VBWD LANDLOCKED BASIN FLOOD MITIGATION COMPREHENSIVE PLANNING STUDY

SCOPE OF WORK

This Scope of Work is for a flood mitigation comprehensive planning study for landlocked basins in the Valley Branch Watershed District (VBWD) that have been experiencing historic high-water levels. The VBWD will be completing this study in partnership with the United States Army Corps of Engineers (USACE), herein referred to as "the team." This partnership is made possible through the USACE Planning Assistance to the States (PAS) program.

The goal of the study is to assess the cost-benefit of water level management options for the following landlocked lakes and ponds, which are shown in Figure 1:

1. Cloverdale Lake
2. McDonald Lake
3. Downs Lake and Eden Park Pond
4. Reid Park Ponds
5. Legion Pond
6. Friedrich's Pond
7. Sunfish Lake
8. Klawitter Pond
9. Goetschel Pond

Through the study, the team will:

1. Evaluate without-project conditions to establish a baseline understanding of damages and impacts if no actions are taken to alleviate high-water conditions on the study basins.

2. Identify up to three alternatives for evaluation including a combination of proposed pumped outlets and nonoutlet (no pumped outlet) from the basins to manage high-water conditions. Nonoutlet options could include purchasing of flood-prone homes or modifications to the basin's watershed (e.g., upstream flood storage, stormwater diversions, as appropriate given an understanding of the contributing watershed characteristics).

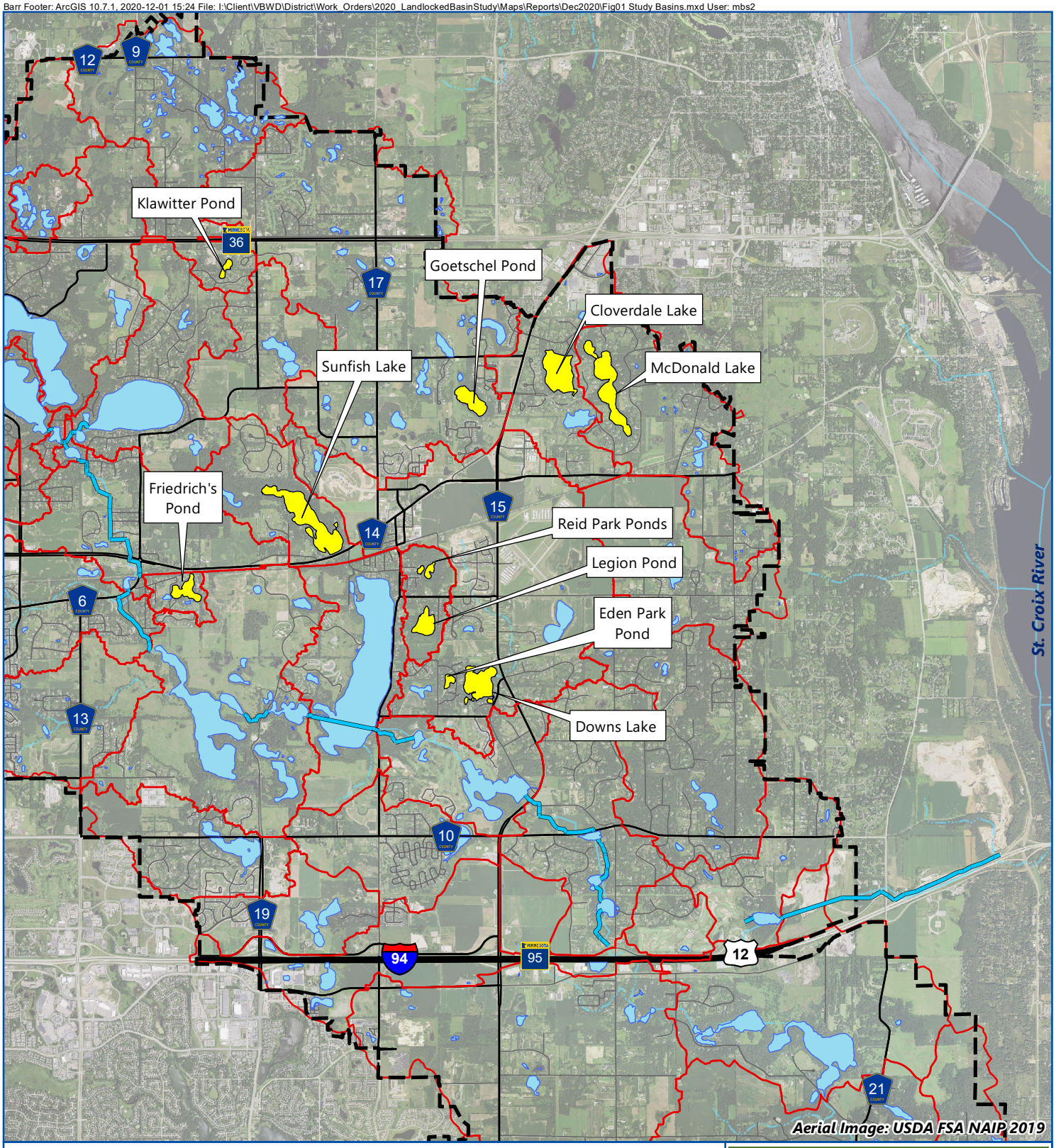
   For each alternative, we will:

   a. Develop planning-level costs.

   b. Summarize potential water quantity benefits to the properties adjacent to the basin and impacts to downstream basins.

   c. Summarize potential water quality impacts to downstream basins and management methods to limit negative impacts.

3. Recommend the preferred high-water level management strategy for each basin based on the results of the analysis, cost, and input from project stakeholders.



Project 1007 Alignment
Landlocked Study Basins
Lakes, Ponds, Streams and Rivers
Major Subwatershed Boundary
VBWD Legal Boundary

0 6,000
Feet

STUDY BASINS
Landlocked Basin Study
Valley Branch Watershed District

FIGURE 1

Background

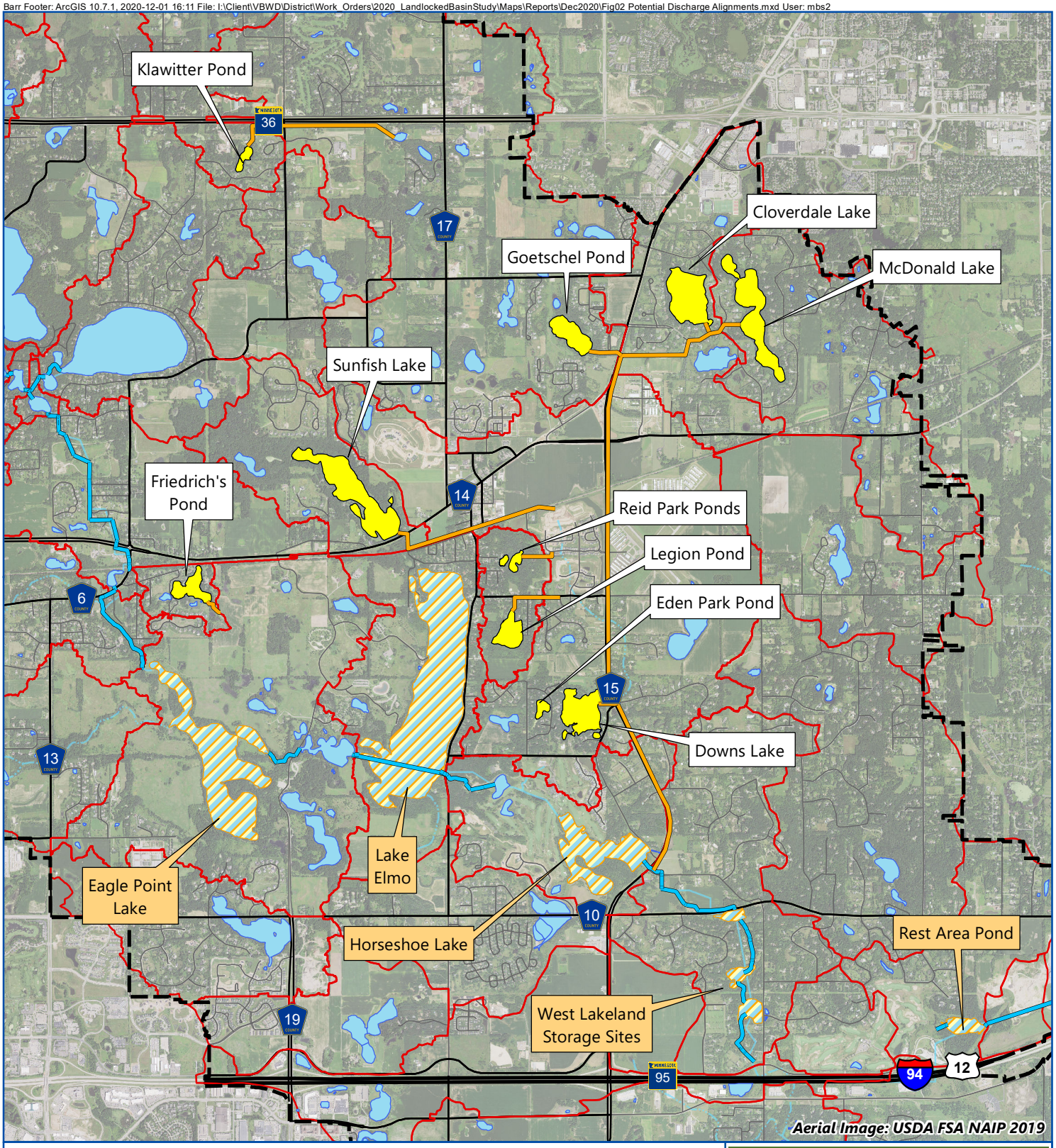
For central Washington County and the VBWD, the past decade has been the wettest on record since 1891. These historically wet conditions resulted in high groundwater conditions and record high water levels on many of the landlocked basins in the VBWD. In 2020, the VBWD and Washington County performed emergency pumping at several landlocked basins (Downs Lake and Eden Park Pond, Legion Pond, Goose Lake, Reid Park Ponds, Friedrich's Pond, Rose Lake) in the VBWD to protect homes, roadways, and sewage systems. The VBWD also heard concerns from residents about high water levels and flooding at landlocked Klawitter Pond, Cloverdale Lake, McDonald Lake, and Sunfish Lake. Decisions made during flood emergencies might not be the wisest. Therefore, further study is needed to identify alternatives to manage high water levels.

In early 2020, the Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Natural Resources (MnDNR) met to discuss whether outlets and stormwater diversions from landlocked basins would be permitted. They also discussed what, if any, jurisdiction they have if projects were to be constructed, given that they would involve new or expanded discharges to the St. Croix River, which is an Outstanding Resource Value Water with an approved total maximum daily load (TMDL). Based on these conversations, the MPCA preliminarily determined that the installation of outlets at these landlocked basins does not fit into their MS4 permit and that they do not have jurisdiction over lake water discharge in these circumstances. However, the MPCA would likely provide guidance related to water quality effects and mitigation efforts. Additionally, lake outlet projects would need to conform to the MnDNR requirements (as outlined in Minnesota Statute 103G.405 Water Level Control for Landlocked Lakes) and some of the pumped outlets could need to conform to Minnesota Statutes 103G.285 Surface Water Appropriations as well.

Additionally, with the creation of outlets from landlocked basins, the water level and quality impact on downstream waterbodies needs to be evaluated. For example, Downs Lake is currently listed as impaired for excessive nutrients and could potentially receive discharges from upstream waterbodies as well as discharge to downstream waterbodies more frequently. Some waterbodies in the study are too small to be reviewed by the MPCA but have poor water quality. Others are large enough for MPCA review and will likely be listed for excessive nutrients once the MPCA performs its next review cycle. To protect the water quality of downstream receiving waters, the comprehensive planning study will identify potential water quality mitigation measures to protect the quality of the downstream receiving resources in the VBWD and the St. Croix River.

In recent years, conveyance of the pollutant per- and polyfluoroalkyl substances (PFAS), including perfluorooctane sulfonate (PFOS) which is one of the most recognized and studied compounds in the PFAS group, has been a concern along the VBWD's Project 1007 flood control system which was constructed in 1987. The MPCA recently released surface water criteria for PFOS. Although any proposed outlet project will not impact the sources of this pollutant, a baseline understanding of the levels of this contaminant in the proposed study waterbodies is needed because any outlets will likely convey water to and through the Project 1007 system. This baseline data can inform conversations with the MPCA regarding any anticipated implications this pollutant may have on the ability to install pumped outlets and any future permitting and design considerations.

To produce this scope of work, the team developed some preliminary routes for discharges from the landlocked basins to determine which basins and waterbodies need to be evaluated as part of this study. Figure 2 shows the location of the proposed landlocked study basins as well as high-level outlet alignments. These preliminary alignments are based on reviews from historic studies performed by the VBWD, knowledge of watershed drainage patterns, as well as evaluations from recent flooding and emergency pumping efforts. Table 1 summarizes the anticipated receiving waters for each of the landlocked basins. All of the discharged water from each of these landlocked basins will eventually make its way to the VBWD Project 1007 flood control system, which outlets to Minnesota Department of Transportation (MnDOT) storm sewer that discharges to the St. Croix River.



Project 1007 Alignment
Potential Discharge Alignments
Landlocked Study Basins
Study Receiving Waters
Lakes, Ponds, Streams and Rivers
Major Subwatershed Boundary
VBWD Legal Boundary

0 4,500
Feet

POTENTIAL DISCHARGE ALIGNMENTS

Landlocked Basin Study
Valley Branch Watershed District

FIGURE 2

Table 1. Landlocked basins to be included in this study, including downstream waters that may be impacted by discharged water

Landlocked Lake or Pond	Potential Downstream Receiving Waterbodies
Reid Park Ponds **Legion Pond** **Sunfish Lake**	• Downs Lake • Assume Bypass Horseshoe Lake • West Lakeland Storage Sites • Rest Area Pond • St. Croix River (Outstanding Resource Value Water)
Klawitter Pond	• Goetschel Pond • Assume Bypass Downs Lake and Horseshoe Lake • West Lakeland Storage Site • Rest Area Pond • St. Croix River (Outstanding Resource Value Water)
Friedrich's Pond	• Eagle Point Lake • Lake Elmo (only during high water/high flow conditions) • Horseshoe Lake • West Lakeland Storage Site • Rest Area Pond • St. Croix River (Outstanding Resource Value Water)
McDonald Lake **Cloverdale Lake** **Goetschel Pond** **Downs Lake and Eden Park Pond**	• Discharge along Manning Avenue • Assume Bypass Horseshoe Lake • West Lakeland Storage Site • Rest Area Pond • St. Croix River (Outstanding Resource Value Water)

Work Plan Tasks

This work plan identifies an approach to studying high-water/flooding conditions in nine of the watershed's landlocked basins, developing and evaluating water level management alternatives, and determining potential water quantity and water quality impacts of the proposed alternatives on downstream receiving waters. Ultimately, this planning process will identify a recommended water management approach for each of the nine landlocked basins that have experienced historic high or flooding conditions in recent years.

Task 1: Stakeholder Engagement

Stakeholder engagement will be critical for this study. Without broad engagement throughout the study, it will be difficult to gain stakeholder buy-in with the results. In addition to the landowners of the area, the anticipated stakeholders include the VBWD, MPCA, MnDNR, MnDOT, Washington County, City of Lake Elmo, Baytown Township, West Lakeland Township, Metropolitan Airports Commission, Washington County Agricultural Society (Washington County Fairgrounds), the Lake Elmo Lake Association, and the United States Department of the Interior.

An advisory panel, with representatives from the stakeholders organizations, will be appointed by the VBWD Managers. Virtual monthly meetings (as needed) with the advisory panel over a 2-year period (up to 24 meetings) are assumed. Anticipated meetings would include a kickoff meeting, regular advisory meetings through the planning process, presentations of the draft plan, and public open house planning. The kickoff meeting with all identified stakeholders will be held to review the scope and discuss information that may be needed from stakeholder communities.

Approximately three public stakeholder meetings are assumed: the initial project kickoff meeting/open house, one progress meeting, and a meeting to discuss the final plan.

Within this task, the team will coordinate with the MnDNR for compliance with Minnesota Statutes and Rules regarding creating outlets for landlocked basins, prepare for a possible MnDNR Flood Damage Reduction Grant to fund implementation of a recommended project, and coordinate with the MPCA regarding water quality implications of the proposed water level management alternatives and the ongoing Project 1007 PFAS study.

A dedicated page on the VBWD website should be made for this study to communicate progress.

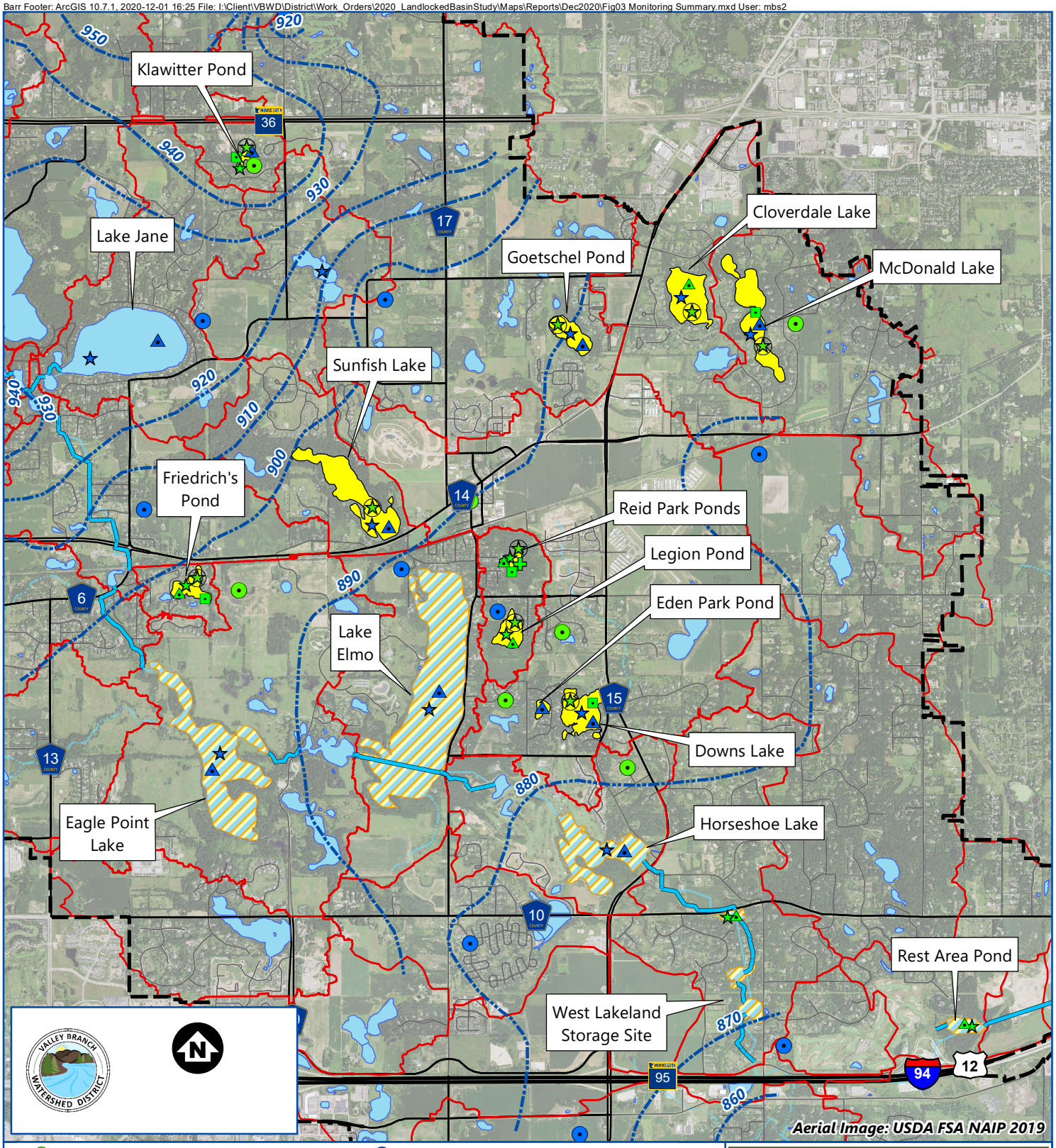
Deliverable: Up to 24 project meetings (assumed that most meetings will be virtual and up to 3 in-person meetings (as needed)

Task 2: Data Collection

The first step in the process is to review and compile existing information and fill necessary data gaps through data collection. Due to the efforts of the stakeholders in the watershed, there are quite a few studies and data sets available for assessing impacts of the proposed outlets for the landlocked basins. However, some of the models or data sets might be outdated, use different methodology, or were collected in different years, making it difficult to compare water body conditions at the same point in time.

The VBWD will complete the following subtasks to collect information necessary to evaluate the existing conditions in the landlocked basins and to develop the information and tools that will be used to evaluate the impact of the proposed pumping along the potential discharge routes. Figure 3 summarizes existing

monitoring locations as well as proposed locations for specific monitoring efforts outlined in the workplan tasks below.



- Proposed Groundwater Well
- Proposed Water Level
- Proposed WQ* Monitoring (Std)
- Proposed WQ Monitoring (PFOS)
- Proposed Sediment Cores
- Proposed Plant Survey (AIS)
- VBWD Legal Boundary
- Existing Groundwater Well
- Existing Water Level
- Existing Annual WQ Monitoring
- 2019 Groundwater Contours
- Project 1007 Alignment
- Landlocked Study Basins
- Study Receiving Waters
- Major Subwatershed Boundary

*WQ = Water Quality

MONITORING SUMMARY
Landlocked Basin Study
Valley Branch Watershed District

FIGURE 3

Task 2a: Compile and Review Previous Studies

In Task 2a, previous water quantity and quality data and studies for the waterbodies listed in Table 1 will be compiled and reviewed. Additionally, the team will compile and review local and regional water quality studies and data, groundwater and surface water model studies, biological data and studies, and other relevant analyses.

The anticipated data and studies to be compiled include:

- Defined MnDNR Ordinary High-Water Level (OHWL) data and historic water levels.
- Groundwater monitoring and modeling studies (including the studies and modeling performed as part of the Project 1007 PFAS/PFOS studies).
- Water quality monitoring data for each lake or stream.
- Biological data including aquatic invasive species (AIS) and aquatic vegetation surveys.
- Recent XP-SWMM modeling completed by the VBWD.
- Past water quality studies from the VBWD.

Task 2b: Low Floor/Critical Structure Survey

For each basin in the scope, the estimated low floor/basement elevations were estimated using a GIS/desktop analysis. This analysis used the MnDNR 2011 LiDAR and building footprint data for parcels adjacent to these waterbodies to estimate the lowest homes around these water bodies. For homes with estimated low floor elevations within 5 feet of the current VBWD 100-year flood elevation, topographic surveys of low floor, low openings, septic systems, and well locations are assumed to be needed.

The team will work with Washington County and stakeholder communities to compile relevant building permit and septic system data as available from the community databases and records. However, initial conversations with staff indicated that the specific data needed may be limited, especially for older homes.

We have assumed that survey will need to be conducted on all the estimated lowest homes based on the desktop assessment above; however, this will be refined based on the data we are able to obtain from the stakeholders. The team will coordinate right of entry with property owners for topographic survey of up to 160 homes around the waterbodies and downstream receiving waters.

This data will be used, along with the MnDNR OHWL data and monitoring and modeling data, to establish the target water elevations on waterbodies for the evaluation of the proposed pumped outlets and estimate impacts of various alternatives on estimated flood elevations, structures, and freeboard.

Task 2c: Bathymetric Survey

For the development of the groundwater, hydrologic and hydraulic, and water quality models (as applicable), the best available bathymetric data from the MnDNR, the VBWD Watershed Management Plan, and past studies will be used to establish the estimated bathymetry for the study basins. This will

help quantify the estimated groundwater–surface water interactions and inform modeling and water quality evaluations, as necessary.

However, for some basins, there is very limited information on the basin depth and bathymetry. In this task, the team will collect bathymetric data on the following basins, based on the summary of the available data outlined in Table 2, below:

- Downs Lake and Eden Park Pond
- Reid Park Ponds
- Legion Pond
- Friedrich's Pond
- Klawitter Pond
- Rest Area Pond

Table 2: Summary of bathymetric data for study basins

Lake or Stream	MnDNR Bathymetric Data Available?[1]	Max Depth[2] (feet)	Average Depth[2](feet)	Comments
Cloverdale Lake (82-0009W)	No	28.0	10.0	Volume below discharge elevation determined
McDonald Lake (82-0010W)	No	13.0	6.0	Volume below discharge elevation determined
Downs Lake (82-0110W) and Eden Park Pond (82-0463W)	No	7.0	5.0	Bathymetric data not available; volume below discharge elevation not determined
Reid Park Ponds (82-0460W)	No	N/A	N/A	Bathymetric data not available; volume below discharge elevation not determined
Legion Pond (82-0462W)	No	N/A	N/A	Bathymetric data not available; volume below discharge elevation not determined
Friedrich's Pond (82-0108W)	No	N/A	N/A	Bathymetric data not available; volume below discharge elevation not determined
Sunfish Lake (82-0107P)	No	13.0	5.2	In-lake model (TMDL) storage curve developed
Klawitter Pond (82-0368W)	No	N/A	N/A	Bathymetric data not available; volume below discharge elevation not determined
Goetschel Pond (82-0313W)	No	14.0	4.0	Volume below discharge elevation determined
Eagle Point Lake (82-0109P)	No	6.0	3.0	In-lake model (WRAPS) storage curve developed
Lake Elmo (82-0106P)	Yes	137	N/A	Bathymetric data available from MnDNR

Lake or Stream	MnDNR Bathymetric Data Available?[1]	Max Depth[2] (feet)	Average Depth[2](feet)	Comments
West Lakeland Storage Area (82-0488W)	No	N/A	N/A	Basin dry during past years; determine bottom elevation based on LiDAR data
Rest Area Pond (No MnDNR Designation)	No	N/A	N/A	Bathymetric data not available; volume below discharge elevation not determined

[1]MnDNR GIS Dataset, [2]VBWD Watershed Management Plan

Task 2d: Drainage Infrastructure Survey

In this task, the team will survey important drainage infrastructure (to be identified during the modeling and project development process) if pertinent information (e.g. pipe inverts, diameters, materials, etc.) is missing from other sources, such as GIS data or as-built drawings (to be provided by project stakeholders). Two days of survey per basin watershed is assumed to collect missing infrastructure data.

Task 2e. Water Quality and Ecological Data Collection

Changes to the hydrologic characteristics of these lakes and ponds could affect their water quality and ecological conditions. Furthermore, an understanding of discharged water quality is critical in determining potential impacts to downstream receiving waters. The team will collect additional data to support the assessment of water quality and ecological impacts to downstream waters.

Water Quality Monitoring

The VBWD contracts with Washington Conservation District to monitor the water quality on several of the potentially affected waterbodies included in this study. However, a few waterbodies have minimal data and the monitored years don't often align (Table 3). To best understand water quality impacts from the with-project conditions, a complete data set should be developed for all waterbodies in the same year.

Lakes and ponds that will be monitored for chlorophyll-*a*, total phosphorus, and Secchi depth (Metropolitan Council Citizen-Assisted Monitoring Program [CAMP] monitoring) as part of the annual, routine VBWD monitoring program are listed below. Collection of additional profile data (dissolved oxygen, temperature, specific conductivity) and hypolimnetic total phosphorus sampling will also be done during the course of annual monitoring on those water bodies flagged with an asterisk (*).

- Downs Lake* and Eden Park Pond
- Lake Elmo
- Friedrich's Pond*
- Sunfish Lake*
- Eagle Point Lake
- Horseshoe Lake
- McDonald Lake*

The following lakes and ponds should also be monitored for chlorophyll-*a*, total phosphorus, and Secchi depth (CAMP monitoring). In addition, collection of profile data (dissolved oxygen, temperature, specific conductivity) and hypolimnetic total phosphorus sampling should be done as part of this scope to develop a complete water quality data set for evaluating water quality and ecological impacts during this study:

- Goetschel Pond

- Cloverdale Lake
- Klawitter Pond
- Legion Pond
- Reid Park Pond – East Basin
- West Lakeland Storage
- Rest Area Pond

This scope assumes that VBWD will hire the Washington Conservation District to collect the monitoring data and samples and that the Metropolitan Council laboratories will do the testing (as is done through the annual water quality monitoring programs).

Because the study area is impacted by PFOS/PFAS in groundwater, surface water PFOS/PFAS monitoring should occur to establish baseline concentrations in the waterbodies. One sample will be collected in each of the nine study waterbodies as a screening tool to compare concentrations to levels in receiving waterbodies along the Project 1007 system. This scope assumes that PFOS/PFAS sampling has been conducted in waterbodies along the Project 1007 as part of separate studies. It also assumes that data will be available for comparison to receiving water concentrations and state standards and to facilitate conversation with state agency staff as needed.

Sediment Monitoring

Poor water quality in lakes or ponds may be due to the release of phosphorus from lake bottom sediments. Thus, the installation of outlets from these waterbodies may require some treatment or mitigation to reduce phosphorus loads to downstream waterbodies and the St. Croix River. For those waterbodies with poor water quality (water quality typically worse than state standards for shallow lakes) and no current sediment data, sediment cores will be collected to estimate potential internal phosphorus loading rates (Table 2). Sediments will be evaluated for sediment phosphorus release under anoxic conditions and sediment phosphorus fractions to determine phosphorus release drivers and potential remedial actions as well as potential alum treatment dosing rates to improve water quality.

Sediment cores will be collected from the following waterbodies:

- Downs Lake
- McDonald Lake
- Friedrich's Pond
- Reid Park Ponds
- Klawitter Pond

AIS Survey

One of the risks in connecting previously disconnected waterbodies is the transmission of AIS from one waterbody to the next. Because the outlets for the landlocked basins are likely to be pumps, the highest risk for transmission are invasive plants and mussels. Almost all of the waterbodies have recent plant surveys, which would identify any invasive plants. Invasive plants currently identified in the watershed include Eurasian watermilfoil (EWM), purple loosestrife, curlyleaf pondweed (CLP), yellow iris, narrowleaf and hybrid cattail, and reed canary grass. Common carp, also considered an invasive species, are also found in the watershed. An aquatic plant survey will be conducted on Reid Park Ponds to investigate the presence of invasive aquatic plants.

Only a few lakes in Washington County are currently listed as infested for zebra mussels, including the St. Croix River and White Bear Lake. No lakes in the VBWD are currently on the state list for zebra mussels. Because the majority of the waterbodies in this study do not have a public access and there are no known reports of zebra mussels in these lakes and ponds, the VBWD will assume that none are infested with zebra mussels for the purposes of this study.

Task 2f. Water-Level Data Collection

In addition to groundwater level and water quality data collection, corresponding lake-level data for the nine landlocked study basins and downstream receiving waters should be collected to inform the groundwater model calibration and XP-SWMM model development and validation.

We assume that the following lakes, which have been monitored regularly over the past several years, will have water levels monitored as part of the annual routine VBWD monitoring program:

- Cloverdale Lake
- Downs Lake, Eden Park Pond, South Downs Wetland, South Downs Pond
- Lake Elmo
- Lake Jane
- Sunfish Lake
- Eagle Point Lake
- Horseshoe Lake
- McDonald Lake
- Klawitter Pond
- Goetschel Pond
- Rest Area Pond

However, this study scope includes collection of lake-level data on the following waterbodies where data has not been routinely collected, either in the past or in recent years:

- Friedrich's Pond

- Legion Pond
- Reid Park Ponds – East and West Basin
- West Lakeland Storage

Table 3. Currently available water quality (past 5 years), sediment, biological data (past 11 years), and lake-level data for the study waterbodies

Lake or Stream	Water Quality Data Available?[1]	Sediment Data Available?	Ecological Data Available (AIS, plants, fish, other)?	AIS	Lake-Level Data Available?
Study Basins					
Cloverdale Lake (82-0009W)	2016, 2019	No; good water quality	2011, 2012–2014 (Point-Intercept [PI])	Purple loosestrife	1990–2020, recently monitored every few years
McDonald Lake (82-0010W)	2015–2019	No; to be collected	2011 2013–2014 (PI)	Curlyleaf pondweed (CLP)	1986–2020, recently monitored annually
Downs Lake[2] (82-0110W)	2015–2019	No; to be collected	2012		1965–2020, recently monitored annually
Reid Park Ponds (82-0460W)	No data	No; to be collected	No Data	--	Not regularly monitored
Legion Pond (82-0462W)	2017	No; good water quality	2013		2008-2010, not regularly monitored
Friedrich's Pond (82-0108W)	2018	No; to be collected	2009	CLP, purple loosestrife	2008–2010, 2020, not regularly monitored
Sunfish Lake[2] (82-0107P)	2015–2019	Yes	2007–2012 2013–2014 (PI)	CLP	1973–2020, recently monitored annually

Lake or Stream	Water Quality Data Available?[1]	Sediment Data Available?	Ecological Data Available (AIS, plants, fish, other)?	AIS	Lake-Level Data Available?
Klawitter Pond (82-0368W)	2015–2019	No; to be collected	2009		1991–2020, recently monitored annually
Goetschel Pond (82-0313W)	2019	No; good water quality	2013	Purple loosestrife	1999–2010, 2020, not regularly monitored
Other Waterbodies (Downstream Receiving Waters)					
Eagle Point Lake (82-0109P)	2015–2019	Yes	2010–2012, 2013–2014 (PI)	Common carp CLP	1969–2020, recently monitored annually
Lake Elmo (82-0106P)	2015–2019	No	2007–2014	CLP, Eurasian watermilfoil (EWM)	1965–2020, recently monitored annually
Horseshoe Lake (82-0074P)	2015–2019	Yes	2000, 2007, 2009, 2012, 2012–2014 (PI)	CLP, EWM	1969–2020, recently monitored annually
West Lakeland Storage Area (82-0488W)	1986–1989	No	2009	Purple loosestrife	1975–2020, not regularly monitored
Rest Area Pond (No MnDNR Designation)	2015–2019	No	2009	CLP	1986–2016, not regularly monitored

[1]Previous 5 years; [2]Impaired for nutrients

Deliverables:

- Water level and water quality data of study basins and downstream receiving waters
- Sediment monitoring data to estimate potential sediment phosphorus release rates
- Baseline PFAS concentrations for study basins
- Survey of low floor/critical structure information (up to 160 structures)
- Bathymetric survey of select study waters where approximate depth information is not available
- Survey of critical drainage infrastructure where data is not available from project stakeholders

Task 3: Baseline (Without-Project) Modeling

Task 3a: Baseline Groundwater Modeling

Typical surface water hydrologic and hydraulic models are not adequate to meet the project goals. Water levels at the landlocked basins result from longer-term climatic conditions rather than a single storm event. The longer-term climatic conditions also affect groundwater levels, which in turn affect the surface water-groundwater interconnection at landlocked basins. For many of the landlocked basins in this study, surface hydrology and groundwater hydrology are inextricably linked.

Surface water hydrologic and hydraulic models, such as XP-SWMM, treat groundwater as a "black box" in which water can be stored and extracted, as needed, but cannot reliably predict how climate will impact groundwater conditions and affect lake levels. Conversely, a stand-alone groundwater model does not directly account for the effects of precipitation, topography, and land use on groundwater conditions. Both updated surface water hydrologic and hydraulic models (see Task 3b) and a subregional groundwater model will be developed for this project to evaluate the impact of pumped outlets on these basins as well as downstream waterbodies. Combined, these models will account for the entire water balance, allowing for a better understanding of how the landlocked basins respond to changes in groundwater levels, more accurate estimates of pumping rates needed to maintain water levels and prevent flooding, and estimate the long-term volume of anticipated pumped water volume from these basins.

The groundwater model developed for this project will build off existing and widely accepted regional groundwater models of the area. This includes the Twin Cities Metro Regional Groundwater Flow Model (Metro Model 3, Metropolitan Council, 2014), the North East Metro Lakes Model (Jones et. al., 2017), which is built off of the Metro Model 3, and a model being developed for the Project 1007 watershed as part of MPCA's source assessment and feasibility study related to PFAS contamination in the east metro (if made publicly available in time for this study). These existing models provide an excellent starting point by accounting for the regional groundwater flow system and providing well-defined boundary conditions. However, the spatial resolution of these regional models may not be sufficient to simulate the groundwater system near each of the landlocked basins with the detail necessary. These existing models were designed to primarily simulate the deeper bedrock aquifer systems. To accurately simulate

groundwater and surface water interaction for landlocked basins, more detail is needed in the model(s) to better represent groundwater conditions near the surface. To achieve this, a subregional groundwater model will be developed with a refined computational grid that allows for incorporation of geologic and hydrologic detail important for groundwater and surface water interaction at the landlocked basins included in this study.

The coupled groundwater model will be calibrated using PEST. PEST is a model-independent software that aids in the automatic inverse optimization (often referred to as "calibration") of models. PEST numerically minimizes the difference between calibration target values (e.g., water-level observations) and model results. PEST automatically quantifies the sensitivity of all model parameters to observations and can provide a means for characterizing the model's predictive uncertainty and help evaluate how additional data can help, or not help, in reducing predictive uncertainty. Calibration targets will include groundwater levels, stream baseflows (groundwater contribution to streams), vertical hydraulic gradients, and heuristic information such as interpreted groundwater flow directions.

Once calibrated, the groundwater model will be used to develop a groundwater interaction (inflows/discharges) time series from 1980 through 2020 at each of the landlocked basins within the study area as well as other critical locations. Additionally, the Metropolitan Council is in the process of updating the Metro Model 3 to evaluate the impact of a range of projected climate scenarios on the hydrogeologic conditions in the Twin Cities. This effort, expected to be wrapped up by the end of 2020, is utilizing seven downscaled global climate models with different CO2 emission scenarios to develop daily precipitation and temperature data sets and evaluate the impact of future climatic scenarios on groundwater recharge rates and levels through the end of the century. This effort should be reviewed, used to identify two future climatic scenarios representing estimated wet and dry future climatic conditions, and to develop a time series for groundwater conditions into the future to understand the potential range of groundwater conditions.

The estimated groundwater interaction time series will be used in the continuous simulation runs for the hydrologic and hydraulic modeling to evaluate the frequency, duration, and impact of pumped discharges on water levels in these basins and on downstream receiving waters. This improved understanding of the groundwater conditions is critical to developing a conceptual pumped outlet system that doesn't continuously pump at a high volume, causing very high operation and maintenance costs.

Task 3b: Baseline Hydrologic and Hydraulic Modeling

Surface water hydrologic and hydraulic models are needed to size infrastructure for the new outlets and evaluate hydrologic and hydraulic impacts on downstream receiving waters. The hydrologic and hydraulic modeling effort will use existing VBWD XP-SWMM models, as available. However, for several of the project study basins, there are no XP-SWMM model available; for others, older XP-SWMM models may be available, but were not developed using the current watersheds, land cover, or XP-SWMM methodology. Current available models and recommended updates are provided in Table 4.

Table 4. Existing hydrologic and hydraulic models and study recommended updates

Landlocked Lake or Pond	Hydrologic/Hydraulic Model	
	Existing	**Study Update Requirements**
Cloverdale Lake	HEC-HMS model[1]	New model
McDonald Lake	XP-SWMM[1]	Update model
Downs Lake	2015 XP-SWMM	None
Reid Park Ponds	No model available	New model
Legion Pond	No model available	New model
Friedrich's Pond	2019 XP-SWMM model	None
Sunfish Lake	2014 XP-SWMM model	None
Klawitter Pond	XP-SWMM[1]	Update model
Goetschel Pond	2014 XP-SWMM model	None
Horseshoe Lake **West Lakeland Storage Area** **Rest Area Pond**	2020 XP-SWMM model (in development)	None

[1]Current model is older and used different methodology than current VBWD models utilizing continuous simulations

Hydrologic and Hydraulic Model Construction and Validation

The team will use existing conditions XP-SWMM hydrology and hydraulics models where possible for the watershed as the baseline conditions to evaluate the impact of the potential outlets on downstream water surface elevations and flow rates.

Over the past few years, the VBWD has created existing-conditions XP-SWMM models of the Project 1007 watersheds, from the upstream areas downstream to Lake Elmo. Models of the Goetschel Pond and Downs Lake watersheds have also been completed. Additionally, the VBWD is in the process of developing XP-SWMM models of the Horseshoe Lake, West Lakeland Storage, and Rest Area Pond watersheds. These models are continuous simulation models that have been or will be calibrated to observed water surface data from August 2011 to August 2014. We assume that these models will be used "as-is" with no significant updates to the modeling—the only exception will be updates to the

continuous precipitation input files and the inclusion of the estimated groundwater interaction time series based on the long-term simulations from the calibrated groundwater modeling.

H&H models do not currently exist for Legion Pond and Reid Park Ponds. Models for Cloverdale Lake, McDonald Lake, and Klawitter Pond were developed in the early 2000s. The Cloverdale Lake watershed model is a HEC-HMS model, which is primarily a hydrologic model with limited hydraulic evaluation capability. The McDonald Lake model is an older XP-SWMM model that was developed for Washington County in updating the Federal Emergency Management Agency (FEMA) floodplain mapping and uses a different methodology for the incorporation of groundwater inflows and losses. The McDonald Lake model was validated against lake-level data from the early 2000s but has not been validated against any recent lake-level data. The Klawitter Pond model is an older XP-SWMM model that was also developed for Washington County in updating the FEMA floodplain mapping and uses a different methodology for the incorporation of groundwater inflows and losses.

Five updated/new models will be developed for watersheds with outdated models or where no model exists. New models will be developed for Cloverdale Lake, Legion Pond, and Reid Park Ponds. Updated models will be developed for McDonald Lake and Klawitter Pond watersheds, following the VBWD's current modeling methodology. All modeling for these areas will include reviewing and revising subwatersheds to reflect current infrastructure and topography, developing hydrologic inputs, and incorporating current conveyance infrastructure. Project stakeholders are assumed to be able to provide GIS data of existing drainage infrastructure as well as as-built drawings of key infrastructure such as pond outlet structures, although we have anticipated needing to conduct some survey of infrastructure to fill any data gaps (see Task 2d).

The updated and new models will be developed using the more recent VBWD methodology, which uses continuous simulation, calibrating to observed water surface data from August 2011 to August 2014, and using the groundwater model simulations to inform the groundwater influence in the model.

Validation and Baseline Condition Establishment

For all XP-SWMM models, a groundwater interaction time series for each of the key basins based on the calibrated groundwater model will be developed. A continuous simulation of the XP-SWMM models will be run for 1980 through 2020 to validate the estimated water levels in the project study basins (including the landlocked basins and the receiving waters) against observed water-level data.

As outlined in Task 3a, two future climatic scenarios are planned for evaluation, representing both wet and dry climatic predictions, based on review of the Metropolitan Council study. This climate data will be utilized to develop future-conditions precipitation files and groundwater interaction time series for key basins for use in the hydrologic and hydraulic models.

The existing conditions models will be run from 1980–2020, as well as into the future for the two different climatic scenarios. The model results will be summarized, and statistical analyses will be performed to understand peak water surface elevation frequency and potential impacts to existing homes, inflow volumes from both groundwater and surface runoff.

Additionally, because portions of the VBWD are still developing, we will update the all the existing conditions models to reflect future land use conditions (based on the Metropolitan Council Land Use for 2040 and the associated impervious assumptions by land use from the existing conditions model calibration). These future conditions models will also be run from 1980–2020, as well as into the future for the two different climatic scenarios. The model results will be summarized, and statistical analyses will be performed to understand peak water surface elevation frequency and potential impacts to existing homes, inflow volumes from both groundwater and surface runoff. The future conditions model may also account for future projects, such as the proposed outlet from Goose Lake that the VBWD is currently evaluating. This will be discussed early in the landlocked basin study, based on recommendations from the Goose Lake study.

Ultimately, the future land use conditions models will serve as a baseline for comparison to quantify the impacts of the proposed pumping scenarios.

Additionally, the both the existing and future land use models will be run for the Atlas 14 2, 10, and 100-year design storm events, estimating the starting water elevations based on the water level results from the continuous simulations.

This baseline evaluation, along with the groundwater monitoring and analysis proposed as part of this study, will be used to estimate the capacity of the pumps needed to drawdown and maintain long-term water levels and estimate the anticipated long-term discharge volumes from these basins.

Task 3c: Climate Change Assessment

In Task 3c, the team will perform a climate change assessment as required by and in accordance with USACE Engineering and Construction Bulletin (ECB) 2018-14. This qualitative assessment is intended to enhance USACE climate preparedness and resilience by incorporating relevant information about observed and expected climate change impacts in hydrologic analyses for USACE projects. This qualitative assessment, along with the review of the future climate evaluation performed in tasks 3a and 3b above, can inform the decision process related to future without project conditions, formulation, and evaluation of the performance of alternative plans, and other decisions related to project planning, engineering, operation, and maintenance.

Deliverables:

- Calibrated groundwater model
- Calibrated existing-conditions continuous simulation hydrologic and hydraulic models with groundwater interaction time series to perform statistical analyses on water elevations at key locations in the watershed along with evaluation of Atlas 14 design storm event results.
- Qualitative climate change assessment and summary

Task 4: Flood Risk Analysis and Establishment of Water-Level Targets

Before evaluating with project alternatives including conceptual configurations and designs for the outlets from each waterbody, an analysis of potential impacts of a without project ("do nothing") scenario will be performed. This will include evaluation of the baseline XP-SWMM model results and statistical analysis from the period from 1980 through the future conditions, for both a wet and dry future climatic scenario.

The results of the without project evaluation will provide an understanding of expected changes in groundwater conditions over the long-term and will estimate the impacts of resulting water levels on homes near these waterbodies. This analysis will be used to identify impacted homes and infrastructure such as septic system and roadways. This will then be used to estimate potential flood damages based on depth-damage relationships for residential structures developed by the United States Army Corps of Engineers (USACE, 2003). Additionally, this analysis will also identify damages and loss of road service, utility service, etc. The duration of loss of function will be estimated based on the hydrologic and hydraulic modeling results, along with daily average traffic counts for potentially flooded roads (available through Google Earth Pro, as directed by FEMA benefit-cost assessment guidance and derived from MnDOT, Washington County, and local data). This effort will help set the stage for pursuing project funding through the MnDNR flood-damage-reduction grant program as well as potential federal programs (if the benefit-cost ratio meets the federal project requirements).

As part of this task, the VBWD will also establish target water levels and pumping rates in each of the landlocked basins that will be used to direct the with-project alternative development. This effort will utilize the baseline modeling results, surface water and groundwater-level data, low opening and low floor elevation data, and OHWL data to set the target water levels for the nine study basins. Typically, on landlocked basins, the MnDNR allows outlets between 1.5 feet below the OHWL and the OWHL; if lower than this, additional approval is required. Additionally, we will need to evaluate the proposed pumping as it relates to the Minnesota statutes related to Surface Water Appropriations as well.

Table 5 summarizes the MnDNR OWHL available for the nine study basins. For those that do not have an OHWL established, we will request that the MnDNR establish OHWL on those basins.

Table 5. OHWL for study basins.

Basin	OHWL (ft MSL, Vertical Datum)
Cloverdale Lake	900.7 ft MSL (NGVD29)
McDonald Lake	887.5 ft MSL (NGVD29)
Downs Lake and Eden Park Pond	889.1 ft MSL (NGVD29)
Reid Park Ponds	N/A
Legion Pond	884.0 (NAVD88)
Friedrich's Pond	N/A
Sunfish Lake	896.4 ft MSL (NGVD29)
Klawitter Pond	954.9 ft MSL (NGVD29)
Goetschel Pond	900.7 ft MSL (NGVD29)

Deliverables:

- Summary of baseline conditions and estimated damages for a baseline (without-project) conditions for landlocked basins for wet and dry climatic scenarios
- Estimates of potentially impacted structures under the baseline (without project) conditions
- OHWL established by MnDNR on all study basins
- Summary of target water levels and pumping rates for landlocked basins with proposed pumped outlets

Task 5: With-Project Alternatives Analysis and Cost Estimates

Once the baseline models are established, evaluation of up to three alternatives, considering various outlet configurations, pumping scenarios, and non-pumping alternatives will be completed.

Task 5a: Develop Conceptual With-Project Alternatives

Based on the established target water levels for the various lakes and the baseline analysis, the team will work with stakeholders to develop up to three alternatives for with project alternatives for the landlocked basins. Conceptual alignments will consider modeling output to minimize both water quantity and quality impacts, easement and land ownership considerations, and infrastructure limitations or required upgrades. It is important to note that this will likely be an iterative process, taking into account downstream impacts as the alternatives are developed.

Examples of with-project alternatives that could be considered may include:

- No pumped outlets and acquisition of all at-risk/impacted homes.
- Installation of proposed pumped outlets on all nine study waterbodies, routed as shown on Figure 2. Again, these alignments reflect the most realistic alignments based on reviews from historic studies performed by the VBWD, knowledge of watershed drainage patterns, as well as evaluations from recent flooding and emergency pumping efforts.
- Installation of proposed pumped outlets on select study waterbodies and acquisition of select/lowest homes (details to be determined based on baseline assessment).

These options would also include identification of water quality mitigation measures as needed to reduce estimated negative downstream water quality impacts that could result from the proposed pumping scenarios. Mitigation measures would be intended to reduce total phosphorus loading to downstream waterbodies, including the St. Croix River. these measures could include:

- Alum treatment of lakes or ponds to improve in-lake water quality or treatment of pumped discharge to improve discharge water quality.
- Downstream filtration or infiltration of discharge.
- Watershed stormwater best management practices to improve lake or pond water quality.

Task 5b: Hydrologic Impacts Assessment of Alternatives

Once the preliminary alternatives are developed, the baseline XP-SWMM models will be used to evaluate the impact of the proposed pumping concepts on downstream flows and water levels. This will be based on statistical analysis of the results for the continuous run period and comparison of the relative difference between the baseline- and proposed-conditions model results along the receiving water alignments. This will include summarizing impacts to homes along the receiving water alignments.

Task 5c: Water Quality and Ecological Condition Assessment

In addition to quantifying impacts on downstream water quantity conditions, a high-level assessment will be performed to quantify the impact on water quality and pollutant loads (specifically total phosphorus) based on the estimated pumping/discharge rates and water quality monitoring data. Lake response models (either the detailed in-lake model or the simplified mass-balance models) will be used to estimate the potential water quality impacts on downstream waterbodies. Based on this assessment, mitigation options for upstream waterbodies that may be discharging poor quality water and negatively impacting receiving waters will be identified and evaluated.

AIS management will also be considered to minimize the potential spread of AIS among the waterbodies.

Task 5d: Planning-Level Cost Assessments and Permit Requirements

Planning-level cost estimates will be developed for each alternative, including estimated easement/land acquisition, planning, engineering and design, and construction costs. A summary of potential permitting requirements will also be summarized for the alternatives.

Deliverables:

- Summary of hydrologic and hydraulic impacts
- Summary of potential water quality impacts on downstream receiving waters and identification of mitigation measures to address waters that are negatively impacted
- GIS-based concept plans
- Planning-level cost estimates

Task 6: Comprehensive Planning Study Report

A comprehensive planning study report summarizing the findings and recommendations for the proposed VBWD landlocked basin flood mitigation project will be drafted. It will be based on input and feedback from stakeholders throughout the process. A draft report will be provided to the stakeholders to review for one round of comments and those comments will be incorporated into a final report. The final report will be provided in pdf format.

Deliverable: Draft report and final report

Assumptions

1) Stakeholders will provide any available drainage infrastructure data (e.g., storm sewer, culverts). GIS or CAD format are preferred, as available.
2) Existing VBWD models will fully contain all storm events as run through the continuous simulation and no additional water capture is needed—this is likely the case as they have been run with the "1987 superstorm."
3) Zebra mussels are not present in the proposed study lakes.
4) The current scope of work will not include additional investigations that may be necessary to complete final design and/or permitting, such as:
    a. Detailed topographic survey.
    b. Wetland delineation.
    c. Cultural/historical investigation.
    d. Geotechnical or environmental investigations.
5) Ongoing conversations with regulatory agencies will not result in major changes to the tasks in this scope of work document