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For the Comfort Lake-Forest Lake Watershed District

(5228-K) WASHINGTON JUDICIAL DITCH 6 ASSESSMENT AND FEASIBILITY STUDY: PHASE 2

May 2020

Cover Image

Tributary to Washington Judicial Ditch 6 between Highway 97 and CR-50 [Mike Majeski, May 2019]

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1. INTRODUCTION

The 2018 Forest Lake Diagnostic Study identified a phosphorus reduction goal of 169 lb/yr from the Washington Judicial Ditch 6 (WJD 6) subwatershed for Forest Lake to meet the District's long-term goal of in-lake growing season average phosphorus concentrations at or below 30 µg/L. An Assessment and Feasibility Study was completed in the WJD 6 Subwatershed in 2018 to target specific sources of phosphorus and identify potential project locations.

The 2018 water quality monitoring results indicated a large percentage of the total phosphorus load from the WJD 6 subwatershed to Forest Lake is being delivered from the main branch of WJD 6 between Highway (Hwy) 97 and County Road 50 (CR-50), approximately 800 pounds of phosphorus per year. Potential sources are; bank erosion along the ditch system and/or phosphorus release from the surrounding wetland system. Based on these results, it was determined this area would be a prime candidate for a large-scale stream and wetland restoration project. The 2018 water quality monitoring results also indicated that approximately 100 pounds of phosphorus discharge from the R7D wetland annually and could be an alternative candidate for a wetland restoration project in the future if additional phosphorus reductions are needed for Forest Lake to meet the District's long-term goal.

This feasibility and assessment study expanded on the scope of the 2018 WJD 6 diagnostic study to include additional tributary monitoring, modeling, and wetland assessments to further feasibility of potential projects in the drainage area to the main branch of WJD 6 between CR-50 and Hwy 97 and the R7D wetland. A geomorphic stream assessment, wetland water level monitoring, phosphorus grab sampling, surveying, wetland assessment, and preliminary project designs and cost estimates were completed along the main branch of WJD 6 between CR-50 and Hwy 97. A review of historical imagery, wetland survey and wetland water level monitoring were completed in the R7D wetlands to support future project designs, but no preliminary project designs and cost estimates were completed in this lower priority drainage area. All findings from work completed in 2019 are described in Section 2. Additional project feasibility findings and recommendations for next steps are described in Section 3.

2. ASSSESSMENT

2.1. WJD 6 Main Channel between Hwy 97 and CR-50

A geomorphic stream assessment, wetland water level monitoring, phosphorus grab sampling, surveying and wetland assessment were completed along the WJD 6 main channel between Hwy 97 and CR-50 to inform preliminary project design and cost estimates. Findings from these 2019 assessments are described in the following sections.

2.1.1. Geomorphic Assessment

A geomorphic assessment was completed along the WJD 6 main channel from Hwy 97 to the wetland outlet upstream of CR-50 (Figure 1). The water quality results from the 2018 WJD 6 assessment indicated that bank erosion may be occurring within the ditch that flows through the wetland complex. However, the 2019 geomorphic survey indicated that little bank erosion is occurring within the existing stream channel. The previously ditched channel is primarily in a stable pattern, with meanders developing along the reach. In addition, the dense riparian vegetation growing along the stream banks is protecting the stream channel from bank erosion. Two very different channel types were identified during the survey. The majority of the WJD 6 reach consisted of a stable “E” channel from Hwy 97 to approximately 750 feet north of CR-50. At this point, the channel transitioned to an “F” channel that extended south of CR-50 to the wetland outlet.

In general, “E” channels have accessible floodplains, high channel sinuosity, stable banks, and transport sediment effectively. This section of WJD 6 frequently overtops the stream banks and partially floods the adjacent broad wetland floodplain. The stable condition of this reach can be attributed to dense grass cover along the banks, which provides ample surface protection during flood events (Figure 2). However, EOR observed some areas along the east edge of WJD6 that had been mowed and cleared of vegetation by a landowner. The channel adjacent to the mowed area is beginning to erode and is wider than the rest of the stream channel where vegetation had not been removed (Figure 3). The channel within the mowed area is much more susceptible to erosion and will likely continue to widen without vegetation to protect the stream banks.

WJD 6 transitions from a stable “E” channel to an “F” channel in the wooded corridor where a ditch was excavated through an upland area. In general, “F” channels are laterally unstable, disconnected from the floodplain, and do not transport sediment effectively. However, the high ditch banks within the wooded corridor are actually quite stable, though do show evidence of sheet erosion in a few areas. Although the channel does not have a functional floodplain, sediment aggradation has occurred, resulting in the formation of low, narrow floodplain benches along sections of the ditch. The presence of these low floodplain benches is a sign that the channel is beginning to transition from an F channel back to a more stable “E” channel. However, these floodplain benches are susceptible to erosion due to a lack of vegetation as a result of heavy shade from the existing tree canopy (Figure 4). Removing the trees in this reach would facilitate establishment of more beneficial vegetation and would stabilize and promote further development of the floodplain benches within the ditched channel, as shown in Figure 5.

Additionally, many small tributaries and groundwater seeps with oxidized iron deposits were observed along the east side of the channel (Figure 6). Anecdotal reports suggest an artesian spring also exists in one of the small ponds in the adjacent wetland east of the WJD 6 channel. More regionally, multiple groundwater dependent resources are mapped within the WJD 6 subwatershed (Figure 10, EOR 2003). Regional groundwater primarily flows from the high moraine areas in the east toward WJD 6 and north to Forest Lake. Groundwater also flows toward WJD 6 from the west, but with less of a gradient and therefore less volume.

Figure 1. Geomorphic assessment of WJD 6

Figure 2. View of stable "E" channel of WJD 6. View of channel bed in top right.

Figure 3. View of mowed area with bank erosion along WJD 6.


Figure 4. View of an "F" channel in the wooded area north of CR-50. Note the development of a floodplain bench (sediment/ mud flat) within the wide ditch channel.

Figure 5. View of a recovering “F” channel to a more stable “E” channel just north of CR-50. Note the low floodplain benches have become vegetated as a result of increased light penetration through the thin tree canopy.


Figure 6. Oxidized iron deposits from a groundwater seep.

2.1.2. Wetland Water Levels

EOR assessed wetland hydrology along WJD 6 to determine the effect of the ditch on wetland water levels, soil saturation, and the potential for increased soil wet/dry cycles causing phosphorus release. Piezometers were installed along three transects to monitor water levels in the ditch and adjacent wetland from June to October 2019 (Figure 9). Five piezometer locations were selected on each transect: one piezometer to capture water levels within the WJD 6 channel, two piezometers on either side of the channel but within the estimated zone of lateral effect, and two piezometers on either side of the channel but just outside the estimated zone of lateral effect. One reference piezometer (PR) was installed well outside the estimated zone of lateral effect to represent conditions in the wetland that would not be influenced by ditch drainage. Lateral effect is the width on either side of a drainage ditch with water surface elevations artificially lowered by the presence of a drainage ditch cut into the landscape (Figure 7). The greater the width of the lateral effect, the greater the influence of a drainage ditch on water surface elevations and potential for increased soil wet/dry cycles that cause phosphorus release. The transects and piezometer spacing were selected based on estimated lateral effect from the van Schilfgaarde equation, 2-foot Lidar, and observations from the geomorphic assessment.

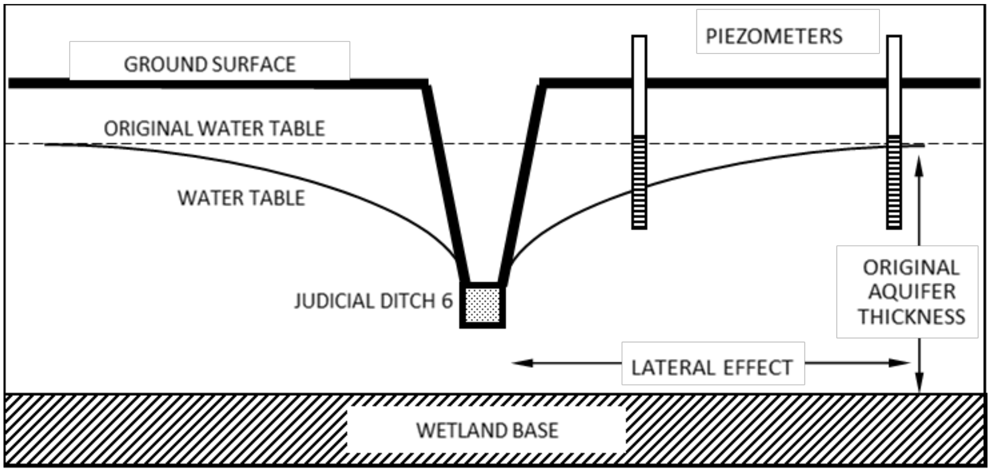


Figure 7. Ditch lateral effect on wetland water surface elevations

Wetland well surface water elevations during the 2019 growing season are shown in Appendix C. Piezometers within the estimated zone of lateral effect (P2, P4, P7, P9, P11, P13) did not show a strong drawdown effect from the ditch. Wetland water surface elevations along each transect cross section are also shown to illustrate the rate of drawdown before, during and after a storm event on July 15, 2019. There was very little difference between the drawdown response of the piezometers within the estimated zone of lateral effect compared to the piezometers outside the estimated zone of lateral effect. If drawdown of wetland water surface elevations was occurring in response to the rainfall event, it was within a narrower zone than originally estimated. In general, the drawdown effect of WJD 6 on wetland water surface elevations was less than expected.

It should be noted that 2019 was an exceptionally wet year. The CLFLWD 2019 Water Monitoring Report indicated that 2019 was the second wettest year on record for Forest Lake, MN. In addition, according to the Minnesota State Climatology Office rainfall records, the WJD 6 subwatershed received about 26% more rain than normal. Stream flow within WJD 6 and water levels within the piezometers generally increased from mid-June to late October. Any drawdown effect of WJD 6 wetland water surface elevations may have been masked by the higher-than-average precipitation of 2019.

Because of the higher-than-average precipitation of 2019, the WJD 6 subwatershed was also modeled in PCSWMM to estimate the amount of flow and depth of water in the WJD 6 channel to compare data collected in 2019 to other years (2016-2018). The results of the modeling showed that there is not much variation in WJD 6 channel water depth within each year or from year to year. Figure 8 shows that the mean water depth (horizontal bar in each annual plot) in the last four years varied between 0.13 and 0.3 feet, and a majority of the time the water stayed within a 0.5-foot range (as illustrated by the height of the box in each annual box and whisker plot). This small amount of change in WJD 6 channel water levels would not result in a large drawdown effect of the WDJ 6 channel on wetland water surface elevations. Based on our monitored and modeled data, this wetland does not appear to exhibit frequent water level fluctuations that can lead to phosphorus releases from frequent soil wet/dry cycles. Continued water level monitoring in the wetland (preferably using remote loggers) would be helpful in assessing if this wetland exhibits water level changes over a range of seasons and variable climatic conditions.

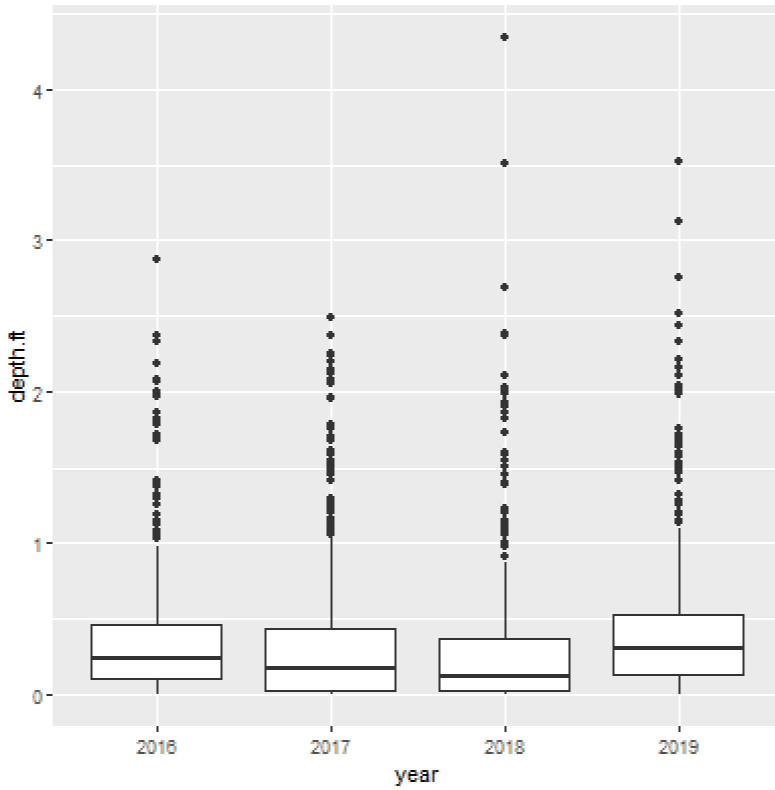


Figure 8. Depth of Water in Ditch for 2016, 2017, 2018, 2019. Mean Annual Depth (horizontal bar), 1st Standard Deviation (box), 2nd Standard Deviation (line above and below box), Outliers (points).

Figure 9. Wetland piezometer transect locations along WJD 6.

2.1.3. Longitudinal Profile Grab Samples

There are many overland flowpaths and groundwater seeps along the WJD 6 banks that results in a mixture of surface water and groundwater discharged from the WJD 6 subwatershed. The large volumes of regional groundwater in this subwatershed originate from the high moraine areas east of the WJD 6 channel that result in groundwater flow towards WJD 6 and Forest Lake. In addition, the 2003 North Washington County Groundwater Study (EOR 2003) identified large portions of the wetlands upstream of CR-50 in the WJD 6 subwatershed as groundwater dependent natural resources (Figure 10).

Observations of oxidized iron discharging from groundwater seeps during the geomorphic assessment (see Section 2.1.1) indicates high iron levels in the groundwater that were under reduced conditions and become oxidized once the groundwater reaches the surface. These conditions contribute to low phosphorus sorption in the wetland soils and high concentrations of ortho-phosphate discharged from the wetland (as observed in the 2016 and 2018 stream monitoring data from this subwatershed).

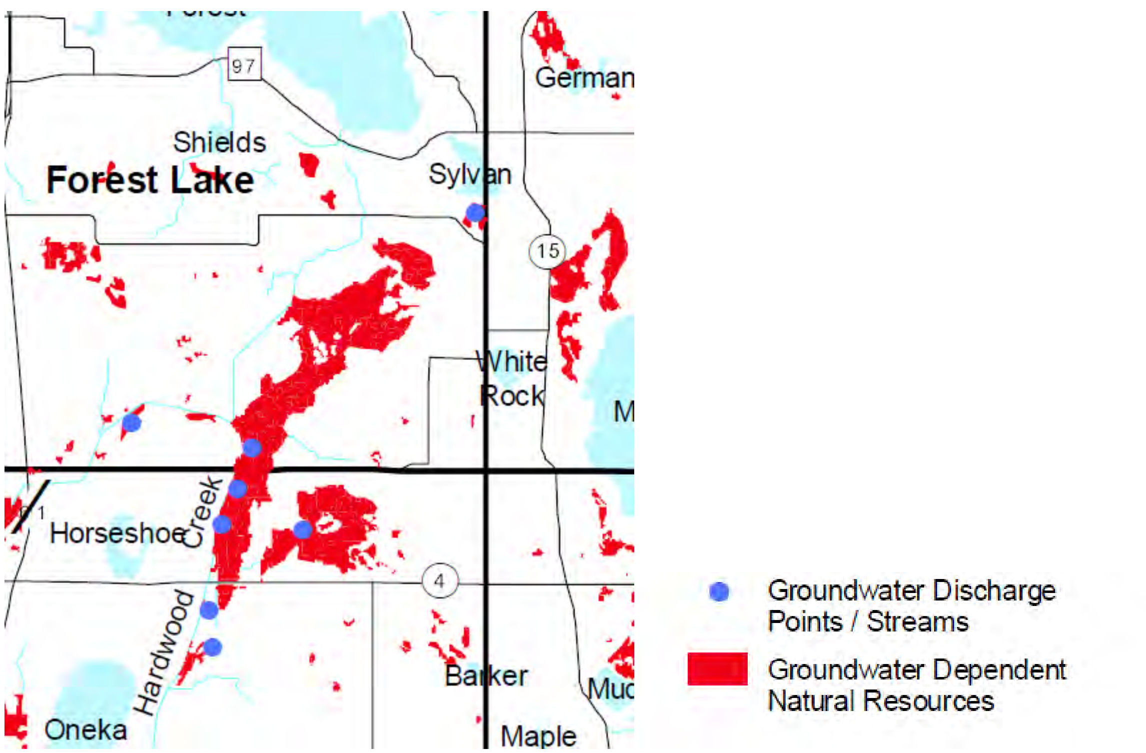


Figure 10. Groundwater dependent natural resources in and around the WJD 6 subwatershed (adapted from Figure ii.5 from EOR 2003)

Water quality grab samples were collected at various points along the WJD 6 channel between Hwy 97 and south of CR-50 to determine if any of these overland flowpaths or groundwater seeps were contributing a disproportionate amount of phosphorus to the channel. A total of 16 samples were collected between Hwy 97 and CR-50 on July 3, 2019 from the main channel, tributaries, and groundwater seeps (Table 1, Figure 11). An additional 5 samples were collected from the main channel upstream of CR-50 on July 22, 2019. The water samples were analyzed for total phosphorus only due to the remote field conditions that limited the transport of large volumes of water for additional chemical analyses.

In general, the phosphorus concentrations from overland flowpath tributaries were similar to phosphorus concentrations in the main channel (0.2-0.35 mg/L), except Tributary 1 (Trib 1 in Figure 11, Panel C) . The phosphorus concentrations in the 3 groundwater seeps and Tributary 1 were higher (0.41-1.7 mg/L) than the main channel (0.2-0.35 mg/L). Higher observed phosphorus concentrations in the groundwater seeps indicates that there is low phosphorus sorption in the wetland soils under the oxygen-poor groundwater conditions; some of this phosphorus may settle with dissolved iron as it oxidizes upon reaching oxygen-rich conditions in surface water, contributing to the lower phosphorus concentrations observed in overland runoff and within the channel compared to groundwater. Tributary 1 may have higher phosphorus concentrations compared to the other tributaries due to less iron in the groundwater that removes phosphorus from the water upon oxidation.

Overall, the high phosphorus concentrations observed throughout the WJD 6 subwatershed during the 2019 sampling were likely related to widespread iron and phosphorus-rich groundwater sources in this region of Forest Lake. Groundwater phosphorus sources may have masked other hotspots or legacy sources such as failing septics or accumulation of nutrients in the wetlands from past cropping and livestock activities. A longitudinal survey of phosphorus concentrations along WJD 6 following a rain even in a drier year with less groundwater inputs may reveal other hotspots or legacy sources.

Table 1. WJD 6 longitudinal profile phosphorus concentrations

Location Type	Figure 11 Panel	**Sample ID from Figure 11** (in order from upstream to downstream within each location type)	Total Phosphorus (mg/L)	
			7/3/19	7/22/19
Main Channel	D	**South Grab**		0.277
	D	**Mid South**		0.238
	D	**Mid North**		0.304
	C/D	**Upstream Pipe North**	0.290	0.121
	C/D	**R7U** (at CR-50)	0.280	0.331
	A	**R7E** (just upstream of Hwy 97)	0.311	
	A	**R7** (downstream of Hwy 97)	0.339	
Overland Flowpaths/ Tributaries	C	**Trib 1 up** (In the channel upstream of tributary 1)	0.547	
	C	**Trib 1 down** (In the channel downstream of tributary 1)	0.541	
	B	**Trib 2**	0.221	
	B	**Trib 3 up** (In the channel upstream of tributary 3)	0.318	
	B	**Trib 3 down** (In the channel downstream of tributary 3)	0.314	
	B	**Trib 4 up** (In the channel upstream of tributary 4)	0.319	
	B	**Trib 4 down** (In the channel downstream of tributary 4)	0.314	
	A/B	**Trib 5 up** (In the channel upstream of tributary 5)	*	
	A/B	**Trib 5 down** (In the channel downstream of tributary 5)	0.356	
Groundwater Seep	B/C	**Seepage 1**	1.673	
	A	**Seepage 2**	0.478	
	A	**Seepage 3**	0.408	

* Sample potentially contaminated by particulates and phosphorus concentration not reported

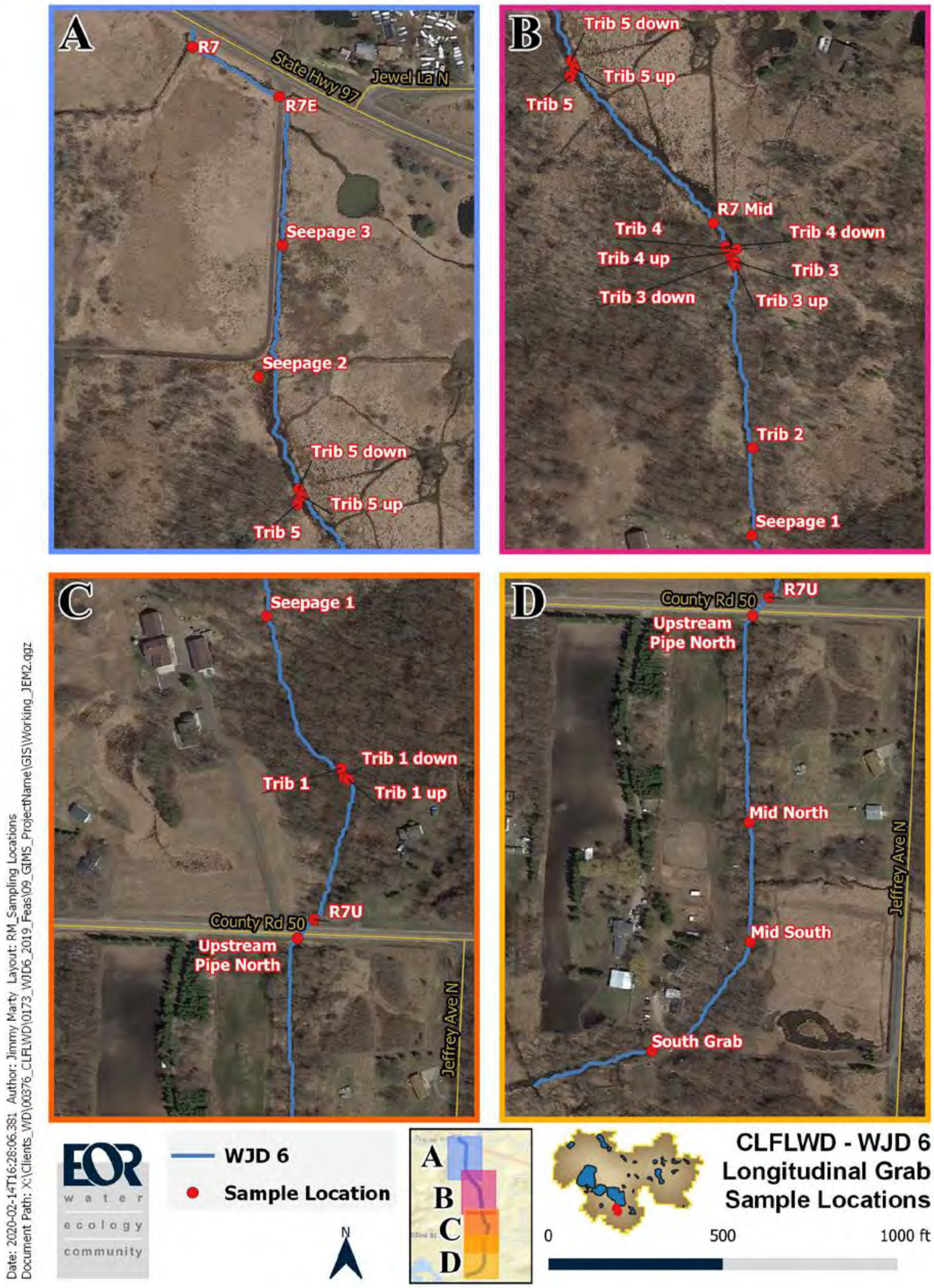


Figure 11. Longitudinal Grab Sample Locations (Note the Overview Map of the panels within the title block)

2.1.4. Historic versus current profile

WJD 6 was constructed in the early 1920's to provide drainage for agricultural activities. The early 1920's plans show clay drain tiles ranging in size from 14- to 24-inch in the upper portions of WJD 6, with an average slope of 0.1%. The drain tile originally had a discharge location just north of the existing CR-50 road crossing. Downstream of CR-50, the channel was an open ditch with a 4-foot wide bottom and 1:1 side slope. Prior to ditching, WJD 6 was a meandering stream channel. The open ditch had a constant slope of 0.33% until it reached its discharge location in the wetland areas on the south shore of the east basin of Forest Lake. Two pipe crossings for road access were also included in the original plans. Both of these road crossings had 48-inch corrugated metal pipes.

The 1921 plans used a generic datum that cannot be directly adjusted into a sea level datum. The translation of the original WJD 6 elevations from the 1921 drawing to the NAVD88 datum was completed utilizing both field surveyed soil cores and survey elevation of a portion of the original drain tile line. The soil cores along the length of WJD 6 showed a depth of silt and sediment accumulation atop native soils. Each of these depths were subtracted from the current surface elevations to yield an approximate original surface elevation. The original ditch alignment was then superimposed onto these elevations at the specified stationing per the 1921 drawing. A portion of the original drain tile was found at approximately station 58+15. The surveyed elevation of the located drain tile was utilized to corroborate the superimposed drain tile, and in turn, ditch profile elevations.

The original and current profiles are illustrated in Appendix A. The existing WJD 6 system is not being actively maintained. The system is still operational, however very little active agriculture still exists in this corridor. The drain tile appears to be in general disrepair and/or converted to open ditch. The open ditch portion has started to revert back to a natural meandering stream. Sediment levels were generally found to be higher under existing conditions than in the historic profile. The difference between the original and current profiles was greater at the upper end of the reach. The current road crossing at Highway 97 was increased in size at some point since 1921 from the original 48-inch CMP to a 4' x 6' concrete box structure.

The historic profile was modeled in PCSWMM to assess potential differences in high water levels if WJD 6 were dredged/restored to the original profile. Modeling was performed by adjusting node elevations from the original tile outlet to the Hwy 97 crossing such that the ditch slope was constant and matched that shown on the original design drawing (0.33%). Transects were adjusted to have a 4-foot bottom width 1:1 side slope to match the typical cross-section shown on the original design drawing. Transect slopes were adjusted to reflect the average slope between the upstream and downstream nodes. The culvert under Hwy 97 was also reduced from the existing 4' x 6' box culvert to a 48" corrugated metal pipe to match the historic configuration.

Table 2 shows the difference between high-water levels predicted by the model if the ditch were to be restored to its historic profile. A negative number indicates that returning the current ditch system to its original profile would result in a decrease in the predicted high-water level. Where restoring the ditch to its original profile results in lower water elevations, the ditch will increase drainage of the wetland in these areas and increase wet/dry cycles that release phosphorus. A positive number indicates that returning the ditch system to the original configuration would result in an increase in the predicted high-water level. Where restoring the ditch to its original profile results in higher water elevations, there may be impacts of flooding on previously drained areas of the subwatershed.

For the portions of the ditch upstream (or south) of the mowed area (see Figure 1), returning the ditch to its original profile is predicted to lower water elevations by 2-3 feet. The causes of these predicted reductions are the removal of accumulated sediment in the existing ditch compared to its original configuration, and the lowering of a private culvert crossing at station 66+00 (sheet 03 of 03 in Appendix A) that is currently set higher than the original profile. This means that the current degraded condition of the ditch upstream of 68+00 keeps water levels higher than if the ditch had been maintained at its original profile. If the ditch was ever maintained to restore its original profile, there would be increased drainage of the large wetland complex south of CR-50, which would negatively impact Forest Lake by resulting in greater phosphorus release.

For the lower portions of the ditch, returning the ditch to its original profile resulted in mixed predictions, with some storms raising water levels by 0.03-0.91 feet and other storms lowering water levels by 0.34-1.25 feet. This is primarily due to a very small difference in sediment levels between the current and original profile, and the current higher capacity and lower invert of the culvert at Hwy 97 (station 99+00 on sheet 03 of 03 in Appendix A) compared to the original profile. Returning the ditch to its original profile is predicted to raise water levels in the northern part of the wetland complex just south of Hwy 97 during most storm events, which would improve water quality treatment and habitat function but result in minor (about one foot or less) flooding impacts.

Table 2. PCSWMM predicted difference between current and future high-water levels (in feet) along the ditch by restoring the ditch to its original profile for various storm events.

Negative values are bolded denoting a predicted decrease in water levels.

Station	Location (see Figure 1)	1-inch	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
68+00	E/F channel transition	**-2.29**	**-2.54**	**-2.54**	**-2.56**	**-2.54**	**-2.51**	**-2.42**	**-2.31**
78+00	S of mowed area	**-1.99**	**-2.05**	**-1.99**	**-2.04**	**-2.15**	**-2.18**	**-2.04**	**-1.85**
88+00	S of field driveway	**-0.34**	0.22	0.49	0.71	0.69	0.91	0.35	**-0.54**
98+00	S of Hwy 97	0	0.71	0.88	0.68	0.03	**-0.44**	**-0.67**	**-1.25**

2.1.5. Floodplain

The PCSWMM model was enhanced for the WJD 6 reach between CR-50 and Hwy 97 with an additional feature that provides improved accuracy needed to model the extent of the ditch floodplain under different storm events. PCSWMM models are usually 1D, meaning that flow is routed through the model in one direction through a series of connected channels. Integrated 1D-2D modeling allows flow to spread out across the land surface in all directions. The integrated 1D-2D model was based on surveyed cross-sections and the Digital Elevation Model (DEM) for this area. Each tile in Figure 12 shows the floodplain extent for an individual storm event, starting in the upper left with a 1-inch storm event and increasing to the 100-year storm event. This figure shows how extensive the floodplain is along this section of the corridor. Protecting this flood capacity is important for both flood attenuation and capturing of sediments and nutrients that would otherwise be delivered to Forest Lake under large storm events.

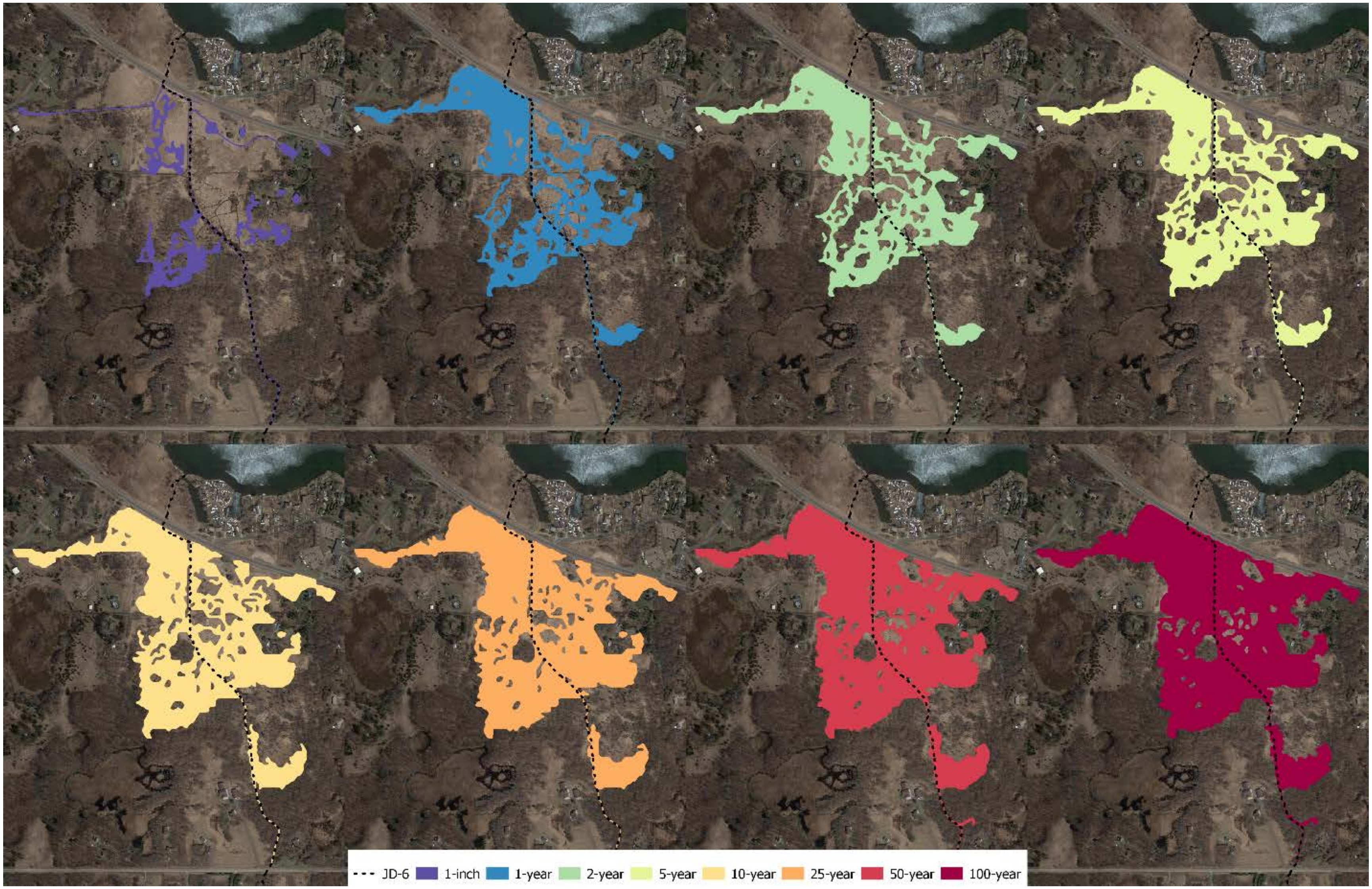


Figure 12. WJD 6 channel floodplain extent under a range of rainfall events (1-inch to the 100-year)

2.1.6. Vegetation Survey

EOR mapped wetland plant communities within the WJD 6 subwatershed based on desktop and field data. Desktop data included: National Wetland Inventory (Figure 13), NRCS hydric soils, aerial imagery, and 2-foot elevation contours. Vegetation mapping was completed within an 85-acre Assessment Area (Figure 14). The Assessment Area focused on the main portion of the wetland complex adjacent to WJD 6, and was determined based on the MPCA Rapid Floristic Quality Assessment (RFQA) Manual (Bourdaughs 2014). The Assessment Area does not represent a wetland boundary, as its fringes are likely connected to additional wetlands via narrow drainageway wetlands.

Two field visits to conduct vegetation mapping were completed on July 3 and September 11, 2019; some portions of the Assessment Area were not observed due to limited mobility through the large area. Vegetation within observed areas was mapped based on desktop data and direct observations of nearby areas.

Eight wetland plant communities were mapped within the Assessment Area (Figure 14). The majority of wetland adjacent to WJD6 consists of fresh meadow in the northern portion and hardwood swamp in the southern portion. Large areas of shallow marsh and shrub-carr are also present within the Assessment Area. An area of sedge meadow is located in the northwestern portion of the Assessment Area. The southern portion of the sedge meadow consists of a floating mat. Small areas of shallow open water are located in the northern portion of the Assessment Area.

Wetland condition generally ranged from poor to fair due to presence of invasive species. Fresh meadow and shrub-carr were dominated by reed canary grass, and some areas of shallow marsh were dominated by hybrid/invasive cattail and reed canary grass. The highest quality areas included the sedge meadow and the southern-most shallow marsh.

Groundwater influence was observed throughout the Assessment Area and appears to significantly influence wetland hydrology. As mentioned in previous sections, evidence of groundwater influence included iron deposits and flow patterns.

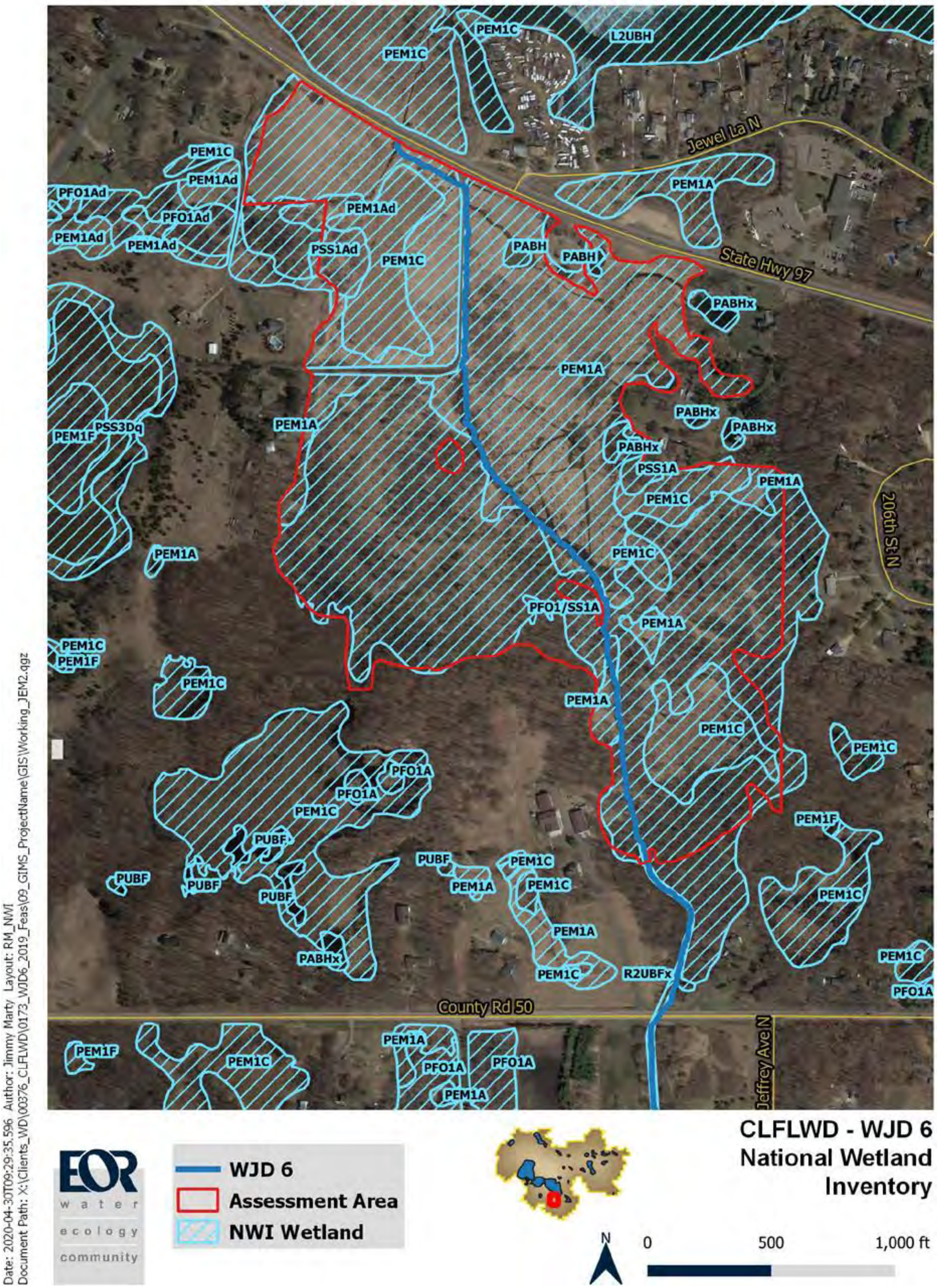


Figure 13. National Wetland Inventory mapped wetlands within the WJD 6 Assessment Area.

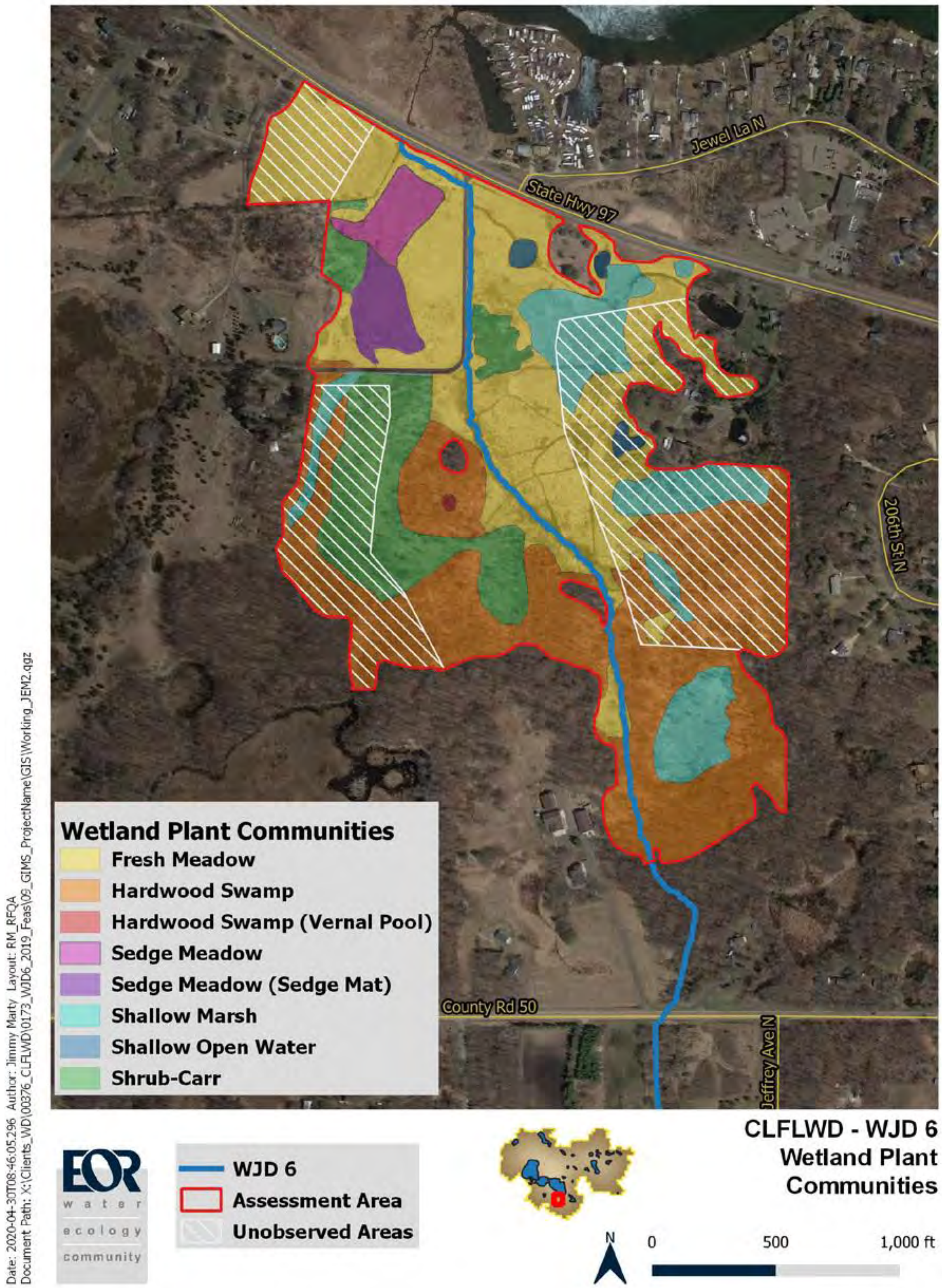


Figure 14. Wetland plant communities mapped by EOR within the WJD 6 Assessment Area.

Unobserved areas were not directly observed in the field but mapped based on desktop data and observations of the nearby areas.

2.2. R7D Wetland

The R7D subwatershed includes two large wetland basins situated in the north and central portion of the subwatershed (Figure 15). The tributary ditch flowing from the R7D subwatershed to WJD 6 is well-defined, flowing into and out of the R7D north wetland between the R7D and R7W monitoring locations (Figure 15). The 2018 WJD 6 Assessment and Feasibility Study indicated that approximately 100 pounds of phosphorus discharge from the R7D north wetland annually. The 2018 assessment identified the potential to stabilize the outlet to maximize storage and evapotranspiration and provide some water quality benefits. The 2019 assessment included a review of historical aerial imagery, a wetland boundary survey, a survey of potential for private property impacts, and water level monitoring of the R7D north wetland to assess the feasibility of a stabilized outlet.

The north basin is a DNR Public Waters basin; the interconnecting ditches are not DNR Public Waters watercourses, but the north basin encompasses the ditch extending toward Ivywood Avenue. The R7D tributary ditches connecting to WJD 6 are not on the official WJD 6 alignment. However, projects that involve alterations to the ditches may still require Drainage Law proceedings if it is determined that this is a lawfully connected private ditch.

2.2.1. Historical Aerial Imagery Review

EOR reviewed historical aerial imagery from 1936, 1953, 1964, 1991, 1997, 2003, and 2016 (see Appendix A). Considerable changes in hydrology were evident based on the review, with both R7D wetlands becoming wetter, but particularly the south wetland. Both R7D wetlands were drier between 1936 and 1964. Much of the existing wetland area was in hay/pasture during this time, and no surface water was visible in the R7D south wetland. In 1991, the wetlands appear to be wetter, with most existing wetland areas no longer in pasture and the R7D north wetland appearing similar to existing conditions. However, no surface water is visible in the R7D south wetland and it still appears to be significantly drier relative to existing conditions. Between 1991 and 1997, the R7D south wetland became inundated with surface water with some wooded vegetation remaining. By 2003, the R7D south wetland consists of open water and cattail marsh and resembled existing conditions. The cause of the hydrologic shift is not clear. Changes to the drainage system and drainage area were not evident in reviewed images.

2.2.2. Wetland Boundary Assessment

EOR completed a wetland boundary assessment to assess feasibility, permitting, and private property constraints on a potential project. The boundary assessment was completed based on desktop and field assessment (Figure 16). The desktop assessment was completed first and included review of National Wetland Inventory, NRCS hydric soils, aerial imagery, and 2-foot elevation contours. The field boundary assessment verified portions of the desktop boundary and was completed in September 2019. The field boundary assessment was conducted based on visual observations of vegetation and hydrology. Potential conflicts with private property near the wetland boundary were identified.

The mapped wetland boundary was compared with hydric soils maps to evaluate areas that may have historically been wetland (Appendix A: Figure 36). Overall, hydric soils generally align or are slightly smaller in area than the mapped wetland boundary, suggesting that the historical wetland likely did not extend further beyond the mapped wetland boundary. The wetland boundary generally included areas of "All Hydric" soil, with some areas of "Predominately Hydric" soil beyond the mapped wetland boundary. The areas of "Predominately Hydric" soil beyond the wetland boundary consist of developed residential lots and an agricultural field. Areas of "Predominately Not Hydric" were included within the wetland boundary, most prominently within the northwestern portion of the R7D north wetland within an area that was used for hay production between 1936 and 1964.

Specific land use concerns were identified along the wetland boundary that could be impacted by water level changes caused by a potential future project (Figure 16). Most concerns were noted around the R7D north wetland. Several tree plantings are located along the northern and eastern boundary of the R7D north wetland. A mowed trail network exists along the eastern extent of the R7D north wetland and follows closely along the wetland boundary. A vehicle access road is located adjacent to the northern boundary of R7D north wetland. Land use surrounding the R7D south wetland consists of two residential lots, an agricultural field (planted in hay during the 2019 field visit), and wooded areas. A low spot is located within the agricultural field between the two R7D wetlands and portions of the residential yards are adjacent to the wetland; slopes near the remaining areas of the agricultural and residential lots are fairly steep (Appendix A: Figure 36).

2.2.3. Water Level Monitoring

One piezometer was installed within the open water pond on the north end of the R7D north wetland to investigate fluctuations in surface water levels (Figure 16). Surface water levels were recorded at this location from August to October. Based on 2019 piezometer data, the surface water of the R7D north wetland does not exhibit much water level bounce in response to storm events and appears relatively stable. Therefore, a stabilized outlet as proposed in the 2018 WJD 6 study may not result in much added benefit. Additionally, the existing wetland boundary crosses numerous private properties, and the stabilized outlet would likely change hydrology and increase water levels on these private properties. Therefore, the originally conceptualized project for the R7D north wetland may not have desired effect of reducing bounce and may affect private property along the boundary of the north R7D basin.

Figure 15. Overview of R7D wetlands and surrounding area.

Figure 16. Wetland boundary of R7D wetlands with potential private property impacts and piezometer location.

3. PROJECT FEASIBILITY

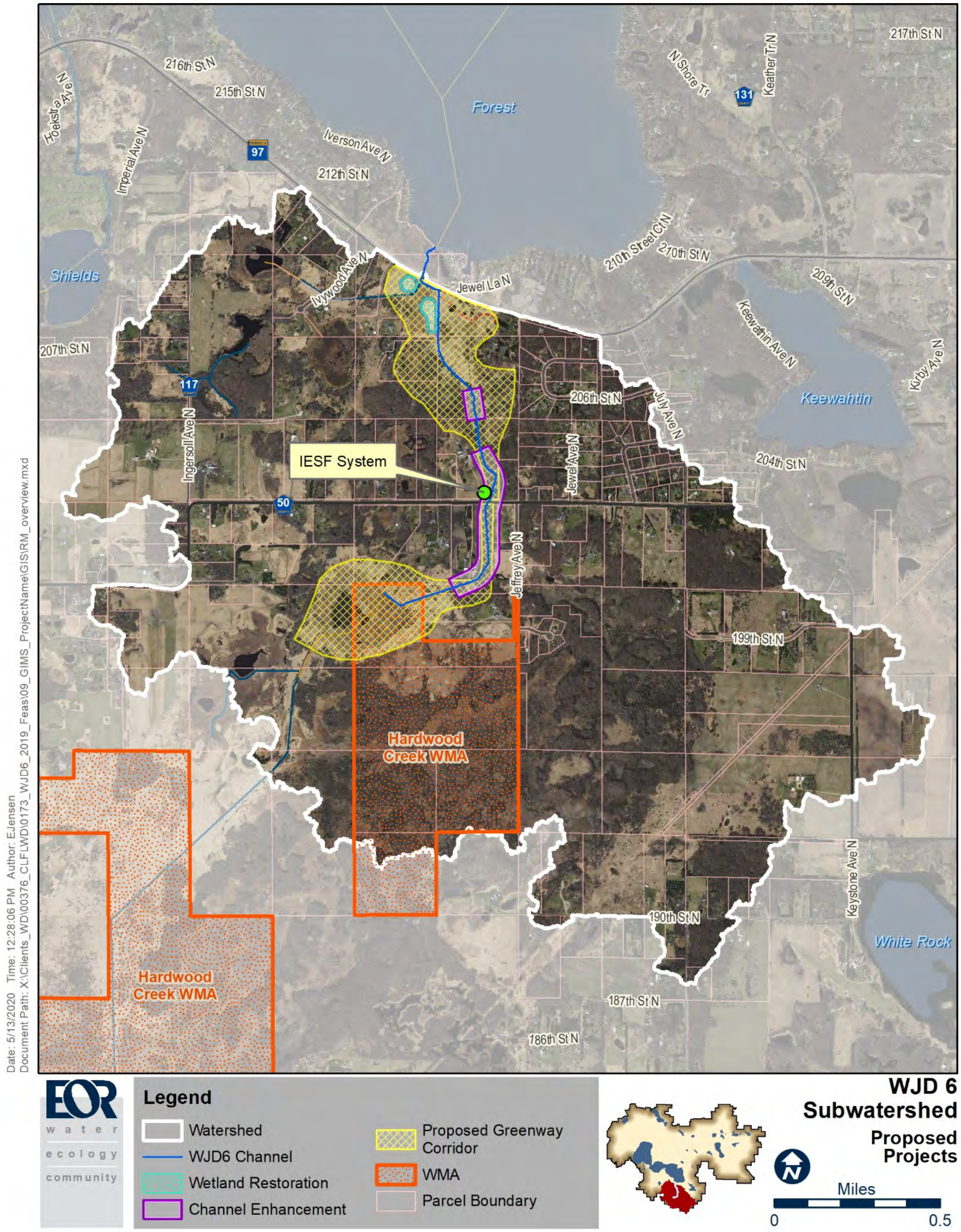


Figure 17. WJD 6 Subwatershed Proposed Projects Overview Map

A multi-year, conservation plan is proposed for the WJD 6 subwatershed, ultimately resulting in the establishment of a greenway corridor along WJD 6 (Figure 17). Several individual projects are also proposed that should be implemented in a phased approach while longer-term efforts to acquire parcels and establish partnerships for a contiguous greenway corridor are taking place. The greenway corridor and 4 individual projects are summarized in more detail in the following sections, followed by a summary of the proposed multi-year, conservation plan and recommendations for a phased approach.

3.1. Greenway Corridor

The WJD 6 subwatershed has been identified for conservation by the City of Forest Lake, Washington County, and Minnesota Department of Natural Resources (DNR). The City of Forest Lake's future desired land use for the WJD 6 subwatershed was identified as conservancy in the City of Forest Lake 2040 Comprehensive Plan (Figure 19). As defined by the 2040 Plan, this category provides protection for areas with valuable natural resources. These are portions of the community that are particularly environmentally sensitive and include large, continuous wetland areas. The future desired land use for the area north of CR-50 was identified by the City of Forest Lake as rural residential. This land use includes one-family homes that are difficult to serve with municipal wastewater treatment systems for the foreseeable future and limit density to 0.2 units per acre.

Washington County identified the Hardwood Creek corridor in central Hugo and southeastern Forest Lake as one of the top ten priority conservation areas in the County (Figure 18), and the DNR has a management plan for the Hardwood Creek corridor. The WJD 6 subwatershed is adjacent to the Hardwood Creek WMA; the Hardwood Creek WMA is comprised of two non-contiguous parcels totaling 583 acres consisting of about 10% small planted prairies and 90% wooded wetlands with wooded upland islands and is part of the largest complex of native habitat remaining in Washington County. Any efforts by the CLFLWD to expand the protection of the Hardwood Creek WMA along the WJD 6 corridor would complement local, county and State conservation efforts.

The WJD 6 ditch was historically a meandering stream. This stream is beginning to restore itself and much of the reach is in stable condition. Projects along the corridor would help ensure geomorphological and vegetative stability along the banks and enhance its ecological function. Being that this is a public ditch, extra caution is needed to ensure that such activities do not inadvertently impact drainage rights. However, the WJD 6 system is no longer serving its intended purpose. Agricultural activities have been very limited for a long period of time along this corridor. The corridor contains large areas of wetland and floodplain and is slowly reverting back to its natural state. Since the ditch system is no longer serving its intended purpose, the District may want to consider abandoning the ditch system and converting the drainage and adjacent wetlands and floodplain into a greenway corridor (Figure 17).

An approximate boundary for the proposed greenway corridor is depicted in Figure 17 and Figure 20, with approximately 85 acres located north of CR-50 and 75 acres located south of CR-50. The greenway corridor could be established in a two-phased approach, with the District focusing efforts on acquiring easements north of CR-50 first where the individual projects will be implemented, and then south of CR-50 to connect with the larger, regional Hardwood Creek corridor. There are up to 18 private parcels that intersect with the proposed greenway corridor: 10 located north of CR-50 and

8 located south of CR-50. Acquiring property and/or easement along this corridor as opportunities arise would help protect this continuous corridor from becoming segmented and support local, county and statewide conservation efforts. In particular, if an opportunity arose to acquire the properties being served by the private driveway cutting through northern part of the wetland and alternative access to the residences provided, the driveway could be removed restoring the original natural wetland connection (the 13.64 acre and 27.23 acre parcels in the northwest portion of the corridor shown in Figure 20). Alternatively, additional culverts could be added through the driveway to increase the hydrologic connectivity of the wetland complex on either side of the driveway.

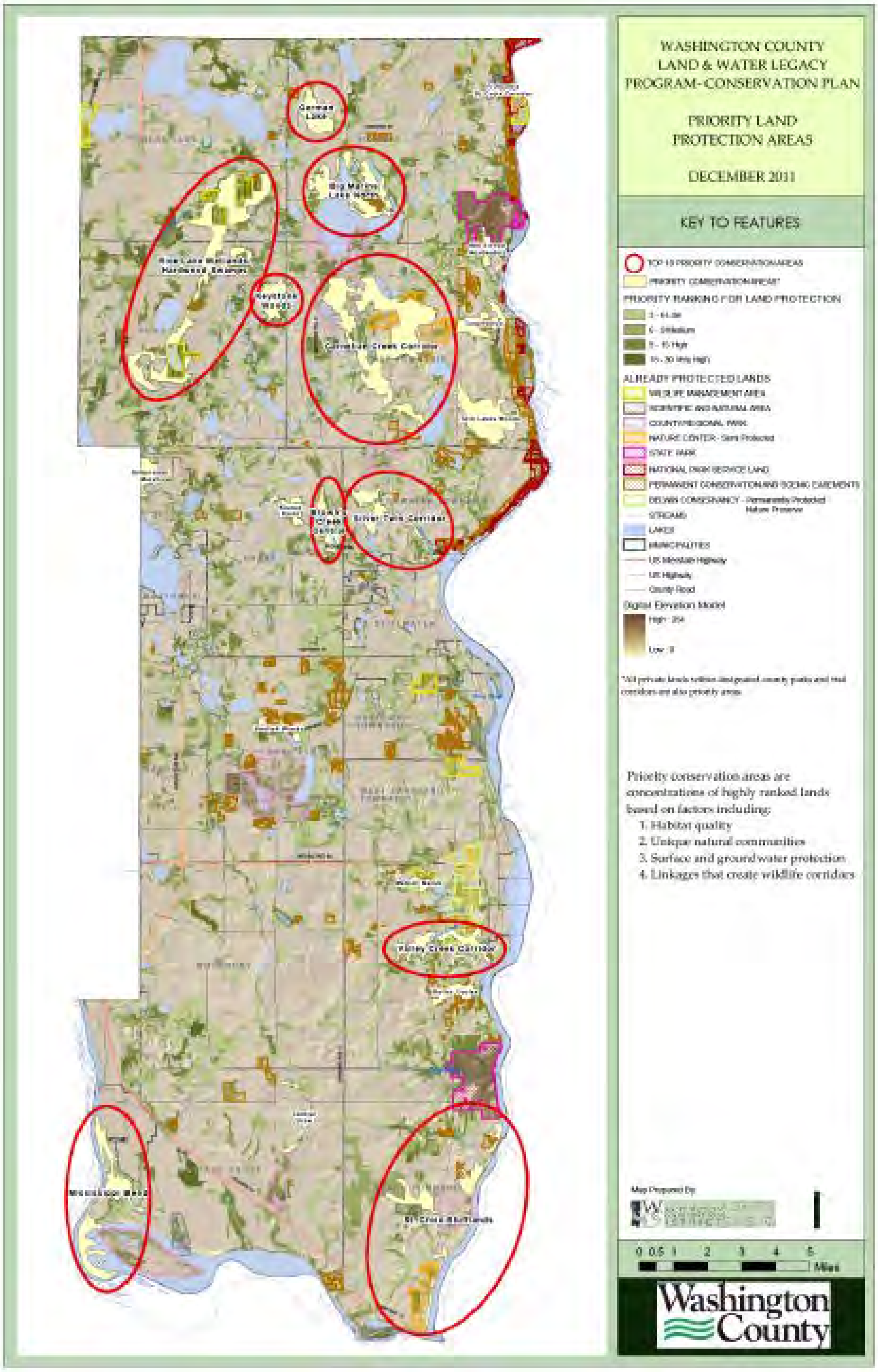


Figure 18. Washington County Top Ten Conservation Areas (December 2011)

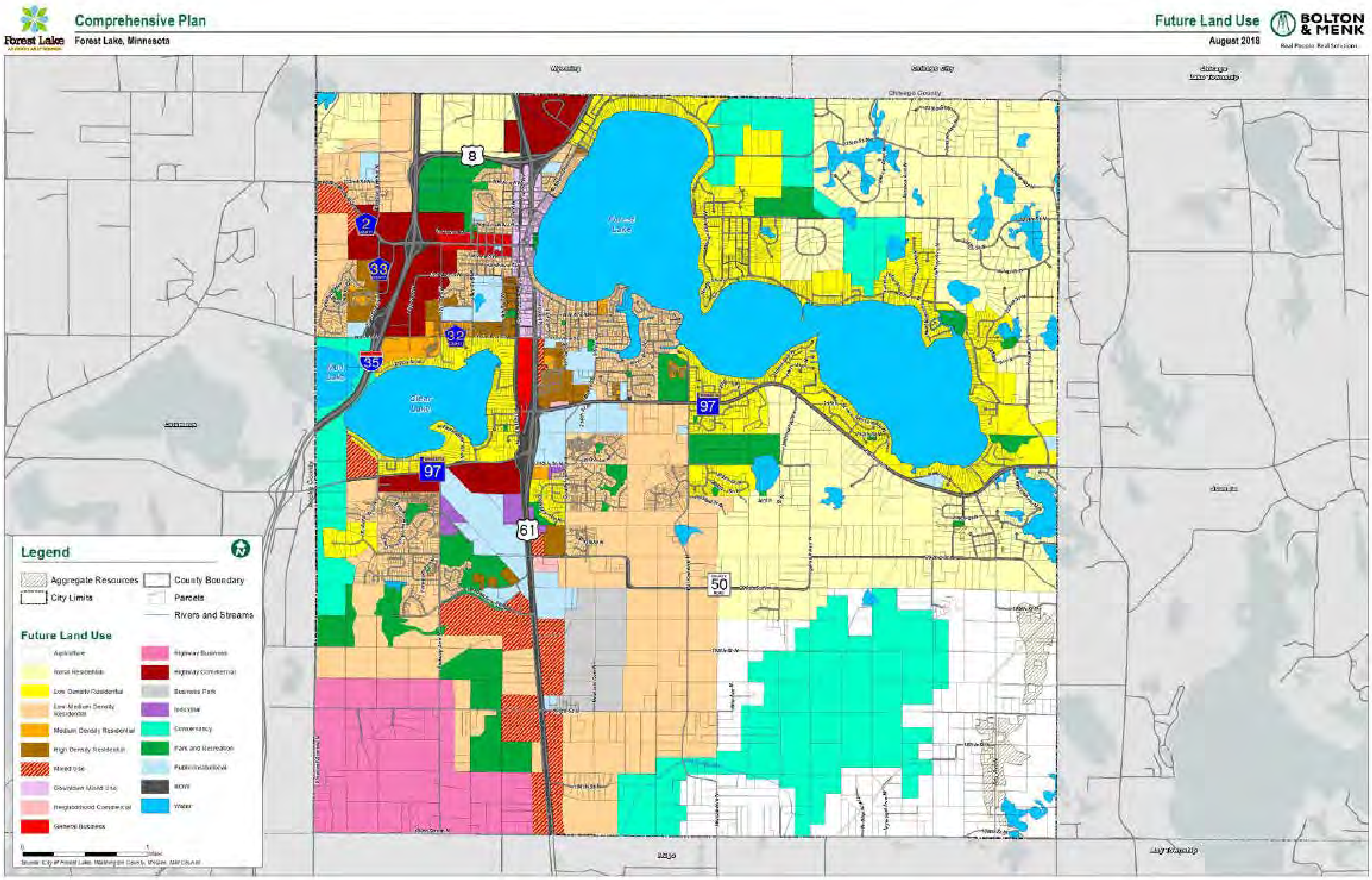


Figure 19. City of Forest Lake Future Land Use (Figure 2-3 from the 2040 City of Forest Lake Comprehensive Plan)

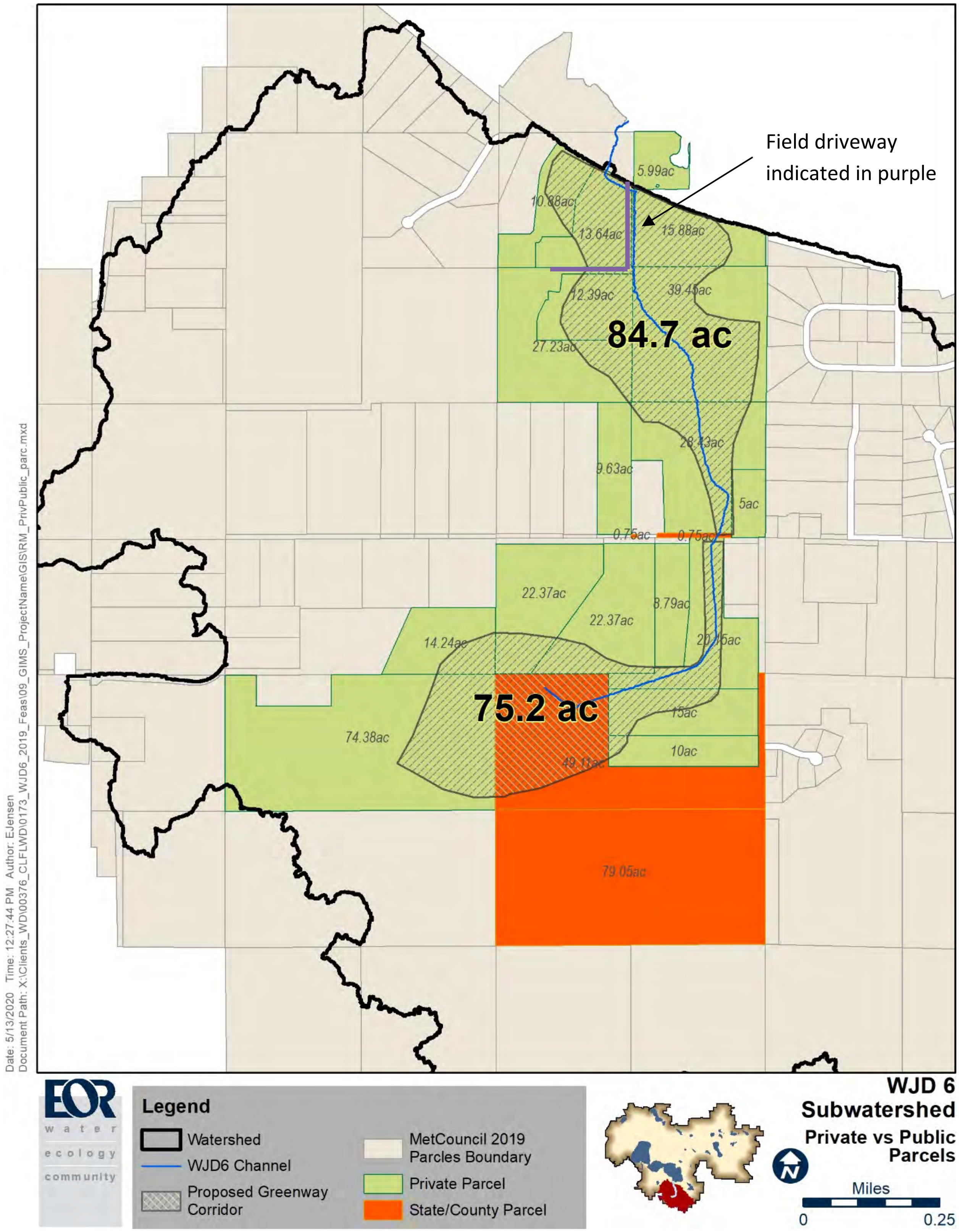


Figure 20. WJD 6 Proposed Greenway Corridor impacted parcels

3.2. CR-50 Iron-Enhanced Sand Filter Treatment System

The headwaters of WJD 6 is dominated by wetlands and contributes nearly half of the total phosphorus load in the WJD 6 system, most of which is dissolved and difficult to remove with traditional best management practices. Diagnostic monitoring of phosphorus concentrations along the entire WJD 6 channel, from major tributaries, and from several groundwater seeps discharging to the WJD 6 channel, indicate that high levels of dissolved phosphorus are widespread throughout this subwatershed. No phosphorus hotspots that would have led to more cost-effective opportunities were identified through multiple years of diagnostic monitoring, field reconnaissance, and discussions of historic conditions with landowners. Moreover, because the WJD 6 subwatershed is a judicial ditch system, implementation of any project that alters the hydrology of the system would require a public hearing and consent of all benefited properties. Therefore, other best management practices in this portion of the subwatershed would result in a higher cost and require extensive permitting and landowner agreements.

An offline IESF is the most cost effective and feasible BMP for this subwatershed at this time because it does not alter the hydrology of the judicial ditch system and impacts a relatively small area of upland. In addition, an IESF specifically targeted at CR-50 would capture a large portion of the dissolved phosphorus load in the WJD 6 subwatershed and can potentially be sited at an elevation that achieves recommended drawdown rates to maximize the removal efficiency of iron-enhanced sand, and is located near an electrical source for operation of the system pump. Modeling of the IESF using two years of continuous monitored flow data at CR-50 indicate that there is sufficient flow to maintain operation of the IESF system throughout most of the growing season and maximize the cost-effectiveness of IESF operation.

An offline, multi-cell IESF treatment system is recommended at CR-50. Concept design plans and a preliminary cost estimate are provided in Appendix E. The proposed project would create an intake point near the downstream end of the CR-50 culvert. A pump and associated electrical will be installed to lift water up to where the IESF will be situated on higher ground. Pre-treatment would be provided either by an underground chamber prior to pumping or in a pre-treatment pond after lifting the water. The means of pretreatment will need to be determined once final project siting and available land is determined. After pre-treatment, the water will be discharged into a large IESF cell for a set period of time. After that set period of time the water will drawdown allowing the filter to dry out. This dry out period is necessary for proper operation and dissolved phosphorous removal associated with the IESF. Utilizing multiple cells will allow for filling of one cell while another dries out. After running through the IESF, the water will be picked up by a network of draintile pipes which will then send the treated water back into the WJD 6 ditch system.

The proposed IESF at CR-50 is estimated to remove 85 pounds of phosphorus per year or 50% of the WJD 6 subwatershed reduction goal, and 9% of the total watershed load reduction goal for Forest Lake. Most of the phosphorus load in the WJD 6 watershed is dissolved (70% on average), for which iron-enhanced sand filtration is a proven method for removing large fractions of dissolved phosphorus. Design guidance for IESF in the MN Stormwater Manual recommends assuming 60% removal rates of dissolved phosphorus for estimation purposes. However, this recommendation is for average dissolved phosphorus concentrations which are lower than the 70% dissolved phosphorus concentration measured in WJD6. At this higher concentration, the effective removal rate could be higher than 60% (although 60% removal is what was conservatively used to calculate the 85 lb/yr phosphorus reduction estimate). As a comparison, effectiveness monitoring of a constructed IESF with similar high dissolved P concentrations indicated removals in excess of 80% in the nearby Carnelian-Marine-St. Croix Watershed District.

Secondary benefits of this project include preservation and restoration of terrestrial wildlife habitat adjacent to the WJD 6 channel next to the project. Design of the IESF will be sited in such a way to minimize impacts to existing high-quality trees and vegetation, incorporate native vegetation and trees in a buffer area, and preserve a buffer along the WJD 6 channel. The project will be designed with plant species that are pollinator friendly. The project is also designed as an offline IESF to reduce hydrological impacts and preserve/augment baseflow in the WJD 6 channel.

There is an interested landowner near the CR-50 road crossing that has been in discussions with the District. The exact location of the facility has not yet been determined as alternative site are being considered. Discussions regarding landowner agreements and siting of this project are currently underway.

3.3. WJD 6 Wetland Restoration

The large wetland complex south of Hwy 97 west of WJD 6 presents an excellent opportunity for stormwater treatment prior to entering Forest Lake immediately downstream (the easternmost wetland restoration identified in Figure 17). Routing phosphorus-laden water from this stretch of WJD 6 into the wetland complex would allow natural treatment as the flows migrate through the wetland. Concept design plans and a preliminary cost estimate are provided in Appendix F.

To achieve this treatment, a culvert could be installed at the southern bend of the private driveway to divert a portion of the WJD 6 baseflow to the wetland complex on the west side of the driveway as seen in Appendix F. The location and elevation of this culvert would need to be designed to divert a portion of the baseflow but not so much as to cause the original ditch alignment to dry out. The diverted baseflow would enter an area of excavated wetland on the west side of the driveway and eventually overtop through an outlet control structure back into the ditch on the east side of the driveway. The western half of the wetland complex on the west side of the driveway is primarily a high-quality sedge meadow and would not be affected, while the eastern portion of the wetland complex on the west side of the driveway has been primarily overrun with reed canary grass and could be excavated to create deeper pools to re-establish the wetland with emergent native species. The pools would be excavated to create a maximum depth of approximately five feet under normal conditions. This proposed project would affect two landowners; the owner of the driveway under which the inlet culvert would be installed and the owner of parcel the wetland is contained within (the 13.64 acre and 27.23 acre parcels in the northwest portion of the corridor shown in Figure 20).

Multiple design configurations were evaluated in the existing SWMM model to assess the potential impacts of culvert sizing and placement on the proportion of flows that would be diverted due to this project. First, two outlet configurations were considered: the first configuration diverted flows back into the ditch directly to the north of the wetland, downstream of the driveway crossing; and the second configuration diverted flows under the driveway into the wetland, then back under the driveway into the ditch a short distance downstream. Although Alternate 2 could mitigate the impacts of drying in the case where a larger proportion of flows is diverted into the wetland, the primary concern with this configuration is its potential inefficiency in performing phosphorus treatment due to short-circuiting. Additionally, modeling indicated that Alternate 2 would more significantly limit the proportion of flows that could be diverted since placing the outlet so close to the inlet reduces the hydraulic gradient through the wetland. For these reasons, Alternate 1 is considered a better option.

Multiple culvert sizes were evaluated, ranging from a 12” circular pipe to a 36” equivalent arch pipe. Pipes of equivalent capacity (size and slope) were modeled at the inlet and outlet of the wetland. The pipe inlet was assumed to be approximately 3” off the bottom of the ditch. The proportion of flows that could be diverted through the wetland under these configurations varied between about 25% and 60%. An 18” pipe was found to divert approximately 30% of total flow volume during a continuous simulation from April-October 2018. Considering the large drainage area and relatively small available footprint, diverting 30% of flows appears to be a reasonable target that could result in significant phosphorus removal while avoiding significant alteration to existing hydrology.

Assuming a 40% reduction in total phosphorus load from the fraction of flow diverted under the field driveway, this project may result in a phosphorus reduction of up to 96 lb/yr to the east basin of Forest Lake. The 40% reduction estimate is based on effectiveness monitoring data collected from Bixby Park; due to the higher fraction of ortho-phosphate in the WJD 6 discharge (70%) compared to Bixby Park (55%), this reduction estimate should be considered the upper end of achievable reductions for this project. Sorption media enhancements to the project would increase phosphorus reductions by targeting the ortho-phosphate fraction of the total phosphorus load, but at a higher overall project cost.

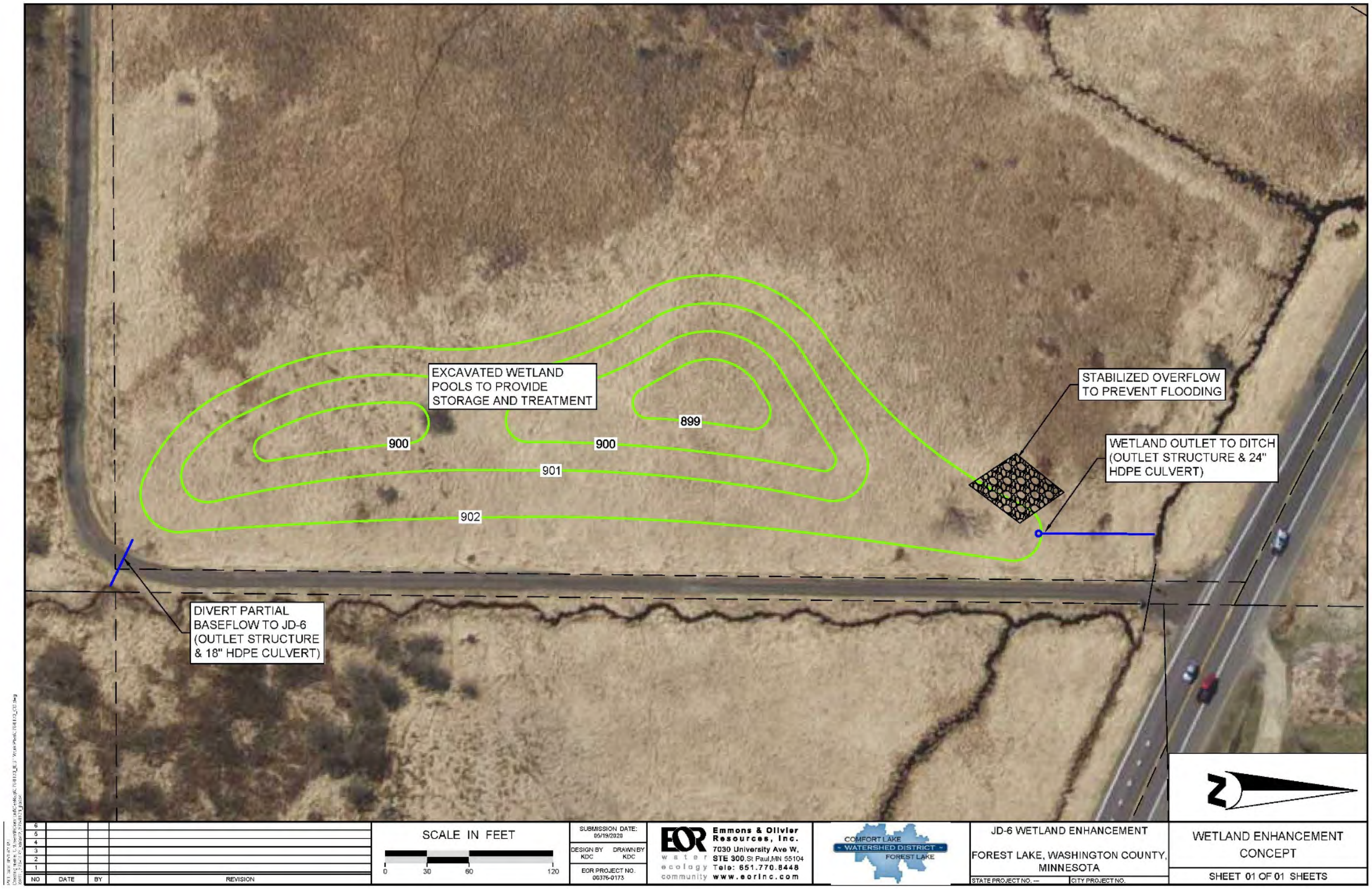


Figure 21. WJD 6 Wetland Restoration Design Schematic

3.4. Channel / Ditch Enhancements

The existing channel from Hwy 97 to approximately 750 feet north of CR-50 is in a stable pattern. Management efforts should focus on landowner education to eliminate or reduce mowing activities that have occurred along the mowed section of the stream where bank erosion has been documented. Ideally, mowing activity would cease in the wetland and along the streambanks; however, even a narrow strip of undisturbed vegetation along the streambanks would benefit the channel and allow grasses and sedges to become reestablished.

Priority management efforts should focus on tree thinning along the "F" channel located north and south of CR-50 (Figure 17). As documented during the geomorphic assessment, the channel was stable and contained dense riparian vegetation in areas where the tree canopy was absent or was reduced. However, the channel was in a degraded condition where the tree canopy was dense, which coincided with limited riparian vegetation along the stream banks. Thinning out the dense tree canopy along the ditch will promote the development of riparian vegetation and further stabilize the low floodplain benches that are forming within the "F" channel. Ideally, tree thinning would occur within 30 feet of the ditch banks to target those trees directly overhanging and shading the channel. It is not recommended to remove all the trees along the ditch, but to remove pioneer species such as box elder, cottonwood, and aspen. Significant trees or high value trees could be left undisturbed and large woody debris could be incorporated into the channel during tree thinning to maintain habitat for fish and invertebrates.

Bank shaping or other excavation activities are not recommended based on the existing condition of the channel and projected cost to develop and implement a project. As shown in Figure 5, the channel is self-healing in areas where the tree canopy is reduced and would continue to self-heal if tree thinning activities where implemented. The District would realize a far greater return on investment to implement a tree-thinning project compared to a project that would entail construction plan development and earthwork activities.

3.5. R7D Wetland Enhancement

The relatively stable water levels observed within the R7D north wetland during 2019 suggest that a constructed outlet designed to stabilize water levels would not provide much water quality benefit at this time. Additionally, there could be potential private property concerns near the existing boundary of the R7D north wetland if the water level were altered with a new outlet structure. However, review of historical aerial imagery revealed a relatively recent and significant shift in the hydrology of the R7D south wetland between 1991 and 1997 to a wetter, less wooded condition. The cause and effect of this hydrologic shift is not evident based on reviewed images, but a potential explanation is that the ditched outlet from the R7D south wetland to the R7D north wetland may be poorly functioning and backing up water in the south wetland. A redesigned outlet that lowers wetland water levels would allow some portions of the basin to naturally regenerate woody species present in portions of the basin prior to inundation between 1991 and 1997. Regeneration of woody species increases the diversity of habitats for wildlife compared to the existing open marsh while also reducing runoff volumes through increased evapotranspiration from woody vegetation.

We recommend installation of a long-term wetland well with a remote sensing water level logger to better characterize water levels and fluctuations in the R7D south wetland, similar to the logger recently installed in the Bone Lake Outlet wetland complex. Future data collection could also include a detailed survey of the channel between the north and south wetlands, including reconnaissance to investigate potential drain tile or infrastructure installations that may have contributed to the hydrologic shift to wetter conditions, a survey of the southern basin, and modeling of the proposed modified outlet.

Another potential project for treatment of phosphorus discharging from the R7D subwatershed is to construct a treatment wetland downstream of both R7D wetlands along the ditched tributary to WJD6 (the westernmost wetland restoration identified in Figure 17). This project would be similar to the WJD 6 wetland restoration discussed for the main branch. For this tributary water could be diverted into excavated/enhanced wetland cells for added treatment. Areas that are primarily dominated be invasive species (i.e. reed canary grass) would be targeted. This area could eventually be part of the contiguous wetland and floodplain complex if the greenway corridor was to be implemented.

3.6. Recommendations

A multi-year, conservation plan is proposed for the WJD 6 subwatershed, ultimately resulting in the establishment of a greenway corridor along WJD 6 (Figure 17). Several individual projects are also proposed that should be implemented in a phased approach while longer-term efforts to acquire parcels and establish partnerships for a contiguous greenway corridor are taking place. A decision tree for implementing the individual projects in a phased approach while concurrently pursuing a holistic greenway corridor is illustrated in Figure 22

The Iron-Enhanced Sand Filter (IESF) proposed just north of CR-50 should be implemented first to significantly reduce phosphorus loads discharging to Forest Lake before implementing other future potential downstream projects. This project was submitted for a BWSR Clean Water Fund Grant. The project ranked very highly and was awarded $747,400 in grant funds in 2020. Following construction of the CR-50 IESF, we recommend the implementation of an extensive monitoring program to determine its effectiveness.

If after CR-50 IESF construction and monitoring, additional downstream treatment is required to meet Forest Lake's phosphorus reduction goals, then the WJD 6 Wetland Restoration project could be considered. This project would divert a portion of the WJD 6 flow into an excavated wetland that has been artificially cut off from floodplain flows by a private driveway. The excavation component of the project would be focused in areas currently dominated by invasive species.

Concurrently with implementation of the IESF and wetland restoration projects, the District should determine if it wants to pursue a holistic greenway corridor with ditch abandonment in the WJD 6 subwatershed. Reaching out to the City of Forest Lake, Washington County and MN DNR to gage interest in partnerships for land acquisition in funding could be a key decision point. There are strong local and regional benefits to establishing this corridor, but easements on all or portions of 10-18 parcels will require large investments of District staff and legal counsel time, in addition to the land acquisition costs, which are not eligible for all types of grant funding. Creating a greenway corridor will require long-term visioning, planning, and coordination with the City, County, DNR, and individual property owners to synchronize conservation efforts, establish partnerships and identify funding sources for land acquisition costs. The District has reached out to several of the landowners in the WJD 6 subwatershed as part of the 2019 field data collection efforts, and this serves as a starting point for establishing the landowner relationships necessary to develop a greenway corridor.

Concurrently, the District can pursue ditch decommissioning by first determining if there are any benefited properties that object to ditch abandonment. If ditch abandonment is infeasible due to lack of landowner willingness, we recommend implementing ditch stabilization practices and other wetland treatment projects that do not infringe on drainage rights of the benefitted parcels.

The R7D wetland restoration project at this time does not appear to be a priority, and we recommend continuing wetland water level monitoring in the R7D wetlands. The downstream portion of the R7D subwatershed could become part of the wetlands and floodplain associated with the proposed greenway corridor if the District pursues that option.

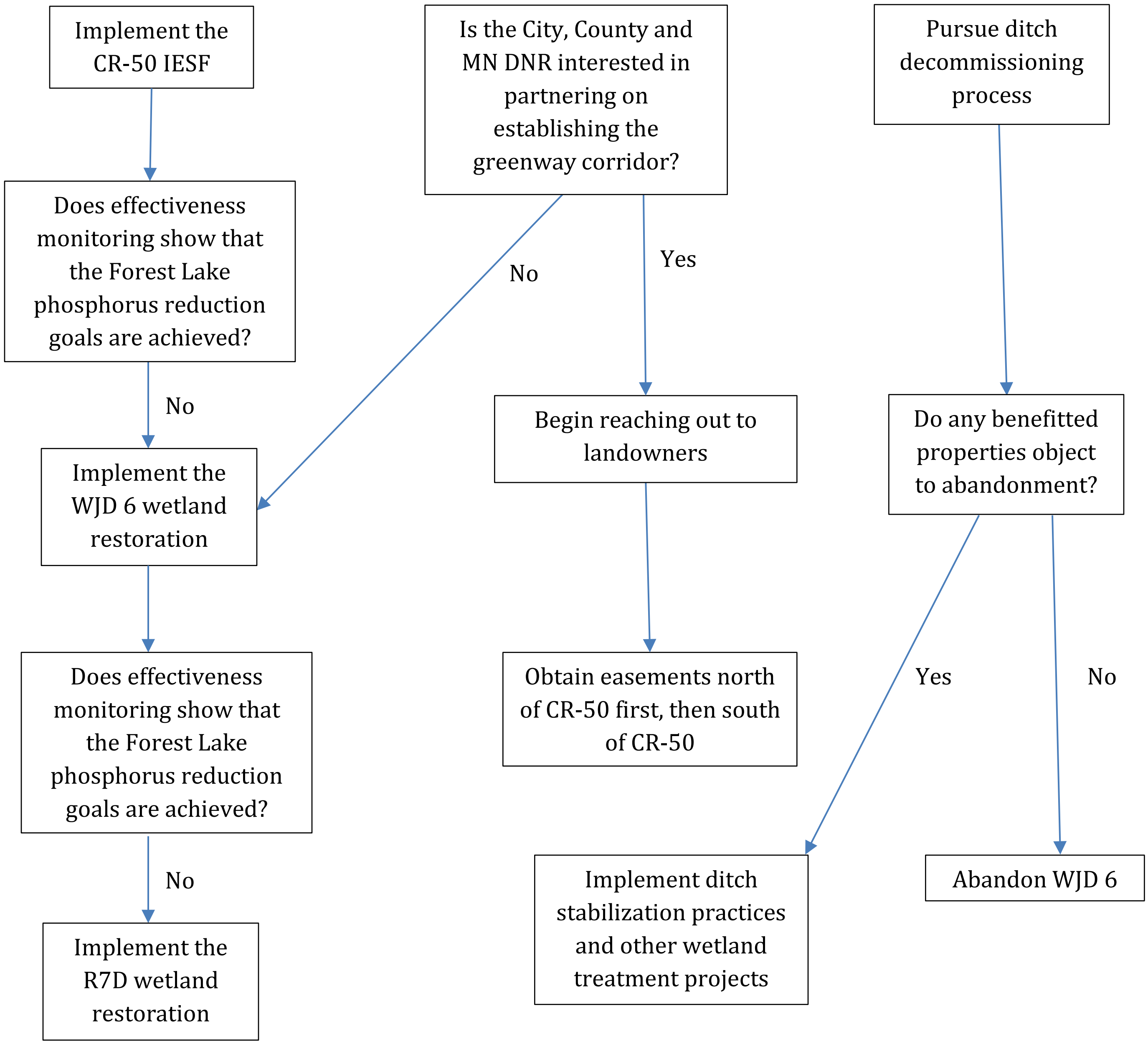


Figure 22. WJD 6 Subwatershed Phased Conservation Plan Decision Tree

4. REFERENCES

Bourdaghs, Michael. 2014. Rapid Floristic Quality Assessment Manual. wq-bwm2-02b. Minnesota Pollution Control Agency.

Emmons & Olivier Resources (EOR). 2003. Integrating Groundwater and Surface Water Management - North Washington County. Available online at: https://www.co.washington.mn.us/DocumentCenter/View/733/Integrating-Groundwater-and-Surface-Water-Management---North-Washington-County?bidId=

Minnesota DNR State Climatology Office. 2020. Wetland Delineation Precipitation Data Retrieval from a Gridded Database, http://climateapps.dnr.state.mn.us/gridded_data/precip/wetland /wetland.asp. Accessed 2/26/2020.

APPENDIX A. WJD 6 WETLAND WELL WATER SURFACE ELEVATION DATA

Figure 23. WJD 6 Transect 1 wetland well water surface elevations in 2019. Breaks in data indicated missing data or periods of groundwater equilibration.

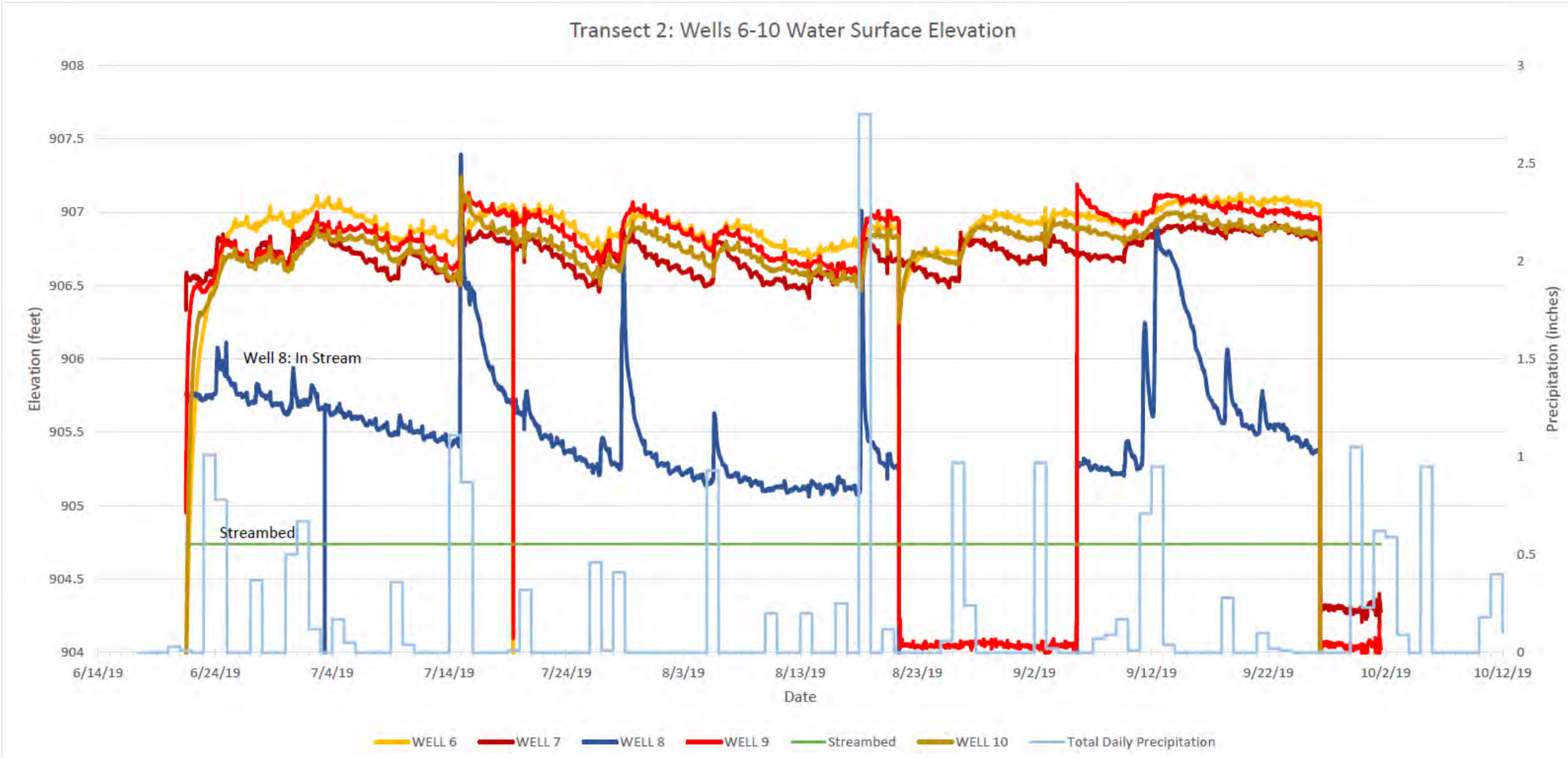


Figure 24. WJD 6 Transect 2 wetland well water surface elevations in 2019. Breaks in data indicated missing data or periods of groundwater equilibration.

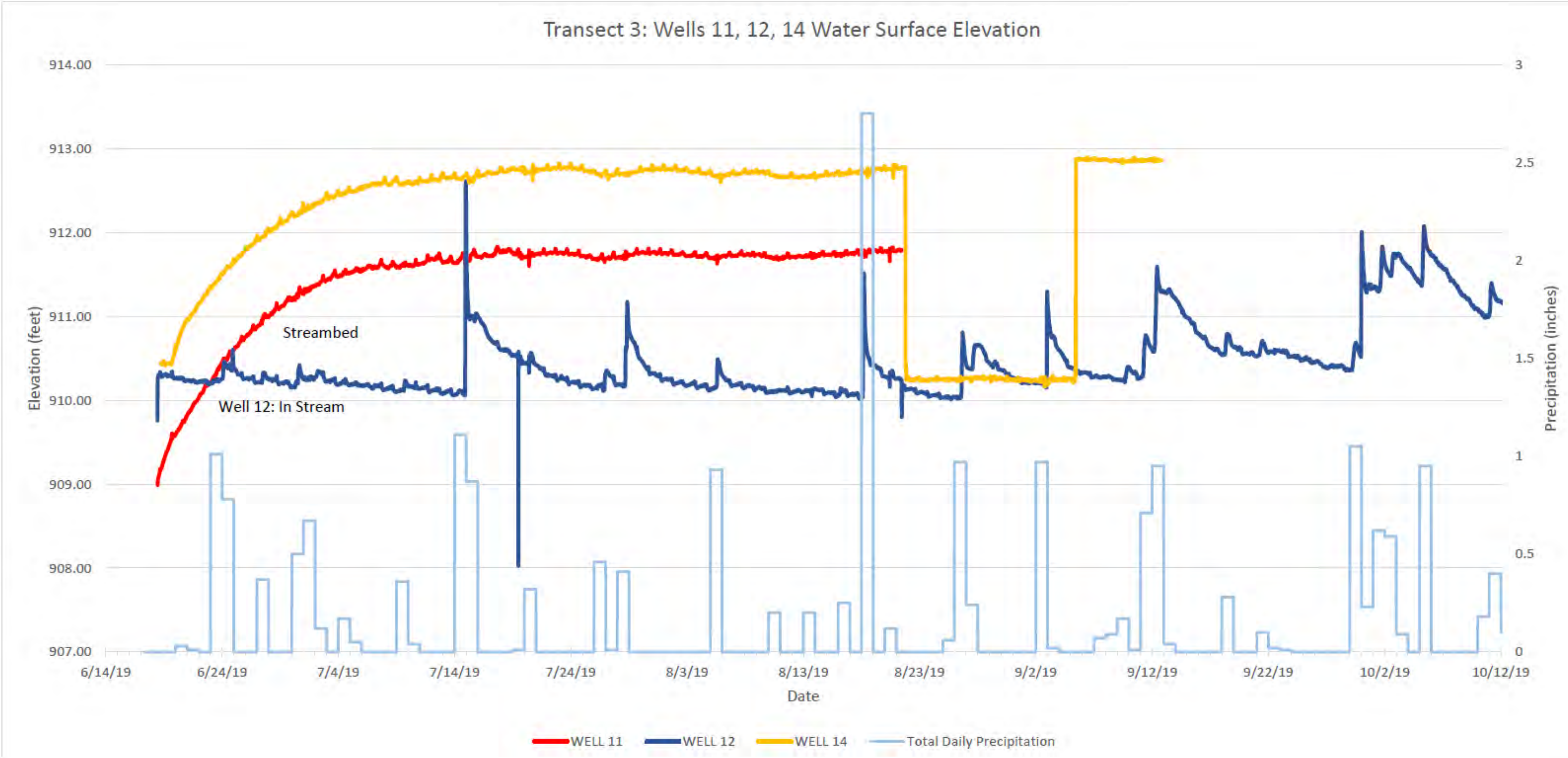


Figure 25. WJD 6 Transect 3 wetland well water surface elevations in 2019. Breaks in data indicated missing data or periods of groundwater equilibration.

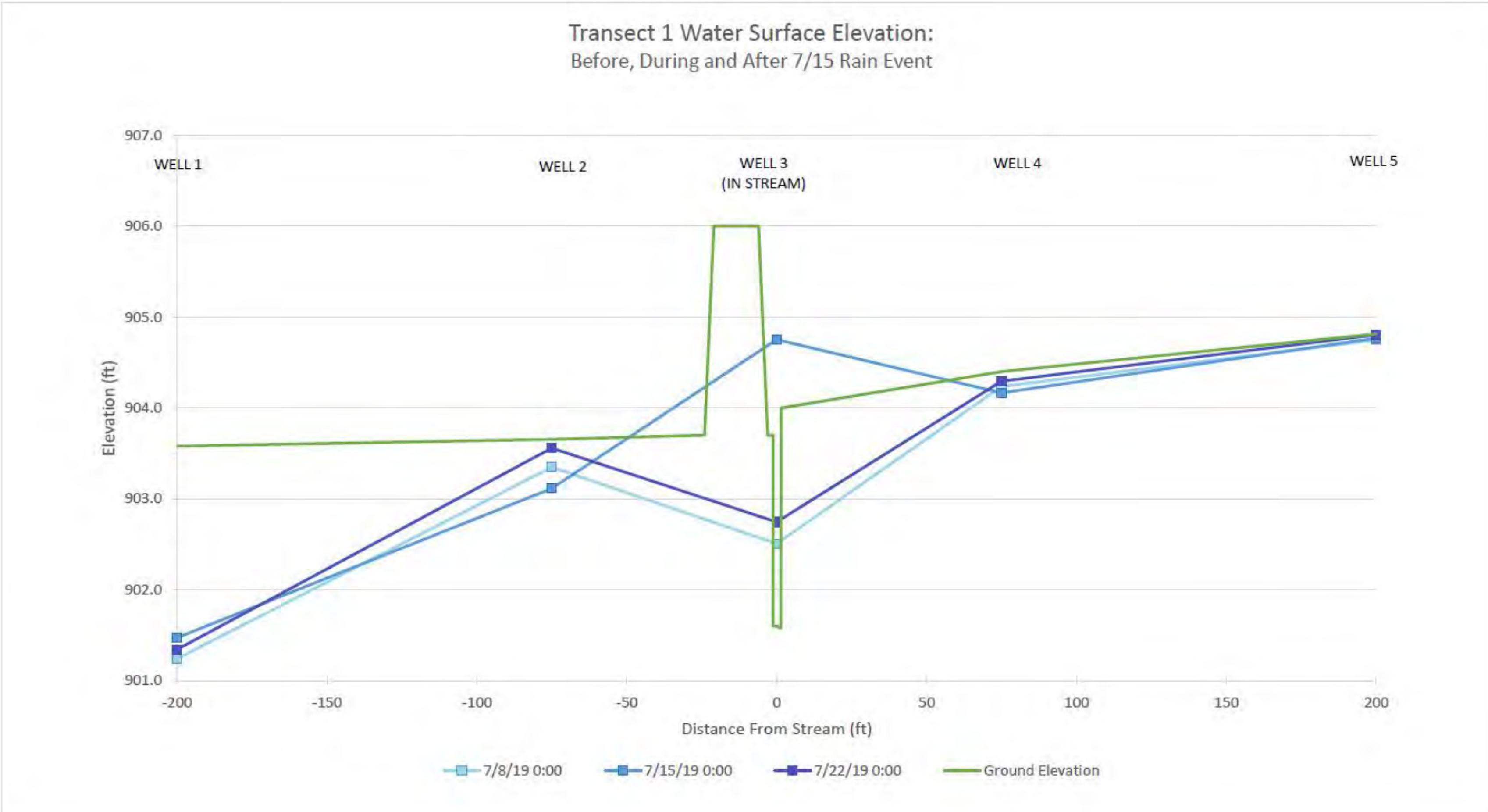


Figure 26. WJD 6 Transect 1 wetland well water surface elevations before, during, and after the July 15, 2019 rain event (left to right denotes west to east)

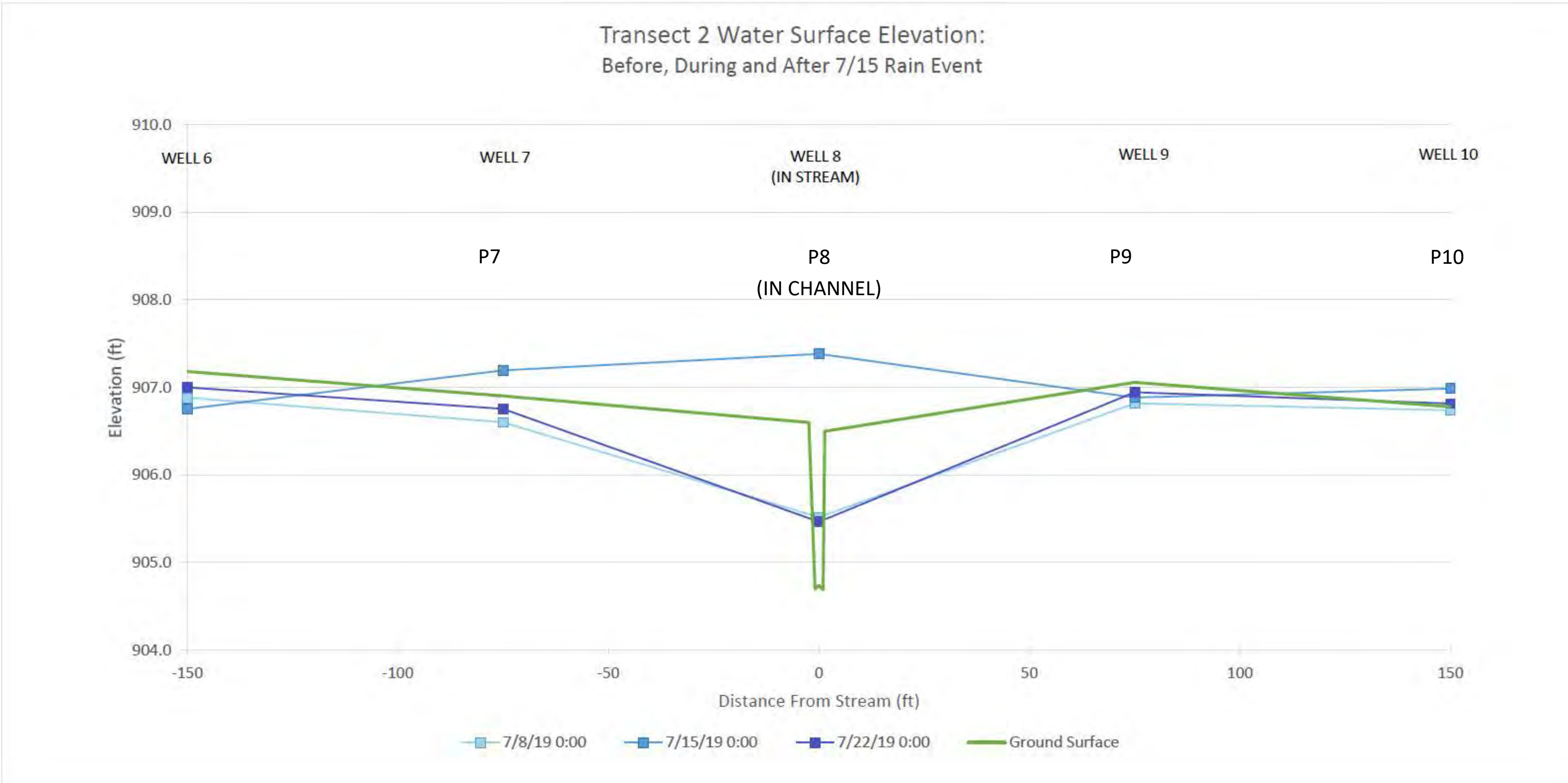


Figure 27. WJD 6 Transect 2 wetland well water surface elevations before, during, and after the July 15, 2019 rain event (left to right denotes west to east)

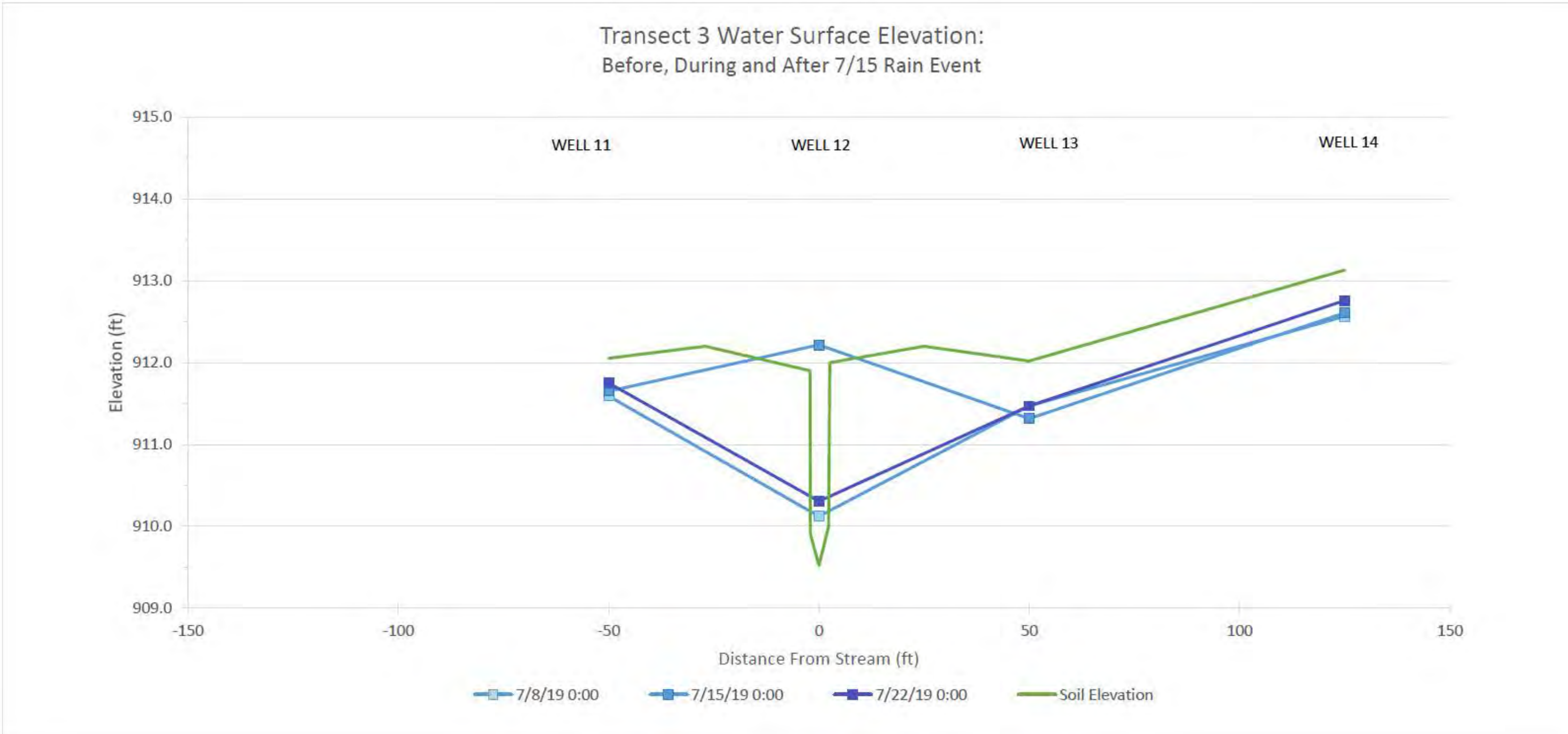
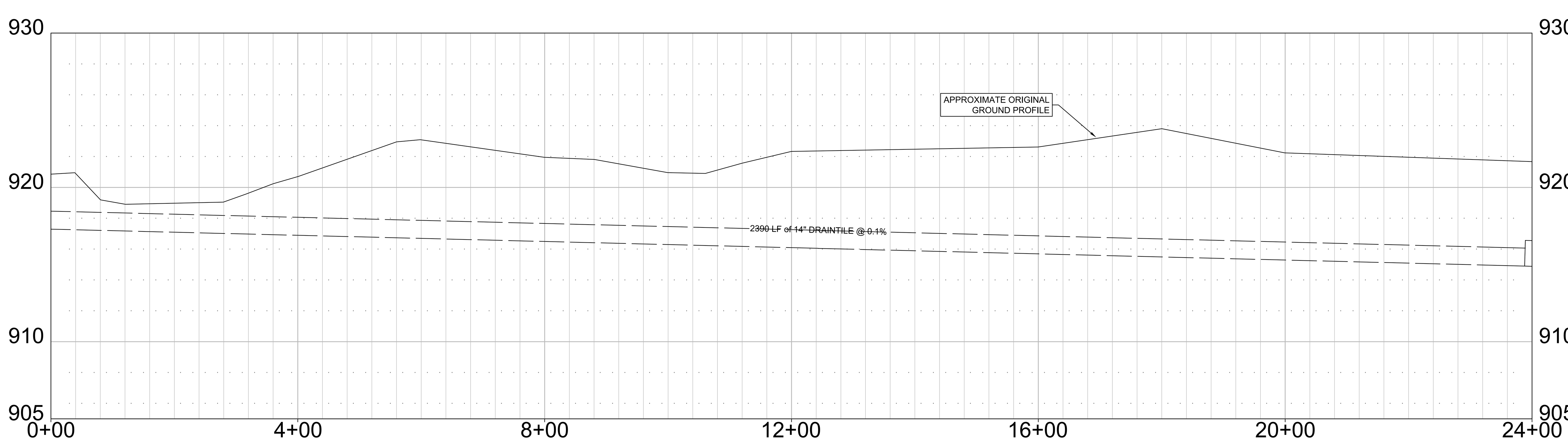


Figure 28. WJD 6 Transect 3 wetland well water surface elevations before, during, and after the July 15, 2019 rain event (left to right denotes west to east)

APPENDIX B. WJD 6 HISTORIC AND CURRENT PLAN AND PROFILE DRAWINGS



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SUBMISSION DATE: 04/30/2020

DESIGN BY KDC

DRAWN BY KDC

EOR PROJECT NO. 00376-0173

EOR water ecology community

Emmons & Olivier Resources, Inc.
1919 University Ave W
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www.eorinc.com

COMFORT LAKE - WATERSHED DISTRICT - FOREST LAKE

JD-6 DITCH ALIGNMENT
FOREST LAKE, WASHINGTON COUNTY, MINNESOTA

APPROXIMATE ORIGINAL JD-6 PROFILE
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STATE PROJECT NO. ---

CITY PROJECT NO. ---

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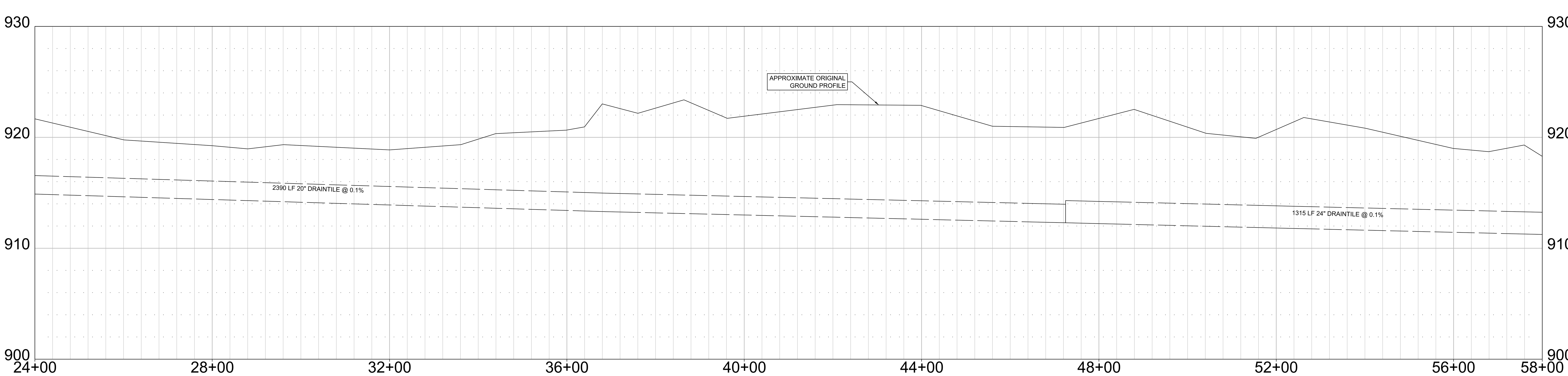

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DESIGN BY KDC | DRAWN BY KDC

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COMFORT LAKE ~ WATERSHED DISTRICT ~ FOREST LAKE

JD-6 DITCH ALIGNMENT
FOREST LAKE, WASHINGTON COUNTY, MINNESOTA

STATE PROJECT NO. --- | CITY PROJECT NO. ---

APPROXIMATE ORIGINAL JD-6 PROFILE
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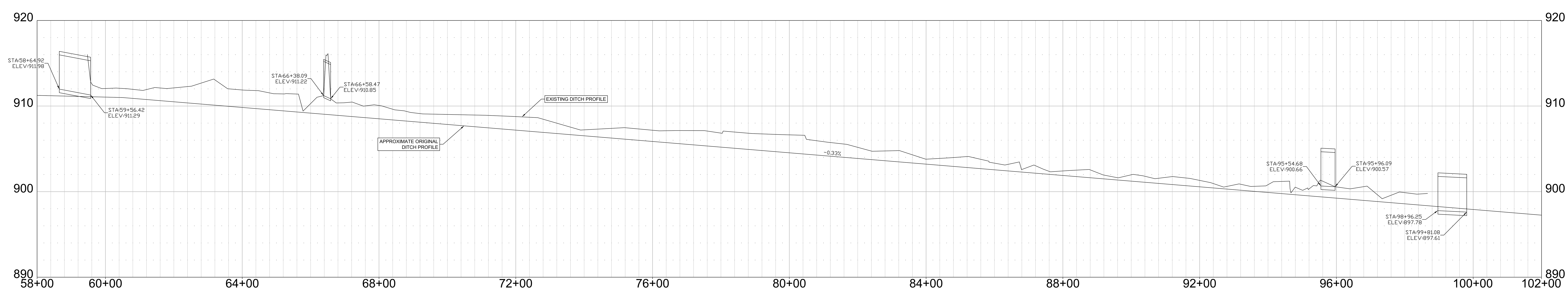
SHEET 02 OF 03 SHEETS



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SUBMISSION DATE: 04/30/2020

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PROFILE COMPARISON
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SHEET 03 OF 03 SHEETS

APPENDIX C. R7D SUPPLEMENTARY FIGURES

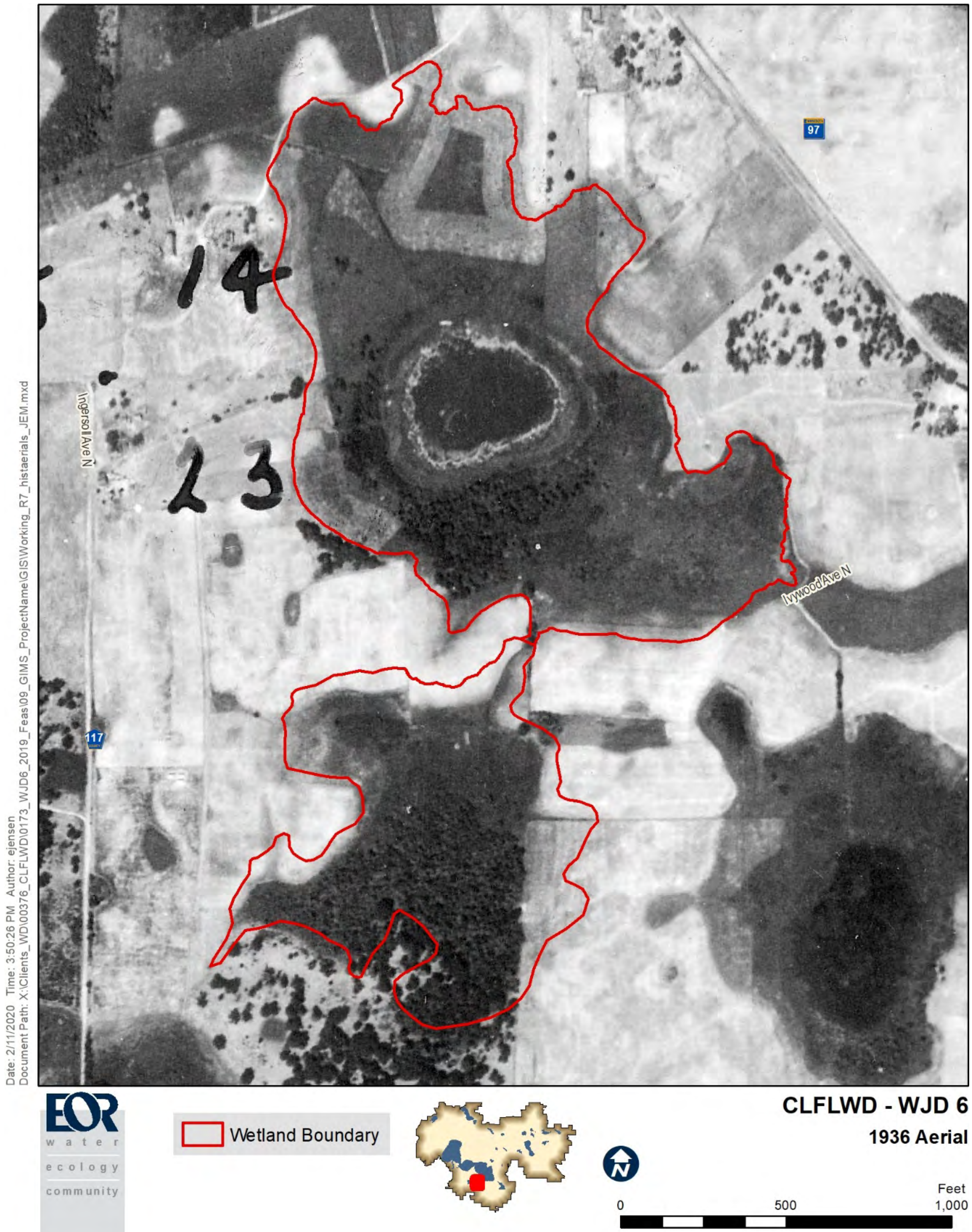

Figure 29. 1936 aerial image of R7D wetlands.

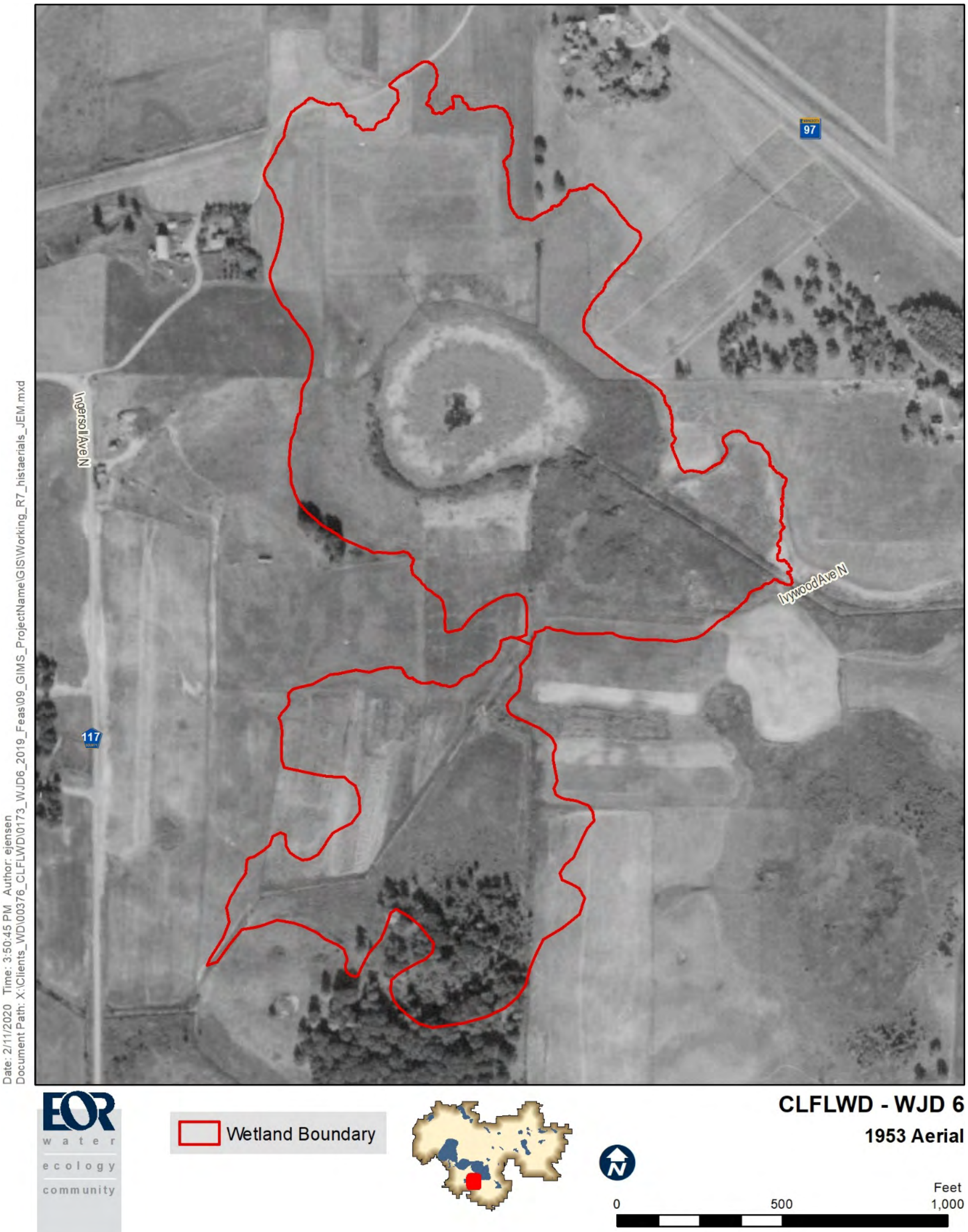

Figure 30. 1953 aerial image of R7D wetlands.

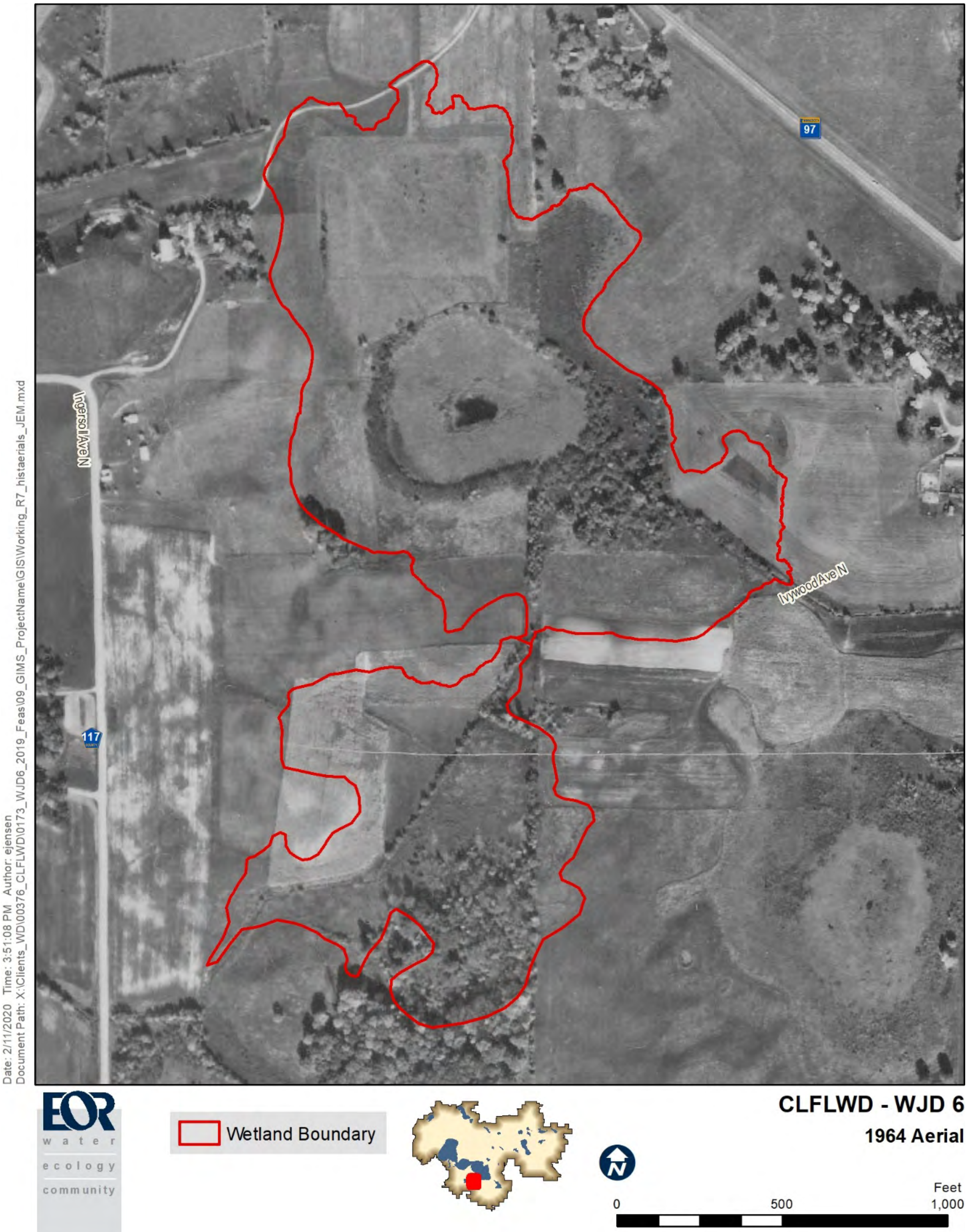

Figure 31. 1964 aerial image of R7D wetlands.

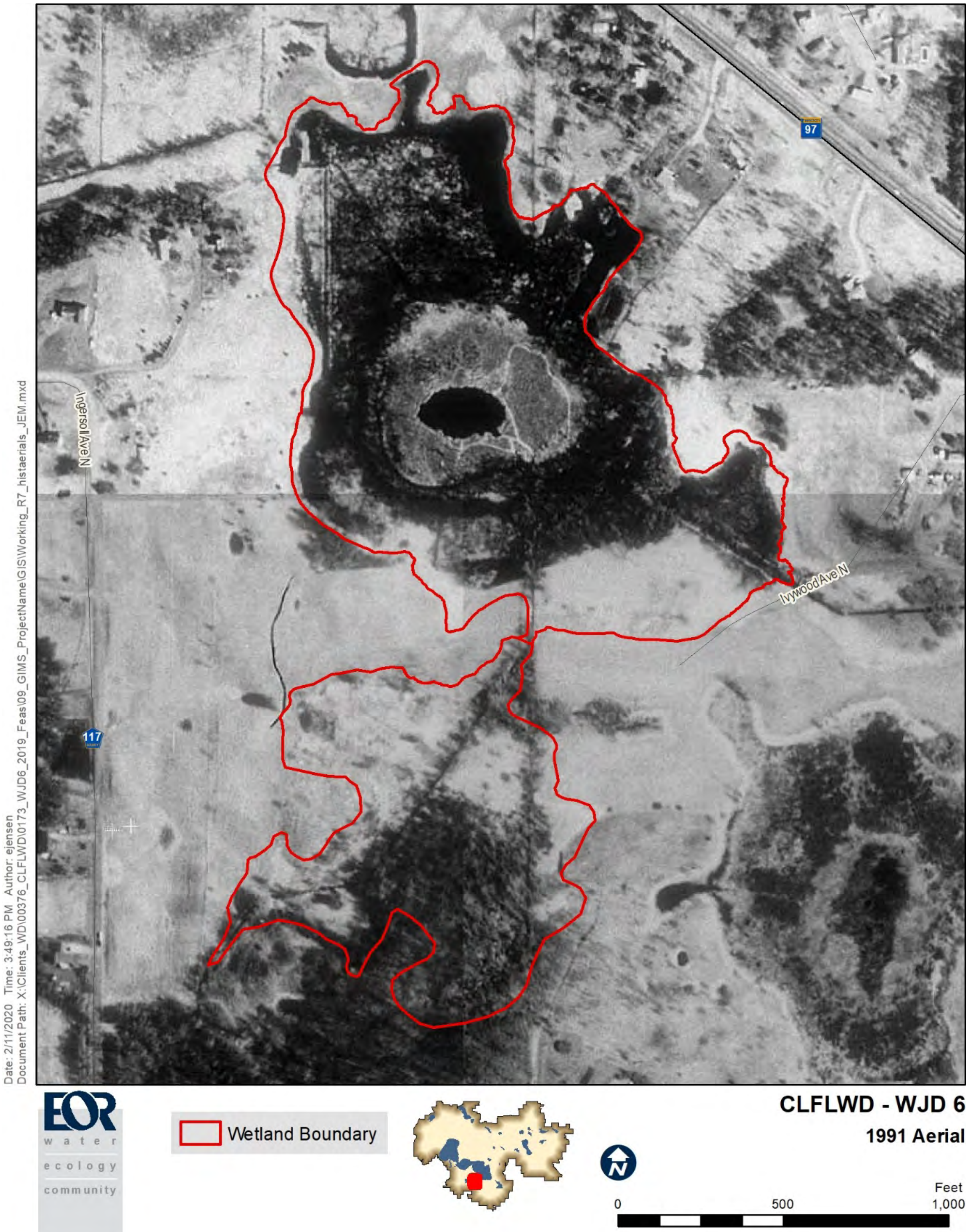

Figure 32. 1991 aerial image of R7D wetlands.

Figure 33. 1997 aerial image of R7D wetlands.

Figure 34. 2003 aerial image of R7D wetlands.

Figure 35. 2017 aerial image of R7D wetlands.

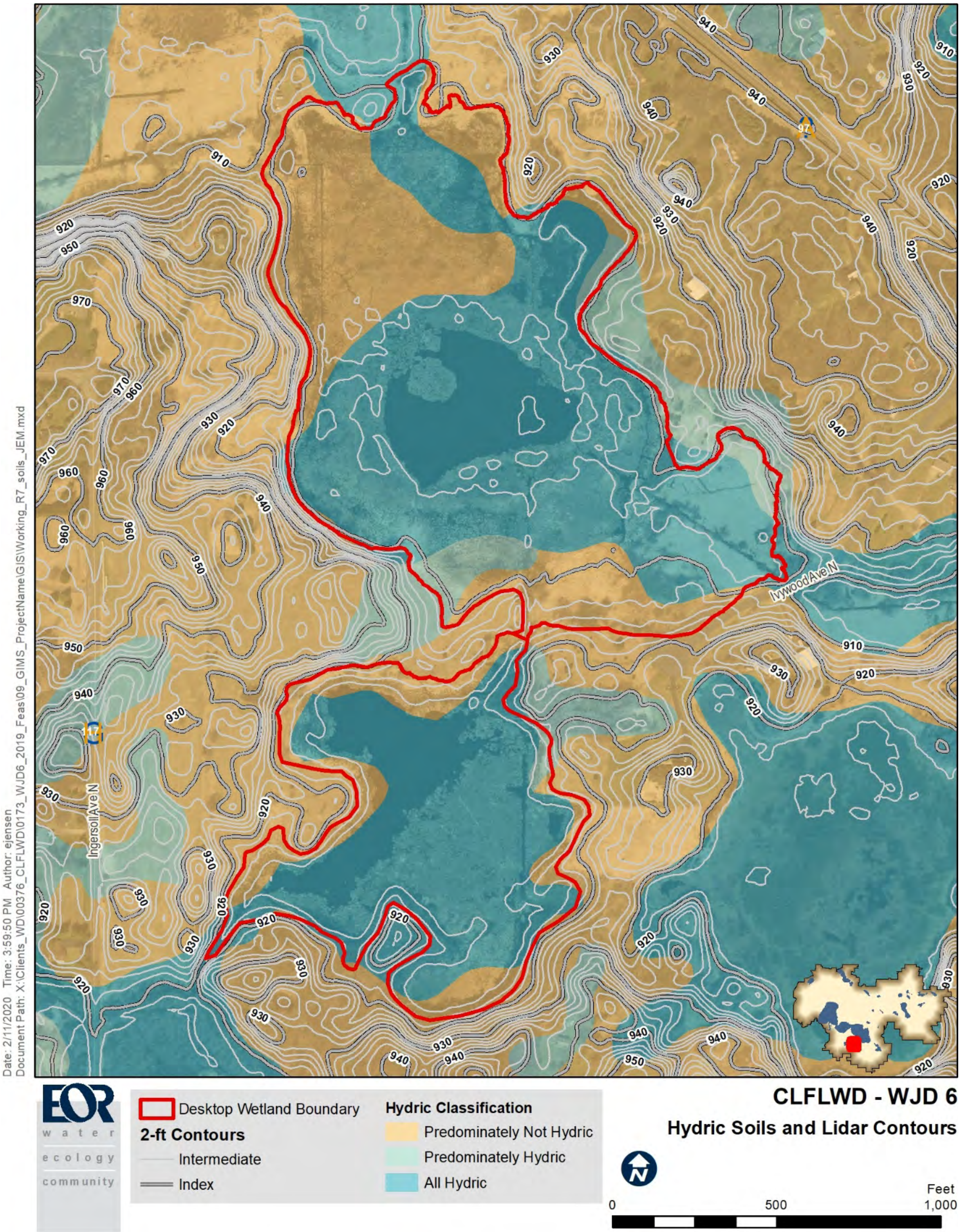

Figure 36. Hydric soils and 2-foot elevation contours of R7D wetlands and surrounding area.

APPENDIX D. R7D WETLAND WELL WATER SURFACE ELEVATION DATA

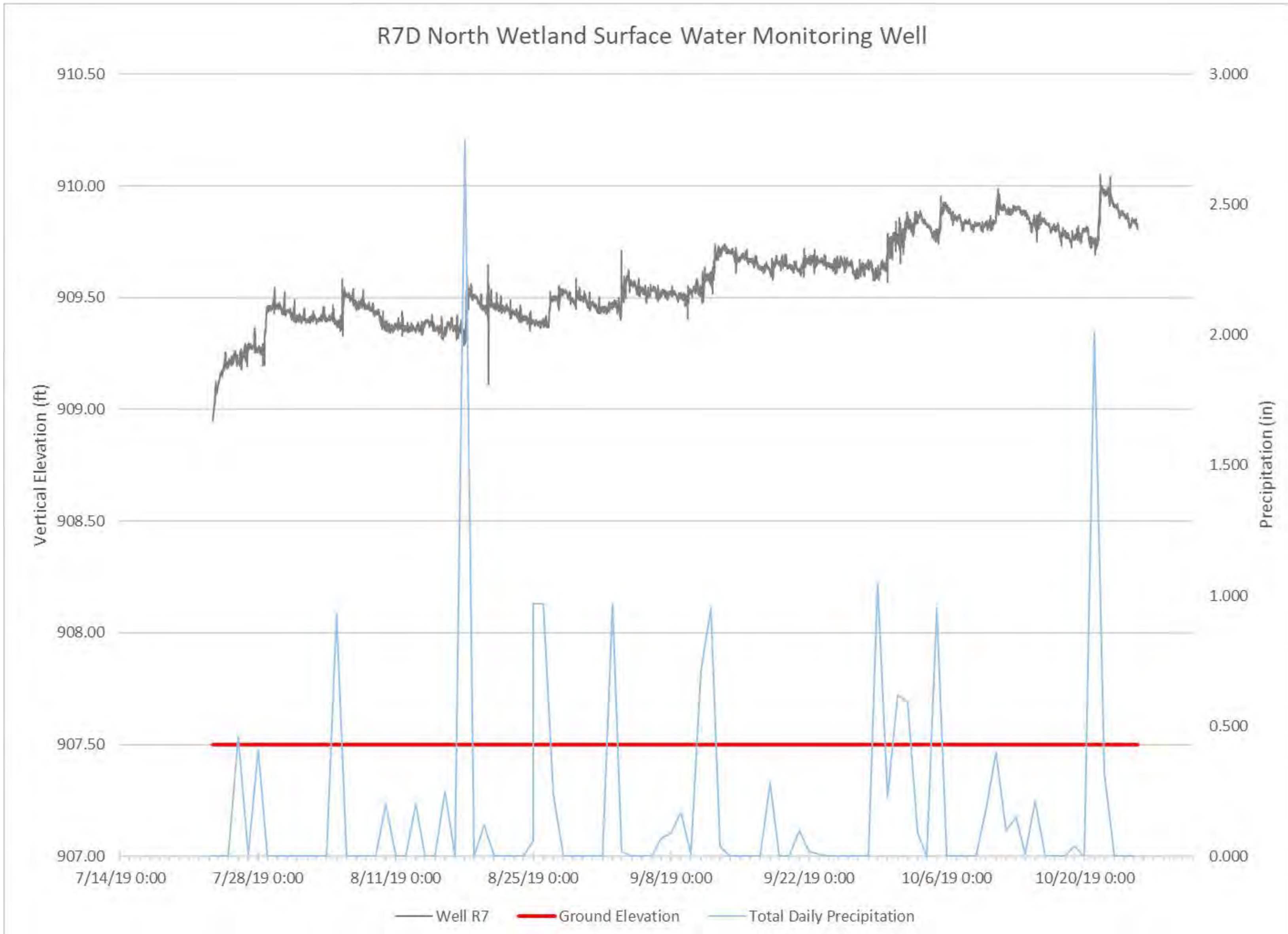

Figure 37. R7D North Wetland 2019 water level characteristics. Piezometer was located in the open water pond on the north end of the R7D north wetland.

APPENDIX E. CR-50 IESF DESIGN SCHEMATIC AND COST ESTIMATE

NO	DATE	BY	REVISION
6			
5			
4			
3			
2			
1			

SCALE IN FEET

0 50 100 200

SUBMISSION DATE: 08/19/2019

DESIGN BY KDC | DRAWN BY KDC

EOR PROJECT NO. 00376-0173

EOR water ecology community
Emmons & Olivier Resources, Inc.
7030 6th Street North
Oakdale, MN 55128
Tele: 651.770.8448
www.eorinc.com

COMFORT LAKE FOREST LAKE WATERSHED DISTRICT
44 LAKE STREET SOUTH
FOREST LAKE, MN 55025

JD-6 FEASIBILITY

FOREST LAKE, WASHINGTON COUNTY, MINNESOTA

STATE PROJECT NO. ---
CITY PROJECT NO. ---

JD-6 WATER QUALITY TREATMENT CONCEPT

SHEET 01 OF 01 SHEETS

Plot Date: 08/19/2019
Drawing name: X:\Clients_WD\00376_CLFLWD\0173_WJD6_2019_Feas\09_GIMS_ProjectName\dwg\JD-6 Ditch Aligment.dwg
Xrefs:, X-Base_Survey points

Item	MnDOT Reference #	Unit	Estimated	Estimated Unit Cost	Extended Cost
Mobilization	2021.501	LS	1.00	42,000.00	$ 42,000.00
Common Excavation	2105.507	CY	6,940.00	13.00	$ 90,220.00
Washed Sand (P)	2105.507	CY	600.00	40.00	$ 24,000.00
Washed Aggregate - River Run Pea Stone (P)	2105.507	CY	1,190.00	55.00	$ 65,450.00
IESF Mixture (Iron Filings - 5% by Weight)	2106.507	CY	1,780.00	120.00	$ 213,600.00
18" RCP Apron	2501.502	EA	2.00	1,000.00	$ 2,000.00
8" Perforated Dual Wall HDPE Draintile	2501.502	LF	1,595.00	16.00	$ 25,520.00
18" RCP Storm Sewer	2501.502	LF	200.00	85.00	$ 17,000.00
8" Dual Wall HDPE	2501.502	LF	190.00	30.00	$ 5,700.00
8" HPDE Cleanout w/ Grate Vent	2506.602	EA	9.00	550.00	$ 4,950.00
8" HDPE Cleanout w/ Threaded Cap	2506.602	EA	9.00	450.00	$ 4,050.00
8" Valterra Knife Gate Valve & 16" PVC Housing w/ Lid	2506.602	EA	4.50	2,200.00	$ 9,900.00
Pump Station (Manhole, Pump, Controls, etc.)	2506.602	EA	1.00	120,000.00	$ 120,000.00
Inlet Structure	2506.602	EA	1.00	10,000.00	$ 10,000.00
Pre-Treatment / Storage Vault	2506.602	EA	1.00	50,000.00	$ 50,000.00
EPDM Liner, 45 mil	2511.504	SY	3,970.00	15.00	$ 59,550.00
Electrical Service and Connection	2545.601	EA	1.00	15,000.00	$ 15,000.00
Stabilized Construction Exit	2573.501	EA	1.00	2,000.00	$ 2,000.00
9" Sediment Control Log Type Wood Fiber	2573.503	LF	730.00	4.25	$ 3,102.50
Standard Silt Fence	2573.503	LF	1,000.00	3.25	$ 3,250.00
Erosion Control Blanket, Cateogry 3N	2575.504	SY	4,000.00	2.25	$ 9,000.00
Seeding	2575.505	ACRE	1.50	3,500.00	$ 5,250.00
Construction Subtotal					**$ 781,542.50**
CONSTRUCTION CONTINGENCY				**30.00%**	**$ 234,462.75**
Construction Total					**$ 1,016,005.25**
ESTIMATED ACCURACY RANGE***			**-25.0%**		**$ 762,003.94**
			40.0%		**$ 1,422,407.35**

***This **feasibility-level (Class 5, 0 to 2% design completion per ASTM E 2516-06)** cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of completion of design, but are not included at this level of project definition. **The estimated accuracy range for the Total Project Cost as the project is defined is -10% to +20%.** The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. **The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.** Operation and Maintenance costs are not included.

PARAMETERS FOR ACCURACY RANGE

Estimate Class	LEVEL OF PROJECT DEFINITION (% ENGINEERING Complete)	ACCURACY RANGE
5	0% to 2%	-25% to +40%
4	1% to 15%	-15% to +25%
3	10% to 40%	-10% to +15%
2	30% to 70%	-7.5% to +7.5%
1	50% to 100%	-4% to +6.5%

PARAMETERS FOR CONSTRUCTION CONTINGENCY

PHASE OF PROJECT	PERCENTAGE ENGINEERING COMPLETED	APPLICABLE CONSTRUCTION CONTINGENCY PERCENTAGE (%)
FUNDING, SCOPE AND BUDGET	0 TO 5%	30.00%
SCHEMATIC DESIGN	5% TO 15%	25.00%
PRELIMINARY	15% TO 60%	20.00%
FINAL	60% TO 100%	10.00%
CONSTRUCTION	100%	5.00%
***THIS PROJECT PHASE		

APPENDIX F. WJD 6 WETLAND RESTORATION COST ESTIMATE

Item	MnDOT Reference #	Unit	Estimated	Estimated Unit Cost	Extended Cost
Mobilization	2021.501	LS	1.00	25,000.00	$ 25,000.00
Clearing	2101.505	ACRE	3.00	5,000.00	$ 15,000.00
Channel and Pond Excavation	2105.507	CY	15,000.00	15.00	$ 225,000.00
Storm Sewer, HDPE 18"	2501.502	LF	30.00	70.00	$ 2,100.00
Storm Sewer, HDPE 24"	2501.502	LF	70.00	80.00	$ 5,600.00
CMP Apron, 18"	2501.502	EA	2.00	1,000.00	$ 2,000.00
CMP Apron, 24"	2501.502	EA	2.00	1,500.00	$ 3,000.00
Agri-Drain Outlet Control Structure	2506.602	EA	2.00	6,500.00	$ 13,000.00
Geotextile Filter, Type ___	2511.504	SY	60.00	5.00	$ 300.00
Random Riprap, Class ___	2511.507	CY	20.00	125.00	$ 2,500.00
Traffic Control	2563.601	LS	1.00	10,000.00	$ 10,000.00
Temporary Erosion and Sediment Control	2573.501	LS	1.00	20,000.00	$ 20,000.00
Dewatering	2575.501	LS	1.00	10,000.00	$ 10,000.00
Hydraulic Bonded Fiber Matrix	2575.508	LB	7,000.00	2.00	$ 14,000.00
Seed, Mixture 34-171	2575.508	LB	10.00	200.00	$ 2,000.00
				Construction Subtotal	**$ 349,500.00**
			CONSTRUCTION CONTINGENCY	**30.00%**	**$ 104,850.00**
				Construction Total	**$ 454,350.00**
ESTIMATED ACCURACY RANGE***			**-25.0%**		**$ 340,762.50**
			40.0%		**$ 636,090.00**

***This **feasibility-level (Class 5, 0 to 2% design completion per ASTM E 2516-06)** cost estimate is based on feasibility-level designs, alignments, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. A construction schedule is not available at this time. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of completion of design, but are not included at this level of project definition. **The estimated accuracy range for the Total Project Cost as the project is defined is -10% to +20%.** The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. **The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency.** Operation and Maintenance costs are not included.

PARAMETERS FOR ACCURACY RANGE

Estimate Class	LEVEL OF PROJECT DEFINITION (% ENGINEERING Complete)	ACCURACY RANGE
5	0% to 2%	-25% to +40%
4	1% to 15%	-15% to +25%
3	10% to 40%	-10% to +15%
2	30% to 70%	-7.5% to +7.5%
1	50% to 100%	-4% to +6.5%

PARAMETERS FOR CONSTRUCTION CONTINGENCY

PHASE OF PROJECT	PERCENTAGE ENGINEERING COMPLETED	APPLICABLE CONSTRUCTION CONTINGENCY PERCENTAGE (%)
FUNDING, SCOPE AND BUDGET	0 TO 5%	30.00%
SCHEMATIC DESIGN	5% TO 15%	25.00%
PRELIMINARY	15% TO 60%	20.00%
FINAL	60% TO 100%	10.00%
CONSTRUCTION	100%	5.00%
***THIS PROJECT PHASE		