Zylstra Lake Water Rights Management Assessment

Prepared for Washington Water Trust

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NORTHWEST
Land & Water, INC.
Consulting in Hydrogeology

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Northwest Land &Water's professional services were performed, its findings obtained, and this report prepared in accordance with generally accepted hydrogeologic practices at this time and in this area, exclusively for the use of Washington Water Trust and the other project partners (San Juan Preservation Trust, San Juan County Land Bank, San Juan Islands Conservation District, Washington State Department of Ecology, and Washington State Department of Fish & Wildlife). This warranty is in lieu of all other warranties, expressed, or implied.

Introduction

The San Juan Preservation Trust (SJPT) is in the process of purchasing 313 acres of land formerly owned by the Tomas family on San Juan Island. This land includes two lakes — Upper Zylstra Lake (UZL) and Lower Zylstra Lake (LZL) — which were created behind earthen dams that had been constructed by the end of 1965. **Figure 1** is a map showing the location of the Zylstra Lakes. These lakes are the headwaters of False Bay Creek (FBC), which flows about 2.5 miles into False Bay on the west side of San Juan Island.

Project Goals & Scope

Washington Water Trust (WWT) and its partners have several goals for this project. One is to assess the feasibility of using Zylstra Lake (UZL/LZL) during low-flow months to augment downstream flows in a restored FBC. Another is to explore the possibilities for increasing the success of fish passage into the lake, which would expand available habitat for a variety of species such as freshwater cutthroat trout, sea-run cutthroat trout, and possibly chum and coho salmon. A third goal is to assess possible recreational uses — boating, fishing, and swimming — at Zylstra Lake. Finally, WWT and its partners would also like to understand the potential for lake releases to remain instream after FBC is restored.

These assessments were conducted by Northwest Land & Water, Inc., (NLW) with assistance from Smayda Environmental Associates, Inc., (SEA). Earthfx, Inc., provided technical support for data processing.

An additional assessment goal was stated at the outset of this project: using Zylstra Lake as a source of water for the Town of Friday Harbor. However, on January 6, 2016, a phone discussion with the Town administrator revealed that Friday Harbor supports this project but was no longer interested in pursuing water from Zylstra Lake. Thus, this assessment goal was dropped from the project scope of work.

Zylstra Lake Characteristics

Lake Dimensions

Documentation on file with Ecology's Dam Safety group, information from other sources, and analyses conducted as part of this study, indicate the following estimates of lake dimensions:

Table 1: Zylstra Lake Dimensions (Full-Pool Conditions) Cited in Different Sources

Source	1	2	3	4	5
UPPER ZYLSTRA LAKE					
Storage volume (AF)	285	350	440	379.7	471.8
Area (acres)	48	48	53	47.6	44.0
Maximum depth (ft)	11, 12.3	16	---	16	24
LOWER ZYLSTRA LAKE					
Storage volume (AF)	7 - 8	---	---	37.5	37.5
Area (acres)	3	---	---	7.2	7.2
Maximum depth (ft)	6	---	---	10	10

Sources: *(1) Ecology water rights documents; (2) Water Supply Bulletin 43, measurements 3/18/74; (3) Water Supply Bulletin 46; uncertain if volume and area refer to UZL or UZL + LZL; (4) This study: UZL bathymetry based on Water Supply Bulletin 43a lakebed soundings, 3/18/74, LZL bathymetry based on USGS 7.5-min Friday Harbor Quad 20-foot contours, 1954; (5) This study: UZL and LZL bathymetry based on USGS 7.5-min Friday Harbor Quad 20-foot contours, 1954*

"Full-pool" conditions, which have likely occurred during most spring seasons since 1965, are presumed to be 54 and 43.5 feet msl, respectively, for the UZL and LZL. These elevations were estimated from observations during a site visit on 11/12/15, interpretation of LiDAR topography, and the assumption that the maximum number of "stop" boards is placed at the UZL and LZL dams. As such, our estimate is likely accurate to approximately +/– 1 foot.

The range of lake volume, area, and depths shown in **Table 1** reflects different investigators using different methods of calculation. Our estimates (sources #4 and #5) for the UZL volume and area are based on different data sets. The UZL volume difference (#4 versus #5), to some degree, may reflect sediment accumulation in the lake from 1965 to 1974. We believe that source #4 likely best represents the current UZL and LZL full-pool conditions.

Water Rights & Uses

The lake was permitted by the Ecology for irrigation and/or stock uses under two rights — a reservoir water right and a surface water right. Ecology's Water Resources Explorer water rights web portal[1] contains the following records for the UZL and LZL:

- **Reservoir Water Right**
  Record No: R1-*17690CWRIS
  Priority Date: January 17, 1963
  Annual Volume: 285 acre-feet (AF)
  For Use On: 295 acres
  Purpose: Irrigation

- **Surface Water Right**
  Record No: S1-*16996ALCWRIS
  Priority Date: May 15, 1961
  Instantaneous Diversion Rate: 0.39 cfs, irrigation; 0.01cfs, stock
  Annual Volume: 80 AF
  For Use On: 40 acres
  Purpose: Irrigation, Stock Water

Preliminary discussions with WWT's representative and two project partners (Ecology and SJPT) suggest that the reservoir water right has been perfected, is valid, and is transferable to recreation and instream purposes. Anecdotal information suggests that little irrigation has occurred under the surface water right in many years; consequently, all or part of that right may be found to be relinquished.

Watershed View

Figure 1 shows Zylstra Lake (UZL/LZL) in relation to the FBC watershed, three subwatersheds, streams, and other features. Watershed boundaries were delineated by Earthfx using LiDAR from the San Juan County / Puget Sound LiDAR Consortium.

False Bay Creek Watershed

This watershed is the largest area that potentially affects the long-term success of an implemented Zylstra Lake – FBC restoration project. Land activities here, including water withdrawals, can influence the flow and quality of surface and groundwater that occurs upstream and downstream of Zylstra Lake and that flows via FBC to False Bay.

Zylstra Lake Subwatershed

This subwatershed is the source of water to the UZL via, direct precipitation into the UZL/LZL, runoff from precipitation, groundwater exchange, and evapotranspiration. Surface water flows into the UZL at three inflow points (**Figure 1)**. The Town of Friday Harbor stores and diverts its municipal supplies from within 7.59 of the 8.93 square miles (or 85 percent) that comprise this subwatershed. Other landowners also consumptively use water from wells and ponds. This water use is not quantified as part of this assessment but is believed to be less than the Town's annual diversion and the annual runoff that reaches Zylstra Lake.

False Bay Creek Subwatershed

Activities in this subwatershed have the potential to "make or break" FBC restoration efforts. Careful planning, design, and coordination will be needed to shape the FBC's physical structure and ultimately its ability to support a diversity of species and their life cycles. Key to these planning efforts will be developing an understanding of surface water – groundwater interactions and managing land in ways that do not impact water quality.

San Juan Creek Subwatershed

Similar to the FBC subwatershed, activity in this area has the potential to influence the habitat quality downstream of its confluence with FBC and the estuary conditions in False Bay.

Three Assessments

Three assessments were conducted for this investigation:

- An assessment of the ability of Zylstra Lake to provide reliable downstream flows to FBC under specific average and drought conditions
- An assessment of the likelihood that flows in a restored FBC will remain instream despite withdrawals in the watershed for various uses
- An analysis of annual flows into Zylstra Lake to determine whether it can be replenished under average, drought, and extreme drought conditions

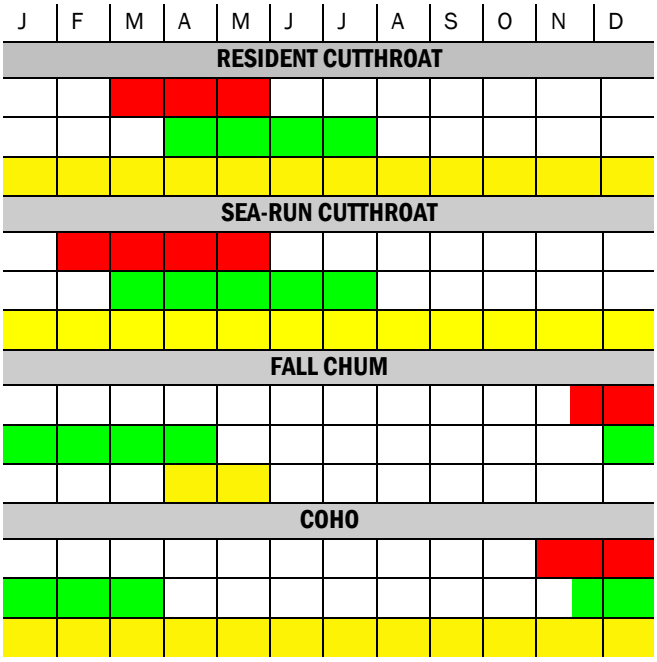
The methodology and results of these assessments are described below.

[1] *https://fortress.wa.gov/ecy/waterresources/map/WaterResourcesExplorer.aspx*

Zylstra Lake as Downstream Flow Source

WWT et al. (2012) described the potential for restoring salmonid creek habitat within FBC between Zylstra Lake and the False Bay estuary. This habitat, if used by resident and sea-run cutthroat, would require "survival" flows of an estimated 0.25 cfs in late spring to mid-summer, followed by 0.1 cfs through early fall. Flows of 0.25 cfs or greater from spring through fall are preferable. Other salmonids that could potentially use a restored FBC are fall chum and coho. "Optimal" flows for potential fish in FBC may be on the order of 1 cfs (email comm., Boessow, 1/29/16). The life cycle of four species is shown in **Table 2**.

Table 2: Potential Salmonid Use of False Bay Watershed by Species, Life Stage, & Season



From A Catalog of Washington Streams and Salmon Utilization, Volume 1, Dept. of Fisheries; Red = Spawning, Green = Incubation (includes intra-gravel development of fry up to emergence), Yellow = Rearing

Table 3: Flow Upstream & Downstream of Zylstra Lake

LOCATION ID	FLOW RATE (CFS)	DATE
006-OUGA	0.09	9/14/15
006-OUGA	0.11	8/9/15
006-OUGA	0.06	7/20/15
006-OUGA	0.11	6/15/15
006-OUGA	0.19	5/19/15
006-OUGA	0.54	4/14/15
006-OUGA	36.31	3/17/15
006-OUGA	20.93	2/9/15
006-OUGA	15.48	1/21/15
Bailer Hill Rd	4.5	3/10/11
SJ Valley Rd	0.84	3/10/11
SJ Valley Rd	1.53	5/25/10

All locations are approximately 0.3 miles upstream of Zylstra Lake except Bailer Hill Rd, which is 1.8 miles downstream. Station 006-OUGA is near the Town's Augmentation 2 facility.

Streamflow data for inflow to Zylstra Lake and downstream in FBC are limited. The San Juan Island Conservation District (SJICD) and Washington Department of Fish & Wildlife have measured flow at Wold Road near the inflow to UZL and Bailer Hill Road on FBC. These flows (**Table 3**) are consistent with observations on San Juan Island of variable runoff (variable streamflow) from rain events November through April as well as with observations of negligible streamflow from May through October. Thus, late spring, summer, and early fall flow restoration in FBC downstream of the lakes requires water to be released from storage at Zylstra Lake.

Below we examine two scenarios of flow release from Zylstra Lake downstream to FBC:

- **Scenario 1** is for average conditions, with flow releases from Zylstra Lake occurring from June 1 to October 1.
- **Scenario 2** is for drought conditions, with flow releases from Zylstra Lake required from April 1 through November 1.

Zylstra Lake drawdown was tracked from month to month using a water-balance worksheet developed during this study; lake drawdown is based on the relationship between lake storage and water level (source #4

data, **Table 1**) derived from a bathymetry analysis of the UZL and LZL.

Scenario 1: "Average" UZL/LZL Condition

The following assumptions were used to develop this average water-balance scenario:

- UZL and LZL are at full pool (54 and 43.5 feet msl) on June 1.
- Surface water inflow to UZL/LZL ends on June 1.
- Substantial fall rains start on October 1.
- Flow release is 0.25 cfs for June and July and 0.1 cfs for August and September. The release is from the UZL, passing through the LZL, to the FBC.
- Gains to UZL/LZL via groundwater inflow are offset by losses from the two lakes due to shoreline plant transpiration plus dam leakage. Dam leakage, while a loss from the lake, is a gain to FBC. Note that other potential gains to FBC downstream of LZL are from groundwater, ponds, and tributary streams (including San Juan Valley creek).
- LZL is used as a "pass-through" water body for flow out of UZL and for migrating fish; consequently, there is no flow release for FBC from LZL.

The results of Scenario 1 are shown in **Table 4**. The total drawdown in the UZL from June 1 to October 1 is 2.3 feet. **Figure 2** shows the UZL shoreline for full pool (June 1; green polyline) along with the shoreline for 2 feet of drawdown (red polyline). Polylines representing the shorelines were generated in 1-foot increments to approximate the actual drawdowns. About 23 percent of the full-pool surface area in the UZL is lost by October 1. Note that the LZL drawdown of 1.3 feet is modeled to result only from evaporation.

Scenario 1 achieves the objectives for meeting downstream target flows and leaving sufficient water in the UZL for cutthroat to find thermal refuge at deeper levels. Additionally, recreational values will likely be maintained to a reasonable degree; the drawdown of 2.3 feet is not expected to significantly shift the UZL shoreline and will leave a sufficient depth for small sailboats.

Scenario 2: "Drought" UZL/LZL Condition

The following assumptions were used to develop this drought water-balance scenario:

- UZL and LZL are at full pool (54 and 43.5 feet msl) on April 1.
- Surface water inflow to UZL/LZL ends on April 1.
- Substantial fall rains start on November 1.
- Flow release is 0.25 cfs for April 1 to November 1. The release is from the UZL, passing through the LZL, to the FBC.
- The lake evaporation rate increases by 10 percent above the Scenario 1 rate.
- Gains to UZL/LZL via groundwater inflow are offset by losses from the two lakes due to shoreline plant transpiration plus dam leakage. Dam leakage, while a loss from the lake is a gain to FBC. Note that other potential gains to FBC downstream of LZL are from groundwater, ponds, and tributary streams (including San Juan Valley creek).
- LZL is used as a "pass-through" water body for flow out of UZL and for migrating fish; consequently, there is no flow release for FBC from LZL.

The results of Scenario 2 are shown in **Table 5**. The total drawdown in the UZL from April 1 to November 1 is 4.6 feet. The UZL area for full pool (April 1) is shown in **Figure 3** (green polyline), along with the shoreline for 5 feet of drawdown (red polyline). Again, polylines representing the shorelines were generated in 1-foot increments to approximate the actual drawdowns. About 31 percent of the full-pool surface area of the UZL is lost by October 1. Note that the LZL drawdown of 1.7 feet is only from evaporation.

The Scenario 2 shoreline position is more substantially reduced than Scenario 1, as we can see by comparing **Figures 2 and 3**. Releasing water from the LZL instead of the UZL would reduce UZL drawdown. As an example, 0.25 cfs released for 1 month from the LZL instead of the UZL would reduce the UZL drawdown by about 0.3 feet. There has also been discussion about raising the LZL spillway by 2 feet. This would add about 15 AF of storage, approximately 0.25 cfs released for 1 month. Assuming a raised LZL spillway and 2 months of 0.25 cfs release from the LZL instead of the UZL, drawdown in the UZL would be decreased by about 0.7 feet, to approximately 3.9 feet instead of 4.6 feet.

With a full-pool condition on April 1, the UZL storage is sufficient to release water under this drought Scenario 2. However, this 4- to 5-foot drawdown has potential to:

- Reduce cool-water refugia in the lake
- Increase the internal loading of phosphorus
- Promote algae blooms
- Expand the extent of macrophyte colonization within the lake
- Generally make the lake smaller, warmer, weedier, and more eutrophic

Although these impacts would reduce the lake's suitability to support salmon (cutthroat and juvenile) and water recreation, some benefits to fish and humans would remain. Understanding these types of issues will be important to developing lake management scenarios. The low-pool elevation of Zylstra Lake, which is yet to be determined, will also inform management scenarios. Note that during years of extremely low / warm water, conditions are relatively poor for native fish but may be excellent for native amphibians and other species and that this type of fluctuation may be acceptable to the project partners.

Flow Release Water Remaining Instream

Wells and ponds occur downstream of the LZL dam. These wells and ponds are likely hydraulically connected to the FBC, a condition that will not change after restoration. As such, they represent locations where landowners can withdraw or divert water, resulting in some depletion of FBC flows. Water will also be lost from dug ponds through the process of evapotranspiration. The non-use of these wells and ponds for domestic or irrigation purposes would potentially represent a net gain in flow over the current condition. Therefore, it is important to understand who is using this water, how much they are using, and how and where they are using it in order to refine the water budget for FBC.

Although such a detailed analysis is beyond the scope of this investigation, we can estimate the potential impacts of pumping using a simple calculation. A GIS count reveals 14 wells in or very near the FBC subwatershed north of Bailer Hill Road. It would be reasonable to assume that each of these wells withdraws water at rates ranging from 150 to 250 gpd, a typical per-household range that planners often use in the absence of substantial irrigation. Given these assumptions, the total amount of water pumped from these wells would range from 2,100 to 3,500 gpd or 0.003 to 0.005 cfs, which represents between 1 and 2 percent of the 0.25 cfs of flow released to FBC. A significant amount of this pumped water would potentially recharge the source aquifer via return flow from septic systems. Diversion and irrigation from dug ponds in the subwatershed would further increase water consumption and potentially affect the released flow in FBC.

Annual Flows to Zylstra Lake

Scenarios 1 and 2 indicate that Zylstra Lake can meet recreational needs and supply the target flow rates in the downstream FBC. However, an additional question remains about whether rainfall and runoff volumes are sufficient from the Zylstra Lake subwatershed to refill the lake annually and meet full-pool conditions each spring.

The first step of this analysis entailed extrapolating rainfall at a station near the Town's water treatment facility upstream of Zylstra Lake, which had a shorter period of record than the station at Olga. We correlated rainfall at the two stations for the period from January 1993 to November 2015 (r^2=0.79) and used this information to extend the rainfall for the treatment facility station back to 1891. Three conditions were then selected to assess how much water was "available" to refill of Zylstra Lake given historic rainfall and Friday Harbor's production from the upstream subwatershed:

- Average rainfall, years 1993 to 2015
- Drought, water years 1993 and 1994
- Extreme drought, water years 1929 and 1930

The Thornthwaite-Mather model developed in Water Supply Bulletin 43 (1975) was used to graphically generate runoff from the Zylstra Lake subwatershed under these three conditions. Because the Town stores and diverts water from a large part of the subwatershed, a simple annual-basis water balance worksheet was developed to assess how much runoff is "available" to Zylstra Lake after municipal demands are met from the Trout Lake reservoir.

Figure 4 shows the reservoir level and precipitation trend for the period 1993 to 2015. The drought years of 1993 and 1994 are reflected in the significantly lower reservoir levels. Two events occurred after 1994. First, the Town stopped supplying a gravel operation. Second, it brought its Augmentation 2 water source online, increasing the volume of water pumped into the Trout Lake reservoir. Since 1994, Friday Harbor has operated

the reservoir at levels ranging between 0 to approximately 60 inches below the spillway. This has been achieved by pumping its Augmentation 1 and 2 stations during runoff periods from October 1 or November 1 through April 15 (as stipulated in the Town's water rights) to the Trout Lake reservoir for storage, conveying it to the treatment facility, and ultimately distributing it to customers.

Table 6 shows the results of this analysis for average, drought, and extreme drought conditions, respectively. Note that the Town's average production is for years 2003 through 2011.

- Under the average condition, runoff from the Zylstra Lake subwatershed is sufficient to meet the needs of the Town and refill Zylstra Lake.
- Under the drought condition, we see the potential for reduced runoff into the main inflow point to UZL. Note that Friday Harbor's water rights are junior to Zylstra Lake and a provision in one of Friday Harbor's water rights states that the Town is obligated to allow 372.2 AF of water to flow into UZL by June 1 of each year.
- The extreme drought condition shows a challenging situation during which the Town's production and flows to UZL are not met for the first of two consecutive drought years and are not collectively met in the second year. The two consecutive years of drought mean that water stored in both Trout Lake reservoir and Zylstra Lake are effectively "mined" without the necessary replenishment.

Note that consecutive years of drought further exacerbate water scarcity when the Town's deficit at Trout Lake is carried over from one drought year to the next. We have not accounted for this carryover in Trout Lake. This accounting should be quantified using Town data in future analyses.

Summary

Whether the UZL has a full pool starting April 1 followed by 7 months of no lake inflow (drought condition) or a full pool on June 1 followed by 3 months of no lake inflow (average condition), it appears there is sufficient water stored in the UZL for release downstream to meet target flows of 0.1 to 0.25 cfs. The maximum UZL drawdown under the Scenario 2 drought condition would be less than 5 feet, which decreases the UZL surface area by about 30 percent. Under the drought condition, this UZL drawdown could be reduced by releasing water from the LZL.

The historic rainfall record contains an extreme drought period (1929 and 1930). Based on the annual precipitation during these years, using the Thornthwaite-Mather model, we estimate insufficient water to both maintain the Town's water supply reservoir at optimal levels and refill Zylstra Lake. The annual likelihood of this type of extreme drought — and its effects on a restored creek, habitat, and the resiliency of species to adapt — should be further evaluated in the context of project feasibility. Drought planning and mitigation should be part of this analysis.

The design and construction of the lake outlet-control structures, plus improvements to habitat conditions in FBC, should be undertaken to optimize aquatic habitat and overall ecosystem functioning. The scope of these activities depends on the planned flow releases from Zylstra Lake.

Recommendations

Stakeholder Meeting

WWT, its partners, and local citizens should meet to discuss the nature of this project, scrutinize its many "moving parts," develop project concepts with key questions that should be addressed, and identify funding sources.

The discussion should build on the current work by SJICD's Watershed Plan Implementation and Flow Achievement (PIFA) program, which is assessing in-stream flow needs, improving pond/ditch management, and collecting hydrogeologic data in the FBC and San Juan Valley areas.

Field Investigations

If the project or initial project phase is a "go," then a list of field action items should be developed and implemented. Such a list may include:

- Conducting seasonal experimental flow releases from Zylstra Lake and monitoring/measuring flow

and other parameters in FBC downstream of LZL to False Bay

- Measuring seasonal seepage loss/gain of water along select reaches of FBC downstream of LZL to False Bay
- Constructing a stream-gaging station or conducting sufficiently frequent streamflow measurements at each UZL/LZL inflow-outflow location
- Conducting a high-resolution GPS survey of the UZL, LZL, and pertinent features around the lakes
- Surveying the bathymetry of the UZL/LZL lakebed
- Installing automated staff gages in the UZL and LZL
- Installing automated staff gages in any downstream pond that could be identified as potential FBC habitat or a water source for spring through fall flow
- Placing a multi-depth thermistor station in the UZL and LZL to monitor continuous lake temperatures; identifying other key parameters and adding sensors to monitor seasonal and stratified lake conditions
- Capturing data from SJICD's station at Wold Road and the FBC station at Bailer Hill Road
- Installing a gage on San Juan Creek upstream of its confluence with FBC
- Conducting a detailed dam inspection and quantifying leakage to the extent possible
- Installing piezometers with a water-level sensor to better understand groundwater-lake interactions around Zylstra Lake
- Installing piezometers and instrumenting them with water-level sensors at locations near and within the FBC subwatershed to better understand creek-groundwater interactions
- Accounting for current and potential future water use from exempt wells in the FBC watershed to support (1) the change application and report of examination for the Zylstra water rights and (2) an instream flow rule (if pursued) to protect a restored FBC

Additional Analysis

A list of other planning-level analyses and work tasks should also be developed. Such a list may include:

- Developing a conceptual understanding of the Zylstra Lake system (using data from the field investigations) to inform the path forward for this project. More specifically, conducting a limnology study to characterize the aquatic ecology of the lake — its temperature; water chemistry; populations of phytoplankton, zooplankton, and fish (for example bass, bluegill); intraspecific competition; and lake species response to restoring anadromous fish.
- Examining the likelihood, consequences, and response to extreme drought as they relate to projected climate change, the Town's need to supply water, and this project's restorations goals. This effort should involve Town staff and data, focus on evaluating changes in precipitation/runoff patterns, consider other analyses (for example, the use of multiple hydrologic models), and include the concept / cost to dredge the lakes and/or raise the LZL dam as a potential hedge against future drought.
- Engaging with landowners in the FBC subwatershed to seek consensus for creek restoration and developing relationships that not only honor their family history / legacy, desires, and needs but also enhance environmental conditions in the watershed. This work should build on, or become part of, San Juan County's and SJICD's existing Voluntary Stewardship Program (VSP).
- Developing initial project costs (capital and long-term maintenance) and identifying funding sources. When applying for grant monies, the project partners should use the existing local programs (PIFA and VSP) as examples that show how local restoration goals for the FBC watershed are congruent with the regional goals of protecting and restoring Puget Sound.
- Developing and implementing a plan to monitor land activities in the entire FBC watershed. This plan should use existing agencies or resources to the extent possible to monitor and anticipate changes in the watershed's hydrology and environmental quality. A strategy should be developed to respond to the anticipated changes in an actionable way that aligns with the FBC restoration goals.
- Studying FBC's flow needs for all species (fish and others) in the context of survival, growth, and resiliency. This will allow additional water-release scenarios to be further evaluated, both with and without the other potential water sources to FBC — dam leakage, groundwater, ponds, and streams (including San Juan Valley creek).

- Evaluating options for raising the LZL dam and for improvements needed to manage release flows and fish passage through the dams.
- Developing a plan to restore habitat and ecosystem functioning in the FBC watershed.

References

Brown and Caldwell, 2013, *Friday Harbor Water System Plan Update*, Prepared for the Town of Friday Harbor, Washington, June 2013

Washington State Department of Ecology, 1975, *Geology and Water Resources of the San Juan Islands, San Juan County, Washington*, Water Supply Bulletin No. 46, 1975

Washington State Department of Ecology and U.S. Geological Survey, 1976, *Reconnaissance Data on Lake in Washington*, Water Supply Bulletin 43,Vol 1, 1976

Washington Water Trust, 2012, False Bay Flow and Habitat Assessment, San Juan County, Washington February 2012

Table 4 Results of Scenario 1: "Average" UZL/LZL Condition

Upper Zylstra Lake	**Units**	**Apr 1**	**May 1**	**Jun 1**	**Jul 1**	**Aug 1**	**Sep 1**	**Oct 1**	**Nov 1**	**Difference Jun 1 - Oct 1**
Lake Level	ft msl	---	---	54.0	53.3	52.6	52.1	51.7	---	**2.3**
Lake Area	ac	---	---	47.6	40.0	38.4	37.3	36.5	---	**11.1**
Water Budget Components, Inflow:										
Direct precipitation (on lake surface)	in	---	---	0	0	0	0	---	---	
Surface water inflow	cfs	---	---	0	0	0	0	0	---	
Groundwater discharge	cfs	u	u	u	u	u	u	u	u	
Water Budget Components, Outflow:										
Released instream to False Bay Creek[1]	cfs	0	0	0.25	0.25	0.1	0.1	0	0	
Lake evaporation	in	---	3.51	4.37	4.95	4.20	2.47	1.30	---	
Shoreline plant transpiration	in	u	u	u	u	u	u	u	u	
Dam leakage	cfs	u	u	u	u	u	u	u	u	
Lower Zylstra Lake										
Lake Level	ft msl	---	---	43.5	43.1	42.7	42.4	42.2	---	**1.3**
Lake Area	ac	---	---	7.2	6.9	6.6	6.4	6.2	---	**1.0**

Notes: u = unknown

[1] Total Volume Released Jun 1 - Oct 1 = 42.35 acre-feet

Table 5 Results of Scenario 2: Drought UZL/LZL Condition

Upper Zylstra Lake	**Units**	**Apr 1**	**May 1**	**Jun 1**	**Jul 1**	**Aug 1**	**Sep 1**	**Oct 1**	**Nov 1**	**Difference Apr 1 - Nov 1**
Lake Level	ft msl	54.0	53.7	53.1	52.3	51.4	50.6	50.0	49.4	**4.6**
Lake Area	ac	47.6	45.0	39.8	37.7	36.2	34.9	33.9	33.0	**14.6**
Water Budget Components, Inflow:										
Direct precipitation (on lake surface)	in	0	0	0	0	0	0	0	---	
Surface water inflow	cfs	0	0	0	0	0	0	0	---	
Groundwater discharge	cfs	u	u	u	u	u	u	u	u	
Water Budget Components, Outflow:										
Released instream to False Bay Creek[1]	cfs	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	
Lake evaporation	in	0.00	3.87	4.81	5.45	4.61	2.72	1.43	0.00	
Shoreline plant transpiration	in	u	u	u	u	u	u	u	u	
Dam leakage	cfs	u	u	u	u	u	u	u	u	
Lower Zylstra Lake										
Lake Level	ft msl	43.5	43.5	43.2	42.8	42.4	42.1	41.9	41.8	**1.7**
Lake Area	ac	7.2	7.2	7.0	6.7	6.4	6.2	6.0	6.0	**1.3**

Notes: u = unknown

[1] Total Volume Released Apr 1 - Nov 1 = 106.12 acre-feet

Table 6 **Results of Senarios A, B, and C: Average, Drought, and Extreme Drought Conditions**

Zylstra Lake Subwatershed Upstream Analysis

	1	2	3	4	5	6	7	8	9	10
	Future Year or Period Similar To Years or Sequence Below[1]	Annual Precipitation at Water Treatment Facility	Zylstra Lake Subwatershed Area	Estimated Runoff (i.e. Annual Flow from) Zylstra Lake Subwatershed[2]		Average Annual Friday Harbor Production (Diversion) from Zylstra Lake Subwatershed[3]	"Available" Water after Friday Harbor's Production (Diverson) from Zylstra Lake Subwatershed	Friday Harbor's Water Right Provision for Annual Flow to Zylstra Lake by June 1	Difference: Columns 7 - 8	Annual Flow to Zylstra Lake Provision Met?
		inches	sq miles	inches	ac-ft	ac-ft	ac-ft	ac-ft		
Scenario A: Average Conditions	Average of 1/1993 through 11/2015	27.6	8.93	8.4	4,001	380	3,622	372.2	3,249	**YES**
Scenario B: Drought Conditions	1990	27.7	8.93	8.8	4,168	380	3,788	372.2	3,416	**YES**
	1991	22.3	8.93	4.5	2,143	380	1,764	372.2	1,392	**YES**
	1992	23.8	8.93	5.7	2,691	380	2,312	372.2	1,940	**YES**
	1993	20.8	8.93	3.8	1,810	380	1,431	372.2	1,058	**YES**
	1994	17.9	8.93	1.3	619	380	240	372.2	**(133)**	**Partly**
	1995	27.5	8.93	8.2	3,906	380	3,526	372.2	3,154	**YES**
	1996	34.8	8.93	13.9	6,597	380	6,218	372.2	5,845	**YES**
Scenario C: Extreme Drought Conditions	1925	26.1	8.93	7.3	3,477	380	3,098	372.2	2,725	**YES**
	1926	21.0	8.93	3.6	1,715	380	1,335	372.2	963	**YES**
	1927	23.2	8.93	5.2	2,453	380	2,074	372.2	1,701	**YES**
	1928	22.0	8.93	4.3	2,048	380	1,669	372.2	1,296	**YES**
	1929	13.3	8.93	0	0	380	**(380)**	372.2	**(752)**	**NO**
	1930	17.7	8.93	1.2	548	380	168	372.2	**(204)**	**Partly**
	1931	24.1	8.93	5.8	2,763	380	2,383	372.2	2,011	**YES**
	1932	26.5	8.93	7.7	3,644	380	3,264	372.2	2,892	**YES**

Notes:

[1] Scenario A average precipitation is calculated from calendar year data; Scenario B and C precipitation is calculated from water year (Oct 1 - Sep 30) data

[2] Estimated from WSB 46, Figure 11

[3] Based on years 2003 through 2011

(xxx) Indicates deficit water volume

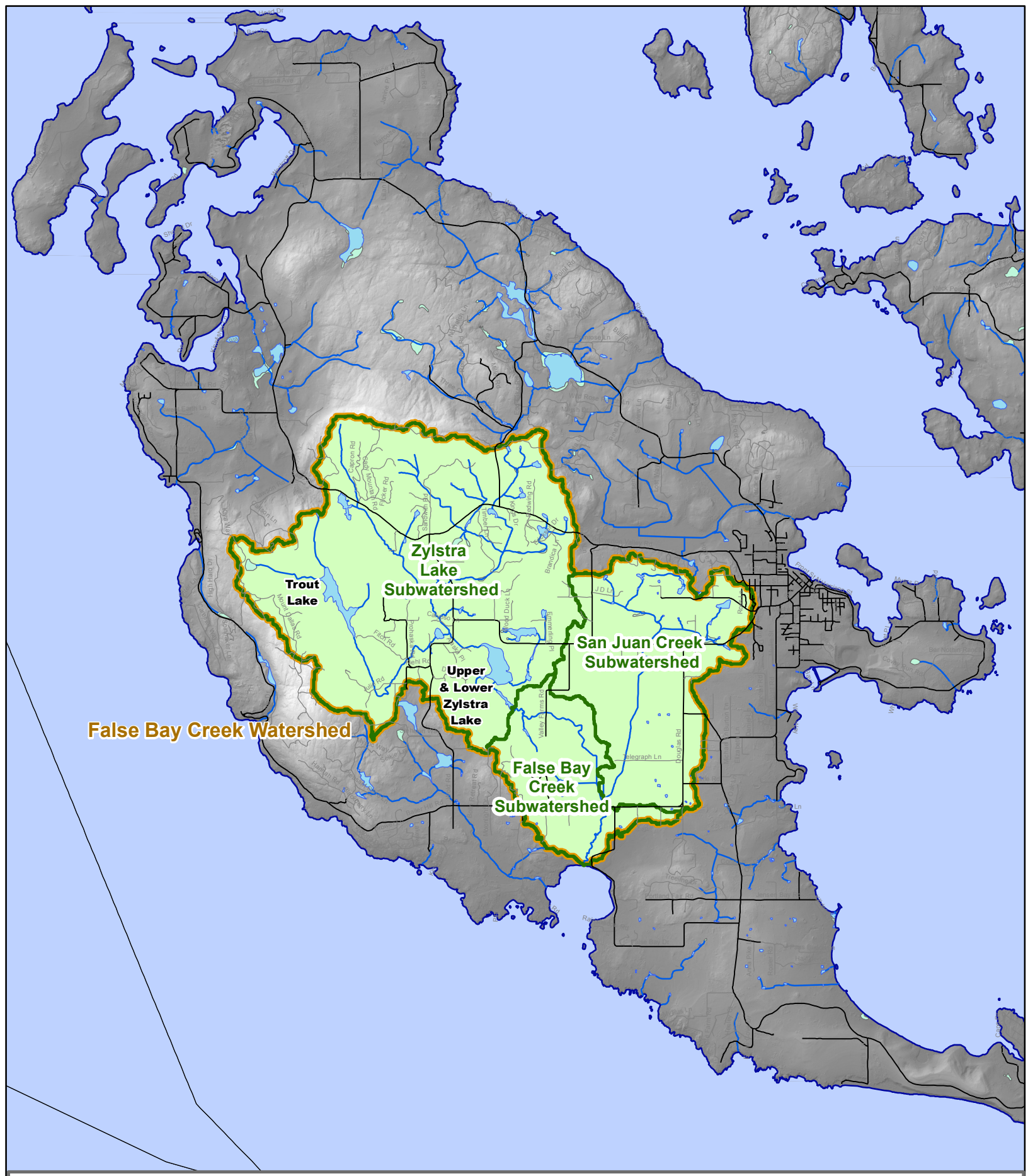
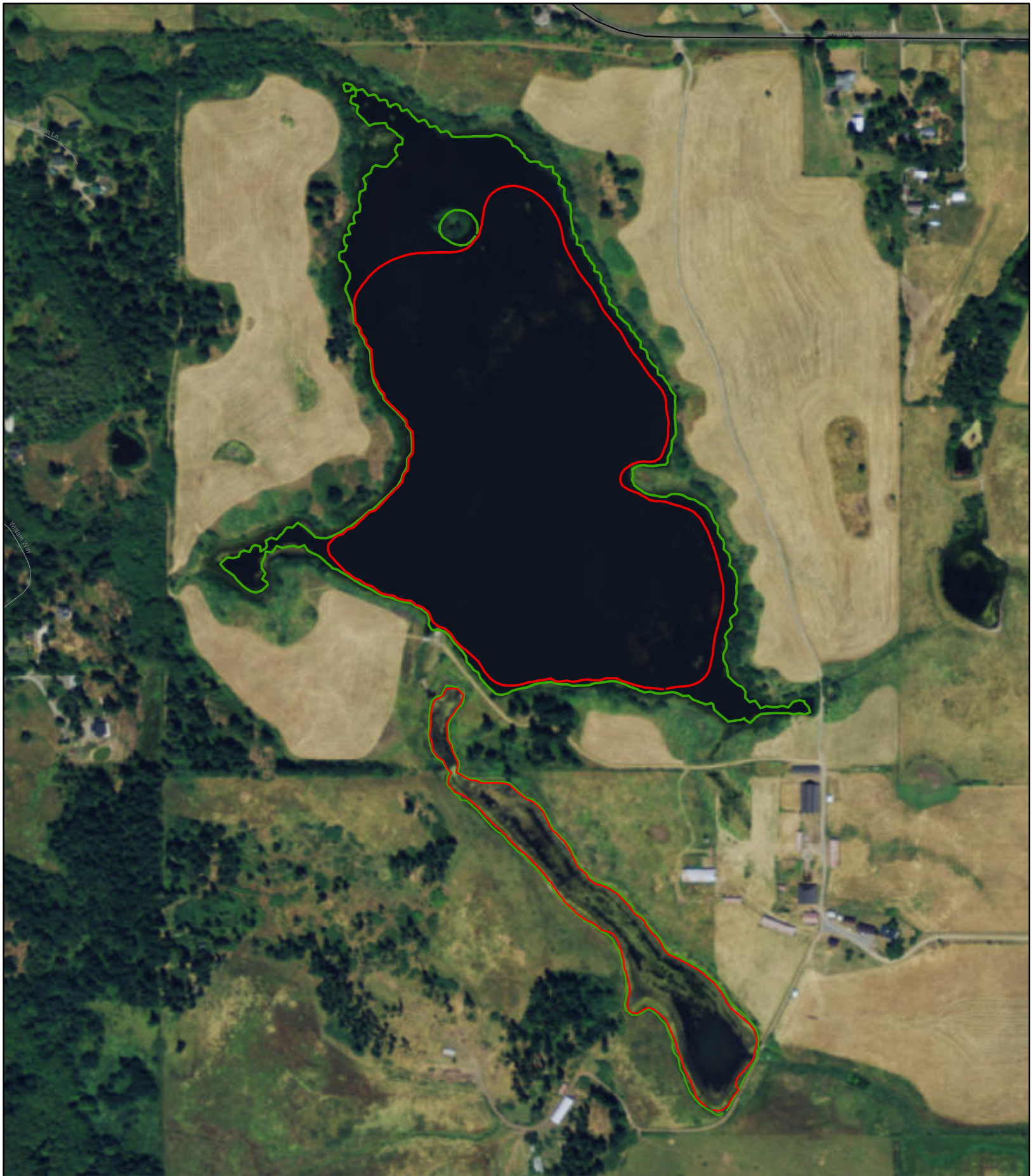


Figure 1. Zylstra Lake, Subwatersheds, and FBC Watershed San Juan Island, Washington

Zylstra Lake Water Rights Management Assessment

Washington Water Trust

NORTHWEST Land & Water, INC.



Legend

- UZL & LZL, Full Pool
- UZL & LZL, 2- & 1-ft Drawdown

N

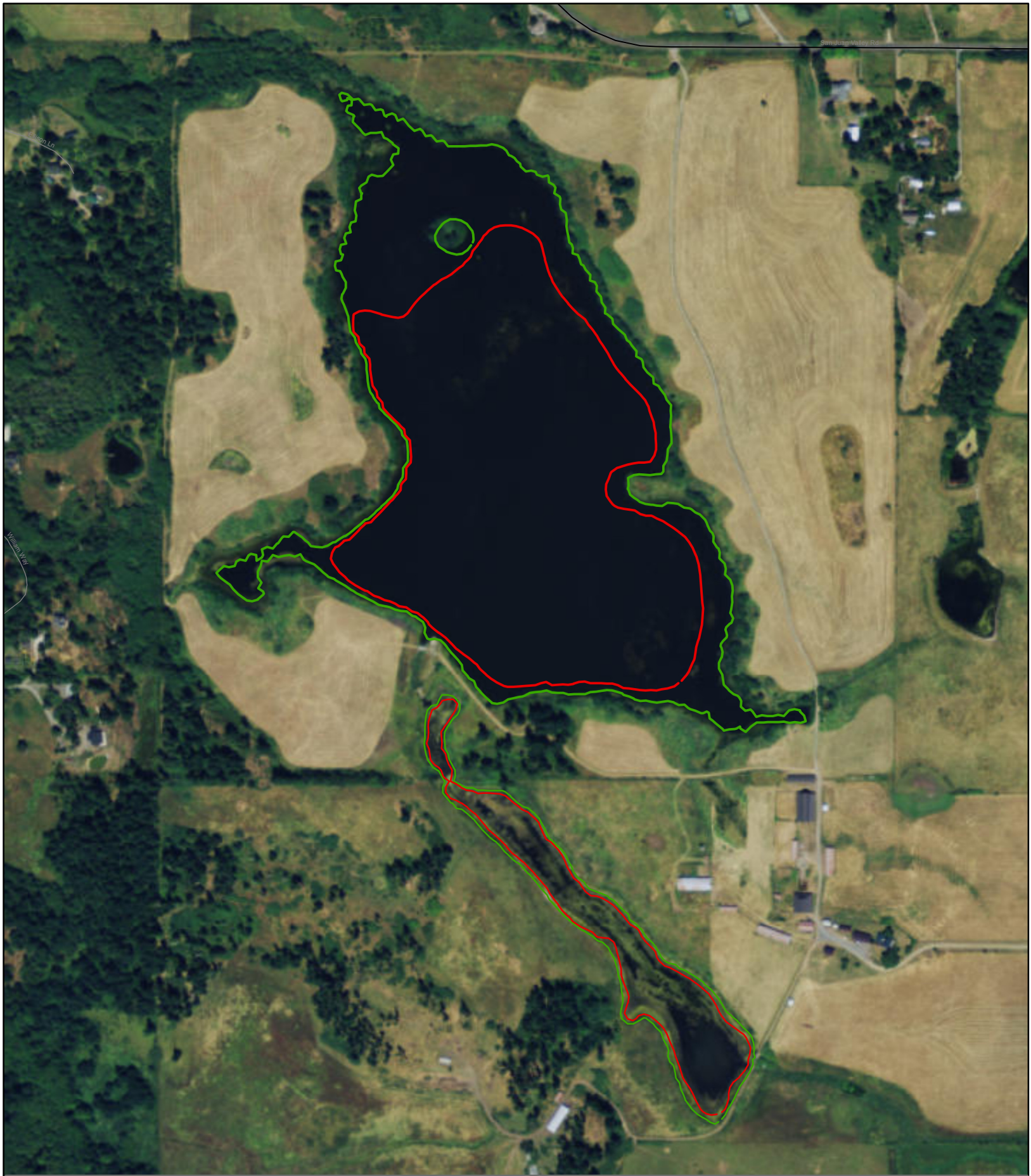
500 250 0 500 Feet

Figure 2. Approximate Scenario 1 Shorelines, UZL & LZL Drawdown of 2 and 1 ft

Zylstra Lake Water Rights
Management Assessment

Washington Water Trust

NORTHWEST Land & Water, INC.



Legend

- UZL & LZL, Full Pool
- UZL & LZL, 5- & 2-ft Drawdown

N

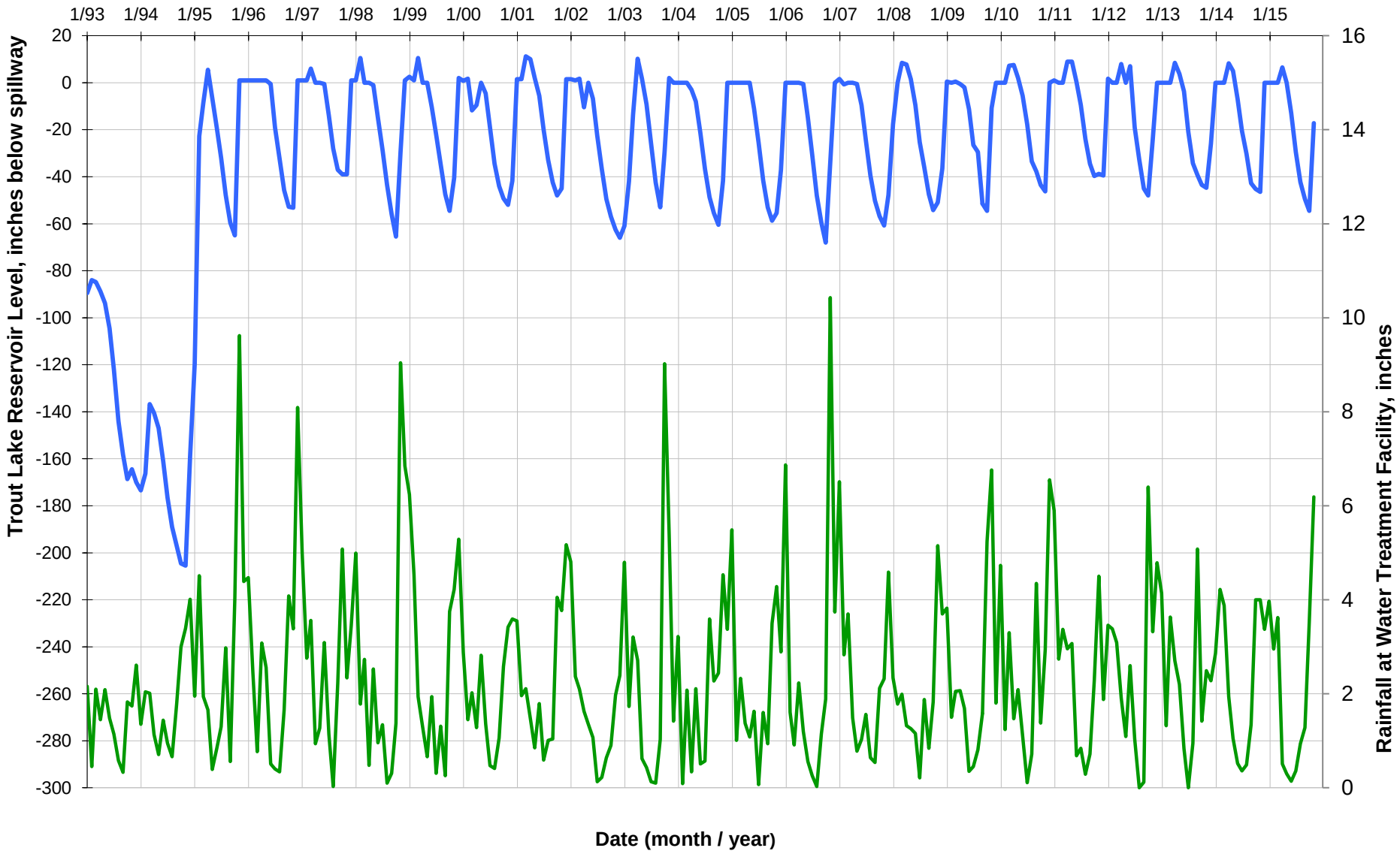
500 250 0 500 Feet

Figure 3. Approximate Scenario 2 Shorelines, UZL & LZL Drawdown of 5 and 2 ft

Zylstra Lake Water Rights Management Assessment

Washington Water Trust

NORTHWEST Land & Water, INC.



Trout Lake Reservoir Level

Trout Lake Water Treatment Facility Rainfall

Figure 4
Trout Lake Reservoir Level and Precipitation Trend for 1993 - 2015

WWT & Zylstra Lake Partners

NORTHWEST Land & Water, INC.

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