Hydrogeologic Evaluation Report
Water Right Application G4-34915

Prepared for
Washington State Department of Ecology

Aspect consulting
earth+water

Project No. 040028-001-22 • December 29, 2009 Final

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WATER RIGHT APPLICATION G4-34915
Twin Lakes Aquifer Coalition
Cost Reimbursement Project
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Executive Summary

This report presents the results of a hydrogeologic evaluation (Phases 1A and 1B) of Twin Lakes Aquifer Coalition (TLAC) groundwater right application G4-34915 under the cost reimbursement program. The findings of the Phase 1 analysis were documented in a previous report prepared by Aspect Consulting, dated March 28, 2005. The application requests a water right appropriation within the Methow River Basin, Water Resources Inventory Area (WRIA) 48. The objective of this evaluation is to provide technical analyses to assist Washington State Department of Ecology (Ecology) in evaluating whether the TLAC application meets the criteria for expedited processing as defined under 173-152-050 Washington Administrative Code (WAC) (Hillis Rule). The work was performed by Aspect Consulting under Ecology Water Resources Contract No. C0500006.

The TLAC water right application requests a maximum withdrawal rate of 4,500 gallons per minute (gpm) and a quantity of 2,000 acre-feet per year (afy) from wells located near the Methow River. The proposed purpose of use is restoration of water levels in Barnsley and Twin Lakes and the associated aquifer (herein referred to as the Twin Lakes Aquifer) by recharge of pumped groundwater. The application identifies four places of use for lake recharge augmentation, including Barnsley Lake, Big Twin Lake, infiltration galleries positioned along the water conveyance pipeline, and the Twin Lakes Aquifer.

The hydrogeologic characterization of the Twin Lakes Aquifer area and evaluation of the TLAC lake recharge proposal included an initial field investigation and evaluation (Phase 1A) documented in a prior draft report (Aspect Consulting, 2006). In addition to data collection, this initial effort included development of a groundwater flow model to assist in evaluating the TLAC proposal. A supplemental field investigation (Phase 1B) was designed to fill identified data gaps, reduce model uncertainties, and address stakeholder comments on the draft report. This report presents the findings of the Phase 1B effort, which included:

- Collection of supplemental field data to address data gaps and model uncertainties identified based on the Phase 1A study;
- Refinement of the groundwater flow model based on the updated understanding of hydrogeologic conditions in the study area; and
- Predictive simulations to evaluate the TLAC project proposal utilizing the refined groundwater flow model, including changes in the timing and magnitude of aquifer and lake levels and stream flows under various groundwater withdrawal conditions and place of use scenarios.

The range of groundwater withdrawal scenarios for lake level augmentation were defined to reflect compliance with established regulatory baseflows (minimum in-stream flows) and/or more stringent target flows recommended by Washington State Department of Fish and Wildlife (WDFW). Three augmentation scenarios were defined for evaluation

based on stakeholder input, including: (1) pumping during periods when WDFW recommended target flows (between 800 and 6,000 cubic feet per second [cfs]) from April 1 to July 15 are met, (2) pumping under WDFW target flows through July 15 and under 173-548 WAC (Water Resources Program in the Methow River Basin, WRIA 48) through September 30, and (3) pumping only during periods when base flows set under 173-548 WAC from April 1 through September 30 are met.

Assumptions used in evaluating the TLAC project proposal were developed in consultation with Ecology and included consideration of recommendations provided by the WDFW in a Comment Letter to Ecology dated June 25, 2005. Copies of the TLAC water right application and the WDFW Comment Letter are provided in Appendix A. For example, the place of use for all three scenarios assumed direct discharge (recharge augmentation) to Big Twin Lake only based on WDFW review comments. The secondary benefit of augmenting water levels in Big Twin Lake on Barnsley Lake water levels was evaluated, however direct discharge to Barnsley Lake was not.

Comments on the draft version of this report were provided by Ecology and TLAC and are presented in Appendix D of this document. Follow-up discussions with TLAC and Ecology on the draft report resulted in scoping an additional work phase to evaluate the benefits of aquifer storage for addressing multiple water use needs in the basin. A project phase is currently underway that evaluates the feasibility of using Twin Lakes and Barnsley Lake for water storage to restore lake levels and provide additional baseflow to the Methow River for water right mitigation purposes. The mitigation quantity could be used to offset impacts to Methow River flows associated with future downstream diversions.

Results of the multipurpose storage evaluation will be presented in a separate storage assessment report. The evaluation will be performed using an updated groundwater model to that described in this document. Additional survey data is being collected as part of the multipurpose storage assessment to better define lake storage capacities in the model. The additional survey points also provide additional model calibration points and the model is being recalibrated using these new survey data and an updated evapotranspiration rate. Results of predictive simulations presented herein, therefore, are expected to change if these same predictive scenarios were run on the updated model. The reader is directed to results of the forthcoming multipurpose storage evaluation which will present the results of predictive simulations for storage using the updated groundwater model.

For the study presented herein, Ecology's Central Regional Office developed a list of tasks and specific questions that needed to be addressed to support evaluation of the TLAC water right application. The scope of the Phase 1A and 1B evaluations were designed to address these questions. A summary of findings (based on investigations completed to date), presented as responses to each of the specific questions and tasks defined in the Ecology Scope of Work (in bold type) for ease of review is provided below. A more complete discussion of results is presented in the body of the report.

1.) Propose a site for TLAC's pumping well where it is likely that it can produce the requested quantity of water. The pumping well needs to be sited upstream from the Winthrop National Fish Hatchery at a location where it will not cause impairment or significant interference with the operation of the fish hatchery well, the hatchery's surface water spring source, or any other wells in the area. The pumping time frame proposed in the application is the period when river flows exceed base flows established in Chapter 173-548 WAC.

The points of groundwater withdrawal proposed in the TLAC water right application are located within two ¼, ¼ sections of Haub Brothers Enterprises Trust property near the Methow River, between the Douglas County PUD Hatchery (State Hatchery) and the National Fish Hatchery (the NW¼ of the SW¼ of Section 3, T34N, R21E and the NE¼ of the SW¼ of Section 3, T34N, R21E). The TLAC application proposes up to two wells, one located in each of these two, 40-acre subsections. The locations of points of groundwater withdrawal were modified based on our analysis to minimize impact to the existing State Hatchery wells and to the Spring Branch spring and to reflect observed pumping capacities from vicinity wells. Several of the nearby State Hatchery wells, completed within the deeper alluvial aquifer at depths of about 100 to 150 feet, exhibit pumping capacities over 1,000 gpm per well, and new wells installed in the vicinity and completed at comparable depths could be expected to yield similar quantities of water. Based on model results, two wells completed in the deeper alluvial aquifer and capable of a combined instantaneous withdrawal rate of up to 2,000 gpm were sufficient to fill and maintain Big Twin Lake water levels. The locations of the wells are distributed across the easterly most ¼, ¼ section (NE¼ of the SW¼ of Section 3, T34N, R21E) identified on TLAC's application to minimize interference with State Hatchery wells and between the proposed TLAC wells.

The pumping effects associated with new wells will not likely impair nor result in significant interference drawdown impacts to existing wells. The model results indicate interference drawdown at existing State Hatchery wells due to pumping of the new proposed wells would likely be less than 5 feet. These results are consistent with estimates of long-term water level drawdown between hatchery wells, based on an assessment completed by GeoEngineers for Douglas County PUD (GeoEngineers, July 19, 1991). GeoEngineers predicted drawdown from well interference ranging from 0.5 to 2 feet for 90 to 180 days of pumping at 1,200 gpm at distances ranging from 280 to 800 feet.

The National Hatchery, located downriver from the State Hatchery, obtains water supply from two wells and a spring. Although there are no well logs available, they are large diameter, shallow groundwater collectors. Minor drawdown interference with the National Hatchery's surface water spring source (<0.5 feet) is anticipated as a result of the project. A maximum drawdown of 0.5 feet occurs beneath the State hatchery wells and Spring Branch Spring during the lake fill period when pumping withdrawals are at their maximum. The impact diminishes to about a 0.25 feet as pumping diminishes to maintenance withdrawals. A slight increase in water levels occurs at Spring Branch Spring during non-pumping periods. Similarly, little impact is predicted at Foghorn ditch. Maximum drawdown in the shallow aquifer beneath Foghorn ditch in closest proximity to the TLAC pumping well field was about 1 foot (ft) based on model results.

The TLAC application specifies that pumping withdrawals will occur only when flow in the Methow River exceeds regulatory baseflows (minimum instream flows) specified in 173-548 WAC. In addition, comments provided by WDFW on the TLAC application, include recommendations to Ecology that would restrict groundwater withdrawal to the period of April 1 to July 15 and only when flows at the Methow River at Winthrop gage station are between 800 and 6,000 cfs.

Baseflow requirements established under 173-548 WAC do not significantly limit the period of withdrawals throughout the year. Methow River flows have historically exceeded the 173-548 WAC baseflow requirements for 20 of the 24 half-month periods specified in the regulation (greater than 80 percent of the time). Consequently, groundwater withdrawal could occur nearly year round under the WAC. The lowest probability time period for river flows to exceed promulgated base flow occurs from April 1 to May 14, when the base flow requirement is still met 91 percent of the time.

The WDFW target "window" for groundwater withdrawals is more limiting than those specified under 173-548 WAC. The WDFW target flow window (800 to 6,000 cfs) is met between 53 and 90 percent of the time, with the period from April 1 to April 14 having the lowest probability of meeting flow restrictions and the period from June 15 to July 15, the greatest probability of meeting flow restrictions.

2.) Determine how much of the water that is pumped up into the Twin Lakes and Barnsley Lake will be consumed and not make it back to the Methow River. This would include losses due to evaporation as well as water consumed and lost due to lawn\garden irrigation and general domestic use and any other losses. The county will provide a figure on anticipated future development. The consultant should assume that the future domestic wells will be completed into the bedrock. As such, the consultant should consider increased leakage from the sediment aquifer and decreased discharge from the bedrock aquifer.

The TLAC water right application requests an appropriation of 2,000 afy, which is approximately the cumulative volume at an instantaneous flow rate of 4,500 gpm for the period April 1 to July 15. However, according to model results, substantially less than 2,000 afy will be needed to maintain water levels in Big Twin Lake at the target level of 1,799 feet elevation, if water is discharged only into Big Twin Lake.

The following scenarios were used in the simulations:

- Existing Conditions.
- Scenario 1: Future Domestic Well Buildout (without TLAC project).
- Scenario 2 (WDFW scenario): TLAC withdrawals limited by WDFW target flows (April 1 – July 15), and future buildout conditions.

- Scenario 3 (WDFW/WAC): TLAC withdrawals limited by combination WDFW target flows (April 1 – July 15) and 173-548 WAC (July 16 – September 30), and future buildout conditions.
- Scenario 4 (WAC): TLAC withdrawals limited by 173-548 WAC (April 1 – September 30), and future buildout conditions.

Table ES-1 summarizes water balance components and model results for the withdrawal scenarios used in the predictive simulations. The future buildout condition was used as the baseline for evaluation of water balance changes from the project under all withdrawal scenarios. In addition, a range of TLAC project transfer capacities (i.e., pumping rates of 500, 1,000, 1,500, and 2,000 gpm) were also evaluated for each scenario.

Most of the water pumped by the TLAC project during the first few years fills aquifer storage in the vicinity of Big Twin Lake. During the first year, 400 to 700 afy of lake leakage goes into aquifer storage depending on the scenario. Under full buildout, evapotranspiration is less than the current condition before the project is initiated as a result of a smaller lake footprint and lower lake levels associated with full buildout pumping. After about 10 years of project operation, the quantity of lake seepage going to aquifer storage ranges from 20 to 40 afy depending on the scenario. Eventually, aquifer storage would approach no net average gain or loss.

After Big Twin Lake is filled, evapotranspiration (ET) from Big Twin and Little Twin Lakes is calculated by the model to increase on the order of 30 to 36 afy, compared to the future domestic buildout condition. The model calculates a small amount of additional ET at Barnsley Lake and Dibble Lake. The increase in ET for Twin Lakes was computed using multiple methods to address inherent uncertainty in the model results. The model ET-related uncertainty is due to limited topographic control and the model grid cell size which may under predict the footprint of the Twin Lakes and near-shore area. An alternative computational method (outside the model) estimates annual ET losses ranging from 62 to 87 afy. The project should allow a contingency for additional lake maintenance volumes to account of this and other model uncertainties.

An estimated 125 to 139 afy discharges from the lake as leakage for the TLAC project scenarios. Of this, approximately 72 percent (90-100 afy) flows toward the Methow River near the point of withdrawal (i.e., follows a northerly flow path out of Big Twin Lake). Much of this water would be captured by the project pumping wells, reducing the pumping impact on Methow River flows. About 25 to 28 percent (35 to 39 afy) flows into the Methow River southeast of Big Twin Lake, effectively by-passing about 3 miles of the Methow River.

Total annual quantity of water resulting from increased lake evaporation and “by-pass” reach discharge is calculated by the model to range between 65 afy and 75 afy depending on the TLAC project scenario.

Table ES-1

Comparison of Model Annual Water Balance Components for >1,000 gpm Withdrawal Rate[1]

Annual Water Balance Component	Future Buildout Scenario	Withdrawals under WDFW Target Window	Withdrawals under WDFW/WAC Scenario	Withdrawals under 173-548 WAC
Big Twin Lake Fill Duration	NA	~15 years @ 500 gpm ~3 years @1,000 gpm 1 year @ >1,500 gpm	~5 years@ 500 gpm ~2 years @ 1,000 gpm 1 year @ >1,500 gpm	~4 years@ 500 gpm ~2 years@ 1,000 gpm 1 year @ >1,500 gpm
Volume Required to Maintain Big Twin Lake Level	NA	176 afy	214 afy	214 afy
Average Big Twin Lake Elevation	1,791 ft	1,798 ft	1,799 ft	1799 ft
Big Twin Lake Level Fluctuations[2]	~2 ft	~ 1 ft	~ 0.5 ft	~ 0.5 ft
Twin Lakes Evaporative Losses	-8 afy	30 afy	36 afy	36 afy
Return Flow to Methow River – Northerly Component	-98 afy	90 afy	100 afy	100 afy
Return Flow to Methow River – Southeasterly Component ("by pass" quantity)	-39 afy	35 afy	39 afy	39 afy
Aquifer/Lake Storage	-22 afy	20 afy	38 afy	38 afy

1.) Values shown are relative to baseline (current) condition. For the purposes of summarizing data, values shown are approximate. The reader is referred to the main text for more precise values. Values based on average of last five model years (model years 13 through 17).

2.) Lake level fluctuations reflect steady state condition after lake is filled, except for full buildout conditions.

Future domestic buildout in the area was estimated to add an equivalent of about 600 exempt wells west of the Methow River, based on parcel data provided by Okanogan County. Consumptive-use pumping was assumed to be 250 gallons per day (gpd) per well, for an estimated additional 170 afy of exempt well withdrawals, or 0.23 cfs continuously. Model results indicate that future domestic wells completed in saturated bedrock were not affected by the TLAC proposal. That is, the sustainable yield of the saturated bedrock is sufficient to support future buildout of exempt wells in the absence of proposed lake level augmentation.

3.) As proposed in the application, a portion of the pumped water will be discharged to Barnsley Lake. It is assumed by the applicant that water leaking from Barnsley Lake to groundwater will discharge toward Twin Lakes and augment the Twin Lakes aquifer. Verify the accuracy of this assumption. If incorrect, identify the probable pathway, location and timing of the discharge.

Evaluation of water level data measured in August 2006, December 2007, and May 2008 indicate groundwater under current conditions flows from Big Twin Lake to both the north and the southeast. At Big Twin Lake, the groundwater table is at approximately 1,792 feet elevation, and groundwater flows northward toward the Methow River with a stage elevation of 1,765 feet near the State Hatchery, and southeasterly toward the Methow River with a stage of about 1,690 feet near the High School.

The elevation of Barnsley Lake appears to be a reflection of the local water table when standing water is present for any appreciable period. The water level in Barnsley Lake was surveyed at elevation 1775 and is about 16 feet lower in elevation than Big Twin Lake. Water added to Barnsley Lake would be expected to flow radially outward from a localized mound created beneath the lake. This lake seepage would ultimately flow northward to the Methow River with the regional groundwater gradient unless groundwater levels were raised sufficiently to reverse the regional gradient.

The model predicts that by filling Big Twin Lake to the target elevation, a regional increase in aquifer levels will raise Barnsley Lake elevations about 1 to 1.5 feet. The fate of recharge in Barnsley Lake will be further evaluated in the multipurpose storage assessment in the next project phase.

4.) Determine how much of the pumped water will return to the Methow River and at what locations; and 5.) Determine the time frame for the return of pumped water to the Methow River.

Based on the model results, it will take about 3 years to fill most of the aquifer storage before there is appreciable discharge to the Methow River from the project. Return flows increase significantly from year 3 to about year 10 of the project, at which time they begin to approach a steady state condition. After about 10 years, 65 to 71 percent of water pumped to Big Twin Lake each year (WDFW scenario) seeps to groundwater and eventually discharges to the Methow River or is captured by the TLAC pumping wells. About 90 to 100 afy of the water pumped to Big Twin Lake will flow north toward the Methow River. About 35 to 39 afy of water pumped to Big Twin Lake will flow to the southeast.

6.) Determine within the boundaries of the Twin Lakes Aquifer whether existing and/or future domestic wells will have a significant effect on the water used to augment lake levels.

Model results indicate water level decline in Big Twin Lake is predicted to be about 1 foot after 15 years due to full domestic buildout, and in the absence of the proposed TLAC project. There was no predicted decline in the withdrawals of existing domestic and/or production wells, and future domestic wells were able to withdraw at a consumptive-use rate of 250 gpd. The model results indicate that storage in saturated bedrock approaches a steady state condition at the end of the 17-year period. Consequently, the sustainable yield of the aquifer appears sufficient to support future buildout with or without the TLAC project.

1 Introduction

1.1 Project Background

This report presents the results of the Phases 1A and 1B evaluation of Twin Lakes Aquifer Coalition (TLAC) groundwater right application G4-34915. The objective of this hydrogeologic evaluation is to assist Washington State Department of Ecology (Ecology) in determining whether the TLAC application meets the criteria for expedited processing found in 173-152-050 Washington Administrative Code (WAC) (i.e., Hillis Rule). The work was performed by Aspect Consulting under Contract No. C0500006 with Ecology. The TLAC groundwater right application is provided in Appendix A.

The TLAC water right application proposes to withdraw 4,500 gallons per minute (gpm) and a maximum annual quantity of 2,000 acre-feet from wells located near the Methow River for the proposed purpose of restoring water levels in Barnsley and Twin Lakes and the associated aquifer. The application proposes four places of use: Barnsley Lake, Big Twin Lake, infiltration galleries positioned along the conveyance pipeline and the Twin Lakes Aquifer.

This evaluation augments the Phase 1 analysis (Aspect Consulting, March 2005) previously completed, to assess processing under the cost reimbursement program. The results of the evaluation presented herein also provide much of the technical background needed to process the TLAC application, whether expedited or not. The scope of work for this project was based on objectives and tasks provided by Ecology and Aspect Consulting's discussions with Ecology. These objectives are summarized in the Executive Summary.

The investigation consisted of developing a conceptual hydrogeologic framework for the Twin Lakes project area, water balance analysis, an evaluation of proposed TLAC well site, and groundwater modeling. The conceptual hydrogeologic model, water balance, and well siting evaluation served as the foundation for development of the numerical groundwater model. The numerical groundwater model predicts relative changes in the timing and magnitude of lake and aquifer levels and stream flows and provides a basis for Ecology to determine whether the criteria for expedited processing as defined under 173-152-050 WAC are met.

During development of the conceptual hydrogeologic framework, uncertainties in the site hydrogeologic model became apparent, specifically resolution of bedrock barriers to groundwater flow, paucity of groundwater and lake elevations to assess hydraulic continuity, and recharge from Thompson Creek. Following discussions with Ecology, contract amendments were issued to field locate and survey wells in the project area, measure water levels in these wells, install staff gages in the major lakes in the area, and gage stream flow.

The initial project model was constructed in 2006 and presented in a draft report (Aspect Consulting, 2006) following the first phase of field work. The initial field work included surveying and obtaining water level measurements in approximately 31 wells, and installation of staff gages in Big Twin, Little Twin and Dibble Lakes. An expanded field effort was performed to resolve some model uncertainties and findings from the second phase of field work are incorporated into the updated model presented in this report. The expanded field work included surveying and water level measurements in an additional 19 wells, and the initial 31 wells, installation of a staff gage in Barnsley Lake (permission could not be obtained for this staff gage in the initial phase of field work) and gaging of Thompson Creek flows.

The Washington State Department of Fish and Wildlife (WDFW) reviewed the TLAC application and provided comments to Ecology and conditioned support for processing under the Hillis Rule based on an assessment of substantial net benefit to the trophy fishery in Big Twin Lake (WDFW, June 25, 2004). WDFW recommended to Ecology that water right approval consider the following restrictions: limiting groundwater withdrawals to periods of spring runoff, no new wells (including exempt wells) be permitted for the aquifer in hydraulic continuity with Big Twin Lake, recharge augmentation be limited to Big Twin Lake, the permit be temporary with renewal conditions, monitoring be implemented, and an evaluation of potential impacts be completed. Specifically, the WDFW proposed that groundwater withdrawal for the project be restricted to flow conditions when Methow River flows are between a minimum 800 cubic feet per second (cfs) and maximum 6,000 cfs from April 1 to July 15. The recommended restrictions constraining groundwater withdrawal are referred to as WDFW target flows in this report. The WDFW Comment Letter is provided in Appendix A. This study evaluates the project both with respect to the minimum instream flow rules (173-548 WAC) and WDFW target flow conditions.

1.2 Forthcoming Multipurpose Storage Assessment

An additional work phase was developed subsequent to issuing the draft of this report to evaluate the feasibility of water storage in the Twin Lakes area to address multiple water resource needs. Based on comments received from TLAC and follow-up discussions with Ecology and TLAC, an additional work phase was developed to evaluate the feasibility of a multipurpose storage project. While the report presented herein focuses on raising water levels in Big Twin Lake for recreational and habitat enhancement purposes by pumping groundwater sourced near the Methow River solely to Big Twin Lake, the multipurpose study evaluates other water storage options. These options include direct fill of Barnsley Lake and the use of infiltration galleries and associated benefits to streamflow that result from lake seepage.

The predictive modeling presented herein focuses on compliance with the WDFW target withdrawal period and WAC 173-548 minimum instream flows and expedited processing of a new water right under the Hillis Rule. The focus of the multipurpose storage evaluation assumes that the withdrawal quantities (i.e., 200, 300, or 400 afy) will be offset through acquisition of an existing water right.

The multipurpose storage assessment builds on hydrogeologic evaluations presented herein. Additional topographic control is being obtained in the multipurpose storage assessment to better define the storage capacity of the lakes. The groundwater model presented herein is being recalibrated using the additional topographic data. In addition, the model evapotranspiration rates are being further investigated. The reader is directed to the forthcoming storage feasibility memorandum which will present the results of predictive simulations for storage using the updated groundwater model. It should be noted that the results of the model scenarios presented herein would likely vary if the same scenarios were rerun on the updated model.

1.3 Report Outline

The following sections of the report present the data and analysis used to evaluate changes in the hydrologic system as a result of the TLAC proposal:

Section 2 presents the hydrogeologic data used in the simulation of groundwater conditions in the numerical groundwater model. This section includes a discussion of the physiography, climate, surface water hydrology, geology, hydrogeology and land use.

Section 3 presents a water balance for the Twin Lakes project area, including numerous discharge and recharge components.

Section 4 presents the numerical groundwater analysis, including a discussion of the model construction and calibration.

Section 5 presents a discussion of the proposed groundwater withdrawal, including a proposed location, time frame and discussion of the effects of the withdrawal.

2 Hydrogeologic Framework

This section presents the hydrogeologic framework for the Twin Lakes project area, located in the vicinity of Winthrop, Washington. The hydrogeologic data provided in the following sections was used in the simulation of groundwater conditions in the numerical groundwater model. The major components of the hydrogeologic framework include:

- Physiography
- Climate
- Surface Water Hydrology
- Geology
- Hydrogeology
- Land Use

Each of these components is discussed in detail in the following sections.

2.1 Physiography

The Twin Lakes project area is located within the Methow River Basin in North-Central Washington State (Figure 2.1.1). The river basin consists of numerous U-shaped valleys resulting from extensive glacial erosion during the Pleistocene Epoch. The ridges and peaks bordering the glacial valleys are generally in excess of 7,000 feet, with several peaks reaching almost 9,000 feet (Barksdale, 1975).

The Twin Lakes project area is located near the confluence of the Methow and Chewuch Rivers. Physiographic features of the area include the recent alluvial channel of the Methow River, a glaciofluvial terrace occupied by Barnsley, Big Twin, Little Twin, and Dibble Lakes and an upland area separating Twin Lakes from the Methow River cored by shallow bedrock. During glaciation, drainages within many areas of the basin were diverted, causing sediment-laden meltwater streams to deposit their load around ice remnants. These remaining blocks of ice eventually became buried by sediments and when the ice melted, lakes known as “kettle lakes” formed within the resulting depressions (Walters and Nassar, 1974). The numerous lakes in the project area, including Barnsley, Big and Little Twin and Dibble Lakes were likely formed by this process.

Figure 2.1.2 presents a topographic map of the Twin Lakes project area, delineating the area included in the numerical groundwater model. Big and Little Twin Lakes are located within the west-central portion of the model area and the town of Winthrop (population of 349 in 2000) is located within the northeastern corner of the model area. Platted parcels of the Sun Mountain-Twin Lakes development surround Twin Lakes. Other developments, such as Rodeo Trails and Wolf Creek Views are also present within the model area. Current buildout in the model area is about one third of future buildout. The model area is bordered by Lewis Butte (3,346 feet mean sea level [MSL]) to the north, Patterson Mountain (3,511 feet MSL) to the west and several ridges to the south and east (greater than 2,600 feet MSL).

The lower slopes of the Methow River Valley between Mazama and Twisp are generally unforested, but in some regions may be covered by sparse ponderosa pine, steppe mosaic with bitterbrush and beardless bluebunch wheat grass (Barksdale, 1975). Agriculture in the area is somewhat limited occurring predominantly in Sections 3, 4, 22 and 23 of Township 34 – North, Range 21 – East (based on aerial photographs and available water right information), and the most common crop is alfalfa. An estimated 550 acres is in irrigated agriculture production based on air photo review.

2.2 Climate

2.2.1 Precipitation

The climate of the Methow River Basin in the vicinity of Winthrop is generally classified as semi-arid (Barksdale, 1975). Winthrop has a mean annual precipitation of 14.25 inches over the period of record (1931-2005), based on the National Oceanic and Atmospheric Administration (NOAA) Weather Observation Station (Winthrop 1 WSW). Figure 2.2.1 illustrates the annual precipitation over the period of record for Winthrop, as well as the cumulative departure from the mean. The cumulative departure from the mean is calculated by taking the mean of the respective station for the period of record, computing the departure from the mean for each year, and running a cumulative total of the departures. Downward slopes indicate periods of below normal precipitation, while upward slopes indicate periods of above average precipitation. As indicated on Figure 2.2.1, the annual precipitation for the Methow River Basin in the vicinity of Winthrop has been below the mean annual precipitation since the year 2000, with the exception of the year 2003.

Mean monthly precipitation for the Winthrop 1 WSW Station is presented in Figure 2.2.2. The greatest precipitation typically falls as snow between the months of November and February (7.8 inches). Precipitation recorded at the Winthrop 1 WSW Station (1,755 feet MSL) is not representative of precipitation for the surrounding ridges due to orographic effects. Data from the United States Weather Bureau (1965) estimates an annual precipitation of between 20 and 25 inches for the ridges surrounding the Twin Lakes project area (Walters and Nassar, 1974).

2.2.2 Evapotranspiration

Evapotranspiration is the consumptive use of water through plant transpiration and evaporation of water from soil and other surfaces (Jensen and others, 1990).

The Penman Montieth method has become the accepted method of computing evapotranspiration. However, in the Winthrop area, climate parameters (solar radiation, relative humidity, temperature and wind speed) for computation of evapotranspiration using this method were not available. In lieu of this method, a less rigorous Blaney Criddle SCS temperature based method was applied using mean annual temperature data for Winthrop. Results of the analysis indicate an evapotranspiration rate of about 40 inches annually computed for an alfalfa reference crop (ET_r). The grass reference evapotranspiration would be about 37 inches per year. The Blaney Criddle Method may result in an underestimate of ET (about 15 percent) (see Jensen and others, 1990).

Long-term mean monthly evapotranspiration computed by modified Penman Equation for the Yakima WB AP Station (http://www.wrcc.dri.edu/htmlfiles/westevap.final.html) is also presented in Figure 2.2.2. As illustrated on Figure 2.2.2, the mean annual potential evapotranspiration is 51.9 inches, with the greatest amount of potential evapotranspiration occurring in July (9.8 inches). The long-term mean annual potential evapotranspiration rate for Yakima is very close to USGS estimate (51.5 inches annually) developed as part of a regional study of the Methow River Basin using the Jensen-Haise method (Ely, 2003). The modified Penman methods may result in a slight over estimate of ET (about 6 percent) (see Jensen and others, 1990).

Other evapotranspiration rates were obtained from the WSU Public Agricultural Weather station in Sunnyside and Wenatchee (Figure 2.2.2). Annual totals from these stations fall between the range defined by Yakima (and the Methow River Basin) and Winthrop. As the Yakima data provided the best long-term average of annual evapotranspiration computed from a combination equation (i.e., an equation that combines several atmospheric energy sources) and was similar to an annual estimate reported for the Methow River basin, it was used in the groundwater model. Other evaporation rates were evaluated outside the model.

Figure 2.2.2 also illustrates that between February and October the mean monthly potential evapotranspiration exceeds mean annual precipitation. Therefore, recharge from direct precipitation during an average year generally occurs during the period of November to January. Much of the precipitation occurs as snowfall and correspondingly, much of the recharge occurs during melt-off. Precipitation can also exceed available amounts of evapotranspiration during large rain events, resulting in additional recharge.

2.3 Surface Water Hydrology

2.3.1 Principal Lakes

As discussed in Section 2.1, the principal lakes within the project area are Barnsley, Big and Little Twin and Dibble Lakes. These lakes are likely “kettle lakes” formed during periods of glaciation. Big Twin Lake is the largest and deepest of the lakes with a surface area of 79 acres and a maximum depth of 67 feet. Little Twin Lake has a surface area of 23 acres and a maximum depth of 33 feet. Dibble Lake has a surface area of 4.7 acres and a maximum depth of 21 feet. Limited information was available on the surface area and typical water depth of Barnsley Lake; however, various personal communications indicate that the lake is often dry. A summary of the available information on the lakes located within the Twin Lakes project area is provided below (Wolcott, 1973):

Lake	TRS Location	Surface Area (acres)	Depth (ft)	Volume (acre-feet)	Year of Survey
Barnsley	T34N/R21E-10	9.5	20	-	-
Big Twin	T34N/R21E-15	79	67	1922	1946
Little Twin	T34N/R21E-15	23	33	331	1947
Dibble	T34N/R21E-23	4.7	21	59.7	1946

August 2006, field activities conducted by Aspect Consulting personnel included the installation and survey of staff gages at Big and Little Twin and Dibble Lakes to provide current and future monitoring points for lake levels. Big Twin, Little Twin, and Dibble Lakes are "windows" on the groundwater system, and water levels in these lakes reflect groundwater levels. A staff gage was later installed and surveyed at Barnsley Lake during December 2007 field activities. Barnsley Lake was originally thought to be perched above the water table based on DEM elevations; however, subsequent surveyed lake level measurements indicate that Barnsley Lake levels are also reflective of groundwater levels, with appreciable water (about 2 to 3 feet at the staff gage location) during the December 2007 and May 2008 field visits. Lake level measurements are provided in Table B-1 of Appendix B (Field Investigations).

2.3.2 Principal Rivers

The principal rivers within the Twin Lakes project area are the Methow and Chewuch Rivers. Figure 2.3.1 illustrates the locations of the rivers and the respective stream gage sites. Figure 2.3.2 presents Methow and Chewuch River daily flows for the respective periods of record and exceedance probabilities for the Methow River.

The mean daily flow of the Methow River immediately below the confluence with the Chewuch River (USGS Station # 12448500, Methow River near Winthrop) is 1,145 cfs, for the period of record (1989-2006) (Figure 2.3.2, upper graph). The mean daily flow of the Chewuch River immediately above the confluence with the Methow River (USGS Station #12448000) is 386 cfs, for the period of record (1991-2006). Therefore, the approximate mean daily flow of the Methow River above the confluence with the Chewuch River is 759 cfs. Because both the Methow and Chewuch Rivers are snowmelt dominated rivers, maximum yearly flows are found to occur in spring, generally during the months of May or June.

In order to determine the quantity of water transferred between the Methow River and groundwater within the project area, an analysis of the locations and timing in which the Methow River is gaining or losing water was conducted. The analysis was based on a study by the United States Geological Survey (USGS), which determined the gains and losses for several distinct reaches of the Methow River during 2001 and 2002 (Konrad and others, 2005) (Figure 2.3.1). Analysis of the 2001 and 2002 data illustrates that the Methow River from Goat Creek to Winthrop is typically a gaining river (i.e., more water is transferred from groundwater to the river than from the river to groundwater). However, from Winthrop to Twisp, the Methow River is transient in that it gains and loses, but is typically a losing river, meaning more water is transferred from the river to groundwater than from groundwater to the river.

The 2001 and 2002 analysis of the locations and timing in which the Methow River was gaining or losing water was applied to the entire record of Methow River flows (1989-2006) in order to estimate both monthly and yearly net gains/losses within the project area. Results of this analysis are presented in Figure 2.3.3. The upper portion of Figure 2.3.3 illustrates that the period of greatest Methow River net gains from Goat Creek to Winthrop generally occurs from March to August, with the highest average monthly net gain occurring in June (31.3 acre-ft per month). The total net yearly gain from Goat Creek to Winthrop is approximately 125 acre-ft per year (afy). The lower portion of

Figure 2.3.3 illustrates that the period of greatest Methow River net losses from Winthrop to Twisp also generally occurs from March to August, with the highest average monthly net loss occurring in May (-13.6 acre-ft per month). The total net yearly loss from Winthrop to Twisp is -40 afy.

It is important to note that although the Methow River is generally a gaining river from Goat Creek to Winthrop throughout the year, the Methow River from Winthrop to Twisp is much more transient and depends on Methow River flows. When the river flows are high during the spring snowmelt, the river between Winthrop and Twisp is generally a losing river (Figure 2.3.3). The river is nearly neutral during the relatively low, fall and winter flows from September to February when groundwater elevations exceed river stage. In addition, a bedrock constriction occurs at the downstream end of the study area. This constriction likely results in an upwelling of groundwater to the Methow River, and overall river losses in the model area below Winthrop may be relatively minor.

Methow River flows were evaluated with respect to regulatory baseflow requirements (minimum instream flows or “WAC”) under 173-548 WAC and WDFW target window for withdrawals. Under 173-548-020 WAC, baseflows for the upper Methow range from a low of 100 cfs (August 15 through September 30) to a high of 790 cfs (June 1 to June 30). Baseflows under the WAC are specified based on 24, approximate half month, time intervals. The control station for the Upper Methow Management unit is at the gage Methow River near Winthrop. TLAC water right applications specify that withdrawals will only occur when 173-548 WAC baseflow conditions are met.

WDFW reviewed the TLAC application and recommended TLAC withdrawals be limited to periods from April 1st through July 14th, when stream flows are between 800 to 6,000 cfs (Appendix A). No withdrawals are recommended by WDFW for the period from July 15 through March 31. As such, the period for allowable pumping under the WDFW recommended withdrawal window are far more restrictive than under 173-548 WAC.

The 10 percent, 50 percent and 90 percent probability that the Methow River flow will exceed either the WAC or the WDFW target window is shown in Figure 2.3.2 (bottom graph). Table 2.3.1 presents the percent of days that exceed either the WAC or WDFW streamflow criteria for the period 1989 to 2006 for the Methow River at Winthrop. Streamflows meeting the WAC baseflow criteria are met 20 out of 24 bimonthly periods. Periods not meeting the baseflow criteria 100 percent of the time include April 1 to May 14 and July 1 through 14, but baseflow requirements are met most days during these periods (Table 2.3.1).

From early April through July, 50 percent or more of the daily Methow River flows would be within the WDFW recommended flow window. The greatest probability (90 percent) these flows will be met occurs from June 15 to June 30 (Table 2.3.1), while the lowest probability occurs from April 1 through 14.

2.3.2.1 Thompson Creek

Thompson Creek originates from springs located along Thompson Ridge, to the southwest of Patterson Lake. The creek flows to the east, between Big Twin and Dibble Lakes, before ultimately discharging into the Foghorn irrigation ditch. The drainage receives recharge from a number of sources, including surface runoff, seepage from irrigated fields and likely seepage out of the south end of Patterson Lake. After flowing out of a relatively steep canyon, the creek discharges into a forested wetland area to the east of Moccasin Lake Ranch and south of Big Twin Lake. Discharge from the wetland area splits, with some of the water flowing north into a nearby sinkhole, and the remainder of the water eventually discharging into the Foghorn irrigation ditch.

Significant surface water diversions from Thompson Creek include a diversion upstream of Moccasin Lake Ranch, which diverts water to nearby Moccasin Lake, and a diversion near the creek's discharge into the Foghorn irrigation ditch, which diverts water for nearby irrigation. Overflow from Moccasin Lake flows through a pipeline to Moccasin Lake Ranch where it is used for irrigation. Unused Moccasin Lake overflow discharges into the forested wetland area to the south of Big Twin Lake.

During the December 2007 and May 2008 field visits, personnel from Aspect Consulting conducted stream gaging along Thompson Creek to quantify the discharge and determine reaches that are gaining or losing groundwater. Figure 2.3.4 presents the gaging locations and the streamflow at each location in December 2007 and May 2008. Gaining and losing reaches are also summarized on Figure 2.3.4. Table B-2 in Appendix B (Field Investigations) presents discharge measurements at the upstream and downstream end of each reach and inflows and diversions that occurred along each reach. No upstream surface water diversions were identified that would seasonally influence Thompson Creek flows (see Appendix B for further discussion).

Based on gage measurements, very little surface water is gained or lost in the canyon upstream of the Moccasin Lake Ranch (Stations 1U to 2UD, Figure 2.3.4). An average loss of less than 0.1 cfs (within measurement error) was identified for the two measurement periods. The Moccasin Lake diversion occurs along Reach 1. A diversion of about 1.6 cfs occurred along this diversion in May 2008. There was no diversion in December 2007.

Across the upper portion of Moccasin Lake Ranch (Reach 2, Stations 2UD to 2D), streamflow losses of about 0.6 cfs and 0.1 cfs were computed for December and May measurement periods, respectively. Much of this loss apparently discharges in the forested wetland in the lower portions of Moccasin Ranch (Reach 3 from Stations 2D to Stations 3 and 4U). Gains in the wetland area were about 1.0 and 1.5 cfs, for the December and May measurements, respectively. A tile drain system underlies the fields in Moccasin Lake Ranch and this system could collect and convey water losses from the upper portion Moccasin Lake Ranch (Reach 2) as well as irrigation return flow to the wetland area (Reach 3). In addition, Moccasin Lake overflow also contributes to the gain in Reach 3.

Flow splits in the wetland area and a portion of the flow is diverted into the "sinkhole" northwest of the wetlands with the remainder discharging to the east, where it passes through the Rodeo Grounds, becomes channelized through fields and finally discharges into Foghorn Ditch. One irrigation outtake occurs along this reach (Reach 4, between stations 4DU and 4D). Losses of about 0.6 and 0.1 cfs were measured along this reach in December and May, respectively.

The "sinkhole" is a depression in the glaciofluvial outwash where water infiltrates. There is no outflow from the sinkhole. Water infiltrating through the sinkhole averaged 0.27

cfs, with a slightly higher discharge during the December 2007 measurements. Surface water discharging into the sinkhole directly contributes to groundwater recharge in the project area.

2.3.3 Springs

Spring Branch Springs is located near the Methow River, to the north of Twin Lakes and west of Wolf Creek Road, near the State and National Fish Hatcheries. The spring discharge was measured by Ecology as part of a water right application change at the State Hatchery and had a discharge of between 1.5 and 2 cfs, but no routine monitoring of the springs has ever been conducted. Flow occurs in several seep areas on National Hatchery property and between National Hatchery property and Wolf Creek Road. West of Wolf Creek Road, the springs currently consist of a moist, vegetated area (Fred Wurster, personal communication, February, 2007).

2.3.4 Irrigation Canals

Figure 2.3.1 illustrates the locations of principal irrigation canals within the project area. The most important irrigation canals with respect to the numerical groundwater model are the Wolf Creek and Foghorn irrigation ditches. Both of these irrigation canals are located west of the Methow River, within the project area.

The Wolf Creek Reclamation District (WCRD) began diverting water from Little Wolf Creek and Wolf Creek to Patterson Lake and the Twin Lakes project area in 1922. The irrigation canal was unlined until August 2001, when the WCRD completed a conversion of approximately 13,480 feet of the irrigation canal to pressurized pipe (IRZ Consulting, 2003). Conversion of the irrigation canal to pipe prevents seepage of surface water into the groundwater aquifer within the Twin Lakes project area. The conveyance canal for the outflow from Patterson Lake remains unlined.

The Foghorn irrigation canal is operated by the National Fish Hatchery and diverts water from the Methow River near Spring Creek. The water is conveyed in an unlined irrigation canal adjacent to the Methow with tailwater discharged into a low-lying wet area south and east of Dibble Lake.

2.4 Geology

On a regional scale, the Twin Lakes project area is located within the Methow-Pasayten graben (down-dropped block of Earth’s crust), in which Jurassic (144 to 213 million years ago), Cretaceous (65 to 144 million years ago) and Tertiary (1.6 to 65 million years ago) sedimentary and volcanic rocks are preserved in a structural low between metamorphic and igneous highs to the northeast and southwest. The graben is bound by the Chewack-Pasayten fault to the northeast and the Foggy Dew and Twisp River faults to the southwest (Barksdale, 1975). On a more local scale, the Twin Lakes project area is part of an upward thrust block of sedimentary rock defined by the northwest/southeast-trending Moccasin Lake thrust fault to the southwest and a northwest/southeast-trending unnamed normal fault to the northeast, which runs parallel to Chewack-Pasayten fault. Several smaller north/south-trending faults are also present in the vicinity of Patterson Lake.

Bedrock within the vicinity of the Twin Lakes project area generally consists of Jurassic and Cretaceous sedimentary rock formations of the Newby Group. The Twisp Formation [Jm(t)] is the oldest and most predominant sedimentary rock formation in the vicinity of the project area, consisting of folded and faulted, thin-bedded black argillitic shales and interbedded lithic sandstones. The sedimentary deposits of the Twisp Formation are greater than 4,000 feet thick approximately 4 miles west of Winthrop and are thought to be of marine origin. Located immediately east of the Methow River, and overlying the Twisp Formation, is the younger Buck Mountain Formation [KJvs(n)]. The Buck Mountain Formation consists of several informal members, which are composed of lithic sandstone, siltstone, and black shale, as well as andesitic breccia (Barksdale, 1975). The bedrock aquifer within the model area is composed primarily of shale, sandstone, and siltstone from the Twisp and Buck Mountain Formations, but also includes the presence of limited sandstone interbeds. The fine-grained units of the Twisp and Buck Mountain Formations were likely deposited in a low energy marine environment.

Figure 2.4.1 presents a surficial geologic map of the Twin Lakes project area. Based on Figure 2.4.1, unconsolidated sediments (Qs) are predominantly present at the surface within the project area. As further discussed in Section 2.5.1, a bedrock ridge buried beneath unconsolidated Quaternary deposits separates Twin Lakes from the Methow River to the east. Overall, the fine-grained units within the project area generally consist of glacial till and glaciolacustrine silts and clays, while the coarse-grained units primarily consist of sands and gravels (Konrad and others, 2005).

The unconsolidated sediments that overlie bedrock in the vicinity of the Twin Lakes project area consist of both fine-grained and coarse-grained, glaciofluvial units (sediments deposited by streams originating from glaciers) which were deposited during the Pleistocene (10,000 years ago to 1.6 million years ago) and Holocene (present-day to 10,000 years ago) Epochs. Glacial deposits from late Wisconsin (10,000 to 18,000 years ago) alpine and continental ice sheets formed much of the kame-moraine landscape in the vicinity of Big and Little Twin Lakes (Waitt, 1972).

Waitt (1972) indicates the presence of a buried alluvial valley diverging from the present-day Methow River valley, north of Barnsley Lake, and running southeast beneath Barnsley, Big and Little Twin and Dibble Lakes before converging with the present-day Methow River valley, east of Dibble Lake. Waitt (1972) hypothesized that because the change in drainage coincided with the largest morainal features in the region (created by the glacial deposition of sediments), it is likely related to deglaciation events of the region.

A detailed discussion of the unconsolidated sediments composing the hydrostratigraphic units delineated for the numerical groundwater model is discussed in the following section.

2.5 Hydrogeology

The hydrogeology of the Twin Lakes project area was determined based on:

- the compilation of well logs completed for the drilling of both domestic and municipal wells in the project area;
- USGS publications (Konrad and others, 2005) and consultants reports (GeoEngineers, 1990); and
- A field program that consisted of surveying and obtaining water level measurements in approximately 51 wells and installing staff gages in Barnsley, Big Twin, Little Twin and Dibble Lakes (Appendix B).

Wells logs were obtained from the Washington State Department of Ecology (DOE) well log database. A total of 418 wells logs were initially obtained from the well log database for Sections 1-4, 9-12, 13-16 and 21-24 of Township 34-North and Range 21-East. Four additional well locations without wells logs were added to the list based on field work conducted in August 2006, and seven additional well locations were added to the list based on field work conducted in December 2007 and May 2008, providing a total of 429 well locations.

Wells from the DOE well log database are located based on the center of the quarter-quarter section listed on the well log. Errors in identifying the appropriate ¼ ,¼ section location are common on well logs. The locational accuracy of the wells was improved through correlation to USGS locations and lot locations and through survey of 44 wells. The USGS monitors groundwater levels of numerous wells throughout Washington and have obtained Global Positioning System (GPS) locations of some of these wells. The GPS located wells were correlated to the DOE well logs to improve locational accuracy. Locational accuracy was also improved by correlating well logs with specified lot numbers to the center of the lot location provided on the Okanogan County Assessors map.

After examination of the accuracy of the respective well locations and the overall geology of the Twin Lakes project area, several data gaps and uncertainties in the site stratigraphic model were recognized for the area surrounding Big and Little Twin Lakes. In order to resolve these data gaps, personnel from Aspect Consulting made a site visit to the Twin Lakes project area from August 28, 2006 to September 1, 2006. During this site visit, 25 of the wells with quarter-quarter section locations were located and surveyed by Erlandsen and Associates Inc., with water level measurements collected in order to resolve the data gaps/uncertainties surrounding Big and Little Twin Lakes. In addition to the 25 surveyed wells, water levels were also obtained from six additional wells that had been previously surveyed by the USGS. Subsequent site visits (December 2007 and May 2008) led to the location and measurement of water levels for an additional 19 wells bringing the total number of survey wells to 50.

A summary of the DOE well log information, location information and accuracy, geologic information and static water level data for the 429 well locations is presented in Table 2.5.1. Figure 2.5.1 provides a map of the respective well locations. Wells in Figure

2.5.1 are identified by completion unit (symbol color) and locational source (symbol shape).

2.5.1 Hydrostratigraphic Units

A group of 278 well logs were selected from the 429 well locations discussed above based on well depth and geographic distribution to determine the extent and thickness of the hydrostratigraphic units within the Twin Lakes project area. Based on this examination of the well logs, four principal hydrostratigraphic units were delineated within the project area and used to define the layering within the numerical groundwater model:

- Upper Aquifer
- Aquitard
- Lower Aquifer
- Bedrock

The subsurface relationship of these units is presented in the hydrostratigraphic cross-sections shown in Figures 2.5.1 through 2.5.4 as follows:

- Figure 2.5.1 provides a cross-section and well location map for the project area.
- Figure 2.5.2 – Cross Section A-A' extends north-south from the Methow River, through Barnsley, Big and Little Twin and Dibble Lakes, following the hypothesized buried alluvial channel (Waitt, 1972).
- Figure 2.5.3 – Cross Section B-B' extends approximately east-west from the Wolf Creek irrigation canal to the Methow River in the vicinity of Barnsley Lake.
- Figure 2.5.4 – Cross Section C-C' (Figure 2.5.3) extends approximately east-west from the Wolf Creek irrigation canal to the Methow River, but in the vicinity of Big and Little Twin Lakes.

Ground surface elevations on the cross-sections are based on a Digital Elevation Model (DEM) for the project area. Surveyed wells included on the cross sections are shown at the surveyed elevation DEM ground surface elevations are generally accurate to within plus or minus 33 feet. Comparison of surveyed and DEM points indicates a standard deviation of 16 feet. Additional survey control for the project was obtained after generating the geologic cross sections. This additional data was used in numerical modeling, but cross sections were not updated with this information. As such, some of the layer thicknesses depicted on the cross sections may vary from those used in the numerical model.

Identification and delineation of the hydrostratigraphic units was based on geologic descriptions provided on driller’s logs. The Upper Aquifer is composed predominantly of glaciofluvial sands and gravels and Recent Alluvium at locations proximal to the Methow River. Near mountain front locations, the shallow aquifer may contain alluvial fan deposits. Where Thompson Creek flows out of the relatively steep canyon to the east of Thompson Ridge, the evaluation of well logs (22E01 and 22E02) indicated the presence of finer grained deposits, likely associated with alluvial fan deposits.

The aquitard separating the upper and lower alluvial units consists predominantly of glacial till and glaciolacustrine silts and clays and silty gravels with occasional sand and gravel interbeds. Glaciofluvial sands and gravels comprise the Lower Aquifer.

The Upper and Lower Aquifers serve as the main source of groundwater for domestic, municipal and irrigation wells within the Twin Lakes project area. A few wells are completed within water-bearing portions of the aquitard. The upper aquifer is unsaturated throughout much of the project area. Numerous (on the order of 100) domestic water supply wells in the Twin Lakes project area have been completed in bedrock. The bedrock aquifer is comprised predominantly of sandstones and shales. These rocks have little or no intrinsic permeability and storage and transmission of groundwater occurs via fractures. There is little or no reported use of the bedrock aquifer for purposes other than domestic use. Most wells are completed within the upper 300 ft of bedrock suggesting adequate permeability in this portion of the aquifer for domestic use.

Figure 2.5.5 presents an isopach map of the unconsolidated sediments. Figure 2.5.6 presents a structure contour map of the elevation of the top of bedrock based on the individual isopach grids for the hydrostratigraphic units. A series of isopach (thickness) maps for the unconsolidated hydrostratigraphic units were also created using the contouring program (Surfer) to assess the distribution and extent of these units and for use in the numerical groundwater model (Upper Aquifer, Aquitard and Lower Aquifer). Descriptions of the lithology, extent and thickness of the individual hydrostratigraphic units are presented below.

A bedrock high occurs between the Twin Lakes region and the Methow River. This largely buried bedrock ridge separates the buried channel hypothesized by Waitt (1972) from the Methow River (Figure 2.5.6) with much of the ridge occurring above elevation 1,800 feet. The greatest areas of alluvial thickness occur within the channel west of the bedrock divide, between Barnsley and the Twin Lakes and in the vicinity of Big and Little Twin Lakes where alluvial thickness is greater than 120 feet (Figure 2.5.5). These areas also generally have top of bedrock elevations at or below 1,760 feet MSL (Figure 2.5.6).

The hydrostratigraphic units are somewhat variable in the vicinity of Barnsley Lake. The Upper Aquifer is generally between 20 and 30 feet thick and consists primarily of coarse gravels and boulders. The Aquitard is significantly thicker, ranging between 40 and 100 feet in thickness, and consists of a mixture of clay, hardpan, fine sand and silty gravel. Based on examination of the well logs, the Lower Aquifer was not identified in the vicinity of Barnsley Lake.

The hydrostratigraphic units in the vicinity of Big and Little Twin Lakes are also relatively variable. The Upper Aquifer in this area is approximately 20 to 80 feet in thickness and composed primarily of fine and coarse sands, coarse gravels and boulders. The Aquitard is approximately 15 to 30 feet thick and consists predominantly of sandy clay, hardpan, silty gravel, and cemented boulders. The Lower Aquifer thickness ranges between 10 and 80 feet and is composed primarily of sand and gravel with some interbeds of clay. An area of greater thickness of the Lower Aquifer unit is likely associated with an apparent low in the top of bedrock elevation found in the vicinity of

Big and Little Twin Lakes (Figure 2.5.6). An alluvial thickness of about 130 feet was identified at well 15H01.

2.5.2 Groundwater Conditions

2.5.2.1 Water Level Data

Groundwater flow in the vicinity of the Twin Lakes project area can be interpreted based on a groundwater elevation contour map; where groundwater flows from regions of higher to lower potentiometric elevations. Historical static groundwater levels (hydrographs) for several wells completed in the Upper Aquifer, Lower Aquifer, and Bedrock within the project area are presented in Figure 2.5.7. The hydrographs presented in Figure 2.5.7 are based on a limited number of static groundwater levels measurements and therefore present a general sense of historical static groundwater levels.

Wells completed in the Upper Aquifer, Lower Aquifer and Bedrock all show a slight decrease in static groundwater levels (less than 10 feet) from November 2000 through August 2001 (Figure 2.5.7). This decrease in static water levels was likely due to several below average years of precipitation (Figure 2.2.1) and the conversion of the Wolf Creek irrigation canal to a pressurized pipe (started in 1999, completed in 2001). The erratic interval between water level measurements highlights the need for routine water level monitoring.

As part of the August 28, 2006 through September 1, 2006 site visit by Aspect Consulting personnel, static groundwater levels were measured in several wells previously monitored by the USGS (34N/21E-14E03, 34N/21E-15R01, 34N/21E-22A03 and 34N/21E-23K02). These static groundwater level measurements generally show a slight increase (approximately 0.5 to 3.5 feet) in static water levels from August 2001 to August 2006. Subsequent groundwater level measurements indicate a slight decrease (approximately 1.2 to 4.1 feet) in static water levels between August 2006 and May 2008.

Static groundwater level measurements, Methow River elevation measurements, and lake elevation measurements of Big and Little Twin and Dibble Lakes obtained by Aspect Consulting in August 2006, December 2007, and May 2008 were used to create groundwater elevation contour maps of the Twin Lakes project area (Figures 2.5.8 through 2.5.10). These figures also depict areas in which the unconsolidated alluvium is unsaturated and groundwater is found within the bedrock. Wells identified as pumping or recovering during the respective water level surveys are shown in red font and were not used in interpreting the potentiometric surfaces.

As discussed in Section 2.5.2.3, vertical groundwater gradients between and within units were found to be small and the groundwater elevations for the various units were contoured collectively.

2.5.2.2 Groundwater Flow

The various groundwater elevation contour maps (Figures 2.5.8, 2.5.9 and 2.5.10) each show similar seasonal groundwater flow directions, with the May 2008 groundwater elevation contour map having the greatest refinement due to access gained to additional wells south and southeast of Big Twin Lake. Based on the groundwater elevation contour maps, groundwater flow in the ancestral alluvial valley occupied by Twin Lakes consists of convergent flow from the valley margins. An easterly flow component is driven by the upland areas on the east side of Patterson Mountain and a westerly flow is driven by higher heads found on the bedrock high between Twin Lakes and the Methow River.

Within the valley itself, flow becomes parallel to the valley margin, with divergent groundwater flow (a groundwater divide) in the vicinity of Big and Little Twin Lakes. Groundwater flow to the north of the lakes is north-northwest, towards the Methow River, between the areas of relatively high bedrock elevations (Figures 2.5.8, 2.5.9, and 2.5.10). Groundwater elevations show a uniform decline from an elevation of 1791 (NGVD 29 or MSL) at Big and Little Twin Lakes to an elevation of about 1767 at the Methow River near the State Hatchery (Figure 2.5.10). Groundwater flow to the south of Big and Little Twin Lakes is generally interpreted to be to the southeast, with a decline in groundwater elevations to about 1673 (NGVD 29 or MSL) at the Methow River, downstream of Winthrop. The groundwater gradient steepens appreciably near the High School as flow exits the ancestral alluvial channel. The steepening in gradient in this area is attributed to lower hydraulic conductivity of the shallow aquifer in this area and pinching out of the lower aquifer. Two wells in this area (23J02 and 23J05) indicate a lower permeability aquifer in this area. The divergent groundwater flow in the vicinity of Big and Little Twin Lakes is likely caused by groundwater recharge from the lakes and the nearby sinkhole.

Two regions of relatively high potentiometric elevation define the potentiometric high east of Twin Lakes and west of the Methow River . Defined predominantly by bedrock wells, groundwater elevations east of Barnsley Lake exceed 1,815 feet (MSL) with groundwater flow discharging radially outward from a high defined by wells 10K01, 11F03, and 14E05. East of Big and Little Twin Lakes, groundwater flows from a potentiometric high (greater than 1,810 at wells 14M02 and 23D01) along the flank of the bedrock ridge into the ancestral alluvial channel. The relative volume of recharge to the ancestral alluvial channel from the bedrock ridge area is expected to be relatively small due to the low permeability of the bedrock.

A portion of the flow east of the groundwater divide in the bedrock ridge area likely flows eastward through the bedrock, ultimately discharging into the Methow River; however, the volume of flow is also expected to be relatively small due to the low permeability of the bedrock. Easterly groundwater flow from Barnsley and Big and Little Twin Lakes toward the Methow River is precluded by the higher heads within the bedrock ridge.

Using the top of bedrock elevation contour map (Figure 2.5.6) and the August 2006 groundwater elevation contour map (Figure 2.5.8), it is possible to estimate the saturated thickness of the alluvial (unconsolidated) sediments within the Twin Lakes project area. Figure 2.5.11 presents a saturated alluvial thickness contour map; where the blue shaded regions represent areas in which the alluvial sediments are saturated (contours indicate thickness) and the unshaded regions represent areas in which the static groundwater level is below the elevation of the top of bedrock (contours indicate thickness of unsaturated bedrock). The regions in which the top of bedrock elevation is below about 1,800 feet MSL, including near the Methow River and Barnsley, Big and Little Twin and Dibble Lakes, generally have saturated alluvial sediments. The greatest thickness of saturated unconsolidated sediments (approximately 120 feet) is found in the vicinity of Big and

Little Twin Lakes. The pattern of continuous saturated alluvium along the alluvial channel axis is consistent with the presence of a buried alluvial valley in the vicinity of Barnsley, Big and Little Twin and Dibble Lakes as indicated by Waitt (1972).

During the May 2008 site visit, groundwater elevations of Big and Little Twin Lakes were comparable; however, approximately a 2-foot difference in groundwater elevation was noted between the lakes during the August 2006 site visit. Lake elevations reported on USGS topographic maps indicate a similar relative difference. Thus, Little Twin Lake may be partly supported by seepage losses from Big Twin Lake during the summer (Table B-1 in Appendix B). Continued lake level monitoring is recommended to further define seasonal differences in lake levels.

2.5.2.3 Groundwater Vertical Gradient

An evaluation of vertical groundwater gradients for the Twin Lakes project area was performed by examining the vertical gradients of wells completed in different hydrostratigraphic units in close proximity. Vertical gradients were found to be relatively small both between and within hydrostratigraphic units. Wells 11P01 and 14E05 (distance of approximately 225 feet) were used to examine vertical gradients within the Bedrock aquifer and wells 14P03 and 14P02 (distance of approximately 300 feet) were used to examine vertical gradients between the Lower Aquifer and Bedrock (Figure 2.5.8). Groundwater flow within both the Bedrock and between the Bedrock and Lower Aquifer was found to be in an upward direction at these locations. The vertical groundwater gradient within the Bedrock was found to be approximately 0.005, while the vertical groundwater gradient between the Bedrock and the Lower Aquifer was found to be 0.04. The buildup of up to 8 feet of hydraulic head associated with recharge augmentation into Big Twin Lake will not likely influence vertical gradients in the system.

2.5.3 Hydraulic Parameters

Hydraulic Conductivity

Hydraulic conductivity (ft/day) is the quantitative measure of an aquifer's ability to transmit water. The hydraulic conductivity of an aquifer can often be estimated based on the specific capacity (gpm/ft) of water supply wells within a project area. Specific capacity is an empirical measure of well productivity, calculated by dividing well yield by drawdown. Specific capacity values for water supply wells with available well yield and drawdown information in the project area are provided in Table 2.5.1. A summary of the specific capacity values for the delineated hydrostratigraphic units are provided in the Table 2.5.2.

Most wells in the project area were tested using airlift methods and, as such, no drawdown or specific capacity data is available. Because of the limited specific capacity data available for the wells examined (most hydrostratigraphic units have six or fewer data points, Table 2.5.2), the above table only presents a general comparison of specific capacity values for the hydrostratigraphic units within the Twin Lakes project area.

Hydraulic conductivity was estimated from the specific capacity data using the relationship presented by Driscoll (1986) and shown in Figure 2.5.2 to compute transmissivity, and dividing transmissivity by the average hydrostratigraphic thickness

(Table 2.5.2). The Upper and Lower Aquifers both have the greatest range and mean hydraulic conductivity values, consistent with a composition of predominantly glaciofluvial sands and gravels. The single specific capacity measurement within the aquitard was low, consistent with a composition of predominantly glacial till and glaciolacustrine silts and clays. The Bedrock Aquifer has a relatively large range of specific capacity values, but a relatively low mean specific capacity value. This is likely due to the high variability in the amount of fracturing present within the bedrock and the preferential groundwater flow associated with the fracturing.

Konrad and others (2005) calculated hydraulic conductivity values for the glaciofluvial units within the Methow River Basin based on specific capacity data from 36 wells. Of the 36 wells, 26 were completed in an unconfined glaciofluvial unit similar to the Upper Aquifer hydrostratigraphic unit defined in Section 3.5. The USGS found that the hydraulic conductivity of the unconfined unit ranged between 20 and 3,500 ft/day with a median of 430 ft/day, similar but slightly greater than the ranges presented in Table 2.5.2. The remaining 10 wells were completed in a confined glaciofluvial unit similar to the Lower Aquifer hydrostratigraphic unit defined in Section 3.5. Hydraulic conductivity values of the confined unit ranged between 50 and 2,600 ft/day with a median of 460 ft/day, also similar to, but slightly greater than ranges presented in Table 2.5.2.

Pump tests performed as part of Phase 3 (well TW-10) and Phase 4 (wells: PW-1, PW-2 and PW-3) Hydrogeologic Services for the Spring Chinook Hatchery and Rearing Facility in Winthrop, Washington (GeoEngineers, 1990 and 1991) also provide additional information on hydraulic conductivity values of the hydrostratigraphic units in the Twin Lakes project area. Analysis of the pump test data for TW-10 indicates a specific capacity of 156 gpm/ft and a hydraulic conductivity of 504 ft/day for the Upper Aquifer; and a specific capacity of 240 gpm/ft and a hydraulic conductivity of 1008 ft/day for the Lower Aquifer (GeoEngineers, 1990). Analysis of pump test data for PW-1, PW-2 and PW-3 indicates that the specific capacity values of the wells range between 40 and 115 gpm/ft, while the hydraulic conductivity values of the glaciofluvial units present in the vicinity of the wells ranges between 1152 and 1296 ft/day (GeoEngineers, 1991). These values define the upper end of the ranges presented in Table 2.5.2, but are within the ranges defined by the USGS.

EMCON (1993) found hydraulic conductivity values for the glaciofluvial units within the Methow River Basin to range between 150 and 850 ft/day.

Initial assignment of hydraulic conductivity values for the delineated hydrostratigraphic units (Upper Aquifer, Aquitard, Lower Aquifer and Bedrock Aquifer) in the numerical groundwater model was based on soil descriptions from well logs and respective literature values (Anderson and Woessner, 1992). A lower hydraulic conductivity value was used in the area where Thompson Creek flows out of the relatively steep canyon to the east of Thompson Ridge. The lower hydraulic conductivity was consistent with the finer grained deposits observed in the well logs (22E01 and 22E02) in this area, which likely originate from alluvial fan deposits. Another region of lower hydraulic conductivity, consistent with an aquitard, was interpreted to be present within the ancestral alluvial valley near Dibble Lake (wells 23J02 and 23J05). The hydraulic conductivity values used are consistent with the reported ranges discussed above.

Additional details on the assignment of hydraulic conductivity values are discussed in Section 5.2.4.1.

2.6 Land Use

2.6.1 Current Land and Water Use

Land use in the project area is predominantly residential with agricultural land use largely located along the western and southwestern margins. With the exception of the Winthrop National Fish Hatchery and the Methow Hatchery, agricultural irrigation (groundwater and surface water) represents the largest water use within the study area. Figure 2.6.1 presents an aerial photograph showing parcel locations and irrigated lands. Based on the aerial photograph, the greatest areas of irrigated land are located throughout Sections 4, 22 and 23, and the western quarter of Sections 3, 10 and 15 of Township 34-North and Range 21-East (Figure 2.6.1).

The Winthrop National Fish Hatchery has the following certificated/permitted surface water and groundwater rights for Section 3, of Township 34 North, Range 21 East:

WRTS Control Number	Water Right Document Type/Number	Bussiness Name	Priority Data	Qi (cfs)	Qi (gpm)	Qa (acre-ft)	Source Name
Surface Water							
S4-*00705CWRIS	Cert. No. 848	US Dept Fish & Wildlife	1/10/22	50	-	31,934	Infiltration Gallery #3 (10 cfs max)
S4-*07733CWRIS	Cert. No. 3023	US Bureau Reclamation	6/4/43	10	-	-	Spring Branch Springs
Groundwater							
G3-*08665PWRIS	Permit cancelled 2/21/69	USDOI Bureau Sport Fisheries & Wildlife	4/6/67	-	1000	1610	Well
G4-*08664CWRIS	Cert. no. 7209-A	US Dept Fish & Wildlife	4/6/67	-	1500	2420	Infiltration Trench
G4-*11685CWRIS	Cert. No. 7590-A	US Dept Fish & Wildlife	2/17/71	-	1500	2400	Infiltration Trench

The surface water sources for the hatchery include the Methow River and Spring Branch Springs. However, Spring Branch Springs is no longer used as a source due to water quality issues. The groundwater sources for the hatchery include a total of three Ranney collectors (infiltration galleries) completed to a depth of 20 feet (Fred Wurster, Personal communication February, 2007).

The State Hatchery has the following certificated surface water and groundwater rights for Section 3, of Township 34 North, Range 21 East:

WRTS Control Number	Water Right Document Type/Number	Business Name	Priority Data	Qi (cfs)	Qi (gpm)	Qa (acre-ft)	Source Name
Surface Water							
S4-29912C	Certificate	Douglas Cnty PUD 1	1/19/1989	18	-	13,099	Methow River
Groundwater							
G4-29911CWRIS	Certificate/G4-29911C	Douglas Cnty PUD 1	1/19/1989	-	4500	7277	Well

The surface water source for the hatchery includes a diversion from the Methow River that feeds surface water flows into Foghorn Ditch. The groundwater sources for the hatchery include a total of five operational production wells (PW-1 through PW-5) and one domestic well located on the property.

Of the 429 wells listed in the Ecology well log database (Section 2.5), 386 are used for domestic water supply, 8 are associated with the fish hatcheries, and 35 are associated with water rights for agricultural irrigation, based on a correlation of well logs with irrigation water rights from the Water Right Tracking System (WRTS) database.

Current consumptive domestic groundwater use for the project area is estimated to be approximately 108 afy, using 250 gpd per household (200 gpd per capita use [Lane, 2004] at 2.5 persons per household and assuming 50 percent of the total volume is consumptively use). Solley and others (1998) reports consumptive domestic water use ranges from 10 to 50% and average 26% nationwide. The assumption of 50% used in the Methow Valley is based on total domestic use in Okanogan County being among the highest in Washington (Lane, 2004). The higher per capita domestic use is attributed to higher irrigation demand that is significantly more consumptive than domestic use.

There is considerable uncertainty in the total water use for agricultural irrigation. A significant portion of the surface water supply is “imported” from outside the project area, and the amount of groundwater pumpage occurring within the project area for irrigation use is uncertain. Based on Ecology’s WRTS (Water Right Tracking System) database (Table 3.2.1) the sum of groundwater claims and certificated water rights is 1,835 afy of groundwater. Of this amount, 826 afy represents certificated water rights. Generally, the amount of water right appropriation listed in Ecology’s WRTS database (often referred to as “paper” rights) exceeds, in many cases significantly, actual annual water use and therefore other indirect methods of analysis are used to better approximate water use for purposes of constructing a water balance. Aerial photo analysis was used to estimate actual agricultural irrigation demand for the project area. Total water use (surface water and groundwater) was derived by determining the total number of irrigated acreage (estimated to be on the order of 550 acres) and applying an appropriate crop water duty (based on the Washington Irrigation Guide), assuming alfalfa as the representative crop. Agricultural irrigation water use utilizing this methodology, is estimated to be on the order of 1,283 afy. A significant portion of this quantity is estimated to be provided by surface water.

Approximately 35 percent of water applied for agricultural irrigation (458 afy) is estimated to return to the aquifer as irrigation return flow (USDA, 1997 and Nim Titcombe, personal communication). Therefore, estimated total consumptive use through irrigation is 825 afy of which half is assumed to be supplied from groundwater (see Section 3.2.1). Total consumptive groundwater use for domestic and irrigation purposes is estimated at 525 afy (108 afy consumptive domestic use + ((1,283 afy irrigation withdrawal/2)(0.65)) (Table 2.6.1).

2.6.2 Projected Land and Water Use

Based on the locations of the current domestic supply wells and the available parcels within the model area, projected land use includes the addition of 595 domestic water supply wells. Current zoning of the subdivisions indicates that the greatest density of projected domestic water supply wells would be north of Big and Little Twin Lakes and south of Barnsley Lake. The addition of 595 domestic water supply wells would increase the total annual yearly water usage by 167 afy to a total groundwater usage of 692 afy, assuming no additional water use for agricultural irrigation.

The following table presents a summary of both current and projected water usage for the Twin Lakes project area:

Table 2.6.1

Total Current and Projected Consumptive Groundwater Water Use

	Current		Projected New		Projected Total	
Type of Water Usage	**Number of Wells**	**Yearly Usage (acre-ft)**	**Number of Wells**	**Yearly Usage (acre-ft)**	**Number of Wells**	**Yearly Usage (acre-ft)**
Domestic (Values)	386	108	595	167	981	275
Domestic (%)	92%	21%	100%	100%	97%	40%
Agricultural (Values)	35	417	-	-	35	417
Agricultural (%)	8%	79%	-	-	3%	60%
Total	**421**	**525**	**595**	**167**	**1016**	**692**

Based on the above table, current domestic water supply wells (not including the non-consumptive fish hatchery wells) account for 92 percent of the total number of wells, but only 21 percent of the yearly water usage. After including the 595 new domestic water supply wells necessary to obtain full projected buildout, the projected domestic water supply wells would account for 97 percent of the total number of wells and 40 percent of the yearly water usage. Therefore, increasing the number of domestic water supply wells within the Twin Lakes project area to obtain full projected buildout would increase the percentage of yearly water usage for domestic water supply wells by approximately 19 percent.

3 Water Balance

A calculation of the water balance for the Twin Lakes project area was performed in order to determine the major components of both groundwater recharge and discharge and support development of the groundwater flow model. Table 3.1.1 presents a summary of the water balance for the project area and the following sections discuss the major components of groundwater recharge and discharge.

3.1 Recharge

3.1.1 Precipitation Infiltration

Precipitation infiltration is the largest component of groundwater recharge within the project area at 752 afy. Recharge was approximated as the monthly difference between precipitation and evapotranspiration and runoff. As discussed in previous sections, the actual recharge from precipitation can be delayed to periods of melting. Precipitation during large rain events may also exceed available amounts of potential evapotranspiration and runoff, causing additional recharge.

The computed spreadsheet recharge value of 1.4 inches may slightly underestimate recharge for the model area due to data limitations. Precipitation used in the computation was based on valley measurements recorded at Winthrop. Runoff values, on the other hand, were computed from USGS region-wide runoff estimates (36 percent of precipitation) that include considerable mountain areas and likely overestimate runoff for the model area. Similarly, uncertainties in evapotranspiration may result in an underestimate of precipitation recharge. The USGS estimated a region-wide recharge rate of 4.2 inches inclusive of irrigation canal seepage or about 13 percent of a basin-wide average precipitation (32.6 inches) (Konrad and others, 2005) compared to 10 percent computed on Table 3.1.1.

The actual groundwater recharge rate due to aerially distributed precipitation likely lies between the 1.4 and 4.2 inches. Precipitation infiltration was further evaluated in the model calibration and found to be close to 10 percent of precipitation.

3.1.2 Mountain Front Recharge

Mountain front recharge along the western boundary of the project area accounts for approximately 190 afy of recharge. Because mountain front recharge is difficult to quantify, it was calculated from the water balance to ensure zero annual change in aquifer storage and was checked against literature values. The check was performed on Patterson Mountain and the Thompson Creek drainage, where bedrock is exposed at the surface (approximately 5,800 acres). Precipitation quantities for the area of contribution were computed from Prism Data, in order to account for orographic effects (9,700 afy). Based on this calculation, approximately 2 percent of the total annual precipitation ends up as mountain front recharge. This quantity is within the relatively wide percentage of precipitation range (between 0.2 percent and 38 percent) presented in Mountain-Block Hydrology and Mountain-Front Recharge (Wilson and Guan, 2004).

3.1.3 Subsurface Inflow

Subsurface inflow of groundwater at the northwestern boundary of the project area accounts for 1,906 afy of recharge. The amount of subsurface inflow was calculated by from Darcy's Law (Fetter, 2001):

$$Q = KiA$$

where:

K = Hydraulic conductivity (ft/day)

i= dh/dl, Groundwater gradient (ft/ft)

A = Cross Sectional subsurface area (ft^2)

The quantity of subsurface inflow was computed from a hydraulic conductivity of 215 ft/day, based on the geometric mean of the estimated hydraulic conductivities for the alluvial units. A calculated groundwater gradient of 0.003 was used based on 2001 groundwater elevations from the USGS Report (Konrad and others, 2005). The subsurface area was calculated using 85 feet for the average thickness and 3,700 feet for the average width of alluvial sediments in the area of inflow (Figure 2.5.5).

3.1.4 Methow River Losses

An estimated quantity of 40 afy of recharge is provided by Methow River losses (Table 3.1.1). As discussed in Section 2.3.2, within the project area, the Methow River loses water between Winthrop and Twisp. An analysis based on a study by the USGS, which determined the gains and losses for several distinct reaches of the Methow River during 2001 and 2002 (Konrad and others, 2005) was used in order to determine the net yearly contributions to recharge (Figure 2.3.3).

3.1.5 Irrigation Return Flow based on Water Rights

Irrigation return flow (458 afy) is one of several significant components of recharge in the project area. As described in Section 2.6.1, irrigation return flow was estimated for the approximately 550 acres of irrigated land based on analysis of aerial photos. Irrigation efficiency was estimated at 35 percent with 28 inches of applied irrigation, 18 inches consumptive use and 10 inches of irrigation return flow recharging the groundwater system (Nim Titcombe, personal communication). This irrigation efficiency is consistent with large gun-type irrigation sprinkler systems (USDA, 1997). It was also assumed that the irrigation return flow was evenly distributed during a 5-month growing season (April through August).

3.1.6 Thompson Creek Discharge

As discussed in Section 2.3.2.1, a portion of Thompson Creek was determined to discharge into the sinkhole located to the south-southwest of Big Twin Lake, near Moccasin Lake Ranch. This quantity of water is considered as a separate component of mountain front recharge in the water balance because of its proximity and importance in effecting lake levels.

Based on discharge measurements collected during the December 2007 (0.30 cfs) and May 2008 (0.23 cfs) site visits by Aspect Consulting personnel (Table B-2 in Appendix B), it was determined that the average discharge was approximately 0.26 cfs. Since the discharge measurements were relatively consistent during both site visits, it was assumed that there is very little seasonal variation in the portion of Thompson Creek discharging into the sinkhole. Therefore, the average discharge was applied as recharge to the Twin Lakes Aquifer on a monthly basis.

Total recharge from mountain front (0.35 inches), Thompson Creek (0.3 inches) and aerially distributed precipitation (1.4 inches) is estimated at 2.05 inches. Because of the uncertainty with respect to these values, they are further evaluated in the model calibration process.

3.2 Discharge

3.2.1 Net Domestic Well Withdrawal

Net domestic well withdrawal accounts for 108 afy of discharge. Calculation of the net domestic well withdrawal is based on a total of 429 wells within the project area (Section 2.5), 386 of which are domestic wells, 8 of which are associated with the fish hatcheries, and 35 of which are irrigation wells. It is assumed that domestic consumptive water usage is 250 gpd, based on a 200 gpd per capita usage (Lane, 2004) at 2.5 persons per household and 50 percent consumptive use.

3.2.2 Irrigation Well Withdrawal

Although Ecology’s WRTS database identifies a large appropriation of groundwater based on certificated groundwater rights, actual annual pumpage is estimated to be considerably less given the estimated number of irrigated acres (approximately 550 acres) and significant use of surface water supply. For purposes of the water balance analysis and model simulation, it was assumed that up to 50 percent of the irrigated land may be supplied by groundwater pumpage. Irrigation well withdrawals were estimated at 642 afy. As with irrigation return flow, the quantity of irrigation well withdrawal was evenly distributed over a 5-month irrigation season (April through August). Irrigation return flow from groundwater withdrawals are included under the Irrigation Return Flow recharge component (Table 3.1.1).

3.2.3 Subsurface Outflow

Subsurface outflow at the southeast boundary of the project area accounts for 1,514 afy of discharge. As with subsurface inflow, subsurface outflow was calculated using Darcy’s Law. A groundwater gradient of 0.004 was used based on 2001 groundwater elevations from the USGS Report (Konrad and others, 2005). The geometric mean of the alluvial sediment hydraulic conductivity of 215 ft/day was used. A subsurface area of alluvial sediments was calculated based on a thickness of 75 feet and a width of 3,000 feet (Figure 2.5.5).

3.2.4 Methow River Gain

An estimated quantity of 125 afy of discharge is provided from Methow River gains. As discussed in Section 2.3.2, within the project area, the Methow River gains water between Goat Creek and Winthrop. An analysis based on a study by the USGS, which determined the gains and losses for several distinct reaches of the Methow River during 2001 and 2002 (Konrad and others, 2005) was used in order to determine the net yearly contributions to discharge (Figure 2.3.3).

3.2.5 Lake Evaporation

Lake evaporation of Big and Little Twin and Dibble Lakes accounts for 346 afy of discharge. Some evaporation can also be assigned to Barnsley Lake, but the area of the lake varies with depth, much more so than the other lakes. As with river evaporation, lake evaporation was based on the monthly modified Penman estimates of potential evaporation from the Yakima WB AP. The monthly evaporation was applied to lake areas based on a 1946 and 1947 State Department of Game Survey (Section 2.3.1). Lake evaporation estimates based on other evaporation rates are discussed in Section 5.4.3.

3.2.6 River Evaporation

Evaporation of the Methow River within the project area accounts for approximately 1,000 afy of loss from the hydrologic system. The quantity of river evaporation was based on potential evapotranspiration calculated using the modified Penman method for the Yakima WB AP station. The calculation assumed computed potential evapotranspiration values were equivalent to open water evaporation (an open water crop coefficient of 1.0). The monthly evaporation was applied to a Methow River length of 9.5 miles, a river width of 125 feet, and a riparian width of 75 feet.

4 Analysis of Proposed TLAC Wells and Discharge Points

4.1 Location and Number of Withdrawal Wells

The TLAC water right application identifies two groundwater wells positioned near the State Hatchery on the Haub Brothers Enterprises Trust property with depths of up to 150 feet, or the use of infiltration galleries as the proposed point(s) of withdrawal. Ecology specified that the "wells are to be sited upstream of the National Fish Hatchery, where it will not cause impairment or significant interference with [hatchery operations]." In its comment letter to Ecology on the water right application, WDFW specified that "the point of withdrawal be placed landward of the Foghorn Ditch." The use of shallow interceptor wells proposed for withdrawals was not evaluated based on the potential impacts on Foghorn Ditch flows.

The number of wells required depends on the yield of the aquifer and the TLAC project system capacity. The system capacity is a function of water availability, desired time necessary to fill the lakes, and cost. More than two wells would likely be necessary to withdraw 4,500 gpm, but two wells could supply up to 2,000 gpm instantaneous flow based on the performance of nearby wells. The nearby State Hatchery uses five wells to withdraw up to 4,500 gpm. New wells installed in the vicinity and completed at comparable depths could be expected to yield similar quantities of water. Thus, (up to) five wells are proposed, located between the State and National Hatcheries, next to and landward of the Foghorn Ditch. As discussed in Section 5, two wells at 2000 gpm are adequate to fill Big Twin Lake in the first year and the additional wells are located as a contingency should additional yield be required as a result of model uncertainty. Figure 4.1.1 shows the proposed locations for these wells. For modeling purposes, TLAC wells 1 and 2 were evaluated. The wells are distributed across the more easterly of the two ¼, ¼ sections indicated on the TLAC application to maximize distance and minimize well interference between project wells and the State Hatchery wells. The wells are evenly distributed throughout the ¼, ¼ section to minimize well interference between project wells.

4.2 Period of Permitted TLAC Withdrawals

The TLAC water right application proposes a maximum annual quantity of 2,000 afy, which is equivalent to 100 days of pumping at 4,500 gpm. Groundwater withdrawals are restricted to "the period when river flows exceed base flows established in 178-548 WAC." Table 2.3.1 lists the probability of Methow River flows exceeding the established regulatory baseflows for each half-month period of the year. Figure 2.3.2 shows the river discharge for high flows (10 percent exceedance), median flows (50 percent exceedance) and low flows (90 percent exceedance), as well as baseflows for the Upper Methow River at Winthrop per 178-548 WAC. Low flows (90 percent exceedance) usually exceed

WAC baseflows and median flows (50 percent exceedance) always exceed WAC baseflows. WAC flow exceedances are further discussed in Section 2.3.2.

The WDFW recommended a “target window” for defining the period of permitted TLAC withdrawals which is more restrictive than 173-548 WAC, and is based on two additional constraints. The first WDFW constraint limits withdrawals to between April 1 and July 15. The second WDFW constraint limits withdrawals to when the river flows are between 800 cfs and 6,000 cfs. Table 2.3.1 lists the probability of Methow River flows exceeding the DWF Target Window for each half-month period of the year. The WDFW constraints were evaluated based on the pattern of daily mean flows at Winthrop for the years from 1990 to 2006. Proposed TLAC withdrawals would have been permitted at least 50 percent of the time, or about 50 days between April 1 and July 15, even during low river flow years. TLAC wells pumping at 4,500 gpm for 50 days would produce about 1,000 acre-feet of water. Refer to Section 2.3.2 for additional details of period meeting withdrawal criteria.

Two additional withdrawal scenarios were evaluated based on input from project stakeholders. These include a) TLAC withdrawals limited by WDFW target flows between April 1 and July 14, and in accordance with 173-158 WAC between July 15 and September 30, and b) TLAC withdrawals in accordance with 173-158 WAC between April 1 and September 30.

4.3 Proposed Place of Use

The TLAC water right application includes a description of the place of use, which generally corresponds with the boundary of the Twin Lakes Aquifer. Specifically, it proposes discharge of water to Big Twin Lake, Barnsley Lake and infiltration galleries positioned along the future pipeline. The WDFW conditioned their recommendation for approving the water right by limiting the discharge point to Big Twin Lake only, in support of the designated fish habitat. This study evaluates recharge augmentation directly to Big Twin Lake, based on field data collected in August 2006 through May 2008 and the groundwater model (see Section 5). Based on surveyed elevations, Barnsley Lake appears to be an expression of local groundwater levels, and the water level in Barnsley Lake will increase if water is added only to Big Twin Lake.

Barnsley Lake was not modeled as a proposed place of use. Barnsley Lake water elevation is approximately 16 ft lower than the level of Big Twin Lake. Water added to Barnsley Lake would be expected to flow radially outward from a localized mound created beneath the lake. This lake seepage would ultimately flow northward to the Methow River with the regional groundwater gradient unless groundwater levels were raised sufficiently to reverse the regional gradient. Maintenance of Barnsley Lake levels was evaluated as part of the Big Twin Lake amendment scenarios.

The proposal to add water to infiltration galleries positioned along the future pipeline was not considered based on the WDFW comments and direction by Ecology.

5 Numerical Model Analysis

A numerical groundwater flow model of the Twin Lakes area near Winthrop, Washington was constructed to evaluate the proposed TLAC water right application. The groundwater model was constructed and updated to address specific issues about the feasibility and design of the TLAC proposal, and to identify impacts if the TLAC water right were granted. The model was constructed with the best available data, tools, and techniques. However, data limitations required that certain simplifying assumptions be made in developing the model to reasonably represent the physical system. The model provides a robust tool for evaluating the relative changes in the timing and magnitude of lake levels and stream flows due to the proposed TLAC project. The sections below provide a description of the modeled scenarios, model construction, model calibration including a description of model refinements performed since the 2006 draft report, and model results.

5.1 Model Scenarios

Multiple scenarios were evaluated to address the issues identified by Ecology in the revised scope of work (dated November 12, 2007) as well as the conditions recommended by the WDFW. Scenarios are summarized in the following table and described below.

Table 5.1.1
Numerical Groundwater Model Scenario Components

Withdrawal/Point of Use Model Component	Existing Conditions	Scenario 1	Scenario 2a	Scenario 2b	Scenario 2c	Scenario 2d	Scenario 3a	Scenario 3b	Scenario 3c	Scenario 3d	Scenario 4a	Scenario 4b	Scenario 4c	Scenario 4d
Current Domestic Buildout	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Future Domestic Buildout		●	●	●	●	●	●	●	●	●	●	●	●	●
WDFW Target Flows 4/1-7/14			●	●	●	●								
WDFW Target Flows 4/1-7/14, 173-548 WAC 7/15-9/30							●	●	●	●				
173-548 WAC 4/1-9/30											●	●	●	●
TLAC Project Transfer System 500 gpm Capacity			●				●				●			
TLAC Project Transfer System 1,000 gpm Capacity				●				●				●		
TLAC Project Transfer System 1,500 gpm Capacity					●				●				●	
TLAC Project Transfer System 2,000 gpm Capacity						●				●				●

Existing Conditions – Established baseline conditions for the current land use and buildout, which includes 325 existing exempt domestic wells and 28 non-exempt wells. This model was used for calibration of aquifer parameters and flow boundary conditions.

Scenario 1: Future Domestic Well Buildout (without TLAC project) – Quantified effects of 595 future exempt wells on existing wells, Twin Lakes water levels, and Methow River/groundwater exchange. Future domestic wells were set at the center of currently unoccupied tax parcels, identified as those parcels without a well. Tax parcel GIS coverage was provided by Okanogan County. Future domestic wells were completed in saturated bedrock. Subsequent scenarios included future domestic well buildout.

Scenario 2: TLAC withdrawals limited by WDFW target flows, evaluating range of system capacities – Quantified effects of TLAC withdrawals on existing wells, future wells, Twin Lakes water levels, and Methow River/groundwater exchange. Limited TLAC withdrawals according to WDFW target flows from April 1 through mid-July, and augmentation recharge only to Big Twin Lake. Evaluated effects of TLAC transfer system capacities of 500 gpm (Scenario 2a), 1,000 gpm (Scenario 2b), 1,500 gpm (Scenario 2c), and 2,000 gpm (Scenario 2d). These pumping rates were determined in conjunction with the preliminary engineering design, where the time to establish lake levels with a given pumping rate was determined in the model and then compared to pipeline costs to convey that quantity. The modeled rates provide the most likely range of pumping rates based on this analysis.

Scenario 3: TLAC withdrawals limited by combination WDFW target flows and 173-548 WAC, evaluating range of system capacities, – Quantified effects of TLAC withdrawals on existing wells, future wells, Twin Lakes water levels, and Methow River/groundwater exchange. Limited TLAC withdrawals according to WDFW target flows from April 1 through mid-July, and by 173-548 WAC from mid-July through September 30, with augmentation recharge only to Big Twin Lake. Evaluated effects of TLAC transfer system capacities of 500 gpm (Scenario 3a), 1,000 gpm (Scenario 3b), 1,500 gpm (Scenario 3c), and 2,000 gpm (Scenario 3d).

Scenario 4: TLAC withdrawals limited by 173-548 WAC, evaluating range of system capacities – Quantified effects of TLAC withdrawals on existing wells, future wells, Twin Lakes water levels, and Methow River/groundwater exchange. Limited TLAC withdrawals according to 173-548 WAC from April 1 through September 30, with augmentation recharge to Big Twin Lake. Evaluated effects of TLAC transfer system capacities of 500 gpm (Scenario 4a), 1,000 gpm (Scenario 4b), 1,500 gpm (Scenario 4c), and 2,000 gpm (Scenario 4d).

5.2 Model Construction

5.2.1 Model Code and Run Setup

Groundwater flow was simulated using MODFLOW-SURFACT (Hydrogeologic, Inc., 1996), an industry-standard model designed to simulate groundwater flow in partially saturated groundwater systems. MODFLOW-SURFACT was used to simulate groundwater flow from river and recharge sources to wells and evapotranspiration sinks through an aquifer system with vertically-variable hydraulic parameters.

The standard river, recharge, drain, and evapotranspiration packages were used. Recharge was set to be applied to the top active layer. Evapotranspiration was applied at ground surface, including the bottom of lakes. Drain cells were used only to quantify the TLAC pumping necessary to keep the lake full without overfilling.

Several packages and model-run options specially designed to be used with MODFLOW-SURFACT were used. The block-centered flow (BCF4) package was used, implementing the variably saturated flow option with pseudo-soil relations and upstream weighting. All layer types were set to unconfined (with LAYCON = 43). The fracture well (FWL4) package was used to simulate wells. Pumping levels were set at the bottom elevation of the well. Screen and casing diameter were set based on well log information. The preconditioned conjugate gradient (PCG5) solver was used to perform the calculations, with the head-change criterion for convergence set to 0.005 foot to minimize mass balance errors. The damping factor and Newton-Raphson linearization were applied for model convergence. The adaptive time-stepping and output control (ATO4) package was used for optimizing the transient model calculations. The combination of model run parameters resulted in mass-balance errors of less than 0.02 percent, which is below the 0.1 percent goal for most groundwater models.

5.2.2 Model Timeline

Each of the scenarios were modeled using average monthly hydrologic conditions (precipitation, river stage, and evapotranspiration) over 17 years for a total of 204 timesteps. Future Methow River flows cannot be known and the historic record was used in the predictive model simulations to determine TLAC transfer quantities. For Scenarios 2, 3, and 4, TLAC withdrawals are limited according to actual flows measured for the 17-year period of record for the Methow River at Winthrop between October 1989 and September 2006. The first day of the model run represents the first day of the water year – October 1. Model results are presented for the arbitrary period beginning October 1, 2010.

Model results were dependent on initial groundwater levels. The calibration model was rerun iteratively until groundwater conditions approached equilibrium, where water levels and water balance components were similar for successive years. During model rerun cycles, calculated water levels from a previous run were used to establish initial water levels. Predictive models used equilibrium water levels established during calibration.

5.2.3 Model Extent and Grid

The model includes the valley alluvium aquifer surrounding the Twin Lakes area, and the underlying bedrock. The lateral extent of the model is the valley alluvium, based on the Washington State Department of Natural Resources (DNR) 1:100,000 geologic map (see Figure 2.4.1). The model includes the section of the Methow River from about River Mile 45 to about River Mile 52.

The horizontal grid spacing is uniformly 175 feet, resulting in 30,625 square-foot cells. Each layer contains 9295 cells (approximately 6,500 acres). The grid was rotated 45 degrees to align better with the Methow River.

5.2.4 Model Hydrostratigraphy

The model simulates hydrostratigraphy using separate layers for each major hydrostratigraphic unit. Figure 5.2.1 shows a model cross section (approximately east-west orientation) passing through Twin Lakes, as well as the Methow River, and illustrates the different layers.

The model hydrostratigraphy was updated in 2008 to reflect additional survey control. The geologic cross section shown were developed in 2006 and do not reflect these more recent data. Of greatest significance is lake bottom elevations that are interpreted to be beneath the aquitard in the numerical model (i.e., a window in the aquitard occurs at Barnsley and Big Twin Lakes) based on the new elevation data.

5.2.4.1 Alluvial Sequence

The 3 layers representing alluvial units (layers 2, 3 and 4) have spatially variable thicknesses. In general, the upper aquifer (layer 2) is separated from the lower aquifer (layer 4) by a fine-grained aquitard (layer 3).

To improve model calibration, the model area was divided into zones to reflect major differences in aquifer parameters (hydraulic conductivity and storage parameters) (see Figure 5.2.2). These zones include the area along the Methow River (Methow River

Zones on Figure 5.2.2), the higher, eastern area including the ancestral channel, Big Twin, Little Twin, Barnsley, and Dibble lakes (Upper Area on Figure 5.2.2), the area representing the Thompson Creek alluvial fan (Thompson Creek Alluvial Fan on Figure 5.2.2), and a zone of lower permeability between Dibble Lake and the Methow River (Low-Permeability Feature on Figure 5.2.2).

Aquifer parameters were initially set using reported values (Section 2.5.3 and Table 2.5.1), and were adjusted during calibration within the range of literature values (Anderson & Woessner, 1992) based on the soil descriptions on well logs.

A calibrated horizontal hydraulic conductivity of 0.02 centimeters per second (cm/s), representing silty sands and gravels, was used for the upper and lower aquifers in the vicinity of Twin Lakes (Upper Area). This value is close to, but slightly less than the geometric mean for the upper and lower aquifers of about 0.04 cm/sec (Table 2.5.2). A hydraulic conductivity of 0.0005 cm/s, representing sandy silt, was used for the aquitard in the vicinity of Twin Lakes. This value is significantly less than the single value reported in Table 2.5.2, an expected result as a well completion within the aquitard would be representative of the most permeable portions of the aquitard.

The calibrated hydraulic conductivity of 0.2 to 0.4 cm/s, representing clean and coarse sands and gravels, was used for the upper and lower aquifers along the Methow River, and is within the range of State Hatchery pumping tests (Methow River Zone). A hydraulic conductivity of 0.007 cm/s, representing silty sands, was used for the aquitard along the Methow River.

A hydraulic conductivity of 0.0005 cm/s was used for both the Thompson Creek alluvial fan and the low-permeability feature between Dibble Lake and the Methow River based on model calibration.

The alluvial deposits were assumed to have vertical anisotropy with horizontal to vertical hydraulic conductivity (Kh:Kv) of 10:1.

Aquifer storage related hydraulic constants were obtained from literature values typical of the material identified on well logs. Specific yield was set to 20 percent for the aquifers, and to 10 percent for the aquitard (Fetter, 1980). Specific storage was set to 0.0003 per foot for the upper aquifer and aquitard, and to 0.00003 per foot for the lower aquifer.

5.2.4.2 Bedrock Sequence

A 300-foot thick bedrock sequence was simulated below the valley alluvium. An analysis of well depth indicated very few wells present beneath this depth, providing an indication of the utilized depth of the bedrock aquifer. The bedrock sequence was subdivided equally into six 50-foot layers to better simulate well completion intervals (layers 5 through 10). The very low permeability bedrock (calibrated hydraulic conductivity of 0.00004 cm/s) is representative of fractured shales and sandstones, and was assumed to be isotropic (Kh:Kv = 1:1). The calibrated hydraulic conductivity value is well within the range of values computed from specific capacity data (Table 2.5.2). Specific yield of the bedrock was set to 10 percent. Specific storage for the bedrock was set to 0.000001 per foot. Lower values of hydraulic conductivity and specific yield for the bedrock sequence resulted in model non-convergence problems.

5.2.4.3 Lakes

The top layer of the model simulates the open water condition of the lakes, assuming the lakes to be in good communication with the aquifer. The bottom elevation of the top layer was adjusted from the USGS DEM to reflect lake bathymetry for Big Twin, Little Twin, Barnsley, and Dibble Lakes based on information in Lakes of Washington (Ecology WSB 14, 1973), and surveyed elevations. Open water conditions in the lakes were modeled by setting an isotropic hydraulic conductivity at a high value of 4 cm/s. Specific yield was set to 100 percent.

5.2.5 Boundary Conditions

5.2.5.1 Rivers and Creeks

The Methow River (see Figure 2.1.2) was simulated in the model using the “River” boundary condition. Contributions from the Chewuch River were included in the Methow River depth values. Discharge from Thompson Creek based on field observation (southwest of Big Twin Lake) was simulated infiltrating at the sinkhole near Big Twin Lake using the “Recharge” boundary condition, at rates described above (see Section 3). Bear Creek (on the east side of the Methow River) was simulated using mountain front recharge (see below).

The “River” boundary condition used to simulate the Methow River allows flow between the river and the aquifer depending on the relative hydraulic gradient. The conductance was set at 1,400,000 square feet per day representing a river in good continuity with the aquifer. The elevation of the bottom of the river was defined as 5 feet below the bottom of the USGS digital elevation model (DEM). Figure 5.2.3 shows the simulated river stage (river bottom plus river depth), as well as August 2006 surveyed water levels along the Methow River. Figure 5.2.3 also illustrates the accuracy of the DEM which is an important consideration in model calibration. DEM river stage differs from surveyed Methow River stage values by as much as 10 feet. As discussed in Section 5.3.2, with respect to model calibration, the standard deviation of the difference between all surveyed points and DEM-based points was 16 feet.

The monthly average depth of the river was assigned for the 50th percentile flows reported for the USGS Winthrop river gage downstream of the confluence with the Chewuch River. River depth upstream of the confluence was adjusted to account for Chewuch River flows, using Manning’s equation for open channel flow. The monthly variation in river stage is shown in Figure 5.2.4, and reflects differences in stage upstream and downstream of the Chewuch River.

5.2.5.2 Agricultural Return Flow and Irrigation Canal Leakage

The model simulates agricultural return flow from irrigated fields based on 2004 aerial photographs (see Figure 2.6.1) at rates as described above (see Section 3) using “Recharge” cells. A map of the recharge zones in the model is shown in Figure 5.2.5. The model does not simulate irrigation canal leakage, reflecting the tightlining of the Wolf Creek Irrigation Canal. Foghorn Ditch is located in the river flood plain, adjacent to the Methow River. Given the proximity to the Methow River, and the limited information available regarding ditch flows, Foghorn Ditch was not included as a separate boundary condition. The Methow River acts as a hydraulic barrier and return flows from irrigation canals or ditches located across the river do not influence Twin Lakes water levels.

5.2.5.3 Lake Recharge, Evapotranspiration and Precipitation Recharge

All of the precipitation that fell on, and runoff discharging to, open water lakes was treated as recharge in the groundwater model (see Figure 2.2.2). A map of the recharge zones in the model is shown in Figure 5.2.5.

Evapotranspiration was modeled at rates equal to potential evapotranspiration (see Figure 2.2.2) at ground surface, declining linearly to zero at an extinction depth of 5 feet below ground surface (or lake bed surface). In the absence of site-specific data, the extinction depth was considered an appropriate assumed value for the mixed vegetation types found along the riparian areas of the Methow River and area lakes and is within published ranges (Robinson, 1958). Thus, open water lakes evaporated water at the maximum rate, whereas groundwater below 5 or more feet below ground surface was not subject to evapotranspiration.

Precipitation recharge was varied between 5 and 20 percent of incident precipitation and 10 percent of incident precipitation was found to give the best model calibration. This value was consistent with spreadsheet estimates (Table 3.1.1) and the study by Konrad (2005) of the entire Methow Basin where recharge was found to be 13% of precipitation. A map of the recharge zones in the model is shown in Figure 5.2.5.

5.2.5.4 Mountain Front Recharge

Mountain front recharge includes both surface and subsurface inflows to the aquifer. Mountain front recharge was simulated using constant-rate recharge values at the boundaries of the model, at rates as described above (Section 3). Mountain front recharge was varied between half and double the calibrated value, and the model calibration was found to be sensitive. A map of the recharge zones in the model is shown in Figure 5.2.5.

5.2.5.5 Existing Domestic Wells

A total of 325 existing domestic wells were assigned to the model. Wells were located based on the most accurate available location information, including (from most to least accurate) survey coordinates, lot description, or quarter-quarter designation. Wells located outside the model extent were not included. Multiple wells located at the same coordinates (quarter-quarter accuracy) were set at distances of at least 264 feet from each other to prevent over-pumping one particular model cell (i.e., wells located at the same ¼, ¼ center). Well completion intervals in the model were set at depths according to available information on completion intervals and/or total well depths from Ecology well logs. Consumptive domestic water use was assumed to be continuous throughout the year at 250 gpd per household (see Section 3.2.6). Two non-pumping observation wells near the State Hatchery (3M06 and 3M07) were also included. The total pumping due to existing domestic wells in the model was calculated to be about 84 afy, or about 0.12 cfs. The difference between the model (84 afy) and spreadsheet estimates (108 afy) of domestic pumping are attributed to uncertainty of well elevations and locations (e.g., inaccuracies in the DEM) placing some wells in the model located above the calculated water table.

5.2.5.6 Existing Irrigation and Hatchery Wells

A total of 28 existing irrigation or hatchery production wells with associated water rights were assigned to the model, including 5 State Hatchery production wells near the proposed TLAC points of withdrawal. Only wells correlated by owner name with water rights using the WRTS database were included in the model. Wells located outside the model extent were not included. Wells were located in the model based on the most accurate location information, including survey coordinates or quarter-quarter designation. Well completion intervals in the model were set at depths according to available information on completion intervals and/or total well depths from well logs.

Agricultural well pumping rates were assigned to pump from April 1 through September 30 at the maximum instantaneous rate identified in the water right, and were distributed equally between wells when there were multiple wells associated with a single groundwater water right. The total pumping due to existing agricultural withdrawals was calculated to be about 728 afy (Table 3.1.1). The difference between spreadsheet values and model irrigation pumping is attributed to uncertainty of well locations and shallow wells located above the calculated water table.

State Hatchery well pumping rates were assigned according to monthly average production from 2003 through 2005 provided by Douglas County PUD, which were generally consistent with the water right of 4,500 gpm, or 7,277 afy (or about 10 cfs). A discharging well was assigned at the river near the State Hatchery to simulate non-consumptive groundwater return flow, with a flow rate equal to the water right.

The National Hatchery uses three shallow groundwater collectors (about 20 ft depth) situated near the river for non-consumptive use, as well as a spring source. A third collector recently installed had fewer collector laterals and consequently, produced less. The spring source is no longer used due to water quality problems. The points of withdrawal and discharge are within the same hydrostratigraphic unit and proximal to each other. Thus, the points of withdrawal and discharge were not explicitly included in the model.

5.2.5.7 Future Domestic Wells

A total of 595 additional domestic wells were assigned to the model to simulate full domestic buildout west of the Methow River. Tax parcel information, provided by Okanogan County, established the potential domestic buildout. A total of 325 tax parcels were identified as currently “built-out” based on proximity to 325 existing domestic wells. The remaining tax parcels were considered as future buildout. A well was placed at the center of the future buildout parcels. Bedrock well completion intervals in the model were set in saturated bedrock between 200 and 250 feet below ground surface, based on maximum alluvial thickness and depth to water. Domestic well pumping rates were assumed to be continuous throughout the year at 250 gpd per household (Lane, 2004). Thus, the total additional pumping due to domestic buildout west of the Methow River would be about 170 afy, or about 0.23 cfs.

5.2.5.8 Proposed TLAC Wells and Reintroduction Points

The TLAC water right application was for 4,500 gpm. Preliminary model results indicated that less than half this pumping rate is required to fill Big Twin Lake and maintain the lake level at the target level (1,799 ft elevation from IRZ Consulting, 2003). Two wells were used in the model to achieve up to 2,000 gpm instantaneous rate required to fill Big Twin Lake to the target level and maintain that level through the target period. Well pumping rates were based on yields from the nearby State Hatchery wells of approximately 1,000 gpm per well. The hypothetical TLAC wells used in the model were located along the landward side of Foghorn Ditch between the State and National Hatcheries (TLAC 1 and TLAC 2 in Figure 4.1.1). Well completion intervals were set in the lower aquifer, similar to the State Hatchery wells. If actual well yields are less than anticipated, additional wells may be drilled to meet the recommended TLAC transfer system capacity at locations identified in Figure 4.1.1 as TLAC 3, TLAC 4, and TLAC 5. Pumped groundwater was simulated to discharge to Big Twin Lake using a specified flux cell simulating discharge from the conveyance pipeline.

Pumping rates were initially set based on the pumping timeframe established by withdrawals limited by WDFW or minimum instream flows (WAC) defined by 173-548 WAC. In addition, TLAC transfer system capacities were evaluated over a range of 500 gpm to 2,000 gpm. The limited pumping timeframes generally provided enough water to raise the level in Big Twin Lake above the 1,799 feet target elevation. Filling the lake above this elevation, presumably would have the potential of flooding nearby properties. Thus, TLAC pumping rates were reduced until maximum Big Twin Lake water levels were maintained near the target 1,799 feet elevation. The required pumping rates are described below in the “Model Results” section.

5.2.5.9 No Flow Boundaries

Where other boundary conditions were not assigned, the model simulates “no flow” conditions, and flow is relatively parallel to the model boundary.

5.3 Calibration

Aquifer parameters and boundary conditions were optimized within a range of reasonable values by a combination of parameter estimation and standard trial-and-error method during the calibration process. Much of the calibration adjustments were made to improve model convergence and simulation accuracy. The calibration process included testing MODFLOW packages, layer thicknesses, recharge and evapotranspiration areas, well distributions, and river setup. Model sensitivity to minor changes to aquifer parameter values and flow boundary rates or heads was also tested.

5.3.1 Model Refinements and Calibration Improvements

The initial project model was constructed in 2006 and presented in a draft report (Aspect Consulting, December 2006). A supplemental field investigation (Phase 1B) was designed to address identified data gaps, model uncertainties, and stakeholder comments on the draft report. Field data collection efforts included gaging of Thompson Creek flows, additional survey control, installing a staff gage in Barnsley Lake, and expanded lake and well water level measurements. Based on these results, several model refinements were made that lead to improved model calibration and changes in the predictive simulations. These refinements are summarized as follows:

1. Ground surface elevation was modified from the USGS DEM using the available surveyed ground surface data. This was performed because significant discrepancies between surveyed ground surface elevation and DEM were identified.
2. The elevation of Barnsley Lake (lakebed) was lowered in the model to reflect the true survey elevation, thus correcting a significant error associated with use of the DEM. Seasonal water in Barnsley Lake is interpreted to be a reflection of the Twin Lakes aquifer water table when water is present in the lake for an appreciable period of time.
3. The rate of Thompson Creek discharge to the sinkhole was modified based on field measurements. Discharge was reduced from 1 cfs during 6 months of the year to about 0.25 cfs for the entire year.
4. Rates of mountain front recharge and lake inflows (incident precipitation and runoff) were modified during model calibration.
5. Four separate zones of hydraulic conductivity were identified based on specific capacity data from well logs, aquifer test data, geologic interpretation and model calibration. Using the higher uniform hydraulic conductivity value of the earlier model, lake levels in Dibble Lake could not be calibrated. This change also improved calibration of water levels in wells between Twin Lakes and Dibble Lake, and in the vicinity of Thompson Creek.
6. Model calibration was improved with 24 additional locations of groundwater and surface water level elevations measured during the Phase 1B field effort. Modeled fluctuations observed in Big Twin, Little Twin and Dibble Lakes more closely follow the measured range in lake levels taken since August 2006.
7. The model period was adjusted from five years to seventeen years to utilize nearly the entire period of record for Methow River gaging.
8. TLAC withdrawal periods and rates were determined based on historical flows on the Methow River, as opposed to average conditions used in the previous model. This refinement addresses the ability to fill the lake during drought periods.
9. TLAC withdrawals were simulated from two wells rather than five wells as a result of lower instantaneous withdrawal rates needed to maintain lake levels

Collectively, these model changes resulted in a significant improvement in model calibration using more model calibration points. Modification of parameters during calibration was made based on matching heads and maintaining model parameters within ranges indicated by existing data and/or literature values. Calibration targets and statistics discussed below reflect these improvements in model calibration.

5.3.2 Calibration Targets

A total of 57 water level data points, based on field measurements taken by Aspect Consulting, were used as model calibration targets. These included 5 river stage elevations, lake levels in Big Twin, Little Twin, Barnsley and Dibble Lakes, and groundwater levels in 48 wells.

5.3.3 Calibration Statistics

Figure 5.3.1 compares the measured water level elevations with the model calculated elevations. Calibration residual is calculated as the observed minus calculated water levels. A set of standard modeling statistics is provided in the table below the graph, with the statistics provided for groundwater, surface water and overall. The groundwater mean calibration residual was 11 feet, and is shown on Figure 5.3.1 by points that deviate from the 1:1 line. The bedrock wells account for many of the targets with higher residuals. The residual standard deviation was 18 feet, which compares favorably with the “surveyed minus DEM elevation” standard deviation of about 16 feet. Normalized calibration residual, represented by the standard deviation divided by the range in observed water levels (170 feet), was low at 7 percent and indicates a good calibration.

The targets with largest residuals were generally associated with wells completed in bedrock. The residuals indicate that calculated water levels in bedrock were generally lower than observed water levels. This may indicate that a recharge source to bedrock at higher elevations (and outside the model domain) may supply these wells. By not including this source in the model, the effects of future domestic well buildout may be overestimated by the model.

Initial model calibration runs indicated the most sensitive boundary condition was the location and rate of Thompson Creek discharge, since it represents a significant water balance input in the vicinity of Twin Lakes area. Subsequent measurements of groundwater inflow at the sinkhole has eliminated this uncertainty. The model also showed sensitivity to other boundary conditions, including: agricultural withdrawal rates and locations; agricultural return flow rates and locations; and evapotranspiration rates. The hydraulic conductivity of the Upper and Lower Aquifers would be adjusted to account for changes in recharge and maintain a good calibration. Adjustments to these model parameters could potentially alter model calibration and predicted groundwater flows. A discussion of model uncertainty is presented in Section 5.4.4.

5.4 Groundwater Model Results

The following presents a comparative analysis of baseline conditions or existing conditions, future buildout, and the three TLAC withdrawal scenarios. The effect of system capacity is explored for each of the TLAC withdrawal scenarios by varying the assumed well-field pumping rates.

Results are presented in the following Figures:

Figure 5.4.1 – Presents a comparison of lake level changes under existing and future domestic buildout baseline conditions (without lake augmentation) and for each withdrawal scenario using a pumping rate of 1,000 gpm.

Figure 5.4.2 – Compares water balance components of the existing buildout and future domestic buildout conditions. The spreadsheet model for the existing buildout is also shown in this figure for comparison with numerical model results.

Figure 5.4.3 – Presents detailed water budgets for each of the predictive scenarios at a withdrawal rate of 1,000 gpm. The graphs in Figure 5.4.3 from top to bottom are:

- Change in ET – Evapotranspiration due to changes in lake and groundwater levels;
- Bypass Reach – Big Twin Lake seepage to the southeast past Dibble Lake to the Methow River – termed "bypass reach" due to the reduced flows in the Methow River between the TLAC wells and discharge to the River. Quantified as the difference between Scenario 1 (future buildout) and the predictive scenario for groundwater inflow along an approximate 3-mile reach of river extending from Winthrop to the downstream model extent.
- Aquifer storage – Annual change in storage due to increased groundwater levels in the vicinity of Big Twin Lake, and decreased groundwater levels in the vicinity of the TLAC wells;
- Return Flow – Big Twin Lake seepage to the north toward Barnsley Lake and the TLAC wells near the Methow River.

Figure 5.4.4 – Summarizes potential annual withdrawals based on historical Methow River flows and permitted pumping periods (top graph), and calculated withdrawals required to fill and maintain Big Twin Lake (bottom graph) for each of the scenarios at a 1,000 gpm withdrawal rate.

Figure 5.4.5 – Displays aquifer drawdowns at Foghorn Ditch, State Hatchery wells, and Spring Branch Springs.

A 1,000 gpm withdrawal rate was used for illustrative purposes to the effects of the three scenarios at the same pumping rate. Comparison of water balance components using withdrawal rates of 500, 1,000, 1,500 and 2,000 gpm are presented in a series of figures in Appendix C as follows:

Figure C.1 – Presents observed and calculated water level changes under the WDFW scenario for Big Twin, Barnsley and Dibble Lakes.

Figure C.2 – Compares water balance components under the WDFW withdrawal scenario for each of the four pumping rates.

Figure C.3 – Summarizes potential and annual withdrawals under the WDFW scenario.

Figures C.4 through C.6 present the same information for the WDFW/WAC scenarios.

Figures C.7 through C.9 present the same information for the WAC scenarios.

Figure C-10 shows the average monthly water budget at steady state (last 5 years of model run) for each of the scenarios at a 1,000 gpm withdrawal rate relative to baseline conditions (or current conditions).

Comparisons for each scenario are described in the following sections.

5.4.1 Existing Conditions

Water levels in Big Twin Lake calculated by the model for the baseline scenario, are consistent with the recent measurements (approximately elevation 1,792 feet), and are 7 feet below the maximum target elevation of 1,799 feet. Figure 5.4.1 shows the 17-year hydrograph of calculated water levels in Big Twin Lake, as well as the recently observed water levels. A maximum historical lake elevation of approximately 1,800 feet (IRZ Consulting, 2003) was reportedly observed in 1946, however this elevation represents potential flooding conditions of existing land use around Big Twin Lake. Water levels shown for Barnsley Lake and Dibble Lake are presented as a change in water level (Figure 5.4.1).

Overall, the model water balance compares well with the spreadsheet water balance (Figure 5.4.2). The parameters of greatest uncertainty include mountain front recharge, and the withdrawal rate and annual volume of groundwater withdrawn for irrigation (see Section 5.4.4 for a discussion of model uncertainty parameters). Minor differences in other components of the water balance are due to rounding errors associated with the method of analysis (lumped-parameter vs. spatially distributed).

5.4.2 Predictive Models of TLAC Project Scenarios

Predictive models were run for each of the scenarios presented in Table 5.1.1 (existing condition, future buildout, and WDFW, WDFW/WAC, and WAC). For each scenario, the predictive models investigate the timing for lake fill and water balance components.

Scenario 1 – Future Domestic Well Buildout

The "Future Domestic Well Buildout" scenario showed declines in lake water levels reflecting general declines in groundwater levels across the area (Figure 5.4.1). Pumping rates in existing wells were not measurably affected by future domestic well buildout. A decline of 1.35 feet in Big Twin Lake was predicted after 17 years as a result of future domestic buildout. Similarly, Barnsley Lake and Dibble Lake declined about 2.5 feet and 1 foot, respectively, due to the distribution of future domestic wells.

Figure 5.4.2 shows a 164 afy increase in well withdrawals as a result of full domestic buildout (difference between 844 afy existing buildout and 1008 afy future domestic buildout, Figure 5.4.2). Net discharge from the aquifer to the Methow River decreased by 137 afy as a result of domestic well pumping (difference between 142 afy under existing conditions model buildout and 279 afy at full buildout, Figure 5.4.2). Loss of aquifer storage due to drawdown in groundwater levels accounts for much of the remaining effects of full domestic buildout (about 57 afy, Figure 5.4.2).

The water balance components in the conceptual model (spreadsheet analysis, Table 3.1.1) and in the numerical model compare favorably. Spreadsheet results are shown graphically in blue on Figure 5.4.2. The most significant difference occurs in the mountain front recharge component, of which there was considerably uncertainty in the spreadsheet analysis.

Figure 5.4.3 shows that, under the future buildout scenario, lake evapotranspiration declines by about 8 afy in year 2026 as water levels decline and the surface area of the lakes are reduced. Annual groundwater discharge to the Methow River south of Twin Lakes declines by about 39 afy. Annual groundwater discharge to the Methow River north of Twin Lakes declines by about 98 afy.

Figure 5.4.5 shows a small decline in groundwater levels due to distributed pumping under future domestic buildout. The model results show a drawdown of about 0.5 foot under Foghorn Ditch in the vicinity of the proposed TLAC wells, about 1 foot at the State Hatchery, and about 0.5 feet near Spring Branch spring. Seasonal fluctuations in the drawdown reflect seasonally variable boundary conditions (recharge, agricultural pumping, etc.).

The model simulation assumed that all new domestic wells are completed in saturated bedrock. The model does not simulate a source of water to bedrock other than the alluvium. Water transferred from the alluvium to bedrock occurs via recharge through the unsaturated alluvium and by vertical movement through saturated alluvium; however, lateral inflow from bedrock fracture networks at the model boundaries is not included. Thus, all water pumped by future domestic wells was calculated to come from the alluvium – which is a conservative "worst-case" assumption. The possibility exists that sources of water to bedrock other than the alluvium, namely lateral networks of fractures that could supply some of the water for future wells. However, the understanding of these sources was too limited to simulate with the groundwater model.

Scenario 2 – TLAC withdrawals limited by WDFW Target Flows, including future domestic well buildout

TLAC withdrawals under the WDFW scenario are limited by the WDFW Target Flows of 800 and 6000 cfs from April 1 through July 14. Withdrawals are allowed when flows are between these values. Figure 5.4.1 indicates the target level in Big Twin Lake was achieved in the 3rd year with a pumping rate of 1,000 gpm (the target lake level elevation of 1799 ft is indicated with a green dashed line in Figure 5.4.1). After the lake is filled, total pumping withdrawals are reduced to maintain lake levels.

Seasonal water levels fluctuate approximately 1 to 2 ft in Big Twin Lake during the project under the WDFW scenario. Lake levels peak during the allowed pumping periods and then decline when withdrawals cease (Figure 5.4.1). The annual fluctuation is greatest when the lake is filling and is reduced to about 1 ft when the lake is filled. Water levels in Barnsley Lake and Dibble Lakes increase about 1.5 feet and 2.5 feet (above current levels), respectively, after about 10 years of maintaining the Big Twin Lake level. The increase in lake stage is the result of long term increase in aquifer storage. A decline in lake levels occurs in Barnsley Lake during the first two years as the levels are affected by pumping, but have not yet received the benefit of increased northerly discharge from Big Twin Lake (Figure 5.4.1).

The historic water line for Barnsley Lake was identified by TLAC and was surveyed at about elevation 1778 feet. Barnsley Lake elevations were measured at 1775 and 1775.5

feet in December 2007 and May 2008, or about 2.5 to 3 feet below the target elevation. The model predicted rise of 1.5 feet suggests that lake levels will be 1 to 1.5 feet below target lake elevation in Barnsley Lake by supplementing water in Big Twin Lake.

Figure C.1 shows that, for the WDFW scenario at 500 gpm capacity, the target level in Big Twin Lake was achieved in the 15th year. For the 1,500 and 2,000 gpm capacities, the target level was achieved in the 1st year. At steady state, about 90 afy will seep from Big Twin Lake and flow northward, returning to the Methow River. This return flow largely off-sets aquifer declines occurring from full domestic build out (Figure C.2, bottom graph). Relative to current, baseline conditions a similar quantity (i.e., about 100 afy) would be expected to discharge to the Methow River.

Changes in the steady state water balance parameters are summarized in Table 5.4.1. Figures 5.4.3 and C.2 shows that lake evapotranspiration and bypass reach flows increased under the WDFW scenario, compared to full domestic buildout. The increase in evapotranspiration related to the project is estimated in the numerical model at about 30 afy (WDFW scenario) when compared to the future domestic buildout scenario (Table 5.4.1).

Approximately 35 afy of water will seep from Big Twin Lake and flow southeast into the Methow River, effectively bypassing about 3 miles of the Methow River (Table 5.4.1). This increased seepage effectively offsets declines in southerly flow related to future domestic buildout condition (Figure C-2, second graph from top). Again, relative to baseline conditions a similar quantity (i.e., about 35 afy) would be expected to discharge to the Methow River via the bypass reach.

The calculated TLAC withdrawal rates under the WDFW scenario and the potential withdrawal rate were nearly equal during the first two years of operation as the lake was being filled to the target level (Figure 5.4.4). Following initial filling in year three (2012, Figure 5.4.4), the modeled withdrawal diminishes, providing only for lake level maintenance, and is less than the potential water available. The maximum annual withdrawal was about 460 afy for the WDFW scenario and the 1,000 gpm pumping rate. Withdrawals begin to approximate a steady state condition in year 2016 (Figure 5.4.4, 1,000 gpm – WDFW scenario). After initial filling, the annual TLAC withdrawals under the WDFW withdrawal window was generally less than 200 afy and averaged 176 acre for the last 5 years shown. The different annual withdrawal rates depend on initial lake levels, permitted periods of withdrawal, and system capacities.

Figure 5.4.5 shows that, compared to future domestic buildout, drawdown increases during TLAC pumping periods, but decreases when TLAC wells are off. The maximum drawdown is highest while filling Big Twin Lake, and diminishes as TLAC withdrawals maintain water levels in Big Twin Lake. The additional drawdown below Foghorn Ditch next to the TLAC wells is calculated to be less than 0.5 feet (compares to full buildout), while TLAC wells are pumping. The drawdown near the State Hatchery wells and beneath Spring Branch spring is calculated to be less than 0.25 feet, while TLAC wells are pumping. While TLAC wells are not pumping, there is a small increase in water levels due to seepage return flow from Big Twin Lake, compared to full domestic buildout conditions.

On a monthly basis under the WDFW scenario, return flow to the Methow River via the northerly path ranges from slightly more than 1 af/month in August to about 14 af/month in April for steady state conditions (Figure C-10, bottom graph). Monthly values shown in Figure C-10 reflect changes in flow relative to baseline (current) conditions. Return flow via the bypass reach is relatively constant throughout the year at about 3 af/month. Peak combined monthly return flow to the Methow River is predicted to occur in April and is about 17 af/month or an average monthly discharge of 126 gpm. Total lake evapotranspiration ranges from a low in December of less than 0.5 af/month to a high of about 6 af/month in July.

A comparison of the potential water available for the WDFW scenario under flow rates of 500, 1,000, 1,500, and 2,000 gpm is presented in Figure C.3. The amount of water that can be withdrawn in model year 2010 (climate year 1989) is about 220, 460, 690, and 910 afy for 500, 1,000, 1,500 and 2,000 gpm pumping rates, respectively. Higher pump rates allow for withdrawal of a greater quantity of water when Methow River flows are within the allowable WDFW withdrawal window. The optimum pumping rate is, therefore, a function of desired lake fill time and costs associated with the pumping and conveyance infrastructure and operation.

Scenario 3 – TLAC withdrawals limited by a combination of WDFW Target Flows and WAC, including future domestic well buildout

The scenario with TLAC withdrawals limited by the combination of WDFW Target Flows from April 1 through mid-July and WAC from mid-July through September 30 (hereafter “WDFW/WAC combination scenario”) indicate Big Twin Lake water levels are within a foot of the target level after one year of pumping at 1,000 gpm and filled by year 2 (Figure 5.4.1). The more rapid fill rate under the WDFW/WAC scenario, when compared to the WDFW scenario occurs as a result of the extended withdrawal window.

For the 1,000 gpm and higher TLAC system capacities, the target level in Big Twin Lake was achieved in the 1st year under the WDFW/WAC scenario (Figure C.4). For the 500 gpm capacity, the target level in Big Twin Lake was achieved in the 5th year. Barnsley Lake and Dibble Lake water levels increased slightly compared to the WDFW scenario (Figure 5.4.1).

Figure 5.4.3 shows that lake evapotranspiration and bypass reach flows increased slightly under the WDFW/WAC combination scenario, compared to the WDFW scenario. When compared to the future domestic buildout scenario, evapotranspiration increased by about 36 acre-ft and the by-pass reach flow increased 39 acre-ft (Table 5.4.1 and Figures 5.4.3 and C.5).

Figure 5.4.4 shows calculated TLAC withdrawal rates limited by the WDFW/WAC combination scenario were slightly higher than TLAC withdrawal rates limited by WDFW target flows because of the longer permitted pumping period. The maximum annual withdrawal was about 760 afy for the WDFW/WAC combination scenario and the 1,000 gpm withdrawal capacity. After initial filling, the annual TLAC withdrawal under the WDFW-limited withdrawal window was generally less than 220 afy. At 1,500 and 2,000 gpm withdrawal rates, total volume pumped during the first year was in excess of 800 afy (Figure C.6).

Figure 5.4.5 shows that the small amount of drawdown in the vicinity of Foghorn ditch, Spring Branch Spring and State Hatchery wells is maintained for a longer period during the TLAC withdrawals under the WDFW/WAC combination scenario, compared to the WDFW scenario. Otherwise, the magnitude of drawdown is comparable to the WDFW scenario.

On a monthly basis under the WDFW/WAC scenario, return flow to the Methow River via the northerly path ranges from slightly more than 3 af/month in October to about 12 af/month in July (Figure C-10). Return flow via the bypass reach is relatively constant throughout the year at just over 3 af/month. Peak combined return flow to the Methow River occurs in July and is about 16 af/month or an average discharge rate of 119 gpm.

Scenario 4 – TLAC withdrawals limited by WAC, including future domestic well buildout

The scenario with TLAC withdrawals limited by the WAC from April 1 through September 30 (hereafter "WAC scenario") indicate Big Twin Lake water levels are nearly filled during the first year, completely filled in year 2, and were maintained near target levels throughout the year at the 1,000 gpm and higher pumping rates (Figures 5.4.1 and C.7). During the winter, water levels in Big Twin Lake slightly exceeded the target of 1,799 ft elevation.

For the 1,000 gpm and higher TLAC transfer system capacities, the target level in Big Twin Lake was achieved in the 1st year (Figure C.7). For the 500 gpm capacity, the target level in Big Twin Lake was achieved in the 4th year (Figure C.7). Barnsley Lake and Dibble Lake water levels were similar to the WDFW/WAC combination scenario.

Figures 5.4.3 and C.8 shows that lake evapotranspiration and bypass reach flows under the WAC scenario are similar to WDFW/WAC combination scenario.

Figure 5.4.4 shows calculated TLAC withdrawal rates limited by the WAC scenario were similar to TLAC withdrawal rates limited by the WDFW/WAC scenario. The maximum annual withdrawal was about 760 afy for the WAC scenario and the 1,000 gpm system capacity. After initial filling, the annual TLAC withdrawal under the WDFW-limited withdrawal window was generally less than 220 afy. Slightly greater volumes (about 840 afy) are withdrawn under the WAC scenario at pumping rates of 1500 and 2000 gpm.

Monthly water budget for the WAC scenario (Figure C-10) is similar to the WDFW/WAC scenario.

Figure 5.4.5 shows that drawdown due to TLAC withdrawals under the WAC scenario is comparable to the WDFW/WAC scenario.

5.4.3 Model Uncertainties

Several uncertainties were identified and simplifying assumptions utilized during model construction due to a lack of data. Despite these uncertainties, the model provides a robust tool for evaluating the relative changes in the timing and magnitude of lake levels and stream flows, due to the proposed TLAC project.

Actual Groundwater Use – The model relies on matching irrigation water rights with well logs. Where a match was made, the well was pumped at the full irrigation water right. No data is available on the actual groundwater use.

Irrigation Return Flow – Irrigation return flow was based on an estimate of irrigated acres approximated from air photos and applied at 10 inches annually based on alfalfa. Variations in cropping patterns and number of crops grown within a season would effect these estimates.

Aquifer Hydraulic Parameters – Spatially variable hydraulic conductivity data were limited and as such, up to 4 zones with different hydraulic conductivity were applied to each model layer to improve model calibration. Region-specific data on aquifer storage parameters was also unavailable. Lower values than that assumed in the model would result in less TLAC pumping being required.

Evaporation – The extinction depth for native vegetation was estimated at 5 feet; however, no area specific data was identified to verify this assumption. Changes in extinction depth are expected to have only a small influence on lake evaporation due to the relatively steep bounding slopes of the lakes.

Lake Evapotranspiration –Uncertainty in the model-estimated lake evapotranspiration is due to the limited surface topography data available in the vicinity of the lakes, and the limitation of the model to simulate an accurate change in lake area given the cell size (175 ft square, or about ¾ acre). To bound this uncertainty, lake evaporation was estimated outside the model using a range evapotranspiration rates and lake area increases determined from bathymetric mapping.

A spreadsheet calculation was made to check the change in evaporative lake area using bathymetric data from Lakes of Eastern Washington (Wolcott, 1973). The calculation assumed that the "zero" bathymetric contour corresponds to a lake elevation of 1800, and a surface water area of 102 acres for both Big and Little Twin Lakes. The 10-ft bathymetric contour (1790 ft elevation) was determined to have an area of 77 acres. Lake areas for elevations between 1790 ft and 1800 ft were interpolated linearly. The spreadsheet calculation evaluated two "bounding" ET rates detailed in Section 2.2.2: 37 inches per year for Winthrop, and 52 inches per year for the Methow Basin (Yakima). A comparison of spreadsheet and numerical results is presented in the table below.

Table 5.4.2

Comparison of Lake Evaporation Estimates (Big and Little Twin Lakes)

	Lake Condition		Spreadsheet ET Results (afy)		Model ET Results (afy)
Description	Elevation (ft)	Area (acres)	Winthrop	Methow Basin	Methow Basin
WDFW/ WAC scenario; WAC scenario	1799	99.5	307	430	408
WDFW scenario	1798	97	299	420	402
Existing Conditions	1792	82	253	355	382
Future Domestic Buildout	1791	79.5	245	344	378
Increase in ET under WDFW scenario			57	79	24
Increase in ET under WDFW/WAC or WAC scenarios			62	87	30

The annual ET values compare favorably between the spreadsheet Methow Basin and model results, being within 10 percent or less of one another. ET rates for the Methow Basin were used in the model, and are expected to be higher than Winthrop ET.

Compared to spreadsheet results, the model underestimates ET under TLAC project scenarios, and overestimates ET under existing and full domestic buildout scenarios. The cumulative effect is that the calculated increase in ET based on model results is about half as much as the increase based on Winthrop-estimated ET, and about one-third as much as the increase based on Methow Basin-estimated ET.

Other model results regarding the TLAC water budget are not expected to be affected by the accuracy of the model ET calculation, with the exception of the required annual TLAC withdrawals. An offset for increase in ET would need to be reflected in the required annual TLAC project transfers, but rates of lake seepage and aquifer storage are not expected to change significantly.

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Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the use of the Washington State Department of Ecology for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 2.3.1 Mean Daily Methow River Exceedances of 173-548 WAC and WDFW Target Minimum Instream Flows

TLAC Water Right Application
Winthrop, Washington

Time Period	WAC 173-548 Minimum Instream Flows (MIF)		DFW Withdrawal Limits (800 - 6000 cfs)
	MIF (cfs)	% Above MIF	% Within Limit
January 1 - 14	120	100.0%	-
January 15 - 31	120	100.0%	-
February 1 - 14	120	100.0%	-
February 15 - 28	120	100.0%	-
March 1 - 14	120	100.0%	-
March 15 - 31	120	100.0%	-
April 1 - 14	199	93.7%	52.5%
April 15 - 30	300	90.8%	84.6%
May 1 - 14	480	97.9%	84.5%
May 15 - 31	690	100.0%	73.0%
June 1 - 14	790	100.0%	67.2%
June 15 - 30	790	100.0%	90.1%
July 1 - 14	694	91.6%	84.0%
July 15 - 31	240	100.0%	-
August 1 - 14	153	100.0%	-
August 15 - 31	100	100.0%	-
September 1 - 14	100	100.0%	-
September 15 - 30	100	100.0%	-
October 1 - 14	122	100.0%	-
October 15 - 31	150	100.0%	-
November 1 - 14	150	100.0%	-
November 15 - 30	150	100.0%	-
December 1 - 14	135	100.0%	-
December 15 - 31	120	100.0%	-

Notes:
Methow River flow data from USGS Station # 12448500 (Methow River at Winthrop) for period of record (1989 - 2006)

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-1G01	1G01	NORMAN HEBERT PEART	1724927	1147045	2615	Ecology Well Database	7/28/92	265	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1F01	1F01	BARDAHL	1723603	1147047	2609	Ecology Well Database	3/30/87	210	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-1F02	1F02	BARDAHL	1723603	1147047	2609	Ecology Well Database	7/16/77	445	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1F03	1F03	BARDAHL PROJECT	1723603	1147047	2609	Ecology Well Database	-	205	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-1F04	1F04	BARDALL MANUFACTURING	1723603	1147047	2609	Ecology Well Database	11/25/97	305	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1E01	1E01	KATHY MC GANN	1722279	1147050	2434	Ecology Well Database	6/5/96	245	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-1E02	1E02	TAMI WELLIZER	1722279	1147050	2434	Ecology Well Database	7/1/04	300	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1M01	1M01	DAVE SCOTT	1722273	1145726	2386	Ecology Well Database	7/28/01	200	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1P01	1P01	MIKE WALKER	1723594	1144404	2513	Ecology Well Database	-	163	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-1N01	1N01	ROSS ABBOTT	1721690	1144568	2051	USGS Groundwater Data	12/6/01	240	6	20	240	Bedrock Aquifer	-	-	-	12/4/98	80.00	-	-	USGS Data
34N/21E-1SW01	1SW01	RANDY SACKETT	1722932	1145064	2482	Ecology Well Database	3/11/87	122	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2A01	2A01	JOHN LATESTE	1720961	1148379	2290	Ecology Well Database	3/25/81	172	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2A02	2A02	RICHARD BRODALE	1720961	1148379	2290	Ecology Well Database	2/8/01	260	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2B01	2B01	HERB ROSENBERG	1720121	1148891	2185	USGS Groundwater Data	5/29/84	192	6	-	-	Bedrock Aquifer	15	10	1.5	5/29/84	30.00	-	-	USGS Data
34N/21E-2B02	2B02	HERB ROSENBERG	1720142	1148871	2187	USGS Groundwater Data	11/28/90	410	6	280	410	Bedrock Aquifer	-	-	-	4/23/01	20.94	-	-	USGS Data
34N/21E-2B03	2B03	GEENA STACEY	1719635	1148388	2123	Ecology Well Database	10/29/04	365	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2H01	2H01	CURT STEWART	1720955	1147053	2174	Ecology Well Database	1/25/00	130	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-2H02	2H02	LOU PEPPER	1720955	1147053	2174	Ecology Well Database	10/11/99	70	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2G01	2G01	MARK ENDRESEN	1719635	1147057	1997	Ecology Well Database	12/4/98	240	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2G02	2G02	MARK ENDRESEN	1719635	1147057	1997	Ecology Well Database	12/6/98	180	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2G03	2G03	SULLIVAN CEMETERY	1719635	1147057	1997	Ecology Well Database	8/30/04	200	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2G04	2G04	ANDY CONKEY / CAROL FISHER	1719635	1147057	1997	Ecology Well Database	12/8/04	205	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2C01	2C01	DON & TERI SWAN	1718307	1148395	1858	Ecology Well Database	3/20/91	152	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2D01	2D01	HERB ROSENBERG	1716982	1148402	1779	Ecology Well Database	10/2/92	330	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2F01	2F01	GEORGE BAUMGARDNER	1719173	1143850	1757	Aspect/Erlandsen Survey	7/21/05	60	6	-	-	Lower Aquifer	-	-	-	8/29/06	37.83	1721.38	No	Aspect Data
34N/21E-2E01	2E01	RICK LANGERDSEN	1716995	1147068	1768	Ecology Well Database	4/28/90	310	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2J01	2J01	CITY OF WINTHROP	1720951	1145726	2032	Ecology Well Database	2/25/84	91	12	-	-	Bedrock Aquifer	1000	17	58.8	-	-	-	-	-
34N/21E-2K01	2K01	WITHROP K.O.A.	1719637	1145727	1821	Ecology Well Database	8/25/88	54	8	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2Q01	2Q01	C.J. HECKENDORN	1719637	1144399	1749	Ecology Well Database	6/8/73	11	30	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2Q02	2Q02	DAN MCAULIFFE	1719637	1144399	1749	Ecology Well Database	3/18/90	170	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2Q03	2Q03	DAN MCAULIFFE	1719637	1144399	1749	Ecology Well Database	-	310	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-2SE01	2SE01	OSCAR FODOR	1720293	1145064	1819	Ecology Well Database	7/12/98	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW01	2SW01	JIM ROERE	1717667	1145065	1749	Ecology Well Database	3/22/92	265	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW02	2SW02	GARY BELSBY	1717667	1145065	1749	Ecology Well Database	5/31/98	38	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW03	2SW03	GARY BELSBY	1717667	1145065	1749	Ecology Well Database	5/31/98	46	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW04	2SW04	GARY BELSBY	1717667	1145065	1749	Ecology Well Database	6/1/98	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW05	2SW05	GARY BELSBY	1717667	1145065	1749	Ecology Well Database	6/1/98	31	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW06	2SW06	GARY BELSBY	1717667	1145065	1749	Ecology Well Database	6/1/98	42	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW07	2SW07	TOWN OF WINTHROP	1717667	1145065	1749	Ecology Well Database	-	25	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW08	2SW08	TOWN OF WINTHROP	1717667	1145065	1749	Ecology Well Database	-	44	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-2SW09	2SW09	TOWN OF WINTHROP	1717667	1145065	1749	Ecology Well Database	-	55	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3B01	3B01	ED SUCHAN	1714738	1148431	1837	USGS Groundwater Data	3/12/99	220	8	103	220	Bedrock Aquifer	-	-	-	7/31/01	60.10	-	-	USGS Data
34N/21E-3C01	3C01	NEIL LIBBY	1713011	1148392	1788	Ecology Well Database	5/15/77	40	6	-	-	-	20	10	2.0	-	-	-	-	-
34N/21E-3C02	3C02	FRANK L. AND ANN C. BUELL	1713011	1148392	1788	Ecology Well Database	-	12	48	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3C03	3C03	AJOHN BLETHEN	1709466	1145816	1782	Lot Locations	8/14/90	73	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-3F01	3F01	LEO HERMAN	1713430	1146722	1767	USGS Survey	-	40	6	-	-	Upper Aquifer	-	-	-	7/31/01	10.40	-	-	USGS Data
34N/21E-3F02	3F02	LOUIS KOUSSA	1713023	1147061	1762	Ecology Well Database	7/11/90	40	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-3F03	3F03	DARREN BELSBY	1713023	1147061	1762	Ecology Well Database	12/4/99	37	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3E01	3E01	MICHAEL SCOTT, MD	1711624	1148062	1772	Lot Locations	5/9/95	43	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3E02	3E02	DOUGLAS CO. PUD	1711699	1147059	1762	Ecology Well Database	8/10/89	127	12	60	80	Upper Aquifer	2000	12.7	157.5	-	-	-	-	-
34N/21E-3NW01	3NW01	JIM BIRD	1712356	1147726	1766	Ecology Well Database	11/14/00	46	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3J01	3J01	JUANITA RICHARD	1715310	1143690	1892	Lot Locations	11/12/97	280	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-3Q01	3Q01	SUN MOUNTAIN LODGE	1712453	1144721	1782	USGS Survey	9/8/93	38	6	-	-	Upper Aquifer	-	-	-	7/31/01	10.80	-	-	USGS Data
34N/21E-3Q02	3Q02	TOD GRAVES	1715201	1144286	1896	Lot Locations	12/29/04	285	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-3Q03	3Q03	FRED DAVIS	1714374	1144397	1847	Ecology Well Database	3/30/05	175	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3M01	3M01	DOUGLAS COUNTY P.U.D.	1711767	1146260	1768	USGS Groundwater Data	3/9/91	72	6	60	70	Upper Aquifer	-	-	-	7/31/01	16.20	-	-	USGS Data
34N/21E-3M02	3M02	DOUGLAS COUNTY PUD	1711523	1146241	1772	USGS Groundwater Data	2/8/91	125	16	92	122	Lower Aquifer	1500	16.5	90.9	2/8/91	9.50	-	-	USGS Data

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-3M03	3M03	DOUGLAS COUNTY PUD	1711524	1145957	1773	USGS Groundwater Data	2/15/91	150	16	122	147	Lower Aquifer	1300	33.5	38.8	2/15/91	6.00	-	-	USGS Data
34N/21E-3M04	3M04	ERIC ROBINOWITZ	1711341	1146443	1771	USGS Groundwater Data	4/14/87	44	8	43.5	44.5	Upper Aquifer	-	-	-	7/31/01	15.10	-	-	USGS Data
34N/21E-3M05	3M05	PUD #1 DOUGLAS COUNTY	1711658	1146363	1768	USGS Groundwater Data	2/15/99	145	14	54.3	140	Lower Aquifer	-	-	-	2/15/99	14.00	-	-	USGS Data
34N/21E-3M06	3M06	PUD #1 OF DOUGLAS COUNTY	1711712	1145729	1775	Ecology Well Database	4/6/98	110	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3M07	3M07	PUD #1 OF DOUGLAS COUNTY	1711625	1146381	1783	USGS Survey	4/17/98	110	6	-	-	Lower Aquifer	-	-	-	5/7/08	16.09	1769.69	Yes	Aspect Data
34N/21E-3M08	3M08	DOUGLAS COUNTY PUD	1711509	1146474	1768	USGS Groundwater Data	2/1/91	140	16	101.5	135	Lower Aquifer	1500	17.5	85.7	2/1/91	12.00	-	-	USGS Data
34N/21E-3P01	3P01	JANITA RICHARDS | c/o MIKE GAGEK	1715052	1143918	1880	Aspect/Erlandsen Survey	11/24/97	280	6	-	-	Bedrock Aquifer	-	-	-	5/5/08	77.54	1805.46	No	Aspect Data
34N/21E-3N01	3N01	Victor Lara/Susan Hahn	1711724	1144400	1795	Ecology Well Database	8/5/94	97	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-3X01	3X01	TAYLOR G. BURTON	1713694	1146395	1762	Ecology Well Database	-	8	30	-	-	-	-	-	-	-	-	-	-	-
34N/21E-3X02	3X02	CLARENCE WALKER	1713694	1146395	1762	Ecology Well Database	5/18/61	8	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A01	4A01	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/12/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A02	4A02	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/9/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A03	4A03	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/9/93	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A04	4A04	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/10/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A05	4A05	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/10/93	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A06	4A06	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/14/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A07	4A07	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/15/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A08	4A08	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/16/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A09	4A09	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/16/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A10	4A10	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/16/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A11	4A11	KONRAD ASSOC	1710365	1148385	1778	Ecology Well Database	12/10/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A12	4A12	KIN & ASSOC	1710365	1148385	1778	Ecology Well Database	12/15/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4A13	4A13	LLOYD PALM	1710365	1148385	1778	Ecology Well Database	8/3/99	40	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4B01	4B01	KONRAD ASSOC	1709047	1148387	1775	Ecology Well Database	12/11/93	100	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4H01	4H01	CALVIN MERRIMAN	1710375	1147057	1762	Ecology Well Database	11/30/97	45	8	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-4G01	4G01	ALVIN BROWN	1709054	1147058	1772	Ecology Well Database	12/6/90	40	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4G02	4G02	DENNIS KNUTZEN	1709054	1147058	1772	Ecology Well Database	11/30/04	43	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4C01	4C01	JACK TRIBOLET	1708679	1147863	1768	USGS Groundwater Data	4/25/81	70	6	-	-	Lower Aquifer	-	-	-	7/31/01	29.30	-	-	USGS Data
34N/21E-4C02	4C02	JIN MACTORIA	1707729	1148388	1775	Ecology Well Database	6/29/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4C03	4C03	KONRAD & ET. AL.	1707729	1148388	1775	Ecology Well Database	11/10/93	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4C04	4C04	IDDING	1707729	1148388	1775	Ecology Well Database	5/9/94	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4C05	4C05	SUN MT RANCH	1707729	1148388	1775	Ecology Well Database	6/3/97	54	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4C06	4C06	HAUB BROS	1707729	1148388	1775	Ecology Well Database	9/2/01	140	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4C07	4C07	HAUB BROTHERS	1707729	1148388	1775	Ecology Well Database	12/19/02	79	18	-	-	-	1640	22.7	72.2	-	-	-	-	-
34N/21E-4C08	4C08	BUD HOVER	1707729	1148388	1775	Ecology Well Database	10/15/03	40	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4F01	4F01	DON HOVER	1707732	1147060	1789	Ecology Well Database	10/18/87	50	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4F02	4F02	PAUL NUCCIO	1710050	1146104	1775	Lot Locations	12/14/90	60	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4F03	4F03	RICHARD (JOHN WILLET)	1707732	1147060	1789	Ecology Well Database	5/19/90	50	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4F04	4F04	TERRY O'REILLY	1709543	1146470	1775	Lot Locations	6/16/96	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4E01	4E01	SOLVEIG TORVIK & KAREN WEST	1710368	1145682	1779	Lot Locations	9/4/90	60	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4J01	4J01	BRUCE VAWPORVLIES	1708590	1146780	1778	Lot Locations	9/11/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4J02	4J02	M H ATRUST C/O ROBERT KEASEY	1710187	1146436	1772	Lot Locations	9/8/90	80	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4J03	4J03	M. H. A. TRUST C/O ROBERT KENSEY	1709096	1146485	1775	Lot Locations	9/7/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4J04	4J04	MERY LRECESENGE	1708609	1145996	1785	Lot Locations	9/10/90	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4J05	4J05	MICHAEL ROY HICKSON	1709029	1145881	1782	Lot Locations	9/10/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4J06	4J06	MICHAEL TODD JOHNSON	1709624	1146187	1775	Lot Locations	9/9/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4J07	4J07	THOMAS THONSOW	1710386	1145727	1778	Ecology Well Database	8/31/90	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4K01	4K01	CAROLE BAARONS	1709488	1147013	1768	Lot Locations	3/10/91	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4K02	4K02	CAROLE BEASONS	1709214	1146901	1772	Lot Locations	3/10/91	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4K03	4K03	PEGGY GOODAL	1709060	1145729	1785	Ecology Well Database	-	50	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4R01	4R01	DENNIS CHANDRUY	1710396	1144399	1795	Ecology Well Database	7/21/88	118	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4R02	4R02	DRAGSETH	1710396	1144399	1795	Ecology Well Database	9/5/90	120	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-4R03	4R03	MATIN LEE	1710396	1144399	1795	Ecology Well Database	6/9/87	96	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4SE01	4SE01	JOHN HENRY	1709727	1145063	1788	Ecology Well Database	6/15/87	48	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4SE02	4SE02	PAUL CHRISTEN	1709856	1145756	1781	Lot Locations	9/3/91	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4SE03	4SE03	ROBERT KEASEY	1709727	1145063	1788	Ecology Well Database	-	40	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4SE04	4SE04	WOLF CRK NORDIC ASSOC.	1709157	1146228	1778	Lot Locations	9/4/70	60	6	-	-	-	-	-	-	-	-	-	-	-

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-4N01	4N01	MIKE-CONNIE MARREY	1706411	1144401	1994	Ecology Well Database	10/15/94	40	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-4X01	4X01	KIRIC AINKLEY	-	-	-	Ecology Well Database	8/20/90	50	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-4X02	4X02	TERRY HINKLEP	-	-	-	Ecology Well Database	8/31/90	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9A01	9A01	GAEL GENIESSE	1710397	1143073	1924	Ecology Well Database	6/4/92	185	8	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9A02	9A02	HAROLD BOWERS	1715825	1134097	1887	Lot Locations	4/12/91	133	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9A03	9A03	DAN KUPERBERG	1710397	1143073	1924	Ecology Well Database	7/6/01	186	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9B01	9B01	DAVE THOMSEN	1709068	1143074	1942	Ecology Well Database	6/3/96	180	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-9H01	9H01	RHIAEHART	1710387	1141751	1935	Ecology Well Database	4/15/83	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9H02	9H02	KENT GILDRIST	1710387	1141751	1935	Ecology Well Database	9/8/98	220	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-9H03	9H03	KENT GILCHIEST	1710387	1141751	1935	Ecology Well Database	9/10/98	180	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-9H04	9H04	KENT GILCHRIST	1710387	1141751	1935	Ecology Well Database	6/11/02	300	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9H05	9H05	KENT GILCHRIST	1710387	1141751	1935	Ecology Well Database	6/14/02	270	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9G01	9G01	FRITZ NORDMANN	1709060	1141753	2182	Ecology Well Database	10/12/77	302	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9G02	9G02	VIRGINIA NORDROM	1709060	1141753	2182	Ecology Well Database	4/13/94	220	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9G03	9G03	KENT GILCHRIST	1709060	1141753	2182	Ecology Well Database	12/7/97	220	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-9G04	9G04	MARK RICHARDSON	1709060	1141753	2182	Ecology Well Database	1/22/00	490	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9G05	9G05	BOB BAISEN	1709946	1140829	2036	Lot Locations	7/18/05	345	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9C01	9C01	JOHN BLETHENS	1707095	1142048	2641	USGS Groundwater Data	8/15/92	100	6	-	-	Bedrock Aquifer	-	-	-	8/1/01	40.60	-	-	USGS Data
34N/21E-9C02	9C02	CHARLES FITZGERALD	1707738	1143075	2045	Ecology Well Database	8/2/98	200	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-9D01	9D01	STEPHEN AND CYNTHIA FISHER	1706409	1143075	2518	Ecology Well Database	5/30/02	205	8	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9E01	9E01	KEITH MC COWN	1706402	1141755	2950	Ecology Well Database	10/26/94	200	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9J01	9J01	COURY SEIFORD	1710378	1140429	1999	Ecology Well Database	6/16/99	284	8	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9J02	9J02	BRIAN AND CAROLE REID	1710378	1140429	1999	Ecology Well Database	4/3/02	320	6	-	-	Bedrock Aquifer	10	98	0.1	-	-	-	-	-
34N/21E-9K01	9K01	SANDAS FEBER	1710236	1140599	2010	USGS Groundwater Data	11/3/95	287	6	240	287	Bedrock Aquifer	-	-	-	8/1/01	217.60	-	-	USGS Data
34N/21E-9K02	9K02	DON HUTSHIN	1709050	1140430	2250	Ecology Well Database	9/8/95	307	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9L01	9L01	PHLYLISS WEISHARA	1707721	1140432	2756	Ecology Well Database	4/5/91	140	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-9M01	9M01	BOG TRAVETTE	1706393	1140433	3209	Ecology Well Database	6/11/89	180	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-9N01	9N01	TED & BEV MUSTER	1709873	1140212	2080	USGS Groundwater Data	10/13/88	180	6	-	-	Bedrock Aquifer	-	-	-	8/1/01	109.50	-	-	USGS Data
34N/21E-9SW01	9SW01	WINTHORP REALTY	1707053	1139771	3166	Ecology Well Database	8/15/87	148	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10A01	10A01	DORTHY THERRLAULT	1715701	1143061	1862	Ecology Well Database	1/13/92	80	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-10B01	10B01	PETER & MAUREEN NAVA	1715337	1138966	1865	Lot Locations	11/28/95	102	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-10H01	10H01	DAVID PREDEGAR	1715576	1141723	1843	Aspect/Erlandsen Survey	10/23/99	185	6	-	-	Bedrock Aquifer	-	-	-	5/5/08	33.66	1811.36	Yes	Aspect Data
34N/21E-10H02	10H02	TOM BJORNSON	1715364	1142725	1837	Lot Locations	9/13/00	180	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10H03	10H03	SHERRIE FARMER	1717917	1141288	1859	Lot Locations	10/7/03	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10H04	10H04	AL STEWART	1715693	1141380	1877	Lot Locations	9/3/05	195	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-10G01	10G01	GARY BARRETT	1716367	1138752	1860	Lot Locations	3/28/88	145	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10G02	10G02	JERRY JOHNSON	1713211	1138800	1877	Lot Locations	10/5/91	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10G03	10G03	JIM BAERUELDT	1715642	1142537	1815	Aspect/Erlandsen Survey	10/4/92	195	6	-	-	Bedrock Aquifer	-	-	-	5/5/08	8.79	1807.99	Yes	Aspect Data
34N/21E-10G04	10G04	JIM HARBOUR	1714904	1142145	1872	USGS Survey	6/8/90	330	6	-	-	Bedrock Aquifer	-	-	-	8/31/06	54.50	1818.98	Yes	Aspect Data
34N/21E-10NE01	10NE01	MARK RICHARDS	1715340	1143465	1886	Lot Locations	8/22/92	280	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10D01	10D01	DAVID SHAW	1711725	1143073	1824	Ecology Well Database	6/27/86	104	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10D02	10D02	JOHN MALONE	1711725	1143073	1824	Ecology Well Database	6/15/91	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10D03	10D03	STEVE MALONE	1711298	1143470	1837	USGS Survey	7/18/88	86	6	-	-	Lower Aquifer	-	-	-	7/31/01	61.50	-	-	USGS Data
34N/21E-10D04	10D04	RANDY VANBEC	1711725	1143073	1824	Ecology Well Database	7/22/98	145	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-10D05[a]	10D05	NIGEL CUSHING	1712307	1143306	1819	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/7/08	46.90	1774.34	Yes	Aspect Data
34N/21E-10F01	10F01	BRACE BAFER CATHY CILE'S	1714348	1141661	1877	Lot Locations	6/30/90	328	6	60	328	Bedrock Aquifer	-	-	-	6/30/90	60.00	-	-	USGS Data
34N/21E-10E01	10E01	R M. CHRISTENSEN	1711715	1141750	1837	Ecology Well Database	10/18/79	115	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10E02	10E02	WARREN Q WILLIS	1711715	1141750	1837	Ecology Well Database	1/1/52	112	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10E03	10E03	REID COWELL	1712138	1141733	1820	Aspect/Erlandsen Survey	1/25/03	60	6	-	-	Aquitard	-	-	-	5/7/08	43.98	1778.25	Yes	Aspect Data
34N/21E-10J01	10J01	DAN NORSBY	1715819	1138909	1880	Lot Locations	6/25/94	120	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-10J02	10J02	VICTORIA MALLY	1715564	1140918	1840	Lot Locations	4/28/00	54	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10K01	10K01	E. H. BROWN	1714901	1142148	1872	Aspect/Erlandsen Survey	10/9/85	200	6	-	-	Bedrock Aquifer	-	-	-	5/5/08	33.80	1839.71	Yes	Aspect Data
34N/21E-10R01	10R01	DARYLE RYKER	1715369	1140116	1875	Lot Locations	6/30/92	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10R02	10R02	SUN MOUNTAIN RANCH	1715456	1138916	1867	USGS Groundwater Data	9/15/73	160	6	40	160	Bedrock Aquifer	0.75	160	0.0	9/15/73	20.00	-	-	USGS Data
34N/21E-10R03	10R03	LYLE & ETHEL HEYREND	1714879	1138863	1841	Lot Locations	9/10/98	103	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10Q01	10Q01	GEORGE ANDERSON	1714346	1139089	1851	Ecology Well Database	7/29/91	67	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10Q02	10Q02	JAMIE TACKMAN	1714087	1140896	1885	Aspect/Erlandsen Survey	4/1/91	190	6	-	-	Bedrock Aquifer	-	-	-	5/8/08	102.57	1783.78	Yes	Aspect Data

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-10Q03	10Q03	JOHN LLARSEN	1715553	1139760	1873	Lot Locations	-	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10Q04	10Q04	JON LARSON	1714682	1140295	1880	Lot Locations	6/6/94	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10Q05	10Q05	DARRELL BRANDONBERG	1714891	1139654	1879	Lot Locations	1/9/02	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10L01	10L01	E. A. BROWN	1714508	1141780	1873	Aspect/Erlandsen Survey	3/29/91	330	6	-	-	Bedrock Aquifer	-	-	-	5/8/08	62.86	1812.23	Yes	Aspect Data
34N/21E-10L02	10L02	WILLIAM BOREN	1716290	1138964	1880	Lot Locations	10/17/90	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10L03	10L03	RICHARD & BARBARA COUSINS	1713321	1140496	1881	Lot Locations	8/7/05	142	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10M01	10M01	RONALD HARRISON	1716117	1139763	1869	Lot Locations	4/12/94	106	6	-	-	Upper Aquifer	-	-	-	4/12/94	85.00	-	-	USGS Data
34N/21E-10P01	10P01	LAUREL & RHONDA DAVIS	1712691	1138702	1880	USGS Groundwater Data	6/17/76	94	6	84	92	Lower Aquifer	10	4	2.5	6/17/76	79.00	-	-	USGS Data
34N/21E-10P02	10P02	ALLEN & LINDA NORBACK	1712647	1139253	1882	Lot Locations	8/5/96	122	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10P03	10P03	DAVID GRAVES	1714424	1139824	1892	Lot Locations	9/8/96	125	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10P04	10P04	AL & LINDA MUZZY	1713058	1139991	1876	Lot Locations	8/29/98	113	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-10N01	10N01	BOB JOHNSON	1714092	1141746	1856	Lot Locations	10/10/94	60	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-10X01	10X01	TUCKER BARKSDALE	1711888	1142200	1831	Lot Locations	12/16/77	85	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-10X02	10X02	H. NEIL STAMEY	1713700	1141079	1844	Ecology Well Database	4/15/80	180	6	-	-	-	3.5	170	0.0	-	-	-	-	-
34N/21E-11A01	11A01	LOT 4 / GLEN SEARINS	1720667	1142678	1732	USGS Groundwater Data	-	50	6	-	-	Upper Aquifer	-	-	-	4/26/01	22.80	-	-	USGS Data
34N/21E-11A02	11A02	WELL NO I / GLEN SEARINS	1720667	1142678	1732	USGS Groundwater Data	-	50	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-11A03	11A03	WELL NO III / GLEN SEARINS	1720803	1142354	1729	USGS Groundwater Data	-	50	6	-	-	Upper Aquifer	-	-	-	4/26/01	22.09	-	-	USGS Data
34N/21E-11A04	11A04	WELL NO II / GLEN SEARINS	1720803	1142364	1730	USGS Groundwater Data	-	50	6	-	-	Upper Aquifer	-	-	-	5/28/95	16.00	-	-	USGS Data
34N/21E-11H01	11H01	LOT I / DAVID WHITE	1720973	1141929	1732	USGS Groundwater Data	-	40	6	-	-	Upper Aquifer	-	-	-	5/28/95	16.00	-	-	USGS Data
34N/21E-11D01	11D01	STEVE BURGESS	1715751	1142214	1842	Aspect/Erlandsen Survey	10/25/04	260	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-11F01	11F01	ROBERT GRIMM	1718320	1141748	1864	Ecology Well Database	7/7/94	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-11F02	11F02	RICHARD HARRIS	1716600	1139775	1881	Lot Locations	5/20/96	140	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-11F03[a]	11F03	DICK HAMEL	1718203	1141477	1831	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/8/08	7.76	1826.00	Yes	Aspect Data
34N/21E-11E01	11E01	ELMER GROSS	1715908	1137798	1824	Aspect/Erlandsen Survey	9/4/91	187	6	-	-	Bedrock Aquifer	-	-	-	5/5/08	29.33	1795.97	Yes	Aspect Data
34N/21E-11E02[a]	11E02	CASCADE GRAVEL PIT	1716356	1141536	1872	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/5/08	64.94	1812.55	Yes	Aspect Data
34N/21E-11J01	11J01	JAY FULCHER	1720936	1140451	1716	Ecology Well Database	5/21/01	43	8	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-11Q01	11Q01	K O A CAMPGROUND	1719486	1142785	1749	USGS Groundwater Data	9/19/73	52	6	41	52	Bedrock Aquifer	30	5	6.0	9/19/73	20.00	-	-	USGS Data
34N/21E-11P01	11P01	MIKE AMOS	1716414	1138561	1851	Aspect/Erlandsen Survey	7/18/97	276	6	-	-	Bedrock Aquifer	-	-	-	8/29/06	46.42	1806.91	No	Aspect Data
34N/21E-12A01	12A01	BRIAN MOTAN	1726250	1143093	2596	Ecology Well Database	8/28/99	335	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12B01	12B01	CLAUDE BANNICK	1724920	1143090	2509	Ecology Well Database	-	90	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12H01	12H01	WINANT/SIDRAN	1726244	1141779	2618	Ecology Well Database	8/26/99	205	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12G01	12G01	ERIC & JOANI ROTH	1724916	1141776	2416	Ecology Well Database	5/3/05	246	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12G02	12G02	JOY VERDETTI	1724916	1141776	2416	Ecology Well Database	5/2/05	266	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12C01	12C01	SHARON PAWKNER	1723592	1143086	2541	Ecology Well Database	-	350	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12D01	12D01	GEORGE & IRENE REMSBURG	1722262	1143083	2056	Ecology Well Database	3/16/76	150	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12D02	12D02	DAVE SABOLD	1722262	1143083	2056	Ecology Well Database	9/25/00	205	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12E01	12E01	DAVE SABOLD	1722261	1141773	1798	Ecology Well Database	9/5/81	40	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12E02	12E02	DOUGLAS POTLER	1721989	1142397	1827	USGS Groundwater Data	10/6/90	245	6	-	-	Bedrock Aquifer	-	-	-	8/1/01	60.80	-	-	USGS Data
34N/21E-12E03	12E03	STEVEN DAMSON	1721987	1141274	1768	USGS Groundwater Data	3/2/77	40	6	-	-	Upper Aquifer	15	2	7.5	3/2/77	25.00	-	-	USGS Data
34N/21E-12R01	12R01	DAVID WHITE (LOT #4)	1726236	1139149	2117	Ecology Well Database	5/29/95	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12R02	12R02	DAVID WHITE (LOT #2)	1726236	1139149	2117	Ecology Well Database	-	50	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-12R03	12R03	DAVID WHITE (LOT #3)	1726236	1139149	2117	Ecology Well Database	5/29/95	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12L01	12L01	CHARLES SHART	1722936	1140163	1770	USGS Groundwater Data	6/20/73	120	6	80	120	Bedrock Aquifer	10	20	0.5	6/20/73	80.00	-	-	USGS Data
34N/21E-12L02	12L02	ROBERT THOMPSON	1723069	1140670	1801	USGS Groundwater Data	6/21/71	105	6	-	-	Upper Aquifer	20	2	10.0	6/21/71	50.00	-	-	USGS Data
34N/21E-12L03	12L03	ELSIE HENRICKSON	1723585	1140463	1842	Ecology Well Database	7/2/94	65	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12L04	12L04	ELSIE HENRICKSON	1723585	1140463	1842	Ecology Well Database	7/4/94	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12L05	12L05	SHANE ROBLEY	1723585	1140463	1842	Ecology Well Database	10/18/00	44	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12L06	12L06	JOHN NORTHCOTT	1723585	1140463	1842	Ecology Well Database	12/26/02	165	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12M01	12M01	DON MILLER	1722259	1140461	1752	Ecology Well Database	4/8/94	41	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12M02	12M02	WES MC KECKNIES	1722259	1140461	1752	Ecology Well Database	5/10/95	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12M03	12M03	RICK FULCHER	1722259	1140461	1752	Ecology Well Database	5/11/95	42	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-12P01	12P01	MIKE RIDER	1722808	1138743	1732	USGS Groundwater Data	6/24/74	55	6	22	55	Bedrock Aquifer	20	1	20.0	6/24/74	18.00	-	-	USGS Data
34N/21E-12P02	12P02	JULIET RHODES	1723583	1139150	1767	Ecology Well Database	5/17/01	52	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-12P03	12P03	STANLEY & DOROTHY WRIGHT	1723583	1139150	1767	Ecology Well Database	-	35	20	-	-	-	-	-	-	-	-	-	-	-
34N/21E-12X01	12X01	DAVID SABOLD	1721586	1142063	1765	USGS Groundwater Data	4/27/78	70	6	14	70	Bedrock Aquifer	2.5	59	0.0	11/7/00	12.59	-	-	USGS Data
34N/21E-12X02	12X02	WILLIAM MC KINIGHT	1724253	1141120	2036	Ecology Well Database	11/27/73	111	6	-	-	-	30	15	2.0	-	-	-	-	-
34N/21E-13A01	13A01	CLOUD BANNICH	1726232	1137823	1833	Ecology Well Database	8/14/93	345	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information								Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-13A02	13A02	STEVE HORDY	1726232	1137823	1833	Ecology Well Database	12/4/90	60	6	-	-	-	6	56	0.1	-	-	-	-	-
34N/21E-13B01	13B01	ANNETTE LLOYD	1724908	1137824	1785	Ecology Well Database	-	60	6	-	-	-	2	81	0.0	-	-	-	-	-
34N/21E-13B02	13B02	GEORGE KAY	1724908	1137824	1785	Ecology Well Database	8/9/77	112	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13B03	13B03	DAVID KELLER	1724559	1136125	1768	USGS Groundwater Data	11/20/98	62	6	20	50	Bedrock Aquifer	-	-	-	7/31/01	26.80	-	-	USGS Data
34N/21E-13H01	13H01	CLOUD BANNICK	1726235	1136489	1821	Ecology Well Database	-	65	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13G01	13G01	CARY KAUFMAN	1724912	1136489	1776	Ecology Well Database	12/17/91	310	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13G02	13G02	DAVE HOLLER	1724912	1136489	1776	Ecology Well Database	7/21/89	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13G03	13G03	EVAN FINK	1724912	1136489	1776	Ecology Well Database	4/4/88	190	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13G04	13G04	TYLER MILLER	1724912	1136489	1776	Ecology Well Database	11/20/94	105	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13G05	13G05	ERIC BAKKE	1726391	1135332	1795	USGS Groundwater Data	10/15/98	55	6	-	-	Lower Aquifer	-	-	-	8/1/01	11.50	-	-	USGS Data
34N/21E-13C01	13C01	MRS. ROY PAINTER	1723351	1137731	1736	USGS Groundwater Data	6/25/73	44	6	-	-	Upper Aquifer	30	2	15.0	6/25/73	24.00	-	-	USGS Data
34N/21E-13C02	13C02	KURT RAMCKE	1723583	1137824	1744	Ecology Well Database	4/25/01	30	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13D01	13D01	CLIFF ARKILL / NAME BARK	1722259	1137825	1709	Ecology Well Database	9/15/90	38	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-13F01	13F01	LEONARD HUBER	1723589	1136490	1732	Ecology Well Database	5/26/90	30	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13F02	13F02	LYLE SANDERSON	1723589	1136490	1732	Ecology Well Database	5/27/77	120	6	-	-	Bedrock Aquifer	15	3	5.0	-	-	-	-	-
34N/21E-13E01	13E01	EVAN FRINK	1722267	1136492	1730	Ecology Well Database	3/10/79	200	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13E02	13E02	ROLF BORGERSEN	1722267	1136492	1730	Ecology Well Database	3/30/94	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13E03	13E03	JOHN & RONANNE RILEY	1723141	1136544	1719	USGS Groundwater Data	9/16/99	40	6	-	-	Lower Aquifer	-	-	-	8/1/01	13.80	-	-	USGS Data
34N/21E-13E04	13E04	LEONARD SOUCHEK	1722267	1136492	1730	Ecology Well Database	7/15/03	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13NW01	13NW01	STANLEY & DEROTHY WRIGHT	1722925	1137158	1719	Ecology Well Database	-	28	4	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13J01	13J01	SIG BAKKE	1726522	1134704	1788	USGS Groundwater Data	8/30/99	40	6	35	40	Lower Aquifer	-	-	-	11/28/00	15.64	-	-	USGS Data
34N/21E-13J02	13J02	JOHN CRANDALL	1726237	1135154	1791	Ecology Well Database	11/3/03	67	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13J03	13J03	ROBERT CRANDALL	1726237	1135154	1791	Ecology Well Database	10/29/03	51	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13K01	13K01	DAVID EBENGER	1725387	1135051	1800	USGS Groundwater Data	8/24/96	343	6	40	335	Bedrock Aquifer	-	-	-	8/2/01	67.20	-	-	USGS Data
34N/21E-13R01	13R01	GUY VINTIN	1726237	1133820	1791	Ecology Well Database	4/21/77	42	6	-	-	-	15	8	1.9	-	-	-	-	-
34N/21E-13R02	13R02	ALEXA SPINY	1726237	1133820	1791	Ecology Well Database	10/26/04	45	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13Q01	13Q01	ARLEN PRENTICE	1724918	1133821	1802	Ecology Well Database	7/20/04	145	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13L01	13L01	ELAINE OMACHI	1723595	1135156	1726	Ecology Well Database	-	300	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13L02	13L02	JANE GUBERTSON	1723595	1135156	1726	Ecology Well Database	4/16/85	95	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13L03	13L03	LOU SCHULTZ	1723595	1135156	1726	Ecology Well Database	10/25/89	125	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13L04	13L04	RUSS HERMSTAD	1723595	1135156	1726	Ecology Well Database	11/9/91	121	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13P01	13P01	VERNE DONNET	1726607	1133792	1782	USGS Groundwater Data	7/10/94	40	6	22	34	Bedrock Aquifer	-	-	-	11/3/00	8.30	-	-	USGS Data
34N/21E-13N01	13N01	EBENGER & WRIGHT	1722282	1133822	1696	Ecology Well Database	9/17/90	140	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-13N02	13N02	EBENGER & WRIGHT	1722282	1133822	1696	Ecology Well Database	9/17/90	50	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-13N03	13N03	JIM NORTON	1722282	1133822	1696	Ecology Well Database	9/8/76	31	6	-	-	-	7	2	3.5	-	-	-	-	-
34N/21E-13X01	13X01	DANA VISALLI	1724254	1135826	1759	Ecology Well Database	5/1/78	34	6	-	-	-	10	3	3.3	-	-	-	-	-
34N/21E-14B01	14B01	JOHN BELTHEN, SUNNYVIEW FARM	1719621	1137796	1923	Ecology Well Database	7/6/84	280	6	-	-	Bedrock Aquifer	12	190	0.1	-	-	-	-	-
34N/21E-14G01	14G01	DALE LUNGEARKER	1719625	1136466	1887	Ecology Well Database	4/1/81	70	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14G02	14G02	TOM CORNISH	1714152	1139224	1855	Lot Locations	10/3/89	96	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-14C01	14C01	DICK SIEVERS	1714533	1138187	1879	Lot Locations	5/6/93	163	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14C02	14C02	GLEN REINSTRA	1717003	1140136	1875	Lot Locations	11/1/93	260	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14C03	14C03	JERRY COLE	1717018	1139659	1880	Lot Locations	8/7/94	92	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14C04	14C04	LEE PILKINSON	1718302	1137778	1923	Ecology Well Database	10/26/98	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14D01	14D01	JACK BONNIFIELD	1716591	1139548	1880	Lot Locations	1/25/98	130	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-14D02	14D02	LARRY & VALOY DELSI	1714715	1139430	1871	Lot Locations	8/9/94	122	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14D03	14D03	R. E MELLINGER	1716469	1137521	1813	Aspect/Erlandsen Survey	7/3/79	110	6	-	-	Bedrock Aquifer	5	96	0.1	5/7/08	14.52	1799.44	Yes	Aspect Data
34N/21E-14F01	14F01	KATHY MELLENGER	1715252	1139163	1874	Lot Locations	7/24/94	94	6	80	86	Bedrock Aquifer	-	-	-	8/2/01	28.40	-	-	USGS Data
34N/21E-14F02	14F02	EDSON & LLOYD	1717438	1139298	1887	Lot Locations	6/4/97	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14F03	14F03	PAM & GORDON SWANK	1718304	1136450	1939	Ecology Well Database	7/13/98	78	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14F04	14F04	GORDON SWANK	1717408	1138800	1865	Aspect/Erlandsen Survey	6/7/02	125	4	-	-	Bedrock Aquifer	-	-	-	5/5/08	75.83	1791.39	Yes	Aspect Data
34N/21E-14E01	14E01	DALE HUSTON	1716983	1136435	1880	Ecology Well Database	6/5/81	75	6	-	-	-	10	30	0.3	-	-	-	-	-
34N/21E-14E02	14E02	FRANCIS UNICK	1716983	1136435	1880	Ecology Well Database	5/5/81	185	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14E03	14E03	RICK & CATHIE LEWIS	1716801	1136414	1849	USGS Survey	8/13/96	75	6	-	-	Lower Aquifer	-	-	-	5/7/08	58.32	1792.48	Yes	Aspect Data
34N/21E-14E04	14E04	BILL LOEHR	1716983	1136435	1880	Ecology Well Database	8/20/01	104	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14E05	14E05	RANDY ANDERSON	1716636	1138568	1864	Aspect/Erlandsen Survey	4/7/98	100	6	-	-	Bedrock Aquifer	5	50	0.1	5/5/08	49.35	1816.49	Yes	Aspect Data
34N/21E-14J01	14J01	FRANK SIGURISON	1717585	1140908	1872	Lot Locations	6/10/93	142	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14J02	14J02	TOM MORRISS	1715169	1139572	1880	Lot Locations	5/4/94	120	6	-	-	-	-	-	-	-	-	-	-	-

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-14R01	14R01	CHUCK DENSON	1717555	1136959	1923	Lot Locations	6/11/88	160	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14R02	14R02	METHON VALLEY SCHOOL DIST.	1720959	1133815	1778	Ecology Well Database	8/6/86	90	8	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-14R03	14R03	WALTER LINDSAY	1716746	1134968	1877	Lot Locations	2/14/91	135	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14R04	14R04	METHOW VALLEY SCHOOL DIST	1721312	1133340	1762	Aspect/Erlandsen Survey	6/2/01	109	10	-	-	Lower Aquifer	-	-	-	5/7/08	69.31	1693.74	Yes?	Aspect Data
34N/21E-14R05	14R05	ROY BREILER	1720959	1133815	1778	Ecology Well Database	10/28/05	267	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14L01	14L01	BOB SUGGS	1713943	1137834	1911	Aspect/Erlandsen Survey	8/2/73	160	6	-	-	Lower Aquifer	-	-	-	5/5/08	126.30	1786.12	Yes	Aspect Data
34N/21E-14M01	14M01	FREDERICK GOODMAN	1716981	1135108	1886	Ecology Well Database	-	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14M02	14M02	S. ELDRED	1717176	1134767	1851	Aspect/Erlandsen Survey	5/21/93	305	6	-	-	Bedrock Aquifer	-	-	-	8/29/06	33.71	1819.04	No	Aspect Data
34N/21E-14M03	14M03	STEVE EDDY	1716694	1138108	1857	Lot Locations	8/20/01	51	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14M04	14M04	ED RHINEHART	1716981	1135108	1886	Ecology Well Database	9/16/98	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14M05	14M05	DAN AND BRIANNE AYERS	1716916	1135219	1887	Lot Locations	7/13/03	122	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14P01	14P01	GEORGE WILSON	1718306	1133792	1866	Ecology Well Database	-	140	6	-	-	Bedrock Aquifer	16	135	0.1	-	-	-	-	-
34N/21E-14P02	14P02	TRIPLETT	1718034	1133751	1825	Aspect/Erlandsen Survey	5/17/90	80	6	50	80	Bedrock Aquifer	-	-	-	5/7/08	38.95	1788.77	Yes	Aspect Data
34N/21E-14P03	14P03	TOM AND LORI TRIPLETT	1717856	1134011	1811	Aspect/Erlandsen Survey	5/17/02	60	6	-	-	Lower Aquifer	-	-	-	5/7/08	24.72	1788.88	Yes	Aspect Data
34N/21E-14N01	14N01	ARCHIE FILBERT	1716979	1133781	1870	Ecology Well Database	4/16/91	95	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14N02	14N02	DARRELL FOLO	1716979	1133781	1870	Ecology Well Database	9/11/91	108	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-14N03	14N03	MARKO IAKANOVIA	1718764	1133601	1861	Lot Locations	12/20/92	165	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-14N04[a]	14N04	LORRAINE LAZZELL	1716453	1133398	1848	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/7/08	59.09	1790.22	Yes	Aspect Data
34N/21E-14X01	14X01	JOHN KECNER	1718968	1135788	1893	Ecology Well Database	12/5/79	102	6	-	-	-	20	62	0.3	-	-	-	-	-
34N/21E-14X02	14X02	MILTON UNICK	1716784	1137133	1886	Lot Locations	11/30/87	139	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15A01	15A01	PAUL CHRISTEN	1715665	1137755	1819	Ecology Well Database	12/30/90	97	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15A02	15A02	RAY SYRE	1715665	1137755	1819	Ecology Well Database	7/5/80	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15A03	15A03	VELDA BLAIR	1715665	1137755	1819	Ecology Well Database	8/2/99	115	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15A04	15A04	RANDY POWERS	1713398	1139718	1901	Aspect/Erlandsen Survey	8/13/99	140	6	-	-	Lower Aquifer	-	-	-	5/5/08	120.97	1781.81	Yes	Aspect Data
34N/21E-15B01	15B01	D. BASSEN	1717349	1138623	1857	Lot Locations	4/18/92	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B02	15B02	GAY NORSBY	1715884	1138233	1879	Lot Locations	4/27/80	151	6	-	-	-	5	35	0.1	-	-	-	-	-
34N/21E-15B03	15B03	JACK POLINY	1715676	1139592	1870	Lot Locations	7/20/93	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B04	15B04	STEVE LADYE	1714340	1137763	1890	Ecology Well Database	6/24/92	160	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15B05	15B05	W. E. ANDERSON	1714340	1137763	1890	Ecology Well Database	5/5/80	83	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B06	15B06	WAYNE & NANCY RANES	1715564	1138563	1871	Lot Locations	5/20/95	94	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B07	15B07	SAN LEIGH	1713010	1138898	1883	Lot Locations	6/5/94	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B08	15B08	DAVID RUSSELL	1715252	1139163	1874	Lot Locations	6/27/94	110	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B09	15B09	HAROLD JOHNSON	1714340	1137763	1890	Ecology Well Database	7/20/98	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15B10	15B10	TARA KELLY	1713632	1140023	1919	Aspect/Erlandsen Survey	5/30/04	160	6	-	-	Lower Aquifer	-	-	-	5/5/08	139.41	1780.76	Yes	Aspect Data
34N/21E-15B11[a]	15B11	FRED & DOTTY NOYES	1714328	1138253	1911	Aspect/Erlandsen Survey	7/26/2002	150	6	-	-	Lower Aquifer	-	-	-	5/5/08	124.83	1787.95	Yes	Aspect Data
34N/21E-15H01	15H01	KENNY CARWILE	1712287	1138231	1881	Lot Locations	4/29/91	130	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-15H02	15H02	ROD & MAXINE BIELL	1715661	1136430	1798	Ecology Well Database	10/13/95	45	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15H03	15H03	FRED EDELMAN	1714488	1140629	1862	Lot Locations	7/15/98	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15H04	15H04	BRAD KORNISH	1715661	1136430	1798	Ecology Well Database	8/8/02	82	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15H05	15H05	LARRY GREEN	1716289	1138314	1837	Lot Locations	8/24/03	65	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15H06	15H06	FRED EDELMAN	1715661	1136430	1798	Ecology Well Database	10/30/04	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15H07	15H07	ED NIELAN	1715661	1136430	1798	Ecology Well Database	4/15/05	184	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-15G01	15G01	MARJORIE HAGEN	1715805	1137918	1841	Lot Locations	10/12/89	105	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15G02	15G02	RICK JENNING	1717143	1139013	1873	Lot Locations	9/10/93	82	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15G03	15G03	WALT MUELLER	1714974	1138344	1842	Lot Locations	7/20/95	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15G04	15G04	ROBERT L BAISDEN JR	1715390	1138743	1863	Lot Locations	8/3/99	102	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15G05	15G05	JAY GREMMERT	1714338	1136440	1798	Ecology Well Database	5/14/99	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15G06	15G06	ROBERT THIRSK	1715369	1140116	1875	Lot Locations	8/20/02	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15G07	15G07	CHARLIE KEITH	1715611	1135872	1816	Lot Locations	5/21/04	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15NE01	15NE01	FRED PACOCK	1715000	1137097	1820	Ecology Well Database	10/11/79	163	6	-	-	-	2	150	0.0	-	-	-	-	-
34N/21E-15NE02	15NE02	JOHN KEENER	1715000	1137097	1820	Ecology Well Database	9/10/91	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15NE03	15NE03	RICHARD HARDY	1716087	1138220	1870	Lot Locations	10/19/79	140	6	-	-	-	4	130	0.0	-	-	-	-	-
34N/21E-15NE04	15NE04	WILBURN L. BUCHANAN	1713466	1138295	1869	Lot Locations	-	101	6	-	-	-	16	2	8.0	-	-	-	-	-
34N/21E-15C01	15C01	GRADY MATHIS	1713680	1138414	1875	Lot Locations	9/7/91	97	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15C02	15C02	HAROLD LEE	1715421	1138215	1850	Lot Locations	11/13/93	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15C03	15C03	TARY POWELL	1713016	1137771	1873	Ecology Well Database	8/6/93	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15C04	15C04	WENDY DAVIS	1713443	1138842	1871	Lot Locations	9/8/91	120	-	-	-	Aquitard	-	-	-	-	-	-	-	-

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-15D01	15D01	BILL SCHNIEDER	1711689	1137779	1952	Ecology Well Database	11/15/96	30	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15D02	15D02	BONITAT DAFNOR	1713497	1137902	1861	Lot Locations	4/30/92	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15D03	15D03	LESLIE CORFMAN	1711689	1137779	1952	Ecology Well Database	6/30/88	75	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15D04	15D04	GEORGE MC WHIRTER	1711689	1137779	1952	Ecology Well Database	8/21/95	87	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15F01	15F01	MIKE BROWN	1712650	1138648	1880	Lot Locations	8/23/92	140	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F02	15F02	PETER OSGARD	1714092	1138498	1892	Lot Locations	8/27/90	150	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15F03	15F03	RICK STONE	1713015	1136449	1860	Ecology Well Database	4/13/91	150	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F04	15F04	STEVE EDGUIST	1713246	1137370	1837	Lot Locations	10/8/93	70	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F05	15F05	TOM JOHNSON	1713015	1136449	1860	Ecology Well Database	10/13/91	196	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F06	15F06	ELIZABETH LAMMERS	1712648	1139050	1880	Lot Locations	6/11/95	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F07	15F07	STAN HILLIER	1712652	1138243	1880	Lot Locations	-	120	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15F08	15F08	BARD SCHULER	1711991	1136591	1947	USGS Groundwater Data	8/11/99	224	6	140	224	Bedrock Aquifer	-	-	-	11/10/00	133.36	-	-	USGS Data
34N/21E-15E01	15E01	JOHN BLESHEN	1711691	1136459	2021	Ecology Well Database	12/6/92	140	6	-	-	Aquitard	-	-	-	-	-	-	-	-
34N/21E-15E02	15E02	JOHN BLETHEN	1711691	1136459	2021	Ecology Well Database	-	180	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-15E03	15E03	DANNY HIGBEE	1711691	1136459	2021	Ecology Well Database	8/29/95	100	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15E04	15E04	ED BEHRENS	1711691	1136459	2021	Ecology Well Database	10/15/00	180	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15J01	15J01	BECKY VANSTEENKISTE	1715658	1135106	1841	Ecology Well Database	3/16/91	60	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15J02	15J02	ED BEHREMS	1715658	1135106	1841	Ecology Well Database	-	94	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15J03	15J03	VANDERPOOL	1713633	1137812	1863	Lot Locations	7/29/99	103	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-15J04	15J04	PETE & KRISTIE EDWARDS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15J05[a]	15J05	ROBIN & TERESSA SAFFORD	1715556	1135705	1808	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/7/08	18.76	1791.30	Yes	Aspect Data
34N/21E-15K01	15K01	DON VEY	1714336	1135116	1798	Ecology Well Database	3/24/92	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15K02	15K02	FRANK JOHNSON	1713585	1135724	1814	Aspect/Erlandsen Survey	12/20/92	40	6	-	-	Aquitard	-	-	-	5/7/08	23.14	1792.10	Yes	Aspect Data
34N/21E-15K03	15K03	PAT JOHNSON	1714336	1135116	1798	Ecology Well Database	6/17/89	55	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15K04	15K04	JR WELLS	1714336	1135116	1798	Ecology Well Database	5/11/99	173	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-15R01	15R01	ASSEMBLY OF GOD CHURCH	1716136	1134110	1882	USGS Survey	4/19/80	164	6	-	-	Lower Aquifer	-	-	-	5/7/08	91.95	1791.82	Yes	Aspect Data
34N/21E-15R02	15R02	DALE HUSTON	1716586	1137571	1858	Lot Locations	10/2/88	101	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15R03	15R03	FRANK & JANITE POOFF	1715654	1133780	1890	Ecology Well Database	-	178	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-15R04	15R04	GARY RANSHOTTOM	1715654	1133780	1890	Ecology Well Database	2/15/91	88	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15R05	15R05	STEVE STAFFORD	1715754	1134516	1875	Aspect/Erlandsen Survey	8/18/93	120	6	-	-	Lower Aquifer	-	-	-	5/8/08	85.32	1791.11	Yes	Aspect Data
34N/21E-15R06	15R06	TOM RISTE	1715495	1133722	1881	Aspect/Erlandsen Survey	6/18/80	112	6	-	-	Lower Aquifer	-	-	-	5/7/08	97.09	1785.28	Yes	Aspect Data
34N/21E-15R07	15R07	TUCKER BARKSDALE	1713416	1139310	1887	Lot Locations	5/6/81	136	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15SE01	15SE01	DEN AMES	1714996	1134449	1818	Ecology Well Database	7/12/81	140	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15L01	15L01	CORKY SCHARF	1715952	1133625	1884	Aspect/Erlandsen Survey	12/17/90	105	6	-	-	Lower Aquifer	-	-	-	5/7/08	88.86	1790.72	Yes	Aspect Data
34N/21E-15N01	15N01	DENNIS CHANDY	1711691	1133815	2160	Ecology Well Database	8/16/92	120	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-15X01	15X01	JERRY PARTLOW	1716915	1136606	1887	Lot Locations	7/6/86	77	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-15X02	15X02	RUSSELL SAGE	1713677	1135784	1801	Ecology Well Database	-	117	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-16A01	16A01	HARRIS BORTON	1710363	1137784	2318	Ecology Well Database	7/15/79	54	6	-	-	Aquitard	5	20	0.3	-	-	-	-	-
34N/21E-22A02	22A02	ERIKA BURTSCH	1715119	1132894	1875	Aspect/Erlandsen Survey	1/28/91	104	6	-	-	Lower Aquifer	18	0	-	5/7/08	87.59	1790.74	Yes	Aspect Data
34N/21E-22A03	22A03	MIKE & CATHY CORRIGAN	1715245	1132545	1893	USGS Survey	10/7/85	124	6	-	-	Lower Aquifer	-	-	-	8/29/06	99.87	1795.18	No	Aspect Data
34N/21E-22A04	22A04	OLAV KYTE	1715794	1132098	1886	Aspect/Erlandsen Survey	6/7/97	100	6	-	-	Lower Aquifer	-	-	-	5/7/08	98.62	1788.78	Yes	Aspect Data
34N/21E-22A05[a]	22A05	DICK EWING	1715803	1132839	1878	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/7/08	89.16	1790.08	Yes	Aspect Data
34N/21E-22E01	22E01	MOCCASIN LAKE RANCH	1711054	1130650	1992	Aspect/Erlandsen Survey	9/11/01	100	6	-	-	Lower Aquifer	-	-	-	5/7/08	34.29	1958.85	Yes?	Aspect Data
34N/21E-22E02	22E02	MOCCASIN LAKE RANCH	1713123	1131098	1948	Aspect/Erlandsen Survey	2/4/97	40	6	20	30	Lower Aquifer	-	-	-	5/7/08	23.55	1924.88	Yes	Aspect Data
34N/21E-22J01	22J01	VIOLA EBERLE	1715650	1129813	2168	Ecology Well Database	4/16/80	113	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-23A01	23A01	MIKE MCMILLEN	1720959	1132484	1783	Ecology Well Database	8/4/96	140	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-23A02	23A02	GEORGE SUKOVATY	1721536	1132845	1735	Aspect/Erlandsen Survey	-	72	6	-	-	-	-	-	-	5/7/08	52.80	1692.04	Yes	Aspect Data
34N/21E-23A03	23A03	GEORGE SUKOVATY	1720959	1132484	1783	Ecology Well Database	-	92	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-23C01	23C01	HUGH MOORE	1718304	1132466	1834	Ecology Well Database	8/9/80	95	6	-	-	Lower Aquifer	10	25	0.4	-	-	-	-	-
34N/21E-23D01	23D01	ARTHUR LANGLINE	1718617	1133958	1874	Aspect/Erlandsen Survey	6/12/90	365	6	-	-	Bedrock Aquifer	-	-	-	8/29/06	58.72	1818.55	No	Aspect Data
34N/21E-23D02	23D02	JAKK NUTTER	1718398	1131591	1854	Lot Locations	11/21/91	101	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-23D03[a]	23D03	DAVID STEPHENSON	1717305	1132281	1868	Aspect/Erlandsen Survey	-	90	-	-	-	-	-	-	-	5/7/08	80.95	1788.23	Yes	Aspect Data
34N/21E-23F01	23F01	BILL DENNIS	1718300	1131144	1870	Ecology Well Database	4/16/81	124	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-23F02	23F02	DON PORTMAN	1718300	1131144	1870	Ecology Well Database	5/8/80	92	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-23F03	23F03	MIKE SALMON	1716760	1131812	1881	Aspect/Erlandsen Survey	10/24/91	118	6	-	-	Lower Aquifer	-	-	-	5/7/08	96.20	1787.97	Yes	Aspect Data
34N/21E-23F04	23F04	PETER KENNEDY	1718300	1131144	1870	Ecology Well Database	1/9/81	100	6	-	-	-	-	-	-	-	-	-	-	-

Table 2.5.1
Summary of Well Completion Information
TLAC Water Right Application
Winthrop, Washington

Location Information							Completion Information						Well Productivity			Static Water Levels				
TRS Identifier	Short Name	Owner	X Coord WA SPS83	Y Coord WA SPS83	Ground Elevation NGVD 29	Location Source[b]	Completion Date	Depth (ft)	Dia (in)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Unit of Completion	Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Date	Static Water Level (ft bTOC)	Static Water Elevation (ft MSL)	Recently Pumped	Source
34N/21E-23F05	23F05	MOCCASIN LAKE RANCH	1718300	1131144	1870	Ecology Well Database	2/4/97	40	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-23NW01	23NW01	ED FILBERT	1717639	1131801	1876	Ecology Well Database	-	90	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-23NW02	23NW02	JEFF SANDINE	1717476	1131401	1865	Aspect/Erlandsen Survey	8/25/98	96	6	-	-	Lower Aquifer	-	-	-	5/8/08	77.88	1787.37	Yes	Aspect Data
34N/21E-23J01	23J01	MICHAEL AHRNINS	1720940	1129832	1801	Ecology Well Database	7/16/86	185	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-23J02	23J02	RON BULINER	1720940	1129832	1801	Ecology Well Database	10/28/88	80	8	-	-	-	4.5	58	0.1	-	-	-	-	-
34N/21E-23J03	23J03	RICHARD AITKINS	1720940	1129832	1801	Ecology Well Database	10/22/95	310	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-23J04	23J04	R D SCHRIER	1720940	1129832	1801	Ecology Well Database	-	35	6	-	-	-	20	0	-	-	-	-	-	-
34N/21E-23J05	23J05	THOMAS LEUSCHEN	1720940	1129832	1801	Ecology Well Database	11/29/01	80	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-23K01	23K01	DEE VINNING	1720953	1129145	1822	Aspect/Erlandsen Survey	11/23/92	285	6	200	285	Bedrock Aquifer	-	-	-	5/7/08	53.30	1770.45	No	Aspect Data
34N/21E-23K02	23K02	NIM TITCUM	1720023	1130476	1819	USGS Survey	9/4/90	66	6	-	-	Lower Aquifer	-	-	-	5/9/08	43.35	1778.98	Yes	Aspect Data
34N/21E-23K03	23K03	NIM TITCUM	1720023	1130476	1841	USGS Groundwater Data	9/4/90	66	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-23L01	23L01	TONY RUGEL	1718585	1130782	1856	Aspect/Erlandsen Survey	11/3/94	96	6	-	-	Lower Aquifer	-	-	-	5/7/08	71.42	1785.94	Yes	Aspect Data
34N/21E-23X01	23X01	JOHN VANDERHALF	1718962	1130488	1870	Ecology Well Database	8/10/78	96	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-24A01	24A01	TERRY GAINES	1726236	1132492	1785	Ecology Well Database	3/19/91	42	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-24B01	24B01	JANE GILBERTSON	1724917	1132492	1883	Ecology Well Database	3/14/91	145	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-24B02	24B02	WAYNE WILSON	1724917	1132492	1883	Ecology Well Database	5/5/94	60	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-24H01	24H01	GARY REED	1726233	1131171	1771	Ecology Well Database	6/1/94	60	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-24H02	24H02	OKANOGAN CO WORKS MAINT	1726233	1131171	1771	Ecology Well Database	5/9/03	84	8	-	-	-	-	-	-	-	-	-	-	-
34N/21E-24G01	24G01	DIANE SHEFFIELD	1724911	1131169	1714	Ecology Well Database	3/4/91	295	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-24G02	24G02	CRAIG BOSSELL	1724980	1130895	1709	USGS Groundwater Data	4/18/99	60	6	-	-	Lower Aquifer	-	-	-	8/2/01	31.00	-	-	USGS Data
34N/21E-24NE01	24NE01	BRUCE WOOD	1725574	1131831	1834	Ecology Well Database	9/30/92	145	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-24C01	24C01	RON EVANS	1723599	1132490	1697	Ecology Well Database	10/24/80	60	6	-	-	Upper Aquifer	-	-	-	-	-	-	-	-
34N/21E-24C02[a]	24C02	DALE SEKIJIMA & NANCY FARR	1723373	1133162	1699	Aspect/Erlandsen Survey	-	-	-	-	-	-	-	-	-	5/8/08	15.42	1687.00	Yes	Aspect Data
34N/21E-24F01	24F01	JIM PIGOTT	1723592	1131167	1686	Ecology Well Database	7/18/05	65	6	-	-	-	-	-	-	-	-	-	-	-
34N/21E-24F02	24F02	TOD SLATER	1723592	1131167	1686	Ecology Well Database	8/16/05	85	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-24E01	24E01	STEVE DAMON	1721663	1131279	1742	Aspect/Erlandsen Survey	5/25/87	85	-	-	-	Lower Aquifer	-	-	-	5/7/08	59.11	1684.94	Yes	Aspect Data
34N/21E-24E02	24E02	TONY DAMMON	1722273	1131165	1719	Ecology Well Database	6/2/92	118	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-24R01	24R01	RON PERROW	1726224	1128531	1696	Ecology Well Database	6/10/02	60	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-24L01	24L01	TOM ARON	1723585	1129843	1680	Ecology Well Database	12/16/98	240	6	-	-	Bedrock Aquifer	-	-	-	-	-	-	-	-
34N/21E-24P01	24P01	COLIN MACKENZIE	1723577	1128518	1684	Ecology Well Database	11/15/01	43	6	-	-	Lower Aquifer	-	-	-	-	-	-	-	-
34N/21E-24X02	24X02	OKANOGAN NATIONAL FOREST	1725341	1130238	1709	USGS Groundwater Data	6/1/50	105	6	-	-	-	-	-	-	6/1/50	40.00	-	-	USGS Data

Notes:

[a] Domestic water supply well located during site visit by Aspect Consulting personnel. No well log was avaiblable for the respective well in the Ecology Well Log Database.

[b] Well location sources are as follows:

Ecology Well Database is from the Washington State Department of Ecology Well Log Database.
Aspect/Erlandsen Survey is from August 2006, December 2007 and May 2008 site visits.
USGS Groundwater Data is from the USGS Groundwater Data for Washington Database.
USGS Survey is data from the Hydrogeology of Unconsolidated Sediments, Water Quality, and Ground-Water/Surface-Water Exchanges in the Methow River Basin, Okanogan County, Washington (Konrad et. al, 2005).

- Indicates either no information was available or was not evaluated.

Table 2.5.2
Hydraulic Parameters
TLAC Water Right Application
Winthrop, Washington

		Specific Capacity		Transmissivity		Hydraulic Conductivity			
Hydrostratigraphic Unit	Number of Values	Range of Values (gpm/ft)	Geometric Mean (gpm/ft)	Range of Values (gpd/ft)	Geometric Mean (gpd/ft)	Range of Values (ft/day)	Geometric Mean (ft/day)	Range of Values (cm/sec)	Geometric Mean (cm/sec)
Upper Aquifer	4	7.5 - 157	20.5	11,250 - 1,200,000	64,030	30 - 1152	139	0.011 - 0.4	0.049
Aquitard	1	0.3	NA	500	NA	3	NA	0.0010	NA
Lower Aquifer	5	0.4 - 91	12.5	800 - 1,350,000	48,530	2 - 1296	119	0.0008 - 0.46	0.042
Bedrock Aquifer	13	0.005 - 59	0.4	9 - 117,647	873	0.004 - 52	0.4	0.0000015 - 0.02	0.00014

Notes:
NA = Not Applicable
Transmissivity (in gpd/ft) was calculated for wells without pumping test reports using the following equations:

Unconfined Aquifer (Upper Aquifer):

$$\frac{Q}{s} = \frac{T}{1500}$$

Confined Aquifer (Aquitard, Lower Aquifer, and Bedrock Aquifer):

$$\frac{Q}{s} = \frac{T}{2000}$$

where:
Q is the pumping rate in gallons per minute
Δs is the drawdown in feet over a log cycle of time

Hydraulic conductivity was calculated for wells without pumping test reports based on an average hydrostratigraphic unit thickness from the cross-sections:

Upper Aquifer:	50 ft
Aquitard:	22.5 ft
Lower Aquifer:	45 ft
Bedrock Aquifer:	300 ft

Table 3.1.1

Estimated Average Monthly Water Balance

TLAC Water Right Application

Winthrop, Washington

Hydrologic Component	Sub-Area (acres)	January		February		March		April		May		June		July		August		September		October		November		December		Annual		Comments
		in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/mo	AF/mo	in/yr	AF/yr	
General Hydrologic Components																												
Precipitation	-	2.01	1,095	1.40	762	0.92	501	0.77	419	0.97	528	1.10	599	0.60	327	0.60	327	0.56	305	0.93	506	1.90	1,035	2.49	1,356	14.25	7,760	NOAA Station: WINTHROP 1 WSW, WASHINGTON (459376).
Potential Evapotranspiration (Yakima)	-	0.80	436	1.40	762	2.90	1,579	4.50	2,451	6.60	3,594	7.80	4,248	9.80	5,337	7.90	4,302	5.30	2,886	2.90	1,579	1.30	708	0.70	381	51.90	28,263	Monthly Average Pan Evaporation from Yakima WB AP using Penman Equation.
Potential Evapotranspiration (Omak)	-	0.31	169	0.83	452	2.29	1,247	4.07	2,216	6.01	3,273	7.38	4,019	8.94	4,868	7.33	3,992	4.67	2,543	2.17	1,182	0.58	316	0.25	136	44.83	24,413	Monthly Average Evapotranspiration from Omak, Washington Station (OMAW).
Runoff	-	0.72	394	0.50	274	0.33	180	0.28	151	0.35	190	0.40	216	0.22	118	0.22	118	0.20	110	0.33	182	0.68	372	0.90	488	5.13	2,794	Simulated runoff from the basin occurs as 36% of the annual precipitation (USGS, 2005)
Recharge Components of the Twin Lakes Aquifer Water Balance																												
Precipitation Infiltration	-	0.49	265	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.89	487	1.38	752	Precipitation - Evapotranspiration - Runoff.
Incident Lake Precipitation and Runoff to Lakes	80	0.05	28	0.04	19	0.02	13	0.02	11	0.02	13	0.03	15	0.02	8	0.02	8	0.01	8	0.02	13	0.05	26	0.06	35	0.36	198	Incident precipitation to lakes equal to Winthrop precipitation. Runoff (36% of precip) within area approximately 3x lake area assumed to drain to lake.
Mountain Front	5800	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.35	190	Mountain Front Recharge calculated to ensure zero annual change in aquifer storage. The resulting proportional MFR represents about 2% of annual precipitation for the drainage area for Twin Lakes and Thompson Creek. This percentage of annual precipitation is consistent with values from "Mountain-Block Hydrology and Mountain-Front Recharge" by Wilson and Guan (2004)).
Subsurface Inflow	-	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	0.29	159	3.50	1906	Q=VA=KA(dh)/(dl); K = 215 ft/day (geomean of alluvial units), dh/dl = 0.00335; Assumes width of alluvial sediments to be 3700 ft and an average thickness of 85 ft.
Methow River Losses	152	0.00	0	0.00	0	0.00	1	0.01	5	0.02	14	0.02	13	0.01	5	0.00	1	0.00	0	0.00	0	0.00	1	0.00	0	0.07	40	Average Methow River Losses from Winthrop to Twisp (30.5 cu ft/sec; 2001-2002). Sub-area calculated from river distance of 10 miles and width of 125 ft.
Irrigation Return Flow	550	0.00	0	0.00	0	0.00	0	0.17	92	0.17	92	0.17	92	0.17	92	0.17	92	0.00	0	0.00	0	0.00	0	0.00	0	0.84	458	Sub-area of irrigated lands is based on 2004 DNR aerial photographs. Assumes 28 inches of water is applied to land with 18 inches going to the plants and 10 inches going to recharge (personal communication with Nim Titcomb).
Thompson Creek Discharge	-	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.03	16	0.35	188	Average discharge measured to be 0.26 cfs. Due to similar discharge measurements during site visits in December 2007 and May 2008, this average discharge was evenly distributed for all months.
Discharge Components of the Twin Lakes Aquifer Water Balance																												
Net Domestic Well Withdrawal	-	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.02	9	0.20	108	Based on 200 gpd per capita, 2.5 persons per household and 50% consumptive use (250 gpd per household). Based on 422 wells (387 domestic wells, 35 irrigation wells)
Irrigation Well Withdrawal	275	0.00	0	0.00	0	0.00	0	0.24	128	0.24	128	0.24	128	0.24	128	0.24	128	0.00	0	0.00	0	0.00	0	0.00	0	1.18	642	Sub-area served by groundwater estimated as 50% of irrigation return flow sub-area. Assumes 28 inches of water is applied over 5 month growing season.
Subsurface Outflow	-	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	0.23	126	2.78	1514	Q=VA=KA(dh)/(dl); K = 215 ft/day (geomean of alluvial units), dh/dl = 0.00372; Assumes width of alluvial sediments to be 3000 ft and an average thickness of 75 ft.
Methow River Gain	205	0.01	3	0.01	3	0.01	5	0.03	17	0.05	25	0.06	31	0.03	19	0.01	6	0.01	3	0.01	4	0.01	5	0.01	4	0.23	125	Average Methow River Gains from Goat Creek to Winthrop (137 cu ft/sec; 2001-2002). Sub-area calculated from river distance of 13.5 miles and width of 125 ft.
Lake Evaporation	80	0.01	5	0.02	9	0.04	19	0.06	30	0.08	44	0.10	52	0.12	65	0.10	53	0.06	35	0.04	19	0.02	9	0.01	5	0.64	346	Evaporation calculated using Monthly Average Pan Evaporation from Yakima WB AP. Sub-area estimated as 75% of lake-full areas of Big Twin (79 acres), Little Twin (23 acres), and Dibble (4.7 acres) Lakes provided from 1946 and 1947 survey by State Department of Game from Lakes of Washington (Wolcott, 1973).
River Evaporation	230	0.03	15	0.05	27	0.10	56	0.16	86	0.23	127	0.27	150	0.35	188	0.28	152	0.19	102	0.10	56	0.05	25	0.02	13	1.83	996	Evaporation calculated using Monthly Average Pan Evaporation from Yakima WB AP. Sub-area calculated from river distance of 9.5 miles and river width of 125 ft and riparian width of 75 ft.
Water Balance Summary																												
Total Recharge	-	0.89	483	0.39	210	0.37	204	0.55	297	0.57	309	0.57	310	0.54	295	0.54	292	0.36	198	0.37	203	0.40	217	1.31	712	6.85	3,732	
Total Discharge	-	0.29	159	0.32	174	0.40	215	0.73	397	0.84	459	0.91	497	0.98	536	0.87	474	0.51	275	0.39	214	0.32	174	0.29	157	6.85	3,731	
Change in Aquifer Storage	-	0.59	324	0.07	35	-0.02	-11	-0.18	-100	-0.28	-150	-0.34	-186	-0.44	-240	-0.33	-182	-0.14	-77	-0.02	-11	0.08	44	1.02	555	0.00	0	Annual change in aquifer storage is defined as zero for average hydrologic conditions.

Note: Linear rates have been normalized to the model area. Model area is 6535 acres.

Table 3.2.1
Summary of Surface Water and Groundwater Rights for Irrigated Lands
TLAC Water Right Application
Winthrop, Washington

TRS Location	Surface Water Rights						
	Minimum Irrigated Acres with Water Right	Maximum Irrigated Acres with Water Right	Total Irrigated Acres with Water Right	Min Instantaneous Water Right for Irrigated Lands (cfs)	Max Instantaneous Water Right for Irrigated Lands (cfs)	Sum of Instantaneous Water Rights for Irrigated Lands (cfs)	Sum of Yearly Water Rights for Irrigated Lands (ac-ft)
T34N/R21E-02	2	2	2	0.10	0.10	0.10	7.59
T34N/R21E-03	2	440	482	0.28	10.00	15.28	4708.00
T34N/R21E-04	440	440	440	5.00	25.00	30.00	2625.00
T34N/R21E-09	8	8	8	0.16	0.16	0.16	24.00
T34N/R21E-10	-	-	-	-	-	-	-
T34N/R21E-11	-	-	-	-	-	-	-
T34N/R21E-14	-	-	-	-	-	-	-
T34N/R21E-15	5	15	20	0.20	0.22	0.42	64.71
T34N/R21E-22	2	2	2	0.01	0.01	0.01	3.00
T34N/R21E-23	15	36	51	0.36	1.49	1.85	405.00
T34N/R21E-24	3	13	16	0.09	3.51	3.60	22.00
Total			**1021**			**51**	**7859**

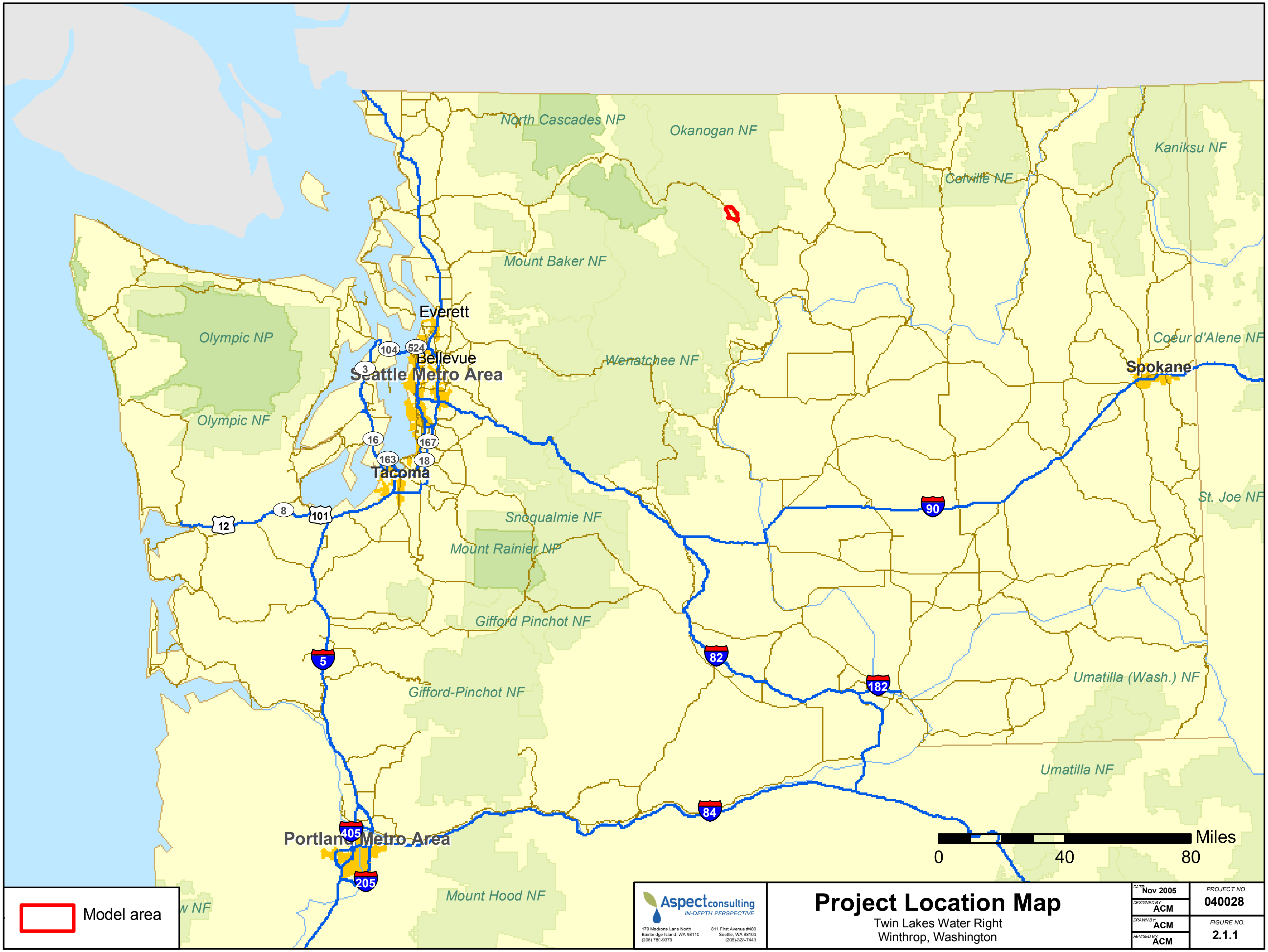
TRS Location	Groundwater Rights						
	Minimum Irrigated Acres with Water Right	Maximum Irrigated Acres with Water Right	Total Irrigated Acres with Water Right	Min Instantaneous Water Right for Irrigated Lands (cfs)	Max Instantaneous Water Right for Irrigated Lands (cfs)	Sum of Instantaneous Water Rights for Irrigated Lands (cfs)	Sum of Yearly Water Rights for Irrigated Lands (ac-ft)
T34N/R21E-02	7	7	7	55.00	55.00	55.00	22.80
T34N/R21E-03	1	17	57	10.00	180.00	720.00	266.76
T34N/R21E-04	1	188	231	10.00	1683.00	2032.00	859.20
T34N/R21E-09	-	-	-	-	-	-	-
T34N/R21E-10	1	1	1	5.00	10.00	15.00	2.50
T34N/R21E-11	-	-	-	-	-	-	-
T34N/R21E-14	-	-	-	-	-	-	-
T34N/R21E-15	6	6	6	60.00	60.00	60.00	20.29
T34N/R21E-22	-	-	-	-	-	-	-
T34N/R21E-23	3	3	6	15.00	40.00	55.00	17.00
T34N/R21E-24	160	160	160	1630.60	1630.60	1630.60	646.67
Total			**467**			**4568**	**1835**

Note: Water rights compiled only for records that list areas of irrigated lands; includes both claims and certificates.

Table 5.4.1
Summary of Steady State Conditions Water Balance
TLAC Water Right Application
Winthrop, Washington

Scenario	Statistic	TLAC Withdrawal	Big Twin and Little Twin Lake ET	Lake Seepage to the North	Lake Seepage to the South	Lake/Aquifer Storage
WDFW	**average**	176	30	90	35	20
	maximum	211	31	93	36	58
	minimum	136	30	88	35	-20
WDFW/WAC	**average**	214	36	100	39	38
	maximum	215	37	102	40	42
	minimum	214	36	99	38	35
WAC	**average**	214	36	100	39	38
	maximum	214	37	102	40	42
	minimum	214	36	98	38	35

Notes:
All values in acre-feet per year.
Steady state conditions taken as average of last five years of model run.
Statistics based on last five years of model run.
Changes relative to full buildout condition.
Results presented for 1000 gpm TLAC system capacity; results for greater than 1000 gpm capacity are similar.
Refer to Appendix C for detailed water budget graphs.



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179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370

811 First Avenue #480
Seattle, WA 98104
(206)-328-7443

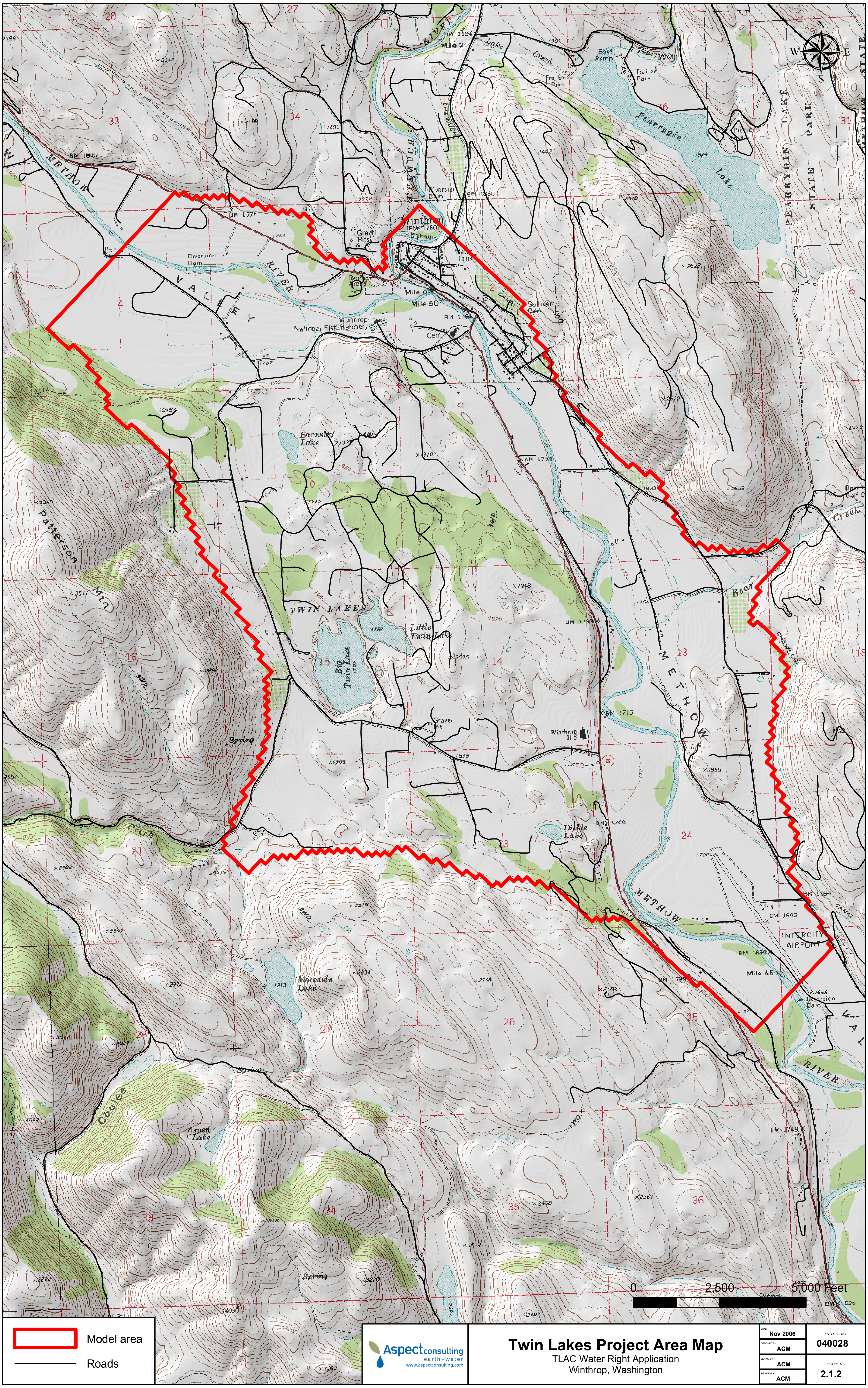
Project Location Map

Twin Lakes Water Right
Winthrop, Washington

DATE: Nov 2005
DESIGNED BY: ACM
DRAWN BY: ACM
REVISED BY: ACM

PROJECT NO. 040028

FIGURE NO. 2.1.1



Twin Lakes Project Area Map
TLAC Water Right Application
Winthrop, Washington

DATE: Nov 2006	PROJECT NO. 040028		
DESIGNED BY: ACM			
DRAWN BY: ACM	FIGURE NO. 2.1.2		
REVISED BY: ACM			

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Note: Annual precipitation data from Winthrop 1 WSW (NOAA Station 459376) for period of record (1931-2005).

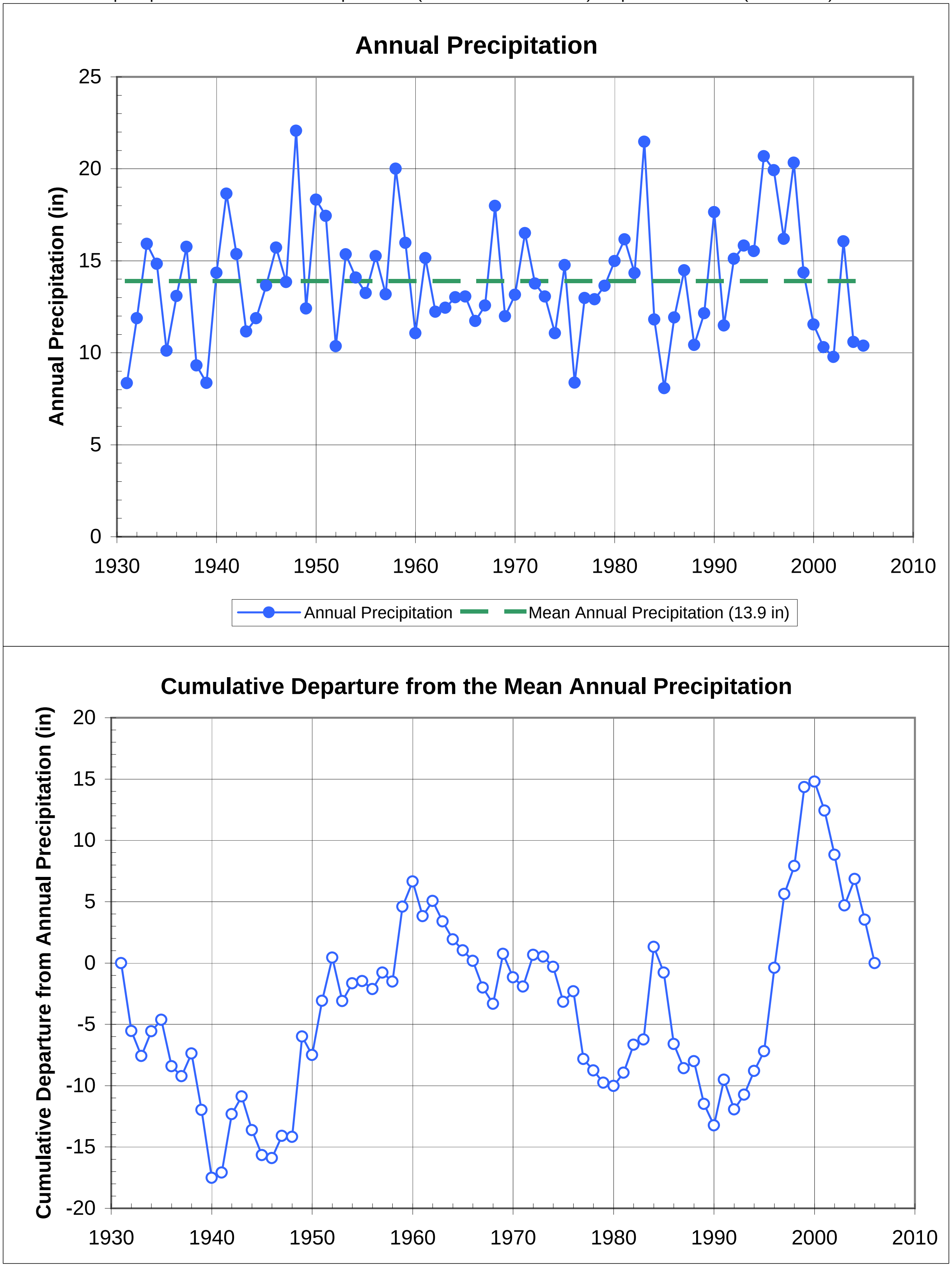


Figure 2.2.1

Long-term Precipitation Analysis

TLAC Water Right Application

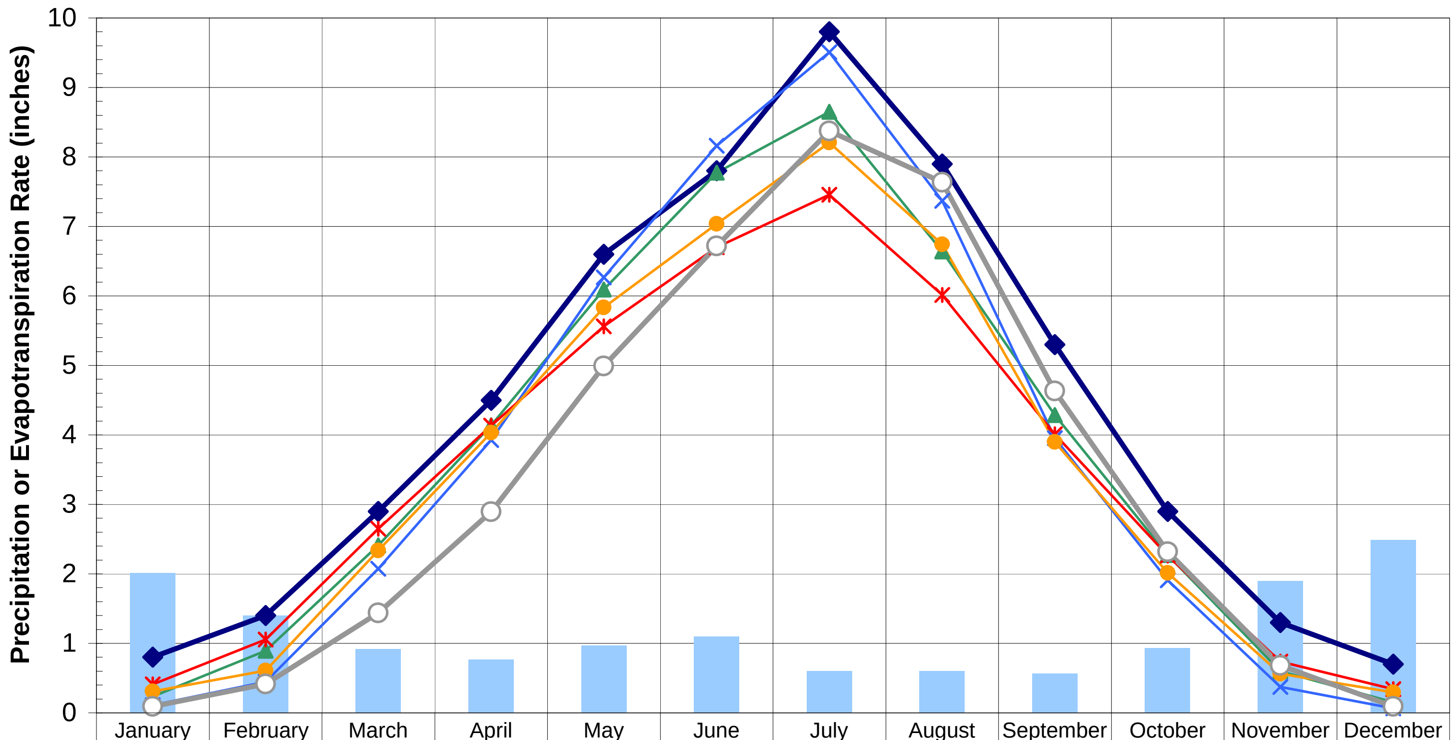
Winthrop, Washington

Aspect Consulting

12/14/2006

W:\040028 Water Resources Consultant Pool FY 04-05\Twin Lakes\Deliverables\Hydrogeologic Eval\WaterBalance2.xls

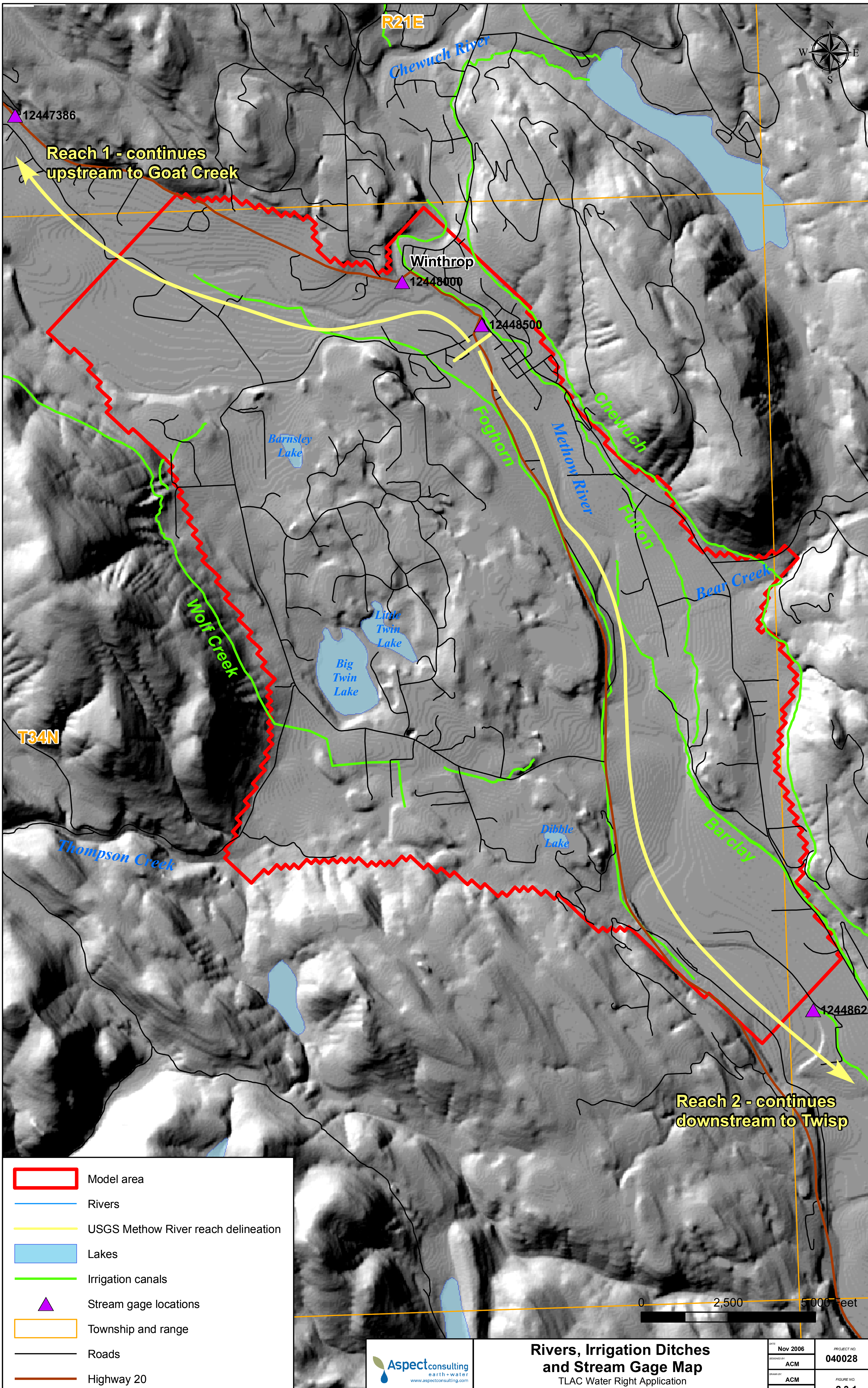
Note:
Precipitation data from Winthrop 1 WSW (NOAA Station 459376) for period of record (1931-2005).
Normal evapotranspiration (ET) at Yakima reported by Western Regional Climate Center.
Alfalfa reference ET (ETr) and grass reference ET (ETo) at Sunnyside and Wenatchee from PAWS network.
Alfalfa reference ET (ETr) at Winthrop calculated by Aspect using Blaney-Criddle SCS method based on normal temperature values from Winthrop 1 WSW.



	January	February	March	April	May	June	July	August	September	October	November	December
Precipitation (Winthrop)	2.01	1.4	0.92	0.77	0.97	1.1	0.6	0.6	0.56	0.93	1.9	2.49
ET (Yakima WRCC)	0.80	1.40	2.90	4.50	6.60	7.80	9.80	7.90	5.30	2.90	1.30	0.70
ETr (Sunnyside PAWS)	0.23	0.90	2.41	4.14	6.09	7.77	8.65	6.64	4.29	2.27	0.60	0.15
ETr (Wenatchee PAWS)	0.11	0.45	2.07	3.93	6.27	8.16	9.51	7.37	3.96	1.91	0.37	0.07
ETo (Sunnyside PAWS)	0.41	1.05	2.65	4.13	5.56	6.70	7.45	6.01	4.01	2.26	0.74	0.34
ETo (Wenatchee PAWS)	0.31	0.61	2.34	4.03	5.83	7.04	8.21	6.74	3.90	2.01	0.56	0.30
Etr (Winthrop Blaney-Criddle)	0.09	0.41	1.44	2.90	4.99	6.72	8.37	7.63	4.63	2.32	0.68	0.09

Figure 2.2.2
Mean Monthly Precipitation and Evapotranspiration
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting
12/14/2006
W:\040028 Water Resources Consultant Pool FY 04-05\Twin Lakes\Deliverables\Hydrogeologic Eval\WaterBalance2.xls



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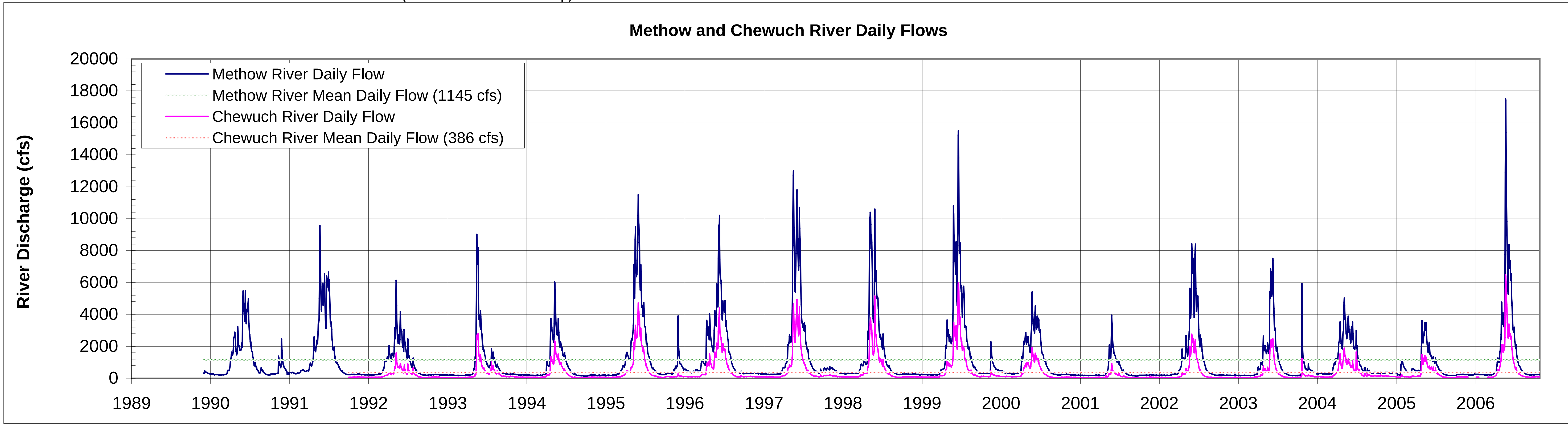
Note: Methow River flow data from USGS Station # 12448500 (Methow River at Winthrop).



Note: Minimum instream flow taken from WAC 173-548 for Methow River from the confluence with Boulder Creek to the confluence with the Chewuch River.

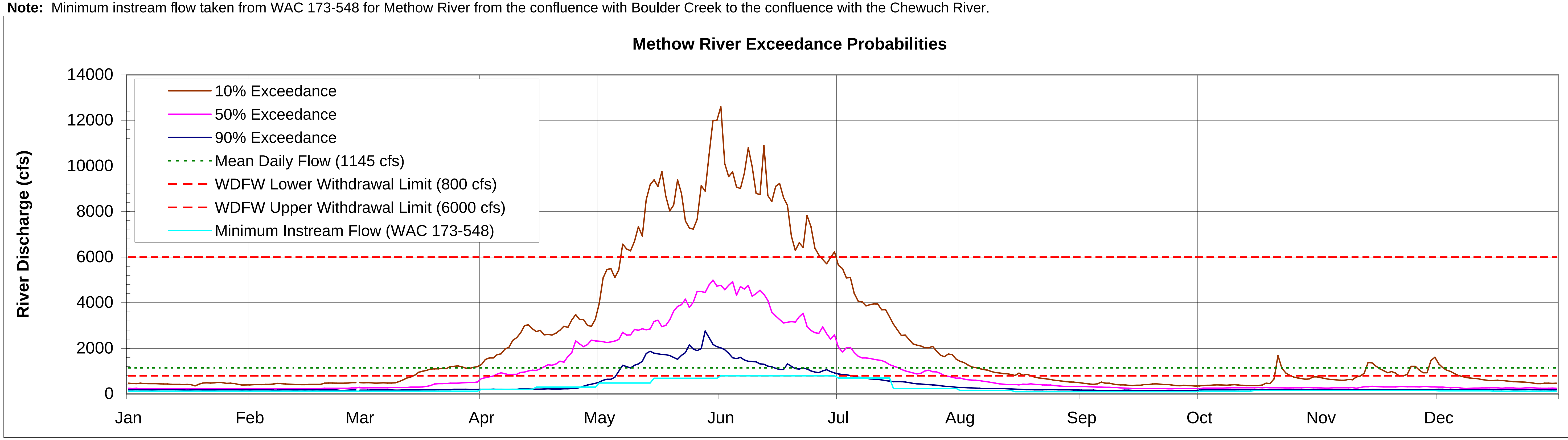


Figure 2.3.2
Methow and Chewuch River Flows and Exceedance Probabilities
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting
6/12/09
W:\040028 Water Resources Consultant Pool FY 04-05\Twin Lakes ASP 1\Deliverables\Hydrogeologic Eval\Final Report\Tables\RiverFlows.xls

Note: Average monthly net river gains and losses are based on 2001 and 2002 Methow River gains and losses calculated from the *Hydrogeology of the Unconsolidated Sediments, Water Quality, and Ground-Water/Surface-Water Exchanges in the Methow River Basin, Okanongan County, Washington* (USGS, 2005) and applied to the 2001 and 2002 water years for USGS Station # 12448500 (Oct. 2000 - Sept. 2002).

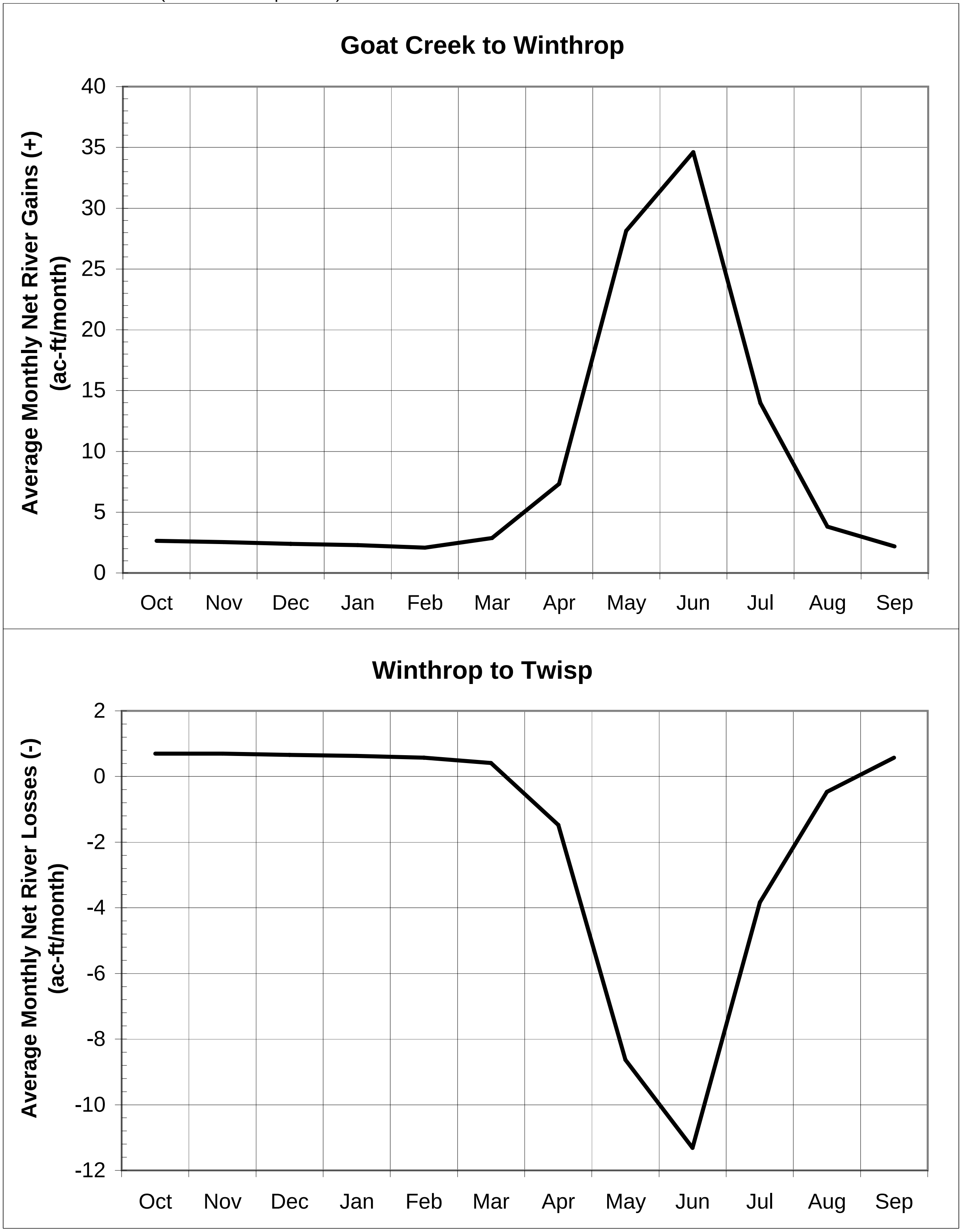
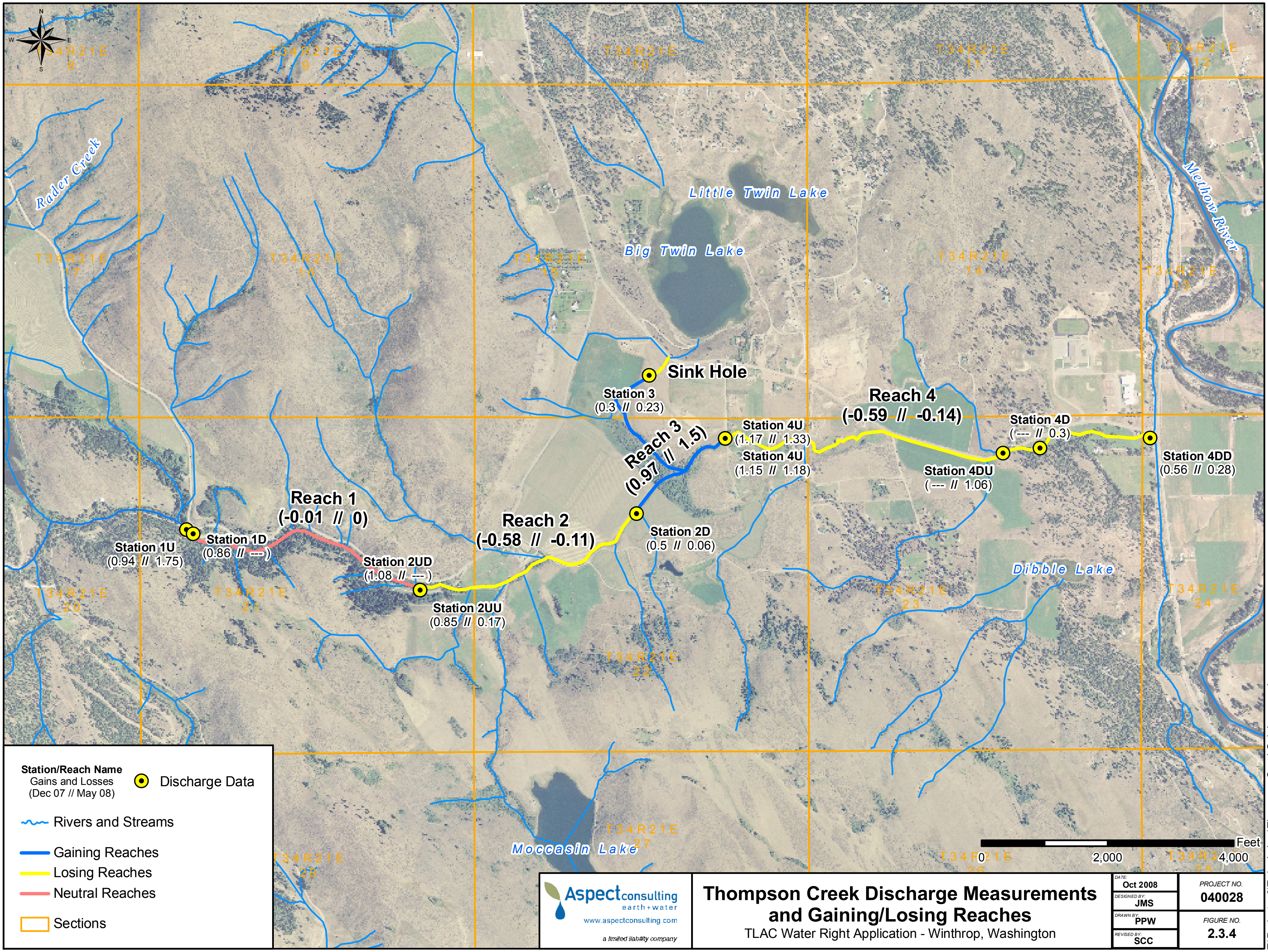


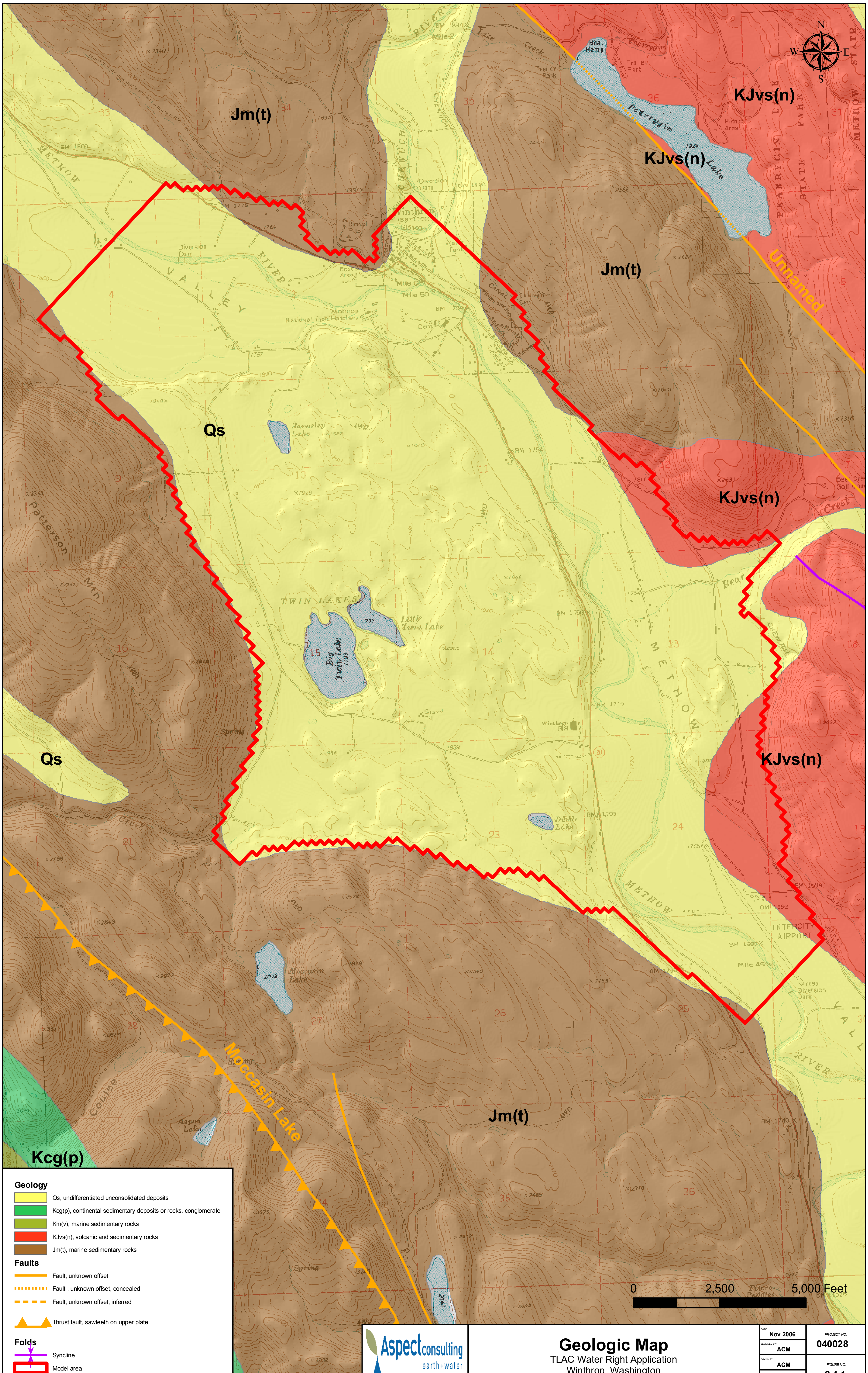
Figure 2.3.3
Average Monthly Net River Gains and Losses for Methow River
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting
6/12/09
W:\040028 Water Resources Consultant Pool FY 04-05\Twin Lakes ASP 1\Deliverables\Hydrogeologic Eval\Final Report\Tables\RiverFlows.xls



Thompson Creek Discharge Measurements and Gaining/Losing Reaches

TLAC Water Right Application - Winthrop, Washington



Jm(t)
KJvs(n)
KJvs(n)
Jm(t)
Unnamed
Qs
KJvs(n)
Qs
KJvs(n)
Moccasin Lake
Jm(t)
Kcg(p)
N
S
E
W
Geology
Qs, undifferentiated unconsolidated deposits
Kcg(p), continental sedimentary deposits or rocks, conglomerate
Km(v), marine sedimentary rocks
KJvs(n), volcanic and sedimentary rocks
Jm(t), marine sedimentary rocks
Faults
Fault, unknown offset
Fault , unknown offset, concealed
Fault, unknown offset, inferred
Thrust fault, sawteeth on upper plate
Folds
Syncline
Model area
0
2,500
5,000 Feet
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Geologic Map
TLAC Water Right Application
Winthrop, Washington
Nov 2006
ACM
ACM
ACM
040028
2.4.1
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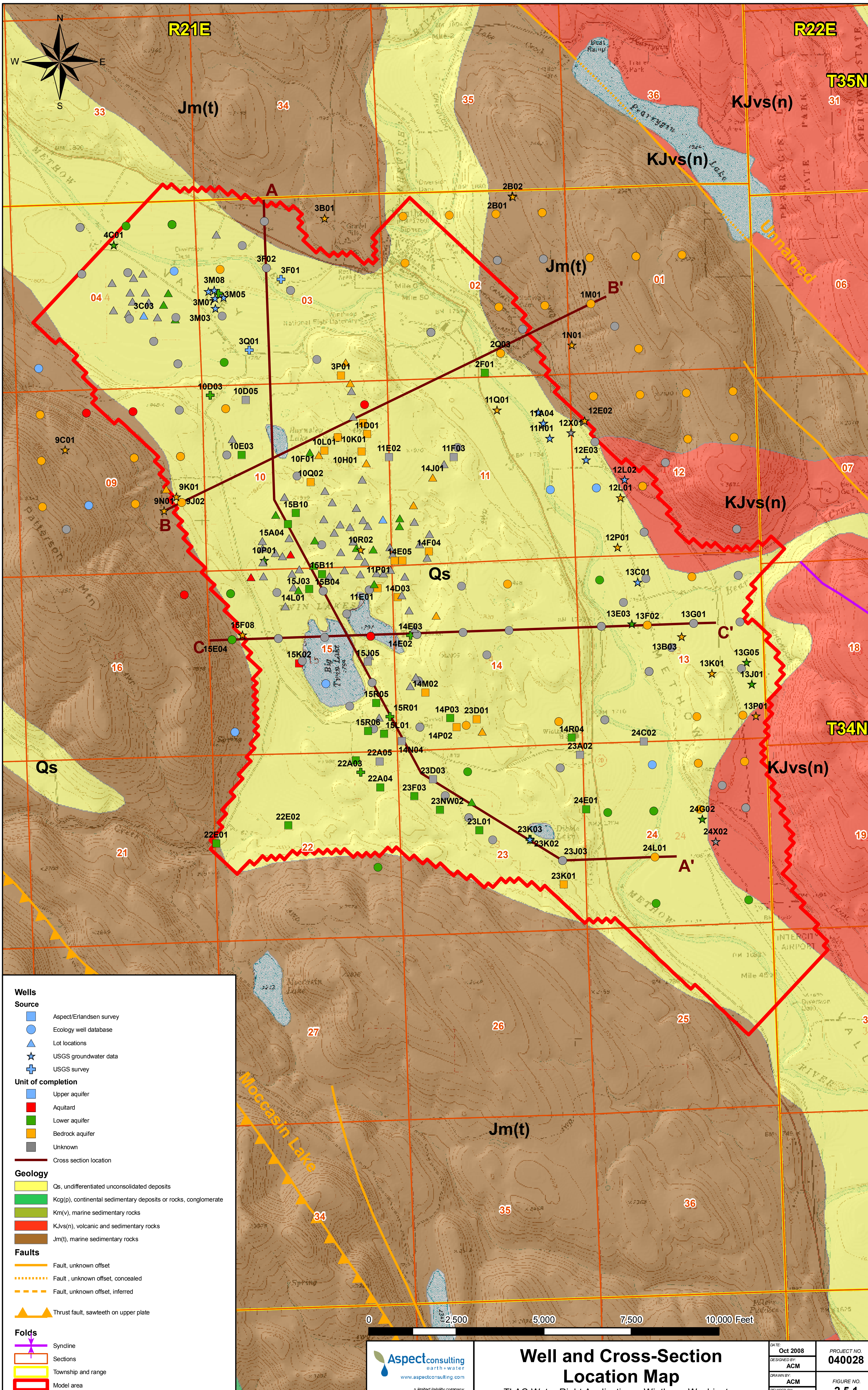

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Well and Cross-Section Location Map

TLAC Water Right Application -- Winthrop, Washington

DATE: Oct 2008
DESIGNED BY: ACM
DRAWN BY: ACM
REVISED BY: SCC
PROJECT NO. 040028
FIGURE NO. 2.5.1

T:\projects_8\Twin_Lakes\crosssection.mxd

Notes:

1. Big and Little Twin and Barnsley Lake depths taken from Lakes of Washington (Wolcott, 1973).
2. Ground surface and unit contact elevations are based on DEM elevations. Select well locations verified by survey.
3. This cross section was developed in 2006 using available DEM. DEM was adjusted to match survey points for the groundwater model in 2008. Model layering was adjusted at that time. Model stratigraphy varies slightly from that depicted on this cross section.

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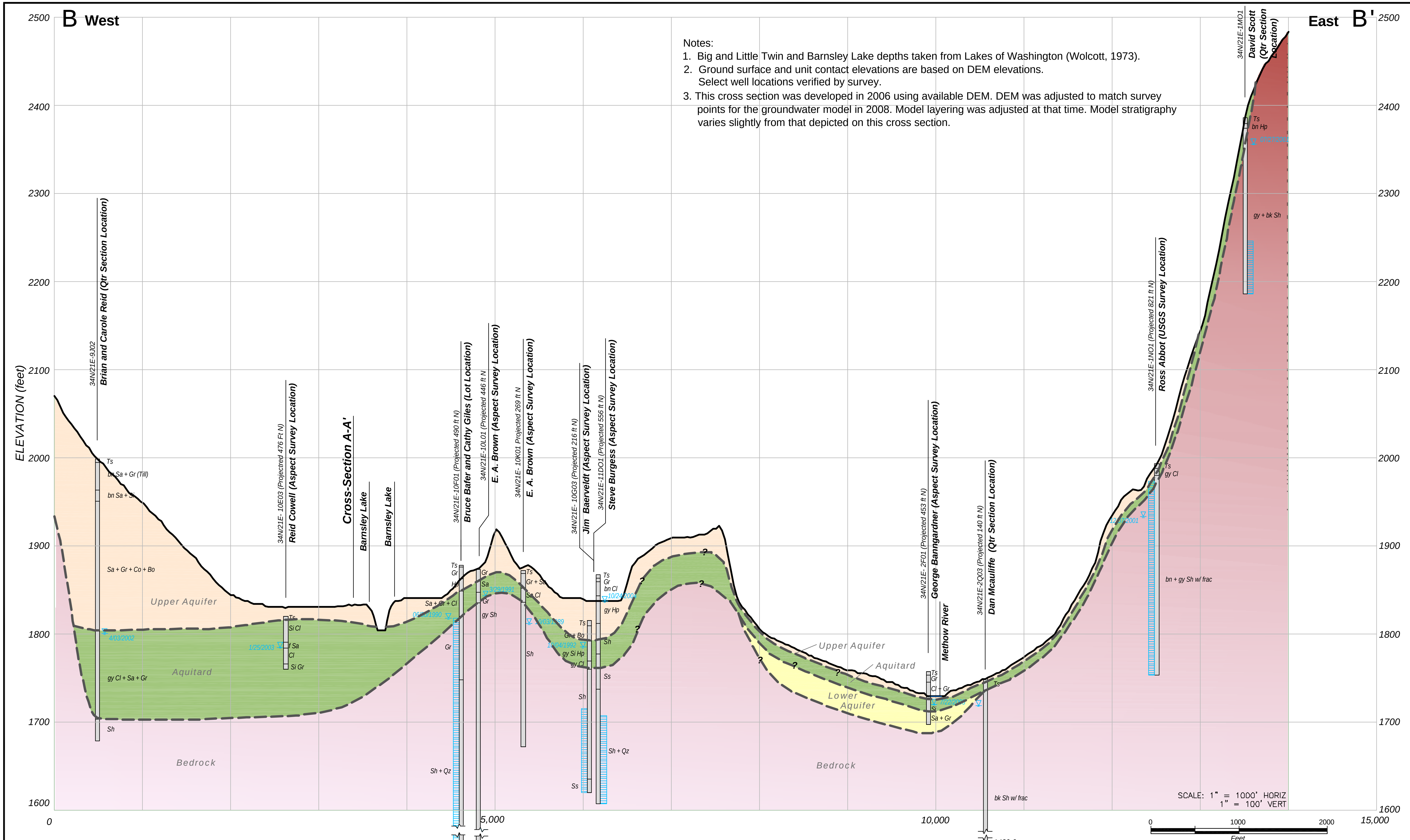
Cross Section A-A'

TLAC Water Right Application
Winthrop, Washington

DATE: Dec 2006
DESIGNED BY: JJP
DRAWN BY: PMB
REVISED BY: EWM (June 2009)
PROJECT NO. 040028
FIGURE NO. 2.5.2

Q:Water Resources Consultants\040028 Twin Lakes\2006-11\040028-AA.dwg



Q:\Water Resources Consultants\040028 Twin Lakes\2006-11\040028-BB-2.dwg

LEGEND

SYMBOLS

- Approximate Ground Surface
- Approximate Geologic Unit Contact
- Well Screen or Perforated Zone
- Static Water Level Reported on Well Log
- Well Completion and Corresponding SWL
- F1 Interpreted Hydrostratigraphic Unit

Qtr = Center of Quarter-Quarter Section Location
ACS = Aspect Consulting Location
USGS = USGS Survey Location
Lot = Center of Lot Location

REPORTED SOIL DESCRIPTIONS

bk = black	wh = white	And = Andesite	Ts = Topsoil	occ = occasional	cem = cemented
bl = blue	ye = yellow	Cl = Clay	Pt = Peat	sc = scattered	int = interbeds
bn = brown	l = light	Si = Silt	Org = Organic	tr = trace	lam = laminations
gr = green	dk = dark	Sa = Sand	Pum = Pumice	w/ = with	lay = layers
gy = gray		Ss = Sandstone	Volc = Volcanic	li = little	len = lenses
ol = olive		Sh = Shale	Wd = Wood	s = some	ox = oxidized
or = orange		Gr = Gravel	Ls = Limestone	+ = and	
pu = purple		Co = Cobbles	Gt = Granite	abd = abundant	
rd = red		Bo = Boulders	Qz = Quartzite	f = fine	
ru = rusty		Dr = Dropstone	Sc = Schist	m = medium	
tn = tan		Hp = Hardpan	Ar = Argillite	c = coarse	
		Till = Till		frac = fractures	

Example: bn gy f-c SiGr, s Sa, tr Co + Bo

Brownish gray, fine to coarse Silty Gravel, some sand, trace cobbles and boulders.

(Colors refer to fine grained portion.)

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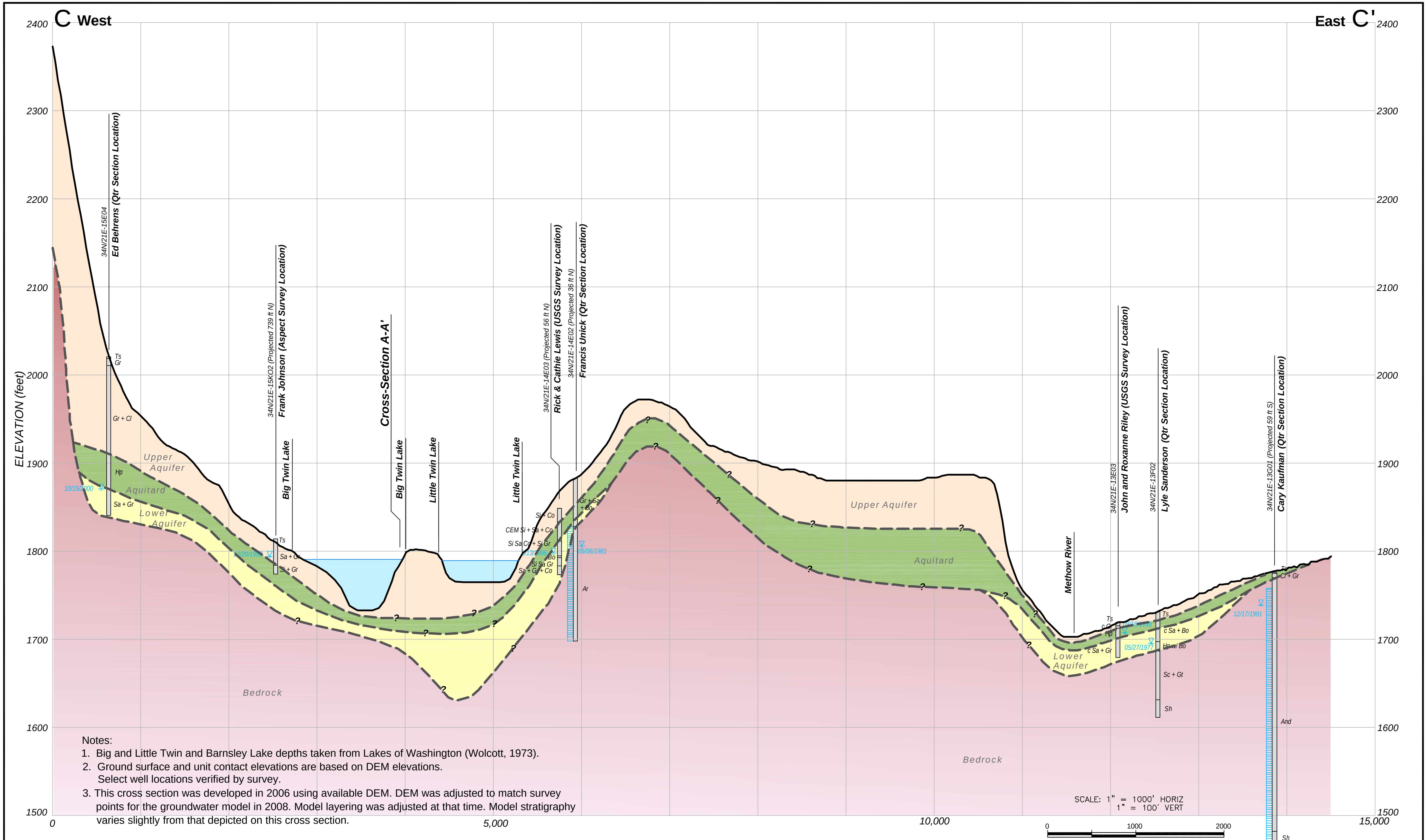
Cross Section B-B'

TLAC Water Right Application
Winthrop, Washington

DATE:	Dec 2006
DESIGNED BY:	JJP
DRAWN BY:	PMB/LAL
REVISED BY:	EWM (June 2008)
PROJECT NO.	040028
FIGURE NO.	2.5.3



Notes:
1. Big and Little Twin and Barnsley Lake depths taken from Lakes of Washington (Wolcott, 1973).
2. Ground surface and unit contact elevations are based on DEM elevations. Select well locations verified by survey.
3. This cross section was developed in 2006 using available DEM. DEM was adjusted to match survey points for the groundwater model in 2008. Model layering was adjusted at that time. Model stratigraphy varies slightly from that depicted on this cross section.

LEGEND

SYMBOLS

- Approximate Ground Surface
- Approximate Geologic Unit Contact
- Well Screen or Perforated Zone
- Static Water Level Reported on Well Log
- Well Completion and Corresponding SWL
- F1 Interpreted Hydrostratigraphic Unit

Qtr = Center of Quarter-Quarter Section Location
ACS = Aspect Consulting Location
USGS = USGS Survey Location
Lot = Center of Lot Location

REPORTED SOIL DESCRIPTIONS

bk = black	wh = white	And = Andesite	Ts = Topsoil	occ = occasional	cem = cemented	
bl = blue	ye = yellow	Cl = Clay	Pt = Peat	sc = scattered	int = interbeds	
bn = brown	l = light	Si = Silt	Org = Organic	tr = trace	lam = laminations	
gr = green	dk = dark	Sa = Sand	Pum = Pumice	w/ = with	lay = layers	
gy = gray		Ss = Sandstone	Volc = Volcanic	li = little	len = lenses	
ol = olive		Sh = Shale	Wd = Wood	s = some	ox = oxidized	
or = orange		Gr = Gravel	Ls = Limestone	+ = and		
pu = purple		Co = Cobbles	Gt = Granite	abd = abundant		
rd = red		Bo = Boulders	Qz = Quartzite	f = fine		
ru = rusty		Dr = Dropstone	Sc = Schist	m = medium		
tn = tan		Hp = Hardpan	Ar = Argillite	c = coarse		
		Till = Till		frac = fractures		

Example: bn gy f-c SiGr, s Sa, tr Co + Bo

Brownish gray, fine to coarse Silty Gravel, some sand, trace cobbles and boulders.

(Colors refer to fine grained portion.)

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Cross Section C-C'

TLAC Water Right Application

Winthrop, Washington

DATE: Dec 2006	PROJECT NO. 040028
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 2.5.4
REVISED BY: EWM (June 2009)	

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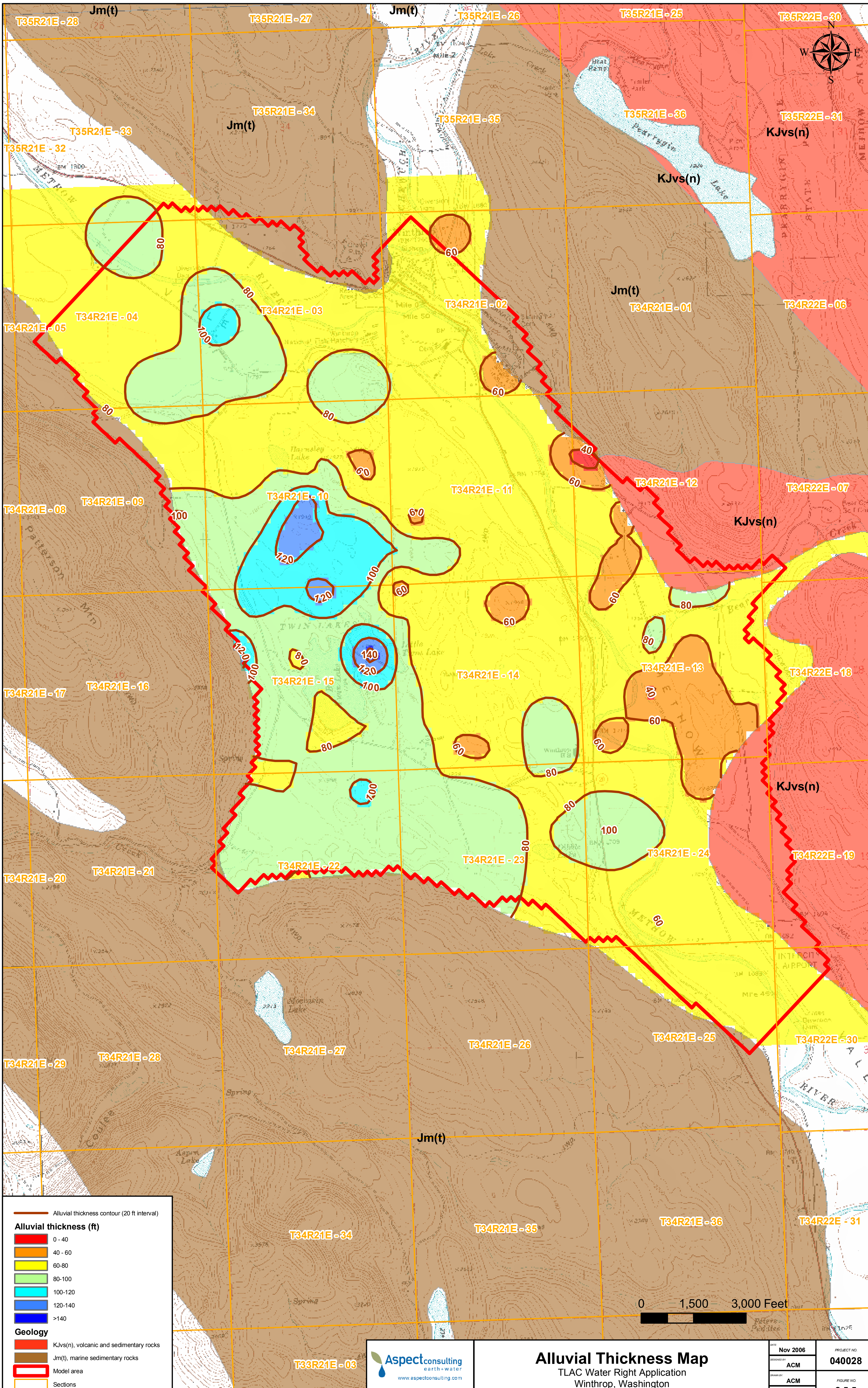

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Alluvial Thickness Map
TLAC Water Right Application
Winthrop, Washington

DATE: Nov 2006	PROJECT NO. 040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 2.5.5
REVISED BY: ACM	

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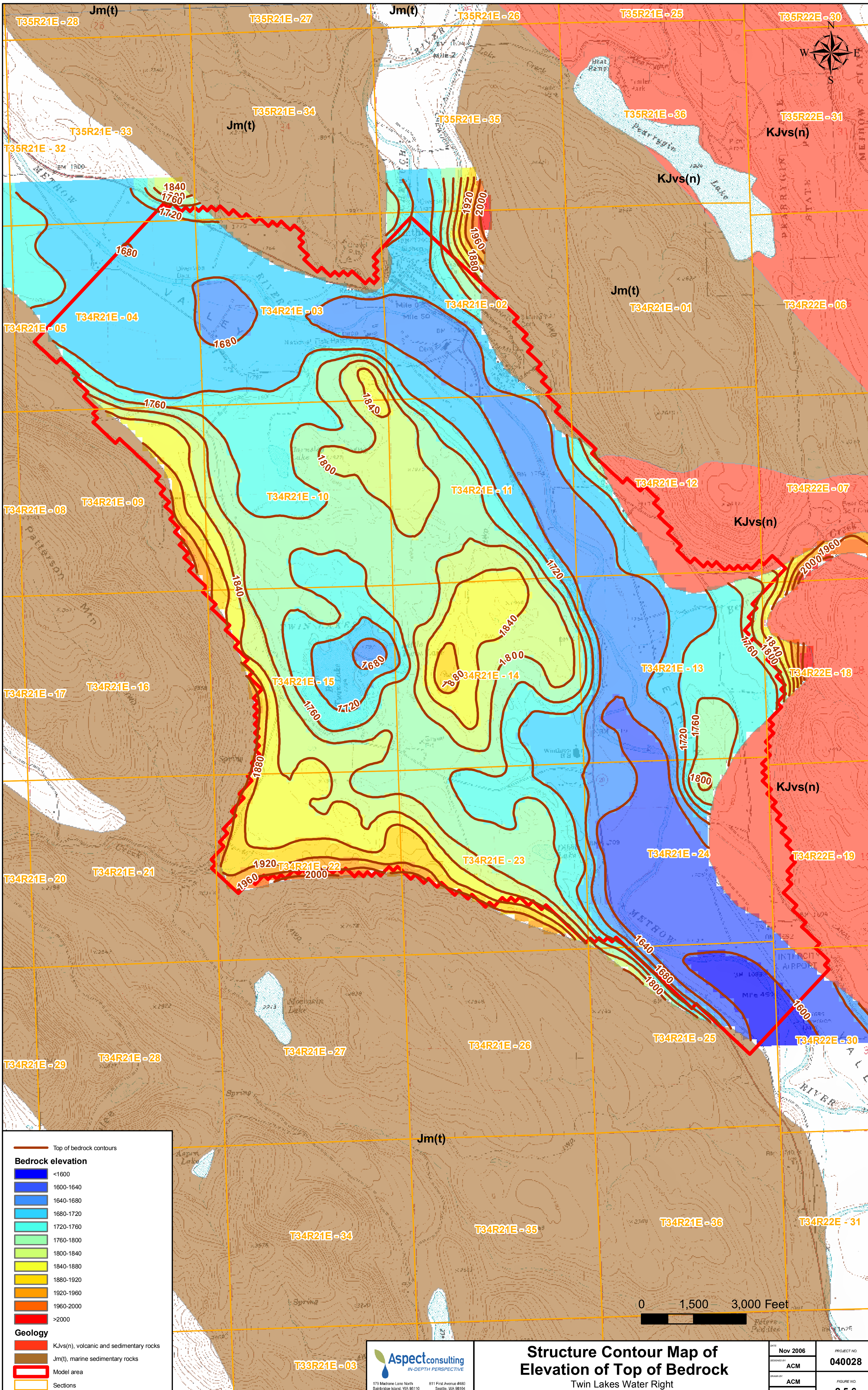

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179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370

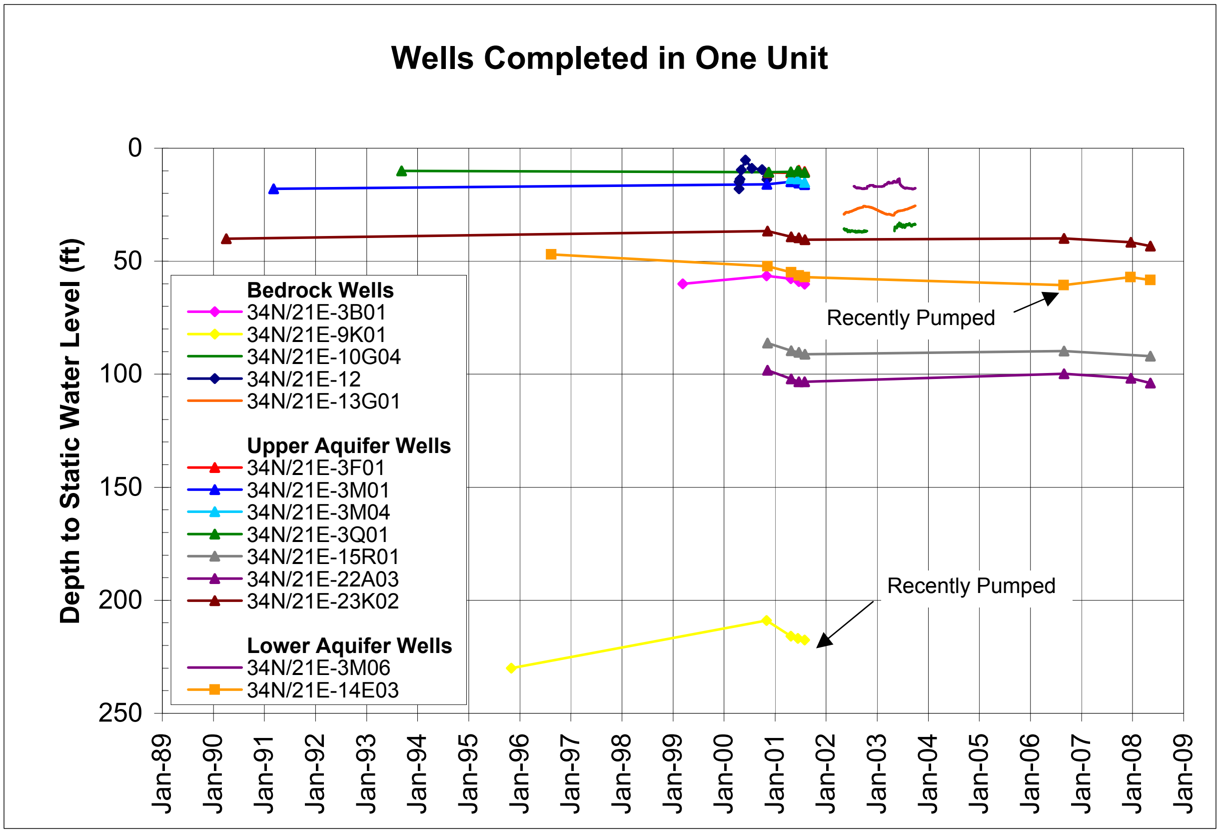
811 First Avenue #480
Seattle, WA 98104
(206) 328-7443

Structure Contour Map of Elevation of Top of Bedrock

Twin Lakes Water Right
Winthrop, Washington

DATE: Nov 2006	PROJECT NO. 040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 2.5.6
REVISED BY: ACM	

T:\projects_8



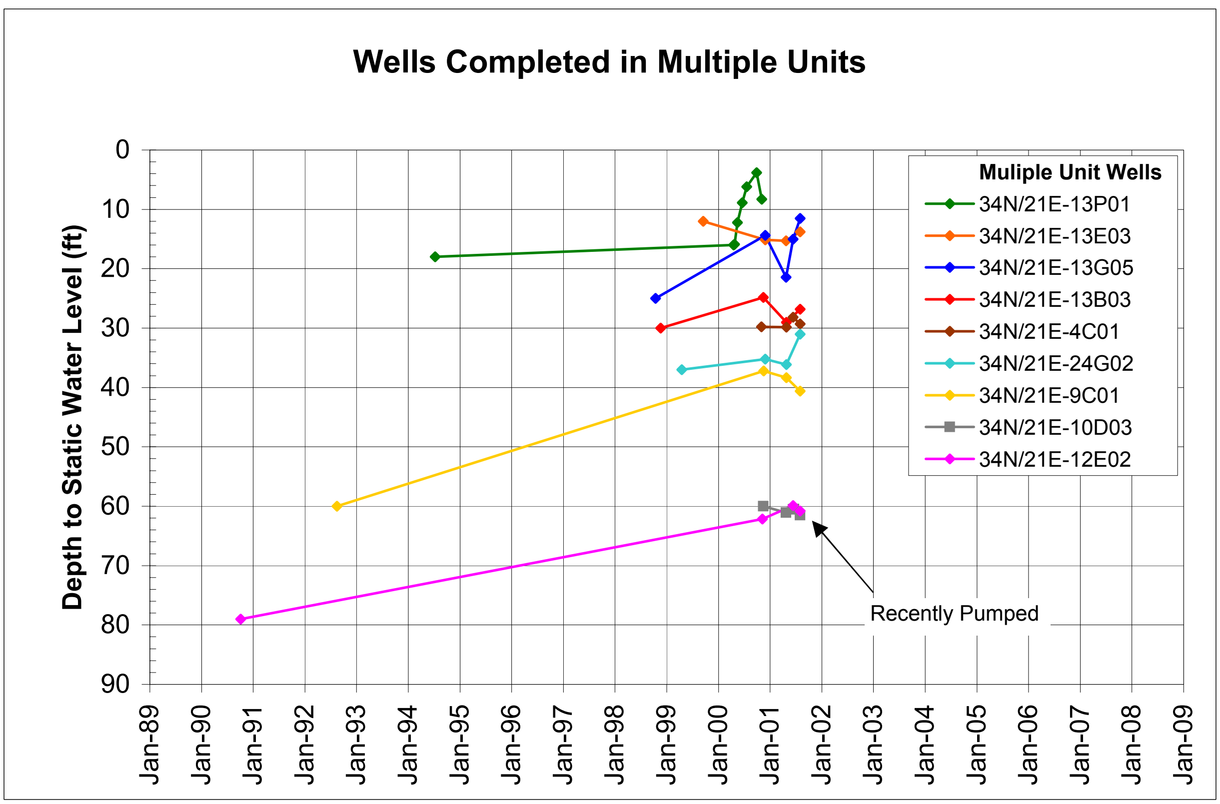
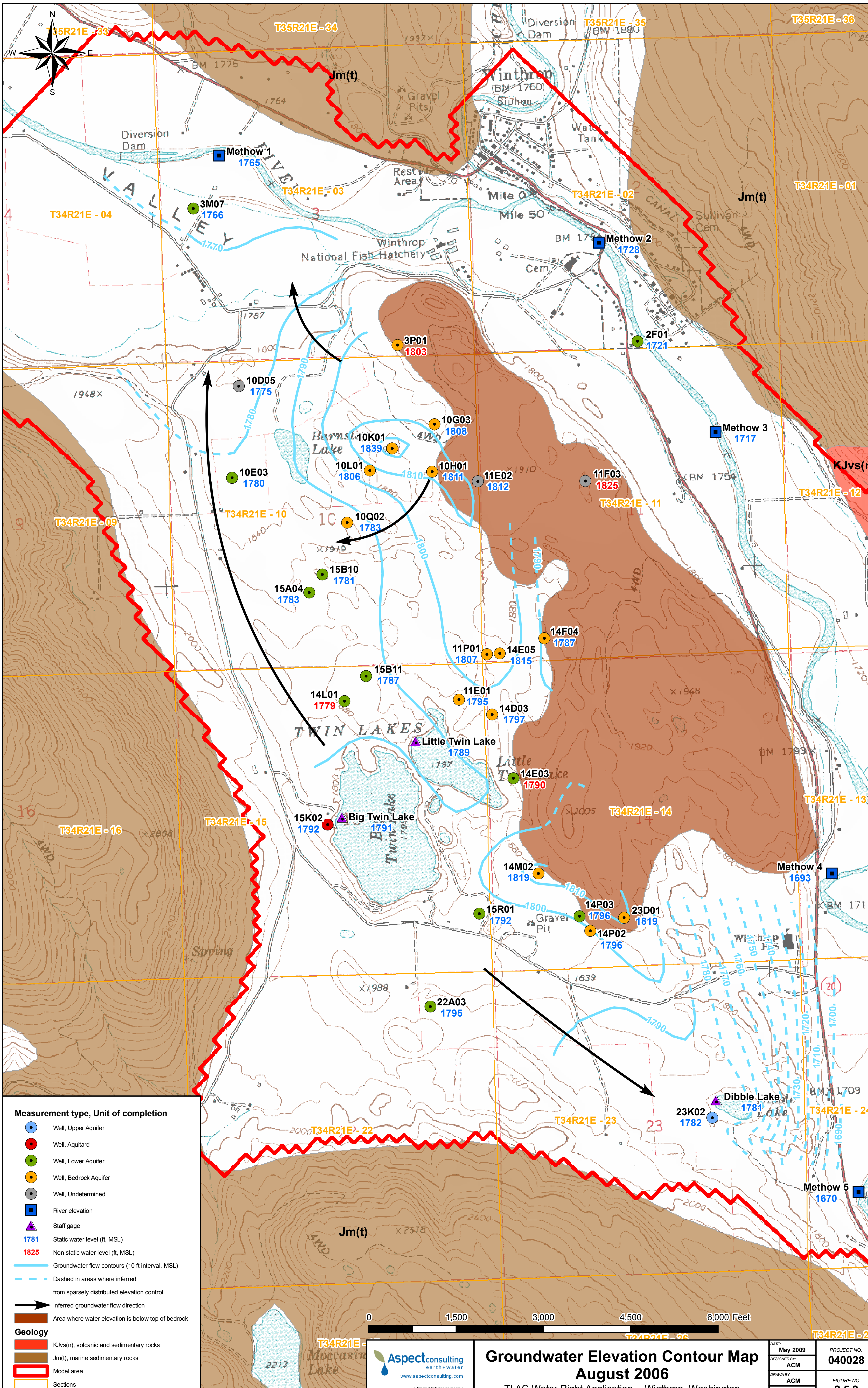
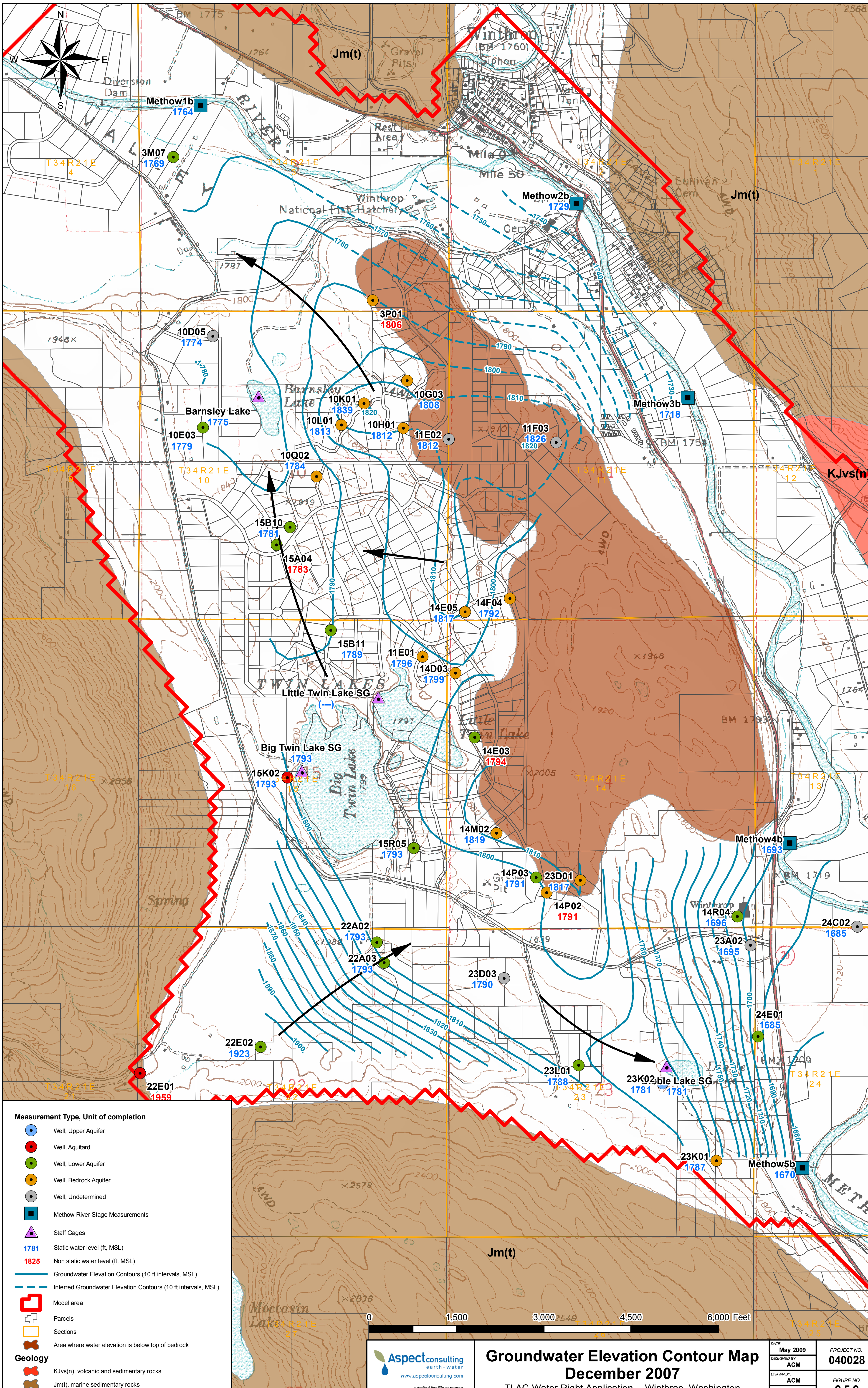


Figure 2.5.7
Well Hydrographs
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting
12/13/2006
P:\Twin Lakes\May 2008 Field Data Collection\May 2008 Hydrographs.xls



Groundwater Elevation Contour Map
August 2006
TLAC Water Right Application -- Winthrop, Washington



Aspect consulting earth + water
www.aspectconsulting.com
a limited liability company

Groundwater Elevation Contour Map
December 2007

TLAC Water Right Application -- Winthrop, Washington

DATE:	PROJECT NO.
May 2009	040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO.
REVISED BY: SCC	2.5.9

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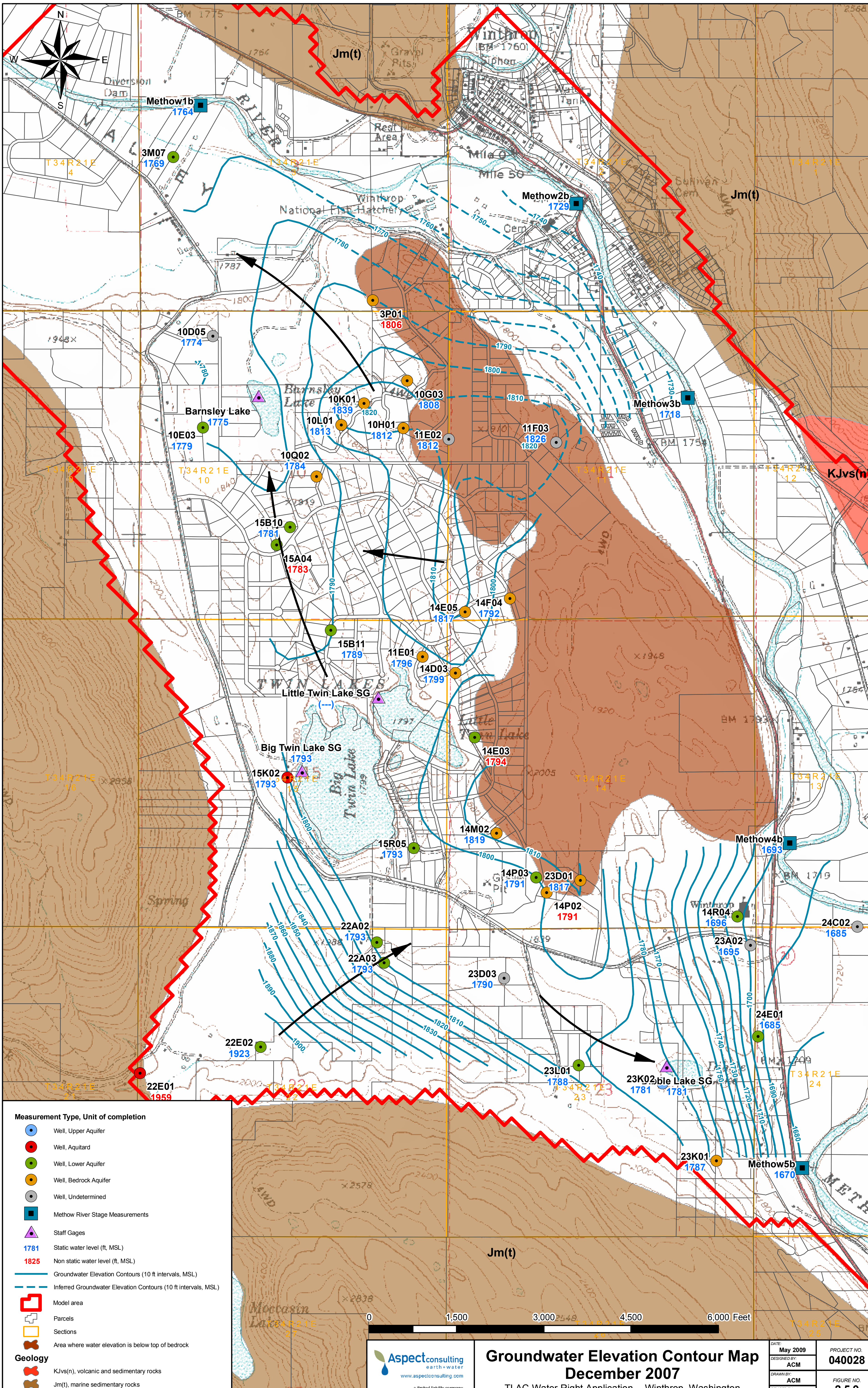

Aspect consulting earth + water
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Groundwater Elevation Contour Map December 2007

TLAC Water Right Application -- Winthrop, Washington

DATE: May 2009	PROJECT NO. 040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 2.5.9
REVISED BY: SCC	

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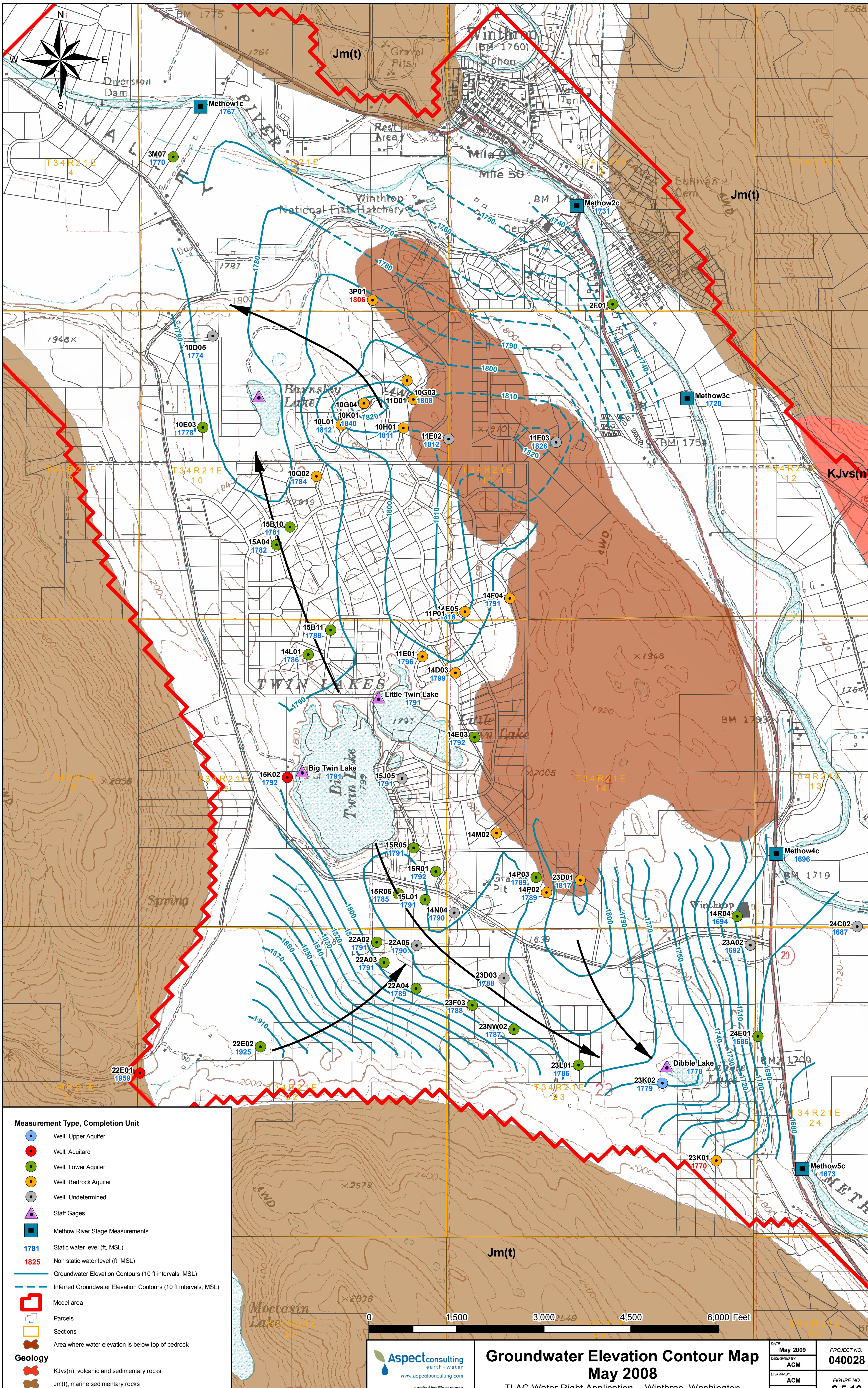
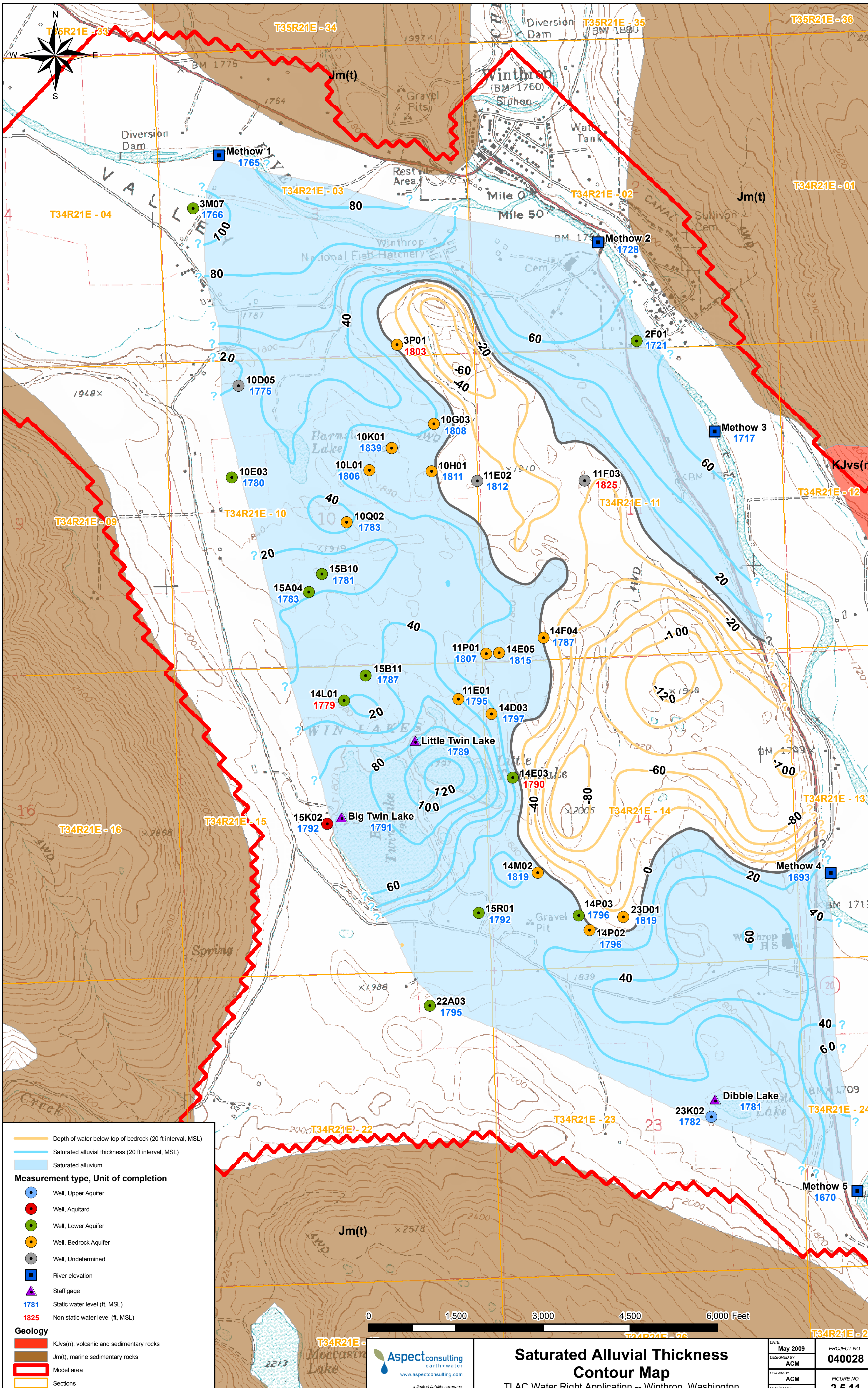


Aspect consulting — earth + water — www.aspectconsulting.com — a limited liability company

Groundwater Elevation Contour Map May 2008

TLAC Water Right Application -- Winthrop, Washington

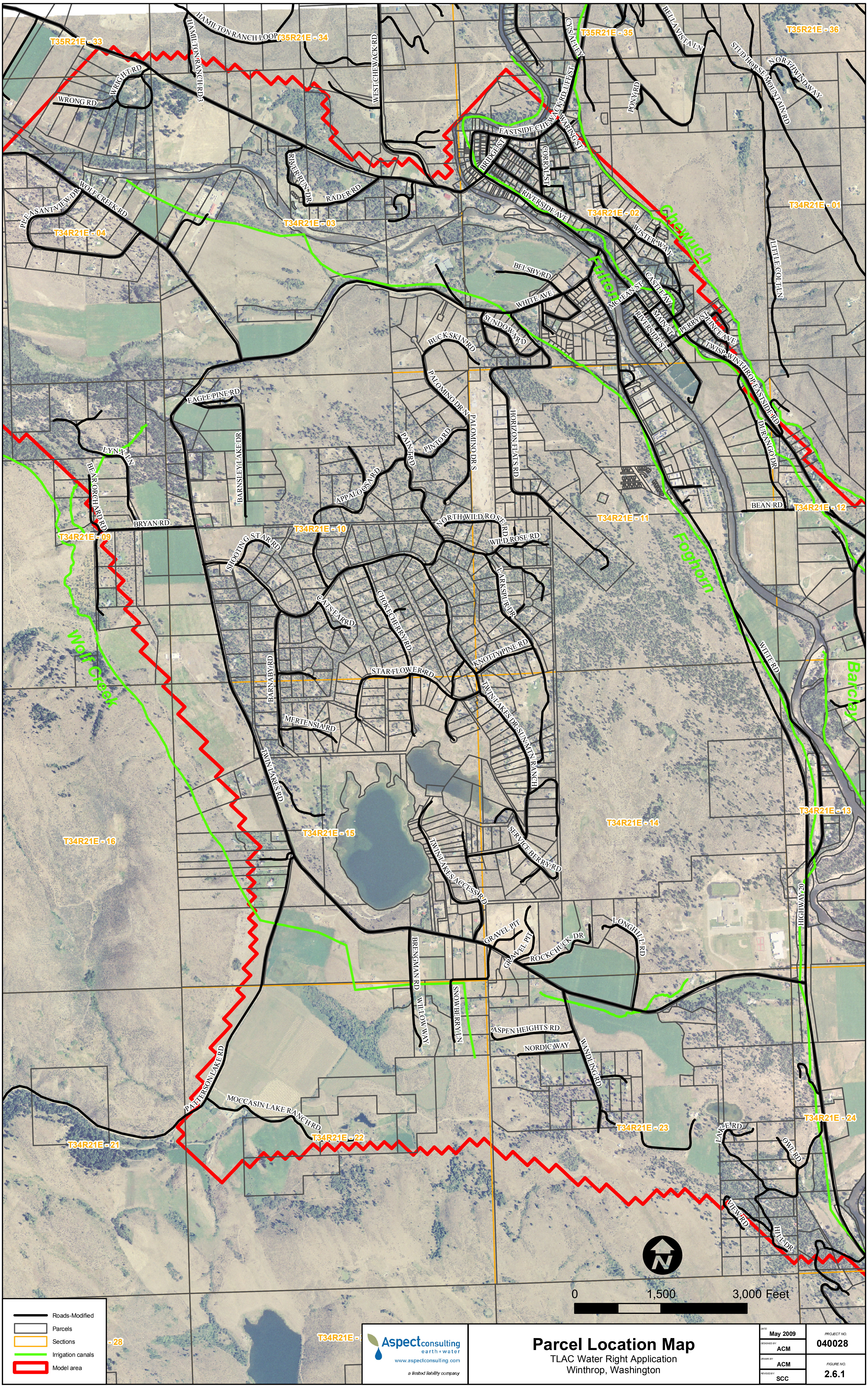
DATE: May 2009 | DESIGNED BY: ACM | DRAWN BY: ACM | REVISED BY: SCC | PROJECT NO. 040028 | FIGURE NO. 2.5.10



Saturated Alluvial Thickness Contour Map

TLAC Water Right Application -- Winthrop, Washington

Note: Saturated alluvial thickness based on August 2006 groundwater elevation contour map.



Parcel Location Map

TLAC Water Right Application
Winthrop, Washington

DATE: May 2009	PROJECT NO. 040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 2.6.1
REVISED BY: SCC	

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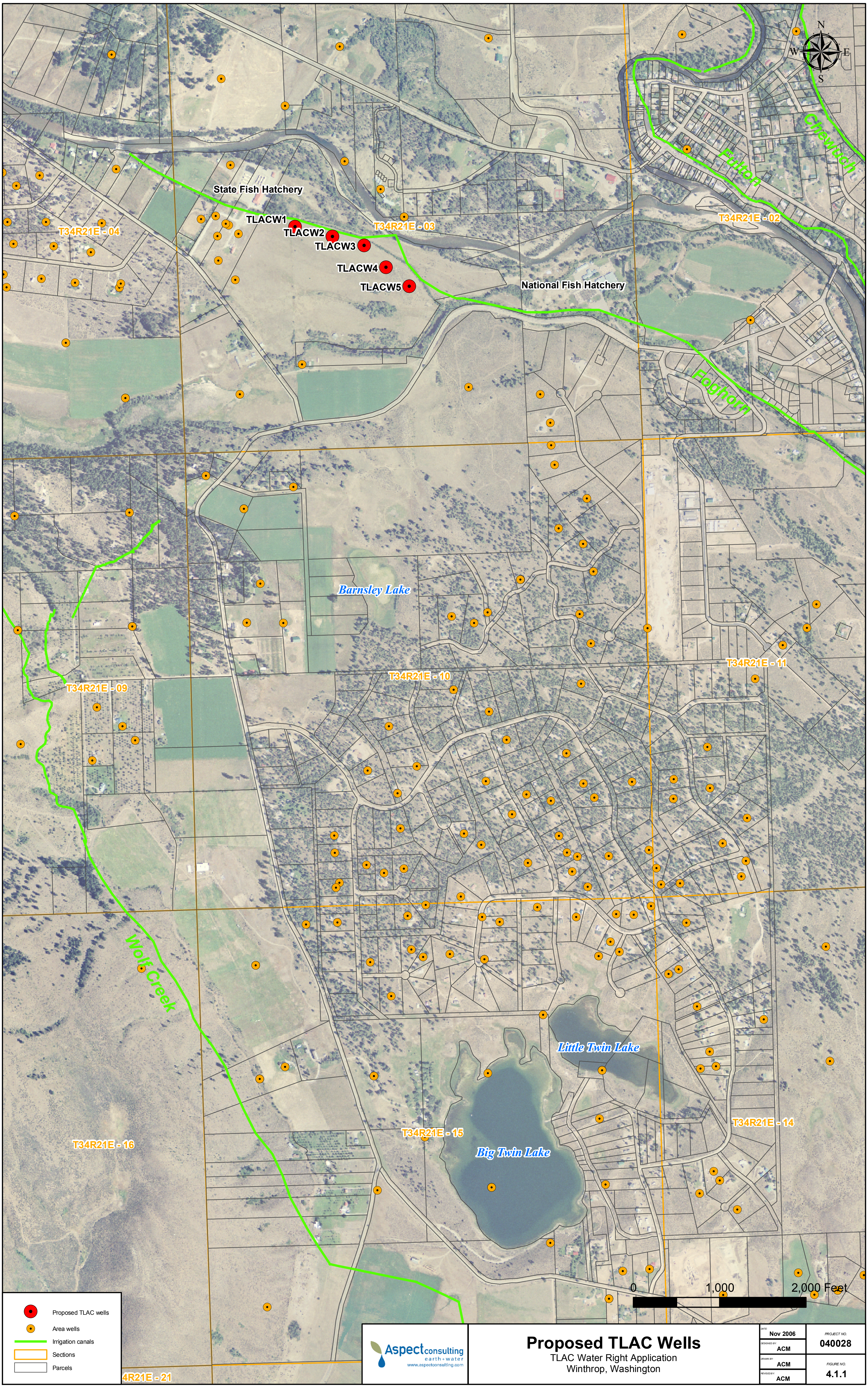

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earth + water
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Proposed TLAC Wells

TLAC Water Right Application
Winthrop, Washington

DATE: Nov 2006	PROJECT NO. 040028
DESIGNED BY: ACM	
DRAWN BY: ACM	FIGURE NO. 4.1.1
REVISED BY: ACM	

T:\projects_8\Twin_Lakes\Pre2008update\proposed_tlac_wells.mxd

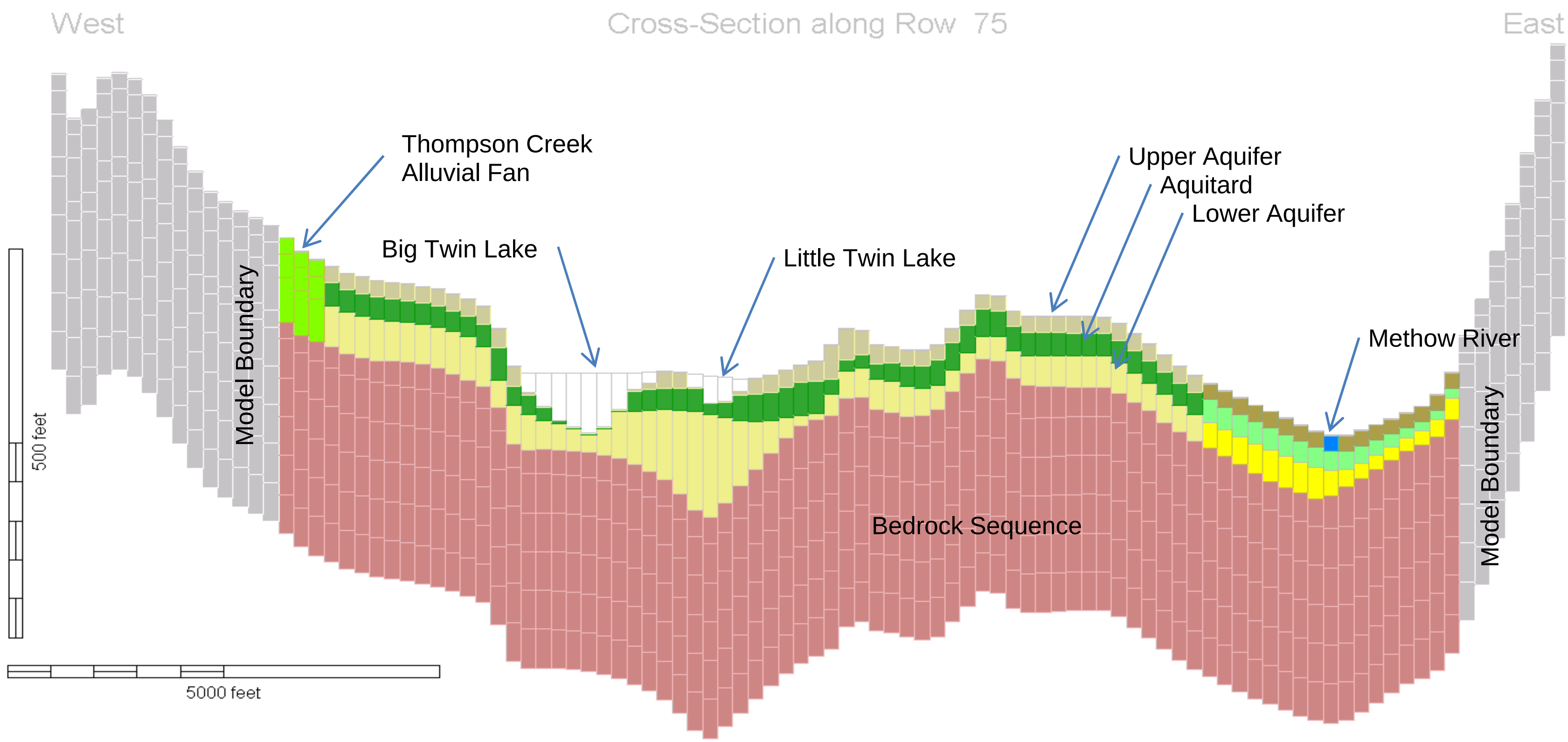

Figure 5.2.1

Model Cross-Section Showing Layers

TLAC Water Right Application

Winthrop, Washington

Aspect Consulting, LLC

10/8/2008

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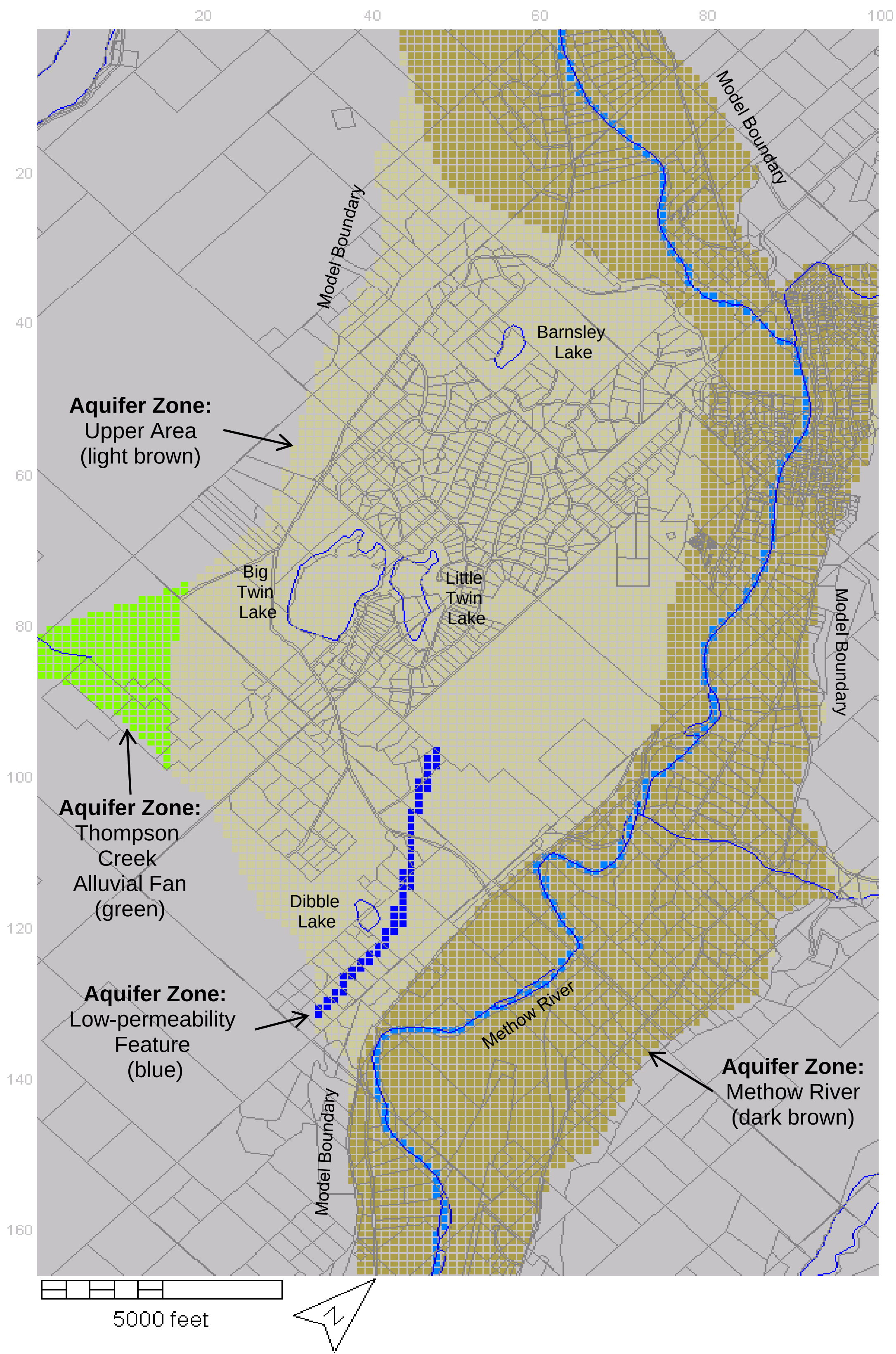


Figure 5.2.2
Model Map showing Aquifer Zones
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\TLACComparison.xlsx

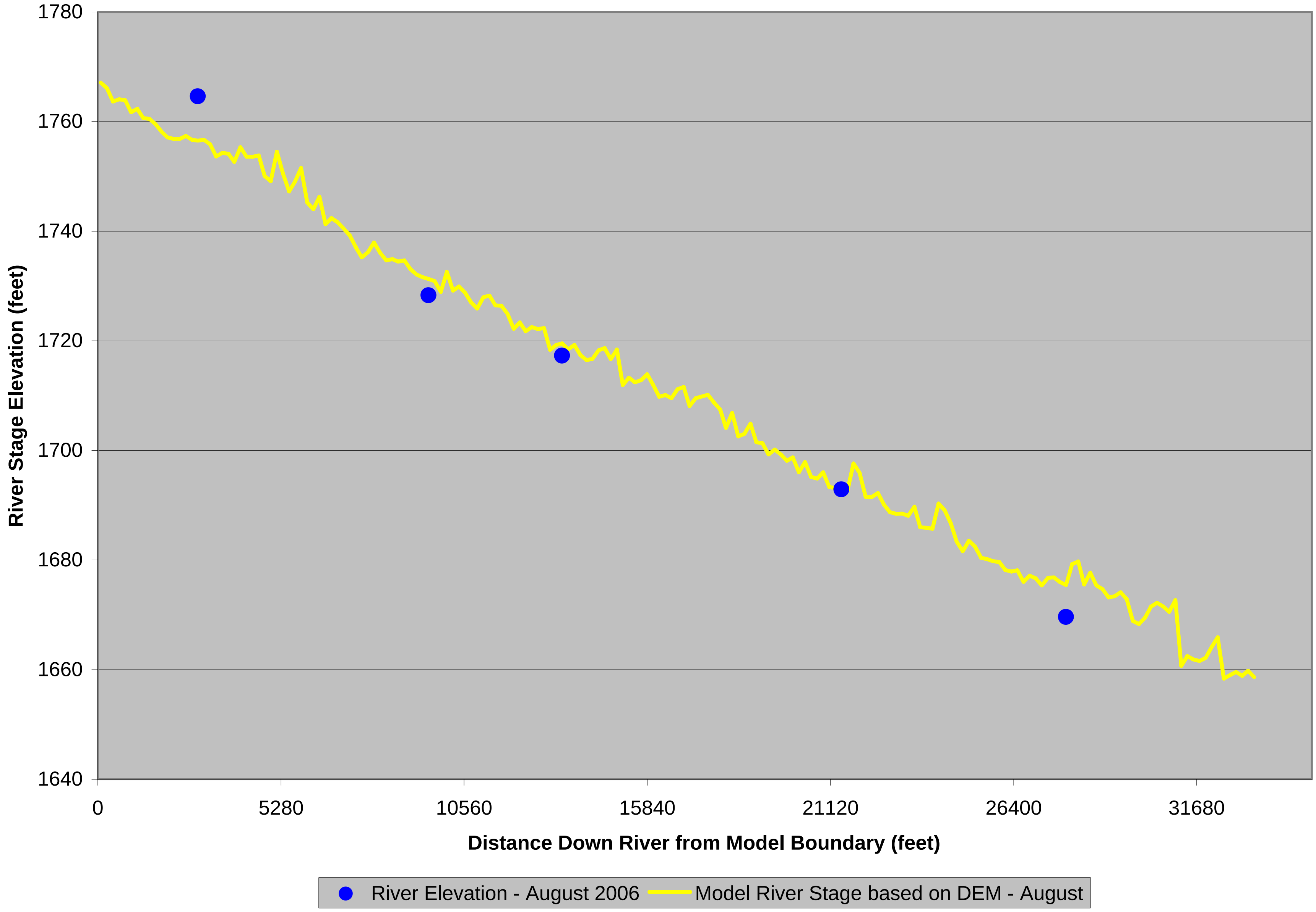
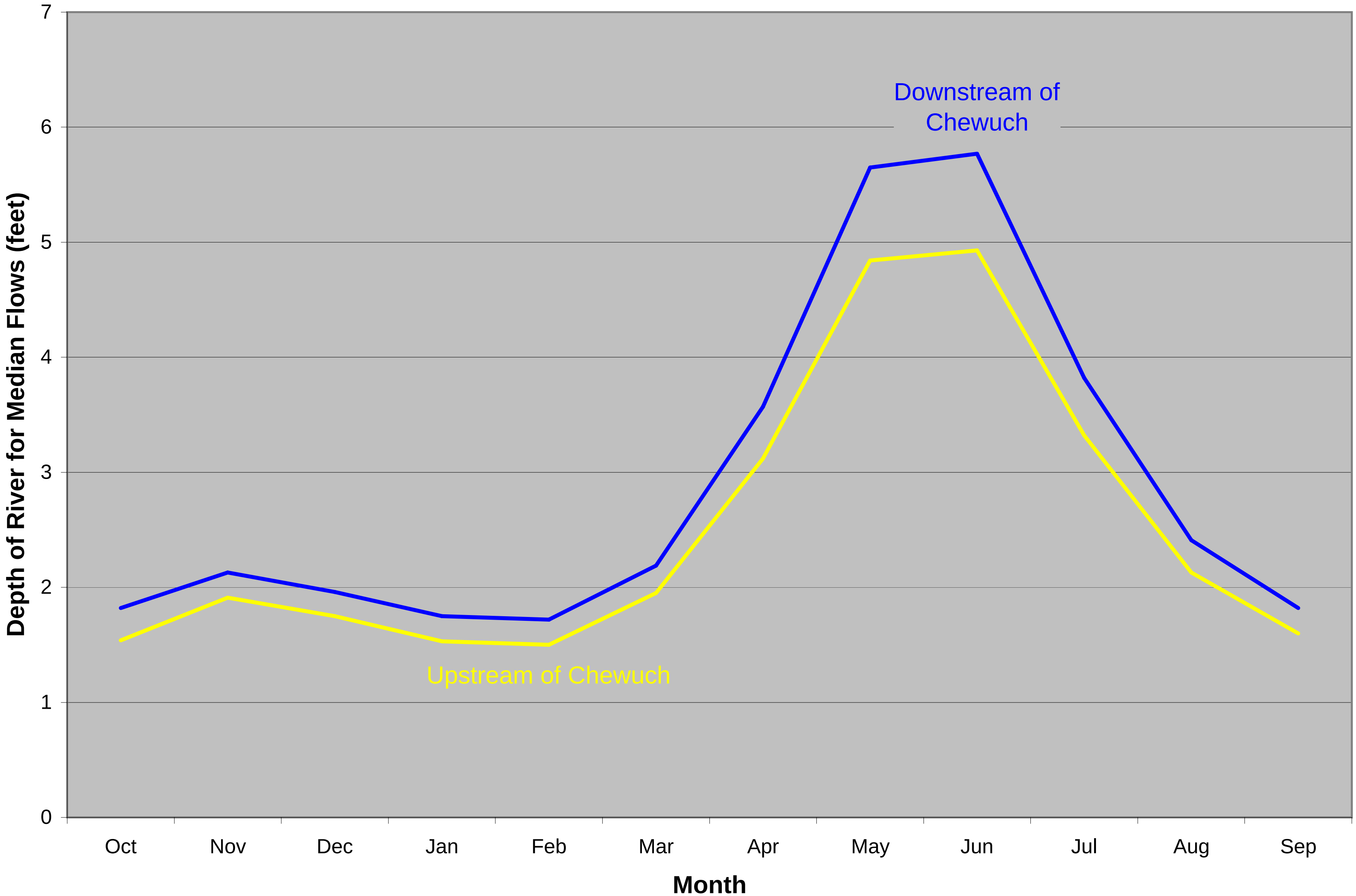


Figure 5.2.3

River Stage Comparison

TLAC Water Right Application
Winthrop, Washington

Aspect Consulting
12/14/2006
W:\040028 Water Resources Consultant Pool FY 04-05\Twin Lakes\Deliverables\Hydrogeologic Eval\TargetData.xls



Aspect Consulting
12/14/2006
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Figure 5.2.4
River Depth Comparison
TLAC Water Right Application
Winthrop, Washington

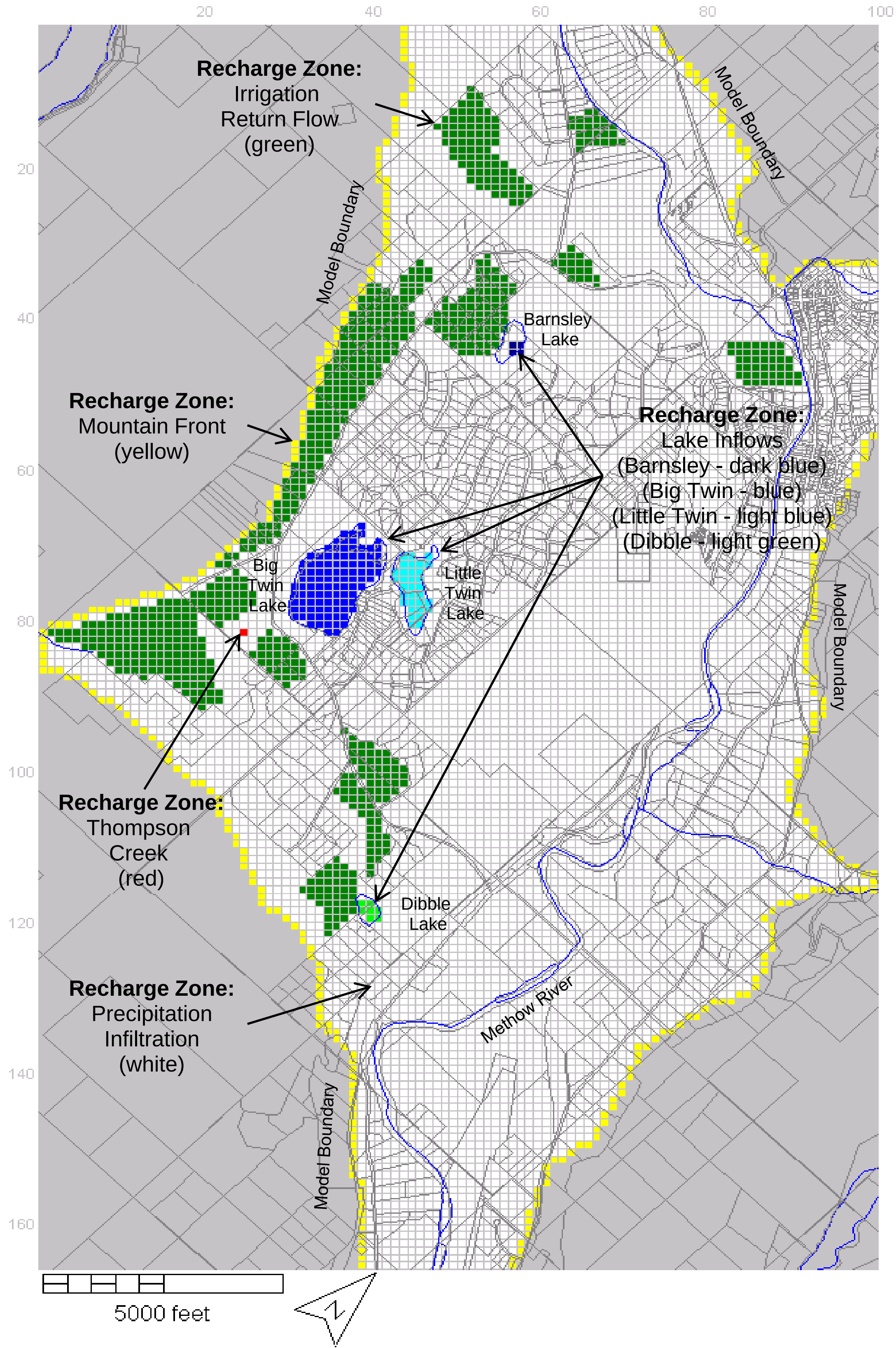
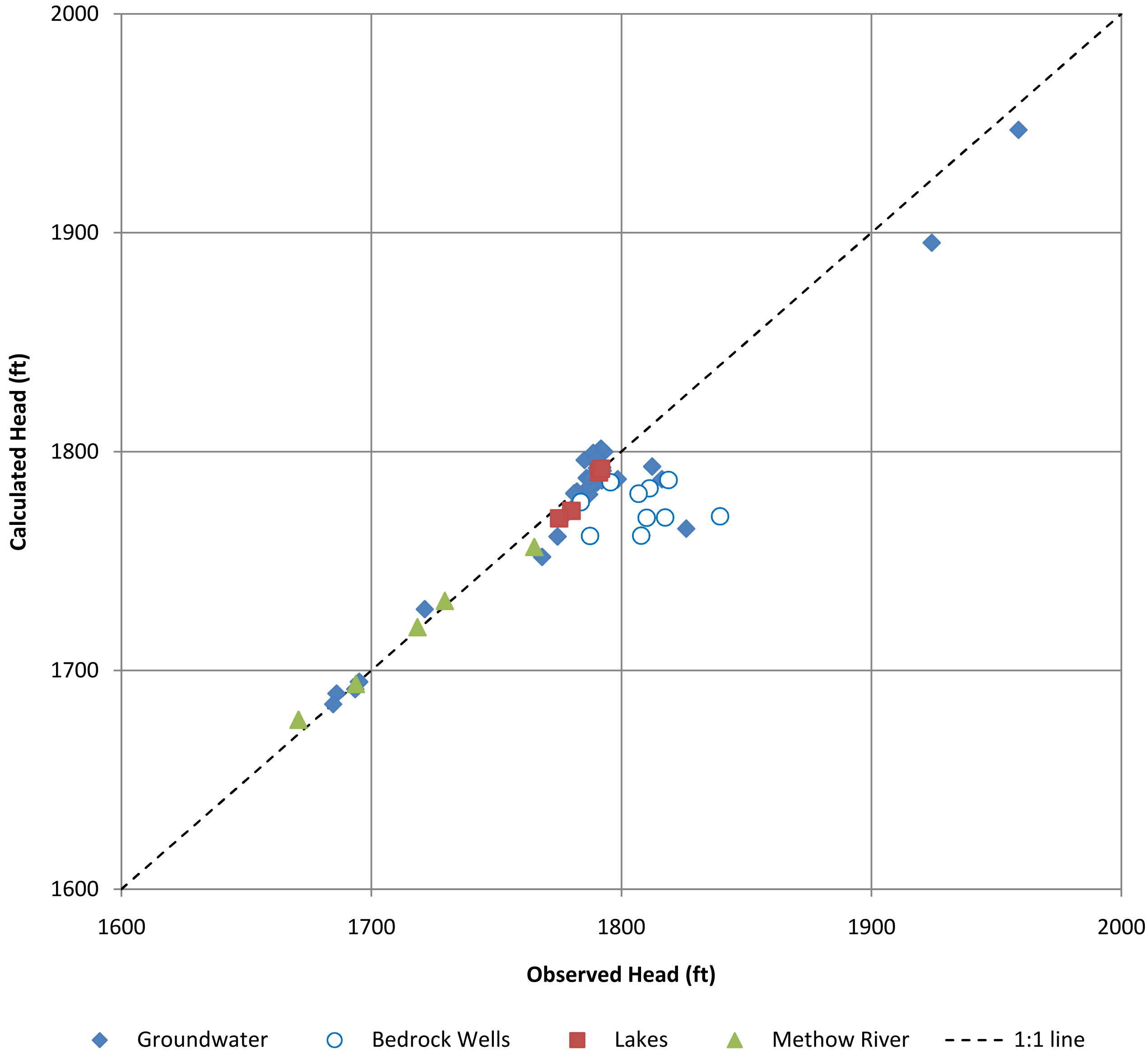


Figure 5.2.5
Model Map showing Recharge Zones
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\TLACComparison.xlsx



Model Calibration Statistics

	Groundwater	Surface Water	Overall
Residual Mean	11	1	9
Res. Standard Deviation	18	5	17
Res. Sum of Square	21358	213	21572
Absolute Res. Mean	13	4	12
Min. Residual	-11	-7	-11
Max. Residual	69	9	69
Range of Observed Values	274	121	288
St. Dev./Range	7%	4%	6%

Residual = Observed - Calculated
A "good" head calibration has St. Dev./Range less than 10%.
The average mass balance error is less than 0.02%.

Figure 5.3.1
Model Calibration
TLAC Water Right Application
Winthrop, Washington

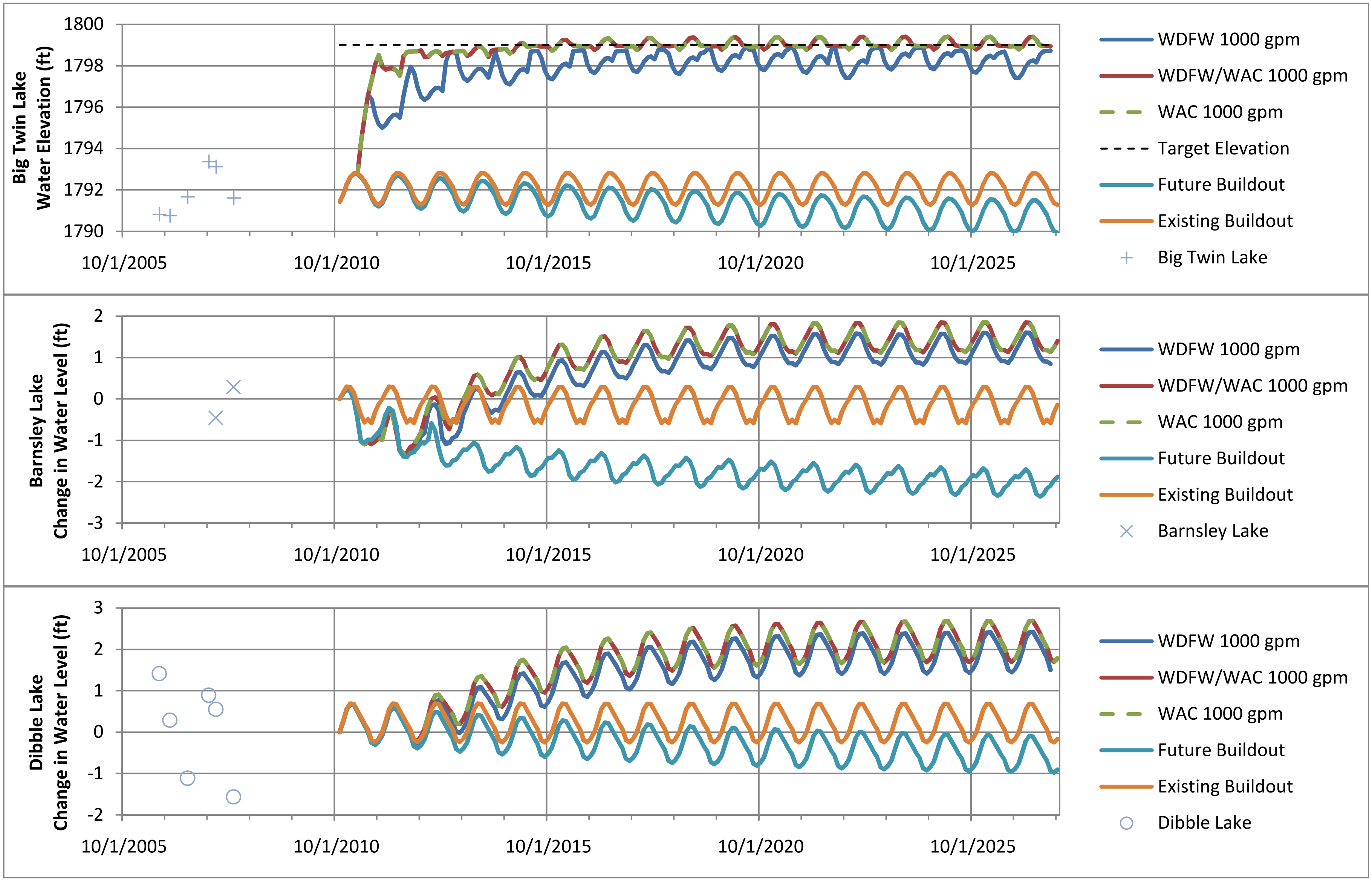


Figure 5.4.1

Observed and Calculated Lake Levels

TLAC Water Right Application

Winthrop, Washington

Aspect Consulting, LLC

10/8/2008

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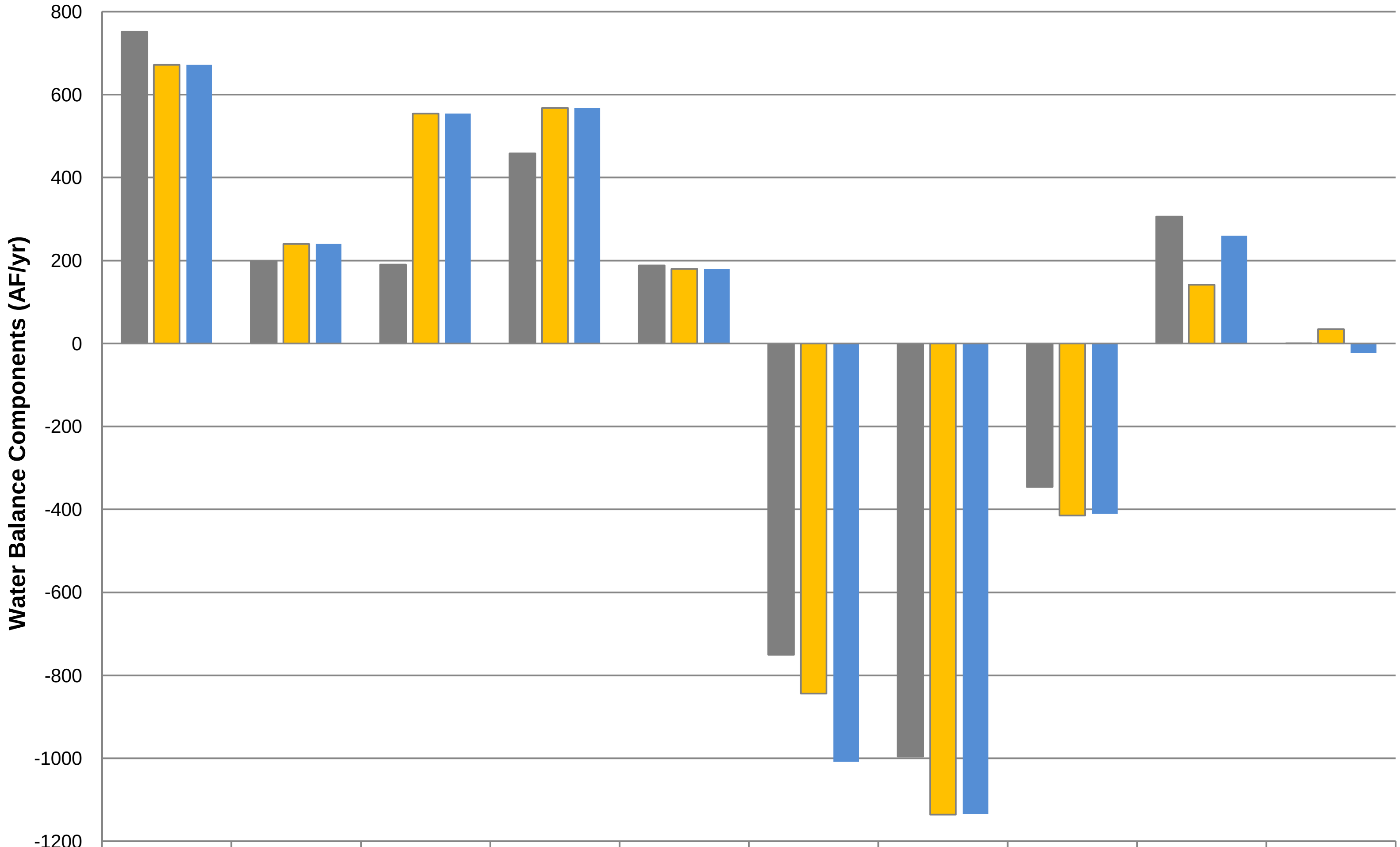
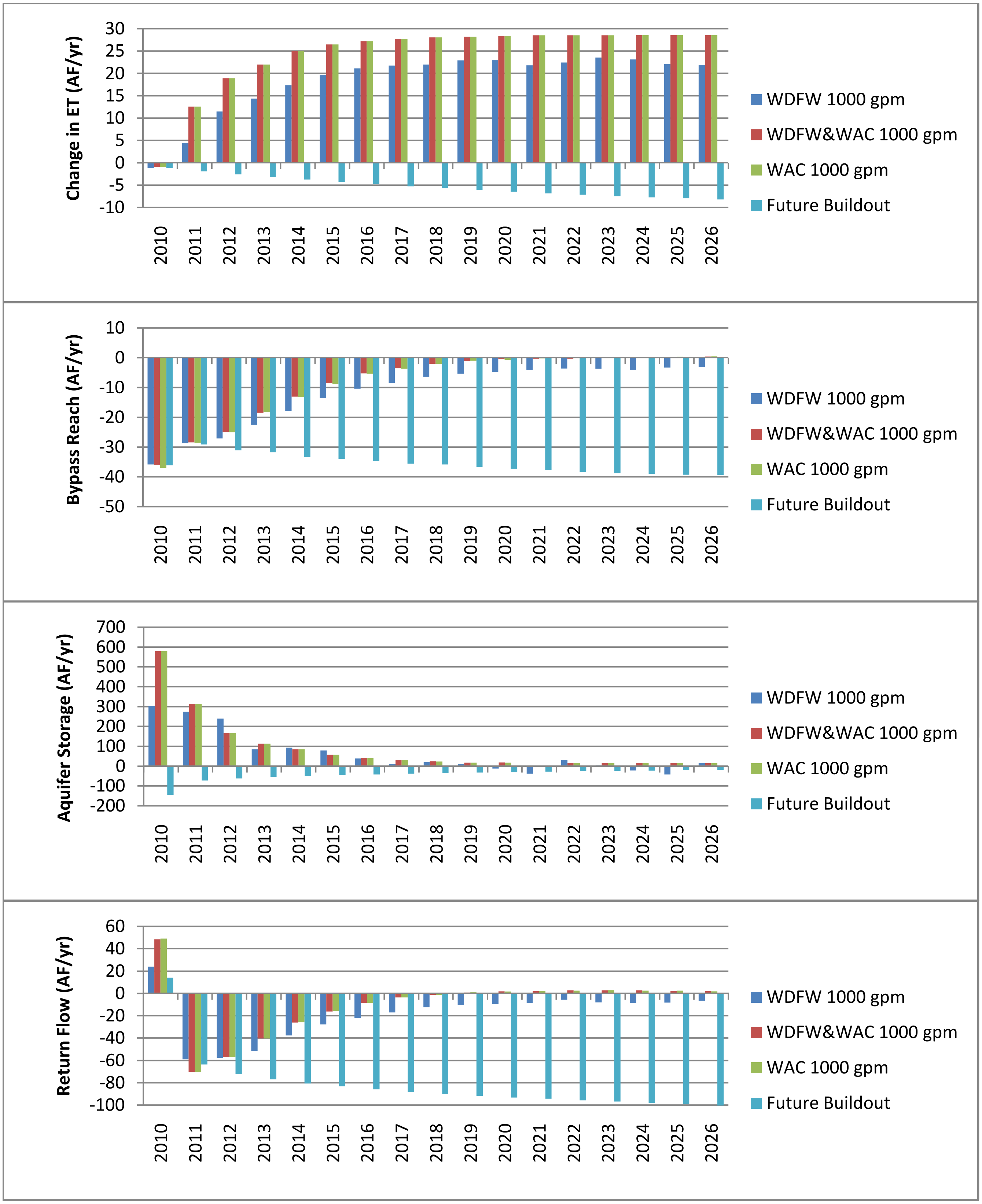


	Precipitation Infiltration	Lake Inflows	Mountain Front Recharge	Irrigation Return Flow	Thompson Creek Discharge	Domestic & Agricultural Pumping	River ET	Lake ET	Net Underflow & River Discharge to GW	Change in Aquifer Storage
Spreadsheet Analysis	752	198	190	458	188	-750	-996	-346	306	0
Existing Buildout Model	671	240	554	568	180	-844	-1136	-415	142	35
Future Buildout Model	671	240	554	568	180	-1008	-1135	-411	260	-22

Figure 5.4.2
Water Balance Comparison
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\WaterBalance Table.xls



Aspect Consulting, LLC
5/27/2009
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Figure 5.4.3
Annual Water Budgets for Predictive Scenarios
TLAC Water Right Application
Winthrop, Washington

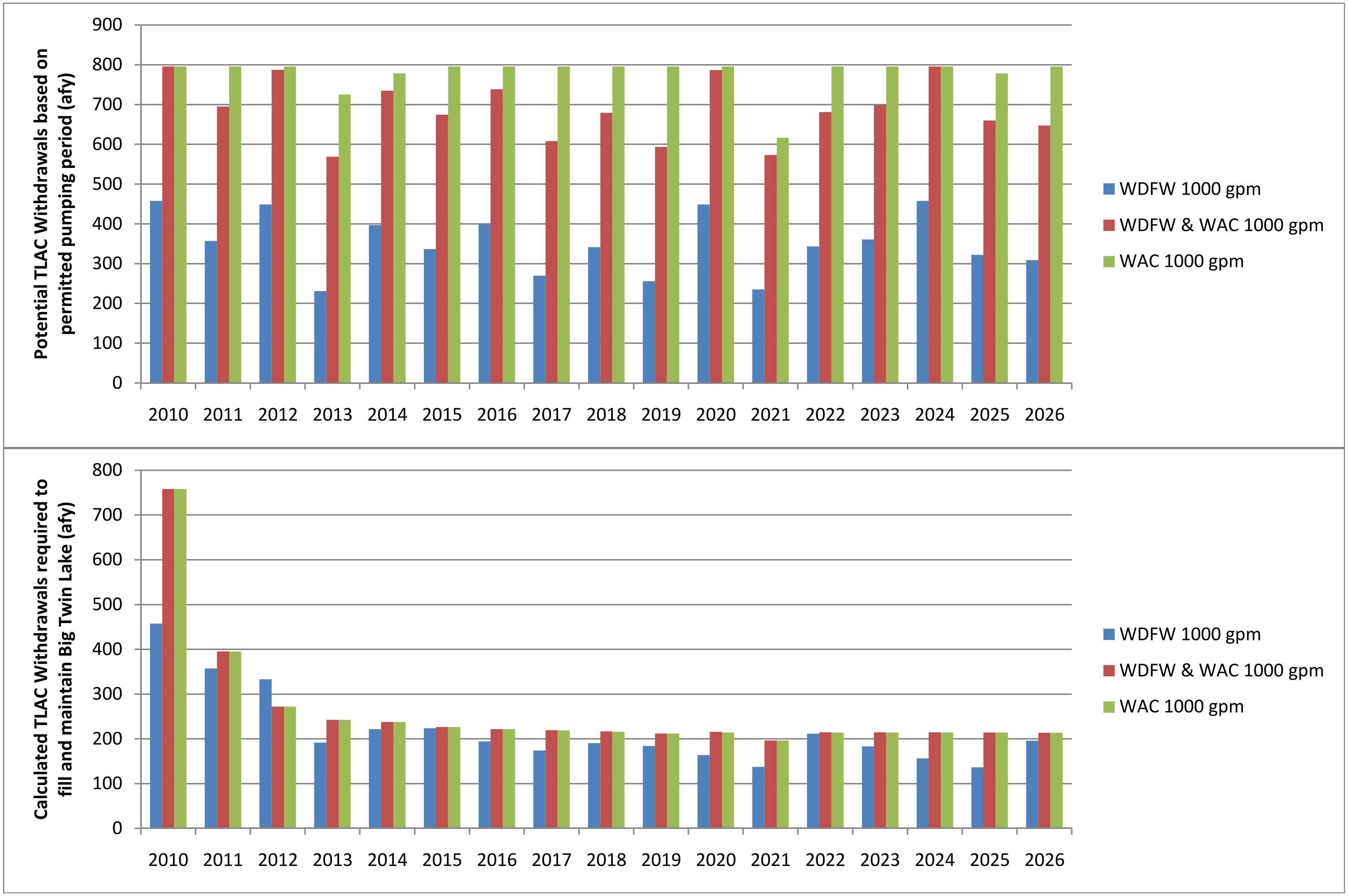


Figure 5.4.4
Potential and Calculated TLAC Withdrawals
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\TLACComparison.xlsx

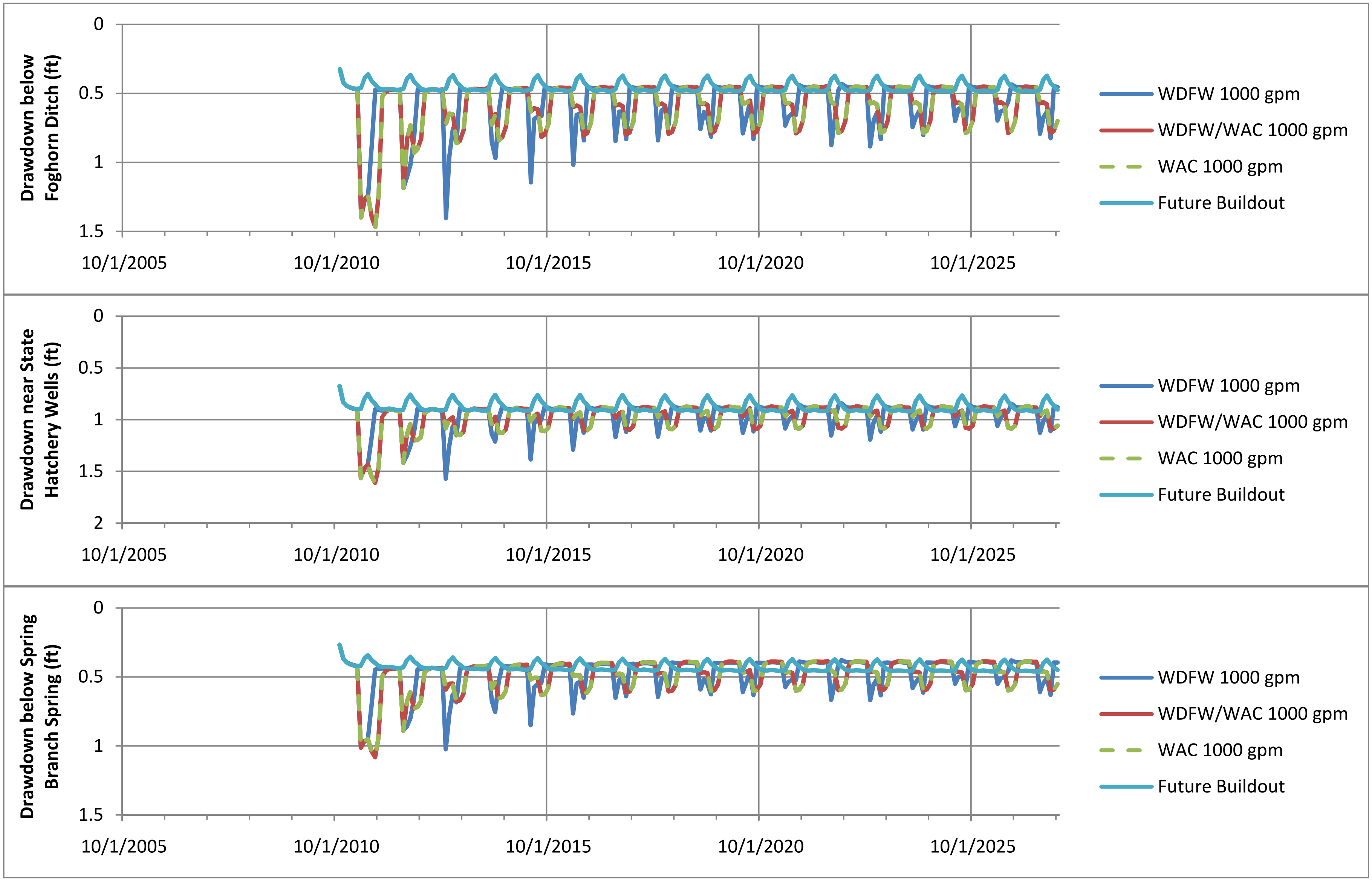


Figure 5.4.5
Calculated Drawdown Hydrographs
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\TLACComparison.xlsx

APPENDIX A

TLAC Water Right Application and WDFW Comment Letter

FILE: G4-34915

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

DEPT. OF ECOLOGY Received JUN 28 2004 CENTRAL REGION OFFICE

June 25, 2004

Robert Barwin, Section Manager
Water Resource Program
Washington Department of Ecology
Central Regional Office
15 West Yakima Avenue, Suite 200
Yakima, WA 98902-3452

Dear Mr. Barwin:

After several meetings, site visits and consulting with other WDFW staff, I am prepared to offer a recommendation for moving the Twin Lakes Aquifer Coalition (TLAC) water right application G4-34915 to the front of the line under the Hillis Rule (WAC 173-152-050 (2)). These conditions will be very similar to those outlined by Dennis Beich in his March 16, 2004 letter to you. My recommendations have included some of the details that Dennis purposely left for my office to develop.

Dennis stated "We believe the proposal does provide a substantial net benefit if appropriate conditions are placed on the permit". Dennis was referring to the benefits of a trophy trout fishery in Big Twin Lake. At this time that is the only substantial net benefit that WDFW is willing to consider. It is widely recognized that water levels in the lakes in the watershed fluctuate greatly and are probably within the range of historic natural levels.

In order to stem the problem of fish die-offs and lowering of the lake level I am recommending that water from the Methow River near the Methow Fish Hatchery in Winthrop be pumped to Big Twin Lake with the following conditions:

1. Water only be withdrawn during the spring runoff following the schedule set in figure 1.
2. No new wells (including exempt wells) be permitted from the aquifer in continuity with Twin Lakes.
3. Water may only be added to Big Twin Lake.
4. Permit should be issued as a temporary permit with a clause to allow for renewal as appropriate.
5. Baseline and ongoing monitoring plans are implemented.
6. Discussions of mitigation of negative impacts should take place.

It is important to maintain the high flow functions of the Methow River such as wood and sediment redistribution, channel formation and maintenance, bank storage and aquifer recharge. The setting of high flow limitations during the spring runoff should address that issue. We have chosen a rather unique approach that sets not only a minimum instream flow, but a maximum as well. The minimum instream flows are set above regulatory base flows in WAC 173-548-020 in order to ensure sufficient protection for key life stages for salmonids. We are also recommending that the point of withdrawal (infiltration trenches) be placed landward of the Foghorn Ditch. The recommended flows in Figure 1 are only meant as a preliminary estimate of the discharge needed to maintain high flow functions. These numbers will be revised as more information is reviewed.

WAC 173-152-050 specifically states that new water rights must be non-consumptive. WDFW has concerns that as the Twin Lakes aquifer recharges there will be a temptation to drill exempt wells to take advantage of that water. For that reason we are asking that the local basin to be closed to new wells. The intent of the closure is that water added to Big Twin Lake under this application not be available for consumptive uses. Groundwater not in continuity with Twin Lakes or the Twin Lakes aquifer would not be affected by this closure.

The water right application requests several introduction points for adding river water to the aquifer. Since we are focusing on the benefits to the trout fishery in Big Twin Lake then the only acceptable point of introduction would be directly into the lake itself.

The relative contributions of continued drought and the lining of the Wolf Creek Irrigation Ditch on lake levels have yet to be quantified. There is significant evidence that the entire region is suffering under the affects of a prolonged drought. If we move into a normal or wet cycle and the lakes rebound naturally then there would be no need for the water right. I am proposing a permit that would be reviewed at three years and expire at five years with a five year renewal clause if Twin Lakes actually benefit in that time. By issuing the permit with an expiration date and allowing renewal as appropriate we maintain the intent of the water right to enhance the Twin Lakes fishery and address concerns that the water right not be transferred or used for other purposes.

If a water right permit is granted then monitoring is a must. Monitoring of surrounding existing wells (at point of withdrawal and point of use), river banks and overflow channels, lake levels and fishing pressure should all be conducted starting before water is added to Big Twin Lake. This monitoring plan is not consistent with pumping this year as a full spring-summer-fall of baseline data should be collected. The monitoring requirement should have an explicit timeline and the plan should be approved by WDFW. Additional monitoring may include plant and animal communities associated with the changing water conditions.

Baseline data

In addition to monitoring I would like to see discussion of mitigation for cumulative impacts. At this point the form that mitigation might take is unclear. Some ideas would include riparian property purchases, conservation easements or purchase of upstream water rights.

Any questions or comments should be directed to me at (360) 902-2410 or boesssnb@dfw.wa.gov.

Sincerely,

Steve Boessow, Water Rights Biologist
Habitat Program

SB:sb

Attachment

cc: Dick Burdick, WDOE
Dick Ewing, TLAC
Carl Samuelson
Hal Beecher
Dennis Beich
Heather Bartlett
Alan Wald

Figure 1. Establishment of *Preliminary* Minimum and Maximum Flows in the Methow River at Winthrop for Operating the Recharge Project for Big Twin Lake.

		Methow River (12.4485.00)	
Month	Day	Minimum	Maximum
Jan.	1	*	*
Feb.	1	*	*
Mar.	1	*	*
Apr.	1	800	6,000
May	1	800	6,000
Jun.	1	800	6,000
Jul.	1	800	6,000
Jul.	15	*	*
Aug.	1	*	*
Sep.	1	*	*
Oct.	1	*	*
Nov.	1	*	*
Dec.	1	*	*

* No withdrawal during the time period July 15 through March 31.
Note: Flow recommendations are subject to change as more data are collected.

SB 25 June 2004

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
1550 Alder Street NW • Ephrata, Washington 98823 • (509) 754-4624 FAX (509) 754-5257

March 16, 2004

Mr. Robert F. Barwin, Section Manager
Water Resources Program
WA Department of Ecology
15 West Yakima Avenue, Suite 200
Yakima, WA 98902-3452

DEPT. OF ECOLOGY
Received
MAR 18 2004
CENTRAL REGION OFFICE

RE: Surface Water Application No. G4-34915

Dear Mr. Barwin,

Your letter of November 10, 2003 sought the opinion of WA Department of Fish and Wildlife (WDFW) as to whether or not the proposal submitted by the Twin Lakes Aquifer Coalition constitutes a "substantial net benefit" to the natural environment. This response applies only to the Methow River well option, which we understand to be the proponent's preferred option request. We believe the proposal does provide a substantial net benefit if appropriate conditions are placed on the permit.

Twin Lakes (Big and Little) have historically provided excellent fishing recreation to the extent that Big Twin is managed as "quality" trout water; that is to say, the lake is highly productive and is one of a relatively few waters in North Central Washington that lends itself to a fishery for large trout.

In recent years, water levels in Twin Lakes have declined markedly, to the point that partial, but unusual, fish die-offs have occurred, while surviving fish have exhibited declines in growth and robustness. As a consequence, fewer anglers have been attracted to these popular waters.

The North Central Region of Washington State has been in prolonged drought for at least the last decade. Over the past two years, a number of lakes in this area have been experiencing a decrease in lake water levels. Whether or not current Twin Lakes water levels have been significantly changed by efficiencies to the Wolf Creek irrigation distribution system is uncertain. However, it is entirely plausible that such has occurred to some, as yet undefined, degree. Nevertheless, artificial recharge of the aquifer would be a desirable short term goal to maintain historic fish and wildlife benefits.

In earlier comments on this proposed project, WDFW has stated the Methow River Well option as our preferred option. This was based on the likelihood of providing the greatest amount of water, and the likelihood of the water being pathogen-free. WDFW still prefers this option, but with the caveat that the well water be delivered directly and entirely to Big Twin Lake. Designing a system that includes Barnsley Lake seems imprudent in the absence of a more thorough analysis of the hydro-geomorphology of the Twin Lakes aquifer. There is no current knowledge to assure that water added to Barnsley Lake will reach the Twin Lakes area. Additional investigation needs to show strong subsurface continuity of flow before use of Barnsley Lake can be considered a viable adjunct.

In supporting the Methow River well option WDFW has previously stated that this option is only viable during peak spring flows. We will be providing the Department of Ecology with additional information describing the lower limits of peak flow withdrawal.

In recent months WDFW has reviewed other proposals in the Methow drainage that propose to withdraw water from spring run off peak flow event(s). Future requests to withdraw water from peak flow events should be subject to a cumulative effect analysis to determine at what point withdrawal of peak flows will negatively impact the overall river ecology.

Although supportive of this proposal, WDFW has concerns with its long-term viability and the proposals ability to set precedence. Our support for this proposal is based on the positive impacts increased water levels will have on resident fish in Twin Lakes. We realize that by increasing the water level of Twin Lakes the surrounding aquifer level will also rise and provide a benefit to existing surrounding well users. Our concern is that development of additional home sites and wells within the aquifer will eventually deplete the aquifer level and consequently the Twin Lakes water surface level. This could take us back to the same dilemma we face today, that is inadequate water in Twin Lakes to support a quality fishery. WDFW support of this proposal should not be construed as precedence for future diversions of Methow River water to artificially raise aquifer levels.

If I can be of further assistance, please let me know.

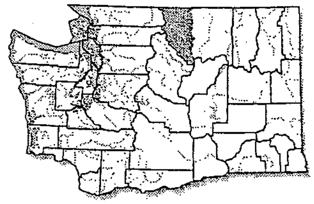
Sincerely,

Dennis Beich
Regional Director

cc: Sen. Linda Evans-Parlette
Tracy Lloyd
Joe Foster
Hal Beecher
Connie Iten

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
15 West Yakima Avenue, Suite 200 • Yakima, Washington 98902-3452 • (509) 575-2490

November 12, 2003



Dick Ewing
25 B Snowberry Ln
Winthrop WA 98862

Re: Ground Water Application No. G4-34915 – Twin Lakes Aquifer Coalition

We have received your application for a water right and have assigned the application number indicated above. It would help us if you referred to it by number in future correspondence.

If you have any questions or concerns, please call Water Resources Customer Service at (509) 575-2490.

Sincerely,

Robert F. Barwin, Section Manager
Water Resources Program

RFB:eg

ap-10b.doc

FILE COPY

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
15 West Yakima Avenue, Suite 200 • Yakima, Washington 98902-3452 • (509) 575-2490

November 10, 2003

Mr. Paul Ward
Yakama Nation
PO Box 151
Toppenish, WA 98948-0151

Mr. Dennis Beich, Regional Director
WA Department of Fish and Wildlife
Region 2, 1550 Alder Street NW
Ephrata, WA 98823-9651

RE: Surface Water Application No G4-34915

I am writing to request your opinion of a proposal I received from IRZ Consulting, LLC at the request of the Twin Lakes Aquifer Coalition (TLAC). IRZ was retained by TLAC to establish the feasibility and develop a plan for the restoration and maintenance of water levels in an aquifer located about two miles south of the Town of Winthrop.

The report was funded by a small grant from Ecology. Prior to completion of the report, the Legislature appropriated $750,000 for the construction of a system to restore water levels in Twin Lakes and the surrounding aquifer. TLAC wishes to construct a well field and pipeline, which is described in Section 2.1. TLAC submitted an application for water right for the well and pipeline project on October 7, 2003.

The proposal I have enclosed for your review is a complete description of the TLAC range of alternatives and includes comments they received from Ecology on the draft report that IRZ prepared in January 2003.

My specific request is for your opinions as to whether the proposal constitutes a "substantial net benefit" (SEB) to the natural environment. SEB is one criterion within Ecology's water right processing rule (WAS 170-170) that, if met, could qualify an applicant for a new water right for processing ahead of the other applicants in the pending queue. The other criterion for a new water right is that the proposal has to be for a non-consumptive use.

I would appreciate your comments and any opinion about the significance of the potential environmental benefits that might be achieved by implementation of the project. If you have any questions, please feel free to call me at (509) 574-3989.

Sincerely,

Robert F. Barwin, Section Manager
Water Resources Program

RFB:gh
031105

Enclosure: Twin Lakes Aquifer Recharge Project, Final Conceptual Design Report
Application No. G4-34915 (copy)

FILE COPY

WASHINGTON STATE DEPARTMENT OF ECOLOGY

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

PROGRESS SHEET

☐ SURFACE WATER ☑ GROUND WATER

COMPUTER INPUT
☐ APPLICATION
☐ PERMIT
☐ CERTIFICATE
☐ OTHER

NAME: Twin Lakes Aquifer Coalition	CONTACT: Dick Ewing, 25 B Snowberry Ln, Winthrop 98862		TELEPHONE NO. 509.996.2098
ADDRESS: PO Box 92	(CITY) Winthrop	(STATE) WA	(ZIP CODE) 98862-0092 509.996.2098
ASSIGNED TO		TELEPHONE NO.	DATE ASSIGNED
ADDRESS	(CITY)	(STATE)	(ZIP CODE)
APPLICATION NO. 64-34915	PERMIT NO.	CERTIFICATION NO.	
DATE AMENDED	DATE CANCELLED	W.R.I.A 48 OKANOGAN	

APPLICATION

DATE APPLICATION RECEIVED: October 7, 2003	INITIAL $10.00 FEE RECEIVED ☑ YES ☐ NO	DATE FEE RECEIVED: October 7, 2003
STATEMENT OF ADDIDTIONAL EXAMINATION FEE $	DATE SENT	DATE RECEIVED
DATE RETURNED FOR COMPLETION OR CORRECTION	DATE RECEIVED	

TEMPORARY PERMIT

APPROVED BY	DATE ISSUED

PUBLICATION

APPROVED BY	DATE APPROVED	DATE NOTICE SENT			
PROTESTED BY AND DATE					
DATE AFFIDAVIT RECEIVED	CHECKED BY	TIME EXPIRED	DATE AMENDED NOTICE SENT	DATE AFFIDAVIT RECEIVED	TIME EXPIRED

DEPARTMENT OF GAME AND FISHERIES REPORT

APPROVED	PROVISO	PROTEST

EXAMINATION

DATE EXAMINATION MADE	MADE BY	DATE REPORT OF EXAM. WRITTEN	WRITTEN BY	CHECKED BY
DATE PERMIT FEE REQUESTED	AMOUNT DUE	DATE RECEIVED		

PERMIT

PERMIT APPROVED BY	DATE APPROVED	PERMIT NO.	DATE ISSUED

BEGINNING OF CONSTRUCTION

DATE NOTICE SENT	DATE FILED	EXTENSION FEE
EXTENDED TO	EXTENDED TO	

WELL DRILLER'S AND/OR CONSTRUCTION REPORT

DATE SENT	DATE FILED

COMPLETION OF CONSTRUCTION

DATE NOTICE SENT	DATE FILED	EXTENSION FEE
EXTENDED TO	EXTENDED TO	

PROOF OF APPROPRIATION

DATE SENT	DATE FILED	EXTENSION FEE	EXTENDED TO	
DATE CERTIFICATE FEE REQUESTED	AMOUNT DUE	DATE RECEIVED	DATE APPROVED FOR CERTIFICATE	APPROVED BY

CERTIFICATION

PROOF EXAM. REQUIRED ☐ YES ☐ NO	CERTIFICATE NUMBER	DATE ISSUED

REMARKS

WASHINGTON STATE DEPARTMENT OF ECOLOGY

DEPT. OF ECOLOGY Received OCT 07 2003 CENTRAL REGIONAL OFFICE

For Ecology Use
FA
Fee Paid 10.00
Date 10/7/03
CK #121

State of Washington
Application for a Water Right

Please follow the attached instructions to avoid unnecessary delays.

Section 1. APPLICANT - PERSON, ORGANIZATION, OR WATER SYSTEM

Name Twin Lakes Aquifer Coalition Home Tel:(509) 996-2098

Mailing Address P.O. Box 92 Work Tel:( ) - same

City Winthrop State WA Zip+4 98862+ FAX:(509) 996-3754

Section 2. CONTACT - PERSON TO CALL ABOUT THE APPLICATION

☐ Same as above

Name Dick Ewing Home Tel:(509) 996-2098

Mailing Address 25B Snowberry Lane Work Tel:( ) - same

City Winthrop State WA Zip+4 98862+ FAX:(509) 996-2098

Relationship to applicant Chair of TLAC

Section 3. STATEMENT OF INTENT

The applicant requests a permit to use not more than 4500 (☒ gallons per minute or ☐ cubic feet per second) from a ☐ surface water source or ☒ ground water source (check only one) for the purpose(s) of See P. 4 of application. ATTACH A "LEGAL" DESCRIPTION OF THE PLACE OF USE. (See instructions.) *NOTE: A tax parcel number or a plat number is not sufficient.* See attached Description of Place of use

Estimate a maximum annual quantity to be used in acre-feet per year: 2,000 acre feet per year

☐ Check if the water use is proposed for a short-term project. Indicate the period of time that the water will be needed:

From ___/___/___ to ___/___/___

Section 4. WATER SOURCE

If SURFACE WATER	If GROUNDWATER
Name the water source and indicate if stream, spring, lake, etc. If unnamed, write "unnamed spring," "unnamed stream," etc.: Number of diversions:	A permit is desired for up to 2 well(s).
Source flows into (name of body of water):	Size & depth of well(s): Depth - up to 150 ft with up to 18 inch casing or a shallow interceptor well see IR2 Assessment Attached.

LOCATION

Enter the north-south and east-west distances in feet from the point of diversion or withdrawal to the nearest section corner: well #1 2700 feet south and 1000 feet east of the northwest corner

well #2 2720 feet south and 1400 feet east of the northwest corner

	¼ of	¼ of	Section	Township	Range(E/W)	County	If location of source is platted, complete below: Lot	Block	Subdivision
#1	NW	SW	3	34	21	Okanogan			
#2	NE	SW	3	34	21	Okanogan			

For Ecology Use Date Received: October 7, 2003 Priority Date: October 7, 2003 OKANOGAN

SEPA: Exempt/Not Exempt FERC License # ___ Dept. Of Health # ___

Date Accepted As Complete 10/08/03 By [initials] Date Returned ___ By ___ WRIA 48

Appl. No.: G4-34915

Section 5. GENERAL WATER SYSTEM INFORMATION

A. Name of system, if named: Twin Lakes Environmental and Aquifer Enhancement System

B. Briefly describe your proposed water system. (See instructions.)

See Attachment titled: Section 5 Part B Water System Description

C. Do you already have any water rights or claims associated with this property or system? ☐ YES ☑ NO
PROVIDE DOCUMENTATION.

Section 6. DOMESTIC / PUBLIC WATER SUPPLY SYSTEM INFORMATION
(Completed for all domestic/public supply uses.)

A. Number of "connections" requested:_________ Type of connection _________________ (Homes, Apartment, Recreational, etc.)

B. Are you within the area of an approved water system? ☐ YES ☐ NO
If yes, explain why you are unable to connect to the system. *Note: Regional water systems are identified by your County Health Department.*

Complete C. and D. only if the proposed water system will have fifteen or more connections.

C. Do you have a current water system plan approved by the Washington State Department of Health? ☐ YES ☐ NO
If yes, when was it approved? ______________ Please attach the current approved version of your plan.

D. Do you have an approved conservation plan? ☐ YES ☐ NO
If yes, when was it approved? ______________ Please attach the current approved version of your plan.

Section 7. IRRIGATION/AGRICULTURAL/FARM INFORMATION
(Complete for all irrigation and agriculture uses.)

A. Total number of acres to be irrigated: ________

B. List total number of acres for other specified agricultural uses:

Use______________________________Acres________
Use______________________________Acres________
Use______________________________Acres________

C. Total number of acres to be covered by this application: ________

D. Family Farm Act (Initiative Measure Number 59, November 3, 1977, as amended by Chapter 237, Laws of 2001)
Add up the acreage in which you have a controlling interest, including only:
- ‡ Acreage irrigated under water rights acquired after December 8, 1977;
- ‡ Acreage proposed to be irrigated under this application;
- ‡ Acreage proposed to be irrigated under other pending application(s).

1. Is the combined acreage greater than 6000 acres? ☐ YES ☐ NO
2. Do you have a controlling interest in a Family Farm Development Permit? ☐ YES ☐ NO
   If yes, enter permit no:______________________________

E. Farm uses:
Stockwater - Total # of animals ___________ Animal type _____________ (If dairy cattle, see below)
Dairy - # Milking __________ # Non-milking __________

Section 8. WATER STORAGE

Will you be using a dam, dike, or other structure to retain or store water? ☐ YES ☑ NO

NOTE: If you will be storing 10 acre-feet or more of water and/or if the water depth will be 10 feet or more at the deepest point, and some portion of the storage will be above grade, you must also apply for a reservoir permit. You can get a reservoir permit application from the Department of Ecology.

Section 9. DRIVING DIRECTIONS

Provide detailed driving instructions to the project site. From Winthrop heading towards Twisp on highway 20 turn onto Twin Lakes Road just after crossing the Methow River. After about 1.2 miles turn right onto Wolf Creek Road. Drive to the Methow River Spring Chinook Hatchery. The well sites are east of the hatchery along the Foghorn Ditch. To get to the places of use: From Winthrop turn onto Twin Lakes Rd as noted above. After 1.6 miles turn left onto the drive to Eagle Pine Chalets. Keep straight following the bike trail signs through the fence. Barnsley Lake is over the hill, south. To access Big Twin proceed another 1.3 miles on Twin Lakes Road to Big Twin Campground. Ask at office for location of lake inflow point.

Section 10. REQUIRED MAP

A. Attach a map of the project. (**See instructions.**)

Section 11. PROPERTY OWNERSHIP

A. Does the applicant own the land on which the water will be used? ☐ YES ☑ NO
If no, explain the applicant's interest in the place of use and provide the name(s) and address(es) of the owner(s):

The places of use are the introductory points for putting Water in Barnsley, Big Twin Lake and the aquifer. See attachment Section 11 for names and addresses of owners

B. Does the applicant own the land on which the water source is located? ☐ YES ☑ NO
If no, submit a copy of agreement:

I certify that the information above is true and accurate to the best of my knowledge. I understand that in order to process my application, I grant staff from the Department of Ecology access to the site for inspection and monitoring purposes. Even though I may have been assisted in the preparation of the above application by the employees of the Department of Ecology, all responsibility for the accuracy of the information rests with me.

Richard E Ewing, Jr — Date: 9/30/2003
Applicant (or authorized representative) — Date

Hans Bodleens Enterprises Trust by: [signature], Attorney — Date: 10/1/03
Landowner for place of use (if same as applicant, write "same") — Date
Barnsley Lake

[signature] — Date: 9-28-03
Landowner Big Twin Lake — Date

[signature] — Date: 9/28/03
Landowner infiltration points — Date

Use this page to continue your answers to any questions on the application. Please indicate section number before answer.

Section 3 Purpose of Use

General Statement: Restore Barnsley and Twin Lakes and associated aquifer for the following specific purposes of use:

1) Restore and maintain Twin Lakes Aquifer levels
2) Restore and maintain recreational trout fishery in Big and Little Twin Lakes
3) Restore and maintain riparian and lowland habitat for aquatic species and mammels that use Barnsley and Twin Lakes
4) Water storage enhancement for increasing streamflows in mainstem Methow River and Thompson Creek during low flow periods
5) Restor natural aesthetic appeal of lake areas
6) Increase recreational opportunities
7) Maintain or enhance water quality for trout fishery and recreation

We are returning your application for the following reason(s):	
______ Examination fee was not enclosed	APPLICANT PLEASE RETURN TO CASHIER, PO BOX 5128, LACEY, WA 98509-5128
______ Section number(s) ______________________ is/are incomplete	APPLICANT PLEASE RETURN TO THE APPROPRIATE REGIONAL OFFICE
Explanation:	
Please provide the additional information requested above and return your application by ______________________ (date).	

Ecology staff______________________ Date______________

Ecology is an Equal Opportunity and Affirmative Action employer.

To receive this document in alternative format, contact the Water Resources Program at (360) 407-6604 (Voice) or (360) 407-6006 (TDD).

DESCRIPTION OF THE PLACE OF USE
Twin Lakes Aquifer Coalition
Application for a Water Right

There are four places of use:

1) **Barnsley Lake** which is located primarily in the Southeast quarter of the Northwest quarter, section 10, Township 34, Range 21 and partially in the Northeast corner of Northwest quarter of Section 10, Township 34, Range 21.
2) **Big Twin Lake** which is located in the Southwest quarter of the Northeast quarter of section 15, Township 34, Range 21 and in the Northwest quarter of the Southeast quarter of Section 15, Township 34, Range 21. The lake extends partially into the Southeast quarter of the Northeast quarter of Section 15, Township 34, Range 21 and partially into the Northeast quarter of the Southeast quarter of Section 15, Township 34, Range 21
3) **Infiltration Galleries positioned along the pipeline:** To facilitate introduction of water into the aquifer infiltration galleries are proposed alongside the pipe on Lupine Drive in the Sun Mountain Ranch Club. The road begins in the Southeast quarter of the Southwest quarter of Section 10 Township 34 Range 21 and runs through the Northeast quarter of the Northwest quarter of Section 15, Township 34 and Range 21.
4) **Twin Lakes Aquifer:** The aquifer boundary is noted on the attached map and denotes the extent to which the introduced water will potentially infiltrate and restore the original groundwater levels.

SECTION 5. GENERAL WATER SYSTEM INFORMATION
PART B WATER SYSTEM DESCRIPTION
Twin Lakes Aquifer Coalition Application for a Water Right

Development of the project will proceed according to these phases: identifying well location and type of well (deep cased well or shallow interceptor well), construction of up to two wells, testing of well production capacity, final engineering of pump sizes and type and delivery system based upon well productivity, construction, operation and monitoring of the system. The delivery system will be buried pipe with outflows into Barnsley and Big Twin Lakes. The outflows into the lakes will be short stream segments designed to aerate the water before entry into the lakes. Along the pipe route, where practical, ground water injection points will be constructed to introduce water into Twin Lakes Aquifer to facilitate its recovery. Water will be taken from the Methow River aquifer during the period when river flows exceed base flows established in WAC 178-548. The pumped water will be stored in Twin and Barnsley Lakes. Seepage from the lakes will also introduce water into the aquifer which will also flow into the Methow River. This seepage and outflow benefits the recreational trout fishery in Twin Lakes and endangered fish in the Methow River. It is anticipated that customary aquifer levels will be achieved in about five years. Once customary water levels are restored the monitoring program will identify the water needed to maintain aquifer and lake levels. For complete details on well construction refer to the Twin Lakes Aquifer Recharge Project Final Conceptual Design Report by IRZ Consulting, June 30, 2003.

SETION 11. PROPERTY OWNERSHIP
PART A. OWNERS OF PLACE OF USE
Twin Lakes Aquifer Coalition Application for a Water Right

1. **Owner of Barnsley Lake**
   Haub Brothers Enterprises Trust
   C/O John Barline, Agent
   Williams, Kastner, Gibbs PLLC
   1301 A Street, Suite 900
   Tacoma, WA 98402-4200
2. **Owner of Big Twin Lake**
   Johnson Family Trust
   C/O Ben Johnson
   210 Twin Lakes Road
   Winthrop, WA 98862
3. **Owner of easement for infiltration points for aquifer**
   Sun Mountain Ranch Club Property Association
   P.O. Box 24
   Winthrop, WA 98862

SECTION 11. PROPERTY OWNERSHIP, PART B AGREEMENT
AGREEMENT OF GENERAL UNDERSTANDING
BETWEEN TWIN LAKES AQUIFER COALITION AND HAUB BROTHERS
ENTERPRISES TRUST

Haub Brothers Enterprises Trust (Haub) is in general agreement with the intentions of the application submitted by the Twin Lakes Aquifer Coalition. (TLAC). Haub supports the stated environmental beneficial uses contained in the application. Haub agrees in principal to allow use of a portion of its properties for well construction and pipeline easements, subject to mutually acceptable written agreements described below hereafter being negotiated and entered into by the parties. No such agreements now exist.

TLAC and Haub understand that the purpose of this Agreement of General Understanding is to provide assurance to Ecology that both are committed to the restoration of Twin Lakes, so that a water right for said project may be secured. Once the water right is obtained separate agreements will be negotiated between Haub and TLAC or the proposed entity that will be created to maintain the Twin Lakes Environmental and Aquifer Enhancement System (TLEAS). Said agreements will be in the following order, dependent upon one another and as described as follows: 1) Test Well Access Agreement - for the purposes of siting and drilling test wells; 2) Well and Pipeline Construction and Easement Agreement – for the purpose of constructing and operating a well(s) on Haub property, and building and maintaining a delivery pipeline across Haub property. Any and all such agreements must be mutually agreed to by all parties.

Haub understands that TLAC may require three attempts to find a suitable interceptor well. If the interceptor well does not work then TLAC will need to drill test wells to determine where to locate the two production wells in the process of securing the necessary water for the project. TLAC understands that these well tests are to be located within a 100 foot wide strip parallel to and bordering the Foghorn Canal and within the area described in the TLAC permit application. In any and all of the cases TLAC agrees to obtain consent from Haub regarding location of the proposed attempts and the final production well(s) and entry onto Haub properties for any and all purposes. However, until the water right is approved for the project specific agreements will not be drawn up regarding these points and TLAC's or TLEAS' responsibilities to see that the project is completed and operated in an orderly fashion and the Haub properties restored to their original condition after project completion. TLAC and Haub are merely expressing their mutual agreement that both will use their best efforts to work these points out in good faith between them so the project can be completed.

TLAC specifically acknowledges that Haub will require any and all agreements for access to, over, or under the Haub properties for all steps of this project contain, among other things: 1) assurances that the system will be used, operated and maintained at all times in good working condition and in a manner consistent with protecting Haub's property and interests; 2) indemnities to Haub by the Operating Entity for any and all damages directly or indirectly caused by the system; 3) insurance and bonding to insure the indemnity; and 4) financial assurance that the obligations of the Operating Entity are capable legally and financially of being achieved. Haub makes no warranty as to the quality of the water for the intended use. Nor will Haub restrict its current or future use of its property in any manner by reason of the planned wells and pipelines.

TLAC is committed to creating the necessary public entity that will eventually hold the water right, operate the wells, and pipeline that will be accountable legally and financially on behalf of the landowners (beneficiaries of the agreement) in the Twin Lakes area. The creation of this entity will follow development of the wells and the determination of their adequacy for the restoration project.

Both TLAC and Haub understand that any water right that may come from this application is limited to the beneficial uses stated in the application.

[signature], Attorney

Signature of Agent Representing Haub Brothers Enterprises

Haub Brothers Enterprises Trust

Address:
c/o John D. Barline, Attorney
Williams Kastner & Gibbs PLLC
1301 A Street, Suite 900

Tacoma, WA. 98402

Contact Information #253-552-4081 jbarline@wkg.com

II.

Richard E. Ewing

Signature of Chair, TLAC

25 B Snowberry Lane

Address

PO Box 92

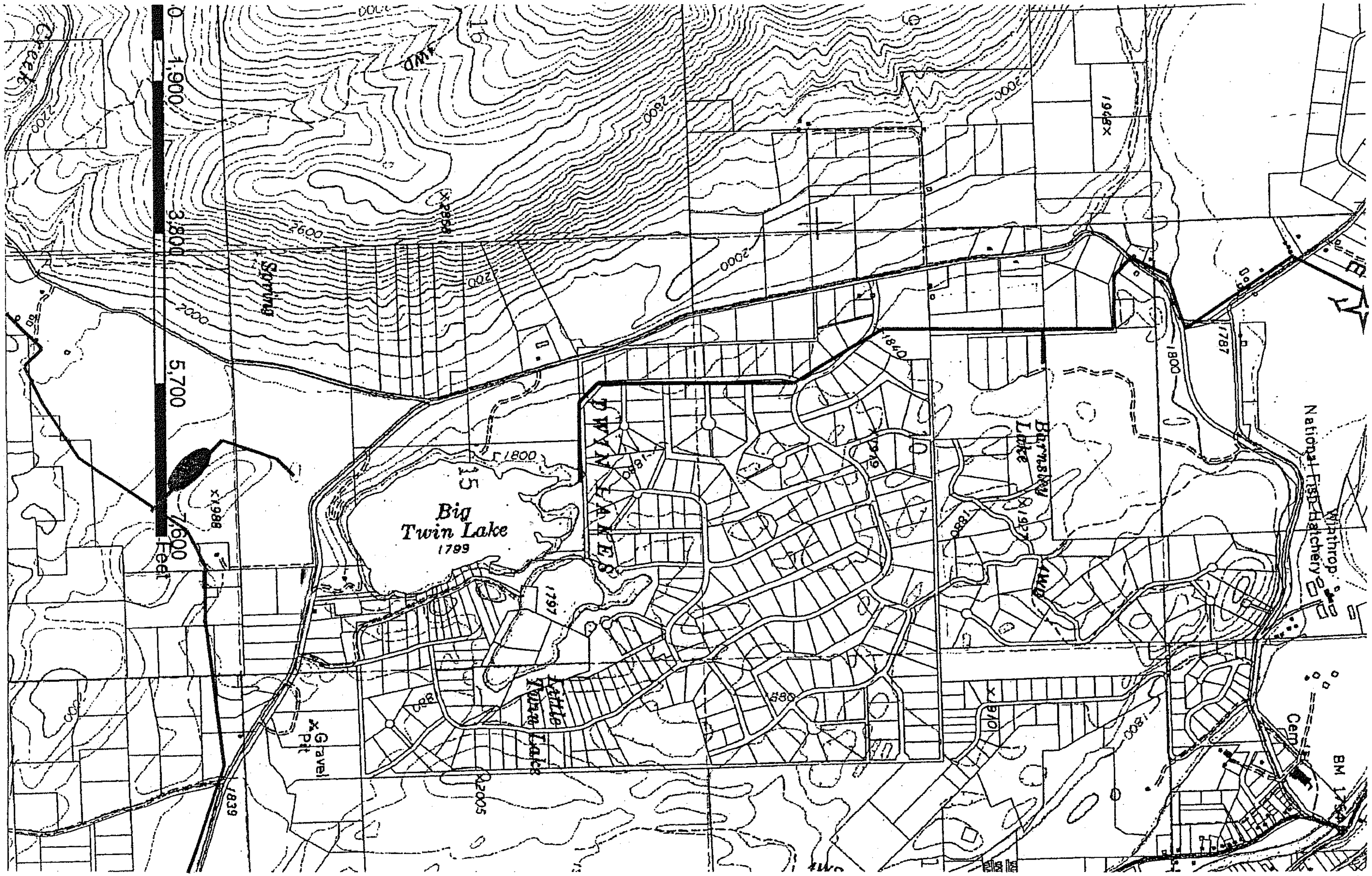
Winthrop, WA 98862

509 996 2098 fawn@mymethow.com

Contact Information

1470179.1

METHOW WELL AND PIPE LOCATION



1.0 PROJECT ACTIVITIES SINCE THE INTERIM REPORT

The purpose of this section is to describe project activities since the completion of the Final Interim Report in January 2003 and how these activities led to the development of this conceptual design report. These include the review of the Interim Report by the affected organizations, additional field work, and conceptual design activities. Many of the geographic areas or engineering features discussed in this report are shown on Figure 1.

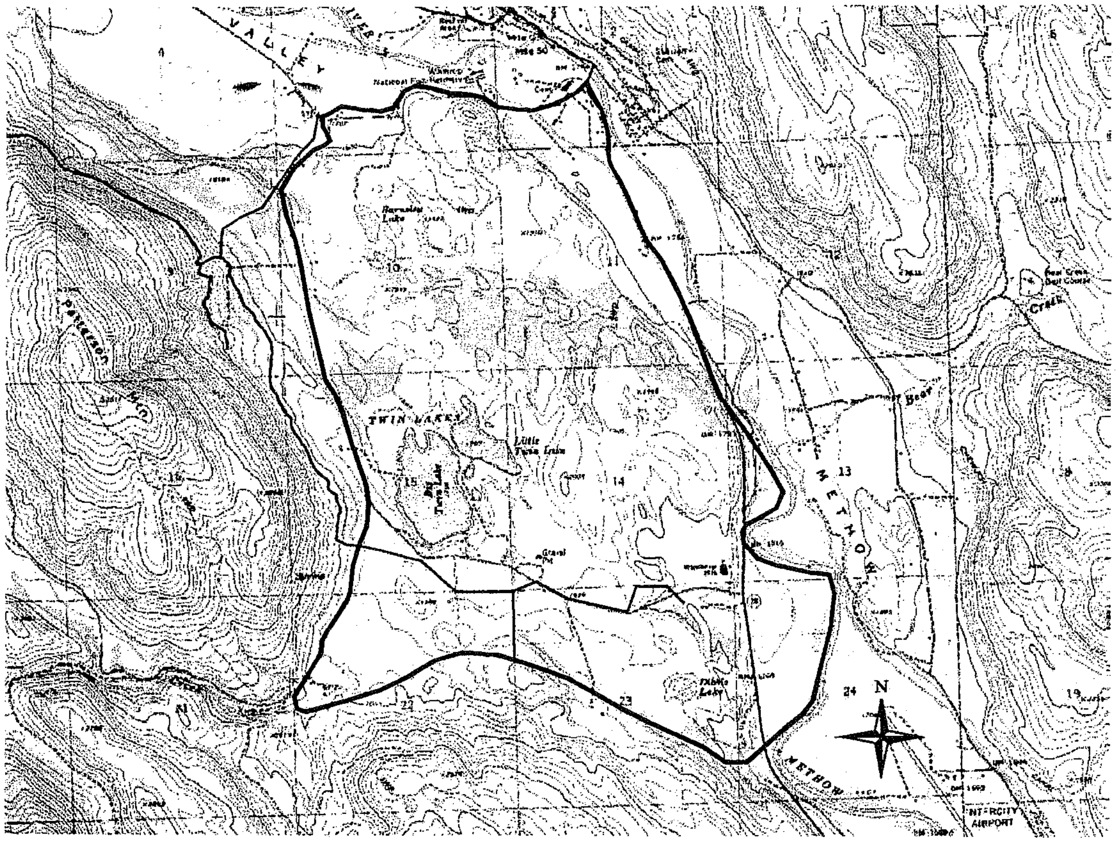


Figure 1. Location Map of Twin Lakes Aquifer (approximate boundary shown by heavy black line) and the Wolf Creek Reclamation District's Delivery System (red line).

1.1 Review of the Interim Report by Affected Organizations

The Final Interim Report (IRZ, 2003) was a feasibility study that reviewed seventeen options to add water to the Twin Lakes Aquifer (Aquifer). The seventeen options were generally lumped as approaches that added more water to the Aquifer by pumping or gravity. These options were evaluated through a spreadsheet matrix that considered costs, quantity of water that could be added, and acceptance of the option by the affected parties. Based on a meeting in December 2002, IRZ revised the matrix to provide additional weight to the regulatory community acceptance.

APPENDIX B

Field Investigations

B.1 Field Investigations

As discussed in Section 2.5, several data gaps in key areas surrounding Big and Little Twin Lakes were identified during the project. In order to resolve these data gaps, personnel from Aspect Consulting made a site visit to the Twin Lakes project area from August 28, 2006 through September 1, 2006. The scope of work for addressing the identified data gaps is provided in a letter to the Washington State Department of Ecology, dated June 7, 2006. Authorization of the scope of work was received on August 3, 2006. The following tasks were completed during the site visit.

- Locate and survey domestic water supply wells with quarter-quarter section locations that were identified as key wells in the delineation of hydrostratigraphic units and the presence of a possible bedrock barrier to groundwater flow.
- Measure static groundwater levels of accurately located domestic water supply wells (GPS locations) in order to better define groundwater flow directions within the project area. This includes wells that were either located by Aspect Consulting personnel or by the USGS.
- Install staff gages at the lakes within the project area to provide long-term measurements of lake elevations and improve the understanding of the groundwater/lake interaction.
- Measure elevations of the Methow River at select locations within the project area in order to provide information on surface water gradients and whether the river is gaining or losing water at these locations.
- Confirm areas where bedrock is outcropping at the surface within the project area.

Following submittal of the December 14, 2006, Draft Hydrogeologic Evaluation (Aspect Consulting, 2006), it was determined that additional static groundwater level measurements were needed to better define seasonal groundwater flow in the buried alluvial valley to the southeast of Big Twin Lake, and towards the Methow River. In addition, discharge measurements of Thompson Creek were needed to better determine seasonal contributions to groundwater recharge. Therefore, additional site visits by Aspect Consulting personnel were completed in December 2007 and May 2008. The following tasks were completed during these site visits:

- Locate, survey, and measure groundwater levels in additional domestic water supply wells with quarter-quarter section locations that were identified as key wells in better defining groundwater flow in the buried alluvial valley to the southeast of Big Twin Lake.
- Install a staff gage at Barnsley Lake to provide long-term measurements of lake elevations and improve the understanding of the groundwater/lake interaction.

- Measure elevations of the Methow River at previously measured locations to determine seasonal changes in surface water gradients and whether the river is gaining or losing water at these locations.
- Collect discharge measurements along Thompson Creek in order to determine which reaches are gaining or losing water and quantify the amount of groundwater recharge.

A brief description of the methods and results for the above tasks is provided below. Table B-1 provides the surface water elevation data for Barnsley, Dibble, Little Twin and Big Twin Lakes, as well as the Methow River. Table B-2 indicates the gaining or losing reaches of Thompson Creek and the respective quantities in cubic feet per second (cfs). Table B-3 provides the groundwater elevation data from each of the wells for the various site visits. In addition, Figures 2.5.8 through 2.5.10 provide groundwater elevation contour maps for the respective site visits, while Figure 2.3.4 provides discharge measurements and indicates which sections of Thompson Creek are gaining or losing water during the December 2006 and May 2007 site visits.

Prior to Aspect Consulting personnel performing the initial site visit, a list of wells important in delineating the hydrostratigraphic units and the presence of a possible bedrock barrier to groundwater flow were identified. Prior to subsequent site visits, additional wells were identified and considered to be key in better defining groundwater flow in the buried alluvial valley to the southeast of Big Twin Lake. The well owners were contacted to gain permission to locate and/or measure the static groundwater level of the respective well. Permission was received to initially measure the static groundwater level of 31 wells. Of these 31 wells, 6 of them were previously located by the USGS with a GPS; therefore, a total of 25 wells were surveyed by Erlandsen and Associates under Aspect Consulting's direction during the initial site visit. During subsequent site visits, static groundwater levels were measured in 19 additional wells, and the locations surveyed by Erlandsen and Associates, to better define groundwater flow to the southeast of Big Twin Lake.

Static groundwater level measurements were collected by Aspect Consulting personnel in August and September 2006, December 2007 and May 2008. The groundwater level was measured with a water level indicator to the nearest 0.01 feet. Notes were taken on the location of the well and whether the well was pumping during the measurement or whether the groundwater level was changing (non-static groundwater level measurement). The measuring point from which the static groundwater level of the well was taken was also marked in order to later survey the elevation of the measuring point and return to the well for subsequent measurements if necessary. Following completion of the groundwater level measurements, Aspect Consulting personnel returned to the respective wells with Erlandsen and Associates to survey the locations and elevations of the respective measuring points for the static groundwater level measurements. The locations and coordinates were surveyed using a differential GPS when possible (limited number of trees present) or with a combination of differential GPS and traditional survey techniques. Elevation accuracies were within 0.1 foot. In addition, the elevation of the Methow River, measured from the edge of the river, was measured at 5 control points within the project area (Figures 2.5.8 through 2.5.10).

Staff gages were installed at Big and Little Twin and Dibble Lakes on August 28, 2006. A staff gage was later installed at Barnsley Lake on December 18, 2007. The porcelain coated metal staff gages (10 feet in length) were attached to steel pipes and driven into the lake bed in approximately 4 feet of water (near the shoreline). After installation of the staff gage, the water level was noted and the elevation of the 10-foot mark was later surveyed to provide an actual lake elevation. The location of bedrock outcrops were also noted and surveyed using a handheld Garmin GPS on August 28, 2006.

Thompson Creek discharge measurements were collected in December 2007 and May 2008. Discharge measurements were collected at the following locations:

Reach 1

- upstream of the Moccasin Lake diversion (1U);
- downstream of the Moccasin Lake diversion (1D);

Reach 2

- upstream of Moccasin Lake Ranch and upstream of an irrigation inflow (2UU);
- upstream of Moccasin Lake Ranch and downstream of an irrigation inflow (2UD);

Reach 3

- upstream of the forested wetland (2D);
- upstream of the sinkhole (3);
- downstream of the forested wetland, near the Rodeo Grounds (4U);

Reach 4

- upstream of the Sukavoty diversion (4DU);
- downstream of the Sukavoty diversion (4D); and
- upstream of the confluence with Foghorn Ditch (4DD).

Discharge measurements were collected using the USGS standard six-tenths-depth area-velocity technique. This method involves measuring the channel cross-sectional area and water velocity at multiple stations across the channel. Each channel cross-section was established by stringing a tape measure across the channel perpendicular to the flow direction. For each location, measurements were taken at approximately 15 to 40 stations, depending on the channel width and uniformity, along the cross section. At each station the following measurements were taken:

- Horizontal position (read from the measuring tape);
- Depth to the channel bottom (measured vertically down from the water surface); and
- Average velocity (measured with a current meter at that station).

Average velocity was measured using a Swoffer 3000 current meter with a 2-inch propeller. The propeller was set at a distance above the channel bottom equal to 60 percent of the total depth. Flow is calculated by dividing the channel into rectangular sections based on the station data and using the following formula:

$$Q = (w_1*d_1*v_1) + (w_2*d_2*v_2) + (w_3*d_3*v_3) + ... + (w_n d_n v_n)$$

where Q is the total flow in cubic feet per second (cfs), w is the width of each rectangle in feet, d is the depth of each rectangle in feet, v is the average velocity in feet per second, and n is the number of rectangles.

Total flow for each transect is calculated as the sum of the velocity-area products for the stations. All measurements are stored in the Swoffer meter. Velocity measurements and total flow were later adjusted to the pre-determined propeller calibration curves.

When practical, for each reach, two Aspect Consulting personnel measured flow at upstream and downstream locations during approximately the same time period to minimize potential for flow changes attributable to upstream influences (diversions, inflows, diurnal temperature changes, etc.). Replicate measurements were taken at several locations for continuity with measurements collected on different days, and to verify previous discharge measurements.

Surface water diversions, upstream of the gaged reach on Thompson Creek, were investigated to evaluate potential seasonal variability in Thompson Creek flows. Two surface water diversions (WRTS Control Numbers S4-34916 and S4-34951) were identified (Aspect, 2005 and PGG, 2005) in the upper portion of the Thompson Creek drainage near Elbow Coulee. The points of diversion for these rights are located in the Elbow Coulee area. Local topography suggests surface water flow in Elbow Coulee is isolated from Thompson Creek (PGG, 2005). Our field reconnaissance of the area confirmed the absence of surface water connection from Elbow Coulee to Thompson Creek. The gaged measurements, therefore, do not appear to be influenced by seasonal changes in surface water withdrawals.

Table B-1

Field Investigations - Surface Water Elevation Data

Additional Hydrogeologic Data Collection and Evaluation
TLAC Water Right Application G4-34915
Winthrop, Washington

Staff Gage Locations and Lake Elevations

Name	X Coordinate (SPS83)	Y Coordinate (SPS83)	Gage Elevation (NGVD29)	Surveyed Staff Gage Reading	Date	Staff Gage Reading	Lake Elevation (ft MSL)	Corrected Lake Elevation	Surveyd Lake Elevation
Dibble Lake	1720085.1	1130769.0	1784.8	10	8/28/06	6.58	1781.4	-	-
					11/30/2006	5.46	1780.3	-	-
					4/10/2007	4.06	1778.9	-	-
					10/1/2007	6.06	1780.9	-	-
					12/20/2007[a]	5.72	1780.5	-	-
					5/9/08	3.61	1778.4	-	1778.3
Little Twin Lake	1715137.1	1137100.9	1793.1	10	8/28/06	6.3	1789.4	-	-
					11/30/2006	7.68	1790.8	-	-
					4/10/2007	8.28	1791.4	-	-
					10/1/2007	9.5	1792.6	-	-
					12/20/07	-	-	-	-
					5/9/08	8.94	1792.0	1791.3	1791.3
Big Twin Lake	1713825.9	1135833.9	1794.9	10	8/28/06	5.92	1790.8	-	-
					11/30/2006	5.86	1790.8	-	-
					4/10/2007	6.76	1791.7	-	-
					10/1/2007	8.46	1793.4	-	-
					12/20/2007[b]	-	1793.1	-	-
					5/9/08	6.71	1791.6	-	1791.4
Barnsley Lake	1713082.5	1142271.8	1776.8	3.38	12/18/07	1.33	1774.8	-	-
					5/8/08	2.07	1775.5	-	1775.6

River Control Point Locations and River Elevations

Name	Date	X Coordinate (SPS83)	Y Coordinate (SPS83)	River Elevation (NGVD29)
Methow1	8/31/06	1712101.6	1147268.9	1764.58
Methow1b	12/20/07	1712094.2	1147263.9	1764.45
Methow1c	5/8/08	1712096.3	1147246.0	1766.60
Methow2	8/31/06	1718567.2	1145559.8	1728.33
Methow2b	12/20/07	1718546.3	1145578.7	1728.61
Methow2c	5/8/08	1718553.3	1145538.4	1731.39
Methow3	8/31/06	1720462.0	1142246.9	1717.31
Methow3b	12/20/07	1720458.6	1142242.0	1717.63
Methow3c	5/8/08	1720448.3	1142232.1	1720.49
Methow4	8/31/06	1722206.5	1134595.7	1692.87
Methow4b	12/20/07	1722208.1	1134596.6	1692.85
Methow4c	5/8/08	1721982.5	1134415.0	1695.69
Methow5	8/31/06	1722488.8	1129114.0	1669.59
Methow5b	12/20/07	1722425.2	1129016.5	1670.04
Methow5c	5/8/08	1722424.2	1129003.3	1672.96

Notes:

[a] Dibble Lake staff gage measurement from top of ice surface.

[b] Big Twin Lake elevation surveyed at edge of open-water.

Table B-2
Field Investigations - Thompson Creek Discharge Measurements
Additional Hydrogeologic Data Collection and Evaluation
TLAC Water Right Application G4-34915
Winthrop, Washington

	Dec. 2007 (cfs)	May 2008 (cfs)
Reach 1 (Station 1U to 2UU)		
Station 1U	0.94	1.75
Diversions (Station 1U to 1D)	0.08	1.58
Inflow	0	0
Station 2UU	0.85	0.17
Gain (+) or Loss (-)	**-0.01**	**0**
Reach 2 (Station 2UU to 2D)		
Station 2UU	0.85	0.17
Diversions	0	0
Inflow (Station 2UU to 2UD)	0.23	0
Station 2D	0.5	0.06
Gain (+) or Loss (-)	**-0.58**	**-0.11**
Reach 3 (Station 2D to 3 & 4U)		
Station 2D	0.5	0.06
Diversions	0	0
Inflow	0	0
Station 3 + Station 4U	1.47	1.56
Gain (+) or Loss (-)	**0.97**	**1.5**
Sinkhole		
Gain (+) or Loss (-)	**-0.3**	**-0.23**
Reach 4 (Station 4U to 4DD)		
Station 4U	1.15	1.18
Diversions (Station 4DU to 4D)	0	0.76
Inflow	0	0
Station 4DD	0.56	0.28
Gain (+) or Loss (-)	**-0.59**	**-0.14**

Station Name	X Coordinate (SPS83)	Y Coordinate (SPS83)	Dec. 2007 Discharge (cfs)	May 2008 Discharge (cfs)[1]
1U	1706449.7	1131399.9	0.94	1.75
1D	1706552.3	1131327.4	0.86	-
2UU	1710149.1	1130423.4	0.85	0.17
2UD	1710149.1	1130423.4	1.08	-
2D	1713592.7	1131621.2	0.50	0.06
3	1713804.9	1133810.3	0.30	0.23
4U	1715005.2	1132810.0	1.15	1.33/1.18
4DU	1719415.3	1132556.5	-	1.06
4D	1720002.7	1132633.8	-	0.30
4DD	1721750.4	1132782.3	0.56	0.28

Notes:
[1]Discharge measurements were collected at Station 4U on both May 6th and May 8th.

Table B-3

Field Investigations - Groundwater Elevation Data (Aug. 2006, Dec. 2007 and May 2008)

Additional Hydrogeologic Data Collection and Evaluation
TLAC Water Right Application G4-34915
Winthrop, Washington

Name	Short Name	X Coordinate (SPS83)	Y Coordinate (SPS83)	MP Elevation (NGVD29)	Stick-up (ft)	Ground Elevation (ft MSL)	Date	Groundwater Level (ft)	Static Groundwater Level (y/n)	Groundwater Elevation (ft MSL)	Date	Groundwater Level (ft)	Static Groundwater Level (y/n)	Groundwater Elevation (ft MSL)	Change in Groundwater Elevation (ft)	Date	Groundwater Level (ft)	Static Groundwater Level (y/n)	Groundwater Elevation (ft MSL)	Change in Groundwater Elevation (ft)
Original Water Level Monitoring Network Wells (August 2006)																				
34N/21E-2F01	2F01	1719172.8	1143850.0	1759.2	2	1757.2	8/29/06	37.83	Y	1721.4	-	-	-	-	-	-	-	-	-	-
34N/21E-3M07	3M07	1711624.5	1146381.0	1785.8	2.3	1783.5	8/29/06	19.44	Y	1766.3	12/21/07	16.92	Y	1768.9	2.5	5/7/08	16.09	Y	1769.7	0.8
34N/21E-3P01	3P01	1715052.0	1143918.1	1883.0	3	1880.0	9/1/06	77.49	N	1802.5	12/19/07	77.43	N	1805.6	3.1	5/5/08	77.54	N	1805.5	-0.1
34N/21E-10D05	10D05	1712306.9	1143306.1	1821.2	2.7	1818.5	8/30/06	46.39	Y	1774.9	12/19/07	47.05	Y	1774.2	-0.7	5/7/08	46.9	Y	1774.3	0.1
34N/21E-10E03	10E03	1712137.5	1141733.1	1822.2	2.45	1819.8	8/30/06	42.72	Y	1779.5	12/18/07	43.67	Y	1778.6	-1.0	5/7/08	43.98	Y	1778.3	-0.3
34N/21E-10G03	10G03	1715641.9	1142536.7	1816.8	1.59	1815.2	8/29/06	8.56	Y	1808.2	12/18/07	9.1	Y	1807.7	-0.5	5/5/08	8.79	Y	1808.0	0.3
34N/21E-10G04	10G04	1714903.8	1142145.3	1873.5	1.2	1872.3	8/31/06	54.5	N	1819.0	-	-	-	-	-	-	-	-	-	-
34N/21E-10H01	10H01	1715576.4	1141722.8	1845.0	2.16	1842.9	8/30/06	34.19	Y	1810.8	12/18/07	33.46	Y	1811.6	0.7	5/5/08	33.66	Y	1811.4	-0.2
34N/21E-10K01	10K01	1714900.7	1142148.2	1873.5	1.69	1871.8	8/29/06	34.3	Y	1839.2	12/18/07	34.05	Y	1839.5	0.3	5/5/08	33.8	Y	1839.7	0.3
34N/21E-10L01	10L01	1714508.0	1141780.1	1875.1	1.91	1873.2	8/29/06	69.38	Y	1805.7	12/18/07	62.56	Y	1812.5	6.8	5/8/08	62.86	Y	1812.2	-0.3
34N/21E-10Q02	10Q02	1714087.2	1140896.0	1886.4	1.83	1884.5	8/30/06	103.17	Y	1783.2	12/18/07	101.93	Y	1784.4	1.2	5/8/08	102.57	Y	1783.8	-0.6
34N/21E-11D01[a]	11D01	1715751.1	1142213.6	1841.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34N/21E-11E01	11E01	1715907.7	1137798.0	1825.3	1.45	1823.8	8/30/06	29.86	Y	1795.4	12/18/07	29.65	Y	1795.6	0.2	5/5/08	29.33	Y	1796.0	0.3
34N/21E-11E02	11E02	1716356.0	1141536.1	1877.5	5.7	1871.8	8/29/06	65.35	Y	1812.1	12/20/07	65.22	Y	1812.3	0.1	5/5/08	64.94	Y	1812.5	0.3
34N/21E-11F03	11F03	1718202.7	1141477.3	1833.8	2.5	1831.3	8/30/06	8.76	N	1825.0	12/20/07	7.81	Y	1825.9	1.0	5/8/08	7.76	Y	1826.0	0.0
34N/21E-11P01	11P01	1716414.0	1138560.9	1853.3	1.93	1851.4	8/29/06	46.42	Y	1806.9	-	-	-	-	-	-	-	-	-	-
34N/21E-14D03	14D03	1716468.7	1137520.6	1814.0	0.6	1813.4	8/29/06	16.5	Y	1797.5	12/18/07	15.08	Y	1798.9	1.4	5/7/08	14.52	Y	1799.4	0.6
34N/21E-14E03	14E03	1716801.2	1136414.3	1850.8	2.22	1848.6	8/28/06	60.62	N	1790.2	12/19/07	57.11	N	1793.7	3.5	5/7/08	58.32	Y	1792.5	-1.2
34N/21E-14E05	14E05	1716636.2	1138568.4	1865.8	2.16	1863.7	8/30/06	50.52	Y	1815.3	12/18/07	49.02	Y	1816.8	1.5	5/5/08	49.35	Y	1816.5	-0.3
34N/21E-14F04	14F04	1717407.8	1138800.4	1867.2	2.14	1865.1	8/29/06	79.74	Y	1787.5	12/18/07	75.63	Y	1791.6	4.1	5/5/08	75.83	Y	1791.4	-0.2
34N/21E-14L01	14L01	1713942.9	1137833.9	1912.4	1.6	1910.8	8/29/06	133.5	N	1778.9	-	-	-	-	-	5/5/08	126.3	Y	1786.1	-
34N/21E-14M02	14M02	1717176.2	1134766.6	1852.8	1.87	1850.9	8/29/06	33.71	Y	1819.0	12/18/07	34.05	Y	1818.7	-0.3	-	-	-	-	-
34N/21E-14P02	14P02	1718034.4	1133751.4	1827.7	2.27	1825.5	8/29/06	32.17	Y	1795.6	12/20/07	37.19	N	1790.5	-5.0	5/7/08	38.95	Y	1788.8	-1.8
34N/21E-14P03	14P03	1717856.1	1134011.1	1813.6	2.31	1811.3	8/29/06	17.81	Y	1795.8	12/20/07	22.93	Y	1790.7	-5.1	5/7/08	24.72	Y	1788.9	-1.8
34N/21E-15A04	15A04	1713398.5	1139718.1	1902.8	1.5	1901.3	8/29/06	120.14	Y	1782.6	12/18/07	120.01	N	1782.8	0.1	5/5/08	120.97	Y	1781.8	-1.0
34N/21E-15B10	15B10	1713631.9	1140023.5	1920.2	1.28	1918.9	8/29/06	138.96	Y	1781.2	12/18/07	138.72	Y	1781.5	0.2	5/5/08	139.41	Y	1780.8	-0.7
34N/21E-15B11	15B11	1714328.5	1138252.9	1912.8	2.19	1910.6	8/29/06	125.78	Y	1787.0	12/18/07	123.78	Y	1789.0	2.0	5/5/08	124.83	Y	1788.0	-1.0
34N/21E-15K02	15K02	1713584.7	1135724.5	1815.2	0.95	1814.3	8/29/06	23.03	Y	1792.2	12/21/07	22.3	Y	1792.9	0.7	5/7/08	23.14	Y	1792.1	-0.8
34N/21E-15R01	15R01	1716135.8	1134110.2	1882.1	1.69	1882.1	8/29/06	89.81	Y	1792.3	-	-	-	-	-	5/7/08	91.95	Y	1791.8	-
34N/21E-22A03	22A03	1715244.7	1132545.3	1895.1	1.57	1893.5	8/29/06	99.87	Y	1795.2	12/20/07	101.81	Y	1793.2	-1.9	5/7/08	103.96	Y	1791.1	-2.2
34N/21E-23D01	23D01	1718617.4	1133958.2	1877.3	3.15	1874.1	8/29/06	58.72	Y	1818.5	12/20/07	60.73	Y	1816.5	-2.0	5/7/08	59.83	Y	1817.4	0.9
34N/21E-23K02	23K02	1720022.9	1130476.0	1822.3	3.65	1818.7	8/28/06	39.95	Y	1782.4	12/20/07	41.59	Y	1780.7	-1.6	5/9/08	43.35	Y	1779.0	-1.8
Additional Water Level Monitoring Network Wells (December 2007)																				
34N/21E-14R04	14R04	1721311.7	1133340.2	1763.0	1.12	1761.9	-	-	-	-	12/19/07	66.6	Y	1696.4	-	5/7/08	69.31	Y	1693.7	-2.71
34N/21E-15R05	15R05	1715754.3	1134516.4	1876.4	1.92	1874.5	-	-	-	-	12/18/07	83.62	Y	1792.8	-	5/8/08	85.32	Y	1791.1	-1.7
34N/21E-22A02	22A02	1715119.4	1132893.9	1878.3	3.02	1875.3	-	-	-	-	12/19/07	85.42	Y	1792.9	-	5/7/08	87.59	Y	1790.7	-2.17
34N/21E-22E01	22E01	1711053.5	1130650.1	1993.1	0.74	1992.4	-	-	-	-	12/18/07	33.79	N	1959.3	-	5/7/08	34.29	Y	1958.8	-0.5
34N/21E-22E02	22E02	1713123.1	1131098.1	1948.4	0.27	1948.2	-	-	-	-	12/18/07	24.97	Y	1923.5	-	5/7/08	23.55	Y	1924.9	1.42
34N/21E-23A02	23A02	1721536.3	1132844.9	1744.8	9.35	1735.5	-	-	-	-	12/18/07	49.8	Y	1695.0	-	5/7/08	52.8	Y	1692.0	-3
34N/21E-23D03	23D03	1717304.7	1132281.2	1869.2	1.25	1867.9	-	-	-	-	12/18/07	79.1	Y	1790.1	-	5/7/08	80.95	Y	1788.2	-1.85
34N/21E-23K01	23K01	1720952.6	1129145.4	1823.7	1.83	1821.9	-	-	-	-	12/18/07	36.29	Y	1787.5	-	5/7/08	53.3	N	1770.4	-17.01
34N/21E-23L01	23L01	1718585.2	1130782.1	1857.4	1.4	1856.0	-	-	-	-	12/18/07	69.2	Y	1788.2	-	5/7/08	71.42	Y	1785.9	-2.22
34N/21E-24C02	24C02	1723372.8	1133161.8	1702.4	2.95	1699.5	-	-	-	-	12/18/07	17.27	Y	1685.2	-	5/8/08	15.42	Y	1687.0	1.85
34N/21E-24E01	24E01	1721663.2	1131278.8	1744.1	1.62	1742.4	-	-	-	-	12/18/07	59.5	Y	1684.6	-	5/7/08	59.11	Y	1684.9	0.39
Additional Water Level Monitoring Network Wells (May 2008)																				
34N/21E-14N04	14N04	1716452.8	1133398.4	1849.3	1.7	1847.6	-	-	-	-	-	-	-	-	-	5/7/08	59.09	Y	1790.2	-
34N/21E-15R06	15R06	1715495.4	1133722.0	1882.4	0.95	1881.4	-	-	-	-	-	-	-	-	-	5/7/08	97.09	Y	1785.3	-
34N/21E-15L01	15L01	1715952.5	1133625.4	1879.6	-4	1883.6	-	-	-	-	-	-	-	-	-	5/7/08	88.86	Y	1790.7	-
34N/21E-15J05	15J05	1715555.5	1135705.4	1810.1	1.6	1808.5	-	-	-	-	-	-	-	-	-	5/7/08	18.76	Y	1791.3	-
34N/21E-22A04	22A04	1715793.5	1132098.2	1887.4	1.9	1885.5	-	-	-	-	-	-	-	-	-	5/7/08	98.62	Y	1788.8	-
34N/21E-22A05	22A05	1715802.9	1132839.3	1879.2	1.65	1877.6	-	-	-	-	-	-	-	-	-	5/7/08	89.16	Y	1790.1	-
34N/21E-23NW02[b]	23NW02	1717476.3	1131400.9	1865.3	-	-	-	-	-	-	-	-	-	-	-	5/8/08	77.88	Y	1787.4	-
34N/21E-23F03	23F03	1716759.5	1131811.7	1884.2	2.7	1881.5	-	-	-	-	-	-	-	-	-	5/7/08	96.2	Y	1788.0	-

Notes:

Shaded values indicate non-static groundwater level measurements.

[a] Well was welded shut. No static groundwater level measurement was taken; well location used only for delineation of hydrostratigraphic units.

[b] No casing stick-up measurement taken.

APPENDIX C

Model Results by Scenario for Various TLAC Withdrawals Capacities

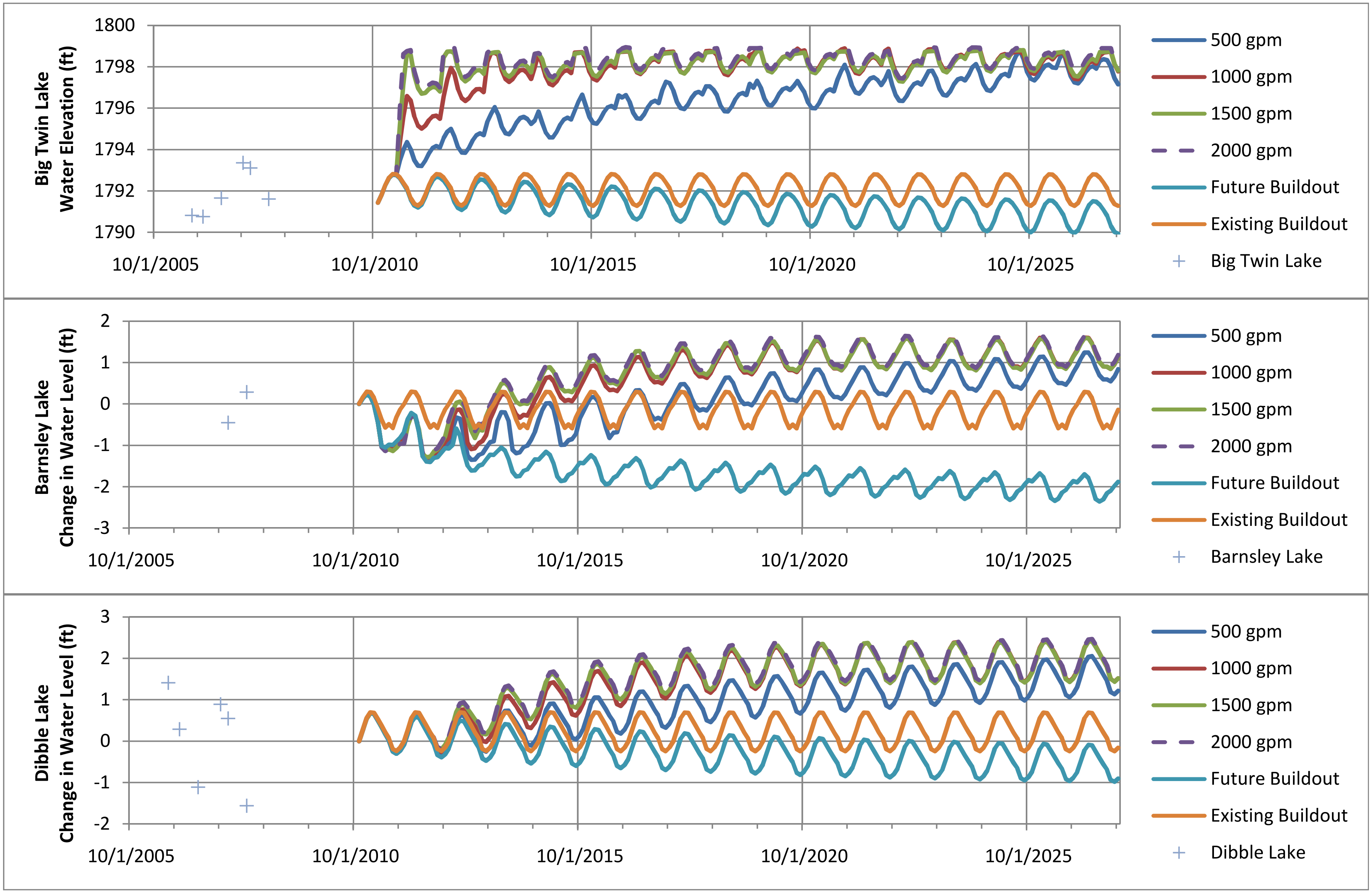


Figure C.1
Observed and Calculated Lake Levels - WDFW Scenario
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
10/8/2008
P:\Twin Lakes\2008 Report Update\TLACPumping3_WDFW3.xlsx

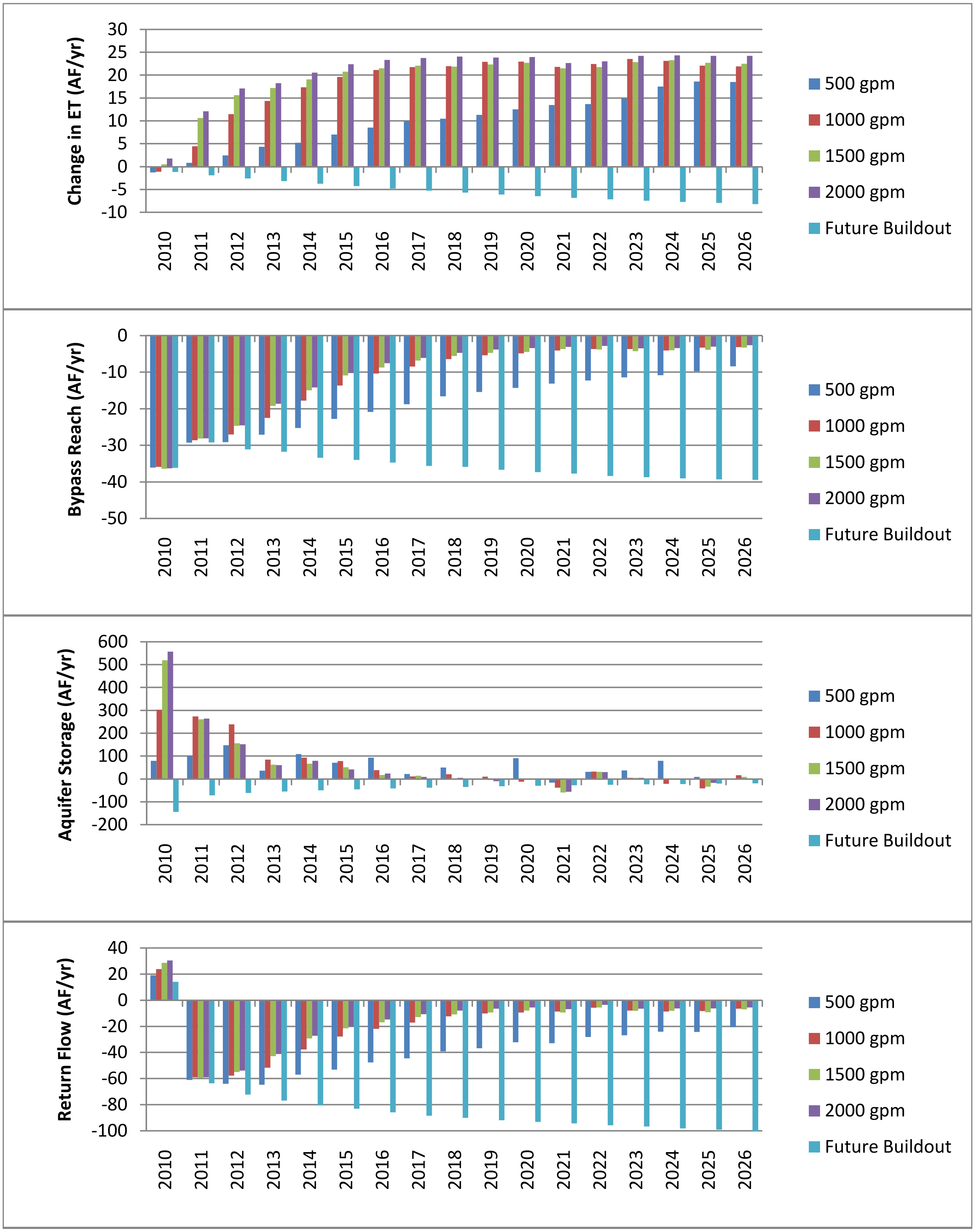
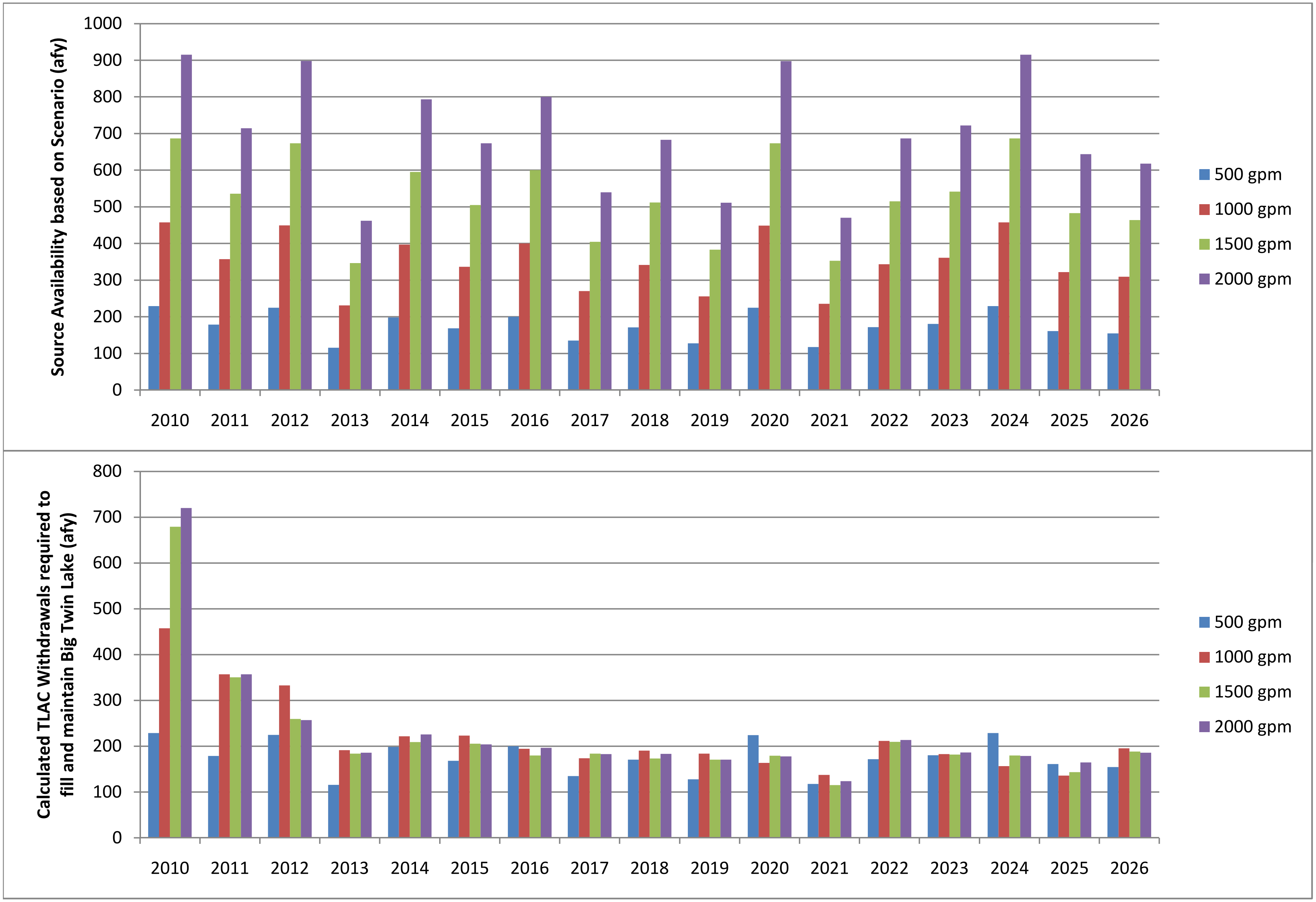


Figure C.2
Annual Water Budget for WDFW Scenario
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
5/27/2009
P:\Twin Lakes\2008 Report Update\TLACPumping3_WDFW4.xlsx



Aspect Consulting, LLC
12/16/2009
P:\Twin Lakes\2008 Report Update\TLACPumping3_WDFW4.xlsx

Figure C.3
Potential and Calculated TLAC Withdrawals - WDFW/MIF Scenario
TLAC Water Right Evaluation

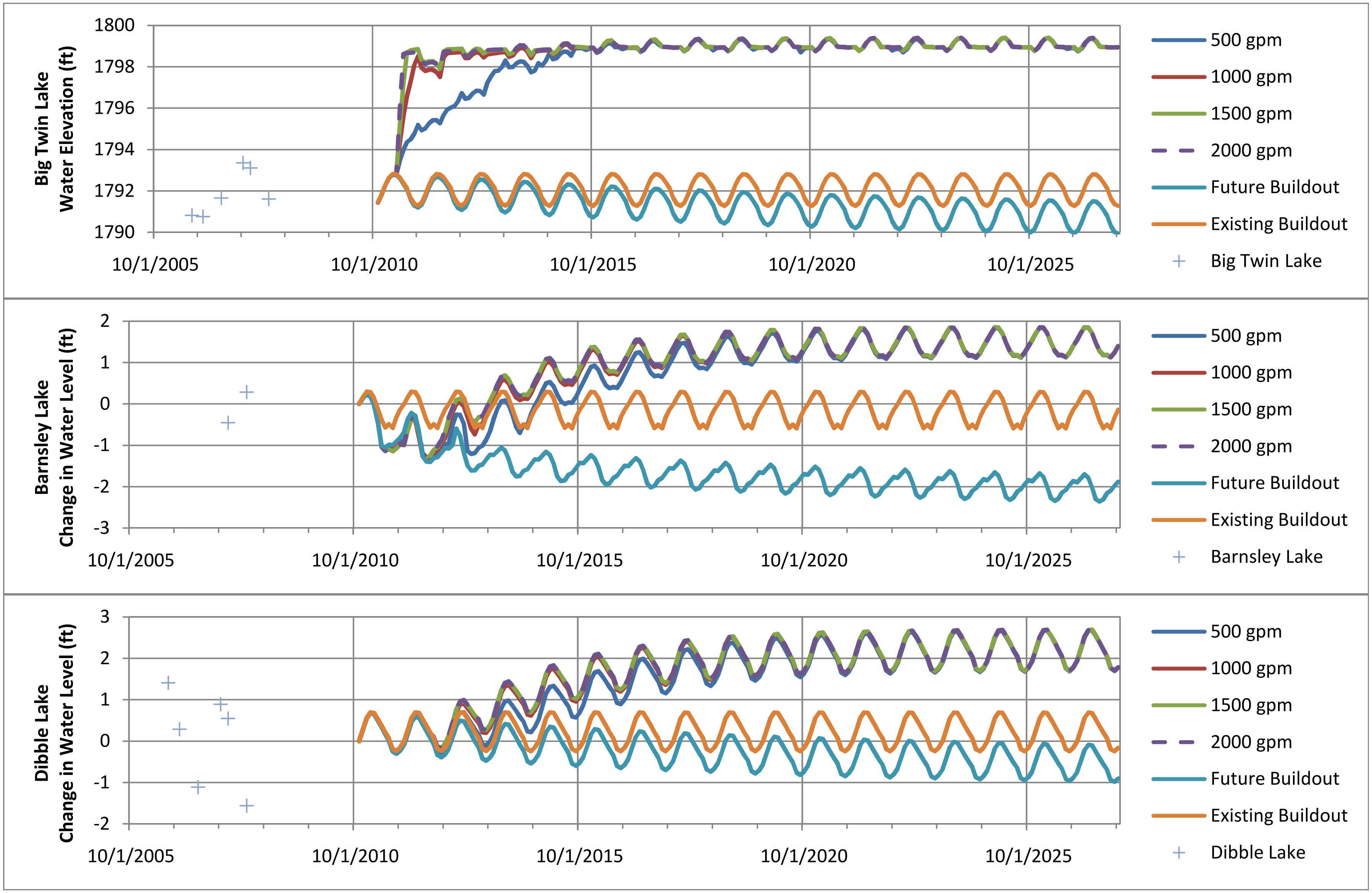


Figure C.4

Observed and Calculated Lake Levels - WDFW/WAC Scenario

TLAC Water Right Application

Winthrop, Washington

Aspect Consulting, LLC

10/8/2008

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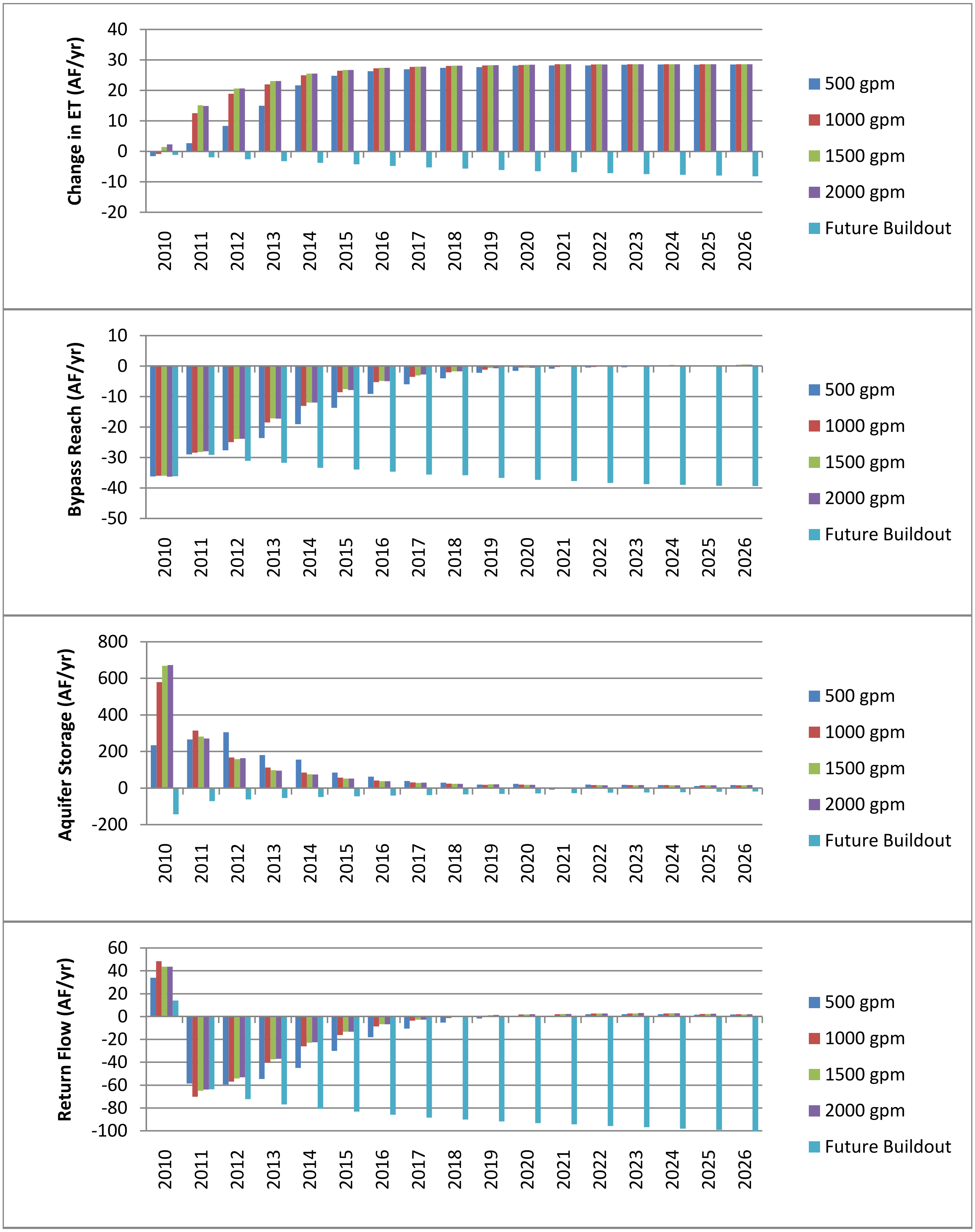
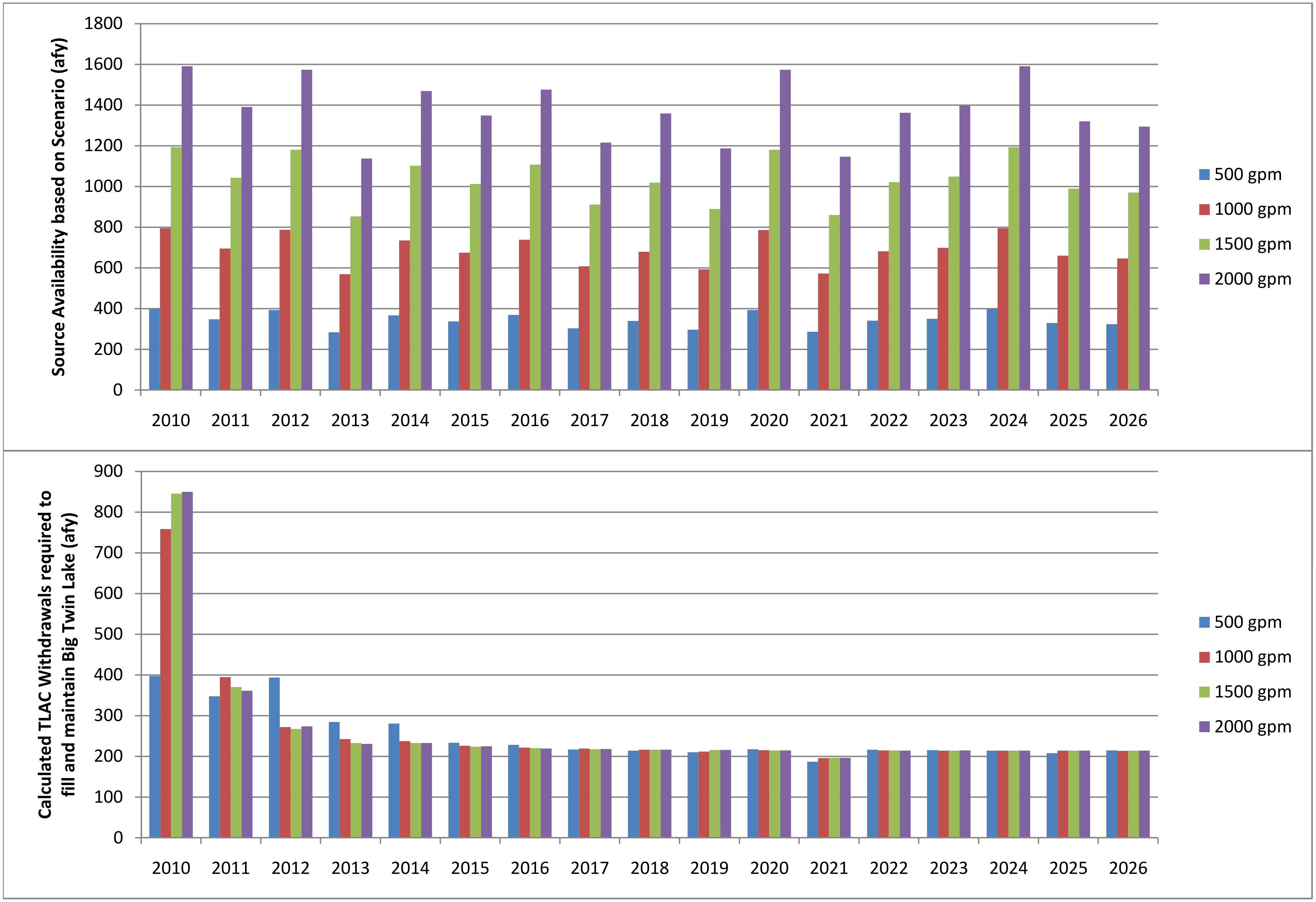


Aspect Consulting, LLC
5/27/2009
P:\Twin Lakes\2008 Report Update\TLACPumping3_WDFW_MIFCombo4.xlsx

Figure C.5
Annual Water Budget for WDFW/WAC Scenario
TLAC Water Right Application
Winthrop, Washington



Aspect Consulting, LLC
12/16/2009
P:\Twin Lakes\2008 Report Update\TLACPumping3_WDFW_MIFCombo4.xlsx

Figure C.6
Potential and Calculated TLAC Withdrawals - WDFW/MIF Scenario
TLAC Water Right Evaluation

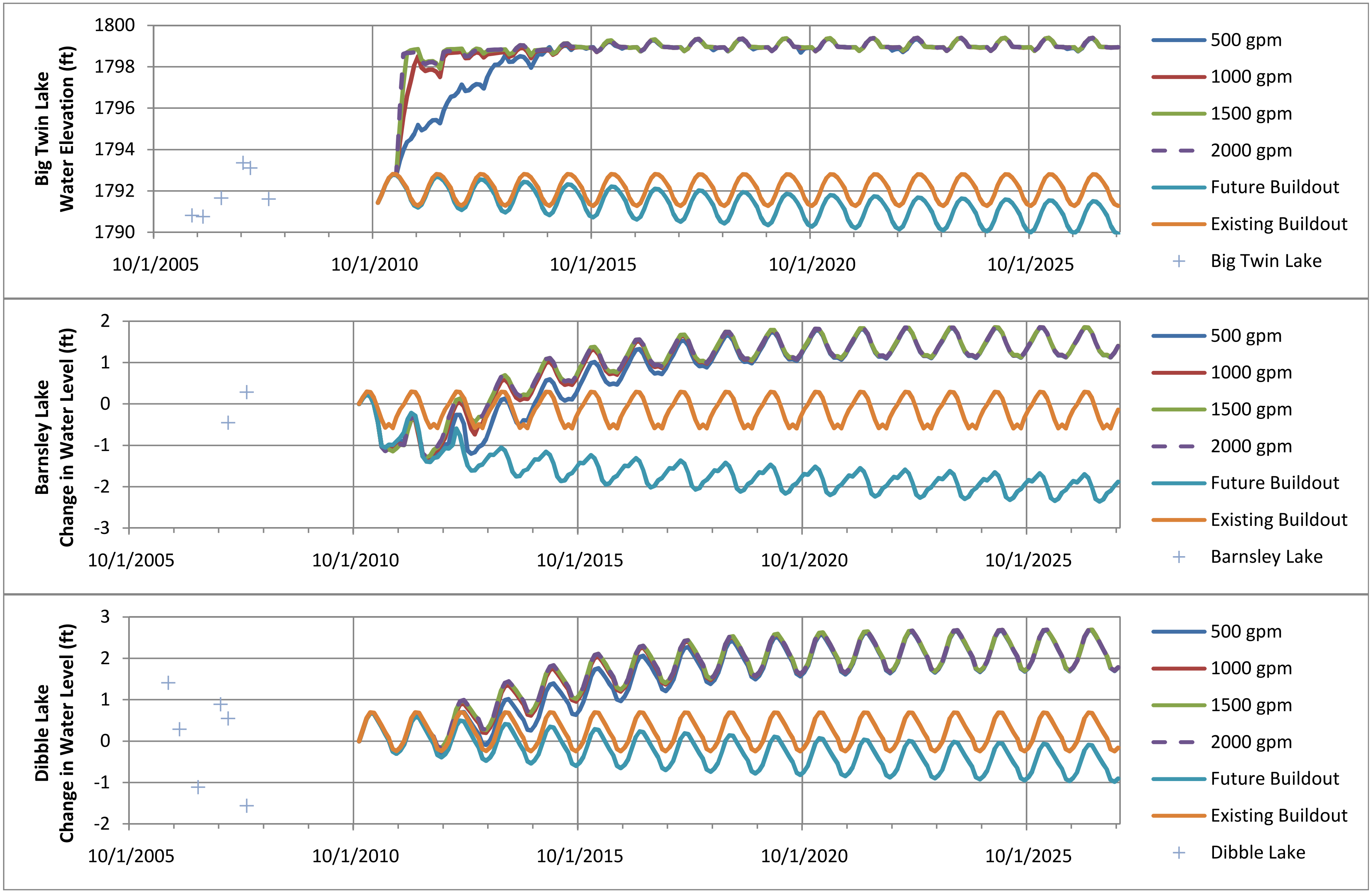


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Figure C.7
Observed and Calculated Lake Levels - WAC Scenario
TLAC Water Right Application
Winthrop, Washington

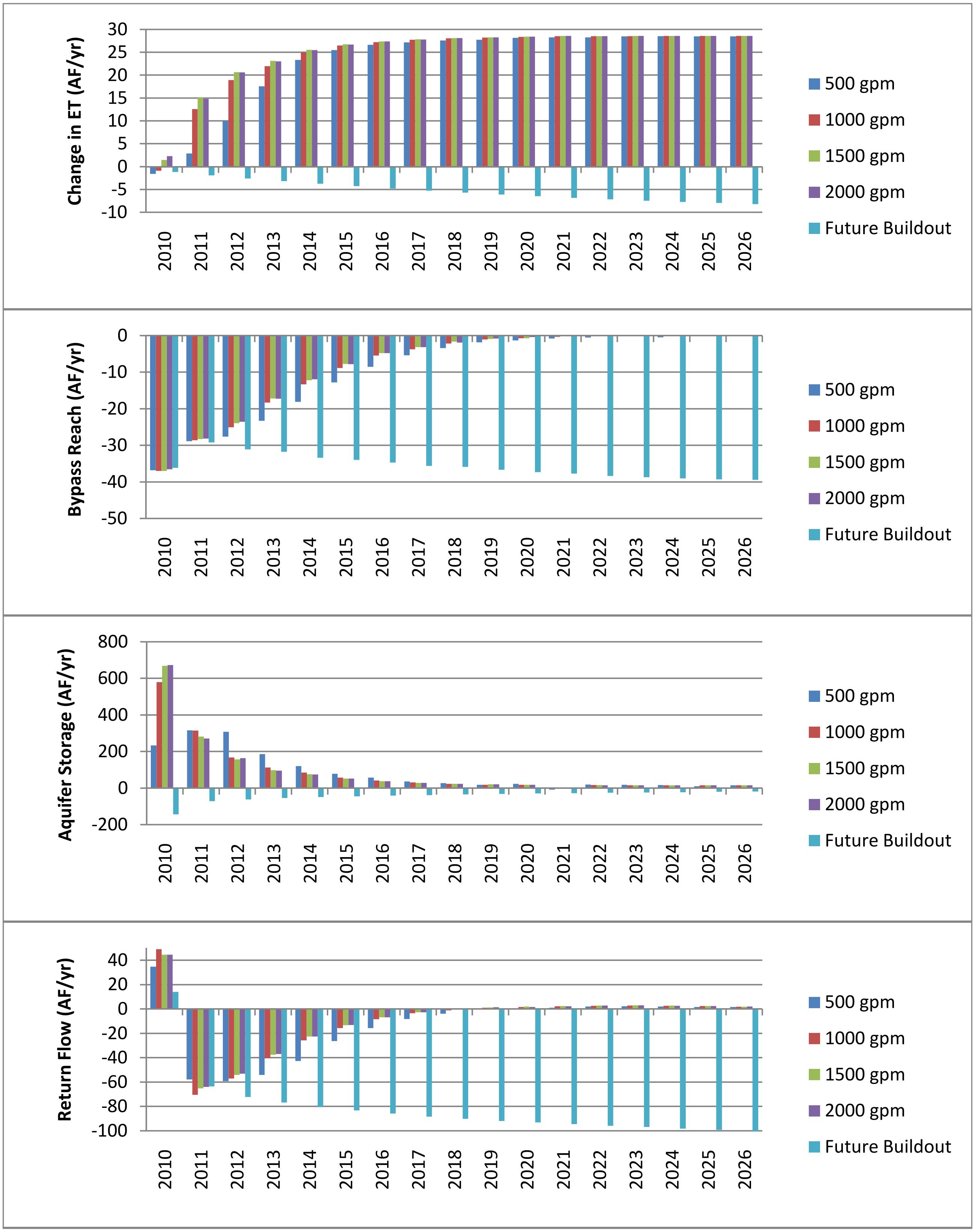

Figure C.8
Annual Water Budget for WAC Scenario
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
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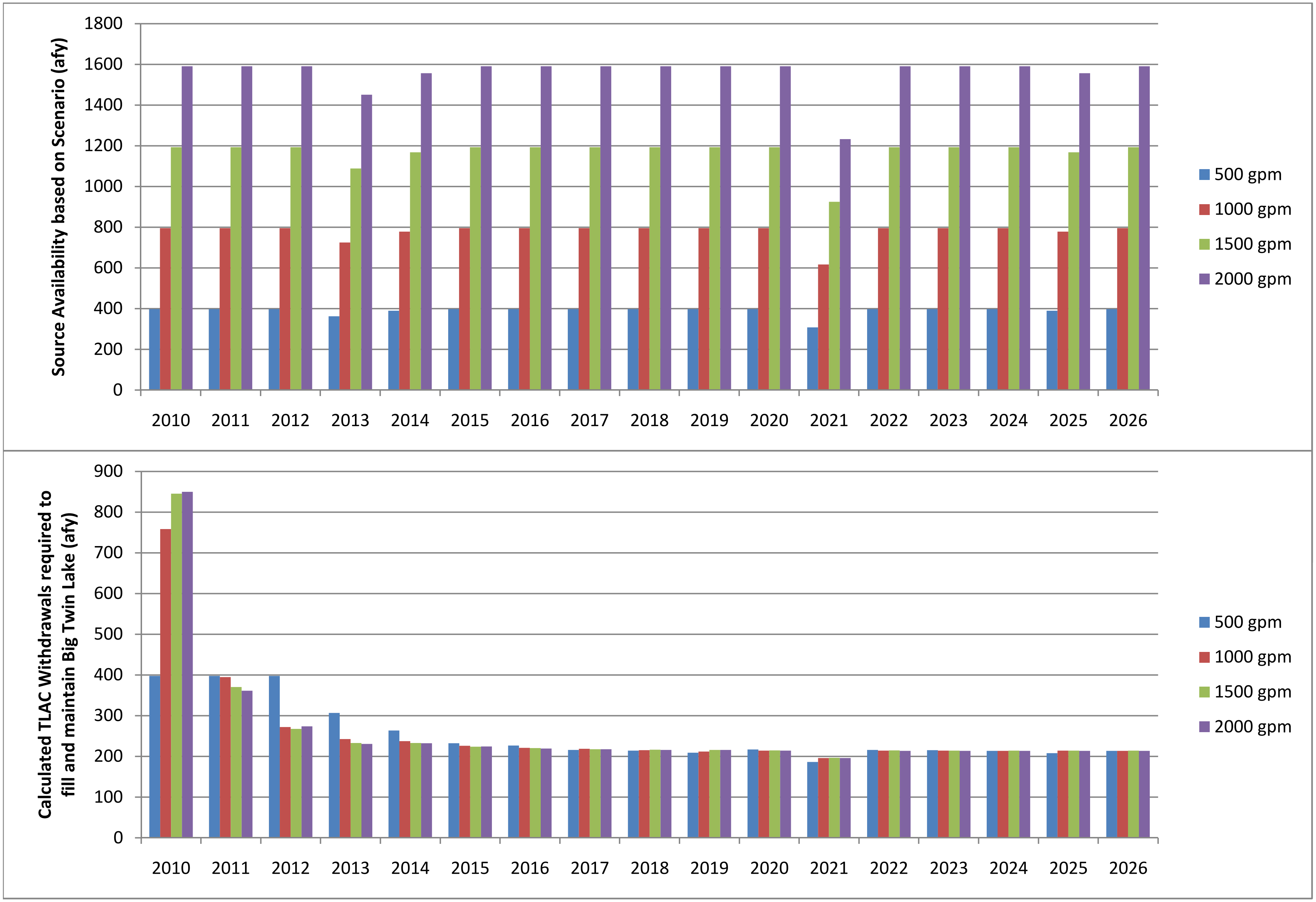
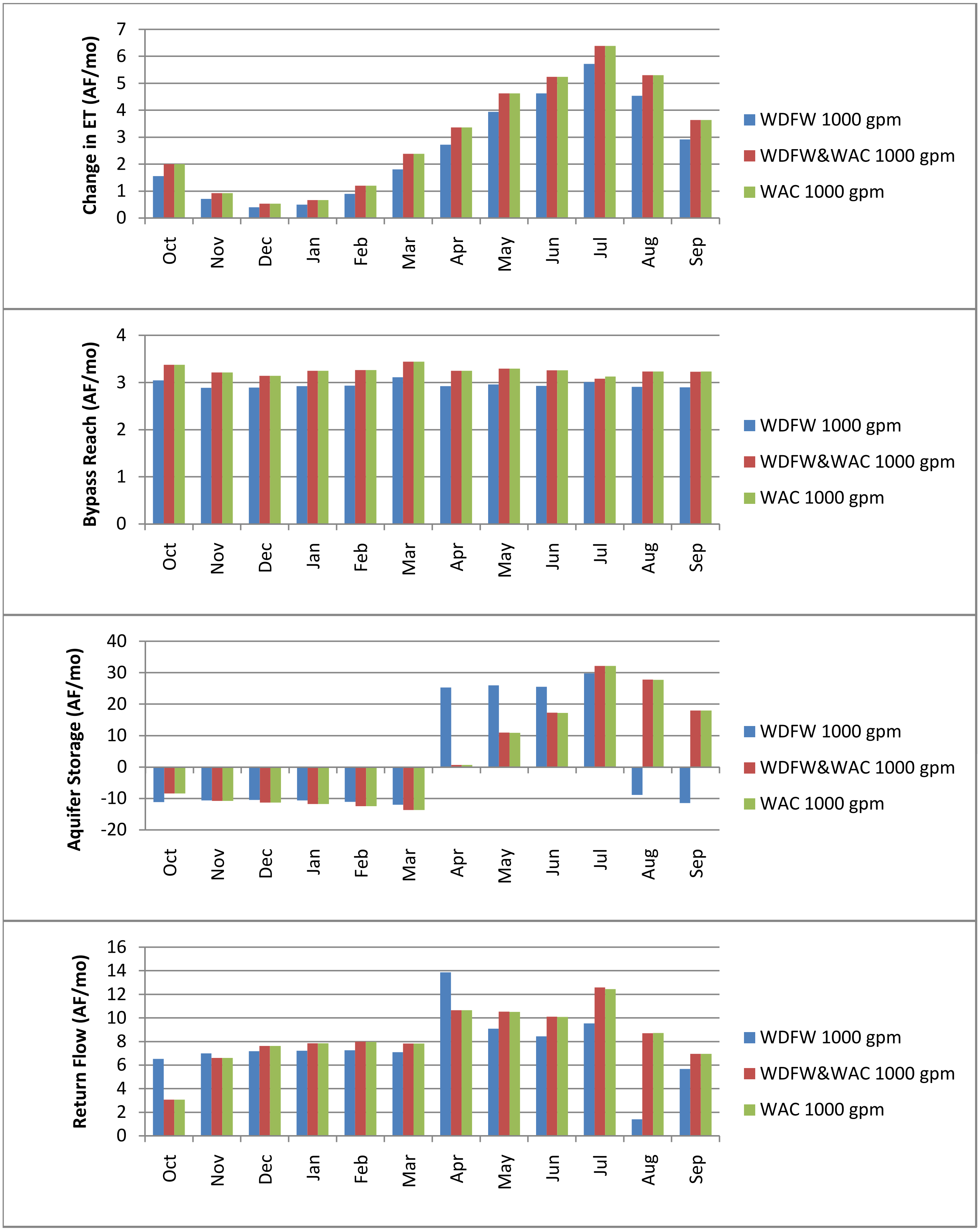
P:\Twin Lakes\2008 Report Update\TLACPumping3_MIF4.xlsx



Aspect Consulting, LLC
12/16/2009
P:\Twin Lakes\2008 Report Update\TLACPumping3_MIF4.xlsx

Figure C.9
Potential and Calculated TLAC Withdrawals - WDFW/MIF Scenario
TLAC Water Right Evaluation



Note: Water budget relative to baseline conditions. Values based on average of last five years of model simulation.

Figure C.10
Monthly Water Budgets for Predictive Scenarios
TLAC Water Right Application
Winthrop, Washington

Aspect Consulting, LLC
5/27/2009
P:\Twin Lakes\2008 Report Update\TLACComparison.xlsx

Appendix D

Draft Report Comments

D.1 Report Comments

Comments on the October 10, 2008 draft report received from TLAC and Ecology are included in this appendix. Comments related to:

- Timing of streamflow benefit;
- Influence of Elbow Creek Coulee on Thompson Creek stream flow and recharge from Thompson Creek; and,
- Other minor comments that required additional explanation

were addressed in this document. Comments related to aquifer storage as part of the mitigation quantities are addressed in the companion planning memorandum.

TLACs comments related to a slow fill scenario under WAC and the potential use of infiltration galleries will be addressed in the storage analysis currently underway.

TWIN LAKES AQUIFER COALITION
25B Snowberry Lane
Winthrop, WA 98862
November 12, 2008

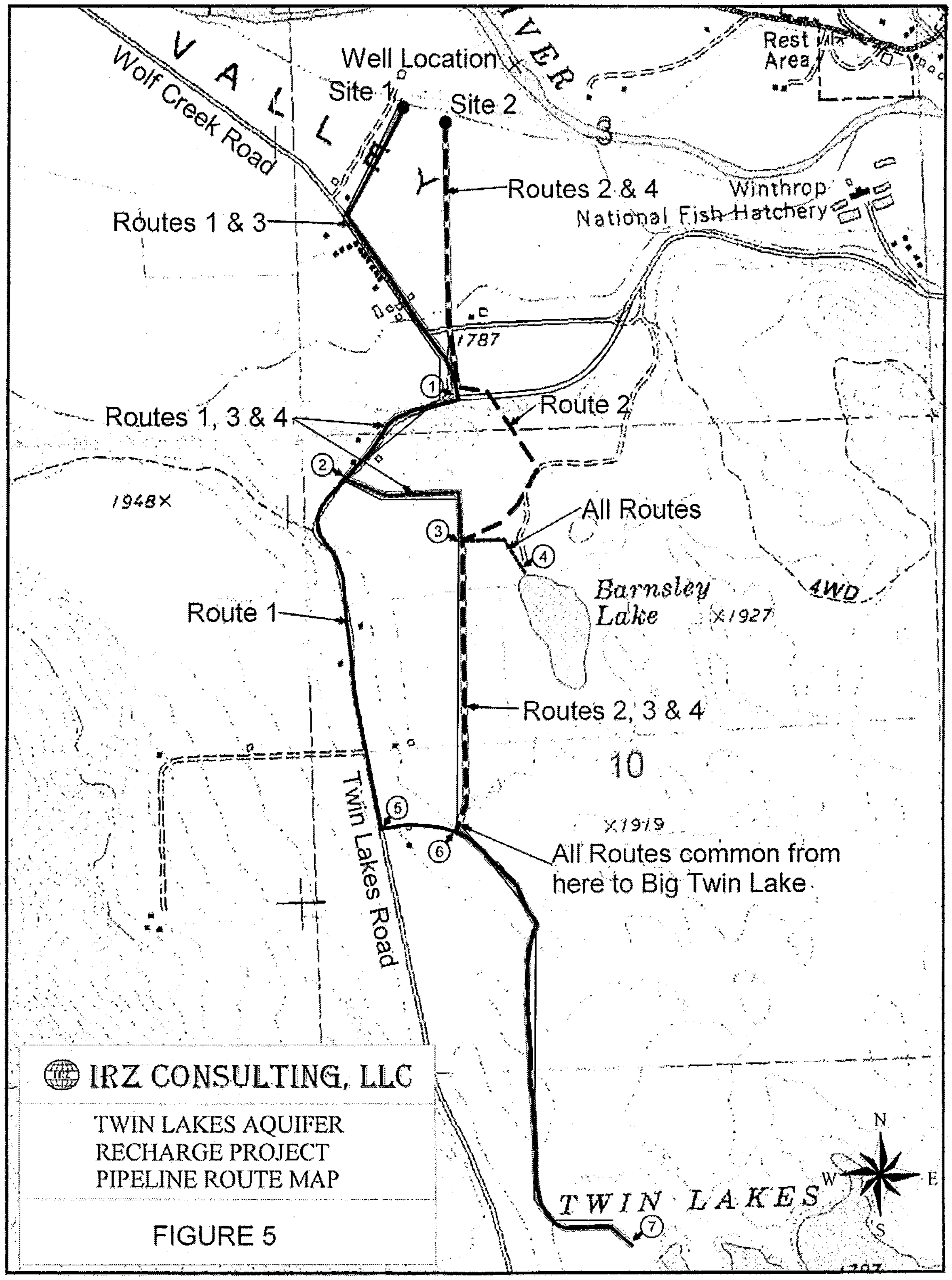
Tim Flynn
ASPECT CONSULTING
179 Madrone Lane North
Bainbridge Island, WA 98110

Dear Tim:

Our board reviewed the October 10th draft report. In general we thought it favored a positive conclusion that the project could be implemented under the Hillis Rule as an environmentally beneficial project. The exception is the requirement that the project needs to be water budget neutral. We noticed that this requirement has been reduced. The December 2006 draft noted evaporative losses to be between 66 and 169 afy and the southward seepage to be 50 afy. This would mean to be water budget neutral a mitigation water right of about 210 afy would be required. The October 2008 draft has reduced this amount to about 69 afy. Our question is how will the required mitigation water right be determined? Would the water right have to provide the mitigating amount only during the diversion period or over the period of time expected for the ET and bypass water amounts are achieved?

In the Memorandum we noticed that the proposed pipeline route is incorrect. Haub Brothers made it clear that their desired easement should run parallel to Foghorn Ditch to the hatchery and then follow the west boundary along the fence line of their property to the County road. From there it was to follow the Haub easement off Twin Lakes Rd past Eagle Chalets which then turns south at the Haub fence line past Barnsley Lake. This is called Barnsley Lake Dr. From there it goes to Shooting Star Rd which connects to Twin Lakes Dr. From there it goes to W. Lupine Dr. (now called Barnaby Dr.) to the open space easement on the south end of the Sun Mountain Ranch Club development. From here the inlet stream is to be created to dump into the northwest bay of Big Twin Lake. Note route highlighted in red on attached figure. The pipe distance and cost for implementing this route needs to be made.

While this issue was not addressed in the scope of work Aspect discounted the infiltration galleries proposed by TLAC on the basis of WDFW's conditioning the permit to only discharge to Big Twin Lake. This is an unscientific answer that coddles the politics, but doesn't help TLAC adequately understand the best choices for improving the lake and aquifer environments. We prefer that a scientific answer be given in the text so we can better answer this question.



This question is important because you must show how filling the lakes and aquifer by one inlet into Big Twin will avoid the reservoir effect that makes using the lakes recreationally undoable and destabilizes bank vegetation.

On p. 23 of the draft it is noted that divergent groundwater flow in the vicinity of Big and Little Twin Lakes is likely caused by groundwater recharge from the lakes and nearby sink hole. The question we have is: "how do you know that all of the water flowing southward towards the high school would not be provided by the sink hole input?"

Lastly, the Barnsley Lake lateral was omitted in the analysis. We wanted to know what amount of water would be necessary to maintain the lake at the water line we noted during the survey. This was to include the amount needed which would be provided by a Barnsley Lake input. It was noted DOE and you decided to omit this. This was done without our consultation and it omits data we need to understand to decide upon an appropriate solution for Barnsley Lake. Again this seems to be decided on political motives rather than good science.

Our board has desired to give you a heads up on these points before the meeting so that we have adequate answers or can decide upon a good direction.

Sincerely,

Dick Ewing, Chair
Lori Triplett, Secretary
Ed Rhinehart, Treasurer
Steve Smith, Member at large
Fred Noyes, Member at large
Ben Johnson, Big Twin Campground

SUMMARY OF TLAC MEETING WITH ASPECT CONSULTING, DOE AND WDFW
Tuesday December 9, 2008, 10:00 AM to 1:00 PM

I. Aspect Consulting Report

Tim Flynn of Aspect reviewed the impacts of the new data collection effort on Assessment Report results. Barnsley Lake levels was shown to be 10 feet below Big Twin Lake. Thompson Creek discharge was reduced from 1 cfs to 0.25 cfs year round. It was discovered that soil permeability towards the High School was significantly less than previously observed. Thus in the bypass reach soil characteristics were acting as a dam.

The result of these finding showed that if Big Twin is filled to desired elevation Barnsley Lake would rise about 1.5 feet. Evaporation from the lakes was reduced from 82-169 afy to 24-30 fy. Lake seepage back to the Methow River was reduced from 274-393 afy to 125-139 afy. The mitigating water right needed to make the project water budget neutral was reduced from up to 219 afy to about 69 afy.

The Memorandum which is a new contribution to the Twin Lakes report developed three basic scenarios for filling the lakes and aquifer with their relative costs. While the project could be done with the 500 gpm option, Aspect pointed to the fact that the 1,000 gpm and 12 inch piping system offered the most flexibility for filling and maintaining the lakes. Also two wells were recommended to obtain the 1000 gpm and the flexibility to use a lesser amount to maintain the lakes when they are filled.

II. Comments on Report were then discussed, but answers were not fully given with the view that these inputs would be reviewed by Aspect and the Report edited to reflect the appropriate answers:

DOE/WDFW submitted comments. Some were housekeeping in nature relating to the Bill Drafting Guide and consistency in water right tracking nomenclature. Regarding the technical details of the report:

- Sensitivity analysis results need to be presented in a comprehensive and organized format to clearly understand model outputs
- The mountain front recharge component in Section 5.4.2 scenario 1 needs more discussion to understand this portion of the model output.
- Is the aquifer to be viewed as a single aquifer unit or a stratified one?
- How is the discharge through the bedrock ridge quantified regarding the bypass reach amount?
- Has higher secondary permeability's been considered in the bedrock barrier?
- Additional comments will be forthcoming from both departments

TWIN LACKS AQUIFER COALITION SUBMITTED THE FOLLOWING QUESTIONS AND COMMENTS:

I. Our view regarding choice of water management scenarios:

1) We question the wisdom of WDFW target flows which confine withdrawal for the lakes from April 1 to July 15 when instream flows are between 800 and 6,000 cfs.
   - The aquifer declines too early in the season to be of benefit to Methow River flows when they are lowest in the Fall.
   - Lake levels fluctuate too much to maintain consistent habitat around the lakes
   - These facts interfere with enjoyment of the recreational opportunities around lake and access to take advantage of recreational fishery.
2) Our preferred compromise is to take the necessary amount of water to fill the lakes during the WDFW flows, then only divert the necessary amount of water to maintain lake levels through September based upon base flows in WAC 173-548.
   - This would address WDFW's concerns to maintain a low impact on the Methow River later in the late season.
   - Would provide instream flow returns later in the fall which is more beneficial for fish
   - Addresses TLAC's concerns noted above regarding recreational access.
3) TLAC doesn't see the basis to not honor WAC 173-548 as the agreed to management for WIRA 48:
   - WAC 173-548-02 (4): "All rights hereafter established shall be subject to the base flows established in WAC 173-548-020 (1) – (3).
   - DOE, WDFW and Okanogan County reaffirmed through the Watershed Planning process 90.82 that WAC 173-548 would remain as the water management tool for the basin with the exception of the proposed reallocation of the 2 cfs reservation.

Does the present assessment support this as the better conclusion?

1) WAC 173-548+WDFW flows would provide water to fill lakes more often than only WDFW flows.
   - WAC base flows would permit withdrawal greater than 80% of the time....water could technically be withdrawn nearly year round.
   - WDFW flows only would restrict the period of withdrawal from April 1 to July 15th with the expectancy of being able to withdraw 53-90% of the time.

2) Report does not provide information to quantify instream benefit with regard to quantity and timing of this benefit.

3) Storage capacity once lakes and aquifer are filled is 139 fy. In dry years even though lakes are not filled there would still be ground water outflow to the Methow River until present observed equilibrium is attained. This could be up to 800 af.

4) It is known from other reports such as the USGS groundwater/surface water study that groundwater inflow is the primary contributor to stream flows in late Fall and Winter.

5) Lake fluctuation for WDFW fill scenario is 1-2 feet per year as noted on p 48. No figure is given for the WAC/WDFW scenario, but figure 5.4.1 shows lake fluctuation is considerably less than the 1-2 feet. This addresses TLAC's desired conditions for good habitat around lakes and lake access.

Our preferred scenario is to divert under WAC 173-548 until September with the goal that the lakes would be full at the end of the diversion period not at the beginning as the WDFW target flows and the combined WDFW/WAC diversion force us to do.
1) This is what the ditch leakage did.
2) The lake would decline into the fall and winter providing maximum recharge at lowest Methow stream flows.
3) If Spring run off and rainy periods which can happen earlier in the spring/summer create excess contribution to the lakes than planned, there is a place for the water to go without flooding the campground.

It was noted by Aspect that it would be better to fill the lakes and aquifer early in the diversion period. Aspect is to provide in the report the rationale for this. Thus TLAC's compromise position would become the preferred option.

II. Questions in addition to the above that must be addressed in Report finalization:

1) The report memorandum notes that the substantial environmental benefit of the project is confined to the enhancement of the trophy trout fishery. Since aquifer restoration and recovery of associated aquatic habitat and wetlands must accompany this enhancement why are these excluded from the environmental benefit? Also the project is a small storage project that contributes to Methow River flows by returning the water at a later more critical time. Is it not possible to include a total package of benefits?
2) Is it correct that only two mitigations have to be implemented to make project water budget neutral: 1) a water right for water lost due to bypass reach and evaporation of 69 afy and 2) requiring future wells be drilled to saturated bedrock? Please clarify in report and answer: how will the required mitigation water right be determined? This ties in with question 3 below.
3) What does the actual instantaneous quantity for the mitigation water right have to be and in what time period does that water have to be delivered?
4) Barnsley Lake was omitted in the analysis. It was noted that Barnsley will only be raised 1.5 feet. How does this compare with the observed water level due to former irrigation canal leakage? The report to our knowledge did not include the restoration level as was noted for Big Twin. The measurement while taken was not included in Appendix B. We want to know what amount of water is necessary to maintain Barnsley Lake at this noted water level.
5) The time frame for the water return to the Methow was only given in rough figures as 139 afy once the aquifer is filled.

a. TLAC wanted to know once the lakes were filled during the filling scenarios at what point did the water reach its return rate where the return rate equals the input minus the evaporation?
b. What is this return rate and how does it tail out once pumping is stopped?
c. The scale of the lake levels in figure C.1 is too small. A typical one year scale needs to be employed. Similarly a larger scale hydrograph of the return rate and how it tails out over a year needs to be included for each scenario.
d. You need to clarify whether or not this is true for all scenarios.
e. The timing for this return needs to be noted for each scenario
f. In dry years when the lakes can't be filled, the potential contribution to Methow stream flows needs to be noted and what the decline rate will be as the aquifer lowers. We can assume that potentially 800 af could be contributed as the aquifer drops the present 7-12 feet.

6) To what extent does the sink hole contribute to the 39 afy by pass? How do you know that this source doesn't provide all the bypass amount?
7) P. 23 Has new data confirmed Waitt's thesis? It seems like Barnsley, Twin Lakes, and Dibble Lakes are in some form of conductivity with each other as observed by Waitt.
8) P. 49: Under the WDFW target flows/WAC 173-548 base flows it is stated that 220 afy is required to maintain lake levels once filled.
    a. What is the necessary pumping rate to fill lakes by July 15th?
    b. What is the maintenance pumping rate to maintain lake levels through September?
    c. At what point as in question 5 does the return rate occur and off set the water introduced into the lakes?
    d. The memorandum did not include the mechanics of how that lake levels would be maintained: will the pump be turned on all the time putting in a lesser amount such as 250 gpm or will it only pump 1000 gpm as needed until the lake reaches a certain level?
9) The report only notes the seasonal fluctuation for WDFW target flows. Can you also include the seasonal fluctuation for scenarios 3 and 4?
10) The WAC 173-548 only scenario was run identically to WDFW and WDFW/WAC scenarios where lakes are filled early in the season. The WAC 173-548 scenario TLAC had envisioned filling the lakes by September as was historically done by the canal leakage. Can you change this scenario to reflect this as it only has meaning in this analysis if it offers this difference of perspective?
11) Several changes were noted in the report and an extension was granted without consultation with TLAC. We are wondering why this was not done and who is the report really for? Note that it is only prepared for DOE, why did it not also include TLAC?
12) The proposed route of the delivery system is incorrect in the Memorandum. This needs to be corrected in the report to reflect the desires of Haub Brothers Estates as noted in the November 12, 2008 letter to Aspect Consulting.

13) The report discounts the infiltration galleries. No rationale is given for this. This should be scientifically noted in the report to assure those who are going to be affected by the project understand that filling Big Twin only will achieve the desired objective.

III. Next Steps in the Process Identified:

Tim Flynn noted that some of the questions that TLAC was asking to be included in the report were best addressed in the Report of Examination which would be issued by DOE. TLAC requested that Aspect Consulting spell out the process in a report addendum that would include itemization of those points to be addressed in the Report of Examination and subsequent points in the process of implementing the project.

The following issues that need resolution to proceed with the project:

1) TLAC noted that the above questions need to be answered in the report (Section II).
2) TLAC also noted that the target flows requested by WDFW need to go as they are not allowed by WAC 173-548 as noted above and the agreement made between WDFW DOE and Okanogan County in adopting the Watershed Plan developed under RCW 90.82. WDFW has not shown adequate justification for the channel forming flows.
3) DOE wants it comments addressed.
4) TLAC wants more information included in the addendum of the report specifying the steps of the project and what information will be needed with each step.
5) TLAC sees many benefits for the project: storage, associated riparian areas as well as the recreational trout fishery. The project is being defined too narrowly…it was WDFW that restricted it. Should we not identify more of these benefits with the project?

Areas of agreement identified:

1) It was agreed that the above questions and comments in section II need to be addressed in a final version of the report.
2) A mitigation strategy would be identified in the Report of Examination.
3) Next step is to initiate the ROE: Create draft, post it for review and comment for 30 days. If appealed goes to Pollution Control Board

Pathways for resolving identified items

1) Aspect to revise report as noted
2) WDFW/DOE to respond to WAC vs WDFW flows
3) More clearly identify benefits to show Hillis Rule benefits for project to overcome potential challenges.
4) Present project to Methow Watershed Council

Next steps for implementation

1) Find mitigating water right for project to complete ROE…thus need to define mitigation water quantities. Purpose of ROE is to explain how mitigations are going to be fulfilled.
2) Washington River Conservancy, Lisa Pelly is to be contacted. The group is active in Methow. Tim with Aspect will make contact then an agreement how to proceed will be developed to present to DOE and TLAC. There is also a project to put additional water into lower Wolf Creek to augment flows for fish. Would this be considered a project similar to TLAC project? Can this same water right serve both the Wolf Creek mitigation and TLAC project? Initial response was to see if this tie in could be made so that two projects can use the same water right.
3) Aspect will wait for full comment inputs on the report before proceeding to make the requested responses in the report.

General Comments

The acronym used for the Washington Department of Fish and Wildlife in the report is not consistent throughout the document. The appropriate acronym is WDFW.

Please use the Bill Drafting Guide at the Office of the Code Reviser for the appropriate conventions for citing statutes and administrative rules. The following link will take you to the Citations section of the Bill Drafting Guide:

> http://www1.leg.wa.gov/Legislature/_templates/Content.aspx?NRMODE=Published&NRNODEGUID=%7b7FAFE3C5-51A4-48D2-8D6E-A0C7A3586476%7d&NRORIGINALURL=%2fCodeReviser%2fBill%2bDrafting%2bGuide%2f&NRCACHEHINT=Guest#X4.6

Section 1 Introduction

In the last paragraph of Section 1.1 a summary of WDFW recommendations for the project is given, including a statement that "no new wells (other than exempt wells) be permitted for the aquifer in hydraulic continuity with Big Twin Lake…" WDFW's June 25, 2004, letter actually states "no new wells (including exempt wells)…"

Section 2 Hydrogeologic Framework

Section 2.6.1 includes two tables listing water rights for the national and state hatcheries. The permit and certificate numbers provided in the table are control numbers from the Ecology's Water Right Tracking System, but are not consistent with the numbers on the water right document. The following numbers should be used:

S4-*00705CWRIS	Certificate No. 848
S4-*07733CWRIS	Certificate No. 3023
G3-*08665PWRIS	Permit Cancelled 2/21/69
G4-*08664CWRIS	Certificate No. 7209-A
G4-*11685CWRIS	Certificate No. 7590-A
G4-29911CWRIS	G4-29911C

Report/Model

The report contains limited parameter sensitivity discussion scattered throughout the report. Sensitivity analysis results need to be presented in a comprehensive and organized format for review and better understanding of the model output as a whole.

The report states that the largest difference between the numerical and spreadsheet analysis occurs due to the mountain front recharge component, section 5.4.2, Scenario 1. This aspect needs additional discussion for review and understanding of the model output as a whole.

Erick W. Miller

Subject: FW: Twin Lakes

From: Schuppe, Mark (ECY) [mailto:msch461@ECY.WA.GOV]
Sent: Wednesday, January 21, 2009 9:31 AM
To: Tim Flynn
Cc: Sandison, Derek (ECY)
Subject: Twin Lakes

Tim, the following are additional comments on the October 10, 2008, Hydrogeologic Evaluation Report on Twin Lakes.

Model Report
Comments / Questions

Pg 4, last paragraph: Model uncertainty due to grid size may under predict the footprint of the twin lakes and near shore area. An outside model predicts more evaporation. Recommendation for project to provide contingency for uncertainty... **Comment**: This and other uncertainties may make achieving acceptable mitigation difficult... at what volume would the "contingency" be enough? Comment: This may suggest the model is not precise enough yet to provide mitigation planning to achieve a non-consumptive project.

Pg 7, Last paragraph, **Comment:** If it takes about 3 years to fill most of the aquifer storage before there is appreciable discharge to the Methow River from the project and between 3 and 10 years before the initial filling volume gradually discharges to the river, then this represents a consumptive use of water and a very large volume of water that needs to be quantified for mitigation under Hillis for the project to qualify as non-consumptive.

> October 15, 2008 Aspect Memorandum for Project No 040028-001-14: **Comment**: The assumption that only lake evaporation and bypass consumptive use requires mitigation is an error. The water remaining in aquifer storage and delayed from returning to the river is consumptive to the source (see comment above). Additionally, the amount of water that is thought to flow north and then is re-captured by the project wells would theoretically never return to the river and should likewise be considered for mitigation to meet any water budget neutral criterion for the project. Further, the volume (approximately 7 feet) needed to fill the lake should be considered consumptive in addition to that ground water which will be in storage and migrating back to the source.

Pg 10, second paragraph: There is an error in the report text where it says the June 25, 2004 WDFW recommended to Ecology that there be "...no new wells (*other than exempt wells*)..." **Comment**: The letter, in item 2, states: "No new wells (*including exempt wells*) be permitted from the aquifer in continuity with Twin Lakes." **Note:** Ecology currently assumes that by casing and sealing new wells into bedrock, the intent of F&W's concerns will be met.

Pg 11, first paragraph: "Of this [flow], approximately 72 percent (90 – 100 afy) flows toward the Methow River near the point of withdrawal (i.e., follows a northerly flow path out of Big Twin Lake). *Much of this water would be captured by the pumping wells, reducing the impact on Methow River flows."* **Comment:** The amount of water that gets recaptured and recycled by the wells and does not discharge to the river needs to be quantified since it would have a consumptive effect on the Methow River.

Pg 13, section 2.2.2: The Blaney Criddle Method may result in an underestimate of ET (about 15 %). Modified Penman may result in a slight over estimate of ET (about 6%).... **Question:** How sensitive is the model to ET input?

Pg14, section 2.3.2: Citing Konrad, 2005, the report states: "...from Winthrop to Twisp, the Methow River is typically a losing river..." **Comment:** Konrad's report, pg 42 and elsewhere, clearly indicate the reach between Winthrop to Twisp is "transient" in that it gains and losses (pgs 41, 45, Konrad) although the losses the study were found to be greater than gains. **Question:** Was the reach downstream of Winthrop modeled as a losing reach only or as a transitional reach? How sensitive is the model to the gaining/losing river boundaries?

Pg 16, Discussion of Thompson Creek gaining and losing reaches, including figure 2.3.4 summarizing the reaches evaluated: Fieldwork on Thompson Creek does not appear to have gone upstream any farther than the intersection of Patterson Lake Road and Elbow Canyon Road. **Comment:** If the model is sensitive to the amount of recharge derived from the Thompson Creek drainage, then this could be problematic as previous field investigations at the Burkholder property suggests a portion of Thompson Creek's flow, may at times, be diverted south into Elbow Coulee (Burkholder letters, February 2008, May 28, 2006, S4-34916 and related files). If no inspection of the creek was made upstream of the gaging stations identified for the Twin Lakes study, it may be incorrect to assume that data gathered represents the total flow volume. (**Note:** Mr. Burkholder contends that flow into Elbow coulee is a natural path of Thompson Creek.)

Pg 21 first paragraph: transmission of water in the bedrock is by fractures... **Question:** Was the fractured bedrock modeled as porous medium?

Pg 21: A series of isopack maps for the unconsolidated units were created using surfer to assess distribution and extent of the upper aquitard, aquitard, and lower aquitard. **Question:** There are sediment thickness maps, etc., but distribution of the individual sedimentary units does not appear to be included in the report. Please make these available to Ecology. See following comment:

> Conceptual model and numerical model "aquitard layer": **Comment:** In all of the Geologic cross sections (figures 2.5.2, 2.5.3 and 2.5.4) and in the Model Cross-Sections (figure 5.2.1), the aquitard/aquitard layer is inferred and depicted as being continuous. **Questions:** Is it assumed the layer exists throughout the modeled area? What is the basis for this assumption? If, however, the low permeable deposits exist as discontinuous lenses and were modeled as discontinuous layer, what changes in model output would be expected and how would model sensitivities change as a result?

Pg 22: Section 2.5.2.3: "Vertical groundwater gradients between and within units were found to be small and the groundwater elevations for the various units were contoured collectively." **Questions:** Do the similar water levels between units suggest that the "aquitard unit" does not confine the lower aquifer unit and has little effect on the system as a whole? Is this consistent with the conceptual and numerical model?

Pg 23: "A portion of the flow from the bedrock ridge area also likely flows eastward through the bedrock..." **Comment/Question:** This sentence is confusing. Does it mean that a portion of the flow from the bedrock ridge area likely discharges eastward?

Pg 24, Section 2.5.2.3: "Groundwater flow within both the bedrock and between the bedrock and lower aquifer was found to be in an upward direction at these locations." **Comment/Question:** Is this direction of groundwater flow consistent with the conceptual and numerical model assumptions?

Pg 25: "Pump test performed...for the... Hatchery...also provide... information on hydraulic conductivity...in the Twin Lakes project area." **Comment:** These tests provide information on the aquifer properties of the mainstem valley alluvial/fluvial and glaciofluvial deposits. The twin lakes area includes a kame moraine complex which reflects a lower energy stagnant ice depositional environment. As such, it is reasonable that K values in Twin Lakes area would be lower than estimates made by USGS, GeoEngineers or by Emcon for mainstem valley alluvial/fluvial and glaciofluvial deposits. **Question:** Are aquifer parameter estimates made for the Twin Lakes area (initial input and calibrated) reasonable for the local depositional environment? (See section 5.2.4.1)

Pg 26: "[Domestic groundwater use] assuming 50% of the total volume is consumptively used." **Question**: How was the 50% derived?

Pg 29: Mountain Front Recharge estimates appear to be uncertain and close to the low end of a wide literature range. **Questions:** How sensitive is the model to Mountain Front Recharge? Since the value is calculated as a left over amount to ensure zero change in storage, is the value subject to the sum of all the errors in the rest of the input parameters?

Pg 39: "A K value of 0.0005 cm/s was used for the Thompson Creek alluvial fan, the low permeable feature..." **Question**: is it reasonable to use the same K value for these features and for the Aquitard unit?

Pg 41: **Question:** is there any basis for precipitation recharge being set between 5 and 20% other than model calibration?

Pg 41: The difference between the model and spreadsheet estimates for pumping due to domestic wells is about 24 afy, or about 85 domestic wells. This amounts to about 26% of the existing domestic wells which may have been located above the calculated water table during model runs. **Question:** What effect do modeled wells above the calculated water table have on precisely estimating mitigation quantities for the project?

Pg 42: Non-consumptive use was modeled at the state hatchery by putting discharge well at the river in the amount of the water right. **Comment:** The right has a consumptive portion due to a recognized by-pass reach. The modeled discharging well location should be slightly downstream of the hatchery buildings. This may or may not be an issue.

Pg 44, Item 4: Rates of mountain front recharge and lake inflows were modified. **Question:** How was the model "modified" during calibration in response to the sensitive parameter of mountain front recharge?
Table B-2: **Question**: Were any GPS coordinates taken for the Thompson Creek Discharge data points? If yes, then, the data needs to be added to the report in an errata sheet or some other form.

General Model Comment: The conceptual model fit to the numerical may have some error involving the aquitard unit and the bedrock unit which may, while calibration appears to be good, introduce some predictive error.

General Project Comments

Pg 27: "[Agricultural irrigation] A significant portion of this quantity [1,283 afy] is estimated to be provided by surface water." **Comment/Questions**: What portion of this quantity is estimated to be imported from outside the project area? What would the effect of agriculture properties transitioning to domestic properties be on the water budget? If this project is in perpetuity, then mitigation values to demonstrate project non-consumptiveness would change over time with land use changes.

June 25, 2004 Fish & Wildlife letter states: *"These numbers [flows on the Methow] will be revised as more information is reviewed."* **Comment**: If the F&W flows are chosen for a permitting pathway, then output modeled presently may not address effects of withdrawals at potential "revised" values.

June 25, 2004 Fish & Wildlife letter states: *"Monitoring of surrounding existing wells..., river banks and overflow channels, lake levels and fishing pressure should all be conducted starting **before** [emphasis added] water is added to Big Twin Lake.* **Comment**: Only ground water and surface water levels have been monitored to date.

Comment: Should the project change its application from a Hillis pathway to that of a reservoir pathway, where recharge locations would include points in addition to Big Twin Lake, consideration needs to be given to the potential of creating new springs or increasing flow from existing springs. This issue was brought up early in the IRZ discussions/comments and it is unknown if any work has addressed this concern.