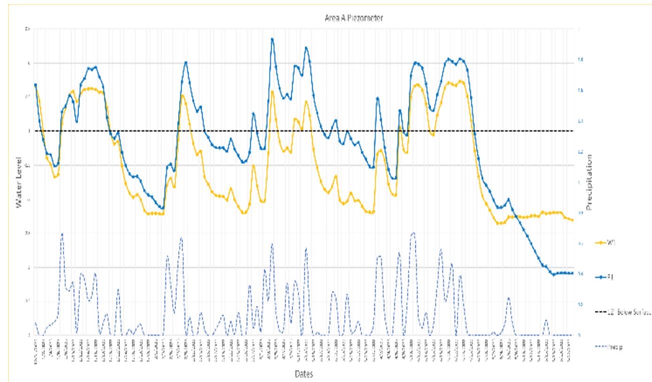
BODENHAMER PROPERTY

CITY OF TUMWATER, WASHINGTON

ADVANCED STUDIES REPORT



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EnviroVector
OPTIMIZE USABLE LAND

14 June 2023

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1.0 INTRODUCTION

1.1 Project Location

The subject property is located in the City of Tumwater, Thurston County WA (**Figure 1; Table 1**).

Table 1. Subject Property

No#	Address	Parcel Number	Map Coordinates	Area
1	3717 49TH AVE SW	12832310700	Section 32 Township 18 Range 2W	50.01
2	3825 58TH LN SW	12832310800		5.00
2 Parcels	Total Size			55.01 acres

The permitting jurisdiction is the City of Tumwater.

1.2 Property Description

The subject property consists of a large (55.01-acre) pasture containing a dense population of livestock (**Figure 1, Table 1, Appendix A, Photos 15-22**). Trampling by large herbivores can cause soil compaction, altering soil permeability and infiltration rates and affecting the plant community (USACE 2010, P 103). Livestock wallow in cool moist soils during hot summer days, which can further compact and alter soils, hydrology, and vegetation through trampling, grazing, and dropping large quantities of manure.

Patches of soft rush (*Juncus effusus*, FACW) and slender rush (*Juncus tenuis*, FAC) with some limited slough sedge (*Carex obnupta*, OBL) occur in livestock wallows on the southern portion of the subject property (**Appendix A, Photos 24, 31, 32, 38, & 42**). However, no hydric soils were identified in these areas and no hydrology was identified during the growing season using the routine onsite determination method. These areas did not satisfy all three (3) criteria (*i.e.*, hydric soils, hydrophytic vegetation, and wetland hydrology) for a wetland determination. Hydric soils and hydrology were not satisfied under the routine on-site determination method.

Although the patches of rushes did not satisfy the hydric soils or wetland hydrology criteria using the routine on-site determination method, High Groundwater Hazard Areas and wetlands have been mapped in these areas by several governmental Agencies, warranting a higher level of evaluation (**Appendices B, C, D, E, & F**).

Generally, soils on the southern portion of the subject property consist of very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3) sandy silt throughout. Soils appear to be consistent within or outside of the patches of rushes. Soil conditions on the southern portion of the subject property generally do not satisfy the hydric soils criteria.

No consistent hydrology indicators were identified on the southern portion of the subject property, including within the patches of rushes, using the routine on-site determination method. Although winter water was detectable in some areas, no water was identified in test pits during the growing season, which did not satisfy the hydrology criterion.

Secondary hydrology indicators were also explored, such as Geomorphic Position (D2) (*i.e., concave depression*) and FAC-Neutral Test (D5). The geomorphic positions at the rush patches are generally flat. A couple of the patches exhibit very slight concave depressions that are difficult to detect by visual observations. However, slight depressions are not exclusive to these areas, the entire southern portion of the subject property contains similar slightly uneven landscape, which is common in active pastures.

Although the FAC-Neutral test was satisfied in some patches of rushes, the test was not satisfied in other patches of rushes, exhibiting a majority of FACU species, including sweet vernal grass (*Anthoxanthum odoratum*, FACU), hairy cat's ear (*Hypochaeris radicata*, FACU), common plantain (*Plantago lancelata*, FACU), and dandelion (*Taraxacum officinale*), over one (1) or two (2) species wetter than FAC. The required two (2) secondary indicators were not satisfied.

Vegetation on the southern portion of the subject property primarily consists of a managed plant community of European pasture grasses and associated non-native forb species typically found in pastures or lawns. The vegetation community is managed to optimize livestock grazing. Areas of rushes are intermixed with European pasture species and non-native forbs. No native plant communities occur on the southern portion of the subject property.

Soils on the southern portion of the subject property have been altered through decades of intensive agricultural practices. Livestock causes soil compaction, altering soil permeability and infiltration rates and affecting the plant community (USACE 2010, P 103). Massive volumes of manure alter the soil chemistry, color, and texture and affect plant composition. Winter water may pond in livestock wallows. Water may follow the path of cattle trails, which can be seen clearly from aerial photographs.

Hydrology on the southern portion of the subject property has been altered from natural conditions. Historical agricultural ditches, labeled Ditch A & Ditch B, remain functional on the southern portion of the subject property (**Figure 2; Appendix A, Photo 66**). The agricultural ditches convey excess winter water from the southern portion of the subject property to Wetland A, delineated by EnviroVector on the northern portion of the subject property (**Figures 2** & **Figure 3**). Ditch A bisects the central portion of the subject property from the eastern fence line to the western property boundary. Ditch B drains from south to north along the southern portion of the western property boundary. This water is piped from the confluence of the two (2) ditches northward along the western property line to Wetland A. Contours suggest that the historical drainage from the southern portion of the subject property flowed westward toward Black Lake.

This long-term alteration of vegetation, soils, and hydrology creates an "atypical" or "difficult" situation as described by the USACE (2010) Regional Supplement.

1.3 Study Summary

The "Routine On-site Determination Method" was applied in areas of normal conditions to identify and delineate wetlands. In difficult areas, advanced wetland methods were applied to provide additional information to assist in the wetland determination. These advanced methods were applied as required when evaluating difficult situations under Chapter 5 of the U.S. Army Corps of Engineers (USACE) (2010) *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0).*

The southern portion of the subject property contains difficult areas that trigger the need for the difficult situation methodology of Chapter 5 of the U.S. Army Corps of Engineers (USACE) (2010) Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0).

The determination of hydric soils, hydrophytic vegetation, or wetland hydrology is in question in patches of soft rush (FACW) and slender rush (FAC). Some areas that satisfy the vegetation criterion, have not satisfied the hydric soil or wetland hydrology criteria. Advanced studies methodologies have been applied in these areas.

Six (6) Study Areas, labeled Study Areas A-F, were established where difficult conditions have been identified (**Figure 4**). The advanced study period was implemented from 31 December 2022 to 23 May 2023. The study period extended for the duration of the wettest part of the growing season.

Seventeen (17) shallow groundwater monitoring wells were installed in difficult areas to determine whether groundwater levels satisfy the US Army Corps of Engineers (USACE) wetland hydrology standard as outlined in Chapter 5 of the USACE (2010) Regional Supplement (**Figure 4**).

Three (3) piezometers were installed within three (3) of the study areas, especially Study Areas A-C (**Figure 4**). Each of the piezometers were paired with a shallow monitoring well to determine the water level response, including whether hydrology in difficult areas is affected by an aquitard or perched aquifer. This pairing of a shallow wells with piezometers also determines whether hydrostatic pressure is pushing up groundwater from below or whether groundwater from precipitation is rapidly draining.

The Redox Test was performed to determine if soils within the Study Areas are functioning as hydric soils. A positive result applying alpha alpha dipyridyl to soils is a primary indicator of hydrology and an indicator of hydric soils. These two (2) additional tests are a supplement to the hydrology study that are in compliance with USACE wetland identification procedures within Chapter 5 of the USACE (2010) Regional Supplement.

1.5 Advanced Study Justification and Procedures

Wetland identification procedures provided in USACE (2010) Chapters 2-4 are always applied prior to advancing to advanced methodologies of Chapter 5. If procedures in Chapters 2-4 are inconclusive as the result of a difficult situation, procedures from Chapter 5 should be applied for the determination of wetlands. Or if indicators are absent in a suspected wetland, Chapter 5 provides advanced procedures to compensate for missing indicators in suspected wetlands.

1.5.1 Difficult Vegetation Methodology of USACE (2010) Regional Supplement Chapter 5

Problematic hydrophytic vegetation can be identified and delineated using a combination of observations made in the field and/or supplemental information from the scientific literature and other sources. These procedures should be applied where indicators of hydric soil and wetland hydrology are present, unless one (1) or both (2) of these factors are also disturbed or problematic, but no indicators of hydrophytic vegetation are evident. **Table 2** provides the procedural steps necessary to apply the correct methodology for a specific difficult situation considering site conditions (USACE 2010, P 99).

Table 2. Chapter 5---*Procedures for Problematic Vegetation*

<table>
<tr><th rowspan="2">Steps</th><th rowspan="2">Description</th><th colspan="2">Decision</th><th rowspan="2">Actions</th></tr>
<tr><th>Yes</th><th>No</th></tr>
<tr><td rowspan="3">Step 1</td><td>1a. One (1) primary indicator of hydric soils</td><td>Go to Step 2</td><td>Go to Step 1b</td><td>No</td></tr>
<tr><td>1b. One (1) primary indicator or two (2) secondary indicators of hydrology o</td><td>Go to Step 2</td><td>Go to Step 1c</td><td>No</td></tr>
<tr><td>1c. Indicators of hydric soils and/or hydrology are disturbed or problematic.</td><td>Go to Step 2</td><td>Not Hydrophytic</td><td>Yes</td></tr>
<tr><td>Step 2</td><td>Landscape Position likely to hold water:
a. Concave Surface
b Active flood plain or low terrace
c. Relatively Flat 0-3% slope
d. Tow of Slope or Convergent Slopes
e. Wetland fringe
f. Restrictive layer or aquitard w/in 24 in
g. Seeps
h. Other (Explain)</td><td>Go to Step 3</td><td>Not Hydrophytic</td><td>(c) relatively flat

Go to Step 3</td></tr>
<tr><td>Step 3</td><td>Use one or more of the approaches to determine whether the vegetation is hydrophytic described in:

* Step 4 (Specific Problematic Vegetation Situations below) or

* Step 5 (General Approaches to Problematic Hydrophytic Vegetation on page 108).</td><td colspan="2">Go to Step 4</td><td>Go to Steps 4 or 5</td></tr>
<tr><td rowspan="8">Step 4

Specific Problematic Vegetation Situations</td><td>a. Temporal Problematic Vegetation Situations</td><td rowspan="8">If yes to one of the Items under Step 4:

Use that specific procedure to determine hydrophytic vegetation.</td><td rowspan="8">If no to all, or none apply:

Go to Step 5</td><td rowspan="8">Apply Procedures

(d) areas affected by grazing

(e) Managed Plant Community</td></tr>
<tr><td>b. Sparse and Patchy Vegetation</td></tr>
<tr><td>c. Riparian Areas</td></tr>
<tr><td>d. Areas Affected by Grazing</td></tr>
<tr><td>e. Managed Plant Communities</td></tr>
<tr><td>f. Aggressive Invasive Plants</td></tr>
<tr><td>g. Areas Created by Fires, Floods, and other natural Disturbances</td></tr>
<tr><td>h. Vigor and Stress Responses to Wetland Conditions</td></tr>
<tr><td rowspan="3">Step 5

General Approaches to Problematic Vegetation</td><td>a. Direct Hydrologic Observations
1. Inundation or saturation
2. Hydrology Monitoring</td><td rowspan="3">If yes to one of the Items under Step 5:

Use that specific procedure to determine hydrophytic vegetation.</td><td rowspan="3">If no to all:

No Hydrophytic Vegetation.</td><td rowspan="3">No comparable reference sites

Apply Hydrologic Monitoring</td></tr>
<tr><td>b. Reference Sites</td></tr>
<tr><td>c. Technical Literature</td></tr>
</table>

1.5.1.1 Areas Affected by Grazing (Page 103 of USACE 2010, Step 4 Procedure d)

Short- and long-term grazing can cause shifts in dominant species in the vegetation. Grazers can influence the abundance of plant species in several ways. For example, trampling by large herbivores can cause soil compaction, altering soil permeability and infiltration rates and affecting the plant community. Grazers can also influence the abundance of plant species by selectively grazing certain species or avoiding other species. Shifts in species composition due to grazing can influence a hydrophytic vegetation determination.

Be aware that shifts in both directions, favoring either wetland species or non-wetland species, can occur in these situations. Limited grazing does not necessarily affect the outcome of a hydrophytic vegetation decision. However, the following approaches are recommended in cases where the hydrophytic vegetation determination would be unreliable or misleading due to the effects of grazing (**Table 3**).

1.5.1.1 Managed Plant Community (Step 4 Procedure e)

Many natural plant communities throughout the region have been altered and are managed to meet human goals. Examples include clearing of woody vegetation on rangelands, periodic disking or plowing, planting of native and nonnative species, irrigation of pastures and hayfields, suppression of wildfires, and the use of herbicides. These actions can result in elimination of certain species and their replacement with other species, changes in abundance of certain plants, and shifts in dominant species, possibly influencing a hydrophytic vegetation determination. The following approaches are recommended if the natural vegetation has been altered through management to such an extent that a hydrophytic vegetation determination may be unreliable (**Table 4**).

1.5.2 Difficult Soils Methodology of USACE (2010) Regional Supplement Chapter 5

Some wetlands can be difficult to identify because wetland indicators may be missing due to natural processes or disturbances. This procedure should be used where indicators of hydrophytic vegetation and wetland hydrology are present or are absent due to disturbance or other problem situations, but indicators of hydric soil are not evident (USACE 2010, P112 under Procedure) (**Table 5**).

Table 3. Areas Affected by Grazing Procedure

Procedures	Results	Description of Results
(1) Examine the vegetation on a nearby, ungrazed reference site having similar soils and hydrologic conditions. Ungrazed areas may be present on adjacent properties or in fenced exclosures or streamside management zones. Assume that the same plant community would exist on the grazed site, in the absence of grazing.	No	No ungrazed reference sites available that are not single-family developments
(2) If feasible, remove livestock or fence representative livestock exclusion areas to allow the vegetation time to recover from grazing, and reevaluate the vegetation during the next growing season.	No	Not practical
(3) If grazing was initiated recently, use offsite data sources such as aerial photography, NWI maps, and interviews with the landowner and other persons familiar with the area to determine the plant community present on the site before grazing began. If the previously ungrazed community was hydrophytic, then consider the current vegetation to be hydrophytic.	No	Grazing has occurred for many years, perhaps decades. Historical aerial photographs show no change in landscape conditions since at least 1990
(4) If an appropriate ungrazed area cannot be located or if the ungrazed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soils and wetland hydrology.	Indeterminate	Apply other methods
Results	Discussion	
Indeterminate	Will apply another methods	

Table 4. Managed Plant Community Procedure

Step	Procedure	Results	Description of Result
Step 1	Examine the vegetation on a nearby, unmanaged reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the managed site, in the absence of human alteration.	No	No reference site available
Step 2	For recently cleared or tilled areas (not planted or seeded), leave representative areas unmanaged for at least one growing season with normal rainfall and reevaluate the vegetation.	No	Not applicable
Step 3	If management was initiated recently, use offsite data sources such as aerial photography, NWI maps, and interviews with the landowner and other persons familiar with the area to determine what plant community was present on the site before the management occurred.	No	Managed plant community has occurred for many years, perhaps decades. Historical aerial photographs show no change in landscape conditions since at least 1990
Step 4	If the unmanaged vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.	Indeterminate	Apply other methods
Results		Discussion	
Indeterminate		Will apply another methods	

Table 5. USACE (2010) Regional Supplement for Difficult Hydric Soils

Procedures	Description for Difficult Hydric Soils	Actions: Yes	Actions: No	Procedures Taken
Step 1	Verify that one or more indicators of hydrophytic vegetation are present or that the vegetation is disturbed or problematic.	Go to Step 2	Relict Hydric Soil (Not a Wetland)	**Vegetation is problematic** **Go to Step 2**
Step 2	Verify that at least one (1) primary or two (2) secondary indicators of wetland hydrology are present or that indicators are absent due to disturbance or other factors.	Go to Step 3	Relict Hydric Soil (Not a Wetland)	**Other factors** **Go to Step 3**
Step 3	Verify that the area is in a landscape position that is likely to collect or concentrate water. a. Concave surface (e.g., depression or swale) b. Active floodplain or low terrace c. Level or nearly level area (e.g., 0- to 3-percent slope) d. Toe slope or an area of convergent slopes e. Fringe of another wetland or water body f. Area with a restrictive soil layer or aquitard within 24 in. (60 cm) of the surface g. Area where groundwater discharges (e.g., a seep) h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)	Go to Step 4	Relict Hydric Soil (Not a Wetland)	**(c) Nearly flat** **Go to Step 4**
Step 4 Use one or more of the following Approaches (NRCS Tech Note 11)	a. Indicator A10, TFs, or TF12	Hydric	Relict Hydric Soil (Not a Wetland)	**Apply** **d. Alpha, alpha-dipyridyl.** **e. Groundwater monitoring** & **e. NTCHS** **b. Oxidation-Reduction Potential (Eh) (Redox Test)** **c. Alpha, alpha-dipyridyl.**
	b. One or More of the Following Present: (1) Moderately to Very Strongly Alkaline Soils (LRR E) (2) Volcanic Ash or Diatomaceous Earth (3) Vegetated Sand and Gravel Bars within Floodplains (4) Dark Parent Materials (5) Recently Developed Wetlands (6) Seasonally Ponded Soils (7) Other (in field notes, describe the problematic soil situation and explain why it is believed that the soil meets the hydric soil definition)			
	c. A mineral layer 4 in. (10 cm) or more thick starting within 12 in. (30 cm) of the soil surface that has a matrix value of 4 or more and chroma of 2 or less becomes redder by one or more pages in hue and/or increases one or more in chroma when exposed to air within 30 minutes.			
	d. Alpha, alpha-dipyridyl. Apply to mineral soil material in at least 60 percent of a layer at least 4 in. (10 cm) thick within a depth of 12 in. (30 cm) of the soil surface results in a positive reaction within 30 seconds evidenced by a pink or red coloration to the reagent during the growing season.			
	e. Groundwater Monitoring or NTCHS. water table is 12 in. (30 cm) or less from the surface, for 14 or more consecutive days during the growing season in most years (at least 5 years in 10, or 50 percent or higher probability) (U.S. Army Corps of Engineers 2005). Or, any soil that meets the NTCHS hydric soil technical standard (NRCS Hydric Soils Technical Note 11): a. Indicator of Reduction in Soils (IRIS) tubes b. Oxidation-Reduction Potential (Eh) c. Alpha, alpha-dipyridyl			

1.5.3 Difficult Hydrology Methodology (USACE 2010 Page 116)

This section describes a number of approaches that can be used to determine whether wetland hydrology is present on sites where indicators of hydrophytic vegetation and hydric soil are present, but hydrology indicators may be lacking due to normal variations in rainfall or runoff, human activities that destroy hydrology indicators, and other factors (**Table 6**).

Table 6. USACE (2010) Regional Supplement for Difficult Hydrology

Procedures	Description for Difficult Hydrology	Action		Procedures Taken
		Yes	No	
Step 1	Verify that indicators of hydrophytic vegetation and hydric soil are present, or are absent due to disturbance or other problem situations. If so, proceed to step 2.	Go to Step 2	No Wetland Hydrology	**Problem Situation** **Go to Step 2**
Step 2	Verify that the area is in a landscape position that is likely to collect or concentrate water. Appropriate settings are listed below. If the landscape setting is appropriate, proceed to step 3. a. Concave surface (e.g., depression or swale) b. Active floodplain or low terrace c. Level or nearly level area (e.g., 0- to 3-percent slope) d. Toe slope or an area of convergent slopes e. Fringe of another wetland or water body f. Area with a restrictive soil layer or aquitard within 24 in. (60 cm) of the surface g. Area where groundwater discharges (e.g., a seep) h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)	Go to Step 3	No Wetland Hydrology	**c. level or nearly level** **Go to Step 3**
Step 3	Use one or more of the following approaches to determine whether wetland hydrology is present and the site is a wetland. In the remarks section of the data form or in the delineation report, explain the rationale for concluding that wetland hydrology is present even though indicators of wetland hydrology described in Chapter 4 were not observed. a. Site visits during the dry season. b. Periods with below-normal rainfall. c. Drought years. d. Years with unusually low winter snowpack. e. Reference sites. f. Hydrology tools. (1) Analyze stream and lake gauge data (2) Estimate runoff volumes to determine duration and frequency of ponding in depressional areas (3) Evaluate the frequency of wetness signatures on aerial photography (4) Model water-table fluctuations in fields with parallel drainage systems using the DRAINMOD model (5) Estimate the "scope and effect" of ditches or subsurface drain lines (6) Estimate the effectiveness of agricultural drainage systems using NRCS state drainage guides (7) Analyze data from groundwater Monitoring wells (Procedure h) g. Evaluating multiple years of aerial photography. h. Long-term hydrologic monitoring.	Wetland Hydrology Present	No wetland hydrology	**a.-e. does not apply** **Apply f(7) and h for long term hydrologic monitoring**

2.0 METHODOLOGY

2.1 Study Outline Overview

Study procedures include:

- Detailed Vegetation Study

  Chapter 5 of the USACE (2010) Regional Supplement Page 108 & 109 (Procedure 5a) provides a general approach to problematic hydrophytic vegetation through verifying that the plant community occurs in an area subject to prolonged inundation or soil saturation during the growing season. These procedures are applied where indicators of hydric soil and wetland hydrology are present or difficult but indicators of hydrophytic vegetation are not evident. Where indicators of hydrophytic vegetation are absent due to disturbance or are difficult, hydrophytic vegetation is considered to be present if the water table is twelve (12) inches (30 cm) or less from the surface for fourteen (14) or more consecutive days during the growing season five (5) years of ten (10). This would be accomplished through our hydrology study in those specific areas.

- Detailed Soil Study

  A detailed soil study was performed based on procedures outlined in the USACE (2010) Regional Supplement for areas of difficult soil where indicators of vegetation and/or hydrology are difficult or absent.

  Soils were excavated using a hand powered mud auger with a two (2) inch diameter bucket, which would minimize any additional soil disturbance. Soil features typically associated with wetlands, such as hydric soils, mottling, a restrictive layer or aquitard, sand lenses, or other features were recorded.

  In disturbed areas, hydric soil indicators may have been obscured. Procedures outlined in Section 3 below will determine if difficult or disturbed soils are functioning as wetland soils. Even if hydric soil indicators are absent or obscured, these procedures will aid in a definitive determination.

- Direct Hydrology Monitoring

  Collected and analyzed groundwater data from groundwater monitoring wells during the wettest portion of the growing season. Water level dataloggers were installed to automate the data collection process. Readings of the groundwater table were collected hourly. This hourly data collection was analyzed to determine if the USACE wetland hydrology stand has been satisfied.

2.2 Wetland Hydrology

2.2.1 Wetland Hydrology Procedural Considerations

Wetland hydrology indicators are used in combination with indicators of hydric soil and hydrophytic vegetation to determine whether an area is defined as a wetland under the USACE (2010) Regional Supplement. Wetland hydrology indicators provide evidence for determining wetland hydrology and are part of the wetland determination. Wetland hydrology indicators provide evidence to determine if an episode of inundation or soil saturation occurred recently.

Page 66 of the USACE (2010) Regional Supplement states that "on highly disturbed or problematic sites, direct hydrologic monitoring may be needed to determine whether wetland hydrology is present." The USACE WRAP (2005) provides a technical standard for monitoring hydrology on such sites. "This standard requires fourteen (14) or more consecutive days of flooding or ponding, or a water table twelve (12) inches (30 cm) or less below the soil surface, during the growing season at a minimum frequency of five (5) years in ten (10) (fifty percent [50%] or higher probability)."

Chapter 5 of the USACE (2010) Regional Supplement provides further information on hydrology studies using groundwater monitoring wells. The USACE WRAP (2005) provides technical standards and detailed specifications for performing groundwater monitoring studies.

The USACE WRAP (2005) is a technical note that describes national standards for the collection, analysis, interpretation, and reporting of hydrologic data, which may be used to help determine whether wetlands are present on disturbed or problematic sites that may be subject to Clean Water Act regulatory jurisdiction.

Some wetlands can be difficult to identify because wetland indicators may be missing due to recent or ongoing disturbances. Chapter 5 of the USACE (2010) Regional Supplement provides guidance for making wetland determinations in difficult to identify wetland situations in the Western Mountains, Valleys, and Coast Region. Chapter 5 includes regional examples of 'atypical' situations as defined in the Corps Manual, as well as other situations that can make wetland delineation more challenging. 'Atypical' situations are wetlands in which vegetation, soil, or hydrology indicators are absent due to recent human activities or natural events.

Human activities have created an 'atypical' situation on the subject property. Thereby procedures in Chapter 5 of the USACE (2010) regional supplement are recommended in the determination of wetland indicators. Vegetation and/or soil indicators are absent in areas on the subject property as a result of this human activity. Chapter 5 of the USACE (2010) Regional Supplement provides field procedures for quantifying the extent of wetlands in areas where wetlands and non-wetlands are recently disturbed.

Chapter 5 of the USACE (2010) Regional Supplement states that "wetland determinations on difficult or problematic sites must be based on the best information available to the field inspector, interpreted in light of his or her professional experience and knowledge of the ecology of wetlands in the region." The project researcher has twenty-five (25) years of experience administrating atypical situations methodologies in difficult areas in the region.

Chapter 5 of the USACE (2010) Regional Supplement describes a number of approaches that can be used to determine whether wetland hydrology is present on sites where hydrology indicators may be lacking due to human activities, or other factors, that alter hydrology indicators.

The procedures that apply specifically to the subject property include:

- Procedure f---*Hydrology tools*
    - (7) Analyze data from groundwater monitoring wells (see item h below for additional information)
- Procedure h---*Long-term hydrologic monitoring.*

The USACE (2010) Regional Supplement provides step-wise procedures to evaluate and delineate potential wetlands.

2.2.2 Well Installation and Specifications (WRAP 2005)

Procedures and specifications of the hydrology monitoring study will follow the USACE Wetlands Regulatory Assistance Program (WRAP) (June 2005) *Technical Standards for Water Table Monitoring of Potential Wetland Sites*. WRAP 2005 provides the technical standards for the installation, analysis, interpretation, and monitoring of data. The hydrology monitoring study methodology is based on this guidance document and on twenty-five (25) years of experience in performing hydrology monitoring studies. Specifications of the monitoring wells are provided in **Insert 1** and **Table 7**. The locations of the installed monitoring wells are found in **Figure 2**.

Insert 1. Shallow groundwater monitoring well and piezometer installation methodology

ERDC TN-WRAP-00-02
July 2000

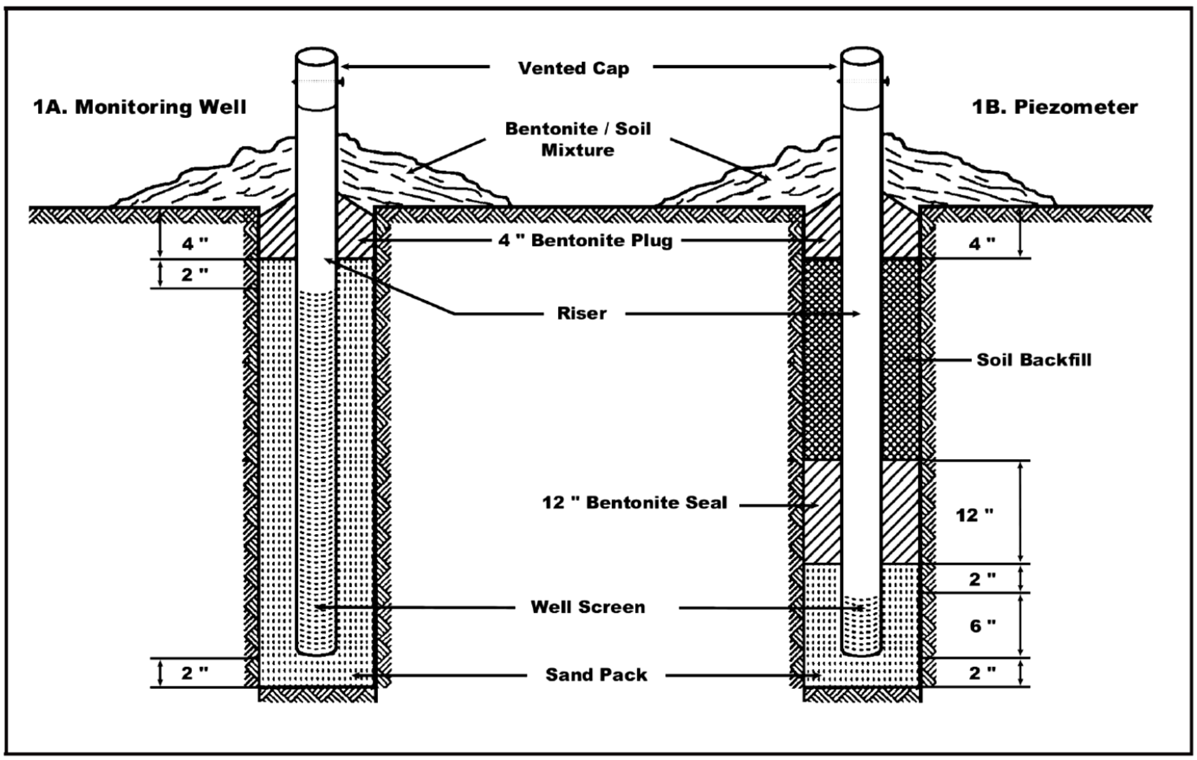


Figure 1. Schematic diagram of installed monitoring well and piezometer. A. Shallow monitoring well. B. Piezometer

Table 7. Specifications of Monitoring Wells

Wells	Types of Wells	Depth	Diameter	Slots	Between slots	Well Placement	Data Collection
Well 1	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area A	Hourly Data Logging
Well 2	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 3	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 4	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area B	Hourly Data Logging
Well 5	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 6	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 7	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area C	Hourly Data Logging
Well 8	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 9	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 10	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area D	Hourly Data Logging
Well 11	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 12	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 13	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area E	Hourly Data Logging
Well 14	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 15	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”	Study Area F	Hourly Data Logging
Well 16	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
Well 17	Shallow Monitoring Well	24-30”	2”	0.010”	0.125”		Hourly Data Logging
P-1	Piezometer	48”	2”	0.010”	0.125”	Study Area A	Hourly Data Logging
P-2	Piezometer	48”	2”	0.010”	0.125”	Study Area B	Hourly Data Logging
P-3	Piezometer	48”	2”	0.010”	0.125”	Study Area C	Hourly Data Logging

2.2.3 Data Loggers

Water level dataloggers were installed in monitoring wells and piezometers in order to record continuous water levels every hour from during the study period. The non-vented HOBO U20 water level logger was installed to collect water data and a HOBO U20L water level logger was used to collect barometric compensation data (**Insert 2**).

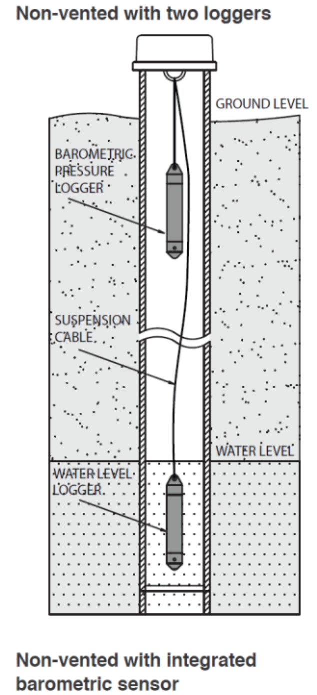
HOBOware software converts these pressure readings to barometrically-corrected water level values. A simple software function performs the mathematics.

Insert 2

Data Loggers

HOBO U20 water level logger for recording water pressure and temperature.

HOBO U20L water level logger for recording barometric pressure.



2.3 Hydrophytic Vegetation

Procedures in Chapter 5 outline steps to determine if hydrophytic vegetation is present in areas. Procedure 5a on page 108 of the USACE (2010) Regional Supplement provides a procedure for problematic hydrophytic vegetation that verifies the criterion for hydrophytic vegetation through direct hydrology observations during the growing season using monitoring wells. Hydrophytic vegetation is considered to be present if surface water is present and/or the water table is twelve (12) inches (30 cm) or less from the surface for fourteen (14) or more consecutive days during the growing season during a period when antecedent precipitation has been normal or drier than normal. The proposed groundwater study has recorded hourly groundwater levels during the wettest port of the growing season at a time of normal precipitation. If the wetland hydrology standard is satisfied, wetland vegetation can be assumed under this procedure.

2.4 Detailed Soil Study

The study evaluated soils to identify hydric soil indicators on the subject property. Soil evaluation utilizes the latest soil analysis procedures outlined in the USACE (2010) Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0). Procedures for faint or no soil indicators are listed in **Table 8**.

Natural Resources Conservation Service (NRCS) Hydric Soils Technical Note 11---*Hydric Soils Technical Standard and Data Submission Requirements for Field Indicators of Hydric Soils* describe the use of alpha, alpha-dipyridyl and shallow groundwater monitoring as quantitative methods to determine if a soil meets the definition of a hydric soil.

Table 8. Procedures for soils with Faint or No Indicators

#	Procedures	Description	Comments
1	Soils Survey	NRCS Soil Survey evaluation and analysis of mapped soil unit and inclusions	Applied, inconclusive
2	Indicators of Hydric Soils.	Document primary and secondary indicators listed in the Corps Regional Supplement for normal, sandy and problem soils. This includes evaluating soil color using the Munsell Color Chart.	Applied, inconclusive
3	Test for Moderately to Very Strongly Alkaline Soils	Test for PH of soils in order to determine if the soils are high alkaline, which may not readily form redox conditions.	No alanine soils in study area. (tested PH)
4	Volcanic Ash or Diatomaceous Earth.	Test for Volcanic Ash or Diatomaceous Earth, which does not readily exhibit hydric soil indicators.	None identified
5	Dark Parent Materials	Evaluate for soils that naturally have dark parent materials that are not hydric soils.	Soils are consistent throughout southern portion of property
6	Seasonally Ponded Soils	Some of these wetlands lack hydric soil indicators due to limited saturation depth, saline conditions, or other factors.	Does not apply
7	Alpha, Alpha-dipyridyl	If the soil is saturated at the time of sampling, alpha, alpha-dipyridyl reagent can be used in the following procedure to determine if reduced (ferrous) iron is present. If ferrous iron is present, then the soil is functioning as a wetland soil.	Applied technique

2.5 Alpha, Alpha Dipyridyl

It is important to consider the purpose of the Chemical Test and what exactly is the chemical testing. Alpha alpha dipyridyl solution is used to confirm the presence of ferrous ($Fe2+$) iron in soils. If the solution turns from clear to red when applied to soil, it indicates the soil is reduced and anaerobic (anoxic) at the time of application. Redox concentrations and depletions are hydric soils indicators that are formed in anoxic soils as a result of redox reactions. Organics accumulate in anoxic soils where the lack of oxygen slows decomposition. When soils are saturated, soil bacteria use up the oxygen and the soils become anoxic. Ferrous iron is released in anoxic soils. If anoxic, soils are functioning as wetland soils and are considered hydric and are not relic hydric soils. Therefore, the chemical is testing for whether the soils are currently functioning as hydric soils.

Natural Resources Conservation Service (NRCS) Hydric Soils Technical Note 11---*Hydric Soils Technical Standard and Data Submission Requirements for Field Indicators of Hydric Soils* describe the use of alpha, alpha-dipyridyl and shallow groundwater monitoring as quantitative methods to determine if a soil meets the definition of a hydric soil.

Soil Procedure (d) on P114 of the USACE (2010) Regional Supplement states that "if the soil is saturated at the time of sampling, alpha, alpha-dipyridyl reagent can be used in the following procedure to determine if reduced (ferrous) iron is present. If reduced (ferrous) iron is present, the soil is functioning as a wetland soil. Soils were chemically tested to determine if reduced (ferrous) iron is present at test plots based on sampling procedures outlined in the USACE (2010) Regional Supplement and in the Natural Resources Conservation Service (NRCS) Technical Notes 8 and 11. NRCS Technical Notes 8 and 11 provide specific procedures for applying the chemical alpha, alpha-dipyridyl to determine if reduced (ferrous) iron is present in soil samples as a wetland indicator. If samples test negative, additional procedures will be applied to strengthen scientific rigor in the determination of hydric soils.

Step 4(d) of the procedures in the USACE (2010) regional supplement tests for relic hydric soils through the chemical application of alpha alpha dipyridyl, which tests whether the soil currently functions as a hydric soil. This procedure is used when wetland plants and hydrology are present or difficult, but indicators of hydric soils are absent or equivocal. To avoid false positives or false negatives, tests were not performed in highly disturbed soils; rather, tests were performed in relatively undisturbed soils within the indicated Study Areas (**Figure 4**).

2.6 Redox Test

The USACE (2010) Regional Supplement, Page 125, states that "any soil that meets the NTCHS Hydric Soil Technical Standard (NRCS Hydric Soils Technical Note 11, http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html) is hydric."

NRCS Hydric Soils Technical Note 11---*Hydric Soils Technical Standard and Data Submission Requirements for Field Indicators of Hydric Soils* describes the use of oxidation-reduction potential (ORP) as a quantitative method to determine if a soil meets the definition of a hydric soil.

Measurements of soil oxidation-reduction potential (ORP) require applying a platinum (Pt) electrode within surface soil layers. Platinum electrode measurements must be anaerobic in order for a soil to meet the anaerobic conditions requirement of the Hydric Soil Technical Standard.

A Hanna Instruments Professional Waterproof Portable pH/ORP Meter Model HI98190 and a platinum wire electrode/reference probe combination was used to collect the data from two (2) samples at each test location. One (1) sample was tested at six (6) to eight (8) inches below the surface, while another (2^{nd}) sample was tested at eight (8) to twelve (12) inches below the surface. The meter also recorded temperature and pH measurements.

The slope of the Eh-pH diagram lines is based on both theoretical (*e.g.,* Nernst equation) and experimental values from scientific literature (Bohn 1985; Vepraskas and Faulkner 2001; Masscheleyn 1990). The NTCHS has established a corrected Eh-pH line with a y-intercept of 595 and slope of 60 [Eh = 595-60(pH). Thereby, the slope function y=mx+b when y=Eh, m=-60, x=pH, and b=595 would be Eh=-60(pH)+595. The Eh value changes with a different pH value. Samples taken with an Oxidation-reduction potential (ORP) value greater than the Eh would be non-anaerobic and not function as a wetland soil and a value less than the Eh would be anaerobic and, thereby, function as a wetland soil.

3.0 BACKGROUND INFORMATION

3.1 Average Precipitation During Study (WETS Tables)

A summary of the National Oceanic and Atmospheric Administration (NOAA) Climate Analysis for Wetlands Table, also known as the WETS Table, shows normal precipitation for the duration of the well monitoring period and three (3) months prior (**Table 9**). However, individual months during the study period fluctuated with some being higher or slightly lower than the range of normal precipitation. Normal precipitation is defined as the range of thirty percent (30%) greater or less than the average precipitation. The month of April, at the beginning of the growing season, exhibited abnormally high levels of precipitation, which was 2.57 inches above the normal range.

Groundwater levels typically stage during winter months. Normal precipitation during the study period would have contributed to normal groundwater staging and representative groundwater levels during the monitoring period. However, abnormally high precipitation levels during the month of April would have caused higher than normal water levels in the monitoring wells during that month and some duration thereafter, which creates a potential False Positive result. A False Negative is unlikely considering this abnormally high precipitation in April and normal staging of groundwater during the study period (**Table 9**).

Table 9. WETS Summary Table

Month	WETS Average[1]	WETS 30% Chance will have[1]		Total Precip.[2]	Deviation from +\- 30%	Normal Precipitation
		Less Than	More Than			
September 2022	2.03	0.88	2.33	0.15	-0.73	**Abnormally Low**
October 2022	4.19	2.42	5.09	3.35	Normal	**Normal**
November 2022	8.13	5.58	9.69	8.3	Normal	**Normal**
December 2022	7.89	5.76	9.28	8.79	Normal	**Normal**
January 2023	7.54	4.76	9.1	4.36	-0.4	**Abnormally Low**
February 2023	6.17	3.92	7.44	3.49	-0.43	**Abnormally Low**
March 2023	5.29	3.91	6.2	4.33	Normal	**Normal**
April 2023	3.58	2.53	4.24	6.81	2.57	**Abnormally High**
May 2023	2.27	1.41	2.74	0.59	-0.82	**Abnormally Low**
Entire study period and 3 months prior		**31.17**	**56.11**	**40.17**	**Normal**	**Normal**

1. WETS Station: TACOMA NO. 1, WA
2. Weather Underground Station KWATACOM151 at East D Street & E 91st Street, Larchmont
2. Weather Underground Station KWATACOM9 at 126th Street E & 78th Avenue E, Puyallup

3.2 Growing Season

The growing season is an important component in the definition of wetland hydrology. The USACE provides a procedure to approximate the growing season. Growing season dates may be approximated by using WETS tables available from the NRCS National Water and Climate Center to determine the median dates of twenty-eight degrees Fahrenheit (28 °F) (−2.2 °C) air temperatures in spring and fall based on long-term records gathered at the nearest appropriate National Weather Service meteorological station (**Insert 3**).

The WETS table approximates the growing season at a nearby weather station located at the Port of Olympia Airport as April 15th through October 27th with fifty (50) percent probability (**Insert 4**). According to the WETS table, the growing season totals one hundred ninety-five days (195) days.

The hydrology study was performed during the wettest part of the growing season and extended through the winter months. In addition, normal precipitation occurred during the study, making a false negative unlikely.

Insert 3. Approximation of Growing Season (USACE Regional Supplement Page 133)

"In the Western Mountains, Valleys, and Coast Region, growing season dates are determined through onsite observations of the following indicators of biological activity in a given year:

(1) above-ground growth and development of vascular plants, and/or
(2) soil temperature (see Chapter 4 for details). (**Insert 5**)
(3) If onsite data gathering is not practical, growing season dates may be approximated by using WETS tables available from the NRCS National Water and Climate Center to determine the median dates of 28 °F (−2.2 °C) air temperatures in spring and fall based on long-term records gathered at the nearest appropriate National Weather Service meteorological station." (**Insert 4**)

Insert 4. NRCS Climatological Tables to Estimate Growing Season

The growing season is defined for wetland hydrology on the basis of soil temperatures, which in turn are estimated based on NRCS reports of 50 percent likelihood of last and first 28° F frost. These dates are available in NRCS soil survey reports, but more current dates are available in the WETS Tables (below). This procedure is also outlined in the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0)

WETS Station: OLYMPIA AP, WA Requested years: 1971 - 2000	
GROWING SEASON DATES	
Years with missing data:	28 deg = 0
Years with no occurrence:	28 deg = 0
Data years used:	28 deg = 30
Probability	28 F or higher
50 percent *	4/15 to 10/27: 195 days
* Percent chance of the growing season occurring between the Beginning and Ending dates.	

Procedure 2 in Chapter 4 on Page 68, states that the growing season has begun when soil temperature measured at the twelve (12) inches (30-cm) depth is forty-one degrees (41°) F (5 °C) or higher (**Insert 3**). Procedure 2 on page 133 (Insert 2) refers to Procedure 2 on Page 68 (**Insert 5**).

Insert 5. Approximation of Growing Season (USACE Regional Supplement Chapter 4 Page 68)

"The growing season has begun in spring, and is still in progress, when soil temperature measured at 12-inches (30-cm) depth is 41 °F (5 °C) or higher. A one-time temperature measurement during a single site visit is sufficient, but is not required unless growing season information is necessary to evaluate particular wetland hydrology indicators. However, if long-term hydrologic monitoring is planned, then soil temperature should also be monitored to ensure that it remains continuously at or above 41° F during the monitoring period. Soil temperature can be measured directly in the field by immediately inserting a soil thermometer into the wall of a freshly dug soil pit."

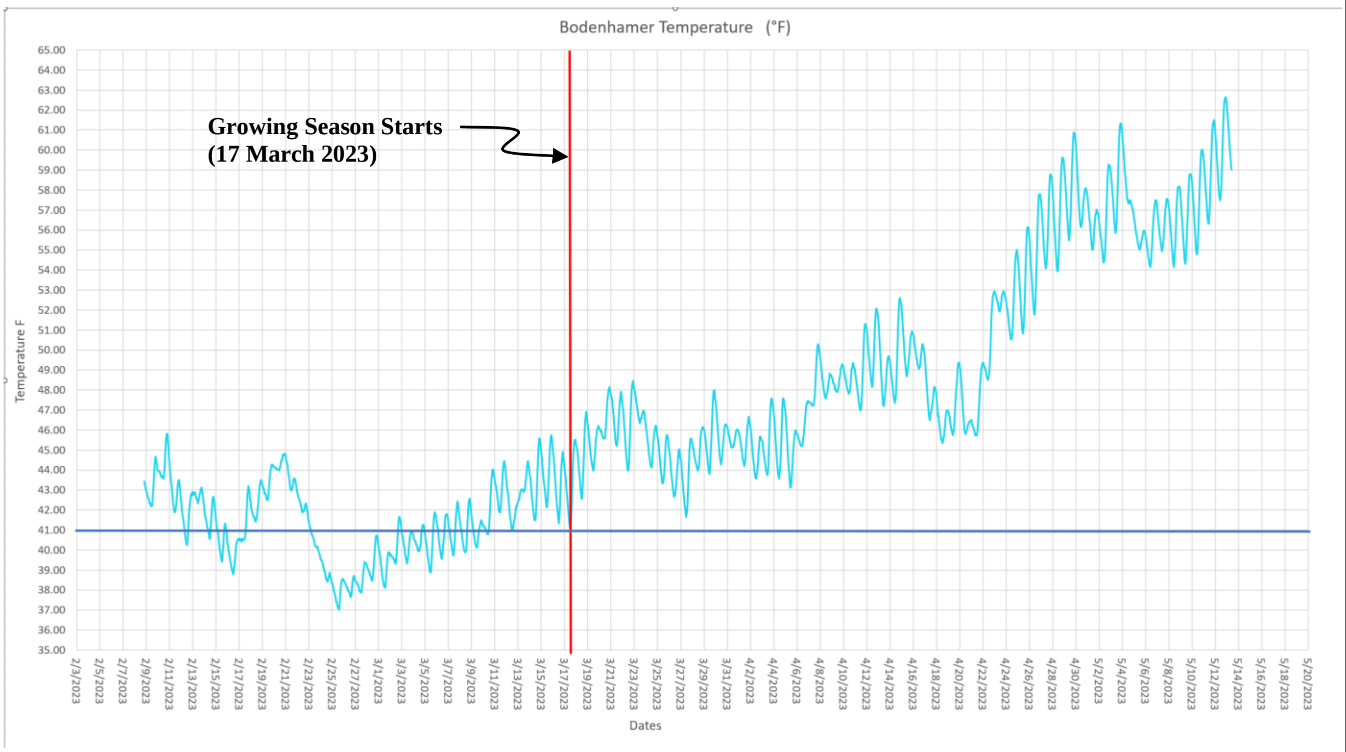
A one-time temperature measurement during a single site visit is sufficient but is not required unless growing season information is necessary to evaluate particular wetland hydrology indicators. However, if long-term hydrologic monitoring is planned, then soil temperature should also be monitored to ensure that it remains continuously at or above forty-one degrees (41°) F during the monitoring period.

Soil temperature can be measured directly in the field by immediately inserting a soil thermometer into the wall of a freshly dug soil pit. However, to ensure capturing the moment the growing season begins at the greatest possible accuracy, two (2) soil temperature data loggers were installed at W1 & W10 to record soil temperatures every hour at twelve (12) inches below the soil surface during the study. Using this information, the exact hour the growing season began during the study period was determined.

According to the dataloggers, the soil temperature remained above forty-one degrees (41°) F on 17 March 2023, and the soil temperature did not decrease below forty-one degrees (41°) F during the remainder of the study period (**Insert 6**). Thereby, the growing season at the subject property began on 17 March 2023.

In conclusion, the WETS table approximates the growing season based on historical patterns, while direct soil temperature readings using a soil temperature datalogger pinpoints the beginning of the growing season for the particular year of the study. Thereby, direct temperature readings using the soil temperature datalogger has been applied in this study.

Insert 6. Bodenhamer Soil Temperature Measurements



3.3 Reliability Alpha, Alpha-dipyridyl

Soil Procedure (d) on Page 114 of the USACE (2010) Regional Supplement states that if the soil is saturated at the time of sampling, alpha, alpha-dipyridyl reagent can be used in the following procedure to determine if reduced (ferrous) iron is present. If reduced (ferrous) iron is present, the soil is functioning as a wetland soil. Soils have been chemically tested to determine if reduced (ferrous) iron is present at test plots based on sampling procedures outlined in the USACE (2010) Regional Supplement and in the NRCS Technical Notes 8 and 11. NRCS Technical Notes 8 and 11 provide specific procedures for applying the chemical alpha, alpha-dipyridyl to determine if reduced (ferrous) iron is present in soil samples as a wetland indicator. If samples test negative, additional procedures will be applied to strengthen scientific rigor in the determination of hydric soils.

The reliability of the testing increases with the minimization of False Negatives or False Positives. The criteria used to define factors that are likely to cause potential False Positives or False Negatives when applying Alpha, Alpha-dipyridyl derive from four (4) sources that include:

1. USACE (2010) Regional Supplement
2. USDA NRCS Technical Note 8
3. USDA NRCS Technical Note 11
4. Richardson & Vepraskas (2011) Wetland Soils: Genesis, Hydrology, Landscapes, and Classification.

Alpha, alpha-dipyridyl solution is used to confirm the presence of ferrous (Fe^{2+}) iron in soils. If the solution turns from clear to red when applied to soil, the color change reaction indicates that soils are anaerobic (anoxic) and that iron in the soil is reduced and at the time of application. Redox concentrations and depletions are hydric soil indicators that are formed in anoxic soils as a result of redox reactions. Organic materials accumulate in anoxic soils where the lack of oxygen slows decomposition. When soils are saturated, bacteria in the soils use up the oxygen and the soils become anoxic. Ferrous iron is released in anoxic soils. If anoxic, soils are functioning as wetland soils and are considered hydric and are not relict hydric soils. Therefore, the alpha, alpha-dipyridyl is testing whether the soils are currently functioning as hydric soils.

A false negative or false positive is possible when this procedure is used incorrectly or if the chemical has been incorrectly prepared or if it has been compromised. A checklist of possible false negatives or false positives has been examined as a part of this study and is provided in **Table 10**.

Table 10. Potential for False Positive or Negative using Alpha Alpha Dipyridyl

POTENTIAL FALSE POSITIVE	QUALIFY	COMMENTS
Abnormally high precipitation and/or flooding (Hydric soils technical note 11)	No	Normal precipitation occurred during the sample period.
If the soils have been moved/ disturbed (Hydric soils technical note 8)	Not recently	No testing had occurred in areas of disturbed soils to avoid both False positives or negatives
Metal fragments hidden in the soil (Hydric soils technical note 8)	Not observed	No metal fragments observed in the soils
Water being recently added to a site	No	It is possibly but unlikely that water has been recently added to the site.
Testing on metal shovel or auger (Wetland Soils2011)	No	Testing occurred on rite in the rain paper

POTENTIAL FALSE NEGATIVE	QUALIFY	COMMENTS
If the soils are not fully saturated (Hydric soils technical note 11)	No	Soils were wet at time of testing
Testing after drought (Hydric soils technical note 11)	No	No draught, abnormally high precipitation occurred at time of sampling
If the soils have been moved/ disturbed (Hydric soils technical note 8)	Not recently	No testing had occurred in areas of disturbed soils to avoid both False positives or negatives
Not in wettest part of the growing season	No	Tests were performed during the wettest part of the growing season.
Not making or storing the dipyridyl correctly (Hydric soils technical note 8)	No	The same batch of chemical worked correctly by getting a positive result at Wetland A
A soil that doesn't contain iron (Richardson & Vepraskas. 20112011)	No	Iron concretions were common in soils throughout the site, which is typical of agricultural land
If a soil sample is exposed to bright sunlight (Richardson & Vepraskas. 20112011)	No	Container covered by aluminum foil, avoiding light penetration. Reference site at Wetland A tested positive using same batch
Chemical in soil/ contaminated site (Richardson & Vepraskas. 2011)	No	No indication that the site is contaminated
No microbial activity in soil type (sand with no organics) (Richardson & Vepraskas. 20112011)	No	Normal microbial activity is likely
Alkaline soils with High pH ≥7.9	No	PH was taken at every sample site. No soil sample recorded a pH of 7.9 or greater
Moving water (flood) (Richardson & Vepraskas. 20112011)	No	No moving water or flooding was observed
Less than fourteen (<14) consecutive days of soil temperatures above 41 degrees F. (true Growing season)	No	Tests at well locations were performed during fourteen (<14) consecutive days of soil temperatures above 41 degrees F

4.0 ADVANCED STUDY RESULTS

4.1 Advanced Studies Results Summary

The results of the Advanced Study procedures are summarized in **Table 11**.

Table 11. Results of Advanced Study Procedures

Study Area	Test Plot	Wetland Hydrology Standard	Chemical Test (Dipyridyl)	Redox Meter	Comments
Study Area A	W1	No	---	---	W2 tested positive for the USACE Wetland Hydrology Standard and for the Redox Test.
	W2	**Yes**	No	**Yes**	
	W3	No	---	---	
Study Area B	W4	No	No	No	No well locations tested positive
	W5	No	---	---	
	W6	No	---	---	
Study Area C	W7	No	No	No	No well locations tested positive
	W8	No	---	---	
	W9	No	---	---	
Study Area D	W10	No	No	No	No well locations tested positive
	W11	No	---	---	
	W12	No	---	---	
Study Area E	W13	No	No	No	No well locations tested positive
	W14	No	---	---	
Study Area F	W15	**Yes**	No	**Yes**	W15 & W16 tested positive for the USACE Wetland Hydrology Standard. And W15 tested positive for the Redox Test
	W16	**Yes**	---	---	
	W17	No	---	---	
Wetland A	TP A1	---	**Yes**	**Yes**	TP-A1 located within Wetland A is the reference sample that tested positive for alpha alpha dipyridyl and for the Redox Test

4.2 Chemical Testing of Soils

Results of chemical testing of soils using alpha alpha dipyridyl is summarized in **Table 12**. The sample locations are shown in **Figure 2**. The reliability of tests is summarized in **Table 10**. The summary of all tests, including alpha alpha dipyridyl, is provided in **Table 12**.

All samples tested negative using alpha alpha dipyridyl, other than the reference site at TP-A1 in Wetland A, which tested positive (**Appendix A, Photos 87-98**). The sample at TP-A1 turned a bright red when alpha alpha dipyridyl was applied, producing a positive result (**Appendix A, Photos 97 & 98**). The TP-A1 sample test was performed on 4 April 2023, which was during the wettest part of the growing season. The other tests being negative at the time of testing, suggests that no hydric soil chemical processes were occurring at the other test plots during the testing period.

Table 12. Alpha Alpha Dipyridyl Summary of Results

No#	Test Plot	Chemical Test (Dipyridyl)	Comments
Study Area A	W2	No	Unlikely occurrence of false negative or false positive
Study Area B	W4	No	Unlikely occurrence of false negative or false positive
Study Area C	W7	No	Unlikely occurrence of false negative or false positive
Study Area D	W10	No	Unlikely occurrence of false negative or false positive
Study Area E	W13	No	Unlikely occurrence of false negative or false positive
Study Area F	W15	No	Unlikely occurrence of false negative or false positive
Wetland A	TP-A1	Yes	Reference area tested positive

A negative test using alpha, alpha-dipyridyl indicates the ‘absence’ of reduced (ferrous) iron in the upper twelve (12) inches. The ‘absence’ of reduced (ferrous) iron indicates that the soil is not functioning as a wetland soil during the sample date (Richardson & Vepraskas 2001).

This standard determines if soils are functioning as hydric or if ‘relict’ or non-hydric soils occur at the sample site that may superficially resemble hydric soils, but not function as hydric soils. Results demonstrate that soils at the monitoring wells were not functioning as hydric soils during the sample date.

Alpha, alpha-dipyridyl is a primary indicator of wetland hydrology according to the USACE (2010) Regional Supplement. The monitoring well locations are lacking this primary indicator of wetland hydrology during the sample date. None of the tests were performed outside of the growing season, which makes a potential ‘False Negative’ or ‘False Positive’ unlikely (See **Table 10**).

Although all the samples within the study areas tested negative, the reference sample within Wetland A at TP-A1 tested positive (**Figures 5 & 6; Appendix A, photos 97 & 98**). When alpha alpha dipyridyl was applied to soils at TP-A1, the reaction turned bright red, indicating a positive reaction (**Appendix A, photos 97 & 98**). This reference test indicates that the batch of alpha alpha dipyridyl was functioning as normal. Because the study area tests were negative indicates that the level of reduced (ferrous) iron in the upper twelve (12) inches of the soil was too low for detection.

4.3 Redox Test

The Redox Test was performed at sample locations to determine if soils are functioning as and meet the definition of hydric soils. A summary of results of the Redox Test is provided in **Table 13, Insert 7, and Figure 5**. The results of the Redox Test are consistent with the hydrology monitoring results, strengthening a wetland determination.

Samples at Well W2 within Study Area A and one (1) of two (2) samples at Well W15 within Study Area F tested positive (**Insert 7; Figure 5, Appendix A, Photos 77-86**). All of the other samples within the other study areas tested negative. Tests at W2 & W15 were weakly positive and barely passed the test (**Insert 7**). One (1) sample at W13 nearly passed the test. However, samples at the reference area TP-A1 within Wetland A strongly tested positive in comparison (**Insert 7; Figure 6**).

Analysis of the Redox Test concludes that soils at W2 and W15 have low level redox reactions, indicating that these soils may be very marginally functioning as hydric soils for some duration of the growing season. This degree of low function is evident when comparing the sample results from Wetland A, which is clearly a wetland.

Insert 7. Results of Redox Test

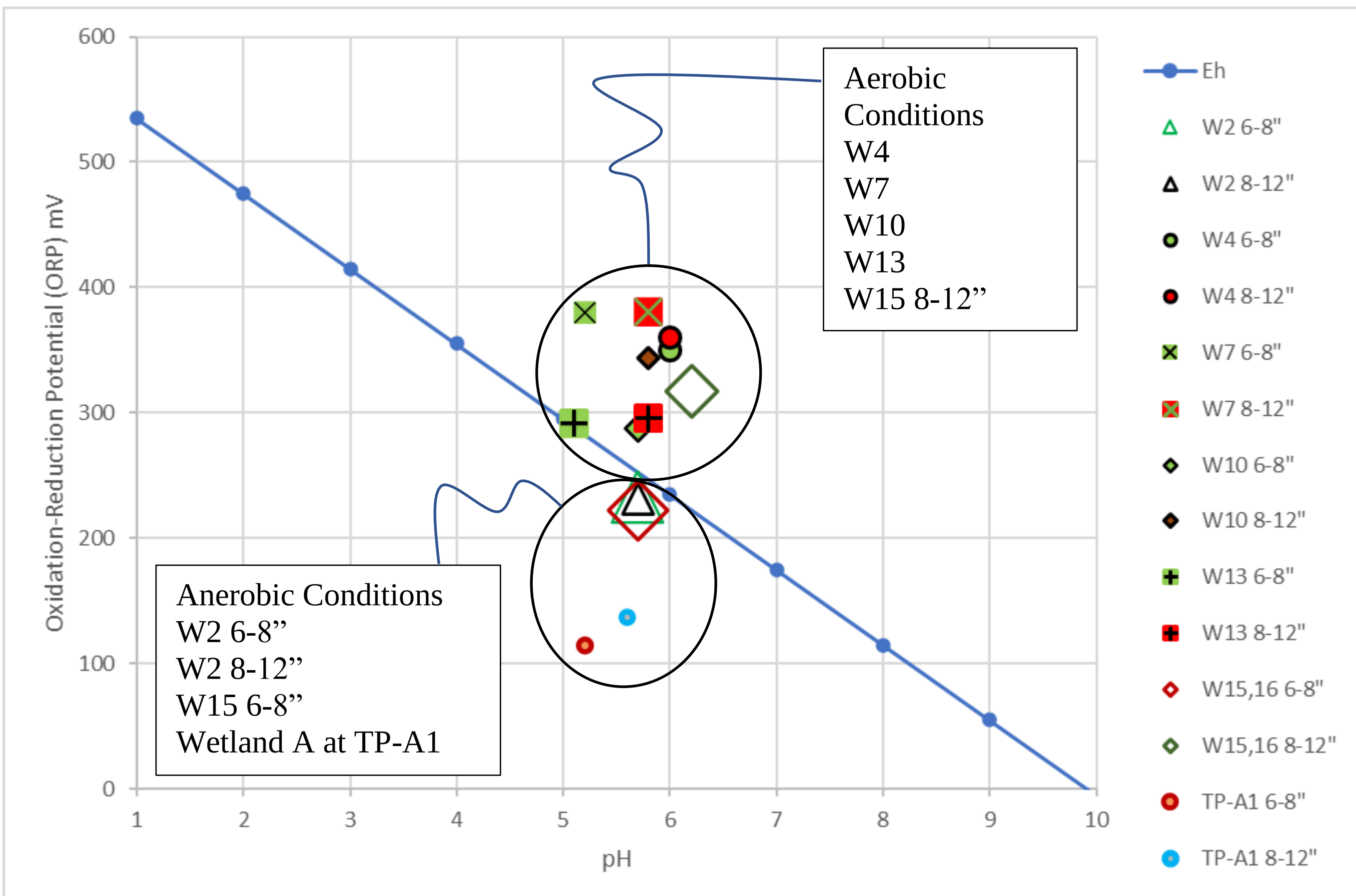


Table 13. Redox Test Results

Data	mv	pH	Anerobic
W2 6-8"	233.0	5.700	**Yes**
W2 8-12"	231.0	5.700	**Yes**
W4 6-8"	350.0	6.000	No
W4 8-12"	360.0	6.000	No
W7 6-8"	380.0	5.200	No
W7 8-12"	380.0	5.800	No
W10 6-8"	288.0	5.700	No
W10 8-12"	344.0	5.800	No
W13 6-8"	292.0	5.100	No
W13 8-12"	296.0	5.800	No
W15,16 6-8"	222.0	5.700	**Yes**
W15,16 8-12"	317.0	6.200	No
TP-A1 6-8"	115.0	5.200	**Yes**
TP-A1 8-12"	137.0	5.600	**Yes**

4.4 Summary of Hydrology Results

4.4.1 General Summary of Results

A summary of the hydrology study can be found in **Table 14** and **Figures 5 & 6**. A map of the well locations is provided in **Figure 4**.

Table 14. Summary of Hydrology Results

Wetland	Wells	Hydrology Standard Satisfied	Comments
Study Area A	W1	No	Well W2 Satisfies the USACE Wetland Hydrology Standard
	W2	**Yes**	
	W3	No	
Study Area B	W4	No	No Well Satisfies the USACE Wetland Hydrology Standard
	W5	No	
	W6	No	
Study Area C	W7	No	No Well Satisfies the USACE Wetland Hydrology Standard
	W8	No	
	W9	No	
Study Area D	W10	No	No Well Satisfies the USACE Wetland Hydrology Standard
	W11	No	
	W12	No	
Study Area E	W13	No	No Well Satisfies the USACE Wetland Hydrology Standard
	W14	No	
Study Area F	W15	**Yes**	Wells W15 & W16 Satisfy the USACE Wetland Hydrology Standard
	W16	**Yes**	
	W17	No	

The wetland hydrology standard is fourteen (14) or more consecutive days of flooding, ponding, or a water table twelve (12) inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of five (5) years in ten (10) (fifty percent (50%) or higher probability). The minimum frequency of five (5) years in ten (10) (50 percent or higher probability) is assumed if the study has occurred during a period of normal precipitation. The study was performed at the time of normal precipitation according to the WETS Table. Thereby, the five (5) years in ten (10) (50 percent or higher probability) is presumed for this study.

4.4.2 Study Area A

Study Area A contains three (3) shallow groundwater monitoring wells, labeled W1-W3, and one (1) piezometer, labeled P1. Well W2 showed water within twelve (12) inches of the surface for more than fourteen (14) consecutive days (19 days) during the growing season at a time of normal precipitation (**Insert 9**). Thereby, Well W2 satisfies the USACE wetland hydrology standard. Wells W1 and W3 do not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days of water within twelve (12) inches of the surface.

Water levels in Study Area A are clearly influenced by precipitation (**Insert 15**). Water levels rise and fall sharpy as much as two (2) feet as a response to storm events. No significant staging of groundwater occurred during the study period. Water levels did not rise gradually during the course of the study period. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

When comparing the pared piezometer (P1) and shallow groundwater monitoring well (W1) at Study Area A, the Water Level Response (WLR) is classified as discharge, meaning that hydrostatic pressure forces water toward the surface (**Insert 16 & 17**). However, water forced to the surface does not drain out as surface water.

4.4.3 Study Area B

Study Area B contains three (3) shallow groundwater monitoring wells, labeled W4-W6, and one (1) piezometer, labeled P2. No water within twelve (12) inches of the surface occurred for more than fourteen (14) consecutive days during the growing season (**Insert 10**). Wells W4-W6 do not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days of water within twelve (12) inches of the surface. The longest duration of consecutive days of water within twelve (12) inches of the surface was seven (7).

Water levels in Study Area B are clearly influenced by precipitation (**Insert 15**). Water levels rise and fall sharpy as much as two (2) feet as a response to storm events. Staging of groundwater is observed in February through April. Water levels rose during the course of the study period. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

When comparing the pared piezometer and shallow groundwater monitoring well at Study Area B, the Water Level Response (WLR) is classified as discharge during later part of the wet season, meaning that hydrostatic pressure forces water toward the surface during this time. However, water forced to the surface does not drain out as surface water (See **Insert 16 & 17**).

4.4.4 Study Area C

Study Area C contains three (3) shallow groundwater monitoring wells, labeled W7-W9, and one (1) piezometer, labeled P3. No water within twelve (12) inches of the surface occurred for more than fourteen (14) consecutive days during the growing season (**Insert 11**). Wells W7-W9 do not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days of water within twelve (12) inches of the surface. The longest duration of consecutive days of water within twelve (12) inches of the surface was a couple days. Well W9 was completely dry during the entirety of the study.

Water levels in Study Area C are influenced by precipitation (**Insert 15**). Water levels rise and fall sharpy as much as one (1) foot as a response to storm events. Staging of groundwater is observed in through the course of the study. Water levels generally rose during the course of the study period. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

When comparing the pared piezometer and shallow groundwater monitoring well at Study Area B, the Water Level Response (WLR) is classified as recharge during the first part of the study and as discharge during the later part of the wet season. Because water levels in the shallow well was higher than the piezometer during the first part of the study, groundwater was recharged through precipitation entering the area. At the later portion of the growing season, the water levels in the piezometer were higher, indicating hydrostatic pressure from below. However, water forced to the surface does not drain out as surface water (See **Insert 16 & 17**). No surface water was observed in Area C during the duration of the study.

4.4.5 Study Area D

Study Area D contains three (3) shallow groundwater monitoring wells, labeled W10-W12. No water within twelve (12) inches of the surface occurred for more than fourteen (14) consecutive days during the growing season (**Insert 12**). Wells W10-W12 do not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days of water within twelve (12) inches of the surface. The longest duration of consecutive days of water within twelve (12) inches of the surface was eight (8) days for W10. Well W12 was dry for the majority of the study and did not rise above twelve (12) inches of the surface.

Water levels in Study Area D are influenced by precipitation (**Insert 15**). Water levels rise and fall sharpy as much as one (1) foot as a response to storm events. Staging of groundwater is observed in through the course of the study. Water levels generally rose during the course of the study period. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

4.4.6 Study Area E

Study Area E contains two (2) shallow groundwater monitoring wells, labeled W13-W14. No water within twelve (12) inches of the surface occurred for more than fourteen (14) consecutive days during the growing season (**Insert 13**). Wells W13-W14 do not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days of water within twelve (12) inches of the surface. The longest duration of consecutive days of water within twelve (12) inches of the surface was eleven (11) days for W10. Well W12 was dry for the majority of the study and did not rise above twelve (12) inches of the surface.

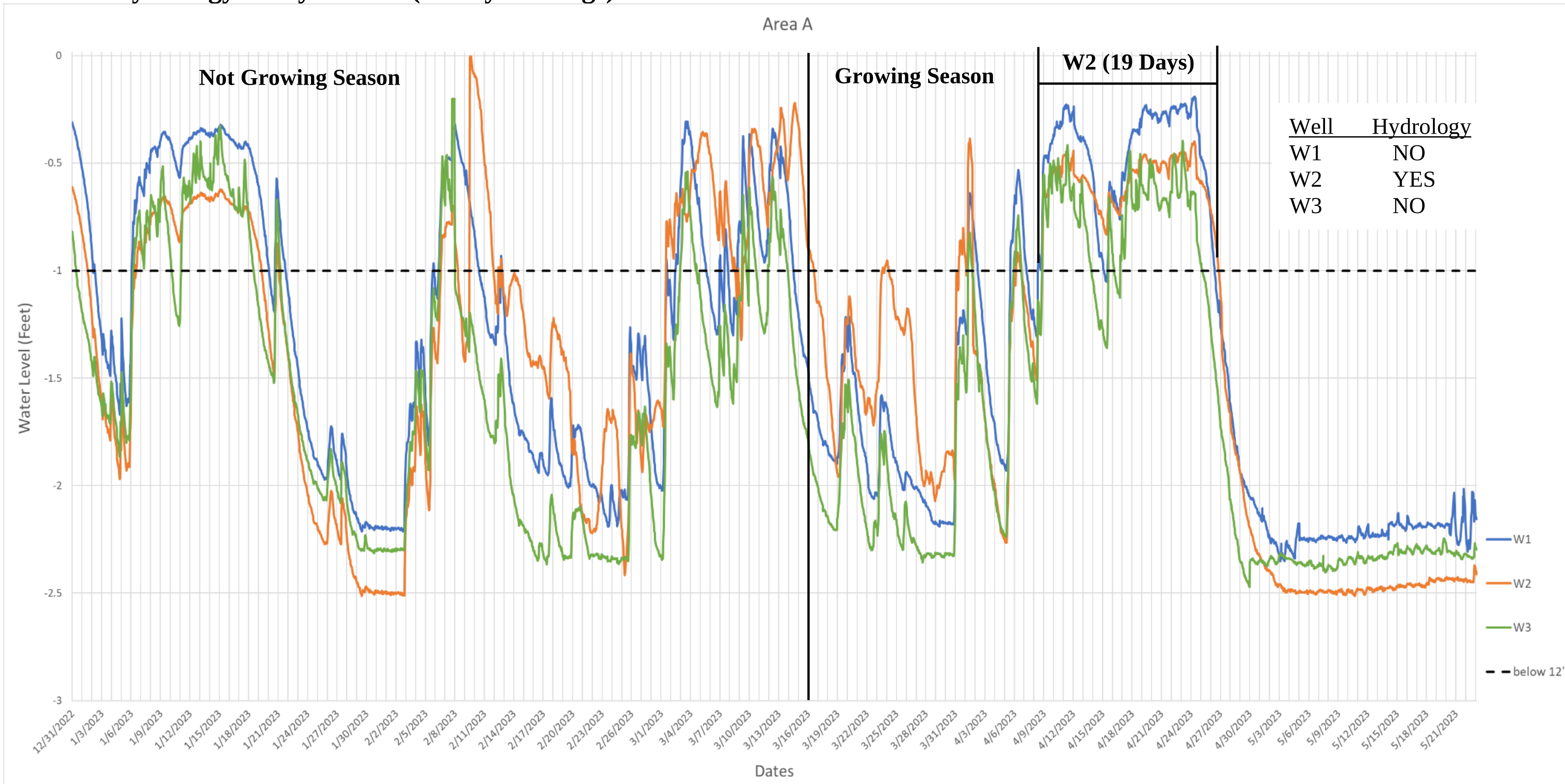
Water levels in Study Area E are influenced by precipitation (**Insert 15**). Water levels rise and fall as much as one and a half (1.5) foot as a response to storm events. Staging of groundwater is observed in through the course of the study. Water levels generally rose during the course of the study period. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

4.4.7 Study Area F

Study Area F contains three (3) shallow groundwater monitoring wells, labeled W15-W17. Wells W15 & 16 showed water within twelve (12) inches of the surface for more than fourteen (14) consecutive days (21 days) during the growing season at a time of normal precipitation (**Insert 14**). Thereby, Wells W15 & 16 satisfy the USACE wetland hydrology standard. Well W17 does not satisfy the USACE wetland hydrology standard with less than fourteen (<14) consecutive days (10 days) of water within twelve (12) inches of the surface.

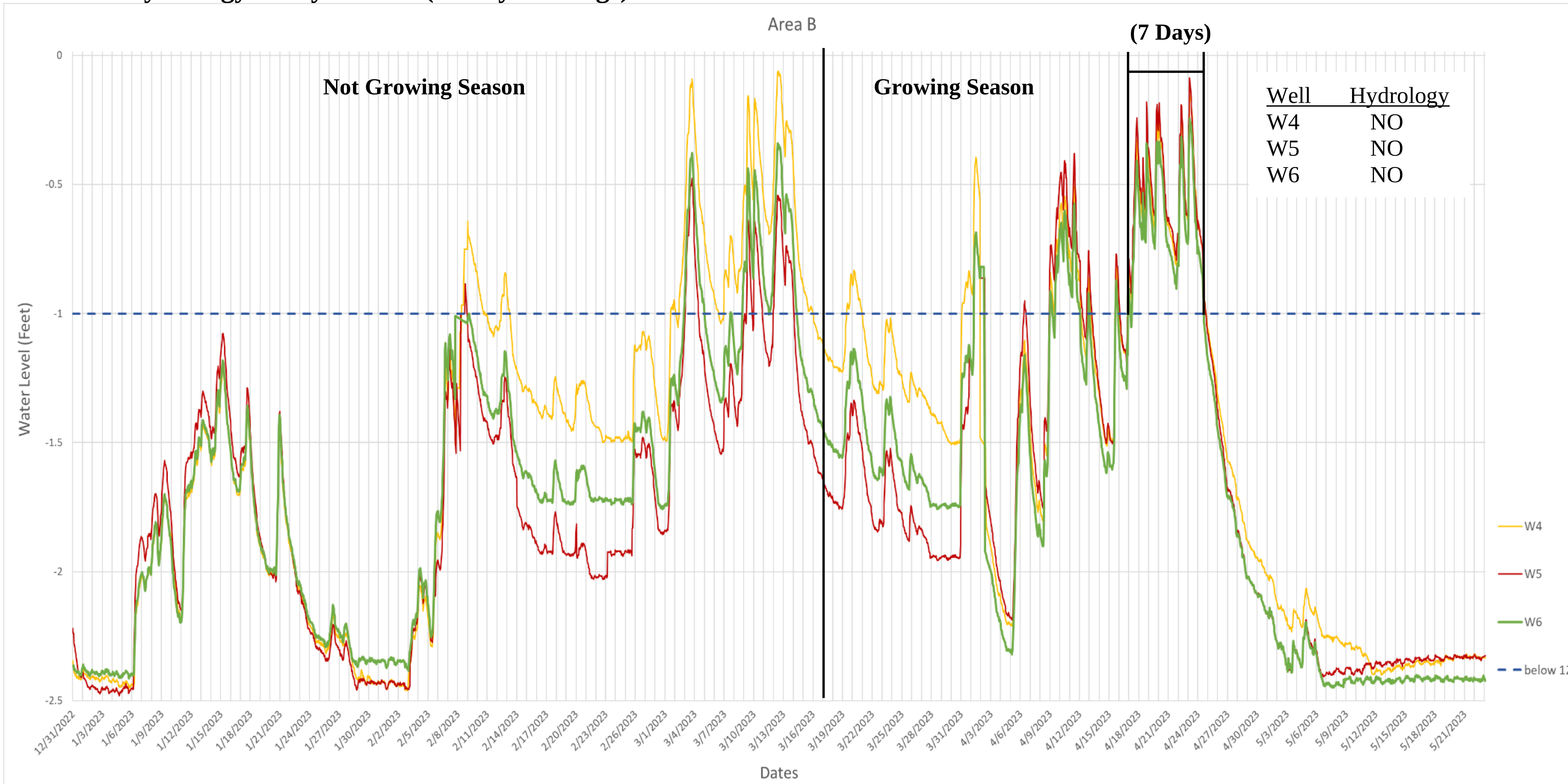
Water levels in Study Area F are influenced by precipitation (**Insert 15**). Water levels rise and fall as much as two (2) foot as a response to storm events. Staging of groundwater occurred less than seen at other study areas. Water appeared to rise during storm events and then fall to dry or almost dry between storm events. The wells went dry during mid-May when winter precipitation waned. This can be seen where water levels seem to hover at their lowest point because the well was dry.

Insert 9: Hydrology Study Results (hourly readings) Area A



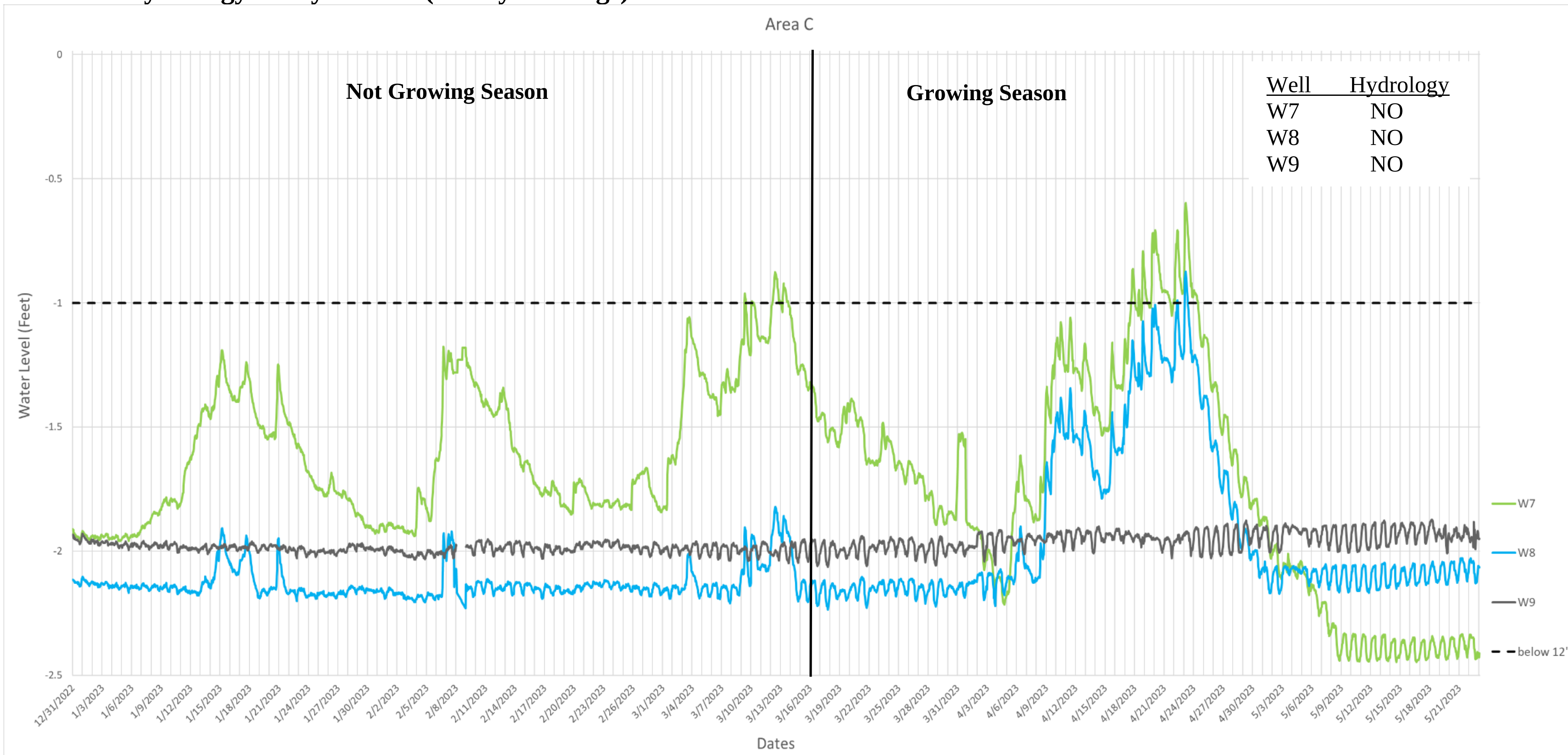
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 10. Hydrology Study Results (hourly readings) for Area B



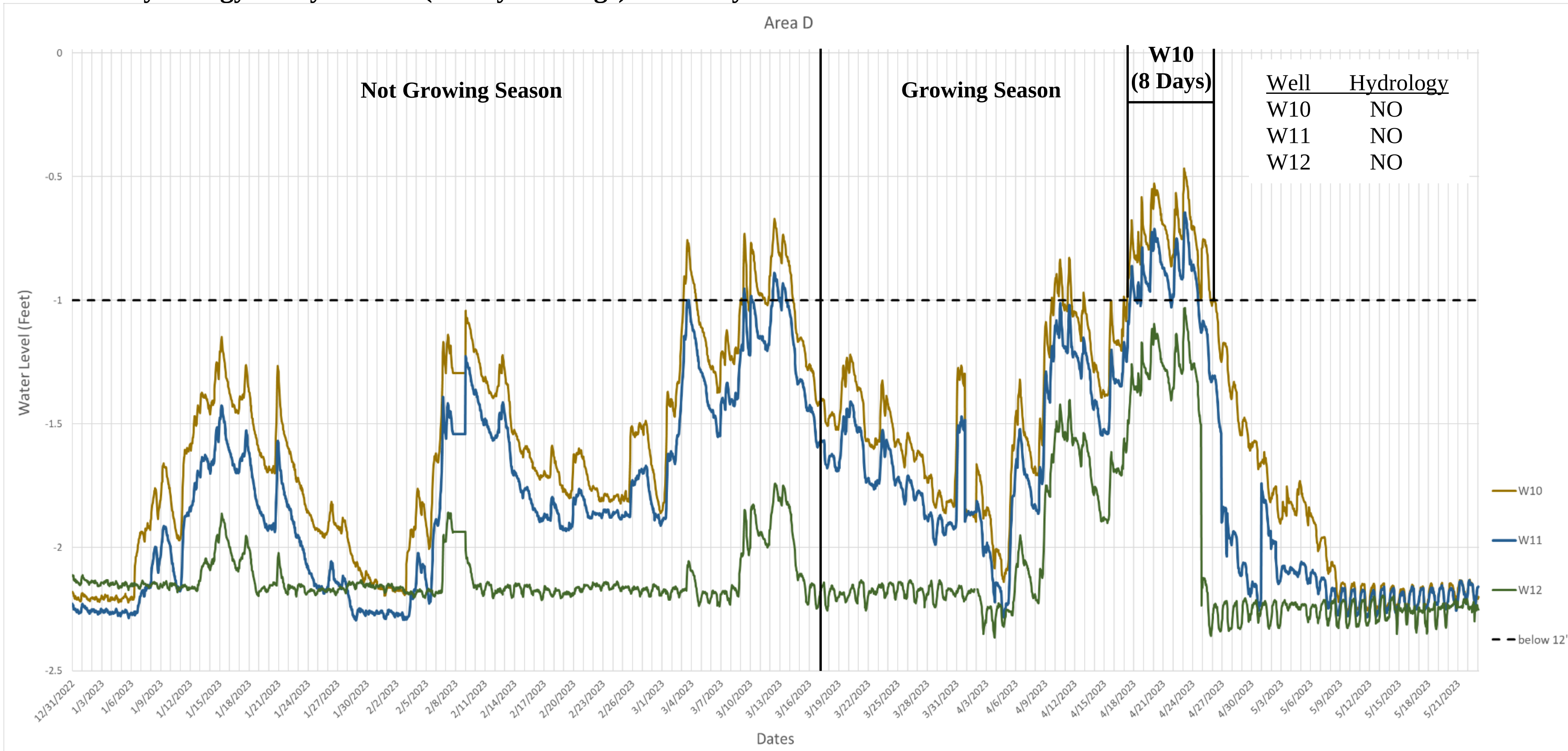
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 11. Hydrology Study Results (hourly readings) for Area C



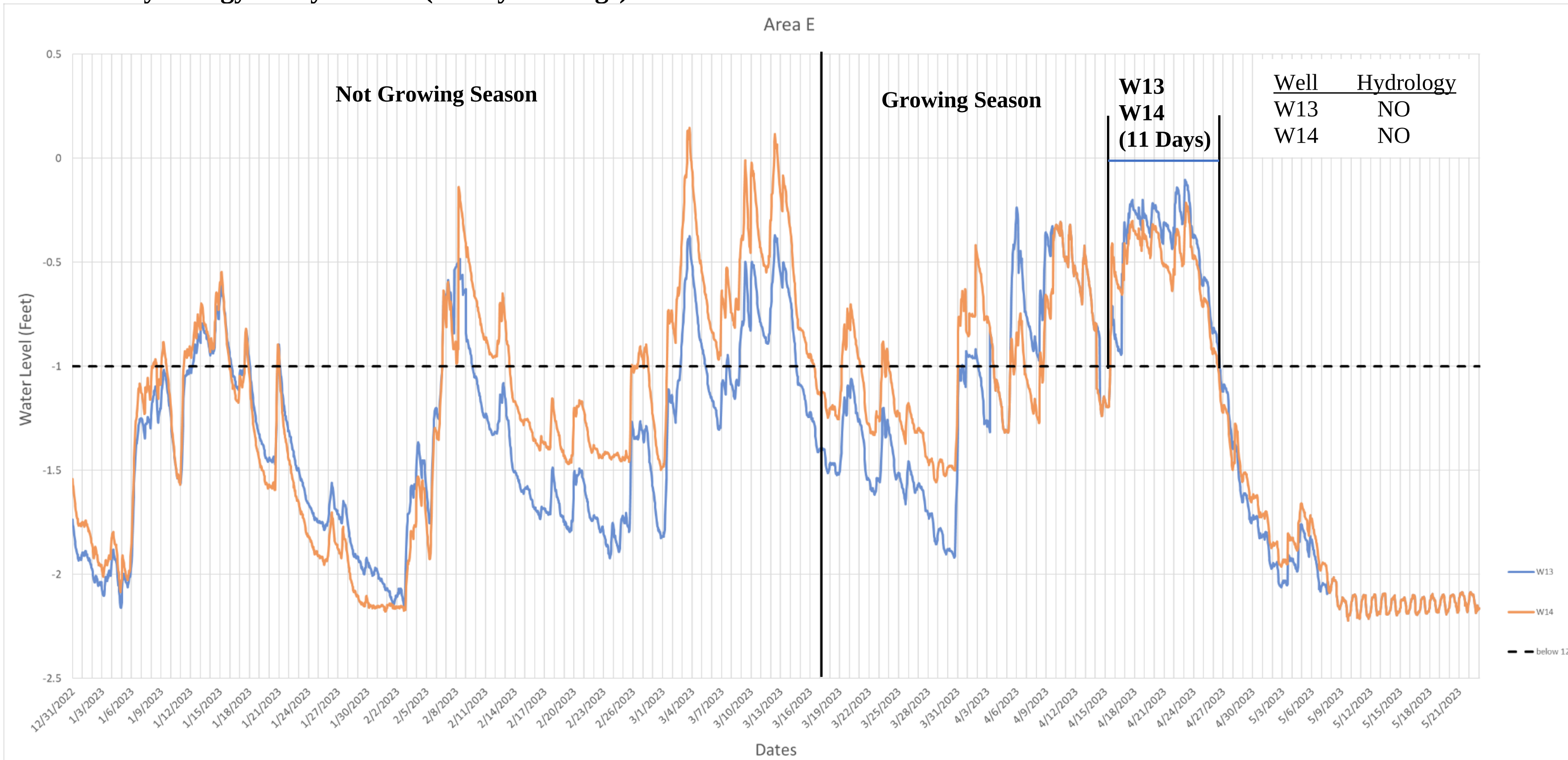
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 12. Hydrology Study Results (hourly readings) for Study Area D



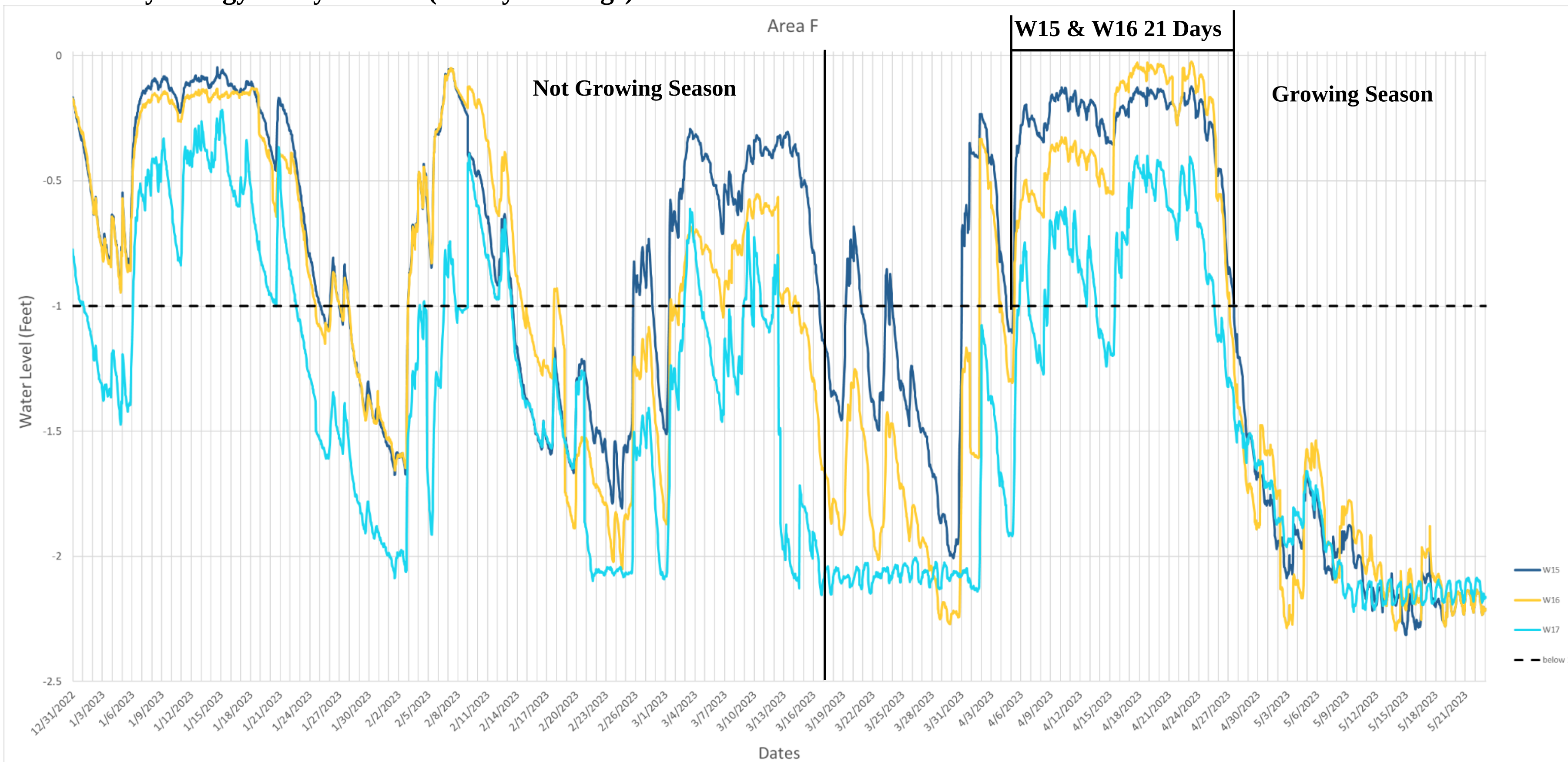
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 13. Hydrology Study Results (hourly readings) for Area E



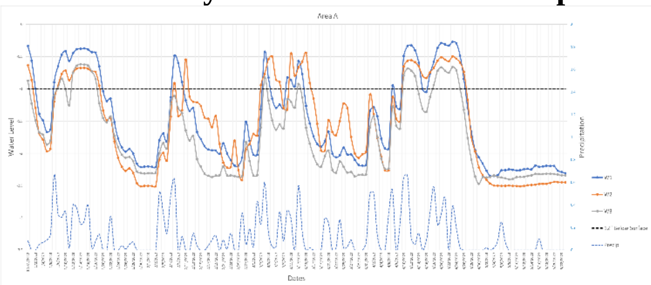
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 14. Hydrology Study Results (hourly readings) for Area F



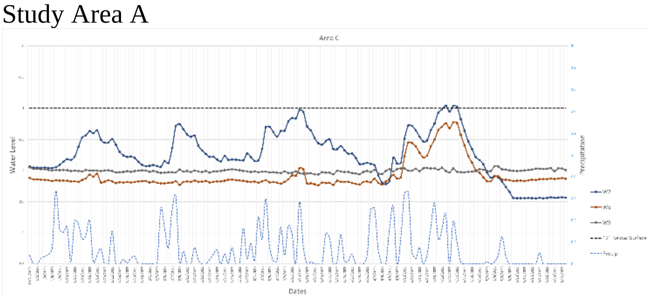
Standard: 14 or more consecutive days of flooding, ponding, or a water table 12 inches (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability)

Insert 15. Daily Water Levels with Precipitation

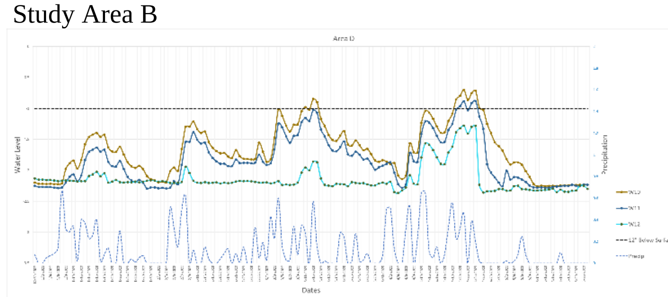


Study Area A

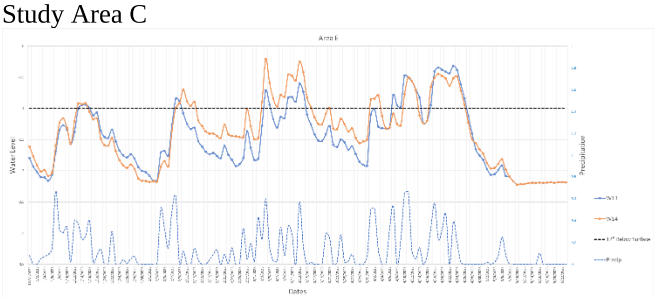
Study Area B



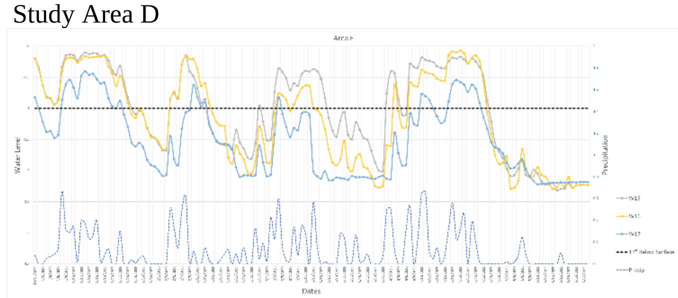
Study Area C



Study Area D



Study Area E



Study Area F

Insert 16. Water Level Response (NRCS [2008] Installing Monitoring Wells in Soils)

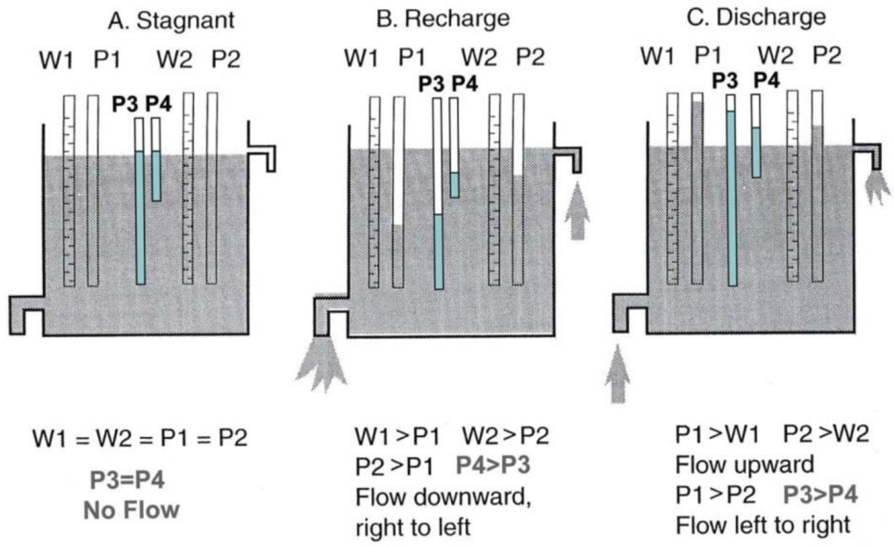
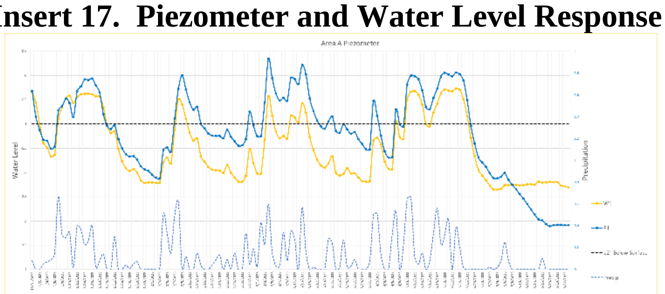


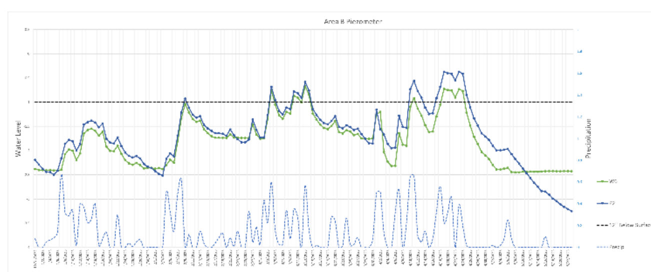
Figure 3. Schematic diagrams of water-table wells (W) and piezometers (P) demonstrating different water-level responses in different instruments. Water flows in tanks differ both laterally and vertically. Instrument pairs 1 vs 2 demonstrate contrasting measurements in instruments of the same length but spaced apart laterally. Instrument pairs P3 vs P4 demonstrate contrasting measurements of piezometers of different lengths located adjacent to each other. **(3A)** In **stagnant water** no head gradients exist, so water levels are the same in all piezometers and wells. **(3B)** In **recharge systems** water flows vertically downward to recharge the groundwater, so shallow P4 intercepts a higher hydraulic head than deeper P3. P1 and P2 pick up the lateral head difference from right to left as well as the vertical difference. **(3C)** In **discharge systems** water flows upward and discharges toward the land surface. Hydraulic gradients and instrument relationships are the reverse of those in recharge system 2B. In all three cases (A, B, and C) water levels are the same in water-table wells. Figure modified from Richardson et al. (2001).

18

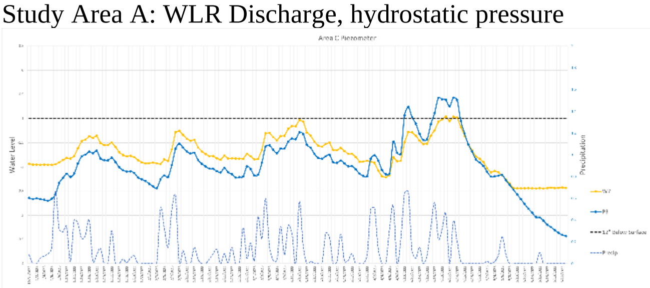
Insert 17. Piezometer and Water Level Response



Study Area A: WLR Discharge, hydrostatic pressure



Study Area B: WLR Discharge, weak hydrostatic pressure



Study Area B: WLR Discharge, weak hydrostatic pressure

Generally, hydrostatic pressure of groundwater increases with hydrological staging as the wet season progresses. The Water Level Response is Discharge because water levels in the piezometers are generally higher than the coupled shallow monitoring well, indicating that hydrostatic pressure pushing groundwater to the surface.

4.4.8 Groundwater or Precipitation Influence

Water levels within the wells correlated with precipitation levels. However, water levels in the wells were delayed for several hours following a storm event, indicating that water levels in the wells are influenced by groundwater moving through a larger basin. Groundwater levels are influenced by precipitation from storm evens in the larger contributing basin. However, some of this time gap between precipitation and groundwater response could be attributed to storms moving from the weather station at the Port of Olympia Airport to the study area, a distance of sixteen (16) miles.

4.4.9 Perched Water Table and Aquitard

Piezometers were paired with shallow groundwater monitoring wells for comparison. Higher water levels in piezometers in comparison to paired shallow wells indicate hydrological recharge originating from groundwater as hydrostatic pressure pushes water to the surface. If no difference between water levels in piezometers and shallow wells, passive groundwater influence can be presumed. Piezometer water depth lower than the paired shallow well typically would indicate that hydrology recharge occurs though precipitation rather than groundwater and/or a perched water table (aquitard) holds water near the soil surface.

Generally, the water levels in onsite piezometers were higher than in paired shallow monitoring wells, indicating a discharge WLR, however, with no surface discharge. Groundwater from the Study areas likely interflowed to the Agricultural ditches. However, recharge of hydrology generally appears to occur from groundwater, which becomes more apparent later in the wet season.

It is important to note that the shallow groundwater monitoring wells were not extended into an impermeable layer, thereby, the shallow wells did not penetrate an aquitard.

5.0 WETLAND DETERMINATION

5.1 General Determination

Two (2) wetlands, labeled Wetland B and Wetland C, have been identified on the southern portion of the subject property using advanced methods described in Chapter 5 of the USACE (2010) Regional Supplement (**Figure 7**). Three (3) shallow groundwater monitoring wells, W2, W15, & W16, tested positive for the USACE Wetland Hydrology Standard (**Figure 5**). The Redox Test supports the hydrology results, indicating positive test results at W2 and W15. However, the positive results at these two (2) test locations are borderline, indicating very marginal wetland conditions. A negative Chemical Test result applying alpha alpha dipyridyl further indicates very marginal wetland conditions, especially considering the obviously positive result at the reference sample in Wetland A.

5.2 Wetland B

Wetland B (2,136 sf) is located with Study Area A (**Figure 7**). Three (3) shallow monitoring wells were installed within Study Area A. The Redox Test and Chemical Test was performed at the sample point with the wettest appearance during the wettest part of the growing season.

Soils and vegetation can be assumed if the USACE hydrology standard is satisfied. The standard calls for fourteen (14) consecutive days of water within twelve (≤12) inches of the surface during the growing season five (5) out of ten (10) years. Well W2 shows water levels above twelve (12) inches of the surface for nineteen (19) consecutive days during the growing season, marginally passing the test, before falling sharply during mid-May (**Insert 5**). The Redox Test also marginally passes at Well W2. However, the Chemical Test does not pass at Well W2, indicating very marginal wetland conditions at best, especially considering the strongly positive test in Wetland A.

The patch of rushes growing in Wetland B can be seen from aerial photographs captured from a drone flown over the southern portion of the subject property (**Appendix A, Photos 25, 26, & 29**). Wetland B is a wallow that attracts livestock, which alter, soils, vegetation, and hydrology (USACE 2010). Livestock compressed soil, consumes the vegetation, and drops massive volumes of manure that alters the appearance and chemistry of the soils. Soil compaction from wallowing livestock can reduce percolation and increased wetness. Manure trampled into the ground can darken the soils, superficially resembling the color of organic soils. Wetter soils containing manure are more likely to exhibit anerobic conditions caused by bacterial decomposition.

Abnormally high precipitation occurred when Well W2 exceeded fourteen (14) consecutive days of water within twelve (12) inches of the surface. This abnormally high precipitation may have contributed to passing the USACE Wetland Hydrology Standard. Thereby, abnormally high precipitation during the month of April created the possibility of a ‘False Positive’ result. However, normal precipitation occurred when considering the entirety of the study and three (3) months prior. Essentially, this abnormally high precipitation made up for several prior months of abnormally low precipitation for levels to even out to normal. When considering that Well W2 did not pass the Chemical Test and marginally passed the Redox Test, the possibility of a ‘False Positive’ increases.

In conclusion, Wetland B is a very marginal wetland with no significant habitat value or wetland functions that may have been created by wallowing livestock. Wetland B is very marginal wetland at best and may not function as a wetland during years of lower precipitation.

5.3 Wetland C

Wetland C (2,136 sf) is located with Study Area F (**Figure 7**). Three (3) shallow monitoring wells were installed within Study Area F, W15, W16, & W17. The Redox Test and Chemical Test was performed at the sample point with the wettest appearance during the wettest part of the growing season.

Soils and vegetation can be assumed if the USACE hydrology standard is satisfied. The standard calls for fourteen (14) consecutive days of water within twelve (≤12) inches of the surface during the growing season five (5) out of ten (10) years. Wells W15 & W16 show water levels above twelve (12) inches of the surface for twenty-one (21) consecutive days during the growing season before falling sharply during mid-May (**Insert 10**). One (1) of the two (2) samples marginally passed the Redox Test at Well W15. However, the Chemical Test did not pass at Well W15, indicating very marginal wetland conditions at best, especially considering the strongly positive test in Wetland A.

Wetland C is a wallow that attracts livestock, which alter, soils, vegetation, and hydrology (USACE 2010). Livestock compressed soil, consumes the vegetation, and drops massive volumes of manure that alters the appearance and chemistry of the soils. Soil compaction from wallowing livestock can reduce percolation and increased wetness. Manure trampled into the ground can darken the soils, superficially resembling the color of organic soils. Wetter soils containing manure are more likely to exhibit anerobic conditions caused by bacterial decomposition.

Abnormally high precipitation occurred when Wells W15 & W16 exceeded fourteen (14) consecutive days of water within twelve (12) inches of the surface. This abnormally high precipitation may have contributed to passing the USACE Wetland Hydrology Standard. Thereby, abnormally high precipitation during the month of April created the possibility of a 'False Positive' result. However, normal precipitation occurred when considering the entirety of the study and three (3) months prior. Essentially, this abnormally high precipitation made up for several prior months of abnormally low precipitation for levels to even out to normal. When considering that Well W15 did not pass the Chemical Test and marginally passed the Redox Test, the possibility of a 'False Positive' increases.

In conclusion, Wetland C is a very marginal wetland with no significant habitat value or wetland functions that may have been created by wallowing livestock. Wetland C is very marginal wetland at best and may not function as a wetland during years of lower precipitation.

6.0 CONCLUSION

Advanced studies were performed on areas defined as difficult situations by the USACE (2010) Regional Supplement. These advanced methods were applied as required when evaluating difficult situations under Chapter 5 of the USACE (2010) Regional Supplement.

These difficult situations consist of patches of soft rush (*Juncus effusus*, FACW) and slender rush (*Juncus tenuis*, FAC) with some limited slough sedge (*Carex obnupta*, OBL) in livestock wallows on the southern portion of the subject property (**Appendix A, Photos 24, 31, 32, 38, & 42**). However, no hydric soils were identified in these areas and no hydrology was identified during the growing season using the routine onsite determination method. These areas did not satisfy all three (3) criteria (*i.e.*, hydric soils, hydrophytic vegetation, and wetland hydrology) for a wetland determination. Hydric soils and hydrology were not satisfied under the routine on-site determination method.

Although the patches of rushes did not satisfy the hydric soils or wetland hydrology criteria using the routine on-site determination method, High Groundwater Hazard Areas and wetlands have been mapped in these areas by several governmental Agencies, warranting a higher level of evaluation (**Appendices B, C, D, E, & F**).

Six (6) Study Areas, labeled Study Areas A-F, were established where difficult conditions have been identified (**Figure 4**). The advanced study period was implemented from 31 December 2022 to 23 May 2023. The study period extended for the duration of the wettest part of the growing season.

Seventeen (17) shallow groundwater monitoring wells were installed in difficult areas to determine whether groundwater levels satisfy the US Army Corps of Engineers (USACE) wetland hydrology standard as outlined in Chapter 5 of the USACE (2010) Regional Supplement (**Figure 4**).

Three (3) piezometers were installed within three (3) of the study areas, especially Study Areas A-C (**Figure 4**). The Redox Test was performed to determine if soils within the Study Areas are functioning as hydric soils. A positive result applying alpha alpha dipyridyl to soils is a primary indicator of hydrology and an indicator of hydric soils. These two (2) additional tests are a supplement to the hydrology study that are in compliance with USACE wetland identification procedures within Chapter 5 of the USACE (2010) Regional Supplement.

Wells W2 and W15 satisfied the USACE Wetland Hydrology Standard and the Redox Test. None of the Well locations satisfied the Chemical Test applying alpha alpha dipyridyl. Because W2 and W15 satisfied the USACE Hydrology Standard and the Redox Test, wetland criteria have been met. A positive determination of wetlands, labeled Wetland B and Wetland C, have been made at these two (2) monitoring wells (**Figure 7**).

Abnormally high precipitation occurred during the month of April. This abnormally high precipitation may have contributed to passing the USACE Wetland Hydrology Standard. Thereby, abnormally high precipitation during the month of April created the possibility of a 'False Positive' result. However, normal precipitation occurred when considering the entirety of the study and three (3) months prior. Essentially, this abnormally high precipitation made up for several prior months of abnormally low precipitation for levels to even out to normal. When considering that Well W2 did not pass the Chemical Test and marginally passed the Redox Test, the possibility of a 'False Positive' increases.

In conclusion, Wetlands B & C are very marginal wetland with no significant habitat value or wetland functions that may have been created by wallowing livestock. These wetlands are very marginal at best and may not function as wetlands during years of lower precipitation.

7.0 REFERENCES

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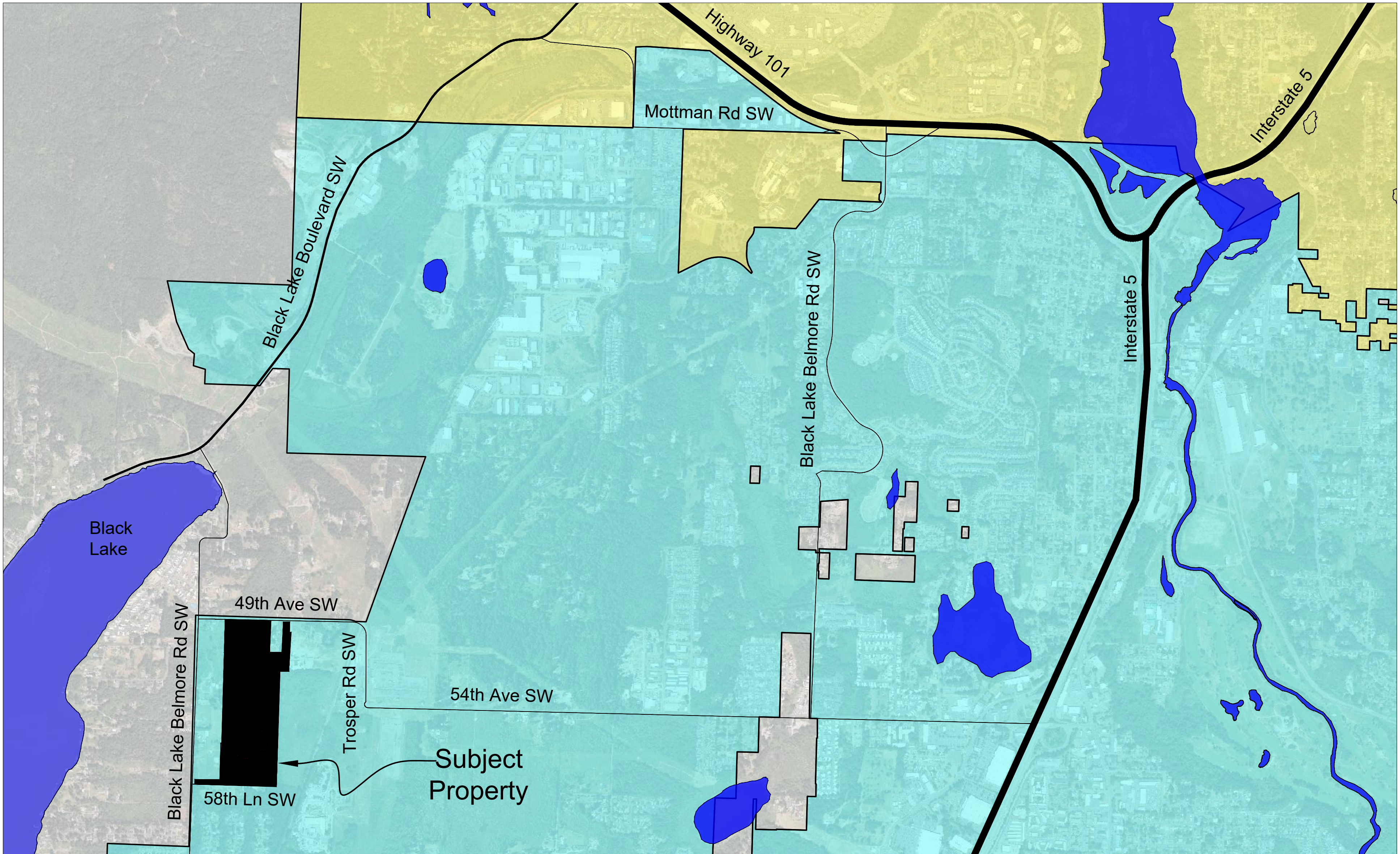
FIGURES



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City of Tumwater
City of Olympia

Figure 1

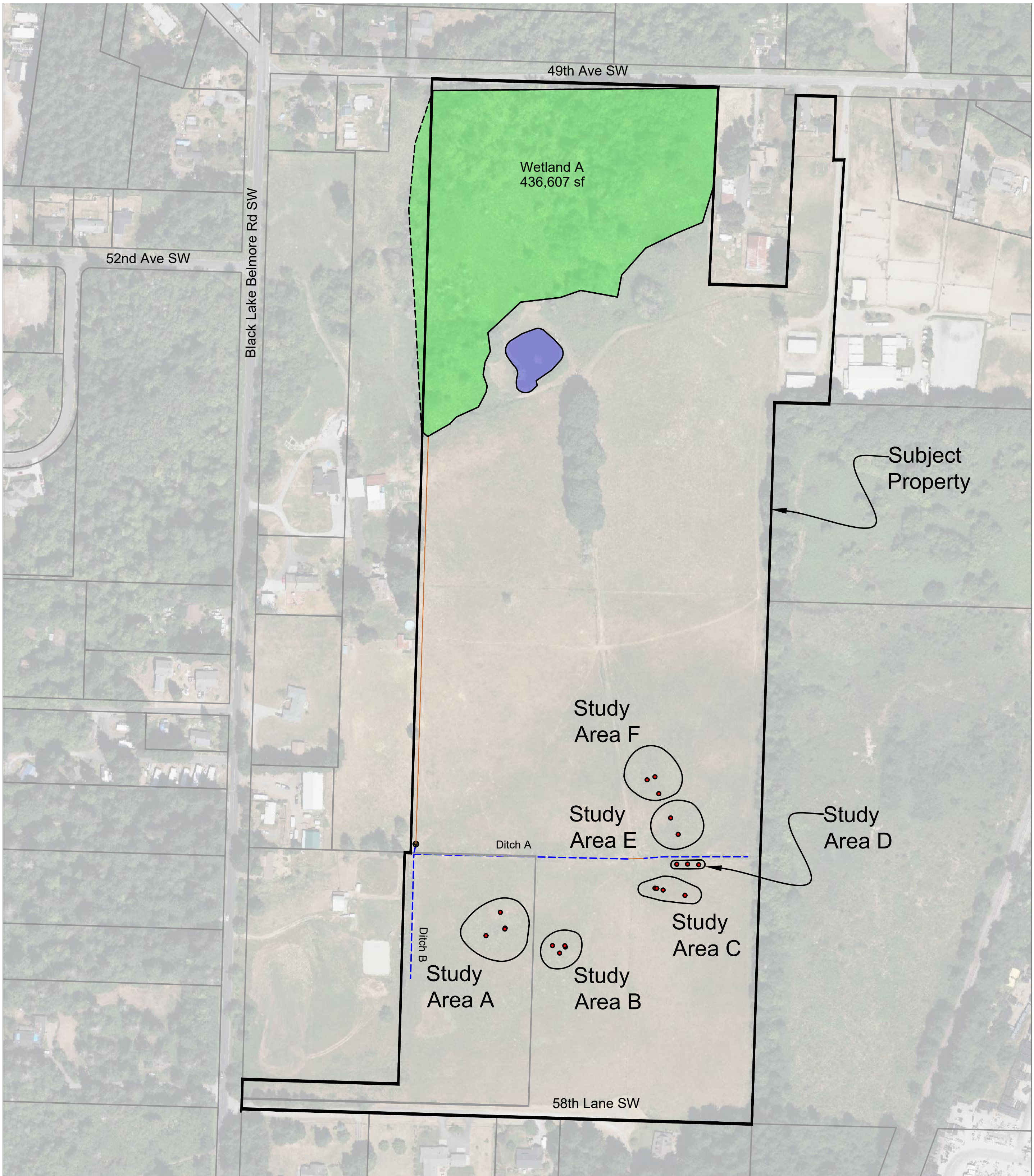
Bodenhamer

Vicinity Map

Scale: 1" = 2200'

0 2200'

14 June 2023



Wetland (Delineated)
Wetland (Not Delineated)
Farm Pond
Farm Ditches
Conveyance Pipes
Monitoring Well Locations

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Figure 2

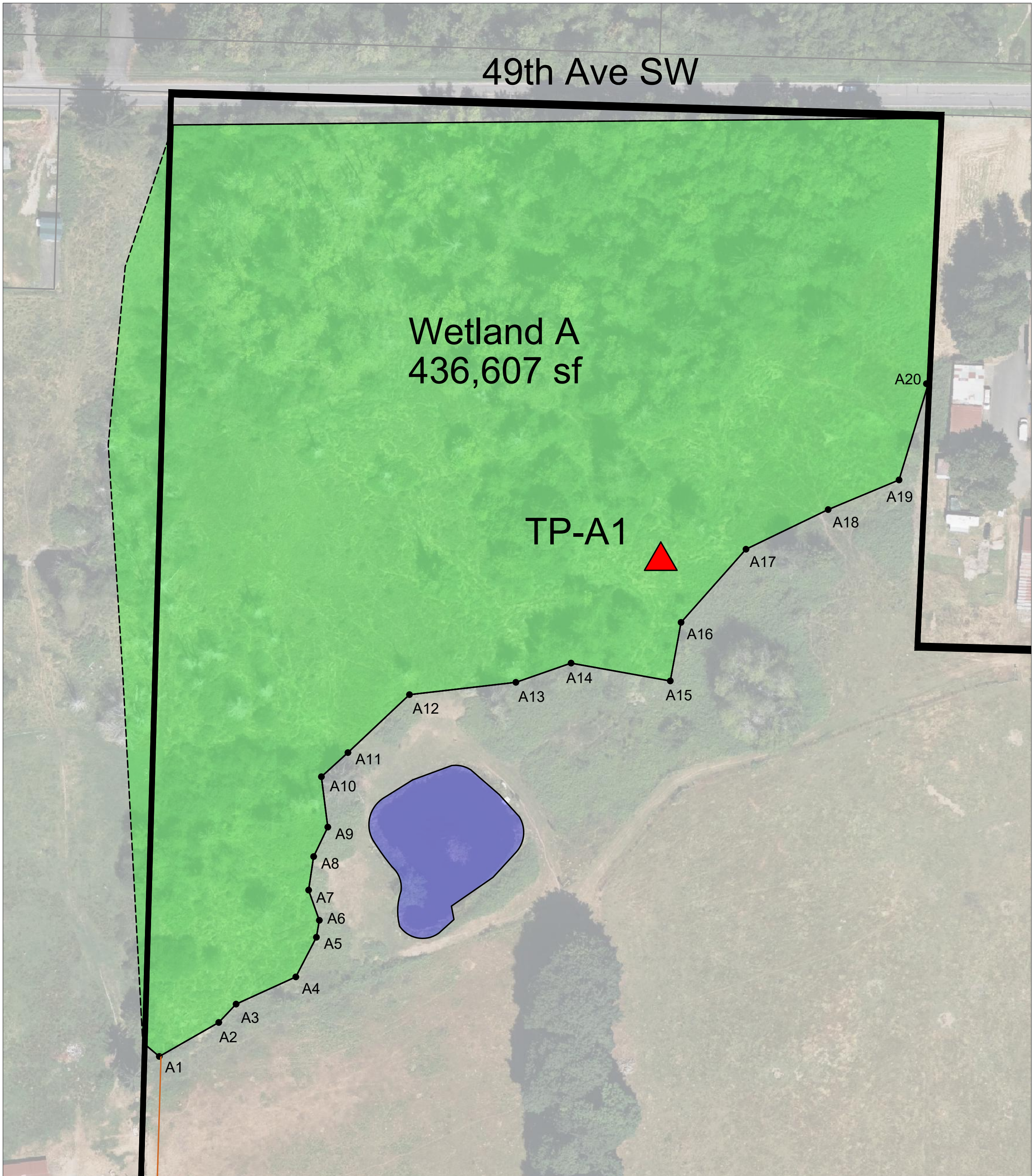
Bodenhamer

Study Areas

Scale: 1" = 350'

0 350'

14 June 2023



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Wetland (Delineated)
Wetland (Not Delineated)
Farm Pond
A1 A2 Wetland Delineation
Conveyance Pipes
TP A1 Test Plot

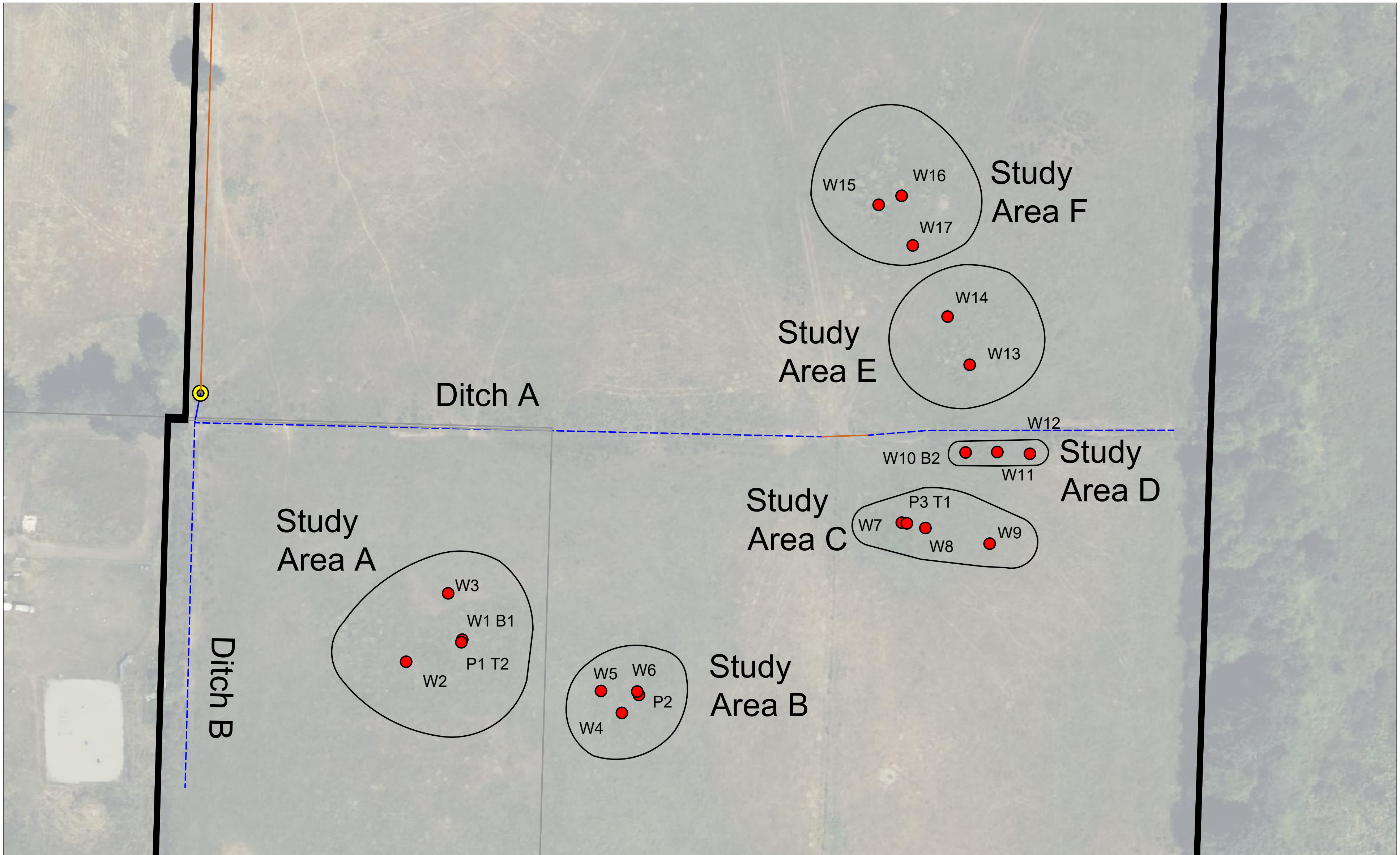
Figure 3

Bodenhamer

Wetland A Delineation

Scale: 1" = 130'
0 130'

14 June 2023



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Monitoring Well Locations
Farm Ditches
Conveyance Pipes

Figure 4

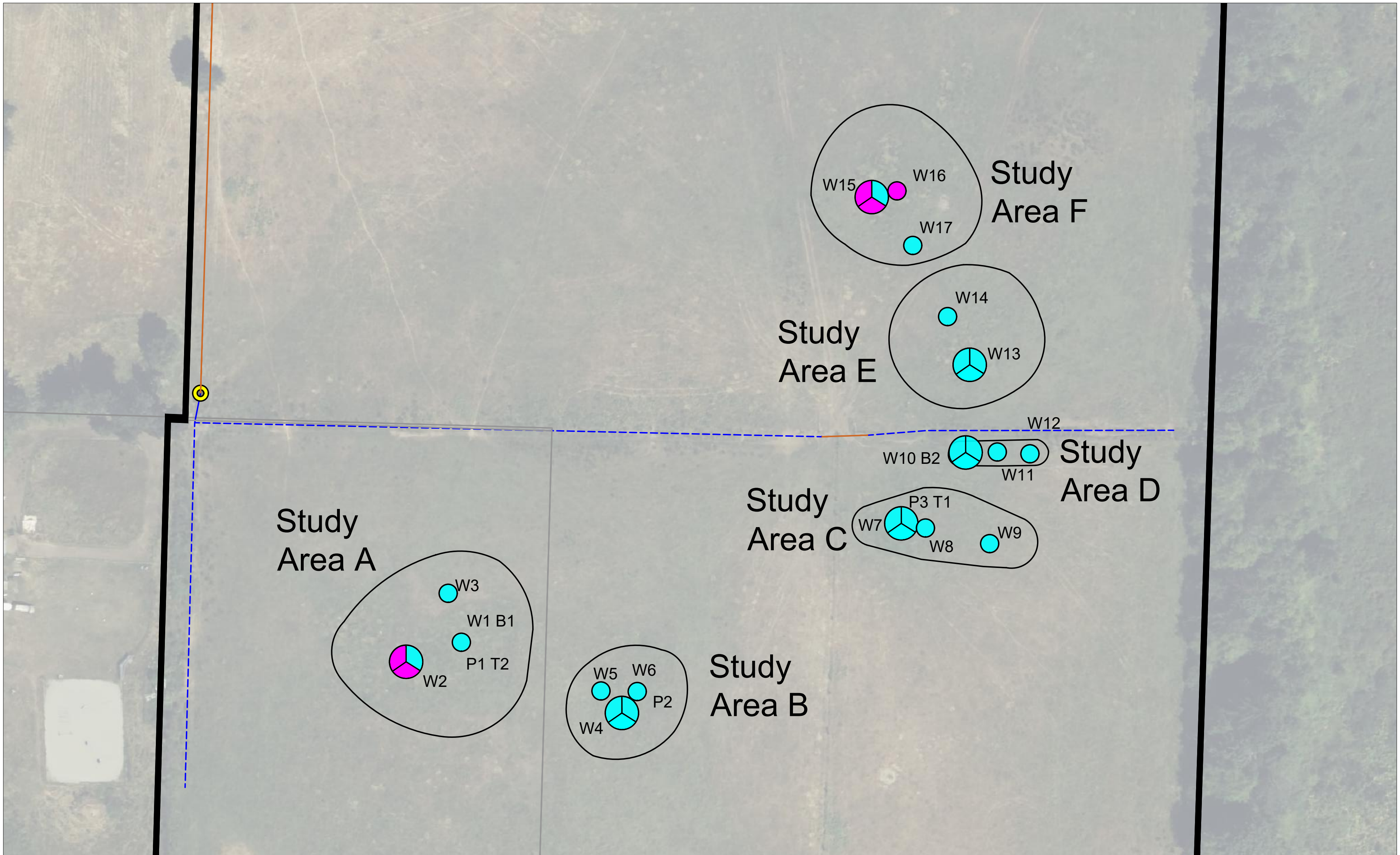
Bodenhamer

Study Areas

Scale: 1" = 120'

0 120'

14 June 2023



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Positive	Negative	Chemical Test
Positive	Negative	Redox Test
Positive	Negative	Well Results (Hydrology)
Positive	Negative	Well Results Alone (Hydrology)

Figure 5

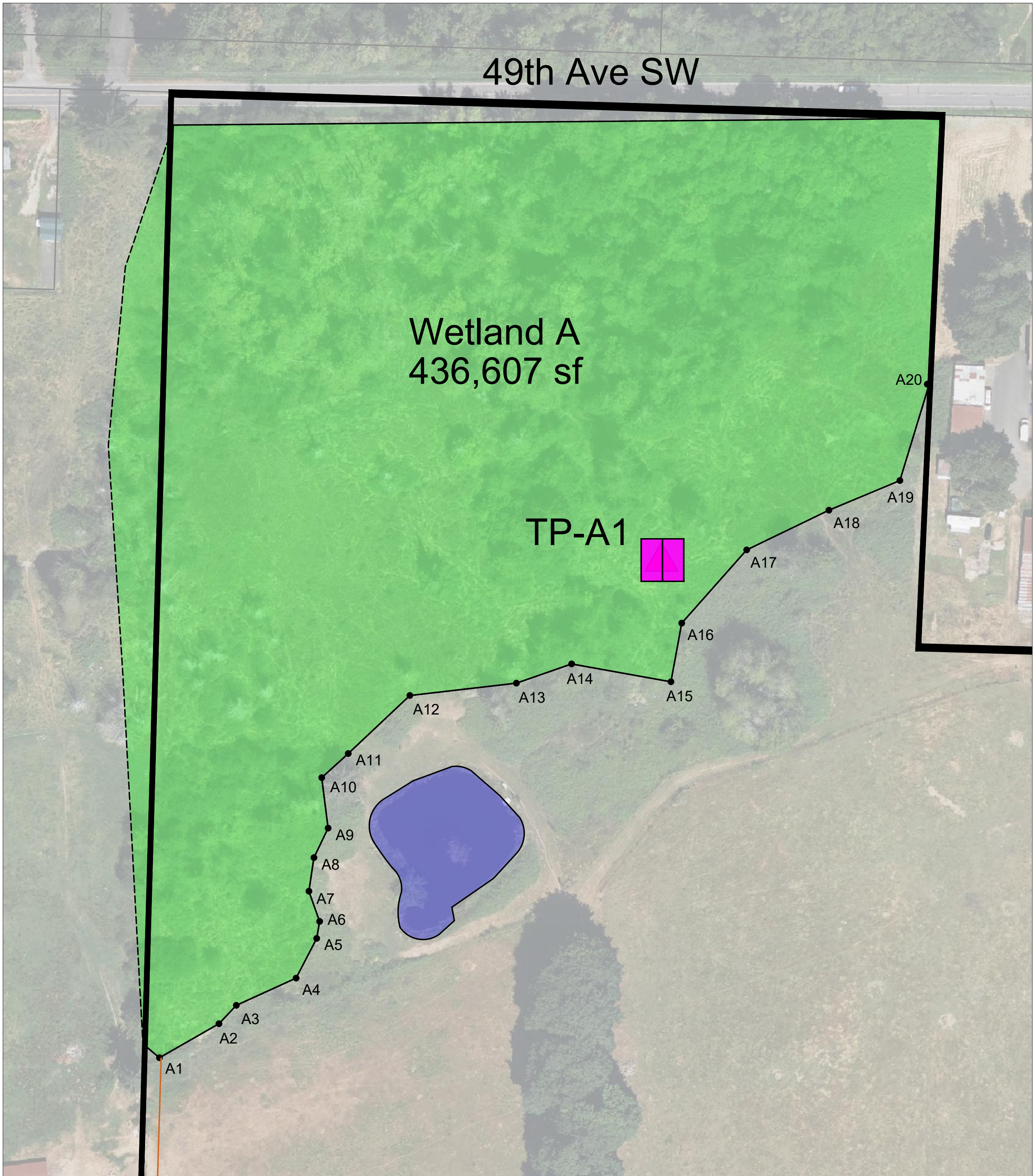
Bodenhamer

Results

Scale: 1" = 120'

0 120'

14 June 2023



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360-790-1559

Wetland (Delineated)
Wetland (Not Delineated)
Active Farm Pond

Positive	Negative	Chemical Test
Positive	Negative	Redox Test

Figure 6

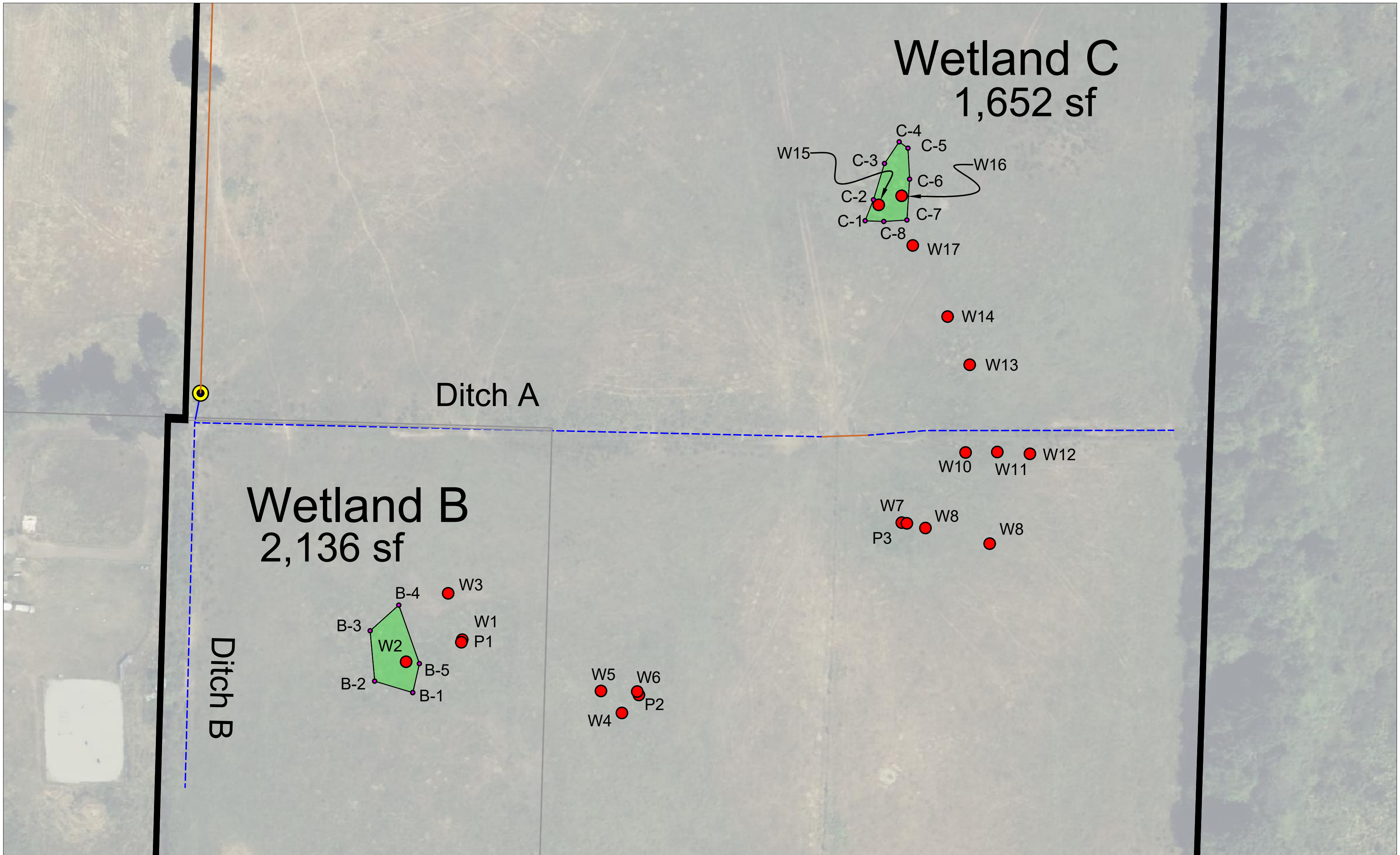
Bodenhamer

Wetland A Reference Test Results

Scale: 1" = 130'

0 130'

14 June 2023



EnviroVector
OPTIMIZE USABLE LAND

curtis@envirovector.com
www.envirovector.com
360-790-1559

Wetland (Delineated)

Figure 7

Bodenhamer

Results

Scale: 1" = 120'

0 120'

14 June 2023

APPENDIX A

Photographs

Subject Property

Photo 1. Livestock roam the entire subject property

Photo 2. Livestock roam the entire subject property

Photo 3. European pasture grasses dominate vegetation

Photo 4. Pastureland, livestock under trees in distance

Photo 5. Pastureland near farm pond, northern portion of property

Photo 6. Pastureland, European grasses


Photo 7. Farm pond on northern portion of property


Photo 8. Farm pond on northern portion of property


Photo 9. Heavily grazed grasses on edge of Wetland A


Photo 10. Heavily grazed pasture on northern part of property


Photo 11. Patches of scotch broom in the pasture

Photo 12. Highly trampled pasture from livestock

Photo 13. Heavily grazed and trampled pasture area

Photo 14. Pastureland facing west

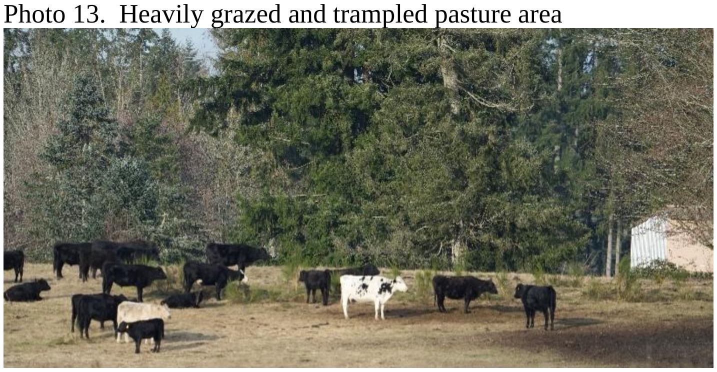


Photo 15. Livestock gathering in the pasture

Photo 16. Livestock near monitoring wells in pasture

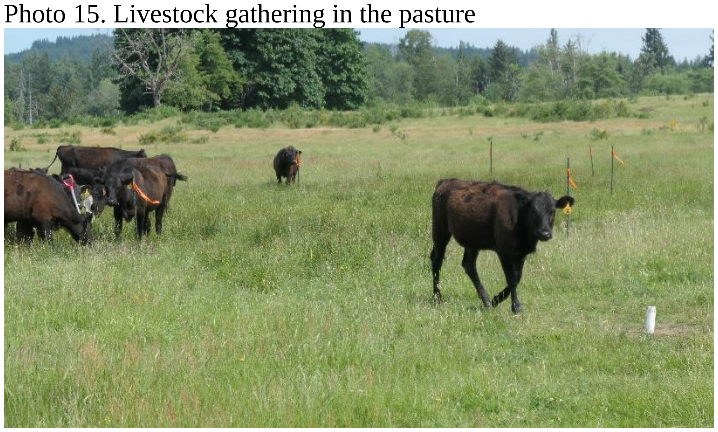


Photo 15. Livestock near Well W17

Photo 16. Livestock at Study Area F

Photo 19. Livestock stole my shovel in Study Atea F

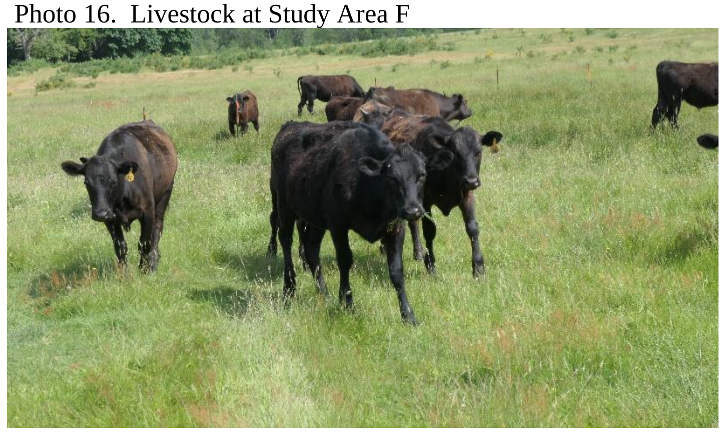


Photo 20. Livestock in Study Area E


Photo 21. Livestock near Well W17


Photo 22. Livestock on the subject property

Study Areas

Photo 23. Area A, winter, no water, buckets over the wells

Photo 24. Area A, summer, no water

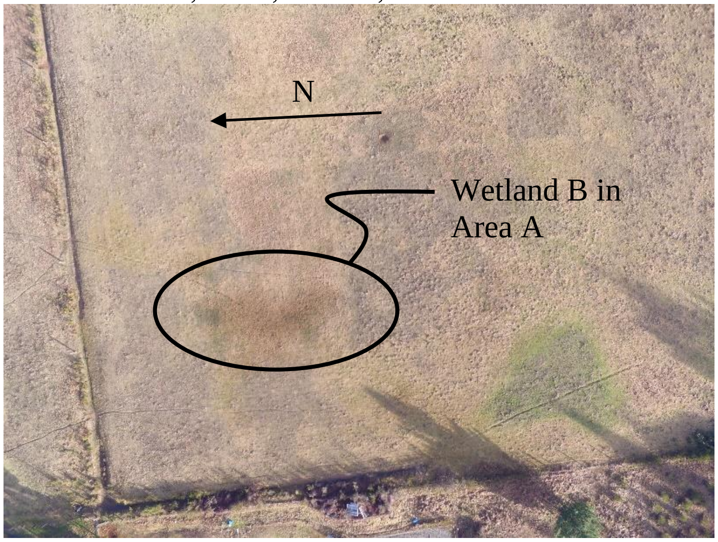


Photo 25. Area A from above

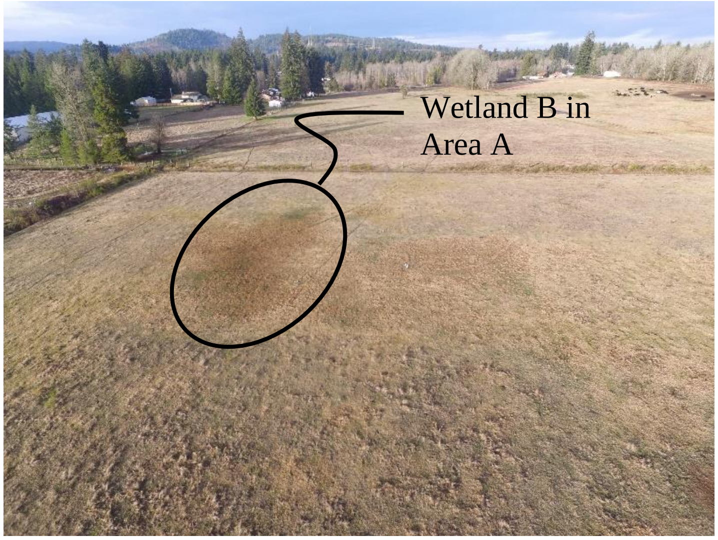


Photo 26. Area A from above

Photo 27. Area B during study, no water

Photo 28. Area B from a distance, no water

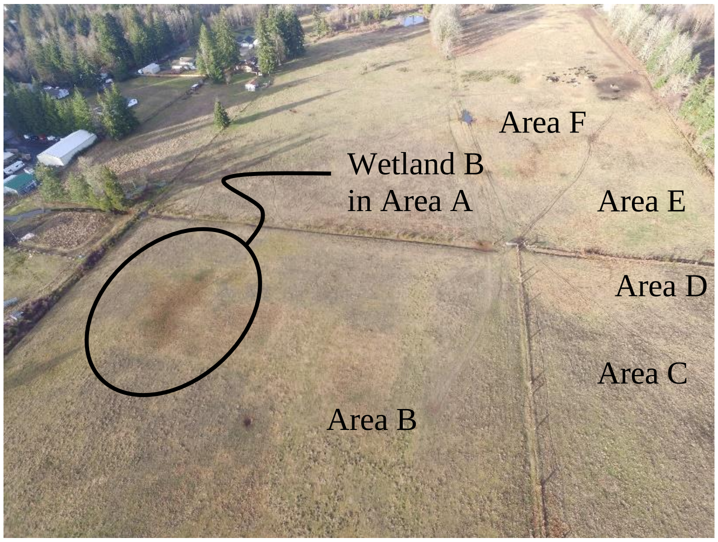


Photo 29. Areas A, B, C, E, & D

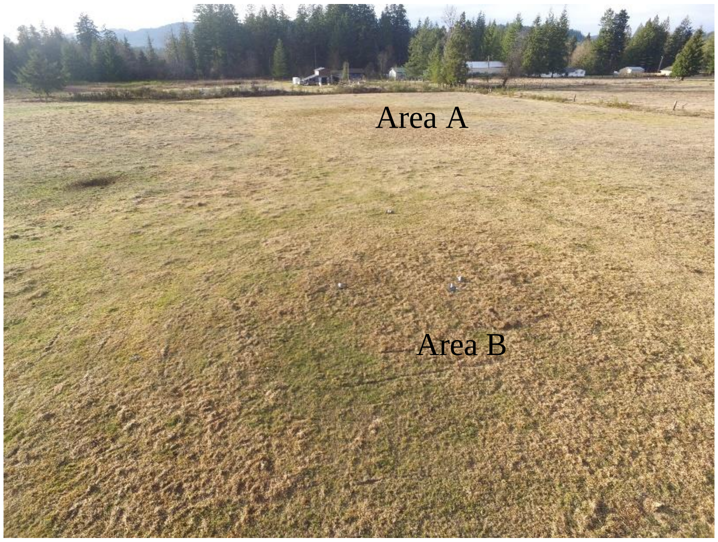


Photo 30. Areas A & B


Photo 31. Area C vegetation change, no water


Photo 32. Area C vegetation change, no water


Photo 33. Areas C & D


Photo 34. Areas B, E, & F


Photo 35. Wells 15 & 16 of Area F


Photo 36. Area F, no surface water


Photo 37. Area D in the winter, no surface water


Photo 38. Area D in the summer, no surface water


Photo 39. Area E in the winter, no surface water


Photo 40. Area E, Area F in background, no surface water

Photo 41. Area F, livestock in background, no surface water


Photo 42. Area F, no surface water, soft and slender rush

Well Monitoring

Photo 43. Installing Well W1 and Piezometer P1

Photo 44. Installing Well W1 and Piezometer P1


Photo 45. Wells W1, W2, & P1 in Area A


Photo 46. Wells W1, W3, & P1 in Area A

Photo 47. Well W2 in Area A

Photo 48. Well W3 in Area A

Photo 49. Well W3 in Area A

Photo 50. Well W3 in Area A

Photo 51. Datalogger in Well W3

Photo 52. Well W4, W6 & P2 in background, no surface water

Photo 53. Datalogger extracted from W3 at end of study, dry

Photo 54. Collecting well data in the field from dataloggers

Photo 55. Well W5 in Area B, no surface water

Photo 56. Well W5 in Area B, no surface water


Photo 57. Well W5 and Study Area B


Photo 58. Well W6 & Piezometer P2 in Study Area B

Photo 59. Well W9 in Study Area C


Photo 60. Device to measure water depth in well

Photo 61. Well W10 in Study Area D


Photo 62. Wells W10, W11, & W12 in Study Area D


Photo 63. Wells W10, W11, & W12 in Study Area D


Photo 64. Wells W10, W11, & W12 in Study Area D

Photo 65. Wells W10, W11, & W12 covered by blue buckets

Photo 66. Wells W10, W11, & W12 covered by blue buckets

Photo 67. Wells W17, W8, W9, & P3 under blue buckets, Area C

Photo 68. Wells W17, W8, & P3 under blue buckets, Area C

Photo 69. Well W11 in Study Area C

Photo 70. Well W12 in Study Area C

Photo 71. Well W15 in Study Area F

Photo 72. Well W15 in Study Area F

Photo 73. Well W16 in Study Area F

Photo 74. Well W17 in Study Area F

Photo 75. Installation of Well W17 in Study Area F

Photo 76. Datalogger installed within monitoring wells

Redox Test

Photo 77. Redox Test at Well W2, Study Area A

Photo 78. Redox Test at Well W2, Study Area A

Photo 79. Redox Test at Well W4, Study Area B

Photo 80. Redox Test at Piezometer W7, Study Area C

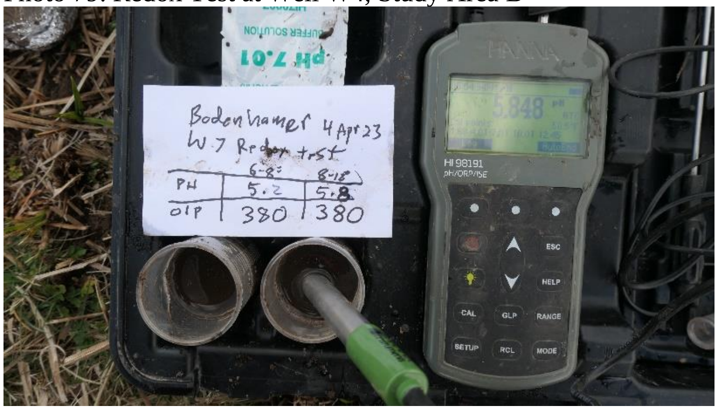


Photo 81. Redox Test at Well W7, Study Area C

Photo 82. Redox Test at Well W10, Study Area D

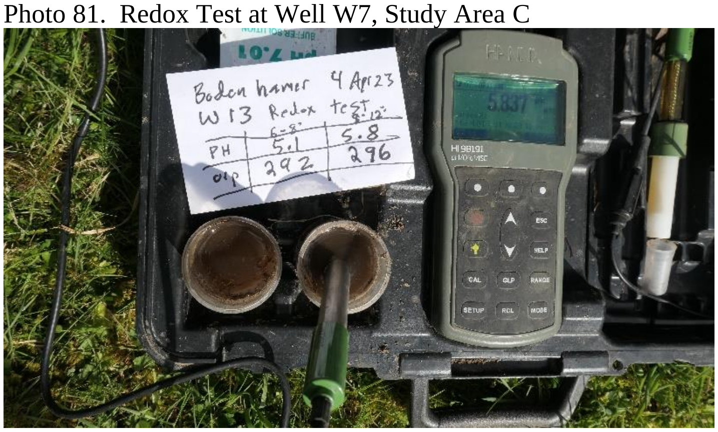


Photo 83. Redox Test at Well W13, Study Area E

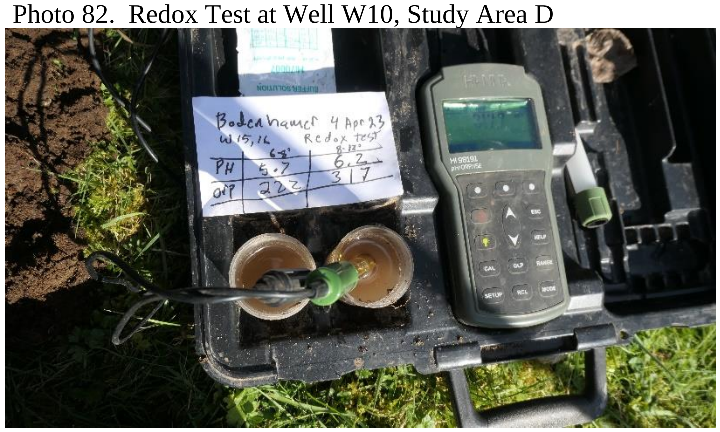


Photo 84. Redox Test at Well W15,W16, Study Area F

Photo 85. Redox Test Positive at TP-A1 in Wetland A

Photo 86. Redox Test Positive at TP-A1 in Wetland A

Chemical Test

Photo 87. Alpha alpha dipyridyl negative at W2, Study Area A

Photo 88. Alpha alpha dipyridyl negative at W2, Study Area A

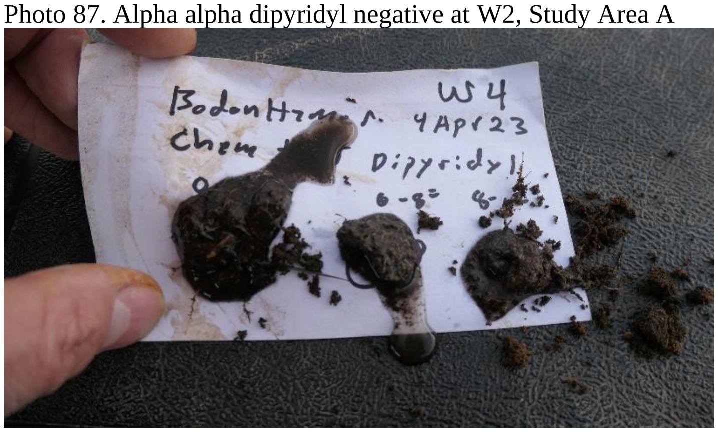


Photo 89. Alpha alpha dipyridyl negative at W4, Study Area B

Photo 90. Alpha alpha dipyridyl negative at W4, Study Area B

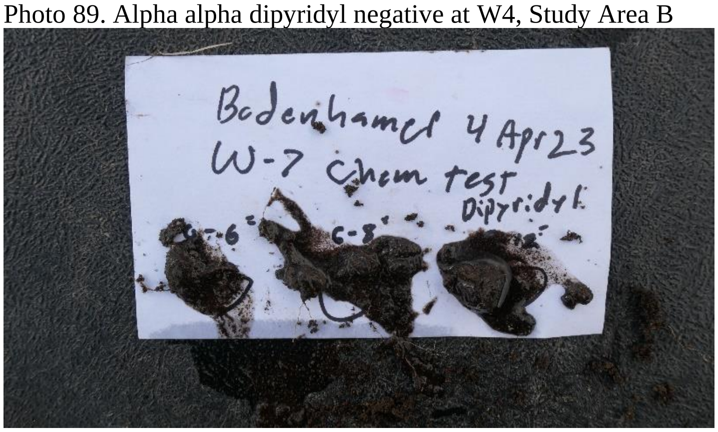


Photo 91. Alpha alpha dipyridyl negative at W7, Study Area C

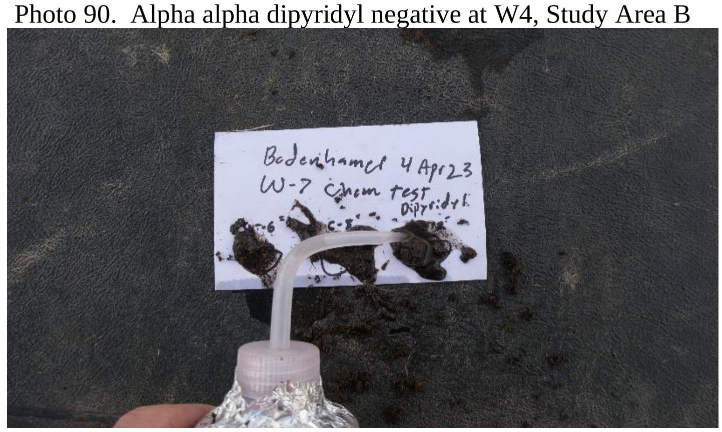


Photo 92. Alpha alpha dipyridyl negative at W7, Study Area C

Photo 93. Alpha alpha dipyridyl negative at W10, Study Area D

Photo 94. Alpha alpha dipyridyl negative at W13, Study Area E

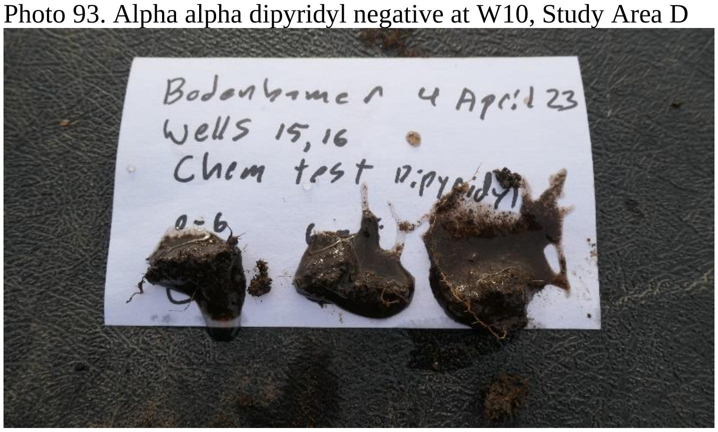


Photo 95. Alpha alpha dipyridyl negative at W15, Study Area F

Photo 96. Alpha alpha dipyridyl negative at W15, Study Area F

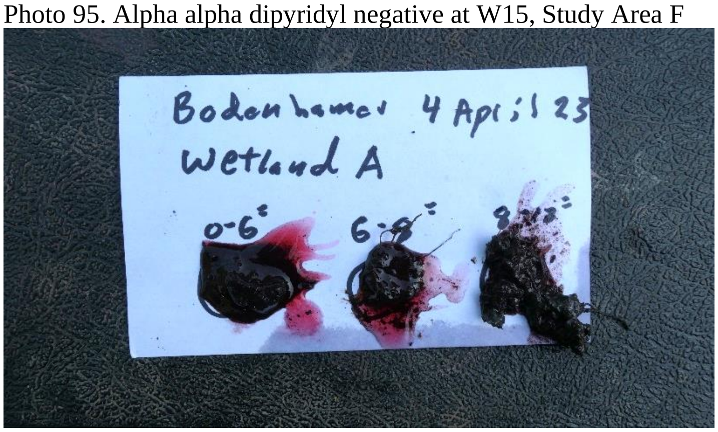


Photo 97. Alpha alpha dipyridyl positive in Wetland A

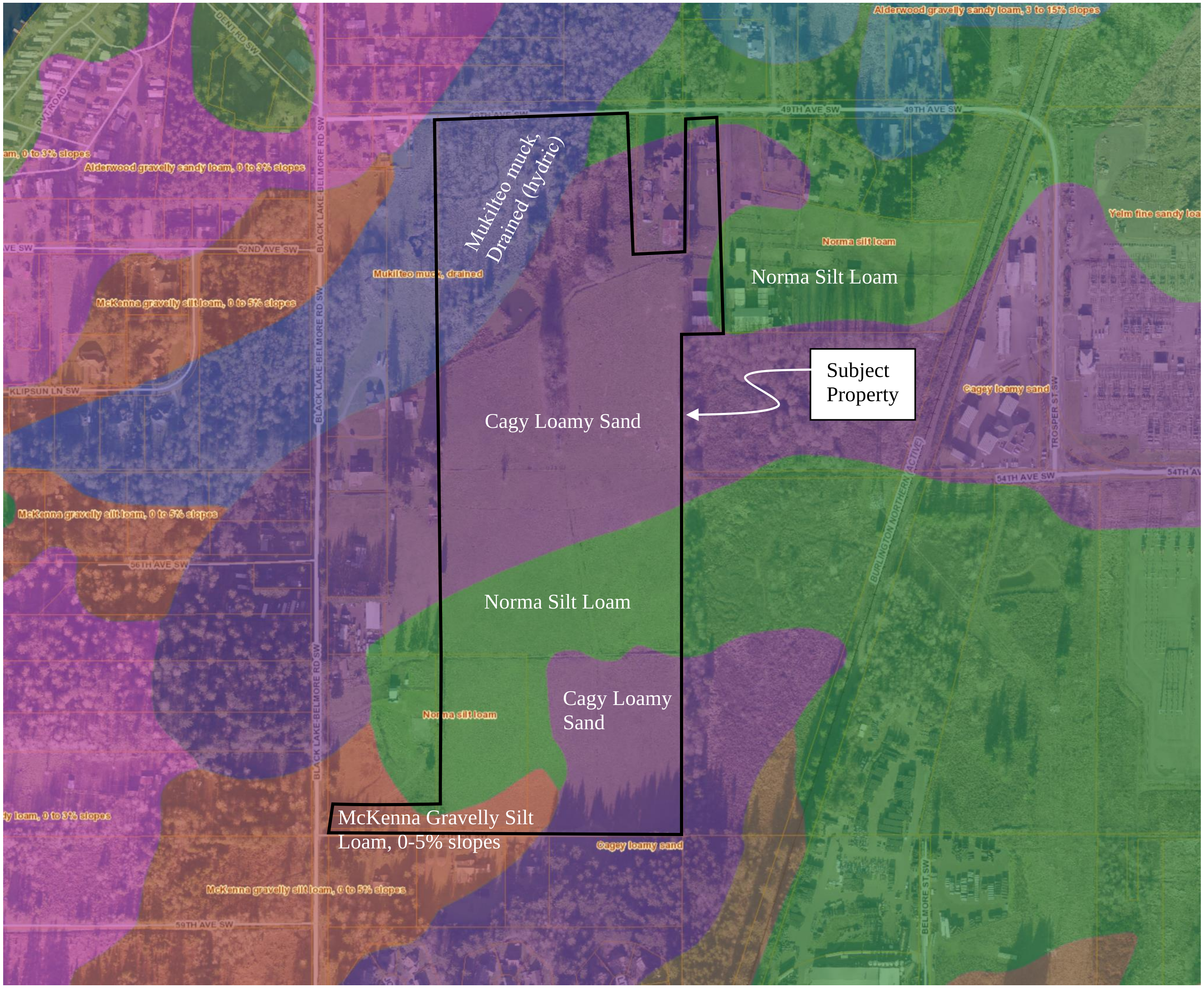
Photo 98 Alpha alpha dipyridyl Positive in Wetland A

Appendix B

Thurston County

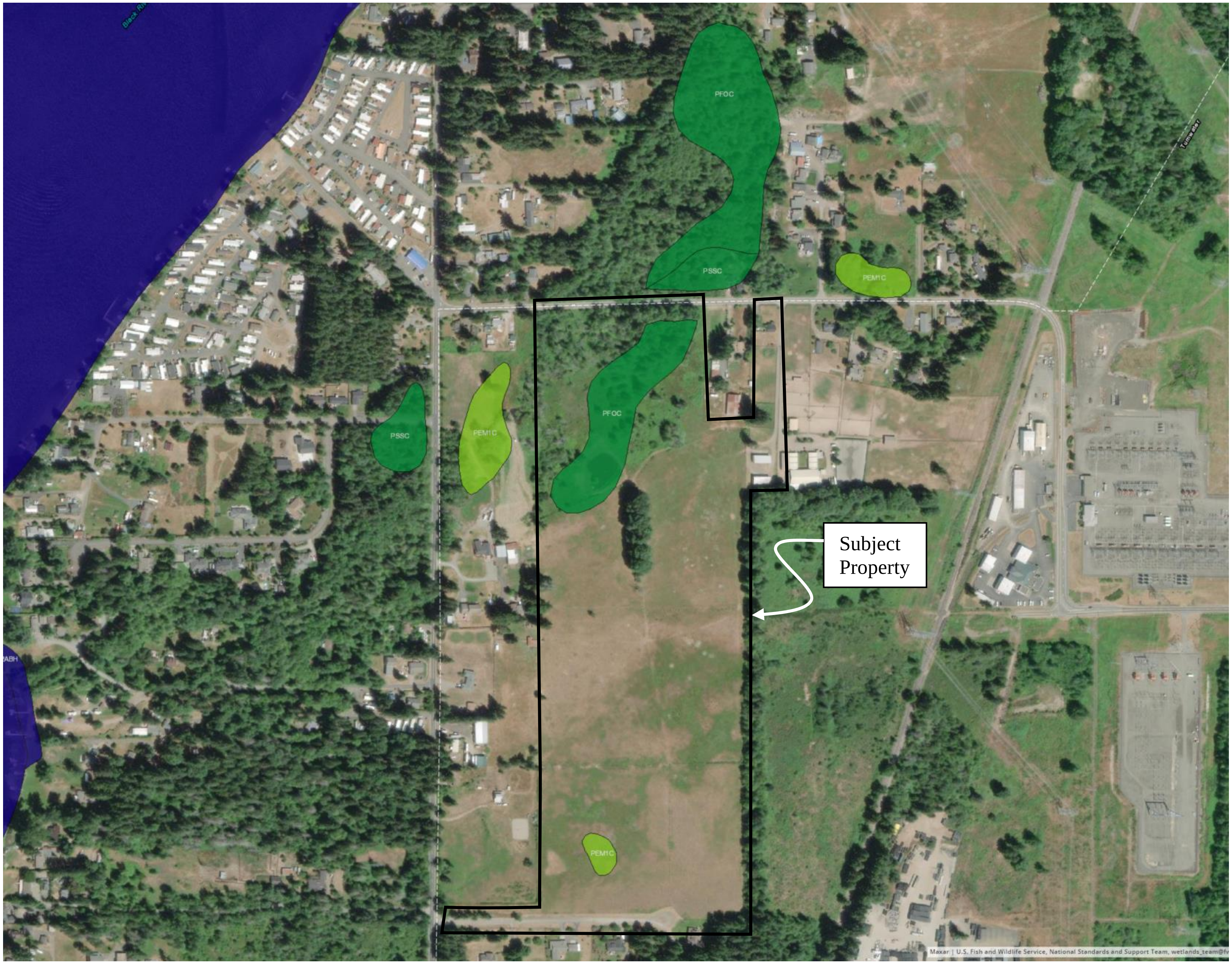
Geodata Center

Soils Survey


Mukilteo muck, Drained (hydric)
Norma Silt Loam
Subject Property
Cagy Loamy Sand
Norma Silt Loam
Cagy Loamy Sand
McKenna Gravelly Silt Loam, 0-5% slopes
Alderwood gravelly sandy loam, 3 to 15% slopes
Alderwood gravelly sandy loam, 0 to 3% slopes
Mukilteo muck, drained
McKenna gravelly silt loam, 0 to 5% slopes
Norma silt loam
Cagey loamy sand
49TH AVE SW
52ND AVE SW
KLIPSUN LN SW
54TH AVE SW
56TH AVE SW
59TH AVE SW
BLACK LAKE BELMORE RD SW
BURLINGTON NORTHERN

Appendix C

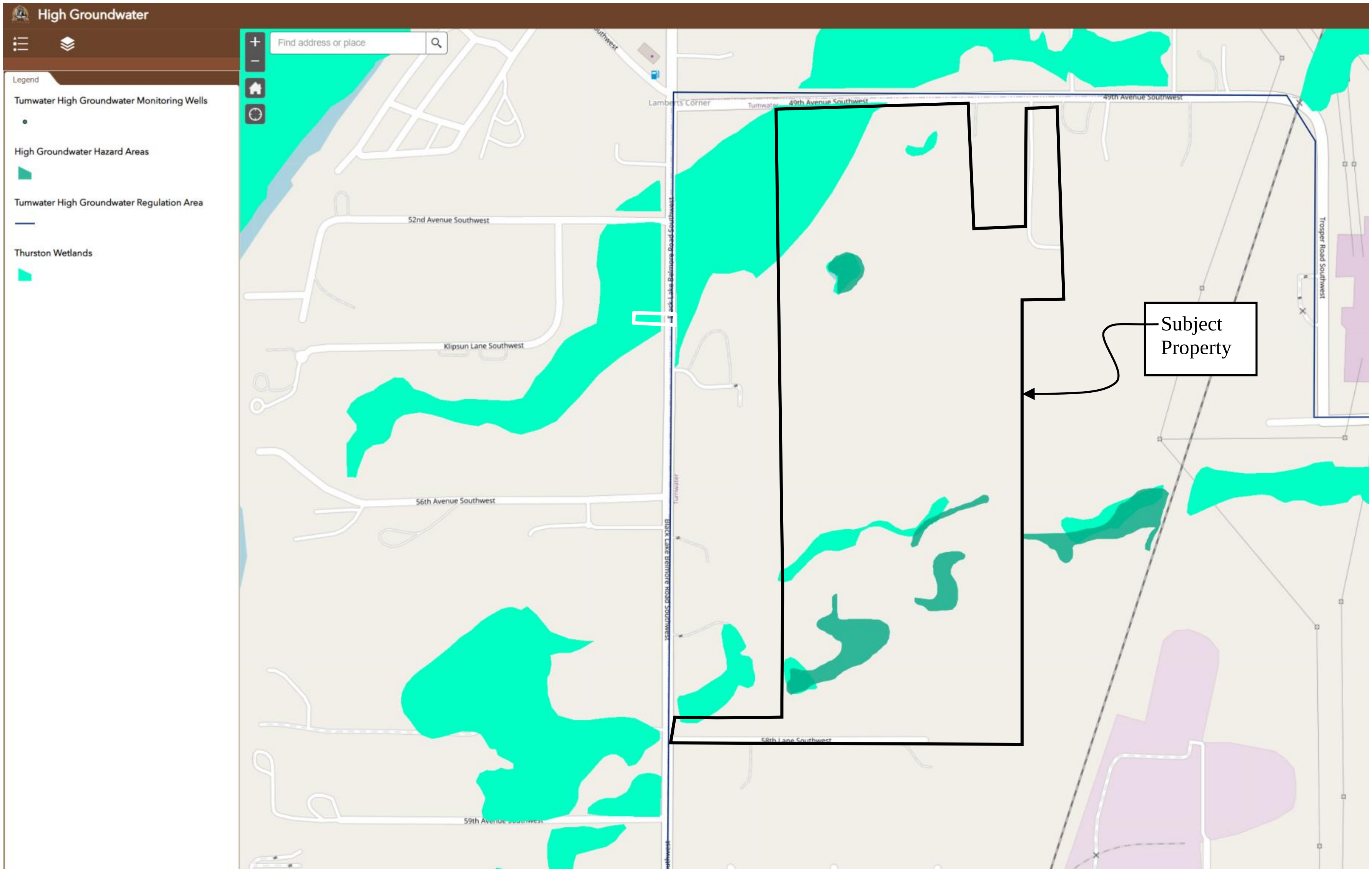
National Wetlands Inventory (NWI)


PFOC
PSSC
PEM1C
PFOC
PSSC
PEM1C
PEM1C
Subject Property

Appendix D

City of Tumwater

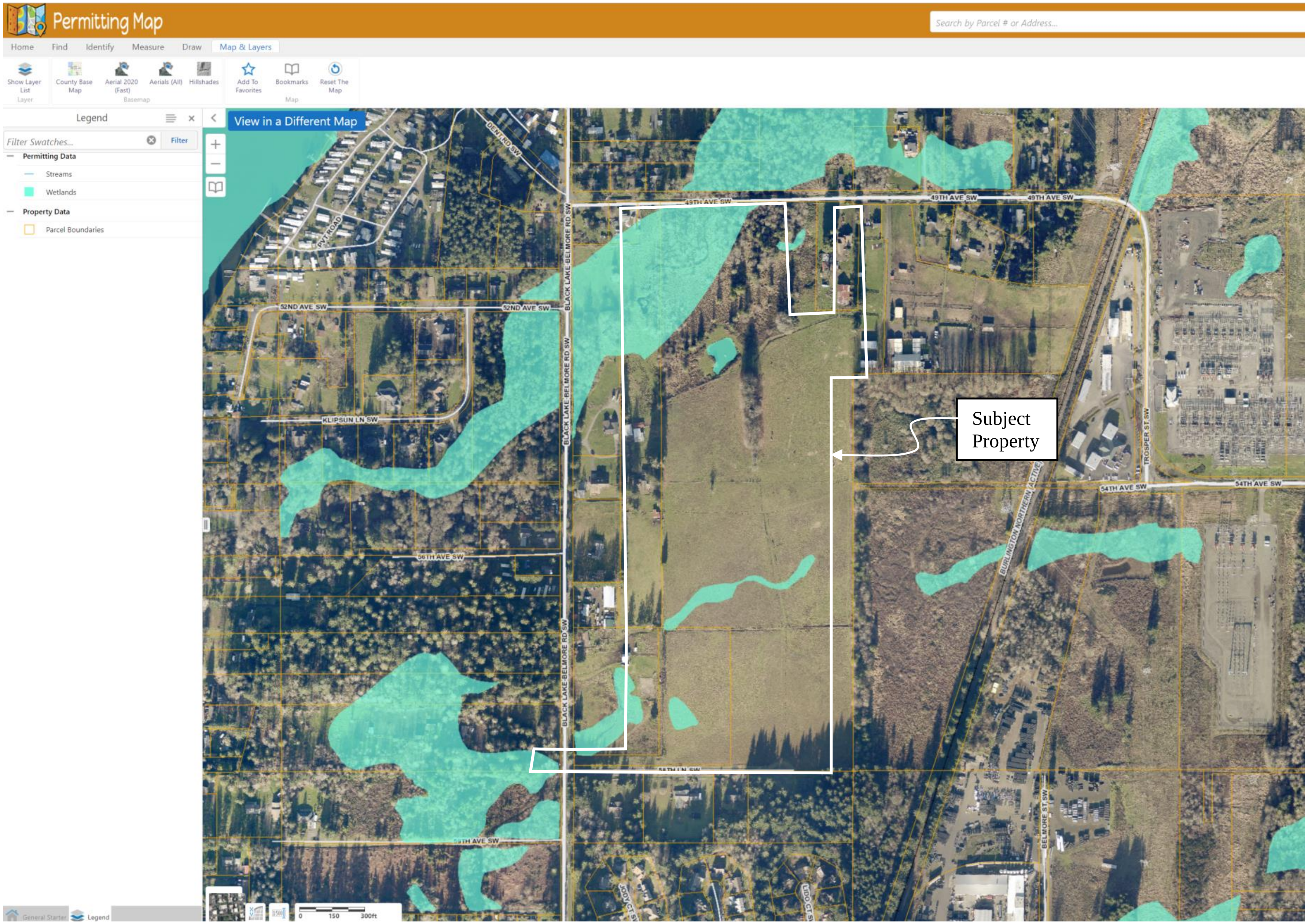
Wetlands and Streams


High Groundwater
Legend
Tumwater High Groundwater Monitoring Wells
High Groundwater Hazard Areas
Tumwater High Groundwater Regulation Area
Thurston Wetlands
Find address or place
52nd Avenue Southwest
Klipsun Lane Southwest
56th Avenue Southwest
59th Avenue Southwest
49th Avenue Southwest
Black Lake Belmore Road Southwest
Trosper Road Southwest
Subject Property

Appendix E

Thurston County

Geodata Center Database



Permitting Map
Search by Parcel # or Address...
Home
Find
Identify
Measure
Draw
Map & Layers
Show Layer List
Layer
County Base Map
Aerial 2020 (Fast)
Aerials (All)
Hillshades
Basemap
Add To Favorites
Bookmarks
Reset The Map
Map
Legend
Filter Swatches...
Filter
Permitting Data
Streams
Wetlands
Property Data
Parcel Boundaries
View in a Different Map
49TH AVE SW
52ND AVE SW
KLIPSUN LN SW
56TH AVE SW
54TH AVE SW
BLACK LAKE-BELMORE RD SW
BURLINGTON NORTHERN (ACTIVE)
TROSPER ST SW
Subject Property
0 150 300ft

Appendix F

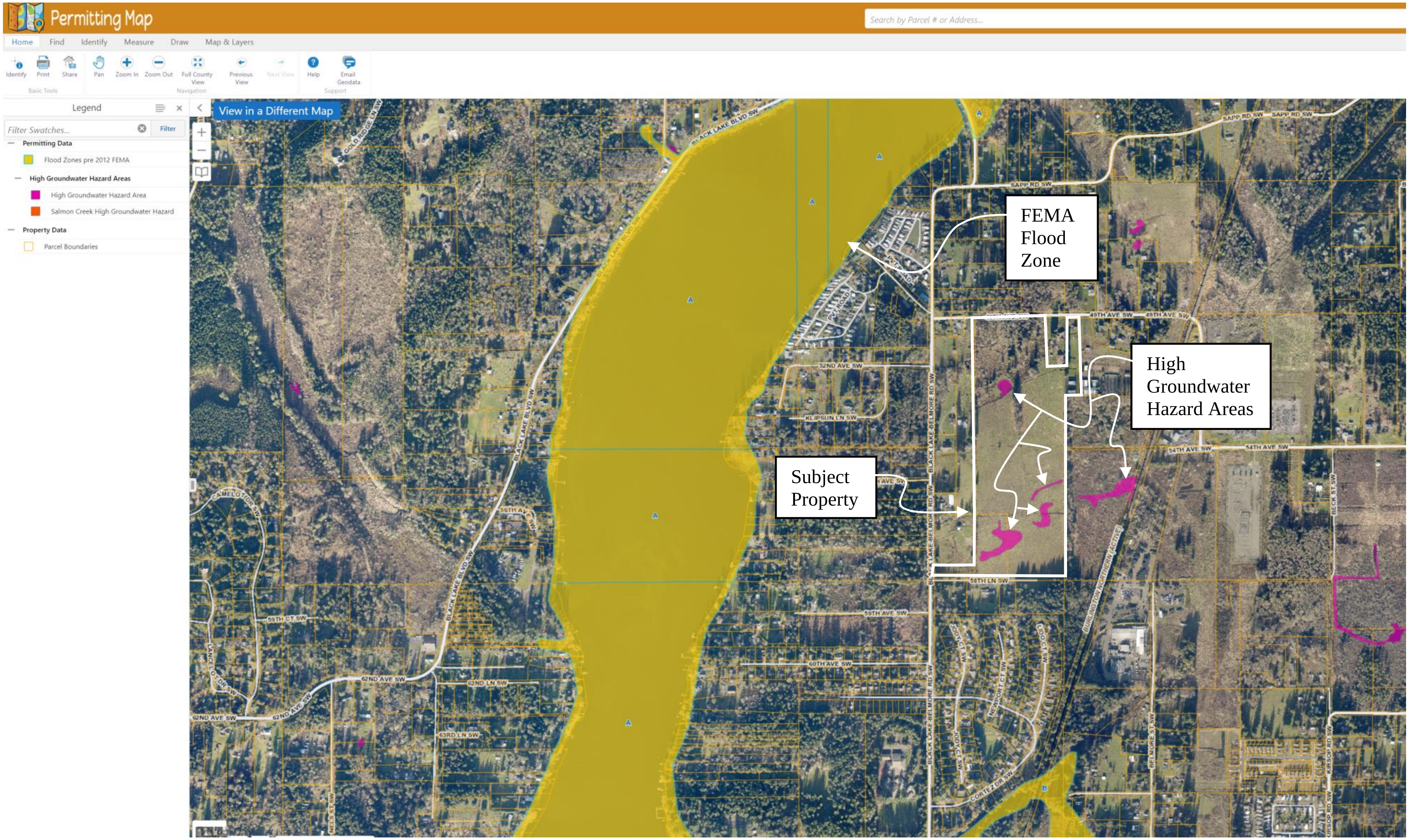
Thurston County

Geodata Center

High Water Hazard Area

&

FEMA Flooding


Permitting Map
Home
Find
Identify
Measure
Draw
Map & Layers
Legend
View in a Different Map
Permitting Data
Flood Zones pre 2012 FEMA
High Groundwater Hazard Areas
High Groundwater Hazard Area
Salmon Creek High Groundwater Hazard
Property Data
Parcel Boundaries
FEMA Flood Zone
High Groundwater Hazard Areas
Subject Property