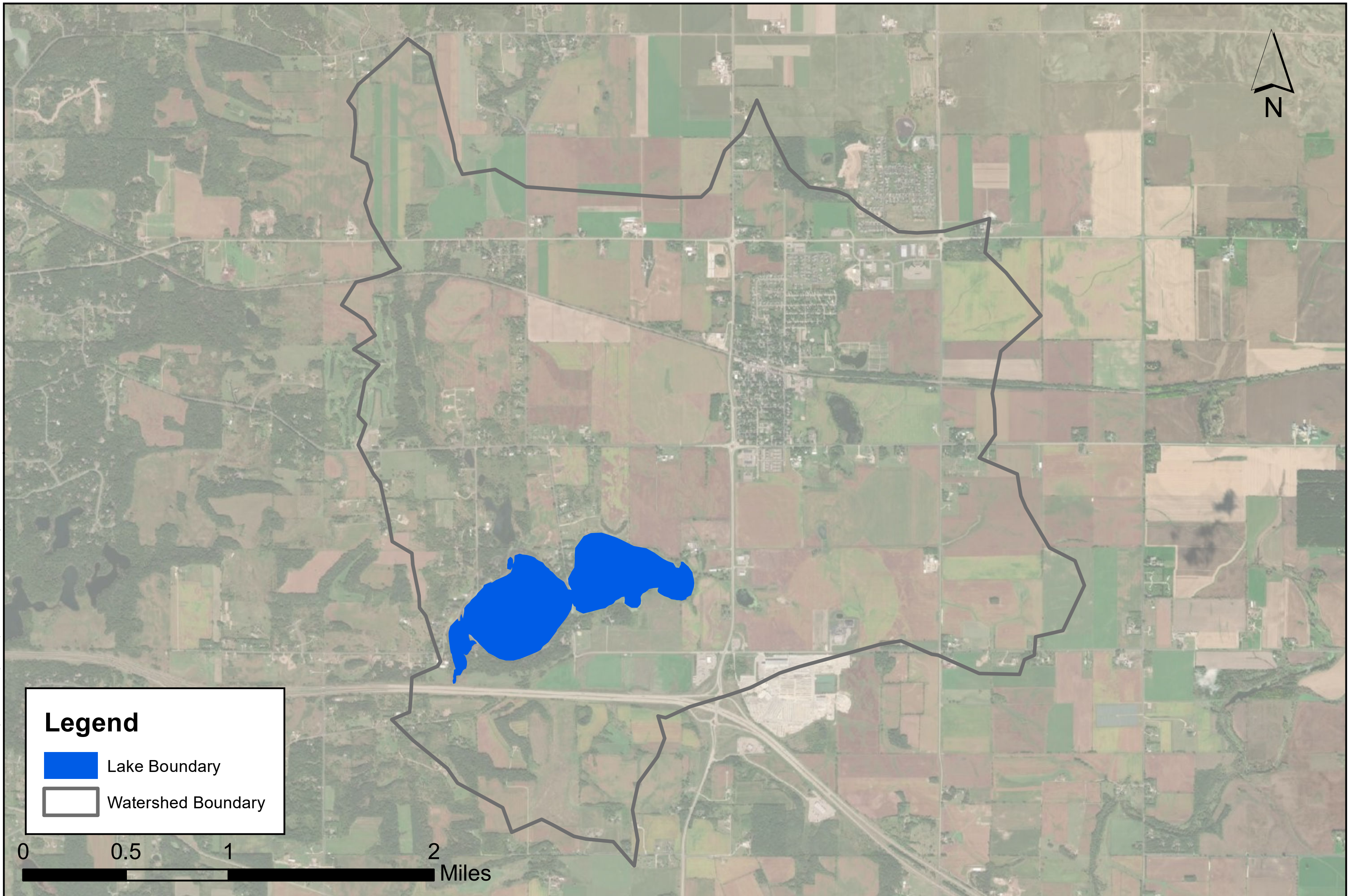


Figure 2. Groundwater Well Trends





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Project: WARTW 155197
Print Date: 8/5/2020

Map by: ebye
Projection:
NAD_1983_HARN_WISCRS_
St_Croix_County_Feet
Source: St. Croix County

Twin Lakes Watershed

Twin Lake Drawdown Study
Roberts/Warren, WI

Figure
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Figure 4. Water-budget model results.

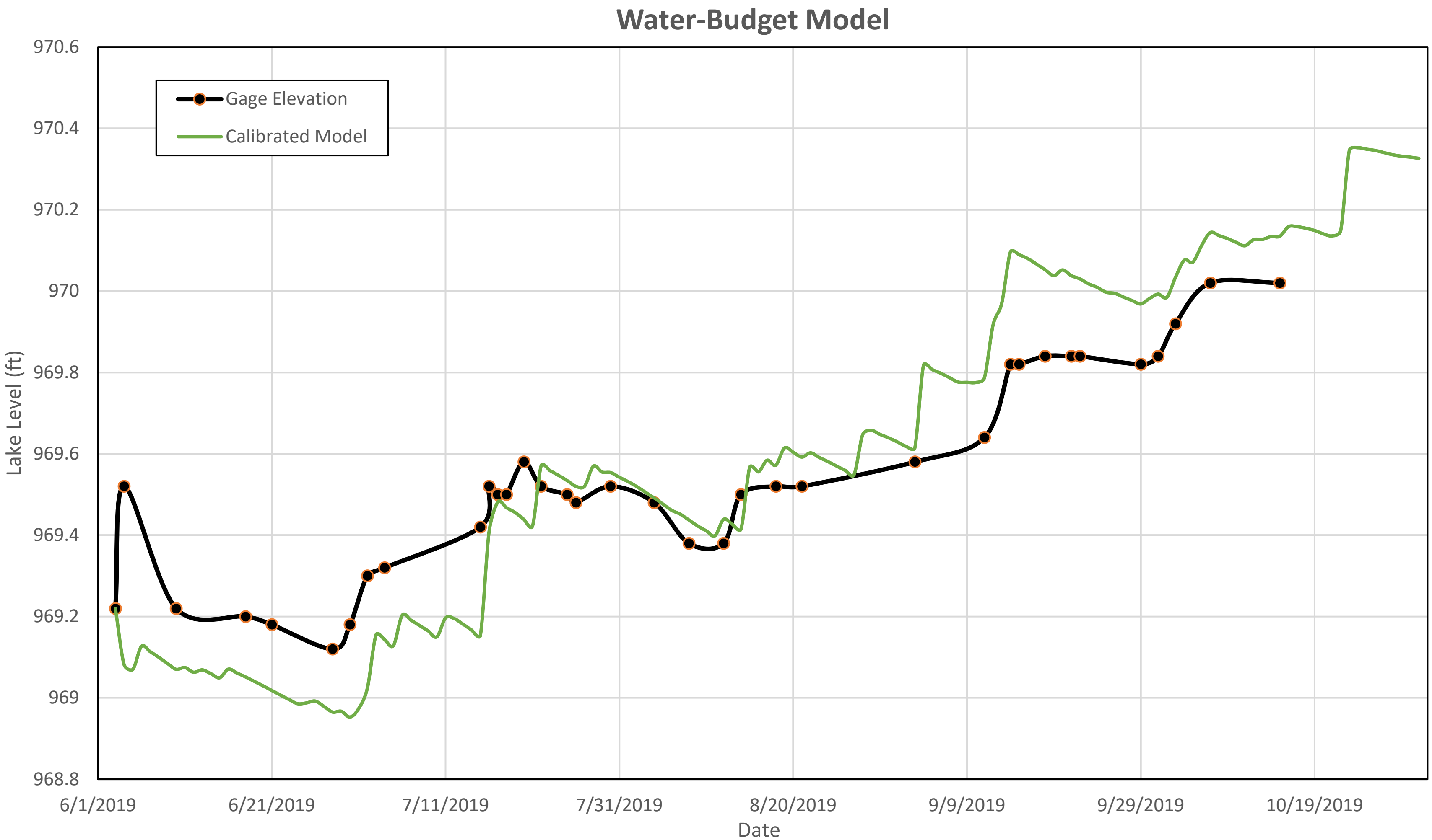


Figure 5. Lake Drawdown Scenarios.

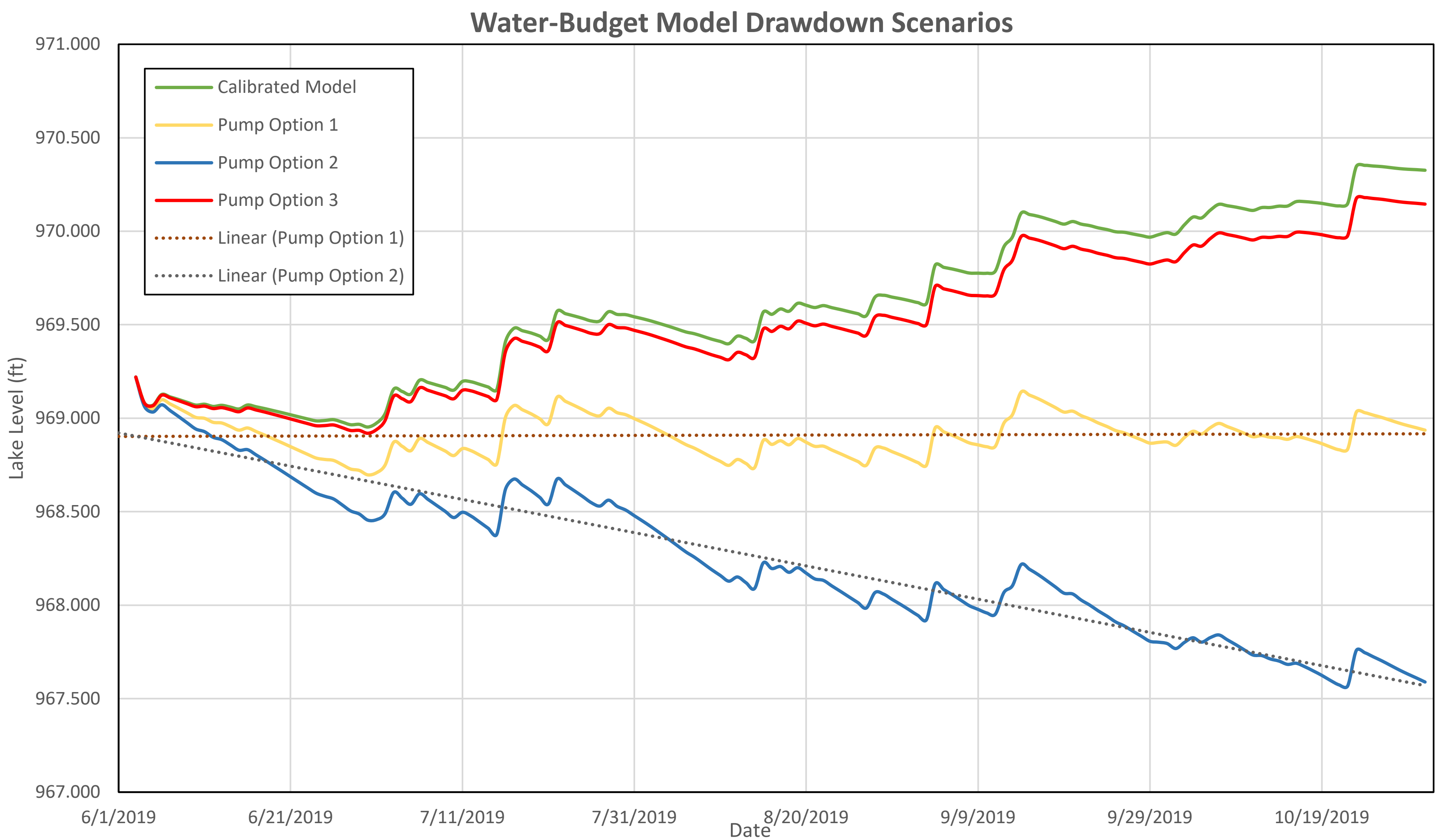
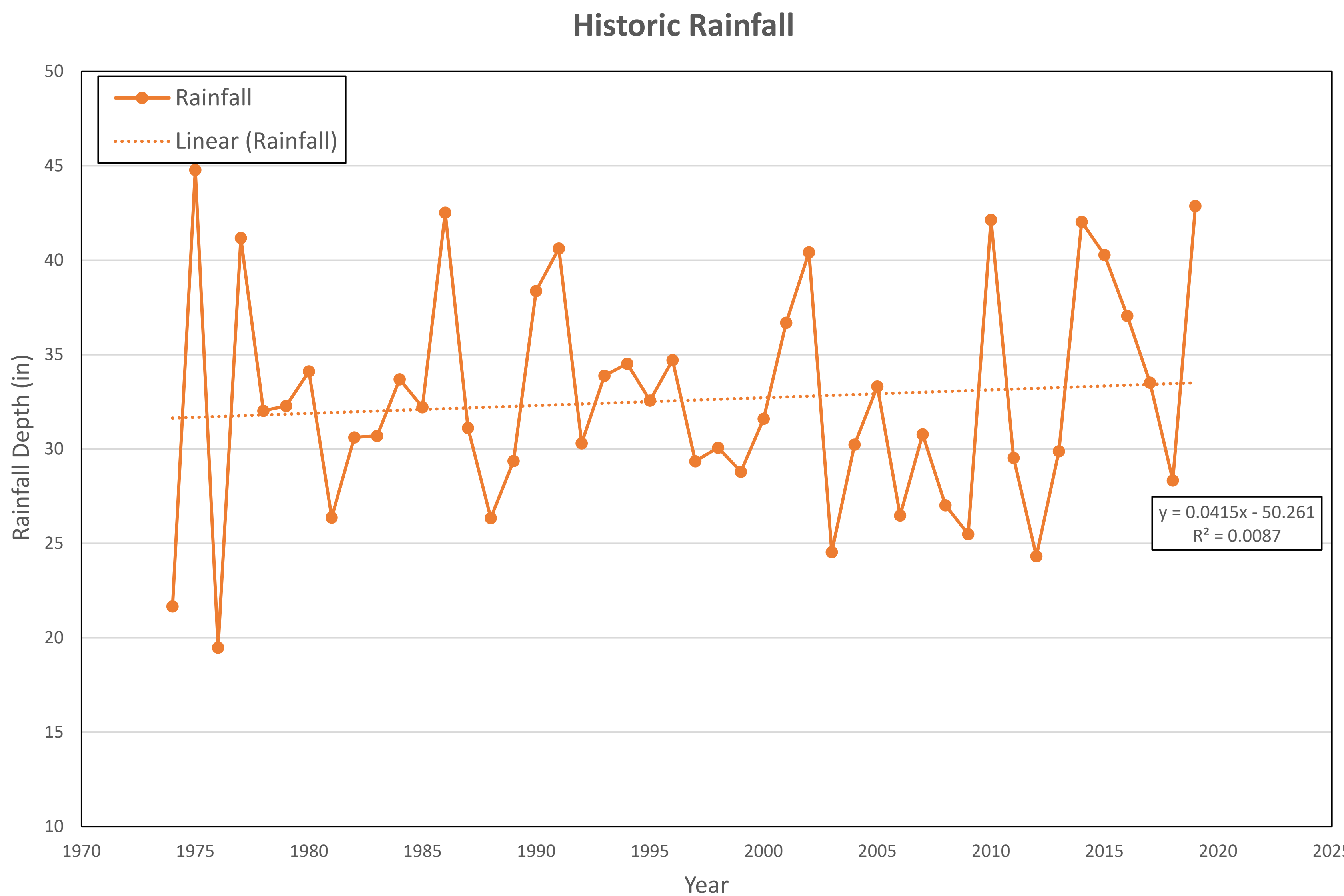
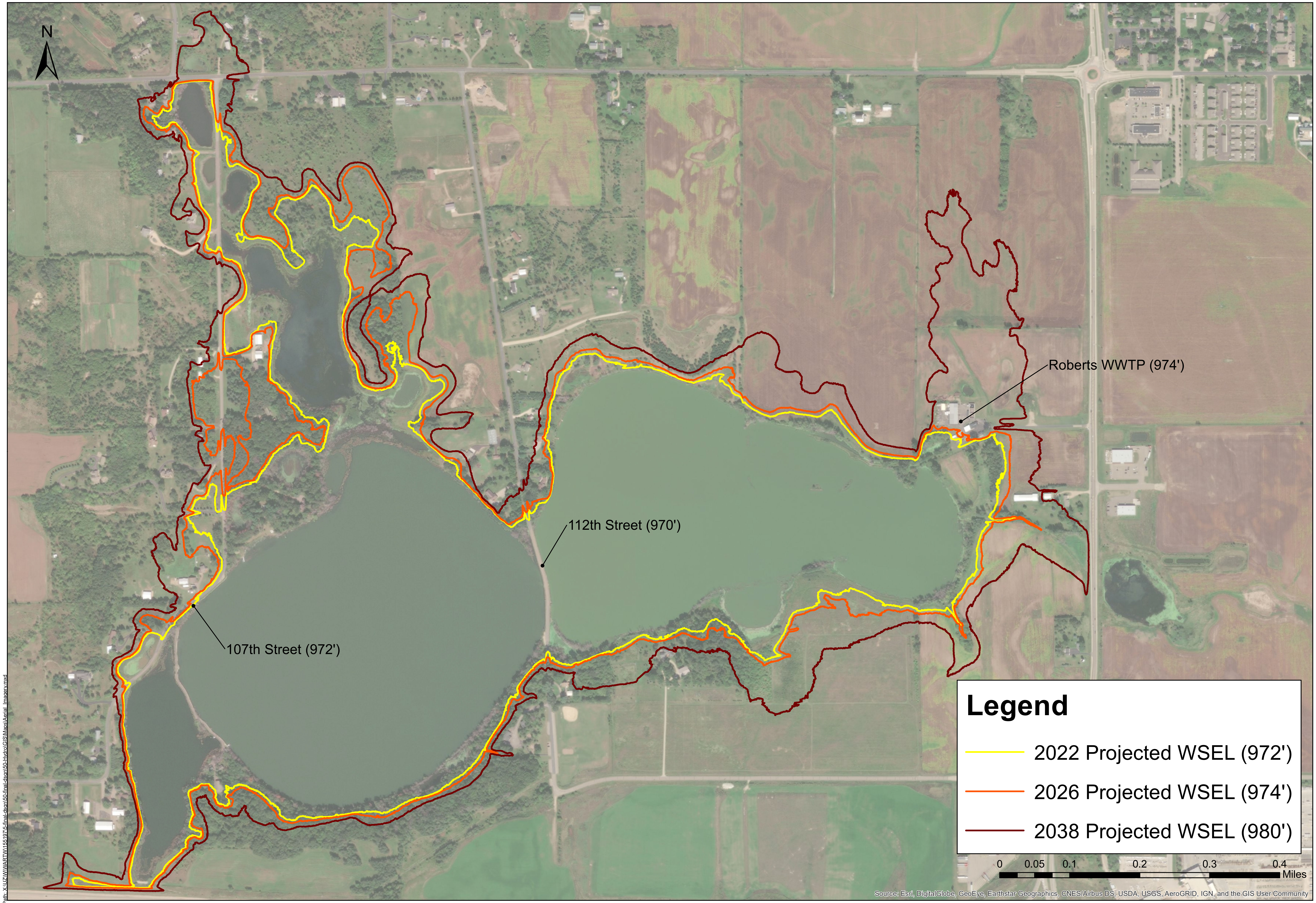


Figure 6. Historic rainfall amounts at Roberts WWTP.





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Map by:
Projection: NAD_1983_HARN_WISCRS_St_Croix_County_Feet
Source: St. Croix County

Projected Future Flooding

Twin Lakes Drawdown Study
Roberts/Warren, WI

Figure
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