June 2013

Drift Creek Storage Project Reconnaissance Investigation

Report II

East Valley Water District
Willamette Basin, Marion County Oregon

Dave Bielenberg, Board Chairman

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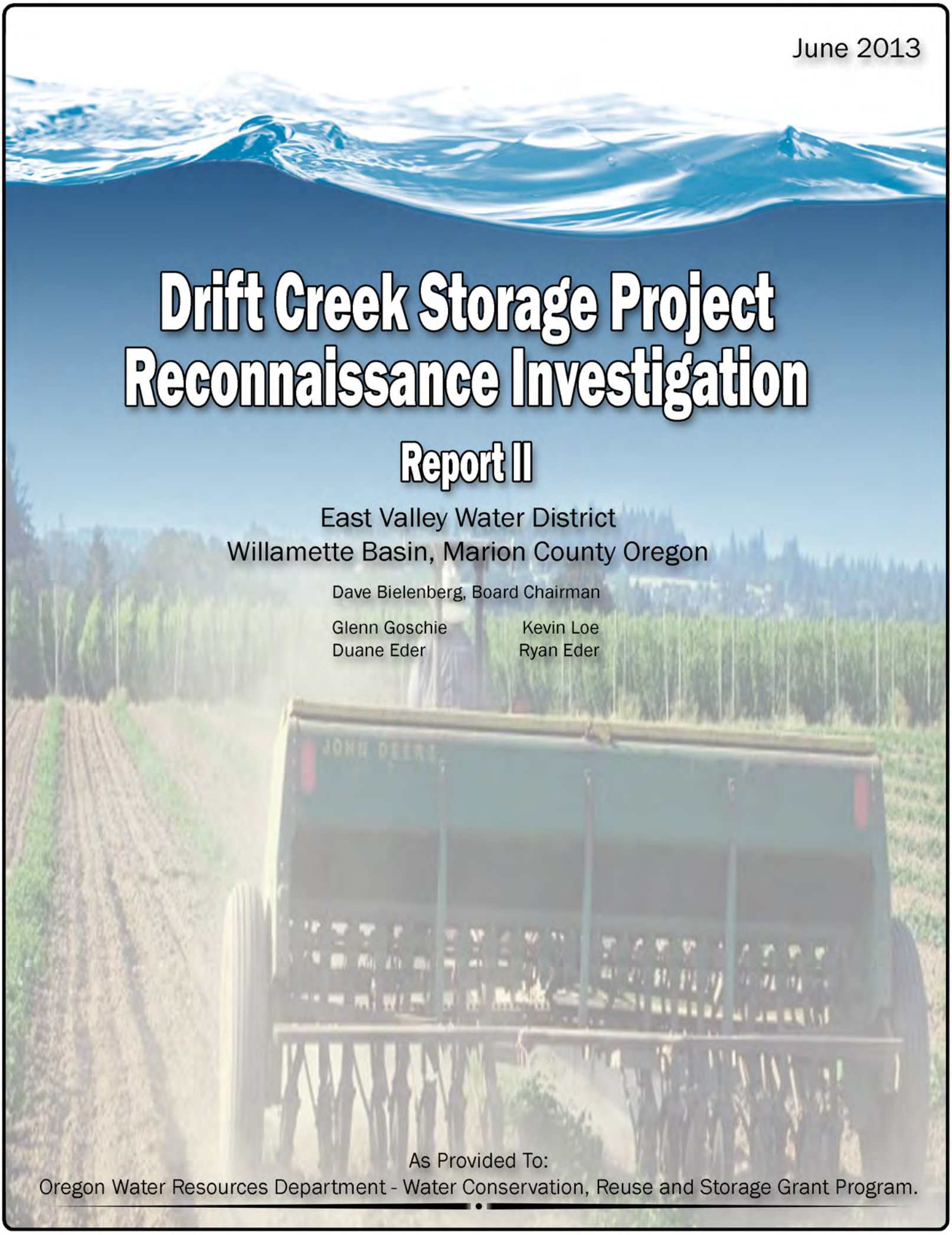

As Provided To:
Oregon Water Resources Department - Water Conservation, Reuse and Storage Grant Program.

June 30, 2013

Mr. Bill Fujii
Oregon Water Resources Department
725 Summer Street NE,
Suite A Salem, OR 97301

SUBJECT: ***DRIFT CREEK STORAGE PROJECT RECONNAISSANCE INVESTIGATION GRANT #GA 0043 13***

Dear Mr. Fujii:

Reconnaissance II, the continuing investigation of the Drift Creek Storage Project, represents a coordinated effort of a team of professional consultants to develop responsive materials to the referenced grant agreement. Section I of the reconnaissance was presented in June 2011, representing preliminary investigations into the environmental effects of the project, geotechnical aspects, water availability and the further permitting feasibility for the project.

This second section of the reconnaissance provides additional studies toward development of the reservoir project. The summary sections make reference to the attachments that contain the detailed reporting and studies for the various specific pieces of work performed under grant #GA 0043 13.

The results continue to indicate that this storage project can feasibly provide cooler summer water to Drift Creek and can meet the target storage of 12,000 AF to mitigate the ground water limitations being experienced by the District's approximate 15,000 acres while successfully mitigating fish and wildlife resources.

The District appreciates the working relationship with the Oregon Water Resources Department on this project and the support it has received through this grant program. The District is committed to facing the challenge of developing a continuing supply of water to its active farm lands and the support of the OWRD in these efforts. The goal continues to be an imperative to achieve a new water supply to replace and supplement current surface water supplies that have been diminished by the lowering of groundwater levels that have resulted in the designation of two groundwater limited areas impacting the ability of the districts' growers to support their crops.

If you have any questions regarding the report, please let us know.

Sincerely,

EAST VALLEY WATER DISTRICT

[ORIGINAL HARD COPY SIGNED]

David Bielenberg, Board Chairman

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LIST OF ATTACHMENTS

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Drift Creek Site A, Runoff Yield Analysis (Update #3), Bolyvong Tanovan, Phd., PE, October 2012

SECTION 3
Geologic Assessment Engineering Report and Geotechnical Report Peer Review Application, submitted to Marion County, June 2013

SECTION 4
Drift Creek Reservoir Model, Irrigation Flows Discharged to Drift Creek Scenarios, Portland State University Department of Civil and Environmental Engineering, Maseeh College of Engineering and Computer Science, December 2012

SECTION 5
Drift Creek Dam: Agriculture Economic Value Analysis, Agricultural and Resource Economics Department, Oregon State University: Dr. Penelope Diebel, Associate Professor; Clark Seavert, Professor; and Bill Anderson, M.S. Graduate Student

SECTION 7
*Reservoir Water Storage Permit, Application R-87871, A*dam Sussman, GSI Water Solutions, submitted to the Oregon Water Resources Department, February 2013

SECTION 9
Simulation of Potential Cutthroat Trout Production in the Drift Creek Watershed, Pudding River Basin, Steve Cramer and Mark Teply, Cramer Fish Sciences, June 2013

Fish Passage Waiver Application, Robert Ellis, Ellis Ecological Services, Inc., submitted to the Oregon Department of Fish and Wildlife, June 2013

SECTION 11
Evaluation of Pumping Versus Piping, Drift Creek Dam Conveyance System, Kevin Crew, PE, Blackrock Consulting, June 2013

SECTION 1
EXECUTIVE SUMMARY

The Project

As described in Reconnaissance I documents developed under the prior grant #GA 0035 09 (http://www.oregon.gov/owrd/Pages/law/2010_Grant_Program_Update.aspx#EastValley), the project consists of a reservoir to store approximately 12,000 acre fee (a.f.) of surface water from Drift Creek and a transmission system to convey water flows from the reservoir to points of delivery within the district to serve its water users. An approximately 70-foot high, 850-foot long dam embankment would be required to impound the 12,000 a.f. of water. The drainage area is approximately 15.4 square miles.

The intended water reservoir impoundment proposed by the District would draw water from Drift Creek, a tributary to the Pudding River. The reservoir site is located approximately six miles southeast of Silverton in Marion County, and the facility would be the cornerstone of a new surface water supply system for the District. Stored winter water would be released during the summertime months and conveyed downstream to the District's service area via either a new raw water pipeline or by natural channel flow along Drift Creek and possibly the Pudding River. Supplied water would be used for irrigation purposes and would require the development of a new water distribution piping system for delivery of irrigation water to served members.

Reconnaissance I described the conceptual design of the reservoir and explored the technical feasibility of the project in support of environmental assessments and permitting activities. The document summarized the conceptual design work while presenting guidance for next step engineering and geotechnical work, as well as updating project cost estimates for further financial planning and projecting a schedule for development of the project by the District. Refer to Reconnaissance I for design recommendations for the outlet configuration, the emergency spillway, embankment and other features of the dam and reservoir. In this report, Reconnaissance II, additional modifications of the concept design to better meet flow considerations and other project needs.

Need for the Project

The East Valley Water District is an irrigation district formed for the purpose of supplying irrigation water to its members' lands and associated agricultural operations in Marion and Clackamas Counties in Oregon. The District service area is approximately 15,000 acres, extending northerly from just north of Silverton to just south of Woodburn and Molalla, between the Pudding River on the west and the Cascade Mountain foothills on the east.

The District's approximately 75 members are currently served by a combination of individual irrigation groundwater wells and direct withdrawals from local surface waters. Limited surface water supplies and lowering groundwater levels make the development of a new surface water source imperative as there are two Groundwater Limited Areas within the district boundaries.

Additional Studies Provided

Reconnaissance II was developed to more specifically determine the feasibility of the components of the project given additional studies in a number of areas to provide the

- updating of the hydrologic profile for further review of sizing the reservoir and flows
- additional monitoring of flows to verify early assumptions
- submittal of the geotechnical assessment and engineering geology report to Marion County
- development of irrigation flow discharge scenarios for modeling water quality results
- agricultural economic value analysis for the ability-to-pay
- finalization of the wetland delineation
- completion of the water right analysis and application
- completion of land use process steps
- continued development toward the granting of a fish passage waiver
- review of conservation measures
- evaluation of water transmission alternatives from reservoir to farm
- next steps description

The following sections of this document will provide detailed analysis of the listed topics and how they will fit into the decision-making process.

Hydrologic Profile and Flow Monitoring
Dr. Tanovan's Runoff Yield Analysis, updated with 2010-2011 water year records and expanded with regression equations from correlations between the Pudding River and Drift creek in additional years, identifies more clearly representative years for low, average and high years of flow. This is the third runoff analysis Dr. Tanovan has provided to East Valley Water District and it further assures the validity of earlier flow analyses as providing adequate fill for a 12,000 acre foot reservoir. In a high runoff water year like 2010-2011, even if the reservoir was empty prior to the beginning of the water year (October 1st) the reservoir would still fill even when meeting required instream flows at the mouth of Drift Creek.

Geotechnical Determination
Working from the three previous geologic studies, East Valley Water District prepared the Geologic Assessment Engineering Geology Report and Geotechnical Report Peer Review Application for submittal to Marion County. The geologic studies determined that the site could be safely constructed with appropriate construction sequencing.

Irrigation Flow Discharge Scenarios - Water Quality Modeling
Portland State University used the model that was developed under Reconnaissance I to expand the scenarios to identify additional parameters for discharges from the proposed reservoir while meeting temperature standards required by the Department of Environmental Quality for Drift Creek. The model used scenarios mixing water from up to three outlets in the dam, using low, average and high flow water years to develop outcomes. The results were a confirmation that mixing water from multiple outlets provided the most cooling water effect. It further defined where a "high level" outlet would be most effectively located. The report provides through graphic representations the range of ability to meet instream flows, irrigation discharges and cooling water effects from the range of scenarios.

Agriculture Economic Value Analysis

Oregon State University's Department of Agriculture and Resource Economics used computerized "AgTool" programs developed by a group of western universities, including OSU, to incorporate crop data from a variety of sources to determine the ability-to-pay by the districts' members. This analysis is required in order to acquire federal loan funding for water projects as reflected in the guidelines of the U.S. Bureau of Reclamation and other federal agencies. Crop patterns, values, farm size, yields, land values and improvements and other factors are fed into the calculation tools to determine the ability per acre of specific crops to arrive at a repayment factor per acre. However, this payment factor is based on 32,364.4 acres, the number of acres the Farm Service Agency (FSA) had records for as representative of crop patterns for the District. That number of acres predicted a per acre payment of $577 per acre based on the total FSA acres.

The current water user base is only 4,000 acres. The District continues to work with the U.S. Bureau of Reclamation and others to try to determine the final actual payment capacity to be presented to its members. The figure of $577 an acre payment capacity assumes most, if not all profits are removed from the crops. The District board members, who are growers, feel that the $18.7 million estimation of value is too high for the total crop value based on the figures actually experienced by the district's growers and may propose a lesser per acre payment recommendation depending upon the final number of acres assessed at the time of financing and as necessary to secure the financing.

Wetland Delineation

Schott and Associates, Ecologists and Wetlands Specialists, completed the wetland determination and delineation study of the site of for the Drift Creek Reservoir and submitted the report and an application to the Division of State Lands in December 2009. A copy of the documents are available as an appendix item to the earlier grant. A total of 9.91 acres of wetlands was identified as impacted by the dam project. Since the submittal of the application, there was change in the rules for review and the approval was delayed while additional information was sought by the agency from the consultant to respond to a specific list of questions to supplement the earlier application. Agency staff indicated that once the review was accomplished, staff would visit the site and make a final determination. Since that time Schott and Associates has continued to request a response from the agency after submitting the information requested in March of 2011. Although a final review was to be received in June of 2013, no information or contact has been received.

Water Supply Analysis

The District filed a water right application February 21, 2013 for surface water from Drift Creek for 12,000 acre feet of water as R-87871. The right will provide for irrigation, supplemental irrigation and flow augmentation as required. Storage will occur between October 1 and April 30 of each year. The District is working with the Oregon Department of Fish and Wildlife to secure a fish passage waiver which may be required before final approval of the order granting the right. Marion County provided a determination that the District, as a special district, was qualified to site a reservoir on lands zoned as Exclusive Farm Use. After review by the Department, the application will be noticed for public and agency input.

Land Use Process

The District is in the process of obtaining an administrative approval from Marion County for development of the reservoir as an outright use under state law in an Exclusive Farm Use

(EFU) zone. The district secured a signed Land Use Information Form from the county in January. (See water supply Section 7 for a copy of the form.) In addition the District is filing an application for the geologic review. (See geologic assessment, Section 3, which contains the application.) At a future date the District will need to obtain approval for development in the floodplain.

Fish Passage/Alternative Mitigation

Under Reconnaissance II, Ellis Ecological Services provided a thorough evaluation of all potential fish passage options for the proposed dam. The District's consultants and the Oregon Department of Fish and Wildlife biologist and fish passage lead have continued to work with the District representatives to establish a mitigation plan for the project. Cramer Fish Sciences developed a model to identify the capability of present habitat conditions in Drift Creek that would support native salmonids and to determine what factors limited production. Spawning gravel, low summer flows and high water temperatures create conditions that impact carrying capacity and spawning. Applying the model it was determined that increase flows from .5 cfs to 2.0 cfs in the later summer months when high temperatures occur, potentially doubling the cutthroat potential from 473 spawning fish to 846. The release of a minimum of 2 cfs, compared to the present .5 cfs, would cool the stream by 6 to 10 degrees Centigrade in the first 3 reaches below the dam.

Conservation Measures

Currently the growers in the East Valley Water District use pressurized systems that apply less water than the department prescribes for the area west of the Cascade Mountains on a per acre basis. More recently growers have begun using linear systems that are supported by the Natural Resources Conservation Service (NRCS), but mainly to conserve electricity. While the intent of the reservoir project is not based on the need to provide additional water resources for changes in cropping patterns, some changes do occur based on external factors such as market prices or other economic conditions. Replacing the groundwater rights that are being depleted by the dropping water table from stored water could provide more instream water benefits and perhaps delay the continuation of the water table drop. If the choice in conveyance system leads to piping water delivery to major points of diversion within the District, there would then be a savings of water through that conservation project.

Water Transmission Alternatives

Black Rock Consulting reviewed earlier documents regarding the two possible conveyance systems for transmission of the water from the reservoir to irrigation deliveries within the district, comparing an enclosed pipe to an open channel system incorporating a pump. There are advantages to each type of conveyance as outlined in the report from Black Rock Consulting. The current draft Fish Passage Waiver (see Section 9) may provide some determining factors that impact the decision between the two conveyances.

SECTION 2
HYDROLOGIC ANALYSIS

Flow Monitoring

East Valley's consultants have now measured Drift Creek flows since October of 2008 after siting and installing a gauging station. In Reconnaissance I, Dr. Bolyvong Tanovan verified that the runoff record as of June 2010 substantiated that 12,000 acre feet (a.f.) should be generally available to the district during the storage season from the recorded flows. Detailed Runoff Yield Analysis #1 and #2, submitted as appendices to Reconnaissance I, provided a comparison of prior years of flow.

In Reconnaissance II, Dr. Tanovan provides an update, Runoff Yield Analysis #3, documenting stream flow data collection from the water 2010-2011. A water year is October 1st through September 30th of the following year. He then uses the addition of that stream flow data in making a comparison among the three years of recorded flow. The results are that

- 2008-2009 can be identified as a dry water year;
- 2009-2010 can be identified as a slightly below average water year; and
- 2010-2011 can be identified as a high water year.

As the result of additional data, he has revised the annual runoff ranking of low, average and high runoff years to update the frequency curve. A strong correlation occurs between the Pudding River and Drift Creek as the result of the recordings developed from this project and other criteria. As a result, Dr. Tanovan was able to extend the 3-year hydrologic records covering a wider range of runoff conditions into a longer span of time through the use of regression equations.

He sets up a daily time step reservoir model including applicable regulatory parameters and irrigation needs to model reservoir operations. In applying the start date of the reservoir refill season with the need to meet instream water rights at the mouth of Drift Creek, he shows that both have limited negative impacts for fill. In a high runoff year like 2010-2011, the reservoir would fill even if it started empty on October 1 and had to meet 100% of the instream flow requirements at the mouth.

His work enabled the Portland State University to update their data and modeling program, as detailed in their "Irrigation Flow Discharge Scenarios" in Section 4.

DRIFT CREEK HYDROLOGIC REPORT #3

(UPDATE #3)

October 2012

Proposed Drift Creek Reservoir Site at SE Fox and SE Victor Point Junction

Report Prepared for

East Valley Water District
Mt. Angel, OR

by
Bolyvong Tanovan, PhD
15795 SW Bobwhite Circle Beaverton OR 97007-8228

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EXECUTIVE SUMMARY

This report pertains to a proposed irrigation project initiated by the East Valley Water District at a site located on Drift Creek, a tributary of the Pudding River, at the junction of Victor Road and Fox Road. It is the third of its kind and uses streamflow data collected during the last three water years (October 2008 – September 2011) to extend hydrologic records at the site. These data were used to help determine the feasibility of the project -- a process based on how the proposed reservoir might be operated, given its physical size, the expected inflow, the required downstream releases, and the irrigation needs.

The first twelve chapters of the report deal with basic hydrology. They document the availability of hydrologic data and their characteristics, and support the qualification of 2008-09 as a dry water year; 2009-2010 as a slightly below average year, and 2010-11 as a high water year. The strong correlation that exists between the streamflow at the proposed project site and some of nearby streams, especially the Pudding River, allows for the extension of the 3-year hydrologic records to a longer time span covering a wider range of runoff conditions through the use of regression equations. Based on those extended numbers, the expectation for a October-April runoff volume of 12,000 acre-feet to be available for annual reservoir refill looks reasonably good.

The second part of the report –chapters 14 and 15—deals with potential reservoir operational scenarios using a daily stime step reservoir model. Model input includes variable initial pool elevations, expected runoff conditions, actual reservoir volume and outlet capacities, projected irrigation needs, and downstream release criteria to meet instream requirements. Two basic reservoir operation criteria were tested, one involving the official start date of the reservoir refill season, and the other one, the role assigned to the local inflow below the reservoir site in meeting water rights at the mouth of Drift Creek. The impacts of those two elements were found to have limited negative impacts on reservoir refill. Another critical factor tested was the initial reservoir pool elevation at the start of the annual refill operation. Under a high runoff water year like 2010-2011, it appears that the project would fill even if it started from empty on October 1 and had meet 100 percent of the in-stream flow required at the mouth.

The appendix contains appropriate streamflow data referred to in this report and the previous two reports. A sample detailed listing of the reservoir model output is also provided for the 2008-2009 water year. Other data used in the analysis are available upon request.

The three (2008-2011) years of streamflow data recorded so far were caused by rainfall; snowmelt, which usually created design floods in the region, has not been a major factor. Additional hydrologic data would help confirm the representativity of the current information, and further enhance the reliability of conclusions reached on project feasibility.

DRIFT CREEK SITE "A" NEAR SILVERTON, OREGON

DRIFT CREEK HYDROLOGIC REPORT

(UPDATE #3)

1. Introduction

This technical report is an update of the February 2011 report on hydrologic data collected on Drift Creek and nearby streams as part of a feasibility study of the Drift Creek irrigation project proposed by East Valley Water District (EVWD). The primary objective of the hydrologic analysis is to evaluate the relationship between Drift Creek and other streams in terms of discharges, watershed characteristics, rainfall-runoff distribution, and to determine how best to use that information to develop the expected project inflow covering as long a period as possible. This September 2012 report is a self-contained document that reviews the more recent October 2010-September 2011 stream flow data, evaluates how those data compare with those previously collected during the October 2008 – September 2010 hydrologic year, and updates the expected runoff yield at the proposed project site. The report also summarizes the results presented in the previous reports.

2. Project Background

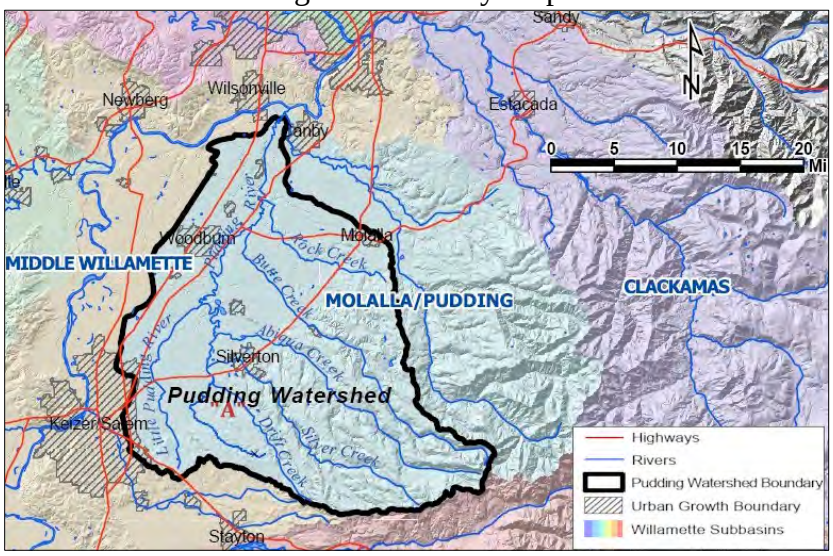
EVWD is planning to build a reservoir to store the runoff of Drift Creek, a tributary of the Pudding River, to meet irrigation purposes in that area. The proposed project site is located on Drift Creek, near the junction of Victor Road and Fox Road, south of Silverton. See Figure 1. It controls a drainage area of 15.4 square miles and has physically the potential of storing up to 12,000 acre-feet of water.

The actual volume of water that could be stored in the reservoir each year, prior to the start of the irrigation season, depends on the Drift Creek run-off and the in-stream flow requirements during the preceding October through April reservoir refill period. This critical data needed for the assessment of the project's feasibility must be as reliable as possible and of sufficient length to provide a good picture of the long-term runoff conditions. It is usually provided by stream flows measurements at the project site, and/or reconstituted flows based on the observed data at comparable nearby streams with good records.

Up until 2008, Drift Creek was a stream with no recorded flow data. Actual, continuous daily stream flow measurements on the creek were only initiated in April 2008 by Marion Soil and Water Conservation District (Marion Co. SWCD). This occurred at two gauging sites. The first gauge was located at the project site, and referred to as "Upper Drift Creek Gauge" or "Victor Road Gauge". The second gauge was at

lower stream location, at the Hibbard Road bridge-crossing near the confluence of Drift Creek with Pudding River, controlling a drainage area of 24.8 square miles. Stream gauging continued at those two sites to this day, with the upper site gauge operated by a contractor to EVWD, and the lower site data collected by a Marion SWCD flow monitoring specialist.

Figure 1. Vicinity Map



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The first hydrologic yield analysis report was prepared in February 2007 to provide estimates of the October through April run-off volume that could be expected at the proposed project site. At the time, no observed stream flow data were available for Drift Creek. As a result, the report only provided a review of existing hydro-meteorological records at nearby streams, and development of synthesized mean monthly discharges at various probability levels of occurrence. The report recommended discharge measurements on the creek to enhance the reliability of the runoff volume estimates.

Following the subsequent stream flow gauging during October 2008-September 2009, Update #1 examined the significance of the newly collected runoff data --a hydrologic year with low Drift Creek runoff-- on the previously estimated runoff volumes. Update #1 took into account the Oregon Water Resources Department (OWRD) water availability data and irrigation and fisheries water rights listed for Drift Creek at the mouth. Daily stream flows were then developed for the dry year, average year, and wet year at the project site. A reservoir routing model was also set up to test how the runoff would be stored at and released from the project every day during those years to meet the required water rights and ecological flow triggers.

The February 2011 report, Update #2, was a direct continuation of the June 2010 report, focusing on stream flows data collected on Drift Creek and other near-by streams, using October 2009-September 2010 data. Data for this average flow year added a higher flow range to the previous year's data. The 2011 report updated earlier findings and strengthened the capabilities of the analytical tools used to generate historical runoff data

and simulate the operation of the proposed reservoir. At that point, records for a low flow and an average flow year have been recorded.

The present September 2012 report, Update #3, is in many ways similar to the previous reports. It updates the runoff-yield analysis with one more year of stream flow data (Oct. 2008 – Sept. 2011 vs. Oct. 2008 – Sept. 2010). The 2010-2011 hydrologic year was an above average flow year for Drift Creek and further extends the range of stream flows recorded so far on that stream. The scope and format of the current study update include the following tasks:

1. Review the more recent October 2010-September 2011 stream flow data at Drift Cr. and nearby streams, with particular reference to runoff magnitude, timing and data correlation between various sites;
2. Update the expected usable runoff at the proposed project site in terms of daily, monthly and statistical frequency data;
3. Develop daily and monthly stream flows at the project site for the dry year, average year, and wet year, and other years of interest;
4. Set up a daily time step reservoir modeling with all applicable regulatory and other release requirements (e.g., Oregon Water Resources Department water availability data, irrigation withdrawals, in-stream water rights, ecological maintenance and flushing flows, etc.);
5. Perform daily time-step analysis of the reservoir volume given historical data and recently gathered flow data at Drift Creek and different levels of irrigation withdrawal levels and different schedules, using a selected period of flow years;
6. Prepare a report documenting the findings and recommended future actions; and
7. Coordinate work activities with and brief the project team as needed.

3. Hydro-Met Data Available

3.1 Hydrologic Data

At the start of the Drift Creek hydrologic study in 2007, although there were no recorded stream flows at the project site itself, some gauging stations of relevance to the project did exist, as listed in Table 1.

The longest stream gage records belong to Pudding River at Aurora with a combined total of 49 years of data, followed by Pudding River near Mt. Angel (28 years), Silver Creek at Silverton (16 years), Zollner Creek near Mt. Angel (13 years), Little Abiqua Creek near Scotts Mills (12 years), and Pudding River near Woodburn (9 years). Some of the periods of records overlap each other, but no stream gauge has records that span the entire 1928 - 2005 period uninterrupted.

Table 1. Stream Gages, Drainage Areas and Period of Records (as of 2007)

Agency	Site Number	Site Name, Drainage Area, Record Period
USGS	14200300	Silver Creek At Silverton, OR F=47.9 sq. mi. (1963-1969 and 1970-1979)
USGS	14200400	Little Abiqua Creek Near Scotts Mills, OR F=9.81 sq. mi. (1993-2004)
USGS	14201000	Pudding River Near Mt. Angel, OR F=203 sq. mi. (1939-1966)
USGS	14201300	Zollner Creek Near Mt. Angel, OR F=15.0 sq. mi. (1993-2005)
USGS	14201340	Pudding River Near Woodburn, OR F=314 sq. mi. (1997-2005)
USGS	14202000	Pudding River Near Aurora, OR F=479 sq. mi., (1928-1963 and 1993-2005)

Table 2 contains the monthly averages of the historical stream flows recorded at the various gauging stations as posted on the Internet. Pertinent monthly values for each year of record are provided in the Appendix.

Table 2. Monthly Flow Averages Available at the Start of the Hydrologic Study (2007)

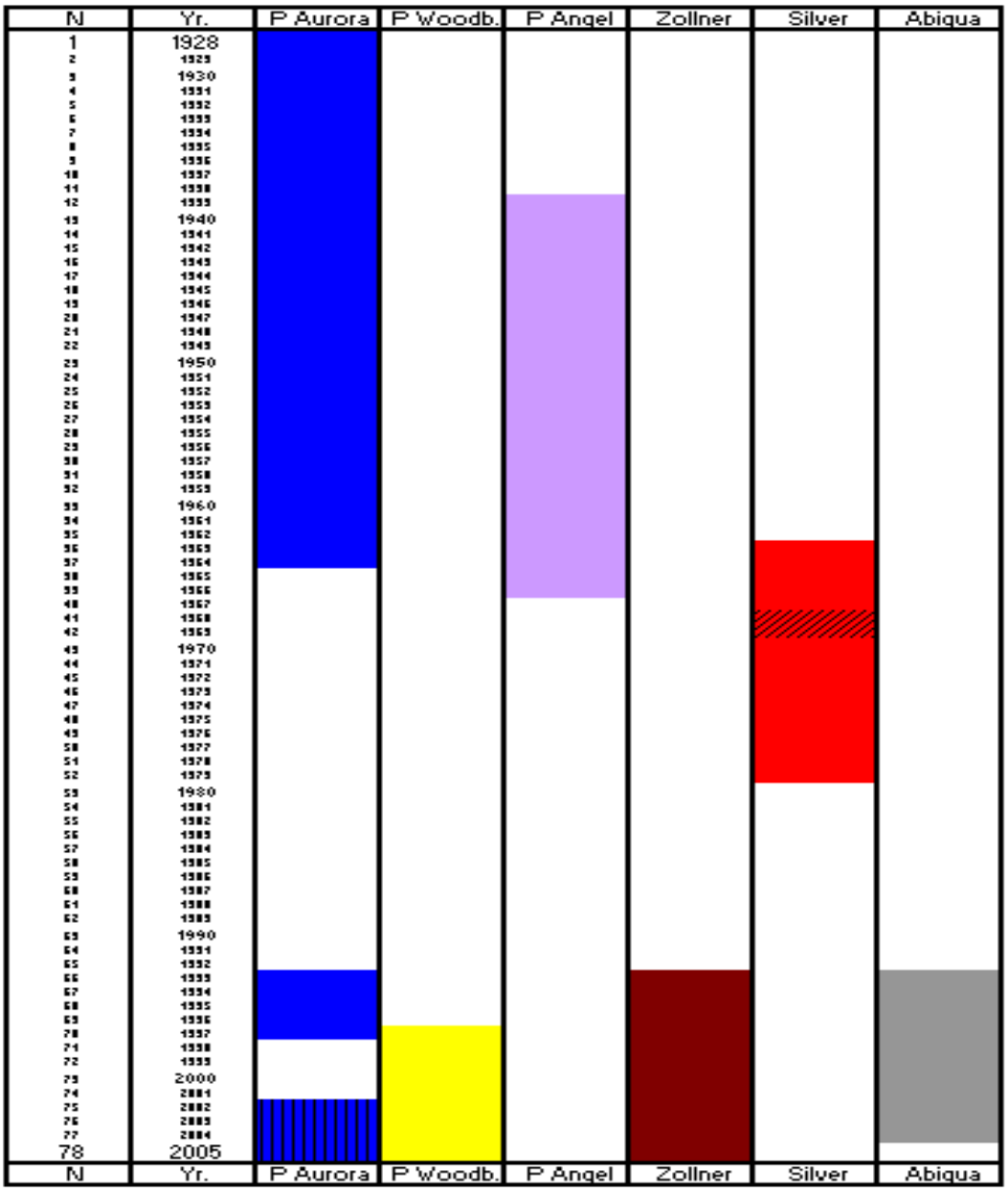
Sta.	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
(1)	526	336	324	226	136	64	25	17	31	46	274	498
(2)	78	76	59	40	28	15	5.8	3.5	4	12	44	80
(3)	55	49	33	14	7.1	3	0.79	0.44	0.841	6.4	36	61
(4)	1,560	1,470	1,140	845	539	237	76	31	44	246	915	1,430
(5)	1,800	1,640	1,360	896	614	310	81	33	48	172	667	1,670
(6)	2,710	2,700	2,100	1,570	889	420	150	68	90	341	1,410	2,430

Stations:
(1): Silver Cr; 1963-68 and 1970-79;
(2): L. Abiqua nr Scotts Mills; 1993-2004
(3): Zollner nr. Mt Angel; 1993-2005
(4): Pudding nr. Mt Angel; 1939-66
(5): Pudding nr. Woodburn; 1997-2005
(6): Pudding at Aurora 1928-63; and 1993-2005

Figure 2 shows a diagram with all the streams that continue to be stream-gauged to this day.

Hydrologic data analyzed so far include the sets of information covered in report updates #1, #2, and #3 prepared after stream flow data collection made in hydrologic years 2008-09, 2009-10 and 2010-11 respectively.

Figure 2. Records Length of Available Stream Flow Data in 2007



Note: (1) Pudding R. at Aurora; (2) Pudding R. nr. Woodburn; (3) Pudding R. nr. Mt. Angel; (4) Zollner Cr. Nr. Mt. Angel; (5) Silver Cr. At Silverton; (6) Little Abiqua Cr. Nr. Scotts Mills.

3.2 Meteorological Data

Daily precipitation (rainfall and snow) and air temperature were recorded at the Salem WSO Station near the airport from 1892 to present. See data on Tables 3.1 and 3.2 retrieved from the website hosted by Western Regional Climate Center, at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or7500

Table 3.1. Precipitation at Salem Airport, OR 1892 to 2012 (updated 16 April 2012)

	in.	in.		in.		1-day Maximum		Total snowfall		
	Mean	High	Year	Low	Year	in.	Date	Mean "	High "	Year
JAN	6.11	15.4	1953	0.24	1985	3.86	18/1911	2.9	32.8	1950
FEB	4.71	13.01	1996	0.34	1920	2.99	06/1985	1.6	25.2	1937
MAR	4.09	10.13	1894	0.59	1911	2.55	31/1943	0.4	10.9	1951
APR	2.56	7.68	1937	0.39	1939	2.21	13/1937	0	0.1	1972
MAY	2.07	5.56	1998	0.05	1992	1.76	17/1991	0	0	1906
JUN	1.32	4.61	1937	0	1918	1.63	06/1985	0	0	1915
JULY	0.39	2.72	1916	0	1893	1.8	18/1987	0	0	1898
AUG	0.52	4.17	1968	0	1894	1.14	31/1971	0	0	1906
SEP	1.54	4.84	1914	0	1975	2.11	05/1911	0	0	1906
OCT	3.2	11.17	1947	0	1895	2.71	31/1994	0.1	5	1935
NOV	6.12	16.99	1896	0.48	1936	3.6	08/1896	0.3	6.1	1977
DEC	6.69	17.54	1933	1.26	1976	4.3	06/1933	1.8	23	1919
Annual	39.31	66.96	1996	23.74	1985	4.3	12/06/33	7.1	33.5	1950
Winter	17.5	30.32	1956	4.97	1977	4.3	12/06/33	6.3	34.9	1969
Spring	8.72	16.05	1894	3	1924	2.55	03/31/43	0.4	10.9	1951
Summer	2.23	7.2	1983	0.21	1919	1.8	07/18/87	0	0	1915
Fall	10.86	21.25	1950	2.18	1936	3.6	11/08/61	0.3	6.1	1977
							M/D/YR			

According to the records listed above, the October-April snow precipitations in excess of 10 inches (snowy conditions) were somewhat infrequent. They occurred in the following 15 years: 1928, 1929, 1936, 1942, 1949, 1955, 1956, 1959, 1961, 1967, 1968, 1970, 1972, 1985 and 1992.

For the 30-year 1971-2000 period, the Salem WSO Station recorded October-April rainfall amounts in excess of 40 inches (average years) in 1931, 1932, 1937, 1942, 1947, 1950, 1955, 1960, 1970, 1973, 1981, 1982, 1994, 1995, 1996, 1998 and 2005. The same station recorded October-April rainfall amounts less than 20 inches (very dry years) in 1976 (11.57”), 2000 (16.89”), and 2004 (18.22”). For comparison purposes, data shown in Tables 4.1, 4.2, 4.3, and 4.4 are more directly related to the 30-year 1971-2000 period, instead of the entire 119-year 1892-2012 period.

Table 3.2. Air temperature at Salem WSO Airport, OR From 1892 to 2012 (updated 16 April 2012)

	Monthly Averages			Daily E				Monthly Extremes			
	Max	Min	Mean	High	Date	Low	Date	Highest	Year	Lowest	Year
	(F)	(F)	(F)	(F)		(F)		(F)		(F)	
JAN	46	33.4	39.7	68	07/1896	-10	31/1950	46.9	1953	27.4	1930
FEB	50.6	34.8	42.7	72	28/1968	-4	Mar-50	48.6	1991	34.7	1989
MAR	55.5	36.8	46.2	80	29/1923	12	Jan-71	52.3	1926	40.9	1951
APR	61.2	39.5	50.4	93	28/1926	23	13/1968	59.3	1926	44.6	1967
MAY	67.7	44.2	55.9	100	28/1983	25	Jan-54	61	1928	51.4	1962
JUN	73.8	49	61.4	105	22/1992	32	06/1899	67	1926	56.8	1976
JULY	81.8	52	66.9	108	23/1927	35	03/1899	72	1941	61.9	1963
AUG	81.7	51.9	66.8	108	Sep-81	30	30/1920	71.6	1967	62	1899
SEP	75.5	48	61.8	104	Feb-88	26	25/1934	66.6	2011	56.6	1893
OCT	64.2	42.5	53.3	93	Feb-70	19	27/1919	59.6	1901	46	1919
NOV	52.6	37.9	45.3	74	Mar-10	9	15/1955	51.1	1995	37.3	1985
DEC	46.7	34.8	40.7	72	Sep-29	-12	Aug-72	47.9	1917	33.2	1985
Annual	63.1	42.1	52.6	108	1.9E+07	-12	12/08/72	55.8	1926	49.8	1893
Winter	47.8	34.3	41.1	72	1.9E+07	-12	12/08/72	44.7	1958	35.9	1949
Spring	61.5	40.2	50.8	100	2E+07	12	03/01/71	56.6	1926	46.6	1955
Summer	79.1	51	65	108	1.9E+07	30	08/30/20	68.8	1958	60.9	1954
Fall	64.1	42.8	53.5	104	2E+07	9	11/15/55	56	1995	48.9	1985
							M/D/Y				

Table 4.1. Precipitation, Monthly and 30-year Annual Averages (1971-2000)

Stations	ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Salem WSO Airport	7500	5.8	5.1	4.2	2.8	2.1	1.5	0.6	0.7	1.4	3	6.39	6.46	40
Silver Creek Falls	7809	9.9	9.4	8.8	7	5	3.5	1.3	1.3	2.8	5.4	11.3	10.6	76.1
Silverton	7823	6.5	5.6	5	3.8	3	2.1	0.9	1	1.9	3.6	7.16	7.07	47.5

Table 4.2. Average number of Days with Selected Precipitation Amounts
Salem WSO Airport, 1971-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
>.01"	17	16	17	14	11	8	3	4	7	11	18	18	144
>.10"	12	12	11	8	6	4	2	2	4	7	13	13	92.9
>.50"	4	3	2	1	1	1	0	0	1	2	4	5	24.7
>1.00"	1	1	0	0	0	0	0	0	0	0	1	2	6.1

Table 4.3. Monthly and Annual Average Temperatures 30-year average (1971-2000)
Salem WSO Airport (degrees F)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max	47.0	51.2	56.3	61.1	67.5	74.0	81.5	81.9	76.6	64.5	52.4	46.4	63.4
Mean min	33.5	34.7	36.6	38.8	43.6	48.4	52.0	52.1	47.7	41.3	37.9	33.9	41.7
Mean temp	40.3	43.0	46.5	50.0	55.6	61.2	66.8	67.0	62.2	52.9	45.2	40.2	52.6
Extreme max	65	71	77	85	100	105	103	108	104	92	71	68	108
Extreme min	6	-1	12	26	28	32	38	36	26	23	11	-12	-12

Mean number of days

Max >90	0	0	0	0	0.4	1.5	5.9	5.8	2.5	0.1	0	0	16.0
Min >32	13.4	10.5	8.1	4.4	0.6	0	0	0	0.1	2.4	7.3	13.0	59.9
Max <32	0.8	0.2	0	0	0	0	0	0	0	0	0.2	1.1	2.3
Min <0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2

Table 4.4. Snowfall, Monthly and Annual 30-year Averages (1971-2000), inches

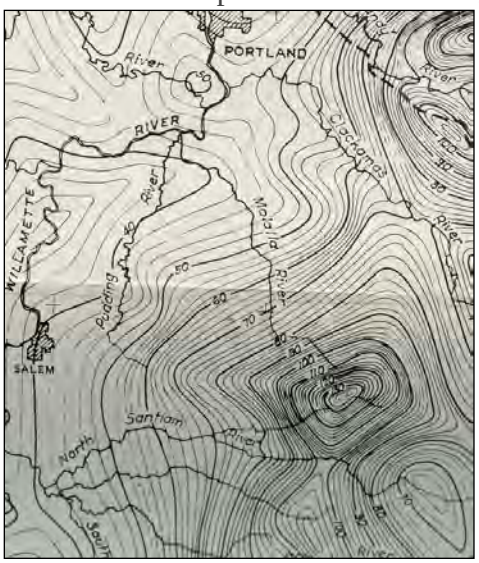
Name	Station ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Salem WSO Airport	7500	1.3	2.1	0.1	0	0	0	0	0	0	0	0.4	2.0	6.0
Silver Creek Falls	7809	3.0	3.4	1.7	0.4	0	0	0	0	0	0	1.3	2.2	14.3
Silverton	7823	1.0	1.3	0	0	0	0	0	0	0	0	0.3	1.3	3.2

Table 4.5. Monthly and Annual Average Heating Degree Days (base 65°F), 1971-2000

Name	Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Salem WSO Airport	7500	769	623	576	451	301	140	39	35	116	376	596	771	4790
Silver Creek Falls	7809	844	711	700	564	410	244	121	124	218	480	702	863	5997
Silverton	7823	780	623	566	441	292	150	50	42	117	356	594	787	4795

Figure 3 shows a map of normal annual precipitation over the Pudding River basin as excerpted from the U.S. Corps of Engineers report, “Procedure for Determination of Maximum Annual Flood Peak and Volume Frequencies for Portland District”, dated February 1969. Based on the isohyets shown on that map and the 1971-2000 average precipitation data listed in Table 4.1, Salem records about 40 inches of rain per year. As expected, this precipitation amount is a lot less than the rainfall over the Drift Creek watershed which is located on much higher ground than Salem and receives as much as 120 inches of rainfall at its headwaters.

Figure 3. Normal Annual Precipitation over Pudding River Basin



4. Drift Creek's Observed Stream Flows

Starting in 2008, Drift Creek's stream flow data were recorded both at the project site (Victor Road) and the Hibbard Rd. gauge located further downstream. The observed flow data at the project site are listed below for each of the three hydrologic years (HY). Table 5.1 refers to HY 2008-09; Table 5.2 to HY 2009-10, and Table 5.3 to HY2010-11. Corresponding stream flow data at the Hibbard Rd. gauge are provided in the Appendix. For each HY, runoff hydrographs are plotted together for the two stations for direct comparison purposes, with separate plots for daily and monthly flows. See Figures 5. 1, 5.2, 5.3, 5.4, 5.5 and 5.6.

4.1 HY 2008-09

Stream flow data and related information (see Table 5.1 and Figures 5.1 and 5.2) were discussed in Report Update #1 and included the following:

- Daily stream flow data collected by Marion Soil and Water Conservation District (Marion SWCD) at two Drift Creek gauges: Victor Point (project site) and Hibbard Rd. (lower station below the project site). Those data were provided by Marion SWCD,
- Daily stream flow data collected by the U.S. Geological Survey (USGS) at six sites on the Pudding River and nearby streams. USGS data were retrieved via the Internet from pertinent websites,
- Ecological and flushing flows prepared by Ellis Ecological Service in March 2010; and
- Revised OWRD's Drift Creek flow availability data made available in April 2010.

Table 5.1 Observed Flows (in cfs) of Drift Creek at Victor Rd., HY 2008-09

DATE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	2008	2008	2008	2009	2009	2009	2009	2009	2009	2009	2009	2009
1	0.50	0.65	17.00	275.00	22.00	91.00	60.00	22.00	11.00	3.00	0.23	0.16
2	0.50	0.70	19.00	500.00	21.00	92.00	81.00	39.00	10.00	2.70	0.23	0.17
3	1.00	1.00	20.00	267.00	21.00	86.00	80.00	39.00	9.80	2.30	0.23	0.19
4	5.00	6.00	19.00	181.00	20.00	74.00	72.00	40.00	10.00	2.00	0.22	0.19
5	4.00	5.00	19.00	173.00	19.00	77.00	64.00	70.00	13.00	2.00	0.23	0.49
6	3.80	3.30	17.00	159.00	23.00	71.00	56.00	98.00	12.00	1.80	0.25	0.90
7	3.50	3.50	17.00	161.00	23.00	65.00	51.00	128.00	11.00	1.70	0.28	0.85
8	3.50	3.00	19.00	198.00	22.00	62.00	46.00	108.00	10.00	1.60	0.35	0.40
9	4.00	3.50	17.00	163.00	22.00	60.00	44.00	89.00	9.30	1.70	0.42	0.29
10	3.00	4.00	16.00	132.00	22.00	58.00	45.00	75.00	8.80	1.80	0.34	0.30
11	2.80	5.00	15.00	115.00	25.00	54.00	38.00	65.00	8.70	1.80	0.30	0.29
12	2.60	22.00	17.00	96.00	24.00	50.00	35.00	59.00	8.40	2.00	0.39	0.27

13	2.50	130.00	26.00	84.00	25.00	46.00	44.00	53.00	7.90	3.00	0.50	0.25
14	2.30	85.00	23.00	73.00	24.00	46.00	42.00	66.00	7.50	2.80	0.35	0.25
15	2.10	54.00	19.00	65.00	24.00	80.00	39.00	54.00	7.20	2.10	0.30	0.73
16	2.00	40.00	17.00	57.00	23.00	92.00	35.00	46.00	6.80	1.60	0.29	3.70
17	1.60	34.00	17.00	50.00	23.00	84.00	35.00	40.00	6.50	1.20	0.26	1.70
18	1.80	28.00	28.00	44.00	22.00	73.00	33.00	36.00	6.20	0.92	0.20	0.83
19	1.30	23.00	25.00	39.00	21.00	66.00	30.00	37.00	6.20	0.78	0.18	0.43
20	1.00	24.00	24.00	35.00	20.00	60.00	27.00	33.00	6.00	0.73	0.17	0.32
21	1.00	25.00	33.00	32.00	19.00	54.00	25.00	29.00	5.80	0.66	0.15	0.27
22	1.20	24.00	60.00	30.00	19.00	62.00	24.00	26.00	5.10	0.63	0.15	0.23
23	0.80	23.00	50.00	28.00	24.00	59.00	23.00	24.00	4.70	0.57	0.15	0.21
24	0.70	22.00	40.00	26.00	71.00	54.00	22.00	22.00	4.40	0.51	0.14	0.20
25	0.60	21.00	50.00	27.00	126.00	61.00	21.00	21.00	4.00	0.40	0.13	0.19
26	0.55	20.00	55.00	25.00	156.00	59.00	20.00	19.00	4.00	0.35	0.13	0.18
27	0.60	20.00	110.00	24.00	123.00	54.00	20.00	18.00	3.50	0.31	0.13	0.17
28	0.60	19.00	200.00	27.00	106.00	56.00	27.00	16.00	3.20	0.29	0.13	0.17
29	0.60	18.00	215.00	25.00		68.00	29.00	15.00	3.20	0.26	0.15	0.18
30	0.55	17.00	160.00	24.00		66.00	24.00	14.00	3.10	0.25	0.16	0.22
31	0.60		130.00	23.00		63.00		11.00		0.24	0.17	
COUNT	31	30	31	31	28	31	30	31	30	31	31	30
AVE, cfs	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.24	1.35	0.24	0.49
VOL, aft	112	1358	2963	6262	2161	4051	2364	2800	431	83	14	29
MONTH	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
	2008	**2008**	**2008**	**2009**	**2009**	**2009**	**2009**	**2009**	**2009**	**2009**	**2009**	**2009**

Annual Oct. 2008-Sep.09 runoff volume= 22,629 acre-feet

Figure 5.1 Hydrographs for HY 2008-09 Drift Creek Daily Flows

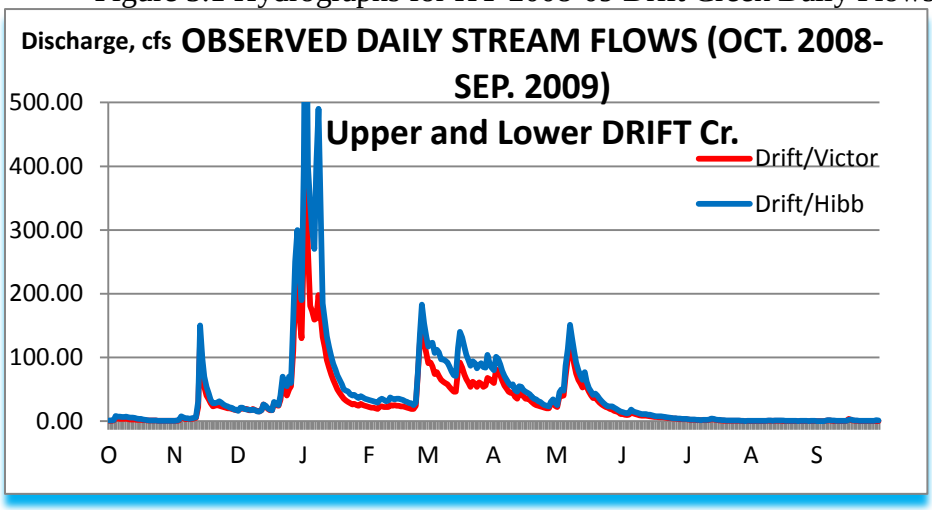
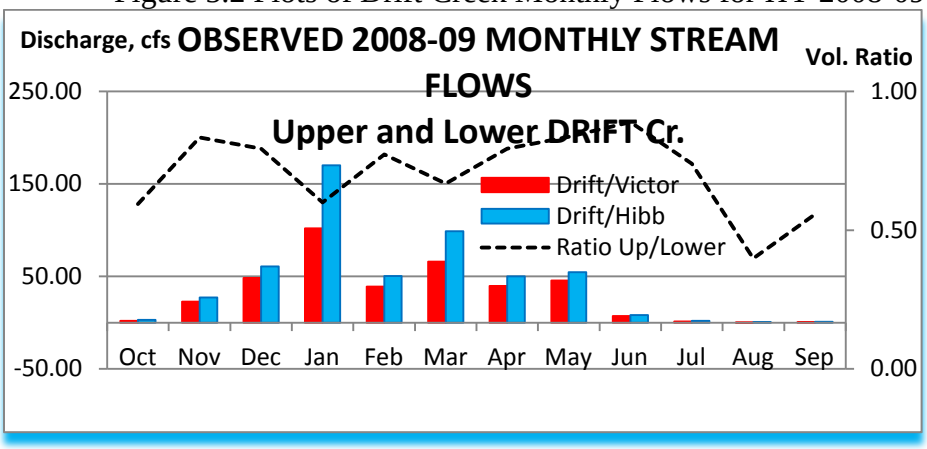


Figure 5.2 Plots of Drift Creek Monthly Flows for HY 2008-09



4.2 HY 2009-10

Stream flows data for the hydrologic years (see Table 5.2 and Figures 5.3 and 5.4) were discussed in Report Update #2 and included the following:

- Daily stream flow data collected at the project site (Victor Point) by a contractor to EVWD (and provided via Ellis Ecological Service).
- Daily stream flow data at Hibbard Rd. below the project site collected by Marion SWCD. The District team also provided daily stream flows they recorded for Silver Creek at Silverton, Abiqua Creek above Gallon House Bridge, and Butte Creek at Monitor.
- Daily stream flow data collected by USGS for the Pudding River near Woodburn and near Aurora. USGS data were retrieved via the Internet.

The 2009-2010 stream flow data at the project site (Victor Point) were complete, except for short gaps during the 1-4 October 2009 and 7-16 November 2009 periods. Those gaps were later filled with corresponding data for the lower site with selected drainage-based correction factors.

Table 5.2 Observed Flows (in cfs) of Drift Creek at Victor Rd., HY 2009-10

DATE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010	2010
1	0.70	10.79	54.39	187.27	45.19	51.35	171.98	70.85	68.46	14.77	3.19	1.00
2	0.70	8.59	48.26	165.74	45.43	47.56	166.41	62.56	136.61	15.78	3.03	1.32
3	0.70	6.66	41.19	132.53	44.04	44.84	181.37	63.13	195.20	15.30	2.80	1.12
4	0.70	5.42	35.61	113.88	44.32	42.01	162.35	56.63	218.07	13.73	2.71	0.77
5	0.79	4.78	31.07	130.90	43.94	37.53	142.77	52.36	174.99	13.06	2.65	0.51
6	5.78	5.08	27.47	191.81	40.61	34.17	129.91	47.98	143.78	12.24	2.40	0.43
7	2.87	36.28	24.13	157.00	38.22	31.81	113.09	43.37	127.85	11.35	2.11	1.13
8	1.42	55.48	21.00	132.48	35.25	35.16	112.58	39.85	100.15	10.54	2.05	2.24

9	0.67	52.93	18.39	124.22	33.35	30.86	92.67	36.46	90.73	9.99	2.60	1.98
10	0.30	46.11	17.07	104.58	31.71	30.79	86.88	38.71	101.39	9.27	2.31	1.51
11	0.14	51.62	16.81	91.60	32.79	32.37	79.64	34.80	106.54	8.93	2.23	1.20
12	0.05	70.48	17.13	99.40	39.27	61.17	74.54	31.07	90.62	8.43	1.96	0.93
13	0.01	66.70	17.46	97.79	45.29	83.26	68.17	28.35	77.12	8.15	1.60	0.76
14	0.41	62.52	16.84	90.21	55.18	72.85	63.26	26.15	67.57	7.40	1.25	0.65
15	0.95	50.95	55.29	91.97	63.16	64.35	99.46	24.13	61.91	6.73	1.05	4.38
16	0.85	41.70	114.32	155.85	68.98	57.41	85.35	22.61	56.13	6.46	0.99	3.89
17	0.91	65.84	103.93	155.43	64.85	52.17	74.17	25.01	48.52	6.12	0.81	2.88
18	2.26	60.65	89.10	143.91	59.67	46.22	65.93	29.70	40.54	6.04	0.61	4.27
19	1.72	52.80	82.03	122.95	54.35	41.64	59.30	29.28	33.76	6.00	0.72	9.06
20	1.07	54.80	80.05	104.39	49.01	37.87	55.28	27.45	32.08	6.06	0.78	8.42
21	1.06	67.07	119.79	91.33	43.59	40.14	60.96	28.51	30.63	5.70	0.69	7.00
22	1.35	79.67	135.69	81.97	38.99	43.58	50.16	53.49	25.78	5.42	0.65	4.66
23	2.09	71.38	110.51	73.89	36.92	37.75	45.01	54.12	25.48	5.12	0.56	3.51
24	4.89	59.61	93.72	70.91	46.62	34.79	43.31	51.45	23.87	4.83	0.44	3.15
25	3.68	50.82	81.40	93.90	50.28	43.75	39.20	51.19	20.65	4.56	0.33	2.76
26	6.11	51.31	70.00	83.75	56.25	94.43	37.25	81.95	18.78	4.26	0.31	2.60
27	10.53	108.69	60.92	73.38	61.95	96.52	62.12	86.80	17.54	3.89	0.51	2.80
28	6.52	89.71	53.72	63.59	55.78	93.94	89.32	75.31	16.39	3.81	0.40	2.42
29	5.80	74.28	48.54	59.02		232.61	94.04	68.72	15.39	3.83	0.24	2.10
30	10.91	62.44	62.75	54.70		263.37	82.19	60.16	14.59	3.64	0.30	1.86
31	12.15		100.94	50.00		215.25		68.22		3.51	0.54	
COUNT	31	30	31	31	28	31	30	31	30	31	31	30
AVE, cfs	2.84	50.84	59.66	109.37	47.32	68.76	89.62	47.43	72.70	7.90	1.38	2.71
VOL, aft	175	3024	3668	6723	2627	4227	5332	2916	4325	486	85	161
MONTH	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
	2009	**2009**	**2009**	**2010**	**2010**	**2010**	**2010**	**2010**	**2010**	**2010**	**2010**	

Annual Oct. 2009-Sep.10 runoff volume= 33,749 acre-feet

Figure 5.3 Hydrographs for HY 2009-10 Drift Creek Daily Flows

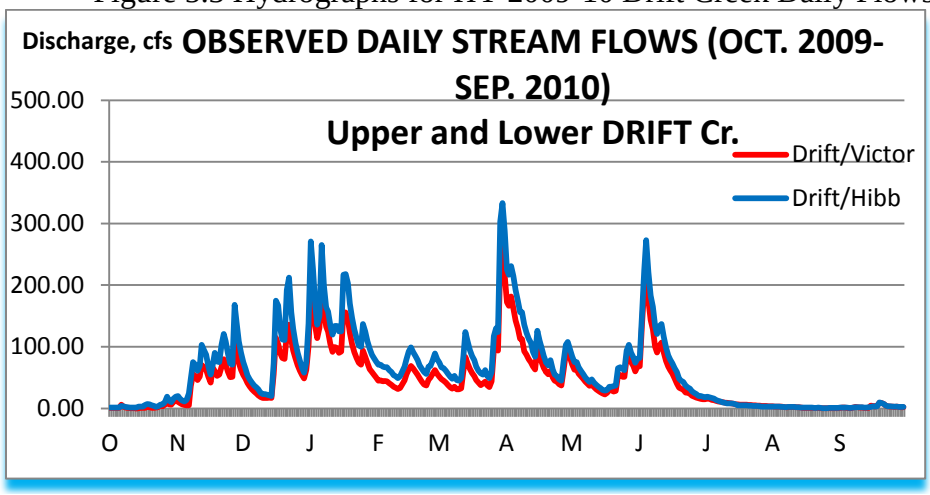
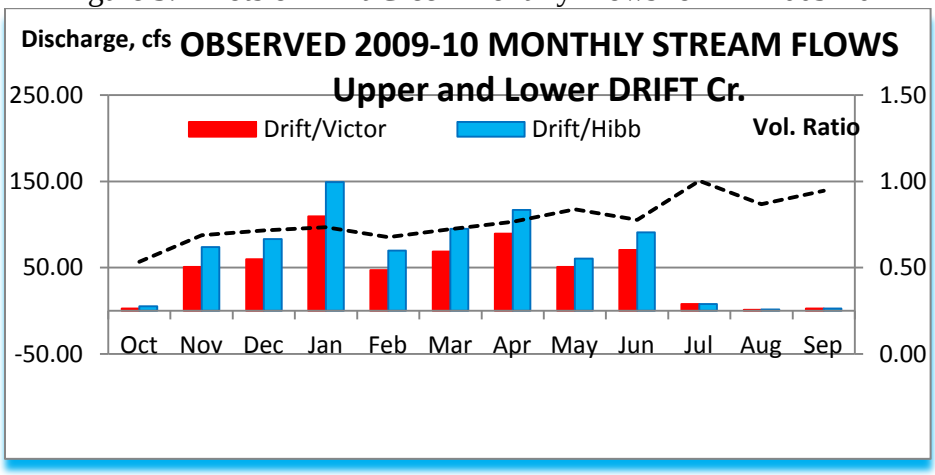


Figure 5.4 Plots of Drift Creek Monthly Flows for HY 2009-10



4.3 HY 2010-11

Stream flow data for the hydrologic year are discussed in this Report Update #3 and include the following:

- Daily stream flow data collected at the project site (Victor Point) by a contractor to EVWD (and provided via Ellis Ecological Service).
- Daily stream flow data collected at Hibbard Rd. gage below the project site by Marion SWCD. The District made "provisional" data available in late April 2012, along with daily stream flow they recorded for Silver Creek at Silverton, Abiqua Creek above Gallon House Bridge, Butte Creek at Monitor, and Zollner Creek near Mt. Angel. Updated 2008-2009 stream flows data for Abiqua Creek were also received.

- Daily stream flow data collected by USGS for the Pudding River near Woodburn and near Aurora were available as usual through the Internet. Some minor changes were noticed between data posted in mid-January and mid-April 2012.

In general the 2010-11 flow meter readings for Drift Creek were all well within the level of accuracy generally expected for this type of discharge measurement. Note that data readings in August and September yielded flows slightly higher at the upper gauge than those recorded at the lower gauge of the creek. This difference involved flows of less than 0.1 cfs that last only a few days, and could be caused by irrigation withdrawal between the two stations.

Table 5.3 Observed Flows (in cfs) of Drift Creek at Victor Rd., HY 2010-11

DATE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011	2011
1	0.93	27.76	150.98	107.95	33.98	197.32	98.27	66.94	58.42	16.74	4.51	1.56
2	0.89	65.17	146.27	91.19	30.72	177.45	104.75	62.00	57.30	13.55	4.09	1.45
3	0.87	52.99	117.08	78.10	28.21	147.41	89.55	56.02	52.73	11.88	4.76	1.34
4	0.85	41.19	97.92	68.02	26.29	131.63	81.81	50.39	46.85	10.96	3.76	1.13
5	0.70	33.72	82.74	61.75	25.39	125.27	86.61	46.05	41.84	10.09	3.51	1.01
6	0.58	32.08	72.05	56.90	24.27	105.42	80.34	43.75	39.17	9.23	3.43	0.66
7	0.48	93.07	62.73	51.46	24.09	92.36	86.91	47.76	35.83	8.84	3.55	0.55
8	0.49	76.55	70.85	52.29	23.23	82.51	82.17	46.90	32.91	8.78	3.64	0.56
9	1.34	72.60	112.46	49.88	24.34	76.97	74.60	49.48	29.38	8.23	3.69	0.69
10	10.27	88.34	161.50	46.57	23.58	121.70	69.10	44.48	26.93	8.03	3.89	0.70
11	12.07	73.01	150.43	42.96	22.57	120.77	75.56	43.92	25.32	8.17	3.14	0.66
12	7.36	64.54	149.68	48.52	21.81	104.77	70.82	47.69	23.32	8.93	2.69	0.72
13	5.38	54.87	216.24	79.27	28.92	103.92	69.17	42.48	24.53	9.65	2.55	0.80
14	4.34	56.06	254.46	97.22	28.09	121.83	68.74	40.20	21.52	8.70	2.90	0.99
15	3.66	54.18	199.07	95.98	56.26	114.71	82.27	44.97	19.45	7.71	2.88	1.10
16	3.31	59.11	157.15	250.04	77.59	130.45	123.00	53.75	17.62	8.31	2.60	1.18
17	2.95	56.68	129.72	302.76	67.17	141.44	130.35	49.46	17.76	11.94	2.34	1.14
18	2.68	147.34	125.35	217.56	60.02	130.18	110.06	43.82	17.88	13.12	2.19	0.98
19	2.45	137.00	112.07	203.90	58.04	121.67	92.64	37.15	16.48	11.37	2.04	1.39
20	2.29	125.47	102.02	153.15	52.18	106.88	78.28	34.01	16.94	10.55	1.72	1.52
21	2.19	104.50	89.26	130.74	47.81	98.89	70.35	31.41	15.67	8.91	1.55	1.20
22	4.66	107.28	77.25	114.96	44.88	90.87	62.51	29.68	14.86	8.36	1.67	1.07
23	6.54	121.10	67.60	97.94	44.00	80.86	55.49	27.57	15.04	7.47	1.65	0.89
24	13.30	99.00	59.93	85.55	44.94	79.09	51.56	25.55	14.21	6.84	1.50	0.73
25	18.51	80.73	54.81	74.58	42.47	76.00	64.36	28.32	13.39	6.37	1.45	0.90
26	23.92	75.48	61.51	66.05	39.01	90.95	63.94	28.72	12.86	6.13	2.79	1.41
27	20.36	101.56	70.77	58.64	37.81	89.78	63.28	42.19	12.31	5.70	2.02	4.04
28	19.53	90.63	148.98	52.69	79.31	89.38	66.73	62.67	13.15	5.40	1.67	3.95

29	21.88	79.97	245.75	47.35		105.84	78.25	63.70	13.04	5.01	1.69	2.78
30	18.34	84.46	164.79	42.39		117.06	73.58	57.14	13.88	4.78	1.78	2.75
31	28.39		129.61	37.93		104.72		54.31		4.75	1.62	
COUNT	31	30	31	31	28	31	30	31	30	31	31	30
AVE, cfs	7.79	78.55	123.90	95.62	39.89	112.20	80.17	45.24	25.35	8.86	2.69	1.33
VOL, aft	479	4673	7617	5878	2215	6897	4769	2781	1508	544	165	79
MONTH	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
	2010	**2010**	**2010**	**2011**	**2011**	**2011**	**2011**	**2011**	**2011**	**2011**	**2011**	**2011**

Annual (Oct. 2010-Sep. 2011) runoff volume= 37,606 acre-feet

Figure 5.5 Hydrographs for HY 2010-11 Drift Creek Daily Flows

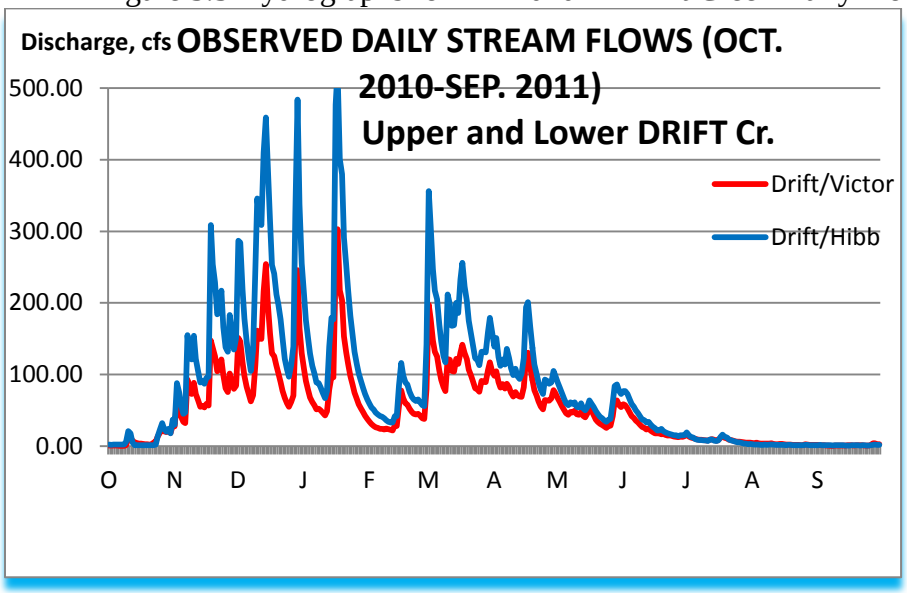
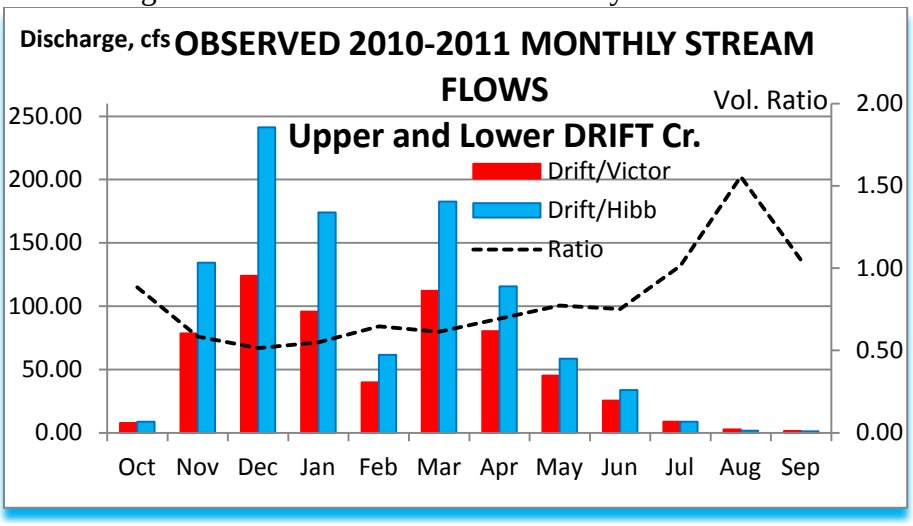


Figure 5.6 Plots of Drift Creek Monthly Flows for HY 2010-11



4.4 HY 2008-11

Figures 5.7 and 5.8 are the hydrographs for Drift Creek at the project site all three HY's on the same plot to show both the year-by-year relative magnitude and shape. Drift Creek's 2010-11 runoff was greater than the runoff recorded during the preceding two hydrologic years 2008-09 and 2009-10. Figure 5.9 shows the monthly flows for the same three years.

Figure 5.7 Shape of Daily Flow Hydrographs for Drift Creek at the project site

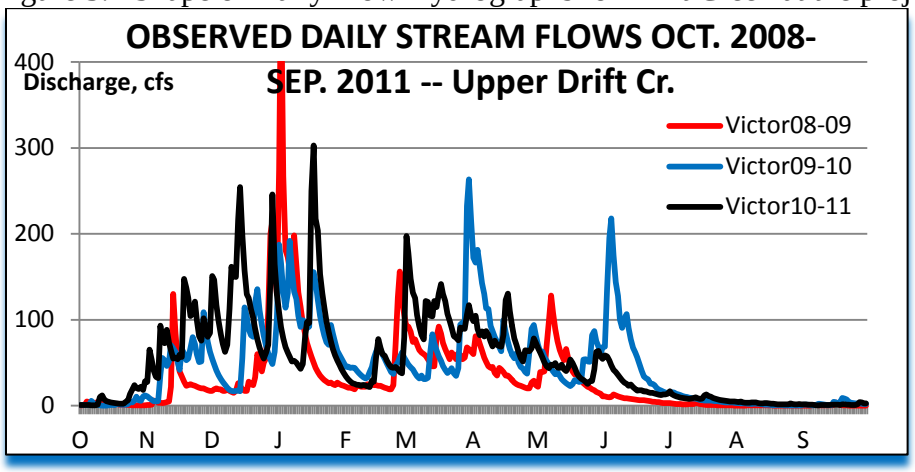


Figure 5.8 Relative Magnitudes of Daily Drift Cr. Flows at the Project Site

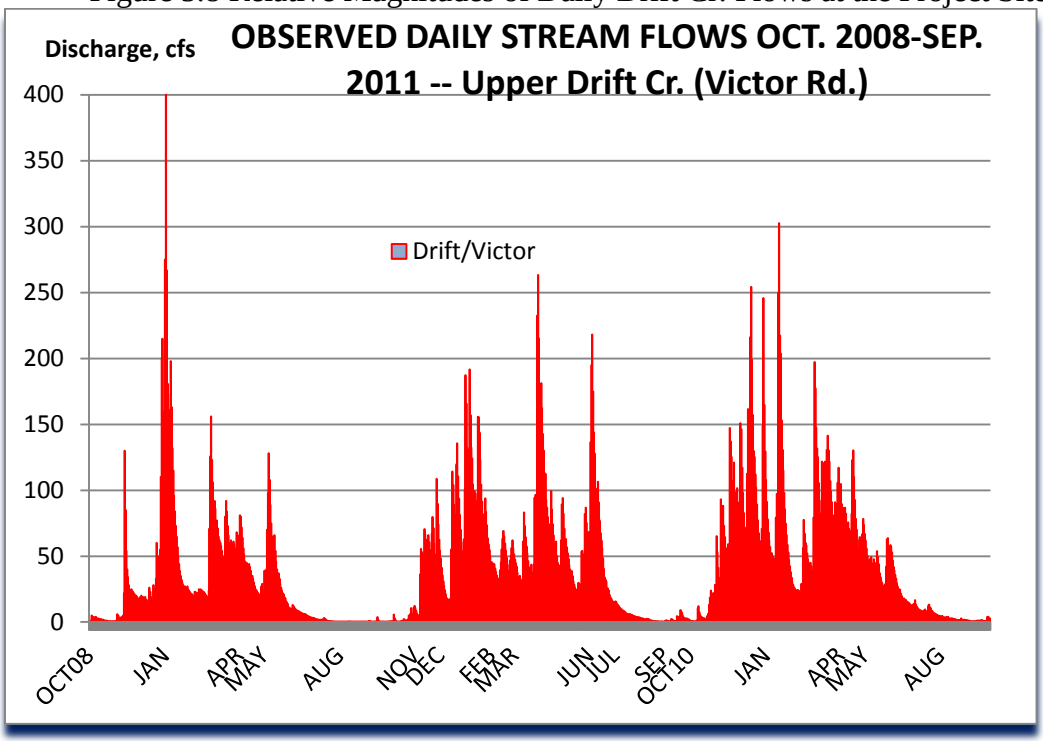
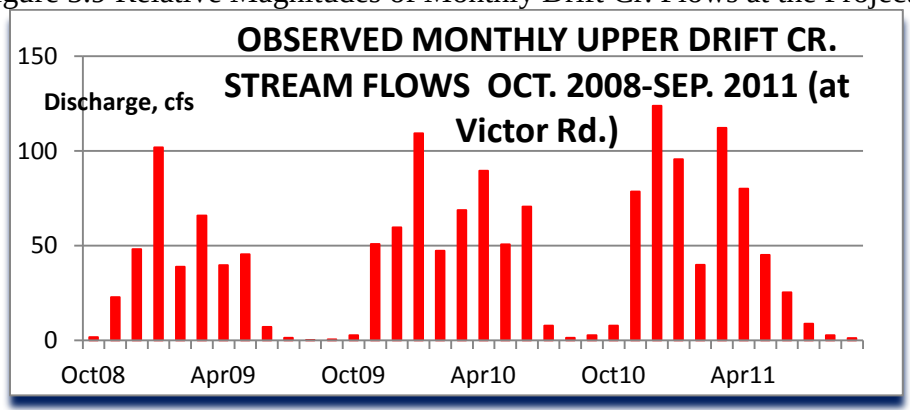


Figure 5.9 Relative Magnitudes of Monthly Drift Cr. Flows at the Project Site



4.5 Statistical Correlation between Upper and Lower Drift Creek Flow data

The hydrographs of the daily flows for the three HY's 2008-09, 2009-10 and 2010-11 are shown in Figure 5.10. Equivalent hydrographs for monthly flows are shown in Figure 5.11.

Figure 5.10 Hydrographs of Drift Creek Daily Stream Flows, 2008-2011

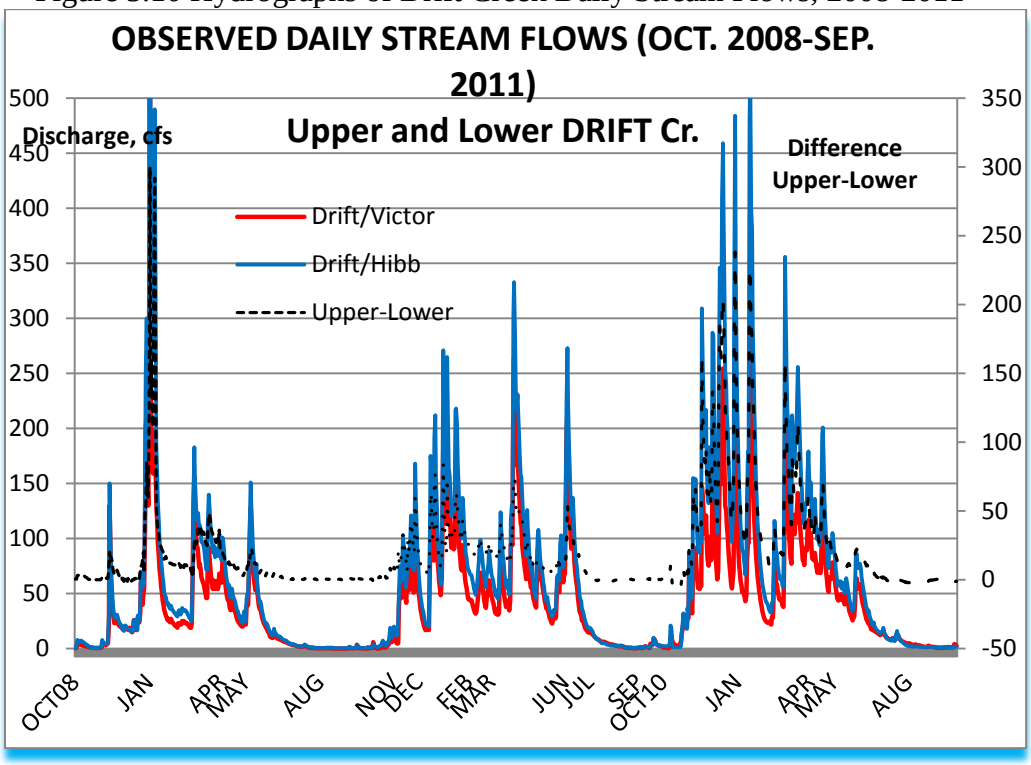


Figure 5.11. Hydrographs of Drift Creek Monthly Flows, 2008-2011

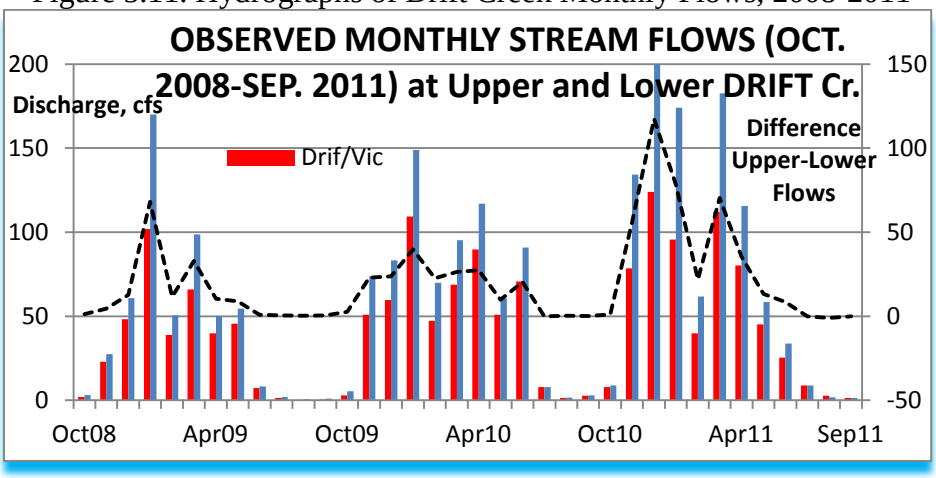


Table 5.4 provides a summary of monthly flow data at both the upper and lower gauging stations for all three HY's, including the monthly runoff volume ratio of the upper station over the lower station.

Table 5.4 Monthly Flows Data at Upper and Lower Drift Cr. (2008-2011)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Drift												
2008-09	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.24	1.35	0.24	0.49
2009-10	2.84	50.84	59.66	109.37	47.32	68.76	89.62	50.77	70.57	7.90	1.38	2.71
2010-11	7.79	78.55	123.90	95.62	39.89	112.20	80.17	45.24	25.35	8.86	2.69	1.33
Lower Drift												
2008-09	3.08	27.38	60.77	170.00	50.39	98.68	50.07	54.45	8.15	1.83	0.59	0.88
2009-10	5.32	73.87	83.32	149.00	69.93	95.16	116.90	60.64	90.79	7.87	1.59	2.87
2010-11	8.82	134.30	241.26	174.00	61.64	182.58	115.67	58.48	33.77	8.73	1.73	1.27
Ratio Up/Lower												
2008-09	0.59	0.83	0.79	0.60	0.77	0.67	0.79	0.84	0.89	0.74	0.40	0.56
2009-10	0.53	0.69	0.72	0.73	0.68	0.72	0.77	0.84	0.78	1.00	0.87	0.95
2010-11	0.88	0.58	0.51	0.55	0.65	0.61	0.69	0.77	0.75	1.01	1.56	1.05

There is a strong correlation between both the daily and the monthly flow data at the two gauging stations in all three HY's. See Figures 6.1 through 6.4 for daily flows and Figures 7.1 through 7.4 for monthly flows. Table 6.1 presents a summary of the polynomial regression equations and the correlation factor R^2 linking Lower Drift Cr. (X) to Upper Drift Cr. (Y).

Daily Flows

Figure 6.1 Drift Cr. Daily Flow Correlation, HY 2008-09

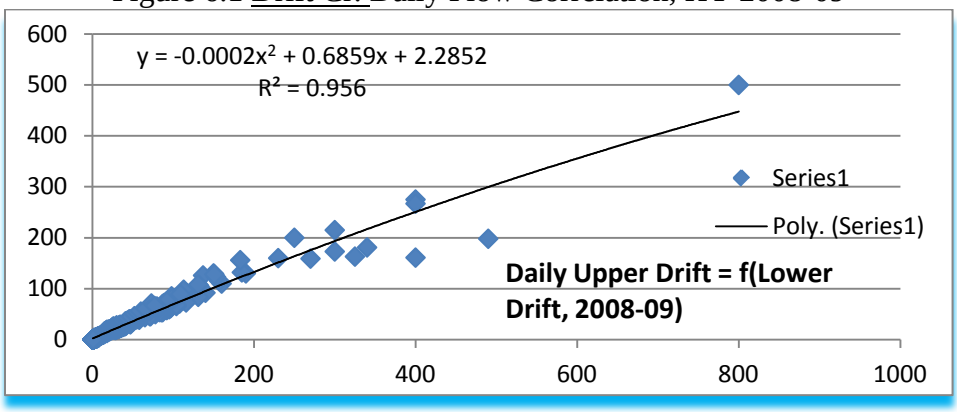


Figure 6.2 Drift Cr. Daily Flow Correlation, HY 2009-10

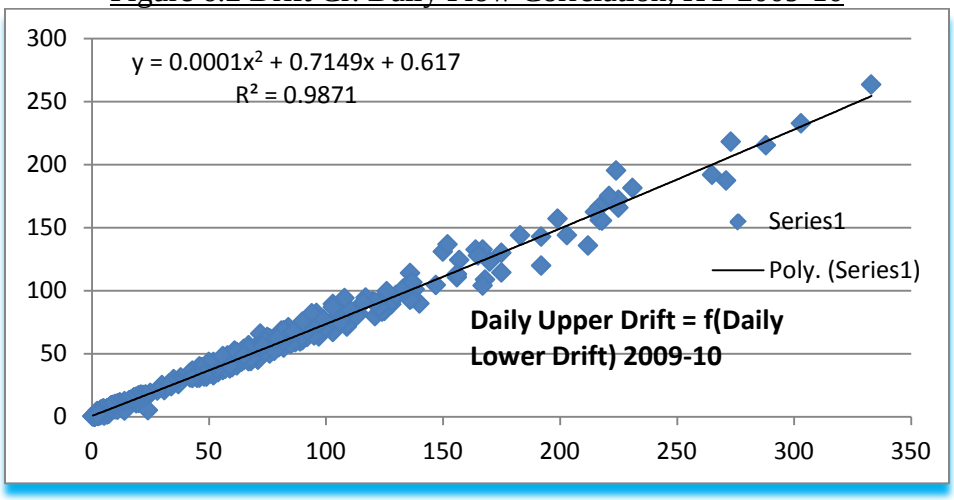


Figure 6.3 Drift Cr. Daily Flow Correlation, HY 2010-11

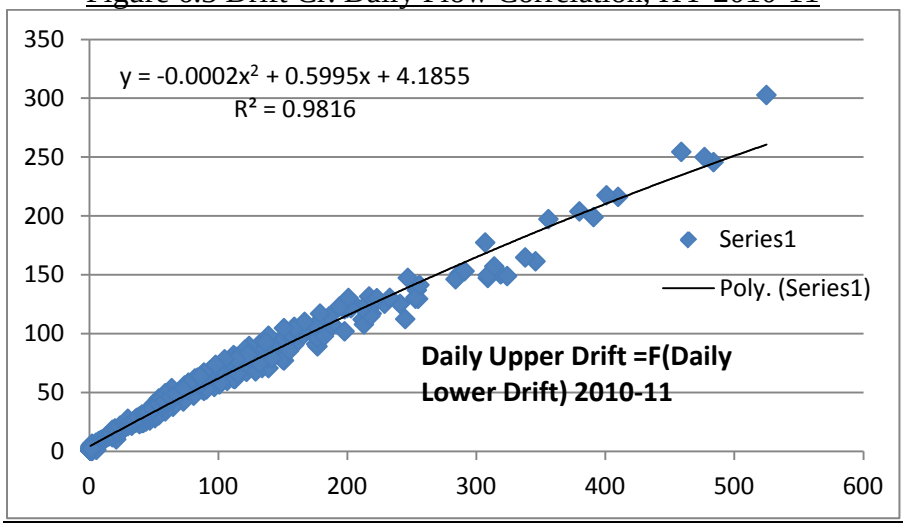
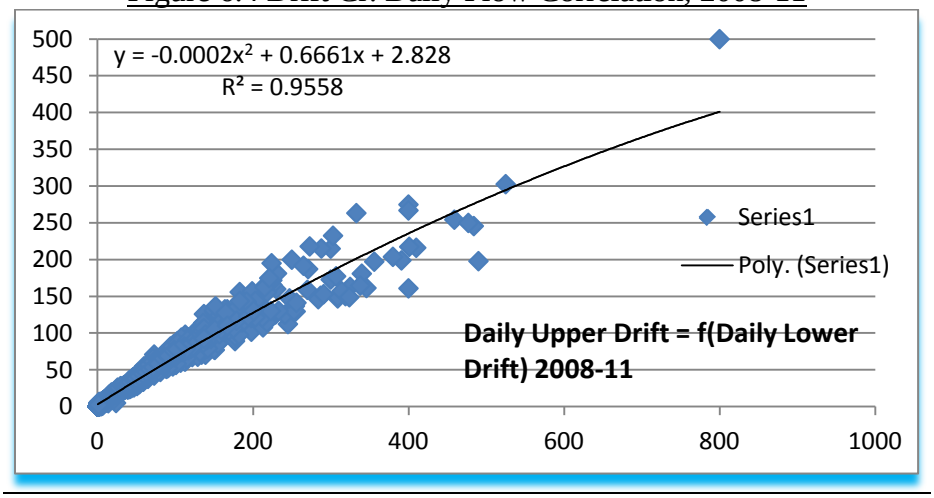


Figure 6.4 Drift Cr. Daily Flow Correlation, 2008-11



Monthly Flows

Figure 7.1 Drift Cr. Monthly Flow Correlation, HY 2008-09

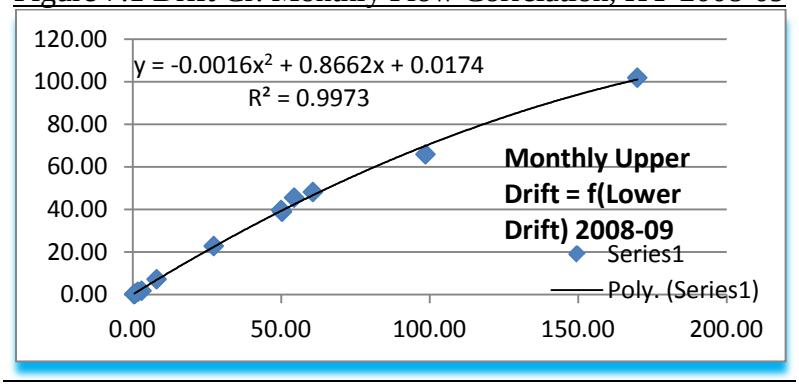


Figure 7.2 Drift Cr. Monthly Flow Correlation, HY 2009-10

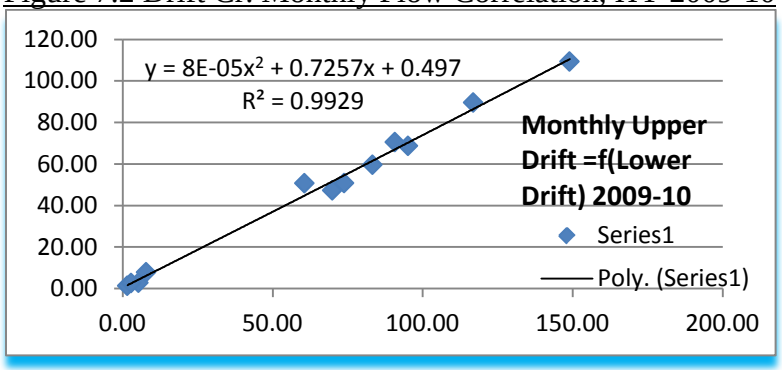


Figure 7.3 Drift Cr. Monthly Flow Correlation, HY 2010-11

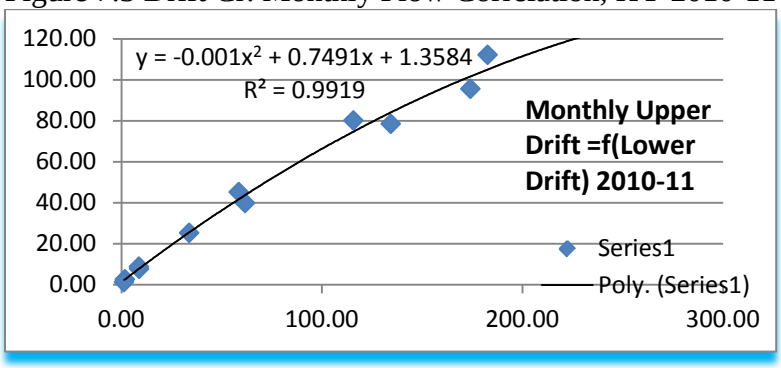


Figure 7.4 Drift Cr. Monthly Flow Correlation, 2008-11

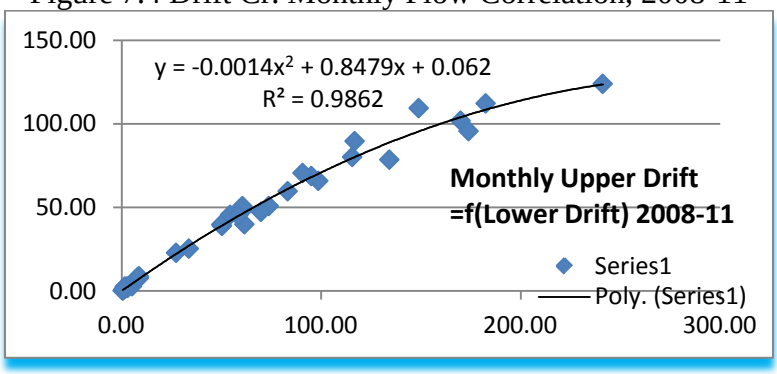


Table 6.1 Regression Equations Linking Lower Drift (X) to Upper Drift (Y)

Daily Flows	Regression Equation	R^2
2008-09	Y= -0.0002*X^2+0.6859*X+2.2852	0.956
2009-10	Y= -0.0001*X^2+0.7149*X+0.617	0.9871
2010-11	Y= -0.0002*X^2+0.599*X+4.1855	0.9861
2008-11	Y= -0.0002*X^2+0.6661*X+2.828	0.9558
Monthly Flows		
2008-09	Y= -0.0016*X^2+0.8661*X+0.00174	0.9973
2009-10	Y= 8E-5*X^2+0.7257*X+0.497	0.9929
2010-11	Y= -0.001*X^2+0.7491*X+1.35840	0.9919
2008-10	Y= -0.0014*X^2+0.8479*X+0.062	0.9862

Stream flow data recorded to date at both the upper and the lower gauging stations have been instrumental in firming up runoff estimates for Drift Creek. The two recording stations are the two nearest stations available on Drift Creek and, as such, provided the most reliable means to cross-check the stream flow readings. They also play a back-up role for one another, in case recordings at one of the stations are missing due to high flood events, equipment failures, and other unusual/unexpected circumstances. Flow records at those two sites will also provide a firmer basis for OWRD to revise their water availability data for the 50% and 80% exceedence frequencies at the mouth of Drift Creek.

5. Stream Flows at Nearby Streams

As mentioned earlier, stream flow data recorded at the following streams and gauges were analyzed in this report: Pudding River at Aurora and at Woodburn, Silver Creek at Silverton, Abiqua Creek above Gallon House Bridge, Butte Creek at Monitor, and Zollner Creek near Mt. Angel. Table 6.2 lists the monthly flows observed at those streams during the last three hydrologic years, 2008-11.

Table 6.2 2008-2011 Monthly Flows at Drift Cr. and Nearby Streams

Streams Gauges=	Pudding Woodburn	Pudding Aurora	Drift Upper	Drift Lower	Silver Silverton	Lo.Abiqua GH Bridge	Butte Monitor	Zollner Mt. Angel
Sq.Mi.	314	479	15.8	24.8	47.9	75.7	58.7	15
Area Ratio	20.39	31.1	1	1.57	3.11	4.79	3.715	0.97
Oct08	74.16	132.58	1.83	3.08	25.71	37.29	31.45	0.90
Nov08	556.73	767.80	22.82	27.38	217.60	315.63	160.10	4.93
Dec08	821.84	1110.10	48.19	60.77	199.65	514.00	237.23	31.03
Jan09	2237.45	3281.81	101.87	170.00	413.52	883.23	578.74	58.67

Feb09	562.86	830.07	38.93	50.39	164.00	203.89	149.04	11.28
Mar09	1146.90	1810.32	65.90	98.68	345.00	458.77	318.00	26.29
Apr09	727.00	1174.83	39.73	50.07	222.30	313.27	238.90	8.99
May09	710.03	1117.77	45.55	54.45	215.48	295.32	223.68	10.47
Jun09	148.20	247.27	7.24	8.15	19.79	57.83	32.94	14.06
Jul09	38.97	57.84	1.35	1.83	15.74	11.68	5.00	0.34
Aug09	15.62	21.65	0.24	0.59	8.61	5.06	2.09	0.26
Sep09	20.23	36.93	0.49	0.88	6.72	12.49	5.58	0.25
Av 08-09	591.0	886.4	31.3	44.0	154.8	260.4	166.0	14.1
Vol Ratio	18.90	28.35	1.00	1.41	4.95	8.33	5.31	0.45
Vol, aft	427,771	641,582	22,629	31,880	112,077	188,487	120,131	10,172
Oct-Apr V	370,748	551,076	19,271	27,847	95,757	165,120	103,653	8,640
Oct09	61.19	99.84	2.84	5.32	22.04	58.90	19.33	0.97
Nov09	777.67	1179.60	50.84	73.87	222.97	343.93	226.80	24.43
Dec09	1007.00	1508.16	59.66	83.32	233.06	368.65	253.58	34.09
Jan10	1954.71	2843.55	109.37	149.00	429.39	628.65	412.16	71.42
Feb10	834.46	1287.64	47.32	69.93	189.46	292.00	177.11	30.14
Mar10	992.10	1452.06	68.76	95.16	298.29	408.39	298.84	24.18
Apr10	1432.77	2252.33	89.62	116.90	383.37	491.87	379.13	26.29
May10	663.55	1076.85	50.77	60.64	202.33	321.21	215.70	9.44
Jun10	1100.64	1676.93	70.57	90.79	306.61	402.57	310.18	24.31
Jul10	126.58	183.74	7.90	7.87	36.68	54.39	24.20	1.04
Aug10	42.39	49.32	1.38	1.59	15.05	12.09	5.41	0.69
Sep10	64.17	90.07	2.71	2.87	38.73	21.97	16.06	1.10
Av 09-10	753.1	1138.7	46.7	63.0	197.8	283.3	194.6	20.6
Vol. Ratio	16.11	24.37	1.00	1.35	4.23	6.06	4.16	0.44
Vol, aft	545,117	824,216	33,827	45,571	143,168	205,055	140,852	14,921
Oct-Apr V	424,646	638,574	25,776	35,690	107,005	155,967	106,365	12,723
Oct10	181.81	275.90	7.79	8.82	53.52	85.81	48.13	8.40
Nov10	1211.53	1857.27	78.55	134.30	310.70	456.73	298.37	45.40
Dec10	2720.65	4140.97	123.90	241.26	665.00	911.61	689.10	95.94
Jan11	2150.13	3344.19	95.62	174.00	506.39	675.74	498.29	51.68
Feb11	624.43	1109.64	39.89	61.64	152.57	235.21	154.75	18.85
Mar11	2233.87	3538.71	112.20	182.58	519.48	697.65	536.19	75.32
Apr11	1535.73	2467.00	80.17	115.67	424.00	589.67	425.67	32.26
May11	712.52	1184.65	45.24	58.48	202.81	342.29	253.77	8.13
Jun11	465.90	798.17	25.35	33.77	127.67	204.83	175.97	4.66
Jul11	133.19	207.94	8.86	8.73	39.81	50.45	33.61	1.75
Aug11	51.23	83.94	2.69	1.73	19.23	17.48	7.85	0.57
Sep11	31.70	50.60	1.33	1.27	17.63	12.11	7.02	0.61
Av 10-11	1009.6	1595.4	52.0	85.5	254.4	358.1	262.0	28.8
Vol. Ratio	19.43	30.71	1.00	1.65	4.90	6.89	5.04	0.55

Vol, aft	730,765	1,154,752	37,606	61,908	184,151	259,175	189,612	20,844
Oct-Apr V	646,026	1,013,493	32,528	55,586	159,411	221,051	160,577	19,888

Streams Gauges=	Pudding Woodburn	Pudding Aurora	Drift Upper	Drift Lower	Silver Silverton	Lo.Abiqua GH Bridge	Butte Monitor	Zollner Mt. Angel

Figure 8.1 shows the hydrographs of the recorded daily flows for all the listed streams to provide the big picture of their runoff magnitude. Figure 8.2 focuses more on the daily hydrographs of the smaller streams.

Figure 8.1 Daily Flow Hydrographs for All Streams, Oct. 2008-Sep. 2011

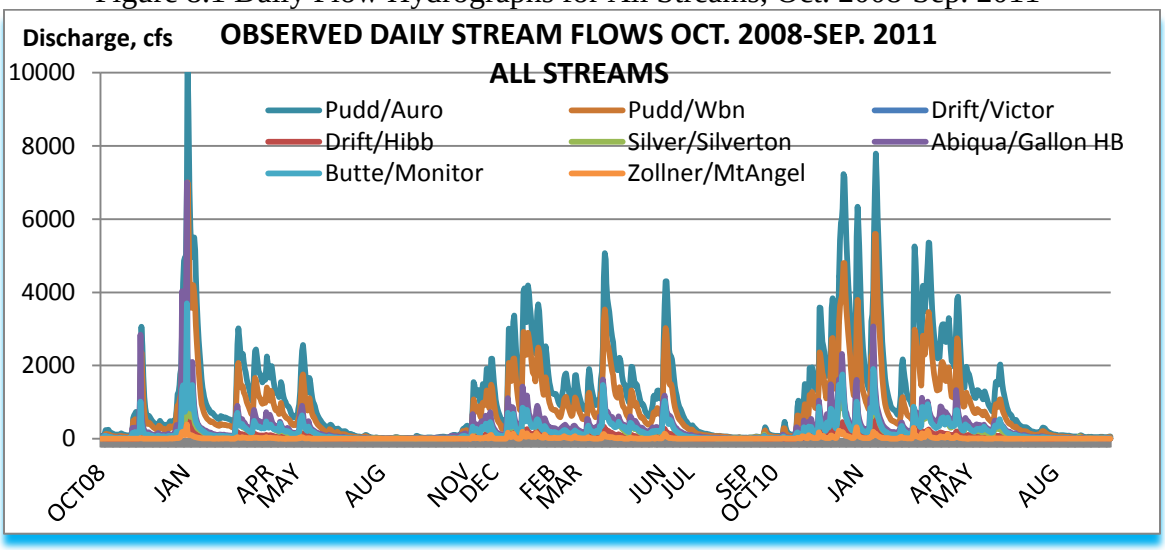
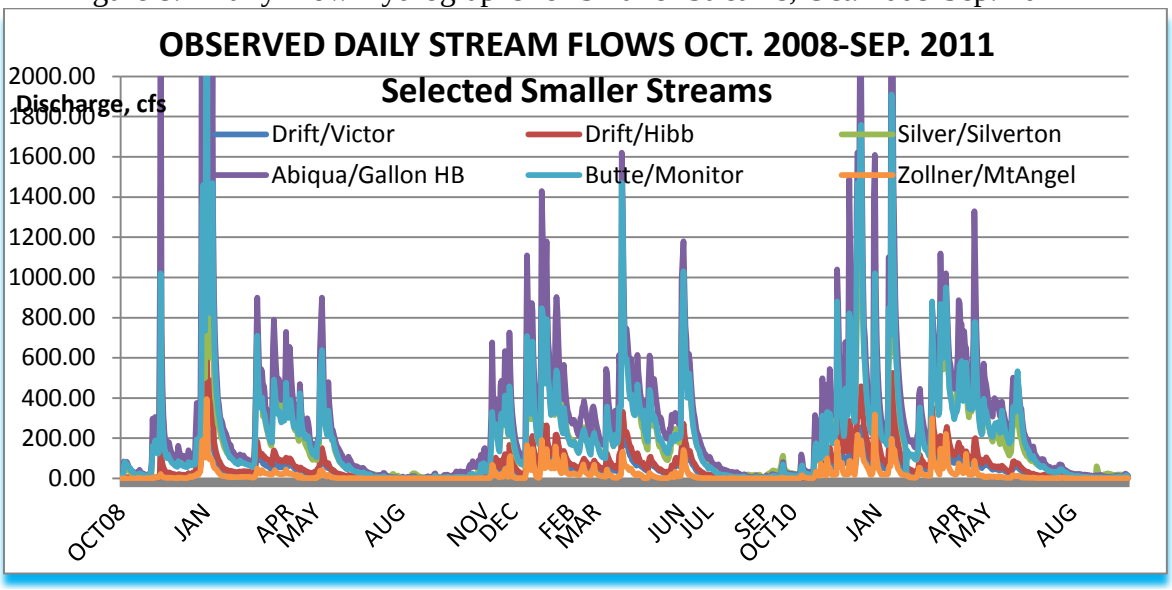
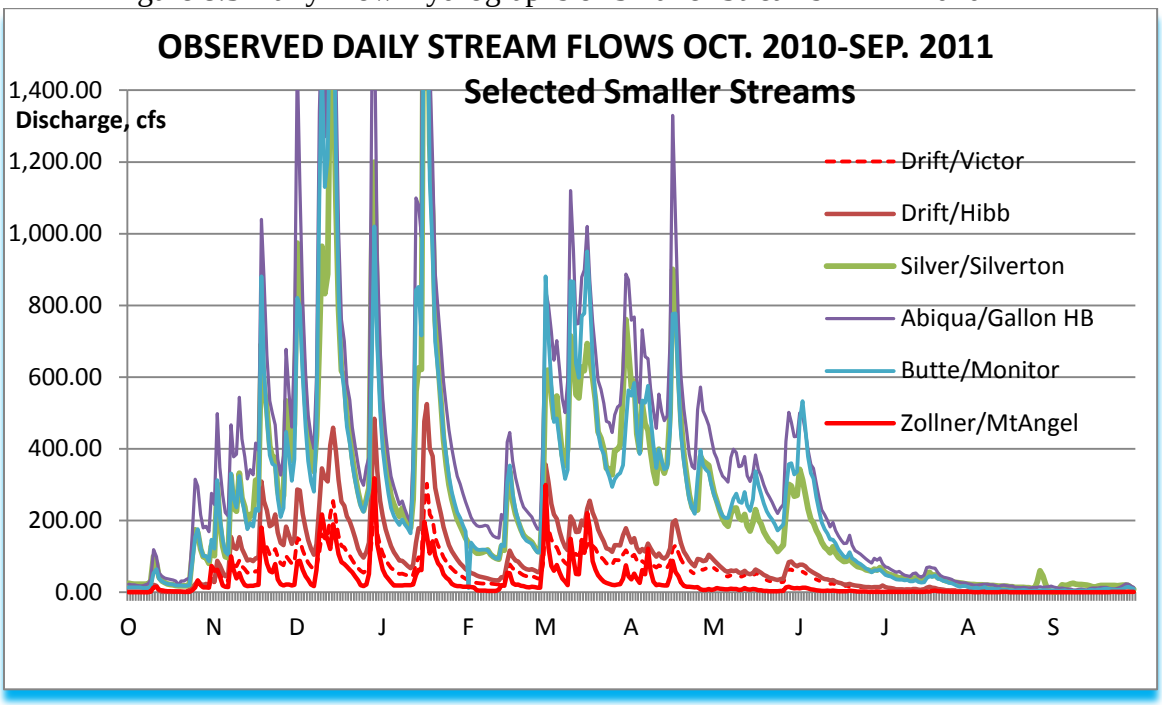


Figure 8.2 Daily Flow Hydrographs for Smaller Streams, Oct. 2008-Sep. 2011



To provide a complete picture of the runoff in the watersheds located next to Drift Creek, Figure 8.3 shows the daily hydrographs of smaller streams for HY 2010-11.

Figure 8.3 Daily Flow Hydrographs of Smaller Streams in HY 2010-11



Figures 8.4 through 8.9 provide a closer, one-on-one comparison between Drift Creek flows and the flows of other nearby streams covering the full three hydrologic years 2008-2011.

Figure 8.4 Daily Flow Hydrograph of Upper Drift and Pudding @ Aurora, 2008-11

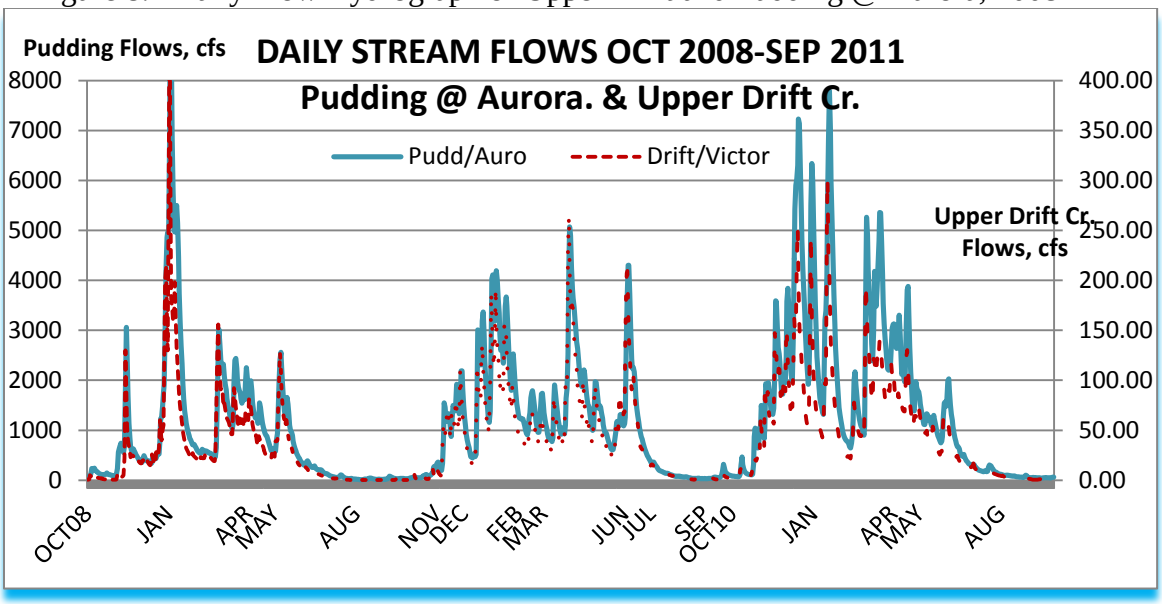


Figure 8.5 Daily Flow Hydrograph of Upper Drift and Pudding @ Woodburn 2008-11

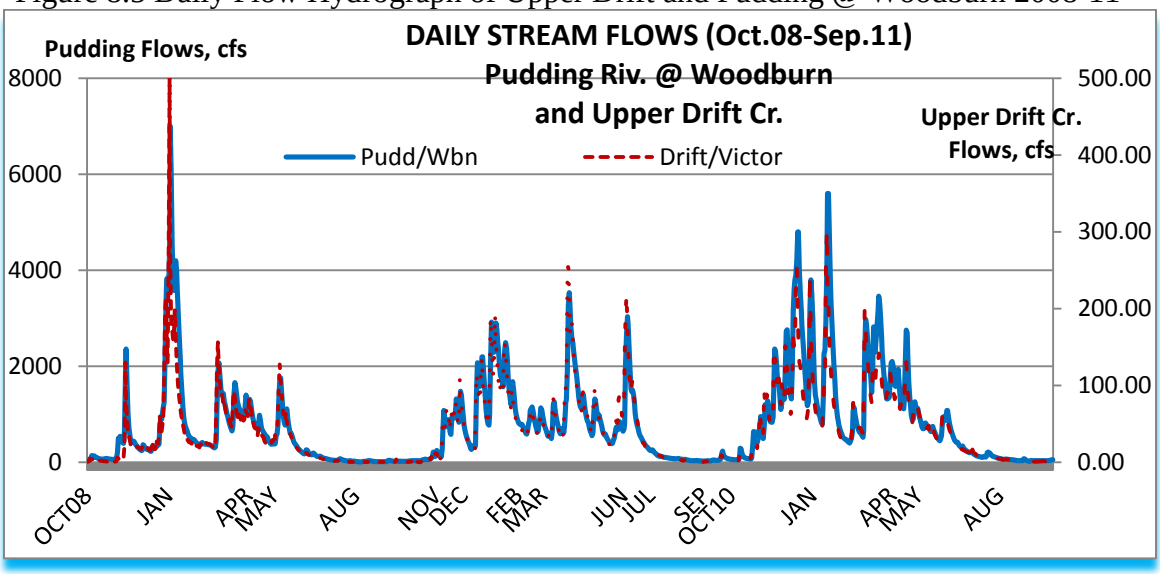


Figure 8.6 Daily Flow Hydrograph of Upper Drift and Silver Cr. @ Silverton, 2008-11

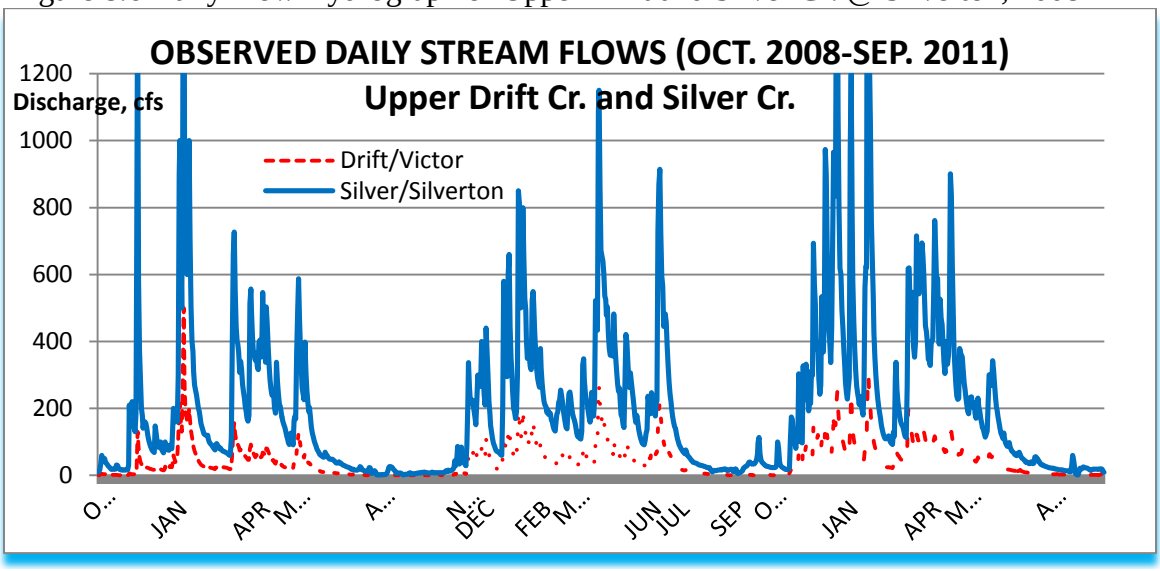


Figure 8.7 Daily Flow Hydrograph of Upper Drift and Abiqua @ Gallon House Bridge 2008-11

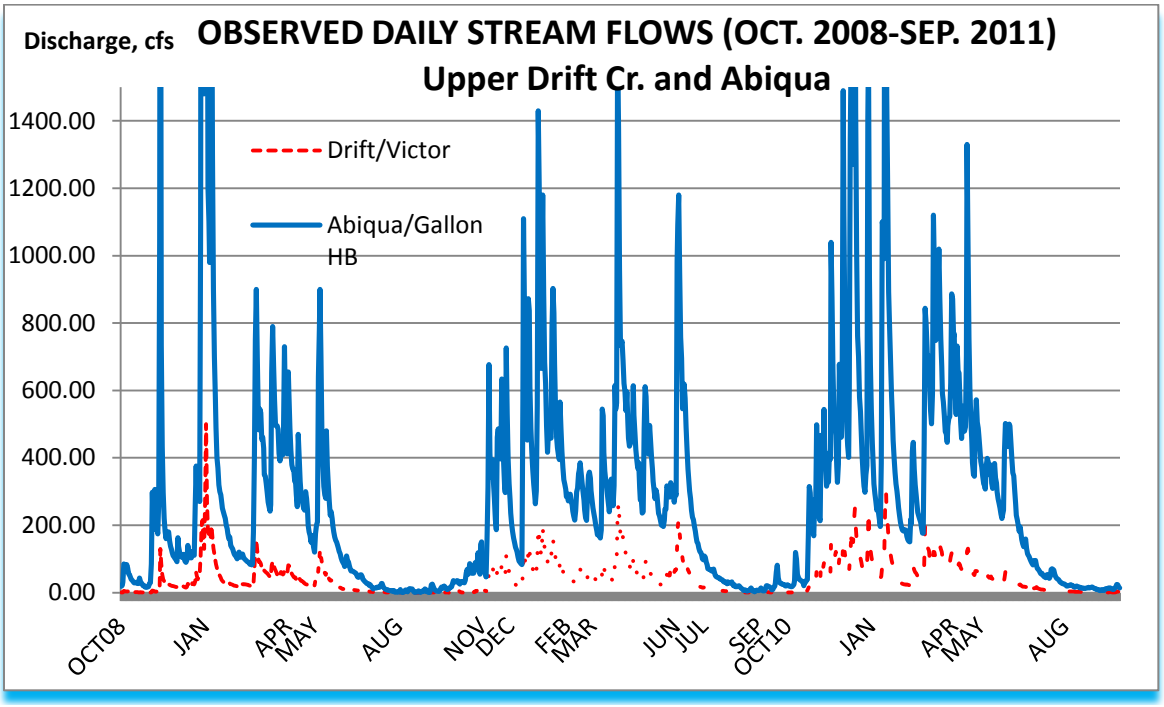


Figure 8.8 Daily Flow Hydrograph of Upper Drift and Butte @ Monitor 2008-11

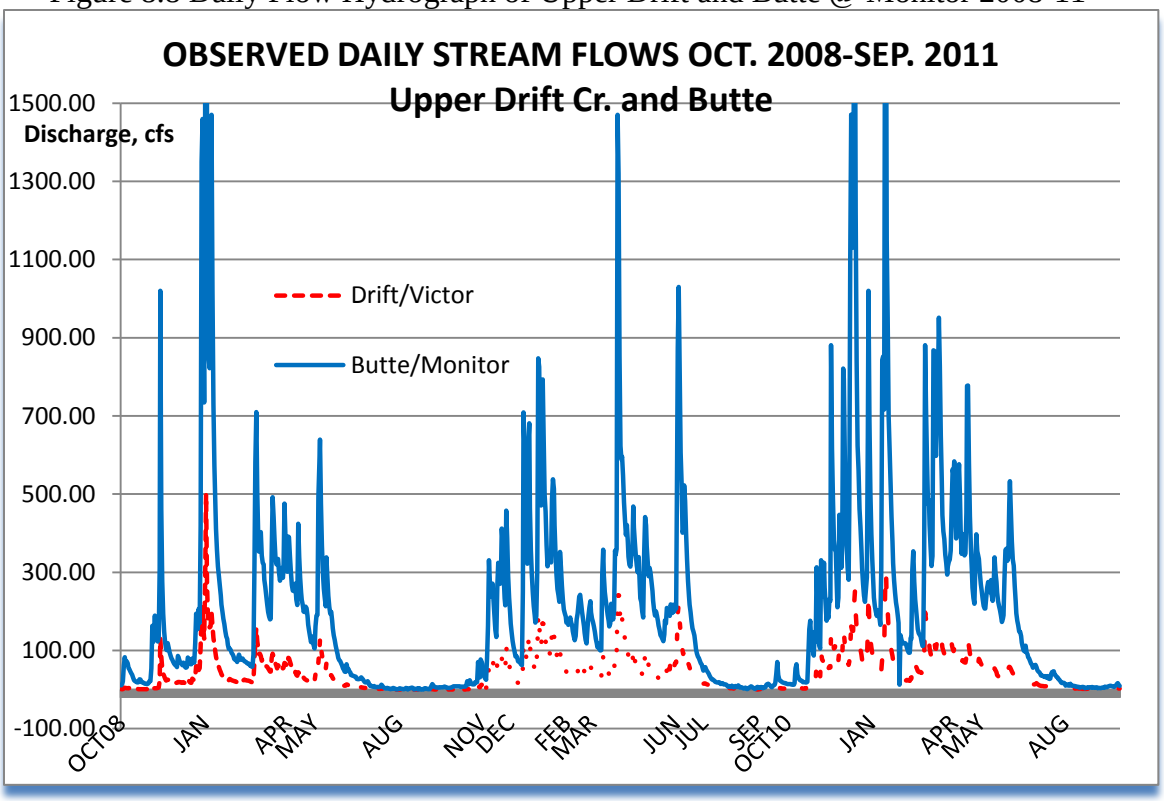
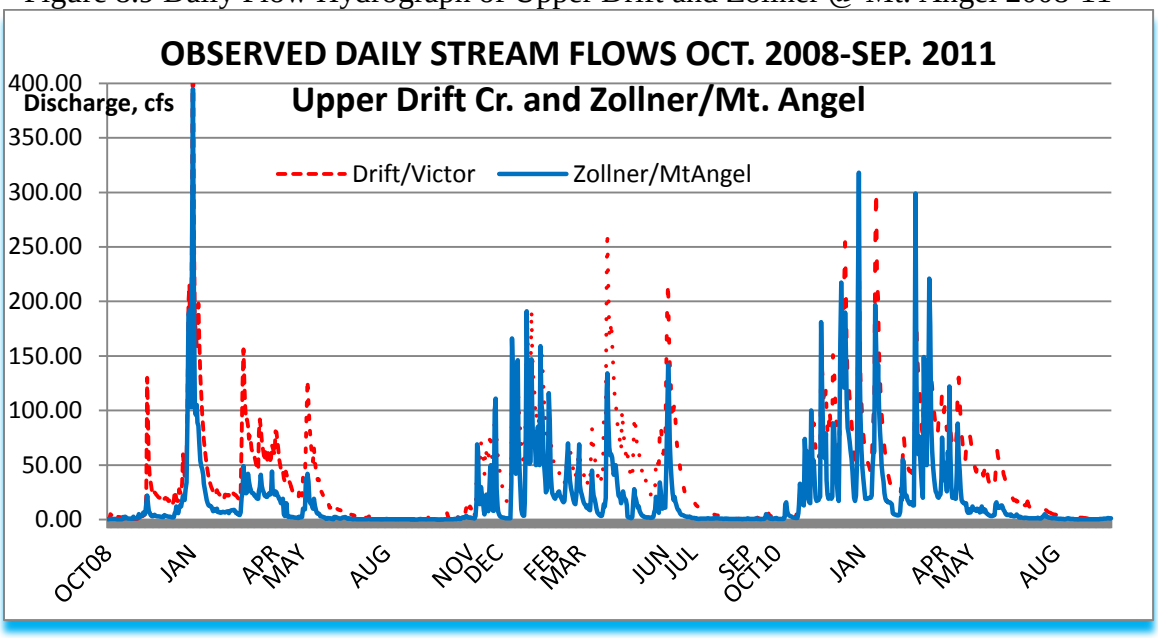


Figure 8.9 Daily Flow Hydrograph of Upper Drift and Zollner @ Mt. Angel 2008-11



Figures 9.1 through 9.6 provide the same type of runoff information but on a monthly basis. The plots also include the runoff volume ratios of the streams involved.

Figure 9.1 Plots of Monthly Flows of Upper Drift and Pudding @ Aurora 2008-11

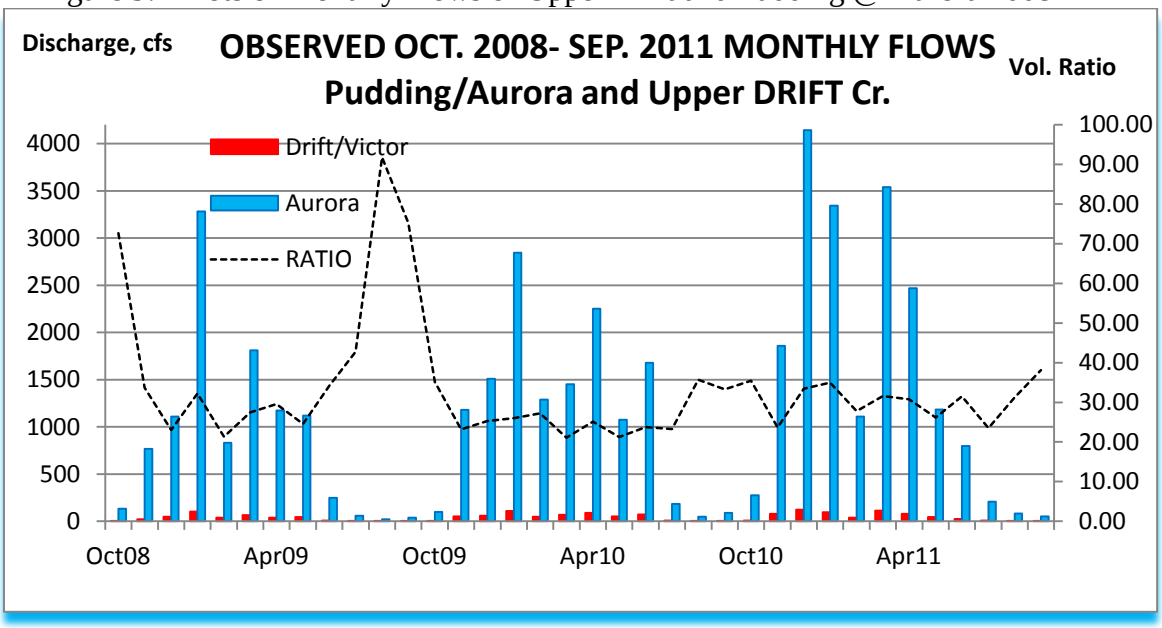


Figure 9.2 Plots of Monthly Flows of Upper Drift and Pudding @ Woodburn 2008-11

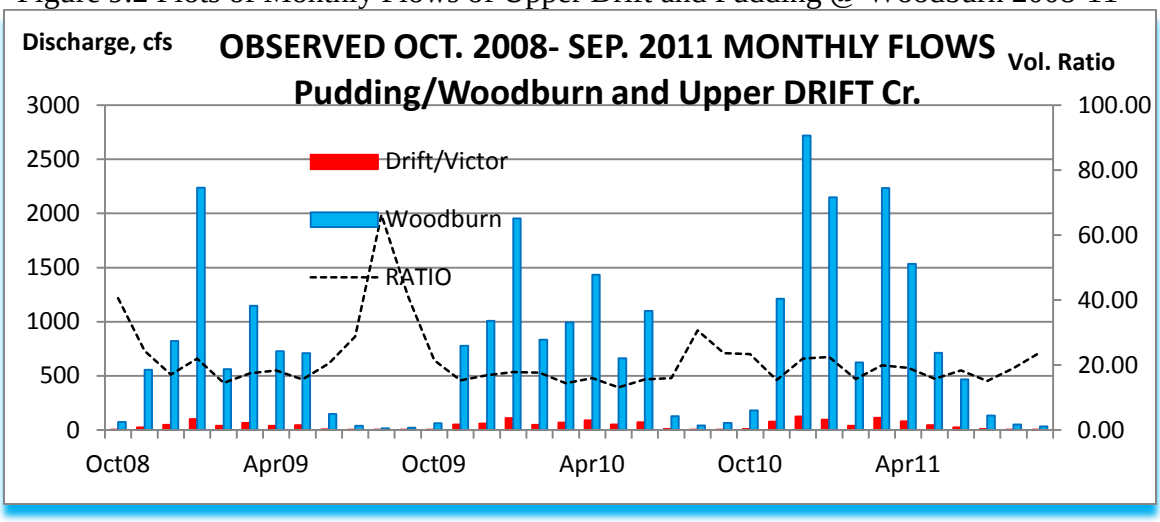


Figure 9.3 Plots of Monthly Flows of Upper Drift and Silver @ Silverton 2008-11

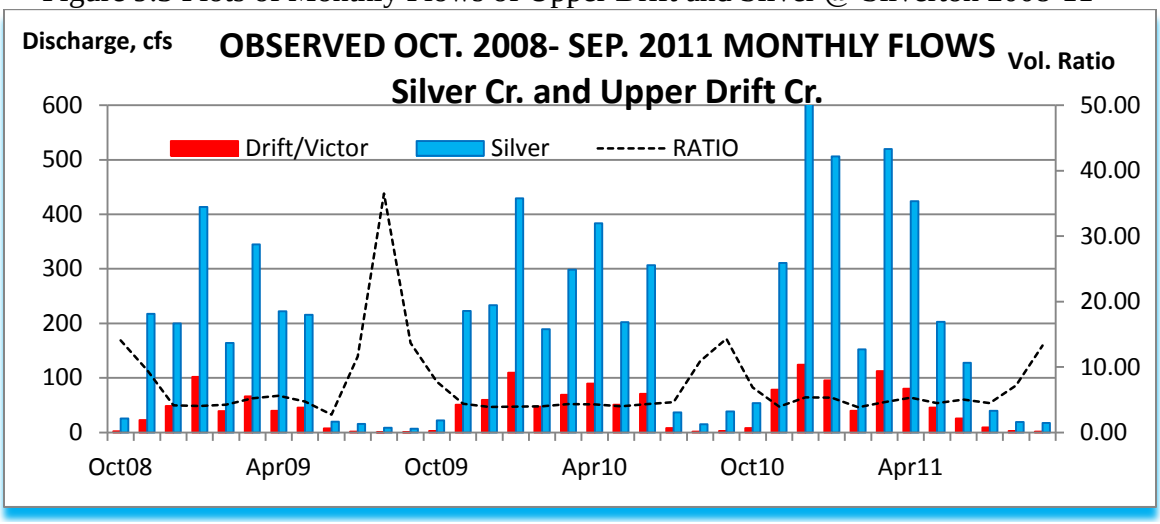


Figure 9.4 Plots of Monthly Flows of Upper Drift and Abiqua @ G. H. Bridge 2008-11

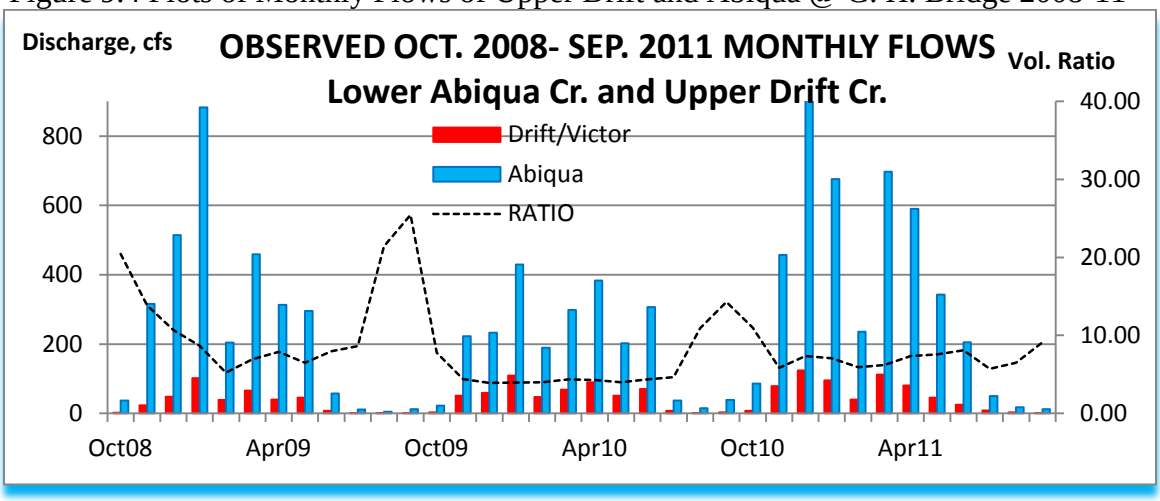


Figure 9.5 Plots of Monthly Flows of Upper Drift and Butte @ Monitor 2008-11

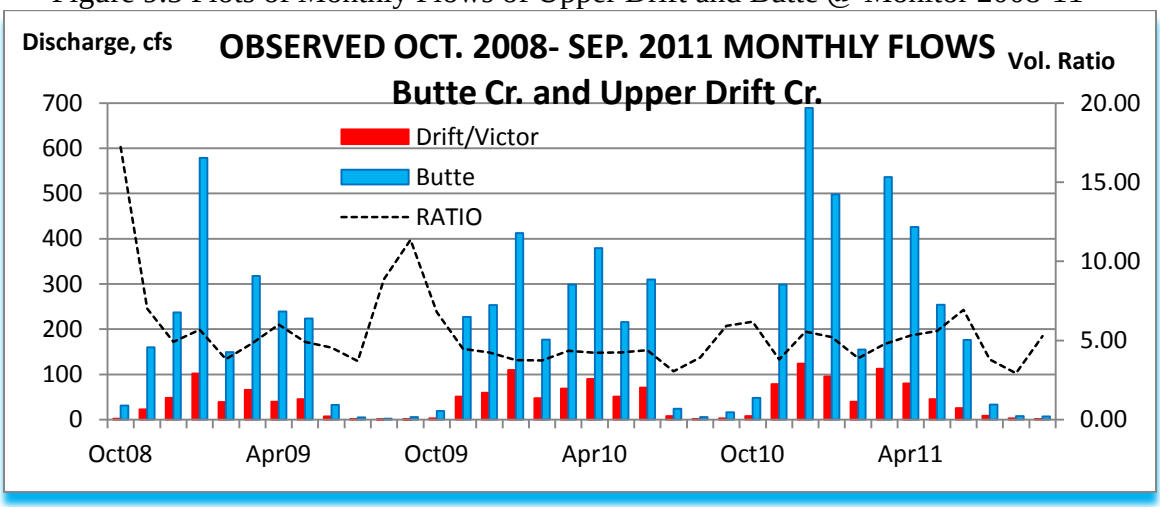
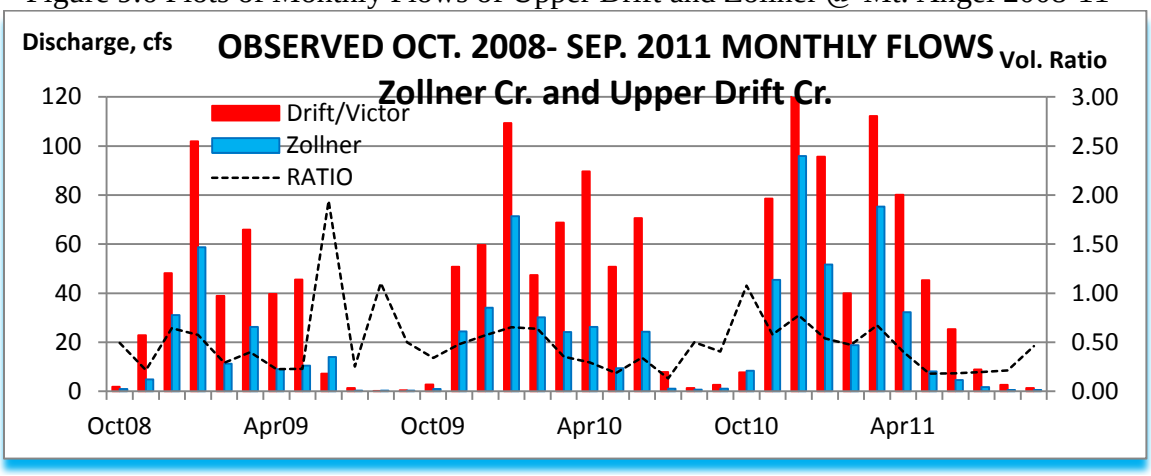
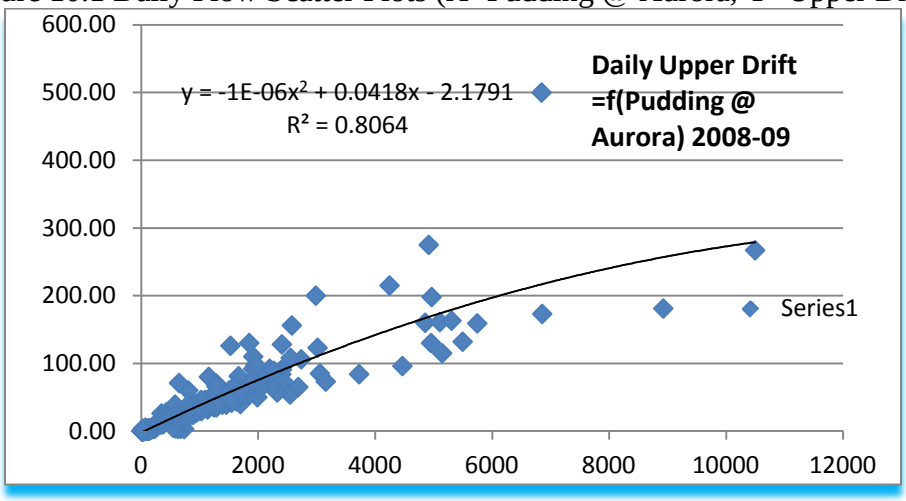


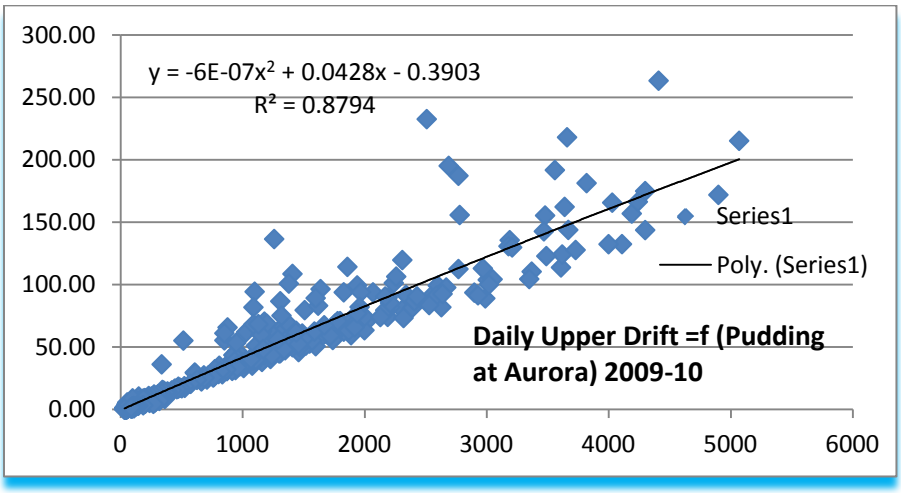
Figure 9.6 Plots of Monthly Flows of Upper Drift and Zollner @ Mt. Angel 2008-11

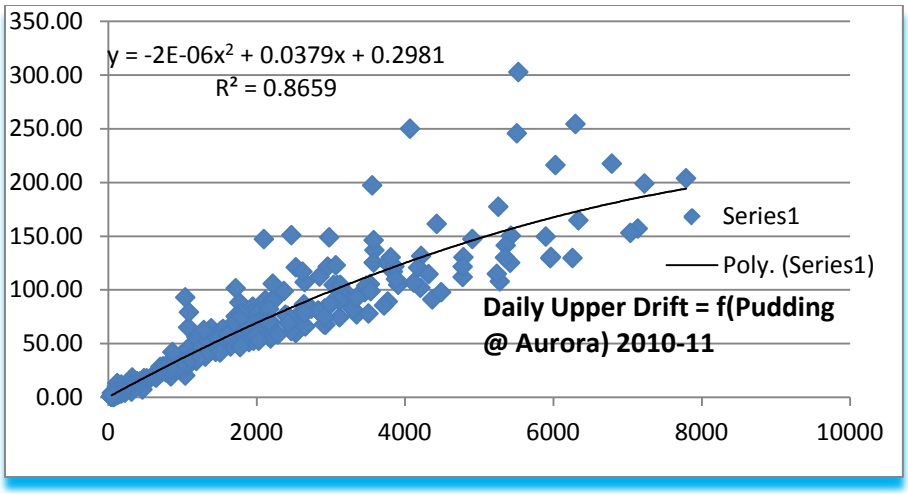


To provide the level of correlation between Upper Drift Creek flows and the corresponding flows at other streams, graphical scatter plots were performed. Those scatter plots define the polynomial regression equations relating the two parameters (X=Drift Creek flows vs. Y=corresponding flows from the other stream), as well as the correlation indicator, R^2. These plots were done separately for daily and monthly flows, and are shown in Figures 10.1 through 10.6 (daily flows) and Figures 11.1 through 11.6 (monthly flows). Each figure includes the plots for 2008-09, 2009-10, 2010-11 and 2008-11. Note that some of the results may not match exactly those shown in previous report updates as some of the data used before had been modified later by the flow data collectors.

Figure 10.1 Daily Flow Scatter Plots (X=Pudding @ Aurora, Y=Upper Drift)







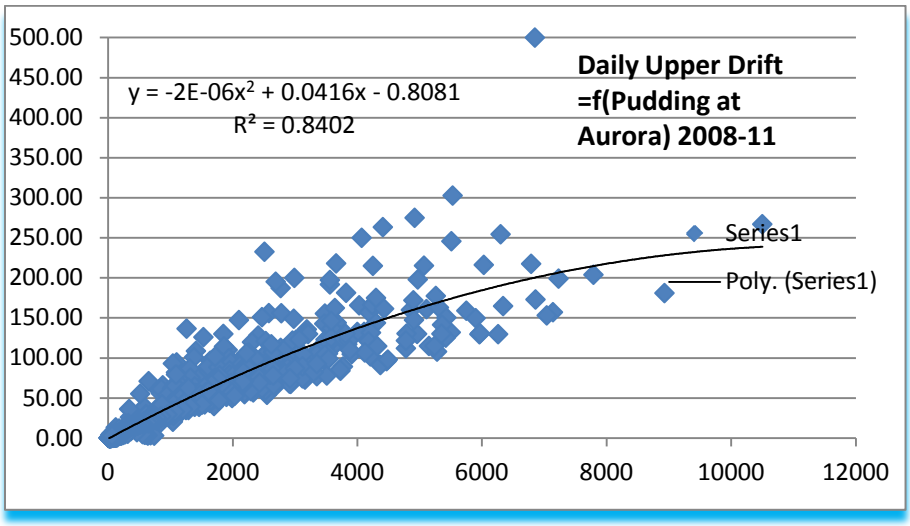
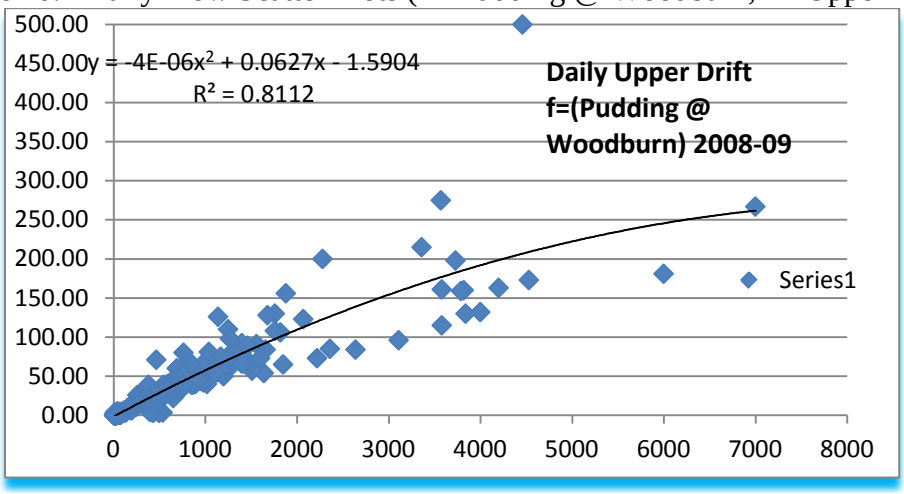
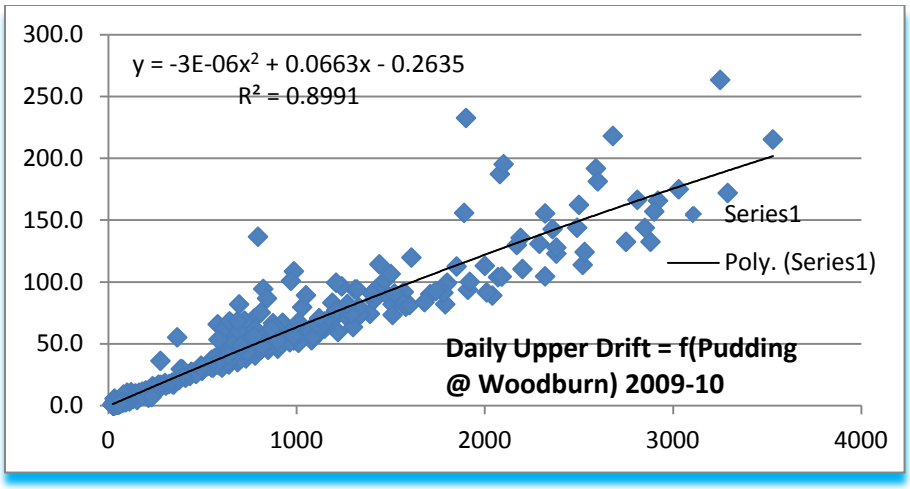
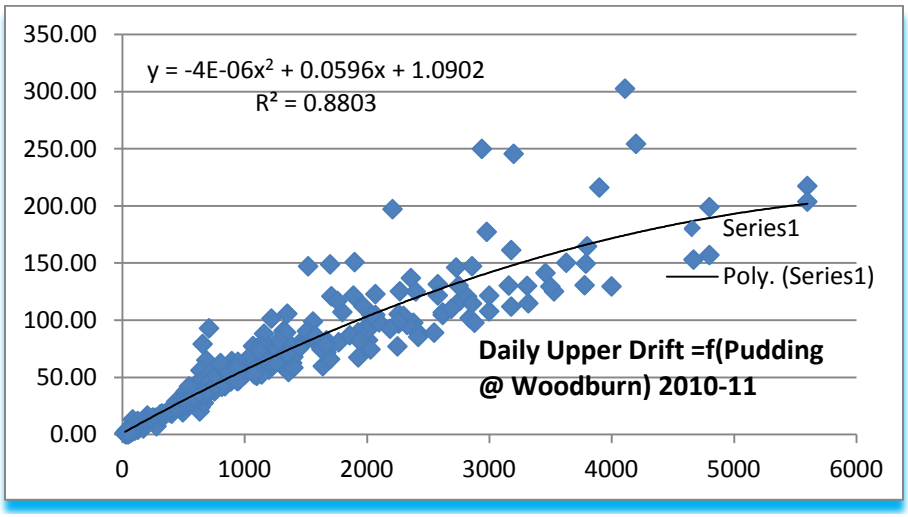
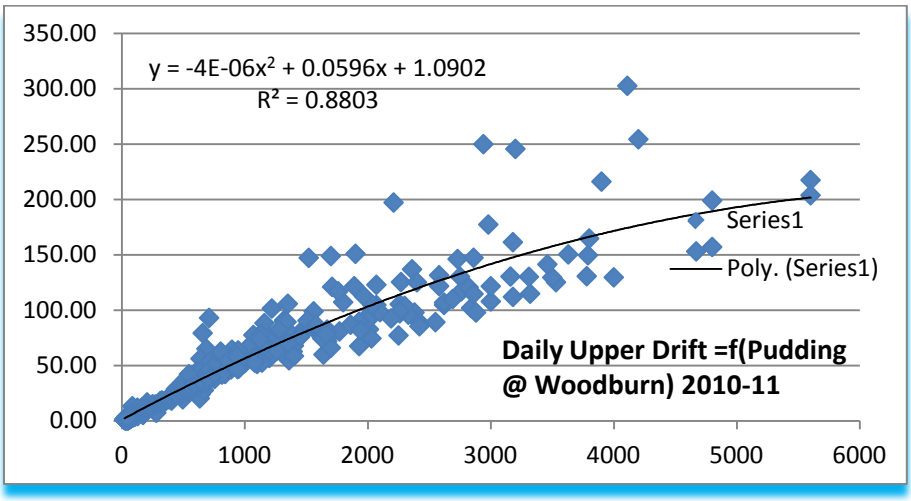


Figure 10.2 Daily Flow Scatter Plots (X=Pudding @ Woodburn, Y=Upper Drift))




y = -3E-06x² + 0.0663x - 0.2635
R² = 0.8991
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
1000
2000
3000
4000
Series1
Poly. (Series1)
Daily Upper Drift = f(Pudding @ Woodburn) 2009-10


y = -4E-06x² + 0.0596x + 1.0902
R² = 0.8803
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0
1000
2000
3000
4000
5000
6000
Series1
Poly. (Series1)
Daily Upper Drift =f(Pudding @ Woodburn) 2010-11


y = -4E-06x² + 0.0596x + 1.0902
R² = 0.8803
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0
1000
2000
3000
4000
5000
6000
Series1
Poly. (Series1)
Daily Upper Drift =f(Pudding @ Woodburn) 2010-11

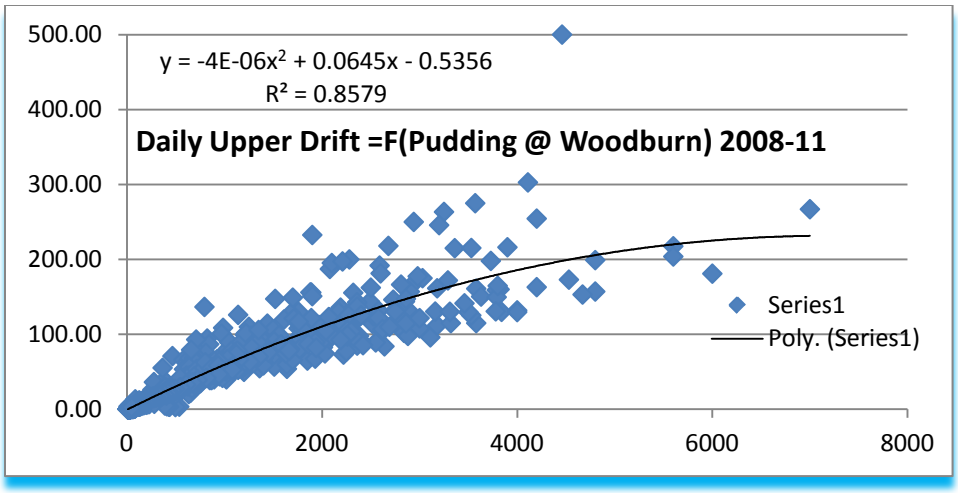
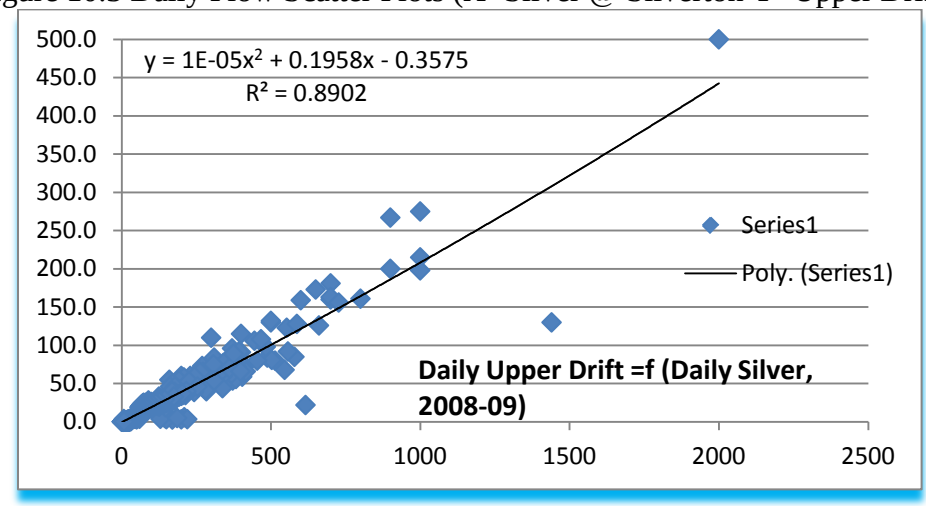
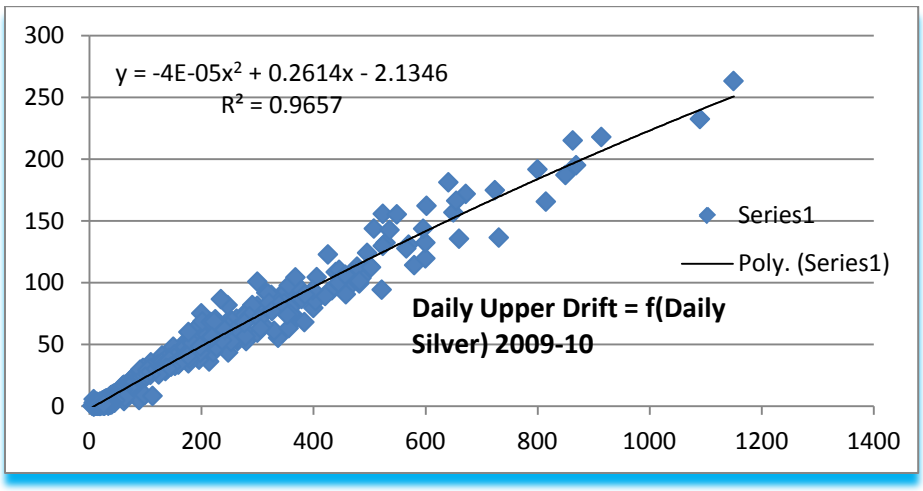
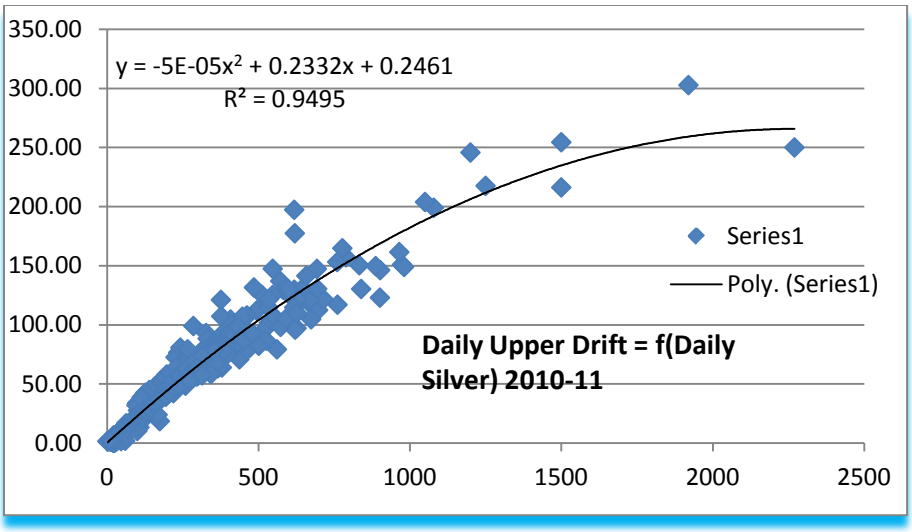


Figure 10.3 Daily Flow Scatter Plots (X=Silver @ Silverton Y=Upper Drift))







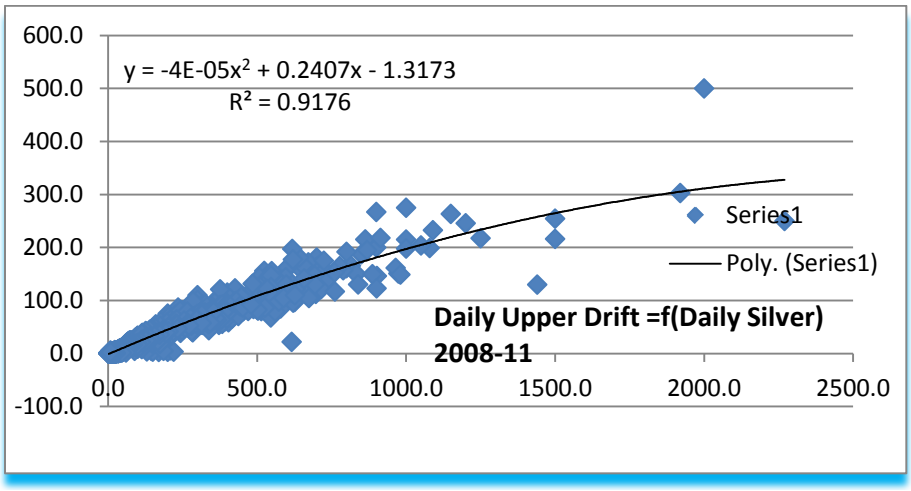
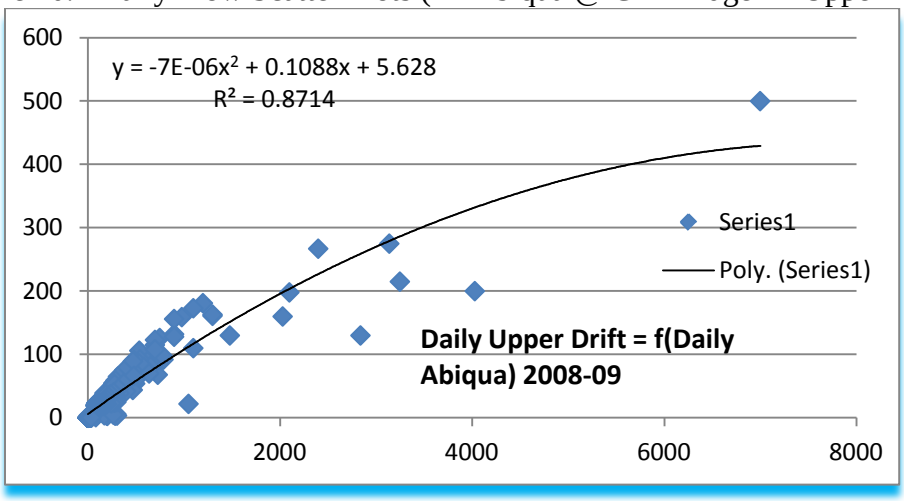
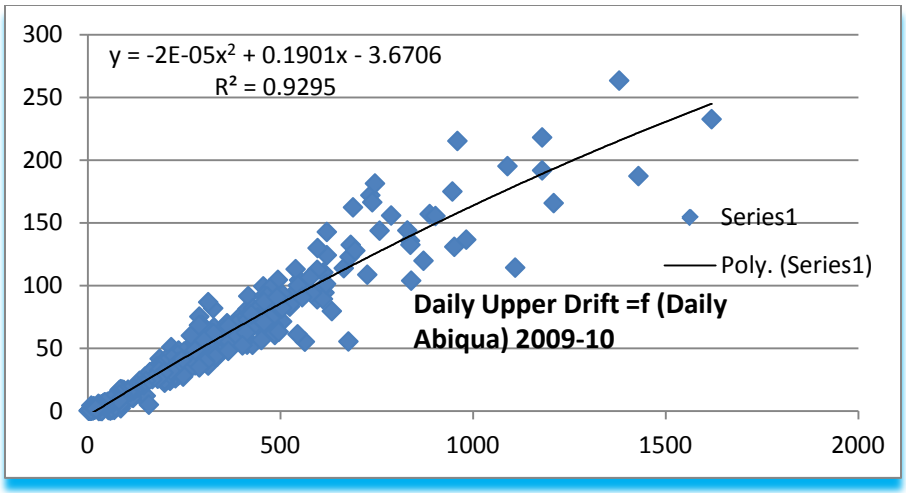
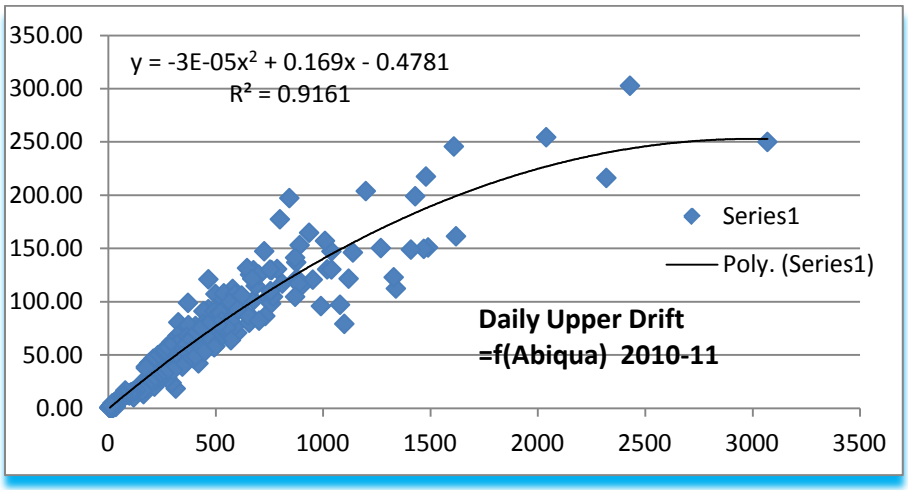


Figure 10.4 Daily Flow Scatter Plots (X=Abiqua @ GH Bridge Y=Upper Drift)




y = -2E-05x² + 0.1901x - 3.6706
R² = 0.9295
Series1
Poly. (Series1)
Daily Upper Drift =f (Daily Abiqua) 2009-10
300
250
200
150
100
50
0
0
500
1000
1500
2000


y = -3E-05x² + 0.169x - 0.4781
R² = 0.9161
Series1
Poly. (Series1)
Daily Upper Drift =f(Abiqua) 2010-11
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0
500
1000
1500
2000
2500
3000
3500

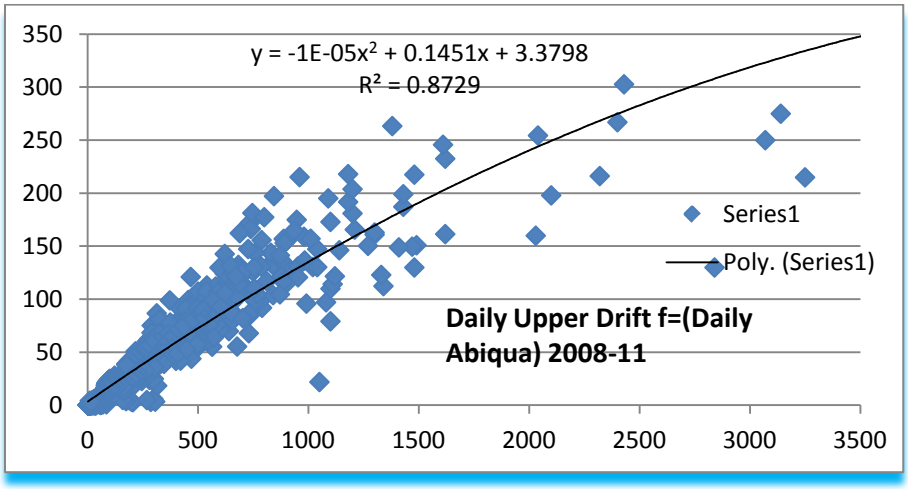
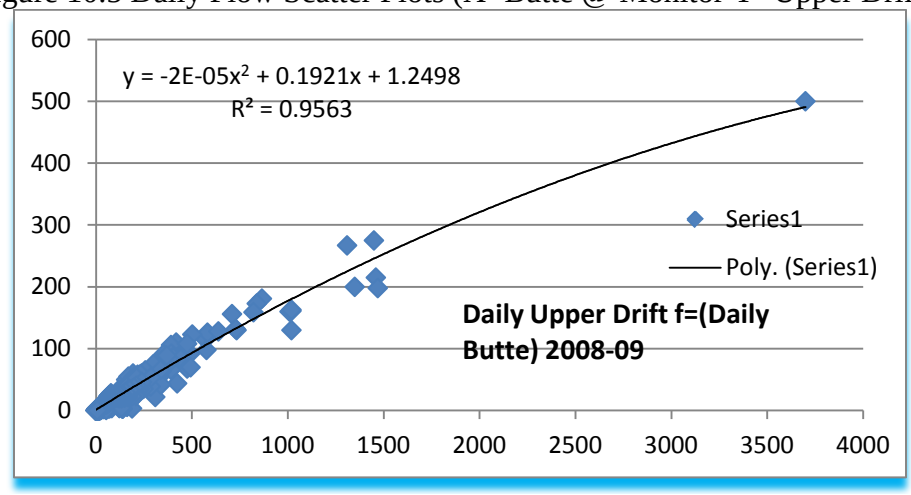
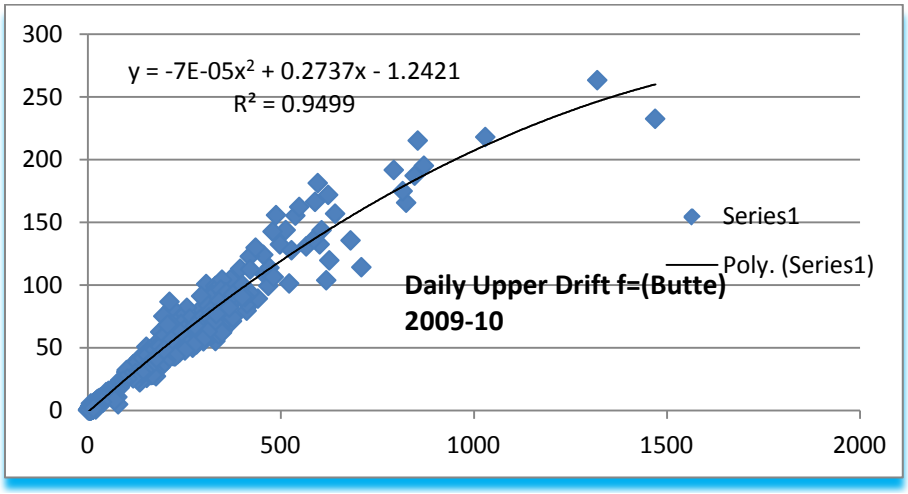
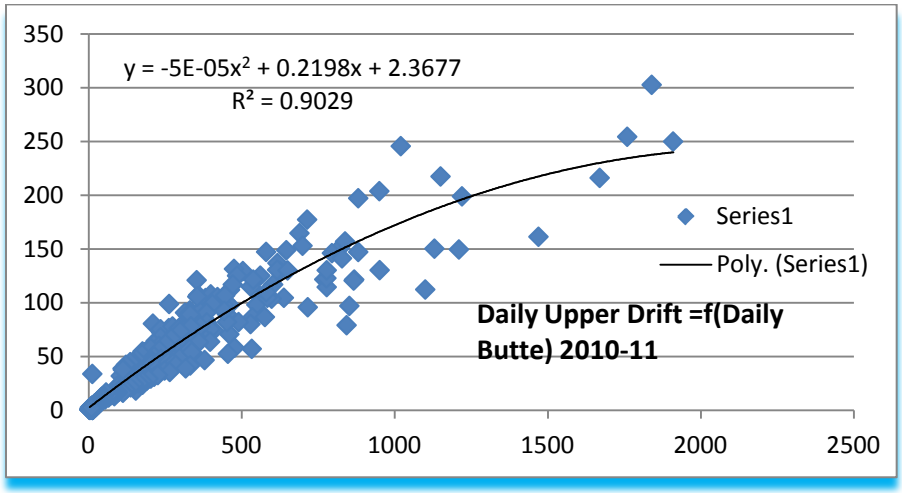

y = -1E-05x² + 0.1451x + 3.3798
R² = 0.8729
Series1
Poly. (Series1)
Daily Upper Drift f=(Daily Abiqua) 2008-11
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500

Figure 10.5 Daily Flow Scatter Plots (X=Butte @ Monitor Y=Upper Drift))







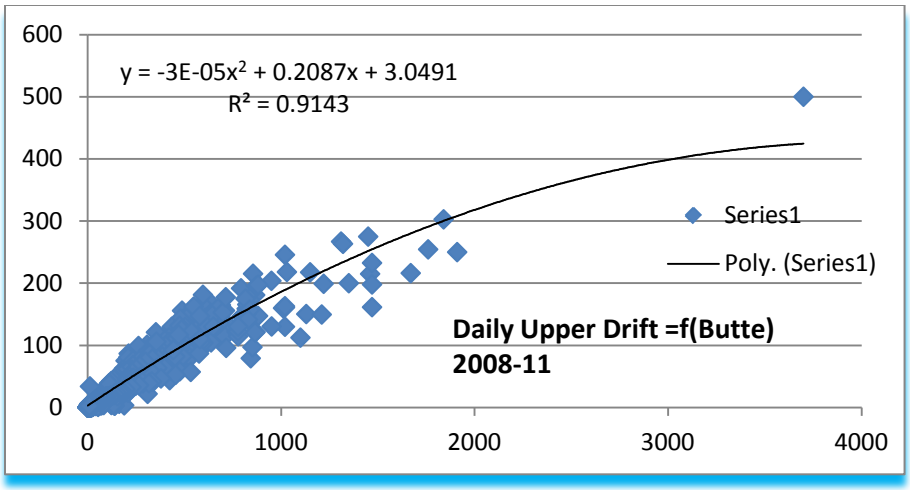
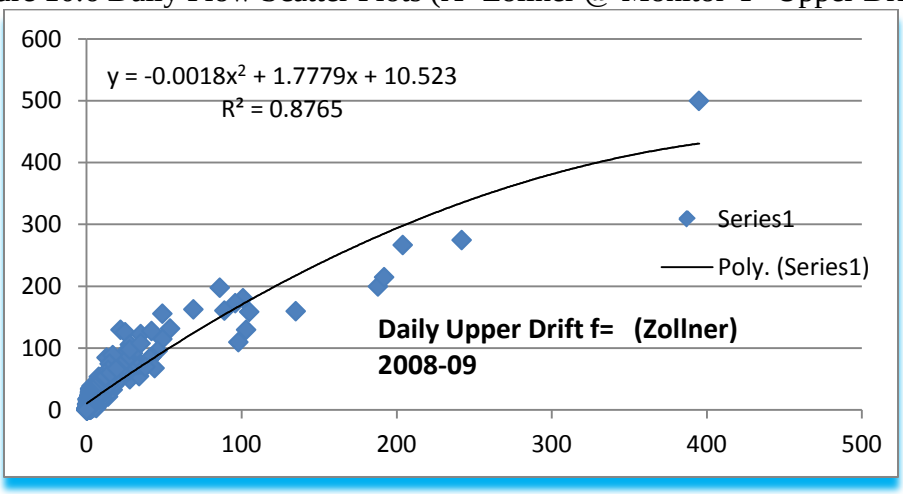
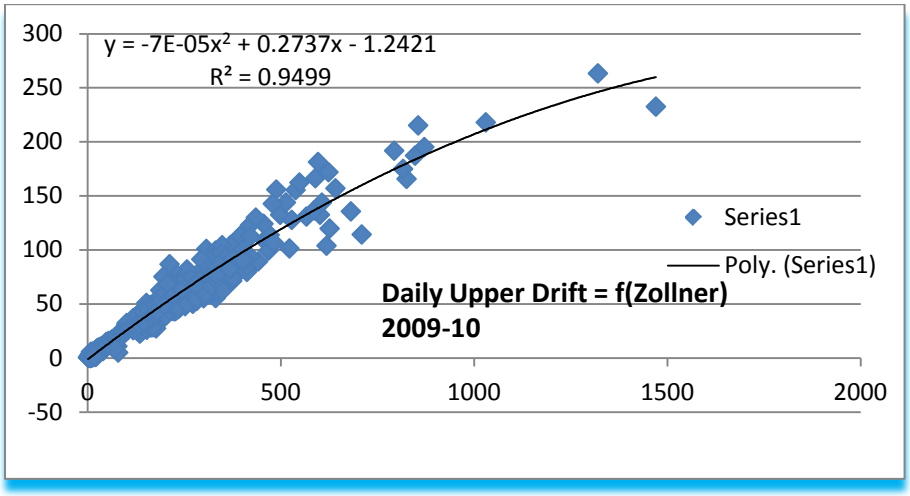
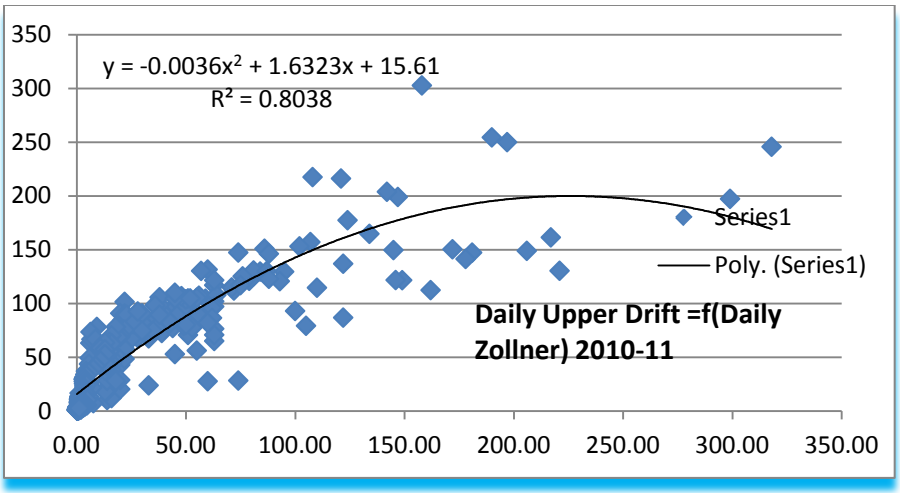


Figure 10.6 Daily Flow Scatter Plots (X=Zollner @ Monitor Y=Upper Drift))







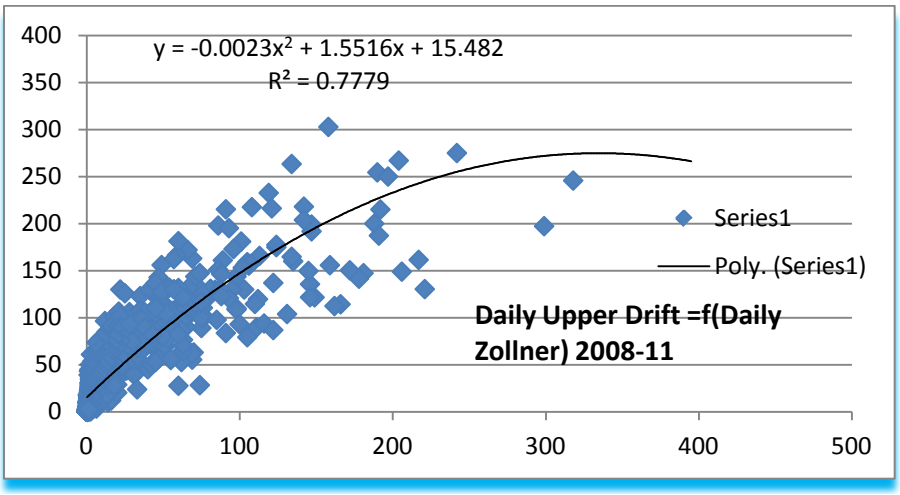
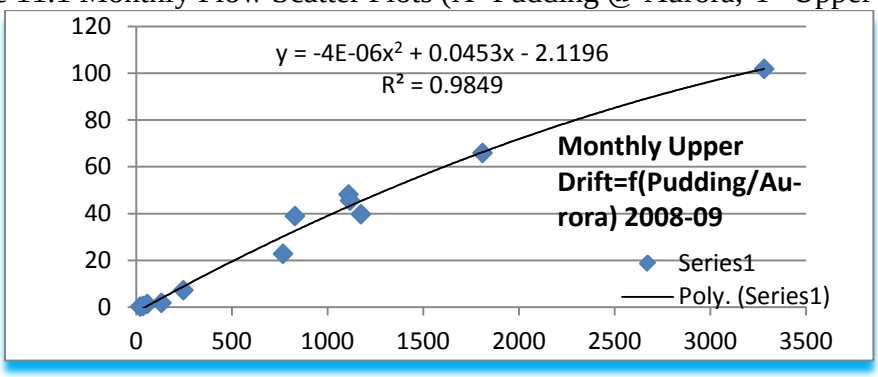
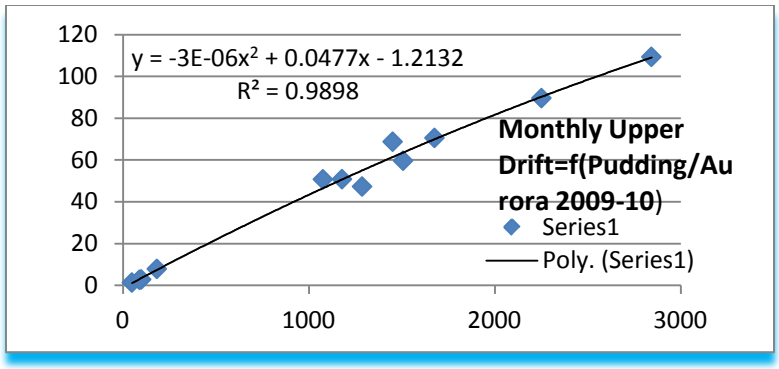
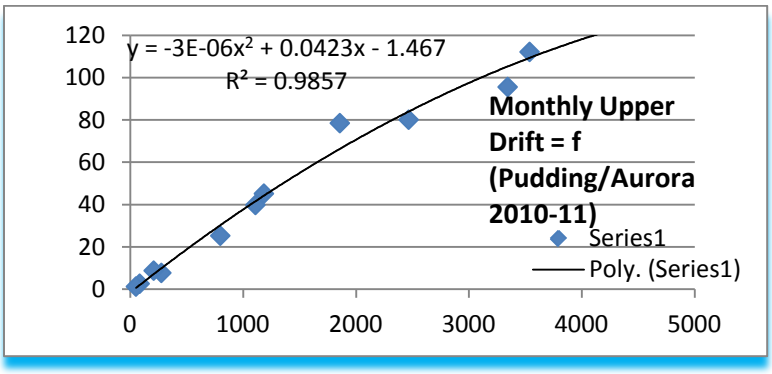


Figure 11.1 Monthly Flow Scatter Plots (X=Pudding @ Aurora, Y=Upper Drift)







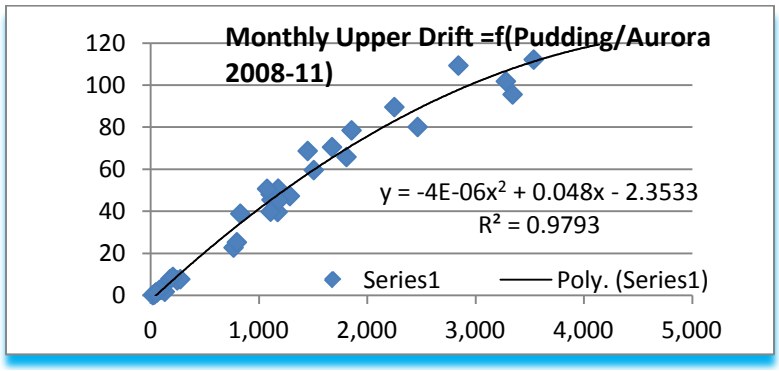
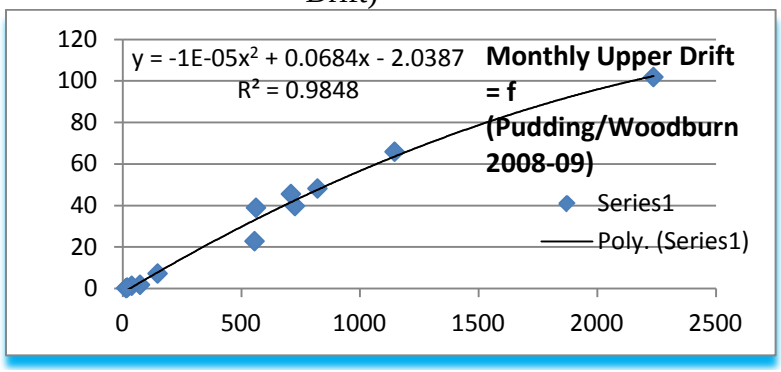
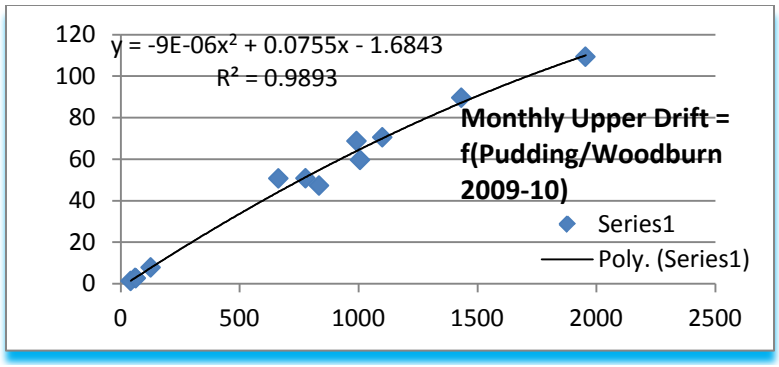
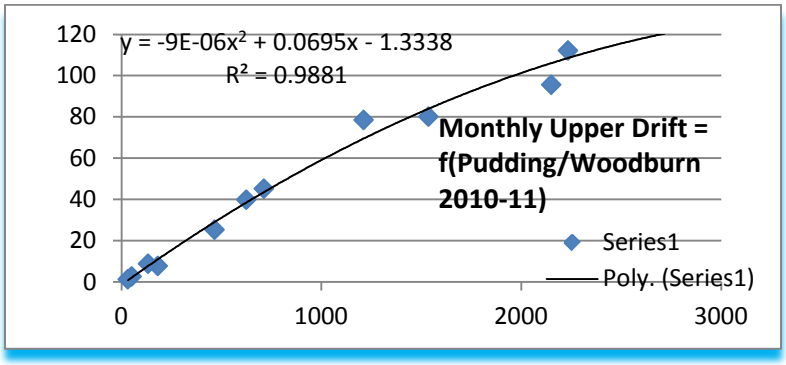


Figure 11.2 Monthly Flow Scatter Plots (X=Pudding @ Woodburn, Y=Upper Drift)







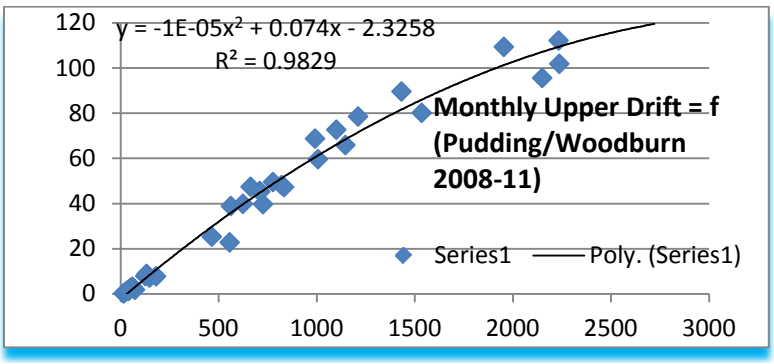
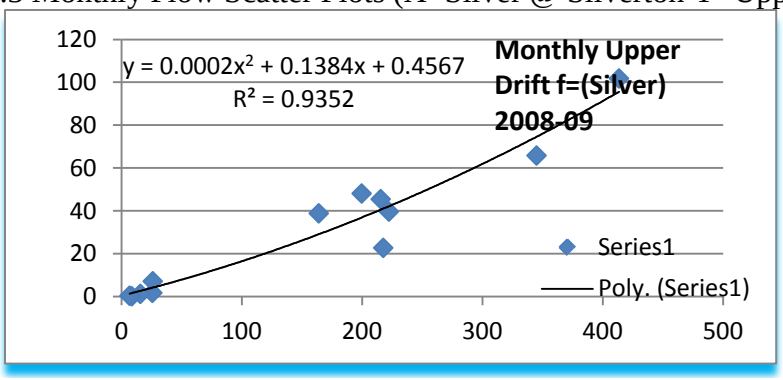
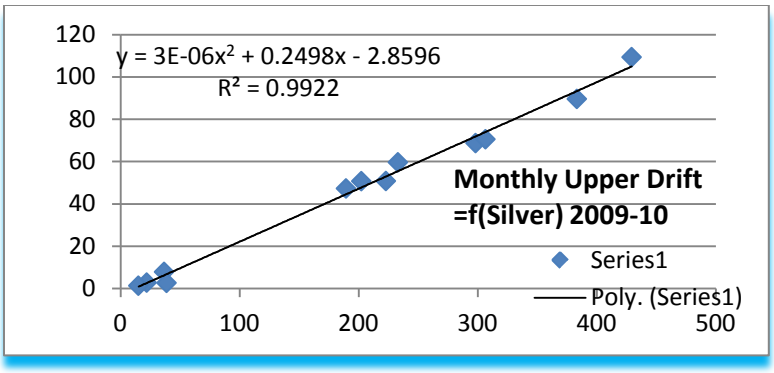
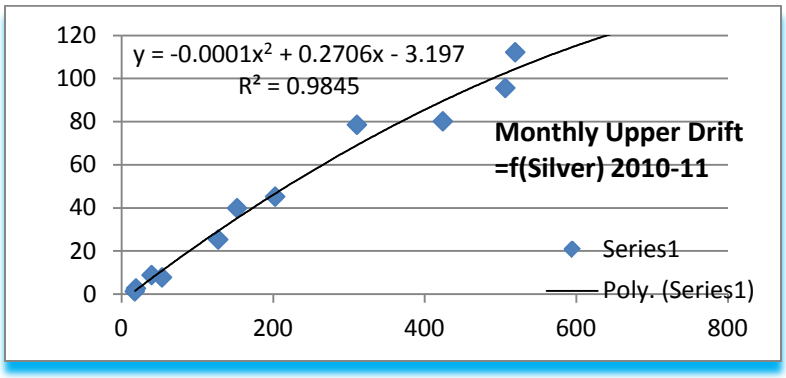


Figure 11.3 Monthly Flow Scatter Plots (X=Silver @ Silverton Y=Upper Drift))







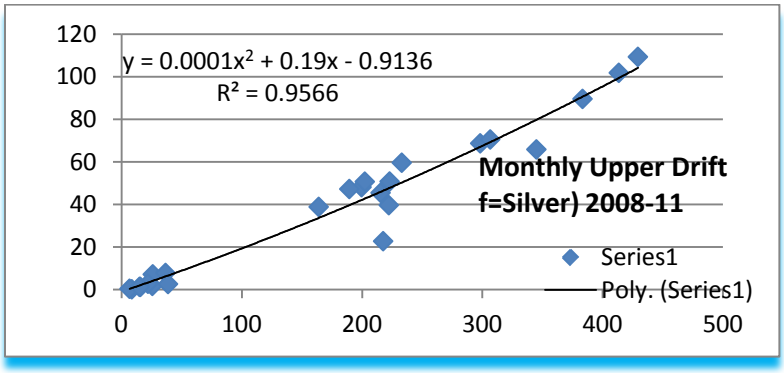
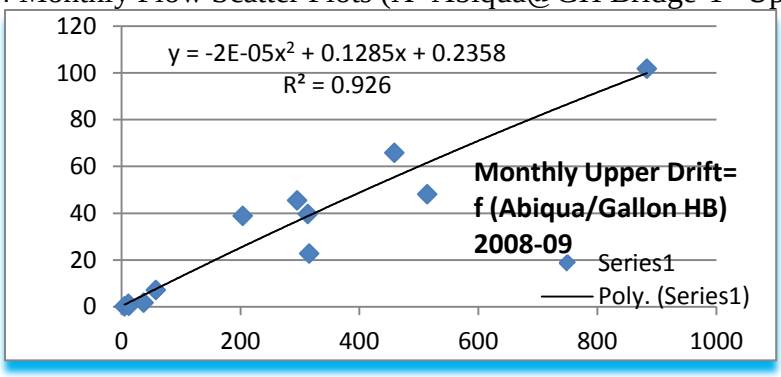
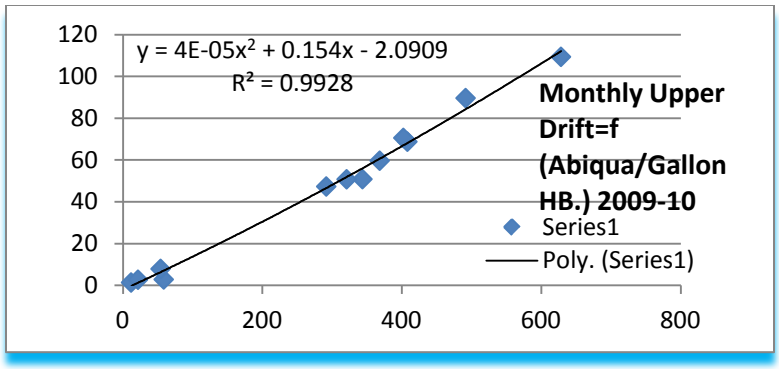
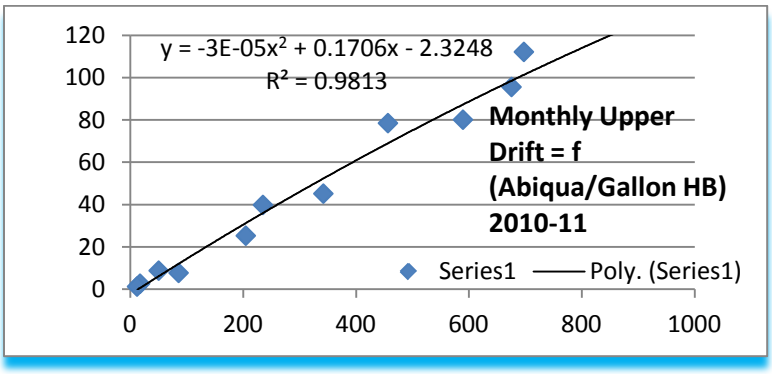


Figure 11.4 Monthly Flow Scatter Plots (X=Abiqua@GH Bridge Y=Upper Drift))







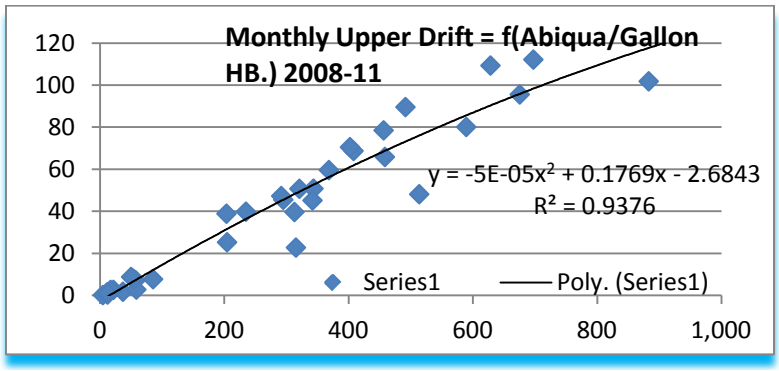
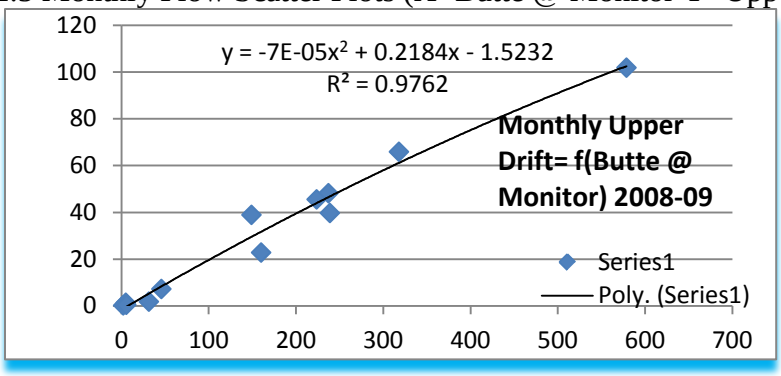
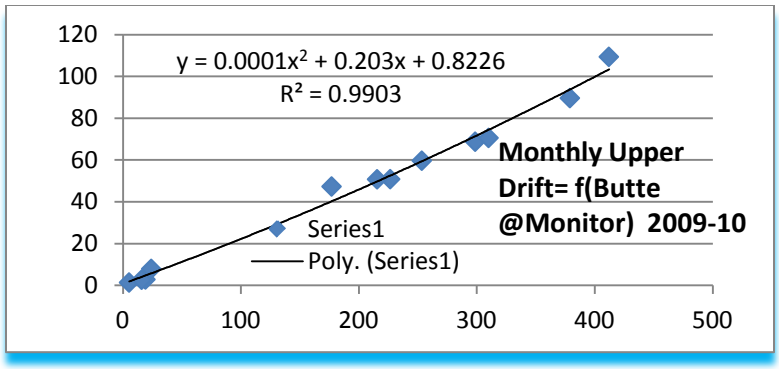
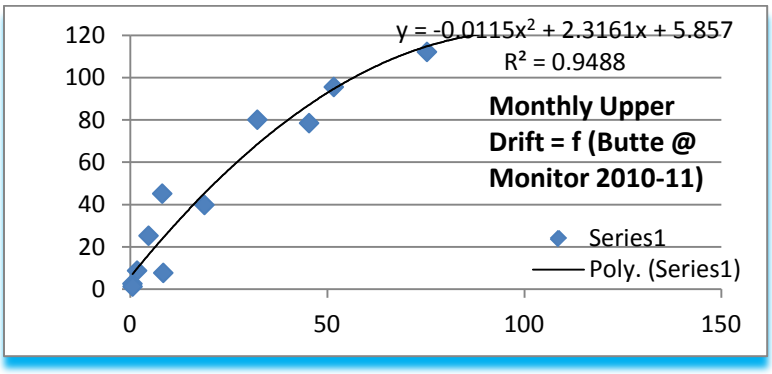


Figure 11.5 Monthly Flow Scatter Plots (X=Butte @ Monitor Y=Upper Drift))







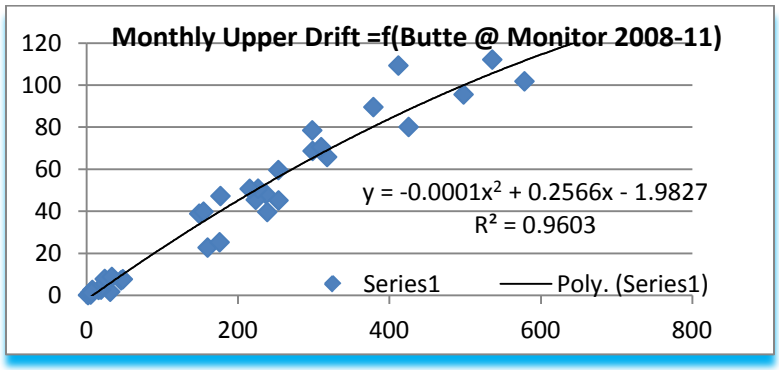
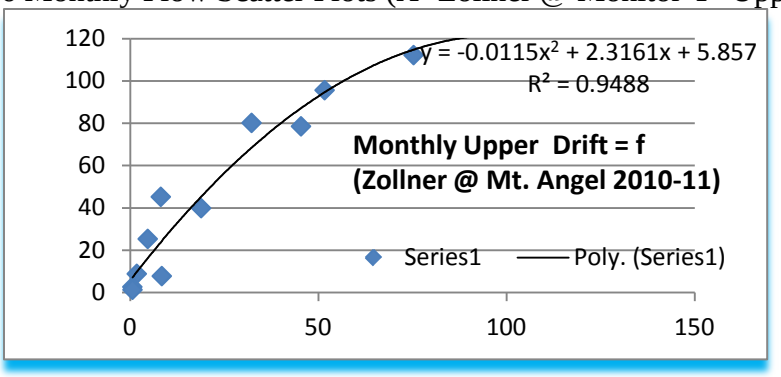
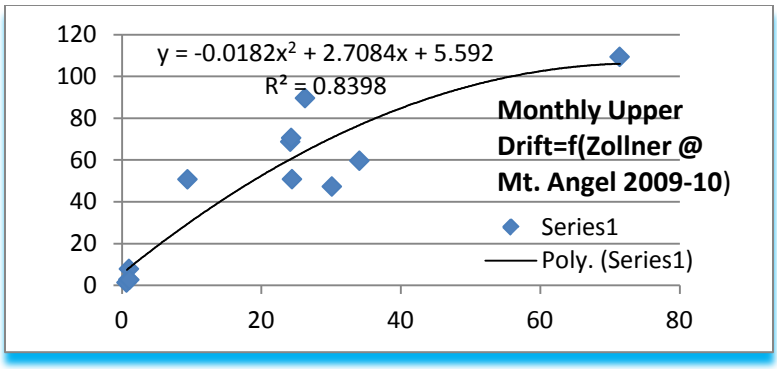
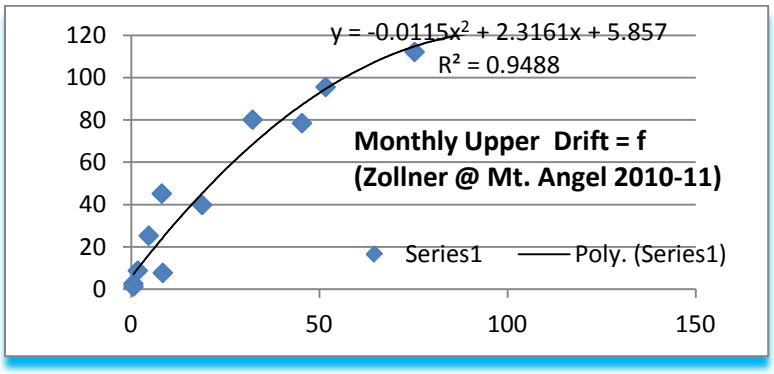


Figure 11.6 Monthly Flow Scatter Plots (X=Zollner @ Monitor Y=Upper Drift))







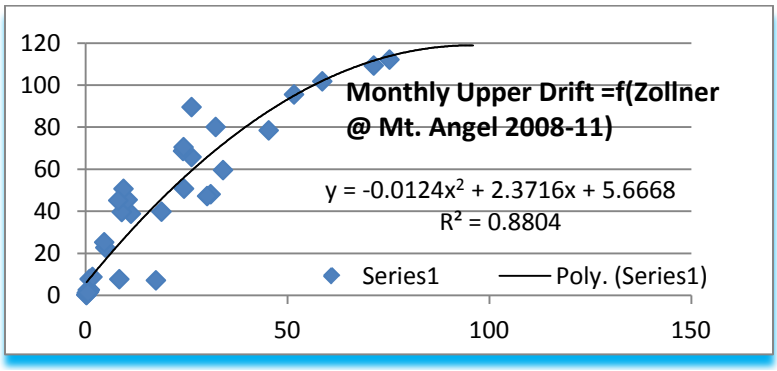


Table 7.1 summarizes the values of the correlation indicator R^2 obtained through the scatter plots. In each case, the highest values are shown in bold and the lowest, in italics. As expected, the flows recorded at the lower Hibbard Road gauge detain the highest R^2 values. The lowest values of R^2 apply to the flows of Zollner Creek @ Monitor.

Table 7.1 Correlation Factor R^2

X Variables	HY 2008-09	HY2009-10	HY2010-11	2008-2011
Daily Flows				
Pudding@Aurora	*0.8064*	*0.8794*	0.8659	0.8402
Pudding@Woodburn	0.8112	0.8991	0.8803	0.8579
Lower Drift	0.9560	**0.9871**	**0.9816**	**0.9558**
Silver	0.8902	0.9657	0.9495	0.9176
Abiqua	0.8714	0.9295	0.9161	0.8729
Butte	**0.9563**	0.9499	0.9029	0.9143
Zollner	0.8765	0.9499	*0.8038*	*0.7779*
Monthly Flows				
Pudding@Aurora	0.9849	0.9898	0.9857	0.9793
Pudding@Woodburn	0.9848	0.9893	0.9881	0.9829
Lower Drift	**0.9973**	**0.9929**	**0.9919**	**0.9862**
Silver	0.9352	0.9922	0.9845	0.9565
Abiqua	*0.9260*	0.9928	0.9813	0.9376
Butte	0.9762	0.9903	*0.9488*	0.9603
Zollner	0.9488	*0.8398*	*0.9488*	*0.8804*

6. Practical Observations on 2010-11 Data

Review of the 2010-11 stream flow data leads to the following observations:

1. The 2010-11 runoff was greater than the runoff recorded during the preceding two hydrologic years 2008-09 and 2009-10 runoff at all the six streams.
2. The shape of the hydrographs of all six streams is generally very similar.
3. The statistical indicators R^2 for the correlation between Drift Creek's discharges and the corresponding discharges of the other streams are fairly high. For daily flows, R^2 ranges from 0.8038 to 0.9816 and for monthly flows, R^2 ranges from 0.9488 to 0.9919. In both cases, the highest R^2 values applies to Drift Cr. @ Hibbard and the lowest value, to Zollner @ Mt. Angel). This was to be expected and clearly supports the fact that flows recorded at the lower Drift Creek gauge are the best indices for the flows recorded at the upper Drift Creek gauge.
4. The year was a below average year for Pudding River, an indicator that should also apply to Drift Creek, which is one of its tributaries.
5. As usual, runoff for all six streams was primarily driven by rainfall. There was no snow fall.
6. Rainfall recorded at the Salem Airport reasonably matches the shape of the hydrographs, especially the timing of the peak discharges.
7. There were no detectable snowmelt impacts. This is to be expected for an average year runoff, since most of Drift Creek watershed lies below elevation 2000 feet.

The correlation indicators R^2 were also calculated using the flows data recorded so far for all three years of records (Oct. 2008 – Sep. 2011), and listed in the last column of Table 7.1. The ranking of these indicators listed in Table 7.2 will help define the best gauging sites that could be used to generate more flow data for Upper Drift Creek.

Table 7.2 Station Ranking Based on Best Correlation Indicators
(Oct. 2008 – Sep. 2011 Stream Flows)

Ranking for **Daily** Flows	Daily Flows Correlation Indicator R^2	Ranking for **Monthly** Flows	Monthly Flows Correlation Indicator R^2
1. Drift Creek @ Hibbard Rd.	0.9558	1. Drift Creek @ Hibbard Rd	0.9862
2. Silver @ Silverton	0.9176	2. Pudding @ Woodburn.	0.9829
3. Butte @ Monitor.	0.9143	3. Pudding @ Aurora	0.9793
4. Abiqua@ G.H. Bridge	0.8729	4. Butte @ Monitor	0.9603
5. Pudding @ Woodburn	0.8579	5. Silver@ Silverton	0.9565
6. Pudding @ Aurora	0.8402	6. Abiqua @ G.H. Bridge	0.9376
7. Zollner @ Mt. Angel	0.7779	7. Zollner @ Mt. Angel	0.8804

The above station ranking is based only on Oct. 2008 – Sep. 2011 stream flow data. Since the main practical purposes of the hydrologic runoff yield study is to develop more historical runoff data for Drift Creek, the selection of the ultimate station to be used as data generation index should also account for the length of the records collected (preferably in the most recent past) at that station. To date (September 2012), data availability is listed in Table 8.

Current focus is on number of years of records, relative drainage sizes, and status of the recording gauge (active vs. discontinued). In that context, the Pudding River is the stream with the longest records. Of the two Pudding River recording sites that are still active (Aurora and Woodburn), the Aurora gauge has by far the longer period of record of the two sites: 49 years of actual flows (and potentially 28 years of additional reconstituted flows between 1963 and 1993). Considering that their R^2 values are not that much different, the data from the Aurora site are more advantageous to use because they cover a longer period of records and, hence, a wider range of run-off conditions.

Table 9 contains the 2008-09, 2009-10, 2010-11 and 1928-2008 mean monthly discharges of the Pudding River near Aurora. Daily discharge data were extracted from USGS website at:

USGS 14202000 PUDDING RIVER AT AURORA, OR
http://waterdata.usgs.gov/or/nwis/dv?cb_00060=on&cb_00010=on&format=html&begin_date=2009-10-03&end_date=2010-10-03&site_no=14202000&referred_module=sw

Table 8. Stream Gages, Drainage Areas, Period of Records and Number of Years

USGS Site Number	Site Name and Location	Drainage Area, sq. mi. (Multiple of Drift Cr. Site A)	Record Period	Number of years
14200300	Silver Creek At Silverton	47.9 (3.03)	1963-1969 and 1970-1979, 2008-2011	16+3
14200400	Little Abiqua Creek Near Scotts Mills	9.81 (0.62)	1993-2004	12
(*)	Lower Abiqua at Gallon House Bridge	75.7 (4.92)	2008-2011	3
14201000	Pudding River Near Mt. Angel	203 (12.85)	1939-1966	28
14201300	Zollner Creek Near Mt. Angel	15.0 (0.95)	1993-2008, 2009/11	16+3
14201340	Pudding River Near Woodburn	314 (19.87)	1997-2008, 2009-11	12+3
14202000	Pudding River Near Aurora	479 (30.32)	1928-1963, 1994-1997, and 2002-11	47+3
14201500	Butte Creek at Monitor	58.70 (3.72)	1936-1985, 2008-11	31+3
(**)	Drift Cr. @ Victor Point Rd	15.8 (1.00)	2008/09, 2009/10, 2010-11	1+1+1
(*)	Drift Cr. @ Hibbard Rd. Bridge	24.8 (1.57)	2008/09, 2009/10, 2010-11	1+1+1

(*) Stations operated by Marion Co. Soil & Conservation District (**) Station operated by EVWD

The October 2010 - September 2011 average annual discharge of 1,595 cfs is greater than the 1,139 cfs average discharge for October 2009 - September 2010 and the 886 cfs average discharge for October 2008- September 2009, and about 29% greater than the October 1928 – September 2011 average annual discharge of 1,236 cfs.

Table 9. Pudding River at Aurora Mean Monthly Discharges (cfs)

Hydro Year=	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Annual
2008-2009	132.6	767.8	1,110.1	3,281.8	830.1	1,810.3	1,174.8	1,117.8	247.3	57.8	21.6	36.9	886.4
2009-2010	99.8	1,179.6	1,508.2	2,843.5	1,287.6	1,452.1	2,252.3	1,076.8	1,676.9	183.7	49.3	90.1	1,138.7
2010-2011	275.9	1,857.3	4,141.0	3,344.2	1,109.6	3,538.7	2,467.0	1,184.6	798.2	207.9	83.9	50.6	1,595.4
1928-2008	323.9	1,408.4	2,451.2	2,845.7	2,636.8	2,067.1	1,525.9	873.7	422.5	140.5	65.3	91.0	1,230.3
1928-2009	319.3	1,403.6	2,431.6	2,845.6	2,608.7	2,054.2	1,541.0	877.9	448.6	141.4	65.0	91.0	1,228.4
1928-2011	318.4	1,412.9	2,466.4	2,855.8	2,578.1	2,084.5	1,559.9	884.2	455.8	142.8	65.4	90.1	1,235.9

A very relevant question is, how does the runoff of the last three hydrologic years (2008-2011) compare with other runoff years, based on the historical records of Pudding River @ Aurora going as far back as 1928, some 80+ years ago? The answer to this question is provided in Table 10, based on the ranking of the annual runoff years. With an annual runoff volume of 641,600 aft, the October 2008-September 2009 hydrologic year would rank 41st in the existing 49 year record period. By the same token, the 824,200 aft volume for 2009-10 would rank 29th -- about five years below the average year—and the 1,154,800 aft volume for 2010-11 would rank 8th for the Pudding River at Aurora. See Figure 12.

Table 10. Pudding River at Aurora: Annual Runoff Volume Ranking

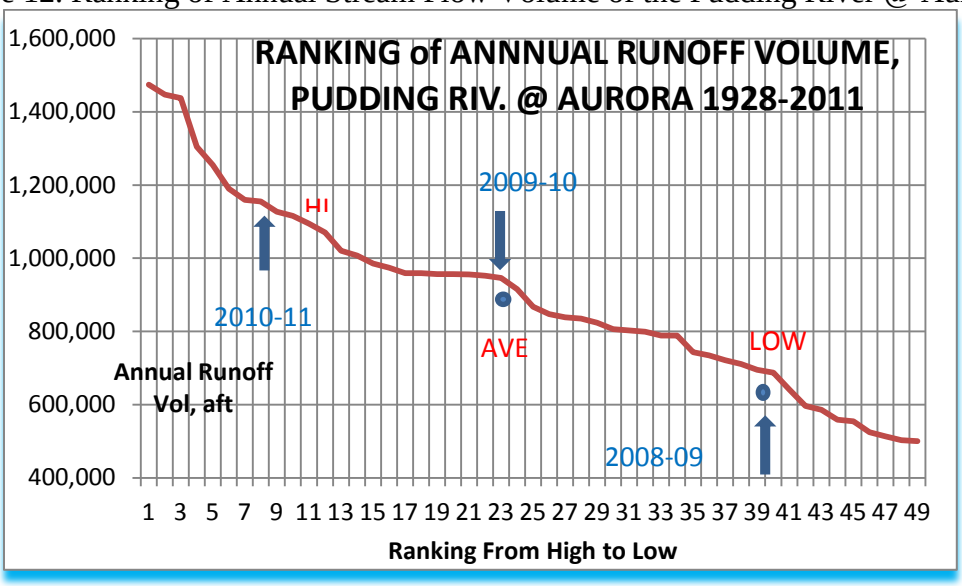
Annual Runoff Volume Rank	Annual Runoff Volume (aft)	Hydrologic Year (Oct-Sep)			Annual Runoff Volume Rank	Annual Runoff Volume (aft)	Hydrologic Year (Oct-Sep)	
1	1,474,450	1996-97			26	847,532	2002-03	
2	1,447,386	1995-96			27	839,022	1934-35	
3	1,437,398	1955-56			28	835,282	1963-64	
4	1,304,908	1950-51			29	824,216	2009-10	
5	1,254,722	1942043			30	806,562	1946-47	
6	1,190,121	1937-38			31	802,527	1954-55	
7	1,159,557	1960-61			32	799,099	1959-60	
8	1,154,752	2010-11			33	789,243	1961-62	
9	1,127,442	1953-54	Hi		34	788,919	2003-04	
10	1,115,792	1949-50			35	743,883	1936-37	
11	1,095,130	1947-48			36	734,391	1941-42	
12	1,069,919	2005-06			37	721,816	1956-57	
13	1,020,183	1932-33			38	711,335	1939-40	
14	1,007,579	1948-49			39	695,169	1944-45	
15	985,724	1931-32			40	687,904	1935-36	lo
16	974,484	1994-95			41	641,582	2008-09	
17	959,376	1952-53			42	596,992	1929-30	
18	959,325	1945-46			43	586,594	1938-39	
19	956,901	1951-52			44	559,244	1930-31	
20	956,679	2006-07			45	554,344	1928-29	
21	955,863	2007-08			46	525,012	1993-94	
22	952,064	1962-63			47	513,563	1943-44	
23	946,422	1958-59			48	502,791	1940-41	
24	916,004	1957-58	Av		49	500,823	2004-05	
25	867,553	1933-34						

Ave.=1 to 49 895,869

The availability of the Oct. 2008 – Sep. 2011 stream flow data justifies the removal of Drift Creek from the list of ungauged watersheds. It provides a real picture of how the runoff is shaped during the last three hydrologic years, including how the timing of its peak discharge is related to the peak rainfall recorded at Salem. However, these measurements still only reflect three of the many possible runoff conditions that could take place in the basin -- a dry 2008-09 year, a slightly below average 2009-10 year, and

a relatively high flow 2010-11 year (based on the flow records for the Pudding River @ Aurora). Any practical conclusions reached so far would be more applicable to years with rainfall-runoff conditions similar to those years. Flow records pertaining to historical heavy precipitation and/or snowfall are still absent.

Figure 12. Ranking of Annual Stream Flow Volume of the Pudding River @ Aurora



An important consideration is the October-April runoff volume. In 2008-09, that volume was 19,300 aft for Drift Creek at the project site and 551,100 aft for Pudding River at Aurora, leading to a volume ratio of 19,300 aft/551,100 aft=0.0350. The volume ratio became 25,800 aft/638,600 aft=0.040 for 2009-10 and 32,500 aft/1,013,500 aft=0.032 for 2010-11. By comparison, the drainage area ratio for those two sites is [15.4 sq. mi. /479 sq. mi.]= 0.03215. The runoff volume ratio for Upper Drift Creek over Pudding @ Aurora for the full October- September hydrologic year was 0.035, 0.041 and 0.033 for 2008-09, 2009-10 and 2010-11 respectively. These ratios are basically the same as those for the October-April period.

According to the normal annual precipitation map for the Pudding watershed, more rainfall is expected to fall each year over Drift Creek's watershed than over Pudding River's watershed. However, because of its much larger drainage area, Pudding River probably has a larger baseflow than Drift Creek. The impact of rainfall over the Drift Creek's runoff volume recorded at the project site was illustrated earlier in the form of monthly rainfall amounts recorded at the Salem Airport. This includes variation of the monthly rainfall amounts as well as the cumulative rainfall amounts.

7. Stream Flows Generation Using Regression Equations

Regression equations have been developed using the statistical correlation between the flows measured at Pudding River flows at Aurora and Drift Creek flows at

Victor Point. This section examines how the model-generated data for Upper Drift Creek compare with data actually observed at the site gauging site for the corresponding recording period. The focus is on regression equations developed based on flow data from all three hydrologic years (Oct. 2008 – Sep. 2011) as listed in Table 11 below. Daily and monthly flow data reconstitution will be presented separately.

Table 11. Regression Equations Used for Upper Drift Cr. (based on Pudding Riv. @ Aurora)

Time Step	Data Base	Regression Equations	R^2
Daily	2008-09	Y=-1E-06X^2+0.0418X-2.1791	0.8064
Daily	2009-10	Y=-6E-07X^2+0.0428X-0.3903	0.8794
Daily	2010-11	Y=-2E-06X^2+0.0379X+0.2981	0.8659
Daily	2008-11	Y=-2E-06X^2+0.0416X-0.8081	0.8402
Monthly	2008-09	Y=-4E-06X^2+0.0453X-2.1196	0.9849
Monthly	2009-10	Y=-3E-06X^2+0.0477X-1.2132	0.9898
Monthly	2010-11	Y=-3E-06X^2+0.0423X-1.464	0.9857
Monthly	2008-11	Y=-4E-06X^2+0.048X-2.3533	0.9793

7.1 Daily Flows

The hydrographs of the **Daily** Observed vs. Synthesized flows at Upper Drift Creek are plotted on Figures 13.1, 13.2 and 13.3 for the 2008-09, 2009-10 and 2011 hydrologic years respectively. The absolute error differences are also shown for each day.

Figure 13.1 Observed vs. Regression-based Daily Flows at Upper Drift Creek 2008-09

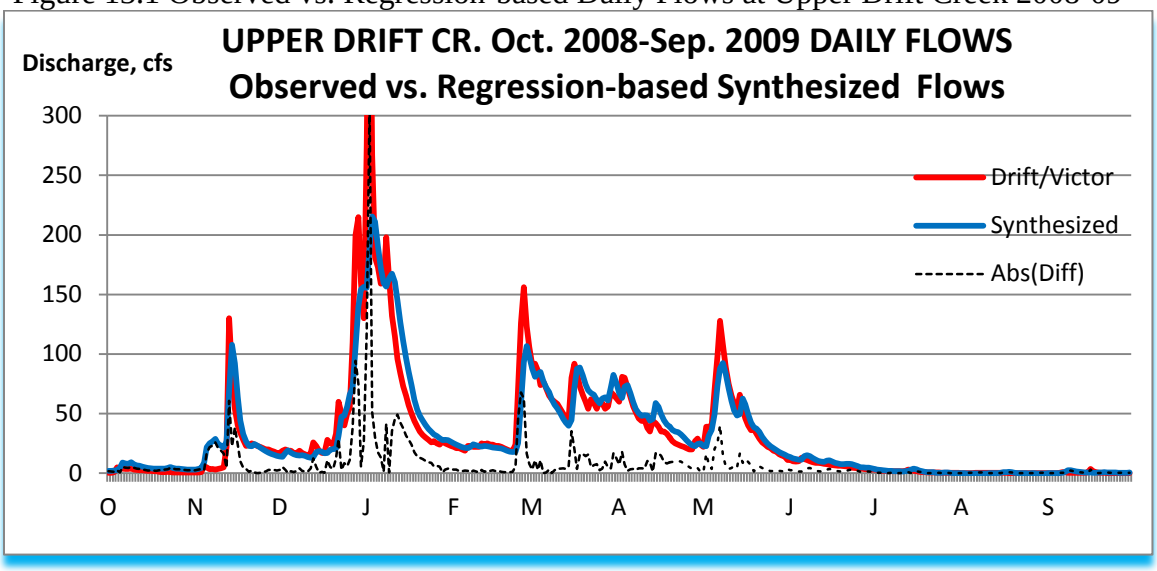


Figure 13.2 Observed vs. Regression-based Daily Flows at Upper Drift Creek 2009-10

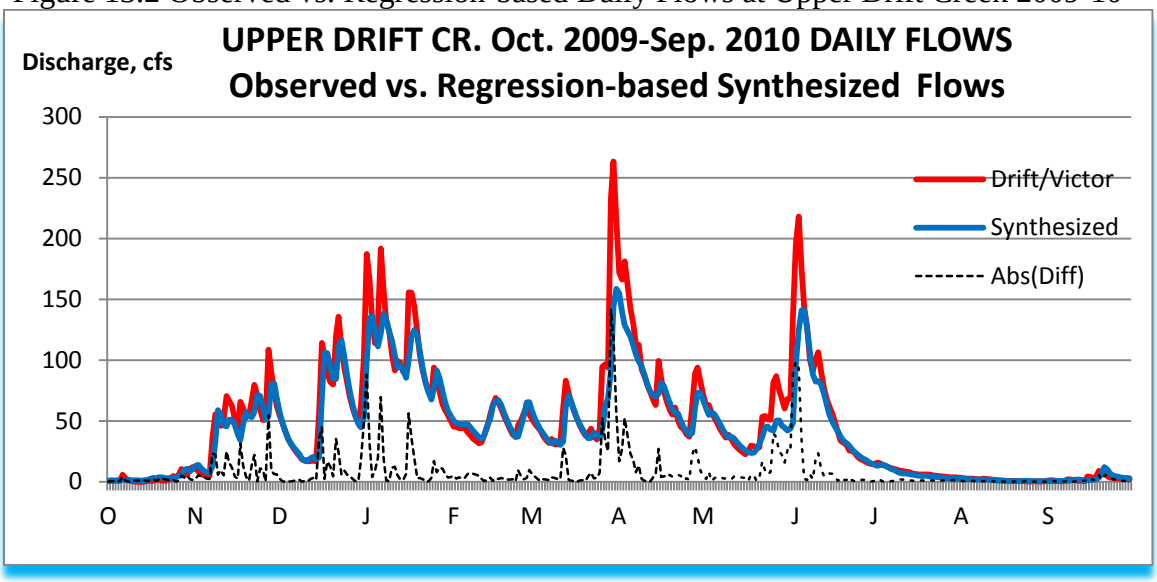
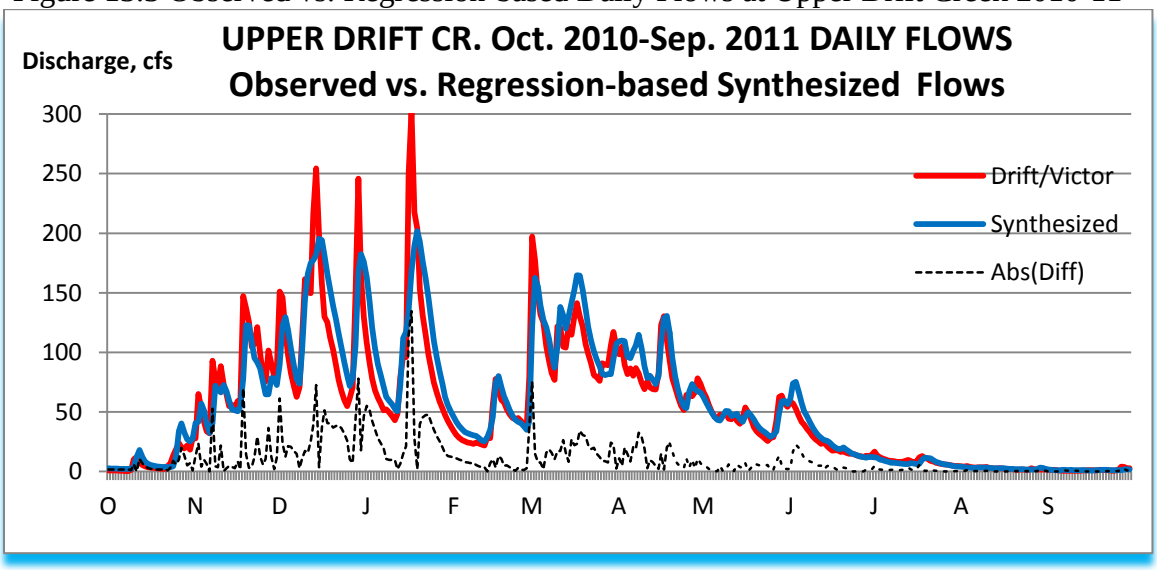


Figure 13.3 Observed vs. Regression-based Daily Flows at Upper Drift Creek 2010-11



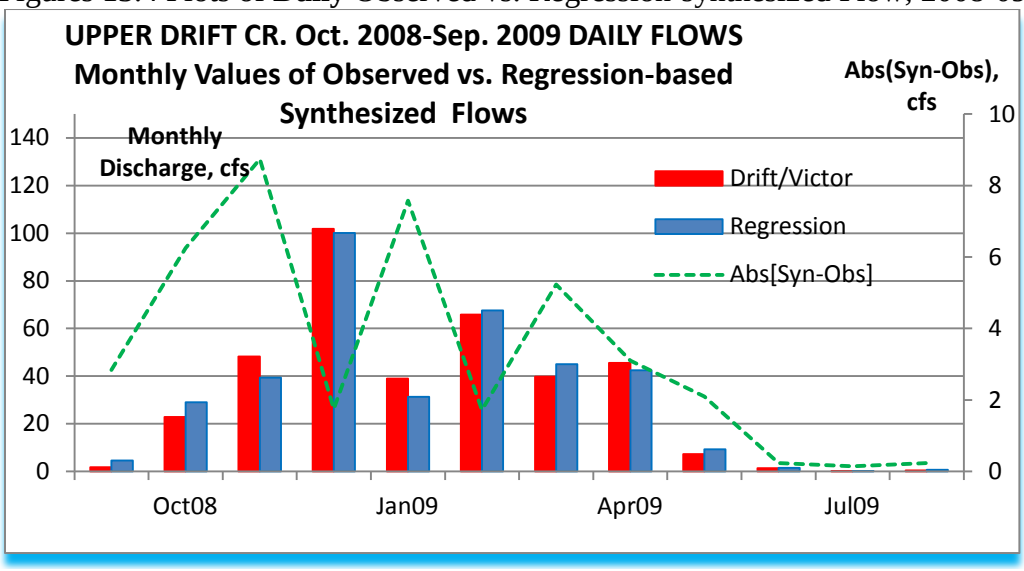
The results of the flows at Upper Drift Creek generated by regression equations involving daily Oct. 2008-2011 data of the Pudding River at Aurora are summarized in Table 12 in the condensed form of monthly values, and plotted in Figures 13.4, 13.5 and 13.6. Differences between monthly observed and calculated values are also shown.

Table 12. Results of Daily Synthesized Flows (Expressed in Monthly Values)

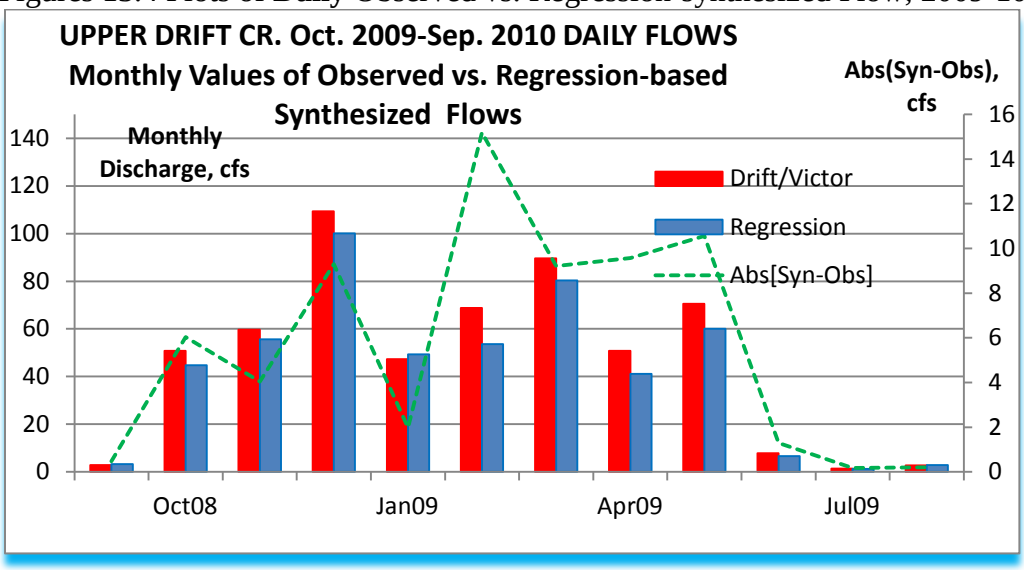
	Drift/Victor	Regression	Abs(Syn-Act)	% Error
Oct08	1.83	4.67	2.84	156
Nov08	22.82	29.07	6.25	27
Dec08	48.19	39.45	8.74	18
Jan09	101.87	100.12	1.75	2
Feb09	38.93	31.36	7.57	19
Mar09	65.90	67.63	1.73	3
Apr09	39.73	44.97	5.23	13
May09	45.55	42.45	3.10	7
Jun09	7.24	9.34	2.10	29
Jul09	1.35	1.59	0.24	17
Aug09	0.24	0.09	0.14	61
Sep09	0.49	0.73	0.24	49
Oct09	2.84	3.32	0.47	17
Nov09	50.84	44.80	6.04	12
Dec09	59.66	55.62	4.04	7
Jan10	109.37	100.07	9.29	8
Feb10	47.32	49.30	1.98	4
Mar10	68.76	53.57	15.19	22
Apr10	89.62	80.40	9.22	10
May10	50.77	41.20	9.57	19
Jun10	70.57	60.01	10.56	15
Jul10	7.90	6.61	1.29	16
Aug10	1.38	1.20	0.18	13
Sep10	2.71	2.91	0.20	7
Oct10	7.79	10.36	2.57	33
Nov10	78.55	69.57	8.98	11
Dec10	123.90	131.63	7.73	6
Jan11	95.62	109.15	13.53	14
Feb11	39.89	42.58	2.68	7
Mar11	112.20	119.42	7.23	6
Apr11	80.17	88.72	8.55	11
May11	45.24	45.55	0.31	1
Jun11	25.35	30.59	5.23	21
Jul11	8.86	7.75	1.11	12
Aug11	2.69	2.67	0.02	1
Sep11	1.33	1.29	0.04	3
Vol, aft				
2008-09	22,629	22,482	147	1

2009-10	33,827	30,010	3817	11
2010-11	37,606	39,898	2292	6
	Drift/Victor	Regression	Abs(Syn-Act)	% Error

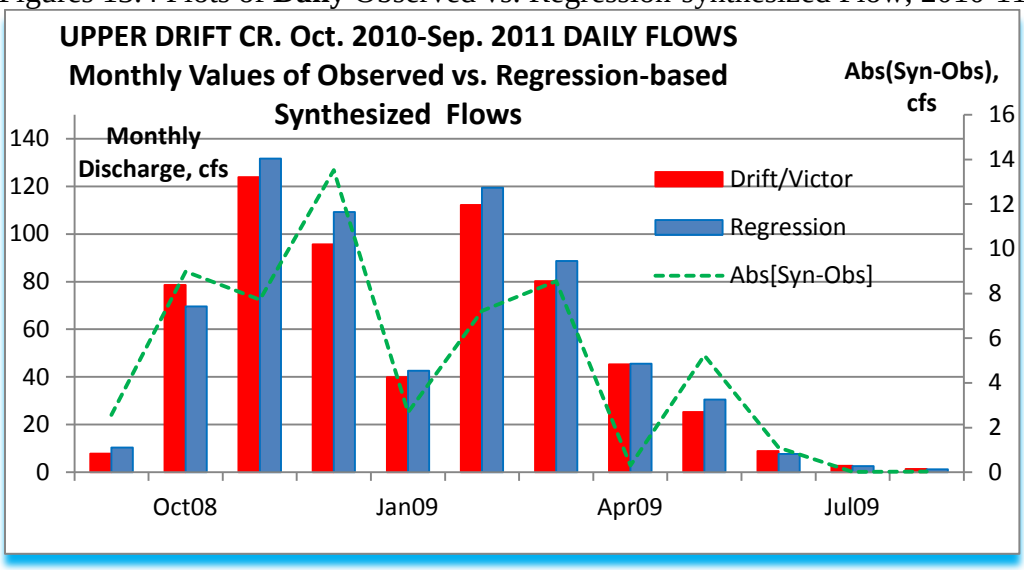
Figures 13.4 Plots of **Daily** Observed vs. Regression-synthesized Flow, 2008-09



Figures 13.4 Plots of **Daily** Observed vs. Regression-synthesized Flow, 2009-10



Figures 13.4 Plots of **Daily** Observed vs. Regression-synthesized Flow, 2010-11



7.2 Monthly Flows

The hydrographs of the **Monthly** Observed vs. Synthesized flows at Upper Drift Creek are plotted on Figures 13.5, 13.6 and 13.7 for the 2008-09, 2009-10 and 2011 hydrologic years respectively. The absolute error differences are also shown for each month.

Figure 13.5 Observed vs. Regression-based Monthly Flows at Upper Drift Creek 2008-09

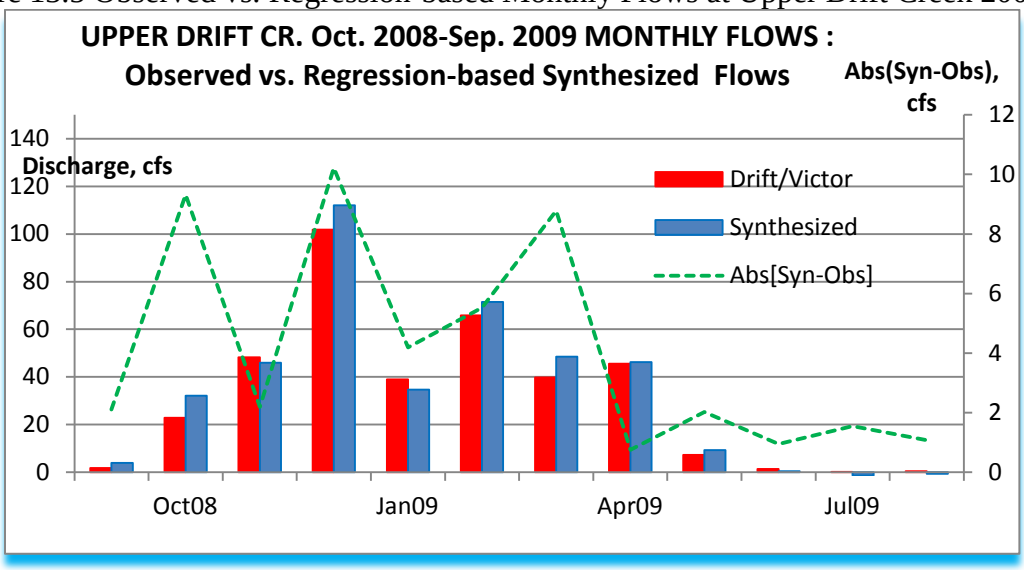


Figure 13.6 Observed vs. Regression-based Monthly Flows at Upper Drift Creek 2009-10

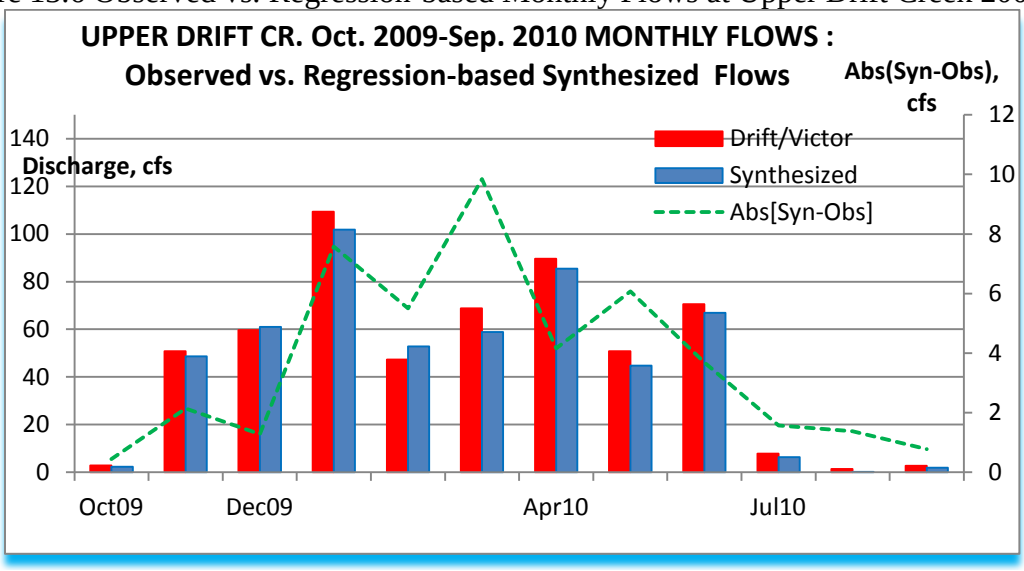
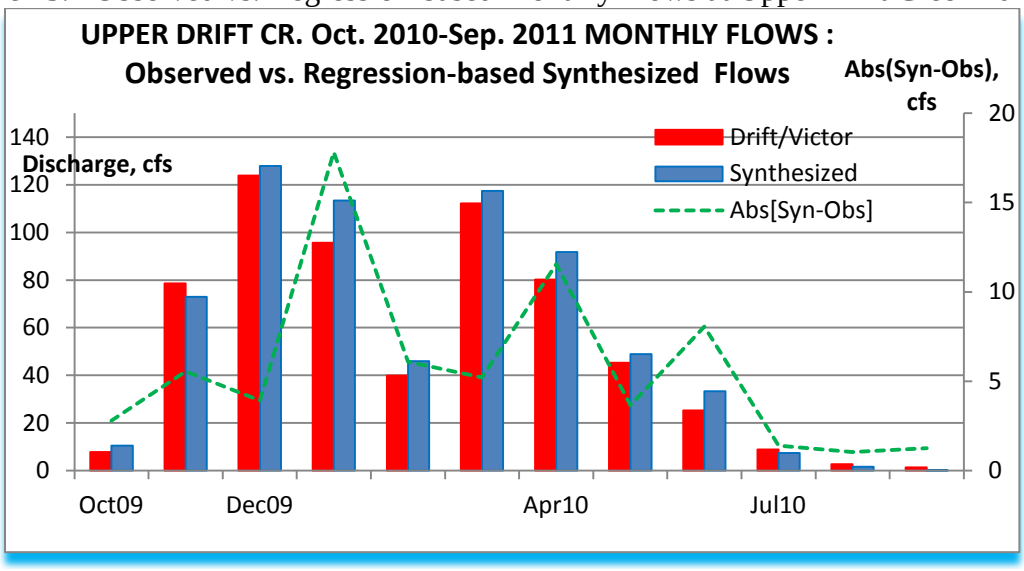


Figure 13.7 Observed vs. Regression-based Monthly Flows at Upper Drift Creek 2010-11



An earlier attempt to generate **monthly** flows of Drift Creek at the project site (Y) using the flows of the Pudding River at Aurora (X) was to apply a straight multiplier equal to the ratio of the annual runoff at the two gauging stations. The multiplier was equal to 22,600/641,600=0.035 for 2008-09; 33,700/821,800=0.041 for 2009-10; and 37,600/1,154,800=0.033 for 2010-11. The average multiplier for the three years was 0.035 + 0.041 + 0.033= 0.036. The new equation that could be used until a new set of stream flows data is available in the near future is now Y=0.036*X. Up to September 2010, that multiplier used to be Y=0.039*X. Table 13 provides a summary of the synthesized monthly flows for Upper Drift Creek using regression equations developed during each of the last three years and a straight multiplier.

Table 13. Comparison of **Monthly** Synthesized and Observed Flows
(Drift Cr. @ Project Site)

Month/Yr	Pud/Aur	Victor0	Regression 08-09	Regression 09-10	Regression 10-11	Regression 08-11	Multiplier y=0.036X
Monthly Flows, cfs							
OCT08	132.58	1.83	3.82	5.06	4.09	3.82	4.77
NOV08	767.80	22.82	30.30	33.64	29.25	30.30	27.64
DEC09	1110.10	48.19	43.24	48.04	41.80	43.24	39.96
JAN09	3281.81	101.87	103.47	123.02	105.05	103.47	118.15
FEB09	830.07	38.93	32.73	36.31	31.58	32.73	29.88
MAR09	1810.32	65.90	66.78	75.31	65.28	66.78	65.17
APR09	1174.83	39.73	45.58	50.69	44.09	45.58	42.29
MAY09	1117.77	45.55	43.52	48.36	42.07	43.52	40.24
JUN09	247.27	7.24	8.84	10.40	8.81	8.84	8.90
JUL09	57.84	1.35	0.49	1.54	0.97	0.49	2.08
AUG09	21.65	0.24	-1.14	-0.18	-0.55	-1.14	0.78
SEP09	36.93	0.49	-0.45	0.54	0.09	-0.45	1.33
OCT09	99.84	2.84	2.36	3.52	2.73	2.36	3.59
NOV09	1179.60	50.84	45.75	50.88	44.26	45.75	42.47
DEC09	1508.16	59.66	57.10	63.90	55.51	57.10	54.29
JAN10	2843.55	109.37	94.35	110.17	94.56	94.35	102.37
FEB10	1287.64	47.32	49.58	55.23	48.03	49.58	46.36
MAR10	1452.06	68.76	55.22	61.72	53.63	55.22	52.27
APR10	2252.33	89.62	79.62	91.00	78.59	79.62	81.08
MAY10	1076.85	50.77	42.02	46.67	40.61	42.02	38.77
JUN10	1676.93	70.57	62.60	70.34	61.03	62.60	60.37
JUL10	183.74	7.90	6.07	7.45	6.21	6.07	6.61
AUG10	49.32	1.38	0.10	1.13	0.62	0.10	1.78
SEP10	90.07	2.71	1.93	3.06	2.32	1.93	3.24
OCT10	275.90	7.79	10.07	11.72	9.98	10.07	9.93
NOV10	1857.27	78.55	68.22	77.03	66.75	68.22	66.86
DEC10	4140.97	123.90	116.88	144.87	122.26	116.88	149.07
JAN11	3344.19	95.62	104.64	124.75	106.44	104.64	120.39
FEB11	1109.64	39.89	43.22	48.02	41.78	43.22	39.95
MAR11	3538.71	112.20	108.09	130.02	110.66	108.09	127.39
APR11	2467.00	80.17	85.29	98.20	84.63	85.29	88.81
MAY11	1184.65	45.24	45.93	51.08	44.44	45.93	42.65
JUN110	798.17	25.35	31.49	34.95	30.39	31.49	28.73
JUL11	207.94	8.86	7.13	8.58	7.20	7.13	7.49
AUG11	83.94	2.69	1.65	2.77	2.07	1.65	3.02
SEP11	50.60	1.33	0.16	1.19	0.67	0.16	1.82

Annual Vol, aft							
2008-09		**22,799**	22,823	26,196	22,550	22,823	23,097
2009-10		**33,827**	29,863	33,982	29,350	29,863	29,672
2010-11		**37,606**	37,660	44,366	37,949	37,660	41,571
V syn./V actual							
2008-09		1.00	1.00	1.15	0.99	1.00	1.01
2009-10		1.00	0.88	1.00	0.87	0.88	0.88
2010-11		1.00	1.00	1.18	1.01	1.00	1.11
Month/Yr	Pud/Aur	Victor0	Regression 08-09	Regression 09-10	Regression 10-11	Regression 08-11	Multiplier y=0.036X

As shown in Table 13, the volumes of the calculated annual runoff are within 1 to 18% of the corresponding observed values. For example, in 2009-10, the observed runoff volume of Upper Drift Creek is 33,827 aft and the calculated runoff volume ranges from a low value of 29,672 aft (88% of 33,827) to a high value of 33,982 aft (close to 100% of 33,827). Figures 14.1, 14.2 and 14.3 provide a graphic representation of the results obtained using the regression equation based on all of the 2008-11 data (7th column in Table 13).

Figure 14.1 Observed vs. Regression Synthesized Monthly Flows, 2008-09

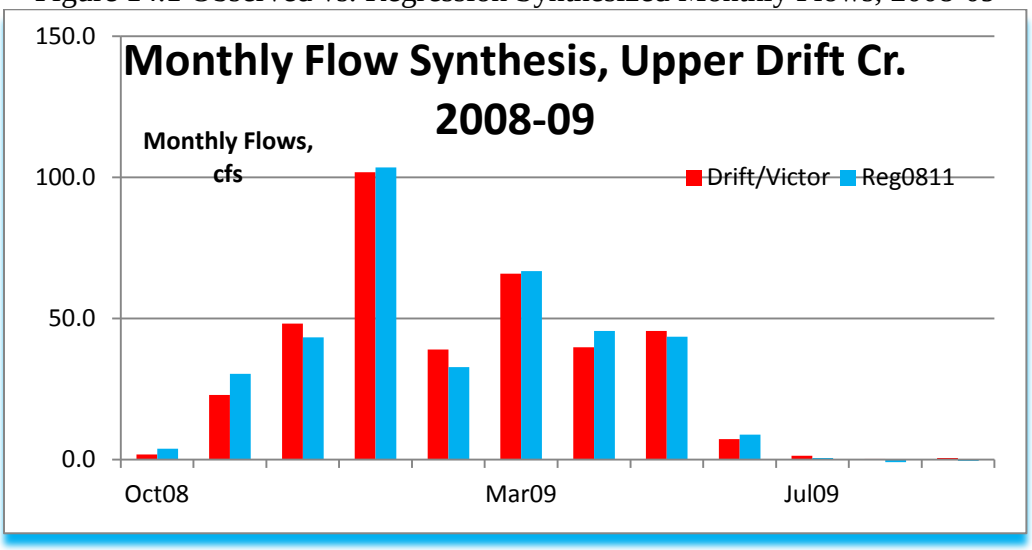


Figure 14.2 Observed vs. Regression Synthesized Monthly Flows, 2009-10

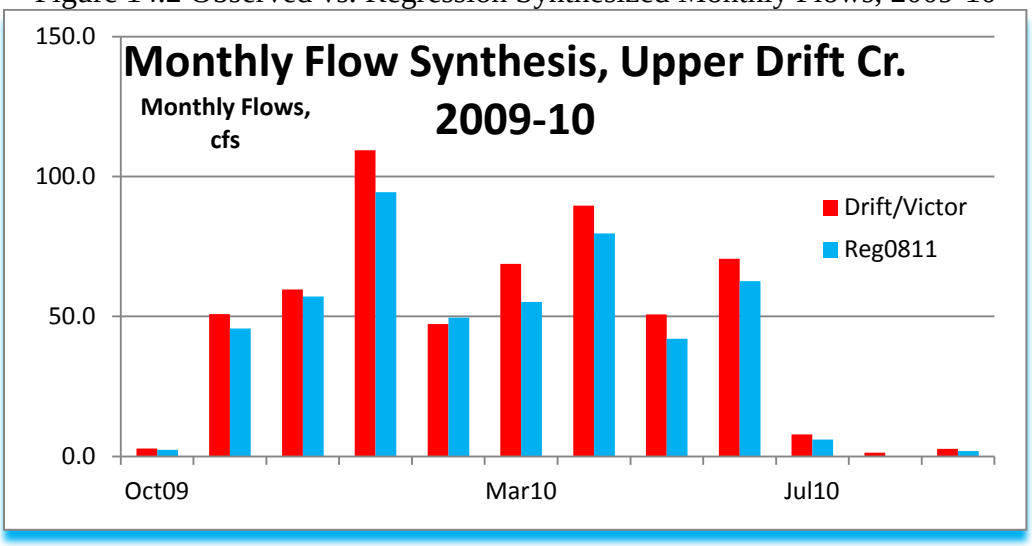
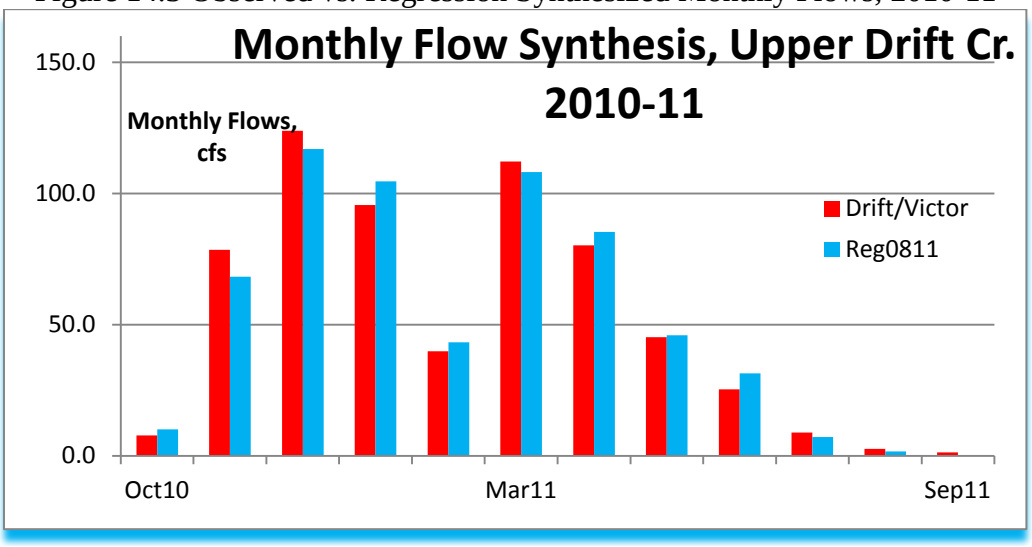


Figure 14.3 Observed vs. Regression Synthesized Monthly Flows, 2010-11



7.3 Comparison of Daily and Monthly Flow Synthesis Results

Results The values of the correlation R^2 factor using X=Observed Upper Drift Flows and Y=corresponding regression synthesized Upper Drift Creek flows are listed in Table 14.

Table 14. Summary Results of the Regression-Synthesized Flows for Upper Drift Creek

	R^2	Maximum Error, cfs
2008-09		
Daily	0.9017	-310 cfs (Jan. 2009)
Monthly	0.9852	-10 cfs (Jan. 2009)
2009-10		
Daily	0.9206	-141 cfs (Mar.2010)
Monthly	0.99	-10 cfs (Mar. 2010)
2010-11		
Daily	0.9142	-134 cfs (Jan. 2011)
Monthly	0.9865	-18 cfs (Jan. 2011)

The results for both the daily and monthly flows synthesis indicate that the stream flow data generated for Drift Creek at the project site using regression equations linked to the Pudding River flows at Aurora are within acceptable ranges. It is possible that using data recorded at a site geographically closer to Victor Point and controlling a smaller catchment area (such as Woodburn for the Pudding River and Silverton for Silver Creek) might yield comparable or even better results. As noted earlier, however, the other important consideration to keep in mind is the record length at those sites compared to Aurora's 49 year records.

8. Stream Flow Reconstitution Summary

One of the primary hydrologic data needed is the range of runoff volume that can be expected during the reservoir refill season. Without any actual stream flow data, earlier runoff estimates for Drift Creek could only be based on drainage area and basin mean annual precipitation. The main driver, stream flow, has been absent until October 2008. Since that time, the 2008-09, 2009-10 and 2010-11 stream flow measurements now provide three full hydrologic years of data that can be used to start developing a more reliable, data-based flow modeling capability.

To take advantage of this additional, albeit limited, real-time information, procedures were used to reconstitute the 2008-09, 2009-10 and 2010-11 data first on a monthly basis and, later, on a daily basis. Mean monthly (and other more seasonal) flows are generally less dependent on precipitation timing and can usually be synthesized using regression models. This section provides a summary of the steps involved in each of the procedures used.

A. Monthly Flows Reconstitution

The two procedures used to reconstitute the monthly stream flows at the project site include the following:

1. Multiply the monthly Pudding River flows near Aurora by a factor equal to the ratio of the annual runoff volume for Drift Creek at the project site divided by annual runoff volume for Pudding River at Aurora. One could use the first multiplier during dry years and the second multiplier for average water years, or use the average of the two multipliers for planning purposes when the size of the annual runoff cannot be determined beforehand.
2. Use the regression equation that relates the monthly flows of the Pudding River near Aurora to the monthly flows of Drift Creek at the project site.

B. Daily Flows Reconstitution

To meet the need for shorter time step data, which are more time-dependent than monthly or seasonal flows, two procedures were used. The first procedure is based on statistical correlation between daily flows, and the second procedure relies on deterministic rainfall-runoff modeling.

B.1. Statistical Correlation of Daily Flows

This procedure relies on regression equations developed from the daily flows recorded at Pudding River near Aurora.

B.2 Rainfall-runoff Modeling

Daily flows for Drift Creek at the project site can also be generated by a deterministic rainfall-runoff model based on the same procedures as the ones used in the U.S. Army Corps of Engineers' "Streamflow Synthesis and Reservoir Regulation" (SSARR) model. For easy reference purposes, the rainfall-runoff model developed for Drift Creek is coded-named FLO4DRIFT. Its main inputs are the watershed runoff characteristics such as drainage area, basin routing coefficients, and rainfall and/or snow data, etc. Model parameters are adjusted as needed to get the model-calculated flows to match the observed runoff volume and shape. For example, in order to match the 2008-09 observed annual runoff volume, rainfall at Salem Airport had to be multiplier by a factor of 1.9 to account for infiltration, evaporation losses, and lack of snow information. For a slightly below average year like 2009-10, the rainfall multiplier is 1.5. For an above average year like 2010-11, the rainfall multiplier is 1.7.

The results of the deterministic modeling work using rainfall data at the Salem airport are documented below in the form of daily hydrograph plots and numerical and graphic tabulations of observed and calculated data. Table 15 provides a sample output for the FLO4DRIFT model. Figures 15.2 (for 2008-09), 15.3 (for 2009-10) and 15.4 (for 2010-11) show hydrographs of observed daily flows for the three years involved. The hydrographs generated by a regression equation using 2008-2011 data for Pudding River near Aurora are also shown for comparison purposes.

Table 15. Sample FLO4DRIFT Model Output

```
            TS=  2.0 TSS=   8.0 TSBF=  24.0 TSBII=   32.0 W(1)= 1.70
  RUNOFF VOL (AF) =   37,673 CAL(Before Routing)=   38,795 OBS/CAL Ratio= 1.030
                          Title:DRIFT CREEK 2010-11
                        RUN DATE:05-20-2012  21:04:02
                                          <.......   D I S C H A R G E S .........>
DD/MM/YR RAIN  ETI   SMI ROP   BII BFP    SUR    SUB    BFL BASE    QCAL    QOBS
          in.  in.   in.                  cfs    cfs    cfs  cfs     cfs     cfs
-------- ----  ---   --- ---   --- ---    ---    ---    ---  ---    ----     ---
 1/10/10 0.00 0.07  0.10 .15  1.00 .20    0.0    0.0    0.0  0.1     0.1     0.9
 2/10/10 0.00 0.07  0.03 .15  0.45 .30    0.0    0.0    0.0  0.1     0.1     0.9
 3/10/10 0.00 0.07  0.00 .15  0.21 .44    0.0    0.0    0.0  0.1     0.1     0.9
 4/10/10 0.00 0.07  0.00 .15  0.09 .58    0.0    0.0    0.0  0.1     0.1     0.9
 5/10/10 0.00 0.07  0.00 .15  0.04 .70    0.0    0.0    0.0  0.1     0.1     0.7
 6/10/10 0.00 0.07  0.00 .15  0.02 .76    0.0    0.0    0.0  0.1     0.1     0.6
 7/10/10 0.00 0.07  0.00 .15  0.01 .78    0.0    0.0    0.0  0.1     0.1     0.5
 8/10/10 0.00 0.07  0.00 .15  0.00 .79    0.0    0.0    0.0  0.1     0.1     0.5
 9/10/10 1.41 0.07  0.00 .15  0.00 .80    2.0    2.7    2.9  0.1     7.7     1.3
10/10/10 0.00 0.07  1.19 .19  0.00 .80    1.0    3.1    4.6  0.1     8.8    10.0
11/10/10 0.00 0.07  1.12 .19  0.00 .80    0.4    2.7    5.5  0.1     8.6    12.0
12/10/10 0.00 0.07  1.05 .18  0.00 .80    0.1    2.0    5.9  0.1     8.1     7.4
13/10/10 0.00 0.07  0.98 .18  0.00 .80    0.0    1.4    5.9  0.1     7.4     5.4
14/10/10 0.00 0.07  0.91 .18  0.00 .80    0.0    1.0    5.6  0.1     6.7     4.3
15/10/10 0.00 0.07  0.84 .18  0.00 .80    0.0    0.7    5.3  0.1     6.0     3.7
16/10/10 0.00 0.07  0.77 .17  0.00 .80    0.0    0.4    4.8  0.1     5.3     3.0
17/10/10 0.00 0.07  0.70 .17  0.00 .80    0.0    0.3    4.3  0.1     4.7     2.9
18/10/10 0.00 0.07  0.63 .17  0.00 .80    0.0    0.2    3.8  0.1     4.1     2.7
19/10/10 0.12 0.07  0.56 .17  0.00 .80    0.1    0.4    3.7  0.1     4.2     2.4
20/10/10 0.00 0.07  0.60 .17  0.00 .80    0.1    0.4    3.4  0.1     3.9     2.0
21/10/10 0.00 0.07  0.53 .17  0.00 .80    0.0    0.3    3.1  0.1     3.5     2.0
22/10/10 0.00 0.07  0.46 .16  0.00 .80    0.0    0.2    2.8  0.1     3.1     4.7
23/10/10 0.00 0.07  0.39 .16  0.00 .80    0.0    0.2    2.4  0.1     2.7     6.5
24/10/10 1.46 0.07  0.32 .16  0.00 .80    2.3    3.0    5.3  0.1    10.7    13.0
25/10/10 1.17 0.07  1.54 .20  0.00 .80    3.4    6.3   10.1  0.1    20.0    19.0
```

RAIN= rainfall amount; ET=evapo-transpiration index; SMI=soil moisture index
ROP = rainfall runoff percent; BII= base flow infiltration index; BFP=base flow percent
SUR =surface runoff; SUB= sub-surface runoff; BASE= base flow; QCAL=calculated discharge
QOBS= observed s=discharge

Figure 15.1 Schematic Diagram of the SSARR Model

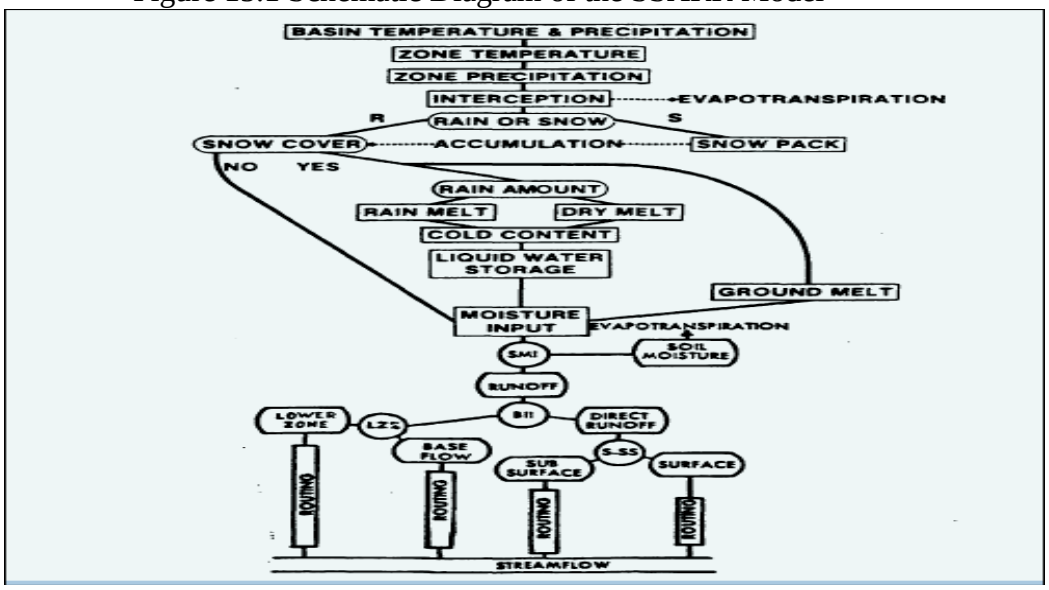


Figure 15.2 **2008-09** Daily Flows Reconstitution using SSARR model

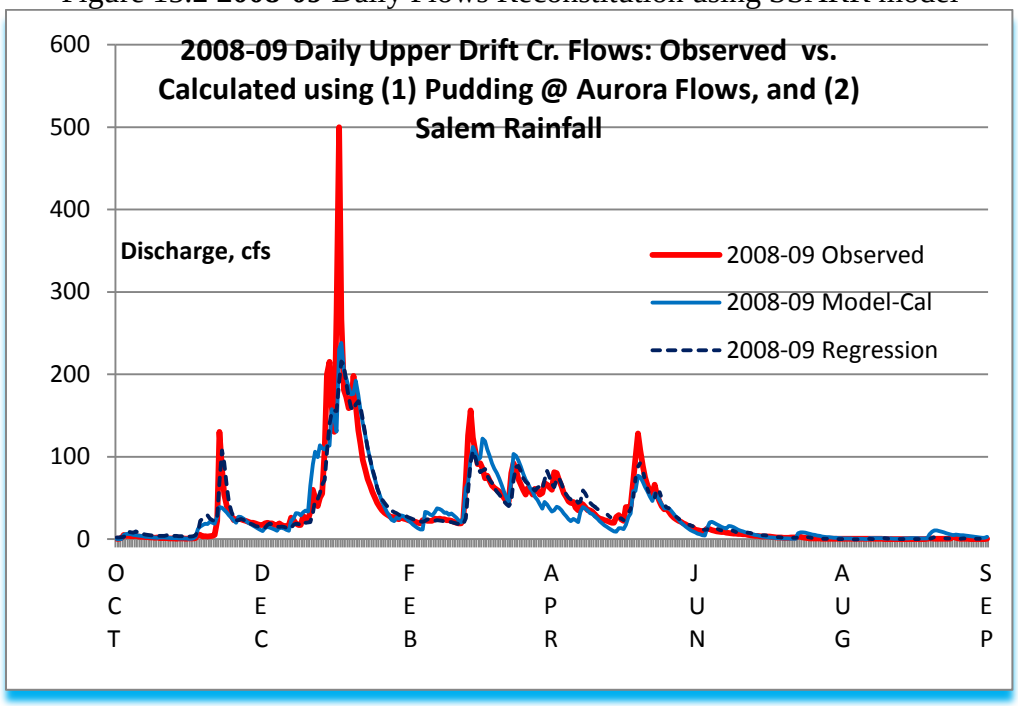


Figure 15.3 **2009-10** Daily Flows Reconstitution Using SSARR Model

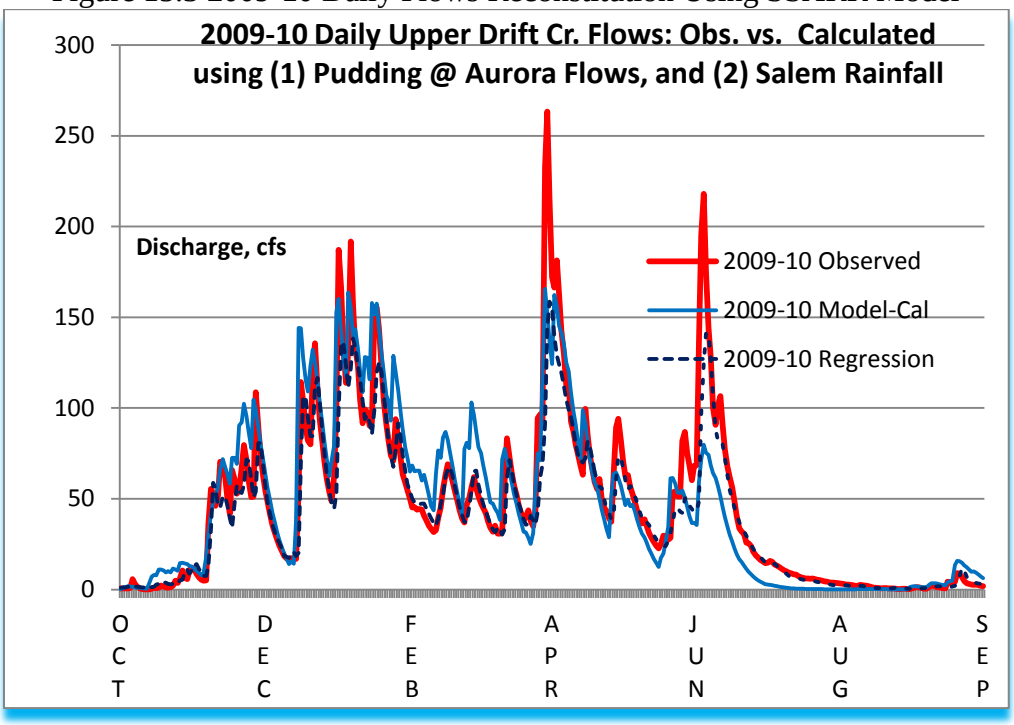
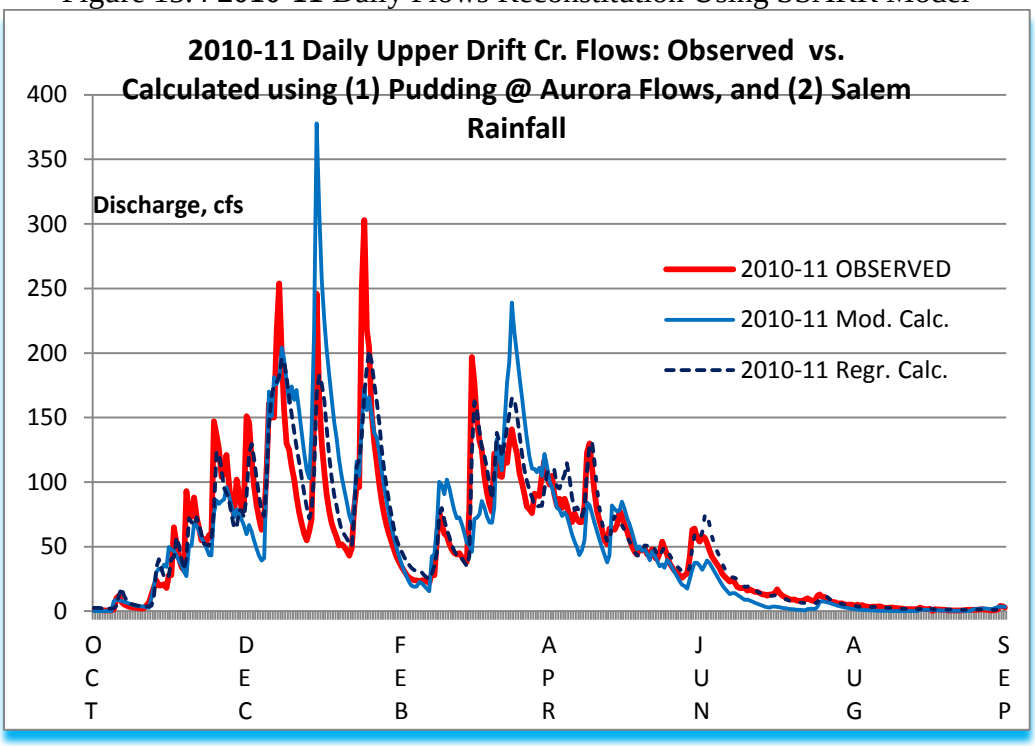


Figure 15.4 **2010-11** Daily Flows Reconstitution Using SSARR Model



To illustrate the relative accuracy of the daily stream flow synthesis using Salem rainfall, scatter plots of Observed vs. Model-calculated daily flows are shown for each of the three hydrologic years in Figures 16.1, 16.2 and 16.3 respectively, also including the values of the correlation indicator R^2.

Figure 16.1 Scatter Plot for 2008-09 Daily Observed vs. Model-Calculated Flows

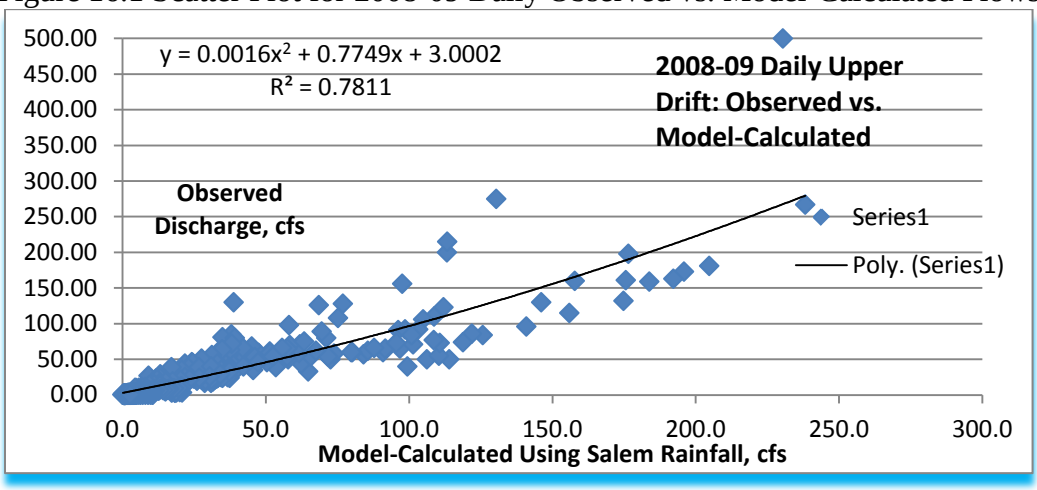


Figure 16.2 Scatter Plot for 2009-10 Daily Observed vs. Model-Calculated Flows

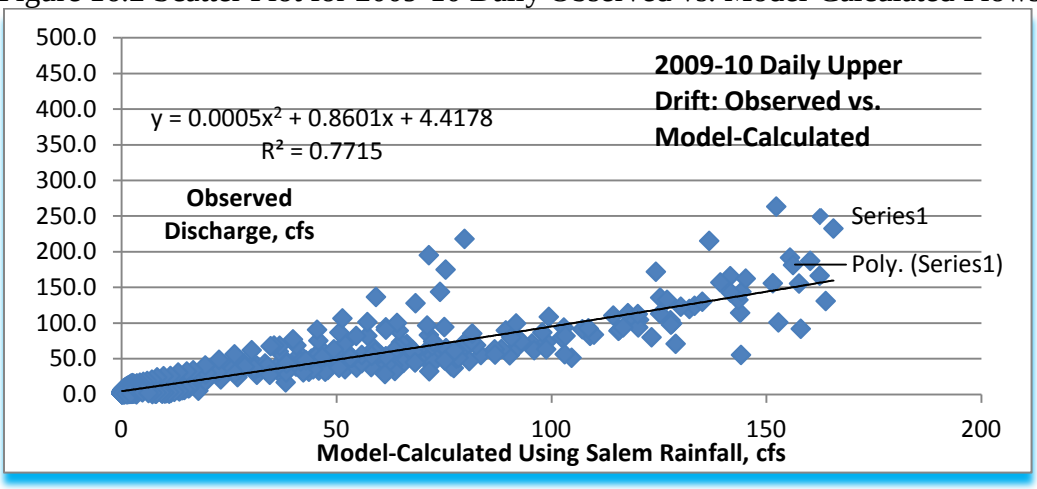
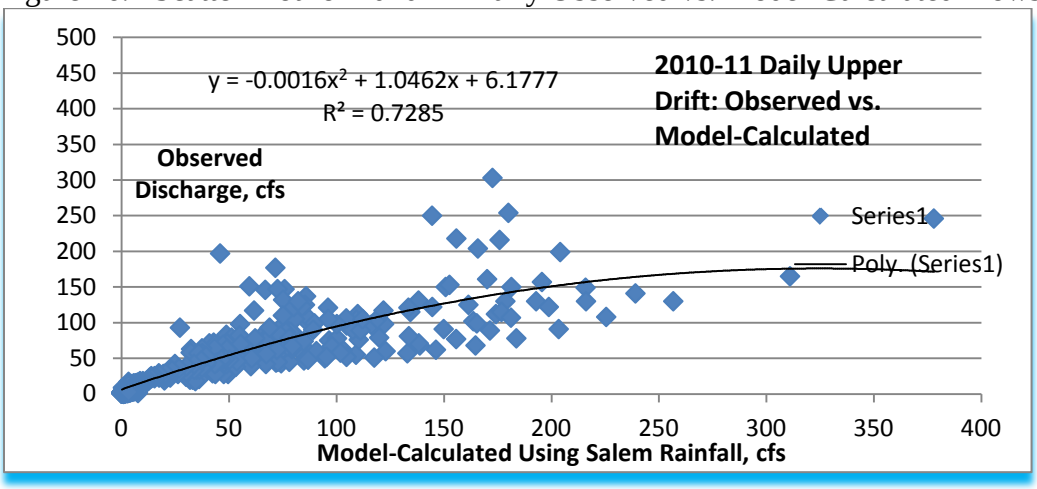


Figure 16.2 Scatter Plot for 2010-11 Daily Observed vs. Model-Calculated Flows



For comparison purposes, the scatter plots of Observed vs. Calculated daily Drift Creek flows based on Pudding River-based regression equations are provided in Figures 17.1, 17.2, and 17.3.

Figure 17.2 Scatter Plot: 2008-09 Daily Observed vs. Regression-Derived Flows

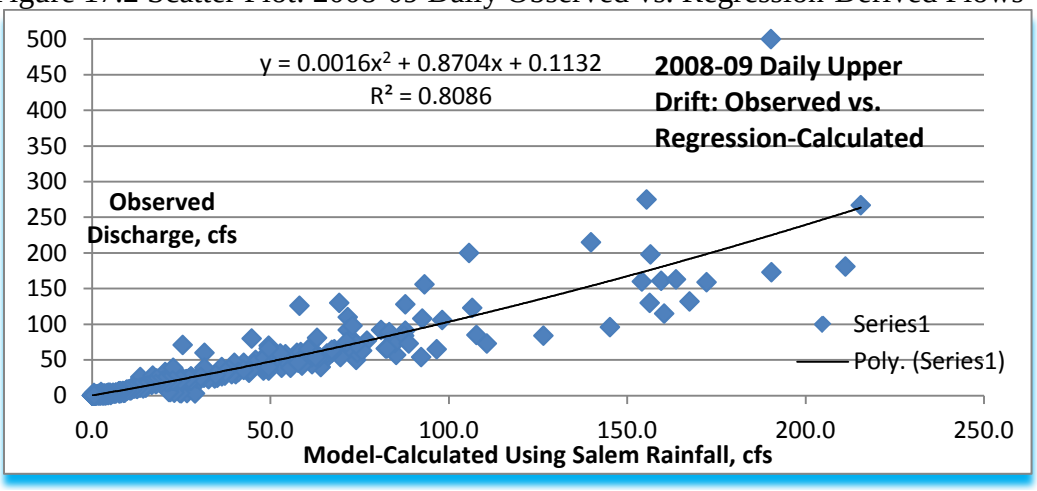


Figure 17.2 Scatter Plot: 2009-10 Daily Observed vs. Regression-Derived Flows

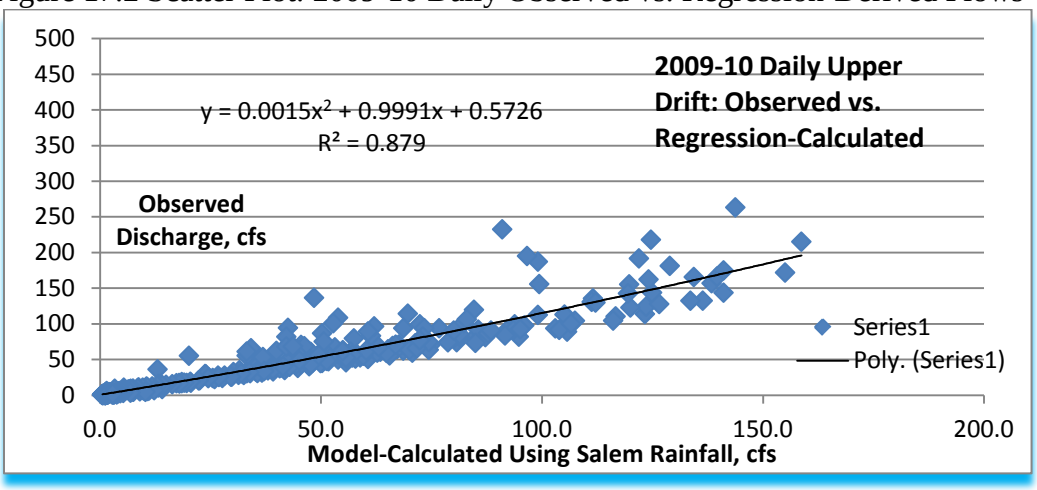


Figure 17.2 Scatter Plot: 2009-10 Daily Observed vs. Regression-Derived Flows

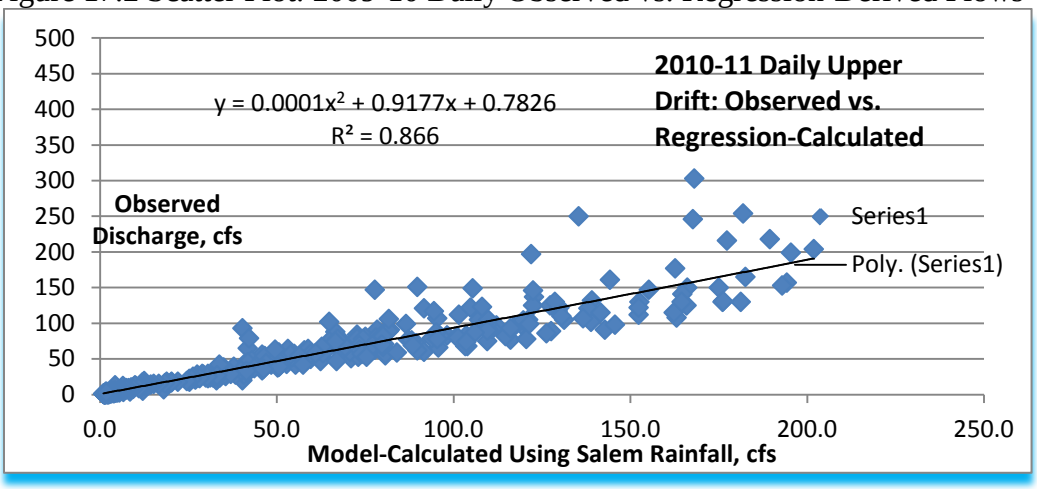


Table 16 summarizes the numerical values of the correlation indicator R^2 for each of the above cases.

Table 16. R^2 Values of Daily Flow Reconstitution by Model and Regression

	2008-09	2009-10	2010-11
Model-Calculated	0.7811	0.7715	0.7285
Regression-based	0.8086	0.879	0.866

The results generated appear to be reasonably acceptable. The shape of the hydrograph and the total runoff volume in particular look very good. Obviously, additional data for different years (other than the year used for the calibration) are needed to further refine the procedures to cover other runoff conditions. Also, the use of other rainfall stations will be necessary to improve the results. Furthermore, a higher runoff year for Drift Creek can be expected to have heavier rainfall, more sluggish soil conditions and some snowfall in the upper part of the basin, conditions that were practically non-existent in 2008-09, not too overwhelming in 2009-10, and still not pronounced in 2010-11.

From the above results, daily discharges calculated by the regression equation Y=-2E-06X^2+0.0451X-2.3054 based on the 2008-11 daily Pudding River flows at Aurora (X) and daily Drift Creek flows at the project site (Y) always led to a higher R^2 value than for the model-calculated, Salem rainfall-based flows. However, both procedures are promising and deserve to be evaluated further because of their complementary application potential in reconstituting historical records and generating future runoff predictions.

9. Representative Low, Average and High Runoff Water Years

Representative low, average and high flow years are needed to define the range of runoff conditions that can be expected at the project site based on historical flow data. Data for the Pudding River near Aurora site were used because they cover the longest stream flow gauging records of all streams in the same general physical area as Drift Creek, and produce a high statistical correlation indicator R^2 with the Drift Creek Upper site data.

Figure 12 and Table 10, which were shown earlier in this report, contain the observed annual (October-September) runoff volumes of the Pudding River at Aurora ranked from highest to lowest for the 49 years between 1928 and 2011. The ranking is used to help identify the typical average, low and high runoff water years as described further below.

The mean annual (October-September) runoff volume for those 49 years is 891,345 aft. This 50% exceedence level volume is between the 916,004 aft recorded in 1957-58 (ranked 24th out of 49) and the 867,553 aft recorded in 1933-34 (ranked 25th out

of 49). Therefore, the 1933-34 water year qualifies as the representative average water year.

The annual (October-September) runoff volume that is exceeded 80% of the 49 years (49 x0.80=39.2 years) corresponds to the 39th ranked. The 1944-45 water year, with an annual runoff volume of 695,169 aft is ranked 39th on Table 24 and thus qualifies as a representative low flow year. By the same token, the annual runoff volume that is exceeded 20% of the 49 years corresponds to the 10th ranked runoff. This happens to be the 1949-50 water year (with an annual runoff volume of 1,127,442 aft), which supersedes the 1947- 48 water year (with an annual runoff volume of 1,095,130 aft) previously selected as a representative high flow year in Report Update #2. This was the result of the 2010-11 water year (with an annual runoff volume of 1,154,752 aft) being ranked 8th, ahead to 1949-50 and 1947-48.

Because of the strong correlation between the stream flows at that site and the stream flows at the project site as confirmed by the data collected in 2008-09, 2009-10, and 2010-11 those same years will be treated as typical average, low, and high water years respectively for Drift Creek at the project site as well.

It should be noted that the changes in average, low, and high water years due to the addition of the latest flow data are purely procedural in nature and may be driven only by a relatively small (less than 0.2%) change in runoff volume and/or water year ranking, and not by the runoff hydrograph shape. In 2009, the set of representative flow years included 1949-50, 1957-58, and 1935-36. In 2010-11, the change in water year ranking led to the retention of 1933-34 and 1944-45 as representative average and low flow years, but called for the replacement of the representative high flow year 1947-48 by HY 1949-50. Because the selection of representative years was only based on annual runoff volume ranking, candidate water years may have comparable volume amounts but the shape of their runoff hydrograph may be different.

Table 17 summarizes the runoff volume of the three representative years derived through the use of a simple, multiplier-based correction factor to convert annual Pudding River runoff to annual Drift Creek runoff for those years. In 2008-09, the annual runoff volume was 22,600 aft for Drift Creek at the project site and 623,000 aft for Pudding River at Aurora -- a runoff volume ratio of 22,600/623,000 = 0.036. In 2009-10, that ratio became 33,800/822,200 = 0.041. The average of the two numbers, (0.036+0.041) = 0.039 was then used (instead of 0.036). In 2010-11, the runoff volume ratio became 37,600/1,154,800=0.033. The average of the three ratios, (0.036+0.041+0.033)=0.037 is now used to produce the estimated annual runoff volumes for the average, low, and high flow years for Drift Creek at the project site.

Table 17. Projected Upper Drift Cr. **Annual** Runoff Volume Using Straight Multiplier (previous year results are shown in parenthesis)

Flow Years	Representative Hydrologic Years	Obs. Oct-Sep. Runoff Vol. (aft), **Pudding** Riv. @ Aurora	New Multi-Plier	Projected Oct-Sep. Runoff Vol. (aft), **Drift** Cr. @ Victor Point Rd.
High	1949-50 (1947-48) (1949-50)	1,115,792 (1,095130) (1,115,792)	0.037 (0.039) (0.036)	41,300 (42,700) (40,500)
Average	1933-34 (1933-34) (1957-58)	867,559 (867,559) (916,004)	0.037 (0.039) (0.036)	32,100 (33.800) (33,300)
Low	1944-45 (1944-45) (1935-36)	695,335 (695,335) (687,904)	0.037 (0.039) (0.036)	25,700 (27,100) (25,000)

Instead of using a fixed multiplier, another option is to apply regression equations described earlier and based on the 2008-11 field data to generate the daily and monthly flows for Drift Creek at the project site. See Table 11. With Y defined as discharge (daily or monthly) for Drift Creek at the project site, and X as discharge (daily or monthly) for Pudding River at Aurora, those equations are:

Daily Flows: Y= -0.0002*X^2+0.0416*X – 0.8081
Monthly Flows: Y= -0.0004*X^2 + 0.048*X – 2.3533

The same, multiplier-based procedure is used to estimate expected **October-April** runoff volume at the project site. For 2010-11, the multiplier is 0.037.

Table 18. Projected Upper Drift Cr. **October-April** Runoff Volume (previous results are shown chronologically in parenthesis)

Flow Years	Representative Hydrologic Years	Observed Oct-Apr. Runoff Vol. (aft), Pudding @ Aurora	New Multiplier	Projected Oct-Apr. Runoff Vol. (aft), Drift Cr. @ Victor Point Rd.
High	1949-50 (1947-48) (1949-50)	1,008,572 (962,160) (1,008,572)	0.037 (0.038) (0.0362)	37,300 (36,562 (36,512)
Average	1933-34 (1933-34) (1957-58)	798,511 (798,511) (851,445)	0.037 (0.038) (0.0362)	32,100 (30,343) (30,823)
Low	1944-45 (1944-45) (1935-36)	550,788 (550,788) (585,279)	0.037 (0.038) (0.0362)	20,400 (20,930) (21,188)

10. Estimated Flow Hydrographs for Representative Flow Years

10.1 Regression-based Procedure

Daily flows for the representative flow years are derived from the historical daily flows recorded for the Pudding River at Aurora using the regression equation based on 2008-2011 observed daily flows of Upper Drift Creek, Y=-2E-06 * X^2 + 0.0417 *X - 0.8081. Daily flow data for the Pudding River at Aurora were extracted from the USGS website at the following address:

http://waterdata.usgs.gov/nwis/dv?cb_00060=on&cb_00010=on&format=rdb&begin_date=1933-10-01&end_date=1934-09-30&site_no=14202000&referred_module=sw (for 1933-34).

Figure 18.1 shows the hydrographs of the estimated daily flows at Upper Drift Creek for the representative low, average and high flow years. Figure 18.2 shows the plots of the equivalent monthly flows.

Figure 18.1 Hydrograph of estimated Drift Creek's daily flows during representative low, average and high flow years.

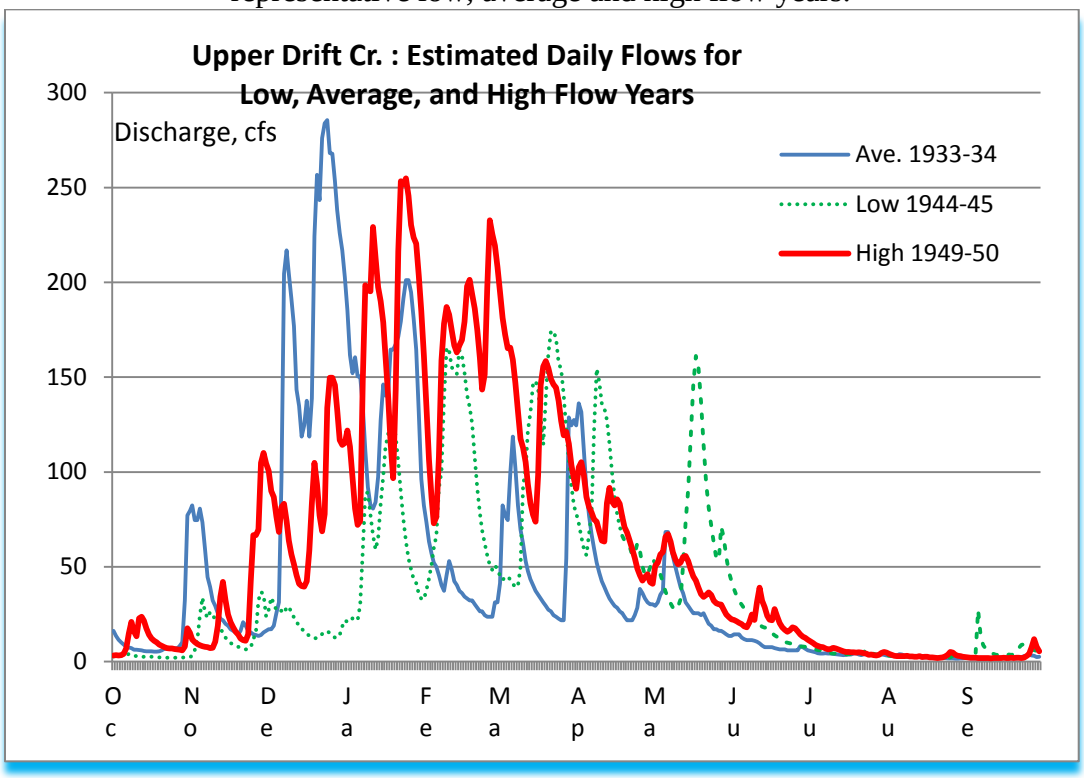


Figure 18.2 Plots of Estimated Drift Creek's Monthly flows during representative low, average and high flow years.

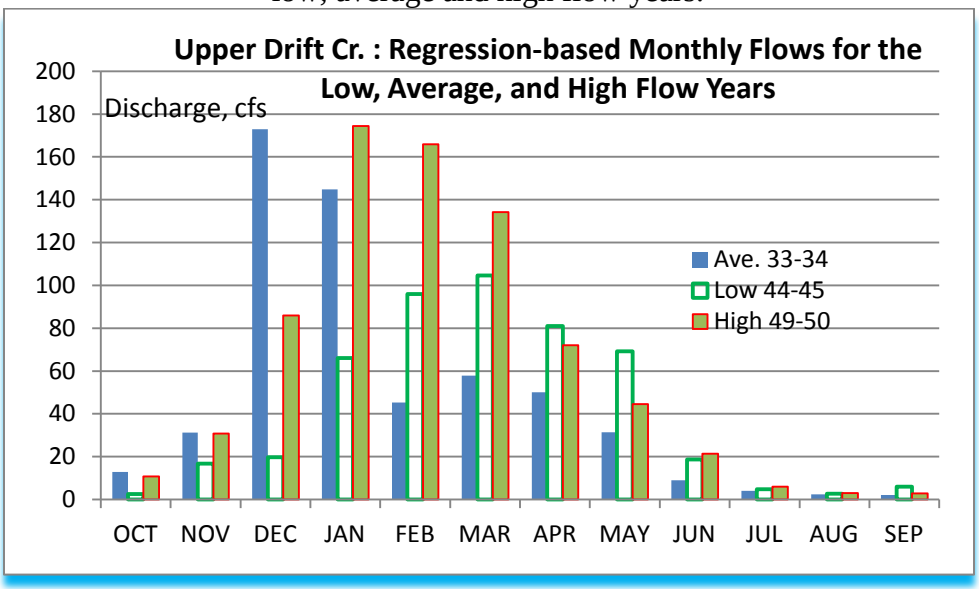


Table 19 shows a summary expressed in monthly values of the following flow data: (1) observed daily flows for the water years 1944-45 (low flows), 1933-34 (average flows) and 1949-50 (high flows) for the Pudding River at Aurora; and (2) the corresponding calculated flows for Upper Drift Creek obtained through the regression equation and converted into monthly values.

Table 19. Regression-based Daily Flows of Representative Flow Years (converted into monthly average values), in cfs

													Annual
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Vol (AF)
Pudding/Aurora													
Ave. 33-34	295	700	5,170	3,633	1,016	1,325	1,142	695	207	102	68	62	875,918
Low 44-45	71	373	436	1,517	2,300	2,527	1,879	1,607	415	116	72	143	684,980
High 49-50	245	700	2,004	4,735	4,316	3,310	1,638	989	472	143	79	77	1,118,590
Drift(Regr)													
Ave. 33-34	12.9	31.3	172.9	144.8	45.3	57.9	50.0	31.3	9.0	4.1	2.5	2.2	34,219
Low 44-45	2.6	16.7	19.7	66.1	95.9	104.6	81.0	69.3	18.7	4.7	2.6	6.0	29,179
High 49-50	10.8	30.8	85.9	174.5	165.9	134.2	72.1	44.5	21.3	6.0	3.0	2.9	44,988
Drift(*.037)													
Ave. 33-34	10.9	25.9	191.3	134.4	37.6	49.0	42.2	25.7	7.7	3.8	2.5	2.3	32,409
Low 44-45	2.6	13.8	16.1	56.1	85.1	93.5	69.5	59.5	15.3	4.3	2.7	5.3	25,344
High 49-50	9.1	25.9	74.1	175.2	159.7	122.5	60.6	36.6	17.4	5.3	2.9	2.9	41,388
Ratio													
Regr/Mult.													

Ave. 33-34	1.18	1.21	0.90	1.08	1.20	1.18	1.18	1.22	1.18	1.08	0.97	0.94	1.06
Low 44-45	0.99	1.21	1.22	1.18	1.13	1.12	1.16	1.17	1.22	1.10	0.99	1.13	1.15
High 49-50	1.19	1.19	1.16	1.00	1.04	1.10	1.19	1.22	1.22	1.14	1.02	1.01	1.09

For comparison purposes, monthly flows for Upper Drift Creek were also calculated during the three representative flow years using a straight multiplier of 0.0307 and tabulated in Table 19. On a monthly basis, the differences between monthly flows calculated by the two procedures are within 1 to 22% range. The annual runoff volume differences vary from 6 to 15%.

An electronic file containing the calculated daily flows of Upper Drift Creek for the three representative flow years has been saved for use in other project-related studies such as water quality simulation currently performed by Portland State University staff.

10.2 Stream Flow Modeling Procedure

The other potential procedure to generate daily flows for those three years is through rainfall and/or snow-based modeling tools. Daily discharge reconstitution for the three representative years using the rainfall-runoff FLO4DRIFT model is part of a daily time-step modeling effort that has not yet been fully pursued due to data constraints and other study priorities. So far and as mentioned in Section 8, calibration of the FLO4DRIFT has been initiated using only three years of data, 2008-09, 2009-10 and 2010-11. More stream flow data are needed to fully support generation of synthesized stream flows beyond those calibration years.

Another impediment is the lack of data on snow-fed runoff data on Drift Creek, as a sizeable portion of the runoff during high flow years in this basin is most probably derived from snow-melt. Snow daily data that are available now through the Portland National Weather Service page: http://www.weather.gov/climate/index.php?wfo=pqr only go back roughly 5 years. If in the future such a reconstitution is deemed necessary, data going back to 1892 from Salem, including daily max/min/average temperature, heating and cooling degree days, precipitation, snowfall and snow depth could be ordered from the Western Regional Climate Center, 2215 Raggio Parkway, Reno, NV 89512 Phone: 775-674-7010 Fax: 775-674-7001 http://www.wrcc.dri.edu

11. Updating of Previous October-April Runoff Volume Frequency

The runoff volume estimates for Drift Creek described in the February 2007 report were only based on drainage area and basin mean annual precipitation, not on actual runoff data which were not available. The first update of the original estimates was made based on the relationships established between actual monthly discharges of the Pudding River near Aurora and those of Drift Creek at the project site using the 2008-2009 stream flow measurements. Those estimates have been gradually updated to reflect the significance of the 2009-10 and 2010-11 stream flow measurements.

The procedure includes the steps listed below and is further illustrated by numbers shown in Table 20:

- Compiling existing historical October-April runoff volumes for Pudding River near Aurora over the entire 1928-2011 period of record
- Multiplying the Pudding River data by a factor of 0.037 (see Table 18) to produce the corresponding October-April runoff volumes for Drift Creek at the project site. The previous multiplier used in Report Update #1 was 0.0362. It was changed to 0.038 in the Report Update #2.
- Performing the statistical frequency analysis to produce an updated frequency curve for the October-April runoff volume. Calculations were made according to the procedure outlined in the U.S. Army Corps of Engineers manual, "Statistical Methods in Hydrology" by L. Beard (1962).

The accuracy of the frequency curve relies heavily on the single multiplier used to convert the October-April runoff volumes from the Pudding River near Aurora to Drift Creek at the project site. That multiplier is only based on three years of observed data, and will need to be updated as more data are collected. Multipliers that vary with the runoff and precipitation conditions and thus change from year to year would be more appropriate. In that sense, data permitting, the use of a precipitation-runoff model would an improvement.

Table 20. Details of Statistical Volume Frequency Calculation

N	Hydro Yr	Pudding	Drift	X=Log	X^2	x=	x^2
		Oct-Apr	Oct-Apr	(Vol)		Dev X-M	
		Vol (aft)	Vol (aft)				
			0.037				
1	1928-29	470,330	17,402	4.24060	17.98273	-0.20437	0.04177
2	1029-30	506,791	18,751	4.27303	18.25879	-0.17194	0.02956
3	1930-31	498,485	18,444	4.26585	18.19751	-0.17912	0.03208
4	1931-32	904,509	33,467	4.52461	20.47214	0.07964	0.00634
5	1932-33	840,124	31,085	4.49255	20.18296	0.04757	0.00226
6	1933-34	798,321	29,538	4.47038	19.98429	0.02541	0.00065
7	1934-35	778,303	28,797	4.45935	19.88581	0.01438	0.00021
8	1935-36	585,279	21,655	4.33556	18.79712	-0.10941	0.01197
9	1936-37	616,209	22,800	4.35793	18.99155	-0.08704	0.00758
10	1937-38	1,122,245	41,523	4.61829	21.32860	0.17332	0.03004
11	1938-39	539,529	19,963	4.30022	18.49186	-0.14476	0.02095
12	1939-40	648,682	24,001	4.38023	19.18645	-0.06474	0.00419
13	1940-41	419,148	15,508	4.19057	17.56087	-0.25440	0.06472
14	1941-42	613,602	22,703	4.35609	18.97551	-0.08888	0.00790
15	1942-43	1,147,435	42,455	4.62793	21.41773	0.18296	0.03347
16	1943-44	451,846	16,718	4.22319	17.83535	-0.22178	0.04919

17	1944-45	550,657	20,374	4.30908	18.56820	-0.13589	0.01847
18	1945-46	894,637	33,102	4.51985	20.42903	0.07488	0.00561
19	1946-47	734,364	27,171	4.43411	19.66136	-0.01086	0.00012
20	1947-48	957,349	35,422	4.54927	20.69588	0.10430	0.01088
21	1948-49	909,843	33,664	4.52717	20.49525	0.08220	0.00676
22	1949-50	1,008,572	37,317	4.57191	20.90235	0.12694	0.01611
23	1950-51	1,237,781	45,798	4.66085	21.72348	0.21587	0.04660
24	1951-52	862,064	31,896	4.50374	20.28369	0.05877	0.00345
25	1952-53	811,270	30,017	4.47737	20.04682	0.03239	0.00105
26	1953-54	1,025,958	37,960	4.57933	20.97028	0.13436	0.01805
27	1954-55	674,511	24,957	4.39719	19.33529	-0.04778	0.00228
28	1955-56	1,353,423	50,077	4.69964	22.08657	0.25466	0.06485
29	1956-57	648,236	23,985	4.37993	19.18383	-0.06504	0.00423
30	1957-58	851,445	31,503	4.49836	20.23523	0.05339	0.00285
31	1958-59	834,219	30,866	4.48948	20.15545	0.04451	0.00198
32	1959-60	637,122	23,574	4.37242	19.11809	-0.07255	0.00526
33	1960-61	1,056,599	39,094	4.59211	21.08749	0.14714	0.02165
34	1961-62	660,499	24,438	4.38807	19.25519	-0.05690	0.00324
35	1962-63	780,119	28,864	4.46036	19.89483	0.01539	0.00024
36	1963-64	743,346	27,504	4.43939	19.70821	-0.00558	0.00003
37	1993-94	473,466	17,518	4.24349	18.00721	-0.20148	0.04060
38	1994-95	890,685	32,955	4.51793	20.41165	0.07295	0.00532
39	1995-96	1,288,619	47,679	4.67833	21.88674	0.23335	0.05445
40	1996-97	1,373,397	50,816	4.70600	22.14642	0.26102	0.06813
41	2002-03	759,339	28,096	4.44864	19.79037	0.00366	0.00001
42	2003-04	685,310	25,356	4.40409	19.39600	-0.04088	0.00167
43	2004-05	381,407	14,112	4.14959	17.21910	-0.29538	0.08725
44	2005-06	1,000,928	37,034	4.56860	20.87215	0.12363	0.01528
45	2006-07	908,008	33,596	4.52629	20.48731	0.08132	0.00661
46	2007-08	831,396	30,762	4.48801	20.14223	0.04304	0.00185
47	2008-09	532,336	19,696	4.29439	18.44176	-0.15059	0.02268
48	2009-10	638,547	23,626	4.37339	19.12658	-0.07158	0.00512
49	2010-11	758,905	27,472	4.43889	19.70375	-0.00608	0.00004
				X	X^2	x=	x^2
			N=	49			
			S(X)=	217.80367		-1.42E-14	0.88562
Log(V)=M+k*S		Mean=	**4.44497**				
			S(X^2)=		969.017	S^2=	0.01845
			[S(X)^2]/N		968.1314	S=	**0.135832**
			S(x^2)=		0.88562		

Pn	0.25	1	10	50	90	99	99.75
k (N=49)	2.97	2.43	1.325	0	-1.325	-2.43	-2.97
Log(V)=	4.84840	4.77505	4.62495	4.44497	4.26499	4.11490	4.04155
Vol, aft	70,532	59,571	42,164	27,858	18,407	13,028	11,003

All three statistical October-April runoff volume estimates made so far are listed in Table 21 for the same frequencies of occurrence. Those estimates include

1) Estimates made in 2007, based on **78** years of observed and **synthesized** Pudding River runoff between 1928 and **2005**),
2) Estimates made in 2010 (based on **47** years of observed Pudding River runoff between 1928 and **2009,** and using a 0.0362 flow conversion multiplier),
3) Estimates made in **2011** (based on **48** years of Pudding River data between 1928 and 2010, and using a 0.038 flow conversion multiplier), and
4) Estimates made in 2012 (based on **49** years of Pudding River data between 1928 and 2011, and using a 0.037 flow conversion multiplier).

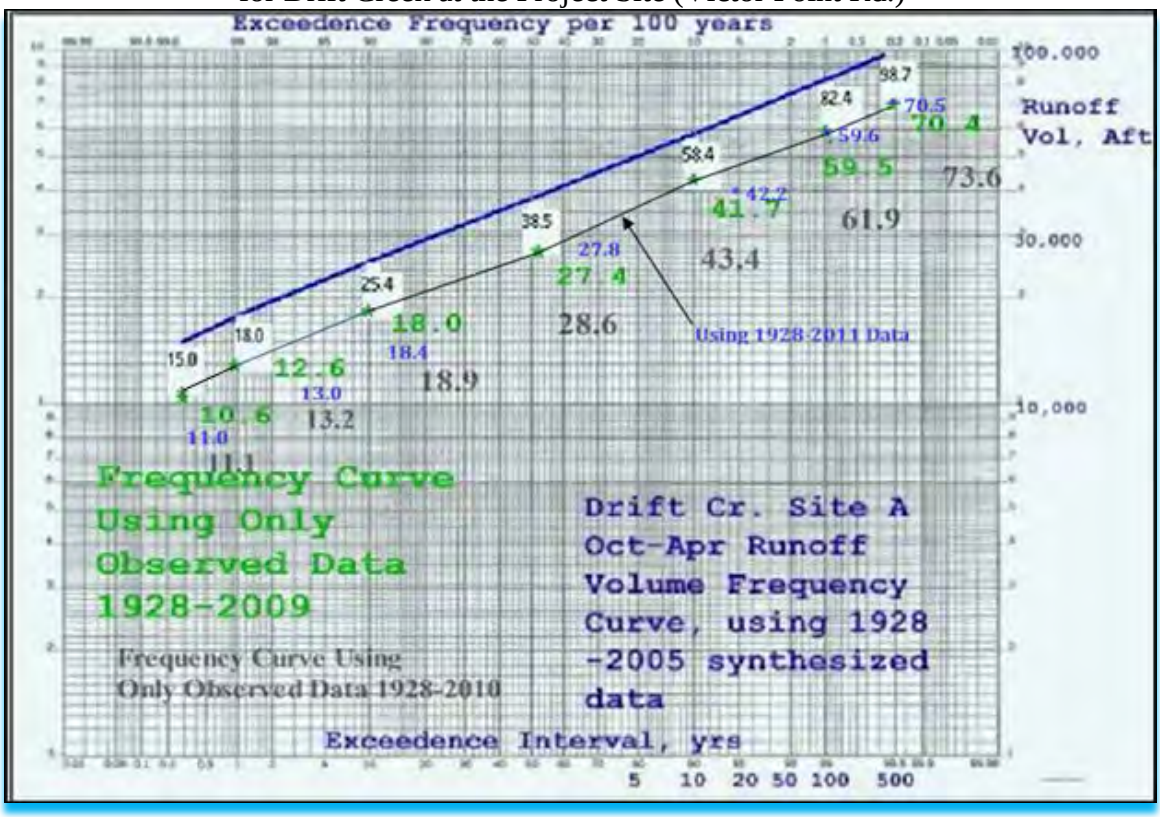
There are some slight volume changes between the various October-April runoff volume estimates made over the past four years. They all look reasonably favorable with respect to the 12,000 acre-foot storage volume target used for the project. They also match OWRD water surface availability data covered in Section 12.

Table 21. Statistical October-April Runoff Volume Estimates for Drift Cr. @ Victor Point, using 49 years of Pudding River Observed Flows

Pn	0.25	1	10	50	90	99	99.75
Years	400	100	10	2	1.11	1.01	1.0025
Vol (date:2012)	70,532	59,571	42,164	27,858	18,407	13,028	11,003
Vol (date:2011)	73,617	61,887	43,377	28,628	18,894	13,243	11,133
Vol (date:2010)	70,468	59,521	41,661	27,360	17,968	12,576	10,622
Vol (date:2007)	98,736	82,429	58,384	38,522	25,417	18,002	15,029

The updated October-April runoff volume frequency curves for Drift Creek at the project site based on the 2008-09, 2009-10 and 2010-11 stream flow gauging are shown in Figure 19. Note that the2008-2009 hydrologic year was a dry water year, the 2009-10 hydrologic year was close to an average year, and the 2010-11 hydrologic year was a relatively high flow year ranked among the top 10 in the 1928-2011 period of record for the Pudding River and presumably for all of its tributaries, including Drift Creek.

Figure 19. Current and Previous October-April Runoff Volume Frequency Curves for Drift Creek at the Project Site (Victor Point Rd.)



For the record and to be fully consistent with the 2007 results, a statistical frequency analysis was also performed using flows for Pudding River near Aurora flows covering the entire 83 years between 1928 and 2011, including 49 years of observed flows and 34 more years of synthesized flows using rainfall and snow data at Salem. A 0.037 multiplier (instead of 0.0362 used in 2010 and 0.038 used in 2011) was used to convert Pudding River flows into Drift Creek flows. The results are summarized in Table 22, along with (1) previously estimated runoff volumes using 82 years of combined observed and synthesized data, and (2) estimated runoff volume using 49 years of actually observed data. Details of the calculation under this procedure are listed in the Appendix.

Table 22. Statistical October-April Runoff Volume Estimates for Drift Cr. @ Victor Point, using 83Years of Pudding River Observed and Synthesized Data (1928-2011)

Pn	0.25	1	10	50	90	99	99.75
k (N=83)	2.897	2.385	1.298	0.000	-1.298	-2.385	-2.897
Log(V)=	4.82535	4.75322	4.59984	4.41685	4.23385	4.08047	4.00834
Vol, aft	66,887	56,651	39,795	26,111	17,133	12,035	10,193
(1) Vol. k(N=82)	71,196	60,061	41,914	27,398	17,909	12,498	10,543
(2) Vol (date:2012)	70,532	59,571	42,164	27,858	18,407	13,028	11,003

12. Water Availability

OWRD makes water availability data for Drift Creek at its confluence with the Pudding River for the 50% and 80% exceedence levels at the following address: http://apps.wrd.state.or.us/apps/wars/wars_display_wa_tables/display_wa_details.aspx?ws_id=70781&exlevel=80&scenario_id=1

Originally, the drainage area used for that site was shown as being 17.91 sq. mi., which is different from the 25.1 sq. mi. area calculated by Harvest Geographics, Inc. for the same location and lower than the 24.8 sq. mi. area used by Marion Water and Conservation Service District for a Drift Creek stream gauging site near Silverton and upstream from the mouth of Drift Creek. Following contacts by members of the project team, OWRD recognized that Drift Creek watershed was incorrectly delineated and subsequently modified their results in early April 2010. The revised drainage area is now 25.25 sq. mi. and previous in-stream flow requirements remain unchanged. OWRD also reports a mean annual precipitation over Drift Creek watershed of 61.61 inches.

The revised water availability data provided by WRD on May 22, 2012 are listed in Table 23 for the 50% and 80% exceedence levels. Compared to the previous data, very slight updates of consumptive uses numbers were made by WRD, all of which have been incorporated in Table 23.

Table 23. Revised Water Availability Data for Drift Creek at Its Mouth, in cfs

a) 50% Exceedence

DRIFT CR > PUDDING R - AT MOUTH
Water Availability Calculation
Monthly Streamflows in Cubic Feet per Second
Storage at 50% Exceedence in Acre-Feet

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	149.00	2.28	147.00	0.00	40.00	107.00
FEB	133.00	2.03	131.00	0.00	40.00	91.00
MAR	108.00	0.03	108.00	0.00	40.00	68.00
APR	68.10	0.04	68.10	0.00	40.00	28.10
MAY	32.70	0.22	32.50	0.00	30.10	2.38
JUN	41.90	0.44	41.50	0.00	13.60	27.90
JUL	18.30	0.77	17.50	0.00	3.00	14.50
AUG	8.40	0.61	7.79	0.00	2.00	5.79
SEP	4.65	0.30	4.35	0.00	2.00	2.35
OCT	7.56	0.02	7.54	0.00	5.26	2.28
NOV	61.10	0.93	60.20	0.00	40.00	20.20
DEC	138.00	2.11	136.00	0.00	40.00	95.90
ANN (50%)	46,300.00	586.00	45,700.00	0.00	17,800.00	27,900.00

Average 50% Ann. Q= 63.9 cfs

b) 80% Exceedence

DRIFT CR > PUDDING R - AT MOUTH

WILLAMETTE BASIN

Water Availability as of 5/22/2012

Watershed ID #:70781

Exceedence Level: 80%

Water Availability Calculation

Monthly Streamflows in Cubic Feet per Second

Storage at 50% Exceedence in Acre-Feet

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	67.30	2.28	65.00	0.00	40.00	25.00
FEB	74.90	2.03	72.90	0.00	40.00	32.90
MAR	66.80	0.03	66.80	0.00	40.00	26.80
APR	48.80	0.04	48.80	0.00	40.00	8.76
MAY	24.20	0.22	24.00	0.00	30.10	-6.12
JUN	11.50	0.44	11.10	0.00	13.60	-2.54
JUL	5.51	0.77	4.74	0.00	3.00	1.74
AUG	3.34	0.61	2.73	0.00	2.00	0.73
SEP	3.09	0.30	2.79	0.00	2.00	0.79
OCT	4.27	0.02	4.25	0.00	5.26	-1.01
NOV	23.70	0.93	22.80	0.00	40.00	-17.20
DEC	65.80	2.11	63.70	0.00	40.00	23.70
ANN(50%)	46,300.00	586.00	45,700.00	0.00	17,800.00	27,900.00

Average 80% Ann. Q= 30.0 cfs

It should be noted that the 50% exceedence flows should be about the same as the long term average flows. Likewise, the 80% exceedence flows should be in the same range as the 2008-09 flows. The following paragraphs document the extent to which the numbers actually fit (or do not fit) with that expectation.

For the 50% exceedence, the OWRD-calculated natural stream flow volume is 39,817 aft for the October-April runoff volume of Drift Creek at its mouth which controls a 25.25 sq. mi. drainage area. As it turned out, the actually observed runoff volume for Drift Creek at the lower gauging station (24.8 sq. mi. drainage area) for October 2009-April 2011 (a slightly below average water year) was 35,699 aft. After drainage area adjustment, the observed runoff volume for Drift Creek at its mouth would be 35,699*(25.25/24.8) = 36,347 aft. As calculated, the two numbers are off by less than 9%, part of which could be attributed to higher rainfall distribution in the lower part of the watershed.

For the 80% exceedence flows, the OWRD-calculated natural stream flow volume for Drift Creek at its mouth is only 18,100 aft. This is considerably lower than the 27,847 aft runoff volume observed at Hibbard Road during the October 2008- April 2009 period, a water year that can classified as a low flow year at the 80% or even a lower exceedence level. This could either indicate that the OWRD data for the 80% exceedence level is underestimated or that the 2008-09 flow year should have been ranked higher compared to other historical years. Obviously, this cannot be reliably determined with just three years of actual stream flow data.

With specific reference to the critical 12,000 aft runoff volume targeted for storage at the proposed project (DA=15.4 sq. mi.) during October through April, it should be noted that the OWRD "net water available" for that period for Drift Creek at its mouth (DA=25.25 sq. mi.) is 24,698 aft for the 50% exceedence level, and only 5,880 aft for the 80% exceedence level. Assuming that both natural stream flows and in-stream flow requirements are directly proportional to the respective watershed drainage areas, the OWRD-based October-April net water volume available for storage at the project site would be only 24,698*15.4/25.25=15,064 aft at the 50% exceedence level, and 5,880*15.4/25.25=3,600 aft at the 80% exceedence level. Actual numbers may be higher due to lower project release requirements.

Because of the data limitation, there is a critical need for the project team to continue to work closely with OWRD staff and ensure that the best available data is being shared and used to firm up the natural runoff estimates.

13. Ecological and Channel Maintenance Flows

A report was completed in March 2010 by Ellis Ecological Services, Inc. to "address the need for the proposed dam to provide trigger flows for upstream fish migration and flushing flows to move coarse bed streams and enhance habitat conditions below the dam".

Ecological Flows

The Ellis report concluded that "Oregon Department of Fish and Wildlife's in-stream flow water right, which increases incrementally from about 3 cfs in September to 40 cfs by mid-November, should be adequate to trigger upstream migration and provide sufficient water depths for migration through the reach. No other trigger flow requirements were identified in the analyses." Even if some habitat enhancement downstream of the dam site is undertaken, and assuming that spawning and rearing habitat was improved in this reach, more than sufficient flow should be available through ODFW's in-stream flow water to allow access to such habitat improvements.

Flushing Flow Analysis

The Ellis report also indicated that "flushing flows needed to move coarse bed streams are usually provided by a 2-3 year flood event", and estimated that the 2-year flood event would be approximately 630 cfs. Therefore, the project will be required to "bypass all flows greater than 630 cfs".

Based on the above, the dam would have to pass all flows up to ODFW's in-stream flow water right and all flows above the 2-year flood peak of 630 cfs.

14. Reservoir Modeling

There is a need to test how the proposed reservoir would best operate under various inflow conditions to meet all the flow requirements mentioned above and still be able to store enough water for irrigation purposes. Because the project would basically operate alone, for a single purpose, and in a not-too-complicated small watershed (see Figure 20), a simple reservoir regulation model, coded name RES4DRIFT, was developed using the Quick-Basic programming language.

RES4DRIFT uses the reservoir storage information prepared by Stuntzner Engineering, including storage elevation, volume, and surface area. See Table 24 and Figures 21.1 through 21.4. Release capability numbers were provided by Murray-Smith & Associates for the outlets (see Figure 21.3), and by PSU for the 50-foot long broad-crest spillway weir (with crest located at Elevation 667 feet msl).

Table 24. Drift Creek Reservoir Storage and Area

Stage (ft, msl)	Dam Height (ft)	Storage (aft)	Outlet Cap., cfs	Spillway Cap., cfs	Total Outlet, cfs
616	0	0	0.0	0	0
620	4	8	0.0	0	0
621	5	49	92.1	0	92
622	6	89	106.4	0	106
623	7	129	118.9	0	119
624	8	170	130.3	0	130
625	9	210	140.7	0	141
626	10	251	150.4	0	150
627	11	291	159.6	0	160
628	12	332	168.2	0	168
629	13	372	176.4	0	176
630	14	413	184.2	0	184
631	15	512	191.8	0	192
632	16	611	199.0	0	199
633	17	710	206.0	0	206

634	18	810	212.7	0	213
635	19	962	219.3	0	219
636	20	1,115	225.7	0	226
637	21	1,268	231.8	0	232
638	22	1,420	237.9	0	238
639	23	1,573	243.7	0	244
640	24	1,726	386.0	0	386
641	25	1,946	394.6	0	395
642	26	2,167	403.1	0	403
643	27	2,388	411.4	0	411
644	28	2,608	419.6	0	420
645	29	2,829	427.6	0	428
646	30	3,050	435.4	0	435
647	31	3,271	443.1	0	443
648	32	3,491	450.7	0	451
649	33	3,712	458.1	0	458
650	34	3,933	465.5	0	465
651	35	4,212	472.7	0	473
652	36	4,490	479.8	0	480
653	37	4,769	486.8	0	487
654	38	5,048	493.7	0	494
655	39	5,327	500.5	0	501
656	40	5,606	507.2	0	507
657	41	5,885	513.9	0	514
658	42	6,164	520.4	0	520
659	43	6,443	526.9	0	527
660	44	6,722	533.3	0	533
661	45	7,035	539.6	0	540
662	46	7,349	545.8	0	546
663	47	7,662	552.0	0	552
664	48	7,976	558.1	0	558
665	49	8,289	564.1	0	564
666	50	8,603	570.1	0	570
667	51	8,917	576.0	0	576
668	52	9,230	581.9	901	1,482
669	53	9,544	587.6	2,547	3,135
670	54	9,857	593.4	4,679	5,273
671	55	10,198	599.1	7,204	7,803
672	56	10,538	604.7	10,068	10,673
673	57	10,878	610.2	13,235	13,845
674	58	11,218	615.8	16,678	17,294
675	59	11,558	621.2	20,377	20,998
676	60	11,898	626.7	24,314	24,941

677	61	12,238	632.1	28,477	29,109
678	62	12,579	637.4	32,854	33,491
679	63	12,919	642.7	37,434	38,077
680	64	13,259	647.9	42,210	42,857
		*	*	**	

* Source: MSA
** Source: PSU Q=25.5*H^1.5 (metric)

Figure 21.1. Satellite Contour Map of the Proposed Project Site

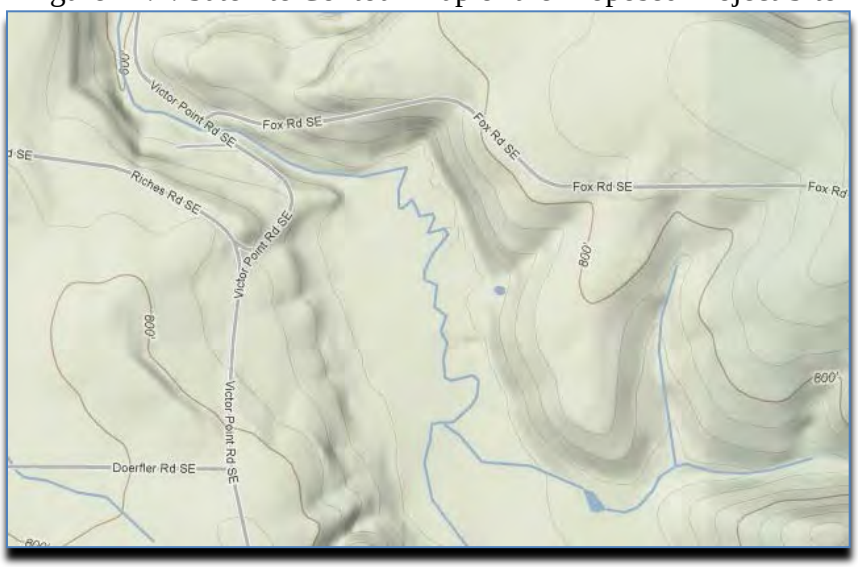


Figure 21.2 Project Dam Height vs. Storage

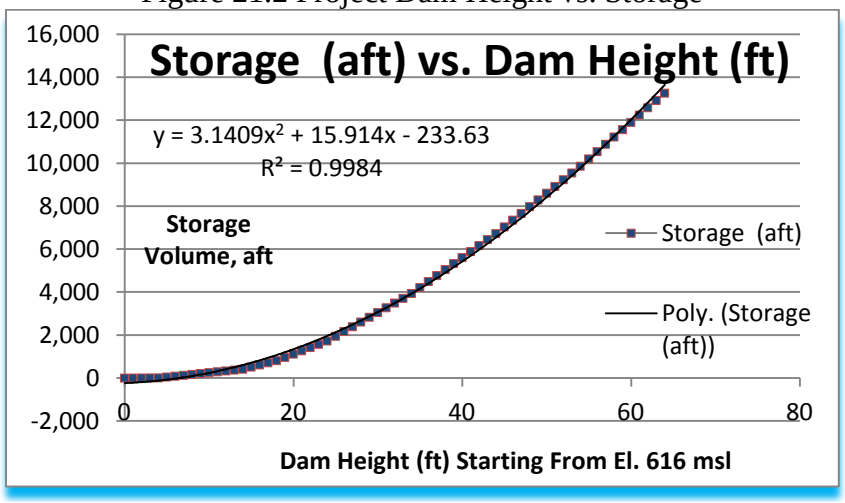


Figure 21.2 Project Area vs. Elevation

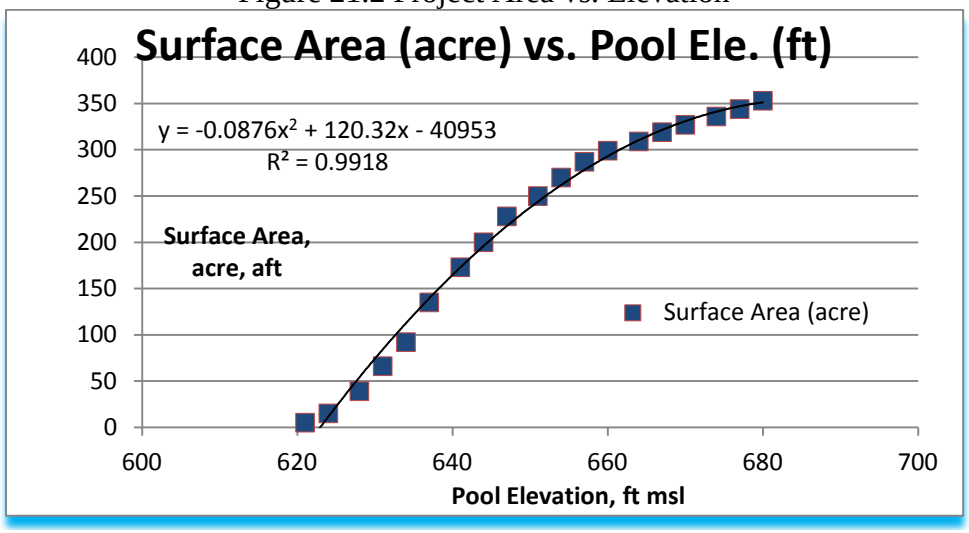


Figure 21.3
Project Outlets Release Capacity (Source: MSA)

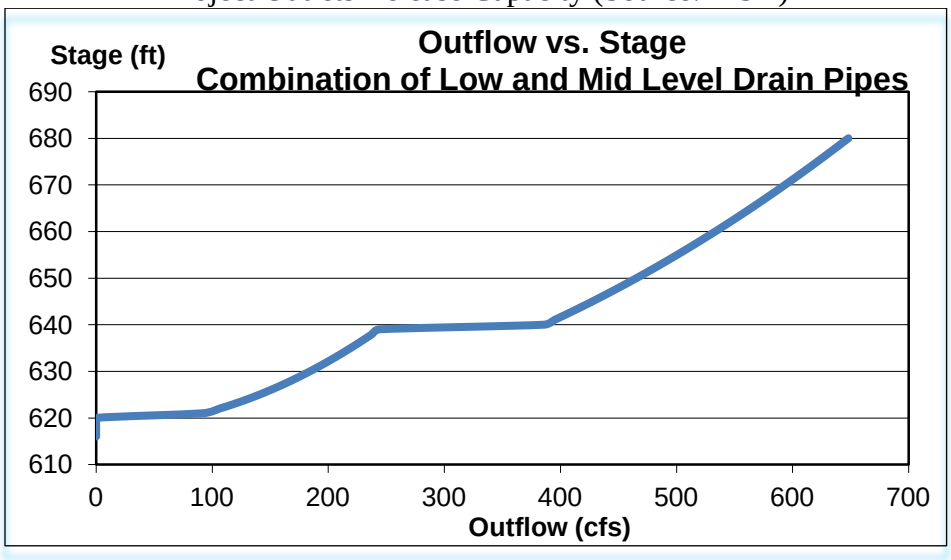
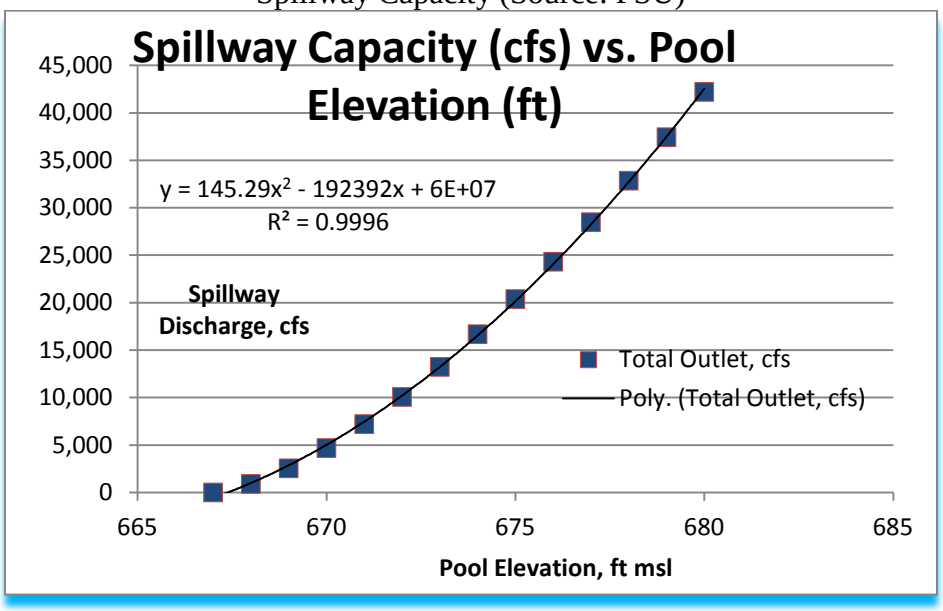


Figure 21.4
Spillway Capacity (Source: PSU)



As quoted in the report, Drift Creek Reservoir model, prepared by PSU Water Quality Research Group in June 2011, "the spillway was … a broad-crested weir. Using the equation for a weir with a well-rounded upstream edge (Streeter and Wylie, 1985): Q=1.67 LH^1.5 where Q was the flow rate (cms), L was the weir width (m) and H was the head". The equation was further reduced to Q(cms)= 22.5 H^1.5, to reflect the 50 foot long spillway width. [Note that the polynomial equation and the R^2 value shown in Figure 21.4 above were automatically provided by MS Excel based on the Outlet Capacity vs. Pool Elevation data. The polynomial equation should yield comparable outlet capacity values as the Q=1.67 LH^1.5 equation].

RES4DRIFT also uses any set of daily inflow data provided by the user. For model testing purpose, flows patterned after the 1957-58 average runoff year were used to simulate the operation. Project releases are subject to flows needed to meet (1) the "Consumptive Uses and Storages", and "Instream Flow Requirement" numbers listed in OWRD Water Availability Calculation table for Drift Creek at the mouth (see Table 24), and (2) the ecological and flushing flow requirements mentioned in the previous section. Project release requirements are summarized in Table 25.

Originally, it was conservatively assumed that the flow requirements at the project site are the same as those specified for Drift Creek at its mouth. In practice, applicable water rights and irrigation flows, among others, would be less at the project site than at the mouth of the creek. A detailed inventory of the sites involved and a good estimate of the local inflow will help determine the right releases to be made -- a task usually accomplished in the more advanced phase of the project feasibility study.

Table 25. Project Release Requirements, in cfs

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Consumptive Use and Storage	2.28	2.03	0.03	0.04	0.22	0.44	0.77	0.61	0.3	0.02	0.93	2.11
Water R.	40	40	40	40	30.1	13.6	3	2	2	5.26	40	40
Total	42.28	42.03	40.03	40.04	30.33	14.04	3.77	2.61	2.30	5.28	40.93	42.11
Flushing*	630	630	630	630	630	630	630	630	630	630	630	630

(*) When inflow exceeds 630 cfs, no storing of water is allowed

Table 26 shows one way to calculate the monthly local inflow between the project site and the mouth of the creek for hydrologic years 2008-09 and 2009-10 respectively. Basically, the local inflow is calculated as the difference between the flow at the mouth (Qmouth) and the flow at the project (Qproj). Qmouth is derived from the flow at the lower (Hibbard Road) station in direct proportion of the drainage area at the mouth (25.25 sq. mi.) and the drainage area at Hibbard Road station (24.8 sq. mi.). Qproj is the flow recorded at the project site (Victor Road).

As confirmed by OWRD staff, the project can rely on that local inflow to meet part of the relevant in-stream water rights (ISWR); the project is also not required to release more than the natural inflow at the project site to meet those water rights. As a result, the water right portions that the project has to meet are lower than the water rights listed for the creek at its mouth.

Table 26. Monthly Water Right Requirements at Project Site, cfs

a) October 2008-2009 Water Year

		Mean Monthly Discharges, 2008-09												AFT
Station	DA	OCT 08	NOV 08	DEC 08	JAN 09	FEB 09	MAR 09	APR 09	MAY 09	JUN 09	JUL 09	AUG 09	SEP 09	annual
Drift/Victor	15.4	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49	22629.8
Drift/Lower	24.8	4.20	28.50	117.20	151.50	51.10	100.50	50.30	55.10	9.00	1.80	0.60	0.90	34602.8
Victor/Lower	0.621	0.435	0.801	0.411	0.672	0.762	0.656	0.790	0.827	0.806	0.753	0.393	0.546	0.654
Drift/mouth	25.25	4.3	29.0	119.3	154.2	52.0	102.3	51.2	56.1	9.2	1.8	0.6	0.9	35230.6
ISWR mouth		5.28	40.92	42.09	42.25	42.01	40.02	40.04	30.23	14.04	3.76	2.61	2.30	18,340
Local Flow	9.9	2.5	6.2	71.1	52.4	13.1	36.4	11.5	10.6	1.9	0.5	0.4	0.4	12,601
ISWR Required		2.8	34.7	-29.0	-10.1	28.9	3.6	28.6	19.7	12.1	3.3	2.2	1.9	8,147
Actual ISWR Release		1.83	22.82	0.00	0.00	28.91	3.60	28.56	19.68	7.25	1.35	0.24	0.49	6,764
Check		4.28	29.02	71.13	52.38	42.01	40.02	40.04	30.23	9.16	1.83	0.61	0.92	19,365
Storageable flows		0.00	0.00	48.19	101.87	10.02	62.30	11.17	25.87	0.00	0.00	0.00	0.5	15,895
Salem Rainfall		0.96	3.59	6.02	3.56	2.90	3.03	1.35	3.03	1.39	0.68	0.18	1.20	27.89
Qmouth/Qproj.	1.640	2.34	1.27	2.48	1.51	1.34	1.55	1.29	1.23	1.26	1.35	2.59	1.87	1.67
Qlocal/Qproj	0.640	1.34	0.27	1.48	0.51	0.34	0.55	0.29	0.23	0.26	0.35	1.59	0.87	0.67

b) October 2009-2010 Water Year

		Mean Monthly Discharges, 2009-10												AFT
Station	DA	OCT09	NOV09	DEC09	JAN10	FEB10	MAR10	APR10	MAY10	JUN10	JUL10	AUG10	SEP10	annual
Drift/Victor	15.4	3.2	50.8	59.7	109.4	47.3	68.8	89.6	47.4	72.7	7.9	1.4	2.7	33,777
Drift/Lower	24.8	5.32	73.87	83.32	149.00	69.93	95.16	116.90	57.00	92.53	7.87	1.59	2.87	45,462
Victor/Lower	0.621	0.594	0.688	0.716	0.734	0.677	0.723	0.767	0.832	0.786	1.003	0.868	0.946	0.743
Drift/mouth	25.25	5.4	75.2	84.8	151.7	71.2	96.9	119.0	58.0	94.2	8.0	1.6	2.9	46,287
ISWR mouth		5.28	40.92	42.09	42.25	42.01	40.02	40.04	30.23	14.04	3.76	2.61	2.30	18,345
Local Flow	9.9	2.3	24.4	25.2	42.3	23.9	28.1	29.4	10.6	21.5	0.1	0.2	0.2	12,508
ISWR Required		3.0	16.6	16.9	-0.1	18.1	11.9	10.6	19.6	-7.5	3.6	2.4	2.1	4,798
Actual ISWR Release		3.02	16.55	16.92	0.00	18.13	11.89	10.64	19.63	0.00	3.64	1.38	2.09	6,221
Check		5.28	40.92	42.09	42.34	42.01	40.02	40.04	30.23	21.51	3.76	1.62	2.30	18,729
Storageable flows		0.14	34.29	42.74	109.37	29.19	56.87	78.98	27.80	72.70	4.26	0.00	2.7	27,671
Salem Rainfall		0.96	3.59	6.02	3.56	2.90	3.03	1.35	3.03	1.39	0.68	0.18	1.20	27.89
Qmouth/Qproj.	1.640	1.71	1.48	1.42	1.39	1.50	1.41	1.33	1.22	1.30	1.01	1.17	1.08	1.34
Qlocal/Qproj	0.640	0.71	0.48	0.42	0.39	0.50	0.41	0.33	0.22	0.30	0.01	0.17	0.08	0.34

Starting from a specified pool elevation, the model currently accepts three modes of operation including (1) releasing daily outflows at pre-defined discharge rates for each month of the year, (2) following a rule curve to reach designated end-of-the month elevations, and (3) releasing water above specified inflow rates. The model automatically controls the project release to prevent the reservoir from going below the project's lower bound or above its upper bound. It also keeps track of the release violations when the project cannot release the required outflow either for lack of available storage or reservoir overflow. See Table 27 and Figure 22.1 and 22.2 (with and without ISWR adjustments) based on the 1957-58 runoff which is about an average year runoff.

Table 27. Sample RES4DRIFT Model Output

SUMMARY RESULTS OF RESERVOIR SIMULATION
Run Date:05-31-2012 20:21:45

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
244	1	6	2009	11.00	679.19	13.60	0.44	3.30	10.74	10.74	13.50	13.50	24.24	0	679.11	12,956
245	2	6	2009	10.00	679.11	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	679.03	12,929
246	3	6	2009	9.80	679.03	13.60	0.44	2.94	11.10	9.80	13.50	13.50	23.30	1	678.95	12,902
247	4	6	2009	10.00	678.95	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	678.87	12,876
248	5	6	2009	13.00	678.87	13.60	0.44	3.90	10.14	10.14	13.50	13.50	23.64	0	678.81	12,854
249	6	6	2009	12.00	678.81	13.60	0.44	3.60	10.44	10.44	13.50	13.50	23.94	0	678.74	12,831
250	7	6	2009	11.00	678.74	13.60	0.44	3.30	10.74	10.74	13.50	13.50	24.24	0	678.66	12,805
251	8	6	2009	10.00	678.66	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	678.59	12,778
252	9	6	2009	9.30	678.59	13.60	0.44	2.79	11.25	9.30	13.50	13.50	22.80	1	678.51	12,751
253	10	6	2009	8.80	678.51	13.60	0.44	2.64	11.40	8.80	13.50	13.50	22.30	1	678.43	12,724
254	11	6	2009	8.70	678.43	13.60	0.44	2.61	11.43	8.70	13.50	13.50	22.20	1	678.35	12,697
255	12	6	2009	8.40	678.35	13.60	0.44	2.52	11.52	8.40	13.50	13.50	21.90	1	678.27	12,671
256	13	6	2009	7.90	678.27	13.60	0.44	2.37	11.67	7.90	13.50	13.50	21.40	1	678.19	12,644
257	14	6	2009	7.50	678.19	13.60	0.44	2.25	11.79	7.50	13.50	13.50	21.00	1	678.11	12,617

QIN=natural inflow; ELE(1) =beginning-of-day storage elevation; ISWR= sum of instream water rights, and storage and irrigation withdrawals; ISWR (instream flow at the creek mouth); CONSU (consumptive use and storage); QLOC= local inflow between project site and the mouth of the creek; REQ=required minimum project release to meet in-stream flow requirements); QREQ (actual release to meet in-stream flow requirements); IRR= required irrigation needs); QIRR (actual release for irrigation); QREL= actual project release; VIOL= violation (0=normal, 1=too small inflow, 2=exceed upper bound, 3=exceed lower bound, 4=pass flow greater than 630 cfs for flushing purposes), 5=exceed outlet capacity; ELE(2(=end-of-day storage elevation, in aft).

Figure 22.1 Project 1957-58 Operation Assuming 100% ISWR

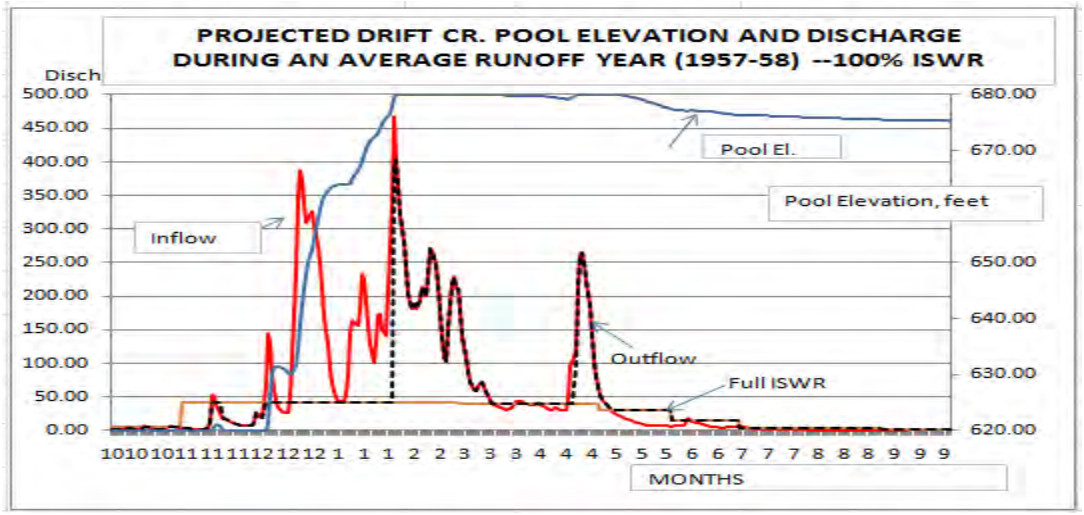
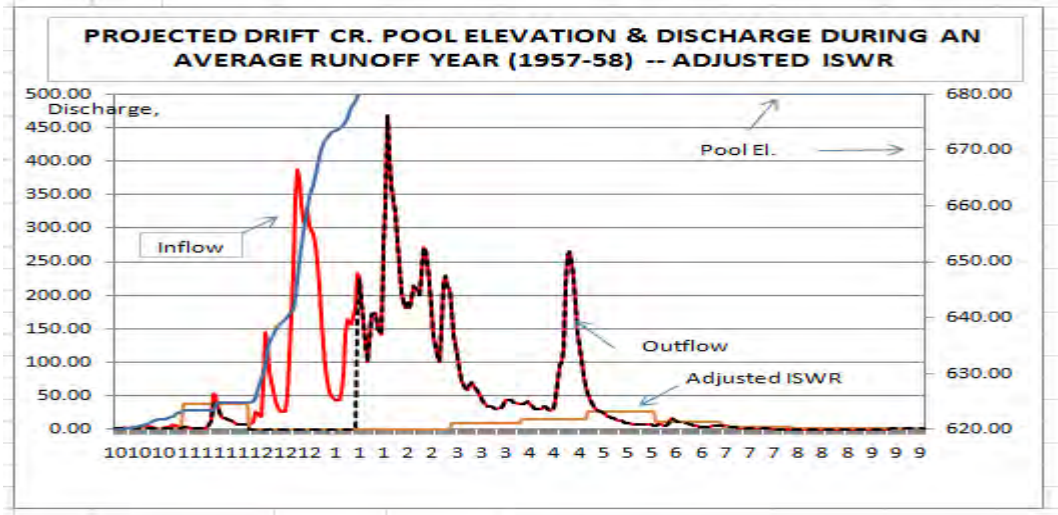


Figure 22.2 Projected 1957-58 Operation Assuming Less than Full ISWR



For comparison purposes, reservoir modeling results for the 2008-09 flows are also graphically provided in Figures 23.1 and 23.2. With the full release requirements in effect, the reservoir would not have been filled under that hydrologic year's flow runoff conditions. However, when relying on the local inflow that occurs between the project site and the mouth of the creek to meet the in-stream water rights at the mouth, the 12,000 acre-foot reservoir would fill.

Figure 23.1 Projected 2008-09 Operations with Full ISWR (and starting from empty)

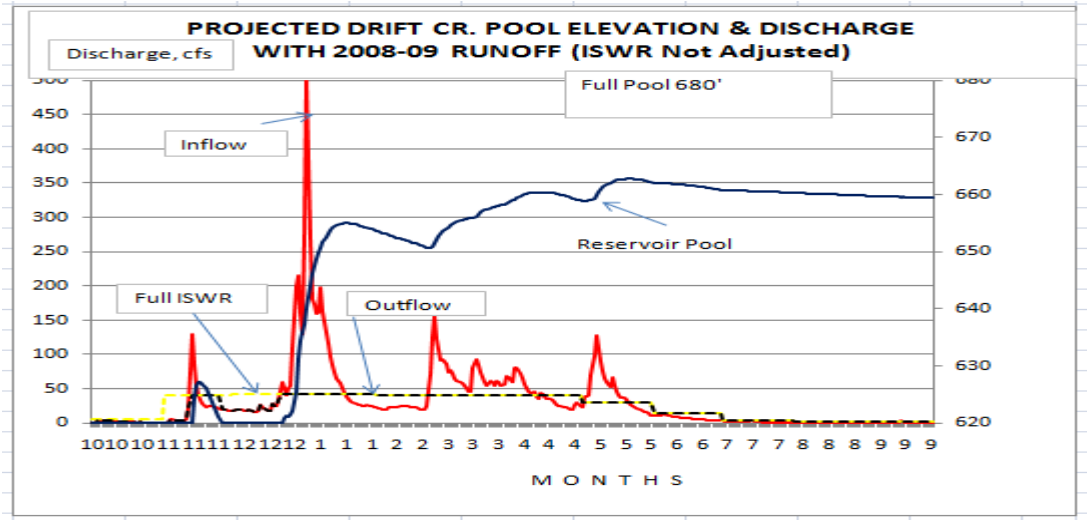
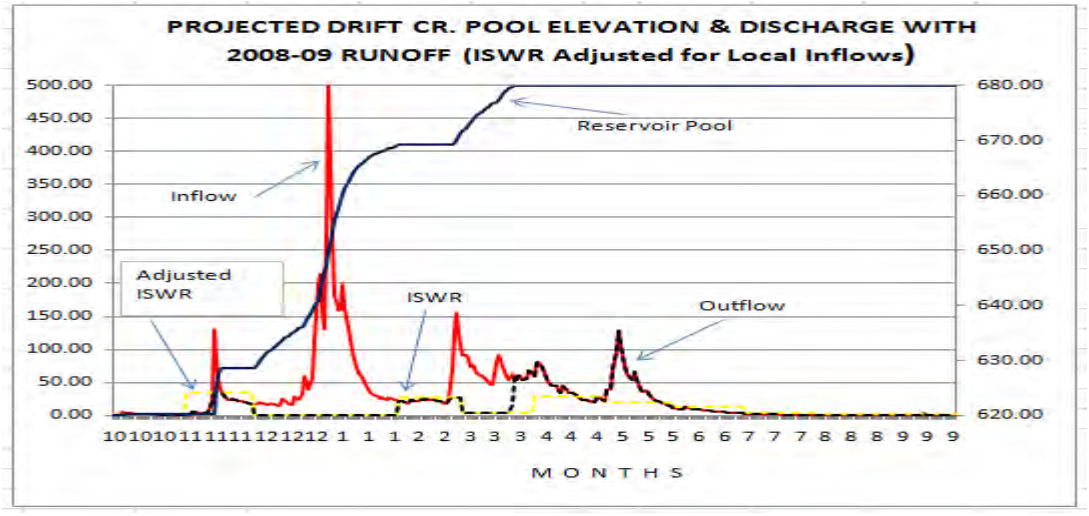


Figure 23.2 Projected 2008-09 Operations with Adjusted ISWR (starting from empty)



Comparable RES4DRIFT results using the 2009-10 stream flows and assuming that the project has to meet a) either the full Adjusted ISWR downstream flow requirements or b) just part of those requirements because of local inflow consideration are plotted in Figures 24.1 and 24.2. The reservoir would be full (at Elevation 680 and with 13,200 aft of storage) in early March if it has to meet only partial ISWR's; but it would only reach elevation 674 ft (11,200 aft) and not be full) by the end of April if it has to meet the full ISWR's.

Those two 2008-09 and 2009-10 test cases apply to the most critical operating scenarios, with the reservoir starting from empty on 1 October. A more realistic scenario with the reservoir starting its refill at a higher elevation is described later.

Figure 24.1. Projected 2009-10 Operations With Full ISWR (and starting empty)

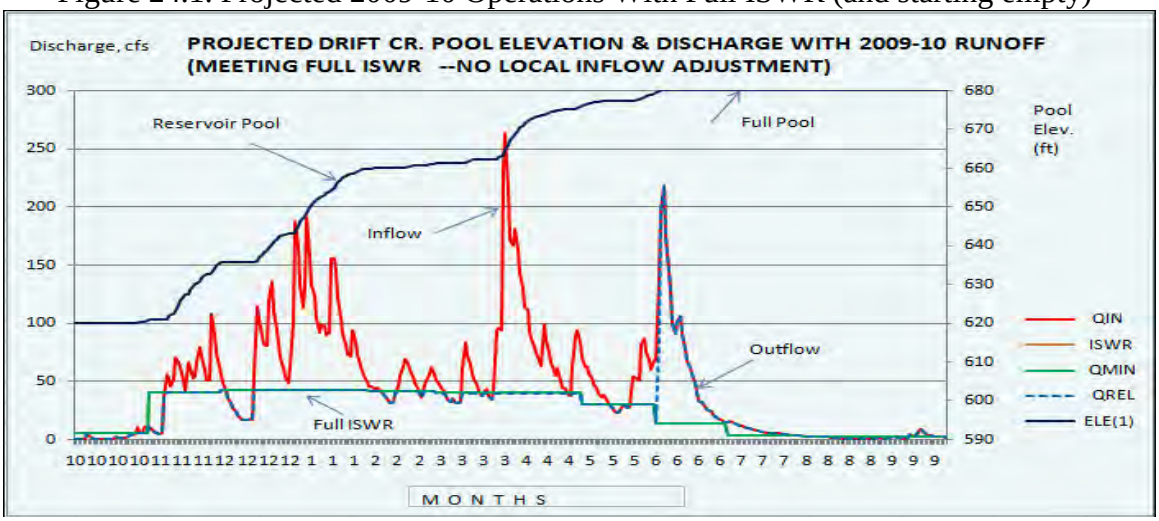
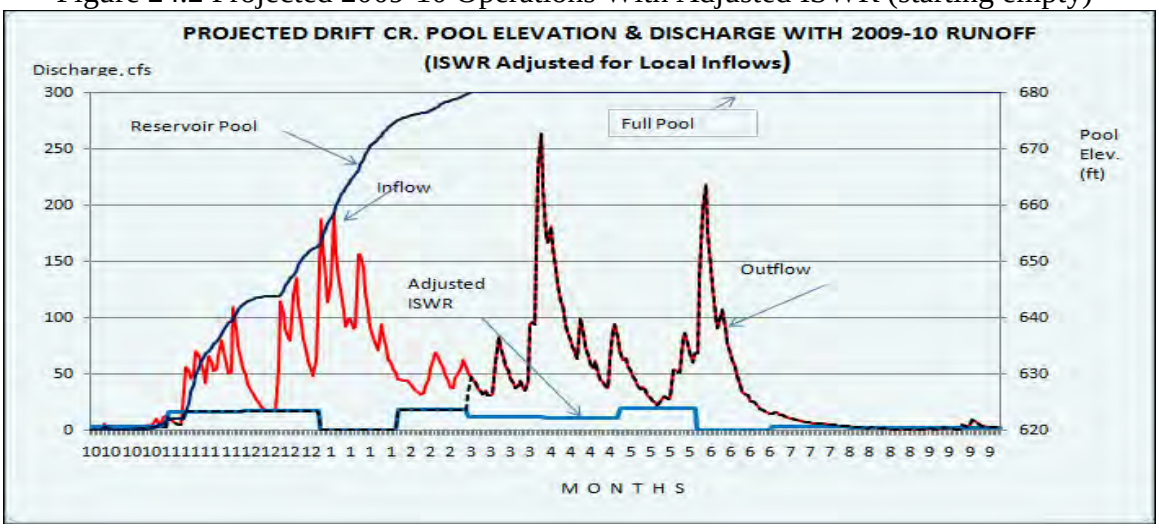


Figure 24.2 Projected 2009-10 Operations With Adjusted ISWR (starting empty)



Obviously, these are only two potential (and rather extreme operating scenarios); many other requirements may still apply that deserve to be looked at later, including the minimum in-stream flow to be maintained for all reaches of the stream, and projected irrigation uses during the May-August reservoir release season.

Assuming that the stored water on April 30 is 8,000 aft, the proposed agricultural release (through the proposed conduit) schedule for those 8,000 aft would be as follows:

10% in May (25.8 AF per day or approximately 13 CFS)
10% in June (26.7 AF per day or approximately 13.5 CFS)
20% in July (51.6 AF per day or approximately 26.0 CFS)
30% in August (77.41 AF per day or approximately 39.0 CFS)
30% in September (80 AF per day or approximately 40.33 CFS)

In a dry year, when the V volume of the water stored in the reservoir on April 30 is less than 8,000 aft, the project release will be proportionately reduced by keeping the same percentage but reducing the base amount from 8,000 aft to V aft. It is also conceivable that under very wet conditions, the reservoir could be full on April 30, with a storage volume of over 13,000 aft. Under that scenario, a different release schedule would be needed to safely and economically operate the project.

More refined data such as outlet capacity, channel capacity, and location of the irrigation withdrawal points, etc. will be needed for a detailed operational simulation. A sample printout for part of the model output is provided in Appendix.

RES4DRIFT model is ready to accept more reliable flow data when it becomes available, along with up-to-date information on proposed irrigation withdrawals after the storage season. It is flexible enough to accommodate any changes in reservoir characteristics and test the feasibility of meeting additional use of the stored water on a daily basis.

15. Multi-Year Continuous Time Step Reservoir Operation Simulation

In May 2012**,** RES4DRIFT was modified to allow for multi-year continuous daily simulation of reservoir operation using the same release criteria as stated above. These criteria include the following:

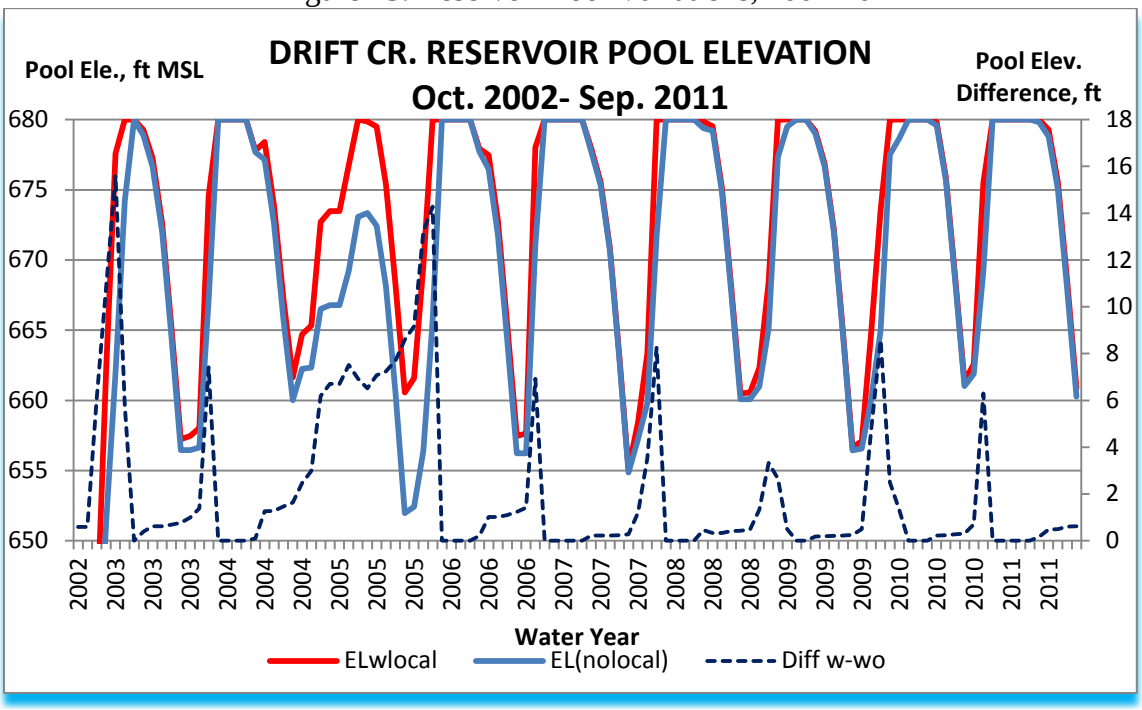
1) Release the lesser of the inflow, the in-stream requirement to meet in-stream flow requirement, and 1 cfs minimum.
2) Provide the option of relying or not relying on the local inflow to meet the in-stream flow requirement at the mouth,
3) Pass inflows greater than 630 cfs for flushing purposes,
4) Limit all reservoir releases to the flow allowed by the hydraulic head for the given pool elevation,
5) Meet the specified monthly irrigation release whenever possible,
6) Keep the reservoir at or below its upper bound elevation of 680 feet m.s.l., and
7) Keep the reservoir at or above its lower bound elevation of 620 feet m.s.l.

Detailed programming instructions are listed in the Appendix.

Daily flow data are also shown in the Appendix. They were entered manually for each day of the 9-year period, from October 1, 2002 through the end of September 2011. The model simulation relies on regression-based daily flows derived from observed daily flow data of Pudding River at Aurora for the October 2002 – September 2008 period, and on actually observed data for Upper Drift Creek for the October 2008 – September 2011 period. October 1, 2002 was the day when stream gauging resumed for the Pudding River at Aurora, after a 5-year inactivity. On this start date, the model assumes the reservoir was empty.

Figure 25 illustrates the variation of the reservoir pool elevation during the October 1, 2002 – September 30, 2011 continuous simulation period. It provides a general idea on the potential storage volume impacts when meeting protected rights at the mouth with and without accounting for local inflow's contribution. In general, the impacts of relying on local inflows to meet the in-stream flow requirements at the mouth of the creek appear to be relatively minor in terms of storage volume reached on 30 April, as the reservoir would fill in all 2002 through 2011 water years except one.

Figure 25. Reservoir Pool Variations, 2002-2011



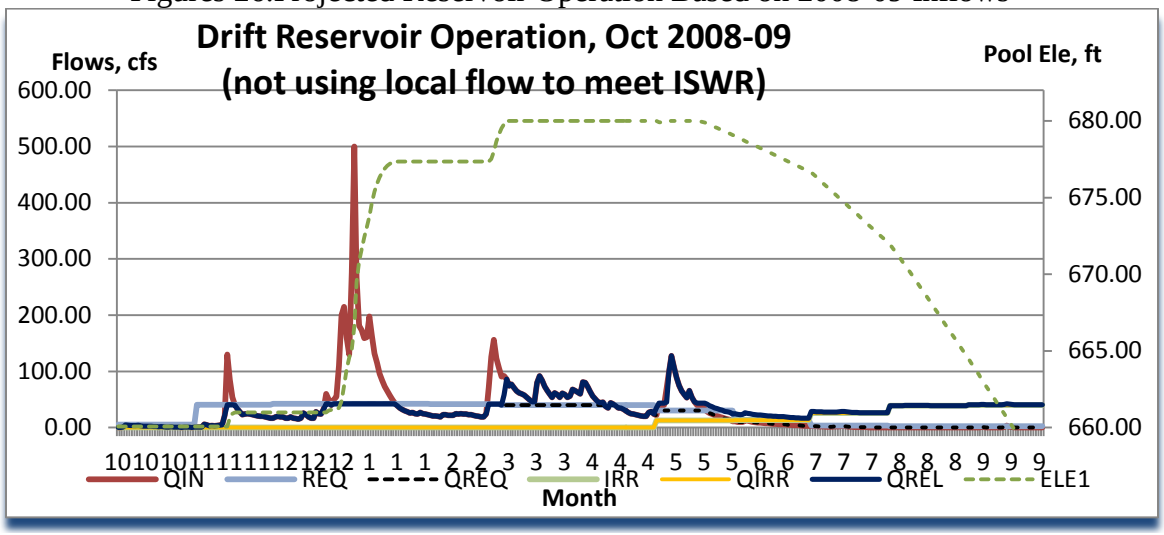
This simulation was mainly designed to test how the project would operate on a continuous basis for a sufficient period of records, using the listed criteria (or within slight variations thereof). The developed model can be used to test the sensitivity of the various criteria on pool variations and reservoir releases.

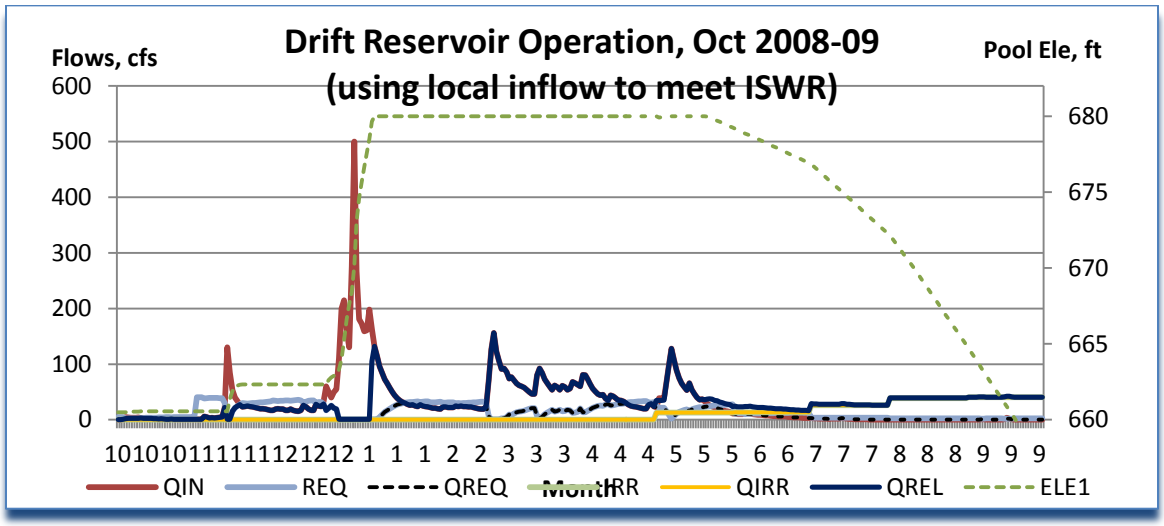
In principle, operational flexibility is a plus. Therefore, not having to meet the full protected rights at the mouth would be advantageous. In practicality, however, that edge really depends on actual runoff situations and can vary from year to year, because (1) regardless of the water rights, we only have to release no more water than what is coming in, and (2) when we reach the top of the reservoir, we have no choice but to release the inflow. To some extent, this is somewhat similar to adopting 1 October as the "official" date for the reservoir refill, while in fact the actual refill is flow and water rights-based -- not a date-based.

More detailed plots are contained in Figures 26 through 28 for the water years 2008-09, 2009-10 and 2010-11 respectively to show the daily variation of the various parameters that dictate the pool variation over those three years. Parameters include the

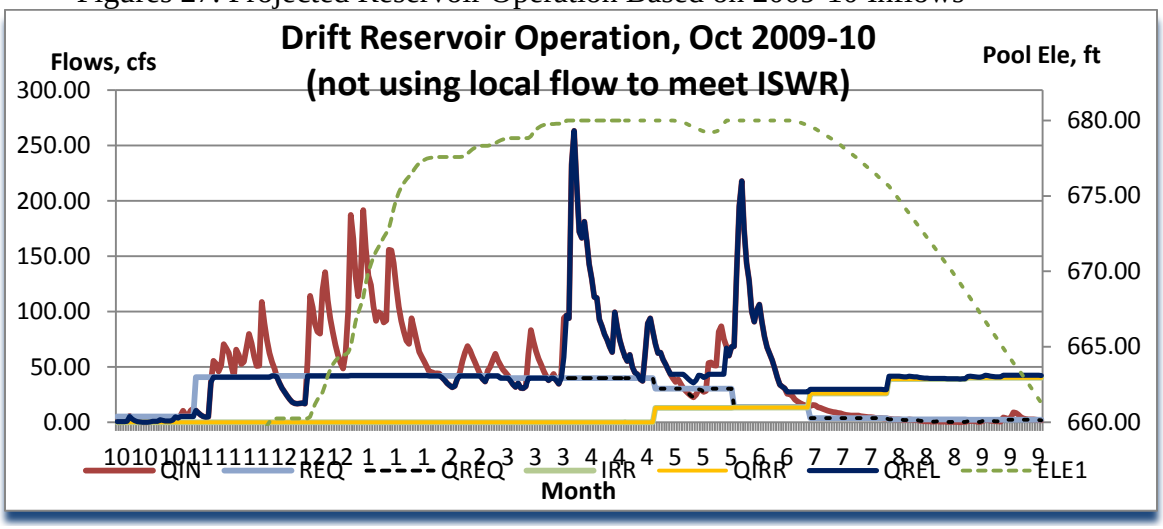
inflow QIN, starting pool elevation ELE1, ins-stream water rights at the creek's mouth ISWR, consumptive use CONSU, theoretical release requirement REQ, actual release requirement QREQ, theorecial irrigation requirement IRR, permissible irrigation requirement QIRR, actual reservoir release QREL, violation code VIOL, end-of-day pool elevation ELE2, and end-of-day reservoir storage STORAGE.

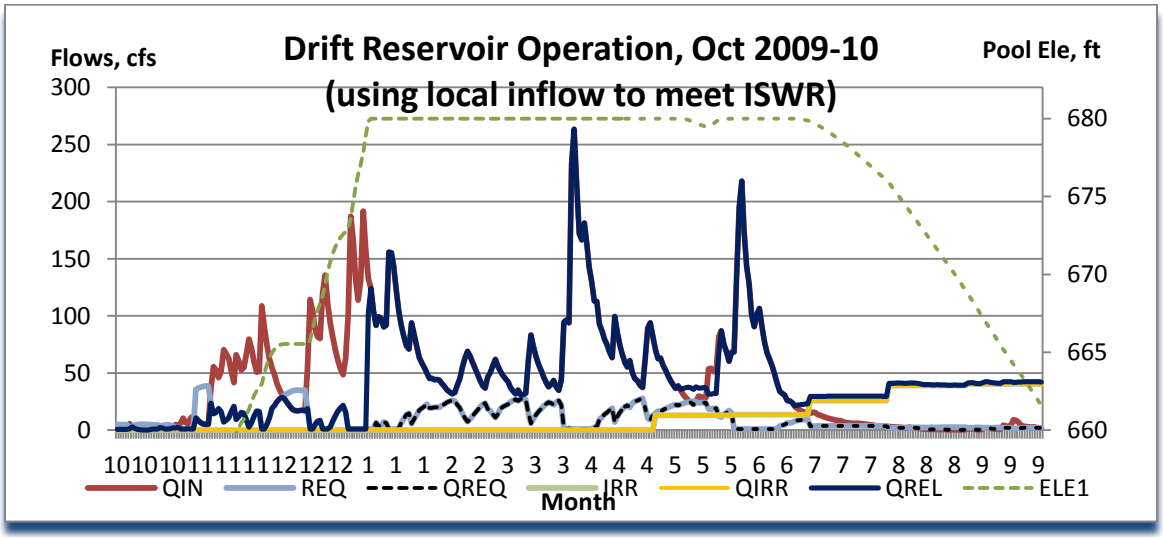
Figures 26.Projected Reservoir Operation Based on 2008-09 Inflows



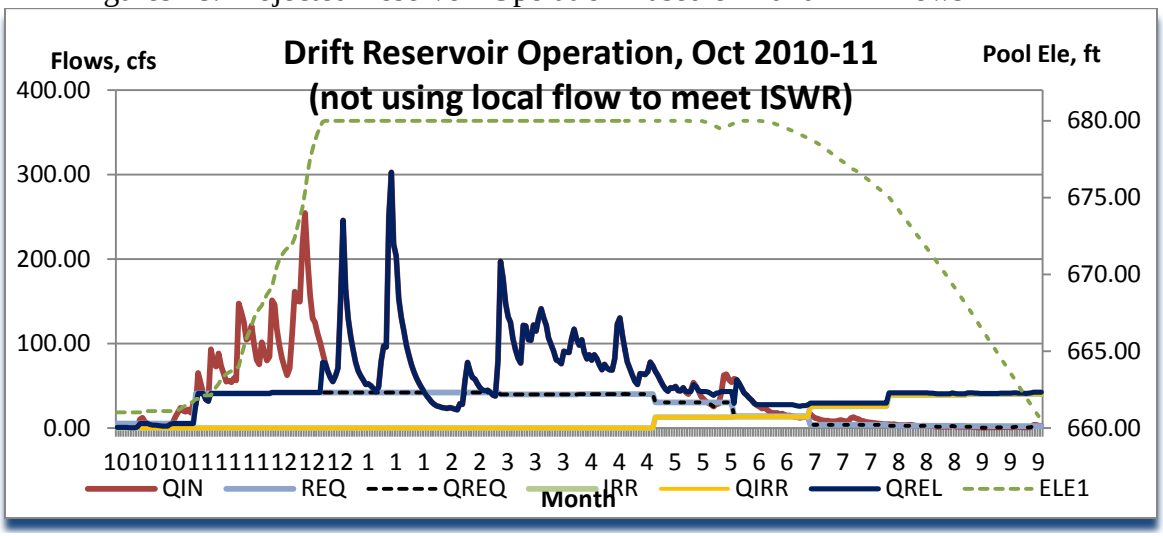


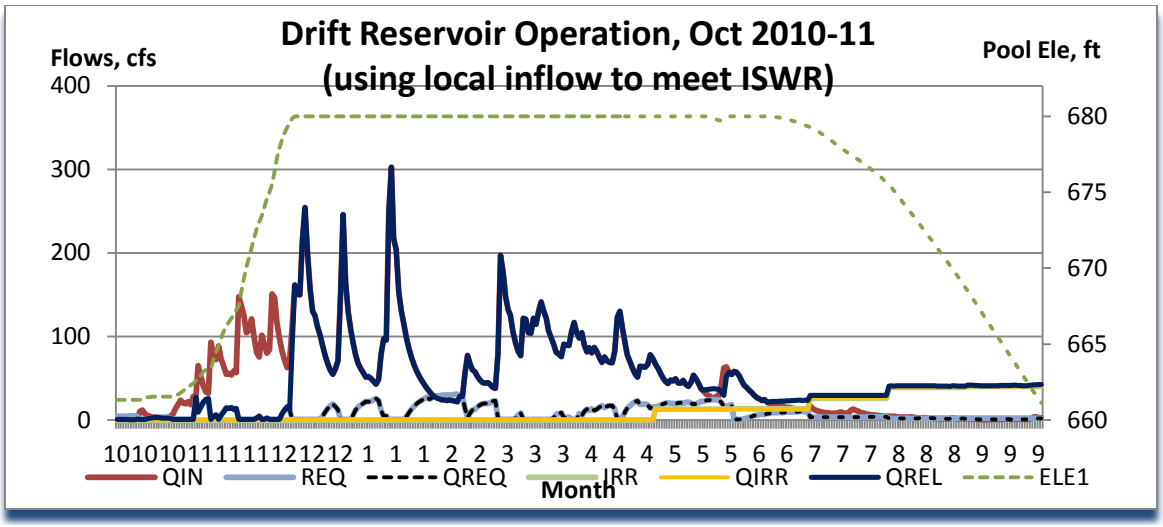
Figures 27. Projected Reservoir Operation Based on 2009-10 Inflows





Figures 28. Projected Reservoir Operation Based on 2010-11 Inflows





More detailed numerical model outputs for the two operating modes –with and without reliance on local inflows to meet in-stream water rights at the mouth—are provided in the Appendix. To save space, only outputs related to 2008-2011 are provided.

Reservoir release violation codes include the following:
0=normal (release unrestricted)
1=too small inflow (release limited by the inflow)
2=exceed upper bound (release made when the reservoir cannot store water)
3=exceed lower bound (release made when the reservoir is empty)
4=pass flow greater than 630 cfs for flushing purposes
5=release limited by outlet capacity

16. Conclusions

This runoff yield report (Update #3) complements the earlier reports prepared in February 2007 (Update #1) and in June 2010 (Update #2) in the light of more recent stream flow data collected for Drift Creek (during October 2010-September 2011). Discharge measurements at the proposed project site on Victor Road and a station further downstream, close to Drift Creek confluence with the Pudding River seem to produce fairly consistent results.

As expected, the challenge continues to be the limited number of real discharge data. So far, only three years of actually observed data stretching from April 2008 to September 2011 are available. 2008-09 was a dry water year; 2009-2010 was a slightly below average year, and 2010-11 was a high water year in the top ten. Those three years cover the lower side and the high side of the expected runoff at the project, but they still leave open questions on the higher side of the runoff with significant snow-melt contribution.

How to extend the stream flow records was the key issue. To address that need, attempts were made to identify reliable statistical correlations between Drift Creek discharges and discharges at other nearby streams. Of the six streams under consideration, Pudding River near Aurora has by far the longest period of records --49 years of observed flows and an additional 34 year period of synthesized flows using rainfall and snow data at Salem. One could either use the Drift Creek versus Pudding River regression equations to generate up to 83 years of flow data for Drift Creek, or develop a rainfall-runoff model to link Drift Creek flows with rainfall and snow data at Salem. It is hard to tell for sure which procedure would lead to the more reliable set of results because of the actual data limitation.

More recent additional data discussed in this report include updated natural water availability, in-stream water rights, ecological and channel maintenance flows. The extent to which OWRD is accounting for the most recent three years of observed stream flow data in developing their natural stream flow for the 50% and 80% exceedence frequencies for Drift Creek at its mouth is still unclear. OWRD data will probably be reviewed in the next few years when more stream flow information becomes available.

Based on the updated water availability information provided by OWRD, the likelihood to see an October-April runoff volume of 12,000 aft available for storage at the project site looks reasonably good for many years. That volume is estimated at 15,000 aft for the 50% exceedence level, and 3,600 aft for the 80% exceedence level under the extreme assumption that the project is meeting 100% of the required in-stream flows listed for Drift Creek at its confluence with the Pudding River. Since the drainage area below the project contributes about 40% of the creek's runoff at the mouth, the actual runoff volume that can be stored is expected to be greater than indicated. Under both the 2008-09 and 2009-10 runoff conditions and assuming that the project starts empty, the project would not have filled under full release requirements but would have filled when relying on the local inflow to meet part of those release requirements. Under the more prolific 2010-11 runoff conditions, the project would have filled even if it starts empty on October 1 and has to release 100 percent of the in-stream flow requirements (when allowed by the actual inflow).

In preparation for more detailed analyses covering a wide range of runoff conditions, both statistical regression and deterministic computer modeling tools have been set up. The statistical procedure was based on 2008-11 data and led to the definition of representative low, average and high flow years.

Two computer models were developed for Drift Creek. The runoff deterministic model is code-named FLO4DRIFT. Once properly calibrated, this runoff model can generate daily flows for any site along Drift Creek based on rainfall (and snow) input. The RES4DRIFT reservoir model, on the other hand, can simulate reservoir operation under various inflow and outflow scenarios on a daily time step. Daily reservoir release criteria closely follow the release requirements currently in effect with regard to meeting consumptive and instream water rights, and pre-planned irrigation releases.

A 9-year continuous time series reservoir simulation was performed for the October 1, 2002 – September 30, 2011 with the reservoir starting empty on October 1, 2002. The inflows to the project for 1 October 2002 through September 30, 2008 were derived through the use of regression equations involving daily flows of the Pudding River at Aurora. Daily inflows for the October 1, 2008 – September 30, 2011 were actually recorded flows at the project site. This simulation indicates that meeting in-stream water rights with and without relying on local inflows may not be that critical to being able to fill the reservoir by April 30 in most years.

There will be a continuing need to work closely with OWRD to ensure that the best available runoff information and pertinent operating criteria are used in more detailed analyses to support the project's feasibility. There will soon be a need to spend significant efforts in other hydrology-related adjacent areas, including dam break analysis and daily operational simulation to support the project's physical and economic feasibility studies.

With specific reference to the last three years of stream flow monitoring at the project site, the most noteworthy observations include the following:

1. The 2009-10 runoff was about 49% greater than the 2008-09 runoff
2. The 2009-10 runoff is estimated to be slightly below an average runoff year
3. The 2010-11 runoff is classified as a high flow year in the top 10 (based on the Pudding River stream flows)
4. There continues to be a strong correlation between the flows (daily and monthly) measured on Drift Creek and many other nearby streams, including the Pudding River
5. Drift Creek stream flows at the project site correlate well with Pudding River data at Aurora, which has the longest period of record of all stations under consideration. Other stations that could be used as strong runoff indices for the project include Silver Creek at Silverton, and Pudding River at Woodburn
6. The current estimates for the October-April runoff volume at the project site generated through statistical frequency analysis and use of regression equations are slightly higher than those estimated before in 2010. Between 2008-09 and 2009-10 the 50% frequency volume went up from 27,400 aft to 28,600 aft (a 4% change).
7. Hydrologic data that would be most useful in the near future are data that relate to high runoff conditions that possibly also include some snow-melt effects.

17. Acknowledgments

Valuable and helpful suggestions, comments, and clarifications were received over the years from the following parties:

- Black Rock Consulting, Bend, OR
- Ellis Ecological Services, Estacada, OR
- Marion Soil and Water Conservation District, Salem, OR
- Murray-Smith & Associates, Inc., Portland, OR
- Oregon Water Resources Department (Hydrographics/Measurement & Reporting)
- Oregon Water Resources Department (Water Rights Program)

- Portland State University Water Quality Research Group
- Water & Energy Resource Services, Clackamas, OR

A P P E N D I X

1. Summary Drainage Areas
2. 2008-2011 Drift Creek Daily Stream Flow at Hibbard Rd by Marion SWCD
3. 2008-11 Daily Flows at Nearby Streams (Pudding River at Aurora and at Woodburn, Zollner Creek, Abiqua, Silver Creek)
4. Monthly Flows of Pudding River at Aurora, 1928-2011
5. Observed Monthly October-April Flows, Pudding River at Aurora
6. Monthly Flows of Other Nearby Streams (Zollner, Pudding/Woodburn)
7. October-April Runoff Volume Statistical Frequency Analysis
8. Computer Modeling (Reservoir and Runoff Model Outputs)

Appendix 1. SUMMARY OF DRAINAGE AREAS

(Source: Marion SWCD)

Lower Abiqua Creek abv. Gallon House Bridge…..	75.7 sq. mi.
Butte Creek @ Monitor (14201500) ……	58.9 sq. mi.
Lower Drift Creek @ Hibbard Rd. ……	24.8 sq. mi.
Upper Drift Creek @ Victor Point Bridge……	15.4 sq. mi.
Upper Pudding River @ Selah Springs Rd. ……	34.5 sq. mi.
Silver Creek @ Silverton, OR (14200300) ……	48.3 sq. mi.

Appendix 2. Drift Cr. Daily Flow Data

Appendix 2.1 2008-09 Daily Flow Data (Finalized 5/4/10)

MARION SOIL AND WATER CONSERVATION DISTRICT

Lower Drift Creek @ Hibbard Rd. Bridge, Silverton, OR

LAT:44 58 36 LONG: 122 49 47 DA 24.8 SQ.MI. CO MARION

DAILY DISCHARGE IN CFS WATER YEAR OCT 2008 TO SEP 2009

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.96	.68	16	400	33	117	80	25	14	3.7	.67	.23
2	.95	.85	21	800	32	122	101	45	13	3.1	.61	.25
3	1.5	2	21	400	31	123	98	50	12	2.7	.46	.21
4	8	7.8	19	340	30	107	89	48	13	2.4	.43	.18
5	7.2	6	18	300	29	112	79	87	18	2.4	.43	.73
6	7.2	4.6	18	270	33	108	71	113	15	2.3	.49	1.6
7	6.5	4.7	17	400	35	97	65	151	14	1.9	.73	1.7
8	6.5	3.8	18	490	33	97	60	131	13	1.7	.79	1.3
9	7.2	4.7	17	325	31	95	56	109	12	1.9	.87	.86
10	6.3	5	15	185	32	92	58	92	11	2	.88	.79
11	5.8	6.2	15	157	37	86	49	80	11	2	.64	.79

12	5.5	31	17	133	35	78	46	71	11	2.6	.82	.71
13	5	150	26	116	34	72	55	65	10	3.9	.86	.47
14	4.2	98	24	101	35	71	54	77	10	3.4	.82	.52
15	3.8	70	20	90	35	115	49	62	9	2.8	.86	.51
16	3.5	54	18	81	34	140	46	52	7.9	2.3	.87	2.2
17	2.4	43	17	72	33	131	44	46	7.8	1.9	.77	2.6
18	2	33	30	65	31	116	42	41	7.6	1.5	.76	1.7
19	1.5	28	27	58	30	104	38	43	7.6	1.4	.54	1.2
20	1.2	28	25	50	28	95	35	40	7.3	1.3	.47	1
21	1.1	29	40	48	28	87	34	35	6.6	1.3	.4	.79
22	1.2	31	70	47	25	94	31	31	6	1.2	.44	.72
23	.86	29	60	42	29	91	30	28	5.4	1.3	.25	.52
24	.68	26	55	40	73	83	27	25	5	1.1	.41	.44
25	.62	24	70	41	137	88	25	23	4.4	.98	.56	.39
26	.58	23	60	38	183	91	24	23	4.4	1	.56	.4
27	.61	21	160	36	153	85	23	23	3.9	.76	.43	.41
28	.62	21	250	39	132	84	30	21	4.1	.52	.27	.54
29	.61	18	300	37		104	34	19	3.6	.17	.44	1.4
30	.64	18	230	35		90	29	17	3.8	.61	.34	1.2
31	.63		190	34		84		15		.65	.49	
Mean	3.1	27.4	60.8	170.0	50.4	98.7	50.1	54.5	9.0	1.8	0.6	0.9

Appendix 2.2

2009-10 Daily Flow Data

Upper Drift Creek @ Victor Rd, OR

DAILY DISCHARGE IN CFS WATER YEAR **OCT 2009 TO SEP 2010**

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.5	0.65	17	275	22	91	60	22	11	3	0.23	0.16
2	0.5	0.7	19	500	21	92	81	39	10	2.7	0.23	0.17
3	1	1	20	267	21	86	80	39	9.8	2.3	0.23	0.19
4	5	6	19	181	20	74	72	40	10	2	0.22	0.19
5	4	5	19	173	19	77	64	70	13	2	0.23	0.49
6	3.8	3.3	17	159	23	71	56	98	12	1.8	0.25	0.9
7	3.5	3.5	17	161	23	65	51	128	11	1.7	0.28	0.85
8	3.5	3	19	198	22	62	46	108	10	1.6	0.35	0.4
9	4	3.5	17	163	22	60	44	89	9.3	1.7	0.42	0.29
10	3	4	16	132	22	58	45	75	8.8	1.8	0.34	0.3
11	2.8	5	15	115	25	54	38	65	8.7	1.8	0.3	0.29
12	2.6	22	17	96	24	50	35	59	8.4	2	0.39	0.27
13	2.5	130	26	84	25	46	44	53	7.9	3	0.5	0.25
14	2.3	85	23	73	24	46	42	66	7.5	2.8	0.35	0.25
15	2.1	54	19	65	24	80	39	54	7.2	2.1	0.3	0.73
16	2	40	17	57	23	92	35	46	6.8	1.6	0.29	3.7
17	1.6	34	17	50	23	84	35	40	6.5	1.2	0.26	1.7
18	1.8	28	28	44	22	73	33	36	6.2	0.92	0.2	0.83
19	1.3	23	25	39	21	66	30	37	6.2	0.78	0.18	0.43
20	1	24	24	35	20	60	27	33	6	0.73	0.17	0.32
21	1	25	33	32	19	54	25	29	5.8	0.66	0.15	0.27
22	1.2	24	60	30	19	62	24	26	5.1	0.63	0.15	0.23
23	0.8	23	50	28	24	59	23	24	4.7	0.57	0.15	0.21
24	0.7	22	40	26	71	54	22	22	4.4	0.51	0.14	0.2

25	0.6	21	50	27	126	61	21	21	4	0.4	0.13	0.19
26	0.55	20	55	25	156	59	20	19	4	0.35	0.13	0.18
27	0.6	20	110	24	123	54	20	18	3.5	0.31	0.13	0.17
28	0.6	19	200	27	106	56	27	16	3.2	0.29	0.13	0.17
29	0.6	18	215	25		68	29	15	3.2	0.26	0.15	0.18
30	0.55	17	160	24		66	24	14	3.1	0.25	0.16	0.22
31	0.6		130	23		63		11		0.24	0.17	
Mean	1.8	22.8	48.2	101.9	38.9	65.9	39.7	45.5	7.2	1.4	0.2	0.5
Vol(AFT)	533.6	11518.4	28941.0	16025.2	15235.8	17039.0	5275.5	5277.9	240.5	12.1	1.9	29.2
Annual Vol (aft)=			100130.2									

Appendix 2.3

2010-11 Daily Flow Data

Upper Drift Creek @ Victor Rd, OR

DAILY DISCHARGE IN CFS WATER YEAR **OCT 2010 TO SEP 2011**

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	*0.7*	10.79	54.39	187.27	45.19	51.35	171.98	70.85	68.46	14.77	3.19	1.00
2	*0.7*	8.59	48.26	165.74	45.43	47.56	166.41	62.56	136.6	15.8	3.03	1.32
3	*0.7*	6.66	41.19	132.53	44.04	44.84	181.37	63.13	195.2	15.3	2.80	1.12
4	*0.7*	5.42	35.61	113.88	44.32	42.01	162.35	56.63	218.1	13.7	2.71	0.77
5	0.79	4.78	31.07	130.90	43.94	37.53	142.77	52.36	175.0	13.1	2.65	0.51
6	5.78	5.08	27.47	191.81	40.61	34.17	129.91	47.98	143.8	12.2	2.40	0.43
7	2.87	*36.28*	24.13	157.00	38.22	31.81	113.09	43.37	127.8	11.3	2.11	1.13
8	1.42	*55.48*	21.00	132.48	35.25	35.16	112.58	39.85	100.1	10.5	2.05	2.24
9	0.67	*52.93*	18.39	124.22	33.35	30.86	92.67	36.46	90.7	9.99	2.60	1.98
10	0.30	*46.11*	17.07	104.58	31.71	30.79	86.88	38.71	101.4	9.27	2.31	1.51
11	0.14	*51.62*	16.81	91.60	32.79	32.37	79.64	34.80	106.5	8.93	2.23	1.20
12	0.05	*70.48*	17.13	99.40	39.27	61.17	74.54	31.07	90.62	8.43	1.96	0.93
13	0.01	*66.70*	17.46	97.79	45.29	83.26	68.17	28.35	77.12	8.15	1.60	0.76
14	0.41	*62.52*	16.84	90.21	55.18	72.85	63.26	26.15	67.57	7.40	1.25	0.65
15	0.95	*50.95*	55.29	91.97	63.16	64.35	99.46	24.13	61.91	6.73	1.05	4.38
16	0.85	*41.70*	114.32	155.85	68.98	57.41	85.35	22.61	56.13	6.46	0.99	3.89
17	0.91	*65.84*	103.93	155.43	64.85	52.17	74.17	25.01	48.52	6.12	0.81	2.88
18	2.26	60.65	89.10	143.91	59.67	46.22	65.93	29.70	40.54	6.04	0.61	4.27
19	1.72	52.80	82.03	122.95	54.35	41.64	59.30	29.28	33.76	6.00	0.72	9.06
20	1.07	54.80	80.05	104.39	49.01	37.87	55.28	27.45	32.08	6.06	0.78	8.42
21	1.06	67.07	119.79	91.33	43.59	40.14	60.96	28.51	30.63	5.70	0.69	7.00
22	1.35	79.67	135.69	81.97	38.99	43.58	50.16	53.49	25.78	5.42	0.65	4.66
23	2.09	71.38	110.51	73.89	36.92	37.75	45.01	54.12	25.48	5.12	0.56	3.51
24	4.89	59.61	93.72	70.91	46.62	34.79	43.31	51.45	23.87	4.83	0.44	3.15
25	3.68	50.82	81.40	93.90	50.28	43.75	39.20	51.19	20.65	4.56	0.33	2.76
26	6.11	51.31	70.00	83.75	56.25	94.43	37.25	81.95	18.78	4.26	0.31	2.60
27	10.53	108.69	60.92	73.38	61.95	96.52	62.12	86.80	17.54	3.89	0.51	2.80
28	6.52	89.71	53.72	63.59	55.78	93.94	89.32	75.31	16.39	3.81	0.40	2.42
29	5.80	74.28	48.54	59.02		232.61	94.04	68.72	15.39	3.83	0.24	2.10
30	10.91	62.44	62.75	54.70		263.37	82.19	60.16	14.59	3.64	0.30	1.86
31	12.15		100.94	50.00		215.25		68.22		3.51	0.54	
Mean	2.8	50.8	59.7	109.4	47.3	68.8	89.6	47.4	72.7	7.9	1.4	2.7

Vol (AFT)	830.6	25659	35828	17204	18520	17777	11899	5496	2414	70.7	11.1	161.3

Annual Vol (aft)= 135873

WATER YEAR OCT09-SEP10 SUMMARY: TOTAL=22,920 MEAN=62.9 MAX=330.0 MIN=0.3 AC-FT=45,462

Appendix 3 Daily Flows at Nearby Streams

Table A3.1 Pudding River at Aurora Daily Discharge (2008-09)

Days	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	70	93	366	4920	644	2410	1790	590	349	105	21	19
2	66	109	354	6850	613	2200	1670	583	323	93	19	20
3	73	128	441	10500	584	2270	1950	808	309	87	17	21
4	81	235	492	8930	559	2320	1990	936	298	79	15	20
5	130	563	447	6860	545	2080	1790	1290	300	73	14	21
6	236	641	414	5750	538	1920	1570	1960	368	67	13	29
7	217	682	391	5110	570	1810	1410	2410	389	68	13	48
8	211	740	381	4970	620	1640	1310	2560	371	61	13	79
9	243	632	390	5310	602	1510	1250	2270	329	59	13	78
10	205	591	377	5500	581	1420	1270	1910	294	59	15	65
11	181	553	351	5150	572	1310	1260	1600	271	55	21	55
12	170	681	334	4470	585	1190	1140	1380	259	59	25	45
13	155	1850	351	3730	580	1100	1180	1260	254	70	21	39
14	141	3060	451	3160	567	1030	1550	1290	277	92	19	34
15	128	2550	480	2690	552	1160	1460	1660	285	110	26	33
16	120	1700	466	2330	546	1920	1290	1520	259	100	42	33
17	113	1140	429	1990	540	2400	1150	1290	231	77	44	31
18	112	842	438	1630	531	2440	1060	1100	215	63	46	29
19	114	681	505	1390	512	2240	1010	989	206	49	39	33
20	112	585	520	1250	487	2000	937	965	203	42	28	38
21	116	583	526	1140	468	1860	903	892	208	40	22	40
22	128	629	809	1040	459	1790	884	782	211	39	21	38
23	147	593	1230	959	466	1750	839	695	203	29	19	35
24	129	555	1260	892	651	1630	775	635	182	26	19	34
25	114	509	1470	838	1530	1540	710	580	163	26	18	32
26	112	476	1760	805	2580	1660	648	536	142	36	20	31
27	105	445	1920	752	3020	1690	602	499	136	35	21	31
28	100	415	2990	711	2740	1610	578	460	132	28	17	31
29	96	395	4250	719		1930	627	431	131	23	15	31
30	94	378	4860	714		2250	642	401	120	20	17	35

31	91		4960	676		2040		369		23	18	
Mean	132.6	767.8	1110.1	3281.8	830.1	1810.3	1174.8	1117.8	247.3	57.8	21.6	36.9

Table A3.2 Pudding River at Aurora Daily Discharge (2009-10)

Pudding @ Aurora

2009-2010

Days	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	41	343	1500	2770	1310	1520	4900	1780	1130	359	76	33
2	49	364	1250	4030	1250	1350	4240	1590	1260	344	79	32
3	48	291	1070	4110	1240	1220	3820	1440	2690	354	79	31
4	54	239	921	3610	1220	1110	3640	1500	3660	366	72	34
5	55	203	808	3180	1230	1020	3470	1460	4300	336	66	37
6	56	200	722	3560	1230	928	3210	1340	4300	308	66	38
7	61	338	653	4190	1160	850	2970	1240	3730	280	64	39
8	56	852	578	4000	1080	810	2770	1110	3020	255	62	37
9	51	1550	475	3620	1010	873	2640	1010	2430	227	67	45
10	48	1460	460	3350	943	853	2410	936	2240	201	67	59
11	49	1200	445	2930	908	774	2170	953	2260	188	60	64
12	47	1180	503	2600	998	852	2000	916	2170	186	55	62
13	48	1330	527	2670	1220	1620	1910	835	1940	177	52	58
14	53	1330	475	2540	1350	1910	1870	765	1670	170	48	53
15	57	1210	516	2340	1650	1730	1940	709	1440	160	44	50
16	87	1010	1860	2780	1760	1530	2210	664	1290	150	39	52
17	95	878	3010	3480	1790	1360	2130	629	1170	142	38	58
18	91	1240	2990	3670	1660	1230	1920	609	1070	138	36	69
19	111	1500	2630	3490	1490	1110	1720	613	956	140	34	100
20	111	1410	2310	3050	1330	1000	1570	684	868	137	34	190
21	96	1390	2310	2590	1180	919	1490	804	820	127	35	319
22	90	1510	3190	2210	1060	930	1470	949	760	122	36	270
23	94	1920	3370	1980	959	1050	1300	1160	689	116	40	187
24	97	1890	2900	1800	956	979	1150	1180	627	109	42	147
25	108	1600	2390	2070	1180	926	1090	1110	572	102	39	131
26	141	1330	2010	2530	1420	1100	1000	1090	524	97	33	120
27	150	1410	1680	2320	1730	1640	1030	1310	489	91	32	106
28	260	2190	1420	2000	1740	1830	1600	1320	462	80	34	98
29	283	2190	1240	1740		2510	1970	1200	421	75	32	94
30	232	1830	1160	1530		4410	1960	1150	386	80	32	89

31	276		1380	1410		5070		1090		79	36	
	99.8	1179.6	1508.2	2843.5	1287.6	1452.1	2252.3	1069.2	1644.8	183.7	49.3	90.1

Table A3.3 Pudding River at Aurora Daily Discharge (2010-11)

Pudding @ Aurora

2010-2011

Days	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	84	1050	2470	5280	1190	3560	3120	1660	1610	313	118	59
2	82	1080	3580	4370	1080	5260	3130	1520	1990	303	112	53
3	80	1500	3840	3510	988	4910	3120	1410	2030	267	103	50
4	78	1330	3460	2910	914	4220	2680	1290	1780	252	99	46
5	77	1030	2920	2470	854	3760	2640	1190	1510	234	94	44
6	75	828	2460	2190	820	3530	2840	1120	1320	216	93	53
7	72	1040	2100	1900	800	3170	3000	1110	1200	201	98	55
8	71	1930	1980	1660	783	2740	3300	1210	1070	196	100	50
9	77	1840	2850	1570	767	2390	2920	1330	952	191	98	53
10	119	1770	4430	1480	715	2960	2430	1320	850	183	97	51
11	319	1950	5430	1380	671	4180	2120	1210	779	180	93	48
12	463	1790	5900	1320	647	3910	2180	1230	722	172	89	47
13	315	1570	6030	1950	741	3480	2080	1260	674	173	86	49
14	226	1360	6300	3210	906	3860	1970	1140	664	190	84	49
15	180	1340	7230	3390	1190	4320	2170	1080	629	186	85	44
16	153	1320	7140	4070	2000	4790	3070	1210	564	173	87	42
17	140	1440	6260	5530	2170	5360	3810	1300	519	177	80	44
18	129	2100	5420	6790	1890	5350	3880	1220	484	261	75	47
19	120	3590	4780	7790	1670	4780	3350	1130	484	307	72	51
20	116	3580	4210	7040	1510	4120	2650	1030	518	296	67	52
21	112	3090	3770	5970	1340	3540	2160	942	472	288	67	53
22	111	2650	3350	5240	1210	3130	1830	886	428	248	65	52
23	106	2530	2930	4490	1120	2830	1580	844	392	220	65	50
24	123	2370	2530	3720	1080	2600	1420	793	371	199	63	47
25	325	2020	2190	3120	1050	2420	1390	749	350	181	61	47
26	871	1720	1920	2660	975	2230	1790	783	327	166	59	45
27	1040	1720	2100	2290	899	2200	1970	867	316	157	59	50
28	846	2120	2980	1960	1090	2220	1850	1290	307	145	67	59
29	691	2110	5510	1650		2220	1790	1550	315	130	99	65
30	648	1950	6340	1450		2620	1770	1570	318	123	92	63
31	704		5960	1310		3040		1480		118	75	

275.9	1857.3	4141.0	3344.2	1109.6	3538.7	2467.0	1184.6	798.2	207.9	83.9	50.6

Appendix 4. Monthly Flows, Pudding River @ Aurora (1928-2011)

USGS 14202000 PUDDING RIVER AT AURORA, OR **00060** Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1928-10-01 -> 2011-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1928										162.0	605.2	1,273
1929	1,875	1,066	1,097	1,752	757.1	374.1	125.0	67.1	57.3	68.5	81.5	1,907
1930	962.2	3,868	1,073	682.9	828.4	374.9	128.1	71.0	79.6	123.4	460.5	573.4
1931	1,464	956.7	1,652	3,086	327.2	349.1	181.2	74.4	70.0	204.6	1,780	2,593
1932	3,304	2,010	3,312	1,754	743.7	332.4	123.1	74.6	60.0	161.3	1,613	2,168
1933	3,574	2,263	2,937	1,262	1,361	1,101	206.9	97.0	205.3	295.5	699.7	5,170
1934	3,633	864.4	1,325	1,142	695.5	207.2	101.8	68.2	62.2	355.4	1,975	2,842
1935	2,992	1,535	1,996	1,217	551.1	183.6	124.3	64.6	72.4	135.9	318.7	668.3
1936	4,352	1,773	1,428	1,002	858.9	489.3	191.2	68.5	79.9	66.1	78.9	662.4
1937	766.5	3,563	2,100	3,239	901.5	730.1	265.7	97.1	109.6	305.1	3,039	3,904
1938	3,670	2,990	3,121	1,668	682.1	216.5	99.0	54.8	60.7	120.3	888.6	1,204
1939	1,853	2,679	1,702	638.3	241.9	294.2	124.3	51.9	64.9	149.7	151.0	1,679
1940	1,353	3,532	2,491	1,477	671.6	158.0	66.7	49.6	81.0	205.1	1,110	1,863
1941	1,885	831.5	598.5	456.3	638.3	337.2	116.8	73.2	212.9	298.2	1,138	3,408
1942	1,719	2,277	916.2	498.4	929.1	661.7	242.7	94.1	60.6	78.1	3,098	4,624
1943	3,768	3,916	1,035	2,713	720.4	616.8	217.2	119.8	94.0	543.8	783.8	1,130
1944	1,463	1,466	1,047	1,120	474.4	283.3	97.3	54.2	58.5	70.9	373.2	435.9
1945	1,517	2,466	2,527	1,879	1,623	414.6	116.4	72.3	142.5	108.2	1,801	2,955
1946	3,488	2,507	3,000	1,028	466.5	263.8	179.1	71.0	83.1	353.0	2,006	3,452
1947	1,572	1,999	1,421	1,448	322.5	475.2	196.6	102.3	96.3	1,774	2,482	1,518
1948	3,664	2,311	2,454	1,730	1,416	395.6	146.1	109.2	116.4	295.3	1,508	3,661
1949	1,209	5,600	2,067	1,086	1,081	250.3	112.5	66.7	90.4	245.0	699.7	2,004
1950	4,735	4,263	3,310	1,638	990.8	471.5	143.4	78.7	77.5	1,170	4,643	3,239
1951	4,853	3,208	2,624	887.2	703.1	203.3	79.5	50.6	64.1	914.4	1,497	3,283
1952	2,241	3,474	1,905	1,130	618.3	327.5	364.0	69.4	64.1	63.8	104.3	792.7
1953	5,576	3,743	2,142	1,179	1,171	897.6	183.2	97.5	91.9	326.7	1,770	4,772
1954	3,721	3,375	1,506	1,656	418.0	707.9	282.5	112.5	157.9	390.6	1,028	1,808
1955	1,895	1,255	1,795	3,054	1,193	500.5	224.4	76.7	107.5	1,036	3,039	5,704
1956	5,722	2,127	3,115	1,630	682.1	365.3	116.4	71.0	76.9	331.8	755.7	1,421

1957	1,108	1,872	3,945	1,361	658.7	360.2	91.2	58.5	41.3	153.1	404.8	2,959
1958	2,982	4,384	1,459	2,011	567.4	305.5	95.2	33.9	60.0	103.3	1,846	1,874
1959	4,017	3,067	1,716	1,347	1,061	441.8	123.1	39.4	180.0	578.6	515.3	879.6
1960	1,374	2,789	2,543	2,037	1,820	532.5	84.2	54.3	73.5	142.4	2,775	1,883
1961	2,006	5,550	4,235	1,264	1,214	271.8	78.9	35.4	86.3	258.6	776.9	2,880
1962	1,322	1,242	2,589	1,882	1,454	417.9	85.7	75.1	77.6	461.1	2,163	2,302
1963	819.2	2,458	1,548	3,355	2,192	287.1	187.3	57.5	85.2	185.3	1,940	1,289
1964	4,513	1,840	1,656	939.9	687.7	467.2	131.0	83.5	84.6			
1993							290.4	116.5	73.6	79.5	99.1	1,114
1994	2,050	1,590	1,741	1,225	375.3	373.1	59.1	11.3	32.8	346.5	2,557	2,957
1995	3,017	3,335	1,595	1,123	812.2	329.4	111.8	54.8	67.8	520.0	2,233	4,323
1996	3,888	6,948	1,988	1,867	1,552	523.5	158.5	38.7	106.2	606.6	3,387	6,090
1997	4,643	2,875	3,728	1,446	727.9	498.3	178.6	63.9	197.6			
2002										86.6	255.4	1,383
2003	2,565	2,973	3,116	2,345	1,034	291.8	53.2	13.1	53.7	93.3	393.6	2,705
2004	3,364	2,884	1,296	727.5	469.7	618.8	98.9	106.2	329.4	428.9	617.0	1,579
2005	758.5	496.7	824.6	1,620	1,132	570.2	180.7	**35.0**	**44.5**	**185.4**	**1,476**	**2,559**
2006	**6,873**	**2,506**	**1,507**	**1,515**	**527.8**	**469.2**	**81.5**	**27.0**	**33.0**	**85.3**	**3,454**	**3,554**
2007	**2,814**	**2,001**	**2,166**	**1,035**	**500.0**	**178.2**	**58.7**	**27.0**	**34.7**	**424.7**	**1,005**	**3,051**
2008	**3,524**	**2,371**	**1,992**	**1,387**	**1,092**	**691.7**	**134.7**	**76.5**	**53.9**	**132.6**	**767.8**	**1,110**
2009	**2,977**	**830**	**1,810**	**1,175**	**1,118**	**247.3**	**57.8**	**21.6**	**36.9**	**103.6**	**1179.6**	**1508.2**
2010	**2843.5**	**1287.6**	**1452.1**	**2252.3**	**1069.2**	**1644.8**	**183.7**	**49.3**	**89.4**	**275.9**	**1857.3**	**4141**
2011	**3344.2**	**1109.6**	**3538.7**	**2467.0**	**1184.6**	**798.2**	**207.9**	**83.9**	**50.6**			
Mean of monthly Discharge thru Sept. 2011	2,839.3	2,608.7	2,054.2	1,541.0	877.8	448.0	141.4	65.0	91.0	319.3	1,403.6	2,431.6
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

** No Incomplete data have been used for statistical calculation. Bold numbers=more recent dat

Appendix 5. Observed Monthly October-April Flows, Pudding River near Aurora (1928-2011)

Hydro Year=	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Oct-Apr Vol (aft)
1928-29	162.0	605.2	1273.0	1875.0	1066.0	1097.0	1752.0	470,330
1929-30	68.5	81.5	1907.0	962.2	3868.0	1073.0	682.9	506,791
1930-31	123.4	460.5	573.4	1464.0	956.7	1652.0	3086.0	498,485
1931-32	204.6	1780.0	2593.0	3304.0	2010.0	3312.0	1754.0	904,509
1932-33	161.3	1613.0	2168.0	3574.0	2263.0	2937.0	1262.0	840,124
1933-34	295.5	699.7	5170.0	3633.0	864.4	1325.0	1142.0	798,321
1934-35	355.4	1975.0	2842.0	2992.0	1535.0	1996.0	1217.0	778,303
1935-36	135.9	318.7	668.3	4352.0	1773.0	1428.0	1002.0	585,279
1936-37	66.1	78.9	662.4	766.5	3563.0	2100.0	3239.0	616,209
1937-38	305.1	3039.0	3904.0	3670.0	2990.0	3121.0	1668.0	1,122,245
1938-39	120.3	888.6	1204.0	1853.0	2679.0	1702.0	638.3	539,529
1939-40	149.7	151.0	1679.0	1353.0	3532.0	2491.0	1477.0	648,682
1940-41	205.1	1110.0	1863.0	1885.0	831.5	598.5	456.3	419,148
1941-42	298.2	1138.0	3408.0	1719.0	2277.0	916.2	498.4	613,602
1942-43	78.1	3098.0	4624.0	3768.0	3916.0	1035.0	2713.0	1,147,435
1943-44	543.8	783.8	1130.0	1463.0	1466.0	1047.0	1120.0	451,846
1944-45	70.9	373.2	435.9	1517.0	2466.0	2527.0	1879.0	550,657
1945-46	108.2	1801.0	2955.0	3488.0	2507.0	3000.0	1028.0	894,637
1946-47	353.0	2006.0	3452.0	1572.0	1999.0	1421.0	1448.0	734,364
1947-48	1774.0	2482.0	1518.0	3664.0	2311.0	2454.0	1730.0	957,349
1948-49	295.3	1508.0	3661.0	1209.0	5600.0	2067.0	1086.0	909,843
1949-50	245.0	699.7	2004.0	4735.0	4263.0	3310.0	1638.0	1,008,572
1950-51	1170.0	4643.0	3239.0	4853.0	3208.0	2624.0	887.2	1,237,781
1951-52	914.4	1497.0	3283.0	2241.0	3474.0	1905.0	1130.0	862,064
1952-53	63.8	104.3	792.7	5576.0	3743.0	2142.0	1179.0	811,270
1953-54	326.7	1770.0	4772.0	3721.0	3375.0	1506.0	1656.0	1,025,958
1954-55	390.6	1028.0	1808.0	1895.0	1255.0	1795.0	3054.0	674,511
1955-56	1036.0	3039.0	5704.0	5722.0	2127.0	3115.0	1630.0	1,353,423
1956-57	331.8	755.7	1421.0	1108.0	1872.0	3945.0	1361.0	648,236
1957-58	153.1	404.8	2959.0	2982.0	4384.0	1459.0	2011.0	851,445
1958-59	103.3	1846.0	1874.0	4017.0	3067.0	1716.0	1347.0	834,219
1959-60	578.6	515.3	879.6	1374.0	2789.0	2543.0	2037.0	637,122
1960-61	142.4	2775.0	1883.0	2006.0	5550.0	4235.0	1264.0	1,056,599
1961-62	258.6	776.9	2880.0	1322.0	1242.0	2589.0	1882.0	660,499
1962-63	461.1	2163.0	2302.0	819.2	2458.0	1548.0	3355.0	780,119
1963-64	185.3	1940.0	1289.0	4513.0	1840.0	1656.0	939.9	743,346

1993-94	79.5	99.1	1114.0	2050.0	1590.0	1741.0	1225.0	473,466
1994-95	346.5	2557.0	2957.0	3017.0	3335.0	1595.0	1123.0	890,685
1995-96	520.0	2233.0	4323.0	3888.0	6948.0	1988.0	1867.0	1,288,619
1996-97	606.6	3387.0	6090.0	4643.0	2875.0	3728.0	1446.0	1,373,397
2002-03	86.6	255.4	1383.0	2565.0	2973.0	3116.0	2345.0	759,339
2003-04	93.3	393.6	2705.0	3364.0	2884.0	1296.0	727.5	685,310
2004-05	428.9	617.0	1579.0	758.5	496.7	824.6	1620.0	381,407
2005-06	185.4	1476.0	2559.0	6873.0	2506.0	1507.0	1515.0	1,000,928
2006-07	85.3	3454.0	3554.0	2814.0	2001.0	2166.0	1035.0	908,008
2007-08	424.7	1005.0	3051.0	3524.0	2371.0	1992.0	1387.0	826,694
2008-09	132.6	767.8	1110.1	2977.0	830.1	1810.3	1174.8	532,336
2009-10	103.6	1179.6	1508.2	2843.5	1287.6	1452.1	2252.3	638,806
2010-11	**275.9**	**1857.3**	**4141**	**3344.2**	**1109.6**	**3538.7**	**2467.0**	758,905
Average (new)	318.4	1,412.9	2,466.4	2,849.6	2,578.1	2,084.5	1,559.9	789,607
Average(old)	323.9	1,408.4	2,451.2	2,839.2	2,636.8	2,067.1	1,525.9	

Note: monthly flows are in cfs; last column numbers represent runoff volume in acre-feet

Appendix 6. Monthly Flows of Other Nearby Streams

A6.1 Zollner Creek

USGS 14201300 ZOLLNER CREEK NEAR MT ANGEL, OR 00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1993-10-01 -> 2008-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993										1.67	1.89	35.6
1994	51.4	55.5	16.0	11.2	2.05	4.75	0.237	0.275	0.294	16.8	70.7	61.6
1995	62.8	48.2	30.7	9.05	4.86	2.60	1.12	0.795	1.00	9.65	86.6	82.0
1996	103.4	113.8	24.5	25.9	21.8	3.65	1.12	0.598	1.70	23.1	121.3	186.9
1997	78.2	45.0	91.5	20.0	6.35	6.60	1.66	0.932	2.54	12.4	24.4	26.1
1998	40.6	33.1	38.6	8.14	10.0	4.91	1.59	0.522	1.22	3.67	55.2	91.8
1999	77.2	102.6	43.4	10.0	4.40	1.53	0.631	0.404	0.239	0.934	27.8	42.1
2000	49.6	57.9	29.2	5.80	5.26	2.05	0.771	0.264	0.698	1.78	3.09	10.9
2001	7.47	9.27	10.4	9.32	3.58	1.67	0.381	0.142	0.185	0.976	33.6	97.6
2002	66.5	37.2	35.9	6.15	2.88	0.950	0.712	0.278	0.434	0.798	1.51	35.0
2003	58.7	37.1	49.9	38.5	7.87	1.63	0.548	0.590	0.686	1.39	5.48	46.6
2004	51.4	40.1	13.7	2.75	2.11	2.41	0.376	0.156	0.278	3.05	5.13	20.8
2005	8.83	6.99	17.5	21.0	14.5	2.67	0.342	0.307	0.450	4.94	42.3	81.8
2006	128.1	32.7	25.2	23.0	5.02	2.98	0.314	0.474	0.281	0.700	78.1	68.6

2007	44.3	39.8	29.1	12.6	4.20	0.932	0.606	0.301	0.481	8.76	19.4	63.0
2008	70.3	32.2	27.1	14.7	2.53	1.17	0.269	0.434	0.331	**0.9**	**16.7**	**123**
2009	**264.1**	**19.0**	**28.0**	**8.6**	**9.8**	**1.1**	**0.3**	**0.3**	**0.3**			
Mean of monthly Discharge	**72.7**	**44.4**	**31.9**	**14**	**6.7**	**2.6**	**0.69**	**0.40**	**0.69**	**5.72**	**37.1**	**67.1**
Old Means (1993-2005)	55	49	33	14	7.1	3.0	0.79	0.44	0.81	6.4	36	61

A6.2 PUDDING RIVER @ WOODBURN

USGS 14201340 PUDDING RIVER NEAR WOODBURN, OR 00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1997-10-01 -> 2008-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997										599.7	936.3	1,024
1998	2,318	1,564	1,613	718.8	846.2	459.5	112.0	39.6	43.5	174.4	1,394	2,845
1999	2,842	2,835	2,082	924.8	812.4	293.5	98.0	52.9	33.4	61.3	1,025	2,023
2000	1,881	1,920	1,346	504.5	677.5	350.5	72.9	25.0	36.9	101.7	202.0	716.9
2001	477.8	460.2	581.5	774.1	429.5	171.2	54.1	25.5	19.9	64.3	787.2	2,507
2002	2,062	1,850	1,639	947.5	353.5	188.7	94.1	22.1	24.3	28.5	173.4	1,059
2003	1,792	2,050	2,117	1,670	694.7	145.1	34.5	13.5	23.4	58.2	314.5	1,964
2004	2,445	2,062	966.3	503.8	278.1	424.4	65.4	56.8	182.7	288.5	505.1	1,195
2005	603.2	386.6	561.0	1,123	819.3	450.2	115.5	28.1	23.3	132.6	1,095	1,720
2006	4,612	1,698	1,113	1,094	347.4	332.2	54.2	21.6	16.3	42.8	2,405	2,359
2007	1,897	1,373	1,469	694.7	299.6	102.9	41.8	18.5	25.6	283.1	713.5	2,069
2008	2,371	1,646	1,437	1,004	723.9	417.8	62.5	47.9	33.7	**74.2**	**556.7**	**821.8**
2009	**2,237**	**562.9**	**1,147**	**727.0**	**710.0**	**148.2**	**39.0**	**15.6**	**20.2**	**61.2**	**777.7**	**1007.0**
2010	**1954.7**	**834.5**	**992.1**	**1432.8**	**685.5**	**1076.7**	**126.6**	**42.4**	**64.7**			
Mean of monthly Discharge	**2,128**	**1,534**	**1,339**	**891**	**583**	**290**	**70**	**31**	**40**	**159**	**842**	**1,692**
Previous Mean Monthly Discharge (1997-2005)	1,800	1,640	1,360	896	614	310.	81	33	48	172	667	1,670

Appendix 7. OCT-APR RUNOFF VOLUME STATISTICAL FREQUENCY
FOR DRIFT CREEK AT PROJECT SITE –BASED ON 83 YEARS OF FLOWS OF PUDDING RIVER NEAR AURORA (49 YEARS OF OBSERVED FLOWS BETWEEN 1928-2011 + 34 YEARS OF SYNTHESIZED FLOWS

N	Hydro Yr Oct-Apr	Pudding Oct-Apr Vol (aft)	Drift Oct-Apr Vol (aft)	Log(Vol) X	X^2	Dev X-M x	x^2
		Multiplier=	0.0362				
1	1928-29	470,330	17,026	4.23111	17.90230	-0.18573	0.03450
2	1929-30	506,791	18,346	4.26354	18.17775	-0.15331	0.02350
3	1930-31	498,485	18,045	4.25636	18.11661	-0.16048	0.02576
4	1931-32	904,509	32,743	4.51512	20.38632	0.09828	0.00966
5	1932-33	840,124	30,413	4.48305	20.09776	0.06621	0.00438
6	1933-34	798,321	28,899	4.46089	19.89951	0.04404	0.00194
7	1934-35	778,303	28,175	4.44986	19.80123	0.03301	0.00109
8	1935-36	585,279	21,187	4.32607	18.71489	-0.09077	0.00824
9	1936-37	616,209	22,307	4.34844	18.90890	-0.06841	0.00468
10	1937-38	1,122,245	40,625	4.60880	21.24100	0.19195	0.03685
11	1938-39	539,529	19,531	4.29072	18.41031	-0.12612	0.01591
12	1939-40	648,682	23,482	4.37074	19.10337	-0.04610	0.00213
13	1940-41	419,148	15,173	4.18108	17.48140	-0.23577	0.05559
14	1941-42	613,602	22,212	4.34660	18.89289	-0.07025	0.00494
15	1942-43	1,147,435	41,537	4.61844	21.32996	0.20159	0.04064
16	1943-44	451,846	16,357	4.21370	17.75526	-0.20315	0.04127
17	1944-45	550,657	19,934	4.29959	18.48647	-0.11726	0.01375
18	1945-46	894,637	32,386	4.51036	20.34331	0.09351	0.00874
19	1946-47	734,364	26,584	4.42462	19.57726	0.00777	0.00006
20	1947-48	957,349	34,656	4.53978	20.60959	0.12293	0.01511
21	1948-49	909,843	32,936	4.51767	20.40939	0.10083	0.01017
22	1949-50	1,008,572	36,510	4.56242	20.81563	0.14557	0.02119
23	1950-51	1,237,781	44,808	4.65135	21.63508	0.23451	0.05499
24	1951-52	862,064	31,207	4.49425	20.19827	0.07740	0.00599
25	1952-53	811,270	29,368	4.46787	19.96190	0.05103	0.00260
26	1953-54	1,025,958	37,140	4.56984	20.88342	0.15299	0.02341
27	1954-55	674,511	24,417	4.38770	19.25189	-0.02915	0.00085
28	1955-56	1,353,423	48,994	4.69014	21.99743	0.27330	0.07469
29	1956-57	648,236	23,466	4.37044	19.10076	-0.04640	0.00215
30	1957-58	851,445	30,822	4.48887	20.14991	0.07202	0.00519
31	1958-59	834,219	30,199	4.47999	20.07030	0.06314	0.00399
32	1959-60	637,122	23,064	4.36293	19.03517	-0.05391	0.00291
33	1960-61	1,056,599	38,249	4.58262	21.00039	0.16577	0.02748
34	1961-62	660,499	23,910	4.37858	19.17197	-0.03826	0.00146

35	1962-63	780,119	28,240	4.45087	19.81024	0.03402	0.00116
36	1963-64	743,346	26,909	4.42990	19.62401	0.01305	0.00017
37	1964-65	766,851	27,760	4.44342	19.74398	0.02657	0.00071
38	1965-66	721,428	26,116	4.41690	19.50902	0.00006	0.00000
39	1966-67	657,317	23,795	4.37648	19.15361	-0.04036	0.00163
40	1967-68	708,640	25,653	4.40913	19.44046	-0.00771	0.00006
41	1968-69	1,012,349	36,647	4.56404	20.83045	0.14719	0.02167
42	1969-70	874,116	31,643	4.50028	20.25250	0.08343	0.00696
43	1970-71	1,047,283	37,912	4.57877	20.96516	0.16193	0.02622
44	1971-72	873,458	31,619	4.49995	20.24956	0.08311	0.00691
45	1972-73	470,469	17,031	4.23124	17.90339	-0.18561	0.03445
46	1973-74	1,259,453	45,592	4.65889	21.70526	0.24205	0.05859
47	1974-75	707,696	25,619	4.40856	19.43536	-0.00829	0.00007
48	1975-76	786,755	28,481	4.45455	19.84300	0.03770	0.00142
49	1976-77	197,929	7,165	3.85522	14.86270	-0.56163	0.31543
50	1977-78	668,444	24,198	4.38377	19.21747	-0.03307	0.00109
51	1978-79	418,772	15,160	4.18069	17.47814	-0.23616	0.05577
52	1979-80	757,077	27,406	4.43785	19.69450	0.02100	0.00044
53	1980-81	597,766	21,639	4.33524	18.79431	-0.08161	0.00666
54	1981-82	926,194	33,528	4.52541	20.47934	0.10857	0.01179
55	1982-83	1,012,188	36,641	4.56397	20.82982	0.14712	0.02165
56	1983-84	740,659	26,812	4.42833	19.61008	0.01148	0.00013
57	1984-85	612,787	22,183	4.34602	18.88788	-0.07083	0.00502
58	1985-86	597,101	21,615	4.33476	18.79011	-0.08209	0.00674
59	1986-87	678,463	24,560	4.39023	19.27416	-0.02661	0.00071
60	1987-88	599,374	21,697	4.33641	18.80442	-0.08044	0.00647
61	1988-89	529,715	19,176	4.28275	18.34195	-0.13409	0.01798
62	1989-90	550,087	19,913	4.29914	18.48260	-0.11771	0.01385
63	1990-91	606,560	21,957	4.34158	18.84934	-0.07526	0.00566
64	1991-92	544,536	19,712	4.29474	18.44475	-0.12211	0.01491
65	1992-93	727,869	26,349	4.42076	19.54313	0.00392	0.00002
66	1993-94	473,466	17,139	4.23400	17.92673	-0.18285	0.03343
67	1994-95	890,685	32,243	4.50843	20.32597	0.09159	0.00839
68	1995-96	1,288,619	46,648	4.66883	21.79800	0.25199	0.06350
69	1996-97	1,373,397	49,717	4.69650	22.05716	0.27966	0.07821
70	1997-98	787,841	28,520	4.45515	19.84834	0.03830	0.00147
71	1998-99	758,191	27,447	4.43849	19.70017	0.02164	0.00047
72	1999-00	726,590	26,303	4.42000	19.53638	0.00315	0.00001
73	2000-01	381,814	13,822	4.14056	17.14424	-0.27628	0.07633
74	2001-02	867,323	31,397	4.49689	20.22201	0.08004	0.00641
75	2002-03	759,339	27,488	4.43914	19.70600	0.02230	0.00050
76	2003-04	685,310	24,808	4.39460	19.31247	-0.02225	0.00050
77	2004-05	381,407	13,807	4.14010	17.14041	-0.27675	0.07659

78	2005-06	1,000,928	36,234	4.55911	20.78550	0.14227	0.02024
79	2006-07	908,008	32,870	4.51680	20.40147	0.09995	0.00999
80	2007-08	831,396	30,097	4.47852	20.05711	0.06167	0.00380
81	2008-09	532,336	19,271	4.28489	18.36032	-0.13195	0.01741
82	2009-10	638,547	23,115	4.36390	19.04364	-0.05294	0.00280
83	2010-11	758,905	27,472	4.43890	19.70380	0.02205	0.00049
				X	X^2	x	x^2
			N=	83.00000			
			S(X)=	366.60		0.00	1.63
			M=	4.41685			
			S(X^2)=		1620.84	S^2=	0.019886
			[S(X)^2]/N		1619.21	S=	0.141017
			S(x^2)=		1.63		

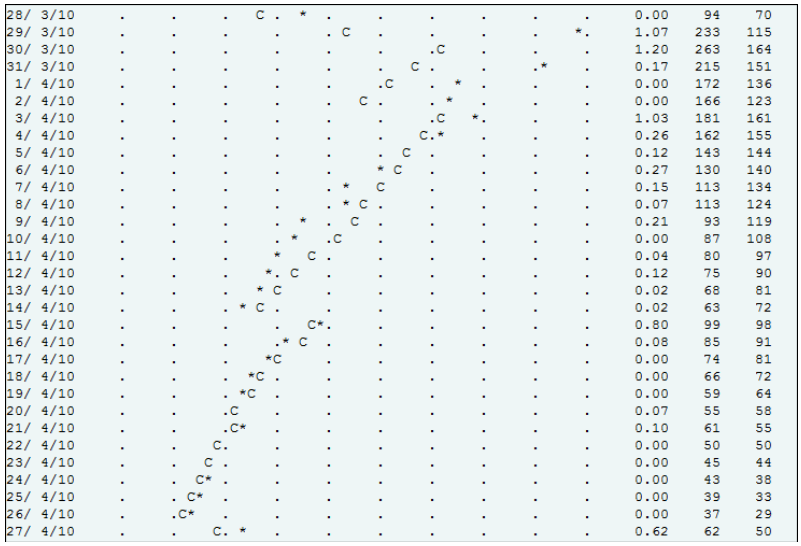
Pn	0.25	1	10	50	90	99	99.75
k (N=83)	2.897	2.385	1.298	0.000	-1.298	-2.385	-2.897
Log(V)=	4.82535	4.75322	4.59984	4.41685	4.23385	4.08047	4.00834
Vol, aft	66,887	56,651	39,795	26,111	17,133	12,035	10,193

Appendix 8. Time Step Computer Modeling

A8.1 Sample FLO4DRIFT Runoff Model Output

								<..... D I S C H A R G E S					.....>
DD/MM/YR	RAIN	ETI	SMI	ROP	BII	BFP		SUR	SUB	BFL	BASE	QCAL	QOBS
	in.	in.	in.					cfs	cfs	cfs	cfs	cfs	cfs
1/ 4/10	0.00	0.15	9.65	.78	0.00	.80		9.4	18.6	107.5	0.1	135.6	172.0
2/ 4/10	0.00	0.15	9.50	.77	0.00	.80		3.1	13.8	106.3	0.1	123.3	166.4
3/ 4/10	1.37	0.15	9.35	.76	0.00	.80		28.6	16.7	115.4	0.1	160.7	181.4
4/ 4/10	0.33	0.15	9.66	.79	0.00	.80		16.8	17.7	120.1	0.1	154.7	162.4
5/ 4/10	0.15	0.15	9.65	.78	0.00	.80		7.5	16.4	119.9	0.1	143.8	142.8
6/ 4/10	0.34	0.15	9.56	.78	0.00	.80		5.5	16.2	118.6	0.1	140.4	129.9
7/ 4/10	0.19	0.15	9.56	.78	0.00	.80		3.5	15.1	115.1	0.1	133.8	113.1
8/ 4/10	0.09	0.15	9.50	.77	0.00	.80		1.8	12.9	109.2	0.1	124.1	112.6
9/ 4/10	0.27	0.15	9.38	.76	0.00	.80		2.6	12.4	103.9	0.1	119.0	92.7
10/ 4/10	0.00	0.15	9.36	.76	0.00	.80		1.2	10.0	96.3	0.1	107.6	86.9
11/ 4/10	0.06	0.15	9.21	.74	0.00	.80		0.7	8.0	88.2	0.1	96.9	79.6
12/ 4/10	0.16	0.15	9.08	.73	0.00	.80		1.2	7.4	81.1	0.1	89.8	74.5
13/ 4/10	0.03	0.15	9.01	.73	0.00	.80		0.7	6.2	73.7	0.1	80.6	68.2
14/ 4/10	0.03	0.15	8.88	.71	0.00	.80		0.4	5.0	66.2	0.1	71.7	63.3
15/ 4/10	1.14	0.15	8.74	.70	0.00	.80		17.6	10.4	69.7	0.1	97.8	99.5
16/ 4/10	0.11	0.15	9.06	.73	0.00	.80		9.3	11.4	70.2	0.1	90.9	85.3
17/ 4/10	0.00	0.15	8.96	.72	0.00	.80		3.5	9.6	67.7	0.1	80.9	74.2
18/ 4/10	0.00	0.15	8.81	.71	0.00	.80		1.2	7.2	63.4	0.1	71.9	65.9
19/ 4/10	0.00	0.15	8.66	.69	0.00	.80		0.4	5.1	58.1	0.1	63.7	59.3
20/ 4/10	0.11	0.15	8.51	.68	0.00	.80		0.6	4.5	53.3	0.1	58.5	55.3
21/ 4/10	0.15	0.15	8.41	.67	0.00	.80		1.0	4.8	49.5	0.1	55.4	61.0
22/ 4/10	0.00	0.15	8.34	.67	0.00	.80		0.4	4.0	45.1	0.1	49.7	50.2
23/ 4/10	0.00	0.15	8.19	.65	0.00	.80		0.2	3.0	40.5	0.1	43.8	45.0
24/ 4/10	0.00	0.15	8.04	.64	0.00	.80		0.1	2.1	35.9	0.1	38.2	43.3
25/ 4/10	0.00	0.15	7.89	.62	0.00	.80		0.0	1.5	31.6	0.1	33.1	39.2
26/ 4/10	0.00	0.15	7.74	.61	0.00	.80		0.0	1.0	27.5	0.1	28.6	37.3
27/ 4/10	1.03	0.15	7.59	.60	0.00	.80		11.1	6.7	32.2	0.1	50.0	62.1
28/ 4/10	0.66	0.15	7.98	.63	0.00	.80		11.2	12.0	39.6	0.1	62.9	89.3
29/ 4/10	0.21	0.15	8.18	.65	0.00	.80		6.0	13.3	44.6	0.1	64.0	94.0
30/ 4/10	0.06	0.15	8.15	.65	0.00	.80		2.5	11.8	46.6	0.1	61.0	82.2

A8.2 Sample FLO4DRIFT Runoff Model Hydrograph Plot



28/ 3/10	.	.	.	C .	* .	.	.	.	.	.	.	0.00	94	70
29/ 3/10	.	.	.	.	. C	.	.	.	.	.	*.	1.07	233	115
30/ 3/10	.	.	.	.	.	.	.C	.	.	.	.	1.20	263	164
31/ 3/10	.	.	.	.	.	.	C .	.	.	.*	.	0.17	215	151
1/ 4/10	.	.	.	.	.	.C	.	*	.	.	.	0.00	172	136
2/ 4/10	.	.	.	.	.	C .	.	*	.	.	.	0.00	166	123
3/ 4/10	.	.	.	.	.	.	.C	*.	.	.	.	1.03	181	161
4/ 4/10	.	.	.	.	.	.	C.*	.	.	.	.	0.26	162	155
5/ 4/10	.	.	.	.	.	.	C .	.	.	.	.	0.12	143	144
6/ 4/10	.	.	.	.	.	* C	.	.	.	.	.	0.27	130	140
7/ 4/10	.	.	.	.	. *	C	.	.	.	.	.	0.15	113	134
8/ 4/10	.	.	.	.	. * C	.	.	.	.	.	.	0.07	113	124
9/ 4/10	.	.	.	. *	. C	.	.	.	.	.	.	0.21	93	119
10/ 4/10	.	.	.	. *	.C	.	.	.	.	.	.	0.00	87	108
11/ 4/10	.	.	.	*	C .	.	.	.	.	.	.	0.04	80	97
12/ 4/10	.	.	.	*. C	.	.	.	.	.	.	.	0.12	75	90
13/ 4/10	.	.	.	* C	.	.	.	.	.	.	.	0.02	68	81
14/ 4/10	.	.	.	* C .	.	.	.	.	.	.	.	0.02	63	72
15/ 4/10	.	.	.	.	C*.	.	.	.	.	.	.	0.80	99	98
16/ 4/10	.	.	.	.* C	.	.	.	.	.	.	.	0.08	85	91
17/ 4/10	.	.	.	*C	.	.	.	.	.	.	.	0.00	74	81
18/ 4/10	.	.	.	*C .	.	.	.	.	.	.	.	0.00	66	72
19/ 4/10	.	.	.	*C	.	.	.	.	.	.	.	0.00	59	64
20/ 4/10	.	.	.C	.	.	.	.	.	.	.	.	0.07	55	58
21/ 4/10	.	.	.C*	.	.	.	.	.	.	.	.	0.10	61	55
22/ 4/10	.	.	C.	.	.	.	.	.	.	.	.	0.00	50	50
23/ 4/10	.	.	C .	.	.	.	.	.	.	.	.	0.00	45	44
24/ 4/10	.	.	C* .	.	.	.	.	.	.	.	.	0.00	43	38
25/ 4/10	.	.	C*	.	.	.	.	.	.	.	.	0.00	39	33
26/ 4/10	.	.C*	.	.	.	.	.	.	.	.	.	0.00	37	29
27/ 4/10	.	.	C. *	.	.	.	.	.	.	.	.	0.62	62	50

A8.3 Release Criteria Used for the Reservoir Model RES4DRIFT

1. Start the pool at a given elevation ELE --normally at Elevation reached at the end of the last calculation time step
2. Input the Inflow to the reservoir for that day, QIN
3. Calculate the storage XSTOR at Elevation ELE --based on Elevation vs. Storage Curve
4. Calculate the capacity of the outlet at Elevation ELE --using the Elevation vs. Capacity Curve
5. Initialize for Time Step IN

viol(in) = 0 'violation code)
qloc(in) = qin(in) * aqloc(i): IF qloc(in) < 0 THEN qloc(in) = 0 'local inflow between Reservoir and River mouth
quse(in) = mquse(i) ' required consumptive use
qinstr(in) = mqinstr(i) ' required instream flows
qirrig(in) = mirrig(i) ' required irrigation flows
qreq(in) = qinstr(in) + quse(in) - qloc(in) ' required release flows from the reservoir
IF qreq(in) < qminmin THEN qreq(in) = qminmin 'release from Reservoir should be at least = a pre-specified Minimum Q
req = qreq(in) 'final reservoir release target for time step IN

6. Sort out release restrictions

6.1 If inflow is >630 cfs, release the full inflow amount. Assign Violation code=4. Go to Step 7

If qin(in) > 630 THEN qrel(in) = qin(in): viol(in) = 4

6.2 If inflow is < the required release, then:
Assign Violation Code=1
- if there is no irrigation requirement, then just release the inflow and go to Step 7
- if there is an irrigation requirement, then release the inflow + the irrigation requirement

```
IF qin(in) <= qreq(in) THEN
viol(in) = 1
IF mirrig(i) = 0 THEN qrel(in) = qin(in): qreq(in) = qin(in):  GOTO 3006
IF mirrig(i) > 0 THEN qrel(in) = qin(in) + qirrig(in): qreq(in) = qin(in): GOTO 3006
END IF
```

6.3 If inflow is > required release, then:
- if there is no irrigation requirement, then release the required amount (instream flow at the mouth minus the local inflow), and go to Step 7
- if there is an irrigation requirement, then release the required amount (instream flow at the mouth minus the local inflow and plus the irrigation amount), and go to Step 7

```
IF qin(in) > qreq(in) THEN
IF mirrig(i) = 0 THEN qrel(in) = qreq(in): GOTO 3006
IF mirrig(i) > 0 THEN qrel(in) = qreq(in) + qirrig(in): GOTO 3006
END IF
```

7. Check for release restrictions
If the proposed release is > release capacity at the given elevation, then:
Assign a violation code 4 and limit the release to the outlet capacity

```
IF qrel(in) > qqcap(in) THEN qrel(in) = qqcap(in): viol(in) = 4
```

8. Calculate the new storage at the end of the time step IN and check for upper/lower bound violation

```
stor(in + 1) = stor(in) + (qin(in) - qrel(in)) * 1.983
```

8.1 If the pool is within the lower and upper bounds, continue to Step 9

```
IF stor(in + 1) < vlupper AND stor(in + 1) > vlower THEN GOTO 3113
```

8.2 If the pool is higher than Upper Bound, set the pool to Upper bound and increase the release as needed

```
IF stor(in + 1) > vupper THEN
delv = stor(in + 1) - vupper: qadj = delv / 1.983
qrel(in) = qrel(in) + qadj: viol(in) = 2: stor(in + 1) = vupper: GOTO 3113
END IF
```

8.3 If the pool is lower than Lower bound, set the pool to Lower Bound and decrease the release as needed

```
IF stor(in + 1) < vlower THEN
delv = stor(in + 1) - vlower: qadj = delv / 1.983
qrel(in) = qrel(in) - qadj: viol(in) = 3: stor(in + 1) = vlower
```

```
END IF
```

9. Double-check for release capacity: Assign violation code to 5 if the release has to be again limited to outlet capacity

```
IF qrel(in) > qcapmax THEN viol(in) = 5: qrel(in) = qcapmax
```

10. If needed, recalculate end-of-time step storage and pool elevation.

```
FOR j = 1 TO npoint: xx(j) = STO(j): yy(j) = E(j): NEXT j:
np = npoint: try = stor(in + 1): ele(in + 1) = out1
```

11. Print results

```
PRINT "  I DA MO   YR     QIN    ELE1  ISWR CONSU   QLOC   REQ  QREQ   IRR  QIRR
QREL V    ELE2   STORAGE"
```

12. Go the next time step IN=1

VIOL= violation code
0=normal
1=too small inflow
2=exceed upper bound
3=exceed lower bound
4=pass flow greater than 630 cfs for flushing purposes
5=release limited by outlet capacity

A8.4 Input Data Used in Multi-Year Reservoir Simulation

```
MULTI-YEAR CONTINOUS RESERVOIR SMILATION Starting Oct 2002 Ending Sep 2011
2002, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT, 79.0, 90.0,132.0,132.0,115.0,109.0,108.0,112.0,110.0, 99.0, 99.0, 95.0, 82.0, 81.0, 80.0
     78.0, 75.0, 73.0, 65.0, 65.0, 73.0, 70.0, 73.0, 71.0, 71.0, 72.0, 70.0, 75.0, 80.0, 75.0, 75.0
NOV, 75.0, 78.0, 90.0, 84.0, 83.0, 99.0,114.0,134.0,162.0,269.0,381.0,365.0,352.0,378.0,387.0
    393.0,379.0,400.0,405.0,391.0,377.0,357.0,296.0,271.0,255.0,245.0,231.0,222.0,197.0,191.0
DEC,183.0,181.0,187.0,178.0,173.0,171.0,164.0,157.0,157.0,171.0,231.0,306.0,629.0, 1020, 1200
     1710, 2610, 2560, 2290, 1960, 1810, 2380, 2440, 2150, 1800, 1480, 1830, 2900, 3080, 3150, 3630
JAN, 4360, 4270, 4080, 4060, 4230, 4110, 3570, 3020, 2530, 2110, 1740, 1510, 1910, 2380, 2380
     2100, 1810, 1560, 1370, 1230, 1130, 1060, 1270, 1500, 1480, 1710, 2760, 2940, 2650, 3290, 5390
FEB, 7620, 8680, 7780, 6330, 5170, 4230, 3440, 2880, 2430, 2030, 1660, 1420, 1290, 1210, 1140
     1150, 1430, 2320, 2700, 2500, 2330, 2370, 2400, 2220, 1950, 1700, 1510, 1360
MAR, 1260, 1200, 1150, 1190, 1150, 1320, 3010, 5510, 6590, 6710, 6140, 5230, 4450, 3850, 3320
     2960, 2610, 2240, 1930, 1790, 1800, 2410, 4000, 4270, 3790, 3340, 3220, 2990, 2700, 2380, 2100
APR, 1970, 2040, 2040, 2150, 2220, 2240, 2430, 2380, 2240, 2220, 2200, 2270, 2790, 3460, 3520
     2920, 2450, 2310, 2140, 1930, 1800, 1850, 1820, 2320, 2850, 2710, 2540, 2340, 2150, 2050
MAY, 1850, 1650, 1470, 1350, 1480, 1650, 1520, 1390, 1310, 1210, 1120, 1170, 1200, 1080,981.0
    930.0,919.0,923.0,898.0,846.0,797.0,750.0,713.0,685.0,656.0,659.0,647.0,602.0,563.0,531.0,506.0
JUN,489.0,468.0,441.0,417.0,390.0,359.0,331.0,311.0,303.0,291.0,291.0,286.0,285.0,297.0,339.0
    315.0,273.0,249.0,219.0,217.0,220.0,225.0,271.0,291.0,254.0,224.0,194.0,179.0,164.0,161.0
JUL,150.0,134.0,125.0,115.0,104.0, 99.0, 99.0, 93.0, 84.0, 77.0, 53.0, 36.0, 30.0, 36.0, 48.0
     61.0, 56.0, 36.0, 27.0, 26.0, 26.0, 21.0, 20.0, 18.0, 14.0, 10.0, 10.0,  9.0, 10.0, 12.0, 11.0
AUG, 10.0,  9.0,  9.0,  9.0, 12.0, 14.0, 15.0, 15.0, 19.0, 27.0, 25.0, 20.0, 13.0, 11.0, 11.0
     14.0, 16.0, 16.0, 13.0, 13.0, 10.0, 12.0,  9.0,  8.0, 11.0, 13.0, 13.0, 13.0, 10.0,  8.0,  8.0
SEP,  9.0, 14.0, 14.0, 13.0, 17.0, 16.0, 13.0, 20.0, 35.0, 67.0, 91.0, 91.0, 83.0, 85.0, 74.0
     74.0, 80.0, 73.0,114.0,112.0, 76.0, 72.0, 65.0, 56.0, 52.0, 48.0, 39.0, 35.0, 35.0, 39.0
2003, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT, 38.0, 34.0, 35.0, 41.0, 47.0, 54.0, 60.0, 66.0, 78.0, 92.0,108.0,122.0,136.0,161.0,155.0
    126.0,129.0,156.0,127.0,113.0,103.0, 93.0, 88.0, 86.0,112.0,116.0, 89.0, 78.0, 74.0, 74.0,102.0
NOV,136.0,121.0,106.0,101.0,102.0, 99.0, 92.0,104.0, 99.0,109.0,102.0,101.0,158.0,177.0,153.0
    151.0,203.0,474.0,687.0,931.0,884.0,721.0,576.0,471.0,480.0,601.0,719.0,691.0,749.0, 1710
DEC, 1840, 1480, 1260, 1450, 1540, 2230, 2450, 2230, 2000, 1820, 1720, 1610, 1970, 4320, 5610
     5430, 4970, 4270, 3500, 2950, 2590, 2240, 1870, 1640, 1820, 2120, 2030, 2180, 3390, 4760, 4580
JAN, 3920, 3580, 3530, 3300, 2870, 2480, 2250, 2560, 3190, 3790, 4130, 3960, 3540, 3200, 3090
     3130, 2970, 2690, 2650, 2670, 2490, 2210, 2010, 2820, 4040, 4160, 3640, 3500, 4150, 5330, 6440
FEB, 7000, 6280, 5350, 4560, 3940, 3400, 3120, 2950, 2680, 2360, 2040, 1770, 1560, 1410, 1360
     1400, 1980, 2850, 3560, 3450, 3010, 2570, 2180, 1900, 1900, 1990, 2070, 2400, 2590
MAR, 2510, 2420, 2140, 1970, 1910, 1960, 2070, 1970, 1790, 1610, 1460, 1330, 1230, 1140, 1070
    998.0,939.0,894.0,876.0,869.0,824.0,779.0,754.0,737.0,756.0,784.0,845.0,938.0,905.0,844.0,840.0
APR,824.0,761.0,714.0,686.0,663.0,634.0,610.0,585.0,562.0,538.0,520.0,502.0,490.0,485.0,551.0
    650.0,712.0,691.0,656.0,687.0,890.0, 1220, 1260, 1140, 1000,892.0,813.0,748.0,694.0,646.0
```

```
MAY,601.0,562.0,530.0,496.0,471.0,464.0,441.0,426.0,460.0,480.0,463.0,483.0,468.0,418.0,392.0
    374.0,390.0,408.0,392.0,393.0,379.0,361.0,359.0,386.0,393.0,363.0,357.0,437.0,664.0,898.0,851.0
JUN,741.0,641.0,559.0,500.0,452.0,434.0,497.0,751.0, 1170, 1260, 1230, 1130,998.0,904.0,842.0
    752.0,673.0,601.0,538.0,481.0,447.0,404.0,374.0,367.0,353.0,330.0,310.0,299.0,274.0,251.0
JUL,233.0,214.0,190.0,180.0,193.0,184.0,166.0,163.0,145.0,158.0,131.0,118.0,118.0, 96.0, 97.0
     83.0, 74.0, 61.0, 58.0, 69.0, 55.0, 34.0, 12.0, 11.0, 31.0, 61.0, 61.0, 35.0, 16.0, 10.0, 10.0
AUG, 20.0, 30.0, 39.0, 33.0, 31.0, 14.0, 13.0, 18.0, 45.0, 92.0, 90.0, 42.0, 24.0, 17.0,  9.0
      8.0,  7.0,  7.0, 19.0, 29.0, 28.0, 33.0, 88.0,237.0,281.0,355.0,451.0,384.0,331.0,279.0,238.0
SEP,213.0,193.0,187.0,198.0,187.0,176.0,158.0,141.0,135.0,128.0,137.0,151.0,197.0,227.0,295.0
    311.0,331.0,408.0,750.0,879.0,788.0,655.0,549.0,468.0,413.0,374.0,343.0,319.0,295.0,275.0
2004, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT,260.0,251.0,240.0,230.0,219.0,215.0,228.0,326.0,347.0,626.0,664.0,542.0,466.0,413.0,370.0
    340.0,331.0,369.0,500.0,655.0,598.0,542.0,520.0,524.0,515.0,503.0,534.0,523.0,488.0,465.0,492.0
NOV,604.0,600.0,928.0, 1330, 1180,973.0,812.0,704.0,628.0,568.0,521.0,482.0,450.0,425.0,409.0
    402.0,437.0,424.0,455.0,524.0,495.0,461.0,439.0,433.0,458.0,636.0,761.0,716.0,652.0,604.0
DEC,591.0,637.0,661.0,629.0,612.0,622.0,668.0,940.0, 2430, 3130, 3560, 4160, 4220, 3620, 3090
     2610, 2130, 1710, 1400, 1220, 1090,985.0,944.0,877.0,802.0,822.0, 1050, 1040,948.0,889.0,854.0
JAN,813.0,795.0,762.0,707.0,659.0,617.0,597.0,614.0,634.0,604.0,582.0,559.0,540.0,553.0,551.0
    543.0,577.0,771.0, 1610, 1540, 1280, 1080,936.0,823.0,743.0,683.0,640.0,616.0,603.0,721.0,761.0
FEB,693.0,642.0,606.0,577.0,568.0,587.0,571.0,584.0,564.0,537.0,517.0,502.0,507.0,545.0,524.0
    496.0,477.0,461.0,454.0,441.0,438.0,421.0,400.0,382.0,368.0,356.0,348.0,342.0
MAR,337.0,340.0,327.0,319.0,306.0,296.0,289.0,283.0,274.0,264.0,267.0,261.0,250.0,236.0,223.0
    222.0,224.0,269.0,282.0,287.0,346.0,372.0,368.0,396.0,425.0,420.0,981.0, 3580, 4470, 4590, 4060
APR, 3000, 2490, 2220, 1960, 1770, 1540, 1400, 1490, 1640, 1500, 1420, 1640, 1580, 1470, 1400
     1380, 2040, 2290, 2240, 2020, 1740, 1500, 1340, 1330, 1350, 1210, 1070,953.0,850.0,765.0
MAY,710.0,664.0,639.0,602.0,603.0,626.0,669.0,662.0,639.0,804.0, 1390, 1560, 1380, 1190, 1060
    980.0, 1010, 1070, 1530, 2070, 2180, 2100, 2010, 1760, 1510, 1310, 1130,970.0,837.0,752.0,683.0
JUN,641.0,676.0,696.0,620.0,560.0,571.0,728.0,988.0, 1040,886.0,751.0,683.0,631.0,573.0,529.0
    493.0,472.0,502.0,512.0,492.0,482.0,445.0,418.0,397.0,364.0,342.0,337.0,372.0,467.0,437.0
JUL,376.0,336.0,303.0,290.0,263.0,233.0,230.0,246.0,235.0,242.0,262.0,252.0,229.0,214.0,198.0
    179.0,154.0,139.0,131.0,119.0,114.0,106.0,105.0,108.0,104.0, 92.0, 79.0, 72.0, 66.0, 63.0, 62.0
AUG, 62.0, 60.0, 54.0, 50.0, 47.0, 42.0, 39.0, 41.0, 46.0, 38.0, 19.0, 25.0, 37.0, 34.0, 41.0
     42.0, 31.0, 23.0, 24.0, 30.0, 32.0, 28.0, 33.0, 31.0, 25.0, 19.0, 15.0, 18.0, 24.0, 39.0, 37.0
SEP, 36.0, 29.0, 22.0, 29.0, 36.0, 39.0, 37.0, 35.0, 29.0, 30.0, 39.0, 51.0, 59.0, 58.0, 55.0
     52.0, 48.0, 55.0, 62.0, 57.0, 52.0, 47.0, 45.0, 43.0, 41.0, 44.0, 50.0, 50.0, 48.0, 57.0
2005, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT,121.0,232.0,224.0,230.0,230.0,185.0,144.0,125.0,118.0,115.0,119.0,117.0,112.0,109.0,110.0
    108.0,123.0,170.0,154.0,140.0,219.0,284.0,225.0,189.0,168.0,158.0,160.0,197.0,280.0,458.0,424.0
NOV,719.0, 2530, 2470, 2030, 2260, 2320, 2300, 1960, 1530, 1200, 1020, 1350, 1750, 2180, 2310
     1910, 1470, 1170,945.0,790.0,672.0,583.0,515.0,464.0,491.0, 1380, 1830, 1450, 1220, 1470
DEC, 1630, 1760, 2620, 2870, 2510, 2090, 1710, 1400, 1190, 1010,888.0,818.0,762.0,706.0,646.0
    589.0,541.0,499.0,489.0,859.0, 1740, 3260, 5000, 5340, 4810, 3990, 3410, 3900, 5400, 6090, %10800
JAN, %13000, %10400, 8220, 6870, 5980, 5370, 5450, 5720, 5830, 6220, 9450, %11500, 9740, 8510, 7720
     6740, 6390, 8550, 8200, 7170, 6730, 6340, 5830, 5250, 4680, 4200, 3940, 4040, 4560, 5000, 5460
FEB, 5790, 5700, 5420, 5270, 5460, 5370, 4880, 4260, 3660, 3140, 2700, 2300, 1930, 1590, 1390
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     1250, 1130, 1030,938.0,878.0,830.0,797.0,771.0,754.0,735.0,697.0,676.0,820.0
MAR, 1870, 2040, 1730, 1480, 1310, 1200, 1110, 1110, 1400, 2140, 2330, 2050, 1770, 1540, 1380
     1290, 1370, 1490, 1590, 1560, 1470, 1390, 1320, 1270, 1410, 1560, 1480, 1360, 1270, 1230, 1200
APR, 1300, 1490, 1540, 1530, 1420, 1330, 1220, 1130, 1280, 1350, 1420, 1390, 1370, 1300, 1810
     2710, 2900, 2640, 2270, 1980, 1780, 1670, 1490, 1320, 1180, 1060,978.0,907.0,858.0,842.0
MAY,803.0,731.0,673.0,632.0,592.0,563.0,544.0,546.0,582.0,541.0,501.0,472.0,438.0,410.0,387.0
    369.0,350.0,327.0,309.0,297.0,312.0,338.0,386.0,455.0,515.0,475.0,518.0,633.0,888.0,979.0,797.0
JUN,661.0,646.0,877.0,902.0,919.0,936.0,828.0,719.0,636.0,579.0,536.0,499.0,466.0,450.0,422.0
    412.0,396.0,392.0,356.0,322.0,296.0,274.0,256.0,233.0,214.0,205.0,186.0,161.0,149.0,149.0
JUL,143.0,133.0,130.0,118.0,109.0,109.0,117.0,127.0,119.0,106.0, 93.0, 94.0,102.0,103.0, 98.0
     91.0, 88.0, 85.0, 73.0, 66.0, 56.0, 44.0, 37.0, 43.0, 41.0, 34.0, 24.0, 27.0, 35.0, 36.0, 47.0
AUG, 53.0, 45.0, 36.0, 23.0, 21.0, 23.0, 20.0, 20.0, 20.0, 27.0, 29.0, 26.0, 26.0, 33.0, 36.0
     34.0, 30.0, 30.0, 36.0, 35.0, 34.0, 37.0, 36.0, 26.0, 17.0, 16.0, 13.0, 13.0, 12.0, 14.0, 15.0
SEP, 14.0, 13.0, 13.0, 13.0, 19.0, 16.0, 13.0, 14.0, 13.0, 10.0, 10.0, 12.0, 16.0, 20.0, 23.0
     32.0, 40.0, 44.0, 49.0, 56.0, 64.0, 68.0, 71.0, 70.0, 68.0, 58.0, 48.0, 42.0, 29.0, 32.0
2006, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT, 44.0, 46.0, 51.0, 50.0, 39.0, 42.0, 50.0, 53.0, 55.0, 61.0, 60.0, 55.0, 62.0, 66.0, 75.0
     89.0,104.0,120.0,116.0,110.0,120.0,136.0,121.0,111.0,108.0,117.0,122.0,119.0,119.0,113.0,109.0
NOV,116.0,129.0,183.0,363.0,801.0, 1620, 2890, 4850, 5250, 5310, 4890, 4350, 3940, 4050, 3830
     3430, 3130, 2650, 2180, 2400, 2900, 3390, 4360, 5110, 5590, 5750, 5690, 5380, 4830, 4260
DEC, 3810, 3440, 3020, 2630, 2250, 1870, 1560, 1370, 1270, 1300, 1330, 1920, 2750, 3740, 5280
     6210, 6040, 5260, 4300, 3460, 3040, 3050, 2950, 3150, 3730, 4980, 5930, 6100, 5560, 4830, 4050
JAN, 3380, 2920, 3660, 5730, 6160, 5970, 5640, 5230, 4970, 4820, 4640, 4250, 3690, 3150, 2700
     2330, 1990, 1670, 1480, 1420, 1440, 1350, 1240, 1160, 1070,999.0,943.0,888.0,828.0,779.0,741.0
FEB,705.0,664.0,627.0,595.0,578.0,567.0,559.0,554.0,583.0,642.0,683.0,788.0,841.0,841.0,880.0
     2390, 4140, 4170, 3570, 3170, 3550, 3590, 3350, 3140, 3430, 3830, 3860, 3730
MAR, 3570, 3390, 3420, 3380, 3190, 2960, 2730, 2680, 2570, 2320, 2160, 2200, 2440, 2280, 1960
     1670, 1470, 1340, 1270, 1390, 1660, 1540, 1370, 1250, 1440, 2370, 2340, 2060, 1770, 1560, 1400
APR, 1340, 1300, 1190, 1080, 1000,920.0,888.0,957.0, 1010, 1210, 1280, 1200, 1110, 1050, 1080
     1050,983.0, 1040, 1120, 1120, 1070, 1070, 1130, 1060,956.0,884.0,822.0,764.0,715.0,663.0
MAY,623.0,621.0,789.0,896.0,862.0,805.0,744.0,692.0,646.0,601.0,561.0,529.0,519.0,510.0,485.0
    451.0,415.0,392.0,375.0,367.0,375.0,412.0,428.0,386.0,353.0,326.0,296.0,274.0,276.0,254.0,237.0
JUN,218.0,205.0,188.0,183.0,171.0,175.0,247.0,254.0,235.0,224.0,245.0,278.0,247.0,212.0,201.0
    196.0,192.0,189.0,168.0,143.0,134.0,131.0,141.0,136.0,119.0,109.0,105.0, 98.0, 93.0,109.0
JUL,127.0,127.0,112.0, 95.0, 87.0, 81.0, 69.0, 58.0, 53.0, 56.0, 50.0, 43.0, 37.0, 35.0, 32.0
     33.0, 34.0, 38.0, 42.0, 62.0, 59.0, 50.0, 59.0, 72.0, 61.0, 53.0, 46.0, 41.0, 38.0, 35.0, 35.0
AUG, 33.0, 23.0, 18.0, 14.0, 14.0, 17.0, 18.0, 19.0, 15.0, 15.0, 16.0, 15.0, 17.0, 19.0, 19.0
     14.0, 12.0, 11.0, 13.0, 21.0, 39.0, 72.0, 89.0, 72.0, 54.0, 40.0, 36.0, 33.0, 26.0, 19.0, 14.0
SEP, 12.0, 10.0, 12.0, 19.0, 29.0, 41.0, 56.0, 46.0, 37.0, 36.0, 28.0, 24.0, 19.0, 19.0, 18.0
     21.0, 27.0, 34.0, 40.0, 47.0, 47.0, 42.0, 39.0, 35.0, 34.0, 33.0, 31.0, 40.0, 69.0, 96.0
2007, Pudding River at Aurora
Regression equation used to convert Pudding 2 Drift flows,-2E-06,0.0416,-0.8081
OCT,136.0,229.0,271.0,275.0,362.0,325.0,243.0,195.0,178.0,186.0,177.0,179.0,190.0,171.0,156.0
    149.0,154.0,206.0,355.0,803.0, 1470, 1570, 1190,847.0,657.0,569.0,487.0,420.0,370.0,338.0,308.0
NOV,284.0,269.0,252.0,230.0,219.0,210.0,206.0,198.0,194.0,192.0,249.0,354.0,380.0,699.0,651.0
    587.0,891.0, 2130, 2940, 3370, 3060, 2520, 2020, 1600, 1290, 1090, 1020, 1040,996.0, 1020
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DEC, 1050, 1130, 2300, 4360, 5140, 5020, 4630, 4080, 3420, 2810, 2340, 1920, 1520, 1260, 1120
     1060, 1010, 1120, 1440, 2670, 3770, 3500, 3220, 4090, 5150, 5080, 4610, 4150, 3880, 3860, 3880
JAN, 3640, 3240, 3450, 3790, 4180, 4720, 4770, 4560, 4800, 5020, 5380, 5430, 5400, 5210, 4960
     4580, 4030, 3470, 2930, 2560, 2250, 1850, 1500, 1310, 1190, 1100, 1800, 3000, 2920, 2910, 3300
FEB, 4130, 4450, 4420, 4110, 3630, 3210, 3230, 3610, 3490, 3240, 3030, 2850, 2630, 2430, 2190
     1940, 1710, 1540, 1420, 1340, 1290, 1260, 1200, 1140, 1090, 1080, 1060, 1030, 1010
MAR, 1110, 1500, 1510, 1370, 1230, 1090,988.0,952.0, 1080, 1110, 1130, 1360, 1400, 2020, 2810
     3250, 3200, 3010, 3320, 3330, 3060, 2740, 2420, 2290, 2270, 2130, 2100, 2030, 1990, 2000, 1940
APR, 1750, 1560, 1410, 1300, 1270, 1290, 1400, 1560, 1670, 1610, 1490, 1390, 1350, 1430, 1460
     1360, 1230, 1120, 1060, 1010,971.0,979.0, 1240, 1590, 1640, 1540, 1420, 1360, 1470, 1690
MAY, 1650, 1480, 1350, 1300, 1280, 1270, 1270, 1190, 1070,967.0,921.0,944.0,907.0,862.0,913.0
     1070, 1300, 1420, 1340, 1190, 1150, 1080, 1030,970.0,935.0,935.0,866.0,799.0,778.0,827.0,790.0
JUN,753.0,706.0,677.0,887.0, 1020,929.0, 1040, 1210, 1100,972.0,964.0, 1000,925.0,845.0,779.0
    716.0,657.0,610.0,563.0,522.0,492.0,477.0,456.0,420.0,384.0,354.0,339.0,319.0,310.0,326.0
JUL,305.0,282.0,259.0,244.0,234.0,226.0,228.0,214.0,193.0,170.0,149.0,135.0,126.0,120.0,115.0
    103.0, 92.0, 88.0, 92.0, 89.0, 87.0, 86.0, 74.0, 71.0, 70.0, 60.0, 52.0, 55.0, 58.0, 53.0, 47.0
AUG, 47.0, 49.0, 61.0, 82.0, 83.0, 71.0, 56.0, 48.0, 47.0, 49.0, 59.0, 62.0, 48.0, 40.0, 38.0
     34.0, 32.0, 34.0, 33.0, 40.0, 71.0,186.0,216.0,167.0,135.0,119.0,110.0,104.0, 94.0, 81.0, 75.0
SEP, 78.0, 75.0, 69.0, 64.0, 58.0, 53.0, 47.0, 47.0, 52.0, 45.0, 38.0, 33.0, 31.0, 30.0, 33.0
     39.0, 38.0, 35.0, 35.0, 34.0, 37.0, 44.0, 52.0, 60.0, 68.0, 77.0, 95.0, 95.0, 82.0, 74.0
2008, Upper Drift Creek
Regression equation used to convert Pudding 2 Drift flows,0,1,0
OCT,  0.5,  0.5,  1.0,  5.0,  4.0,  3.8,  3.5,  3.5,  4.0,  3.0,  2.8,  2.6,  2.5,  2.3,  2.1
      2.0,  1.6,  1.8,  1.3,  1.0,  1.0,  1.2,  0.8,  0.7,  0.6,  0.6,  0.6,  0.6,  0.6,  0.6,  0.6
NOV,  0.6,  0.7,  1.0,  6.0,  5.0,  3.3,  3.5,  3.0,  3.5,  4.0,  5.0, 22.0,130.0, 85.0, 54.0
     40.0, 34.0, 28.0, 23.0, 24.0, 25.0, 24.0, 23.0, 22.0, 21.0, 20.0, 20.0, 19.0, 18.0, 17.0
DEC, 17.0, 19.0, 20.0, 19.0, 19.0, 17.0, 17.0, 19.0, 17.0, 16.0, 15.0, 17.0, 26.0, 23.0, 19.0
     17.0, 17.0, 28.0, 25.0, 24.0, 33.0, 60.0, 50.0, 40.0, 50.0, 55.0,110.0,200.0,215.0,160.0,130.0
JAN,275.0,500.0,267.0,181.0,173.0,159.0,161.0,198.0,163.0,132.0,115.0, 96.0, 84.0, 73.0, 65.0
     57.0, 50.0, 44.0, 39.0, 35.0, 32.0, 30.0, 28.0, 26.0, 27.0, 25.0, 24.0, 27.0, 25.0, 24.0, 23.0
FEB, 22.0, 21.0, 21.0, 20.0, 19.0, 23.0, 23.0, 22.0, 22.0, 22.0, 25.0, 24.0, 25.0, 24.0, 24.0
     23.0, 23.0, 22.0, 21.0, 20.0, 19.0, 19.0, 24.0, 71.0,126.0,156.0,123.0,106.0
MAR, 91.0, 92.0, 86.0, 74.0, 77.0, 71.0, 65.0, 62.0, 60.0, 58.0, 54.0, 50.0, 46.0, 46.0, 80.0
     92.0, 84.0, 73.0, 66.0, 60.0, 54.0, 62.0, 59.0, 54.0, 61.0, 59.0, 54.0, 56.0, 68.0, 66.0, 63.0
APR, 60.0, 81.0, 80.0, 72.0, 64.0, 56.0, 51.0, 46.0, 44.0, 45.0, 38.0, 35.0, 44.0, 42.0, 39.0
     35.0, 35.0, 33.0, 30.0, 27.0, 25.0, 24.0, 23.0, 22.0, 21.0, 20.0, 20.0, 27.0, 29.0, 24.0
MAY, 22.0, 39.0, 39.0, 40.0, 70.0, 98.0,128.0,108.0, 89.0, 75.0, 65.0, 59.0, 53.0, 66.0, 54.0
     46.0, 40.0, 36.0, 37.0, 33.0, 29.0, 26.0, 24.0, 22.0, 21.0, 19.0, 18.0, 16.0, 15.0, 14.0, 11.0
JUN, 11.0, 10.0,  9.8, 10.0, 13.0, 12.0, 11.0, 10.0,  9.3,  8.8,  8.7,  8.4,  7.9,  7.5,  7.2
      6.8,  6.5,  6.2,  6.2,  6.0,  5.8,  5.1,  4.7,  4.4,  4.0,  4.0,  3.5,  3.2,  3.2,  3.1
JUL,  3.0,  2.7,  2.3,  2.0,  2.0,  1.8,  1.7,  1.6,  1.7,  1.8,  1.8,  2.0,  3.0,  2.8,  2.1
      1.6,  1.2,  0.9,  0.8,  0.7,  0.7,  0.6,  0.6,  0.5,  0.4,  0.3,  0.3,  0.3,  0.3,  0.3,  0.2
AUG,  0.2,  0.2,  0.2,  0.2,  0.2,  0.3,  0.3,  0.3,  0.4,  0.3,  0.3,  0.4,  0.5,  0.3,  0.3
      0.3,  0.3,  0.2,  0.2,  0.2,  0.2,  0.2,  0.2,  0.1,  0.1,  0.1,  0.1,  0.1,  0.2,  0.2,  0.2
SEP,  0.2,  0.2,  0.2,  0.2,  0.5,  0.9,  0.9,  0.4,  0.3,  0.3,  0.3,  0.3,  0.3,  0.3,  0.7
      3.7,  1.7,  0.8,  0.4,  0.3,  0.3,  0.2,  0.2,  0.2,  0.2,  0.2,  0.2,  0.2,  0.2,  0.2
2009, UPPER DRIFT CR
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Regression equation used to convert Pudding 2 Drift flows,0,1,0
OCT,  0.7,  0.7,  0.7,  0.7,  0.8,  5.8,  2.9,  1.4,  0.7,  0.3,  0.1,  0.1,  0.0,  0.4,  0.9
      0.9,  0.9,  2.3,  1.7,  1.1,  1.1,  1.3,  2.1,  4.9,  3.7,  6.1, 10.5,  6.5,  5.8, 10.9, 12.1
NOV, 10.8,  8.6,  6.7,  5.4,  4.8,  5.1, 36.3, 55.5, 52.9, 46.1, 51.6, 70.5, 66.7, 62.5, 51.0
     41.7, 65.8, 60.7, 52.8, 54.8, 67.1, 79.7, 71.4, 59.6, 50.8, 51.3,108.7, 89.7, 74.3, 62.4
DEC, 54.4, 48.3, 41.2, 35.6, 31.1, 27.5, 24.1, 21.0, 18.4, 17.1, 16.8, 17.1, 17.5, 16.8, 55.3
    114.3,103.9, 89.1, 82.0, 80.1,119.8,135.7,110.5, 93.7, 81.4, 70.0, 60.9, 53.7, 48.5, 62.8,100.9
JAN,187.3,165.7,132.5,113.9,130.9,191.8,157.0,132.5,124.2,104.6, 91.6, 99.4, 97.8, 90.2, 92.0
    155.8,155.4,143.9,123.0,104.4, 91.3, 82.0, 73.9, 70.9, 93.9, 83.8, 73.4, 63.6, 59.0, 54.7, 50.0
FEB, 45.2, 45.4, 44.0, 44.3, 43.9, 40.6, 38.2, 35.2, 33.4, 31.7, 32.8, 39.3, 45.3, 55.2, 63.2
     69.0, 64.9, 59.7, 54.4, 49.0, 43.6, 39.0, 36.9, 46.6, 50.3, 56.3, 62.0, 55.8
MAR, 51.4, 47.6, 44.8, 42.0, 37.5, 34.2, 31.8, 35.2, 30.9, 30.8, 32.4, 61.2, 83.3, 72.9, 64.3
     57.4, 52.2, 46.2, 41.6, 37.9, 40.1, 43.6, 37.8, 34.8, 43.8, 94.4, 96.5, 93.9,232.6,263.4,215.2
APR,172.0,166.4,181.4,162.4,142.8,129.9,113.1,112.6, 92.7, 86.9, 79.6, 74.5, 68.2, 63.3, 99.5
     85.4, 74.2, 65.9, 59.3, 55.3, 61.0, 50.2, 45.0, 43.3, 39.2, 37.3, 62.1, 89.3, 94.0, 82.2
MAY, 70.8, 62.6, 63.1, 56.6, 52.4, 48.0, 43.4, 39.8, 36.5, 38.7, 34.8, 31.1, 28.3, 26.2, 24.1
     22.6, 25.0, 29.7, 29.3, 27.5, 28.5, 53.5, 54.1, 51.5, 51.2, 82.0, 86.8, 75.3, 68.7, 60.2, 68.2
JUN, 68.5,136.6,195.2,218.1,175.0,143.8,127.8,100.2, 90.7,101.4,106.5, 90.6, 77.1, 67.6, 61.9
     56.1, 48.5, 40.5, 33.8, 32.1, 30.6, 25.8, 25.5, 23.9, 20.6, 18.8, 17.5, 16.4, 15.4, 14.6
JUL, 14.8, 15.8, 15.3, 13.7, 13.1, 12.2, 11.4, 10.5, 10.0,  9.3,  8.9,  8.4,  8.2,  7.4,  6.7
      6.5,  6.1,  6.0,  6.0,  6.1,  5.7,  5.4,  5.1,  4.8,  4.6,  4.3,  3.9,  3.8,  3.8,  3.6,  3.5
AUG,  3.2,  3.0,  2.8,  2.7,  2.6,  2.4,  2.1,  2.0,  2.6,  2.3,  2.2,  2.0,  1.6,  1.2,  1.0
      1.0,  0.8,  0.6,  0.7,  0.8,  0.7,  0.6,  0.6,  0.4,  0.3,  0.3,  0.5,  0.4,  0.2,  0.3,  0.5
SEP,  1.0,  1.3,  1.1,  0.8,  0.5,  0.4,  1.1,  2.2,  2.0,  1.5,  1.2,  0.9,  0.8,  0.7,  4.4
      3.9,  2.9,  4.3,  9.1,  8.4,  7.0,  4.7,  3.5,  3.1,  2.8,  2.6,  2.8,  2.4,  2.1,  1.9
2010, UPPER DRIFT CR.
Regression equation used to convert Pudding 2 Drift flows,0,1,0
OCT,  0.9,  0.9,  0.9,  0.9,  0.7,  0.6,  0.5,  0.5,  1.3, 10.3, 12.1,  7.4,  5.4,  4.3,  3.7
      3.3,  3.0,  2.7,  2.5,  2.3,  2.2,  4.7,  6.5, 13.3, 18.5, 23.9, 20.4, 19.5, 21.9, 18.3, 28.4
NOV, 27.8, 65.2, 53.0, 41.2, 33.7, 32.1, 93.1, 76.6, 72.6, 88.3, 73.0, 64.5, 54.9, 56.1, 54.2
     59.1, 56.7,147.3,137.0,125.5,104.5,107.3,121.1, 99.0, 80.7, 75.5,101.6, 90.6, 80.0, 84.5
DEC,151.0,146.3,117.1, 97.9, 82.7, 72.1, 62.7, 70.8,112.5,161.5,150.4,149.7,216.2,254.5,199.1
    157.1,129.7,125.3,112.1,102.0, 89.3, 77.3, 67.6, 59.9, 54.8, 61.5, 70.8,149.0,245.8,164.8,129.6
JAN,107.9, 91.2, 78.1, 68.0, 61.8, 56.9, 51.5, 52.3, 49.9, 46.6, 43.0, 48.5, 79.3, 97.2, 96.0
    250.0,302.8,217.6,203.9,153.1,130.7,115.0, 97.9, 85.6, 74.6, 66.1, 58.6, 52.7, 47.3, 42.4, 37.9
FEB, 34.0, 30.7, 28.2, 26.3, 25.4, 24.3, 24.1, 23.2, 24.3, 23.6, 22.6, 21.8, 28.9, 28.1, 56.3
     77.6, 67.2, 60.0, 58.0, 52.2, 47.8, 44.9, 44.0, 44.9, 42.5, 39.0, 37.8, 79.3
MAR,197.3,177.4,147.4,131.6,125.3,105.4, 92.4, 82.5, 77.0,121.7,120.8,104.8,103.9,121.8,114.7
    130.4,141.4,130.2,121.7,106.9, 98.9, 90.9, 80.9, 79.1, 76.0, 90.9, 89.8, 89.4,105.8,117.1,104.7
APR, 98.3,104.8, 89.6, 81.8, 86.6, 80.3, 86.9, 82.2, 74.6, 69.1, 75.6, 70.8, 69.2, 68.7, 82.3
    123.0,130.4,110.1, 92.6, 78.3, 70.3, 62.5, 55.5, 51.6, 64.4, 63.9, 63.3, 66.7, 78.3, 73.6
MAY, 66.9, 62.0, 56.0, 50.4, 46.0, 43.8, 47.8, 46.9, 49.5, 44.5, 43.9, 47.7, 42.5, 40.2, 45.0
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JUN, 58.4, 57.3, 52.7, 46.8, 41.8, 39.2, 35.8, 32.9, 29.4, 26.9, 25.3, 23.3, 24.5, 21.5, 19.5
     17.6, 17.8, 17.9, 16.5, 16.9, 15.7, 14.9, 15.0, 14.2, 13.4, 12.9, 12.3, 13.1, 13.0, 13.9
JUL, 16.7, 13.6, 11.9, 11.0, 10.1,  9.2,  8.8,  8.8,  8.2,  8.0,  8.2,  8.9,  9.6,  8.7,  7.7
      8.3, 11.9, 13.1, 11.4, 10.6,  8.9,  8.4,  7.5,  6.8,  6.4,  6.1,  5.7,  5.4,  5.0,  4.8,  4.8
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AUG,  4.5,  4.1,  4.8,  3.8,  3.5,  3.4,  3.5,  3.6,  3.7,  3.9,  3.1,  2.7,  2.5,  2.9,  2.9
      2.6,  2.3,  2.2,  2.0,  1.7,  1.5,  1.7,  1.6,  1.5,  1.4,  2.8,  2.0,  1.7,  1.7,  1.8,  1.6
SEP,  1.6,  1.4,  1.3,  1.1,  1.0,  0.7,  0.5,  0.6,  0.7,  0.7,  0.8,  0.7,  0.8,  1.0,  1.1
      1.2,  1.1,  1.0,  1.4,  1.5,  1.2,  1.1,  0.9,  0.7,  0.9,  1.4,  4.0,  3.9,  2.8,  2.7
END
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A8.5 Model Output for 2008-2009 Multi-Year Simulation (using local inflow)

(Relying on local Inflow in Meeting Water Rights)

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18	18	10	2008	1.80	660.55	5.26	0.02	1.28	4.00	1.80	0.00	0.00	1.80	1	660.55	6,893
19	19	10	2008	1.30	660.55	5.26	0.02	0.92	4.36	1.30	0.00	0.00	1.30	1	660.55	6,893
20	20	10	2008	1.00	660.55	5.26	0.02	0.71	4.57	1.00	0.00	0.00	1.00	1	660.55	6,893
21	21	10	2008	1.00	660.55	5.26	0.02	0.71	4.57	1.00	0.00	0.00	1.00	1	660.55	6,893
22	22	10	2008	1.20	660.55	5.26	0.02	0.85	4.43	1.20	0.00	0.00	1.20	1	660.55	6,893
23	23	10	2008	0.80	660.55	5.26	0.02	0.57	4.71	0.80	0.00	0.00	0.80	1	660.55	6,893
24	24	10	2008	0.70	660.55	5.26	0.02	0.50	4.78	0.70	0.00	0.00	0.70	1	660.55	6,893
25	25	10	2008	0.60	660.55	5.26	0.02	0.43	4.85	0.60	0.00	0.00	0.60	1	660.55	6,893
26	26	10	2008	0.55	660.55	5.26	0.02	0.39	4.89	0.55	0.00	0.00	0.55	1	660.55	6,893
27	27	10	2008	0.60	660.55	5.26	0.02	0.43	4.85	0.60	0.00	0.00	0.60	1	660.55	6,893
28	28	10	2008	0.60	660.55	5.26	0.02	0.43	4.85	0.60	0.00	0.00	0.60	1	660.55	6,893
29	29	10	2008	0.60	660.55	5.26	0.02	0.43	4.85	0.60	0.00	0.00	0.60	1	660.55	6,893
30	30	10	2008	0.55	660.55	5.26	0.02	0.39	4.89	0.55	0.00	0.00	0.55	1	660.55	6,893
31	31	10	2008	0.60	660.55	5.26	0.02	0.43	4.85	0.60	0.00	0.00	0.60	1	660.55	6,893

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
32	1	11	2008	0.65	660.55	40.00	0.93	0.31	40.62	0.65	0.00	0.00	0.65	1	660.55	6,893
33	2	11	2008	0.70	660.55	40.00	0.93	0.34	40.59	0.70	0.00	0.00	0.70	1	660.55	6,893
34	3	11	2008	1.00	660.55	40.00	0.93	0.48	40.45	1.00	0.00	0.00	1.00	1	660.55	6,893
35	4	11	2008	6.00	660.55	40.00	0.93	2.88	38.05	6.00	0.00	0.00	6.00	1	660.55	6,893
36	5	11	2008	5.00	660.55	40.00	0.93	2.40	38.53	5.00	0.00	0.00	5.00	1	660.55	6,893
37	6	11	2008	3.30	660.55	40.00	0.93	1.58	39.35	3.30	0.00	0.00	3.30	1	660.55	6,893
38	7	11	2008	3.50	660.55	40.00	0.93	1.68	39.25	3.50	0.00	0.00	3.50	1	660.55	6,893
39	8	11	2008	3.00	660.55	40.00	0.93	1.44	39.49	3.00	0.00	0.00	3.00	1	660.55	6,893
40	9	11	2008	3.50	660.55	40.00	0.93	1.68	39.25	3.50	0.00	0.00	3.50	1	660.55	6,893
41	10	11	2008	4.00	660.55	40.00	0.93	1.92	39.01	4.00	0.00	0.00	4.00	1	660.55	6,893
42	11	11	2008	5.00	660.55	40.00	0.93	2.40	38.53	5.00	0.00	0.00	5.00	1	660.55	6,893
43	12	11	2008	22.00	660.55	40.00	0.93	10.56	30.37	22.00	0.00	0.00	22.00	1	660.55	6,893
44	13	11	2008	130.00	660.55	40.00	0.93	62.40	1.00	1.00	0.00	0.00	1.00	0	661.36	7,149
45	14	11	2008	85.00	661.36	40.00	0.93	40.80	1.00	1.00	0.00	0.00	1.00	0	661.89	7,315
46	15	11	2008	54.00	661.89	40.00	0.93	25.92	15.01	15.01	0.00	0.00	15.01	0	662.14	7,393
47	16	11	2008	40.00	662.14	40.00	0.93	19.20	21.73	21.73	0.00	0.00	21.73	0	662.25	7,429
48	17	11	2008	34.00	662.25	40.00	0.93	16.32	24.61	24.61	0.00	0.00	24.61	0	662.31	7,448
49	18	11	2008	28.00	662.31	40.00	0.93	13.44	27.49	27.49	0.00	0.00	27.49	0	662.32	7,449
50	19	11	2008	23.00	662.32	40.00	0.93	11.04	29.89	23.00	0.00	0.00	23.00	1	662.32	7,449
51	20	11	2008	24.00	662.32	40.00	0.93	11.52	29.41	24.00	0.00	0.00	24.00	1	662.32	7,449
52	21	11	2008	25.00	662.32	40.00	0.93	12.00	28.93	25.00	0.00	0.00	25.00	1	662.32	7,449
53	22	11	2008	24.00	662.32	40.00	0.93	11.52	29.41	24.00	0.00	0.00	24.00	1	662.32	7,449
54	23	11	2008	23.00	662.32	40.00	0.93	11.04	29.89	23.00	0.00	0.00	23.00	1	662.32	7,449
55	24	11	2008	22.00	662.32	40.00	0.93	10.56	30.37	22.00	0.00	0.00	22.00	1	662.32	7,449
56	25	11	2008	21.00	662.32	40.00	0.93	10.08	30.85	21.00	0.00	0.00	21.00	1	662.32	7,449
57	26	11	2008	20.00	662.32	40.00	0.93	9.60	31.33	20.00	0.00	0.00	20.00	1	662.32	7,449
58	27	11	2008	20.00	662.32	40.00	0.93	9.60	31.33	20.00	0.00	0.00	20.00	1	662.32	7,449
59	28	11	2008	19.00	662.32	40.00	0.93	9.12	31.81	19.00	0.00	0.00	19.00	1	662.32	7,449
60	29	11	2008	18.00	662.32	40.00	0.93	8.64	32.29	18.00	0.00	0.00	18.00	1	662.32	7,449
61	30	11	2008	17.00	662.32	40.00	0.93	8.16	32.77	17.00	0.00	0.00	17.00	1	662.32	7,449

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
62	1	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
63	2	12	2008	19.00	662.32	40.00	2.11	7.98	34.13	19.00	0.00	0.00	19.00	1	662.32	7,449
64	3	12	2008	20.00	662.32	40.00	2.11	8.40	33.71	20.00	0.00	0.00	20.00	1	662.32	7,449
65	4	12	2008	19.00	662.32	40.00	2.11	7.98	34.13	19.00	0.00	0.00	19.00	1	662.32	7,449
66	5	12	2008	19.00	662.32	40.00	2.11	7.98	34.13	19.00	0.00	0.00	19.00	1	662.32	7,449
67	6	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
68	7	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
69	8	12	2008	19.00	662.32	40.00	2.11	7.98	34.13	19.00	0.00	0.00	19.00	1	662.32	7,449
70	9	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
71	10	12	2008	16.00	662.32	40.00	2.11	6.72	35.39	16.00	0.00	0.00	16.00	1	662.32	7,449
72	11	12	2008	15.00	662.32	40.00	2.11	6.30	35.81	15.00	0.00	0.00	15.00	1	662.32	7,449
73	12	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
74	13	12	2008	26.00	662.32	40.00	2.11	10.92	31.19	26.00	0.00	0.00	26.00	1	662.32	7,449
75	14	12	2008	23.00	662.32	40.00	2.11	9.66	32.45	23.00	0.00	0.00	23.00	1	662.32	7,449
76	15	12	2008	19.00	662.32	40.00	2.11	7.98	34.13	19.00	0.00	0.00	19.00	1	662.32	7,449
77	16	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
78	17	12	2008	17.00	662.32	40.00	2.11	7.14	34.97	17.00	0.00	0.00	17.00	1	662.32	7,449
79	18	12	2008	28.00	662.32	40.00	2.11	11.76	30.35	28.00	0.00	0.00	28.00	1	662.32	7,449
80	19	12	2008	25.00	662.32	40.00	2.11	10.50	31.61	25.00	0.00	0.00	25.00	1	662.32	7,449
81	20	12	2008	24.00	662.32	40.00	2.11	10.08	32.03	24.00	0.00	0.00	24.00	1	662.32	7,449
82	21	12	2008	33.00	662.32	40.00	2.11	13.86	28.25	28.25	0.00	0.00	28.25	0	662.35	7,458
83	22	12	2008	60.00	662.35	40.00	2.11	25.20	16.91	16.91	0.00	0.00	16.91	0	662.62	7,543
84	23	12	2008	50.00	662.62	40.00	2.11	21.00	21.11	21.11	0.00	0.00	21.11	0	662.80	7,601
85	24	12	2008	40.00	662.80	40.00	2.11	16.80	25.31	25.31	0.00	0.00	25.31	0	662.90	7,630
86	25	12	2008	50.00	662.90	40.00	2.11	21.00	21.11	21.11	0.00	0.00	21.11	0	663.08	7,687
87	26	12	2008	55.00	663.08	40.00	2.11	23.10	19.01	19.01	0.00	0.00	19.01	0	663.31	7,758
88	27	12	2008	110.00	663.31	40.00	2.11	46.20	1.00	1.00	0.00	0.00	1.00	0	664.00	7,975
89	28	12	2008	200.00	664.00	40.00	2.11	84.00	1.00	1.00	0.00	0.00	1.00	0	665.25	8,369
90	29	12	2008	215.00	665.25	40.00	2.11	90.30	1.00	1.00	0.00	0.00	1.00	0	666.61	8,794
91	30	12	2008	160.00	666.61	40.00	2.11	67.20	1.00	1.00	0.00	0.00	1.00	0	667.61	9,109
92	31	12	2008	130.00	667.61	40.00	2.11	54.60	1.00	1.00	0.00	0.00	1.00	0	668.43	9,365

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
93	1	1	2009	275.00	668.43	40.00	2.28	107.25	1.00	1.00	0.00	0.00	1.00	0	670.15	9,908
94	2	1	2009	500.00	670.15	40.00	2.28	195.00	1.00	1.00	0.00	0.00	1.00	0	673.06	10,898
95	3	1	2009	267.00	673.06	40.00	2.28	104.13	1.00	1.00	0.00	0.00	1.00	0	674.61	11,425
96	4	1	2009	181.00	674.61	40.00	2.28	70.59	1.00	1.00	0.00	0.00	1.00	0	675.66	11,782
97	5	1	2009	173.00	675.66	40.00	2.28	67.47	1.00	1.00	0.00	0.00	1.00	0	676.66	12,123
98	6	1	2009	159.00	676.66	40.00	2.28	62.01	1.00	1.00	0.00	0.00	1.00	0	677.58	12,436
99	7	1	2009	161.00	677.58	40.00	2.28	62.79	1.00	1.00	0.00	0.00	1.00	0	678.51	12,754
100	8	1	2009	198.00	678.51	40.00	2.28	77.22	1.00	1.00	0.00	0.00	1.00	0	679.66	13,144
101	9	1	2009	163.00	679.66	40.00	2.28	63.57	1.00	1.00	0.00	0.00	105.16	2	680.00	13,259
102	10	1	2009	132.00	680.00	40.00	2.28	51.48	1.00	1.00	0.00	0.00	132.00	2	680.00	13,259
103	11	1	2009	115.00	680.00	40.00	2.28	44.85	1.00	1.00	0.00	0.00	115.00	2	680.00	13,259
104	12	1	2009	96.00	680.00	40.00	2.28	37.44	4.84	4.84	0.00	0.00	96.00	2	680.00	13,259
105	13	1	2009	84.00	680.00	40.00	2.28	32.76	9.52	9.52	0.00	0.00	84.00	2	680.00	13,259

106	14	1	2009	73.00	680.00	40.00	2.28	28.47	13.81	13.81	0.00	0.00	73.00	2	680.00	13,259
107	15	1	2009	65.00	680.00	40.00	2.28	25.35	16.93	16.93	0.00	0.00	65.00	2	680.00	13,259
108	16	1	2009	57.00	680.00	40.00	2.28	22.23	20.05	20.05	0.00	0.00	57.00	2	680.00	13,259
109	17	1	2009	50.00	680.00	40.00	2.28	19.50	22.78	22.78	0.00	0.00	50.00	2	680.00	13,259
110	18	1	2009	44.00	680.00	40.00	2.28	17.16	25.12	25.12	0.00	0.00	44.00	2	680.00	13,259
111	19	1	2009	39.00	680.00	40.00	2.28	15.21	27.07	27.07	0.00	0.00	39.00	2	680.00	13,259
112	20	1	2009	35.00	680.00	40.00	2.28	13.65	28.63	28.63	0.00	0.00	35.00	2	680.00	13,259
113	21	1	2009	32.00	680.00	40.00	2.28	12.48	29.80	29.80	0.00	0.00	32.00	2	680.00	13,259
114	22	1	2009	30.00	680.00	40.00	2.28	11.70	30.58	30.00	0.00	0.00	30.00	1	680.00	13,259
115	23	1	2009	28.00	680.00	40.00	2.28	10.92	31.36	28.00	0.00	0.00	28.00	1	680.00	13,259
116	24	1	2009	26.00	680.00	40.00	2.28	10.14	32.14	26.00	0.00	0.00	26.00	1	680.00	13,259
117	25	1	2009	27.00	680.00	40.00	2.28	10.53	31.75	27.00	0.00	0.00	27.00	1	680.00	13,259
118	26	1	2009	25.00	680.00	40.00	2.28	9.75	32.53	25.00	0.00	0.00	25.00	1	680.00	13,259
119	27	1	2009	24.00	680.00	40.00	2.28	9.36	32.92	24.00	0.00	0.00	24.00	1	680.00	13,259
120	28	1	2009	27.00	680.00	40.00	2.28	10.53	31.75	27.00	0.00	0.00	27.00	1	680.00	13,259
121	29	1	2009	25.00	680.00	40.00	2.28	9.75	32.53	25.00	0.00	0.00	25.00	1	680.00	13,259
122	30	1	2009	24.00	680.00	40.00	2.28	9.36	32.92	24.00	0.00	0.00	24.00	1	680.00	13,259
123	31	1	2009	23.00	680.00	40.00	2.28	8.97	33.31	23.00	0.00	0.00	23.00	1	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
124	1	2	2009	22.00	680.00	40.00	2.03	11.00	31.03	22.00	0.00	0.00	22.00	1	680.00	13,259
125	2	2	2009	21.00	680.00	40.00	2.03	10.50	31.53	21.00	0.00	0.00	21.00	1	680.00	13,259
126	3	2	2009	21.00	680.00	40.00	2.03	10.50	31.53	21.00	0.00	0.00	21.00	1	680.00	13,259
127	4	2	2009	20.00	680.00	40.00	2.03	10.00	32.03	20.00	0.00	0.00	20.00	1	680.00	13,259
128	5	2	2009	19.00	680.00	40.00	2.03	9.50	32.53	19.00	0.00	0.00	19.00	1	680.00	13,259
129	6	2	2009	23.00	680.00	40.00	2.03	11.50	30.53	23.00	0.00	0.00	23.00	1	680.00	13,259
130	7	2	2009	23.00	680.00	40.00	2.03	11.50	30.53	23.00	0.00	0.00	23.00	1	680.00	13,259
131	8	2	2009	22.00	680.00	40.00	2.03	11.00	31.03	22.00	0.00	0.00	22.00	1	680.00	13,259
132	9	2	2009	22.00	680.00	40.00	2.03	11.00	31.03	22.00	0.00	0.00	22.00	1	680.00	13,259
133	10	2	2009	22.00	680.00	40.00	2.03	11.00	31.03	22.00	0.00	0.00	22.00	1	680.00	13,259
134	11	2	2009	25.00	680.00	40.00	2.03	12.50	29.53	25.00	0.00	0.00	25.00	1	680.00	13,259
135	12	2	2009	24.00	680.00	40.00	2.03	12.00	30.03	24.00	0.00	0.00	24.00	1	680.00	13,259
136	13	2	2009	25.00	680.00	40.00	2.03	12.50	29.53	25.00	0.00	0.00	25.00	1	680.00	13,259
137	14	2	2009	24.00	680.00	40.00	2.03	12.00	30.03	24.00	0.00	0.00	24.00	1	680.00	13,259
138	15	2	2009	24.00	680.00	40.00	2.03	12.00	30.03	24.00	0.00	0.00	24.00	1	680.00	13,259
139	16	2	2009	23.00	680.00	40.00	2.03	11.50	30.53	23.00	0.00	0.00	23.00	1	680.00	13,259
140	17	2	2009	23.00	680.00	40.00	2.03	11.50	30.53	23.00	0.00	0.00	23.00	1	680.00	13,259
141	18	2	2009	22.00	680.00	40.00	2.03	11.00	31.03	22.00	0.00	0.00	22.00	1	680.00	13,259
142	19	2	2009	21.00	680.00	40.00	2.03	10.50	31.53	21.00	0.00	0.00	21.00	1	680.00	13,259
143	20	2	2009	20.00	680.00	40.00	2.03	10.00	32.03	20.00	0.00	0.00	20.00	1	680.00	13,259
144	21	2	2009	19.00	680.00	40.00	2.03	9.50	32.53	19.00	0.00	0.00	19.00	1	680.00	13,259
145	22	2	2009	19.00	680.00	40.00	2.03	9.50	32.53	19.00	0.00	0.00	19.00	1	680.00	13,259
146	23	2	2009	24.00	680.00	40.00	2.03	12.00	30.03	24.00	0.00	0.00	24.00	1	680.00	13,259
147	24	2	2009	71.00	680.00	40.00	2.03	35.50	6.53	6.53	0.00	0.00	71.00	2	680.00	13,259
148	25	2	2009	126.00	680.00	40.00	2.03	63.00	1.00	1.00	0.00	0.00	126.00	2	680.00	13,259
149	26	2	2009	156.00	680.00	40.00	2.03	78.00	1.00	1.00	0.00	0.00	156.00	2	680.00	13,259
150	27	2	2009	123.00	680.00	40.00	2.03	61.50	1.00	1.00	0.00	0.00	123.00	2	680.00	13,259

151	28	2	2009	106.00	680.00	40.00	2.03	53.00	1.00	1.00	0.00	0.00	106.00	2	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
152	1	3	2009	91.00	680.00	40.00	0.03	37.31	2.72	2.72	0.00	0.00	91.00	2	680.00	13,259
153	2	3	2009	92.00	680.00	40.00	0.03	37.72	2.31	2.31	0.00	0.00	92.00	2	680.00	13,259
154	3	3	2009	86.00	680.00	40.00	0.03	35.26	4.77	4.77	0.00	0.00	86.00	2	680.00	13,259
155	4	3	2009	74.00	680.00	40.00	0.03	30.34	9.69	9.69	0.00	0.00	74.00	2	680.00	13,259
156	5	3	2009	77.00	680.00	40.00	0.03	31.57	8.46	8.46	0.00	0.00	77.00	2	680.00	13,259
157	6	3	2009	71.00	680.00	40.00	0.03	29.11	10.92	10.92	0.00	0.00	71.00	2	680.00	13,259
158	7	3	2009	65.00	680.00	40.00	0.03	26.65	13.38	13.38	0.00	0.00	65.00	2	680.00	13,259
159	8	3	2009	62.00	680.00	40.00	0.03	25.42	14.61	14.61	0.00	0.00	62.00	2	680.00	13,259
160	9	3	2009	60.00	680.00	40.00	0.03	24.60	15.43	15.43	0.00	0.00	60.00	2	680.00	13,259
161	10	3	2009	58.00	680.00	40.00	0.03	23.78	16.25	16.25	0.00	0.00	58.00	2	680.00	13,259
162	11	3	2009	54.00	680.00	40.00	0.03	22.14	17.89	17.89	0.00	0.00	54.00	2	680.00	13,259
163	12	3	2009	50.00	680.00	40.00	0.03	20.50	19.53	19.53	0.00	0.00	50.00	2	680.00	13,259
164	13	3	2009	46.00	680.00	40.00	0.03	18.86	21.17	21.17	0.00	0.00	46.00	2	680.00	13,259
165	14	3	2009	46.00	680.00	40.00	0.03	18.86	21.17	21.17	0.00	0.00	46.00	2	680.00	13,259
166	15	3	2009	80.00	680.00	40.00	0.03	32.80	7.23	7.23	0.00	0.00	80.00	2	680.00	13,259
167	16	3	2009	92.00	680.00	40.00	0.03	37.72	2.31	2.31	0.00	0.00	92.00	2	680.00	13,259
168	17	3	2009	84.00	680.00	40.00	0.03	34.44	5.59	5.59	0.00	0.00	84.00	2	680.00	13,259
169	18	3	2009	73.00	680.00	40.00	0.03	29.93	10.10	10.10	0.00	0.00	73.00	2	680.00	13,259
170	19	3	2009	66.00	680.00	40.00	0.03	27.06	12.97	12.97	0.00	0.00	66.00	2	680.00	13,259
171	20	3	2009	60.00	680.00	40.00	0.03	24.60	15.43	15.43	0.00	0.00	60.00	2	680.00	13,259
172	21	3	2009	54.00	680.00	40.00	0.03	22.14	17.89	17.89	0.00	0.00	54.00	2	680.00	13,259
173	22	3	2009	62.00	680.00	40.00	0.03	25.42	14.61	14.61	0.00	0.00	62.00	2	680.00	13,259
174	23	3	2009	59.00	680.00	40.00	0.03	24.19	15.84	15.84	0.00	0.00	59.00	2	680.00	13,259
175	24	3	2009	54.00	680.00	40.00	0.03	22.14	17.89	17.89	0.00	0.00	54.00	2	680.00	13,259
176	25	3	2009	61.00	680.00	40.00	0.03	25.01	15.02	15.02	0.00	0.00	61.00	2	680.00	13,259
177	26	3	2009	59.00	680.00	40.00	0.03	24.19	15.84	15.84	0.00	0.00	59.00	2	680.00	13,259
178	27	3	2009	54.00	680.00	40.00	0.03	22.14	17.89	17.89	0.00	0.00	54.00	2	680.00	13,259
179	28	3	2009	56.00	680.00	40.00	0.03	22.96	17.07	17.07	0.00	0.00	56.00	2	680.00	13,259
180	29	3	2009	68.00	680.00	40.00	0.03	27.88	12.15	12.15	0.00	0.00	68.00	2	680.00	13,259
181	30	3	2009	66.00	680.00	40.00	0.03	27.06	12.97	12.97	0.00	0.00	66.00	2	680.00	13,259
182	31	3	2009	63.00	680.00	40.00	0.03	25.83	14.20	14.20	0.00	0.00	63.00	2	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
183	1	4	2009	60.00	680.00	40.00	0.04	19.80	20.24	20.24	0.00	0.00	60.00	2	680.00	13,259
184	2	4	2009	81.00	680.00	40.00	0.04	26.73	13.31	13.31	0.00	0.00	81.00	2	680.00	13,259
185	3	4	2009	80.00	680.00	40.00	0.04	26.40	13.64	13.64	0.00	0.00	80.00	2	680.00	13,259
186	4	4	2009	72.00	680.00	40.00	0.04	23.76	16.28	16.28	0.00	0.00	72.00	2	680.00	13,259
187	5	4	2009	64.00	680.00	40.00	0.04	21.12	18.92	18.92	0.00	0.00	64.00	2	680.00	13,259
188	6	4	2009	56.00	680.00	40.00	0.04	18.48	21.56	21.56	0.00	0.00	56.00	2	680.00	13,259
189	7	4	2009	51.00	680.00	40.00	0.04	16.83	23.21	23.21	0.00	0.00	51.00	2	680.00	13,259
190	8	4	2009	46.00	680.00	40.00	0.04	15.18	24.86	24.86	0.00	0.00	46.00	2	680.00	13,259
191	9	4	2009	44.00	680.00	40.00	0.04	14.52	25.52	25.52	0.00	0.00	44.00	2	680.00	13,259
192	10	4	2009	45.00	680.00	40.00	0.04	14.85	25.19	25.19	0.00	0.00	45.00	2	680.00	13,259
193	11	4	2009	38.00	680.00	40.00	0.04	12.54	27.50	27.50	0.00	0.00	38.00	2	680.00	13,259

194	12	4	2009	35.00	680.00	40.00	0.04	11.55	28.49	28.49	0.00	0.00	35.00	2	680.00	13,259
195	13	4	2009	44.00	680.00	40.00	0.04	14.52	25.52	25.52	0.00	0.00	44.00	2	680.00	13,259
196	14	4	2009	42.00	680.00	40.00	0.04	13.86	26.18	26.18	0.00	0.00	42.00	2	680.00	13,259
197	15	4	2009	39.00	680.00	40.00	0.04	12.87	27.17	27.17	0.00	0.00	39.00	2	680.00	13,259
198	16	4	2009	35.00	680.00	40.00	0.04	11.55	28.49	28.49	0.00	0.00	35.00	2	680.00	13,259
199	17	4	2009	35.00	680.00	40.00	0.04	11.55	28.49	28.49	0.00	0.00	35.00	2	680.00	13,259
200	18	4	2009	33.00	680.00	40.00	0.04	10.89	29.15	29.15	0.00	0.00	33.00	2	680.00	13,259
201	19	4	2009	30.00	680.00	40.00	0.04	9.90	30.14	30.00	0.00	0.00	30.00	1	680.00	13,259
202	20	4	2009	27.00	680.00	40.00	0.04	8.91	31.13	27.00	0.00	0.00	27.00	1	680.00	13,259
203	21	4	2009	25.00	680.00	40.00	0.04	8.25	31.79	25.00	0.00	0.00	25.00	1	680.00	13,259
204	22	4	2009	24.00	680.00	40.00	0.04	7.92	32.12	24.00	0.00	0.00	24.00	1	680.00	13,259
205	23	4	2009	23.00	680.00	40.00	0.04	7.59	32.45	23.00	0.00	0.00	23.00	1	680.00	13,259
206	24	4	2009	22.00	680.00	40.00	0.04	7.26	32.78	22.00	0.00	0.00	22.00	1	680.00	13,259
207	25	4	2009	21.00	680.00	40.00	0.04	6.93	33.11	21.00	0.00	0.00	21.00	1	680.00	13,259
208	26	4	2009	20.00	680.00	40.00	0.04	6.60	33.44	20.00	0.00	0.00	20.00	1	680.00	13,259
209	27	4	2009	20.00	680.00	40.00	0.04	6.60	33.44	20.00	0.00	0.00	20.00	1	680.00	13,259
210	28	4	2009	27.00	680.00	40.00	0.04	8.91	31.13	27.00	0.00	0.00	27.00	1	680.00	13,259
211	29	4	2009	29.00	680.00	40.00	0.04	9.57	30.47	29.00	0.00	0.00	29.00	1	680.00	13,259
212	30	4	2009	24.00	680.00	40.00	0.04	7.92	32.12	24.00	0.00	0.00	24.00	1	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
213	1	5	2009	22.00	680.00	30.10	0.22	4.84	25.48	22.00	13.00	13.00	35.00	1	679.92	13,233
214	2	5	2009	39.00	679.92	30.10	0.22	8.58	21.74	21.74	13.00	13.00	34.74	0	679.95	13,242
215	3	5	2009	39.00	679.95	30.10	0.22	8.58	21.74	21.74	13.00	13.00	34.74	0	679.97	13,250
216	4	5	2009	40.00	679.97	30.10	0.22	8.80	21.52	21.52	13.00	13.00	35.52	2	680.00	13,259
217	5	5	2009	70.00	680.00	30.10	0.22	15.40	14.92	14.92	13.00	13.00	70.00	2	680.00	13,259
218	6	5	2009	98.00	680.00	30.10	0.22	21.56	8.76	8.76	13.00	13.00	98.00	2	680.00	13,259
219	7	5	2009	128.00	680.00	30.10	0.22	28.16	2.16	2.16	13.00	13.00	128.00	2	680.00	13,259
220	8	5	2009	108.00	680.00	30.10	0.22	23.76	6.56	6.56	13.00	13.00	108.00	2	680.00	13,259
221	9	5	2009	89.00	680.00	30.10	0.22	19.58	10.74	10.74	13.00	13.00	89.00	2	680.00	13,259
222	10	5	2009	75.00	680.00	30.10	0.22	16.50	13.82	13.82	13.00	13.00	75.00	2	680.00	13,259
223	11	5	2009	65.00	680.00	30.10	0.22	14.30	16.02	16.02	13.00	13.00	65.00	2	680.00	13,259
224	12	5	2009	59.00	680.00	30.10	0.22	12.98	17.34	17.34	13.00	13.00	59.00	2	680.00	13,259
225	13	5	2009	53.00	680.00	30.10	0.22	11.66	18.66	18.66	13.00	13.00	53.00	2	680.00	13,259
226	14	5	2009	66.00	680.00	30.10	0.22	14.52	15.80	15.80	13.00	13.00	66.00	2	680.00	13,259
227	15	5	2009	54.00	680.00	30.10	0.22	11.88	18.44	18.44	13.00	13.00	54.00	2	680.00	13,259
228	16	5	2009	46.00	680.00	30.10	0.22	10.12	20.20	20.20	13.00	13.00	46.00	2	680.00	13,259
229	17	5	2009	40.00	680.00	30.10	0.22	8.80	21.52	21.52	13.00	13.00	40.00	2	680.00	13,259
230	18	5	2009	36.00	680.00	30.10	0.22	7.92	22.40	22.40	13.00	13.00	36.00	2	680.00	13,259
231	19	5	2009	37.00	680.00	30.10	0.22	8.14	22.18	22.18	13.00	13.00	37.00	2	680.00	13,259
232	20	5	2009	33.00	680.00	30.10	0.22	7.26	23.06	23.06	13.00	13.00	36.06	0	679.98	13,253
233	21	5	2009	29.00	679.98	30.10	0.22	6.38	23.94	23.94	13.00	13.00	36.94	0	679.94	13,237
234	22	5	2009	26.00	679.94	30.10	0.22	5.72	24.60	24.60	13.00	13.00	37.60	0	679.87	13,214
235	23	5	2009	24.00	679.87	30.10	0.22	5.28	25.04	24.00	13.00	13.00	37.00	1	679.79	13,188
236	24	5	2009	22.00	679.79	30.10	0.22	4.84	25.48	22.00	13.00	13.00	35.00	1	679.72	13,163
237	25	5	2009	21.00	679.72	30.10	0.22	4.62	25.70	21.00	13.00	13.00	34.00	1	679.64	13,137
238	26	5	2009	19.00	679.64	30.10	0.22	4.18	26.14	19.00	13.00	13.00	32.00	1	679.57	13,111

239	27	5	2009	18.00	679.57	30.10	0.22	3.96	26.36	18.00	13.00	13.00	31.00	1	679.49	13,085
240	28	5	2009	16.00	679.49	30.10	0.22	3.52	26.80	16.00	13.00	13.00	29.00	1	679.41	13,059
241	29	5	2009	15.00	679.41	30.10	0.22	3.30	27.02	15.00	13.00	13.00	28.00	1	679.34	13,034
242	30	5	2009	14.00	679.34	30.10	0.22	3.08	27.24	14.00	13.00	13.00	27.00	1	679.26	13,008
243	31	5	2009	11.00	679.26	30.10	0.22	2.42	27.90	11.00	13.00	13.00	24.00	1	679.19	12,982

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
244	1	6	2009	11.00	679.19	13.60	0.44	3.30	10.74	10.74	13.50	13.50	24.24	0	679.11	12,956
245	2	6	2009	10.00	679.11	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	679.03	12,929
246	3	6	2009	9.80	679.03	13.60	0.44	2.94	11.10	9.80	13.50	13.50	23.30	1	678.95	12,902
247	4	6	2009	10.00	678.95	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	678.87	12,876
248	5	6	2009	13.00	678.87	13.60	0.44	3.90	10.14	10.14	13.50	13.50	23.64	0	678.81	12,854
249	6	6	2009	12.00	678.81	13.60	0.44	3.60	10.44	10.44	13.50	13.50	23.94	0	678.74	12,831
250	7	6	2009	11.00	678.74	13.60	0.44	3.30	10.74	10.74	13.50	13.50	24.24	0	678.66	12,805
251	8	6	2009	10.00	678.66	13.60	0.44	3.00	11.04	10.00	13.50	13.50	23.50	1	678.59	12,778
252	9	6	2009	9.30	678.59	13.60	0.44	2.79	11.25	9.30	13.50	13.50	22.80	1	678.51	12,751
253	10	6	2009	8.80	678.51	13.60	0.44	2.64	11.40	8.80	13.50	13.50	22.30	1	678.43	12,724
254	11	6	2009	8.70	678.43	13.60	0.44	2.61	11.43	8.70	13.50	13.50	22.20	1	678.35	12,697
255	12	6	2009	8.40	678.35	13.60	0.44	2.52	11.52	8.40	13.50	13.50	21.90	1	678.27	12,671
256	13	6	2009	7.90	678.27	13.60	0.44	2.37	11.67	7.90	13.50	13.50	21.40	1	678.19	12,644
257	14	6	2009	7.50	678.19	13.60	0.44	2.25	11.79	7.50	13.50	13.50	21.00	1	678.11	12,617
258	15	6	2009	7.20	678.11	13.60	0.44	2.16	11.88	7.20	13.50	13.50	20.70	1	678.03	12,590
259	16	6	2009	6.80	678.03	13.60	0.44	2.04	12.00	6.80	13.50	13.50	20.30	1	677.96	12,564
260	17	6	2009	6.50	677.96	13.60	0.44	1.95	12.09	6.50	13.50	13.50	20.00	1	677.88	12,537
261	18	6	2009	6.20	677.88	13.60	0.44	1.86	12.18	6.20	13.50	13.50	19.70	1	677.80	12,510
262	19	6	2009	6.20	677.80	13.60	0.44	1.86	12.18	6.20	13.50	13.50	19.70	1	677.72	12,483
263	20	6	2009	6.00	677.72	13.60	0.44	1.80	12.24	6.00	13.50	13.50	19.50	1	677.64	12,457
264	21	6	2009	5.80	677.64	13.60	0.44	1.74	12.30	5.80	13.50	13.50	19.30	1	677.56	12,430
265	22	6	2009	5.10	677.56	13.60	0.44	1.53	12.51	5.10	13.50	13.50	18.60	1	677.48	12,403
266	23	6	2009	4.70	677.48	13.60	0.44	1.41	12.63	4.70	13.50	13.50	18.20	1	677.41	12,376
267	24	6	2009	4.40	677.41	13.60	0.44	1.32	12.72	4.40	13.50	13.50	17.90	1	677.33	12,350
268	25	6	2009	4.00	677.33	13.60	0.44	1.20	12.84	4.00	13.50	13.50	17.50	1	677.25	12,323
269	26	6	2009	4.00	677.25	13.60	0.44	1.20	12.84	4.00	13.50	13.50	17.50	1	677.17	12,296
270	27	6	2009	3.50	677.17	13.60	0.44	1.05	12.99	3.50	13.50	13.50	17.00	1	677.09	12,269
271	28	6	2009	3.20	677.09	13.60	0.44	0.96	13.08	3.20	13.50	13.50	16.70	1	677.01	12,242
272	29	6	2009	3.20	677.01	13.60	0.44	0.96	13.08	3.20	13.50	13.50	16.70	1	676.93	12,216
273	30	6	2009	3.10	676.93	13.60	0.44	0.93	13.11	3.10	13.50	13.50	16.60	1	676.85	12,189

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
274	1	7	2009	3.00	676.85	3.00	0.77	0.03	3.74	3.00	26.00	26.00	29.00	1	676.70	12,137
275	2	7	2009	2.70	676.70	3.00	0.77	0.03	3.74	2.70	26.00	26.00	28.70	1	676.55	12,086
276	3	7	2009	2.30	676.55	3.00	0.77	0.02	3.75	2.30	26.00	26.00	28.30	1	676.40	12,034
277	4	7	2009	2.00	676.40	3.00	0.77	0.02	3.75	2.00	26.00	26.00	28.00	1	676.25	11,983
278	5	7	2009	2.00	676.25	3.00	0.77	0.02	3.75	2.00	26.00	26.00	28.00	1	676.10	11,931
279	6	7	2009	1.80	676.10	3.00	0.77	0.02	3.75	1.80	26.00	26.00	27.80	1	675.95	11,880
280	7	7	2009	1.70	675.95	3.00	0.77	0.02	3.75	1.70	26.00	26.00	27.70	1	675.79	11,828
281	8	7	2009	1.60	675.79	3.00	0.77	0.02	3.75	1.60	26.00	26.00	27.60	1	675.64	11,776

282	9	7	2009	1.70	675.64	3.00	0.77	0.02	3.75	1.70	26.00	26.00	27.70	1	675.49	11,725
283	10	7	2009	1.80	675.49	3.00	0.77	0.02	3.75	1.80	26.00	26.00	27.80	1	675.34	11,673
284	11	7	2009	1.80	675.34	3.00	0.77	0.02	3.75	1.80	26.00	26.00	27.80	1	675.19	11,622
285	12	7	2009	2.00	675.19	3.00	0.77	0.02	3.75	2.00	26.00	26.00	28.00	1	675.04	11,570
286	13	7	2009	3.00	675.04	3.00	0.77	0.03	3.74	3.00	26.00	26.00	29.00	1	674.88	11,519
287	14	7	2009	2.80	674.88	3.00	0.77	0.03	3.74	2.80	26.00	26.00	28.80	1	674.73	11,467
288	15	7	2009	2.10	674.73	3.00	0.77	0.02	3.75	2.10	26.00	26.00	28.10	1	674.58	11,416
289	16	7	2009	1.60	674.58	3.00	0.77	0.02	3.75	1.60	26.00	26.00	27.60	1	674.43	11,364
290	17	7	2009	1.20	674.43	3.00	0.77	0.01	3.76	1.20	26.00	26.00	27.20	1	674.28	11,312
291	18	7	2009	0.92	674.28	3.00	0.77	0.01	3.76	0.92	26.00	26.00	26.92	1	674.13	11,261
292	19	7	2009	0.78	674.13	3.00	0.77	0.01	3.76	0.78	26.00	26.00	26.78	1	673.98	11,209
293	20	7	2009	0.73	673.98	3.00	0.77	0.01	3.76	0.73	26.00	26.00	26.73	1	673.82	11,158
294	21	7	2009	0.66	673.82	3.00	0.77	0.01	3.76	0.66	26.00	26.00	26.66	1	673.67	11,106
295	22	7	2009	0.63	673.67	3.00	0.77	0.01	3.76	0.63	26.00	26.00	26.63	1	673.52	11,055
296	23	7	2009	0.57	673.52	3.00	0.77	0.01	3.76	0.57	26.00	26.00	26.57	1	673.37	11,003
297	24	7	2009	0.51	673.37	3.00	0.77	0.01	3.76	0.51	26.00	26.00	26.51	1	673.22	10,952
298	25	7	2009	0.40	673.22	3.00	0.77	0.00	3.77	0.40	26.00	26.00	26.40	1	673.07	10,900
299	26	7	2009	0.35	673.07	3.00	0.77	0.00	3.77	0.35	26.00	26.00	26.35	1	672.91	10,848
300	27	7	2009	0.31	672.91	3.00	0.77	0.00	3.77	0.31	26.00	26.00	26.31	1	672.76	10,797
301	28	7	2009	0.29	672.76	3.00	0.77	0.00	3.77	0.29	26.00	26.00	26.29	1	672.61	10,745
302	29	7	2009	0.26	672.61	3.00	0.77	0.00	3.77	0.26	26.00	26.00	26.26	1	672.46	10,694
303	30	7	2009	0.25	672.46	3.00	0.77	0.00	3.77	0.25	26.00	26.00	26.25	1	672.31	10,642
304	31	7	2009	0.24	672.31	3.00	0.77	0.00	3.77	0.24	26.00	26.00	26.24	1	672.16	10,591

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
305	1	8	2009	0.23	672.16	2.00	0.61	0.04	2.57	0.23	39.00	39.00	39.23	1	671.93	10,513
306	2	8	2009	0.23	671.93	2.00	0.61	0.04	2.57	0.23	39.00	39.00	39.23	1	671.70	10,436
307	3	8	2009	0.23	671.70	2.00	0.61	0.04	2.57	0.23	39.00	39.00	39.23	1	671.47	10,359
308	4	8	2009	0.22	671.47	2.00	0.61	0.04	2.57	0.22	39.00	39.00	39.22	1	671.25	10,281
309	5	8	2009	0.23	671.25	2.00	0.61	0.04	2.57	0.23	39.00	39.00	39.23	1	671.02	10,204
310	6	8	2009	0.25	671.02	2.00	0.61	0.04	2.57	0.25	39.00	39.00	39.25	1	670.79	10,127
311	7	8	2009	0.28	670.79	2.00	0.61	0.05	2.56	0.28	39.00	39.00	39.28	1	670.57	10,049
312	8	8	2009	0.35	670.57	2.00	0.61	0.06	2.55	0.35	39.00	39.00	39.35	1	670.34	9,972
313	9	8	2009	0.42	670.34	2.00	0.61	0.07	2.54	0.42	39.00	39.00	39.42	1	670.11	9,895
314	10	8	2009	0.34	670.11	2.00	0.61	0.06	2.55	0.34	39.00	39.00	39.34	1	669.87	9,817
315	11	8	2009	0.30	669.87	2.00	0.61	0.05	2.56	0.30	39.00	39.00	39.30	1	669.63	9,740
316	12	8	2009	0.39	669.63	2.00	0.61	0.07	2.54	0.39	39.00	39.00	39.39	1	669.38	9,663
317	13	8	2009	0.50	669.38	2.00	0.61	0.09	2.53	0.50	39.00	39.00	39.50	1	669.13	9,585
318	14	8	2009	0.35	669.13	2.00	0.61	0.06	2.55	0.35	39.00	39.00	39.35	1	668.89	9,508
319	15	8	2009	0.30	668.89	2.00	0.61	0.05	2.56	0.30	39.00	39.00	39.30	1	668.64	9,430
320	16	8	2009	0.29	668.64	2.00	0.61	0.05	2.56	0.29	39.00	39.00	39.29	1	668.39	9,353
321	17	8	2009	0.26	668.39	2.00	0.61	0.04	2.57	0.26	39.00	39.00	39.26	1	668.15	9,276
322	18	8	2009	0.20	668.15	2.00	0.61	0.03	2.58	0.20	39.00	39.00	39.20	1	667.90	9,198
323	19	8	2009	0.18	667.90	2.00	0.61	0.03	2.58	0.18	39.00	39.00	39.18	1	667.65	9,121
324	20	8	2009	0.17	667.65	2.00	0.61	0.03	2.58	0.17	39.00	39.00	39.17	1	667.41	9,044
325	21	8	2009	0.15	667.41	2.00	0.61	0.03	2.58	0.15	39.00	39.00	39.15	1	667.16	8,966
326	22	8	2009	0.15	667.16	2.00	0.61	0.03	2.58	0.15	39.00	39.00	39.15	1	666.91	8,889

327	23	8	2009	0.15	666.91	2.00	0.61	0.03	2.58	0.15	39.00	39.00	39.15	1	666.67	8,812
328	24	8	2009	0.14	666.67	2.00	0.61	0.02	2.59	0.14	39.00	39.00	39.14	1	666.42	8,734
329	25	8	2009	0.13	666.42	2.00	0.61	0.02	2.59	0.13	39.00	39.00	39.13	1	666.17	8,657
330	26	8	2009	0.13	666.17	2.00	0.61	0.02	2.59	0.13	39.00	39.00	39.13	1	665.93	8,580
331	27	8	2009	0.13	665.93	2.00	0.61	0.02	2.59	0.13	39.00	39.00	39.13	1	665.68	8,502
332	28	8	2009	0.13	665.68	2.00	0.61	0.02	2.59	0.13	39.00	39.00	39.13	1	665.43	8,425
333	29	8	2009	0.15	665.43	2.00	0.61	0.03	2.58	0.15	39.00	39.00	39.15	1	665.19	8,348
334	30	8	2009	0.16	665.19	2.00	0.61	0.03	2.58	0.16	39.00	39.00	39.16	1	664.94	8,270
335	31	8	2009	0.17	664.94	2.00	0.61	0.03	2.58	0.17	39.00	39.00	39.17	1	664.69	8,193

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
336	1	9	2009	0.16	664.69	2.00	0.30	0.01	2.29	0.16	40.33	40.33	40.49	1	664.44	8,113
337	2	9	2009	0.17	664.44	2.00	0.30	0.01	2.29	0.17	40.33	40.33	40.50	1	664.18	8,033
338	3	9	2009	0.19	664.18	2.00	0.30	0.02	2.28	0.19	40.33	40.33	40.52	1	663.93	7,953
339	4	9	2009	0.19	663.93	2.00	0.30	0.02	2.28	0.19	40.33	40.33	40.52	1	663.67	7,873
340	5	9	2009	0.49	663.67	2.00	0.30	0.04	2.26	0.49	40.33	40.33	40.82	1	663.42	7,793
341	6	9	2009	0.90	663.42	2.00	0.30	0.07	2.23	0.90	40.33	40.33	41.23	1	663.16	7,713
342	7	9	2009	0.85	663.16	2.00	0.30	0.07	2.23	0.85	40.33	40.33	41.18	1	662.91	7,633
343	8	9	2009	0.40	662.91	2.00	0.30	0.03	2.27	0.40	40.33	40.33	40.73	1	662.65	7,553
344	9	9	2009	0.29	662.65	2.00	0.30	0.02	2.28	0.29	40.33	40.33	40.62	1	662.40	7,473
345	10	9	2009	0.30	662.40	2.00	0.30	0.02	2.28	0.30	40.33	40.33	40.63	1	662.14	7,393
346	11	9	2009	0.29	662.14	2.00	0.30	0.02	2.28	0.29	40.33	40.33	40.62	1	661.89	7,313
347	12	9	2009	0.27	661.89	2.00	0.30	0.02	2.28	0.27	40.33	40.33	40.60	1	661.63	7,233
348	13	9	2009	0.25	661.63	2.00	0.30	0.02	2.28	0.25	40.33	40.33	40.58	1	661.38	7,153
349	14	9	2009	0.25	661.38	2.00	0.30	0.02	2.28	0.25	40.33	40.33	40.58	1	661.12	7,073
350	15	9	2009	0.73	661.12	2.00	0.30	0.06	2.24	0.73	40.33	40.33	41.06	1	660.87	6,993
351	16	9	2009	3.70	660.87	2.00	0.30	0.30	2.00	2.00	40.33	40.33	42.33	0	660.62	6,917
352	17	9	2009	1.70	660.62	2.00	0.30	0.14	2.16	1.70	40.33	40.33	42.03	1	660.37	6,837
353	18	9	2009	0.83	660.37	2.00	0.30	0.07	2.23	0.83	40.33	40.33	41.16	1	660.11	6,757
354	19	9	2009	0.43	660.11	2.00	0.30	0.03	2.27	0.43	40.33	40.33	40.76	1	659.84	6,677
355	20	9	2009	0.32	659.84	2.00	0.30	0.03	2.27	0.32	40.33	40.33	40.65	1	659.55	6,597
356	21	9	2009	0.27	659.55	2.00	0.30	0.02	2.28	0.27	40.33	40.33	40.60	1	659.26	6,517
357	22	9	2009	0.23	659.26	2.00	0.30	0.02	2.28	0.23	40.33	40.33	40.56	1	658.98	6,437
358	23	9	2009	0.21	658.98	2.00	0.30	0.02	2.28	0.21	40.33	40.33	40.54	1	658.69	6,357
359	24	9	2009	0.20	658.69	2.00	0.30	0.02	2.28	0.20	40.33	40.33	40.53	1	658.40	6,277
360	25	9	2009	0.19	658.40	2.00	0.30	0.02	2.28	0.19	40.33	40.33	40.52	1	658.12	6,197
361	26	9	2009	0.18	658.12	2.00	0.30	0.01	2.29	0.18	40.33	40.33	40.51	1	657.83	6,117
362	27	9	2009	0.17	657.83	2.00	0.30	0.01	2.29	0.17	40.33	40.33	40.50	1	657.54	6,037
363	28	9	2009	0.17	657.54	2.00	0.30	0.01	2.29	0.17	40.33	40.33	40.50	1	657.26	5,957
364	29	9	2009	0.18	657.26	2.00	0.30	0.01	2.29	0.18	40.33	40.33	40.51	1	656.97	5,877
365	30	9	2009	0.22	656.97	2.00	0.30	0.02	2.28	0.22	40.33	40.33	40.55	1	656.68	5,797

A8.6 Output Data for 2008-2009 Multi-Year Simulation (not using local inflow)

(Without Relying on local Inflow in Meeting Water Rights)

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* PROGRAM  RESERVOIR REGULATION MODEL FOR DRIFT CREEK *
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TOTAL INFLOW VOLUME (AF)= 22,629
Initial Begin-period: ELE= 660.1  S(aft)=6743.7
Reservoir Upper Bound ELE= 680.00 S(aft)= 13,259
Reservoir Lower Bound ELE= 620.00 S(aft)=      8
SUMMARY RESULTS OF RESERVOIR SIMULATION
 Run Date:05-31-2012 20:29:32
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I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
1	1	10	2008	0.50	660.07	5.26	0.02	0.00	5.28	0.50	0.00	0.00	0.50	1	660.07	6,744
2	2	10	2008	0.50	660.07	5.26	0.02	0.00	5.28	0.50	0.00	0.00	0.50	1	660.07	6,744
3	3	10	2008	1.00	660.07	5.26	0.02	0.00	5.28	1.00	0.00	0.00	1.00	1	660.07	6,744
4	4	10	2008	5.00	660.07	5.26	0.02	0.00	5.28	5.00	0.00	0.00	5.00	1	660.07	6,744
5	5	10	2008	4.00	660.07	5.26	0.02	0.00	5.28	4.00	0.00	0.00	4.00	1	660.07	6,744
6	6	10	2008	3.80	660.07	5.26	0.02	0.00	5.28	3.80	0.00	0.00	3.80	1	660.07	6,744
7	7	10	2008	3.50	660.07	5.26	0.02	0.00	5.28	3.50	0.00	0.00	3.50	1	660.07	6,744
8	8	10	2008	3.50	660.07	5.26	0.02	0.00	5.28	3.50	0.00	0.00	3.50	1	660.07	6,744
9	9	10	2008	4.00	660.07	5.26	0.02	0.00	5.28	4.00	0.00	0.00	4.00	1	660.07	6,744
10	10	10	2008	3.00	660.07	5.26	0.02	0.00	5.28	3.00	0.00	0.00	3.00	1	660.07	6,744
11	11	10	2008	2.80	660.07	5.26	0.02	0.00	5.28	2.80	0.00	0.00	2.80	1	660.07	6,744
12	12	10	2008	2.60	660.07	5.26	0.02	0.00	5.28	2.60	0.00	0.00	2.60	1	660.07	6,744
13	13	10	2008	2.50	660.07	5.26	0.02	0.00	5.28	2.50	0.00	0.00	2.50	1	660.07	6,744
14	14	10	2008	2.30	660.07	5.26	0.02	0.00	5.28	2.30	0.00	0.00	2.30	1	660.07	6,744
15	15	10	2008	2.10	660.07	5.26	0.02	0.00	5.28	2.10	0.00	0.00	2.10	1	660.07	6,744
16	16	10	2008	2.00	660.07	5.26	0.02	0.00	5.28	2.00	0.00	0.00	2.00	1	660.07	6,744
17	17	10	2008	1.60	660.07	5.26	0.02	0.00	5.28	1.60	0.00	0.00	1.60	1	660.07	6,744
18	18	10	2008	1.80	660.07	5.26	0.02	0.00	5.28	1.80	0.00	0.00	1.80	1	660.07	6,744
19	19	10	2008	1.30	660.07	5.26	0.02	0.00	5.28	1.30	0.00	0.00	1.30	1	660.07	6,744
20	20	10	2008	1.00	660.07	5.26	0.02	0.00	5.28	1.00	0.00	0.00	1.00	1	660.07	6,744
21	21	10	2008	1.00	660.07	5.26	0.02	0.00	5.28	1.00	0.00	0.00	1.00	1	660.07	6,744
22	22	10	2008	1.20	660.07	5.26	0.02	0.00	5.28	1.20	0.00	0.00	1.20	1	660.07	6,744
23	23	10	2008	0.80	660.07	5.26	0.02	0.00	5.28	0.80	0.00	0.00	0.80	1	660.07	6,744
24	24	10	2008	0.70	660.07	5.26	0.02	0.00	5.28	0.70	0.00	0.00	0.70	1	660.07	6,744
25	25	10	2008	0.60	660.07	5.26	0.02	0.00	5.28	0.60	0.00	0.00	0.60	1	660.07	6,744
26	26	10	2008	0.55	660.07	5.26	0.02	0.00	5.28	0.55	0.00	0.00	0.55	1	660.07	6,744
27	27	10	2008	0.60	660.07	5.26	0.02	0.00	5.28	0.60	0.00	0.00	0.60	1	660.07	6,744
28	28	10	2008	0.60	660.07	5.26	0.02	0.00	5.28	0.60	0.00	0.00	0.60	1	660.07	6,744

29	29	10	2008	0.60	660.07	5.26	0.02	0.00	5.28	0.60	0.00	0.00	0.60	1	660.07	6,744
30	30	10	2008	0.55	660.07	5.26	0.02	0.00	5.28	0.55	0.00	0.00	0.55	1	660.07	6,744
31	31	10	2008	0.60	660.07	5.26	0.02	0.00	5.28	0.60	0.00	0.00	0.60	1	660.07	6,744

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
32	1	11	2008	0.65	660.07	40.00	0.93	0.00	40.93	0.65	0.00	0.00	0.65	1	660.07	6,744
33	2	11	2008	0.70	660.07	40.00	0.93	0.00	40.93	0.70	0.00	0.00	0.70	1	660.07	6,744
34	3	11	2008	1.00	660.07	40.00	0.93	0.00	40.93	1.00	0.00	0.00	1.00	1	660.07	6,744
35	4	11	2008	6.00	660.07	40.00	0.93	0.00	40.93	6.00	0.00	0.00	6.00	1	660.07	6,744
36	5	11	2008	5.00	660.07	40.00	0.93	0.00	40.93	5.00	0.00	0.00	5.00	1	660.07	6,744
37	6	11	2008	3.30	660.07	40.00	0.93	0.00	40.93	3.30	0.00	0.00	3.30	1	660.07	6,744
38	7	11	2008	3.50	660.07	40.00	0.93	0.00	40.93	3.50	0.00	0.00	3.50	1	660.07	6,744
39	8	11	2008	3.00	660.07	40.00	0.93	0.00	40.93	3.00	0.00	0.00	3.00	1	660.07	6,744
40	9	11	2008	3.50	660.07	40.00	0.93	0.00	40.93	3.50	0.00	0.00	3.50	1	660.07	6,744
41	10	11	2008	4.00	660.07	40.00	0.93	0.00	40.93	4.00	0.00	0.00	4.00	1	660.07	6,744
42	11	11	2008	5.00	660.07	40.00	0.93	0.00	40.93	5.00	0.00	0.00	5.00	1	660.07	6,744
43	12	11	2008	22.00	660.07	40.00	0.93	0.00	40.93	22.00	0.00	0.00	22.00	1	660.07	6,744
44	13	11	2008	130.00	660.07	40.00	0.93	0.00	40.93	40.93	0.00	0.00	40.93	0	660.63	6,920
45	14	11	2008	85.00	660.63	40.00	0.93	0.00	40.93	40.93	0.00	0.00	40.93	0	660.91	7,008
46	15	11	2008	54.00	660.91	40.00	0.93	0.00	40.93	40.93	0.00	0.00	40.93	0	660.99	7,034
47	16	11	2008	40.00	660.99	40.00	0.93	0.00	40.93	40.00	0.00	0.00	40.00	1	660.99	7,034
48	17	11	2008	34.00	660.99	40.00	0.93	0.00	40.93	34.00	0.00	0.00	34.00	1	660.99	7,034
49	18	11	2008	28.00	660.99	40.00	0.93	0.00	40.93	28.00	0.00	0.00	28.00	1	660.99	7,034
50	19	11	2008	23.00	660.99	40.00	0.93	0.00	40.93	23.00	0.00	0.00	23.00	1	660.99	7,034
51	20	11	2008	24.00	660.99	40.00	0.93	0.00	40.93	24.00	0.00	0.00	24.00	1	660.99	7,034
52	21	11	2008	25.00	660.99	40.00	0.93	0.00	40.93	25.00	0.00	0.00	25.00	1	660.99	7,034
53	22	11	2008	24.00	660.99	40.00	0.93	0.00	40.93	24.00	0.00	0.00	24.00	1	660.99	7,034
54	23	11	2008	23.00	660.99	40.00	0.93	0.00	40.93	23.00	0.00	0.00	23.00	1	660.99	7,034
55	24	11	2008	22.00	660.99	40.00	0.93	0.00	40.93	22.00	0.00	0.00	22.00	1	660.99	7,034
56	25	11	2008	21.00	660.99	40.00	0.93	0.00	40.93	21.00	0.00	0.00	21.00	1	660.99	7,034
57	26	11	2008	20.00	660.99	40.00	0.93	0.00	40.93	20.00	0.00	0.00	20.00	1	660.99	7,034
58	27	11	2008	20.00	660.99	40.00	0.93	0.00	40.93	20.00	0.00	0.00	20.00	1	660.99	7,034
59	28	11	2008	19.00	660.99	40.00	0.93	0.00	40.93	19.00	0.00	0.00	19.00	1	660.99	7,034
60	29	11	2008	18.00	660.99	40.00	0.93	0.00	40.93	18.00	0.00	0.00	18.00	1	660.99	7,034
61	30	11	2008	17.00	660.99	40.00	0.93	0.00	40.93	17.00	0.00	0.00	17.00	1	660.99	7,034

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
62	1	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
63	2	12	2008	19.00	660.99	40.00	2.11	0.00	42.11	19.00	0.00	0.00	19.00	1	660.99	7,034
64	3	12	2008	20.00	660.99	40.00	2.11	0.00	42.11	20.00	0.00	0.00	20.00	1	660.99	7,034
65	4	12	2008	19.00	660.99	40.00	2.11	0.00	42.11	19.00	0.00	0.00	19.00	1	660.99	7,034
66	5	12	2008	19.00	660.99	40.00	2.11	0.00	42.11	19.00	0.00	0.00	19.00	1	660.99	7,034
67	6	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
68	7	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
69	8	12	2008	19.00	660.99	40.00	2.11	0.00	42.11	19.00	0.00	0.00	19.00	1	660.99	7,034
70	9	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
71	10	12	2008	16.00	660.99	40.00	2.11	0.00	42.11	16.00	0.00	0.00	16.00	1	660.99	7,034

72	11	12	2008	15.00	660.99	40.00	2.11	0.00	42.11	15.00	0.00	0.00	15.00	1	660.99	7,034
73	12	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
74	13	12	2008	26.00	660.99	40.00	2.11	0.00	42.11	26.00	0.00	0.00	26.00	1	660.99	7,034
75	14	12	2008	23.00	660.99	40.00	2.11	0.00	42.11	23.00	0.00	0.00	23.00	1	660.99	7,034
76	15	12	2008	19.00	660.99	40.00	2.11	0.00	42.11	19.00	0.00	0.00	19.00	1	660.99	7,034
77	16	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
78	17	12	2008	17.00	660.99	40.00	2.11	0.00	42.11	17.00	0.00	0.00	17.00	1	660.99	7,034
79	18	12	2008	28.00	660.99	40.00	2.11	0.00	42.11	28.00	0.00	0.00	28.00	1	660.99	7,034
80	19	12	2008	25.00	660.99	40.00	2.11	0.00	42.11	25.00	0.00	0.00	25.00	1	660.99	7,034
81	20	12	2008	24.00	660.99	40.00	2.11	0.00	42.11	24.00	0.00	0.00	24.00	1	660.99	7,034
82	21	12	2008	33.00	660.99	40.00	2.11	0.00	42.11	33.00	0.00	0.00	33.00	1	660.99	7,034
83	22	12	2008	60.00	660.99	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	661.11	7,069
84	23	12	2008	50.00	661.11	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	661.16	7,085
85	24	12	2008	40.00	661.16	40.00	2.11	0.00	42.11	40.00	0.00	0.00	40.00	1	661.16	7,085
86	25	12	2008	50.00	661.16	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	661.21	7,100
87	26	12	2008	55.00	661.21	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	661.29	7,126
88	27	12	2008	110.00	661.29	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	661.72	7,261
89	28	12	2008	200.00	661.72	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	662.72	7,574
90	29	12	2008	215.00	662.72	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	663.81	7,917
91	30	12	2008	160.00	663.81	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	664.56	8,150
92	31	12	2008	130.00	664.56	40.00	2.11	0.00	42.11	42.11	0.00	0.00	42.11	0	665.11	8,325

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
93	1	1	2009	275.00	665.11	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	666.58	8,786
94	2	1	2009	500.00	666.58	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	669.48	9,694
95	3	1	2009	267.00	669.48	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	670.83	10,139
96	4	1	2009	181.00	670.83	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	671.64	10,414
97	5	1	2009	173.00	671.64	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	672.40	10,674
98	6	1	2009	159.00	672.40	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	673.08	10,905
99	7	1	2009	161.00	673.08	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	673.77	11,141
100	8	1	2009	198.00	673.77	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	674.68	11,449
101	9	1	2009	163.00	674.68	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	675.38	11,689
102	10	1	2009	132.00	675.38	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	675.91	11,867
103	11	1	2009	115.00	675.91	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	676.33	12,011
104	12	1	2009	96.00	676.33	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	676.64	12,117
105	13	1	2009	84.00	676.64	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	676.89	12,200
106	14	1	2009	73.00	676.89	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	677.07	12,261
107	15	1	2009	65.00	677.07	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	677.20	12,306
108	16	1	2009	57.00	677.20	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	677.28	12,335
109	17	1	2009	50.00	677.28	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	677.33	12,351
110	18	1	2009	44.00	677.33	40.00	2.28	0.00	42.28	42.28	0.00	0.00	42.28	0	677.34	12,354
111	19	1	2009	39.00	677.34	40.00	2.28	0.00	42.28	39.00	0.00	0.00	39.00	1	677.34	12,354
112	20	1	2009	35.00	677.34	40.00	2.28	0.00	42.28	35.00	0.00	0.00	35.00	1	677.34	12,354
113	21	1	2009	32.00	677.34	40.00	2.28	0.00	42.28	32.00	0.00	0.00	32.00	1	677.34	12,354
114	22	1	2009	30.00	677.34	40.00	2.28	0.00	42.28	30.00	0.00	0.00	30.00	1	677.34	12,354
115	23	1	2009	28.00	677.34	40.00	2.28	0.00	42.28	28.00	0.00	0.00	28.00	1	677.34	12,354
116	24	1	2009	26.00	677.34	40.00	2.28	0.00	42.28	26.00	0.00	0.00	26.00	1	677.34	12,354

117	25	1	2009	27.00	677.34	40.00	2.28	0.00	42.28	27.00	0.00	0.00	27.00	1	677.34	12,354
118	26	1	2009	25.00	677.34	40.00	2.28	0.00	42.28	25.00	0.00	0.00	25.00	1	677.34	12,354
119	27	1	2009	24.00	677.34	40.00	2.28	0.00	42.28	24.00	0.00	0.00	24.00	1	677.34	12,354
120	28	1	2009	27.00	677.34	40.00	2.28	0.00	42.28	27.00	0.00	0.00	27.00	1	677.34	12,354
121	29	1	2009	25.00	677.34	40.00	2.28	0.00	42.28	25.00	0.00	0.00	25.00	1	677.34	12,354
122	30	1	2009	24.00	677.34	40.00	2.28	0.00	42.28	24.00	0.00	0.00	24.00	1	677.34	12,354
123	31	1	2009	23.00	677.34	40.00	2.28	0.00	42.28	23.00	0.00	0.00	23.00	1	677.34	12,354

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
124	1	2	2009	22.00	677.34	40.00	2.03	0.00	42.03	22.00	0.00	0.00	22.00	1	677.34	12,354
125	2	2	2009	21.00	677.34	40.00	2.03	0.00	42.03	21.00	0.00	0.00	21.00	1	677.34	12,354
126	3	2	2009	21.00	677.34	40.00	2.03	0.00	42.03	21.00	0.00	0.00	21.00	1	677.34	12,354
127	4	2	2009	20.00	677.34	40.00	2.03	0.00	42.03	20.00	0.00	0.00	20.00	1	677.34	12,354
128	5	2	2009	19.00	677.34	40.00	2.03	0.00	42.03	19.00	0.00	0.00	19.00	1	677.34	12,354
129	6	2	2009	23.00	677.34	40.00	2.03	0.00	42.03	23.00	0.00	0.00	23.00	1	677.34	12,354
130	7	2	2009	23.00	677.34	40.00	2.03	0.00	42.03	23.00	0.00	0.00	23.00	1	677.34	12,354
131	8	2	2009	22.00	677.34	40.00	2.03	0.00	42.03	22.00	0.00	0.00	22.00	1	677.34	12,354
132	9	2	2009	22.00	677.34	40.00	2.03	0.00	42.03	22.00	0.00	0.00	22.00	1	677.34	12,354
133	10	2	2009	22.00	677.34	40.00	2.03	0.00	42.03	22.00	0.00	0.00	22.00	1	677.34	12,354
134	11	2	2009	25.00	677.34	40.00	2.03	0.00	42.03	25.00	0.00	0.00	25.00	1	677.34	12,354
135	12	2	2009	24.00	677.34	40.00	2.03	0.00	42.03	24.00	0.00	0.00	24.00	1	677.34	12,354
136	13	2	2009	25.00	677.34	40.00	2.03	0.00	42.03	25.00	0.00	0.00	25.00	1	677.34	12,354
137	14	2	2009	24.00	677.34	40.00	2.03	0.00	42.03	24.00	0.00	0.00	24.00	1	677.34	12,354
138	15	2	2009	24.00	677.34	40.00	2.03	0.00	42.03	24.00	0.00	0.00	24.00	1	677.34	12,354
139	16	2	2009	23.00	677.34	40.00	2.03	0.00	42.03	23.00	0.00	0.00	23.00	1	677.34	12,354
140	17	2	2009	23.00	677.34	40.00	2.03	0.00	42.03	23.00	0.00	0.00	23.00	1	677.34	12,354
141	18	2	2009	22.00	677.34	40.00	2.03	0.00	42.03	22.00	0.00	0.00	22.00	1	677.34	12,354
142	19	2	2009	21.00	677.34	40.00	2.03	0.00	42.03	21.00	0.00	0.00	21.00	1	677.34	12,354
143	20	2	2009	20.00	677.34	40.00	2.03	0.00	42.03	20.00	0.00	0.00	20.00	1	677.34	12,354
144	21	2	2009	19.00	677.34	40.00	2.03	0.00	42.03	19.00	0.00	0.00	19.00	1	677.34	12,354
145	22	2	2009	19.00	677.34	40.00	2.03	0.00	42.03	19.00	0.00	0.00	19.00	1	677.34	12,354
146	23	2	2009	24.00	677.34	40.00	2.03	0.00	42.03	24.00	0.00	0.00	24.00	1	677.34	12,354
147	24	2	2009	71.00	677.34	40.00	2.03	0.00	42.03	42.03	0.00	0.00	42.03	0	677.51	12,411
148	25	2	2009	126.00	677.51	40.00	2.03	0.00	42.03	42.03	0.00	0.00	42.03	0	678.00	12,578
149	26	2	2009	156.00	678.00	40.00	2.03	0.00	42.03	42.03	0.00	0.00	42.03	0	678.66	12,804
150	27	2	2009	123.00	678.66	40.00	2.03	0.00	42.03	42.03	0.00	0.00	42.03	0	679.13	12,964
151	28	2	2009	106.00	679.13	40.00	2.03	0.00	42.03	42.03	0.00	0.00	42.03	0	679.51	13,091

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
152	1	3	2009	91.00	679.51	40.00	0.03	0.00	40.03	40.03	0.00	0.00	40.03	0	679.80	13,192
153	2	3	2009	92.00	679.80	40.00	0.03	0.00	40.03	40.03	0.00	0.00	58.43	2	680.00	13,259
154	3	3	2009	86.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	86.00	2	680.00	13,259
155	4	3	2009	74.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	74.00	2	680.00	13,259
156	5	3	2009	77.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	77.00	2	680.00	13,259
157	6	3	2009	71.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	71.00	2	680.00	13,259
158	7	3	2009	65.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	65.00	2	680.00	13,259
159	8	3	2009	62.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	62.00	2	680.00	13,259

160	9	3	2009	60.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	60.00	2	680.00	13,259
161	10	3	2009	58.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	58.00	2	680.00	13,259
162	11	3	2009	54.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	54.00	2	680.00	13,259
163	12	3	2009	50.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	50.00	2	680.00	13,259
164	13	3	2009	46.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	46.00	2	680.00	13,259
165	14	3	2009	46.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	46.00	2	680.00	13,259
166	15	3	2009	80.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	80.00	2	680.00	13,259
167	16	3	2009	92.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	92.00	2	680.00	13,259
168	17	3	2009	84.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	84.00	2	680.00	13,259
169	18	3	2009	73.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	73.00	2	680.00	13,259
170	19	3	2009	66.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	66.00	2	680.00	13,259
171	20	3	2009	60.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	60.00	2	680.00	13,259
172	21	3	2009	54.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	54.00	2	680.00	13,259
173	22	3	2009	62.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	62.00	2	680.00	13,259
174	23	3	2009	59.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	59.00	2	680.00	13,259
175	24	3	2009	54.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	54.00	2	680.00	13,259
176	25	3	2009	61.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	61.00	2	680.00	13,259
177	26	3	2009	59.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	59.00	2	680.00	13,259
178	27	3	2009	54.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	54.00	2	680.00	13,259
179	28	3	2009	56.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	56.00	2	680.00	13,259
180	29	3	2009	68.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	68.00	2	680.00	13,259
181	30	3	2009	66.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	66.00	2	680.00	13,259
182	31	3	2009	63.00	680.00	40.00	0.03	0.00	40.03	40.03	0.00	0.00	63.00	2	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
183	1	4	2009	60.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	60.00	2	680.00	13,259
184	2	4	2009	81.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	81.00	2	680.00	13,259
185	3	4	2009	80.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	80.00	2	680.00	13,259
186	4	4	2009	72.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	72.00	2	680.00	13,259
187	5	4	2009	64.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	64.00	2	680.00	13,259
188	6	4	2009	56.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	56.00	2	680.00	13,259
189	7	4	2009	51.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	51.00	2	680.00	13,259
190	8	4	2009	46.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	46.00	2	680.00	13,259
191	9	4	2009	44.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	44.00	2	680.00	13,259
192	10	4	2009	45.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	45.00	2	680.00	13,259
193	11	4	2009	38.00	680.00	40.00	0.04	0.00	40.04	38.00	0.00	0.00	38.00	1	680.00	13,259
194	12	4	2009	35.00	680.00	40.00	0.04	0.00	40.04	35.00	0.00	0.00	35.00	1	680.00	13,259
195	13	4	2009	44.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	44.00	2	680.00	13,259
196	14	4	2009	42.00	680.00	40.00	0.04	0.00	40.04	40.04	0.00	0.00	42.00	2	680.00	13,259
197	15	4	2009	39.00	680.00	40.00	0.04	0.00	40.04	39.00	0.00	0.00	39.00	1	680.00	13,259
198	16	4	2009	35.00	680.00	40.00	0.04	0.00	40.04	35.00	0.00	0.00	35.00	1	680.00	13,259
199	17	4	2009	35.00	680.00	40.00	0.04	0.00	40.04	35.00	0.00	0.00	35.00	1	680.00	13,259
200	18	4	2009	33.00	680.00	40.00	0.04	0.00	40.04	33.00	0.00	0.00	33.00	1	680.00	13,259
201	19	4	2009	30.00	680.00	40.00	0.04	0.00	40.04	30.00	0.00	0.00	30.00	1	680.00	13,259
202	20	4	2009	27.00	680.00	40.00	0.04	0.00	40.04	27.00	0.00	0.00	27.00	1	680.00	13,259
203	21	4	2009	25.00	680.00	40.00	0.04	0.00	40.04	25.00	0.00	0.00	25.00	1	680.00	13,259
204	22	4	2009	24.00	680.00	40.00	0.04	0.00	40.04	24.00	0.00	0.00	24.00	1	680.00	13,259

205	23	4	2009	23.00	680.00	40.00	0.04	0.00	40.04	23.00	0.00	0.00	23.00	1	680.00	13,259
206	24	4	2009	22.00	680.00	40.00	0.04	0.00	40.04	22.00	0.00	0.00	22.00	1	680.00	13,259
207	25	4	2009	21.00	680.00	40.00	0.04	0.00	40.04	21.00	0.00	0.00	21.00	1	680.00	13,259
208	26	4	2009	20.00	680.00	40.00	0.04	0.00	40.04	20.00	0.00	0.00	20.00	1	680.00	13,259
209	27	4	2009	20.00	680.00	40.00	0.04	0.00	40.04	20.00	0.00	0.00	20.00	1	680.00	13,259
210	28	4	2009	27.00	680.00	40.00	0.04	0.00	40.04	27.00	0.00	0.00	27.00	1	680.00	13,259
211	29	4	2009	29.00	680.00	40.00	0.04	0.00	40.04	29.00	0.00	0.00	29.00	1	680.00	13,259
212	30	4	2009	24.00	680.00	40.00	0.04	0.00	40.04	24.00	0.00	0.00	24.00	1	680.00	13,259

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
213	1	5	2009	22.00	680.00	30.10	0.22	0.00	30.32	22.00	13.00	13.00	35.00	1	679.92	13,233
214	2	5	2009	39.00	679.92	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.90	13,225
215	3	5	2009	39.00	679.90	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.87	13,216
216	4	5	2009	40.00	679.87	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.85	13,209
217	5	5	2009	70.00	679.85	30.10	0.22	0.00	30.32	30.32	13.00	13.00	45.03	2	680.00	13,259
218	6	5	2009	98.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	98.00	2	680.00	13,259
219	7	5	2009	128.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	128.00	2	680.00	13,259
220	8	5	2009	108.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	108.00	2	680.00	13,259
221	9	5	2009	89.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	89.00	2	680.00	13,259
222	10	5	2009	75.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	75.00	2	680.00	13,259
223	11	5	2009	65.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	65.00	2	680.00	13,259
224	12	5	2009	59.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	59.00	2	680.00	13,259
225	13	5	2009	53.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	53.00	2	680.00	13,259
226	14	5	2009	66.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	66.00	2	680.00	13,259
227	15	5	2009	54.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	54.00	2	680.00	13,259
228	16	5	2009	46.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	46.00	2	680.00	13,259
229	17	5	2009	40.00	680.00	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.98	13,252
230	18	5	2009	36.00	679.98	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.94	13,238
231	19	5	2009	37.00	679.94	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.90	13,225
232	20	5	2009	33.00	679.90	30.10	0.22	0.00	30.32	30.32	13.00	13.00	43.32	0	679.84	13,205
233	21	5	2009	29.00	679.84	30.10	0.22	0.00	30.32	29.00	13.00	13.00	42.00	1	679.77	13,179
234	22	5	2009	26.00	679.77	30.10	0.22	0.00	30.32	26.00	13.00	13.00	39.00	1	679.69	13,153
235	23	5	2009	24.00	679.69	30.10	0.22	0.00	30.32	24.00	13.00	13.00	37.00	1	679.61	13,128
236	24	5	2009	22.00	679.61	30.10	0.22	0.00	30.32	22.00	13.00	13.00	35.00	1	679.54	13,102
237	25	5	2009	21.00	679.54	30.10	0.22	0.00	30.32	21.00	13.00	13.00	34.00	1	679.46	13,076
238	26	5	2009	19.00	679.46	30.10	0.22	0.00	30.32	19.00	13.00	13.00	32.00	1	679.39	13,050
239	27	5	2009	18.00	679.39	30.10	0.22	0.00	30.32	18.00	13.00	13.00	31.00	1	679.31	13,024
240	28	5	2009	16.00	679.31	30.10	0.22	0.00	30.32	16.00	13.00	13.00	29.00	1	679.23	12,999
241	29	5	2009	15.00	679.23	30.10	0.22	0.00	30.32	15.00	13.00	13.00	28.00	1	679.16	12,973
242	30	5	2009	14.00	679.16	30.10	0.22	0.00	30.32	14.00	13.00	13.00	27.00	1	679.08	12,947
243	31	5	2009	11.00	679.08	30.10	0.22	0.00	30.32	11.00	13.00	13.00	24.00	1	679.01	12,921

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
244	1	6	2009	11.00	679.01	13.60	0.44	0.00	14.04	11.00	13.50	13.50	24.50	1	678.93	12,894
245	2	6	2009	10.00	678.93	13.60	0.44	0.00	14.04	10.00	13.50	13.50	23.50	1	678.85	12,868
246	3	6	2009	9.80	678.85	13.60	0.44	0.00	14.04	9.80	13.50	13.50	23.30	1	678.77	12,841
247	4	6	2009	10.00	678.77	13.60	0.44	0.00	14.04	10.00	13.50	13.50	23.50	1	678.69	12,814

248	5	6	2009	13.00	678.69	13.60	0.44	0.00	14.04	13.00	13.50	13.50	26.50	1	678.61	12,787
249	6	6	2009	12.00	678.61	13.60	0.44	0.00	14.04	12.00	13.50	13.50	25.50	1	678.54	12,761
250	7	6	2009	11.00	678.54	13.60	0.44	0.00	14.04	11.00	13.50	13.50	24.50	1	678.46	12,734
251	8	6	2009	10.00	678.46	13.60	0.44	0.00	14.04	10.00	13.50	13.50	23.50	1	678.38	12,707
252	9	6	2009	9.30	678.38	13.60	0.44	0.00	14.04	9.30	13.50	13.50	22.80	1	678.30	12,680
253	10	6	2009	8.80	678.30	13.60	0.44	0.00	14.04	8.80	13.50	13.50	22.30	1	678.22	12,654
254	11	6	2009	8.70	678.22	13.60	0.44	0.00	14.04	8.70	13.50	13.50	22.20	1	678.14	12,627
255	12	6	2009	8.40	678.14	13.60	0.44	0.00	14.04	8.40	13.50	13.50	21.90	1	678.06	12,600
256	13	6	2009	7.90	678.06	13.60	0.44	0.00	14.04	7.90	13.50	13.50	21.40	1	677.98	12,573
257	14	6	2009	7.50	677.98	13.60	0.44	0.00	14.04	7.50	13.50	13.50	21.00	1	677.91	12,546
258	15	6	2009	7.20	677.91	13.60	0.44	0.00	14.04	7.20	13.50	13.50	20.70	1	677.83	12,520
259	16	6	2009	6.80	677.83	13.60	0.44	0.00	14.04	6.80	13.50	13.50	20.30	1	677.75	12,493
260	17	6	2009	6.50	677.75	13.60	0.44	0.00	14.04	6.50	13.50	13.50	20.00	1	677.67	12,466
261	18	6	2009	6.20	677.67	13.60	0.44	0.00	14.04	6.20	13.50	13.50	19.70	1	677.59	12,439
262	19	6	2009	6.20	677.59	13.60	0.44	0.00	14.04	6.20	13.50	13.50	19.70	1	677.51	12,413
263	20	6	2009	6.00	677.51	13.60	0.44	0.00	14.04	6.00	13.50	13.50	19.50	1	677.43	12,386
264	21	6	2009	5.80	677.43	13.60	0.44	0.00	14.04	5.80	13.50	13.50	19.30	1	677.35	12,359
265	22	6	2009	5.10	677.35	13.60	0.44	0.00	14.04	5.10	13.50	13.50	18.60	1	677.28	12,332
266	23	6	2009	4.70	677.28	13.60	0.44	0.00	14.04	4.70	13.50	13.50	18.20	1	677.20	12,306
267	24	6	2009	4.40	677.20	13.60	0.44	0.00	14.04	4.40	13.50	13.50	17.90	1	677.12	12,279
268	25	6	2009	4.00	677.12	13.60	0.44	0.00	14.04	4.00	13.50	13.50	17.50	1	677.04	12,252
269	26	6	2009	4.00	677.04	13.60	0.44	0.00	14.04	4.00	13.50	13.50	17.50	1	676.96	12,225
270	27	6	2009	3.50	676.96	13.60	0.44	0.00	14.04	3.50	13.50	13.50	17.00	1	676.88	12,199
271	28	6	2009	3.20	676.88	13.60	0.44	0.00	14.04	3.20	13.50	13.50	16.70	1	676.80	12,172
272	29	6	2009	3.20	676.80	13.60	0.44	0.00	14.04	3.20	13.50	13.50	16.70	1	676.73	12,145
273	30	6	2009	3.10	676.73	13.60	0.44	0.00	14.04	3.10	13.50	13.50	16.60	1	676.65	12,118

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
274	1	7	2009	3.00	676.65	3.00	0.77	0.00	3.77	3.00	26.00	26.00	29.00	1	676.50	12,067
275	2	7	2009	2.70	676.50	3.00	0.77	0.00	3.77	2.70	26.00	26.00	28.70	1	676.34	12,015
276	3	7	2009	2.30	676.34	3.00	0.77	0.00	3.77	2.30	26.00	26.00	28.30	1	676.19	11,964
277	4	7	2009	2.00	676.19	3.00	0.77	0.00	3.77	2.00	26.00	26.00	28.00	1	676.04	11,912
278	5	7	2009	2.00	676.04	3.00	0.77	0.00	3.77	2.00	26.00	26.00	28.00	1	675.89	11,860
279	6	7	2009	1.80	675.89	3.00	0.77	0.00	3.77	1.80	26.00	26.00	27.80	1	675.74	11,809
280	7	7	2009	1.70	675.74	3.00	0.77	0.00	3.77	1.70	26.00	26.00	27.70	1	675.59	11,757
281	8	7	2009	1.60	675.59	3.00	0.77	0.00	3.77	1.60	26.00	26.00	27.60	1	675.43	11,706
282	9	7	2009	1.70	675.43	3.00	0.77	0.00	3.77	1.70	26.00	26.00	27.70	1	675.28	11,654
283	10	7	2009	1.80	675.28	3.00	0.77	0.00	3.77	1.80	26.00	26.00	27.80	1	675.13	11,603
284	11	7	2009	1.80	675.13	3.00	0.77	0.00	3.77	1.80	26.00	26.00	27.80	1	674.98	11,551
285	12	7	2009	2.00	674.98	3.00	0.77	0.00	3.77	2.00	26.00	26.00	28.00	1	674.83	11,500
286	13	7	2009	3.00	674.83	3.00	0.77	0.00	3.77	3.00	26.00	26.00	29.00	1	674.68	11,448
287	14	7	2009	2.80	674.68	3.00	0.77	0.00	3.77	2.80	26.00	26.00	28.80	1	674.53	11,396
288	15	7	2009	2.10	674.53	3.00	0.77	0.00	3.77	2.10	26.00	26.00	28.10	1	674.37	11,345
289	16	7	2009	1.60	674.37	3.00	0.77	0.00	3.77	1.60	26.00	26.00	27.60	1	674.22	11,293
290	17	7	2009	1.20	674.22	3.00	0.77	0.00	3.77	1.20	26.00	26.00	27.20	1	674.07	11,242
291	18	7	2009	0.92	674.07	3.00	0.77	0.00	3.77	0.92	26.00	26.00	26.92	1	673.92	11,190
292	19	7	2009	0.78	673.92	3.00	0.77	0.00	3.77	0.78	26.00	26.00	26.78	1	673.77	11,139

293	20	7	2009	0.73	673.77	3.00	0.77	0.00	3.77	0.73	26.00	26.00	26.73	1	673.62	11,087
294	21	7	2009	0.66	673.62	3.00	0.77	0.00	3.77	0.66	26.00	26.00	26.66	1	673.46	11,036
295	22	7	2009	0.63	673.46	3.00	0.77	0.00	3.77	0.63	26.00	26.00	26.63	1	673.31	10,984
296	23	7	2009	0.57	673.31	3.00	0.77	0.00	3.77	0.57	26.00	26.00	26.57	1	673.16	10,932
297	24	7	2009	0.51	673.16	3.00	0.77	0.00	3.77	0.51	26.00	26.00	26.51	1	673.01	10,881
298	25	7	2009	0.40	673.01	3.00	0.77	0.00	3.77	0.40	26.00	26.00	26.40	1	672.86	10,829
299	26	7	2009	0.35	672.86	3.00	0.77	0.00	3.77	0.35	26.00	26.00	26.35	1	672.71	10,778
300	27	7	2009	0.31	672.71	3.00	0.77	0.00	3.77	0.31	26.00	26.00	26.31	1	672.55	10,726
301	28	7	2009	0.29	672.55	3.00	0.77	0.00	3.77	0.29	26.00	26.00	26.29	1	672.40	10,675
302	29	7	2009	0.26	672.40	3.00	0.77	0.00	3.77	0.26	26.00	26.00	26.26	1	672.25	10,623
303	30	7	2009	0.25	672.25	3.00	0.77	0.00	3.77	0.25	26.00	26.00	26.25	1	672.10	10,572
304	31	7	2009	0.24	672.10	3.00	0.77	0.00	3.77	0.24	26.00	26.00	26.24	1	671.95	10,520

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
305	1	8	2009	0.23	671.95	2.00	0.61	0.00	2.61	0.23	39.00	39.00	39.23	1	671.72	10,443
306	2	8	2009	0.23	671.72	2.00	0.61	0.00	2.61	0.23	39.00	39.00	39.23	1	671.49	10,365
307	3	8	2009	0.23	671.49	2.00	0.61	0.00	2.61	0.23	39.00	39.00	39.23	1	671.27	10,288
308	4	8	2009	0.22	671.27	2.00	0.61	0.00	2.61	0.22	39.00	39.00	39.22	1	671.04	10,211
309	5	8	2009	0.23	671.04	2.00	0.61	0.00	2.61	0.23	39.00	39.00	39.23	1	670.81	10,133
310	6	8	2009	0.25	670.81	2.00	0.61	0.00	2.61	0.25	39.00	39.00	39.25	1	670.58	10,056
311	7	8	2009	0.28	670.58	2.00	0.61	0.00	2.61	0.28	39.00	39.00	39.28	1	670.36	9,979
312	8	8	2009	0.35	670.36	2.00	0.61	0.00	2.61	0.35	39.00	39.00	39.35	1	670.13	9,901
313	9	8	2009	0.42	670.13	2.00	0.61	0.00	2.61	0.42	39.00	39.00	39.42	1	669.89	9,824
314	10	8	2009	0.34	669.89	2.00	0.61	0.00	2.61	0.34	39.00	39.00	39.34	1	669.65	9,747
315	11	8	2009	0.30	669.65	2.00	0.61	0.00	2.61	0.30	39.00	39.00	39.30	1	669.40	9,669
316	12	8	2009	0.39	669.40	2.00	0.61	0.00	2.61	0.39	39.00	39.00	39.39	1	669.15	9,592
317	13	8	2009	0.50	669.15	2.00	0.61	0.00	2.61	0.50	39.00	39.00	39.50	1	668.91	9,515
318	14	8	2009	0.35	668.91	2.00	0.61	0.00	2.61	0.35	39.00	39.00	39.35	1	668.66	9,437
319	15	8	2009	0.30	668.66	2.00	0.61	0.00	2.61	0.30	39.00	39.00	39.30	1	668.41	9,360
320	16	8	2009	0.29	668.41	2.00	0.61	0.00	2.61	0.29	39.00	39.00	39.29	1	668.17	9,282
321	17	8	2009	0.26	668.17	2.00	0.61	0.00	2.61	0.26	39.00	39.00	39.26	1	667.92	9,205
322	18	8	2009	0.20	667.92	2.00	0.61	0.00	2.61	0.20	39.00	39.00	39.20	1	667.67	9,128
323	19	8	2009	0.18	667.67	2.00	0.61	0.00	2.61	0.18	39.00	39.00	39.18	1	667.43	9,050
324	20	8	2009	0.17	667.43	2.00	0.61	0.00	2.61	0.17	39.00	39.00	39.17	1	667.18	8,973
325	21	8	2009	0.15	667.18	2.00	0.61	0.00	2.61	0.15	39.00	39.00	39.15	1	666.93	8,896
326	22	8	2009	0.15	666.93	2.00	0.61	0.00	2.61	0.15	39.00	39.00	39.15	1	666.69	8,818
327	23	8	2009	0.15	666.69	2.00	0.61	0.00	2.61	0.15	39.00	39.00	39.15	1	666.44	8,741
328	24	8	2009	0.14	666.44	2.00	0.61	0.00	2.61	0.14	39.00	39.00	39.14	1	666.19	8,664
329	25	8	2009	0.13	666.19	2.00	0.61	0.00	2.61	0.13	39.00	39.00	39.13	1	665.95	8,586
330	26	8	2009	0.13	665.95	2.00	0.61	0.00	2.61	0.13	39.00	39.00	39.13	1	665.70	8,509
331	27	8	2009	0.13	665.70	2.00	0.61	0.00	2.61	0.13	39.00	39.00	39.13	1	665.45	8,432
332	28	8	2009	0.13	665.45	2.00	0.61	0.00	2.61	0.13	39.00	39.00	39.13	1	665.21	8,354
333	29	8	2009	0.15	665.21	2.00	0.61	0.00	2.61	0.15	39.00	39.00	39.15	1	664.96	8,277
334	30	8	2009	0.16	664.96	2.00	0.61	0.00	2.61	0.16	39.00	39.00	39.16	1	664.71	8,200
335	31	8	2009	0.17	664.71	2.00	0.61	0.00	2.61	0.17	39.00	39.00	39.17	1	664.47	8,122

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE

I	DA	MO	YR	QIN	ELE1	ISWR	CONSU	QLOC	REQ	QREQ	IRR	QIRR	QREL	V	ELE2	STORAGE
336	1	9	2009	0.16	664.47	2.00	0.30	0.00	2.30	0.16	40.33	40.33	40.49	1	664.21	8,042
337	2	9	2009	0.17	664.21	2.00	0.30	0.00	2.30	0.17	40.33	40.33	40.50	1	663.96	7,962
338	3	9	2009	0.19	663.96	2.00	0.30	0.00	2.30	0.19	40.33	40.33	40.52	1	663.70	7,882
339	4	9	2009	0.19	663.70	2.00	0.30	0.00	2.30	0.19	40.33	40.33	40.52	1	663.45	7,802
340	5	9	2009	0.49	663.45	2.00	0.30	0.00	2.30	0.49	40.33	40.33	40.82	1	663.19	7,722
341	6	9	2009	0.90	663.19	2.00	0.30	0.00	2.30	0.90	40.33	40.33	41.23	1	662.94	7,642
342	7	9	2009	0.85	662.94	2.00	0.30	0.00	2.30	0.85	40.33	40.33	41.18	1	662.68	7,562
343	8	9	2009	0.40	662.68	2.00	0.30	0.00	2.30	0.40	40.33	40.33	40.73	1	662.43	7,483
344	9	9	2009	0.29	662.43	2.00	0.30	0.00	2.30	0.29	40.33	40.33	40.62	1	662.17	7,403
345	10	9	2009	0.30	662.17	2.00	0.30	0.00	2.30	0.30	40.33	40.33	40.63	1	661.92	7,323
346	11	9	2009	0.29	661.92	2.00	0.30	0.00	2.30	0.29	40.33	40.33	40.62	1	661.66	7,243
347	12	9	2009	0.27	661.66	2.00	0.30	0.00	2.30	0.27	40.33	40.33	40.60	1	661.41	7,163
348	13	9	2009	0.25	661.41	2.00	0.30	0.00	2.30	0.25	40.33	40.33	40.58	1	661.15	7,083
349	14	9	2009	0.25	661.15	2.00	0.30	0.00	2.30	0.25	40.33	40.33	40.58	1	660.90	7,003
350	15	9	2009	0.73	660.90	2.00	0.30	0.00	2.30	0.73	40.33	40.33	41.06	1	660.64	6,923
351	16	9	2009	3.70	660.64	2.00	0.30	0.00	2.30	2.30	40.33	40.33	42.63	0	660.39	6,845
352	17	9	2009	1.70	660.39	2.00	0.30	0.00	2.30	1.70	40.33	40.33	42.03	1	660.14	6,765
353	18	9	2009	0.83	660.14	2.00	0.30	0.00	2.30	0.83	40.33	40.33	41.16	1	659.87	6,685
354	19	9	2009	0.43	659.87	2.00	0.30	0.00	2.30	0.43	40.33	40.33	40.76	1	659.58	6,606
355	20	9	2009	0.32	659.58	2.00	0.30	0.00	2.30	0.32	40.33	40.33	40.65	1	659.30	6,526
356	21	9	2009	0.27	659.30	2.00	0.30	0.00	2.30	0.27	40.33	40.33	40.60	1	659.01	6,446
357	22	9	2009	0.23	659.01	2.00	0.30	0.00	2.30	0.23	40.33	40.33	40.56	1	658.72	6,366
358	23	9	2009	0.21	658.72	2.00	0.30	0.00	2.30	0.21	40.33	40.33	40.54	1	658.44	6,286
359	24	9	2009	0.20	658.44	2.00	0.30	0.00	2.30	0.20	40.33	40.33	40.53	1	658.15	6,206
360	25	9	2009	0.19	658.15	2.00	0.30	0.00	2.30	0.19	40.33	40.33	40.52	1	657.86	6,126
361	26	9	2009	0.18	657.86	2.00	0.30	0.00	2.30	0.18	40.33	40.33	40.51	1	657.58	6,046
362	27	9	2009	0.17	657.58	2.00	0.30	0.00	2.30	0.17	40.33	40.33	40.50	1	657.29	5,966
363	28	9	2009	0.17	657.29	2.00	0.30	0.00	2.30	0.17	40.33	40.33	40.50	1	657.00	5,886
364	29	9	2009	0.18	657.00	2.00	0.30	0.00	2.30	0.18	40.33	40.33	40.51	1	656.71	5,806
365	30	9	2009	0.22	656.71	2.00	0.30	0.00	2.30	0.22	40.33	40.33	40.55	1	656.43	5,726

SECTION 3
GEOTECHNICAL RECONNAISSANCE

In Reconnaissance II, the intent was to build on the earlier geotechnical reviews to submit a Geologic Assessment Engineering Report and Geotechnical Report Peer Review Application to Marion County as part of the land use review. A copy of that application is provided in the appendix of this report.

Previously, as part of Reconnaissance I, the district retained three different geologists over a period of time to review the site. The two more recent investigations by Siemens and Associates (July 2009) and GRI (June 2011) were submitted to Marion County as a part of the geologic application. The Siemens and Associates geotechnical study focused predominantly on the dam site adjacent to Victor Point road and to a lesser extent the balance of the reservoir area, providing an enhanced evaluation to a depth of as much as 100 feet and insight to the material at varying depths. Siemens concluded the project was geotechnically feasible but that deep borings and other additional geotechnical work was required.

GRI's investigation observed that there was no evidence of past fault-related ground ruptures beneath the foot print of the dam and that future risk of rupture is low. The investigation provided guidance for development of the conceptual drawings. Some landslide activity extends west of the site. The final result was that the proposed earthfill embankment section is feasible and may be constructed with an adequate factor of safety of internal slope stability. Construction work will need to be sequenced to provide the most protection.

A map of the property covered by the application was developed and provided under Reconnaissance II. The completed application is provided in the appendix.

GEOLOGIC ASSESSMENT
ENGINEERING GEOLOGY REPORT
GEOTECHNICAL REPORT
PEER REVIEW APPLICATION

Planning Division
5155 Silverton Rd. NE
Salem OR 97305
Ph. (503) 588-5038; fax (503) 589-3284
http://www.co.marion.or.us/PW/Planning

Applications submitted by mail will not be accepted

Fee: Please check the appropriate box:

x Geologic Assessment (5 – 8 points) - $200.00
(prepared by a Certified Engineering Geologist)

Engineering Geology Report (9 or higher points) 0 $500.00
(prepared by a Certified Engineering Geologist)

Geotechnical Report (9 or higher points) - $500.00
(prepared by a Geotechnical Engineer)

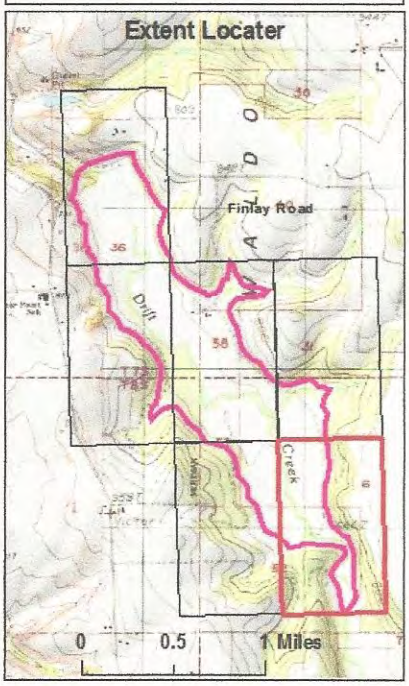
PROPERTY OWNER(S): East Valley Water District (see attached letter)	ADDRESS, CITY, STATE, AND ZIP: P.O. Box 1046 Mt. Angel, Oregon 97362
PROPERTY OWNER(S) (if more than one):	ADDRESS, CITY, STATE, AND ZIP
GEOLOGIST/ENGINEER: 1) J. Andrew Siemens, P.E., G.E. 2) GRI	ADDRESS, CITY, STATE, ZIP 1) 19134 River Woods Drive, Bend, OR 97702 2) 9725 SW Beaverton-Hillsdale Hwy. Suite140
DAYTIME PHONE (if staff has questions about this application): (541) 385-6500	E-MAIL (if any): Beaverton, OR 97025-3364 Siemens@bendcable.com
LOCATION OF SUBJECT PROPERTY: Township _____Range_____Section_____ Various: see attached list properties	SIZE OF SUBJECT PROPERTY: 240 acre reservoir footprint
PROPOSED ACTIVITY: Construction of a 12,000 acre foot reservoir and associated dam and embankment	

PLEASE SUBMIT THREE (3) COPIES OF THE REQUIRED REPORT

_____

Signature of property owner Date

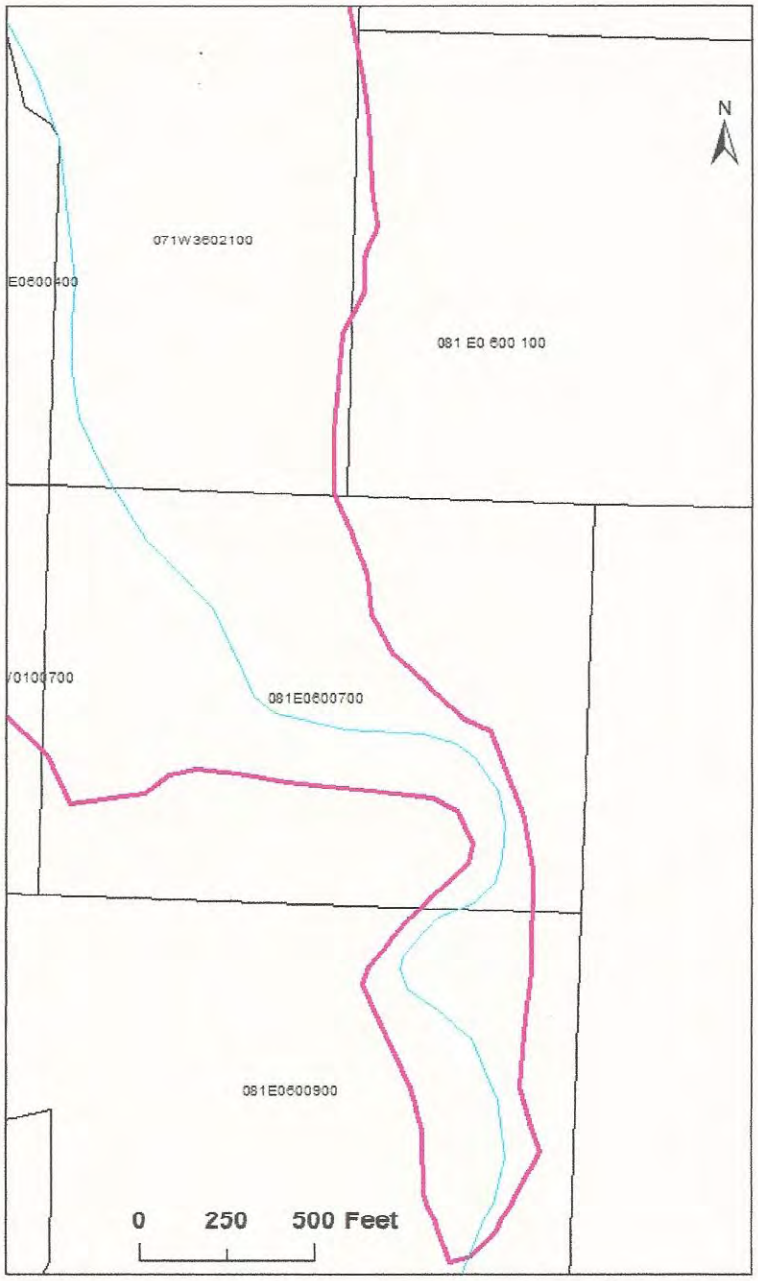
FOR OFFICE USE ONLY:			
Township	Range	Section	Application elements submitted:
Tax lot number(s) Zone: Application accepted by: Date:			D 3 copies of report D Filing fee D Title transfer instrument

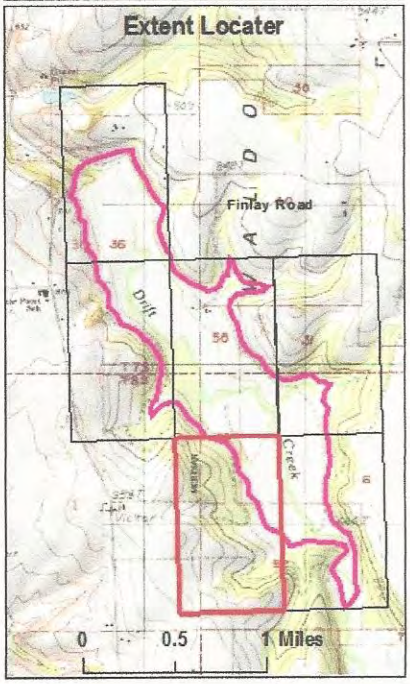


Legend
- Reservoir Footprint (elev. 680 ft)
- Property Line
- Drift Creek

1inch = 400 ft

Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI

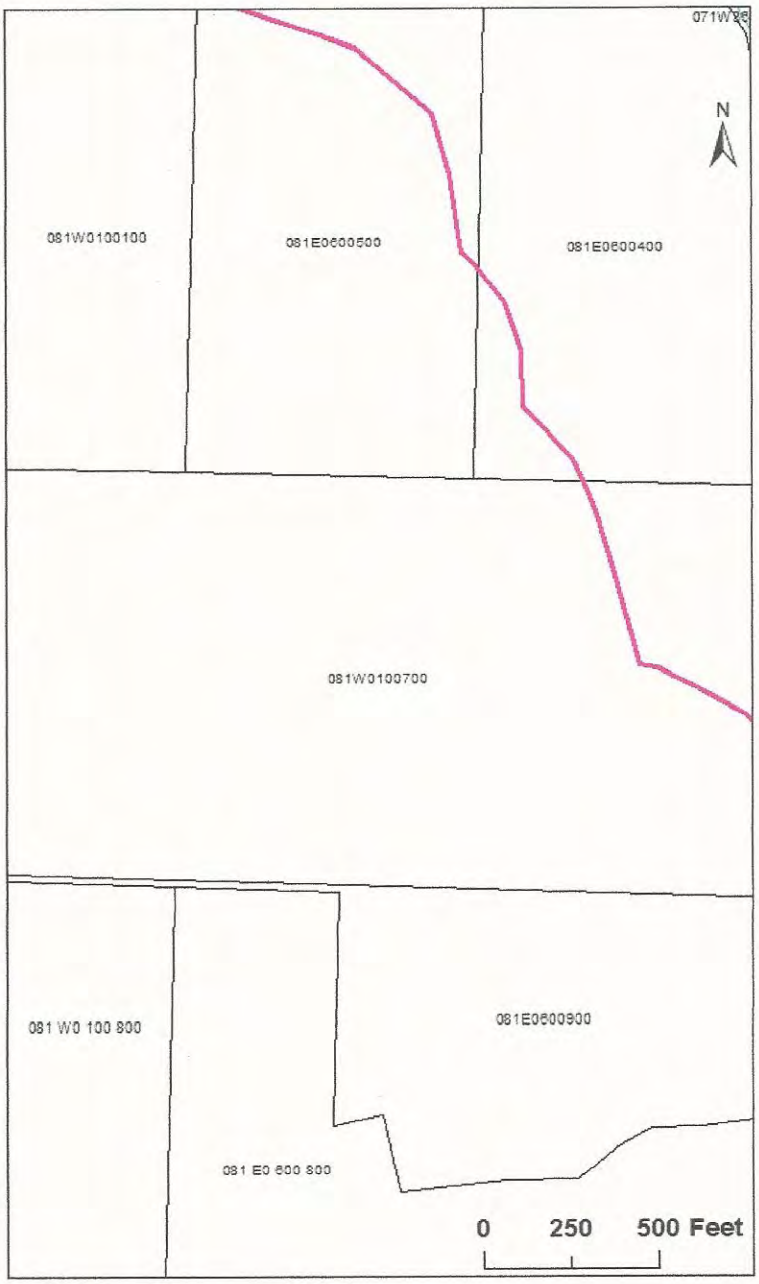


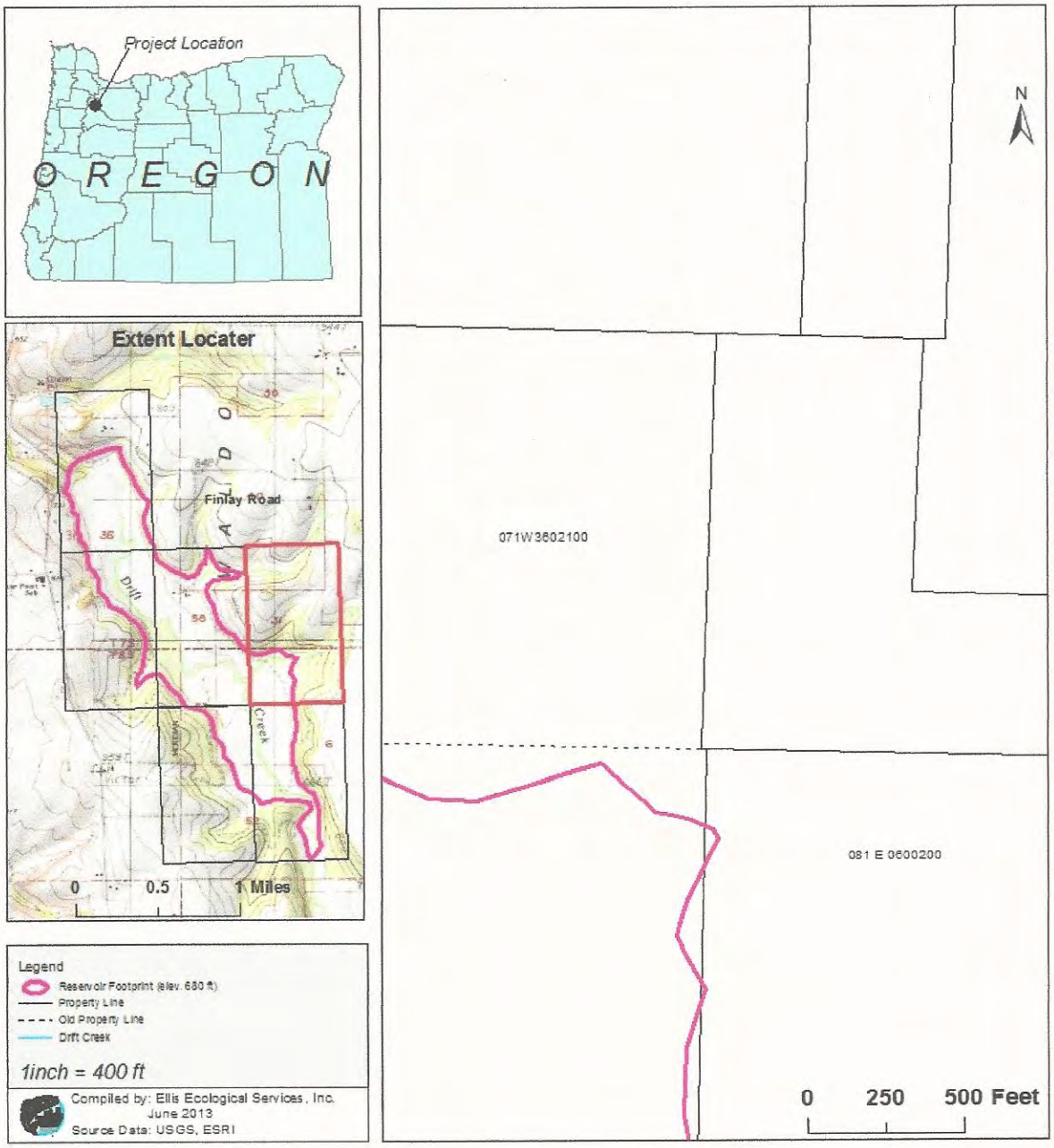


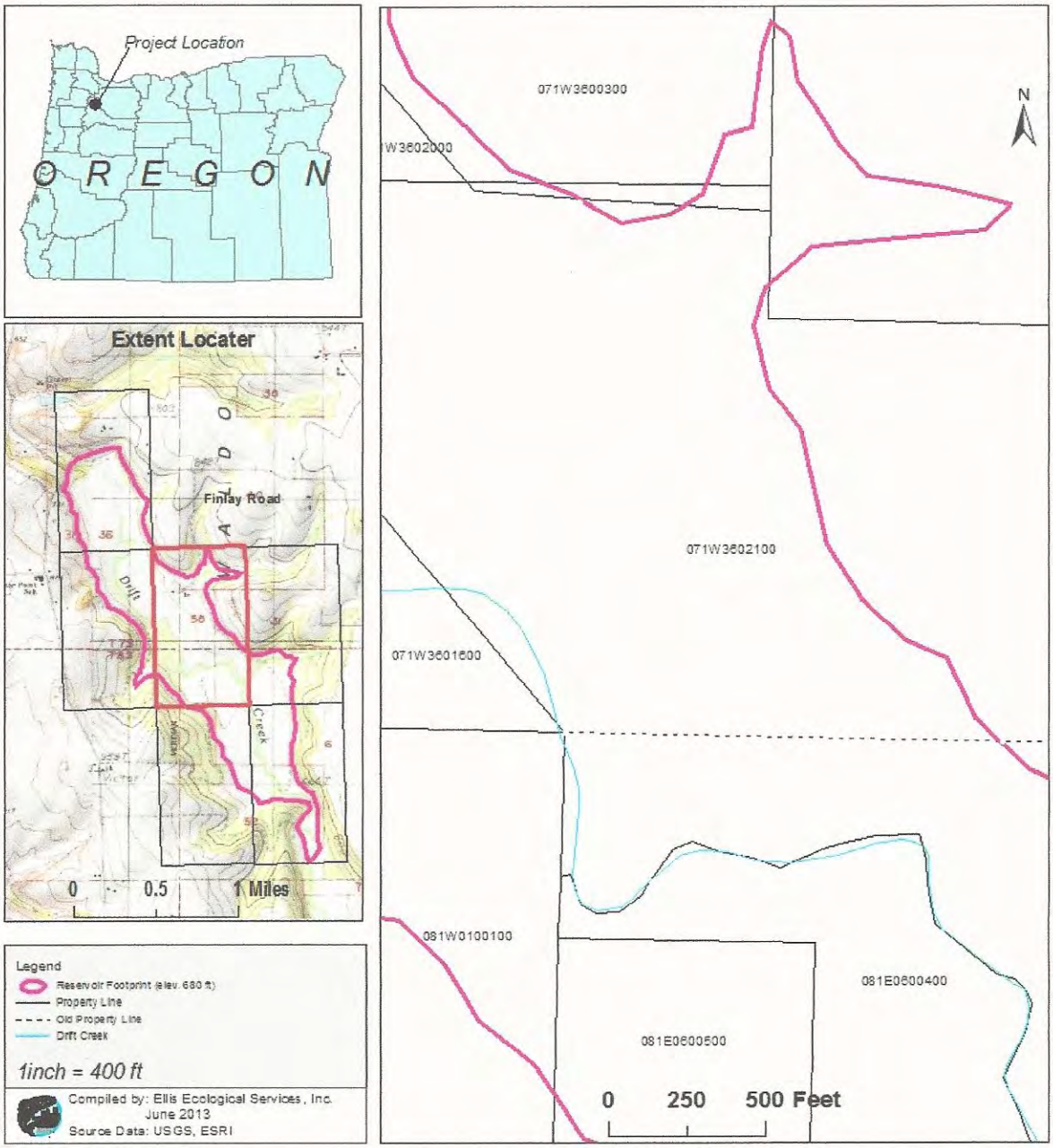
Legend
Reservoir Footprint (elev. 680 ft)
Property Line
Drift Creek

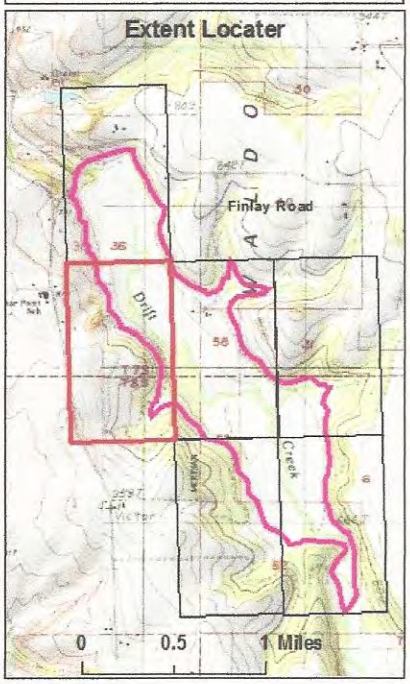
1inch = 400 ft

Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI




Project Location
OREGON
Extent Locater
Finlay Road
Drift
Creek
0
0.5
1 Miles
Legend
Reservoir Footprint (elev. 680 ft)
Property Line
Old Property Line
Drift Creek
1inch = 400 ft
Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI
N
071W3602100
081 E 0600200
0
250
500 Feet


Project Location
OREGON
Extent Locater
Finlay Road
Drift
Creek
0 0.5 1 Miles
071W3600300
W3602000
071W3602100
071W3601600
081W0100100
081E0600400
081E0600500
N
0 250 500 Feet
Legend
Reservoir Footprint (elev. 680 ft)
Property Line
Old Property Line
Drift Creek
1inch = 400 ft
Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI

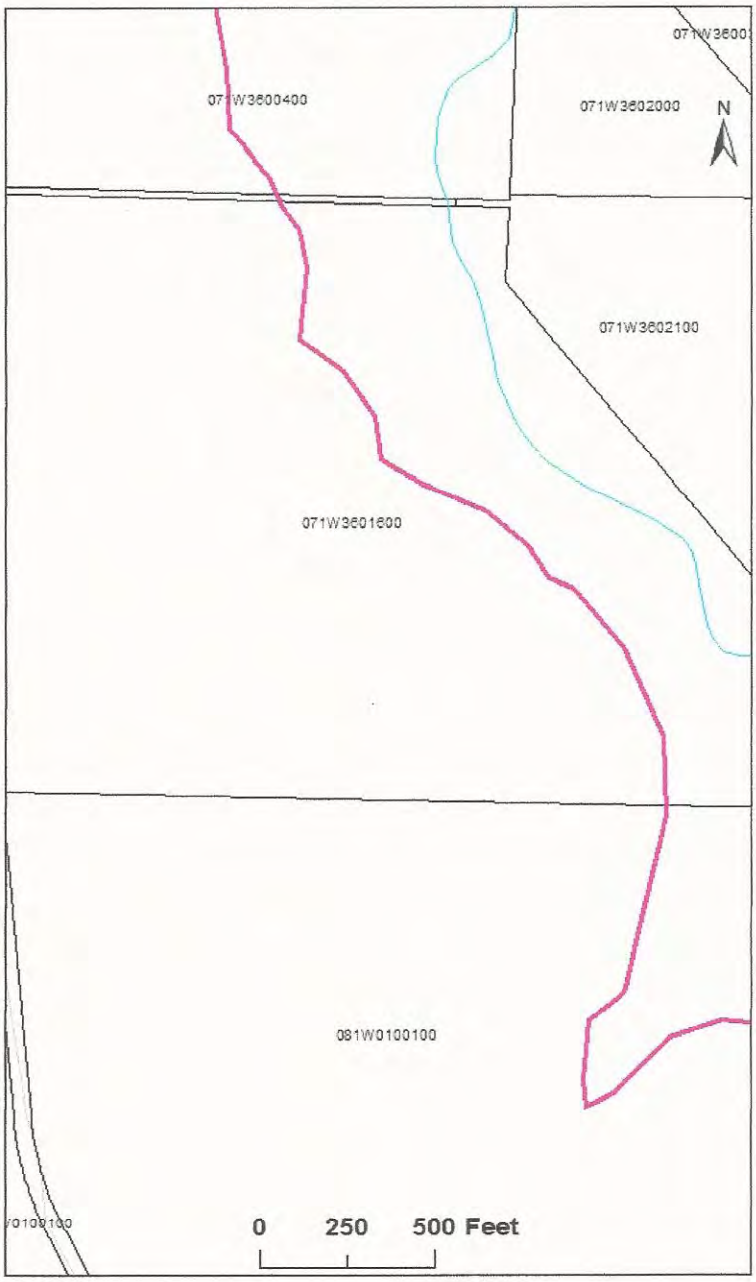


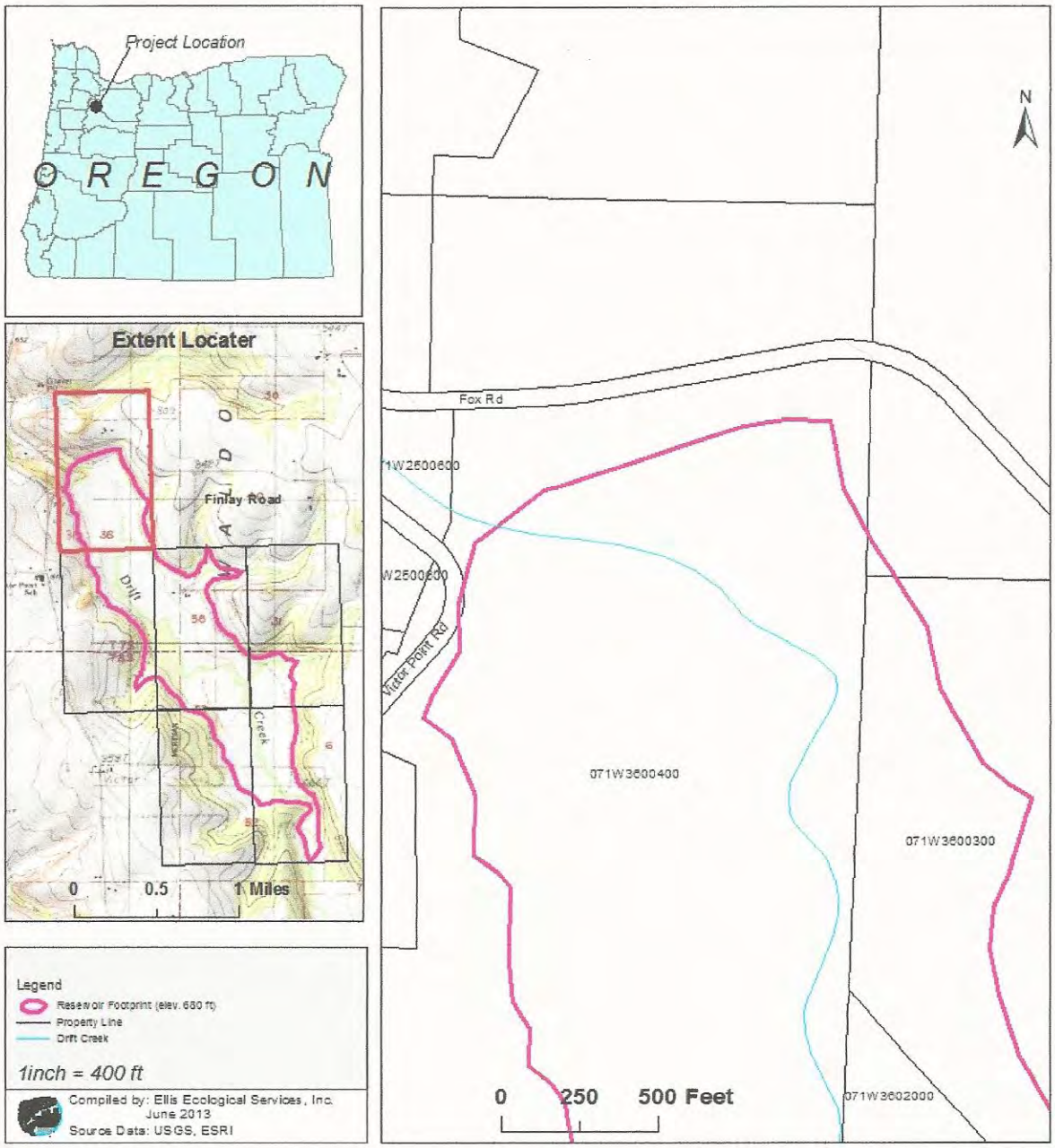
Legend

- Reservoir Footprint (elev. 680 ft)
- Property Line
- Drift Creek

1inch = 400 ft

Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI




Project Location
OREGON
Extent Locater
Finlay Road
Drift
Creek
0
0.5
1 Miles
Legend
Reservoir Footprint (elev. 680 ft)
Property Line
Drift Creek
1inch = 400 ft
Compiled by: Ellis Ecological Services, Inc.
June 2013
Source Data: USGS, ESRI
N
Fox Rd
071W2500600
W2500600
Victor Point Rd
071W3600400
071W3600300
071W3602000
0
250
500 Feet

LANDOWNERS IN DAM FOOTPRINT FOR DRIFT CREEK RESERVOIR

Taxlot	PropID	Owner	Owner Address	Phone	Location
071w3601600	R21854	Joel and Donna Rue*	1316 Victor Point Rd SE, Silverton OR 97381	503-873-4333	Foot Print
071w3600200	R21858	Robert Qualey	1105 E Main St, Silverton OR 97381	503-875-6153	Foot Print
071W3600300	R21862	Robert Qualey	1105 E Main St, Silverton OR 97381	503-875-6153	Foot Print
071w3600400	R21866	Norbert V Domnick	1116 Victor Point Rd NE, Silverton OR 97381	503-873-9704	Foot Print, Dam Site, GRI fault investigations
081W0100700	R28032	Todd F Peters	4742 Liberty RD S PMB 173, Salem Or 97302	503-559-5192	Foot Print
081W0100100	R28035	Robert & Lucelle M Lierman	1985 Victor Point Rd SE, Silverton OR 97381	503-873-4985	Foot Print
081E0600400	R39633	Fox Land Company / Attn: John Fox	16364 Fox Rd SE, Silverton OR 97381	503-873-2330; 503.504.1631	Foot Print
081E0600700	R39635	Floyd T Fox Jr	16364 Fox Rd SE, Silverton OR 97381	503-873-2330	Foot Print
071W3602100	R39640	Bruce Jaquet	14752 Doerfler Rd SE, Silverton OR 97381	503-873-2291	Foot Print
081E0600500	R39642	Todd F Peters	4742 Liberty RD S PMB 173, Salem Or 97302	Listed previously	Foot Print

* This property is under contract sale to the Rue family. Marion County tax assessors office considers them to be the legal owners of the property. However, when MSA was filling out their paperwork they were very sensitive to the idea of leaving out any owners and asked me to find the contact info for Merlin Darby et.al. The best information I could find is listed below. It is possible that MSA may have already prepared this paperwork when they wrote the report because they asked for all this information (sans map) at the time.

Marvin D and Georgie A. Darby

493 Fountain Court

Keizer OR 97303

Merlin Darby 503.463.6770

Black Rock Consulting
19855 4th Street, Suite 106
Bend, Oregon 97701
Attention: Kevin Crew, PE

July 24, 2009

Project Number 1091028

Project: Drift Creek Reservoir and Dam
Victor Point, Oregon

Subject: Geotechnical Reconnaissance

Dear Kevin,
As agreed, we have conducted a reconnaissance for the purpose of identifying geotechnical challenges related to the successful development of the project. Our work began with a paper study to review readily available documents including geologic publications, maps and site specific studies that were performed by others in recent years. This effort was followed by a foot traverse over much of the site mostly reviewing the terrain for indications of slope instability and a surficial review of shallow soil character. Most of our effort concentrated on the dam site which we explored using geophysical methods to gain an understanding of the deeper geology that will ultimately control the performance of the dam structure itself.

Through these efforts, we have discovered no overwhelming evidence to suggest that geotechnical hazards are present that result in recommendation to suspend or halt project feasibility evaluations. We have not identified any fatal flaws in the geology such as reason to suspect active faults in the area or dangerously unstable slopes. We have identified a few items that deserve more rigorous geotechnical evaluation which are listed later in this letter.

Project Understanding
It is our understanding that the proposed reservoir will impound roughly 12,000 acre feet through a portion of the Drift Creek drainage that currently is utilized as farm ground, low land grazing and other agricultural uses. The dam height is proposed at about 65 feet through a narrowing in the drainage near Fox Road and Victor Point Road in rural Marion County about six miles south of the town of Silverton. Cursory geologic investigation has been done by H. G. Schlicker & Associates of

Siemens & Associates siemens@bendcable.com Bend, Oregon
office: 541-385-6500 fax: 503-296-2271

Oregon City in 2005. This work included exploration of shallow soil conditions, review of readily available geologic data, and identification of ancient landslides within the reservoir area and a summary of the geologic setting including a cursory discussion of area faulting.

In general, our findings support the conclusions reached by H. G. Schlicker & Associates which in our opinion could have been presented with a stronger basis - original explorations extended less than 20 feet below grade; yet, it seems that the report is valid. Our work provides information to depths greater than 100 feet at the dam site as described later. Significantly more exploration and analysis including deep drilling, sampling and testing will be required in the future as the project progresses to the design level.

Conditions Encountered

H. G. Schlicker & Associates present a good description of area geology and we will not repeat this discussion here. In general, our findings agree with the expected geologic setting with the dam site dominated by fairly shallow basalt on each side of the canyon although our data indicates that the basalt is of limited thickness, underlain by a material of lesser, yet substantial strength.

The creek bottom supports moderately soft silty, saturated sediments of a thickness on the order of 20 feet. These sediments are compressible but of limited thickness such that the settlement of a heavy earth embankment dam is judged to be substantial but tolerable. Conditions along the creek bottom are depicted by seismic line S-2.

Looking downstream, the left wall of the drainage offers heavily jointed and fractured basalt at the surface along with a fairly thick accumulation of basaltic talus along with large boulders or “haystack” type floater blocks that have broken away from a larger mass and migrated to the current position. This is a common geologic phenomenon when a basalt layer is superimposed on a weaker layer composed of sediments or volcanics such as ash or tuff. The conditions along this slope are depicted by Seismic P-wave tomography S-1.

The right wall offers somewhat more mild slopes and on the surface displays the reddish, clayey silt soils common to the drainage. Below these soils at depths ranging from a few feet to up to about 15 feet we encountered a high P-wave velocity material that we judge to represent the area basalt. The basalt character varies somewhat in terms of P-wave velocity probably due to variation in fracturing, jointing and perhaps weathering. The conditions along this slope are depicted by Seismic P-wave tomography S-3.

We conducted no explorations throughout the reservoir area proper. Our judgment concerning the prevailing conditions is based on surface observations and information previously reported by H. G. Schlicker & Associates. These data suggest that the soils offer reasonably fine grained characteristics and are well suited for controlling seepage and as a source for low permeability construction materials. In fact, we have discovered only evidence of fine grained materials in the shallow subsurface and free-draining soils that would be used to construct internal drainage features of an earth dam may need to be imported – perhaps as processed materials from the basalt quarry just north of the dam site.

Conclusions

Based on the information currently available – which is a bit sparse, we conclude that the project is very likely to be feasible and reasonably economical in terms of dam size compared to reservoir capacity. Several unresolved concerns follow:

We have identified several areas occupied by timbered and heavy vegetation that offer indication of tenuous slope stability. These steep slopes exist along the eastern reservoir boundary and are marked on the USGS site plan that accompanies this letter. Instability appears to be manifest in soils that are in a process of creeping down slope as indicated by the trunks of trees that have bowed out and up to maintain vertical growth as the founding soils move. The stability of these slopes will be compromised when inundated and the severity of a slope failure is related to the thickness of the soil present on these hillsides. If stable rock is located at shallow depth, the failures would be nothing more than a nuisance, if deep, thick soils are present, a more substantial landslide could promote tsunami type waves that could cause overtopping of the dam. In our view, this potential should be evaluated.

While not presented, we conducted a series of DC electrical resistivity surveys through the dam site. These data provide some indication of more permeable seams through the shallow soils that require more characterization and could lead to the implementation of some sort of deep cut-off wall at the dam site to control seepage. Similar seams could exist within the reservoir floor and such possibilities should be explored to begin a process of evaluation to mitigate this potential and prevent disturbance if located in borrow areas.

Limitations

This letter presents our professional opinion based upon limited research, surface observations and

geophysical exploration. The resulting interpretations are intended to represent an endeavor to conform to the standard of practice currently employed by geoprofessionals conducting similar geophysical reconnaissance in the Victor Point, Oregon area – we make no other warranty express or implied.

We appreciate the opportunity to provide this exploration and sincerely hope that it meets your needs. If you have questions concerning the items discussed or the results that we present, just ask.

Respectfully submitted,
Siemens & Associates

J. Andrew Siemens, P.E., G.E.

Encl: References
Description of Geophysical Methods
USGS Site Plan
Dam Site after Stuntzner
Geophysical Profiles S-1, S-2 and S-3

References

1. State of Oregon, Department of Geology and Mineral Industries. Geological Map Series, GMS-100, Earthquake Hazard Maps for Oregon, 1996. By Ian P. Madin and Matthew A. Mabey. Donald A Hull, State Geologist.
2. State of Oregon, Department of Geology and Mineral Industries. Geological Map of the Scotts Mills Quadrangle, Oregon Series, GMS-33, 1984. By Paul R. Miller and William N. Orr. Donald A. Hull, State Geologist.
3. State of Oregon, Department of Geology and Mineral Industries. Geological Map of the Drake Crossing Quadrangle, Marion County, Oregon, Series GMS-50, 1986. By William N. Orr and Paul R. Miller. Donald A. Hull, State Geologist.
4. State of Oregon, Department of Geology and Mineral Industries. Geological Map of the Stayton NE Quadrangle, Oregon, Series GMS-34, 1984. By William N. Orr and Paul R. Miller. Donald A Hull, State Geologist
5. State of Oregon, Department of Geology and Mineral Industries. Statewide Landslide Information Database for Oregon, Release1, SLIDO-1, 2008. By William J. Burns, Ian P. Madin, and Lina Ma. Vicki S. McConnell, State Geologist.
6. State of Oregon, Department of Geological and Mineral Industries. Relative Earthquake Hazard Maps of the Salem East and Salem West Quadrangles, Marion and Polk Counties, Oregon, GMS-105, 1996. By Humei Wang and William J. Leonard. D.A. Hull, State Geologist.
7. State of Oregon, Department of Geology and Mineral Industries. Interpretive Map Series – Disk 1, 2 and 3 of 3, IMS-24, 2008. BY William J. Burns, R. Jon Hofmeister, and Yumei Wang. Vicki S. McConnell, State Geologist.
8. State of Oregon, Department of Geology and Mineral Industries. Maps showing faults, bedrock geology, & sediment, thickness of W. half of Oregon City, 1:100,000 quad, Washington, Multnomah, Clackamas and Marion Counties, Oregon, 1998. By S. Burns, L. Growney, B. Brodersen, R. Yeats, and T. Popowski. John D. Beaulieu, State Geologist.
9. Oregon Department of Geology and Mineral Industries. Oregon Geologic Data Compilation (OGDC), Release 5 (Statewide), 2009. Compiled by Linda Ma, Ian P. Madin, Keith V. Olson, Rudie J. Watzig. Vicki S. McConnell, State Geologist.
10. Stuntzner (untitled) July 2, 2005 report to Dave Bielenberg of East Valley Water District.
11. H. G. Schlicker & Associates, June 24, 2005: Engineering Geologic Information For Feasibility of Proposed Drift Creek Dam, Silverton, Oregon.

Description of Geophysical Methods

Two geophysical methods are presented to gain an understanding of the subsurface conditions through the dam site. The different methods provide a means of improving the interpretations and therefore greater confidence in the data as a whole. The geophysical results provide data regarding much greater volumes of earth than do test pits or drilling and do not disturb the integrity of the foundation soils like test pits do. The disadvantage of these indirect methods is the absence of sample for visual description and laboratory analysis. Geophysical interpretations are presented by annotated color renderings - locations of each survey are defined on the Site Plan of the dam site originally prepared by Stuntzner Engineering & Forestry, LLC. These interpretations are presented as attachments to this appendix.

Location of the proposed dam centerline was determined through review of the Stuntzner site plan using physically mapped features as identified on that plan, a 300 foot fiberglass tape and compass. These methods are fairly crude and the locations of our work should only be considered approximate (accurate to perhaps the nearest 20 feet). Further, elevation data were determined through a process of interpretation of contour data and slope inclination measurement by us. As such, elevation data is also approximate.

Refraction Seismic

Refraction seismic surveying was done to gather P-wave data allowing interpretation of the prevailing geology through generation and review of a two dimensional velocity model. Seismic refraction methods measure the transmission of compression waves (P-waves) through the subsurface. We generated seismic P-waves (signal) using a Betsy Seisgun detonating 400 grain black powder charges and with an 18 pound hammer striking an aluminum plate where we encountered difficult drilling conditions. Seismic refraction methods are suitable to obtain the depth to bedrock surfaces and the water table; to characterize rock/soil type and degree of weathering; and to locate fractures, faults, and buried channels. A straight line arrays composed of 21 to 24 receivers set on 10 foot spacing were used to collect the data. Shot points were induced between every other receiver gathering first arrival times utilized in the interpretation. The data were processed using the latest version (v6.0) of SeisOpt@2D developed by Optim Software, Reno, Nevada.

The 2D velocity models are annotated to describe our interpretation of the conditions encountered. Refraction seismic velocity models are indicative of soil and rock strength particularly when combined with shear-wave data as described in the next section. Since refraction methods rely on a general assumption that the velocity of geologic layers increase with depth (as is typically the case) when this constrain is not satisfied the depth of the velocity model is prematurely terminated.

When investigating for strength characteristics, geophysical methods offer significant advantages over drilling and test pit excavation including depth of investigation, two dimensional coverage (as opposed to

one dimensional boring), limited opportunity to disturb underground utilities and improved opportunity to discover large scale geologic features.

Refraction Microtremor Analysis (ReMi)

The ReMi analysis develops the shear-wave velocity/depth profile using a reasonably conventional engineering seismograph, low frequency receivers (geophones) and array aperture. Ambient surface wave energy is recorded using relatively long (15 to 30 seconds) records which we enhanced at this quiet site by driving a 1 ton truck near the seismic array. The microtremor records are transformed as a simple, two-dimensional slowness-frequency (p-f) plot where the ray parameter "p" is the horizontal component of slowness (inverse velocity) along the array and "f" is the corresponding frequency (inverse of period). The p-f analysis produces a record of the total spectral power in all records from the site, which plots within the p-f axes. If one identifies trends within these axes where a coherent phase has significant power, then the slowness-frequency picks can be plotted on a typical period-velocity diagram for dispersion analysis. Picking the points to be entered into the dispersion curve is done manually along the lowest velocity envelope bounding the energy appearing in the p-f image.

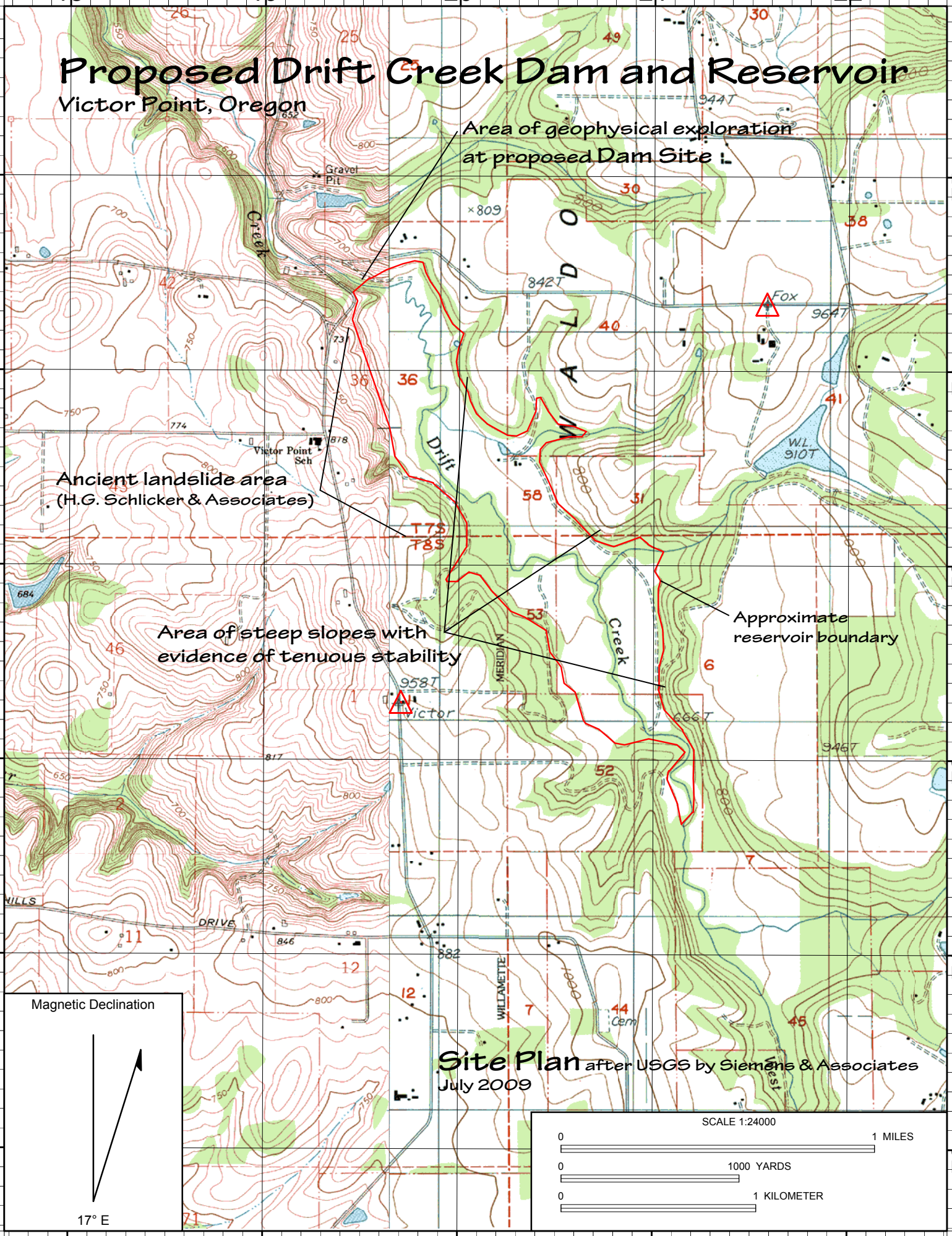
It is important to recognize that the one dimensional interpretation (plot) of shear-wave velocity versus depth from a ReMi survey is representative of the "average" conditions in the area of the survey and may or may not correlate well with data gathered from more traditional methods such as cross-hole techniques that measure conditions at a select location. The ReMi analysis would, however agree well with the average of many down-hole measurements if such extensive work were done in the area of the ReMi survey and agreement would be achieved with a single down-hole test if subsurface conditions were reasonably uniform across the survey site.

At this site, the ReMi interpretation correlates well with the P-wave tomography describing a steady increase in shear wave velocity with depth then a velocity reversal below the base of the refraction models.

Data were recorded with our DAQLINK II digital seismograph and processed using the latest versions of SeisOpt ReMi software.

Proposed Drift Creek Dam and Reservoir

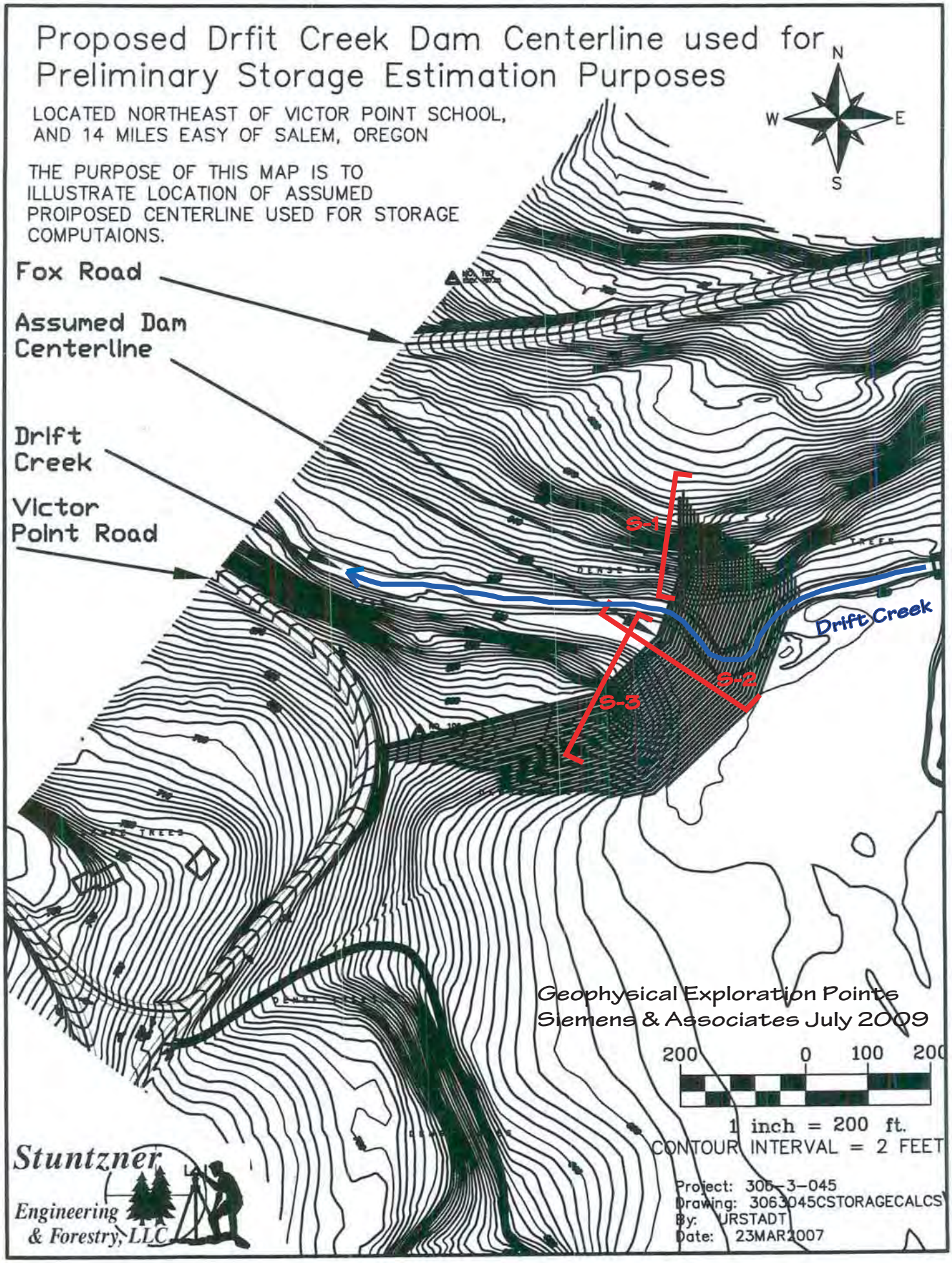
Victor Point, Oregon



Site Plan after USGS by Siemens & Associates
July 2009

Datum: WGS84

Copyright (C) 1997, Maptech, Inc.

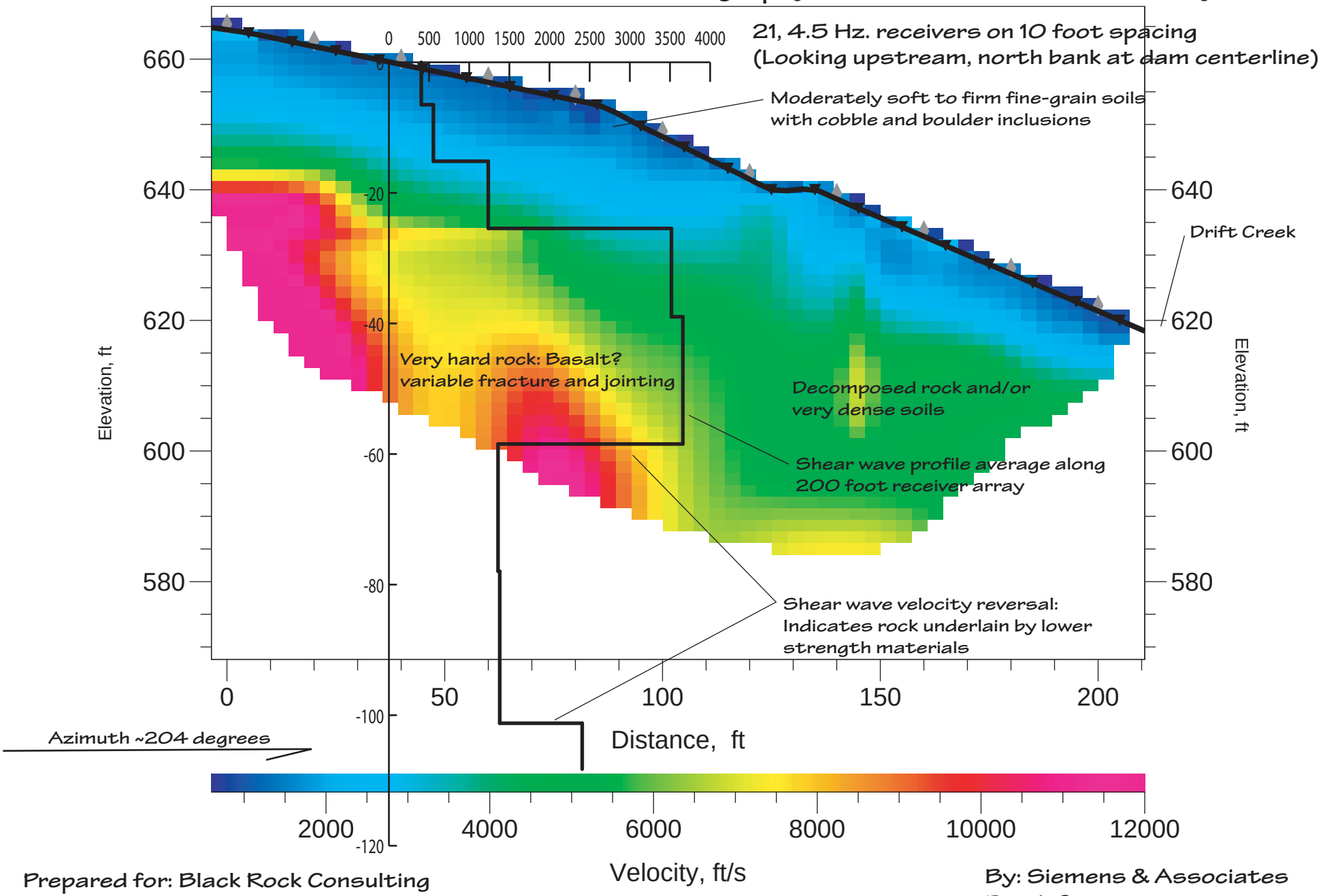

Proposed Drfit Creek Dam Centerline used for Preliminary Storage Estimation Purposes
LOCATED NORTHEAST OF VICTOR POINT SCHOOL, AND 14 MILES EASY OF SALEM, OREGON
THE PURPOSE OF THIS MAP IS TO ILLUSTRATE LOCATION OF ASSUMED PROIPOSED CENTERLINE USED FOR STORAGE COMPUTAIONS.
N
W
E
S
Fox Road
Assumed Dam Centerline
Drift Creek
Victor Point Road
S-1
S-2
S-3
Drift Creek
Geophysical Exploration Points
Siemens & Associates July 2009
200
0
100
200
1 inch = 200 ft.
CONTOUR INTERVAL = 2 FEET
Project: 306-3-045
Drawing: 3063045CSTORAGECALCS
By: URSTADT
Date: 23MAR2007
Stuntzner
Engineering & Forestry, LLC

Drift Creek Dam Site
Victor Point, Oregon

S-1

July 2009

Seismic P-wave Tomography with ReMi Shear-wave overlay



Prepared for: Black Rock Consulting

By: Siemens & Associates
Bend, Oregon

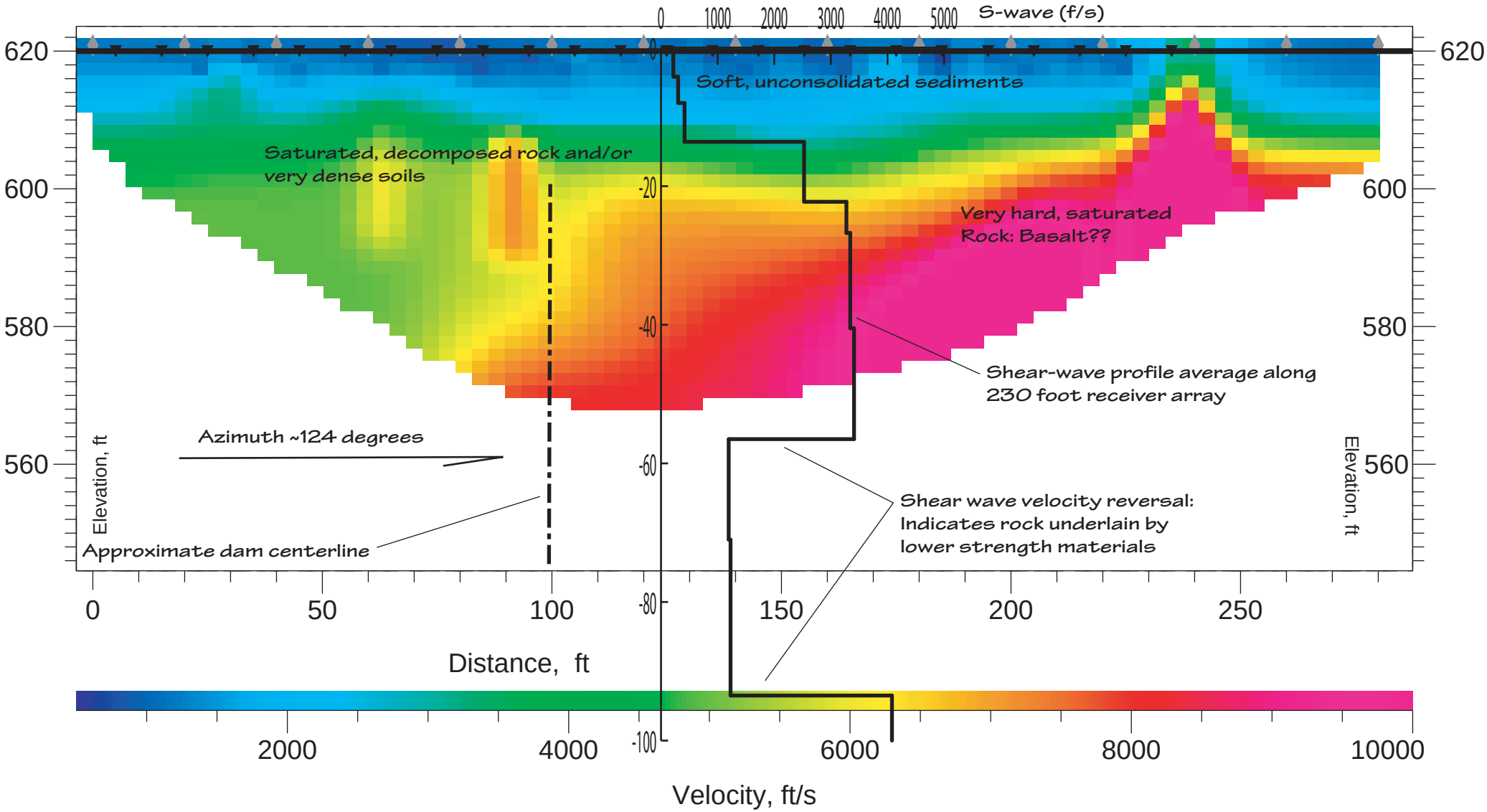
Drift Creek Dam Site
Victor Point, Oregon

July 2009

S-2

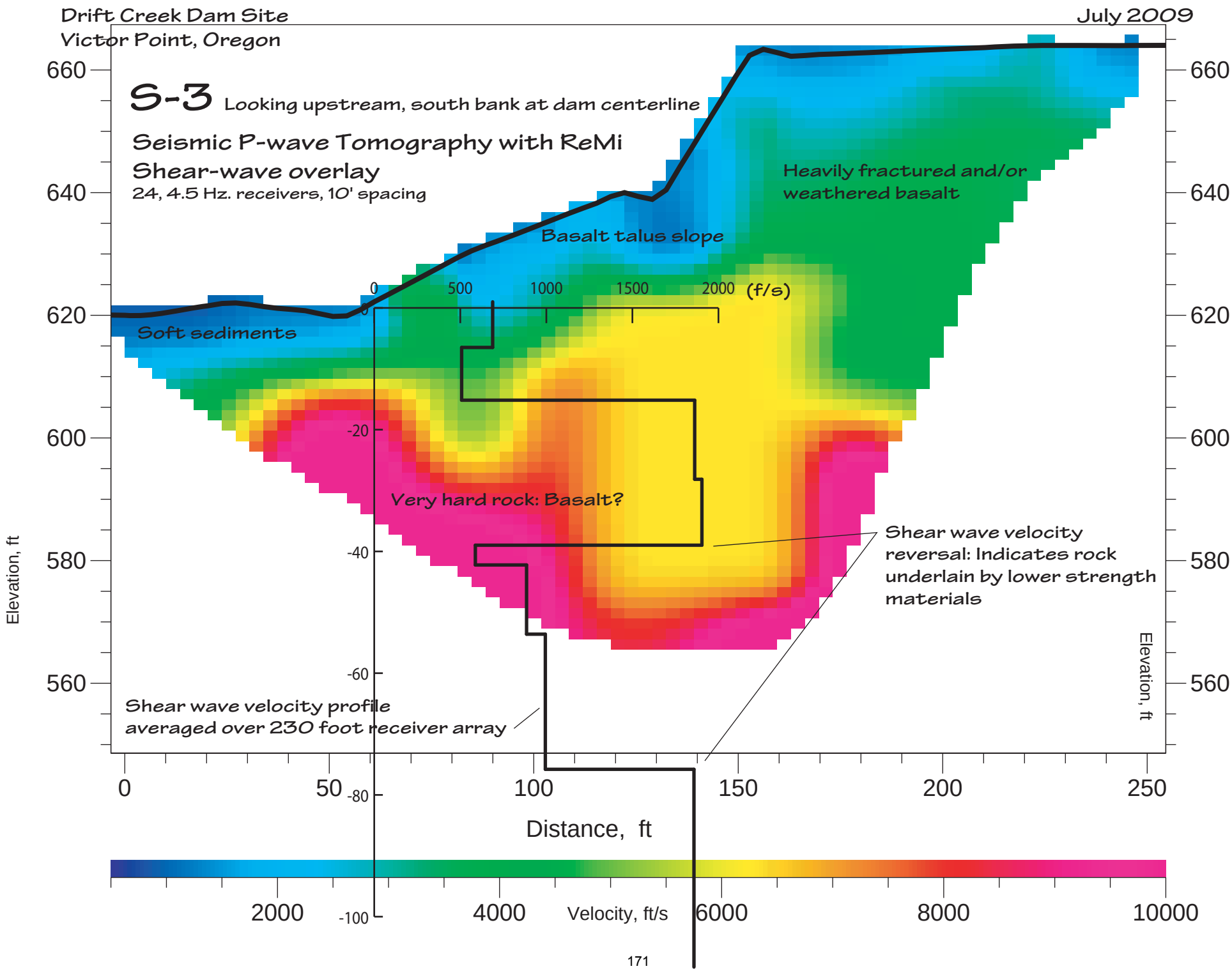
Seismic P-wave Tomography with ReMi Shear-wave overlay

24, 4.5 Hz. receivers on 10 foot spacing



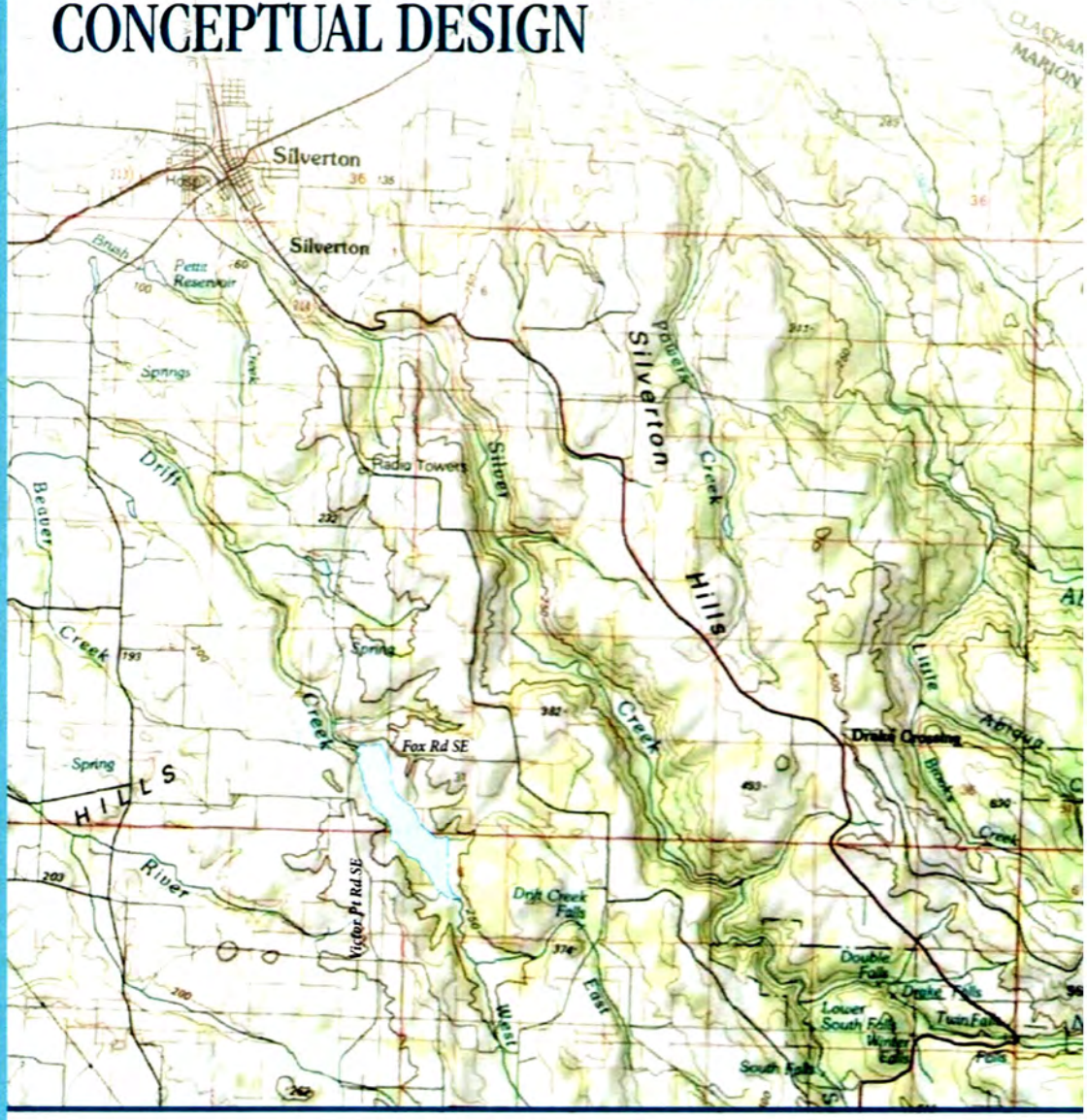
Prepared for: Black Rock Consulting

By: Siemens & Associates
Bend, Oregon


Drift Creek Dam Site
Victor Point, Oregon
July 2009
S-3 Looking upstream, south bank at dam centerline
Seismic P-wave Tomography with ReMi
Shear-wave overlay
24, 4.5 Hz. receivers, 10' spacing
Heavily fractured and/or weathered basalt
Basalt talus slope
Soft sediments
0
500
1000
1500
2000
(f/s)
Very hard rock: Basalt?
Shear wave velocity reversal: Indicates rock underlain by lower strength materials
Shear wave velocity profile averaged over 230 foot receiver array
Elevation, ft
660
640
620
600
580
560
-20
-40
-60
-80
-100
0
50
100
150
200
250
Distance, ft
2000
4000
Velocity, ft/s
6000
8000
10000

Basis of Design Document

DRIFT CREEK DAM AND RESERVOIR CONCEPTUAL DESIGN



MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

East Valley Water District, Oregon

June 201

MSA

SECTION 4

SECTION 4
GEOTECHNICAL ASSESSMENT

General

A conceptual-level geotechnical assessment was completed of the proposed reservoir site by Murray, Smith & Associates, Inc.'s (MSA) geotechnical engineer, GRI Geotechnical & Environmental Consultants (GRI). A report of this assessment and findings are included in Appendix B. The purpose of the preliminary assessment was to investigate the existence of fault-induced ground rupture beneath the dam site, generally assess the risk and impacts of reactivation of mapped landslides, and develop recommendations in support of conceptual designs of the dam and reservoir. The scope of the assessment included review of prior geologic studies and subsurface information, ground-level geologic reconnaissance, test trench and pit excavations, laboratory tests, and engineering analyses and recommendations.

Geotechnical Investigation Results and Preliminary Recommendations

Although significant additional preliminary and final design level geotechnical investigations and engineering are required, the following conclusions and recommendations indicate that the site appears to be generally favorable from a geotechnical and geological perspective.

1. Geotechnical observations at the site and subsurface explorations did not disclose evidence of past fault-related ground rupture beneath the dam footprint. The potential for fault-related ground rupture within the dam footprint is judged to be low.

2. Based on geotechnical observations at the site, limited subsurface explorations, and review of work by others at the site, the hillsides adjacent to the pool area are reported to be mantled and underlain by landslide debris, or weathered rock and soil that had a high risk of slope instability. Landslides mapped through previous work on this project and based on observations revealed that topography indicative of past landslide activity extends west of Victor Point Road SE in some areas. Given these large areas of potential slope instability around the pool, it is not judged to be practical or cost-effective to design mitigation approaches for future possible pool-induced landslides. It is advised that such risk be part of the overall project implementation considerations.

3. Additional exploration work should be accomplished to further evaluate potential borrow areas away from the proposed embankment location. The amount of borrow material available around the dam footprint appears limited to about 2 to 4 feet below the ground surface. To prevent pool floor leakage, borrow areas should be limited in depth to leave at least a 2-foot thick layer of relatively impermeable fine-grained soil above weathered bedrock.

4. Based on the preliminary assessment results and our team's experience with similar projects, it is judged that the proposed earthfill embankment section is feasible and may be constructed with an adequate factor of safety for internal slope stability. However, to safely and economically construct the embankment, a well thought out and sequenced plan of construction work, including foundation preparation, excavation dewatering, select use of available borrow materials, internal drainage and filters, and slope protection will be required.

Recommended Future Geotechnical Work Program

Moving forward through the design process, additional geotechnical assessments will be required, building upon previous work. Recommended geotechnical work includes the following tasks:

- *Preliminary Design* – Building upon the site investigations performed during conceptual design, deep subsurface explorations are recommended to further assess the onsite soil characteristics. Borings, drilled to depths up to 100 feet, should be used to obtain soil samples and install piezometers to log the piezometric pressure. A permanent inclinometer should be installed in the landslide near the left dam abutment at Victor Point Road to monitor ground stability.

- *Seismic Hazard Studies* – A review of existing information regarding the seismicity of the proposed reservoir site should be carried out in order to estimate the ground response during a design earthquake event. Attention should be paid to the potential for amplification of incoming seismic energy throughout the dam and reservoir site and the peak ground/bedrock acceleration should be determined.

- *Final Design Studies* – Final design work should include an evaluation of the final dam embankment footprint and areas which require landslide buttressing. Soil samples from previously identified borrow areas should be tested further in a laboratory to verify their suitability for embankment material. Water seepage through the proposed embankment should be evaluated to determine if a drainage blanket within the embankment is necessary. Slope stability analyses should be performed for static and seismic loading conditions. Additional, more detailed geotechnical recommendations should be developed to support final dam and reservoir designs.

APPENDIX B
Conceptual Level Geotechnical and Geological Investigation Report (GRI)

MSA

GRI
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Beaverton, OR 97005-3364
p| 503-641-3478 f| 503-644-8034

June 17, 2011

5186 GEOTECHNICAL RPT CONCEPTUAL DESIGN

Murray, Smith & Associates, Inc.
121 SW Salmon Street, Suite 900
Portland, OR 97204

Attention: Kate Conrad, PE

SUBJECT: Geotechnical Consultation
Phase 1 Conceptual Design - Fatal Flaw Evaluation
Drift Creek Dam
Marion County, Oregon

At your request, GRI has provided geotechnical consultation for Phase 1 Conceptual Design of the proposed Drift Creek dam. The project site is located about 6 miles south of Silverton, Oregon, in a rural portion of the Waldo Hills. The general location of the site is shown on the Vicinity Map, Figure 1. The East Valley Water District will be the owner/operator of this facility, and the reservoir will be used to store water for irrigation.

The purpose of this consultation was to further evaluate two previously identified potential "fatal flaws" associated with design and construction of the proposed dam: 1) at least two fault lineaments have been mapped in the area of the dam site (Tolan and Beeson, 1999), and it is necessary to demonstrate that these faults are inactive with respect to ground rupture beneath the dam; and 2) landslides have been mapped on the west side of the reservoir; reactivation of these landslides will likely result from filling and operating the reservoir. Concurrent with our field work, we also provided the design team with general geotechnical input as requested.

Our work included a review of available information, a ground-level reconnaissance, focused subsurface explorations, laboratory testing, and engineering analyses. This report describes the work accomplished and our field explorations and laboratory testing program, and provides our findings and conclusions regarding the fault lineaments, landslide potential on the margins of the reservoir, and general considerations for design and construction of the reservoir. Our work was completed in general accordance with our proposal dated December 15, 2010.

Phase 2 will be a preliminary design and will be an expansion of the existing conceptual design studies. Phase 3 will be a detailed seismic hazard analysis, which will evaluate the response of the embankment under seismic loading. Phase 4 will be final design studies and reporting and will include assisting Murray, Smith & Associates, Inc. (MSA) in the preparation of construction drawings and specifications and the contract documents suitable for permitting and bidding the project.

BACKGROUND

Previous geotechnical work and geologic mapping have been completed for the project and in the project area by others. Our consultation included review of the following reports by others:

"Engineering Geologic Information for Feasibility of Proposed Drift Creek Dam, Silverton area, Oregon," prepared by H. G. Schlicker & Associates, Inc. for Stuntzner Engineering, June 24, 2005 (Schlicker)

"Geotechnical Reconnaissance, Drift Creek Reservoir and Dam, Victor Point, Oregon," prepared by Siemens & Associates for Black Rock Consulting, July 24, 2009 (Siemens)

The Schlicker report documents the site geology and subsurface conditions around the dam site and pool. Their work indicates the dam site is underlain by basalt rock and interbedded alluvial sediments of the Drift Creek drainage (silt, sand, cobbles, and wood debris). Explorations completed in the pool area indicate the presence of silt, sand, and clay, underlain by weathered sedimentary rock. Schlicker also mapped several large areas along the western pool perimeter as being old landslides and notes that stability of the reservoir valley slopes would likely decrease as the pool was filled. Some of these large landslide areas are on the order of 2,500 by 2,000 ft in plan, or roughly 100 acres in size.

The Siemens report documents additional reconnaissance work that suggests portions of the eastern pool perimeter are steep and prone to slope instability. Geophysical work near the dam site indicates the likely presence of alluvial sediments, weathered sedimentary rock, and basalt rock.

SITE DESCRIPTION

Topography

The proposed reservoir site is located in the Waldo Hills upland area of the Willamette Valley. Drift Creek drains toward the northwest from higher elevation areas to the southeast. At the dam site, the topography narrows and the width of the Drift Creek valley constricts from about 1,000 to 100 ft. Available topographic information indicates the valley floor at the dam site is at about elevation 620 ft, and valley/pool perimeter ranges from about elevation 800 to 1,000 ft. Where observable and not covered by trees or dense vegetation, slopes along the majority of the pool area are irregular (hummocky).

Geology

The dam site is underlain by Tertiary volcanic and sedimentary rocks. The volcanic rocks are part of the Columbia River Basalt Group, and the sedimentary rocks are locally referred to as Scotts Mills Formation. U.S. Geological Survey (USGS) geological mapping for the site is provided on the Geologic Map, Figure 2. Essentially the entire pool area is underlain by relatively weak, weathered sedimentary rock.

The Oregon Department of Geology and Mineral Industries State Landslide Inventory does not show mapped landslides within or adjacent to the pool area. However, the state landslide inventory is not comprehensive, and local areas around the site, in particular steeply sloping areas underlain by sedimentary rocks, have been mapped as landslides. As noted above, Schlicker and Siemens have mapped or interpreted large portions of the pool perimeter as ancient landslides or areas prone to slope instability.

Fault Potential

USGS mapping indicates the presence of two bedrock fault lineaments north of the site in the Drift Creek drainage (Tolan and Beeson, 1999). The fault traces trend toward the location of the proposed dam, but the USGS mapping ends before (west of) the project site. These faults are not considered to have Holocene displacement (U.S. Geological Survey, 2011).

Groundwater

This site exhibits characteristics of shallow groundwater levels, including seeps, springs, and wet depressions with attendant water-loving plants. We expect that surficial groundwater levels approach the ground surface during the wet, winter season and during periods of prolonged or intense rainfall. Regional aquifers in this area are typically located deep in the basalt underlying the area.

PROJECT DESCRIPTION

The 12,000 acre-ft design developed by MSA includes an embankment up to about 65 ft high from toe to crest (crest elevation 687 ft) and about 700 ft long, constructed across the Drift Creek drainage. The proposed embankment volume will be on the order of 127,000 cubic yards. A Preliminary Grading Plan and Typical Dam Section of the proposed improvements are provided on Figures 3 and 4. The overflow spillway will be constructed on the left abutment to direct water into the drainage northwest of the reservoir. We anticipate that sufficient material to construct the conceptualized embankment can be obtained from the reservoir pool area away from the proposed dam. Granular materials suitable for use in internal drains and as riprap slope protection will need to come from off site. Victor Point Road SE is located adjacent to the west limit of the dam and will require relocation westward away from the pool. Based on topographic information, cuts on the order of 20 ft in height may be required to achieve design grades for the relocated Victor Point Road SE.

SURFACE RECONNAISSANCE

The surficial conditions of the project site and slopes uphill and downhill of the site were evaluated during site visits in March and June 2011, by an engineering geologist and geotechnical engineer from GRI. During these visits, evidence of past landslide activity in the pool area was observed, including a large headscarp west of the site, west of Victor Point Road SE, and irregular (hummocky) topography throughout the slopes along the western and eastern sides of the pool. Exposures of weathered sedimentary rock were observed in the mid-eastern portion of the pool area. Relatively hard basalt rock is exposed along the nose of the ridge at the left (west) abutment.

FIELD EXPLORATIONS

General

On June 7, 2011, subsurface materials were evaluated with two test pits, designated TP-GRI-1 and TP-GRI-2, using a small trackhoe excavator with rubber tracks supplied and operated by Dan J. Fischer Excavating, Inc. of Forest Grove, Oregon. The approximate locations of the test pits are shown on Figure 3. All field explorations were observed by a geotechnical engineer and engineering geologist from GRI, who collected samples and maintained detailed logs of the materials and conditions encountered during the course of the work. Samples recovered from the test pits were returned to our laboratory for further examination and physical testing.

Fault Potential Evaluation

To evaluate the potential presence of geologic features that may indicate the potential for fault rupture below the dam, a relatively long trench was excavated perpendicular to the narrow topographic area near the dam footprint. The location of this exploration, designated trench TP-GRI-1, is shown on Figure 3. This trench measured a total of 230 ft and was completed in accordance with a pre-approved team work plan. The trench was excavated to a depth of 3 to 4 ft and encountered a surficial 2-ft-thick layer of dark brown, clayey silt that contains many fine roots and has a blocky texture. The dark brown unit is underlain by a 1- to 2-ft-thick layer of light brown, clayey silt. The light brown, clayey silt transitioned into decomposed sedimentary rock near the bottom of the excavation along the total length of the trench. The

decomposed sedimentary rock has weathered to the consistency of stiff soil. Near the midpoint of the trench, a short section was excavated to a depth of about 9 ft and the decomposed sedimentary rock continued to the bottom of the excavation. Light groundwater seepage was encountered at a depth of 2.5 to 4 ft below the ground surface.

No indications of fault rupture, shearing, displaced soil horizons, or other indications of faulting were observed.

Supplemental Borrow Area Test Pit

To evaluate the thickness of potential borrow materials, a test pit was excavated in the pool area on June 7, 2011. The location of this exploration, designated test pit TP-GRI-2, is shown on Figure 3. The test pit was excavated to a depth of 5 ft and encountered a surficial 2-ft-thick layer of dark brown, clayey silt underlain by a 2-ft-thick layer of light brown, clayey silt. At a depth of 4 ft, the light brown, clayey silt transitioned into decomposed sedimentary rock. Heavy groundwater seepage was encountered at a depth of 4 to 5 ft below the ground surface.

LABORATORY AND FIELD TESTING

General

Samples obtained from the test pits were returned to our laboratory where the physical characteristics of the samples were further documented. The laboratory testing program included natural moisture content and Atterberg limits. Torvane shear strength testing was completed in the field. The following paragraphs describe the testing program in more detail.

Natural Moisture Content

The natural moisture content of the materials encountered in the test pits was determined in conformance with ASTM D 2216. The results are summarized below:

Test Pit	Sample	Depth, ft	Moisture Content, %	Soil Type
GRI-TP-1	S-1	1	39	Clayey SILT
	S-2	3	38	Clayey SILT
GRI-TP-2	S-1	1	38	Clayey SILT
	S-2	3	52	Clayey SILT
	S-3	5	52	Decomposed sedimentary rock

Atterberg Limits

Atterberg limits tests were performed on representative samples in conformance with ASTM D 4318. The test results are shown on Figure 5.

Torvane Shear Strength

The approximate undrained shear strength of relatively undisturbed soil samples was determined using a Torvane shear device. The Torvane is a hand-held apparatus with vanes that are inserted into the soil. The torque required to fail the soil in shear around the vanes is measured using a calibrated spring.

Multiple Torvane results indicate the clayey soils from test pit GRI-TP-1 have an approximate undrained shear strength of 0.50 tsf. This value is typical for relatively fine-grained soils with moderate to low strength.

FINDINGS AND CONCLUSIONS

Based on our review of the project plans, previous work by others, and our implemented scope of work, we have developed the following findings and conclusions:

1) Our observations at the site and our subsurface explorations did not disclose evidence of past fault-related ground rupture beneath the footprint of the dam. In our opinion, the potential for fault-related ground rupture within the footprint of the dam is low.

2) Our observations at the site, subsurface explorations, and review of work by others at the site indicate the hillsides adjacent to the pool area are mantled and underlain by landslide debris or weathered rock and soil that have a high risk of slope instability. Landslides mapped through previous work on this project and our observations revealed that topography indicative of past landslide activity extends west of Victor Point Road SE in some areas. In our opinion, given these large areas of potential slope instability around the pool, it is not practical or cost-effective to design mitigation approaches for future possible pool-induced landslides. The owner must accept this risk as part of the overall project implementation.

3) Additional exploration work should be accomplished to further evaluate potential borrow areas away from the embankment (outside the area shown on Figure 3). The amount of borrow material available around the footprint of the dam appears limited to about 2 to 4 ft below the ground surface. To prevent pool floor leakage, borrow areas should be limited in depth to leave at least a 2-ft-thick layer of relatively impermeable fine-grained soil above weathered bedrock.

4) Based on the results of our work and experience with similar projects, it is our opinion the proposed earthfill embankment section is feasible and may be constructed with an adequate factor of safety for internal slope stability. However, to safely and economically construct the embankment, a well thought-out and sequenced plan of construction work, including foundation preparation, excavation dewatering, select use of available borrow materials, internal drainage and filters, and slope protection, will be required.

CONSTRUCTION RECOMMENDATIONS

Seasonal Construction - Earthwork and Excavation

The fine-grained soils and weathered sedimentary rock at the site are suitable for construction of the proposed homogeneous embankment; however, they are also moisture-sensitive and will be difficult to place and compact when the moisture content of the materials is significantly above optimum. It appears that the in-place moisture content of the soils is above the optimum moisture content for compaction, and the soils will require considerable drying or amendment with lime or cement to improve the workability of the material for placement as compacted structural fill. In our opinion, with or without the use of soil additives, placement and compaction of fine-grained soil at this site will be limited to periods of extended dry weather, which typically occur from about mid-June to mid-September. As a result, this project may require two or more summer construction seasons for completion of the dam earthworks.

Site Preparation

We recommend the foundation and abutments for the proposed embankment should be cleared of timber, grubbed, and stripped of vegetation. Foundation conditions should be evaluated by the geotechnical engineer at the time of site preparation. Based on observation of the soil exposed in the test pits, the upper 2 ft of soil contains many fine roots and has a blocky texture. For the portion of the embankment footprint established on the relatively flat area near the elevation of the bottom of the pool, we recommend removing the soil from the embankment footprint to expose the underlying decomposed sedimentary rock. Exposed subgrade beneath the embankment should be scarified to a depth of about 12 in. and compacted to a minimum of 95% of the maximum dry density at a moisture content within the range of 2% below to 4% above the optimum moisture content as determined by ASTM D 698.

Areas of seepage encountered within the limits of the embankment should be evaluated by the geotechnical engineer for recommended remedial action.

Cuts and Fills

Permanent cut and fill slopes should have a design slope of 2H:1V or flatter. Deep cuts for the embankment footprint will encounter shallow groundwater and weathered sedimentary rock. Based on the presence of basalt in the dam area, it is likely that trackhoe excavators will be needed to make the excavations. Excavation of weathered sedimentary rock will likely require the use of a medium-size (Cat D-7) or larger bulldozer equipped with a ripper.

On-site fine-grained soils and weathered sedimentary rock are suitable for use in structural fill. Basalt boulders should not be used in fill within the reservoir embankment. All structural fill placed on the site should be approved for placement by a qualified geotechnical engineer. The soil placed in the embankment should be free of organic material. Structural fill should be placed in 6- to 9-in.-thick lifts (before compaction) for fine-grained soil (silt and decomposed siltstone) and 9- to 12-in.-thick lifts (before compaction) for granular materials.

Fine-grained soils and weathered siltstone fill should be compacted using a large (Cat 815) or larger static segmented-pad compactor. Pieces of weathered sedimentary rock that are gravel-size or larger should break down with several passes of the segmented-pad compactor. Use of single-drum vibratory compactors fitted with segmented pads should not be allowed for compaction of fine-grained soils. Fine-grained fill should be compacted to at least 95% of the maximum dry density at a moisture content within the range of 2% below to 4% above the optimum moisture content as determined by ASTM D 698. Actual compaction procedures should be determined in the field at the time of construction by building a test section of the embankment fill material. Fills of fine-grained materials with an outer slope steeper than about 3H:1V should be overbuilt by a thickness of about 2 ft and then cut back to the final grade. It must be recognized that the moisture content of the on-site fine-grained soils and the weathered sedimentary rock is well above optimum, and the materials will require significant drying or amendment with lime or cement prior to placement and compaction.

Granular fill constructed of sand- to gravel-size material should be compacted using a large, smooth-drum vibratory roller to at least 95% of the maximum dry density as determined by ASTM D 698. Coarse granular fill from 3 to 12 in. in diameter may also be compacted into place with a large, smooth-drum roller or by track-walking with a large bulldozer until well keyed.

Side slopes of temporary cuts deeper than 4 ft should not be constructed steeper than 1H:1V. Cut and fill slopes composed of fine-grained materials will be extremely susceptible to erosion. All slopes should be

revegetated or otherwise protected as soon as practical following construction. Surface water should be directed away from the slopes.

Haul Roads

Our experience indicates the fine-grained soils that mantle the site are sensitive to moisture content. Typically, when these soils are in excess of 4 to 5% of their optimum moisture content, construction traffic will remold, rut, and soften the soil and limit its use as a construction haul road. For this reason, we recommend that all construction traffic be limited to movement on granular work pads and haul roads during the season when the moisture content of surface soils is significantly above optimum.

In our opinion, a 12-in.-thick granular work pad should be sufficient to prevent disturbance of the subgrade by lighter construction equipment and limited traffic by dump trucks. Haul roads and other high-density traffic areas will require at least 18 to 24 in. of crushed rock to prevent subgrade deterioration. Any subgrade soils that are disturbed by construction activity should be overexcavated to firm soil and backfilled with coarse, granular compacted structural fill. Any granular fill placed for haul roads within the footprint of the embankment should be removed before constructing embankment fill. Haul road requirements will be reduced if work is accomplished during the driest months of the year.

Geotextiles may be used between the granular haul road materials and the underlying fine-grained subgrade soils as a separation filter to prevent the movement of fines into the crushed rock. Use of these fabrics may improve haul road performance and reduce maintenance, particularly during wet-weather conditions.

Construction Dewatering

Construction dewatering will be essential for project completion. Based on our experience, we are of the opinion that the majority of the excavation can be completed by ditching and pumping from sumps located within the excavation. However, use of this approach will require that the excavation proceed slowly enough for the hydrostatic pressures behind the excavation face to dissipate and the groundwater surface to lower as construction proceeds. The anticipated quantity of water is difficult to estimate, since the majority of the flow, in our opinion, will come from discrete zones, cracks, and fissures in the soil and rock masses, with a very small percentage actually seeping through the soil and rock mass. Consequently, we are of the opinion that the groundwater surface behind the excavation face should fall relatively quickly following completion of the excavation at any given elevation. However, given the nature of the local geology, we also anticipate that large localized flows of groundwater may also be encountered. These concentrated flows could result in areas of instability of the cut face. It may be possible to manage these large flows by placing a layer of free-draining granular material on the exposed face of the excavation. However, if this approach is not able to maintain the stability of the face of the excavation, it will likely be necessary to install a system of relief wells above the top of excavation, or install a series of horizontal drains in the cut face. Regardless of the approach to dewatering, it will be essential to keep the bottom of the excavation free of standing water and monitor the excavation for any increases in water entering the excavation. As previously noted, areas of seepage encountered within the limits of the embankment should be evaluated by the geotechnical engineer for recommended remedial action.

Embankment Drains

Permanent control of seepage through the embankment and management of groundwater levels below the embankment will be important to the stability of the structure. An internal drainage system should be constructed to lower water pressures within the downstream shell of the structure. The proposed drainage

consists of a drainage blanket composed of clean, open-graded granular material that daylights at the elevation of the toe of the embankment and extends to about the centerline of the embankment.

To reduce the risk of piping of the fine-grained embankment material into the drain material leading to clogging of the drain, a filter material will need to be installed between the drain and the surrounding soil. Gradation and thickness of the filter material should be determined after a drain material has been selected. A series of perforated drain pipes should be installed on about 20-ft centers in the drainage material at the downhill toe of the drainage blanket. Water in these pipes should be collected and hard-piped to a discharge point located away from the toe of the reservoir embankment.

Embankment Slope Protection

Sloped portions of the embankment sides exposed to water should be lined with riprap to reduce erosion at the waterline and turbidity. The slope protection should extend from an elevation at least 2 ft below the normal low-water operating level of the reservoir to a point 2 ft above the normal high pool. The riprap should be bedded on a layer of pervious, well-graded gravel or crushed rock with material diameters ranging from about 3/16 to 3 1/2 in. Gradations of the blanket material can be more accurately determined once a slope protection material is selected. This bedding layer should be placed in a single lift that achieves a thickness of at least 12 in. after compaction, measured perpendicular to the slope.

Riprap placed on the embankment should have a minimum thickness of 24 in. measured perpendicular to the slope and should meet the following criteria: maximum size should equal 100 pounds, of which 30 to 40% of the material should be 60 to 100 lbs; 60 to 70% of the material should be 25 to 60 lbs; and less than 10% of the material should be under 25 lbs. The riprap should be placed in a manner to produce a uniform thickness of well-keyed, dense, uniformly distributed rock fragments.

The downstream surface of the embankment may be protected from erosion using a 6-in.-thick cap of 4-in.-minus crushed rock. Outside the area of the spillway, the surface may also be protected by planting a suitable cover of grass or other shallow rooted, low-lying ground-cover vegetation. The downstream slope should be protected from the crest of the dam to the lower limits of the embankment slope.

The surfaces of the embankment should be kept free of deeply rooted vegetation such as trees. The embankment should also be kept free of animal burrows. Downstream surfaces of the embankment and areas within 50 ft downstream of the embankment should be kept free of brushy vegetation that inhibits observations of seeps and springs that may develop following reservoir filling.

LIMITATIONS

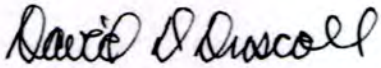
This report has been prepared to aid the owner and engineer in the conceptual planning, design, and construction of this project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the earthwork and design and construction of the dam. In the event that any changes in the design and location of the dam as outlined in this report are planned, we should be given the opportunity to review the changes and to modify or reaffirm the conclusions and recommendations of this report in writing. Additional exploration and geotechnical work will be required as part of the Final Design.

The findings, conclusions, and recommendations submitted in this report are based on the data obtained from the test pits made at the locations indicated on Figure 3 and from other sources of information discussed in this report. In the performance of these types of projects, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in soil and rock conditions

may exist between test pit locations. This report does not reflect any variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions different from those encountered in the explorations are observed or encountered, we should be advised at once so that we can observe and review these conditions and reconsider our recommendations where necessary.

Please contact the undersigned if you have any questions or comments regarding this report, or if we can be of further assistance to you.

Submitted for GRI,



George A. Freitag, CEG Associate	Michael J. Zimmerman, PE, CEG Senior Engineer/Geologist	David D. Driscoll, PE, GE Principal Engineer

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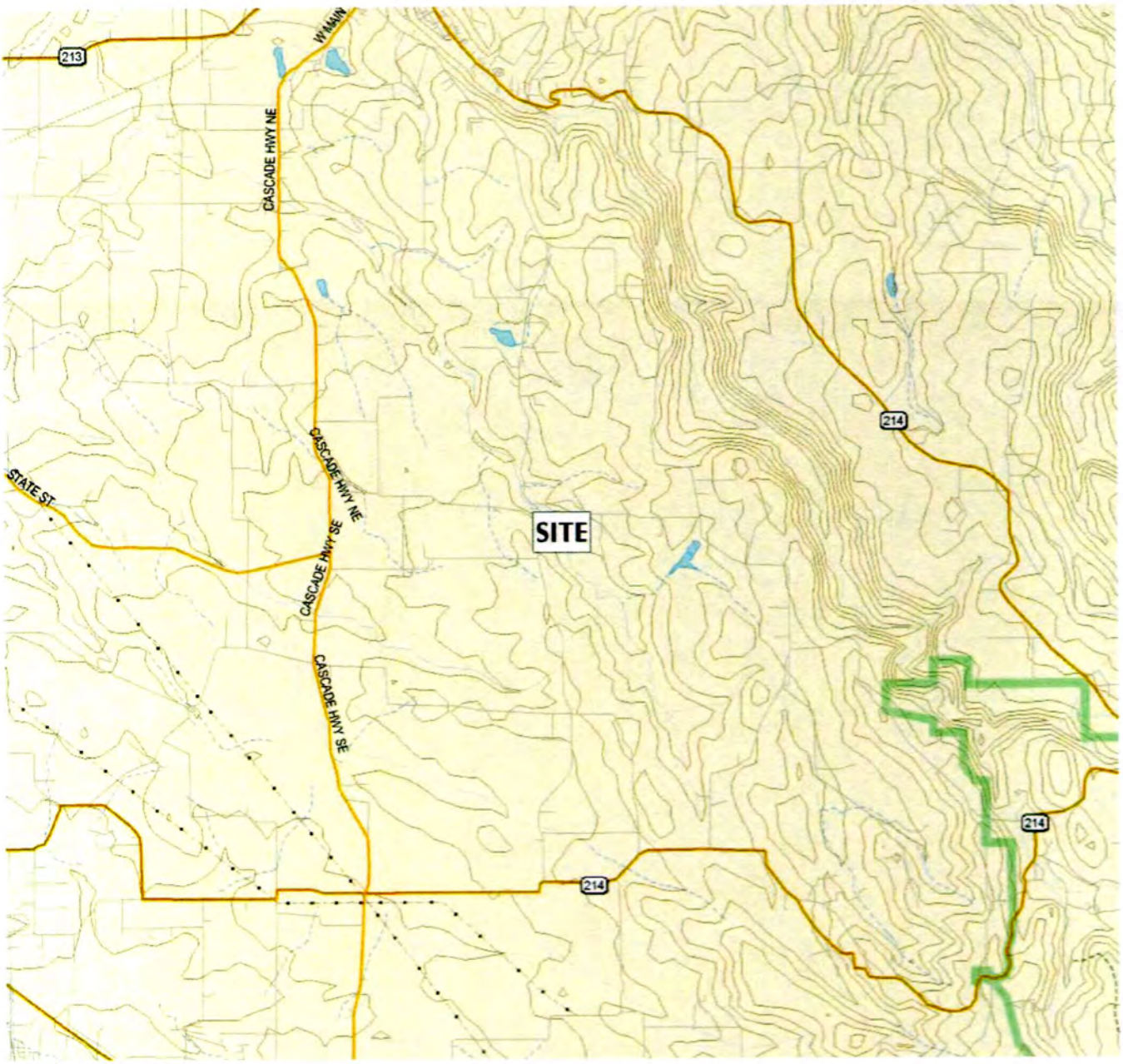

DELORME 3-D TOPOQUADS, OREGON
DRAKE CROSSING, OREG. (3bb) 2004

North

0 2 4 MILES

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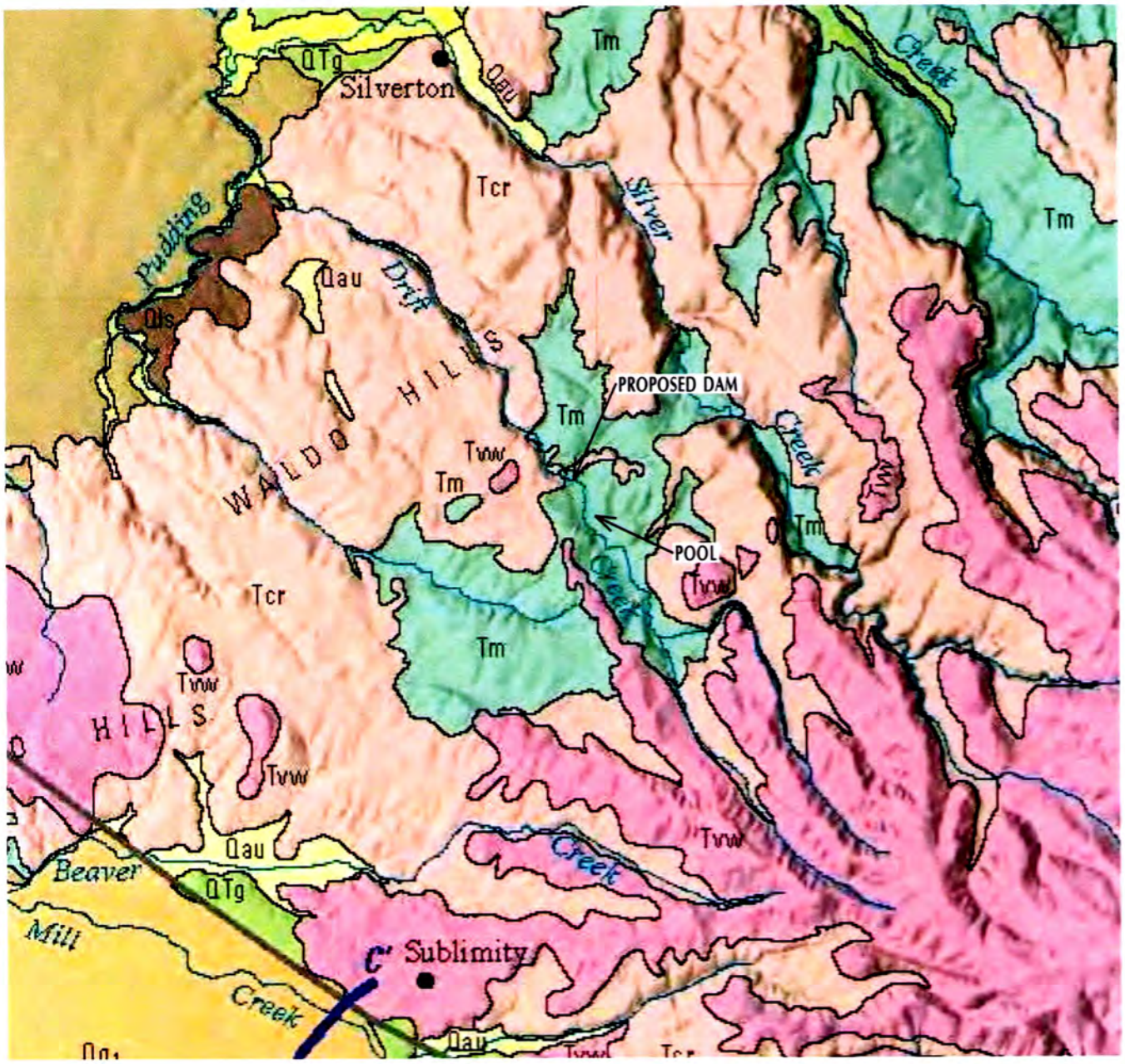
DRIFT CREEK DAM CONCEPTUAL DESIGN

VICINITY MAP

JUNE 2011 JOB NO. 5186 FIG. 1



LEGEND

Tcr	**Columbia River Basalt Group (Miocene)**—Lava flows of dark gray to black, locally porphyritic basalt. Locally deeply weathered. Mostly between 16 and 15 Ma in northern Willamette Valley (M.H. Beeson, Portland State University, written communication, 1998). Also includes small areas of alluvium, colluvium, loess, and landslide debris. Distribution after Gannett and Caldwell (1998)
Tm	**Marine sedimentary rocks (lower Miocene to Eocene)**—Marine sandstone, siltstone, shale, and claystone, with lesser conglomerate, locally tuffaceous. Also includes numerous small mafic intrusions, and small areas of alluvium, colluvium, loess, and landslide debris. Distribution after Gannett and Caldwell (1998).

FROM: O'CONNOR AND OTHERS, DATED 2001

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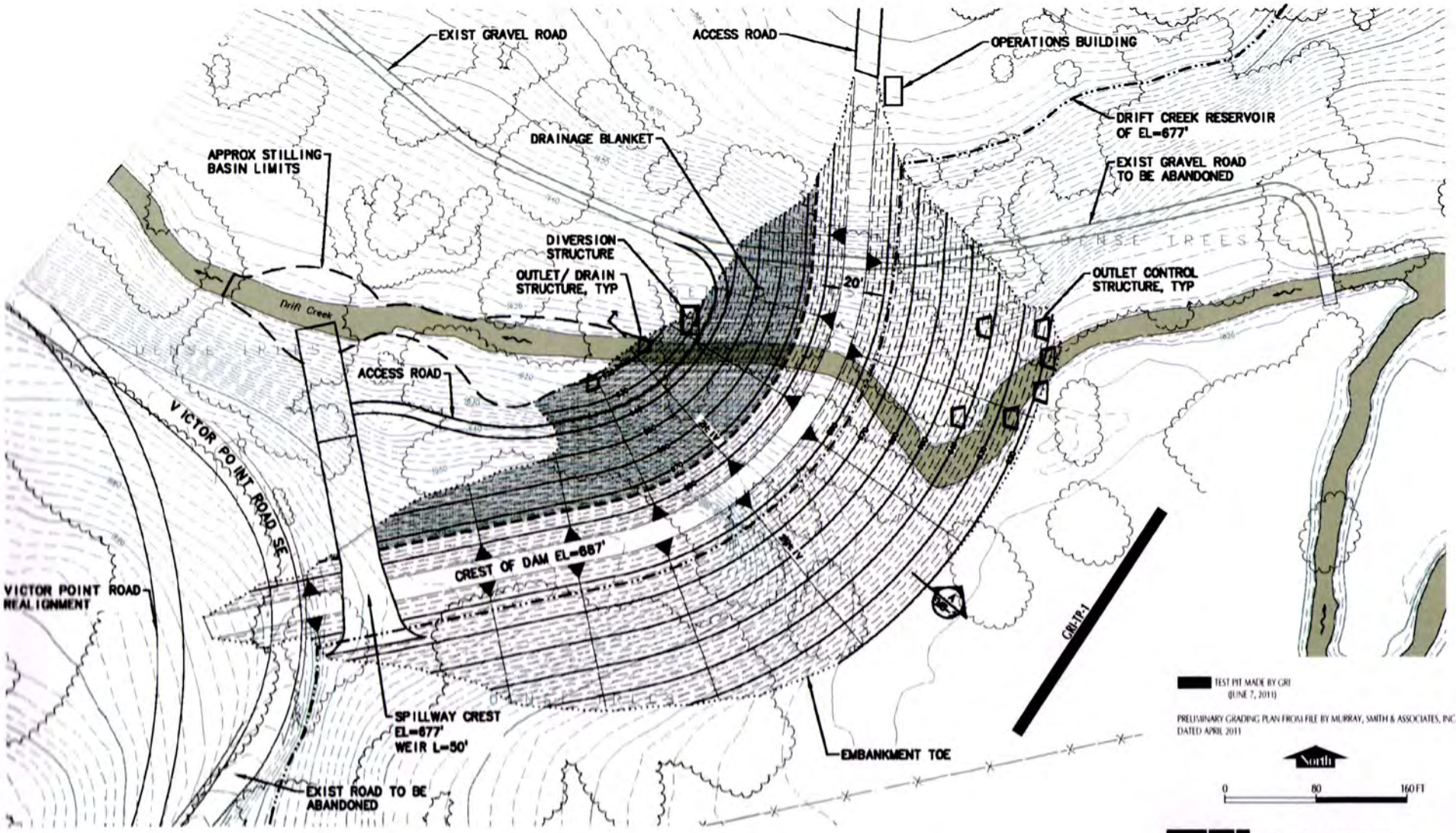
North

0 2.5 5 MILES

GEOLOGIC MAP

JUNE 2011 JOB NO. 5186 FIG. 2



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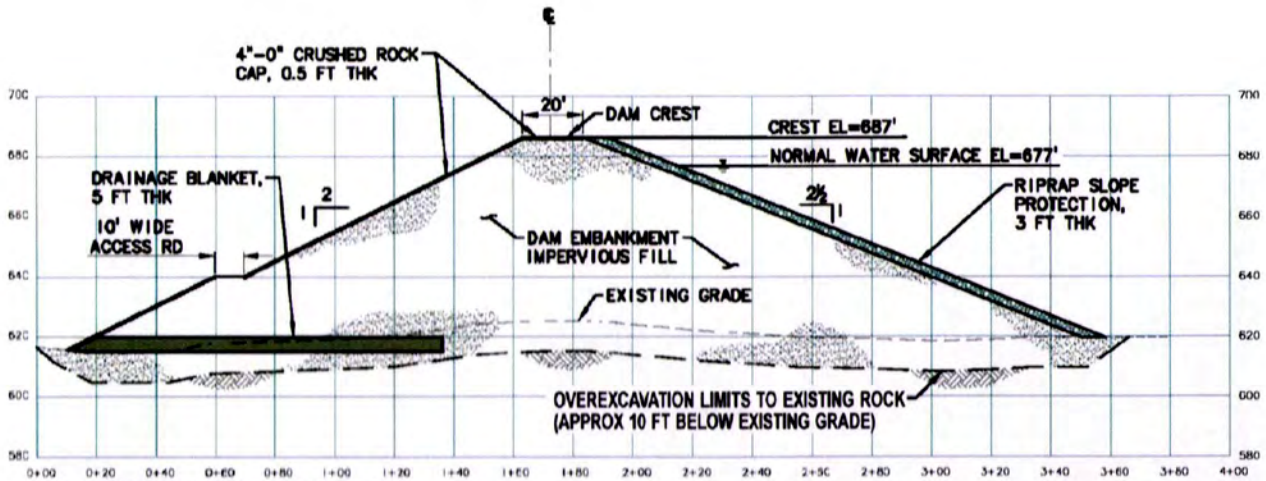
GRI-TP-2

PRELIMINARY GRADING PLAN

JUNE 2011 JOB NO. 5186 FIG. 3



NOTE: PROPOSED HYDRAULIC STRUCTURES NOT SHOWN FOR CLARITY.

TYPICAL DAM SECTION FROM FILE BY MURRAY, SMITH & ASSOCIATES, INC., DATED APRIL 2011

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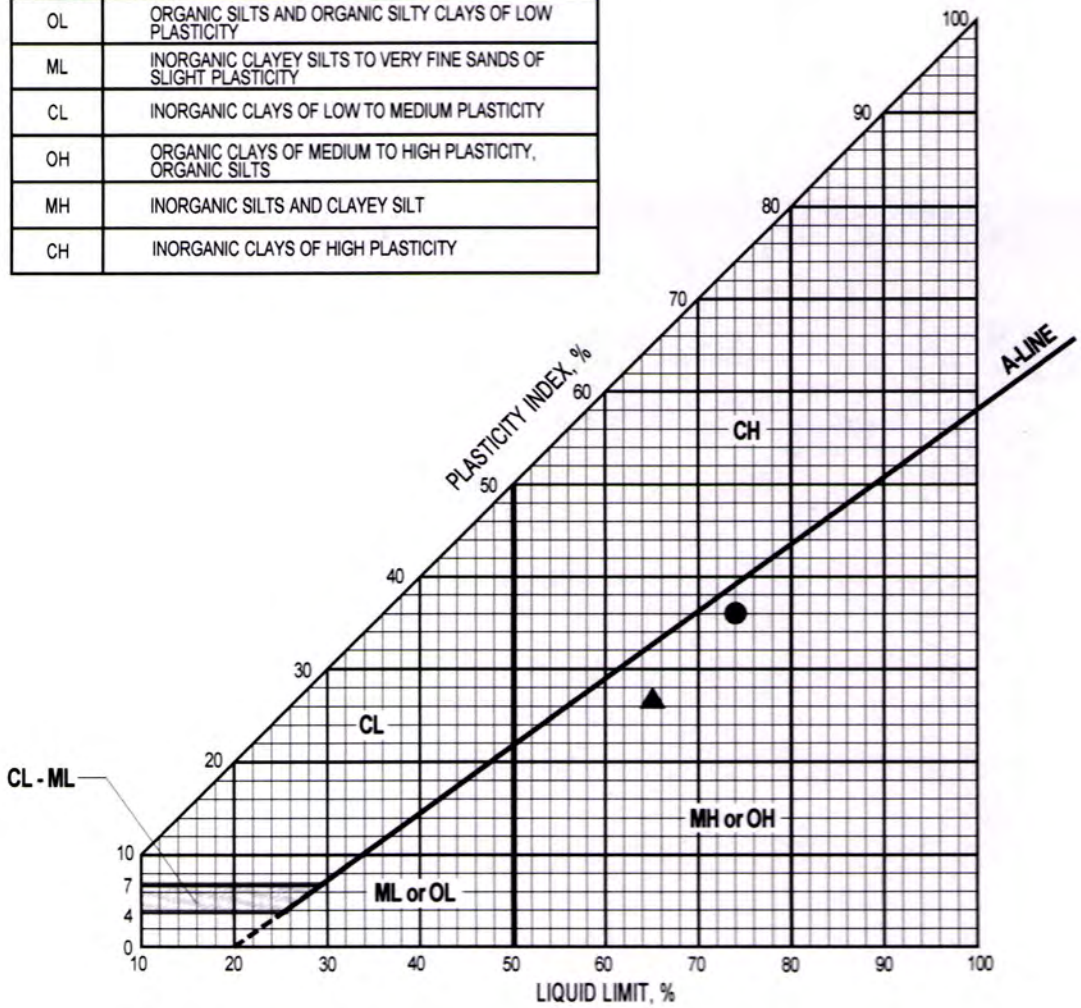
DRIFT CREEK DAM CONCEPTUAL DESIGN

TYPICAL DAM SECTION

JUNE 2011 JOB NO. 5186 FIG. 4

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
ML	INORGANIC CLAYEY SILTS TO VERY FINE SANDS OF SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
MH	INORGANIC SILTS AND CLAYEY SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY



SYMBOL	LOCATION	SAMPLE	MOISTURE CONTENT,%	SOIL DESCRIPTION
●	TP-2	S-2	52	BROWN SILT; TRACE CLAY, TRACE TO SOME MEDIUM- TO COARSE-GRAINED SAND
▲	TP-2	S-3	52	LIGHT BROWN SILT; TRACE TO SOME CLAY, TRACE MEDIUM- TO COARSE-GRAINED SAND, SCATTERED FINE GRAVEL (WEATHERED ROCK)

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DRIFT CREEK DAM CONCEPTUAL DESIGN

PLASTICITY CHART

JUNE 2011 JOB NO. 5186 FIG. 5

SECTION 4
IRRIGATION FLOWS DISCHARGED TO DRIFT CREEK SCENARIOS

Portland State University (PSU) provided the "Drift Creek Reservoir Model – Irrigation Flows Discharged to Drift Creek Scenarios" report as a part of Reconnaissance I in 2011. PSU developed a model to study the impact of removing water from the reservoir/creek system and delivery irrigation water through a pipeline. Dr. Wells of PSU reviews the model and its capabilities in that report.

For Reconnaissance II, the model was used to investigate the water quality impact of discharging irrigation demands to Drift Creek directly. The design concept included middle and lower outlets and the addition of a "high" level outlet to enable the reservoir to operate with discharges from the outlets in order to meet downstream temperature requirements. The reservoir would need to be operated to discharge water from the upper and middle outlets in the spring and the middle and lower outlets during the summer and fall to provide cooling flows for water quality purposes.

This study included two sets of scenarios:

- Assumption that inflows between the toe of the dam and the mouth contribute toward meeting the instream water right; and
- Assumption that the instream water right need would be met at the dam outflow with no credit given for inflows between the toe of the dam and the mouth.

Each scenario was run in one of three water flow periods:

- Low flow as experienced in 1945;
- Average flow as experienced in 1934; and
- High flow as experienced in 1948.

Additionally, the scenarios included

- Using two outlets with no mixing option;
- Using two outlets with a mixing option; and
- Using three outlets with mixing.

The primary goal was to mode the ability to meet stream temperature standards downstream of the dam in Drift Creek. As a result, the following conclusions were drawn:

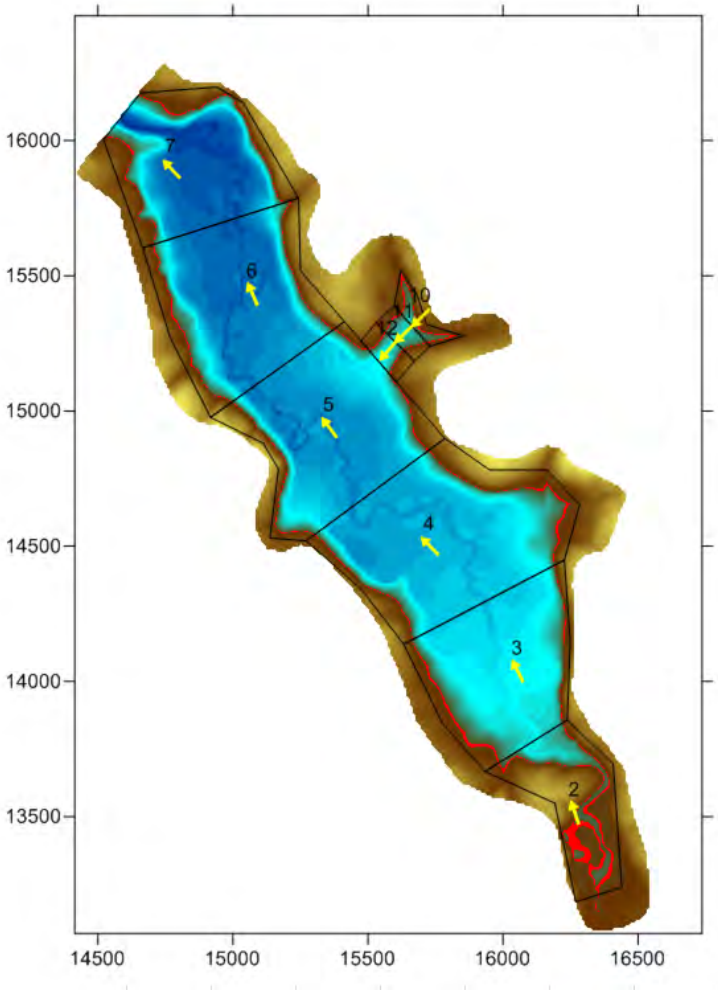
- Mixing from more than one outlet would be required to meet the temperature standard while preserving a cold water pool at the bottom of the reservoir for as long as possible.
- The two outlet scenario with mixing performed better with the mid-outlet elevation sifted upwards to 656.16 feet, allowing water to be withdrawn loser to the surface during the spring and summer while preserving the cold water pool use for late summer and early fall.

- Adding a "high level" outlet at 659.44 feet was the most effective scenario to meet temperature standards.
- Temperatures were warmer when no flow credit was given for inflows between the toe of the dam and the mouth. When mixing flows from the 3 outlets, temperature standards were very

close to being met for 2 out of the 3 years simulated. Slight reduction of agricultural release might preserve enough cold water for standards to be met during the critical October period.

Drift Creek Reservoir Model

Irrigation Flows Discharged to Drift Creek Scenarios



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Drift Creek Reservoir Model:
Irrigation Flows Discharged to Drift Creek Scenarios

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Prepared for East Valley Water District

December 2012

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Introduction

An existing CE-QUAL-W2 water quality model (Berger et al., 2011) of the proposed reservoir formed by the Drift Creek Dam was developed. The reservoir model grid for Drift Creek is shown in Figure 1. This model was used to investigate the water quality impact of discharging irrigation demands to Drift Creek. In the prior study the impact of removing water from the reservoir/creek system and delivering irrigation water through a pipeline was investigated. The proposed dam includes middle and lower outlets and the use of an additional, "high" level outlet was investigated. In order to meet downstream temperature requirements, water will generally be withdrawn from the upper and middle outlets in the spring and the middle and lower outlet during the summer and early fall.

The model used for the reservoir formed by Drift Creek Dam is the public domain model, CE-QUAL-W2 (Cole and Wells, 2010). This model is a 2-dimensional (longitudinal-vertical) hydrodynamic and water quality model capable of predicting water surface elevation, velocity, temperature, nutrient concentrations, algae, dissolved oxygen, pH, alkalinity, and multiple organic matter groups, both dissolved and particulate. The model is set up to predict these state variables at longitudinal segments and vertical layers. Model longitudinal grid spacing is between 86-581 m, and the vertical grid spacing is 1 m.

Two sets of scenarios were simulated. One set assumed that inflows between the toe of dam and the mouth contribute toward meeting the in-stream water right. The second set assumed that no credit was given for inflows between the toe of the dam and the mouth and that the in-stream water right requirements need to be met at the dam outflow. The scenarios include the simulation of low, average, and high flow years. The low flow year was 1945; the average flow year was chosen to be 1934; and the high flow year was 1948. The scenarios simulate the period between January 1 and December 31. January 1 was chosen as the simulation start date because the reservoir would likely be vertically well-mixed on this date.

Scott Wells, Chris Berger, and the Water Quality Research Group at Portland State University have been the primary developers of this model for the ERDC (Engineer Research and Development Center), Environmental Laboratory, Waterways Experiments Station Corps of Engineers for the last 15 years. Since 2000, this model has been used extensively throughout the world in 116 different countries in lakes, reservoirs, estuaries, and river systems. The user manual and documentation can be found at the PSU website for the model: http://www.cee.pdx.edu/w2.

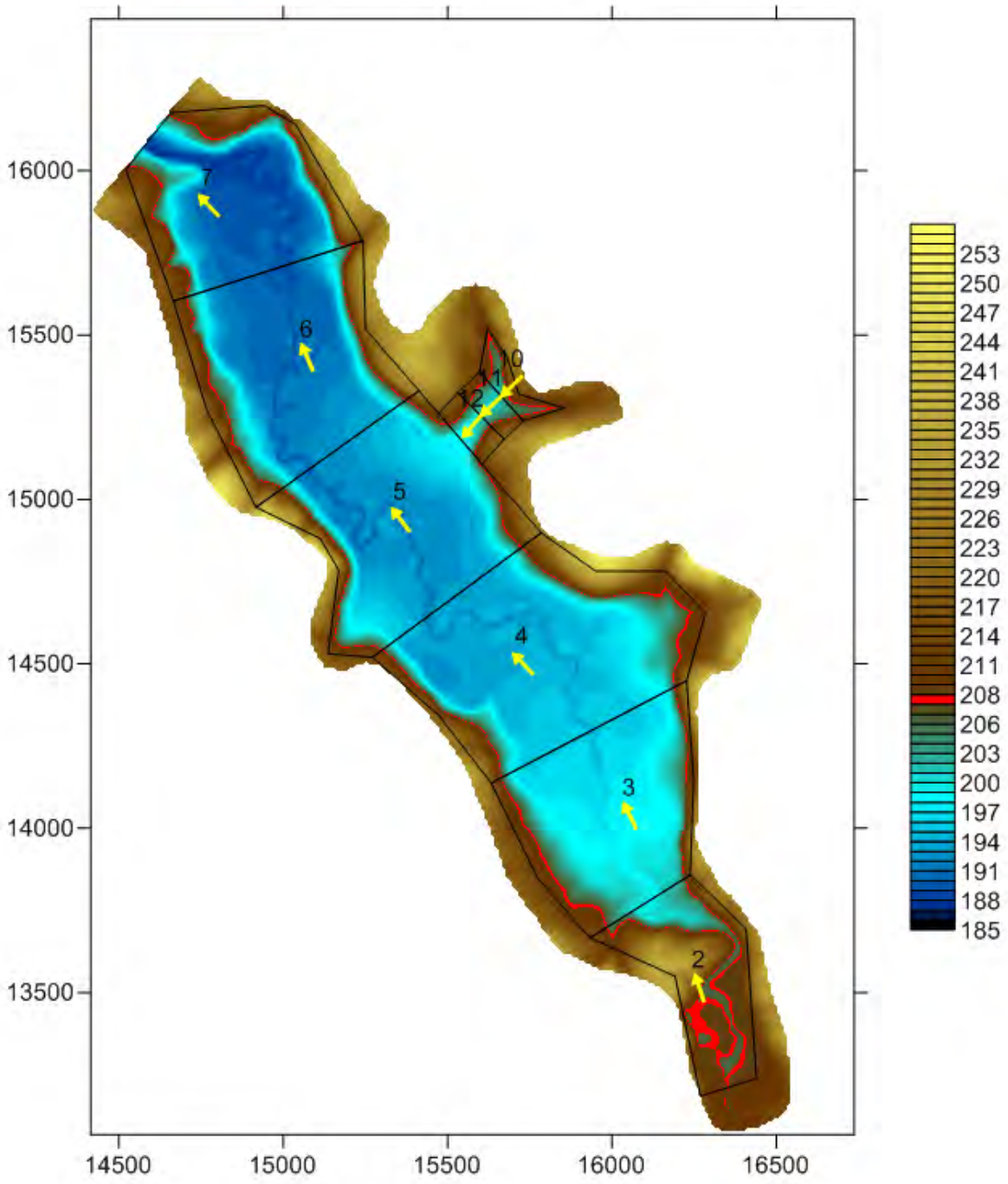

Figure 1. Bathymetry of the Drift Creek Dam Project. The polygons show the model segments for the reservoir model. Elevations were in meters.

Project Scope

The objective of this project was to run additional model scenarios using the existing model of Drift Creek Reservoir. The model can predict water quality impacts of various dam operational strategies. The scenarios investigated in this project involved the option of discharging irrigation demands directly to Drift Creek. Withdrawals from dam outlets were determined in an attempt to meet downstream temperature standards and preserve a cold water "pool" at the bottom of the reservoir. Water from this cold water pool could then be used help meet temperature standards in late summer and early fall. One set of scenarios assumed that inflows between the toe of the dam and mouth could contribute to the in-stream water right, and the other set assumed that no credit would be given and flows at the toe of the dam must meet the in-stream water right requirements. The scenarios included:

1. Water withdrawal from the mid-level outlet, and then the lower outlet (two outlets with no mixing scenario). For this scenario water from the 2 outlets was not "mixed" or combined in order to meet the standard. Flows passed through one outlet or the other. The elevation of the mid-level outlet was adjusted in an attempt to meet downstream temperature standards. Multiple iterations were simulated so that use of the cold water pool at bottom of reservoir would be optimized. Low, average, and high flow years were simulated.
2. Mixing outflows from the two planned outlets. Water from both outlets were withdrawn and combined to meet temperature standards. The elevation of the mid-level outlet was adjusted in an attempt to meet temperature standards. Low, average, and high flow years were simulated.
3. In addition to the mid-level outlet and lower outlets, the impact of adding an upper level outlet that can withdraw water near the surface during late spring and early summer and still meet temperature standards was also evaluated. Flows were from the outlets were also combined (mixed) to meet temperature standards and low, average, and high flow years were simulated.

Reservoir Operations

Dam and reservoir parameters are listed in Table 1. The estimated agricultural release flows, which were provided by the East Valley Water District and assumed a total release for the year of 8000 acre-feet, were shown in Table 2. Table 3 lists the dam release flows necessary to satisfy in-stream water rights (ISWR) assuming that inflows between the toe of the dam and the mouth contribute toward meeting the water right. These are year 2011 release rates provided by Tanovan (2012). If the ISWR monthly release rate was less than 1 cfs, a minimum release rate of 1 cfs was used. Table 4 lists the in-stream water right and consumptive use release requirements assuming that no credit is given for inflows between the toe of the dam and the mouth. For the "no credit" scenarios if reservoir inflows exceeded the release requirements, dam outflows were set to the release requirements plus any agricultural releases. If dam inflows were less than the ISWR and consumptive release requirement, dam outflows were set equal to dam inflows plus any agricultural releases (Tanovan, 2012).

The spillway was modeled as a broad-crested weir. Using the equation for a weir with a well-rounded upstream edge (Streeter and Wylie, 1985):

$$Q=1.67LH32$$

where Q was the flow rate (cms), L was the weir width (m), and H was the head. The spillway width was 15.24 m (50 ft) giving

$$Q=25.5H32$$

This equation was input directly into the model to calculate spillway flow rate. The head was internally calculated by the model by subtracting the spillway crest elevation from the model predicted water surface elevation at the dam segment.

Table 1. Planned Reservoir operations parameters.

Parameter	Value
Spillway crest elevation	677 ft or 206.35 m
Spillway width	50 ft or 15.24 m
Spillway type	ogee
Mid-level Outlet Intake Elevation	645 ft or 196.60 m
Low-level Outlet Intake Elevation	620 ft or 188.98 m
Maximum Flow Rate of Outlets	630 cfs or 17.84 m^3/s
Maximum Pool Elevation	684 ft or 208.49

Table 2. Agricultural release flows.

Month	Percentage of Annual Agricultural Release	Flow Rate (cfs)	Flow Rate (m^3/s)	Flow Rate (acre-feet per day)
May	10%	13.00	0.368	25.8
June	10%	13.50	0.382	26.7
July	20%	26.00	0.736	51.6
August	30%	39.00	1.104	77.41
September	30%	40.33	1.142	80.0

Table 3. In-stream water right release rates assuming credit given for inflows between toe of dam and the mouth.

Month	Instream Water Right Release (Tanovan, 2012), cfs	Modeled ISWR Release Rate, cfs	Modeled ISWR Release m^3/s
January, 2009	0.00	1.00	0.0283
February, 2009	28.91	28.91	0.8186
March, 2009	3.60	3.60	0.1019
April, 2009	28.56	28.56	0.8087
May, 2009	19.68	19.68	0.5573
June, 2009	7.25	7.25	0.2053
July, 2009	1.35	1.35	0.0382
August, 2009	0.24	1.00	0.0283
September, 2009	0.49	1.00	0.0283
October, 2009	3.02	3.02	0.0855
November, 2009	16.55	16.55	0.4686
December, 2009	16.92	16.92	0.4791

Table 4. In-stream water right and consumptive uses release rates assuming NO credit given for inflows between toe of dam and the mouth.

Month	In-stream Water Right (ISWR), cfs	Consumptive Uses and Storages, cfs	Total ISWR and Consumptive Uses and Storages, cfs	Total ISWR and Consumptive Uses and Storages, m^3/s
January, 2009	40	2.28	42.28	1.197

Month	In-stream Water Right (ISWR), cfs	Consumptive Uses and Storages, cfs	Total ISWR and Consumptive Uses and Storages, cfs	Total ISWR and Consumptive Uses and Storages, m^3/s
February, 2009	40	2.03	42.03	1.190
March, 2009	40	0.03	40.03	1.134
April, 2009	40	0.04	40.04	1.134
May, 2009	30.1	0.22	30.32	0.859
June, 2009	13.6	0.44	14.04	0.398
July, 2009	3	0.77	3.77	0.107
August, 2009	2	0.61	2.61	0.074
September, 2009	2	0.3	2.30	0.065
October, 2009	5.26	0.02	5.28	0.150
November, 2009	40	0.93	40.93	1.159
December, 2009	40	2.11	42.11	1.192

Temperature Standards

The Oregon Department of Environmental Quality (DEQ) has designated Drift Creek for "Salmon and Trout Rearing and Migration" and "Salmon and Steelhead Spawning" (ODEQ, 2008 and Cramer Fish Sciences, 2012). The temperature standard for salmon and trout rearing and migration is 18° C and the 7-day average of daily maximum temperature in the stream cannot exceed this standard by more than 0.3° Celsius. The salmon and steelhead spawning criteria is 13° C and this cannot be exceeded by more than 0.5 ° C between October 15 and May 15. The metric used for the salmon and steelhead spawning criteria is the 60-day running average of daily maximum temperature. In addition to the temperature standards, the 7-day average of maximum temperature cannot exceed natural temperatures by 0.3° C for rearing and migration. During the spawning period, the 60-day average of maximum temperature cannot exceed natural temperatures by 0.5 ° C. Temperature data were collected at Victor Point Bridge (located within several hundred feet of the dam site) between 2004 and 2010 and these data are included in temperature plots.

Scenarios with Credit Given for Downstream Inflows

This set of scenarios assumes that inflows between the toe of the dam and the mouth can contribute toward meeting ISWR requirements.

Water Level

The water level predictions of the low, average, and high flow year scenarios are shown in Figure 2. The initial water surface elevation was set to 198 m (649.60 ft).

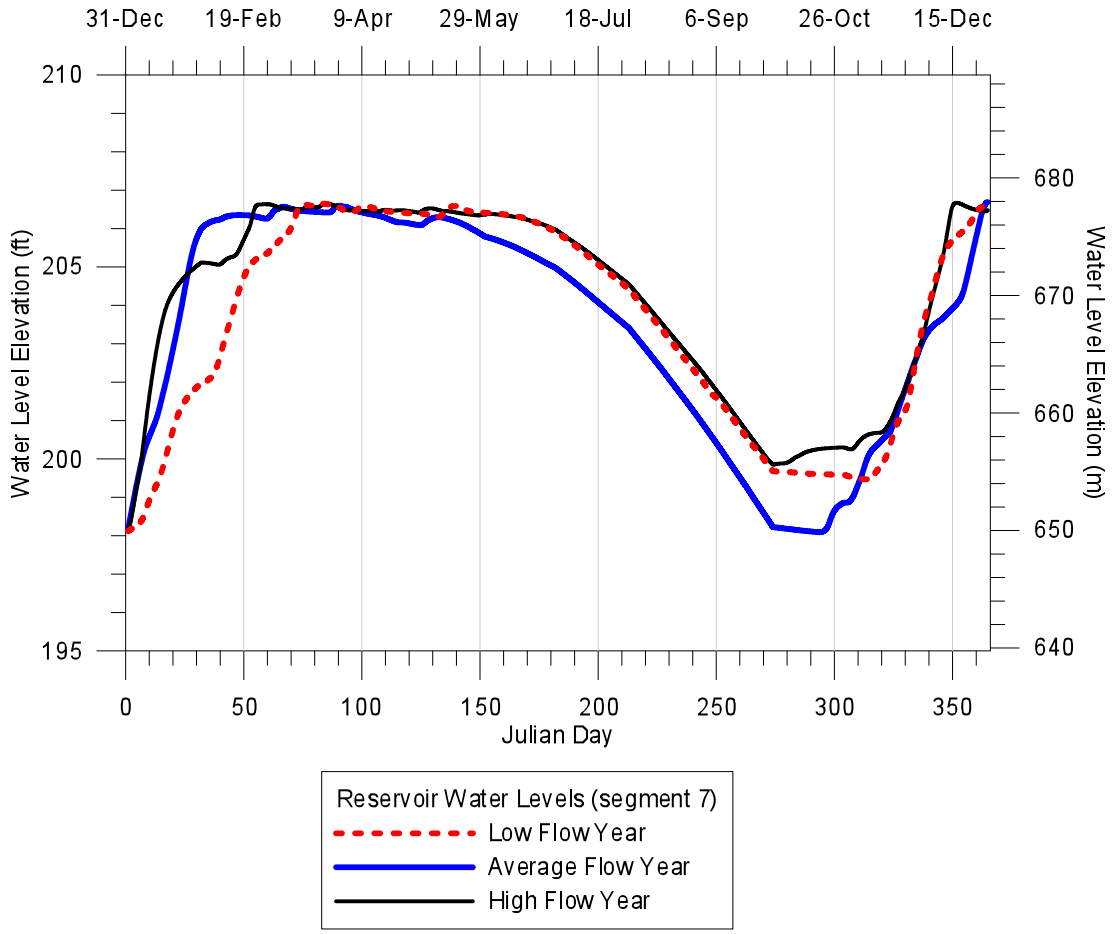

Figure 2. Model predicted water level elevations for the low, average, and high flow year scenarios.

Flow

Figure 3 shows the total dam outflow rates for the low, average, and high flow years. Spillway flows for low, average, and high flow year scenarios are shown in Figure 4.

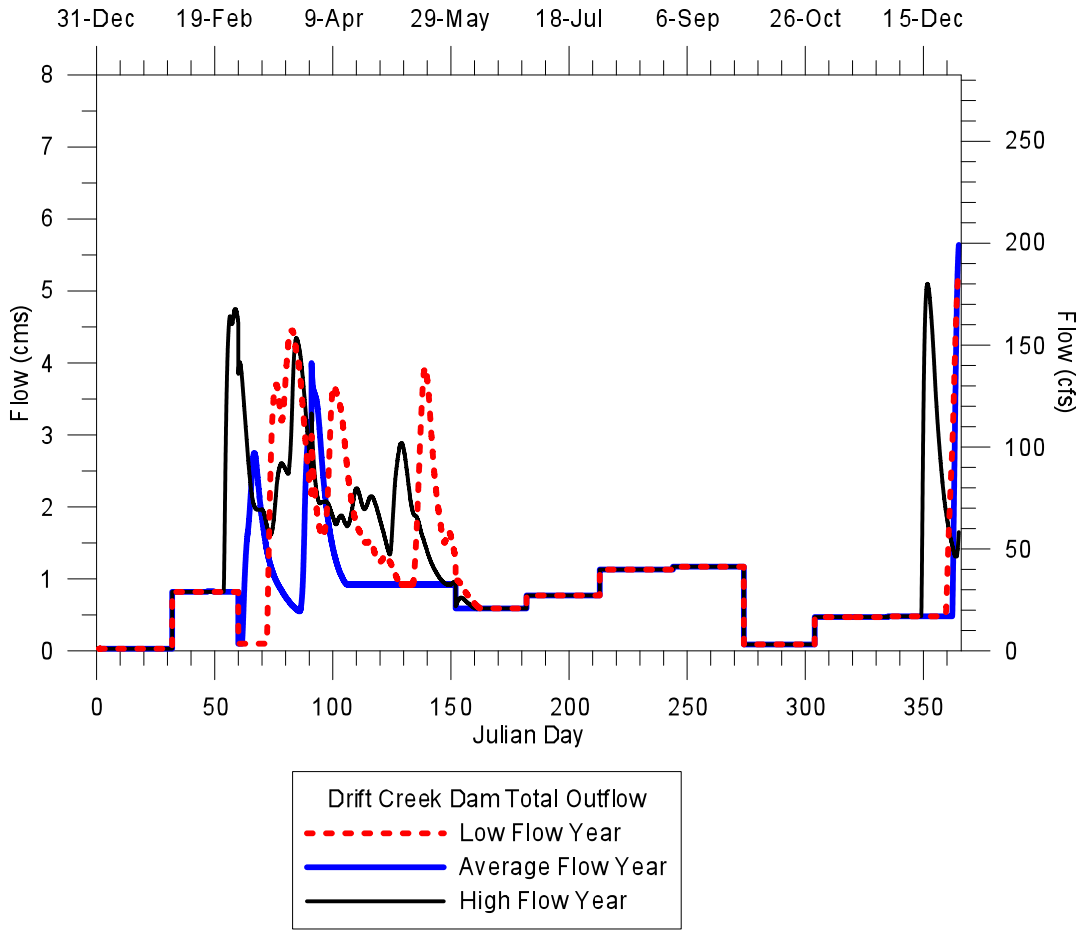

Figure 3. Total reservoir outflows for low, average, and high flow years.

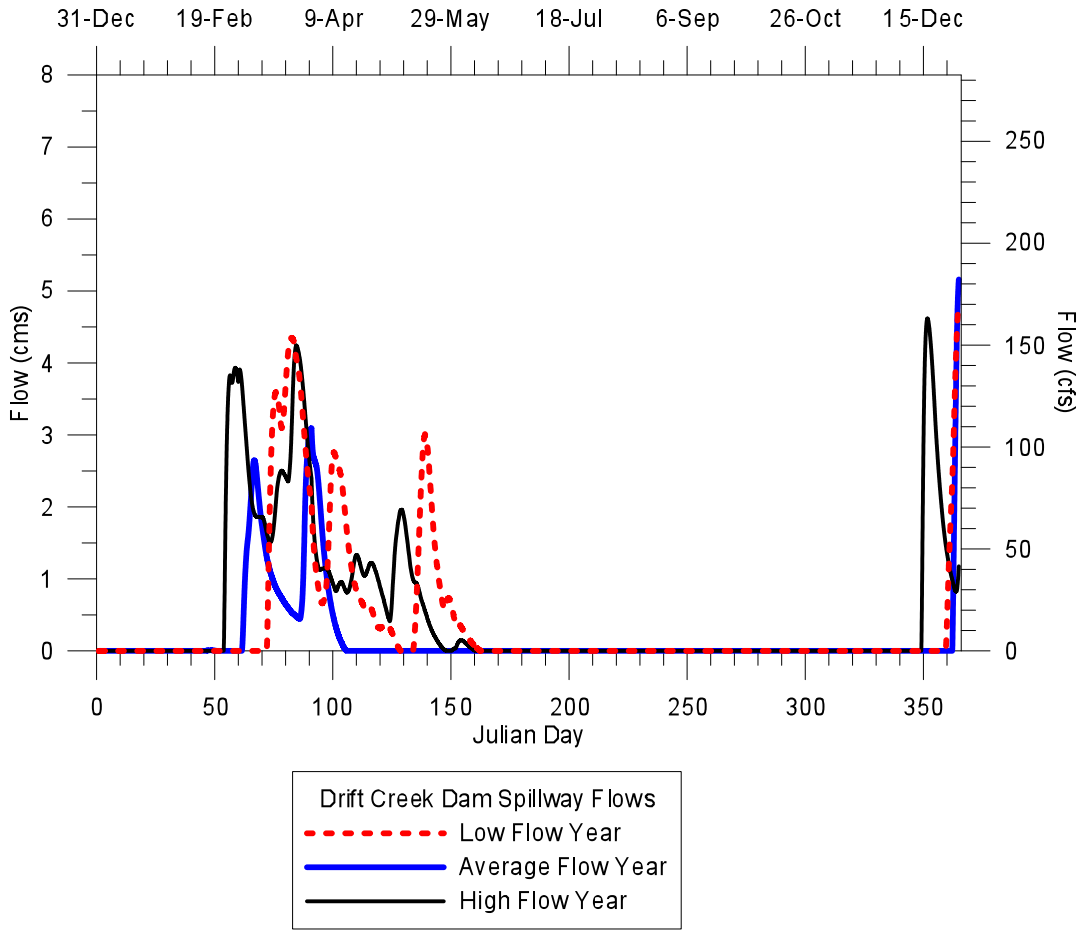

Figure 4. Spillway flows for low, average, and high flow years.

Temperature

Two Outlets with No Mixing Scenario

Outflows from the dam were determined in an attempt to meet temperature standards by using the two planned outlets. For this scenario water from the 2 outlets was not combined or "mixed" in order to meet the standard. Flows passed through one outlet or the other. Water was withdrawn from the mid-level outlet until outflow temperature exceeded the temperature standard or the water level in the reservoir dropped below the elevation of this outlet. Figure 5 through Figure 7 show outlet elevation, outflow temperature and temperature standards for the low, average, and high flow years. For all years the outflows were shifted from the mid-level to low-level outlet during the first half of August. Despite using the low-level outlet, outflow temperatures exceeded the temperature standard in September as the cold water pool in the reservoir was depleted.

7-Day and 60-day average daily maximum temperatures for the low, average, and high flow year scenarios were also plotted along with data measured at Victor Point Bridge in Figure 8 through Figure 10. Victor Point Bridge was located within several hundred feet of the proposed dam site. A time-elevation contour plot of temperature for average flow year was shown in Figure 11. The contour plot corresponds to temperatures predicted in the segment adjacent to the dam. This figure also shows the

dropping water level in the reservoir, with the pool of cooler water in the hypolimnion being depleted through the summer until it is completely gone in early September.

The elevation of the mid-level outlet was also moved above and below the designed elevation in an attempt to meet temperature standards. With the mid-level outlet above the designed elevation at 200 m (656.16 ft), by July 9th outflows had to be from the mid-level outlet to low level outlet, and the cool water pool was depleted by September (Figure 12). Figure 13 shows dam outflow temperature with the mid-level outlet at 193 m (633.19 ft), which was lower than the design elevation. The cold water was depleted in September.

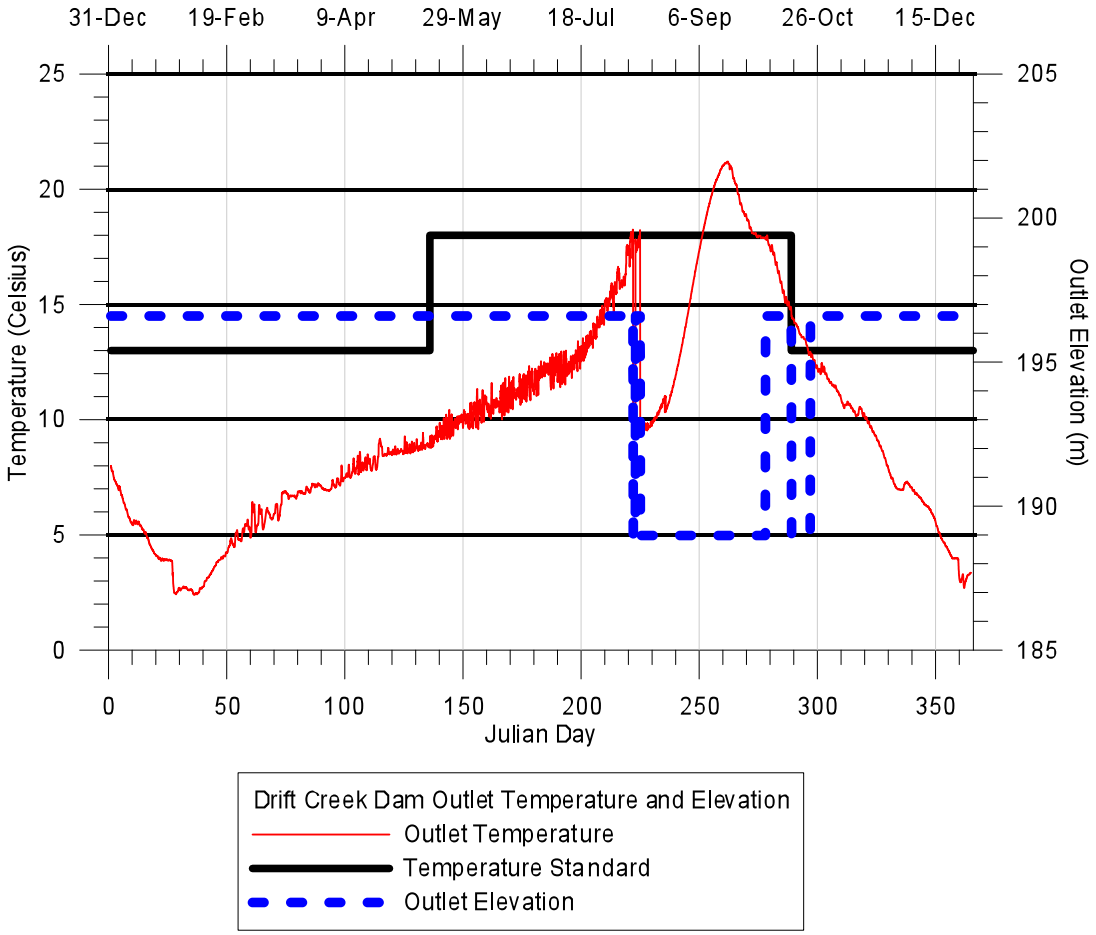

Figure 5. Dam outflow temperature and outlet elevation for the low flow year with flows passing through the mid-level or the low level outlet. Outlet elevations (196.60 m and 188.98 m) are those presently planned for the dam. On Julian Day 222 (August 9th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

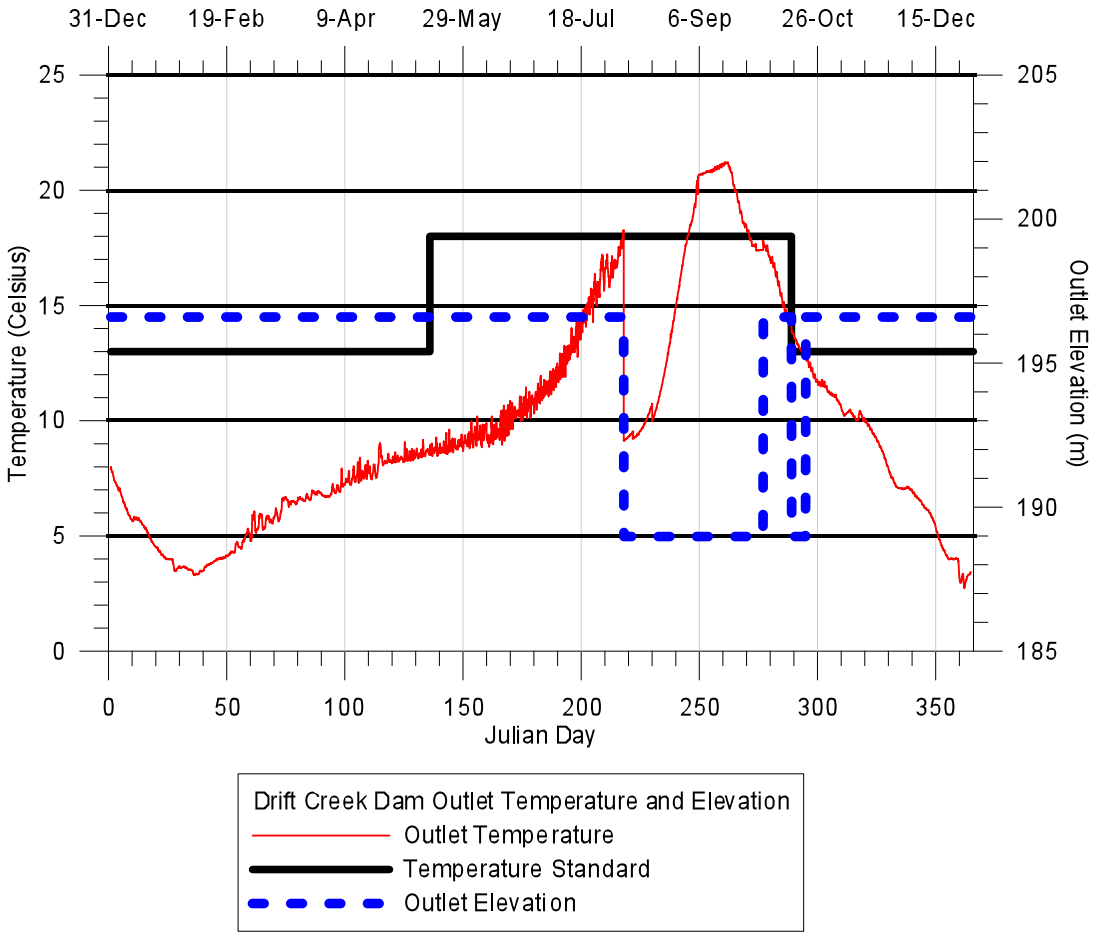

Figure 6. Dam outflow temperature and outlet elevation for the average flow year with flows passing through the mid-level or the low level outlet. Outlet elevations (196.60 m and 188.98 m) are those presently planned for the dam. On Julian Day 218 (August 5th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

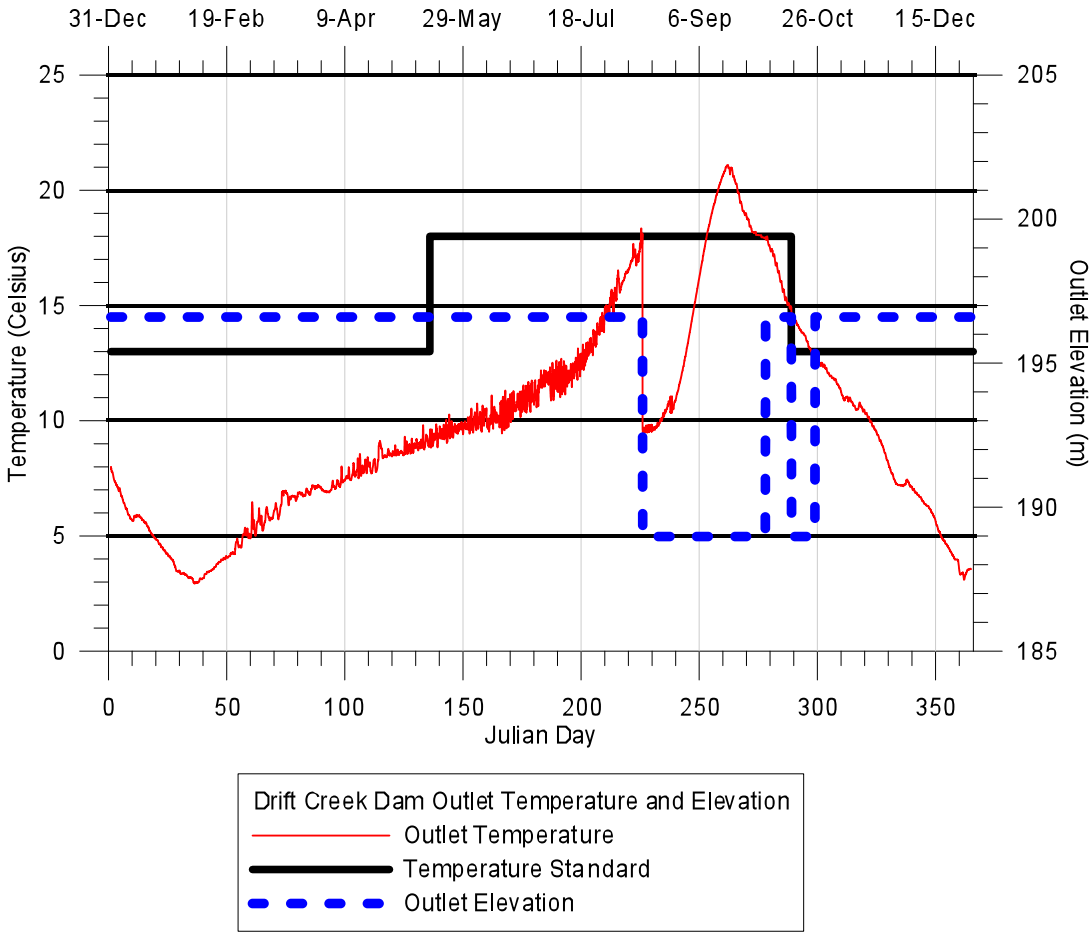

Figure 7. Dam outflow temperature and outlet elevation for the high flow year with flows passing through the mid-level or the low level outlet. Outlet elevations (196.60 m and 188.98 m) are those presently planned for the dam. On Julian Day 226 (August 13th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

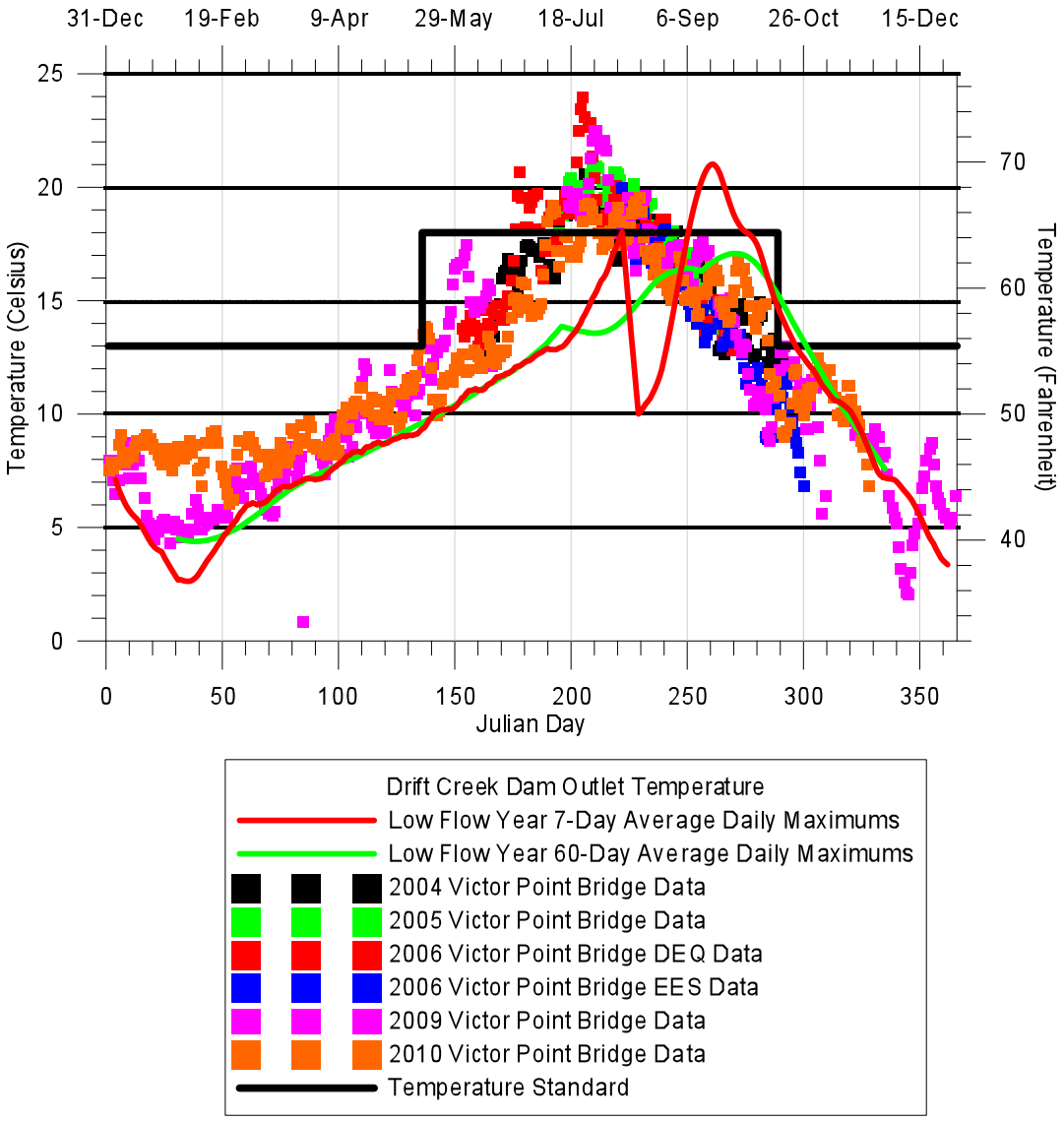

Figure 8. Low flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. Average daily temperature data measured at Victor Point Bridge were also plotted.

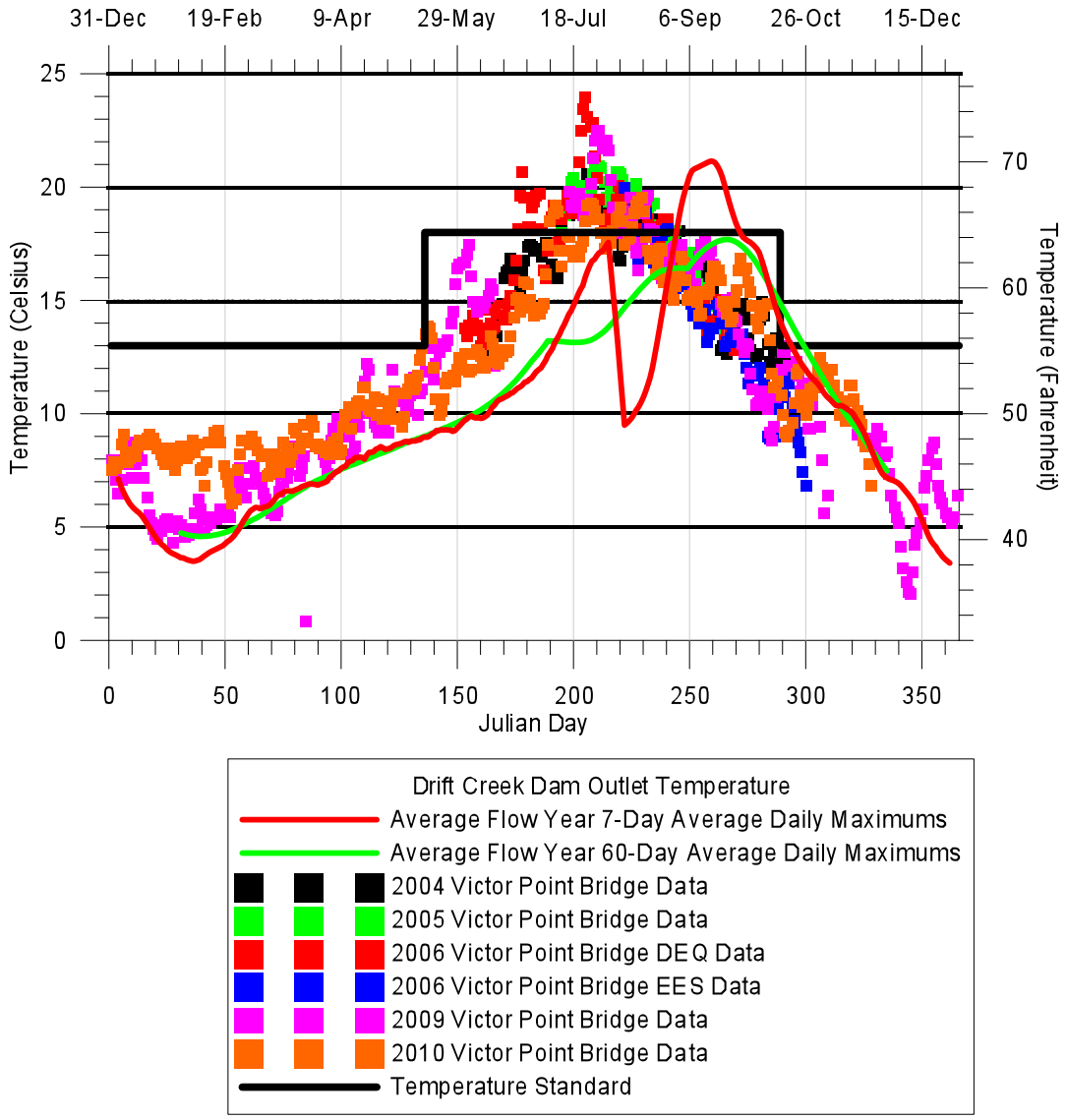

Figure 9. Average flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. Average daily temperature data measured at Victor Point Bridge were also plotted.

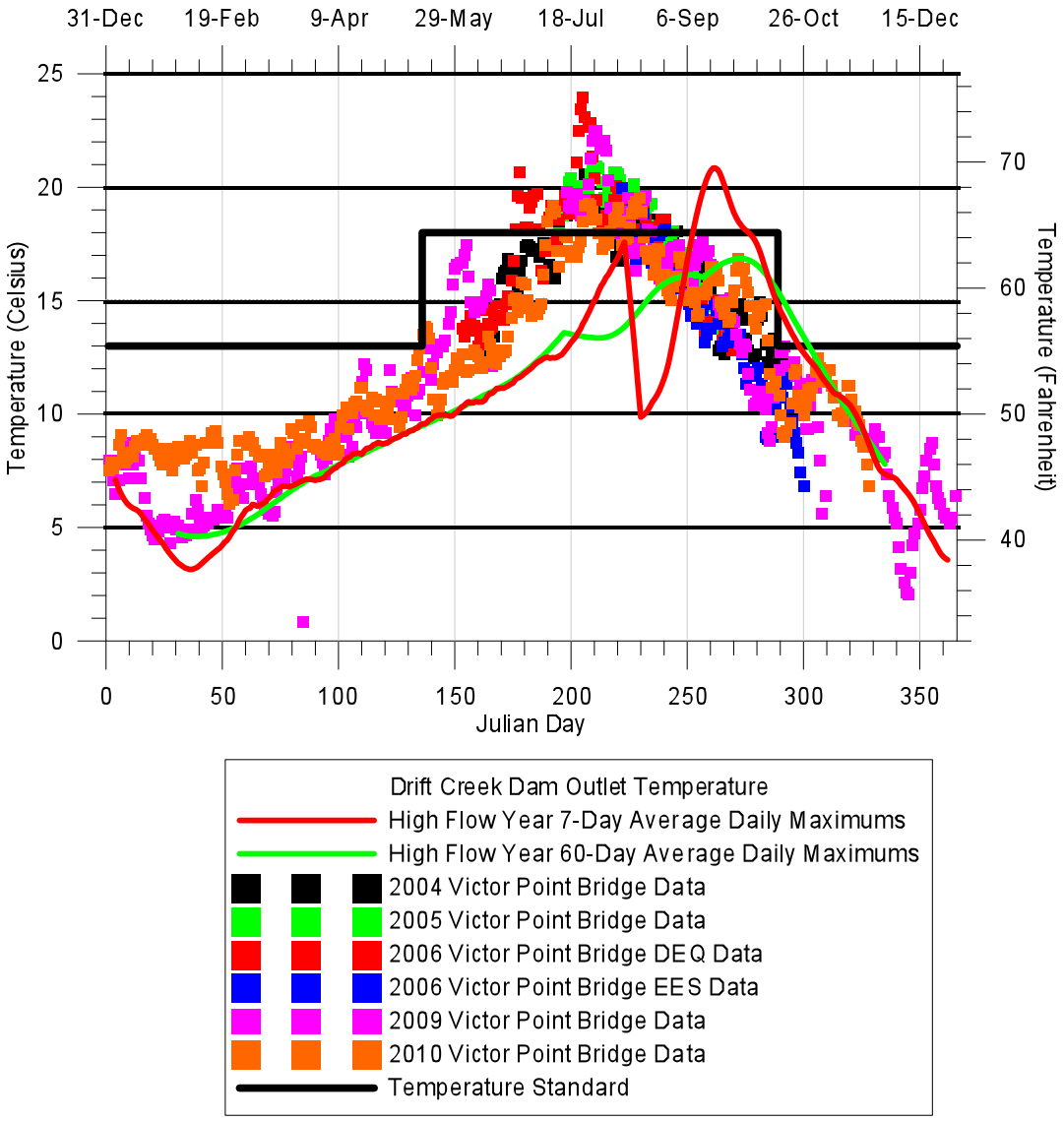

Figure 10. High flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. Average daily temperature data measured at Victor Point Bridge were also plotted.

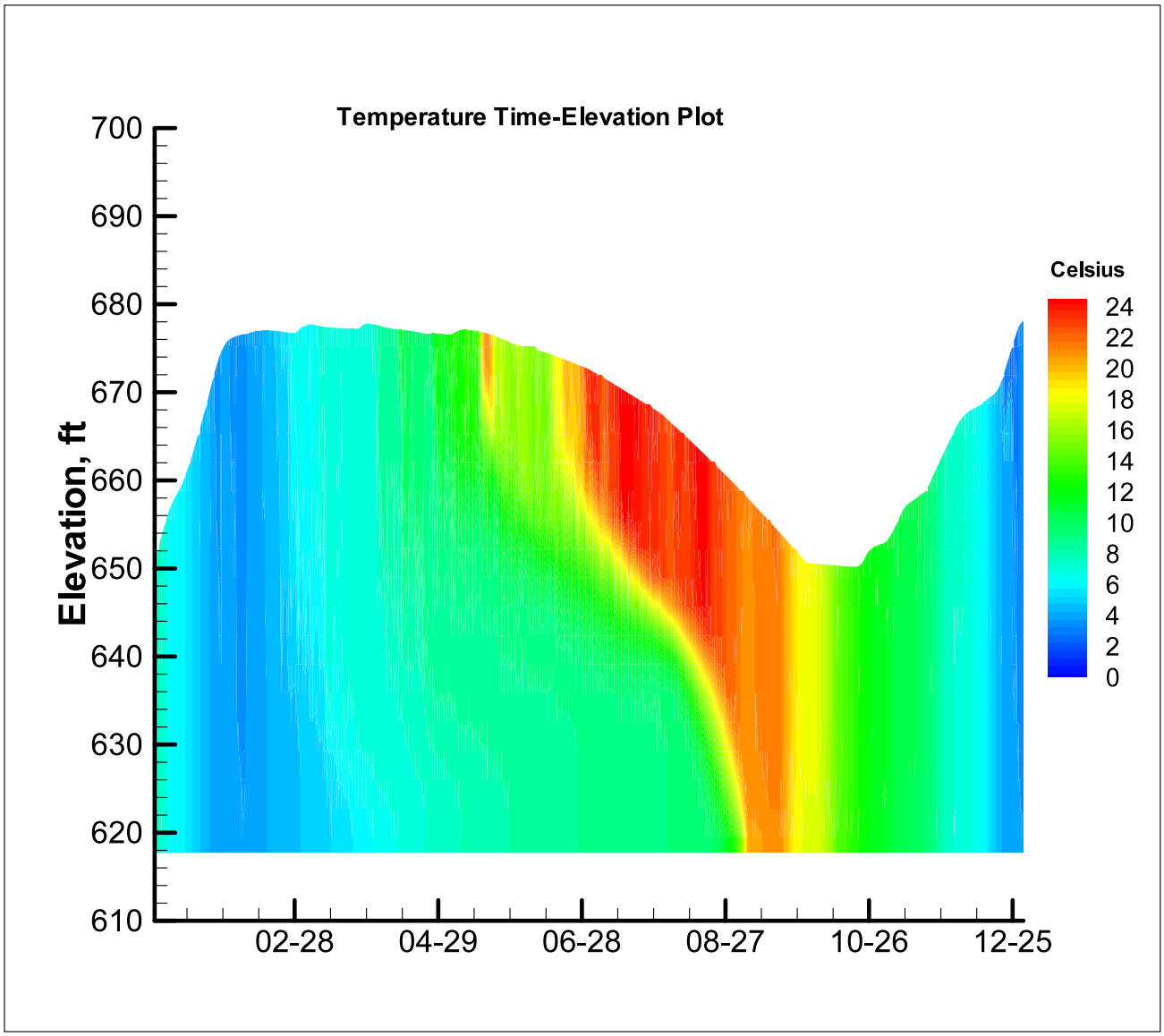

Figure 11. Time-elevation contour plot of temperature for the average flow year scenario with flows passing through either the mid-level outlet or low level outlet.

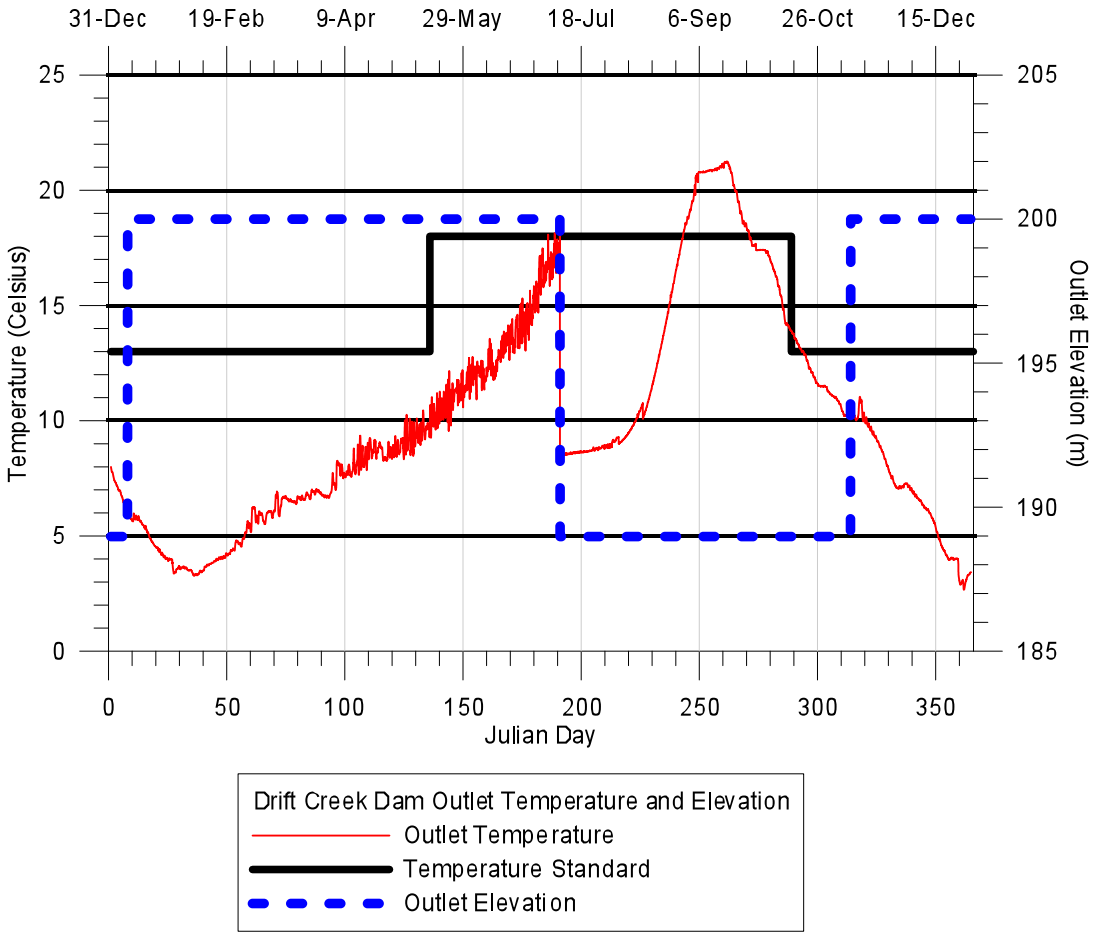

Figure 12. Dam outflow temperature and outlet elevation for the average flow year with flows passing through the mid-level or the low level outlet. The mid-level outlet elevation of 200 m (656.16 ft) was higher than the design elevation of 196.60 m. On Julian Day 191 (July 9th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

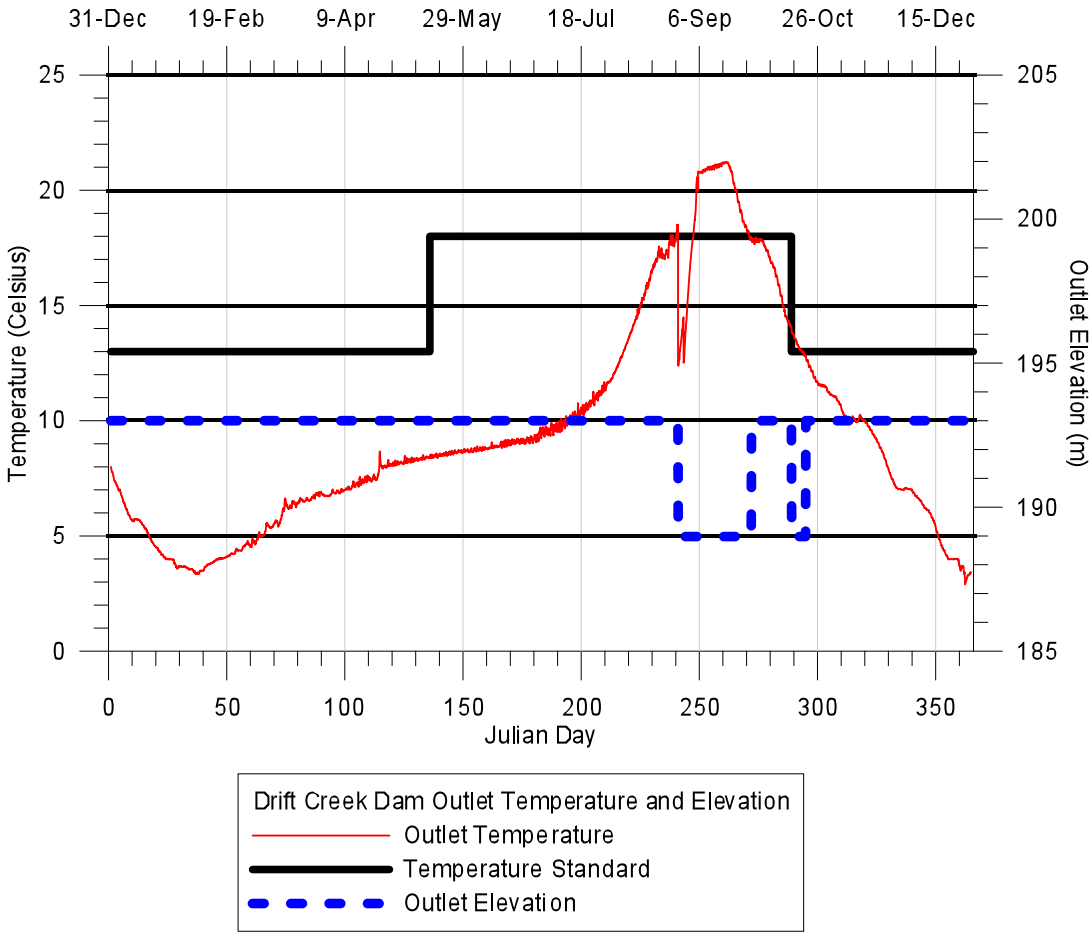

Figure 13. Dam outflow temperature and outlet elevation for the average flow year with flows passing through the mid-level or the low level outlet. The mid-level outlet elevation of 193 m (633.19 ft) was lower than the design elevation of 196.60 m. On Julian Day 241 (August 28th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

Two Outlets with Mixing Scenario

This scenario included the option of mixing flows passing through two outlets in order to meet temperature standards. Figure 14 shows the dam outflow temperatures for the average flow year with the two outlets located at the design elevations of 196.60 m and 188.98 m. The temperature standard was exceeded in September. Figure 15 shows the flow rates through the mid-level and low-level outlets.

If the mid-level outlet is moved upwards to an elevation of 200 m (656.16 ft), dam outflows come closer to meeting the temperature standards (Figure 16 through Figure 18). The higher outlet allows water to be withdrawn closer to the surface in the spring, preserving more cold water to be used later in the summer. Although measured stream temperatures were exceeded in October, only in a few instances were the 13 degree and 18 degree Celsius standards exceeded. Figure 19 shows the time-elevation contour plot of temperature for average flow year.

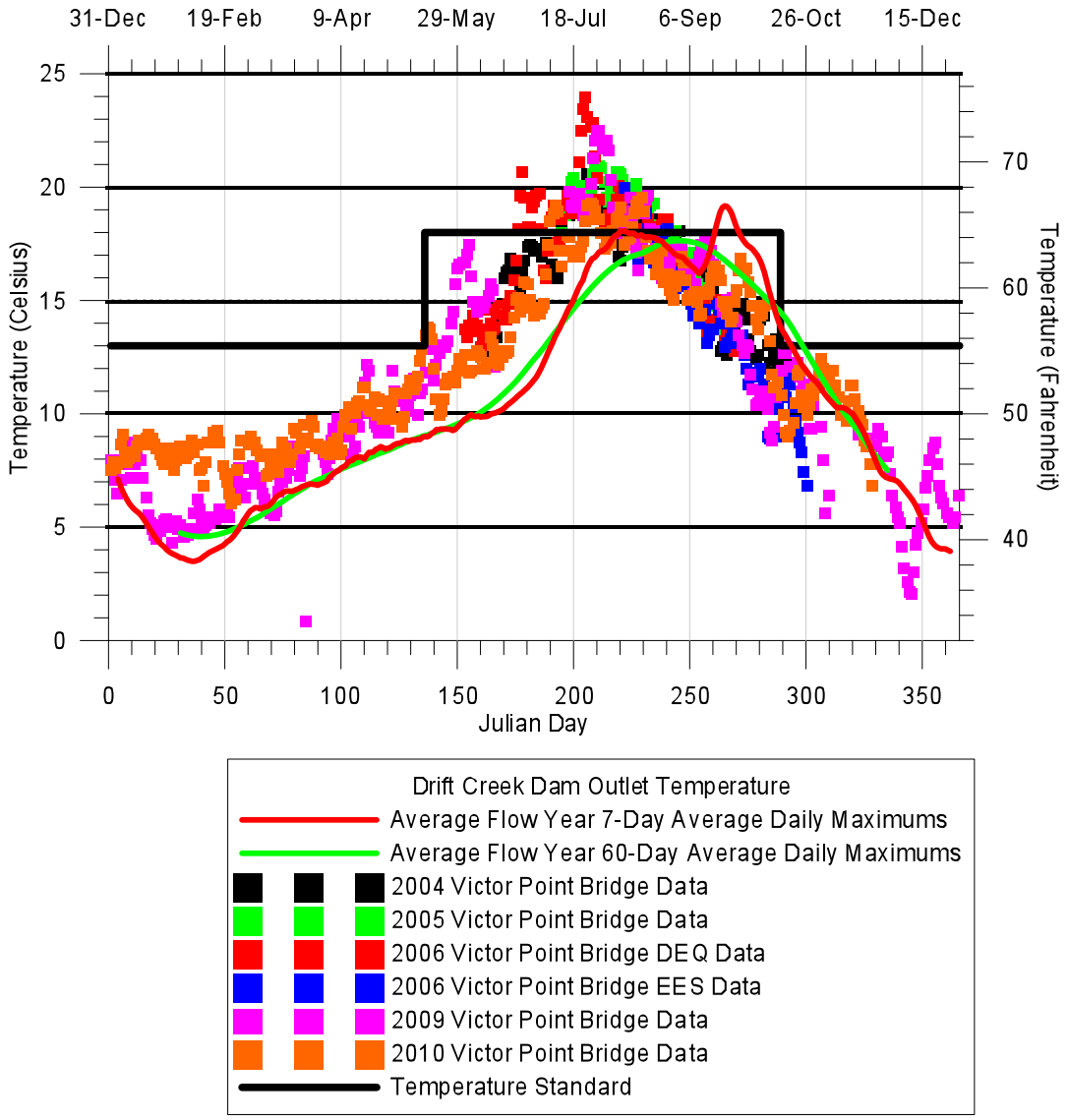

Figure 14. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for average flow year with dam outflows being mixed using the mid-level and the low level outlet. Outlet elevations (196.60 m and 188.98 m) are those presently planned for the dam.

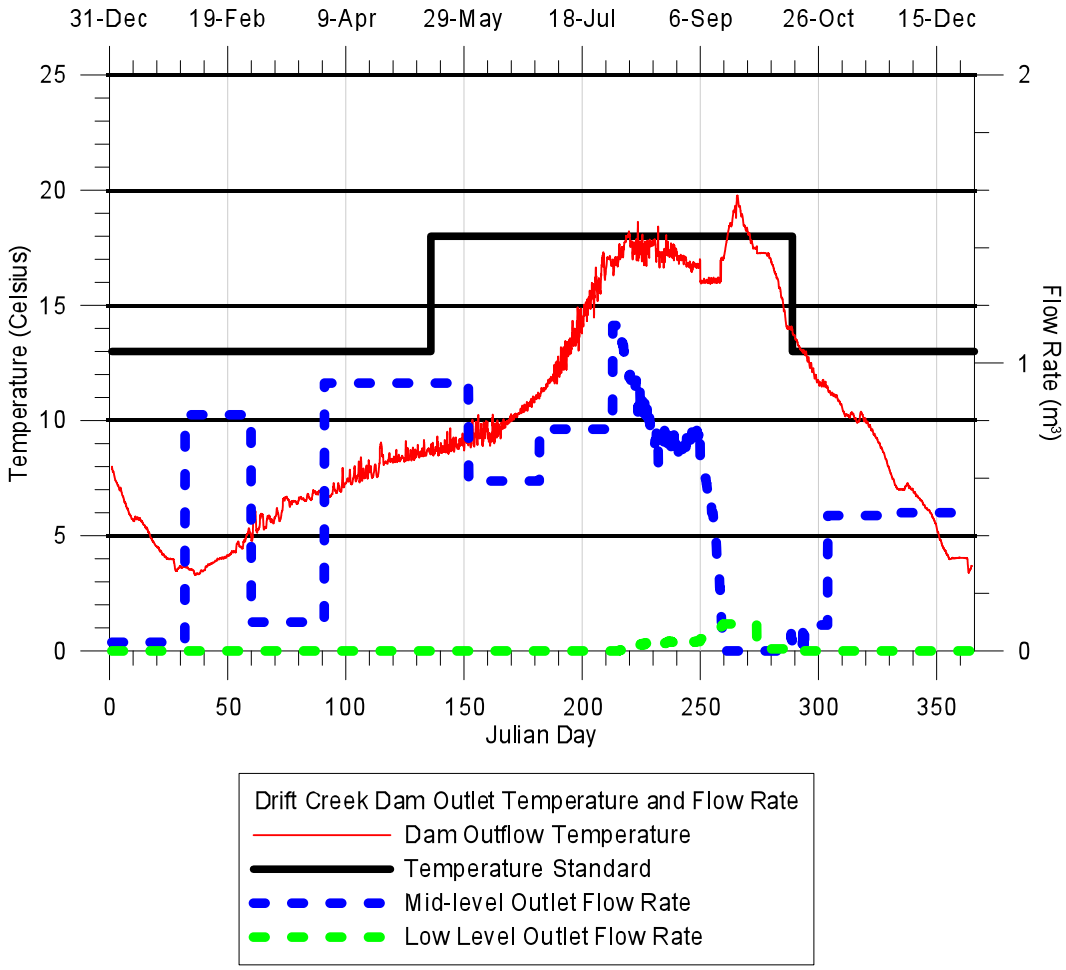

Figure 15. Flow rates through mid-level and low-level outlets for average flow year with mixing scenario. The net dam outflow temperature is also shown.

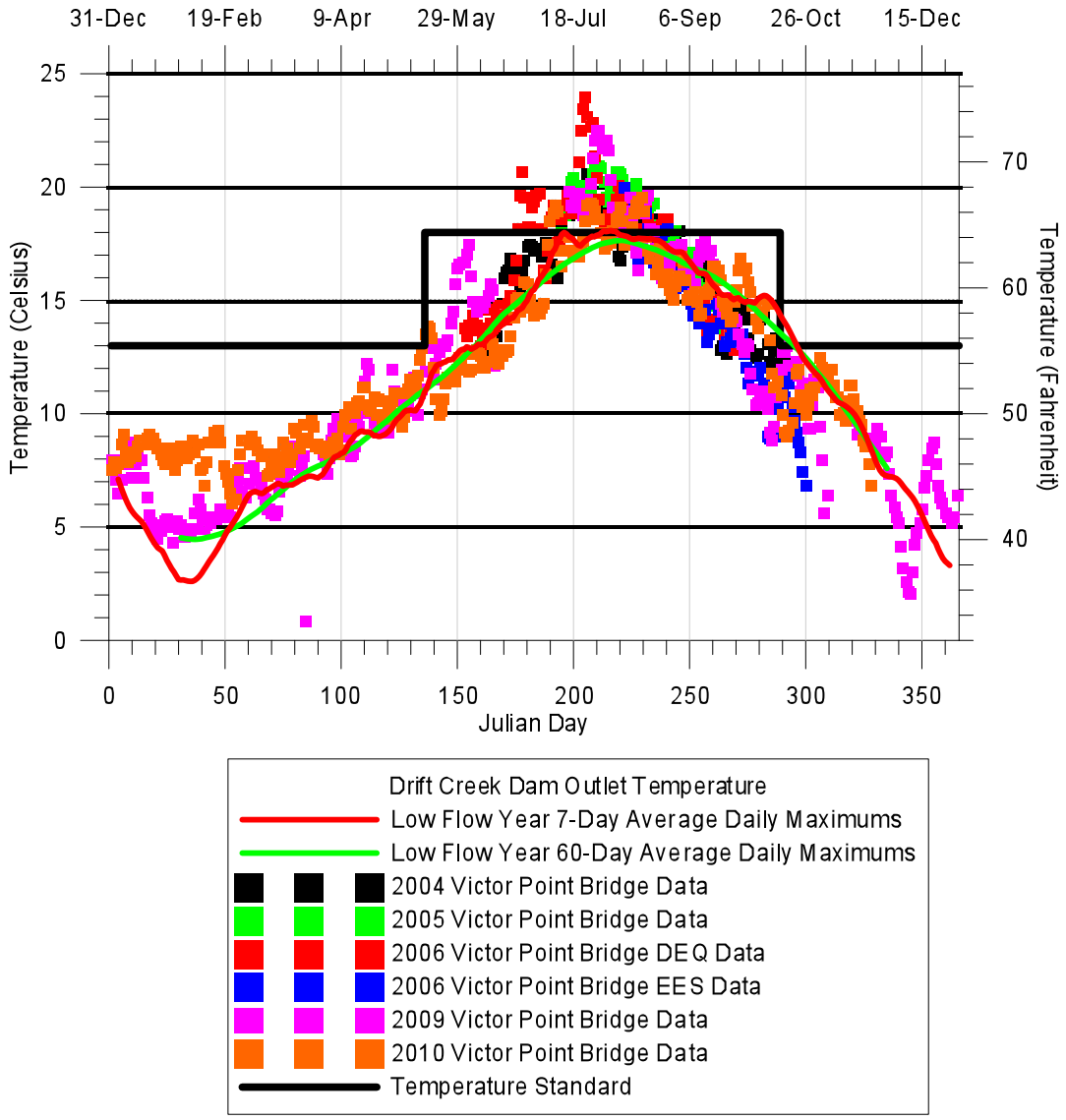

Figure 16. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for low flow year with dam outflows being mixed using the mid-level and the low level outlet. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

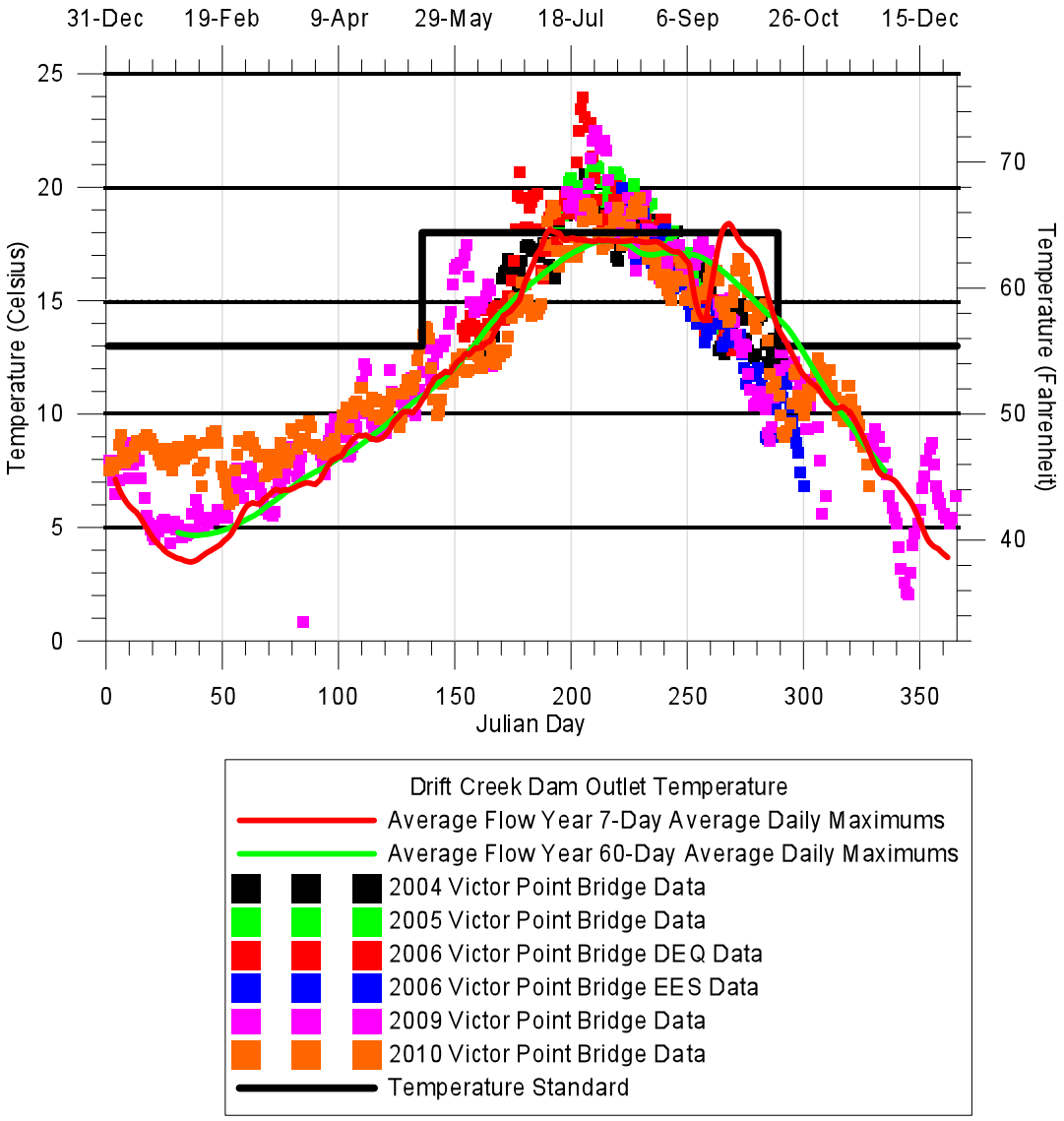

Figure 17. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for average flow year with dam outflows being mixed using the mid-level and the low level outlet. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

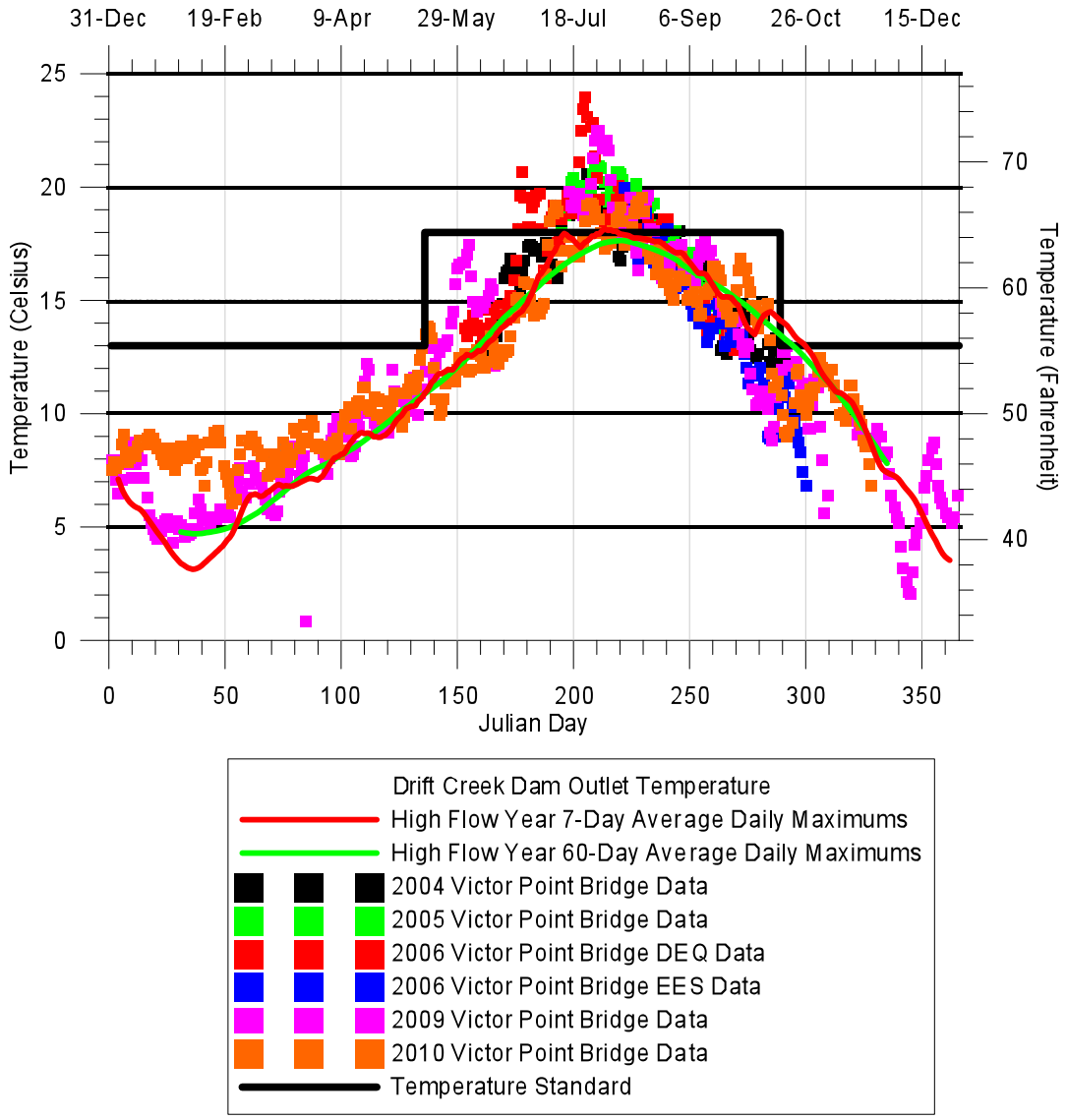

Figure 18. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for high flow year with dam outflows being mixed using the mid-level and the low level outlet. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

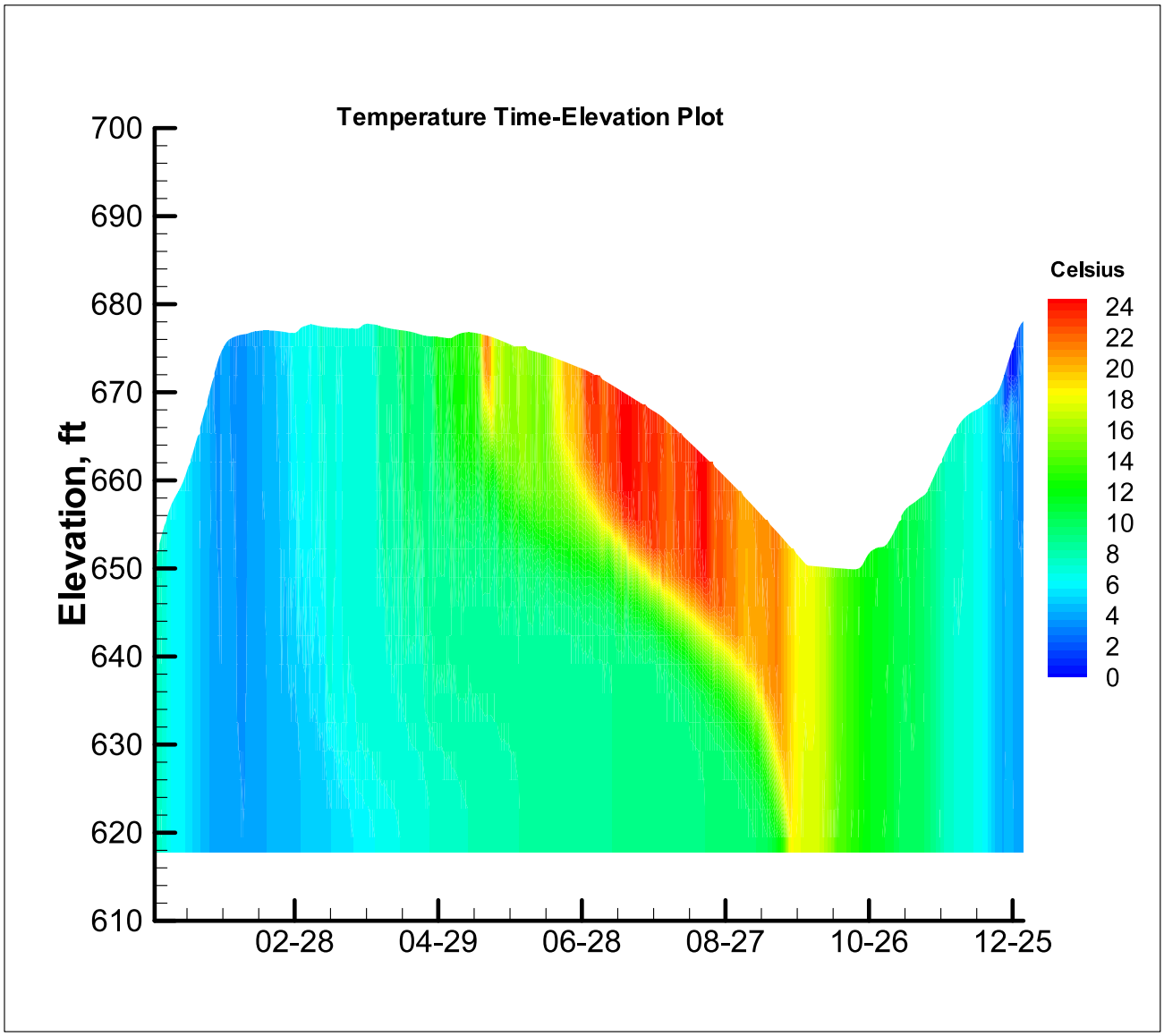

Figure 19. Time-elevation contour plot of temperature for the average flow year scenario using combined mid-level and low level outlet mixed flows.

Three Outlets with Mixing Scenario

In order to better replicate natural stream temperatures and meet the temperature standards, a third "high level" outlet with an of elevation 201 m (659.44 ft) was added that allowed water to be withdrawn closer to the surface in the spring and early summer. Flow through the 3 outlets was also mixed as necessary to meet temperature standards. Mixing combines flows from a pair of outlets so that the temperature standard is being met while preserving cold water pool at the bottom of reservoir for as long as possible. Elevations of the low level and mid-level outlets were set to the design elevations of 188.98 m and 196.60 m. Figure 20 through Figure 22 show the dam outflow 7-Day and 60-day average of daily maximum temperatures for the low, average, and high flow years. Only during the average flow year, which had less reservoir inflows during spring, did temperatures exceed the temperature standards. This occurred during October when outflow temperatures exceeded measured stream temperatures and also for a few days after October 15th when the 13° Celsius standard was exceeded. Flow rates through each

of the 3 outlets of the average flow year are plotted in Figure 23. A time-elevation plot of temperature for the average flow year is shown in Figure 24.

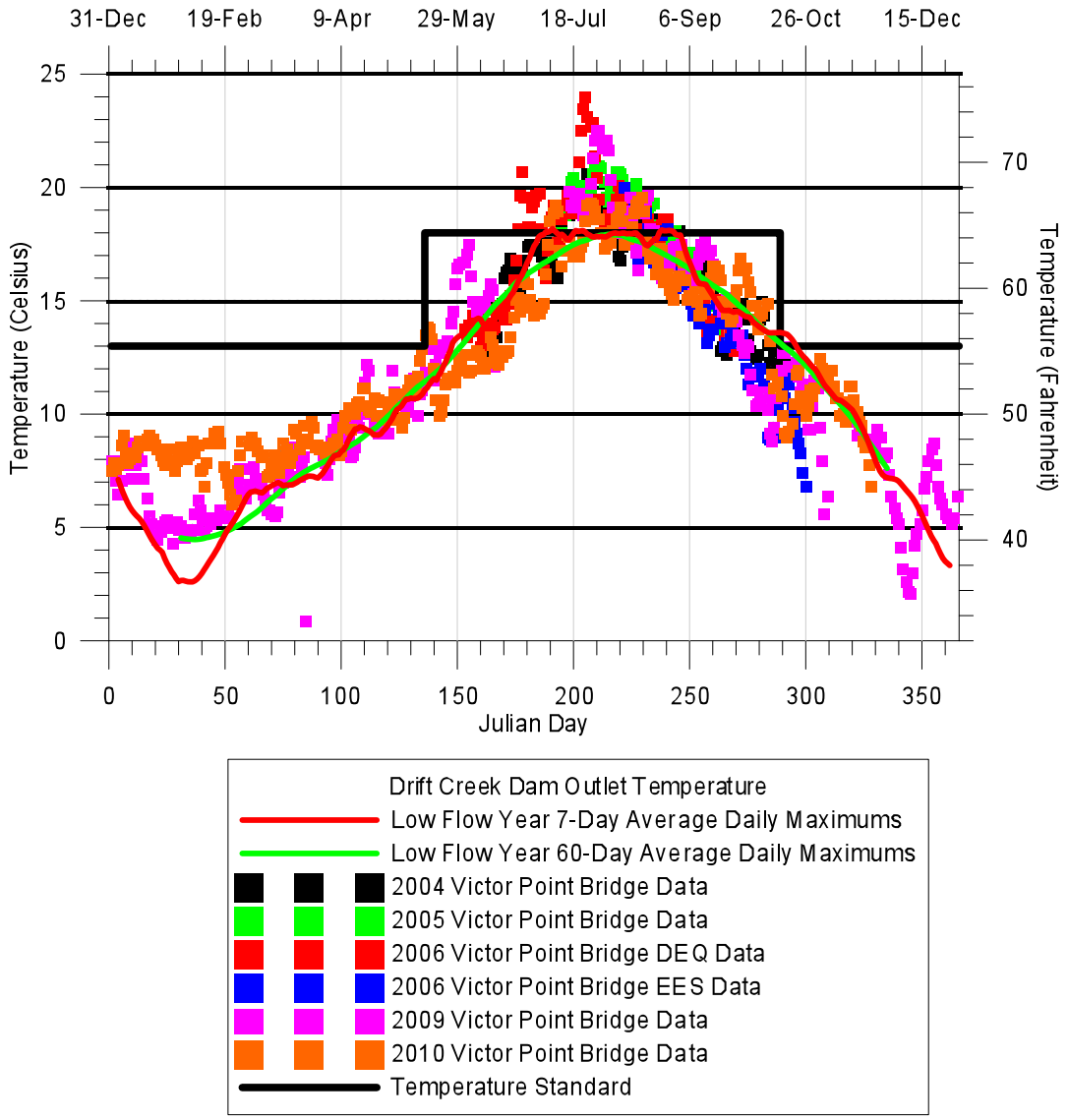

Figure 20. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for low flow year with dam outflows being mixed using three outlets. A new high level outlet elevation (201 m) has been added.

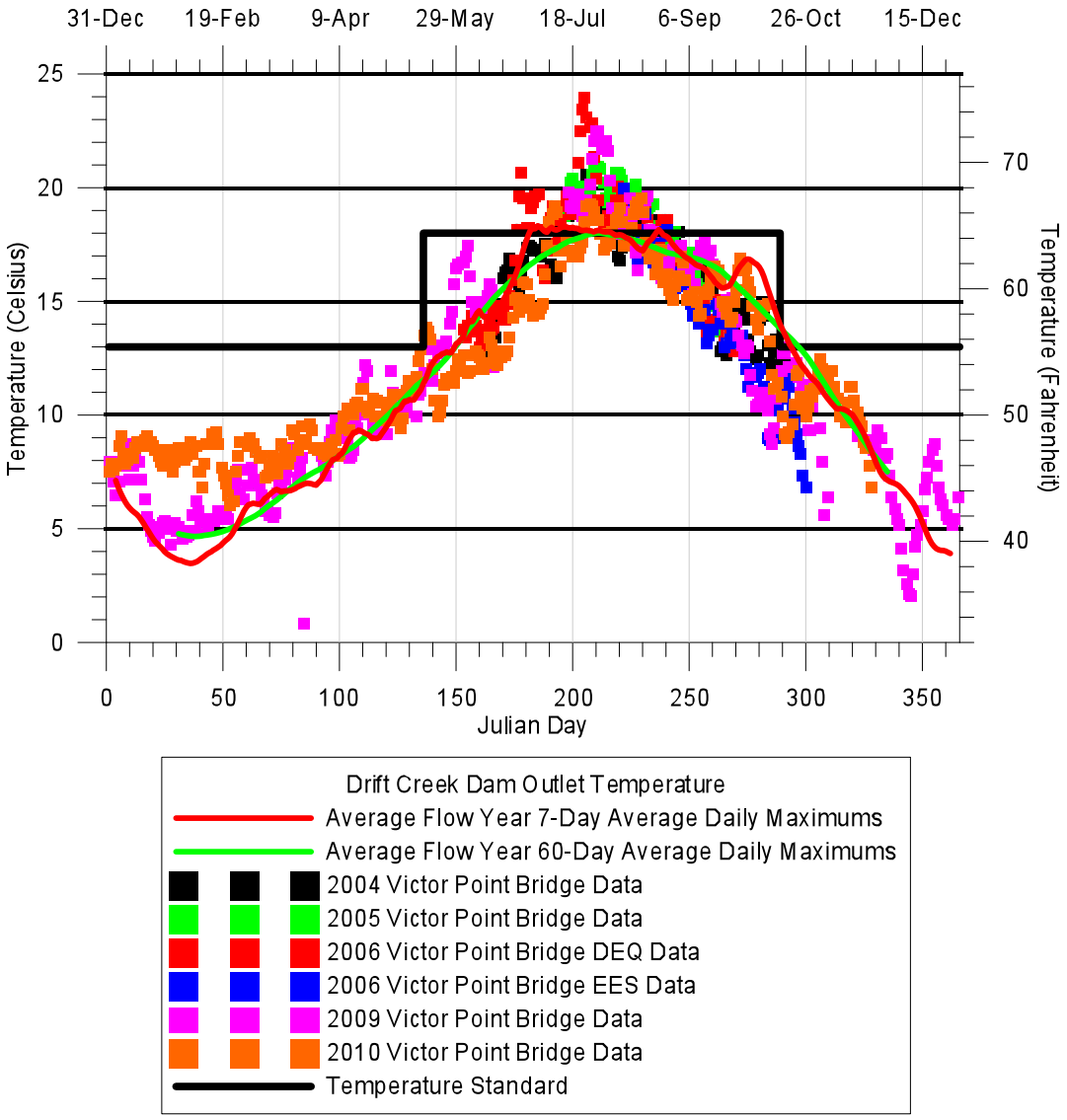

Figure 21. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for average flow year with dam outflows being mixed using three outlets. A new high level outlet elevation (201 m) has been added.

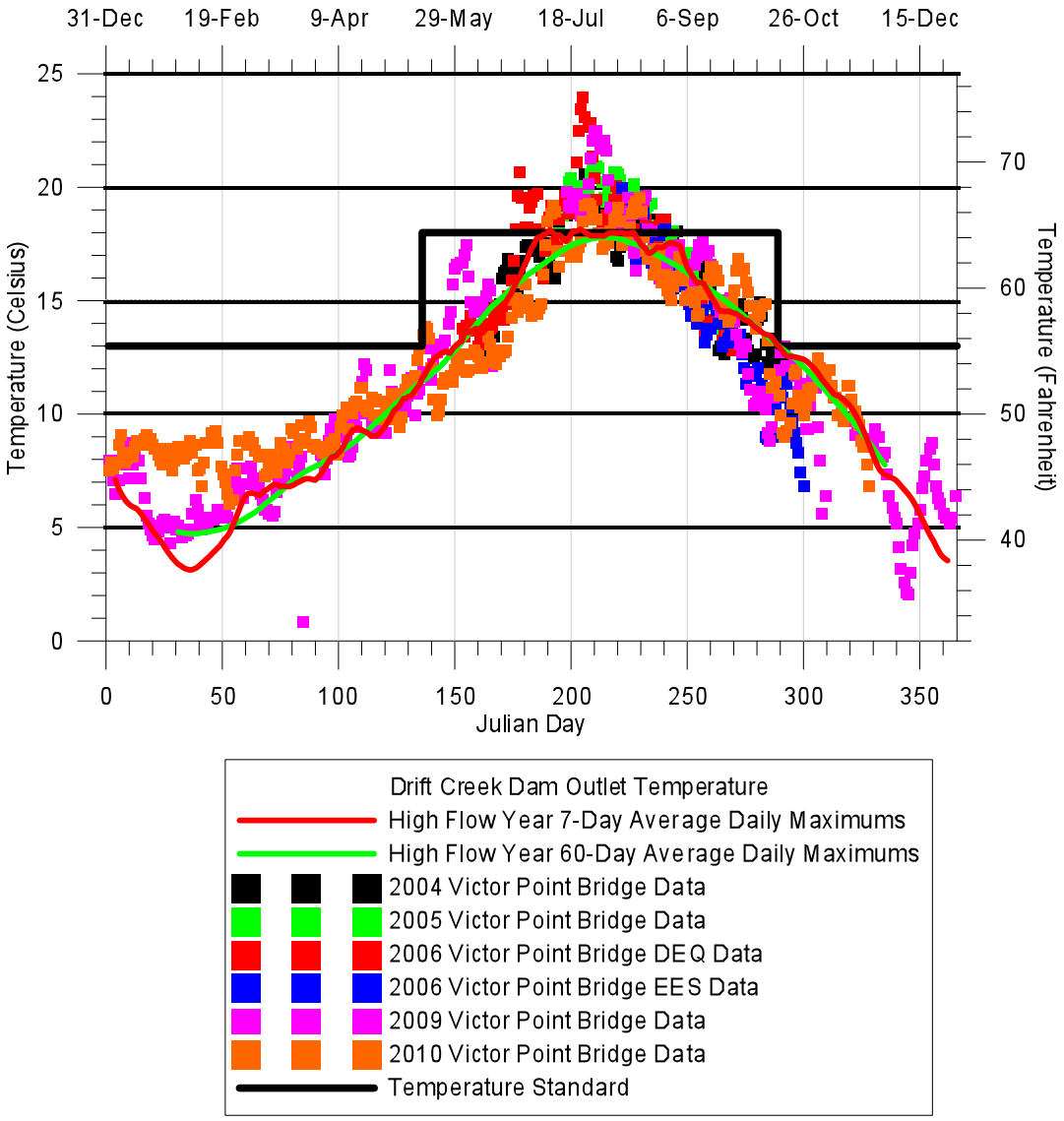

Figure 22. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for high flow year with dam outflows being mixed using three outlets. A new high level outlet elevation (201 m) has been added.

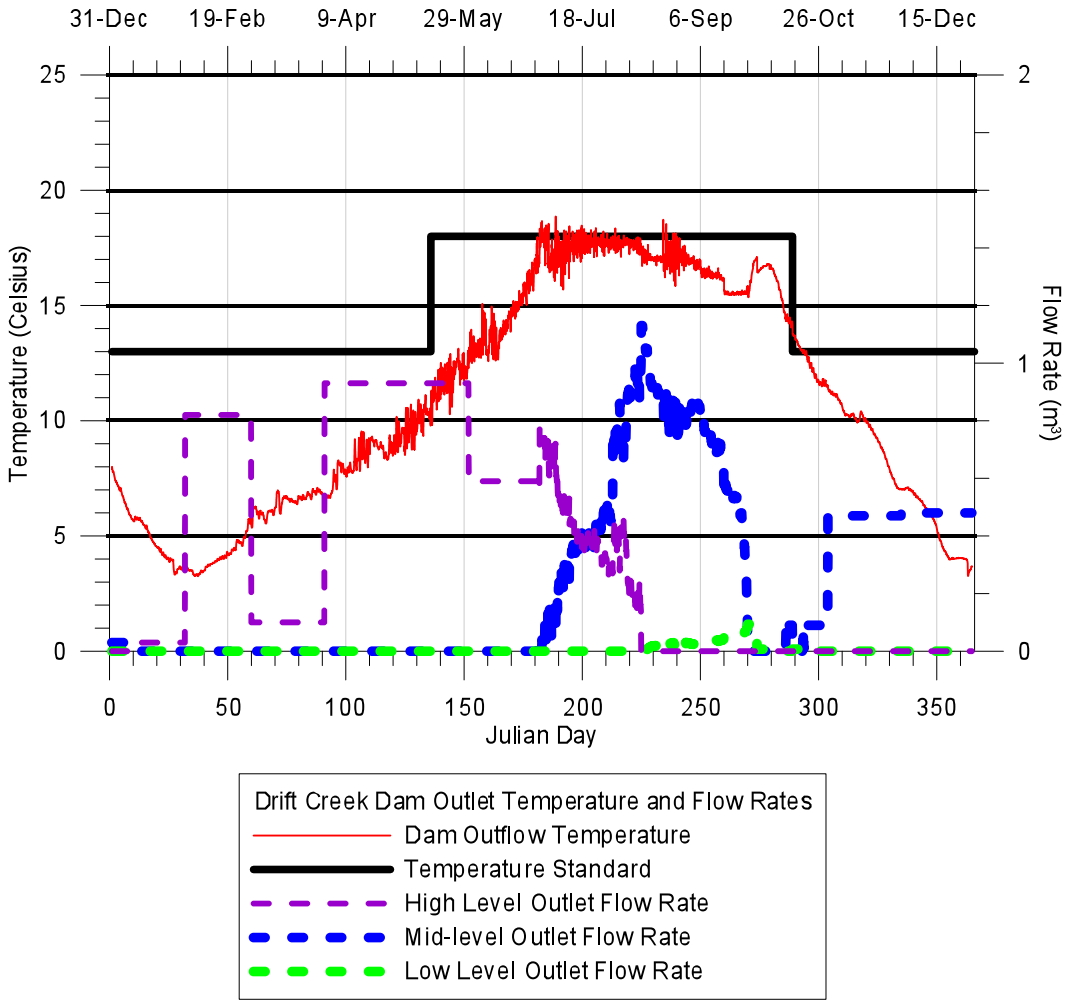

Figure 23. Flow rates through high level, mid-level and low-level outlets for average flow year scenario (three outlets). The net dam outflow temperature is also shown.

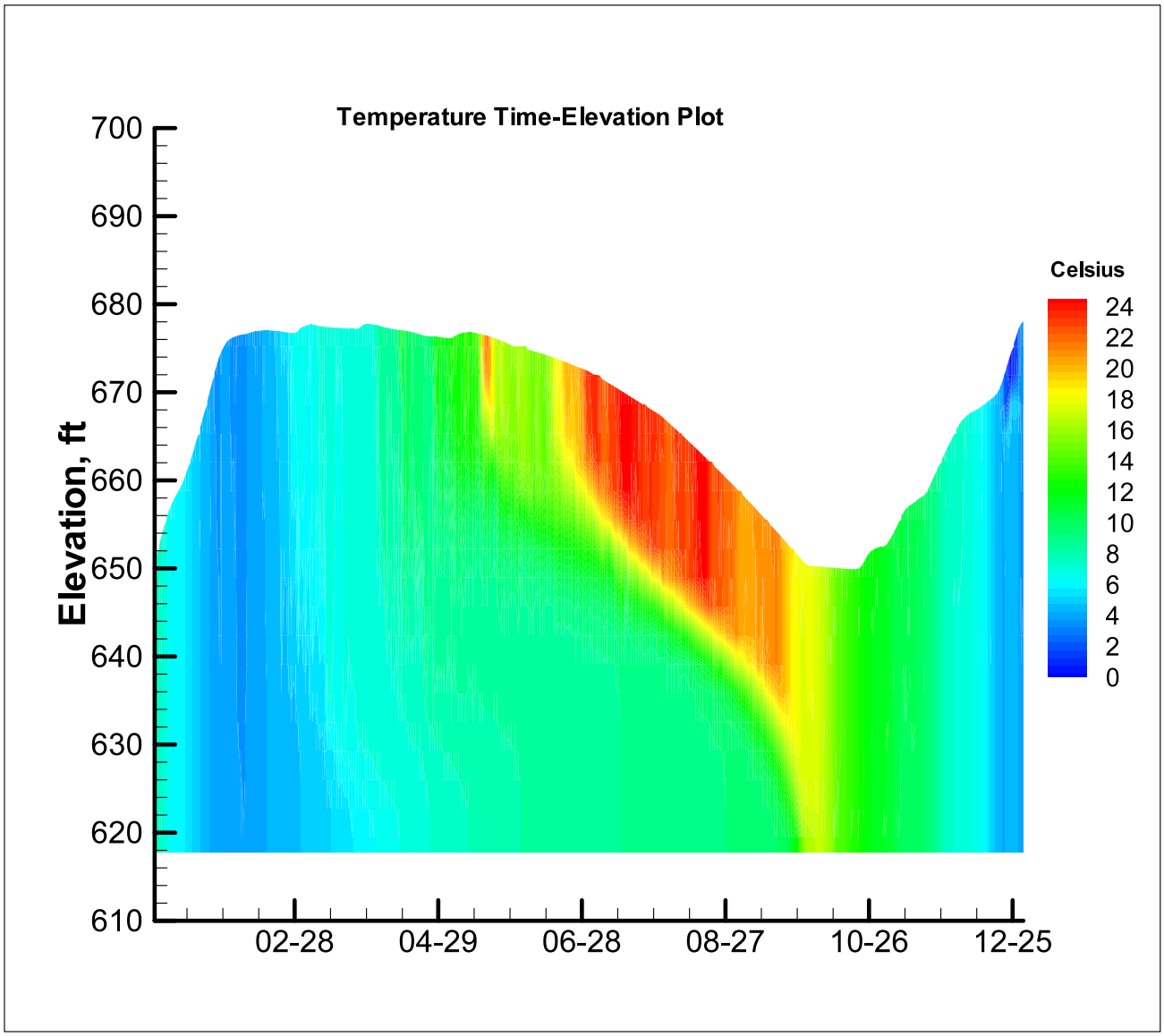

Figure 24. Time-elevation contour plot of temperature of the average flow year with 3 outlets.

Dissolved Oxygen

Dissolved oxygen concentrations during summer and early fall in the proposed reservoir typically became zero in the hypolimnion. Figure 25 shows the time-elevation contour plot of dissolved oxygen for the average flow year scenario with two outlets at the designed elevations with no mixing. The predictions were for the model segment 7, which was adjacent to the dam. Figure 26 shows the DO time-elevation plot of the 3 outlet scenario for the average flow year. Nutrient concentrations in the reservoir inflows were high enough to produce a eutrophic system. The narrow band of super-saturated dissolved oxygen concentrations was caused by high algae productivity during the summer. The dissolved oxygen concentrations from the dam outflow were shown in Figure 27 for the 3 outlet scenario. Dissolved oxygen concentrations drop below 5 mg/l in September and October, indicating that the outlet withdraws water from the hypolimnion during this period. A reaeration device would be required to raise oxygen concentrations in the stream downstream of the dam to acceptable levels.

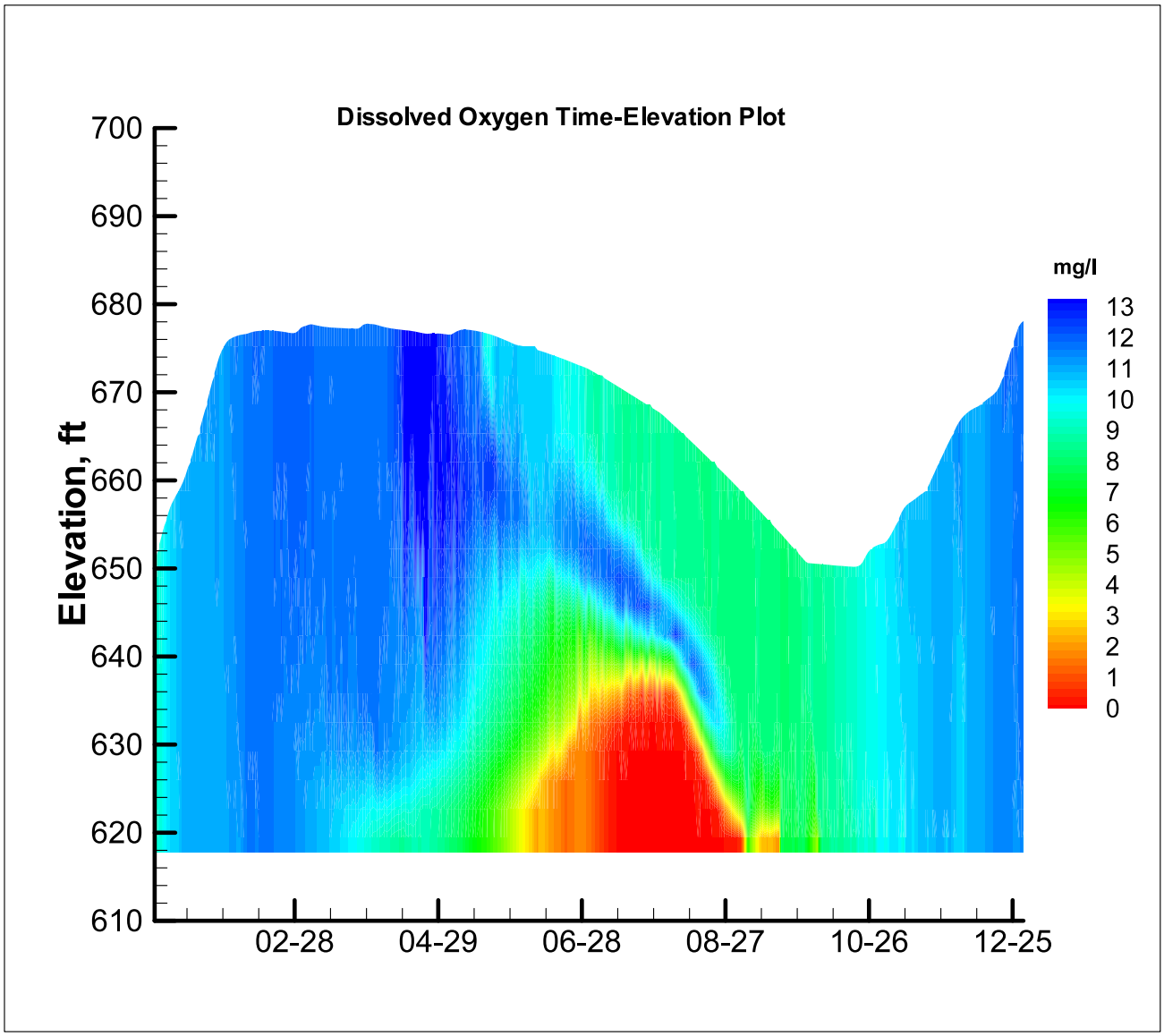

Figure 25. Time-elevation contour plot of model predicted dissolved oxygen concentrations for the average flow year with 2 outlets at their designed elevations (no mixing).

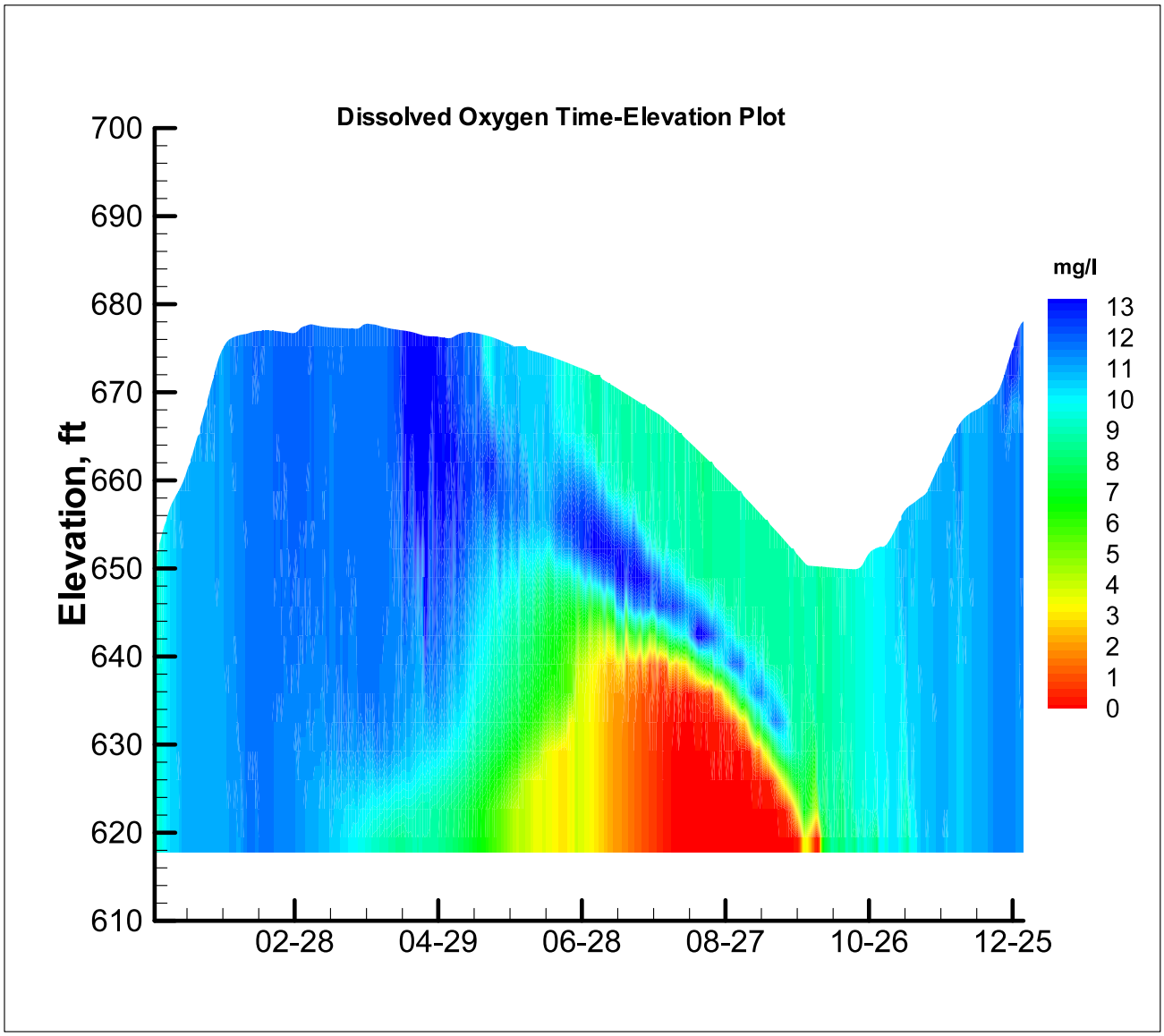

Figure 26. Time-elevation contour plot of model predicted dissolved oxygen concentrations for the average flow year with 3 outlets.

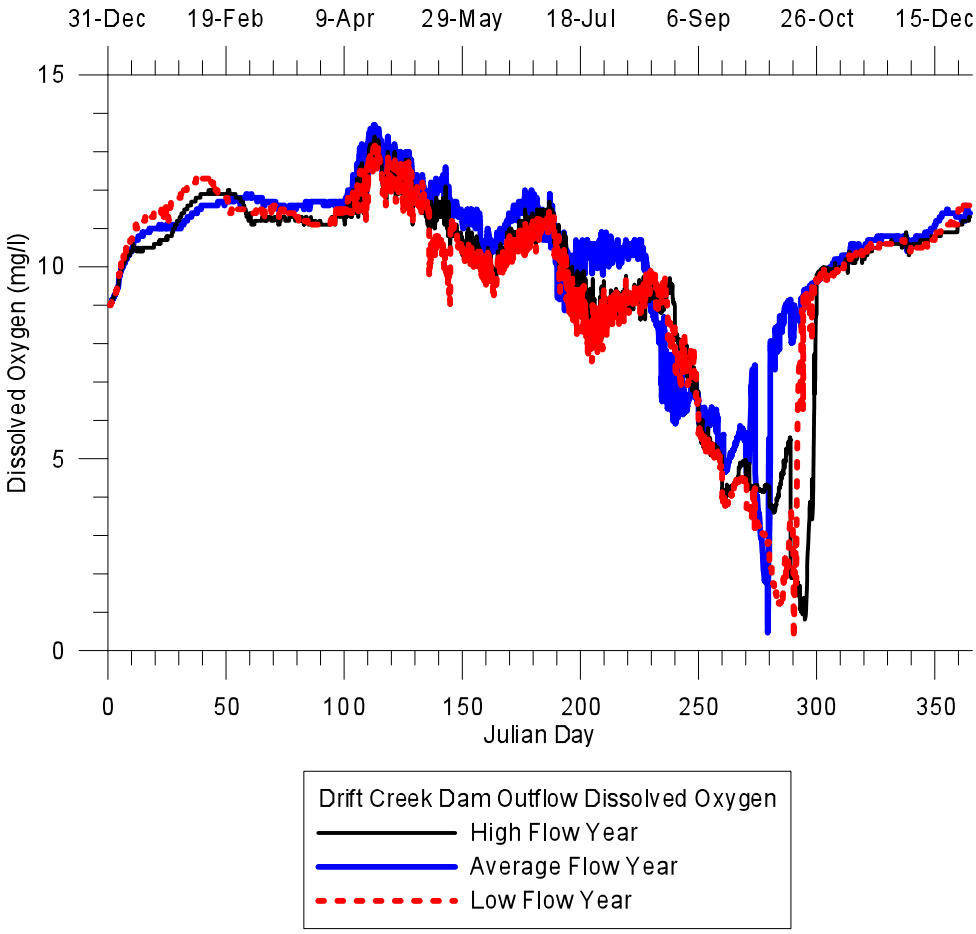

Figure 27. Model predicted dam outlet dissolved oxygen concentrations for three outlet scenario.

Algae and Nutrients

Time-elevation plots of model predicted chlorophyll a concentrations during the average flow year were shown in Figure 28 for the 2 outlet with no mixing scenario and Figure 29 for the three outlet scenario. CE-QUAL-W2 outputs algae predictions in dry mass concentrations, and these were converted to chlorophyll a concentrations by assuming a ratio of 0.2 between algae biomass and chlorophyll a in terms of mg algae/µg chlorophyll a. This value was near the mid-point in the range recommended by the EPA (1985). Predicted chlorophyll a concentrations were generally less than 15 µg/l in the reservoir. Algae generally grew near the surface during the spring, and during the summer grew at a depth of ~15 ft due to the increased availability of nutrients that occurs near the hypolimnion. Chlorophyll a concentrations in the dam outflow plotted in Figure 30 for the 3 outlet scenario. Phosphorus, the limiting nutrient, had larger concentrations in the hypolimnion because of the anaerobic release of nutrients (Figure 31 and Figure 32). During the summer phosphorus was depleted in the epilimnion due to algae growth. Dam outflows of total phosphorus for the 3 outlet scenario were plotted in Figure 33.

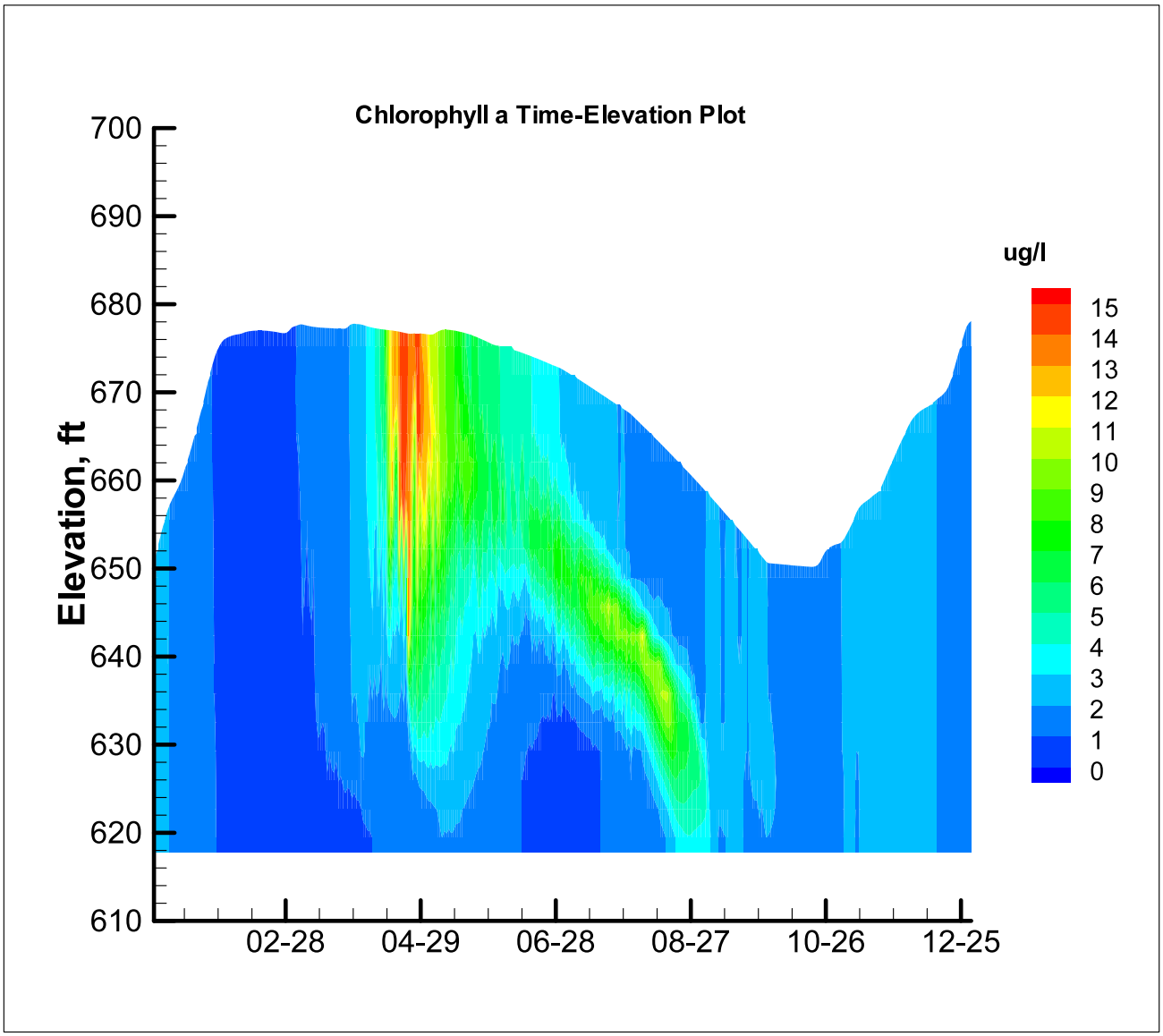

Figure 28. Time-elevation contour plot of model predicted chlorophyll a concentrations for the average flow year with 2 outlets (no mixing) scenario. The concentrations correspond to model segment adjacent to the dam (segment 7).

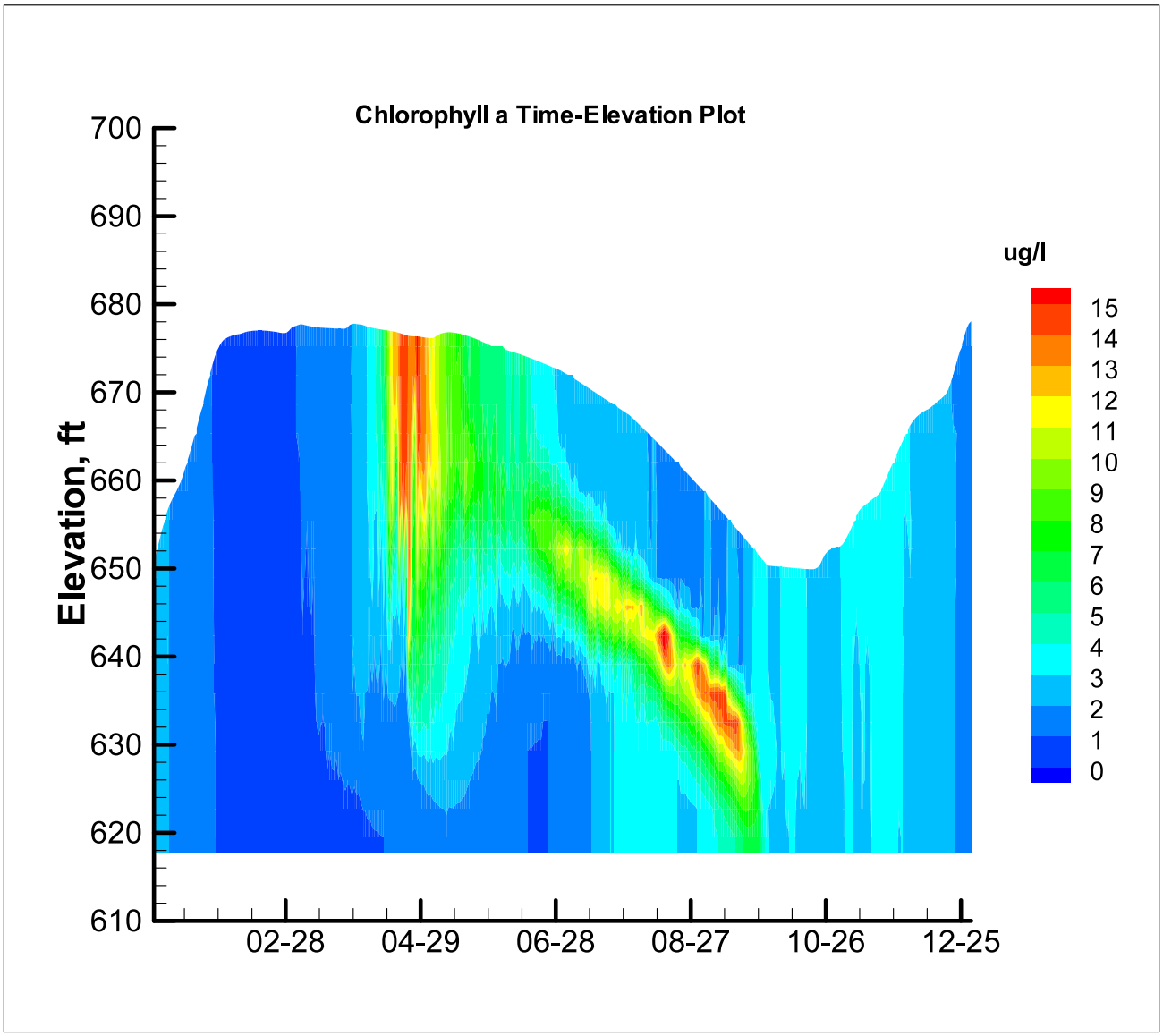

Figure 29. Time-elevation contour plot of model predicted chlorophyll a concentrations for the average flow year with 3 outlets scenario.

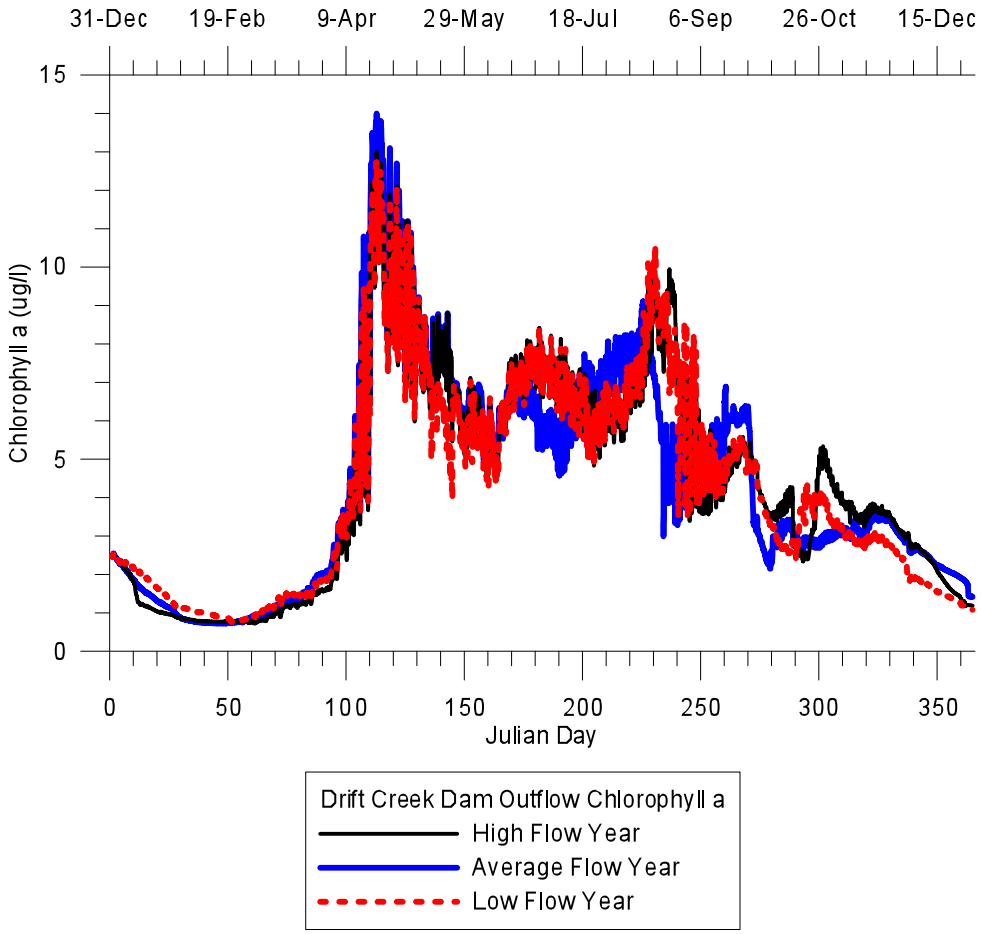

Figure 30. Model predicted dam outlet chlorophyll a concentrations for the three outlet scenario.

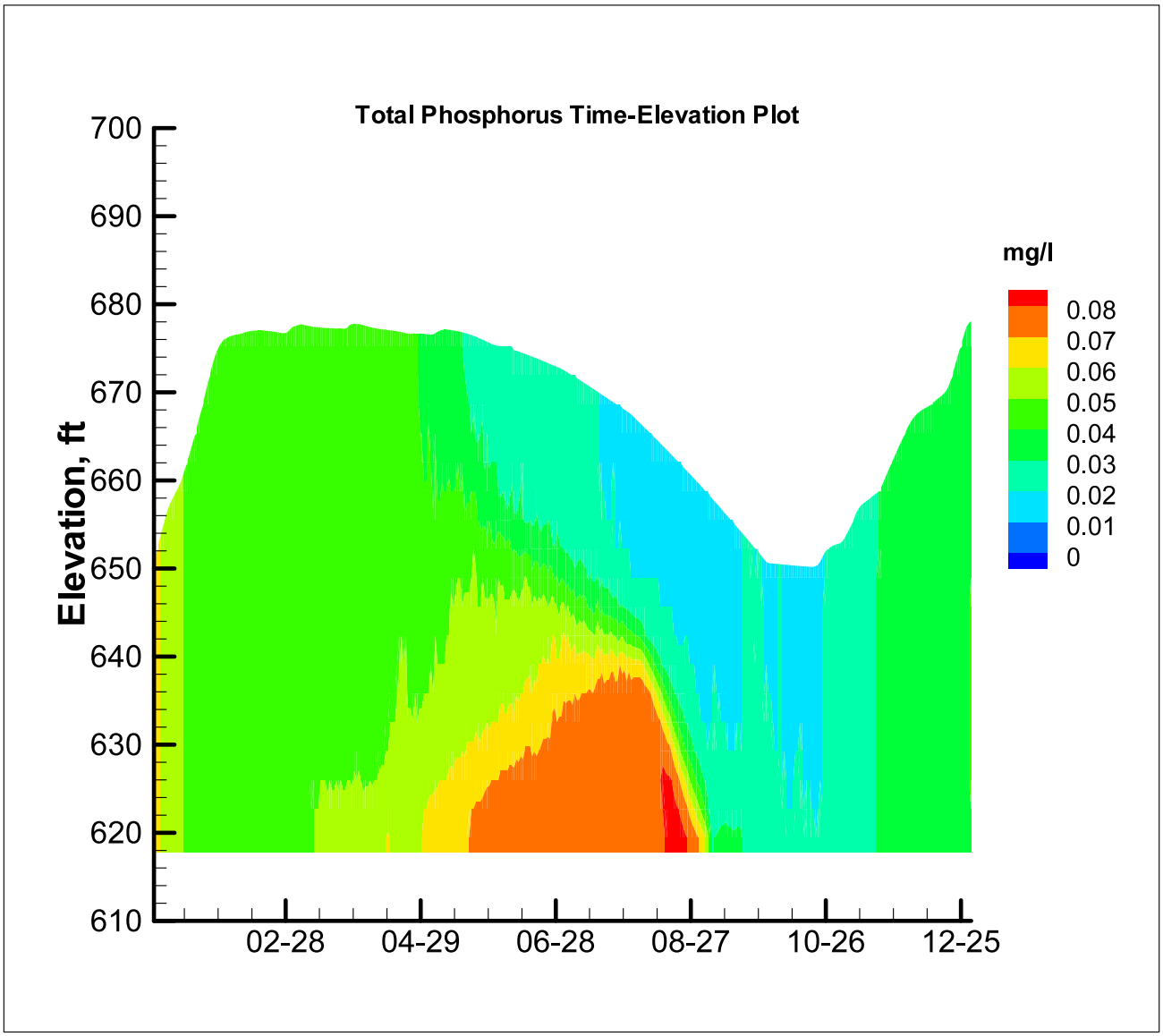

Figure 31. Time-elevation contour plot of model predicted total phosphorus concentrations for the average flow year with 2 outlets (no mixing) scenario. The concentrations correspond model segment adjacent to the dam (segment 7). During the summer phosphorus concentrations were depleted in the epilimnion due to algae growth but increased in the hypolimnion because of the anaerobic release of nutrients.

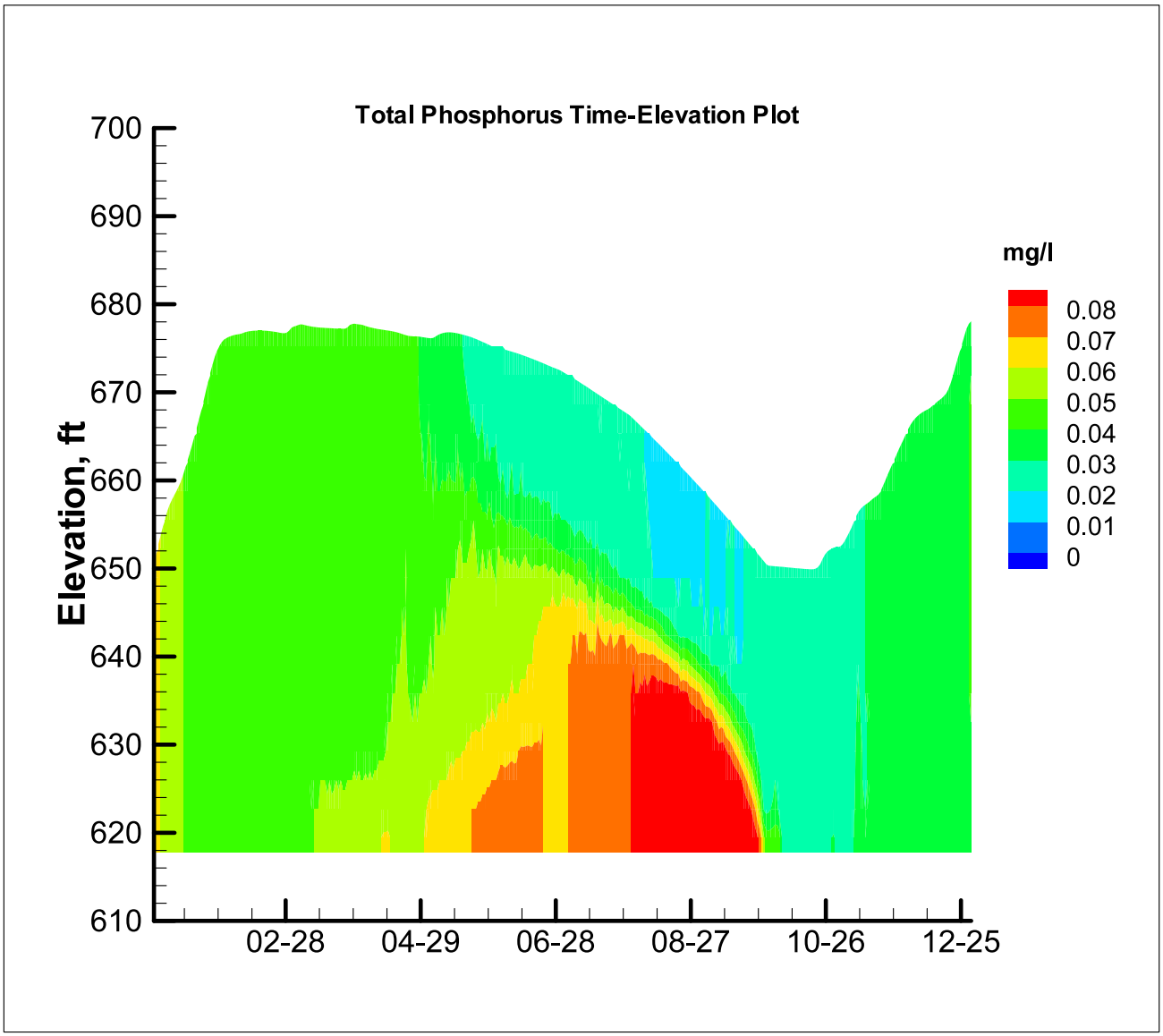

Figure 32. Time-elevation contour plot of model predicted total phosphorus concentrations for the average flow year with 3 outlets scenario.

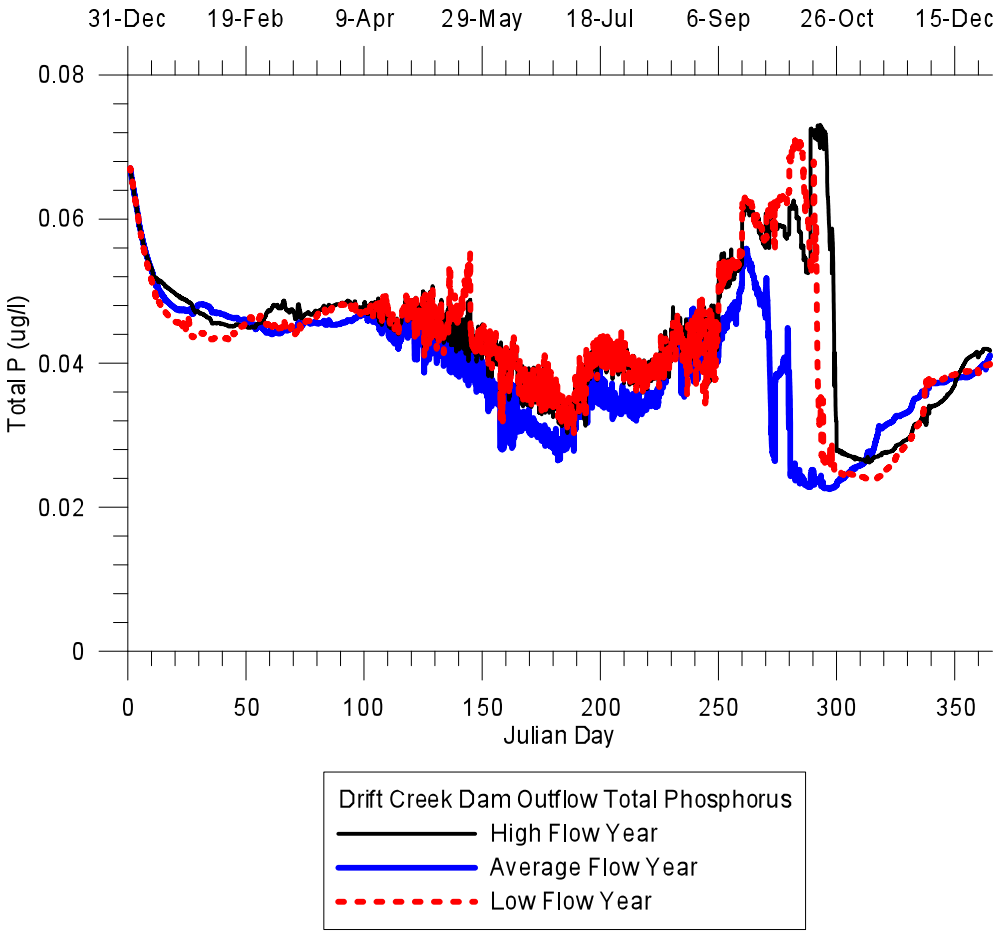

Figure 33. Model predicted dam outlet total phosphorus concentrations for the three outlet scenario.

Scenarios with NO Credit Given for Downstream Inflows

This set of scenarios assumes that inflows between the toe of the dam and the mouth cannot contribute toward meeting ISWR and consumptive use release requirements. Table 4 lists the release requirements. Dam outflows were set equal to the release requirement plus any necessary agricultural releases when reservoir inflows exceeded the release requirements. When reservoir inflows were less than the release requirements, dam outflows were set equal to reservoir inflows plus any necessary agricultural releases.

Water Level

Because of greater outflows, the reservoir took longer to fill for the no credit scenarios when compared with the scenarios that give credit for inflows between the toe of dam and the mouth. Figure 34 shows water level predictions of the low, average, and high flow year scenarios.

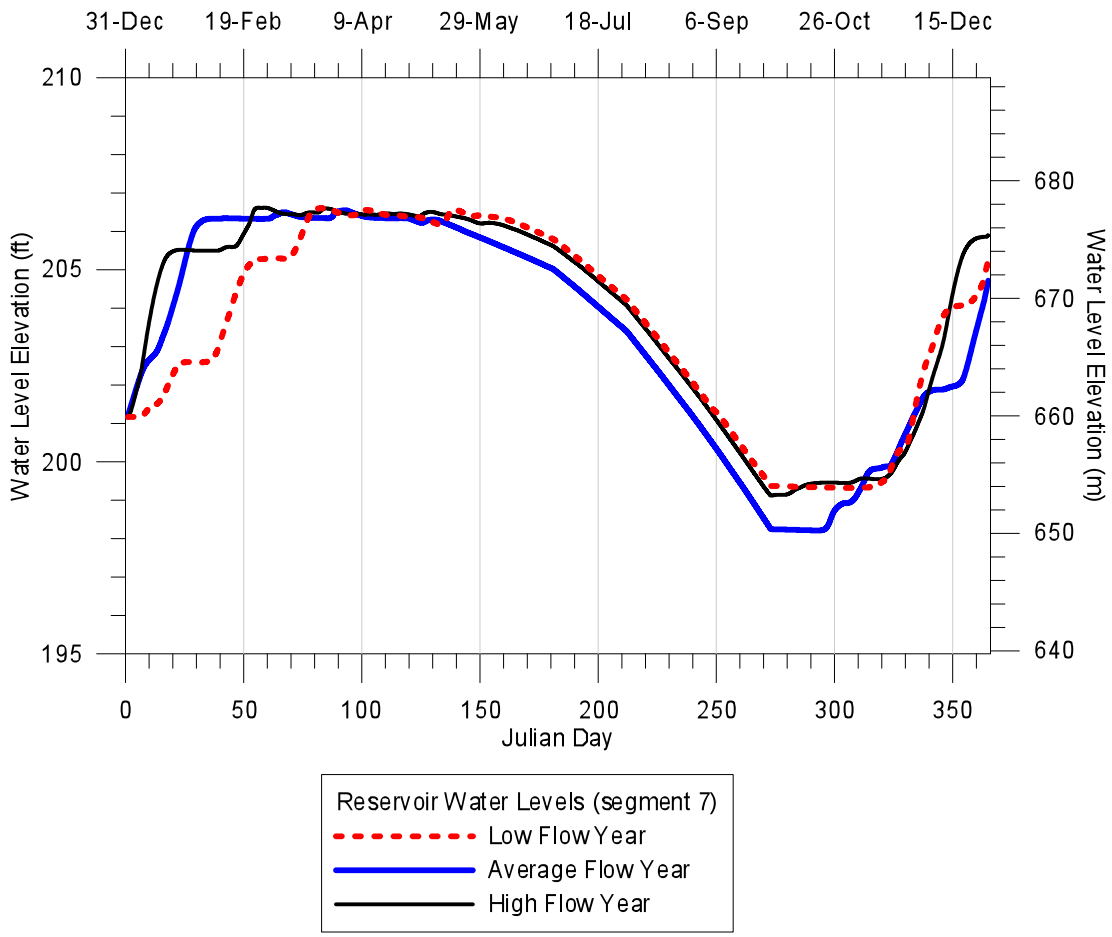

Figure 34. Model predicted water level elevations for the low, average, and high flow year scenarios assuming no credit given for inflows between toe of dam and mouth.

Flow

Figure 35 shows the total dam outflow rates for the low, average, and high flow years.

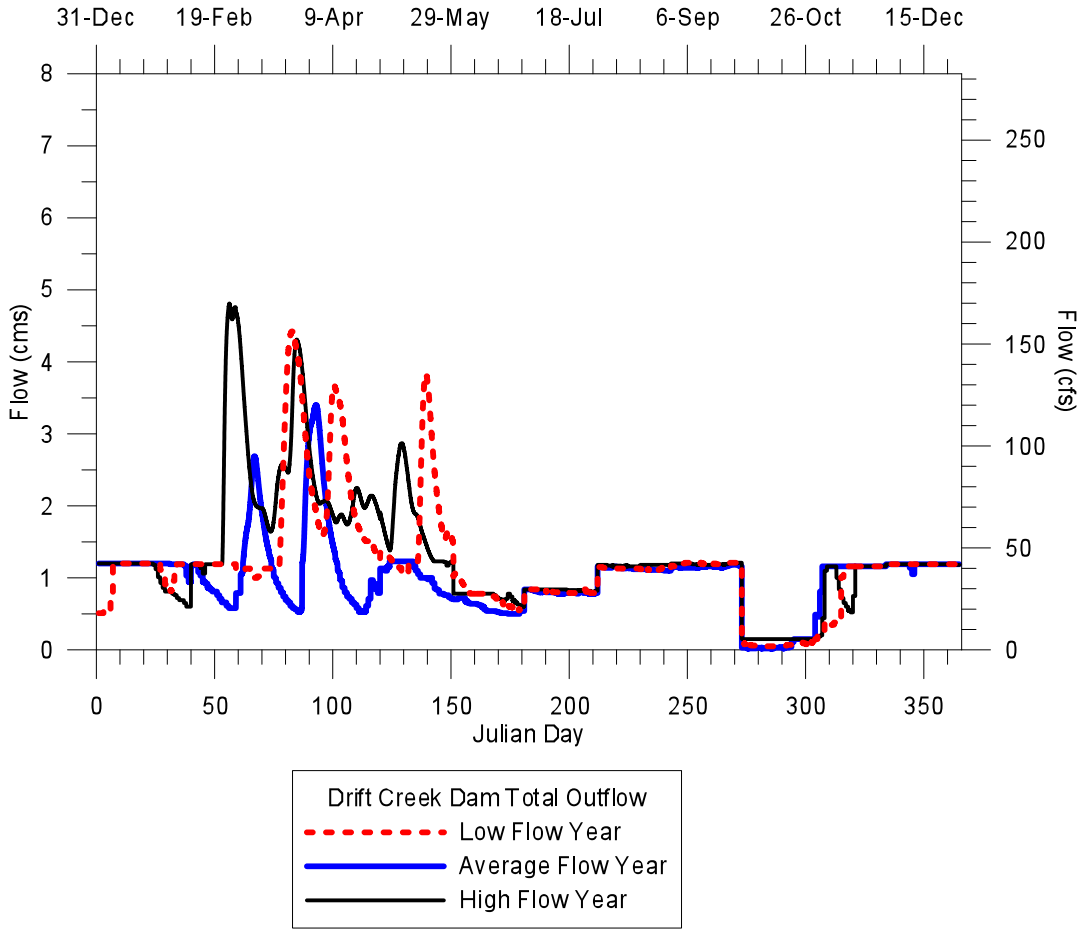

Figure 35. Total reservoir outflows for low, average, and high flow years assuming no credit given for inflows between toe of dam and mouth.

Temperature

Two Outlets with No Mixing Scenario

Outflows from the dam were determined in an attempt to meet temperature standards by using the two planned outlets. For this scenario water from the 2 outlets was not combined or "mixed" in order to meet the standard. Flows passed through one outlet or the other. Water was withdrawn from the mid-level outlet until outflow temperature exceeded the temperature standard or the water level in the reservoir dropped below the elevation of this outlet. Figure 36 shows outlet elevation, outflow temperature and temperature standards for the average flow year. Despite using the low-level outlet, outflow temperatures exceeded the temperature standard in September as the cold water pool in the reservoir was depleted.

Figure 37 through Figure 39 show the 7-Day and 60-day average daily maximum temperatures for the low, average, and high flow year scenarios. A time-elevation contour plot of temperature for average flow year was shown in Figure 40.

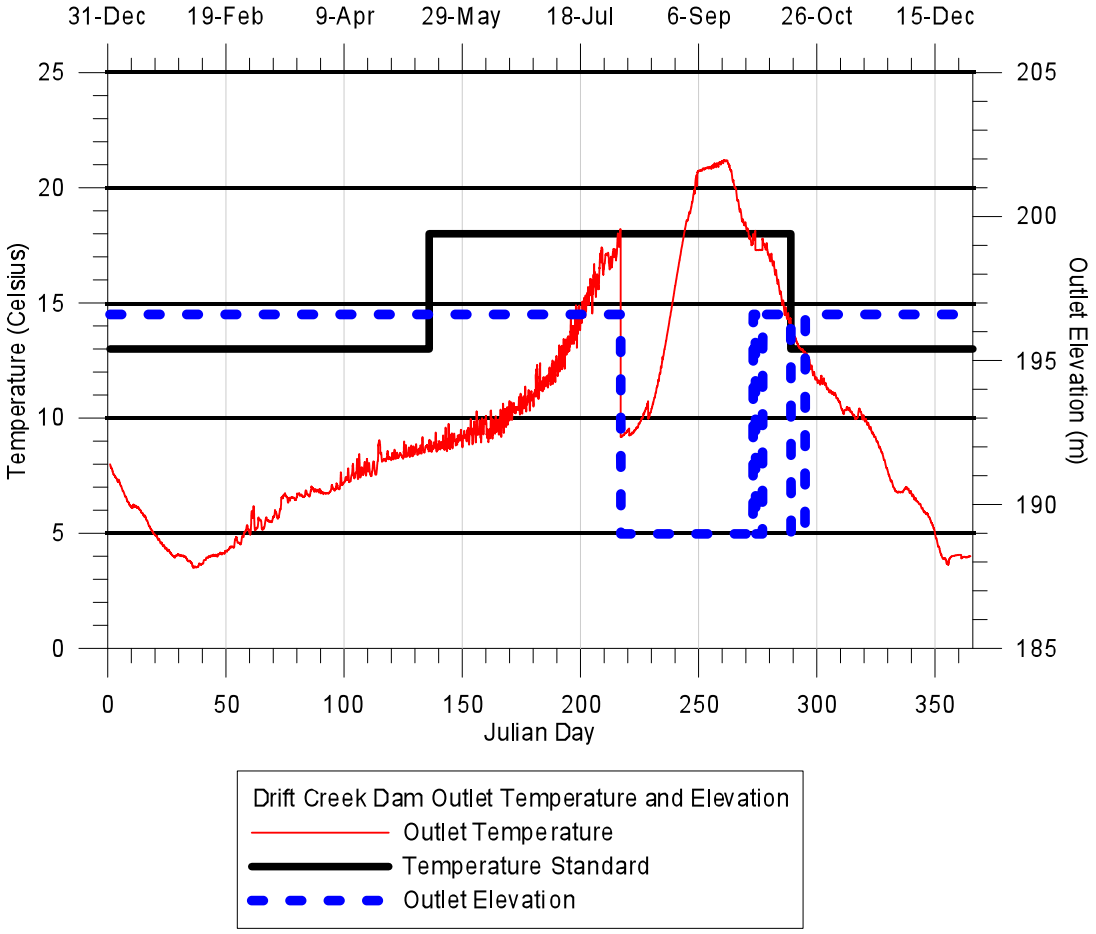

Figure 36. Dam outflow temperature and outlet elevation for the average flow year with flows passing through the mid-level or the low level outlet. This scenario assumed that no credit was given for inflows between toe of dam and the mouth. Outlet elevations (196.60 m and 188.98 m) are those presently planned for the dam. On Julian Day 218 (August 5th) outflows are shifted from the mid-level outlet to the low level outlet in order to meet the temperature standard.

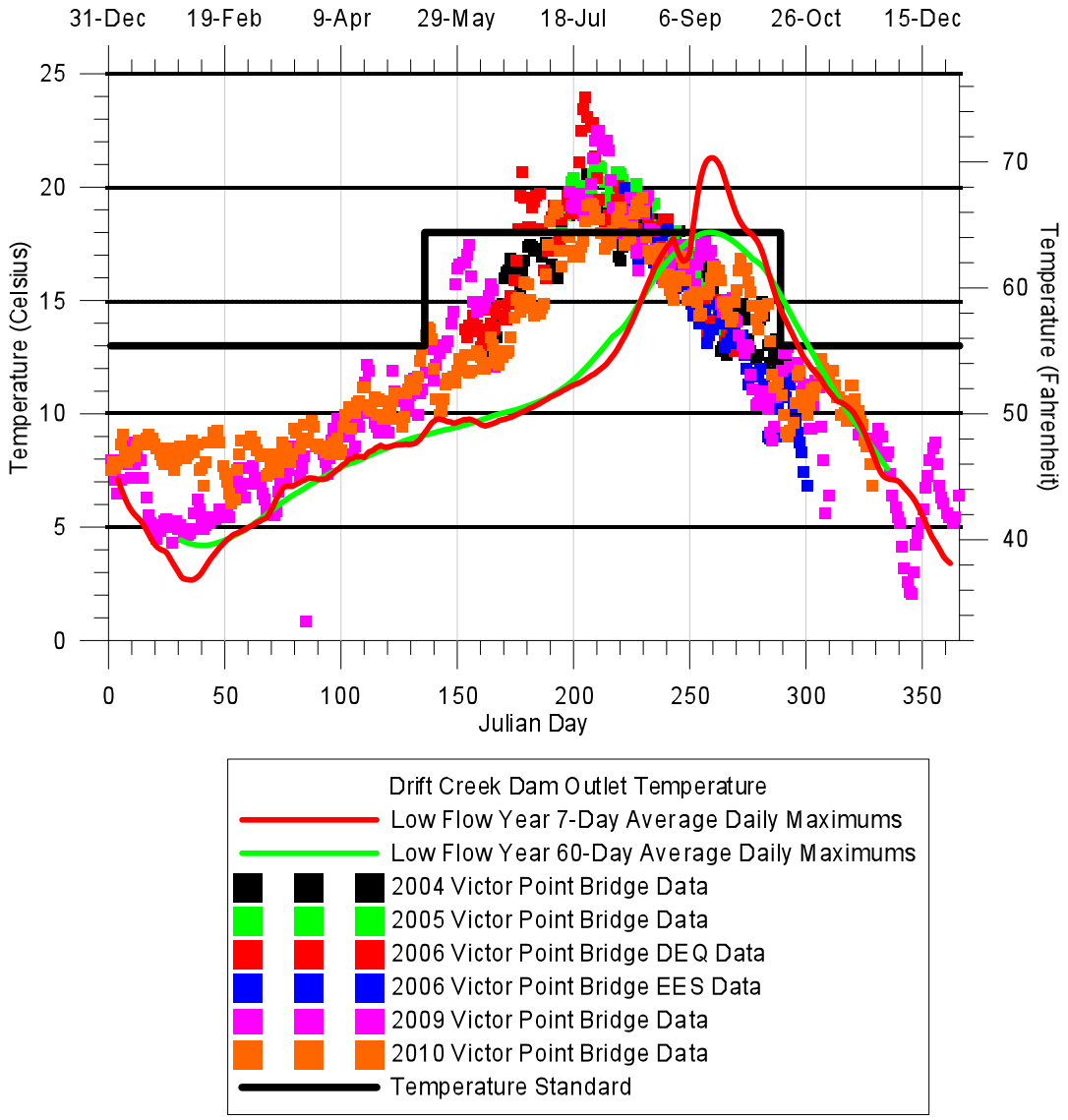

Figure 37. Low flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. This scenario assumed that no credit was given for inflows between toe of dam and the mouth. Average daily temperature data measured at Victor Point Bridge were also plotted.

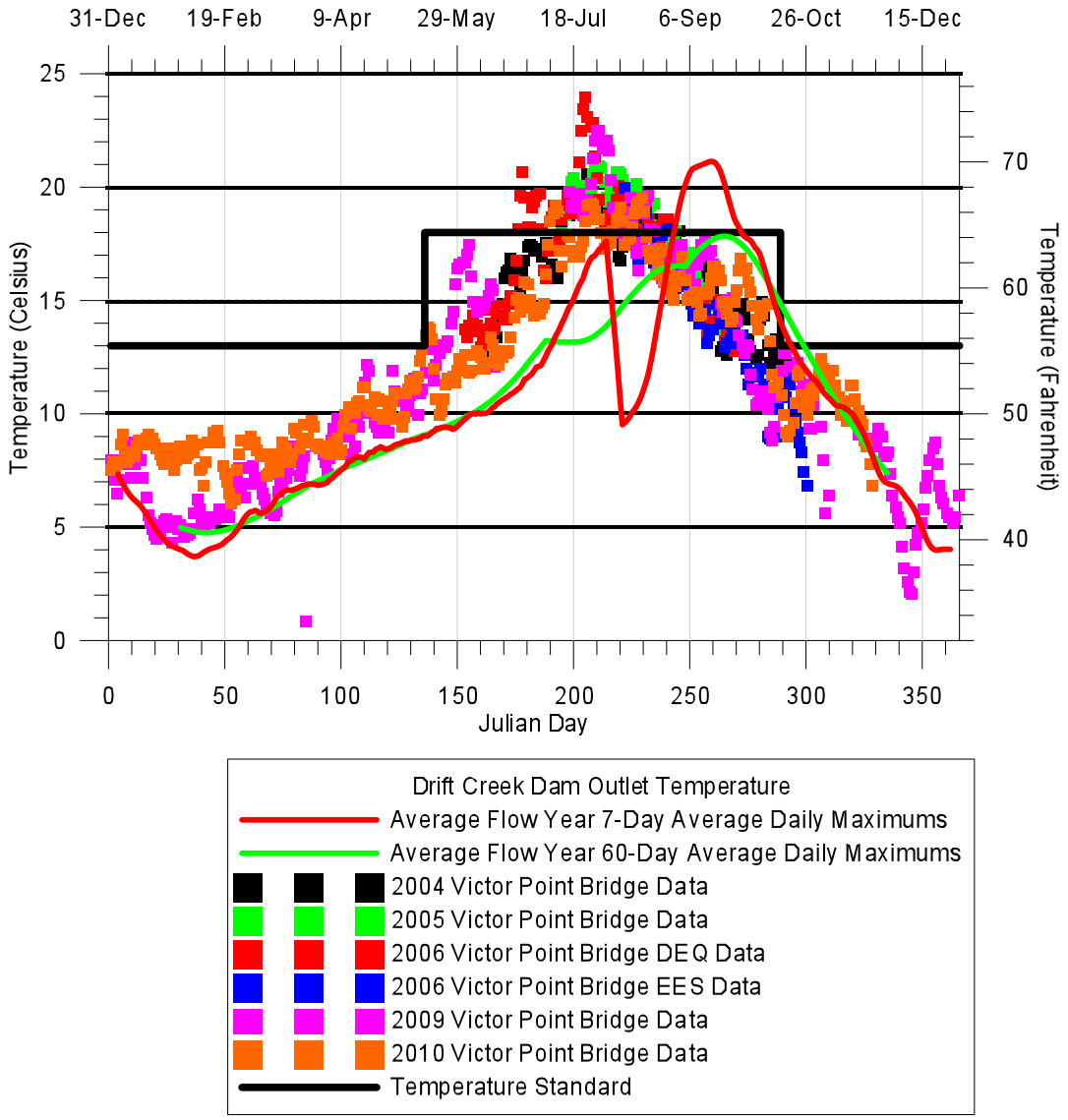

Figure 38. Average flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. This scenario assumed that no credit was given for inflows between toe of dam and the mouth. Average daily temperature data measured at Victor Point Bridge were also plotted.

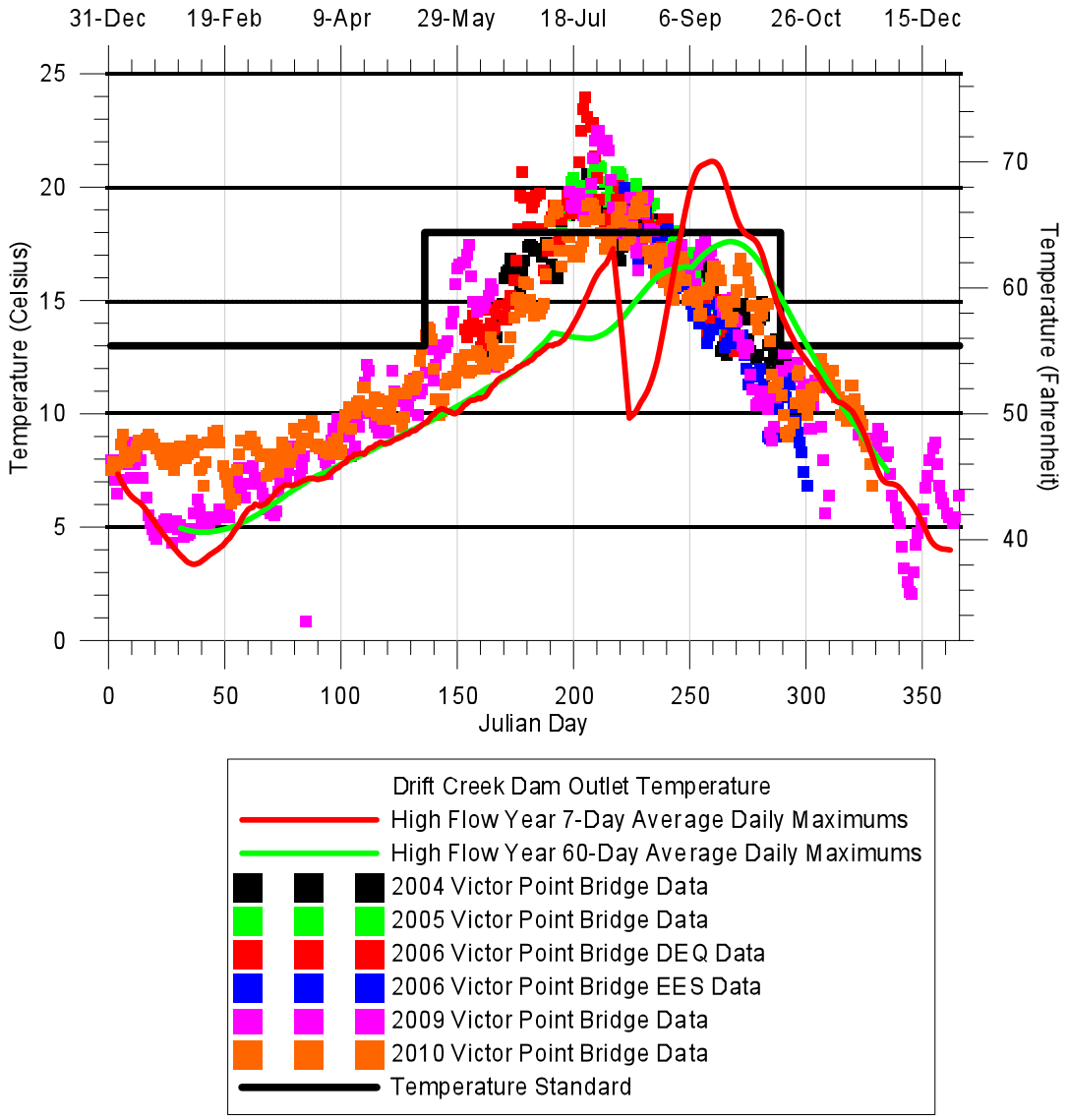

Figure 39. High flow year 7-day and 60-day average daily maximum temperatures of dam outflow temperatures plotted with temperature standards. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. Average daily temperature data measured at Victor Point Bridge were also plotted.

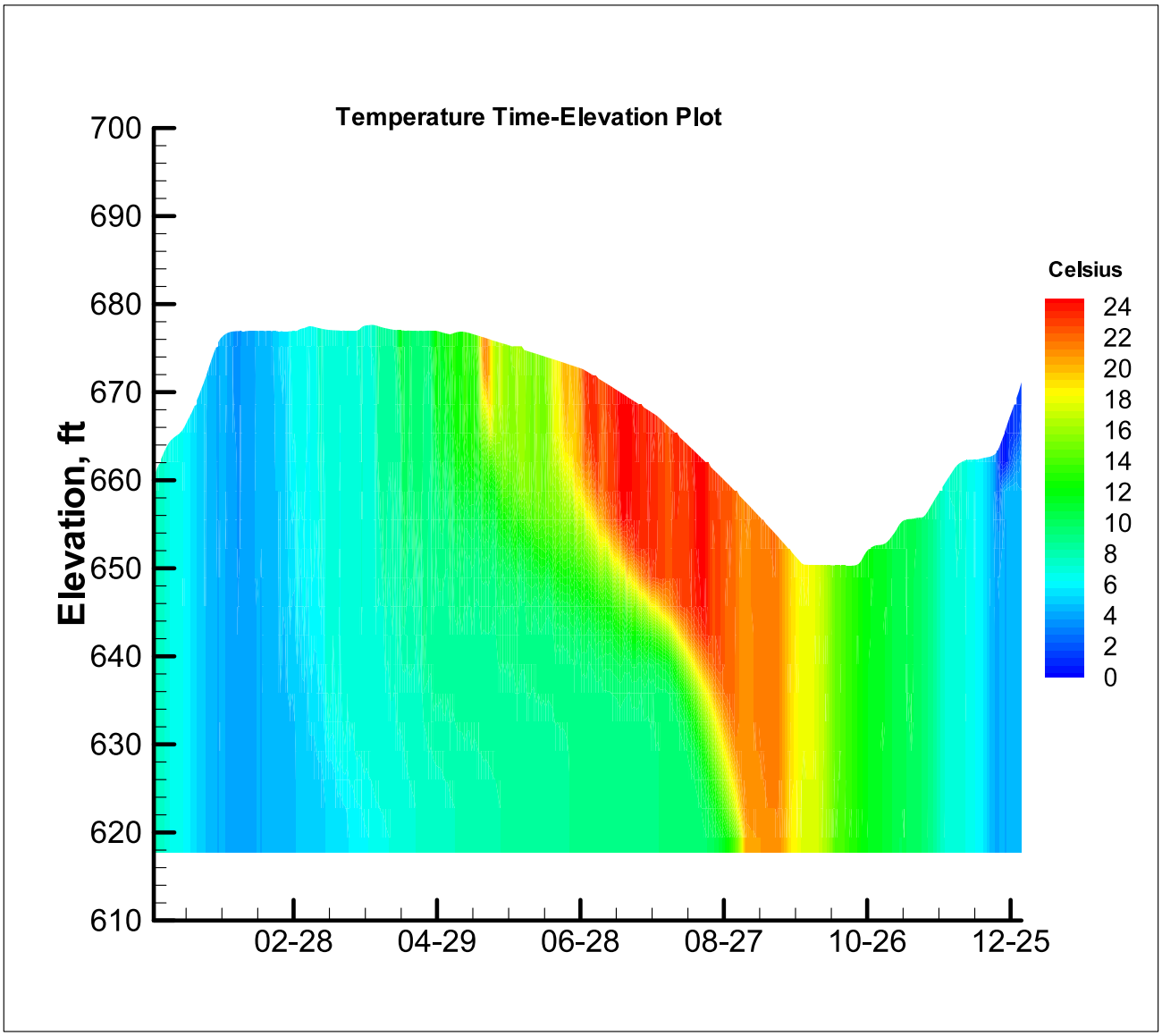

Figure 40. Time-elevation contour plot of temperature for the average flow year scenario with flows passing through either the mid-level outlet or low level outlet. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth.

Two Outlets with Mixing Scenario

This scenario included the option of mixing flows passing through two outlets in order to meet temperature standards. No flow credit was given for inflows between the toe of the dam and the mouth. The mid-level outlet was moved upwards to an elevation of 200 m (656.16 ft) in order to help meet temperature standards. Figure 41 through Figure 43 7-day and 60-day daily maximum temperatures for low, average and high flow years. Outlet temperatures exceeded measured stream temperatures by more than 0.3° C during September and October due to the cold water pool in the bottom of the reservoir being depleted. In addition, the salmon and steelhead spawning criteria of 13° C was exceeded in late October. Figure 44 shows the time-elevation contour plot of temperature for average the flow year.

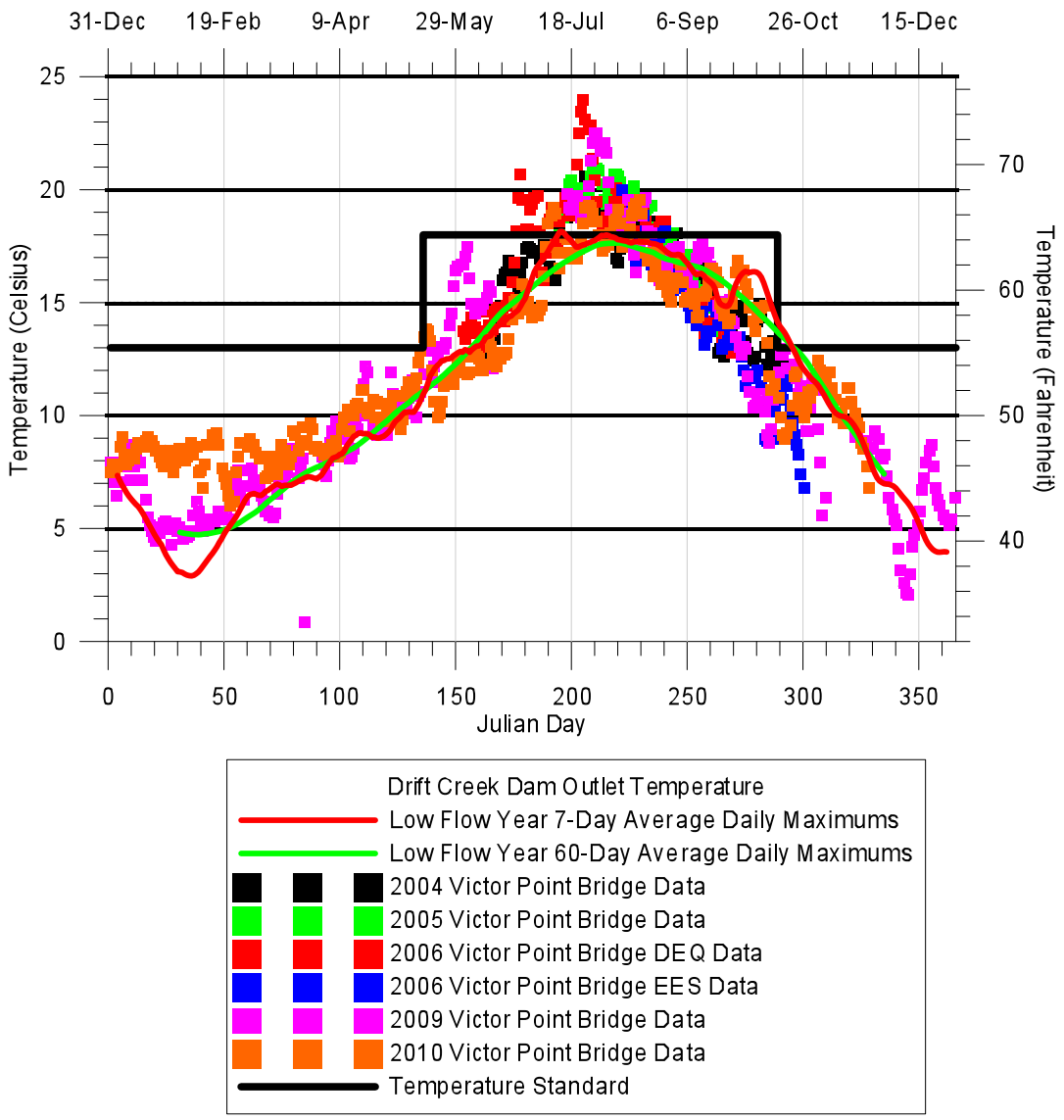

Figure 41. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for low flow year with dam outflows being mixed using the mid-level and the low level outlet. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

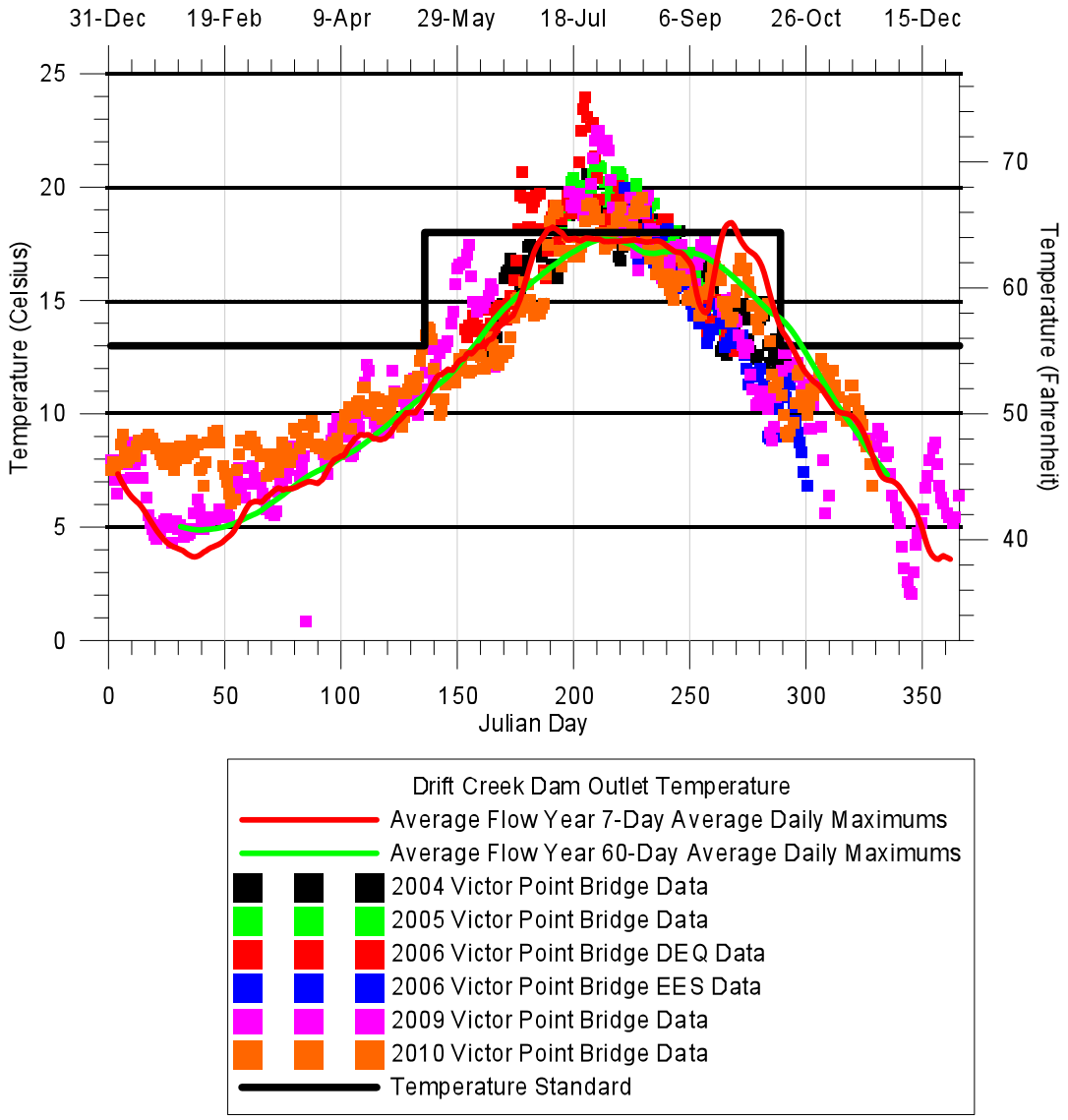

Figure 42. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for average flow year with dam outflows being mixed using the mid-level and the low level outlet. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

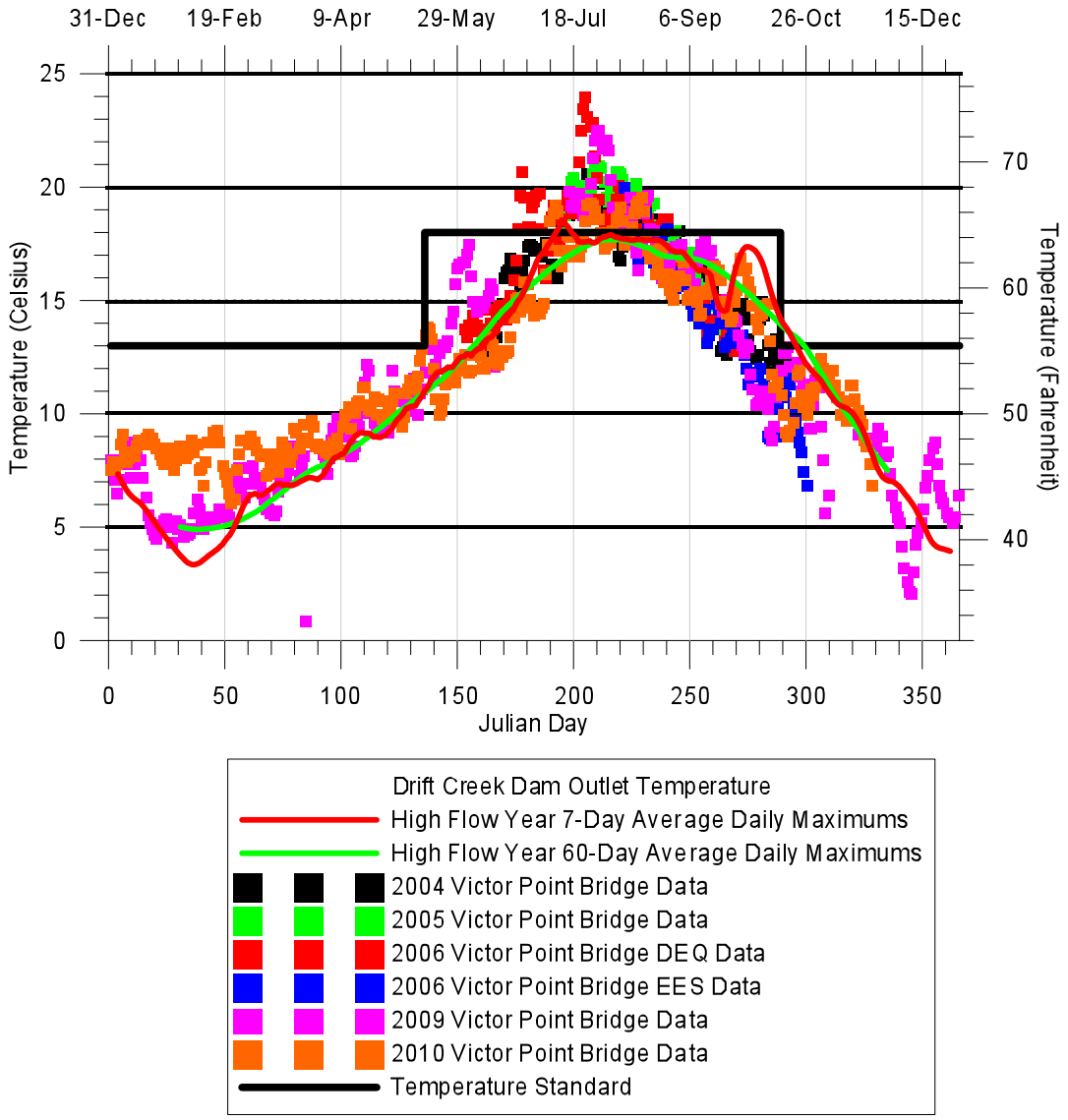

Figure 43. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for high flow year with dam outflows being mixed using the mid-level and the low level outlet. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. The mid-level outlet elevation (200 m) has been shifted to an elevation higher than the designed elevation.

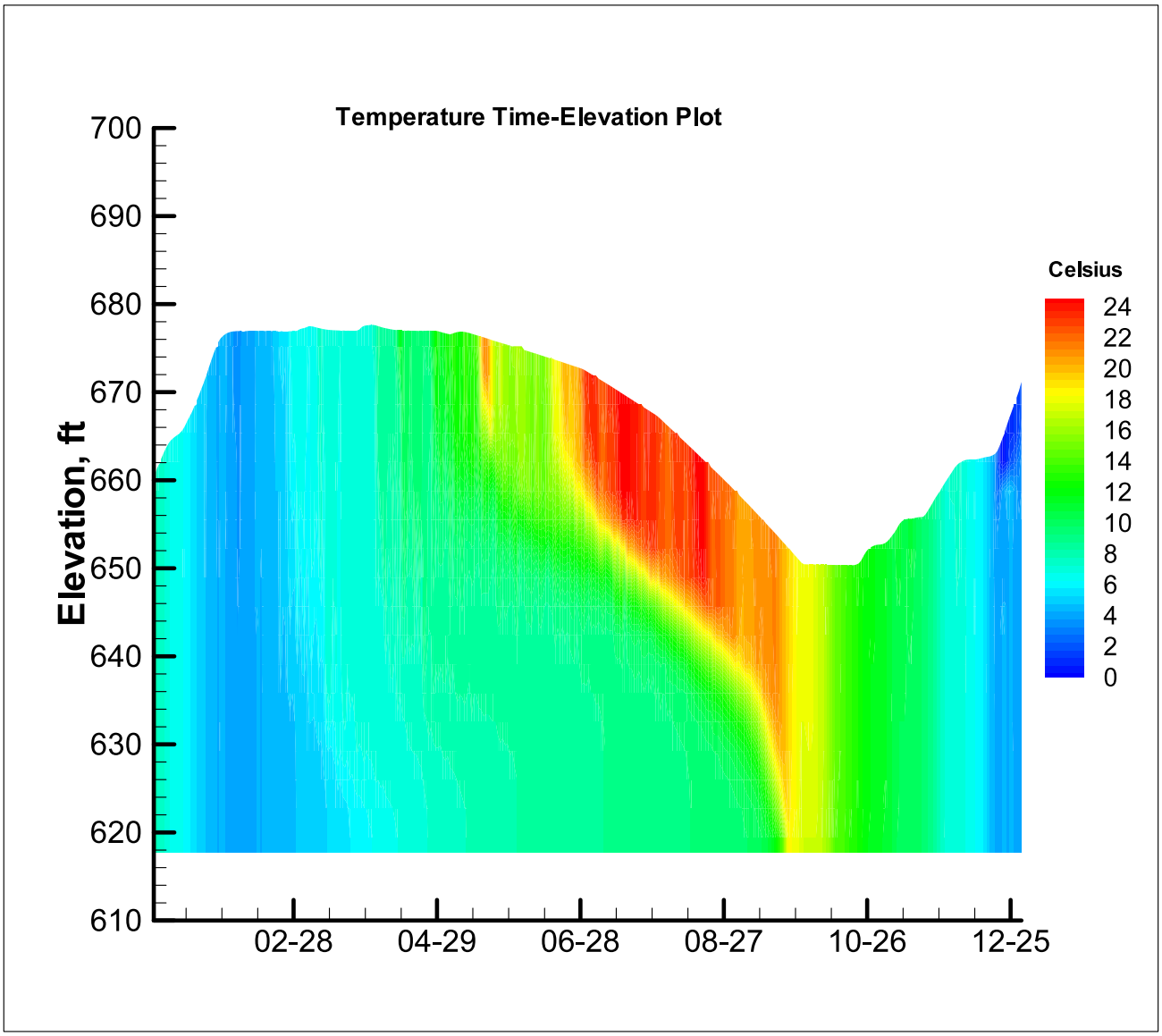

Figure 44. Time-elevation contour plot of temperature for the average flow year scenario using combined mid-level and low level outlet mixed flows. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth.

Three Outlets with Mixing Scenario

The three outlets with mixing scenario was also modeled with no flow credit given for inflows between the toe of the dam and the mouth. The third "high level" outlet had an of elevation 201 m (659.44 ft) allowing water to be withdrawn closer to the surface in the spring and early summer. Flow through the 3 outlets was also mixed as necessary to meet temperature standards. The low level and mid-level outlets were set to the design elevations of 188.98 m and 196.60 m. The dam outflow 7-Day and 60-day average of daily maximum temperatures for the low, average, and high flow years are plotted in Figure 45 through Figure 47. The low and high flow years came very close to meeting temperature standards whereas the average flow year exceeded measured temperatures by much more than 0.3° C during late September and early October. During early October the 7-day average of daily maximums for the low and high flow years slightly exceeded measured stream temperatures by 0.3° C. Figure 48 shows the flow rates through each of the 3 outlets of the average flow year. A time-elevation plot of temperature for the average flow year is shown in Figure 49.

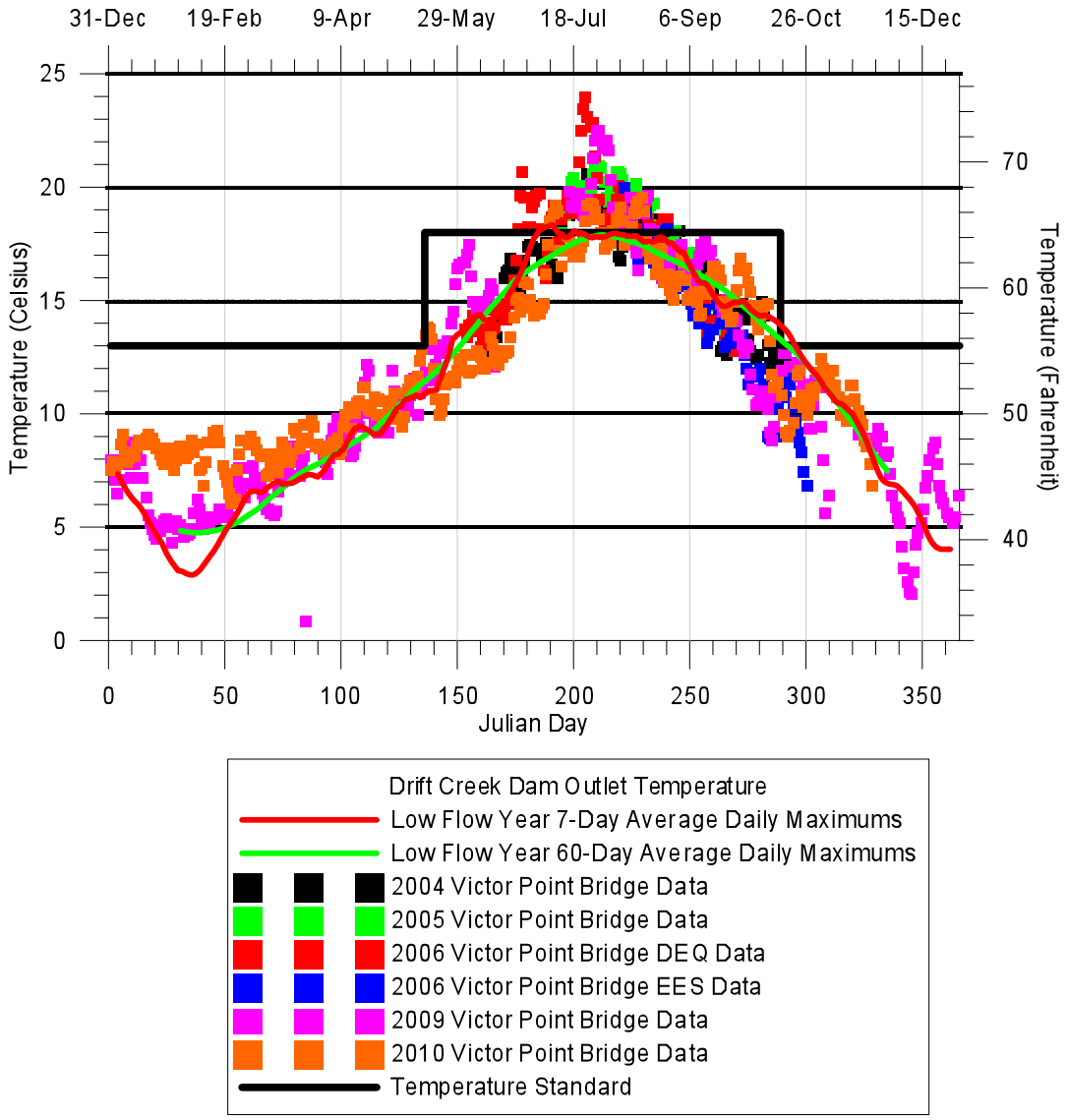

Figure 45. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for low flow year with dam outflows being mixed using three outlets. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. A new high level outlet elevation (201 m) has been added.

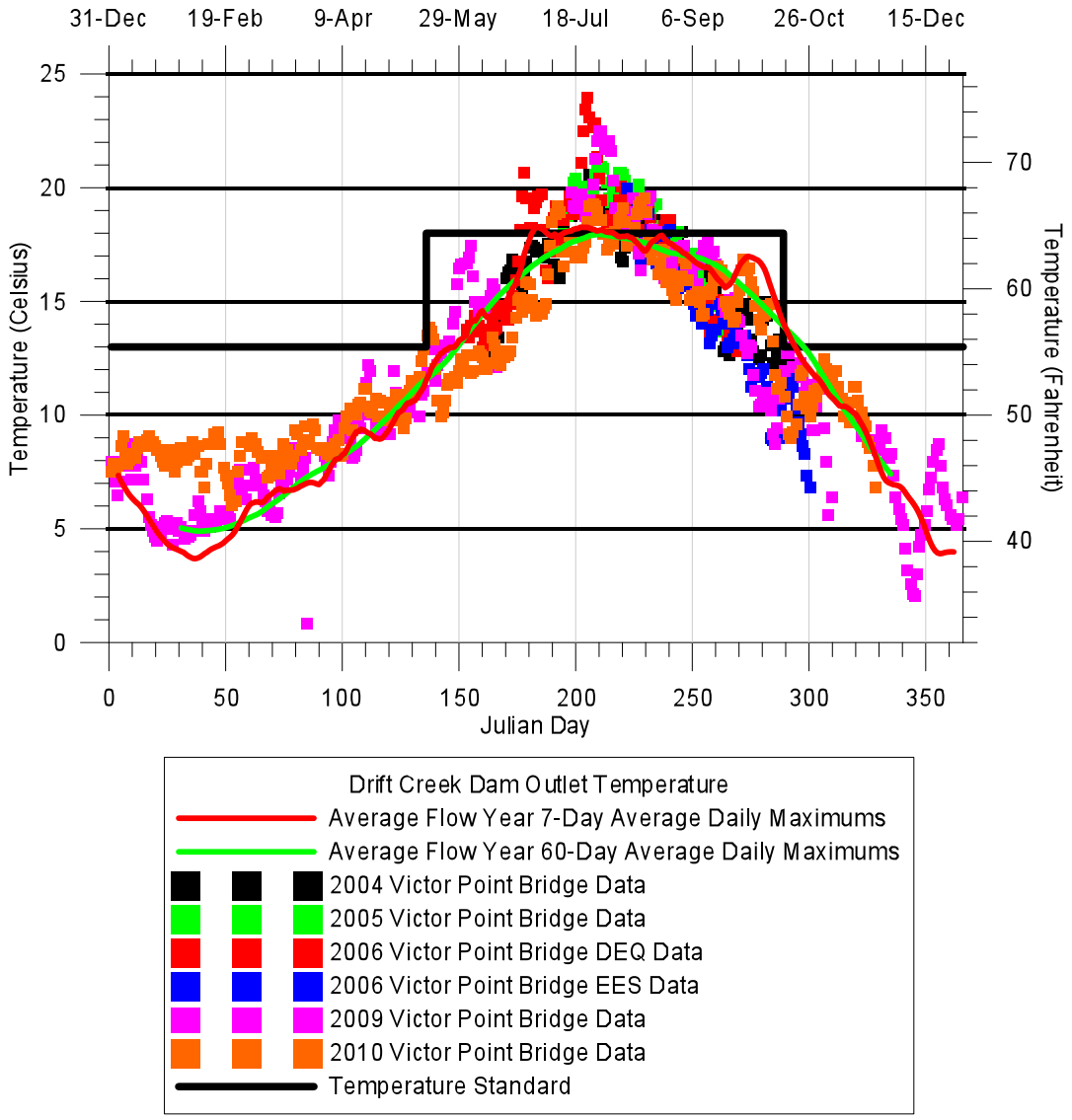

Figure 46. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for average flow year with dam outflows being mixed using three outlets. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. A new high level outlet elevation (201 m) has been added.

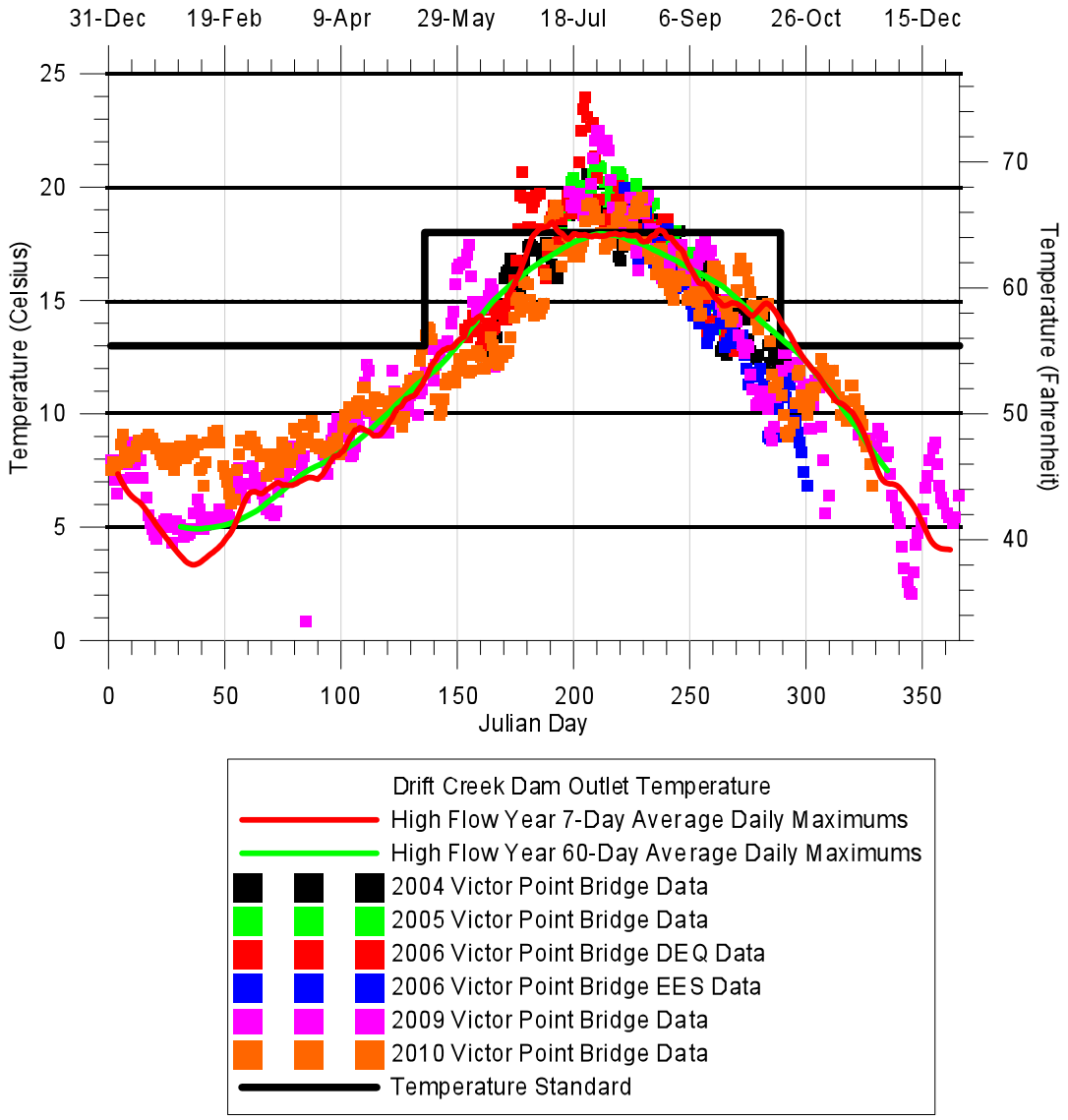

Figure 47. The 7-Day and 60-day average of daily maximum temperatures of dam outflow temperature for high flow year with dam outflows being mixed using three outlets. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth. A new high level outlet elevation (201 m) has been added.

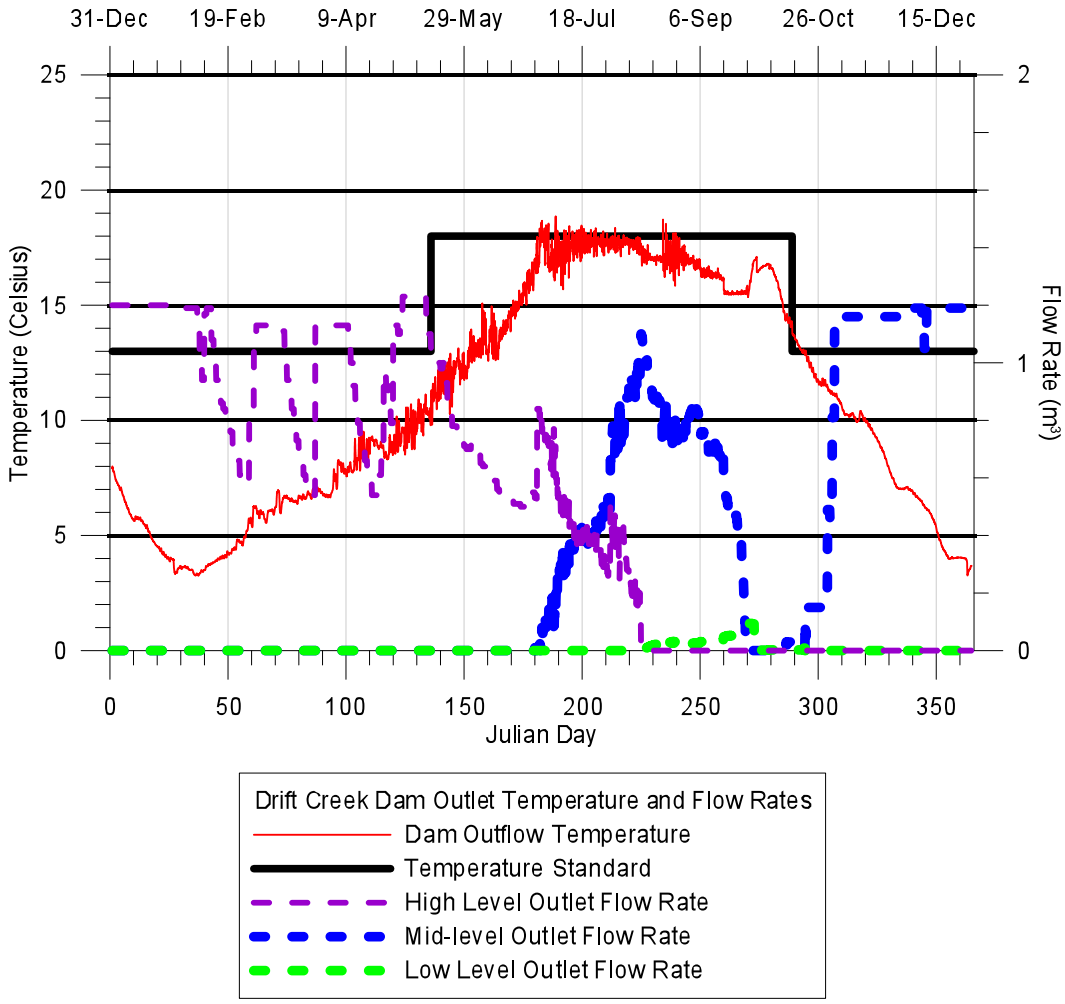

Figure 48. Flow rates through high level, mid-level and low-level outlets for average flow year scenario (three outlets). The net dam outflow temperature is also shown. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth.

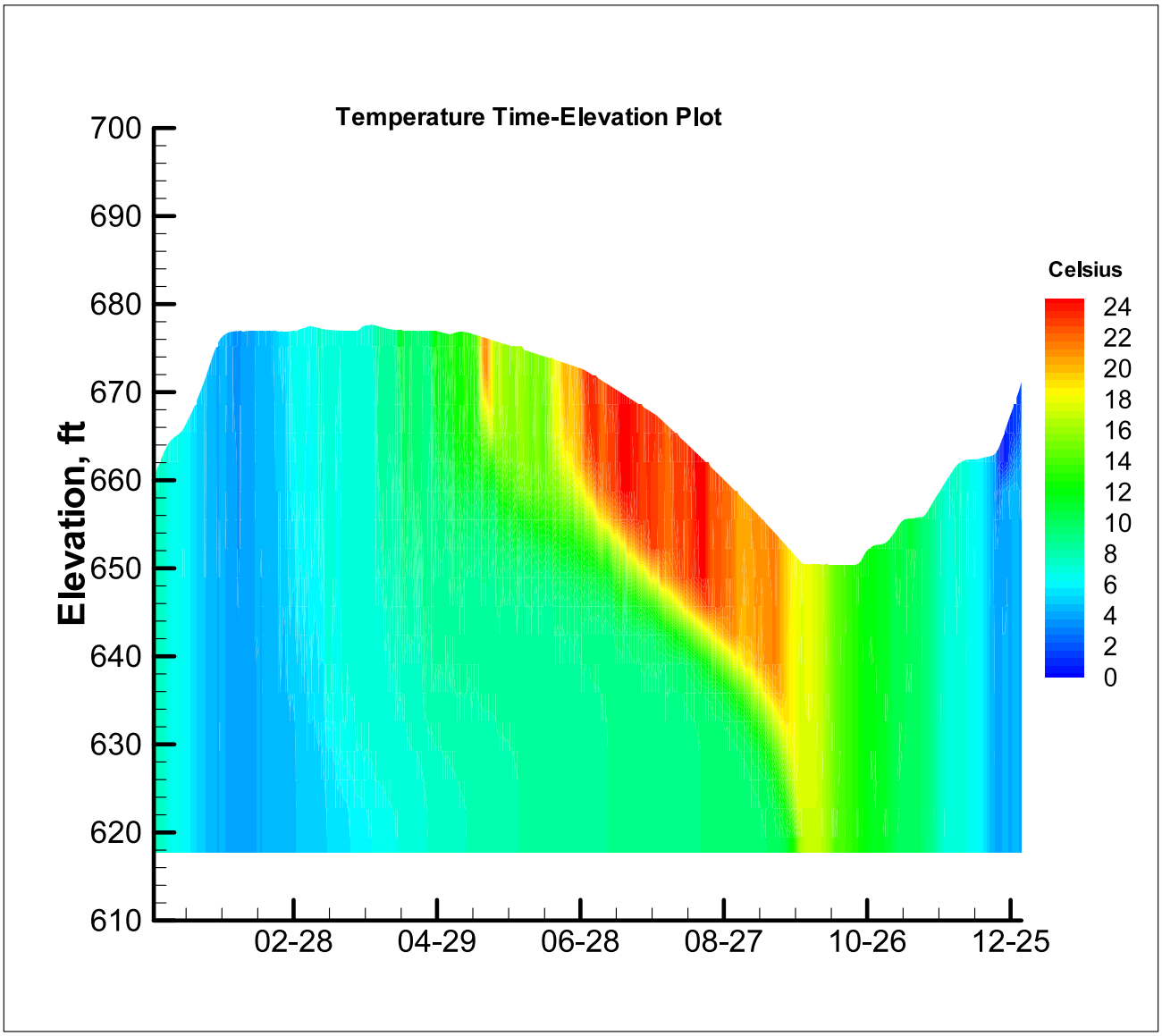

Figure 49. Time-elevation contour plot of temperature of the average flow year with 3 outlets. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth.

Dissolved Oxygen

Figure 50 shows the DO time-elevation plot of the 3 outlet scenario for the average flow year. Results were similar to those where flow credit was given for inflows between toe of dam and the mouth. The dissolved oxygen concentrations from the dam outflow were shown in Figure 27 for the 3 outlet scenario. Reaeration of dam outflows will be necessary during later summer.

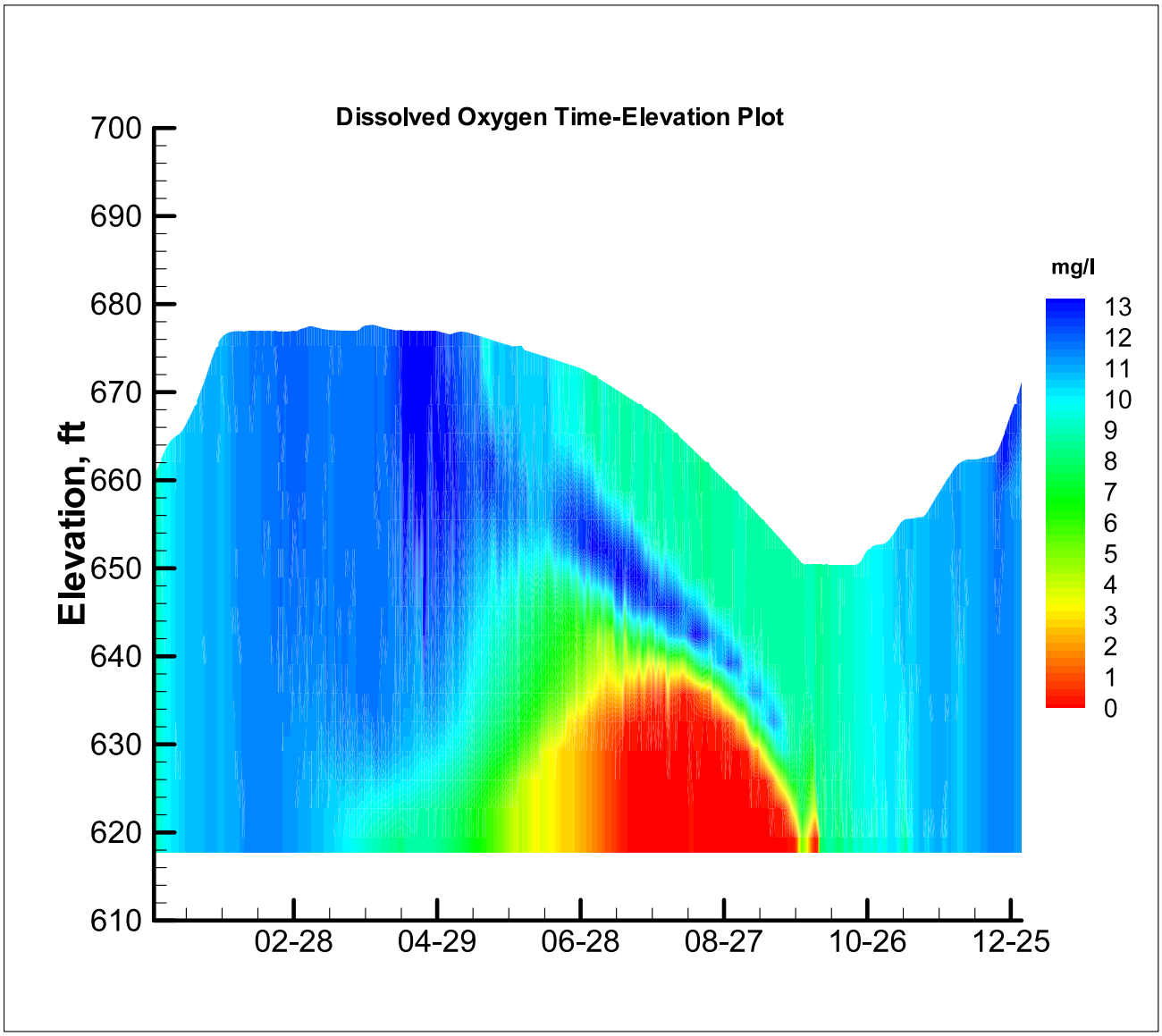

Figure 50. Time-elevation contour plot of model predicted dissolved oxygen concentrations for the average flow year with 3 outlets. This scenario assumed that no flow credit was given for inflows between toe of dam and the mouth.

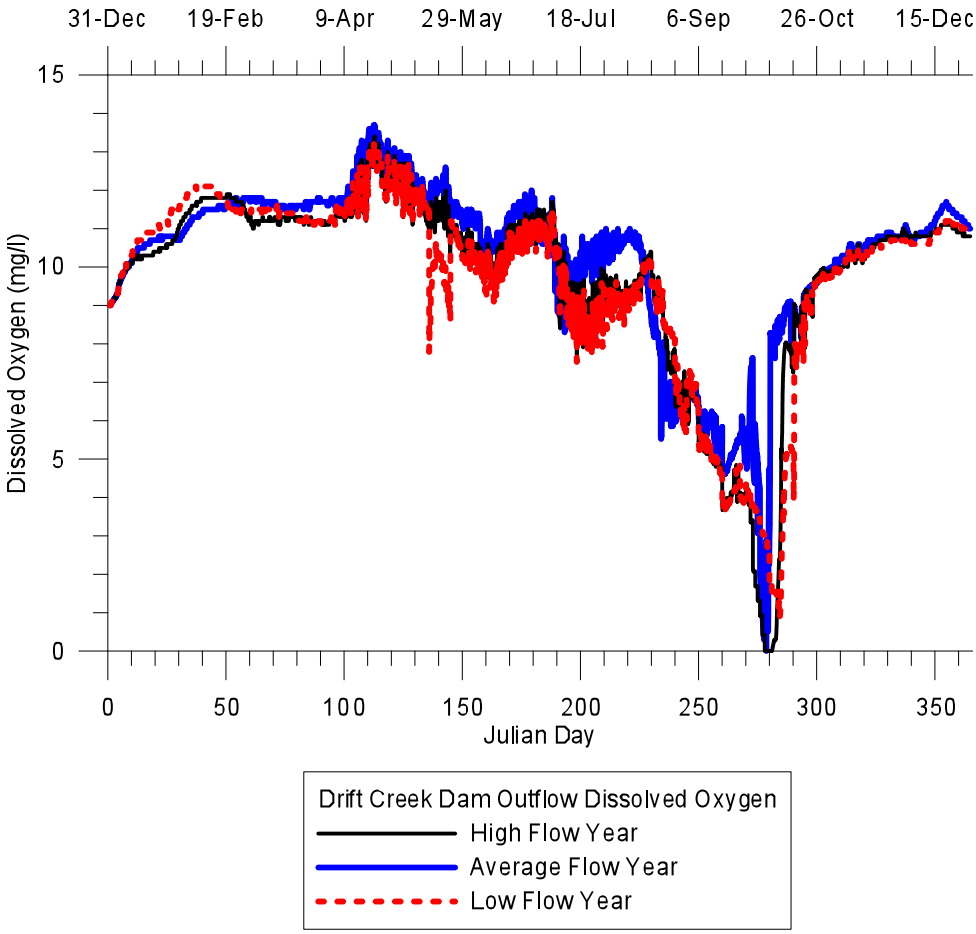

Figure 51. Model predicted dam outlet dissolved oxygen concentrations for three outlet scenario. These scenarios assumed that no flow credit was given for inflows between toe of dam and the mouth.

Algae and Nutrients

Algae and nutrient predictions for the scenarios where no flow credit was given for inflows between the toe of the dam and the mouth were similar to those where flow credit was given. Figure 52 shows chlorophyll a concentrations in the dam outflow for the 3 outlet scenario. Dam outflows of total phosphorus for the 3 outlet scenario were plotted in Figure 53.

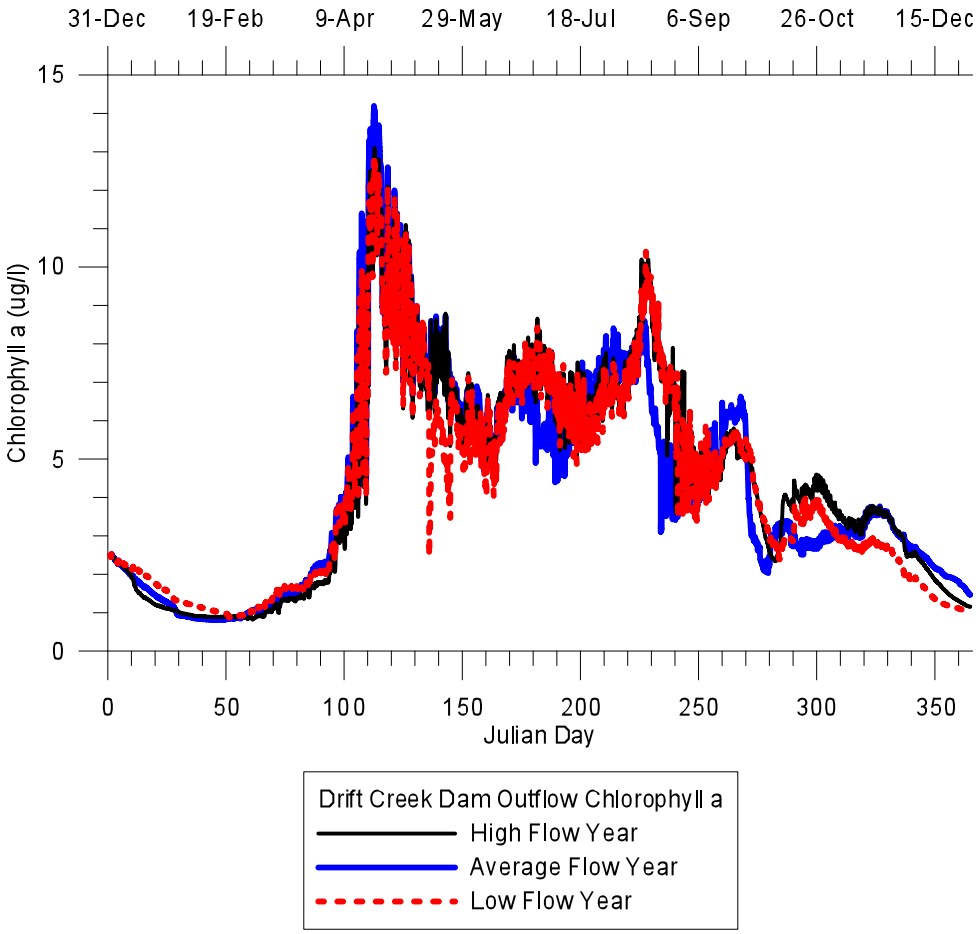

Figure 52. Model predicted dam outlet chlorophyll a concentrations for the three outlet scenario. These scenarios assumed that no flow credit was given for inflows between toe of dam and the mouth.

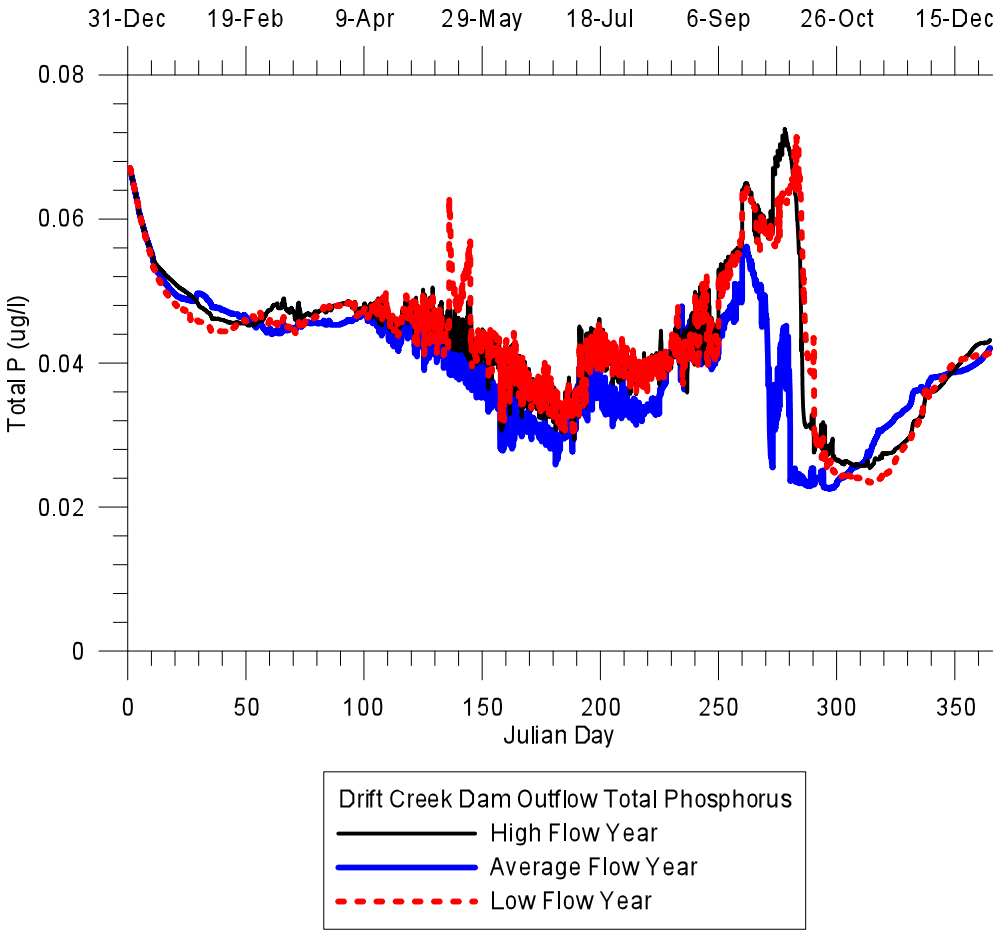

Figure 53. Model predicted dam outlet total phosphorus concentrations for the three outlet scenario. These scenarios assumed that no flow credit was given for inflows between toe of dam and the mouth.

Summary

The CE-QUAL-W2 water quality model of the reservoir formed by the Drift Creek Dam was applied to help evaluate the water quality impact of releasing irrigation flows directly to Drift Creek. The model simulates flow, water level, temperature, dissolved oxygen, organic matter, nutrients and algae. Scenarios included a two outlet with no mixing option, a two outlet with a mixing option, and a three outlet with mixing. Two sets of scenarios were simulated. One set assumed that inflows between the toe of dam and the mouth contribute toward meeting the in-stream water right. The second set assumed that no credit was given for inflows between the toe of the dam and the mouth and that the in-stream water right requirements need to be met at the dam outflow. The scenarios were modeled with low, average, and high flow years using 2008 meteorological conditions. The primary goal of the scenarios was to meet temperature standards downstream of the dam in Drift Creek. The results of the scenarios helped provide the following conclusions:

- It would be very difficult to meet temperature standards without mixing flows from dam outlets. Mixing combines flows from a pair of outlets so that the temperature standard is being met while preserving cold water pool at the bottom of reservoir for as long as possible.
- Although temperature standards were not met part of the time, the two outlet with mixing scenario did better with the mid-outlet elevation shifted upwards to an elevation of 200 m (656.16 ft). This configuration allowed water to be withdrawn closer to the surface during spring and early summer, preserving the cold water pool use in late summer and early fall.
- The scenario with an additional “high level” outlet placed at an elevation 201 m (659.44 ft) was much more effective than the other scenarios in meeting temperature standards and replicating natural stream temperatures.
- When no flow credit was given for inflows between the toe of the dam and the mouth, outflow temperatures were a little warmer. Temperature standards were very close to being met for 2 out of the 3 years simulated when using 3 outlets and mixed flows. Slightly reducing agricultural releases might preserve enough cold water so that standards could be met during the critical October period.

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SECTION 5
AGRICULTURAL ECONOMIC VALUE ANALYSIS

One of the prerequisites for receiving federal loan funding for a water project is an economic value analysis of the ability-to-pay. A set of guidelines that could potentially apply to the Drift Creek Reservoir are detailed in the Bureau of Reclamation guidance document titled "Technical Guidance for Irrigation Ability to Pay and Irrigation Payment Capacity." An ability-to-pay study assesses the financial capability of an irrigation district or contracting entity to pay for increased operational costs that evaluate the farm income generated by typical irrigators in a district. The ability to pay is defined as the farm-level payment capacity aggregated to the entire district, less district obligations, operation and maintenance costs, power costs and reserve fund requirements. This ability-to-pay" is often referred to as the "annual loan amortization capacity."

Ability-to-pay studies consider the district as business entity generating revenue and incurring expenses. A variety of methodological tools may be employed to complete the study. The Reclamation guidelines lay out a potential calculation strategy to evaluate the payment that incorporates a range of criteria, including farm size, cropping patterns, crop yields or livestock animal units and pricing, and land values and improvements.

Key personnel for the financial analysis study included Professor Penelope L. Diebel, Agricultural and Resource Economics Department of the Oregon State University and her team. The team selected the "crop enterprise approach" for the study and used a set of computerized financial tools trademarked as "AgTools", "AgProfit" and "AgFinance", developed by OSU and a group of other western universities. A more detailed explanation of the programs is offered in the report. The data for the study, as input into the tools, was provided by the Farm Service Agency (FSA), the Oregon Agricultural Information Network (OAIN) and the U.S. Department of Agriculture 2007 Census Report. The analysis was applied to both East Valley Water District and to Marion County to maximize the application of data.

The entire boundary of the district represents 77,306 acres, but the study applies to the 32,364.4 acres currently representing the Farm Service Agency acres in the area. The study identifies the crops grown in the district, the number of acres of those crops and the percentage of those crops within the district. The East Valley Water District is part of a highly diversified agricultural region. Crop acreages grown can vary from year-to-year depending upon relative prices. "Enterprise budgets" were determined to reflect actual farm size reflecting the typical operation in a region large enough to provide full employment. Charts within the report provide analysis of representative farms growing specific crops. Specific calculations for nursery operations are reflected as well.

Payment capacity at the district level using 1% farm-gate price inflation under Reclamation conditions is roughly an $18.7 million value for the first project year. That would equate to approximately $577 repayment capacity per acre if conditions meet the scenario described within the study. The results of the ability-to-pay study, according to Reclamation, is that the district could support the necessary payment to develop the project within the estimated budget determined within a period of 30 years or less.

As there are only 4,000 acres within the district currently assessed, representing district members, the cost per acre, if estimated to be the same amount of $577 per acre, would equate to more years

of payback to meet the $18.7 million pricing. The District board feels the value per acre is higher than growers experience in their area and may look at readjusting that based on experienced values and upon the number of acres assessed at the time of financing. The final figure will also be dependent upon the proposed cost of the project.

East Valley Water District

Drift Creek Dam:
Agriculture Economic Value Analysis

April 2013

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East Valley Water District

Drift Creek Dam: Agriculture Economic Value Analysis

Introduction

The East Valley Water District (EVWD) is an irrigation district formed in 2002 for the purpose of supplying irrigation water to its members' lands and associated agricultural operations in Marion and Clackamas Counties in the state of Oregon (Figure 1). The District service area is approximately 15,000 acres extending northerly from Silverton to just south of Woodburn and Molalla, between the Pudding River on the west and the Cascade Mountain foothills on the east (Figure 2). The District's approximately 75 members are currently served by a combination of individual farm wells and direct withdrawals from local surface waters. Limited surface water supplies and lowering groundwater levels make the development of a new surface water source an imperative.

Figure 1: **East Valley Water District Regional Map.**

The District is considering the development of a new water reservoir impoundment on Drift Creek, a tributary to the Pudding River. The intended reservoir site is located approximately six miles southeast of Silverton in Marion County, and the facility would be the cornerstone of a new surface water supply system for the District. Stored winter water would be released during the summertime months and conveyed downstream to the District's service area via either a new raw water pipeline or by natural channel flow along Drift Creek and possibly the Pudding River. Supplied water would be used for irrigation purposes and would require the development of a new water distribution piping system for delivery of irrigation water to served members.

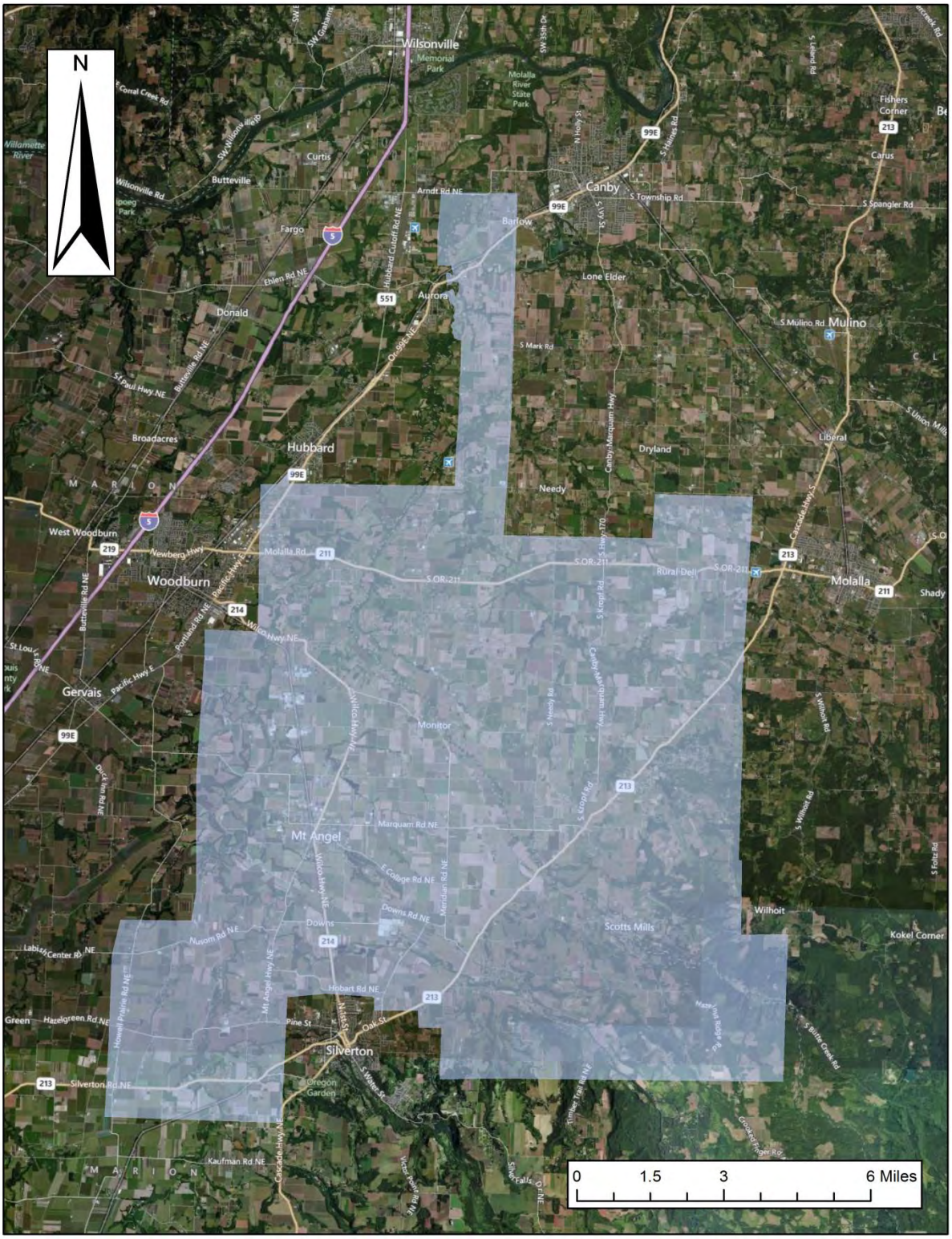

Figure 2: **Proposed District Boundary (GIS Credit: Andrew Wentworth).**

The goal of the associated project is to provide the needed long-term stable water supply for the District farms through the development of an on-channel reservoir in the upper Pudding watershed on Drift Creek. The proposed reservoir, an impervious earth-fill embankment, would impound at least 12,000 acre-feet of water and will relieve pressure in the three limited groundwater areas in the District's service area.

Background Information

The East Valley Water District has completed a significant number of studies toward development of the Drift Creek Reservoir site and this report was the result of a request made for services from Oregon State University's Agricultural and Resource Economics Department.

The following report presents a payment capacity analysis that was conducted in order to ascertain the financial ability of the District and its members to support the project costs. In order to secure project funding, the Secretary of the Interior will have to determine that the suitability of the land can bear the burden of cost according to its productive value.

Guidelines from the Bureau of Reclamation's (BOR) economic analysis program informed this review. In particular, the 2004 BOR report *Technical Guidance for Irrigation Ability to Pay and Irrigation Payment Capacity* provided an outline to assess the District's financial capability to pay for the infrastructure development. The analysis determines the farm-level payment capacity aggregated to the entire District level, less existing obligations, operation and maintenance costs and reserve fund requirements. The components of the payment capacity are examined in this report.

Analytical Methodologies and Tools (A)

The BOR report lists a variety of methodological tools that can be selected to provide the financial analysis, including "crop enterprise or whole farm budgeting, linear programming, quadratic programming, and econometric modeling." (BOR 2004) Of these methods, the crop enterprise or whole farm budgeting approach was selected. This method is able to employ existing enterprise budgetary data developed by university research and extension faculty and do so in a timelier manner when compared to the other methods.

The crop enterprise approach will utilize two programs from AgTools™, a set of financial tools developed by Oregon State University, Washington State University and the Universities of Arizona, Idaho and California-Davis. In particular, AgProfit™ and AgFinance™ will be used to conduct the payment capacity analysis and are referred to throughout the report. A description of each, which can be found directly from the website www.agtools.org, is provided.

AgProfit™ is a computer program designed to assist agricultural producers make long-run decisions when implementing technologies to a specific crop or analyzing cropping systems. AgProfit™ estimates machinery, labor, and production input costs as well as fruit size, grade, and total yield for calculating returns for crops with multiple establishment and production years. The program allows you to inflate specific return and input cost items over time to analyze the net present value, internal rate of return, and financial feasibility when implementing a particular technology, making minor changes to returns or input costs, or comparing cropping systems.

AgFinance™ is a computer program designed to assist agricultural producers make long-run decisions on a whole farm and ranch basis. You can load scenario files from AgProfit™ and AgLease™ into

AgFinance™ to analyze your farm's financial ratios and performance measures, which include working liquidity, solvency, profitability, debt repayment capacity, and efficiency. You can change the number of units in each scenario and observe the financial effects of implementing technologies, adding value to your products, conservation practices, changing cropping systems or livestock enterprises, or leasing additional land.

Datasets and Limitations

Data for the analysis will come predominantly from the Farm Service Agency (FSA) and the Oregon Agricultural Information Network (OAIN). The FSA data provides crop representation for the EVWD but only documents crop information for those farm operations that receive FSA financial support. These geographically referenced FSA data were matched against the District boundary and account for roughly 47% of acreage within the boundary (Figure 2), or just under half. Therefore, the eventual District payment capacity for this report will reflect that for approximately half of the acres within the boundary.

In this report, payment capacity is calculated for both the EVWD and for Marion County. Motivating the analysis for payment capacity beyond the District to the Marion County level is partly due to the aforementioned 47% representation. Additionally, the BOR report specifies that "all enterprises of the typical operator should be represented, whether within irrigation district boundaries or not." (BOR 2004) Therefore, the analysis is extended to represent Marion County at large.

OAIN data is used for the Marion County level analysis. Information on prices and yields from OAIN are also used with FSA District acreage data to determine payment capacity for the EVWD. The major limitation of the OAIN is that some data remain unpublished for anonymity reasons. Therefore, some crops including fresh vegetables are left out of the County analysis, despite their inclusion at the EVWD level. This will underestimate the County's overall payment capacity.

Characteristics of Representative Farms (B)

According to the BOR report, the "analysis should model operatorships, not ownerships." Operatorships are preferred because they provide more details in terms of cropping patterns and farm types and sizes. In approaching this task, enterprise budgets are used to reflect future income in the project area.

Cropping Pattern (B.3)

In the analysis of cropping patterns, two separate sources are drawn upon to provide a representative outlook on crops grown in the District. Both the Oregon Agricultural Information Network (OAIN) and Farm Service Agency (FSA) data are referenced to detail cropping pattern.

EVWD. The FSA crop data are applied to the district boundary line in Figure 2 and the summary results are presented in Table 1. These data are the most geographically refined data that exist for this region. However, these surveys are administered solely to those receiving financial support from the FSA and thus do not pertain to the entire District. The entire boundary consists of approximately 77,306 cropland acres, for which 36,160 acres had a 2012 FSA acreage report on file. As previously mentioned, this represents 47% coverage of the entire boundary.

Table 1: **EVWD Crop Acreage Reported to FSA (continued to next page).**

Crop	Acres	Percentage of EVWD (36160 acres)
Alfalfa	257.4	0.71%
Barley	21.3	0.06%
Beans	1,598.2	4.42%
Beets	108.1	0.30%
Blueberries	283.9	0.79%
Broccoli	243.4	0.67%
Buckwheat	55.7	0.15%
Cabbage	30.8	0.09%
Canary Seed	8.4	0.02%
Caneberries	1,195.4	3.31%
Cauliflower	390.2	1.08%
Cherries	2.8	0.01%
Chicory	104.9	0.29%
Christmas Trees	699.1	1.93%
Clover	721.0	1.99%
Corn	2,201.3	6.09%
CRP	38.7	0.11%
Cucumbers	30.2	0.08%
Fallow	568.4	1.57%
Flowers	852.7	2.36%
Garlic	91.4	0.25%
Grapes	671.1	1.86%
Grass	14,111.2	39.02%
Greens	36.9	0.10%
Hazelnuts	921.9	2.55%
Herbs	25.8	0.07%
Home Garden	1.7	0.00%
Hops	1,129.0	3.12%
Kiwi Fruit	6.6	0.02%
Kohlrabi	13.7	0.04%
Meadow Foam	37.7	0.10%
Mixed Hay / Forage	1,339.9	3.71%
Mustard	22.3	0.06%
Nursery	1,256.1	3.47%
Oats	297.9	0.82%
Olives	4.8	0.01%

Onions	509.4	1.41%
Parsnip	6.0	0.02%
Peas	695.3	1.92%
Peppers	77.3	0.21%
Potatoes	42.6	0.12%
Pumpkins	58.5	0.16%
Radishes	259.6	0.72%
Rhubarb	134.6	0.37%
Squash	174.4	0.48%
Strawberries	230.8	0.64%
Sugar Beets	225.3	0.62%
Trees	28.8	0.08%
Watercress	7.0	0.02%
Wheat	4,299.5	11.89%
Wildlife Food Plot	31.0	0.09%
TOTAL	36,160.0	100.00%

As it is not practical to incorporate all the crops grown within an irrigation district as diverse as the EVWD, some crops grown on a small percentage of total District acres are ignored. For example, watercress and olives are two crops that are excluded from the analysis for this reason. Other small percentage crops will be combined to represent more extensively grown crop acreage, such as grouping alfalfa, mixed hay and forage together. These three enterprises are represented by the alfalfa enterprise budget. Additionally, blueberries/caneberries are represented by blueberries, grass/clover by grass and wheat/oats by wheat. These enterprise combinations are shown in the Table 2. All District and County combinations are disclosed as enterprise budgets and are presented in Table 6.

Table 2**: Selected Acreage of Major Combined EVWD Crops Reported to Farm Service Agency (as shown in Table 1) (FSA).**

Crop	Acres	Percentage of EVWD (36160 acres)
Alfalfa/Mixed Hay/Forage	1,597.3	4.42%
Beans/Broccoli/Cauliflower/Corn/Peas	5,128.4	14.18%
Blueberries/Caneberries	1,479.3	4.09%
Grass/Clover	14,832.2	41.02%
Greens/Radishes/Onions/Misc.	1,422.8	3.93%
Hazelnuts	921.9	2.55%
Hops	1,129.0	3.12%
Nursery	1,256.1	3.47%
Wheat/Oats	4,597.4	12.71%
TOTAL	32,346.4	89.50%

Marion County. The OAIN dataset, although pertaining solely to Marion County and thus geographically less refined than the FSA data, contains annually published crop acreages for several county crops. As a result, five-year cropping patterns are averaged from 2007 to 2011 (Note: 2011 is the most up-to-date year on record).

Table 3: **Total Harvested Crop Acres in Marion County Including Non-Disclosed Acreage (OAIN).**

2007	2008	2009	2010	2011
178,182	178,211	178,953	178,385	183,229

To calculate crop-specific percentages, harvested acreages for each crop was first divided by the corresponding total harvested acreage for that year. Then, these five-year crop percentages were averaged. For example, harvested acres for hazelnuts were 5,800 tons in 2007, 6,000 tons in 2008, 2009, 2010 and 6,200 tons in 2011. These numbers were divided into the corresponding year's acreage listed in Table 3 and then averaged to provide a summary percentage. All enterprise percentages are shown in Table 4.

In the case of processed vegetables, FSA reports for the District contained acreage for processed cauliflower, broccoli and peas. At the County level, these three processed vegetables are omitted as they were not available through OAIN. Grass represents acreage for both perennial ryegrass and tall fescue but the averages for price and yield are used from perennial ryegrass, as it is the dominant grass crop. Alfalfa hay represents acreage for "other hay" as well but yields and prices from alfalfa hay are used.

The hops data from OAIN is for the Willamette Valley. This is a reasonable assumption, given that Marion County hops accounts for 94% of the production in the Willamette Valley. Additionally, processed sweet corn acreage represents Willamette Valley sweet corn. However, there is no way to differentiate Marion County from the Willamette Valley because there are no published OAIN data. Therefore, Willamette Valley sweet corn is treated as Marion County corn.

Table 4: **Selected Crop Acreage of Combined Major Marion County Crops (OAIN).**

Crop	Harvest (acres)	Percentage of Marion County
Alfalfa Hay	10,360	5.77%
Blueberries	1,466	0.82%
Grass	51,280	28.61%
Hazelnuts	6,000	3.34%
Hops	5,232	2.92%
Snap Beans	12,349	6.62%
Sweet Corn	13,880	7.74%
Wheat	16,800	9.33%
Total	117,367	65.15%

Irrigated Crop Acreage

An important aspect for payment capacity is irrigation. Irrigation data is available at the County level through the USDA Census of Agriculture. According to the 2007 Census, Marion County had 96,382 acres in irrigated land. Within this irrigated land, there were 949 farms that irrigated 92,817 acres of harvested cropland. Given that there were 199,832 total acres of harvested cropland according to the 2007

Census (in slight contrast to OAIN), this yields a 46.4% irrigation rate for harvested cropland within Marion County. This information is summarized in Table 5.

Table 5: **Marion County Cropland, Irrigation (USDA 2007).**

Marion County Cropland and Irrigation	Acres
Total Harvested Cropland	199,832
Irrigated Land	96,382
Harvested Cropland within Irrigated Land	92,817
Pastureland and other land under Irrigation	3,565

Farm Type (B.1)

Major enterprises within the District and County were included and crops representing only a small portion of the total district acres were excluded (or modeled on the basis of more extensive crops). However, in the case of nurseries and greenhouses, which represent only a fraction of the District area, their value is sufficiently high to warrant inclusion.

For this project analysis, only croplands were considered and livestock were omitted. In general, cropland is the dominant farm land type in both Marion County (Figure 3) and more precisely the East Valley Water District.

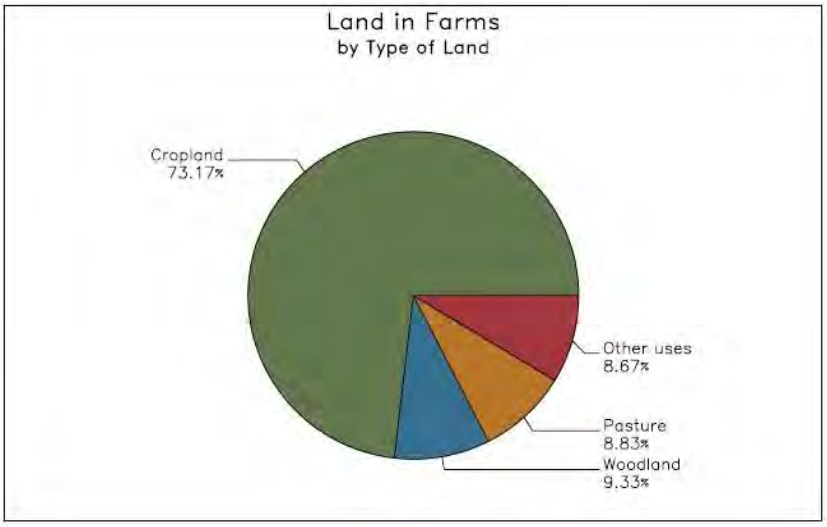

Figure 3: **Marion County Farmland Percentages (USDA 2007).**

It is important to note that the report specifies that "all enterprises of the typical operator should be represented, whether within [the] irrigation district boundaries or not." Therefore, there is some flexibility in considering the characteristics of the representative farms. Payment capacity, as previously mentioned, will thus reflect acreage data from within the boundary (FSA) and across Marion County as a whole (OAIN) and will built upon the use of the enterprise budgets. It is important that these budgets are well-defined, as they are fundamental in this analysis, and so a description is provided below:

Enterprise Budgets

A whole farm analysis was used to determine the repayment capacity. Enterprise budgets are used in this analysis to provide return and cost information for a particular crop.

Enterprise budgets are detailed lists of revenues and expenses for a specific enterprise(s) or common rotation over a one-year period, typically designated on a per-acre basis. For crops like wheat, which are typically grown in rotations, it is assumed that one-half acre is devoted to wheat production and the other half to fallow. Revenues are calculated by multiplying crop prices by their respective market quantities. Expenses for an entire enterprise include packaging, processing, value-added, non-harvest (i.e. fertilizers, chemical pesticides), harvest (i.e. specific machinery, labor) and capital investment costs (i.e. equipment and facilities replacement costs/depreciation). Each budget is regionally specific and represents an estimate of typical costs and returns to the producer in that area. University research faculty, agricultural specialists, local extension agents and economists collaborate with growers and farm suppliers on these budgets, working together to establish a set of guidelines. In general, budgets are designed to reflect common agricultural practices. For practical reasons, they are intended to be a helpful guide in estimating a grower's actual costs and as a result, the budgets do not represent any particular farm or operation. The budgets used in this report are included in Section B of the Appendix.

For this agricultural value analysis, enterprise budgets were used and referenced from several different university-related Extension offices, including the universities of Oregon State, Washington, Idaho and California. These publications are all available online and referenced with links in the Appendix of this report.

By default, nurseries and greenhouses are inherently diverse operations. For example, not only do nurseries differ in their production practices (pot-in-pot, container, bare root, balled and burlapped, protected or any combination), they differ significantly in what they grow as a result. Greenhouses are similar in this sense, each growing unique crops with different requirements. Few enterprise budgets have been developed for these operations. Consequently, production cost and expense information could only be gleaned from publications based in other regions or from Oregon industry experts.

Farm Size (B.2)

As noted by the BOR report, it is important that "farm size should reflect the actual typical farm operations" and furthermore, "should be at least large enough to provide reasonably full employment for the farm operator based on the amount of investment and management expected for the type of farm represented." Figure 4 contains the Census figures for average farm size in Marion County.

Table 6: **Marion County Highlights (USDA 2007).**

	2007	2002	% change
Number of Farms	2,670	3,203	- 17
Land in Farms	307,647 acres	341,051 acres	- 10
Average Size of Farm	115 acres	106 acres	+ 8
Market Value of Products Sold	$586,743,000	$430,666,000	+ 36
Crop Sales $484,818,000 (83 percent) Livestock Sales $101,926,000 (17 percent)			
Average Per Farm	$219,754	$134,457	+ 63

In our decision regarding representative farm choice and farm size, the USDA averages were not used. The enterprise budgets were determined to more accurately reflect actual farm size in that they reflect the typical operation in that region large enough to provide full employment. The Census report data only allow mean size calculations for crop-specific farm size, which are not necessarily indicative of the typical operation due to influence from very small and large sized farms. Due to the fact that we will be basing farm sizes off of the cropping pattern percentages already discussed, farm size is effectively accounted for without the Census. The typical farm sizes extracted from the enterprise budgets, as well as a general description are provided in Table 6.

Table 7: **Representative Farm Sizes, Descriptions, Assumptions and Abbreviations.**

Representative Farm	Description (Enterprise Budgets and FSA)	Representative Farm Abbreviation
Alfalfa Hay	The alfalfa hay farm is based off of 320 acres in the Klamath Basin and is adapted for the Willamette Valley. From the FSA District data, alfalfa will also represent mixed hay and forage acreage. From the OAIN County data, alfalfa hay will also represent other hay acreage.	**A**
Blueberries	The typical blueberry farm will be 20-acres in the Willamette Valley, OR. From the FSA data, blueberries will also represent caneberry acreage. However, they will solely represent blueberry acreage for the OAIN County data.	**B**
Fresh Vegetables	The typical fresh vegetable farm will be 100-acres of rotational lettuce and radishes in the Willamette Valley, OR. From the FSA District data, fresh vegetables will represent acreage from greens, radishes, cabbage, cucumbers, onions, parsnips, peppers, squash, pumpkin and garlic. Unfortunately, due to a lack of data available, fresh vegetables will be excluded from the County payment capacity.	**FV**
Greenhouse	N/A	**GH**
Grass	Due to complementary machinery and implements, the grass budget was developed using machinery from wheat. Therefore, the two were constructed together but are divided out by their respective percentages in the District. The grass budget is modeled after perennial ryegrass. From the FSA District data, this farm will also represent clover. From the OAIN County data, grass will represent perennial ryegrass and tall fescue acreage. Prices and yields for perennial ryegrass are used.	**G**
Hops	The typical hop farm is developed from 660-acres in Yakima Valley, WA.	**H**
Hazelnuts	The typical hazelnut farm is 100-acres in the Willamette Valley, OR. Low yields from OAIN data indicated acres coming into establishment. As a result, yields increase 10% annually.	**HZ**
Nursery	N/A	**N**
Processed Vegetables*	The entire processed vegetable farm is 600-acres in the Willamette Valley. Of that total, 280-acres are sweet corn, 160-acres snap beans, 80-acres broccoli and 80-acres cauliflower. From the FSA data, processed vegetable farm will represent acreage from peas as well. For the OAIN County data, processed vegetables will solely represent Marion County snap beans and Willamette Valley sweet corn.	**PV**
Wheat	The wheat budget was adapted from 2,000 acres in the North Central Region to fit the typical winter wheat farm of 1200 acres in the Willamette Valley Region. From the FSA data, this farm will also represent oat acreage, but wheat prices are used. For the OAIN County data, it will solely represent wheat.	**W**

Nursery and Greenhouse

Nurseries and greenhouses represent the two most diverse enterprises grown within the irrigation district. These industries typically occupy a small acreage amount but generate significant total sales, and thus are included in the payment capacity.

In general, there is a lack of clear data available on nursery and greenhouse characteristics. The only data that exist for these farm types at the County level is aggregate sales value. As a result, a more broad approach will have to be used to include payment capacity by the greenhouse and nursery. This approach will make use of information available from Northwest Farm Credit Services (NFCS). In particular, operating expense ratio and profit margin data will be used in place of the methods followed by other crop enterprises. This margin will be applied to the sales value data to calculate overall payment capacity.

This broad approach is necessary, particularly in the nursery industry, which has faced substantial negative setbacks due to the financial crisis and ensuing drop in new housing units (Northwest Farm Credit Services 2012). Industry averages for Bare Root and Container/Balled & Burlapped nurseries are provided in Tables 7 and 8 as evidence of these impacts.

Nurseries. For Bare Root nurseries, pre-tax profit margins are negative from 2009 – 2011 and for Container/Balled and Burlapped nurseries, the margin is negative from 2008 – 2011. However, the nursery industry currently appears to be on a recovery path and will have the future ability to contribute toward the project costs (Northwest Farm Credit Services 2012). If it's assumed that this recovery will return the industry to its 2006-2007 average operating expense ratio, a pre-tax profit margin can be applied to County specific sales values data from the OAIN to determine its potential contribution.

Table 8: **Bare Root Nursery Industry Overview (NFCS).**

Bare Root Nursery						
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Average Sales	$5,260,996	$4,975,109	$4,667,314	$3,473,495	$2,871,893	$2,851,855
Operating Expense Ratio	88.78 %	91.73 %	98.55 %	105.74 %	118.96 %	111.77 %
Pre-Tax Profit Margin	11.22 %	8.27 %	1.45 %	(5.74) %	(18.96) %	(11.77) %

Table 9: **Container/Balled & Burlapped Nursery Industry Overview (NFCS).**

Container/Balled & Burlapped Nursery						
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Average Sales	$9,195,057	$10,307,949	$9,572,833	$8,411,389	$7,772,421	$7,861,136
Operating Expense Ratio	86.53 %	95.21 %	101.09 %	104.97 %	116.45 %	101.87 %
Pre-Tax Profit Margin	13.47 %	4.79 %	(1.09) %	(4.97) %	(16.45) %	(1.87) %

Table 10: **2010 Oregon Nursery and Greenhouse Survey (OASS).**

Gross Wholesale Sales by Plant Material	
Plant Materials	**Sales Dollars**
Container/Balled & Burlapped	$ 376,300,000
Bare Root	115,000,000
Greenhouse	129,300,000
Other	55,400,000
TOTAL	$ 676,000,000

With different operating expense ratios faced by Bare Root and Container/B&B nurseries, percentage contributions of state sales will be calculated and then applied at the Marion County Level. From Table 10, Container/B&B wholesale sales represent approximately 75% of total wholesale sales when combined with Bare Root nursery sales. Consequently, Bare Root sales contribute the remaining 25% to this category. These percentages will prove useful in application to the OAIN data, which aggregates total nursery sales. OAIN data for nursery sales is provided in Table 11.

Table 11: **Marion County Aggregate Nursery Sales (OAIN).**

Nursery Crops in Marion County (2007 - 2011)	
Year	**Value of Sales**
2007	$ 143,944,000
2008	115,155,000
2009	111,240,000
2010	133,861,000
2011	134,700,000
Average	$ 127,780,000

Using the sales contribution averages, the value of sales can be broken apart into two separate categories, which will enable different pre-tax profit margins to be applied in assessing payment capacity. The data are separated in Table 12.

Table 12: **Segregated Marion County Nursery Sales Data for Bare Root and Container/B&B based on Assumptions from Table 10.**

Nursery Crops in Marion County (2007-2011)			
Year	**Bare Root**	**Container/B&B**	**Total**
2007	$ 35,986,000	$ 107,958,000	$ 143,944,000
2008	28,788,750	86,366,250	115,155,000
2009	27,810,000	83,430,000	111,240,000
2010	33,465,250	100,395,750	133,861,000
2011	33,675,000	101,025,000	134,700,000
Average	$ 31,945,000	$ 95,835,000	$ 127,780,000

Greenhouses. Table 14 summarizes the most recent sales data for the Marion County greenhouse industry. For these five most recent years of data, $37.1 million was the sales value average.

While the nursery industry was heavily impacted by the financial and housing crisis, the greenhouse industry proved more salient. Using greenhouse industry averages provided by Northwest Farm Credit Services, a payment capacity proxy can be calculated using an average pre-tax profit margin on the OAIN Marion County sales data. Due to the industry buoyancy (compared to the nursery industry), the five years from 2007 to 2011 will be used for this average and are show in Table 13.

Table 13: **Greenhouse Industry Overview (NFCS).**

Greenhouse Industry						
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Average Sales	$5,562,451	$6,251,346	$5,812,142	$5,811,144	$6,012,115	$6,124,468
Operating Expense Ratio	91.85%	91.02%	90.96%	89.26%	90.69%	92.64%
Pre-Tax Profit Margin	8.15%	8.98%	9.04%	10.74%	9.31%	7.36%

The 2007-2011 average pre-tax profit margin was approximately 9.086%.

Table 14: **Marion County Aggregate Greenhouse Sales (OAIN).**

Greenhouse Crops in Marion County (2007 - 2011)	
Year	**Value of Sales**
2007	$ 39,478,000
2008	31,582,000
2009	33,824,000
2010	40,139,000
2011	40,790,000
Average	$ 37,162,600

Crop Yields and Prices Received (B.4 and C)

To develop crop yields and prices received, the most recent five years of crop yield and price data from OAIN were averaged. This five-year arithmetic mean (2007-2011) for both yields and farm-gate prices received was then used to project for the five-year period this analysis examines, 2013-2017. **It is important to note that prices and yields are thus held constant over the five-year project period. Later, this consideration will become important because in contrast to yields and prices received, project costs will be inflated over time and consequently, will not remain constant. Overall, with total revenues fixed over time and costs inflating, payment capacity will decrease over time.**

In cases where data from this network were not available or incomplete, data location and assumptions used are noted.

Crop information on broccoli, cauliflower, radishes and spinach are unavailable through OAIN. Consequently, these numbers were pulled directly from recent enterprise budget publications. These are referenced at the end of this report and included in Section B of the Appendix.

Due to incomplete or non-published data through OAIN, hops and sweet corn production are assumed to be equivalent to the Willamette Valley. Hops in Marion County represent approximately 94% of production within the Willamette Valley and this assumption is very reasonable. There is no such approximation for sweet corn production.

Additionally, average hazelnut per-acre yields from the OAIN database were significantly lower than the yields from the hazelnut enterprise budget. This reflects how yields of new orchards, which increased by 400 acres over the past five years (2007-2011), are not fully productive yet. It takes a newly established hazelnut orchard roughly seven years before it reaches full production. To try and account for this acreage reaching heightened productivity, hazelnut yields are increased 10% annually over this five-year analysis.

Table 15: **Price, Yield, Production and Sales Data for Selected Crops Analyzed (OAIN).**

Crop	Unit	Yield (unit/acre)	Price ($/unit)	Value Sales ($)
Alfalfa Hay	**tons**	5.3	186.00	$ 1,734,200
Blueberries	**lbs**	8420.0	1.15	14,113,400
Broccoli	**tons**	5.0	500.00	-
Cauliflower	**tons**	6.0	350.00	-
Greenhouse	**-**	-	-	37,163,000
Hazelnuts	**lbs**	1090.0	0.92	592,640
Hops	**lbs**	1748.0	3.28	29,782,600
Leaf Lettuce	**cartons**	900.0	8.00	-
Nursery	**-**	-	-	127,780,000
Perennial Ryegrass	**lbs**	1640.0	0.61	36,674,800
Radishes	**cartons**	700.0	9.00	-
Snap Beans	**tons**	6.7	206.97	16,502,000
Sweet Corn	**tons**	10.1	107.49	15,064,400
Wheat	**BU**	104.0	5.99	$ 10,816,600

Investment Values (D)

Land Value (D.1)

For this agricultural value analysis, it is assumed that all representative farmland is owned rather than leased. The average market value for land growing grass seed, wheat, alfalfa and mixed hay is $5,000 per acre and all other land $10,000 per acre. Irrigation water cost is excluded from these land investment values.

Buildings, Other Improvements, Orchards, Vineyards, Permanent Crops and Machinery and Equipment (D.2, D.3 and D.4)

Enterprise budgets were used in order to obtain market values for intermediate (10 years or less) and long-term assets (greater than 10 years). Percentages were then developed to represent the composition of intermediate-term assets to the entire asset base (intermediate plus long-term), as well as for the long-term assets to the entire asset base. These percentages were then applied to calculate annual depreciation costs, described more in Section E.4.

Livestock (D.5)

Livestock are not included in this agricultural value analysis.

Farm Expenses (E)

Input Levels (E.1)

Extension Service studies were used in determining the amount of input levels. The Extension published enterprise budgets reflect common practices, not necessarily optimum practices. Input levels are consistent with yield levels and other representative farm practices. Fertilizers, pesticides and other chemicals are aggregated in the enterprise budgets included in the Appendix of this report. To view them individually, please reference the corresponding website link(s) included under each budget.

Input levels are held constant in this analysis due to the fact that yields are held constant. Hazelnuts are the one exception, where per-acre yields increase 10% annually. In this instance, input levels are adjusted accordingly to reflect the higher yields.

Prices Paid (E.2)

The prices for input items were taken during the development of the enterprise budget. As the majority was published between two and four years ago, these budgets reflect up-to-date accounts of revenues and market expenses faced by producers. In instances where an enterprise budget was older, as the case with the Alfalfa budget, production practices were assumed to be the same but equipment prices were taken

from recent budget publications for other enterprises. In the rare instance that this was not possible and a viable substitute could not be located, the price of the item was inflated over time to reflect the current cost.

All input prices are inflated 3% annually across this five-year analysis. In other words, each budget line item's price increases 3% from the previous year for all five-years. As noted previously, prices are held constant initially and will be increased in a sensitivity analysis.

Diesel and gasoline are two important inputs in this analysis. Fuel usage was calculated using the machinery application within AgProfit™, and starting prices for these fuel types were $3.60/gallon and $4.00/gallon, respectively. Fuel prices are inflated 3% annually across the duration of this analysis.

Interest Costs (E.3)

In this report, interest expenses reflect annual operating capital. Interest on annual operating capital is applied to each enterprise budget using the following assumptions:

- Interest Rate: 8%
- Percent of Costs Borrowed: 80%
- Number of Months to Borrow: 6

Depreciation (E.4)

Using the suite of AgTools™ software programs, depreciation costs are calculated annually for each representative farm from crop budgets. These costs represent the reduction in asset value over time, especially due to wear and tear. Depreciation costs for machinery (i.e. tractors and coinciding implements), buildings and other capital investment are divided into two categories: intermediate and long-term assets. Intermediate assets have a useful life of 10 or less years while long-term assets greater than10 years. Asset values for both reflect current market values described in (D.2, D.3 and D.4).

Replacement Costs

There are times however when the value of intermediate and long-term capital assets decline over time on the balance sheet. This may imply that there are insufficient principal payments from loans and capital purchases from cash to replace those assets in a timely manner. In these instances, replacement costs are included to make certain sufficient cash dollars are available to replace longer-term assets that depreciate. These replacement costs are taken from annual cash flows. Intermediate and long-term assets are inflated 2% annually and 1.5%, respectively, across the duration of this analysis.

This step reduces the loan arrangement complications and ensures that aging capital investments will be replaced responsibly, so that the payment capacity will not comprise income that should've been diverted toward reinvestment. However, it does not enable meaningful divisions between debt and equity to be made.

Taxes (E.5)

Property taxes are included as a line item expense in each budget. Per-acre property tax charges for each representative farm are $20 per acre. Other taxes, including workers' compensation and payroll taxes, are covered under hired labor expenses and are not incorporated as an individual budget expense. Approximately 30 percent of per hour wages was added to the wage to cover these taxes.

Insurance (E.6)

Property insurance costs are included as an aggregate budget cost in the payment capacity analysis. On average, these costs are approximately $35 per acre and represent a blanket policy that lumps vehicle, fire, theft, machinery and equipment insurance costs together.

Per-acre property insurance charges for each representative farm are $30 for Alfalfa Hay, Blueberries, Hazelnuts, Hops, Processed Vegetables and $35 per-acre for Fresh Vegetables and Wheat and Perennial Ryegrass.

Repair Costs (E.7)

The repair costs for each piece of machinery and equipment were estimated with coefficients derived by the American Society of Agricultural Engineers. Machinery costs input into this program application were obtained from relevant machinery publications and enterprise budgets cited in both the reference section and within the Appendix. Repair costs appear under the more general per acre machinery cost for each piece of equipment. Repair and maintenance costs are inflated 3% annually across the duration of this analysis.

Hired Labor Expenses (E.8)

Labor expenses were developed during the enterprise budget construction phase. As a result, they reflect the labor associated with the typical farm growing a particular enterprise. Regional wage rates were used in determining labor expenses. No secondary data was specifically referenced in this payment capacity report due to the fact that this information had previously been referenced in the enterprise budget development phase. All labor costs, including harvest and non-harvest, are inflated 3% annually across the duration of this analysis. Additionally, associated labor housing costs are increased 3% annually where applicable.

Custom Expenses (E.9)

There were no custom expenses for farm enterprises included in the analysis.

Nonproject water expenses (E.10)

Nonproject water expenses are not considered in this payment capacity report. All potential project water is treated as replacement water for individually owned wells and groundwater. Irrigation infrastructure for irrigated crops is assumed to be already established and only the associated maintenance and repairs for irrigation systems are considered as farm level expense items. Consequently, the payment capacity will

represent the residual income available for project water charges, including electricity pumping costs and the water itself.

Returns to Operator's Factors of Production (F)

Return to Labor (F.1)

Farm operator's labor is valued at the current wage rate for supervisory and hired labor in the representative farm region. Labor performed by the operator's family is valued at the same wage rate as hired farm labor. These returns to labor are included as budget expense items. The representative farm types developed from the enterprise budgets include farmer operator labor in addition to other labor necessary for the operation.

Return to management (F.2)

An allowance of 10% of net farm income is made for the farm operator's management ability over and above the supervisory labor rate (BOR 2004). This return to management represents an opportunity cost to the farm operator.

The payment capacity analysis utilizes both AgProfit™ and AgFinance™ programs. Individual per-acre budgets are developed for each enterprise using AgProfit™. The output serves as an input to AgFinance™, where each representative farm is built. The net income calculated from the program subtracts annual farm costs, which includes the returns to labor mentioned above, from gross income. The 10% allowance is calculated from this net income. In developing the payment capacity, it is later subtracted alongside the return to equity to find the residual income available for project funding.

Return to equity (F.3)

The return to equity is an allowance for the farm operator's equity subtracted from net farm income. A rate of 3% is applied to the equity (non-debt) share of farm investment and annual operating capital in computing this allowance (BOR 2004). Within the AgFinance™ program, equity appears as net worth. Three percent of this total net worth, which varies from year to year, is subtracted from net farm income.

Payment Capacity for Representative Farms

Gross farm income is derived from crop sales data and from the AgFinance balance sheets. Farm/ranch income is calculated according to the following formula:

Farm/Ranch Gross Income = Total returns from each budget file loaded in this analysis

Farm expenses are subtracted out to determine net farm income. With net farm income, which already accounts for the family's labor contribution, the returns to equity and farm management are subtracted out to yield overall payment capacity, or the measure of the District's repayment capabilities for the project costs. This payment capacity calculation is visually detailed in Attachment 3 of the BOR report and all spreadsheets are provided in Section C of the Appendix.

Payment capacity will drop with each subsequent future year. As previously mentioned, this is in part due to the fact that total revenues remain constant over time since yields and prices received do not change over the project period. With costs inflating, this will cause the future payment capacity to trend downward. Additionally, depreciation and replacement costs will exaggerate this trend with some representative farms, depending on the quantity of depreciable assets and composition of intermediate and long-term assets. For example, per-acre blueberry payment capacity contribution decreases over time largely due to inflating costs. The typical blueberry farm has a relatively low asset base, so its replacement costs are minimal in comparison to other representative farms. For example, the typical hops farm has a large asset base and replacement costs for intermediate and long-term assets are considerable. Consequently, with these costs simultaneously inflating over time, replacement costs are significant in some instances. The Beginning Balance Sheet in the Appendix shows the aggregate asset numbers for intermediate and long-term assets used for each representative farm.

In defending the assumption of constant total revenues (gross income), its effect on payment capacity over time and why this declining trend in ability to pay may not occur exactly as demonstrated here, some visual examples are helpful. The motivation for holding total revenues constant is evidenced in Figures 5 and 7. There have been noticeable and unpredictable fluctuations in farm gate prices received over time, in contrast to the general trend of increasing costs. Conceding this, a historical five-year average arguably provides more reliability in projecting out future prices than other methods. It is worth noting that in some instances, extrapolating future prices using linear regression methods would actually produce future farm gate price estimates that are lower than the five-year OAIN averages used here.

The difference between gross income and annual costs, or the payment capacity, also differs between representative farm types, as shown in Figures 6 and 8. The payment capacity for blueberries, a less capital intensive operation, declines marginally relative to the representative farm growing grass and wheat, an operation with significantly more capital use. This analysis cannot account for the fact these more capital intensive operations may experience technological innovations that will not only reduce production costs but possibly even extend the capital life of the equipment, thus reducing the equipment replacement rate over time. These efficiency changes are especially difficult to model in this short term five-year analysis but would alter the slopes of the red cost lines in a downward direction.

Furthermore, variation in both farm gate prices and input prices in the short term adds insight as to why the decline in payment capacity may not definitively occur as depicted in this analysis. In the short run, fluctuating prices received could increase more than costs due to integration or introduction into new markets or value-added processes. Again, these changes are hard to account for in the five-year analysis. However, these changes along with general increases in demand would tend to alter the blue gross income lines in the upward direction away from the red cost lines, increasing the overall net ability to pay for future project debt. The assumptions used here therefore are more conservative, producing a lower bound

for the District's payment capacity. These will later be overturned in the sensitivity analysis, where farm-gate prices will be inflated over time using 1%, 3% and 5% rates will be considered in addition to other factors.

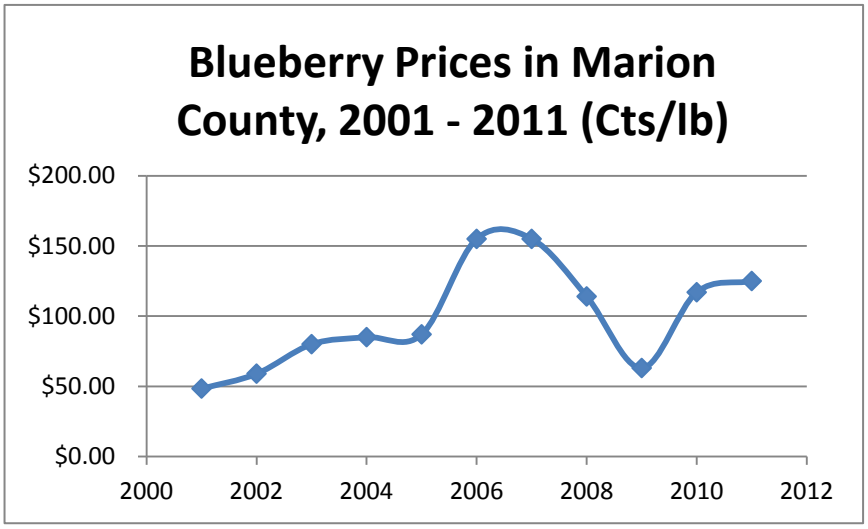

Figure 5: **OAIN Historical Price Data for Blueberries in Marion County.**

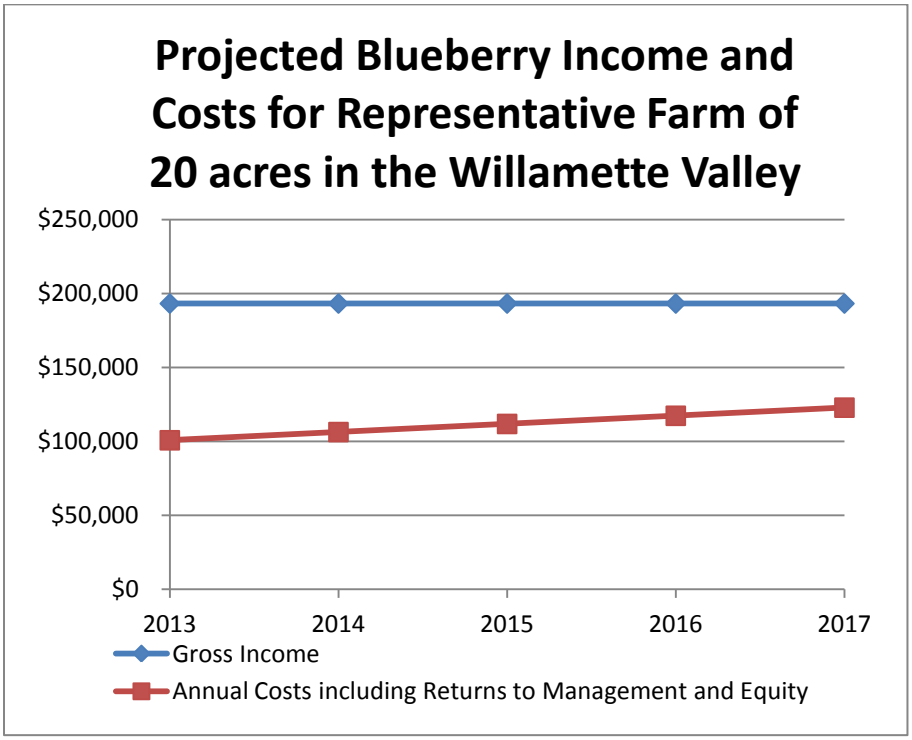

Figure 6: **Projected Gross Income and Costs with Constant 5-Year Averaged Prices for the Representative Blueberry Operation in the Willamette Valley through the years 2013 – 2017.**

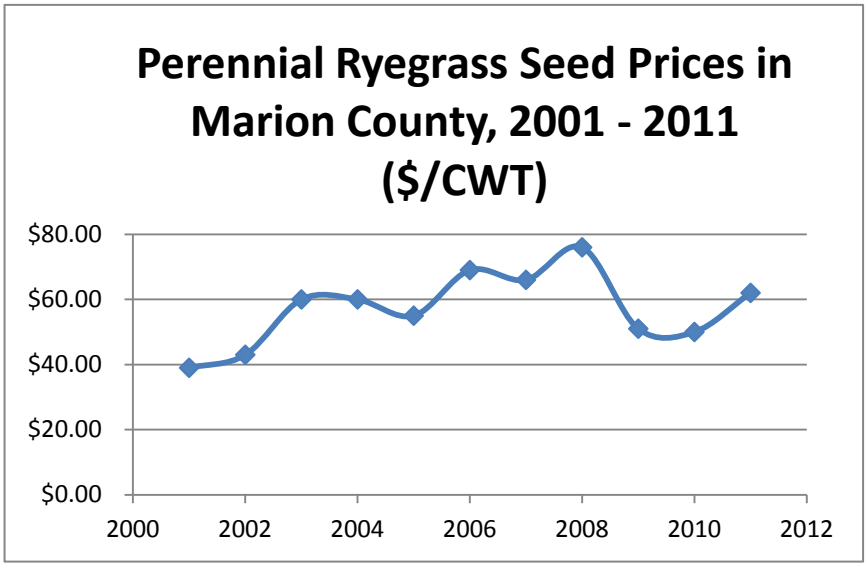

Figure 7: **OAIN Historical Price Data for Perennial Ryegrass Seed in Marion County.**

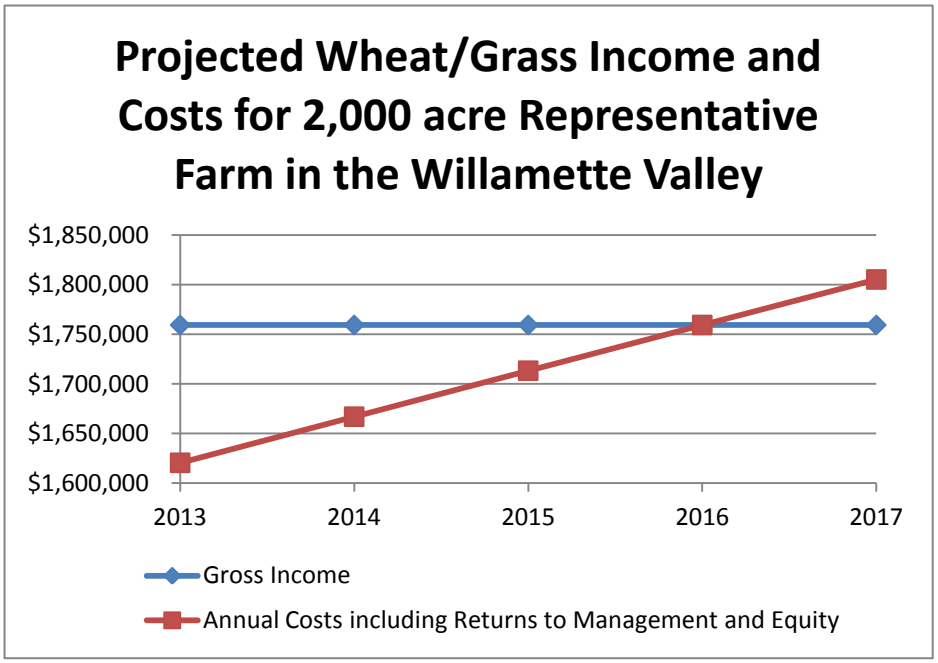

Figure 8: **Projected Income and Costs with Constant 5-Year Averaged Prices for the Representative Wheat/Grass Operation in the Willamette Valley through the years 2013 – 2017.**

Results

Table 16 breaks down the per-acre contributions from each representative farm for all five project years. These per-acre payments will be applied to acreage data from Table 18 to estimate payment capacity for the District and for Marion County at large.

The totals do not sum up to 100% because only the major crops are accounted for, not all crops. It is important to remember that the 89.5% coverage is for the 36,160 acres from FSA records, which represents approximately 47% of the total EVWD boundary of 77,306 acres. The 65.15% coverage represents accountability for the total harvested acres in Marion (Table 3).

For the first project year, $14.8 million is the estimated payment capacity for the EVWD's representative farm. In Section G, total payment capacity for the EVWD, which includes contributions from nurseries and greenhouses, is calculated.

For Marion County's representative farms, the first project year payment capacity is an estimated $24.1 million. In Section G, total payment capacity for Marion County, which includes contributions from nurseries and greenhouses, is calculated. This estimate will be revised upward significantly due to the nursery and greenhouse industry presence in Marion County.

Table 16: **Per-Acre Representative Farm Payment Capacity at 10% Return to Management and 3% Return to Equity ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 253	$ 231	$ 209	$ 187	$ 165
B	4,623	4,347	4,071	3,795	3,520
FV	2,938	2,604	2,271	1,940	1,609
G	69	46	23	(0)	(23)
H	958	811	665	520	376
HZ	(3)	53	107	158	206
PV	188	129	70	12	(45)
W	69	46	23	(0)	(23)

Table 17: **Representative Farm Payment Capacity for EVWD at 10% Return to Management and 3% Return to Equity, Excluding Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	Acres	2013	2014	2015	2016	2017
A	**1,597.3**	$ 404,811	$ 368,891	$ 333,341	$ 298,177	$ 263,409
B	**1,479.3**	6,838,804	6,430,180	6,022,108	5,614,662	5,207,725
FV	**1,422.8**	4,180,717	3,705,465	3,231,770	2,759,677	2,289,233
G	**14,832.2**	1,029,813	685,044	341,729	-	-
H	**1,129.0**	1,081,840	916,021	751,136	587,212	424,288
HZ	**921.9**	-	49,057	98,610	145,486	189,700
PV	**5,128.4**	961,590	660,636	361,300	63,611	-
W	**4,597.4**	319,202	212,337	105,923	-	-
TOTAL	**32,364.4**	$ 14,816,776	$ 13,027,631	$ 11,245,917	$ 9,468,825	$ 8,374,354

Table 18: **Representative Farm Payment Capacity for Marion County at 10% Return to Management and 3% Return to Equity, Excluding Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	Acres	2013	2014	2015	2016	2017
A	**10,360**	$2,625,585	$2,392,604	$2,162,031	$1,933,957	$1,708,454
B	**1,466**	6,777,318	6,372,368	5,967,965	5,564,182	5,160,903
FV	**-**	-	-	-	-	-
G	**51,280**	3,560,416	2,368,432	1,181,476	-	-
H	**5,232**	5,013,451	4,245,017	3,480,904	2,721,253	1,966,230
HZ	**6,000**	-	319,277	641,786	946,865	1,234,625
PV	**26,229**	4,918,013	3,378,795	1,847,856	325,338	-
W	**16,800**	1,166,439	775,929	387,067	-	-
TOTAL	**117,367**	$24,061,222	$19,852,422	$15,669,085	$11,491,595	$10,070,213

Payment Capacity for Nurseries and Greenhouses

As previously emphasized in this report, nurseries and greenhouses receive will receive a payment capacity treatment different than that calculated for the representative farms. Both OAIN data at the Marion County level as well as finance structural information from Farm Credit Services will be used to derive the payment capacity.

Nurseries. For both nursery types (Bare Root and Container/B&B), the representative pre-tax profit margin from 2006 and 2007 will be applied to the County sales data. The 2006-2007 average margin will

be used due to the fact the industry was severely impacted from the Great Recession. This two year window is more representative of a healthy nursery industry, which is plausible with the current recovery.

The 2006-2007 pre-tax profit margins for Bare Root and Container/B&B nurseries are 9.745% and 9.13%, respectively. These margins will be applied to the average 2007-2011 sales value data for Marion County from OAIN.

At the County level, Marion has a total nursery payment capacity of approximately $12.97 million per year. However, this payment capacity does not reflect the EVWD's ability to pay down future debt. In order to approximate this capacity, we will assume that 20% of nursery sales are concentrated in the District. This number, which will be applied to greenhouse sales data as well, reflects informed opinions from several EVWD Board members.

The EVWD has an estimated yearly nursery payment capacity of $2.6 million. With limited data available, this estimate is projected outward for the five years of this analysis.

Table 19: **Marion County Nursery Payment Capacity.**

Nursery Crop Payment Capacity			
Year	**Bare Root**	**Container/B&B**	**TOTAL**
2013	$ 3,113,040	$ 9,856,565	$ 12,969,606
2014	3,113,040	9,856,565	12,969,606
2015	3,113,040	9,856,565	12,969,606
2016	3,113,040	9,856,565	12,969,606
2017	3,113,040	9,856,565	12,969,606

Table 20: **EVWD Nursery Payment Capacity (20% of Marion County Payment Capacity).**

Nursery Crop Payment Capacity			
Year	**Bare Root**	**Container/B&B**	**TOTAL**
2013	$ 622,608	$ 1,971,313	$ 2,593,921
2014	622,608	1,971,313	2,593,921
2015	622,608	1,971,313	2,593,921
2016	622,608	1,971,313	2,593,921
2017	622,608	1,971,313	2,593,921

Greenhouses. The greenhouse industry proved more resilient and did not suffer from the same problems that confounded nurseries in 2007 and later years. As a result, we will use the 2007-2011 five year period to calculate the mean pre-tax profit margin. This average margin for the greenhouse industry during this period was 9.086%. By multiplying the 2007-2011 average greenhouse County sales value data by the

average pre-tax profit margin, payment capacity will be determined. This result is projected over the future five year period.

At the County level, Marion has a total greenhouse payment capacity of approximately $3.78 million per year. However, as previously mentioned, this payment capacity does not reflect the EVWD's ability to pay down future debt for the project costs. In order to approximate this capacity, we will assume that 20% of greenhouse sales are applicable to the District. This number reflects informed opinions from EVWD Board members.

The EVWD has an estimated yearly greenhouse payment capacity of $675,319. With limited data available, this estimate is projected outward for the five years of this analysis.

Table 21: **Marion County Greenhouse Payment Capacity.**

Marion County Greenhouse Payment Capacity	
Year	**Payment Capacity**
2013	$ 3,376,594
2014	3,376,594
2015	3,376,594
2016	3,376,594
2017	3,376,594

Table 22: **EVWD Greenhouse Payment Capacity (20% of Marion County Payment Capacity).**

EVWD Greenhouse Payment Capacity	
Year	**Payment Capacity**
2013	$ 675,319
2014	675,319
2015	675,319
2016	675,319
2017	675,319

Total Payment Capacity for EVWD and Marion County (G)

The total payment capacity incorporates the nursery and greenhouse contribution with the contribution to pay down debt from the representative farms.

Total payment capacity for the EVWD for the first project year is estimated to be $18.1 million. This contribution takes into account farm investment, expenses and returns to management, equity and labor. Payment capacity diminishes over time due to inflation and replacement costs incurred for depreciated capital. It is important to remember that total revenues are held constant over time, with the

aforementioned hazelnut case as the sole exception. This assumption also contributes to this temporal result.

Total payment capacity for Marion County for the first project year is estimated to be $40.4 million. This contribution takes into account farm investment, expenses and returns to management, equity and labor. Payment capacity diminishes over time due to inflation and replacement costs incurred for depreciated capital. It is important to remember that total revenues are held constant over time, with the aforementioned hazelnut case as the sole exception. This assumption also contributes to this temporal result.

No county level data were available through OAIN for fresh vegetables. Therefore, this number will underestimate Marion County's total payment capacity.

Table 23: **Total Payment Capacity for EVWD at 10% Return to Management and 3% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 404,811	$ 368,891	$ 333,341	$ 298,177	$ 263,409
Blueberries	6,838,804	6,430,180	6,022,108	5,614,662	5,207,725
Fresh Vegetables	4,180,717	3,705,465	3,231,770	2,759,677	2,289,233
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,029,813	685,044	341,729	-	-
Hops	1,081,840	916,021	751,136	587,212	424,288
Hazelnuts	-	49,057	98,610	145,486	189,700
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	961,590	660,636	361,300	63,611	-
Wheat	319,202	212,337	105,923	-	-
TOTAL	$ 18,086,016	$ 16,296,871	$ 14,515,157	$ 12,738,065	$ 11,643,594

Table 24: **Total Payment Capacity for Marion County at 10% Return to Management and 3% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 2,625,585	$ 2,392,604	$ 2,162,031	$ 1,933,957	$ 1,708,454
Blueberries	6,777,318	6,372,368	5,967,965	5,564,182	5,160,903
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	3,560,416	2,368,432	1,181,476	-	-
Hops	5,013,451	4,245,017	3,480,904	2,721,253	1,966,230
Hazelnuts	-	319,277	641,786	946,865	1,234,625
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	4,918,013	3,378,795	1,847,856	325,338	-
Wheat	1,166,439	775,929	387,067	-	-
TOTAL	$ 40,407,422	$ 36,198,622	$ 32,015,285	$ 27,837,795	$ 26,416,413

Sensitivity Analysis with Adjustments to Return to Equity, Return to Management and Farm-Gate Prices Received

Sensitivity analysis is a technique used to predict outcomes where input values are subject to change. It is useful to understand how scenario outcomes will differ when these input variables take on new values.

Return to Equity. Most representative farm per-acre payment contributions were positive across this 5-year analysis. However, in some instances, including hazelnuts in the first year and processed vegetables, grass and wheat in the final years, these numbers were negative. This inability to contribute was the conglomeration of a few factors, including low data predicated yield estimates, inflation, depreciation and the corresponding replacement costs. In more capital intensive farm operations like the processed vegetables, these costs also accumulated more quickly than in lower intensive operations like blueberries. Furthermore, the return to equity was substantial in cases with high observable net worth.

If the return to equity is slightly adjusted downward to 2% from 3% (Table 25), all per-acre farm contributions are positive throughout. Per-acre returns from Table 25 are applied to acreage data from Table 18 to complete this sensitivity analysis. Tables 26 and 27 show the analysis for EVWD and Marion County, respectively. Unfortunately, given limited data for nurseries and greenhouses, there was no meaningful way to account for this change. As a result, their contribution is not altered.

At the EVWD level, payment capacity using a 2% return to equity exceeds $21 million for the first project year. This compares to the $18.1 million estimate using the 3% return to equity (Table 23).

At the Marion County level, payment capacity using a 2% return to equity exceeds $51 million for the first project year. This compares to the $40.4 million estimate using the 3% return to equity (Table 24).

Table 25: **Per-Acre Representative Farm Payment Capacity at 10% Return to Management and 2% Return to Equity ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 323	$ 303	$ 284	$ 265	$ 246
B	4,944	4,730	4,514	4,299	4,082
FV	3,131	2,805	2,504	2,201	1,897
G	128	107	86	64	43
H	1,195	1,062	929	795	661
HZ	157	220	280	339	395
PV	313	259	205	150	95
W	128	107	86	64	43

Table 26: **Total Payment Capacity for EVWD at 10% Return to Management and 2% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 515,516	$ 484,766	$ 454,059	$ 423,400	$ 392,788
Blueberries	7,313,852	6,996,502	6,678,167	6,358,873	6,038,454
Fresh Vegetables	4,454,540	3,990,270	3,562,184	3,131,799	2,699,043
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,892,493	1,581,405	1,268,851	954,781	639,159
Hops	1,349,401	1,199,443	1,048,925	897,830	746,147
Hazelnuts	144,775	202,579	258,463	312,411	364,436
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	1,605,979	1,328,527	1,049,853	769,898	488,656
Wheat	586,599	490,174	393,294	295,945	198,114
TOTAL	$ 21,132,394	$ 19,542,907	$ 17,983,037	$ 16,414,177	$ 14,836,037

Table 27: **Total Payment Capacity for Marion County at 10% Return to Management and 2% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 3,343,609	$ 3,144,165	$ 2,945,004	$ 2,746,150	$ 2,547,602
Blueberries	7,248,095	6,933,598	6,618,125	6,301,702	5,984,164
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	6,542,998	5,467,461	4,386,853	3,301,005	2,209,791
Hops	6,253,381	5,558,447	4,860,917	4,160,716	3,457,788
Hazelnuts	942,240	1,318,447	1,682,152	2,033,263	2,371,858
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	8,213,714	6,794,700	5,369,434	3,937,612	2,499,211
Wheat	2,143,572	1,791,212	1,437,190	1,081,452	723,956
TOTAL	$ 51,033,808	$ 47,354,230	$ 43,645,876	$ 39,908,101	$ 36,140,569

Return to Management. Instead of altering the return to equity, additional sensitivity analysis considers what happens with a 5% return to management in lieu of the previous 10% return. Often, farmers pay themselves less in years with reduced yields or higher costs and as a result, this alteration is plausible.

Per-acre returns from Table 28 are applied to acreage data from Table 18 to complete this sensitivity analysis. Tables 28 and 29 show the analysis for EVWD and Marion County, respectively. Unfortunately,

given limited data for nurseries and greenhouses, there was no meaningful way to account for this change. As a result, their contribution is not altered.

At the EVWD level, payment capacity using a 5% return to management is $19.4 million for the first project year (Table 29). This compares to the $18.1 million estimate using the 10% return to equity (Table 23).

At the Marion County level, payment capacity using a 5% return to management is $43.5 million for the first project year (Table 30). This compares to the $40.4 million estimate using the 10% return to equity (Table 24).

Table 28: **Per-Acre Representative Farm Payment Capacity at 5% Return to Management and 3% Return to Equity ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 279	$ 256	$ 233	$ 210	$ 188
B	4,933	4,652	4,371	4,090	3,810
FV	3,158	2,782	2,436	2,091	1,746
G	83	59	35	11	(13)
H	1,051	898	746	595	444
HZ	23	84	142	197	249
PV	219	158	97	36	(24)
W	83	59	35	11	(13)

Table 29: **Total Payment Capacity for EVWD at 5% Return to Management and 3% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 445,752	$ 408,697	$ 371,980	$ 335,613	$ 299,606
Blueberries	7,297,912	6,881,799	6,466,013	6,050,623	5,635,498
Fresh Vegetables	4,492,763	3,958,792	3,466,381	2,975,013	2,484,714
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,230,805	872,496	515,235	159,049	-
Hops	1,186,536	1,014,148	842,497	671,605	501,503
Hazelnuts	21,314	77,369	130,731	181,389	229,362
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	1,122,410	808,653	496,131	184,860	
Wheat	381,501	270,439	159,703	49,299	-
TOTAL	$ 19,448,232	$ 17,561,634	$ 15,717,910	$ 13,876,691	$ 12,419,922

Table 30: **Total Payment Capacity for Marion County at 5% Return to Management and 3% Return to Equity, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 2,891,121	$ 2,650,787	$ 2,412,639	$ 2,176,765	$ 1,943,226
Blueberries	7,232,298	6,819,927	6,407,879	5,996,224	5,584,830
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	4,255,314	3,016,517	1,781,343	549,889	-
Hops	5,498,631	4,699,756	3,904,290	3,112,344	2,324,058
Hazelnuts	138,720	503,543	850,835	1,180,535	1,492,754
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	5,740,520	4,135,823	2,537,445	945,458	
Wheat	1,394,097	988,250	583,591	180,151	-
TOTAL	$ 43,496,901	$ 39,160,802	$ 34,824,222	$ 30,487,565	$ 27,691,069

Farm Gate Prices. Using the original return to equity and management charges, sensitivity analysis can also consider the case when farm-gate prices received inflate over time. Prior to this analysis, all farm-gate prices received were assumed to be held constant. Now, prices will be examined using inflation rates of 1%, 3% and 5%.

Per-acre returns with prices received inflated 1% over time from Table 31 are applied to acreage data from Table 18 to complete this sensitivity analysis. Tables 32 and 33 show the analysis for EVWD and Marion County, respectively. Unfortunately, given limited data for nurseries and greenhouses, there was no meaningful way to account for this change. As a result, their contribution is not altered.

At the EVWD level, payment capacity using 1% farm-gate price inflation under the original BOR conditions is roughly $18.7 million for the first project year (Table 32). This compares to the original $18.1 million estimate (Table 23).

At the Marion County level, payment capacity using 1% farm-gate price inflation under the original BOR conditions is roughly $41.9 million for the first project year (Table 33). This compares to the original $40.4 million estimate (Table 24).

Table 31: **Per-Acre Representative Farm Payment Capacity at 10% Return to Management, 3% Return to Equity and 1% Farm-Gate Price Inflation ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 262	$ 248	$ 234	$ 220	$ 206
B	4,707	4,513	4,317	4,119	3,920
FV	3,056	2,836	2,615	2,392	2,167
G	77	61	45	29	13
H	1,008	910	811	712	613
HZ	6	74	140	205	269
PV	208	170	131	92	53
W	77	61	45	29	13

Table 32: **Total Payment Capacity for EVWD at 10% Return to Management, 3% Return to Equity and 1% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 418,513	$ 395,955	$ 373,431	$ 350,949	$ 328,515
Blueberries	6,963,192	6,675,953	6,386,156	6,093,898	5,799,013
Fresh Vegetables	4,347,825	4,035,590	3,720,774	3,403,391	3,083,454
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,143,323	909,280	673,885	437,155	199,102
Hops	1,138,156	1,027,274	915,933	804,148	691,940
Hazelnuts	5,680	68,153	129,317	189,136	247,599
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	1,067,933	870,726	672,504	473,283	273,098
Wheat	354,385	281,841	208,878	135,501	61,714
TOTAL	$ 18,708,246	$ 17,534,012	$ 16,350,118	$ 15,156,700	$ 13,953,674

Table 33: **Total Payment Capacity for Marion County at 10% Return to Management, 3% Return to Equity and 1% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 2,714,450	$ 2,568,143	$ 2,422,050	$ 2,276,233	$ 2,130,730
Blueberries	6,900,587	6,615,931	6,328,740	6,039,109	5,746,875
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	3,952,860	3,143,691	2,329,853	1,511,393	688,363
Hops	5,274,431	4,760,583	4,244,609	3,726,572	3,206,582
Hazelnuts	36,967	443,563	841,637	1,230,953	1,611,446
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	5,461,900	4,453,292	3,439,495	2,420,588	1,396,747
Wheat	1,295,009	1,029,914	763,290	495,152	225,517
TOTAL	$ 41,982,403	$ 39,361,318	$ 36,715,874	$ 34,046,202	$ 31,352,460

Per-acre returns with prices received inflated 3% over time from Table 34 are applied to acreage data from Table 18 to complete this sensitivity analysis. Tables 31 and 32 show the analysis for EVWD and Marion County, respectively. Unfortunately, given limited data for nurseries and greenhouses, there was no meaningful way to account for this change. As a result, their contribution is not altered.

At the EVWD level, payment capacity using 3% farm-gate price inflation under the original BOR conditions is roughly $19.9 million for the first project year. This compares to the original $18.1 million estimate (Table 23). Here, prices received are held at the same inflation rate as budget expense items. Under this scenario, payment capacity continually increases across the duration of the project.

At the Marion County level, payment capacity using 3% farm-gate price inflation under the original BOR conditions is roughly $45.2 million for the first project year. This compares to the original $40.4 million estimate (Table 24). Here, prices received are held at the same inflation rate as budget expense items. Under this scenario, payment capacity continually increases across the duration of the project.

Table 34: **Per-Acre Representative Farm Payment Capacity at 10% Return to Management, 3% Return to Equity and 3% Farm-Gate Price Inflation ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 279	$ 282	$ 286	$ 289	$ 292
B	4,875	4,850	4,824	4,799	4,770
FV	3,291	3,307	3,324	3,339	3,354
G	92	92	92	91	91
H	1,108	1,110	1,112	1,115	1,117
HZ	25	116	209	304	402
PV	250	253	256	260	263
W	92	92	92	91	91

Table 35: **Total Payment Capacity for EVWD at 10% Return to Management, 3% Return to Equity and 3% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 445,910	$ 450,900	$ 456,074	$ 461,441	$ 466,998
Blueberries	7,212,034	7,174,964	7,136,642	7,099,488	7,056,567
Fresh Vegetables	4,682,040	4,705,865	4,728,925	4,751,217	4,772,694
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,370,337	1,364,557	1,358,661	1,352,641	1,346,501
Hops	1,250,788	1,253,158	1,255,682	1,258,365	1,261,218
Hazelnuts	23,373	106,916	192,620	280,522	370,698
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	1,280,631	1,297,295	1,314,109	1,331,048	1,348,154
Wheat	424,751	422,959	421,131	419,266	417,363
TOTAL	$ 19,959,104	$ 20,045,854	$ 20,133,085	$ 20,223,227	$ 20,309,433

Table 36: **Total Payment Capacity for Marion County at 10% Return to Management, 3% Return to Equity and 3% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 2,892,150	$ 2,924,514	$ 2,958,071	$ 2,992,884	$ 3,028,925
Blueberries	7,147,192	7,110,456	7,072,479	7,035,659	6,993,123
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	4,737,725	4,717,742	4,697,355	4,676,543	4,655,317
Hops	5,796,389	5,807,370	5,819,067	5,831,501	5,844,725
Hazelnuts	152,118	695,840	1,253,632	1,825,720	2,412,610
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	6,549,738	6,634,965	6,720,961	6,807,590	6,895,080
Wheat	1,552,141	1,545,594	1,538,915	1,532,097	1,525,143
TOTAL	$ 45,173,653	$ 45,782,682	$ 46,406,679	$ 47,048,193	$ 47,701,122

Building on this, Figures 6 and 8 are now reexamined when the assumption of constant total revenues is dropped. In allowing farm-gate prices received to increase at the same rate as inflation, gross income now increases over time. Furthermore, gross income always exceeds annual farms costs plus the payment returns to management and equity, as evidenced by Figures 9 and 10.

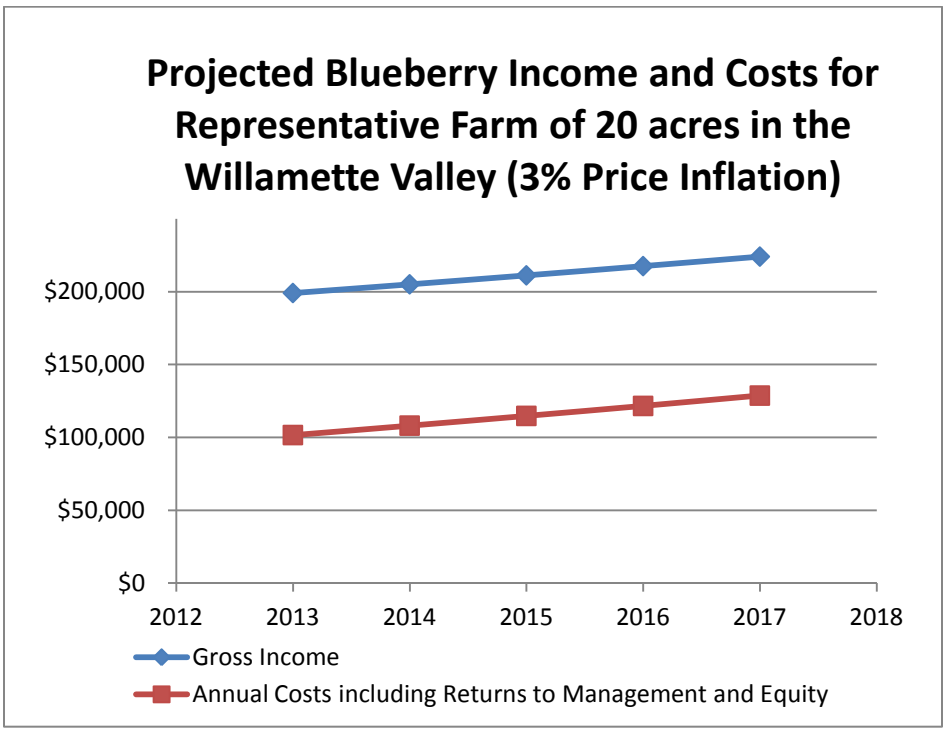

Figure 9: **Projected Income and Costs for the Representative Blueberry Operation in the Willamette Valley through the years 2013 – 2017 (3% Farm-Gate Price Inflation).**

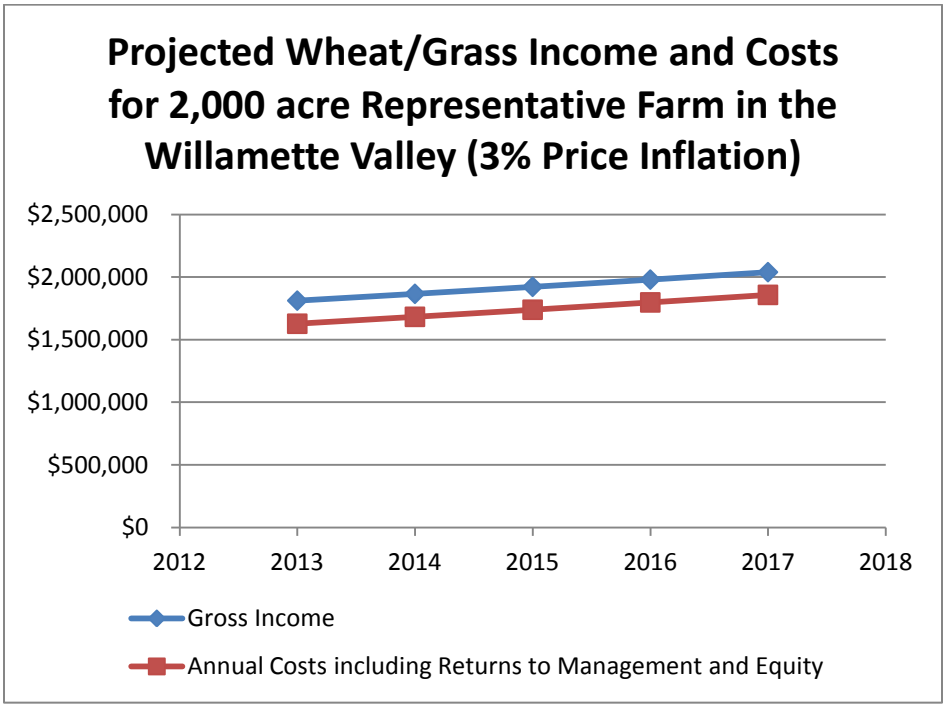

Figure 10: **Projected Income and Costs for the Representative Wheat/Grass Operation in the Willamette Valley through the years 2013 – 2017 (3% Farm-Gate Price Inflation).**

Per-acre returns with prices received inflated 5% over time from Table 37 are applied to acreage data from Table 18 to complete this sensitivity analysis. Tables 31 and 32 show the analysis for EVWD and Marion County, respectively. Unfortunately, given limited data for nurseries and greenhouses, there was no meaningful way to account for this change. As a result, their contribution is not altered.

At the EVWD level, payment capacity using 5% farm-gate price inflation under the original BOR conditions is roughly $21.2 million for the first project year. This compares to the original $18.1 million estimate (Table 23). When prices received are inflated at 5%, an inflation rate higher than that applied to budget expense items, payment capacity continually increases over time and at a rate greater than that of 3%.

At the Marion County level, payment capacity using 5% farm-gate price inflation under the original BOR conditions is roughly $48.3 million for the first project year. This compares to the original $40.4 million estimate (Table 24). When prices received are inflated at 5%, an inflation rate higher than that applied to budget expense items, payment capacity continually increases over time and at a rate greater than that of 3%.

Table 37: **Per-Acre Representative Farm Payment Capacity at 10% Return to Management, 3% Return to Equity and 5% Farm-Gate Price Inflation ($/acre).**

Representative Farm	2013	2014	2015	2016	2017
A	$ 296	$ 317	$ 339	$ 362	$ 386
B	5,043	5,194	5,352	5,518	5,691
FV	3,526	3,788	4,061	4,345	4,641
G	108	123	140	157	175
H	1,208	1,314	1,425	1,542	1,664
HZ	45	159	280	410	547
PV	291	338	386	437	490
W	108	123	140	157	175

Table 38: **Total Payment Capacity for EVWD at 10% Return to Management, 3% Return to Equity and 5% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 473,308	$ 506,944	$ 542,071	$ 578,754	$ 617,063
Blueberries	7,460,807	7,683,882	7,917,613	8,162,623	8,419,282
Fresh Vegetables	5,016,256	5,389,509	5,777,935	6,182,246	6,603,227
Greenhouse	675,319	675,319	675,319	675,319	675,319
Grass	1,597,344	1,828,913	2,071,182	2,324,656	2,589,879
Hops	1,363,419	1,483,548	1,609,195	1,740,625	1,878,110
Hazelnuts	41,066	146,457	258,488	377,527	504,030
Nursery	2,593,921	2,593,921	2,593,921	2,593,921	2,593,921
Processed Vegetables	1,493,330	1,732,384	1,981,704	2,241,784	2,513,136
Wheat	495,114	566,891	641,985	720,552	802,761
TOTAL	$ 21,209,884	$ 22,607,768	$ 24,069,413	$ 25,598,006	$ 27,196,728

Table 36: **Total Payment Capacity for Marion County at 10% Return to Management, 3% Return to Equity and 5% Farm-Gate Price Inflation, Including Nursery and Greenhouse Contributions ($/total acreage).**

Representative Farm	2013	2014	2015	2016	2017
Alfalfa	$ 3,069,851	$ 3,288,012	$ 3,515,845	$ 3,753,766	$ 4,002,238
Blueberries	7,393,728	7,614,798	7,846,428	8,089,235	8,343,587
Fresh Vegetables	-	-	-	-	-
Greenhouse	3,376,594	3,376,594	3,376,594	3,376,594	3,376,594
Grass	5,522,567	6,323,179	7,160,787	8,037,134	8,954,098
Hops	6,318,340	6,875,041	7,457,316	8,066,384	8,703,518
Hazelnuts	267,271	953,183	1,682,314	2,457,058	3,280,376
Nursery	12,969,606	12,969,606	12,969,606	12,969,606	12,969,606
Processed Vegetables	7,637,576	8,860,209	10,135,347	11,465,514	12,853,337
Wheat	1,809,265	2,071,556	2,345,968	2,633,070	2,933,480
TOTAL	$ 48,364,799	$ 52,332,178	$ 56,490,206	$ 60,848,361	$ 65,416,833

Summary

The preceding payment capacity assembled for the East Valley Water District (EVWD) utilized data and information available from the Farm Service Agency (FSA), Oregon Agriculture Information Network (OAIN), university extension publications and the U.S. Department of Agriculture 2007 Census Report. As in all reports of this nature, the data are imperfect and certain assumptions must be used to facilitate the analysis. It is worth summarizing this report by discussing the limitations once more.

The EVWD, as well as Marion County, are highly diversified agricultural regions and consequently, difficult to comprehensively assess. From one year to the next, crop acreages grown in wheat and grass can increase or decrease significantly depending on relative prices, leading to substitution with other crops. It would be near impossible to develop a different sensitivity analysis to try and account for these variable conditions that would affect the District and County's payment capacity. In this regard, the Bureau of Reclamation's (BOR) emphasis on averages helps provide a guide post for analysis. It is noteworthy that acreages for blueberries, hazelnuts and hops all require establishment periods and thus are not subject to change as readily as wheat and grass acres. For this, the analysis works particularly well.

The FSA data on selected crop acreage are used to analyze the EVWD's crop acreage and composition. These data are reported to farms receiving financial support from the FSA and do not apply to all operations within the District boundaries. From the proposed District boundary (Figure 2), 47% of the acreage is accounted for through FSA reporting requirements. The payment capacity numbers in this report all reflect that 47% representation.

The OAIN data are generally from the County level. This is particularly beneficial in trying to establish accurate numbers for prices, yields and acreages. These data interfaced well with crop acreage numbers from the FSA data and provided the basis for the County level analysis. However, not all crop information is published for anonymity reasons. In some instances, there were strong numbers from recent enterprise budget publications to use instead, as in the processed cauliflower and broccoli cases. In other instances, crops were left entirely out of the analysis, as in the fresh vegetable exclusion from the Marion County payment capacity.

Overall, this report makes best use of data available and employs transparent methods to develop an agriculture economic value analysis for the EVWD.

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Appendix

A. OAIN Data

Alfalfa Hay

Forage can be grown for hay, haylage, grass silage and greenchop purposes. However, hay, which includes alfalfa and other tame, small grains, accounts for 13,775 acres of the total 15,552 forage acres. Over a third of these total acres are irrigated, though only 185 out of 560 farms irrigate. The mean non-irrigated forage farm is 34.7 acres and the mean non-irrigated hay farm is 26.0 acres.

Table A.1: **Alfalfa Overview, Marion County (OAIN)**

Alfalfa Hay Production in Marion County (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (tons/acre)**	**Production (tons)**	**Price ($/ton)**	**Value Sales (000)**	**% of Total County**
2007	1,900	5.5	10,450	$ 180.00	$ 1,881	1.07%
2008	1,500	5.0	7,500	$ 190.00	$ 1,425	0.84%
2009	1,700	5.5	9,350	$ 160.00	$ 1,496	0.95%
2010	1,800	5.2	9,360	$ 160.00	$ 1,498	1.01%
2011	1,900	5.2	9,880	$ 240.00	$ 2,371	1.04%
Average	1,760	5.3	9,308	$ 186.00	$ 1,734.20	0.98%

Alfalfa hay is also used to represent other hay acreage at the County level. The production of other hay is shown below:

Table A.2: **Other Hay Overview, Marion County (OAIN)**

Other Hay Production in Marion County (2007 - 2011)					
Year	**Harvest (acres)**	**Yield (tons/acre)**	**Production (tons)**	**Price ($/ton)**	**Value Sales (000)**
2007	9,500	2.8	26,600	$ 160.00	$ 1,277
2008	8,000	2.8	22,400	$ 170.00	$ 3,808
2009	8,500	2.5	21,250	$ 140.00	$ 2,975
2010	8,500	2.3	19,550	$ 130.00	$ 2,542
2011	8,500	2.3	19,550	$ 150.00	$ 2,932
Average	8,600	2.5	21,870	$ 150.00	$ 2,706.80

Blueberries

Blueberry enterprise budget data are based on a 20-acre blueberry field with plants spaced at 3' x 10' for a total of 1,452 plants/acre. In 2007, the mean blueberry farm size was 12.1 acres.

Table A.3: **Blueberry Overview, Marion County (OAIN)**

Blueberry Production in Marion County (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (000 lbs)**	**Price (cts/lb)**	**Value Sales (000)**	**% of Total County**
2007	1,153	9,000	10,377	$ 155.00	$ 16,084	0.65%
2008	1,243	8,200	10,193	$ 114.00	$ 11,620	0.70%
2009	1,305	8,300	10,832	$ 63.00	$ 6,824	0.73%
2010	1,630	8,300	13,529	$ 117.00	$ 15,289	0.91%
2011	2,000	8,300	16,600	$ 125.00	$ 20,750	1.09%
Average	1,466	8,420	12,306	$ 114.80	$ 14,113.40	0.82%

Hazelnuts

Hazelnuts are assumed to be non-irrigated. Their per-acre costs and returns are based on a 100-acre orchard with a 109 trees/acre density and 20' x 20' spacing.
In 2007, the mean hazelnut farm size was 50.3 acres.

Table A.4: **Hazelnut Overview, Marion County (OAIN)**

Hazelnut Production in Marion County (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (tons)**	**Price ($/lb)**	**Value Sales (000)**	**% of Total County**
2007	5,800	1,190	3,451	$ 0.90	$ 6,212	3.26%
2008	6,000	1,100	3,300	$ 0.76	$ 5,016	3.37%
2009	6,000	1,320	3,960	$ 0.75	$ 5,940	3.35%
2010	6,000	790	2,370	$ 1.05	$ 4,977	3.36%
2011	6,200	1,050	3,255	$ 1.15	$ 7,487	3.38%
Average	6,000	1,090	3,267	$ 0.92	$ 5,926.40	3.34%

Hops

Within the OAIN database, there are three years of existing data for hops. However, due to the specific agricultural conditions necessary for their growth and production, the majority of Willamette Valley hops are grown specifically in Marion County, averaging between 93% and 94% for the years 2008 through 2010. Consequently, due to the more robust data released at the regional level, Willamette Valley data will be used in place of Marion County.

Hops are assumed to have drip-irrigation. Their costs and returns based on 660-acres devoted to hop production in Yakima Valley, WA. The drip irrigation system, hop trellis system and hop plants have a 4-year life expectancy. In 2002, the mean hop farm size was 143.5 acres.

Table A.5: **Hops Overview, Marion County (OAIN)**

Hops Production in Marion County (2008 – 2011)							
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (000 lbs)**	**Price ($/lb)**	**Value Sales (000)**	**Harvest (acres)**	**Percentage of WV Harvest (acres)**
2008	5,500	1,580.0	8,690	$ 3.80	$ 33,022	5,900	93.22%
2009	5,600	1,700.0	9,520	$ 2.75	$ 26,180	6,000	93.33%
2010	4,600	1,800.0	8,280	$ 3.75	$ 31,050	4,860	94.65%

Table A.6: **Hops Overview, Willamette Valley (OAIN)**

Hops Production in Willamette Valley (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (000 lbs)**	**Price ($/lb)**	**Value Sales (000)**	**% of Total County**
2007	5,200	1,800.0	9,360	$ 3.12	$ 29,203	2.92%
2008	5,900	1,570.0	9,290	$ 3.80	$ 35,302	3.31%
2009	6,000	1,690.0	10,140	$ 2.81	$ 28,505	3.35%
2010	4,860	1,780.0	8,670	$ 3.75	$ 32,512	2.72%
2011	4,200	1,900.0	7,980	$ 2.93	$ 23,391	2.29%
Average	5,232	1,748.0	9,088	$ 3.28	$ 29,782.60	2.92%

Perennial Ryegrass

The two major grass varieties grown within Marion include Fescue and Ryegrass. According the 2007 Census of Agriculture, approximately one-third of grass and field crops were irrigated. For fescue, there are 171 farms with 38,035 acres (69 farms with 8,205 acres irrigated) for a 222.43 acre mean total. For ryegrass, there are 237 farms with 56,039 acres (111 farms, 22,497 acres irrigated) for a 236.45 acre mean total.

Table A.7: **Perennial Ryegrass Overview, Marion County (OAIN)**

Perennial Ryegrass Production in Marion County (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (000 lbs)**	**Price ($/CWT)**	**Value Sales (000)**	**% of Total County**
2007	48,000	1,600	76,800	$ 66.00	$ 50,688	26.94%
2008	37,000	1,500	55,500	$ 76.00	$ 42,180	20.76%
2009	33,000	1,600	52,800	$ 51.00	$ 26,928	18.44%
2010	30,500	1,750	53,375	$ 50.00	$ 26,688	17.10%
2011	34,000	1,750	59,500	$ 62.00	$ 36,890	18.56%
Average	36,500	1,640	59,595	$ 61.00	$ 36,674.80	20.36%

Table A.8: **Tall Fescue Overview, Marion County (OAIN)**

Tall Fescue Production in Marion County (2007 – 2011)						
Year	**Harvest (acres)**	**Yield (lbs/acre)**	**Production (000 lbs)**	**Price ($/CWT)**	**Value Sales (000)**	**% of Total County**
2007	18,000	1,700	30,600	$ 75.00	$ 22,950	10.10%
2008	18,000	1,600	28,800	$ 67.00	$ 19,296	10.10%
2009	16,000	1,800	28,800	$ 35.00	$ 10,080	8.94%
2010	10,800	1,850	19,980	$ 31.00	$ 6,194	6.05%
2011	11,100	1,850	20,535	$ 48.80	$ 10,021	6.06%
Average	14,780	1,760	25,743	$ 51.36	$13,708.20	8.25%

Snap/Bush Beans (Processed)

The historical OAIN dataset has not published consistent snap bean data for Marion County over the past five years. Of the past five years, only two years worth of County level snap bean data have been published for Marion. However, with two additional years of data from 2000 and 2001, we can see that snap bean production hasn't significantly changed. These numbers are reasonable to use instead of assuming that Marion bean production is equal to that of the Willamette Valley. In 2009 and in 2011, Marion bean production averaged approximately 74% and 66% of total production within Willamette Valley, respectively. Here, data from both are provided but only Marion County is used in the analysis

Processed vegetables included are sweet corn and snap/bush beans. Conventional production practices are assumed for both and costs and returns are on a per-acre basis. The mean processed snap/bush bean farm size was 128.1 acres and thee mean processed sweet corn farm size was 106.8 acres.

Table A.9: **Snap Bean Overview, Marion County (OAIN)**

Snap Bean Production in Marion County (2000-2001, 2009, 2011)						
Year	**Harvest (acres)**	**Yield (tons/acre)**	**Production (tons)**	**Price ($/ton)**	**Value Prod. (000)**	**% of Total County**
2000	13,300	6.3	83,840	$ 185.88	$ 15,584	-
2001	12,140	6.2	75,238	$ 185.97	$ 13,992	-
2009	12,715	6.2	79,224	$ 215.91	$ 17,105	7.11%
2011	11,240	7.1	80,284	$ 198.03	$ 15,899	6.13%
2-Year Average	11,978	6.7	79,754	$ 206.97	$ 16,502	6.62%

The years 2000 and 2001 are not included in the calculation of averages.

Table A.10: **Snap Bean Overview, Willamette Valley (OAIN)**

Snap Bean Production in Willamette Valley (2007 - 2011)					
Year	**Harvest (acres)**	**Yield (tons/acre)**	**Production (tons)**	**Price ($/ton)**	**Value Sales (000)**
2007	18,815	6.4	120,493	$ 199.31	$ 24,015
2008	16,900	6.2	104,076	$ 235.72	$ 24,533
2009	17,820	6.1	108,553	$ 216.12	$ 23,461
2010	16,755	6.7	112,185	$ 178.31	$ 20,004
2011	16,425	6.9	113,186	$ 202.61	$ 22,933
Average	17,343	6.5	111,699	$ 206.41	$ 22,989.20

Sweet Corn (Processed)

No processed sweet corn data were published at the county level, solely statewide. However, the majority of this crop is grown within the Willamette Valley. Although we have no data to suggest the percentage contribution of Marion sweet corn to the total Willamette Valley production, using Willamette Valley sweet corn data is the best county level proxy available.

Table A.11: **Sweet Corn Overview, Willamette Valley (OAIN)**

Sweet Corn Production in Willamette Valley (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (tons/acre)**	**Production (tons)**	**Price ($/ton)**	**Value Sales (000)**	**% of Total County**
2007	13,500	10.1	136,147	$ 93.04	$ 12,667	7.58%
2008	12,090	10.1	122,060	$ 120.02	$ 14,650	6.78%
2009	16,240	9.9	161,376	$ 116.91	$ 18,866	9.08%
2010	13,150	10.3	136,042	$ 86.68	$ 11,792	7.37%
2011	14,420	10.0	143,624	$ 120.78	$ 17,347	7.87%
Average	13,880	10.1	139,850	$ 107.49	$ 15,064	7.74%

Wheat

The wheat enterprise information is based on spring wheat grown on 3000 dryland acres utilizing minimum tillage practices. In 2007, for grain-producing wheat farms, the mean farm size was 54.2 acres.

Table A.12: **Wheat Overview, Marion County (OAIN)**

Wheat Production in Marion County (2007 - 2011)						
Year	**Harvest (acres)**	**Yield (BU/acre)**	**Production (BU)**	**Price ($/BU)**	**Value Sales (000)**	**% of Total County**
2007	1,000	95	95,000	$ 6.00	$ 570	0.56%
2008	13,000	90	1,170,000	$ 6.90	$ 8,073	7.29%
2009	15,000	110	1,650,000	$ 5.20	$ 8,580	8.38%
2010	26,000	110	2,860,000	$ 5.60	$ 16,016	14.58%
2011	29,000	115	3,335,000	$ 6.25	$ 20,844	15.83%
Average	16,800	104	1,822,000	$ 5.99	$ 10,816.60	9.33%

For the following crops included in this analysis, the best data available were sparse. For fresh market vegetables, nursery and greenhouse crops, only the number of acres harvested and the value of both production and sales were available through the OAIN database. Due to categorical diversity and aggregation, no price or yield data were available.

Fresh Market Vegetables

Fresh vegetables include farms growing spinach and leaf lettuce greens in annual rotations, as well as farms with either leaf lettuce and radishes or spinach and radish rotations. For all of these vegetables, conventional production practices are assumed. There are 2 spinach farms and 6 leaf lettuce farms (no total acres) and 7 radish farms representing a total of 70 acres.

Table A.13: **Fresh Market Vegetable Overview, Marion County (OAIN)**

Fresh Market Vegetables in Marion County (2006 - 2008)					
Year	**Harvest (acres)**	**Value Prod. (000)**		**Value Sales (000)**	
2006	25,252	$	32,981	$	32,981
2007	23,460	$	34,886	$	34,886
2008	23,027	$	39,734	$	39,734
Average	23,913	$	35,867	$	35,867

Nursery Crops

Nurseries grow a diverse variety of floricultural crops. Potted flowering plants including poinsettias and geraniums, as well as petunia and marigold flats are assumed to represent the general nursery producing floriculture crops. The mean square footage farm size is 85,200 acres under glass or other protection.

Table A.14: **Nursery Crop Overview, Marion County (OAIN)**

Nursery Crops in Marion County (2007 - 2011)				
Year	**Value Prod. (000)**		**Value Sales (000)**	
2007	$	143,944	$	143,944
2008	$	115,155	$	115,155
2009	$	111,240	$	111,240
2010	$	133,861	$	133,861
2011	$	134,700	$	134,700
Average	$	127,780	$	127,780

Greenhouse Crops

Table A.15: **Greenhouse Crop Overview, Marion County (OAIN)**

Greenhouse Crops in Marion County (2007 - 2011)				
Year	**Value Prod. (000)**		**Value Sales (000)**	
2007	$	39,478	$	39,478
2008	$	31,582	$	31,582
2009	$	33,824	$	33,824
2010	$	40,139	$	40,139
2011	$	40,790	$	40,790
Average	$	37,163	$	37,163

B. Enterprise Budgets

Alfalfa Hay

Alfalfa Production (Marion County)

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Alfalfa Hay	ton	$186.00	5.3	$985.80

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0.03	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Swather (Self-propelled windrower)(3x)	acre	$11.19	1	$11.19
Swather (Self-propelled windrower)(3x) (Labor)	hours	$24.00	0.44	$10.62
Self-Propelled Bale Wagon (3x)	acre	$34.38	1	$34.38
Self-Propelled Bale Wagon (3x) (Labor)	hours	$24.00	0.74	$17.67
Interest on Operating Capital		$73.86	0.03	$2.36

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- CHEMICALS --		$0.00	0	$0.00
Fertilizer (Alfalfa Hay)	acre	$18.91	1	$18.91
Chemical Pest Control (Alfalfa Hay)	acre	$49.14	1	$49.14
-- OTHER COSTS --		$0.00	0	$0.00
Alfalfa Irrigation Repairs	acre	$6.60	1	$6.60
General Overhead (Alfalfa Hay)	acre	$19.79	1	$19.79
Land Lease	acre	$131.95	1	$131.95
Hay Shed - Repairs & Maintenance (Alfal)	acre	$3.71	1	$3.71
-- MACHINERY --		$0.00	0	$0.00
Tractor #1 (Implement: Gopher Machine)	acre	$9.57	1	$9.57
Tractor #1 (Implement: Gopher Machine) (Labor)	hours	$36.30	0.32	$11.52
Tractor #2 (Implement: Spring Tooth Harrow)	acre	$0.86	1	$0.86
Tractor #2 (Implement: Spring Tooth Harrow) (Labor)	hours	$36.30	0.0868	$3.15
Tractor #2 (Implement: Side Delivery Rake)(3x)	acre	$3.03	1	$3.03
Tractor #2 (Implement: Side Delivery Rake)(3x) (Labor)	hours	$36.30	0.26	$9.36
Tractor #2 (Implement: Baler)(3x)	acre	$10.95	1	$10.95
Tractor #2 (Implement: Baler)(3x) (Labor)	hours	$36.30	0.52	$18.72
ATV	acre	$0.32	1	$0.32

ATV (Labor)	hours	$22.00	0.05	$1.10
Pickup	acre	$20.87	1	$20.87
Pickup (Labor)	hours	$24.00	0.68	$16.40
Property taxes (Alfalfa)	acre	$20.00	1	$20.00
Property Insurance (Alfalfa)	acre	$30.00	1	$30.00
Interest on Operating Capital		$385.95	0.03	$12.35

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Swather (Self-propelled windrower)(3x)	acre	$16.74	1	$16.74
Tractor #1 (Implement: Gopher Machine)	acre	$3.87	1	$3.87
Tractor #2 (Implement: Spring Tooth Harrow)	acre	$1.23	1	$1.23
Tractor #2 (Implement: Side Delivery Rake)(3x)	acre	$3.54	1	$3.54
Tractor #2 (Implement: Baler)(3x)	acre	$17.01	1	$17.01
Self-Propelled Bale Wagon (3x)	acre	$42.69	1	$42.69
ATV	acre	$0.08	1	$0.08
Pickup	acre	$7.79	1	$7.79
-- OTHER --		$0.00	0	$0.00
Amortized Establishment Costs	acre	$62.68	1	$62.68
Irrigation Depreciation and Interest	acre	$35.00	1	$35.00
Total Annual Costs				**$665.15**
Returns minus Total Annual Costs				**$320.65**

Eleveld, Bart, Rodney Todd, and William Riggs. 1998. *Alfalfa Establishment, Klamath Basin Area*. Klamath Basin Area: Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8431.pdf.

Orloff, Steve, Karen Klonsky, and Kabir Tumber. 2012. *Sample Costs to Establish and Produce Alfalfa Hay: Intermountain - Siskiyou County*. UC Cooperative Extension. http://coststudies.ucdavis.edu/files/2012/Alfalfa_IM_Scott2012.pdf.

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Notes: Assets developed using AgProfit. Budget built using Klamath Basin, altered using more up-to-date costs on machinery and equipment. All intermediate assets (equipment) valued at $398,400.

Blueberry, Machine Harvest

Blueberries Full Production Machine Harvest

Budget Unit	acre

Returns

Name	Unit	$/Unit	Quantity	Value
Blueberries Processed Market	pound	$1.15	16000	$18,400.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Commission Fees (Bl)	pound	$0.04	16000	$640.00
Interest on Operating Capital		$640.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Machine Harvest Rental (Bl)	pound	$0.12	16000	$1,920.00
Labor - Load & Shipping (Bl)	pound	$0.03	16000	$480.00
Interest on Operating Capital		$2,400.00	0.04	$96.00

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Prune & Rake (Bl)	hour	$13.50	25	$337.50
4 wd Tractor & Fungicide(6x) Insecticide(1x) Appl.	acre	$75.90	1	$75.90
4 wd Tractor & Fungicide(6x) Insecticide(1x) Appl. (Labor)	hours	$22.00	3.3	$72.60
Fungicides (Bl)	appl/acre	$10.00	5	$50.00
Insecticides (Bl)	appl/acre	$10.00	1	$10.00
4 wd Tractor & Fertilizer Application - Sidedress (3x)	acre	$28.86	1	$28.86
4 wd Tractor & Fertilizer Application - Sidedress (3x) (Labor)	hours	$22.00	1.77	$38.88
Fertilizer (Bl)	appl/acre	$50.00	3	$150.00
Bee Hives (Bl)	hive	$50.00	3	$150.00
4 wd Tractor & Flail Mower (10x)	acre	$86.00	1	$86.00
4 wd Tractor & Flail Mower (10x) (Labor)	hours	$22.00	4.85	$106.80
4 wd Tractor & Herbicide Application (1x)	acre	$4.09	1	$4.09
4 wd Tractor & Herbicide Application (1x) (Labor)	hours	$22.00	0.24	$5.34
Herbicides - Spot Spray (Bl)	acre	$12.00	2	$24.00
Herbicides (Bl)	acre	$15.00	1	$15.00
Sawdust Loader - Rental (Bl)	acre	$700.00	0.33	$231.00
Sawdust Mulch (Bl)	ton	$40.00	3.63	$145.20
Irrigation - Labor (Bl)	hour	$13.50	3	$40.50
Irrigation - Repair & Maintenance (Bl)	acre	$25.00	1	$25.00

Trellis - Labor (Bl)	hour	$13.50	2	$27.00
Trellis - Repairs & Maintenance (Bl)	acre	$17.00	1	$17.00
Tissue Analysis (Bl)	acre	$7.00	1	$7.00
Bird Control (Bl)	acre	$50.00	1	$50.00
4 wd Tractor & Wagon	acre	$32.50	1	$32.50
4 wd Tractor & Wagon (Labor)	hours	$36.30	2	$72.60
1/2 Ton Pickup	acre	$101.88	1	$101.88
ATV	acre	$56.00	1	$56.00
Property Insurance (ABC)	acre	$30.00	1	$30.00
Property taxes (ABC)	acre	$20.00	1	$20.00
Miscellaneous & Overhead (ABC)	acre	$200.00	1	$200.00
Interest on Operating Capital		$2,210.65	0.04	$88.43

Capital Investment

Name	Unit	$/Unit	Quantity	Value
4 wd Tractor & Fungicide(6x) Insecticide(1x) Appl.	acre	$32.34	1	$32.34
4 wd Tractor & Flail Mower (10x)	acre	$54.30	1	$54.30
4 wd Tractor & Fertilizer Application - Sidedress (3x)	acre	$20.94	1	$20.94
4 wd Tractor & Wagon	acre	$16.26	1	$16.26
1/2 Ton Pickup	acre	$15.56	1	$15.56
ATV	acre	$19.40	1	$19.40
4 wd Tractor & Herbicide Application (1x)	acre	$1.65	1	$1.65

Total Annual Costs	**$5,595.53**
Returns minus Total Annual Costs	**$12,804.47**

Eleveld, Bart, Bernadine Strik, Karen DeVries, and Wei Yang. 2005. *Blueberry Economics: The Costs of Establishing and Producing Blueberries in the Willamette Valley*. Oregon State University. http://arec.oregonstate.edu/oaeb/files/pdf/EM8526.pdf.

Broccoli, Processed

Broccoli Conventional Processed Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Broccoli	ton	$500.00	5	$2,500.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Hand Harvest (Br)	hour	$12.00	45	$540.00
Hauling (2 Trucks)	acre	$22.42	1	$22.42
Hauling (2 Trucks) (Labor)	hours	$20.00	1	$20.00
Forklift	acre	$21.86	1	$21.86
Forklift (Labor)	hours	$22.00	2	$44.00
2 wd Tractor#4 & Trailer	acre	$37.44	1	$37.44
2 wd Tractor#4 & Trailer (Labor)	hours	$22.00	2	$44.00
4 wd Tractor#3 & 36' Conveyor	acre	$51.42	1	$51.42
4 wd Tractor#3 & 36' Conveyor (Labor)	hours	$22.00	2	$44.00
Interest on Operating Capital		$825.14	0.03	$26.40

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Soil test (AVC)	acre	$2.00	1	$2.00
Lime application (AVC)	acre	$75.00	1	$75.00
4 wd Tractor#1 & Tandem Disk (2x)	acre	$11.06	1	$11.06
4 wd Tractor#1 & Tandem Disk (2x) (Labor)	hours	$22.00	0.21	$4.52
4 wd Tractor#1 & Moldboard Plow (1x)	acre	$6.81	1	$6.81
4 wd Tractor#1 & Moldboard Plow (1x) (Labor)	hours	$22.00	0.13	$2.85
4 wd Tractor#2 & Harrow/Roller Packer (1x)	acre	$4.23	1	$4.23
4 wd Tractor#2 & Harrow/Roller Packer (1x) (Labor)	hours	$22.00	0.0923	$2.03
Pre-plant Fertilizer (Br)	acre	$65.00	1	$65.00
4 wd Tractor#2 & Field Cultivator (2x)	acre	$4.10	1	$4.10
4 wd Tractor#2 & Field Cultivator (2x) (Labor)	hours	$22.00	0.1	$2.26
4 wd Tractor#2 & Rotovator (1x)	acre	$11.96	1	$11.96
4 wd Tractor#2 & Rotovator (1x) (Labor)	hours	$22.00	0.23	$5.08
Herbicides (Br)	acre	$20.00	1	$20.00

2 wd Tractor#4 & Broccoli Planter (1x)	acre	$7.21	1	$7.21
2 wd Tractor#4 & Broccoli Planter (1x) (Labor)	hours	$22.00	0.18	$3.91
Seed (Br)	acre	$150.00	1	$150.00
Insecticides (Br)	acre	$20.00	1	$20.00
Side Dress Fertilizer (Br)	acre	$70.00	1	$70.00
4 wd Tractor#2 & Row Cultivator (1x)	acre	$2.05	1	$2.05
4 wd Tractor#2 & Row Cultivator (1x) (Labor)	hours	$22.00	0.0514	$1.13
Hand Weeding Labor (AVC)	hour	$12.00	14	$168.00
4 wd Tractor#3 & Fertilizer Spreader (1x)	acre	$1.09	1	$1.09
4 wd Tractor#3 & Fertilizer Spreader (1x) (Labor)	hours	$22.00	0.0423	$0.93
Top Dress Fertilizer (Br)	acre	$65.00	1	$65.00
Self-Propelled Boom Sprayer (2x)	acre	$5.72	1	$5.72
Self-Propelled Boom Sprayer (2x) (Labor)	hours	$22.00	0.1	$2.30
Insecticides by Boom Sprayer (Br)	acre	$40.00	1	$40.00
4 wd Tractor#2 & Flail Chop (1x)	acre	$4.58	1	$4.58
4 wd Tractor#2 & Flail Chop (1x) (Labor)	hours	$22.00	0.0982	$2.16
Irrigation Labor (AVC)	hour	$12.00	5	$60.00
Irrigation Pumping Costs (AVC)	acre/inch	$3.50	10	$35.00
Irrigation Repairs & Maintenance (AVC)	acre	$25.00	1	$25.00
Pickup	acre	$52.00	1	$52.00
ATV (4-Wheeler)	acre	$5.56	1	$5.56
Property Insurance (AVC)	acre	$35.00	1	$35.00
Property taxes (AVC)	acre	$20.00	1	$20.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00
Interest on Operating Capital		$1,068.54	0.03	$34.19

Capital Investment

Name	Unit	$/Unit	Quantity	Value
4 wd Tractor#1 & Tandem Disk (2x)	acre	$3.14	1	$3.14
4 wd Tractor#1 & Moldboard Plow (1x)	acre	$2.30	1	$2.30
Self-Propelled Boom Sprayer (2x)	acre	$5.74	1	$5.74
4 wd Tractor#2 & Rotovator (1x)	acre	$1.77	1	$1.77
4 wd Tractor#2 & Flail Chop (1x)	acre	$0.84	1	$0.84
4 wd Tractor#2 & Field Cultivator (2x)	acre	$0.48	1	$0.48
4 wd Tractor#2 & Row Cultivator (1x)	acre	$0.24	1	$0.24
4 wd Tractor#2 & Harrow/Roller Packer (1x)	acre	$1.08	1	$1.08
4 wd Tractor#3 & Fertilizer Spreader (1x)	acre	$0.41	1	$0.41
2 wd Tractor#4 & Broccoli Planter (1x)	acre	$1.44	1	$1.44
Hauling (2 Trucks)	acre	$24.88	1	$24.88
Pickup	acre	$21.16	1	$21.16
ATV (4-Wheeler)	acre	$4.23	1	$4.23
4 wd Tractor#3 & 36' Conveyor	acre	$31.84	1	$31.84

2 wd Tractor#4 & Trailer	acre	$8.16	1	$8.16
Forklift	acre	$12.88	1	$12.88
Total Annual Costs				**$2,074.87**
Returns minus Total Annual Costs				**$425.13**

Julian, Jim, Clark Seavert, Dan McGrath, Robert McReynolds, and Ed Peachey. 2010. *Broccoli, Processed Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0003.pdf.

Cauliflower

Cauliflower Conventional Processed Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Cauliflower	ton	$350.00	6	$2,100.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Hand Harvesting (Ca)	hour	$12.00	36	$432.00
Hauling (2 Trucks)	acre	$22.42	1	$22.42
Hauling (2 Trucks) (Labor)	hours	$22.00	1	$22.00
2 wd Tractor#4 & Trailer	acre	$56.16	1	$56.16
2 wd Tractor#4 & Trailer (Labor)	hours	$22.00	3	$66.00
4 wd Tractor#3 & 36' Conveyor	acre	$49.90	1	$49.90
4 wd Tractor#3 & 36' Conveyor (Labor)	hours	$22.00	2	$44.00
Interest on Operating Capital		$692.48	0.03	$22.16

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Soil test (AVC)	acre	$2.00	1	$2.00
Lime application (AVC)	acre	$75.00	1	$75.00
4 wd Tractor#1 & Tandem Disk (2x)	acre	$11.06	1	$11.06
4 wd Tractor#1 & Tandem Disk (2x) (Labor)	hours	$22.00	0.21	$4.52
4 wd Tractor #1 & Moldboard Plow (1x)	acre	$6.81	1	$6.81
4 wd Tractor #1 & Moldboard Plow (1x) (Labor)	hours	$22.00	0.13	$2.85
4 wd Tractor#2 & Harrow/Roller Packer (1x)	acre	$4.23	1	$4.23
4 wd Tractor#2 & Harrow/Roller Packer (1x) (Labor)	hours	$22.00	0.0923	$2.03
Pre-plant Fertilizer (Ca)	acre	$65.00	1	$65.00
4 wd Tractor#2 & Field Cultivator (1x)	acre	$2.05	1	$2.05
4 wd Tractor#2 & Field Cultivator (1x) (Labor)	hours	$22.00	0.0514	$1.13
4 wd Tractor#2 & Rotovator (1x)	acre	$11.96	1	$11.96
4 wd Tractor#2 & Rotovator (1x) (Labor)	hours	$22.00	0.23	$5.08
Herbicide (Ca)	acre	$20.00	1	$20.00
Custom Transplanting (Ca)	acre	$150.00	1	$150.00
Cauliflower Transplants (Ca)	acre	$250.00	1	$250.00

4 wd Tractor#2 & Row Cultivator (2x)	acre	$4.10	1	$4.10
4 wd Tractor#2 & Row Cultivator (2x) (Labor)	hours	$22.00	0.1	$2.26
4 wd Tractor#3 & Fertilizer Spreader (2x)	acre	$2.18	1	$2.18
4 wd Tractor#3 & Fertilizer Spreader (2x) (Labor)	hours	$22.00	0.0845	$1.86
Top Dress Fertilizer (Ca)	acre	$65.00	1	$65.00
Self-propelled Boom Sprayer (1x)	acre	$2.79	1	$2.79
Self-propelled Boom Sprayer (1x) (Labor)	hours	$22.00	0.0523	$1.15
Insecticides (Ca)	acre	$20.00	1	$20.00
Irrigation Labor (AVC)	hour	$12.00	5	$60.00
Irrigation Pumping Costs (AVC)	acre/inch	$3.50	12	$42.00
Irrigation Repairs & Maintenance (AVC)	acre	$25.00	1	$25.00
Pickup	acre	$52.00	1	$52.00
ATV	acre	$5.73	1	$5.73
Property taxes (AVC)	acre	$20.00	1	$20.00
Property Insurance (AVC)	acre	$35.00	1	$35.00
Interest on Operating Capital		$952.79	0.03	$30.49

Capital Investment

Name	Unit	$/Unit	Quantity	Value
4 wd Tractor#1 & Tandem Disk (2x)	acre	$3.14	1	$3.14
4 wd Tractor #1 & Moldboard Plow (1x)	acre	$2.30	1	$2.30
4 wd Tractor#2 & Rotovator (1x)	acre	$1.77	1	$1.77
4 wd Tractor#2 & Field Cultivator (1x)	acre	$0.24	1	$0.24
4 wd Tractor#2 & Row Cultivator (2x)	acre	$0.48	1	$0.48
4 wd Tractor#2 & Harrow/Roller Packer (1x)	acre	$1.08	1	$1.08
4 wd Tractor#3 & Fertilizer Spreader (2x)	acre	$0.82	1	$0.82
Hauling (2 Trucks)	acre	$25.48	1	$25.48
Pickup	acre	$15.56	1	$15.56
ATV	acre	$0.85	1	$0.85
Self-propelled Boom Sprayer (1x)	acre	$2.87	1	$2.87
2 wd Tractor#4 & Trailer	acre	$12.24	1	$12.24
4 wd Tractor#3 & 36' Conveyor	acre	$44.08	1	$44.08
Total Annual Costs				**$1,808.83**
Returns minus Total Annual Costs				**$291.17**

Julian, Jim, Clark Seavert, Dan McGrath, Robert McReynolds, and Ed Peachey. 2010. *Cauliflower, Processed Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0005.pdf.

Hazelnuts

Hazelnuts Full Production Years

Budget Unit	acre

Returns

Name	Unit	$/Unit	Quantity	Value
Hazelnuts	pound	$0.70	2800	$1,960.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Wash & Dry Nuts (Hz)	pound	$0.05	2800	$128.80
Interest on Operating Capital		$128.80	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Self-propelled nut sweeper (1x)	acre	$8.66	1	$8.66
Self-propelled nut sweeper (1x) (Labor)	hours	$22.00	0.63	$13.92
4-wheel drive tractor & nut harvester (1x)	acre	$8.58	1	$8.58
4-wheel drive tractor & nut harvester (1x) (Labor)	hours	$22.00	0.47	$10.37
2-wheel drive tractor & front-end loader to loading totes	acre	$9.22	1	$9.22
2-wheel drive tractor & front-end loader to loading totes (Labor)	hours	$22.00	1	$22.00
Interest on Operating Capital		$72.75	0.02	$1.55

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Self-propelled power lift to production prune	acre	$16.47	1	$16.47
Self-propelled power lift to production prune (Labor)	hours	$22.00	1.2	$26.40
Maintenance pruning (Hz)	hour	$14.00	1.5	$21.00
2-wheel drive tractor & brush rake (1x)	acre	$2.27	1	$2.27
2-wheel drive tractor & brush rake (1x) (Labor)	hours	$22.00	0.24	$5.34
2-wheel drive tractor & fertilizer spreader (2x)	acre	$1.18	1	$1.18
2-wheel drive tractor & fertilizer spreader (2x) (Labor)	hours	$22.00	0.12	$2.66
Fertilizer - Urea (Hz)	acre	$51.79	1	$51.79
Fertilzer - Potash (Hz)	acre	$19.66	1	$19.66
Lime (Custom) (Hz)	acre	$121.00	0.2	$24.20
4-wheel drive tractor & blast sprayer (3.25x)	acre	$16.15	1	$16.15
4-wheel drive tractor & blast sprayer (3.25x) (Labor)	hours	$22.00	0.74	$16.38
Boron Spray Materials (Hz)	acre	$4.80	1	$4.80
Filbert Worm Spray Materials (Hz)	acre	$13.65	1	$13.65
Aphid/Leafroller Spray Materials (Hz)	acre	$16.64	1	$16.64
IPM Scout Labor (Hz)	hour	$14.00	1	$14.00

IPM Scout Materials (Hz)	acre	$2.57	1	$2.57
Nutrient Analysis (Hz)	acre	$0.58	1	$0.58
2-wheel drive tractor & weed sprayer (4x)	acre	$7.08	1	$7.08
2-wheel drive tractor & weed sprayer (4x) (Labor)	hours	$22.00	0.73	$16.12
Herbicide Strip Sprays (Hz)	acre	$5.10	1	$5.10
Sucker Control Material (Hz)	acre	$9.50	1	$9.50
4-wheel drive tractor & flail mower (3x)	acre	$10.71	1	$10.71
4-wheel drive tractor & flail mower (3x) (Labor)	hours	$22.00	0.73	$16.02
Rodent Control Labor (Hz)	hour	$14.00	1	$14.00
Rodent Control Materials (Hz)	acre	$7.00	1	$7.00
4-wheel drive tractor & level blade (1x)	acre	$2.25	1	$2.25
4-wheel drive tractor & level blade (1x) (Labor)	hours	$22.00	0.16	$3.56
Pickup - 1/2 ton 4x4	acre	$52.00	1	$52.00
Shop	acre	$6.92	1	$6.92
Property Insurance (ANC)	acre	$35.00	1	$35.00
Property Taxes (ANC)	acre	$20.00	1	$20.00
Miscellaneous & Overhead Charge	percent	$447.39	0.08	$35.79
Interest on Operating Capital		$496.79	0.02	$10.56

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Self-propelled nut sweeper (1x)	acre	$12.16	1	$12.16
4-wheel drive tractor & nut harvester (1x)	acre	$20.59	1	$20.59
2-wheel drive tractor & front-end loader to loading totes	acre	$4.38	1	$4.38
Self-propelled power lift to production prune	acre	$18.64	1	$18.64
2-wheel drive tractor & brush rake (1x)	acre	$1.49	1	$1.49
2-wheel drive tractor & fertilizer spreader (2x)	acre	$2.36	1	$2.36
4-wheel drive tractor & blast sprayer (3.25x)	acre	$16.87	1	$16.87
2-wheel drive tractor & weed sprayer (4x)	acre	$3.68	1	$3.68
4-wheel drive tractor & flail mower (3x)	acre	$10.56	1	$10.56
4-wheel drive tractor & level blade (1x)	acre	$1.98	1	$1.98
Pickup - 1/2 ton 4x4	acre	$15.56	1	$15.56

Total Annual Costs	**$818.71**
Returns minus Total Annual Costs	**$1,141.29**

Julian, James, Clark Seavert, and Jeff Olsen. 2008. *Orchard Economics: The Costs and Returns of Establishing and Producing Hazelnuts in the Willamette Valley*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8748-E.pdf.

Notes: Acres harvested averaged to 6,000 acres annually with per-acre yields 1,090 lbs at a price of $0.92/lb. For the representative hazelnut farm, yields were cumulatively increased 10%. Due to the fact that full production yields can produce upwards of 2,800 pounds per-acre, this assumption seems reasonable. Additionally, this conservative estimate should help account for renewal and expansion rates.

Hops

Hops Standard Trellis Drip Irrigation Mature

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Hops	pound	$2.50	2600	$6,500.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Packaging (Hops)	bale	$5.50	13	$71.50
Kiln Fuel (Hops)	bale	$14.00	13	$182.00
Hop Dryer & Baler (Hops)	bale	$10.00	13	$130.00
Interest on Operating Capital		$383.50	0.02	$8.15

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Seasonal Labor (Hops)	hour	$10.00	150	$1,500.00
Fertilizer & Leaf Feed (Hops FP)	acre	$250.00	1	$250.00
Chemicals (Hops FP)	acre	$450.00	1	$450.00
Parts & Repairs (Hops)	acre	$310.00	1	$310.00
Fuel & Oil (Hops)	acre	$200.00	1	$200.00
Trellis Repair (Hops)	acre	$40.00	1	$40.00
Irrigation Repairs (Hops)	acre	$50.00	1	$50.00
Facility Repairs (Hops)	acre	$50.00	1	$50.00
Supplies (Hops)	acre	$150.00	1	$150.00
Utilities (Hops)	acre	$90.00	1	$90.00
Consulting & Custom Hire (Hops)	acre	$20.00	1	$20.00
Insurance all farm (Hops)	acre	$190.00	1	$190.00
Land & Property Taxes (Hops)	acre	$82.50	1	$82.50
Interest on Operating Capital		$3,382.50	0.02	$71.88

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Equipment & Building Replacement (Hops)	acre	$500.00	1	$500.00

Total Annual Costs **$4,346.03**

Returns minus Total Annual Costs	**$2,153.97**

Galinato, Suzette, Ann George, and Herbert Hinman. 2011. *2010 Estimated Cost of Producing Hops in the Yakima Valley, Washington*. Washington State University Extension Service. http://cru.cahe.wsu.edu/CEPublications/FS028E/FS028E.pdf.

Leaf Lettuce and Radish, Conventional

Leaf Lettuce and Radishes Conventional Fresh Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Leaf Lettuce	carton	$8.00	900	$7,200.00
Radishes	carton	$9.00	700	$6,300.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
-- LEAF LETTUCE --		$0.00	0	$0.00
Boxes (AVC)	carton	$1.30	900	$1,170.00
-- RADISHES --		$0.00	0	$0.00
Packing Labor (AVC)	carton	$1.00	700	$700.00
Boxes paper & Ice (AVC)	carton	$1.60	700	$1,120.00
Packing Shed & Equipment (AVC)	carton	$0.15	700	$105.00
-- COMMON COSTS --		$0.00	0	$0.00
Hydo-cooling (AVC)	carton	$0.10	1600	$160.00
Refrigeration (AVC)	carton	$0.10	1600	$160.00
Delivery to Market (AVC)	carton	$0.08	1600	$128.00
Interest on Operating Capital		$3,543.00	0.02	$70.86

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- LEAF LETTUCE --		$0.00	0	$0.00
Harvest Labor (Ll)	carton	$1.30	900	$1,170.00
-- RADISHES --		$0.00	0	$0.00
Harvest Labor (Ra)	carton	$1.50	700	$1,050.00
Field Crates 20/acre (AVC)	times/acre	$13.00	0.5	$6.50
-- COMMON OPERATION --		$0.00	0	$0.00
4 wd Tractor & Trailer (2x)	acre	$136.12	1	$136.12
4 wd Tractor & Trailer (2x) (Labor)	hours	$14.30	13	$185.90
Interest on Operating Capital		$2,548.52	0.02	$50.97

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS --		$0.00	0	$0.00
Lime Application (AVC)	acre	$300.00	0.5	$150.00

4 wd Tractor & Deep Chisel (1x)	acre	$10.04	1	$10.04
4 wd Tractor & Deep Chisel (1x) (Labor)	hours	$14.30	0.61	$8.67
4 wd Tractor & Moldboard Plow (2x)	acre	$29.22	1	$29.22
4 wd Tractor & Moldboard Plow (2x) (Labor)	hours	$14.30	1.62	$23.14
4 wd Tractor & Disk (2x)	acre	$9.68	1	$9.68
4 wd Tractor & Disk (2x) (Labor)	hours	$14.30	0.57	$8.20
4 wd Tractor & Fertilize Spreader (2x)	acre	$3.46	1	$3.46
4 wd Tractor & Fertilize Spreader (2x) (Labor)	hours	$14.30	0.3	$4.22
4 wd Tractor & Rotary Tiller (2x)	acre	$35.22	1	$35.22
4 wd Tractor & Rotary Tiller (2x) (Labor)	hours	$13.00	1.62	$21.02
4 wd Tractor & Cultivator (1.5x)	acre	$7.78	1	$7.78
4 wd Tractor & Cultivator (1.5x) (Labor)	hours	$14.30	1.03	$14.74
2 wd Tractor & Sidedressing Fertilizer (1x)	acre	$5.82	1	$5.82
2 wd Tractor & Sidedressing Fertilizer (1x) (Labor)	hours	$13.00	1.15	$14.90
4 wd Tractor & Insecticide Sprayer (2x)	acre	$6.20	1	$6.20
4 wd Tractor & Insecticide Sprayer (2x) (Labor)	hours	$14.30	0.51	$7.26
4 wd Tractor & Weed Sprayer (4x)	acre	$12.72	1	$12.72
4 wd Tractor & Weed Sprayer (4x) (Labor)	hours	$13.00	1.02	$13.20
-- LEAF LETTUCE --		$0.00	0	$0.00
Fertilizer (Ll)	acre	$90.00	1	$90.00
4 wd Tractor & Transplanter (1x)	acre	$48.06	1	$48.06
4 wd Tractor & Transplanter (1x) (Labor)	hours	$14.30	2.12	$30.25
Planting Labor (Ll)	hour	$10.00	18	$180.00
Lettuce Transplants (Ll)	transplant	$0.03	28000	$840.00
Insecticides (Li)	acre	$100.00	1	$100.00
Herbicides (Ll)	acre	$72.00	1	$72.00
-- RADISHES --		$0.00	0	$0.00
Fertilizer (Ra)	acre	$45.00	1	$45.00
4 wd Tractor & Planter (1x)	acre	$12.06	1	$12.06
4 wd Tractor & Planter (1x) (Labor)	hours	$14.30	0.74	$10.53
Radish Seed (Ra)	acre	$800.00	1	$800.00
Insecticides (Ra)	acre	$75.00	1	$75.00
Herbicides (Ra)	acre	$72.00	1	$72.00
-- COMMON COSTS --		$0.00	0	$0.00
Irrigation Labor Handlines (AVC)	set	$7.50	6	$45.00
Irrigation Electricity (AVC)	set	$10.00	6	$60.00
Irrigation Pipe Rental (AVC)	acre	$110.00	1	$110.00
Pickup #1	acre	$82.67	1	$82.67
Pickup #2	acre	$44.33	1	$44.33
Truck	acre	$158.00	1	$158.00
ATV	acre	$11.20	1	$11.20
Property taxes (AVC)	acre	$20.00	1	$20.00

Property Insurance (AVC)	acre	$35.00	1	$35.00
Field Sanitation Equipment (AVC)	acre	$30.00	1	$30.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00
Interest on Operating Capital		$3,431.59	0.02	$68.63

Capital Investment

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS & COSTS --		$0.00	0	$0.00
4 wd Tractor & Deep Chisel (1x)	acre	$9.01	1	$9.01
4 wd Tractor & Moldboard Plow (2x)	acre	$15.32	1	$15.32
4 wd Tractor & Disk (2x)	acre	$6.14	1	$6.14
4 wd Tractor & Fertilize Spreader (2x)	acre	$1.58	1	$1.58
4 wd Tractor & Cultivator (1.5x)	acre	$2.48	1	$2.48
4 wd Tractor & Insecticide Sprayer (2x)	acre	$1.90	1	$1.90
4 wd Tractor & Trailer (2x)	acre	$15.10	1	$15.10
Pickup #1	acre	$18.67	1	$18.67
Pickup #2	acre	$2.13	1	$2.13
Truck	acre	$10.60	1	$10.60
ATV	acre	$3.88	1	$3.88
2 wd Tractor & Sidedressing Fertilizer (1x)	acre	$2.15	1	$2.15
4 wd Tractor & Transplanter (1x)	acre	$10.66	1	$10.66
4 wd Tractor & Planter (1x)	acre	$7.83	1	$7.83
4 wd Tractor & Weed Sprayer (4x)	acre	$2.56	1	$2.56
4 wd Tractor & Rotary Tiller (2x)	acre	$18.80	1	$18.80
Total Annual Costs				**$9,842.39**
Returns minus Total Annual Costs				**$3,657.61**

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. 2007. *Leaf Lettuce, Conventional, Fresh Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8932.pdf.

Perennial Ryegrass

Perennial Ryegrass (Marion County)

Budget Unit	acre

Returns

Name	Unit	$/Unit	Quantity	Value
Perennial Ryegrass Seed	lb	$0.54	1700	$918.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Commission Assessment + Seed Purity Test	acre	$5.61	1	$5.61
Seed Clean and Bag (PrR)	acre	$136.00	1	$136.00
Interest on Operating Capital		$141.61	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Seed Clean & Bag (NV)(PrR) Yield Propor.	lb	$0.08	1700	$136.00
Commission Assessment Fees (Proportionl)	lb	$0.00	1700	$2.04
Seed Test Pur/Ger (Proportional)	lb	$0.00	1700	$3.57
-- MACHINERY --		$0.00	0	$0.00
Hillside Combine w/ 30' Header	acre	$2.07	1	$2.07
Hillside Combine w/ 30' Header (Labor)	hours	$22.00	0.0573	$1.26
Tractor rubber tracked with Bankout Wagon	acre	$3.78	1	$3.78
Tractor rubber tracked with Bankout Wagon (Labor)	hours	$22.00	0.0632	$1.39
Semi Truck and Trailer	acre	$2.80	1	$2.80
Semi Truck and Trailer (Labor)	hours	$22.00	0.075	$1.65
2 1/2 Ton Truck older	acre	$1.59	1	$1.59
2 1/2 Ton Truck older (Labor)	hours	$22.00	0.06	$1.32
Interest on Operating Capital		$157.47	0.02	$2.68

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Seed Crop Inspection Flat Rate (PrR)	acre	$3.00	1	$3.00
-- FERTILIZER --		$0.00	0	$0.00
Fertilizer (PrR)	acre	$141.20	1	$141.20
-- CHEMICALS --		$0.00	0	$0.00
Chemical Pesticide & Spray (PrR)	acre	$107.71	1	$107.71
-- LAND PREPARATION --		$0.00	0	$0.00
Tractor rubber tracked with 40' Chisel Plow (1x)	acre	$3.82	1	$3.82
Tractor rubber tracked with 40' Chisel Plow (1x) (Labor)	hours	$22.00	0.0573	$1.26
-- CROP PRODUCTION --		$0.00	0	$0.00

Tractor rubber tracked with 36' Grain Drill (1x)	acre	$5.28	1	$5.28
Tractor rubber tracked with 36' Grain Drill (1x) (Labor)	hours	$22.00	0.0718	$1.58
Miscellaneous Business Expenses (Wh)	acre	$30.00	1	$30.00
Tractor rubber tracked with 90' Field Sprayer (2x)	acre	$3.52	1	$3.52
Tractor rubber tracked with 90' Field Sprayer (2x) (Labor)	hours	$22.00	0.0482	$1.06
3/4 Ton Pickup (2)	acre	$10.06	1	$10.06
250 HP Tractor with Disk (3x)	acre	$15.66	1	$15.66
250 HP Tractor with Disk (3x) (Labor)	hours	$22.00	0.29	$6.42
-- OTHER --		$0.00	0	$0.00
Miscellaneous Business Expenses (PrR)	acre	$30.00	1	$30.00
Interest on Operating Capital		$360.57	0.02	$6.13

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Hillside Combine w/ 30' Header	acre	$5.05	1	$5.05
Tractor rubber tracked with Bankout Wagon	acre	$2.12	1	$2.12
Tractor rubber tracked with 40' Chisel Plow (1x)	acre	$2.51	1	$2.51
Tractor rubber tracked with 90' Field Sprayer (2x)	acre	$2.40	1	$2.40
Tractor rubber tracked with 36' Grain Drill (1x)	acre	$2.15	1	$2.15
Semi Truck and Trailer	acre	$1.62	1	$1.62
2 1/2 Ton Truck older	acre	$0.38	1	$0.38
3/4 Ton Pickup (2)	acre	$2.48	1	$2.48
250 HP Tractor with Disk (3x)	acre	$4.47	1	$4.47

Total Annual Costs	**$691.64**
Returns minus Total Annual Costs	**$226.36**

Seavert, Clark, Steven Petrie, and Sandy Macnab. 2012. *Wheat (Winter) Following a Non-cereal Crop, Conservation Tillage, Annual Cropping System, 18-24 Inch Precipitation Zone, North Central Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0039.pdf.

Silberstein, Tom, Bart Eleveld, Bill Young, and Emily Lahmann. 2010. *Perennial Ryegrass Seed, Establishment and Production North Williamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0008.pdf.

Snap/Bush Beans

Bush Beans Conventional Processed Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Beans 1's and 2's	ton	$215.00	6.1	$1,311.50

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Bush Bean Harvester (1x)	acre	$52.56	1	$52.56
Bush Bean Harvester (1x) (Labor)	hours	$22.00	1.18	$25.93
Hauling (2 Trucks)	acre	$22.42	1	$22.42
Hauling (2 Trucks) (Labor)	hours	$22.00	1	$22.00
Interest on Operating Capital		$122.91	0.03	$3.93

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Soil test (AVC)	acre	$2.00	1	$2.00
Lime application (AVC)	acre	$75.00	1	$75.00
4 wd Tractor#1 & Tandem Disk (1x)	acre	$5.53	1	$5.53
4 wd Tractor#1 & Tandem Disk (1x) (Labor)	hours	$22.00	0.1	$2.26
4 wd Tractor#1 & Moldboard Plow (1x)	acre	$6.81	1	$6.81
4 wd Tractor#1 & Moldboard Plow (1x) (Labor)	hours	$22.00	0.13	$2.85
4 wd Tractyor#2 & Harrow/Roller Packer (1x)	acre	$4.23	1	$4.23
4 wd Tractyor#2 & Harrow/Roller Packer (1x) (Labor)	hours	$22.00	0.0923	$2.03
Fertilizer - Pre-plant (Bb)	acre	$65.00	1	$65.00
4 wd Tractor#2 & Field Cultivator (1x)	acre	$2.05	1	$2.05
4 wd Tractor#2 & Field Cultivator (1x) (Labor)	hours	$22.00	0.0514	$1.13
4 wd Tractor#2 & Rotovator (1x)	acre	$11.96	1	$11.96
4 wd Tractor#2 & Rotovator (1x) (Labor)	hours	$22.00	0.23	$5.08
2 wd Tractor#4 & Bean Planter (1x)	acre	$6.26	1	$6.26
2 wd Tractor#4 & Bean Planter (1x) (Labor)	hours	$22.00	0.15	$3.38
Bean Seed (Bb)	acre	$200.00	1	$200.00
Side Dress Fertilizer (Bb)	acre	$50.00	1	$50.00
4 wd Tractor#2 & Row Cultivator (1x)	acre	$2.05	1	$2.05
4 wd Tractor#2 & Row Cultivator (1x) (Labor)	hours	$22.00	0.0514	$1.13

Self-propelled Boom Sprayer (2x)	acre	$5.72	1	$5.72
Self-propelled Boom Sprayer (2x) (Labor)	hours	$22.00	0.1	$2.30
Herbicides (Bb)	acre	$50.00	1	$50.00
Fungicides (Bb)	acre	$50.00	1	$50.00
Insecticide (Bb)	acre	$5.00	1	$5.00
4 wd Tractor#2 & Flail Chop (.5x)	acre	$2.29	1	$2.29
4 wd Tractor#2 & Flail Chop (.5x) (Labor)	hours	$22.00	0.0491	$1.08
Irrigation Labor (AVC)	hour	$12.00	5	$60.00
Irrigation Pumping Costs (AVC)	acre/inch	$3.50	12	$42.00
Irrigation Repairs & Maintenance (AVC)	acre	$25.00	1	$25.00
Pickup	acre	$52.00	1	$52.00
ATV	acre	$5.56	1	$5.56
Property taxes (AVC)	acre	$20.00	1	$20.00
Property Insurance (AVC)	acre	$35.00	1	$35.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00
Interest on Operating Capital		$879.70	0.03	$28.15

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Bush Bean Harvester (1x)	acre	$54.40	1	$54.40
4 wd Tractor#1 & Tandem Disk (1x)	acre	$1.57	1	$1.57
4 wd Tractor#1 & Moldboard Plow (1x)	acre	$2.30	1	$2.30
4 wd Tractor#2 & Rotovator (1x)	acre	$1.77	1	$1.77
4 wd Tractor#2 & Flail Chop (.5x)	acre	$0.42	1	$0.42
4 wd Tractor#2 & Field Cultivator (1x)	acre	$0.24	1	$0.24
4 wd Tractor#2 & Row Cultivator (1x)	acre	$0.24	1	$0.24
4 wd Tractyor#2 & Harrow/Roller Packer (1x)	acre	$1.08	1	$1.08
2 wd Tractor#4 & Bean Planter (1x)	acre	$1.24	1	$1.24
Hauling (2 Trucks)	acre	$16.98	1	$16.98
Pickup	acre	$21.16	1	$21.16
ATV	acre	$4.23	1	$4.23
Self-propelled Boom Sprayer (2x)	acre	$5.74	1	$5.74
Total Annual Costs				**$1,146.06**
Returns minus Total Annual Costs				**$165.44**

Julian, Jim, Clark Seavert, Dan McGrath, Robert McReynolds, and Ed Peachey. 2010. *Bush Beans, Processed Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0004.pdf.

Spinach and Leaf Lettuce, Conventional Fresh

Spinach and Leaf Lettuce Conventional Fresh Market Oregon

Budget Unit	acre

Returns

Name	Unit	$/Unit	Quantity	Value
Spinach	carton	$9.00	750	$6,750.00
Leaf Lettuce	carton	$8.00	900	$7,200.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
-- SPINACH --		$0.00	0	$0.00
Packing Labor (AVC)	carton	$1.00	750	$750.00
Packing Shed & Euipment (AVC)	carton	$0.15	750	$112.50
-- LEAF LETTUCE --		$0.00	0	$0.00
-- COMMON COSTS --		$0.00	0	$0.00
Boxes (AVC)	carton	$1.30	1650	$2,145.00
Hydo-cooling (AVC)	carton	$0.10	1650	$165.00
Refrigeration (AVC)	carton	$0.10	1650	$165.00
Delivery to Market (AVC)	carton	$0.08	1650	$132.00
Interest on Operating Capital		$3,469.50	0.02	$69.39

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- SPINACH --		$0.00	0	$0.00
Harvesting Labor (Sp)	carton	$2.00	750	$1,500.00
Field Crates 20/acre (Sp)	times/acre	$13.00	0.5	$6.50
-- LEAF LETTUCE --		$0.00	0	$0.00
Harvest Labor (Ll)	carton	$1.30	900	$1,170.00
-- COMMON OPERATIONS --		$0.00	0	$0.00
4 wd Tractor & Trailer (2x)	acre	$136.12	1	$136.12
4 wd Tractor & Trailer (2x) (Labor)	hours	$14.30	13	$185.90
Interest on Operating Capital		$2,998.52	0.02	$59.97

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS --		$0.00	0	$0.00
Lime Application (AVC)	acre	$300.00	0.5	$150.00
4 wd Tractor & Deep Chisel (1x)	acre	$10.04	1	$10.04
4 wd Tractor & Deep Chisel (1x) (Labor)	hours	$14.30	0.61	$8.67
4 wd Tractor & Weed Sprayer (4x)	acre	$12.72	1	$12.72

4 wd Tractor & Weed Sprayer (4x) (Labor)	hours	$14.30	1.02	$14.52
4 wd Tractor & Moldboard Plow (2x)	acre	$29.22	1	$29.22
4 wd Tractor & Moldboard Plow (2x) (Labor)	hours	$14.30	1.62	$23.14
4 wd Tractor & Disk (2x)	acre	$9.68	1	$9.68
4 wd Tractor & Disk (2x) (Labor)	hours	$14.30	0.57	$8.20
4 wd Tractor & Fertilize Spreader (2x)	acre	$3.46	1	$3.46
4 wd Tractor & Fertilize Spreader (2x) (Labor)	hours	$14.30	0.3	$4.22
4 wd Tractor & Rotary Tiller (2x)	acre	$35.22	1	$35.22
4 wd Tractor & Rotary Tiller (2x) (Labor)	hours	$14.30	1.62	$23.14
2 wd Tractor & Sidedressing Fertilizer (1x)	acre	$5.82	1	$5.82
2 wd Tractor & Sidedressing Fertilizer (1x) (Labor)	hours	$14.30	1.15	$16.39
4 wd Tractor & Cultivator (3x)	acre	$15.57	1	$15.57
4 wd Tractor & Cultivator (3x) (Labor)	hours	$14.30	2.06	$29.49
4 wd Tractor & Insecticide Sprayer (2x)	acre	$6.20	1	$6.20
4 wd Tractor & Insecticide Sprayer (2x) (Labor)	hours	$14.30	0.51	$7.26
-- SPINACH --		$0.00	0	$0.00
Fertilizer (Sp)	acre	$100.00	1	$100.00
4 wd Tractor & Planter (1x)	acre	$12.06	1	$12.06
4 wd Tractor & Planter (1x) (Labor)	hours	$14.30	0.74	$10.53
Spinach Seed (Sp)	acre	$400.00	1	$400.00
Insecticides (Sp)	acre	$75.00	1	$75.00
Herbicides (Sp)	acre	$72.00	1	$72.00
-- LEAF LETTUCE --		$0.00	0	$0.00
Fertilizer (Ll)	acre	$90.00	1	$90.00
4 wd Tractor & Transplanter (1x)	acre	$48.06	1	$48.06
4 wd Tractor & Transplanter (1x) (Labor)	hours	$14.30	2.12	$30.25
Planting Labor (Ll)	hour	$10.00	18	$180.00
Lettuce Transplants (Ll)	transplant	$0.03	28000	$840.00
Insecticides (Li)	acre	$100.00	1	$100.00
Herbicides (Ll)	acre	$72.00	1	$72.00
-- COMMON COSTS --		$0.00	0	$0.00
Irrigation Labor Handlines (AVC)	set	$7.50	6	$45.00
Irrigation Electricity (AVC)	set	$10.00	6	$60.00
Irrigation Pipe Rental (AVC)	acre	$110.00	1	$110.00
Pickup #1	acre	$82.67	1	$82.67
Pickup #2	acre	$44.33	1	$44.33
Truck	acre	$158.00	1	$158.00
ATV	acre	$11.20	1	$11.20
Property taxes (AVC)	acre	$20.00	1	$20.00
Property Insurance (AVC)	acre	$35.00	1	$35.00
Field Sanitation Equipment (AVC)	acre	$30.00	1	$30.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00

Interest on Operating Capital	$3,114.06	0.02	$62.28

Capital Investment

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS & COSTS --		$0.00	0	$0.00
4 wd Tractor & Deep Chisel (1x)	acre	$4.91	1	$4.91
4 wd Tractor & Moldboard Plow (2x)	acre	$15.32	1	$15.32
4 wd Tractor & Disk (2x)	acre	$6.14	1	$6.14
4 wd Tractor & Fertilize Spreader (2x)	acre	$1.58	1	$1.58
4 wd Tractor & Cultivator (3x)	acre	$4.95	1	$4.95
4 wd Tractor & Insecticide Sprayer (2x)	acre	$1.90	1	$1.90
4 wd Tractor & Trailer (2x)	acre	$15.10	1	$15.10
Pickup #1	acre	$18.67	1	$18.67
Pickup #2	acre	$2.13	1	$2.13
Truck	acre	$10.60	1	$10.60
ATV	acre	$3.88	1	$3.88
2 wd Tractor & Sidedressing Fertilizer (1x)	acre	$2.15	1	$2.15
4 wd Tractor & Transplanter (1x)	acre	$10.66	1	$10.66
4 wd Tractor & Planter (1x)	acre	$7.83	1	$7.83
4 wd Tractor & Rotary Tiller (2x)	acre	$18.80	1	$18.80
4 wd Tractor & Weed Sprayer (4x)	acre	$2.56	1	$2.56
Total Annual Costs				**$9,900.90**
Returns minus Total Annual Costs				**$4,049.10**

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. *Spinach, Conventional, Fresh Market, Willamette Valley Region*. Oregon State University Extension Service, March 2007. http://arec.oregonstate.edu/oaeb/files/pdf/EM8928.pdf.

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. 2007. *Leaf Lettuce, Conventional, Fresh Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8932.pdf.

Spinach and Radish, Conventional

Spinach and Radishes Conventional Fresh Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Spinach	carton	$9.00	750	$6,750.00
Radishes	carton	$9.00	700	$6,300.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
-- SPINACH --		$0.00	0	$0.00
Boxes (AVC)	carton	$1.30	750	$975.00
-- RADISHES --		$0.00	0	$0.00
Boxes paper & Ice (AVC)	carton	$1.60	700	$1,120.00
-- COMMON COSTS --		$0.00	0	$0.00
Packing Labor (AVC)	carton	$1.00	1450	$1,450.00
Hydo-cooling (AVC)	carton	$0.10	1450	$145.00
Refrigeration (AVC)	carton	$0.10	1450	$145.00
Delivery to Market (AVC)	carton	$0.08	1450	$116.00
Packing Shed & Equipment (AVC)	carton	$0.15	1450	$217.50
Interest on Operating Capital		$4,168.50	0.02	$83.37

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- SPINACH --		$0.00	0	$0.00
Harvesting Labor (Sp)	carton	$2.00	750	$1,500.00
Field Crates 20/acre (AVC)	times/acre	$13.00	0.5	$6.50
-- RADISHES --		$0.00	0	$0.00
Harvest Labor (Ra)	carton	$1.50	700	$1,050.00
Field Crates 20/acre (AVC)	times/acre	$13.00	0.5	$6.50
-- COMMON OPERATIONS --		$0.00	0	$0.00
4 wd Tractor & Trailer (2x)	acre	$136.12	1	$136.12
4 wd Tractor & Trailer (2x) (Labor)	hours	$14.30	13	$185.90
Interest on Operating Capital		$2,885.02	0.02	$57.70

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS --		$0.00	0	$0.00
Lime Application (AVC)	acre	$300.00	0.5	$150.00
4 wd Tractor & Deep Chisel (1x)	acre	$10.04	1	$10.04

4 wd Tractor & Deep Chisel (1x) (Labor)	hours	$14.30	0.61	$8.67
4 wd Tractor & Disk (2x)	acre	$9.68	1	$9.68
4 wd Tractor & Disk (2x) (Labor)	hours	$14.30	0.57	$8.20
4 wd Tractor & Moldboard Plow (2x)	acre	$29.22	1	$29.22
4 wd Tractor & Moldboard Plow (2x) (Labor)	hours	$14.30	1.62	$23.14
4 wd Tractor & Fertilize Spreader (2x)	acre	$3.46	1	$3.46
4 wd Tractor & Fertilize Spreader (2x) (Labor)	hours	$14.30	0.3	$4.22
4 wd Tractor & Rotary Tiller (2x)	acre	$35.22	1	$35.22
4 wd Tractor & Rotary Tiller (2x) (Labor)	hours	$14.30	1.62	$23.14
4 wd Tractor & Cultivator (1.5x)	acre	$7.78	1	$7.78
4 wd Tractor & Cultivator (1.5x) (Labor)	hours	$14.30	1.03	$14.74
4 wd Tractor & Insecticide Sprayer (2x)	acre	$6.20	1	$6.20
4 wd Tractor & Insecticide Sprayer (2x) (Labor)	hours	$14.30	0.51	$7.26
4 wd Tractor & Planter (2x)	acre	$24.12	1	$24.12
4 wd Tractor & Planter (2x) (Labor)	hours	$14.30	1.47	$21.06
4 wd Tractor & Weed Sprayer (4x)	acre	$12.72	1	$12.72
4 wd Tractor & Weed Sprayer (4x) (Labor)	hours	$14.30	1.02	$14.52
-- SPINACH --		$0.00	0	$0.00
Fertilizer (Sp)	acre	$100.00	1	$100.00
Spinach Seed (Sp)	acre	$400.00	1	$400.00
Insecticides (Sp)	acre	$75.00	1	$75.00
Herbicides (Sp)	acre	$72.00	1	$72.00
-- RADISHES --		$0.00	0	$0.00
Fertilizer (Ra)	acre	$45.00	1	$45.00
Radish Seed (Ra)	acre	$800.00	1	$800.00
Insecticides (Ra)	acre	$75.00	1	$75.00
Herbicides (Ra)	acre	$72.00	1	$72.00
-- COMMON COSTS --		$0.00	0	$0.00
Irrigation Labor Handlines (AVC)	set	$7.50	6	$45.00
Irrigation Electricity (AVC)	set	$10.00	6	$60.00
Irrigation Pipe Rental (AVC)	acre	$110.00	1	$110.00
Pickup #1	acre	$82.67	1	$82.67
Pickup #2	acre	$44.33	1	$44.33
Truck	acre	$158.00	1	$158.00
ATV	acre	$11.20	1	$11.20
Property taxes (AVC)	acre	$20.00	1	$20.00
Property Insurance (AVC)	acre	$35.00	1	$35.00
Field Sanitation Equipment (AVC)	acre	$30.00	1	$30.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00
Interest on Operating Capital		$2,723.59	0.02	$54.47

Capital Investment

Name	Unit	$/Unit	Quantity	Value
-- COMMON OPERATIONS& COSTS --		$0.00	0	$0.00
4 wd Tractor & Deep Chisel (1x)	acre	$4.91	1	$4.91
4 wd Tractor & Moldboard Plow (2x)	acre	$15.32	1	$15.32
4 wd Tractor & Disk (2x)	acre	$6.14	1	$6.14
4 wd Tractor & Fertilize Spreader (2x)	acre	$1.58	1	$1.58
4 wd Tractor & Cultivator (1.5x)	acre	$2.48	1	$2.48
4 wd Tractor & Insecticide Sprayer (2x)	acre	$1.90	1	$1.90
4 wd Tractor & Trailer (2x)	acre	$15.10	1	$15.10
Pickup #1	acre	$18.67	1	$18.67
Pickup #2	acre	$2.13	1	$2.13
Truck	acre	$10.60	1	$10.60
ATV	acre	$3.88	1	$3.88
4 wd Tractor & Planter (2x)	acre	$15.66	1	$15.66
4 wd Tractor & Rotary Tiller (2x)	acre	$18.80	1	$18.80
4 wd Tractor & Weed Sprayer (4x)	acre	$2.60	1	$2.60
Total Annual Costs				**$10,092.43**
Returns minus Total Annual Costs				**$2,957.57**

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. 2007. *Spinach, Conventional, Fresh Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8928.pdf.

Seavert, Clark, Robert McReynolds, Chip Bubl, Nick Andrews, and Jenny Freeborn. 2007. *Radishes, Conventional, Fresh Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/EM8930.pdf.

Sweet Corn, Conventional Processed

Sweet Corn Conventional Processed Market Oregon

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Sweet Corn	ton	$147.20	7	$1,030.40

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Interest on Operating Capital		$0.00	0.03	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Corn Picker (1x)	acre	$36.69	1	$36.69
Corn Picker (1x) (Labor)	hours	$20.00	0.33	$6.55
Hauling (2 Trucks)	acre	$22.42	1	$22.42
Hauling (2 Trucks) (Labor)	hours	$20.00	1	$20.00
Interest on Operating Capital		$85.66	0.03	$2.74

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Soil test (AVC)	acre	$2.00	1	$2.00
Lime application (AVC)	acre	$75.00	1	$75.00
4 wd Tractor#1 & V-Ripper (1x)	acre	$7.63	1	$7.63
4 wd Tractor#1 & V-Ripper (1x) (Labor)	hours	$22.00	0.15	$3.39
4 wd Tractor#2 & Harrow/Roller Packer (2x)	acre	$8.46	1	$8.46
4 wd Tractor#2 & Harrow/Roller Packer (2x) (Labor)	hours	$22.00	0.18	$4.06
Pre-plant Fertilizer (Sc)	acre	$65.00	1	$65.00
4 wd Tractor#1 & Tandem Disk (1x)	acre	$5.53	1	$5.53
4 wd Tractor#1 & Tandem Disk (1x) (Labor)	hours	$22.00	0.1	$2.26
2 wd Tractor#4 & Corn Planter (1x)	acre	$6.26	1	$6.26
2 wd Tractor#4 & Corn Planter (1x) (Labor)	hours	$22.00	0.15	$3.38
Seed (Sc)	acre	$100.00	1	$100.00
Sidedress Fertilizer (Sc)	acre	$70.00	1	$70.00
4 wd Tractor#2 & Row Cultivator (1x)	acre	$2.05	1	$2.05
4 wd Tractor#2 & Row Cultivator (1x) (Labor)	hours	$22.00	0.0514	$1.13
Self-propelled Boom Sprayer (2x)	acre	$6.58	1	$6.58
Self-propelled Boom Sprayer (2x) (Labor)	hours	$22.00	0.12	$2.72
Herbicides (Sc)	acre	$30.00	1	$30.00
Insecticides (Sc)	acre	$40.00	1	$40.00

4 wd Tractor#3 & Fertilizer Spreader (1x)	acre	$1.09	1	$1.09
4 wd Tractor#3 & Fertilizer Spreader (1x) (Labor)	hours	$22.00	0.0423	$0.93
Fertilizer - Top Dress (Sc)	acre	$60.00	1	$60.00
Topping - Custom (Sc)	acre	$10.00	1	$10.00
4 wd Tractor#2 & Disk (2x)	acre	$8.86	1	$8.86
4 wd Tractor#2 & Disk (2x) (Labor)	hours	$22.00	0.22	$4.74
Irrigation Labor (AVC)	hour	$12.00	3	$36.00
Irrigation Pumping Costs (AVC)	acre/inch	$3.50	10	$35.00
Irrigation Repairs & Maintenance (AVC)	acre	$25.00	1	$25.00
Pickup	acre	$52.00	1	$52.00
ATV	acre	$5.73	1	$5.73
Property Insurance (AVC)	acre	$35.00	1	$35.00
Property taxes (AVC)	acre	$20.00	1	$20.00
Miscellaneous & Overhead (AVC)	acre	$75.00	1	$75.00
Interest on Operating Capital		$804.80	0.03	$25.75

Capital Investment

Name	Unit	$/Unit	Quantity	Value
4 wd Tractor#1 & Tandem Disk (1x)	acre	$1.57	1	$1.57
4 wd Tractor#2 & Disk (2x)	acre	$2.38	1	$2.38
4 wd Tractor#2 & Row Cultivator (1x)	acre	$0.24	1	$0.24
4 wd Tractor#3 & Fertilizer Spreader (1x)	acre	$0.41	1	$0.41
2 wd Tractor#4 & Corn Planter (1x)	acre	$1.24	1	$1.24
Hauling (2 Trucks)	acre	$25.48	1	$25.48
Corn Picker (1x)	acre	$3.31	1	$3.31
4 wd Tractor#1 & V-Ripper (1x)	acre	$1.94	1	$1.94
ATV	acre	$0.85	1	$0.85
Pickup	acre	$15.56	1	$15.56
Self-propelled Boom Sprayer (2x)	acre	$6.76	1	$6.76
4 wd Tractor#2 & Harrow/Roller Packer (2x)	acre	$2.16	1	$2.16

Total Annual Costs	**$980.85**
Returns minus Total Annual Costs	**$49.55**

Julian, Jim, Clark Seavert, Dan McGrath, Robert McReynolds, and Ed Peachey. 2010. *Sweet Corn, Processed Market, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0006.pdf.

Winter Wheat

Conventional Winter Wheat (Marion County)

Budget Unit acre

Returns

Name	Unit	$/Unit	Quantity	Value
Winter Wheat	bushel	$6.00	100	$600.00

Packing Processing and Value Added Costs

Name	Unit	$/Unit	Quantity	Value
Transport to PDX (Yield Proportional)	bushel	$0.27	100	$27.00
Wheat Commission (Wh)	bushel	$0.05	100	$5.00
Interest on Operating Capital		$32.00	0	$0.00

Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Hillside Combine w/ 30' Header	acre	$2.07	1	$2.07
Hillside Combine w/ 30' Header (Labor)	hours	$22.00	0.0573	$1.26
Tractor rubber tracked with Bankout Wagon	acre	$3.78	1	$3.78
Tractor rubber tracked with Bankout Wagon (Labor)	hours	$22.00	0.0632	$1.39
Semi Truck and Trailer	acre	$2.80	1	$2.80
Semi Truck and Trailer (Labor)	hours	$22.00	0.075	$1.65
2 1/2 Ton Truck older	acre	$1.59	1	$1.59
2 1/2 Ton Truck older (Labor)	hours	$22.00	0.06	$1.32
Interest on Operating Capital		$15.86	0.02	$0.27

Non-Harvest Costs

Name	Unit	$/Unit	Quantity	Value
Treated W.Wheat Seed (Winter Wheat)	acre	$20.00	1	$20.00
-- FERTILIZER --		$0.00	0	$0.00
Fertilizer (Winter Wheat)	acre	$82.10	1	$82.10
-- CHEMICALS --		$0.00	0	$0.00
Chemical Pesticide (Insect Herb Fungi)	acre	$51.05	1	$51.05
-- LAND PREPARATION --		$0.00	0	$0.00
Tractor rubber tracked with 40' Chisel Plow (1x)	acre	$3.82	1	$3.82
Tractor rubber tracked with 40' Chisel Plow (1x) (Labor)	hours	$22.00	0.0573	$1.26
-- CROP PRODUCTION --		$0.00	0	$0.00
Tractor rubber tracked with 36' Grain Drill (1x)	acre	$5.28	1	$5.28
Tractor rubber tracked with 36' Grain Drill (1x) (Labor)	hours	$22.00	0.0718	$1.58
Miscellaneous Business Expenses (Wh)	acre	$30.00	1	$30.00
Tractor rubber tracked with 90' Field Sprayer (2x)	acre	$3.52	1	$3.52

Tractor rubber tracked with 90' Field Sprayer (2x) (Labor)	hours	$22.00	0.0482	$1.06
3/4 Ton Pickup (2)	acre	$10.06	1	$10.06
250 HP Tractor with Disk (3x)	acre	$15.66	1	$15.66
250 HP Tractor with Disk (3x) (Labor)	hours	$22.00	0.29	$6.42
Interest on Operating Capital		$231.81	0.02	$3.94

Capital Investment

Name	Unit	$/Unit	Quantity	Value
Hillside Combine w/ 30' Header	acre	$5.05	1	$5.05
Tractor rubber tracked with Bankout Wagon	acre	$2.12	1	$2.12
Tractor rubber tracked with 40' Chisel Plow (1x)	acre	$2.51	1	$2.51
Tractor rubber tracked with 90' Field Sprayer (2x)	acre	$2.40	1	$2.40
Tractor rubber tracked with 36' Grain Drill (1x)	acre	$2.15	1	$2.15
Semi Truck and Trailer	acre	$1.62	1	$1.62
2 1/2 Ton Truck older	acre	$0.38	1	$0.38
3/4 Ton Pickup (2)	acre	$2.48	1	$2.48
250 HP Tractor with Disk (3x)	acre	$4.47	1	$4.47

Total Annual Costs	**$307.06**
Returns minus Total Annual Costs	**$292.94**

Mellbye, Mark, Bart Eleveld, Tom Silberstein, Mike Flowers, and Emily Lahmann. 2010. *Winter Wheat, Conventional Tillage and No-Till, Willamette Valley Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0015.pdf.

Seavert, Clark, Steven Petrie, and Sandy Macnab. 2012. *Wheat (Winter) Following a Non-cereal Crop, Conservation Tillage, Annual Cropping System, 18-24 Inch Precipitation Zone, North Central Region*. Oregon State University Extension Service. http://arec.oregonstate.edu/oaeb/files/pdf/AEB0039.pdf.

Notes: Utilized AgProfit to calculate assets—original wheat budget using Clark's modified for WM, used that for assets but included assets added from other WM wheat budget (Clark's budget based on 2,000 acres, WM one based on 1,200)

C. AgFinance Beginning Balance Sheets and Calculated Payment Capacities

Table C.1: **Alfalfa Hay**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Alfalfa Hay (A)**
Description	320-acre farm
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(All equipment 10 years and under)
Market value of equipment and breeding livestock:	$281,700
Long term Assets	(All equipment 11 years and above, including hay shed)
Market value of facilities and other improvements:	$196,700
Market value of real estate/acre	$5,000
Market value of real estate:	$1,600,000
Total Assets:	$2,112,400
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$36,038
Percentage Allocated to Intermediate Assets	78%
Percentage Allocated to Long-Term Assets	22%
Replacement Costs for Intermediate Assets (Year 1)	$28,170
Replacement Costs for Long-Term Assets (Year 1)	$7,868

Table C.2: **Blueberries**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Blueberries (B)**
Description	20-acre farm
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(Equipment 10 years and under)
Market value of equipment and breeding livestock:	$27,500
Long term Assets	(Equipment 11 year and above plus plants @ 3.50 plant, 1452 trees/acre, 20 acres total)
Market value of facilities and other improvements:	$259,840
Market value of real estate/acre	$10,000
Market value of real estate:	$200,000
Total Assets:	$521,340
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$13,144
Percentage Allocated to Intermediate Assets	21%
Percentage Allocated to Long-Term Assets	79%
Replacement Costs for Intermediate Assets (Year 1)	$2,750
Replacement Costs for Long-Term Assets (Year 1)	$10,394

Table C.3: **Fresh Vegetables**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Fresh Vegetables: Lettuce and Radishes (FV)**
Description	100-acre farm
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(Equipment at 10 years or less)
Market value of equipment and breeding livestock:	$50,500
Long term Assets	(Equipment 11 years and above)
Market value of facilities and other improvements:	$201,500
Market value of real estate/acre	$10,000
Market value of real estate:	$1,000,000
Total Assets:	$1,286,000
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$13,110
Percentage Allocated to Intermediate Assets	39%
Percentage Allocated to Long-Term Assets	61%
Replacement Costs for Intermediate Assets (Year 1)	$5,050
Replacement Costs for Long-Term Assets (Year 1)	$8,060

Table C.4: **Grass and Wheat**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Grass and Wheat (G/W)**
Description	2000-acre farm: 640 wheat (32%) & 1360 grass (68%)
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(All equipment 10 years and under)
Market value of equipment and breeding livestock:	$400,050
Long term Assets	(All equipment 11 years and above)
Market value of facilities and other improvements:	$710,600
Market value of real estate/acre	$5,000
Market value of real estate:	$10,000,000
Total Assets:	$11,144,650
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$68,429
Percentage Allocated to Intermediate Assets	58%
Percentage Allocated to Long-Term Assets	42%
Replacement Costs for Intermediate Assets (Year 1)	$40,005
Replacement Costs for Long-Term Assets (Year 1)	$28,424

Table C.5: **Hops**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Hops (H)**
Description	660 acres (Yakima Valley, WA)
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(General equipment as listed in budget)
Market value of equipment and breeding livestock:	$1,500,000
Long term Assets	(Picker, kiln, shop, baler, office as listed in budget)
Market value of facilities and other improvements:	$6,500,000
Market value of real estate/acre	$10,000
Market value of real estate:	$6,600,000
Total Assets:	$14,634,000
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$410,000
Percentage Allocated to Intermediate Assets	37%
Percentage Allocated to Long-Term Assets	63%
Replacement Costs for Intermediate Assets (Year 1)	$150,000
Replacement Costs for Long-Term Assets (Year 1)	$260,000

Table C.6: **Hazelnuts**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Hazelnuts (HZ)**
Description	100 acres (Willamette Valley)
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	
Market value of equipment and breeding livestock:	$172,900
Long term Assets	
Market value of facilities and other improvements:	$350,000
Market value of real estate/acre	$10,000
Market value of real estate:	$1,000,000
Total Assets:	$1,556,900
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	$1,555,400
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$31,290
Percentage Allocated to Intermediate Assets	55%
Percentage Allocated to Long-Term Assets	45%
Replacement Costs for Intermediate Assets (Year 1)	$17,290
Replacement Costs for Long-Term Assets (Year 1)	$14,000

Table C.7: **Processed Vegetables**

Balance Sheet Information (Beginning)	
Crop and Abbreviation	**Sweet Corn, Snap Beans, Broccoli, Cauliflower (PV)**
Description	375 acres (Willamette Valley)
Assets	
Current Assets	
Cash balance:	$25,000
Prepaid expenses and supplies:	$1,000
Products on hand or not sold:	$0
Invest in growing crops:	$5,000
Accounts receivable:	$0
Other current assets:	$0
Intermediate Assets	(4 crops average and only listing equipment/machinery with a lifespan of 10 years or less)
Market value of equipment and breeding livestock:	$172,950
Long term Assets	(4 crop average, equipment with 11-year or more lifespan)
Market value of facilities and other improvements:	$567,450
Market value of real estate/acre	$10,000
Market value of real estate:	$3,750,000
Total Assets:	$4,524,400
Liabilities	
Current Liabilities	
Accrued interest:	$0
Accounts payable and accrued expenses:	$1,500
Intermediate Liabilities	
Value of loans on intermediate assets:	$0
Long Term Liabilities	
Value of loans on long term assets:	$0
Total Liabilities:	$1,500
Net Worth:	
Depreciation/Replacement Costs (No loans)	
Depreciation Calculated by AgFinance	$39,993
Percentage Allocated to Intermediate Assets	43%
Percentage Allocated to Long-Term Assets	57%
Replacement Costs for Intermediate Assets (Year 1)	$17,295
Replacement Costs for Long-Term Assets (Year 1)	$22,698

Table C.8: **Alfalfa Hay Payment Capacity**

Representative Farm:	Alfalfa Hay (320 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 315,456	$ 151,418	$ 164,038	$ 16,404	$ 2,217,835	$ 66,535	$ 81,099	$ 253
2014	$ 315,456	$ 155,961	$ 159,495	$ 15,950	$ 2,321,422	$ 69,643	$ 73,903	$ 231
2015	$ 315,456	$ 160,640	$ 154,816	$ 15,482	$ 2,418,451	$ 72,554	$ 66,781	$ 209
2016	$ 315,456	$ 165,459	$ 149,997	$ 15,000	$ 2,508,706	$ 75,261	$ 59,736	$ 187
2017	$ 315,456	$ 170,423	$ 145,033	$ 14,503	$ 2,591,964	$ 77,759	$ 52,771	$ 165
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 315,456	$ 151,418	$ 164,038	$ 16,404	$ 2,217,835	$ 44,357	$ 103,278	$ 323
2014	$ 315,456	$ 155,961	$ 159,495	$ 15,950	$ 2,321,422	$ 46,428	$ 97,117	$ 303
2015	$ 315,456	$ 160,640	$ 154,816	$ 15,482	$ 2,418,451	$ 48,369	$ 90,965	$ 284
2016	$ 315,456	$ 165,459	$ 149,997	$ 15,000	$ 2,508,706	$ 50,174	$ 84,823	$ 265
2017	$ 315,456	$ 170,423	$ 145,033	$ 14,503	$ 2,591,964	$ 51,839	$ 78,690	$ 246
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 315,456	$ 151,418	$ 164,038	$ 8,202	$ 2,217,835	$ 66,535	$ 89,301	$ 279
2014	$ 315,456	$ 155,961	$ 159,495	$ 7,975	$ 2,321,422	$ 69,643	$ 81,878	$ 256
2015	$ 315,456	$ 160,640	$ 154,816	$ 7,741	$ 2,418,451	$ 72,554	$ 74,522	$ 233
2016	$ 315,456	$ 165,459	$ 149,997	$ 7,500	$ 2,508,706	$ 75,261	$ 67,236	$ 210
2017	$ 315,456	$ 170,423	$ 145,033	$ 7,252	$ 2,591,964	$ 77,759	$ 60,022	$ 188

C.9: **Alfalfa Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Alfalfa Hay (320 acres)						
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 318,611	$ 151,418	$ 167,193	$ 16,719	$ 2,220,990	$ 66,630	$ 83,844	$ 262
2014	$ 321,797	$ 155,961	$ 165,836	$ 16,584	$ 2,330,917	$ 69,928	$ 79,325	$ 248
2015	$ 325,015	$ 160,640	$ 164,375	$ 16,438	$ 2,437,505	$ 73,125	$ 74,812	$ 234
2016	$ 328,265	$ 165,459	$ 162,806	$ 16,281	$ 2,540,568	$ 76,217	$ 70,308	$ 220
2017	$ 331,547	$ 170,423	$ 161,124	$ 16,112	$ 2,639,918	$ 79,198	$ 65,814	$ 206
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 318,611	$ 151,418	$ 167,193	$ 16,719	$ 2,220,990	$ 44,420	$ 106,054	$ 331
2014	$ 321,797	$ 155,961	$ 165,836	$ 16,584	$ 2,330,917	$ 46,618	$ 102,634	$ 321
2015	$ 325,015	$ 160,640	$ 164,375	$ 16,438	$ 2,437,505	$ 48,750	$ 99,187	$ 310
2016	$ 328,265	$ 165,459	$ 162,806	$ 16,281	$ 2,540,568	$ 50,811	$ 95,714	$ 299
2017	$ 331,547	$ 170,423	$ 161,124	$ 16,112	$ 2,639,918	$ 52,798	$ 92,213	$ 288
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 318,611	$ 151,418	$ 167,193	$ 8,360	$ 2,220,990	$ 66,630	$ 92,204	$ 288
2014	$ 321,797	$ 155,961	$ 165,836	$ 8,292	$ 2,330,917	$ 69,928	$ 87,617	$ 274
2015	$ 325,015	$ 160,640	$ 164,375	$ 8,219	$ 2,437,505	$ 73,125	$ 83,031	$ 259
2016	$ 328,265	$ 165,459	$ 162,806	$ 8,140	$ 2,540,568	$ 76,217	$ 78,449	$ 245
2017	$ 331,547	$ 170,423	$ 161,124	$ 8,056	$ 2,639,918	$ 79,198	$ 73,870	$ 231

C.10: **Alfalfa Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Alfalfa Hay (320 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 324,920	$ 151,418	$ 173,502	$ 17,350	$ 2,227,299	$ 66,819	$ 89,333	$ 279
2014	$ 334,667	$ 155,961	$ 178,706	$ 17,871	$ 2,350,097	$ 70,503	$ 90,332	$ 282
2015	$ 344,707	$ 160,640	$ 184,067	$ 18,407	$ 2,476,377	$ 74,291	$ 91,369	$ 286
2016	$ 355,049	$ 165,459	$ 189,590	$ 18,959	$ 2,606,224	$ 78,187	$ 92,444	$ 289
2017	$ 365,700	$ 170,423	$ 195,277	$ 19,528	$ 2,739,726	$ 82,192	$ 93,558	$ 292
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 324,920	$ 151,418	$ 173,502	$ 17,350	$ 2,227,299	$ 44,546	$ 111,606	$ 349
2014	$ 334,667	$ 155,961	$ 178,706	$ 17,871	$ 2,350,097	$ 47,002	$ 113,833	$ 356
2015	$ 344,707	$ 160,640	$ 184,067	$ 18,407	$ 2,476,377	$ 49,528	$ 116,133	$ 363
2016	$ 355,049	$ 165,459	$ 189,590	$ 18,959	$ 2,606,224	$ 52,124	$ 118,507	$ 370
2017	$ 365,700	$ 170,423	$ 195,277	$ 19,528	$ 2,739,726	$ 54,795	$ 120,955	$ 378
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 324,920	$ 151,418	$ 173,502	$ 8,675	$ 2,227,299	$ 66,819	$ 98,008	$ 306
2014	$ 334,667	$ 155,961	$ 178,706	$ 8,935	$ 2,350,097	$ 70,503	$ 99,268	$ 310
2015	$ 344,707	$ 160,640	$ 184,067	$ 9,203	$ 2,476,377	$ 74,291	$ 100,572	$ 314
2016	$ 355,049	$ 165,459	$ 189,590	$ 9,480	$ 2,606,224	$ 78,187	$ 101,924	$ 319
2017	$ 365,700	$ 170,423	$ 195,277	$ 9,764	$ 2,739,726	$ 82,192	$ 103,321	$ 323

C.11: **Alfalfa Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Alfalfa Hay (320 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 331,229	$ 151,418	$ 179,811	$ 17,981	$ 2,233,608	$ 67,008	$ 94,822	$ 296
2014	$ 347,790	$ 155,961	$ 191,829	$ 19,183	$ 2,369,529	$ 71,086	$ 101,560	$ 317
2015	$ 365,180	$ 160,640	$ 204,540	$ 20,454	$ 2,516,282	$ 75,488	$ 108,598	$ 339
2016	$ 383,439	$ 165,459	$ 217,980	$ 21,798	$ 2,674,519	$ 80,236	$ 115,946	$ 362
2017	$ 402,611	$ 170,423	$ 232,188	$ 23,219	$ 2,844,932	$ 85,348	$ 123,621	$ 386
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 331,229	$ 151,418	$ 179,811	$ 17,981	$ 2,233,608	$ 44,672	$ 117,158	$ 366
2014	$ 347,790	$ 155,961	$ 191,829	$ 19,183	$ 2,369,529	$ 47,391	$ 125,256	$ 391
2015	$ 365,180	$ 160,640	$ 204,540	$ 20,454	$ 2,516,282	$ 50,326	$ 133,760	$ 418
2016	$ 383,439	$ 165,459	$ 217,980	$ 21,798	$ 2,674,519	$ 53,490	$ 142,692	$ 446
2017	$ 402,611	$ 170,423	$ 232,188	$ 23,219	$ 2,844,932	$ 56,899	$ 152,071	$ 475
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 331,229	$ 151,418	$ 179,811	$ 8,991	$ 2,233,608	$ 67,008	$ 103,812	$ 324
2014	$ 347,790	$ 155,961	$ 191,829	$ 9,591	$ 2,369,529	$ 71,086	$ 111,152	$ 347
2015	$ 365,180	$ 160,640	$ 204,540	$ 10,227	$ 2,516,282	$ 75,488	$ 118,825	$ 371
2016	$ 383,439	$ 165,459	$ 217,980	$ 10,899	$ 2,674,519	$ 80,236	$ 126,845	$ 396
2017	$ 402,611	$ 170,423	$ 232,188	$ 11,609	$ 2,844,932	$ 85,348	$ 135,231	$ 423

Table C.12: **Blueberry Payment Capacity**

Representative Farm:	Blueberries (20 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 193,323	$ 69,181	$ 124,142	$ 12,414	$ 642,260	$ 19,268	$ 92,460	$ 4,623
2014	$ 193,323	$ 71,206	$ 122,117	$ 12,212	$ 765,662	$ 22,970	$ 86,935	$ 4,347
2015	$ 193,323	$ 73,292	$ 120,031	$ 12,003	$ 886,985	$ 26,610	$ 81,418	$ 4,071
2016	$ 193,323	$ 75,440	$ 117,883	$ 11,788	$ 1,006,166	$ 30,185	$ 75,910	$ 3,795
2017	$ 193,323	$ 77,654	$ 115,669	$ 11,567	$ 1,123,138	$ 33,694	$ 70,408	$ 3,520
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 193,323	$ 69,181	$ 124,142	$ 12,414	$ 642,260	$ 12,845	$ 98,883	$ 4,944
2014	$ 193,323	$ 71,206	$ 122,117	$ 12,212	$ 765,662	$ 15,313	$ 94,592	$ 4,730
2015	$ 193,323	$ 73,292	$ 120,031	$ 12,003	$ 886,985	$ 17,740	$ 90,288	$ 4,514
2016	$ 193,323	$ 75,440	$ 117,883	$ 11,788	$ 1,006,166	$ 20,123	$ 85,971	$ 4,299
2017	$ 193,323	$ 77,654	$ 115,669	$ 11,567	$ 1,123,138	$ 22,463	$ 81,639	$ 4,082
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 193,323	$ 69,181	$ 124,142	$ 6,207	$ 642,260	$ 19,268	$ 98,667	$ 4,933
2014	$ 193,323	$ 71,206	$ 122,117	$ 6,106	$ 765,662	$ 22,970	$ 93,041	$ 4,652
2015	$ 193,323	$ 73,292	$ 120,031	$ 6,002	$ 886,985	$ 26,610	$ 87,420	$ 4,371
2016	$ 193,323	$ 75,440	$ 117,883	$ 5,894	$ 1,006,166	$ 30,185	$ 81,804	$ 4,090
2017	$ 193,323	$ 77,654	$ 115,669	$ 5,783	$ 1,123,138	$ 33,694	$ 76,191	$ 3,810

Table C.13: **Blueberry Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Blueberries (20 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 195,256	$ 69,181	$ 126,075	$ 12,608	$ 644,193	$ 19,326	$ 94,142	$ 4,707
2014	$ 197,209	$ 71,206	$ 126,003	$ 12,600	$ 771,481	$ 23,144	$ 90,258	$ 4,513
2015	$ 199,181	$ 73,292	$ 125,889	$ 12,589	$ 898,662	$ 26,960	$ 86,340	$ 4,317
2016	$ 201,173	$ 75,440	$ 125,733	$ 12,573	$ 1,025,692	$ 30,771	$ 82,389	$ 4,119
2017	$ 203,185	$ 77,654	$ 125,531	$ 12,553	$ 1,152,526	$ 34,576	$ 78,402	$ 3,920
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 195,256	$ 69,181	$ 126,075	$ 12,608	$ 644,193	$ 12,884	$ 100,584	$ 5,029
2014	$ 197,209	$ 71,206	$ 126,003	$ 12,600	$ 771,481	$ 15,430	$ 97,973	$ 4,899
2015	$ 199,181	$ 73,292	$ 125,889	$ 12,589	$ 898,662	$ 17,973	$ 95,327	$ 4,766
2016	$ 201,173	$ 75,440	$ 125,733	$ 12,573	$ 1,025,692	$ 20,514	$ 92,646	$ 4,632
2017	$ 203,185	$ 77,654	$ 125,531	$ 12,553	$ 1,152,526	$ 23,051	$ 89,927	$ 4,496
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 195,256	$ 69,181	$ 126,075	$ 6,304	$ 644,193	$ 19,326	$ 100,445	$ 5,022
2014	$ 197,209	$ 71,206	$ 126,003	$ 6,300	$ 771,481	$ 23,144	$ 96,558	$ 4,828
2015	$ 199,181	$ 73,292	$ 125,889	$ 6,294	$ 898,662	$ 26,960	$ 92,635	$ 4,632
2016	$ 201,173	$ 75,440	$ 125,733	$ 6,287	$ 1,025,692	$ 30,771	$ 88,676	$ 4,434
2017	$ 203,185	$ 77,654	$ 125,531	$ 6,277	$ 1,152,526	$ 34,576	$ 84,679	$ 4,234

Table C.14: **Blueberry Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Blueberries (20 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 199,123	$ 69,181	$ 129,942	$ 12,994	$ 648,059	$ 19,442	$ 97,506	$ 4,875
2014	$ 205,097	$ 71,206	$ 133,891	$ 13,389	$ 783,235	$ 23,497	$ 97,005	$ 4,850
2015	$ 211,249	$ 73,292	$ 137,957	$ 13,796	$ 922,485	$ 27,675	$ 96,487	$ 4,824
2016	$ 217,587	$ 75,440	$ 142,147	$ 14,215	$ 1,064,929	$ 31,948	$ 95,984	$ 4,799
2017	$ 224,115	$ 77,654	$ 146,461	$ 14,646	$ 1,213,692	$ 36,411	$ 95,404	$ 4,770
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 199,123	$ 69,181	$ 129,942	$ 12,994	$ 648,059	$ 12,961	$ 103,987	$ 5,199
2014	$ 205,097	$ 71,206	$ 133,891	$ 13,389	$ 783,235	$ 15,665	$ 104,837	$ 5,242
2015	$ 211,249	$ 73,292	$ 137,957	$ 13,796	$ 922,485	$ 18,450	$ 105,712	$ 5,286
2016	$ 217,587	$ 75,440	$ 142,147	$ 14,215	$ 1,064,929	$ 21,299	$ 106,634	$ 5,332
2017	$ 224,115	$ 77,654	$ 146,461	$ 14,646	$ 1,213,692	$ 24,274	$ 107,541	$ 5,377
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 199,123	$ 69,181	$ 129,942	$ 6,497	$ 648,059	$ 19,442	$ 104,003	$ 5,200
2014	$ 205,097	$ 71,206	$ 133,891	$ 6,695	$ 783,235	$ 23,497	$ 103,699	$ 5,185
2015	$ 211,249	$ 73,292	$ 137,957	$ 6,898	$ 922,485	$ 27,675	$ 103,385	$ 5,169
2016	$ 217,587	$ 75,440	$ 142,147	$ 7,107	$ 1,064,929	$ 31,948	$ 103,092	$ 5,155
2017	$ 224,115	$ 77,654	$ 146,461	$ 7,323	$ 1,213,692	$ 36,411	$ 102,727	$ 5,136

Table C.15: **Blueberry Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Blueberries (20 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 202,989	$ 69,181	$ 133,808	$ 13,381	$ 651,926	$ 19,558	$ 100,869	$ 5,043
2014	$ 213,139	$ 71,206	$ 141,933	$ 14,193	$ 795,144	$ 23,854	$ 103,885	$ 5,194
2015	$ 223,796	$ 73,292	$ 150,504	$ 15,050	$ 946,940	$ 28,408	$ 107,045	$ 5,352
2016	$ 234,986	$ 75,440	$ 159,546	$ 15,955	$ 1,107,783	$ 33,233	$ 110,358	$ 5,518
2017	$ 246,735	$ 77,654	$ 169,081	$ 16,908	$ 1,278,166	$ 38,345	$ 113,828	$ 5,691
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 202,989	$ 69,181	$ 133,808	$ 13,381	$ 651,926	$ 13,039	$ 107,389	$ 5,369
2014	$ 213,139	$ 71,206	$ 141,933	$ 14,193	$ 795,144	$ 15,903	$ 111,837	$ 5,592
2015	$ 223,796	$ 73,292	$ 150,504	$ 15,050	$ 946,940	$ 18,939	$ 116,515	$ 5,826
2016	$ 234,986	$ 75,440	$ 159,546	$ 15,955	$ 1,107,783	$ 22,156	$ 121,436	$ 6,072
2017	$ 246,735	$ 77,654	$ 169,081	$ 16,908	$ 1,278,166	$ 25,563	$ 126,610	$ 6,330
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 202,989	$ 69,181	$ 133,808	$ 6,690	$ 651,926	$ 19,558	$ 107,560	$ 5,378
2014	$ 213,139	$ 71,206	$ 141,933	$ 7,097	$ 795,144	$ 23,854	$ 110,982	$ 5,549
2015	$ 223,796	$ 73,292	$ 150,504	$ 7,525	$ 946,940	$ 28,408	$ 114,571	$ 5,729
2016	$ 234,986	$ 75,440	$ 159,546	$ 7,977	$ 1,107,783	$ 33,233	$ 118,335	$ 5,917
2017	$ 246,735	$ 77,654	$ 169,081	$ 8,454	$ 1,278,166	$ 38,345	$ 122,282	$ 6,114

Table C.16: **Fresh Vegetable Payment Capacity**

Representative Farm:	Fresh Vegetables (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,350,000	$ 968,363	$ 381,637	$ 38,164	$ 1,654,534	$ 49,636	$ 293,837	$ 2,938
2014	$ 1,350,000	$ 993,904	$ 356,096	$ 35,610	$ 2,001,722	$ 60,052	$ 260,435	$ 2,604
2015	$ 1,350,000	$ 1,020,211	$ 329,789	$ 32,979	$ 2,322,286	$ 69,669	$ 227,142	$ 2,271
2016	$ 1,350,000	$ 1,047,307	$ 302,693	$ 30,269	$ 2,615,424	$ 78,463	$ 193,961	$ 1,940
2017	$ 1,350,000	$ 1,075,216	$ 274,784	$ 27,478	$ 2,880,309	$ 86,409	$ 160,896	$ 1,609
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,353,000	$ 968,363	$ 384,637	$ 38,464	$ 1,654,534	$ 33,091	$ 313,083	$ 3,131
2014	$ 1,350,000	$ 993,904	$ 356,096	$ 35,610	$ 2,001,722	$ 40,034	$ 280,452	$ 2,805
2015	$ 1,350,000	$ 1,020,211	$ 329,789	$ 32,979	$ 2,322,286	$ 46,446	$ 250,364	$ 2,504
2016	$ 1,350,000	$ 1,047,307	$ 302,693	$ 30,269	$ 2,615,424	$ 52,308	$ 220,115	$ 2,201
2017	$ 1,350,000	$ 1,075,216	$ 274,784	$ 27,478	$ 2,880,309	$ 57,606	$ 189,699	$ 1,897
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,353,000	$ 968,363	$ 384,637	$ 19,232	$ 1,654,534	$ 49,636	$ 315,769	$ 3,158
2014	$ 1,350,000	$ 993,904	$ 356,096	$ 17,805	$ 2,001,722	$ 60,052	$ 278,240	$ 2,782
2015	$ 1,350,000	$ 1,020,211	$ 329,789	$ 16,489	$ 2,322,286	$ 69,669	$ 243,631	$ 2,436
2016	$ 1,350,000	$ 1,047,307	$ 302,693	$ 15,135	$ 2,615,424	$ 78,463	$ 209,096	$ 2,091
2017	$ 1,350,000	$ 1,075,216	$ 274,784	$ 13,739	$ 2,880,309	$ 86,409	$ 174,636	$ 1,746

Table C.17: **Fresh Vegetable Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Fresh Vegetables (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,363,500	$ 968,363	$ 395,137	$ 39,514	$ 1,668,034	$ 50,041	$ 305,582	$ 3,056
2014	$ 1,377,135	$ 993,904	$ 383,231	$ 38,323	$ 2,042,357	$ 61,271	$ 283,637	$ 2,836
2015	$ 1,390,906	$ 1,020,211	$ 370,695	$ 37,070	$ 2,403,828	$ 72,115	$ 261,511	$ 2,615
2016	$ 1,404,815	$ 1,047,307	$ 357,508	$ 35,751	$ 2,751,781	$ 82,553	$ 239,204	$ 2,392
2017	$ 1,418,864	$ 1,075,216	$ 343,648	$ 34,365	$ 3,085,529	$ 92,566	$ 216,717	$ 2,167
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,363,500	$ 968,363	$ 395,137	$ 39,514	$ 1,668,034	$ 33,361	$ 322,263	$ 3,223
2014	$ 1,377,135	$ 993,904	$ 383,231	$ 38,323	$ 2,042,357	$ 40,847	$ 304,061	$ 3,041
2015	$ 1,390,906	$ 1,020,211	$ 370,695	$ 37,070	$ 2,403,828	$ 48,077	$ 285,549	$ 2,855
2016	$ 1,404,815	$ 1,047,307	$ 357,508	$ 35,751	$ 2,751,781	$ 55,036	$ 266,722	$ 2,667
2017	$ 1,418,864	$ 1,075,216	$ 343,648	$ 34,365	$ 3,085,529	$ 61,711	$ 247,573	$ 2,476
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,363,500	$ 968,363	$ 395,137	$ 19,757	$ 1,668,034	$ 50,041	$ 325,339	$ 3,253
2014	$ 1,377,135	$ 993,904	$ 383,231	$ 19,162	$ 2,042,357	$ 61,271	$ 302,799	$ 3,028
2015	$ 1,390,906	$ 1,020,211	$ 370,695	$ 18,535	$ 2,403,828	$ 72,115	$ 280,045	$ 2,800
2016	$ 1,404,815	$ 1,047,307	$ 357,508	$ 17,875	$ 2,751,781	$ 82,553	$ 257,079	$ 2,571
2017	$ 1,418,864	$ 1,075,216	$ 343,648	$ 17,182	$ 3,085,529	$ 92,566	$ 233,900	$ 2,339

Table C.18: **Fresh Vegetable Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Fresh Vegetables (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,390,500	$ 968,363	$ 422,137	$ 42,214	$ 1,695,034	$ 50,851	$ 329,072	$ 3,291
2014	$ 1,432,215	$ 993,904	$ 438,311	$ 43,831	$ 2,124,437	$ 63,733	$ 330,747	$ 3,307
2015	$ 1,475,181	$ 1,020,211	$ 454,970	$ 45,497	$ 2,570,183	$ 77,105	$ 332,368	$ 3,324
2016	$ 1,519,437	$ 1,047,307	$ 472,130	$ 47,213	$ 3,032,758	$ 90,983	$ 333,934	$ 3,339
2017	$ 1,565,020	$ 1,075,216	$ 489,804	$ 48,980	$ 3,512,662	$ 105,380	$ 335,444	$ 3,354
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,390,500	$ 968,363	$ 422,137	$ 42,214	$ 1,695,034	$ 33,901	$ 346,023	$ 3,460
2014	$ 1,432,215	$ 993,904	$ 438,311	$ 43,831	$ 2,124,437	$ 42,489	$ 351,991	$ 3,520
2015	$ 1,475,181	$ 1,020,211	$ 454,970	$ 45,497	$ 2,570,183	$ 51,404	$ 358,069	$ 3,581
2016	$ 1,519,437	$ 1,047,307	$ 472,130	$ 47,213	$ 3,032,758	$ 60,655	$ 364,262	$ 3,643
2017	$ 1,565,020	$ 1,075,216	$ 489,804	$ 48,980	$ 3,512,662	$ 70,253	$ 370,570	$ 3,706
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,390,500	$ 968,363	$ 422,137	$ 21,107	$ 1,695,034	$ 50,851	$ 350,179	$ 3,502
2014	$ 1,432,215	$ 993,904	$ 438,311	$ 21,916	$ 2,124,437	$ 63,733	$ 352,662	$ 3,527
2015	$ 1,475,181	$ 1,020,211	$ 454,970	$ 22,749	$ 2,570,183	$ 77,105	$ 355,116	$ 3,551
2016	$ 1,519,437	$ 1,047,307	$ 472,130	$ 23,607	$ 3,032,758	$ 90,983	$ 357,541	$ 3,575
2017	$ 1,565,020	$ 1,075,216	$ 489,804	$ 24,490	$ 3,512,662	$ 105,380	$ 359,934	$ 3,599

Table C.19: **Fresh Vegetable Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Fresh Vegetables (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,417,500	$ 968,363	$ 449,137	$ 44,914	$ 1,722,034	$ 51,661	$ 352,562	$ 3,526
2014	$ 1,488,375	$ 993,904	$ 494,471	$ 49,447	$ 2,207,597	$ 66,228	$ 378,796	$ 3,788
2015	$ 1,562,794	$ 1,020,211	$ 542,583	$ 54,258	$ 2,740,955	$ 82,229	$ 406,096	$ 4,061
2016	$ 1,640,933	$ 1,047,307	$ 593,626	$ 59,363	$ 3,325,026	$ 99,751	$ 434,513	$ 4,345
2017	$ 1,722,980	$ 1,075,216	$ 647,764	$ 64,776	$ 3,962,891	$ 118,887	$ 464,101	$ 4,641
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,417,500	$ 968,363	$ 449,137	$ 44,914	$ 1,722,034	$ 34,441	$ 369,783	$ 3,698
2014	$ 1,488,375	$ 993,904	$ 494,471	$ 49,447	$ 2,207,597	$ 44,152	$ 400,872	$ 4,009
2015	$ 1,562,794	$ 1,020,211	$ 542,583	$ 54,258	$ 2,740,955	$ 54,819	$ 433,506	$ 4,335
2016	$ 1,640,933	$ 1,047,307	$ 593,626	$ 59,363	$ 3,325,026	$ 66,501	$ 467,763	$ 4,678
2017	$ 1,722,980	$ 1,075,216	$ 647,764	$ 64,776	$ 3,962,891	$ 79,258	$ 503,730	$ 5,037
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 1,417,500	$ 968,363	$ 449,137	$ 22,457	$ 1,722,034	$ 51,661	$ 375,019	$ 3,750
2014	$ 1,488,375	$ 993,904	$ 494,471	$ 24,724	$ 2,207,597	$ 66,228	$ 403,520	$ 4,035
2015	$ 1,562,794	$ 1,020,211	$ 542,583	$ 27,129	$ 2,740,955	$ 82,229	$ 433,225	$ 4,332
2016	$ 1,640,933	$ 1,047,307	$ 593,626	$ 29,681	$ 3,325,026	$ 99,751	$ 464,194	$ 4,642
2017	$ 1,722,980	$ 1,075,216	$ 647,764	$ 32,388	$ 3,962,891	$ 118,887	$ 496,489	$ 4,965

Table C.20: **Hazelnut Payment Capacity**

Representative Farm:	Hazelnuts (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 110,308	$ 57,198	$ 53,110	$ 5,311	$ 1,604,750	$ 48,143	$ (344)	$ (3)
2014	$ 120,336	$ 58,914	$ 61,422	$ 6,142	$ 1,665,284	$ 49,959	$ 5,321	$ 53
2015	$ 130,364	$ 60,681	$ 69,683	$ 6,968	$ 1,733,942	$ 52,018	$ 10,696	$ 107
2016	$ 140,392	$ 62,502	$ 77,890	$ 7,789	$ 1,810,664	$ 54,320	$ 15,781	$ 158
2017	$ 150,420	$ 64,377	$ 86,043	$ 8,604	$ 1,895,387	$ 56,862	$ 20,577	$ 206
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 110,308	$ 57,198	$ 53,110	$ 5,311	$ 1,604,750	$ 32,095	$ 15,704	$ 157
2014	$ 120,336	$ 58,914	$ 61,422	$ 6,142	$ 1,665,284	$ 33,306	$ 21,974	$ 220
2015	$ 130,364	$ 60,681	$ 69,683	$ 6,968	$ 1,733,942	$ 34,679	$ 28,036	$ 280
2016	$ 140,392	$ 62,502	$ 77,890	$ 7,789	$ 1,810,664	$ 36,213	$ 33,888	$ 339
2017	$ 150,420	$ 64,377	$ 86,043	$ 8,604	$ 1,895,387	$ 37,908	$ 39,531	$ 395
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 110,308	$ 57,198	$ 53,110	$ 2,656	$ 1,604,750	$ 48,143	$ 2,312	$ 23
2014	$ 120,336	$ 58,914	$ 61,422	$ 3,071	$ 1,665,284	$ 49,959	$ 8,392	$ 84
2015	$ 130,364	$ 60,681	$ 69,683	$ 3,484	$ 1,733,942	$ 52,018	$ 14,181	$ 142
2016	$ 140,392	$ 62,502	$ 77,890	$ 3,895	$ 1,810,664	$ 54,320	$ 19,676	$ 197
2017	$ 150,420	$ 64,377	$ 86,043	$ 4,302	$ 1,895,387	$ 56,862	$ 24,879	$ 249

Table C.21: **Hazelnut Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Hazelnuts (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 111,411	$ 57,198	$ 54,213	$ 5,421	$ 1,605,853	$ 48,176	$ 616	$ 6
2014	$ 122,755	$ 58,914	$ 63,841	$ 6,384	$ 1,668,806	$ 50,064	$ 7,393	$ 74
2015	$ 134,314	$ 60,681	$ 73,633	$ 7,363	$ 1,741,414	$ 52,242	$ 14,027	$ 140
2016	$ 146,092	$ 62,502	$ 83,590	$ 8,359	$ 1,823,837	$ 54,715	$ 20,516	$ 205
2017	$ 158,093	$ 64,377	$ 93,716	$ 9,372	$ 1,916,232	$ 57,487	$ 26,857	$ 269
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 111,411	$ 57,198	$ 54,213	$ 5,421	$ 1,605,853	$ 32,117	$ 16,675	$ 167
2014	$ 122,755	$ 58,914	$ 63,841	$ 6,384	$ 1,668,806	$ 33,376	$ 24,081	$ 241
2015	$ 134,314	$ 60,681	$ 73,633	$ 7,363	$ 1,741,414	$ 34,828	$ 31,441	$ 314
2016	$ 146,092	$ 62,502	$ 83,590	$ 8,359	$ 1,823,837	$ 36,477	$ 38,754	$ 388
2017	$ 158,093	$ 64,377	$ 93,716	$ 9,372	$ 1,916,232	$ 38,325	$ 46,020	$ 460
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 111,411	$ 57,198	$ 54,213	$ 2,711	$ 1,605,853	$ 48,176	$ 3,327	$ 33
2014	$ 122,755	$ 58,914	$ 63,841	$ 3,192	$ 1,668,806	$ 50,064	$ 10,585	$ 106
2015	$ 134,314	$ 60,681	$ 73,633	$ 3,682	$ 1,741,414	$ 52,242	$ 17,709	$ 177
2016	$ 146,092	$ 62,502	$ 83,590	$ 4,180	$ 1,823,837	$ 54,715	$ 24,695	$ 247
2017	$ 158,093	$ 64,377	$ 93,716	$ 4,686	$ 1,916,232	$ 57,487	$ 31,543	$ 315

Table C.22: **Hazelnut Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Hazelnuts (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 113,617	$ 57,198	$ 56,419	$ 5,642	$ 1,608,060	$ 48,242	$ 2,535	$ 25
2014	$ 127,664	$ 58,914	$ 68,750	$ 6,875	$ 1,675,922	$ 50,278	$ 11,597	$ 116
2015	$ 142,452	$ 60,681	$ 81,771	$ 8,177	$ 1,756,668	$ 52,700	$ 20,894	$ 209
2016	$ 158,012	$ 62,502	$ 95,510	$ 9,551	$ 1,851,011	$ 55,530	$ 30,429	$ 304
2017	$ 174,378	$ 64,377	$ 110,001	$ 11,000	$ 1,959,691	$ 58,791	$ 40,210	$ 402
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 113,617	$ 57,198	$ 56,419	$ 5,642	$ 1,608,060	$ 32,161	$ 18,616	$ 186
2014	$ 127,664	$ 58,914	$ 68,750	$ 6,875	$ 1,675,922	$ 33,518	$ 28,357	$ 284
2015	$ 142,452	$ 60,681	$ 81,771	$ 8,177	$ 1,756,668	$ 35,133	$ 38,461	$ 385
2016	$ 158,012	$ 62,502	$ 95,510	$ 9,551	$ 1,851,011	$ 37,020	$ 48,939	$ 489
2017	$ 174,378	$ 64,377	$ 110,001	$ 11,000	$ 1,959,691	$ 39,194	$ 59,807	$ 598
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 113,617	$ 57,198	$ 56,419	$ 2,821	$ 1,608,060	$ 48,242	$ 5,356	$ 54
2014	$ 127,664	$ 58,914	$ 68,750	$ 3,438	$ 1,675,922	$ 50,278	$ 15,035	$ 150
2015	$ 142,452	$ 60,681	$ 81,771	$ 4,089	$ 1,756,668	$ 52,700	$ 24,982	$ 250
2016	$ 158,012	$ 62,502	$ 95,510	$ 4,776	$ 1,851,011	$ 55,530	$ 35,204	$ 352
2017	$ 174,378	$ 64,377	$ 110,001	$ 5,500	$ 1,959,691	$ 58,791	$ 45,710	$ 457

Table C.23: **Hazelnut Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Hazelnuts (100 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 115,823	$ 57,198	$ 58,625	$ 5,863	$ 1,610,266	$ 48,308	$ 4,455	$ 45
2014	$ 132,670	$ 58,914	$ 73,756	$ 7,376	$ 1,683,134	$ 50,494	$ 15,886	$ 159
2015	$ 150,913	$ 60,681	$ 90,232	$ 9,023	$ 1,772,341	$ 53,170	$ 28,039	$ 280
2016	$ 170,647	$ 62,502	$ 108,145	$ 10,815	$ 1,879,318	$ 56,380	$ 40,951	$ 410
2017	$ 191,978	$ 64,377	$ 127,601	$ 12,760	$ 2,005,599	$ 60,168	$ 54,673	$ 547
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 115,823	$ 57,198	$ 58,625	$ 5,863	$ 1,610,266	$ 32,205	$ 20,557	$ 206
2014	$ 132,670	$ 58,914	$ 73,756	$ 7,376	$ 1,683,134	$ 33,663	$ 32,718	$ 327
2015	$ 150,913	$ 60,681	$ 90,232	$ 9,023	$ 1,772,341	$ 35,447	$ 45,762	$ 458
2016	$ 170,647	$ 62,502	$ 108,145	$ 10,815	$ 1,879,318	$ 37,586	$ 59,744	$ 597
2017	$ 191,978	$ 64,377	$ 127,601	$ 12,760	$ 2,005,599	$ 40,112	$ 74,729	$ 747
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 115,823	$ 57,198	$ 58,625	$ 2,931	$ 1,610,266	$ 48,308	$ 7,386	$ 74
2014	$ 132,670	$ 58,914	$ 73,756	$ 3,688	$ 1,683,134	$ 50,494	$ 19,574	$ 196
2015	$ 150,913	$ 60,681	$ 90,232	$ 4,512	$ 1,772,341	$ 53,170	$ 32,550	$ 326
2016	$ 170,647	$ 62,502	$ 108,145	$ 5,407	$ 1,879,318	$ 56,380	$ 46,358	$ 464
2017	$ 191,978	$ 64,377	$ 127,601	$ 6,380	$ 2,005,599	$ 60,168	$ 61,053	$ 611

Table C.24: **Hops Payment Capacity**

Representative Farm:	Hops (660 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,784,070	$ 2,559,992	$ 1,224,078	$ 122,408	$ 15,641,314	$ 469,239	$ 632,431	$ 958
2014	$ 3,784,070	$ 2,636,792	$ 1,147,278	$ 114,728	$ 16,568,499	$ 497,055	$ 535,495	$ 811
2015	$ 3,784,070	$ 2,715,895	$ 1,068,175	$ 106,818	$ 17,408,420	$ 522,253	$ 439,105	$ 665
2016	$ 3,784,070	$ 2,797,372	$ 986,698	$ 98,670	$ 18,158,362	$ 544,751	$ 343,277	$ 520
2017	$ 3,784,070	$ 2,881,293	$ 902,777	$ 90,278	$ 18,815,523	$ 564,466	$ 248,034	$ 376
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,784,070	$ 2,559,992	$ 1,224,078	$ 122,408	$ 15,641,314	$ 312,826	$ 788,844	$ 1,195
2014	$ 3,784,070	$ 2,636,792	$ 1,147,278	$ 114,728	$ 16,568,499	$ 331,370	$ 701,180	$ 1,062
2015	$ 3,784,070	$ 2,715,895	$ 1,068,175	$ 106,818	$ 17,408,420	$ 348,168	$ 613,189	$ 929
2016	$ 3,784,070	$ 2,797,372	$ 986,698	$ 98,670	$ 18,158,362	$ 363,167	$ 524,861	$ 795
2017	$ 3,784,070	$ 2,881,293	$ 902,777	$ 90,278	$ 18,815,523	$ 376,310	$ 436,189	$ 661
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,784,070	$ 2,559,992	$ 1,224,078	$ 61,204	$ 15,641,314	$ 469,239	$ 693,635	$ 1,051
2014	$ 3,784,070	$ 2,636,792	$ 1,147,278	$ 57,364	$ 16,568,499	$ 497,055	$ 592,859	$ 898
2015	$ 3,784,070	$ 2,715,895	$ 1,068,175	$ 53,409	$ 17,408,420	$ 522,253	$ 492,514	$ 746
2016	$ 3,784,070	$ 2,797,372	$ 986,698	$ 49,335	$ 18,158,362	$ 544,751	$ 392,612	$ 595
2017	$ 3,784,070	$ 2,881,293	$ 902,777	$ 45,139	$ 18,815,523	$ 564,466	$ 293,172	$ 444

Table C.24: **Hops Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Hops (660 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,821,911	$ 2,559,992	$ 1,261,919	$ 126,192	$ 15,679,154	$ 470,375	$ 665,352	$ 1,008
2014	$ 3,860,130	$ 2,636,792	$ 1,223,338	$ 122,334	$ 16,682,399	$ 500,472	$ 600,532	$ 910
2015	$ 3,898,732	$ 2,715,895	$ 1,182,837	$ 118,284	$ 17,636,982	$ 529,109	$ 535,444	$ 811
2016	$ 3,937,719	$ 2,797,372	$ 1,140,347	$ 114,035	$ 18,540,572	$ 556,217	$ 470,095	$ 712
2017	$ 3,977,096	$ 2,881,293	$ 1,095,803	$ 109,580	$ 19,390,758	$ 581,723	$ 404,500	$ 613
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,821,911	$ 2,559,992	$ 1,261,919	$ 126,192	$ 15,679,154	$ 313,583	$ 822,144	$ 1,246
2014	$ 3,860,130	$ 2,636,792	$ 1,223,338	$ 122,334	$ 16,682,399	$ 333,648	$ 767,356	$ 1,163
2015	$ 3,898,732	$ 2,715,895	$ 1,182,837	$ 118,284	$ 17,636,982	$ 352,740	$ 711,814	$ 1,079
2016	$ 3,937,719	$ 2,797,372	$ 1,140,347	$ 114,035	$ 18,540,572	$ 370,811	$ 655,501	$ 993
2017	$ 3,977,096	$ 2,881,293	$ 1,095,803	$ 109,580	$ 19,390,758	$ 387,815	$ 598,408	$ 907
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,821,911	$ 2,559,992	$ 1,261,919	$ 63,096	$ 15,679,154	$ 470,375	$ 728,448	$ 1,104
2014	$ 3,860,130	$ 2,636,792	$ 1,223,338	$ 61,167	$ 16,682,399	$ 500,472	$ 661,699	$ 1,003
2015	$ 3,898,732	$ 2,715,895	$ 1,182,837	$ 59,142	$ 17,636,982	$ 529,109	$ 594,586	$ 901
2016	$ 3,937,719	$ 2,797,372	$ 1,140,347	$ 57,017	$ 18,540,572	$ 556,217	$ 527,112	$ 799
2017	$ 3,977,096	$ 2,881,293	$ 1,095,803	$ 54,790	$ 19,390,758	$ 581,723	$ 459,290	$ 696

Table C.24: **Hops Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Hops (660 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,897,593	$ 2,559,992	$ 1,337,601	$ 133,760	$ 15,754,836	$ 472,645	$ 731,196	$ 1,108
2014	$ 4,014,520	$ 2,636,792	$ 1,377,728	$ 137,773	$ 16,912,471	$ 507,374	$ 732,581	$ 1,110
2015	$ 4,134,956	$ 2,715,895	$ 1,419,061	$ 141,906	$ 18,103,278	$ 543,098	$ 734,057	$ 1,112
2016	$ 4,259,005	$ 2,797,372	$ 1,461,633	$ 146,163	$ 19,328,154	$ 579,845	$ 735,625	$ 1,115
2017	$ 4,386,775	$ 2,881,293	$ 1,505,482	$ 150,548	$ 20,588,019	$ 617,641	$ 737,293	$ 1,117
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,897,593	$ 2,559,992	$ 1,337,601	$ 133,760	$ 15,754,836	$ 315,097	$ 888,744	$ 1,347
2014	$ 4,014,520	$ 2,636,792	$ 1,377,728	$ 137,773	$ 16,912,471	$ 338,249	$ 901,706	$ 1,366
2015	$ 4,134,956	$ 2,715,895	$ 1,419,061	$ 141,906	$ 18,103,278	$ 362,066	$ 915,089	$ 1,386
2016	$ 4,259,005	$ 2,797,372	$ 1,461,633	$ 146,163	$ 19,328,154	$ 386,563	$ 928,907	$ 1,407
2017	$ 4,386,775	$ 2,881,293	$ 1,505,482	$ 150,548	$ 20,588,019	$ 411,760	$ 943,173	$ 1,429
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,897,593	$ 2,559,992	$ 1,337,601	$ 66,880	$ 15,754,836	$ 472,645	$ 798,076	$ 1,209
2014	$ 4,014,520	$ 2,636,792	$ 1,377,728	$ 68,886	$ 16,912,471	$ 507,374	$ 801,467	$ 1,214
2015	$ 4,134,956	$ 2,715,895	$ 1,419,061	$ 70,953	$ 18,103,278	$ 543,098	$ 805,010	$ 1,220
2016	$ 4,259,005	$ 2,797,372	$ 1,461,633	$ 73,082	$ 19,328,154	$ 579,845	$ 808,707	$ 1,225
2017	$ 4,386,775	$ 2,881,293	$ 1,505,482	$ 75,274	$ 20,588,019	$ 617,641	$ 812,567	$ 1,231

Table C.24: **Hops Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Hops (660 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,973,274	$ 2,559,992	$ 1,413,282	$ 141,328	$ 15,830,517	$ 474,916	$ 797,038	$ 1,208
2014	$ 4,171,938	$ 2,636,792	$ 1,535,146	$ 153,515	$ 17,145,569	$ 514,367	$ 867,264	$ 1,314
2015	$ 4,380,534	$ 2,715,895	$ 1,664,639	$ 166,464	$ 18,581,955	$ 557,459	$ 940,716	$ 1,425
2016	$ 4,599,561	$ 2,797,372	$ 1,802,189	$ 180,219	$ 20,147,388	$ 604,422	$ 1,017,548	$ 1,542
2017	$ 4,829,539	$ 2,881,293	$ 1,948,246	$ 194,825	$ 21,850,017	$ 655,501	$ 1,097,921	$ 1,664
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,973,274	$ 2,559,992	$ 1,413,282	$ 141,328	$ 15,830,517	$ 316,610	$ 955,343	$ 1,447
2014	$ 4,171,938	$ 2,636,792	$ 1,535,146	$ 153,515	$ 17,145,569	$ 342,911	$ 1,038,720	$ 1,574
2015	$ 4,380,534	$ 2,715,895	$ 1,664,639	$ 166,464	$ 18,581,955	$ 371,639	$ 1,126,536	$ 1,707
2016	$ 4,599,561	$ 2,797,372	$ 1,802,189	$ 180,219	$ 20,147,388	$ 402,948	$ 1,219,022	$ 1,847
2017	$ 4,829,539	$ 2,881,293	$ 1,948,246	$ 194,825	$ 21,850,017	$ 437,000	$ 1,316,421	$ 1,995
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 3,973,274	$ 2,559,992	$ 1,413,282	$ 70,664	$ 15,830,517	$ 474,916	$ 867,702	$ 1,315
2014	$ 4,171,938	$ 2,636,792	$ 1,535,146	$ 76,757	$ 17,145,569	$ 514,367	$ 944,022	$ 1,430
2015	$ 4,380,534	$ 2,715,895	$ 1,664,639	$ 83,232	$ 18,581,955	$ 557,459	$ 1,023,948	$ 1,551
2016	$ 4,599,561	$ 2,797,372	$ 1,802,189	$ 90,109	$ 20,147,388	$ 604,422	$ 1,107,658	$ 1,678
2017	$ 4,829,539	$ 2,881,293	$ 1,948,246	$ 97,412	$ 21,850,017	$ 655,501	$ 1,195,333	$ 1,811

Table C.25: **Processed Vegetable Payment Capacity**

Representative Farm:	Processed Vegetables (600 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 893,854	$ 658,664	$ 235,190	$ 23,519	$ 4,711,914	$ 141,357	$ 70,314	$ 188
2014	$ 893,854	$ 677,387	$ 216,467	$ 21,647	$ 4,883,772	$ 146,513	$ 48,307	$ 129
2015	$ 893,854	$ 696,671	$ 197,183	$ 19,718	$ 5,034,854	$ 151,046	$ 26,419	$ 70
2016	$ 893,854	$ 716,535	$ 177,319	$ 17,732	$ 5,164,523	$ 154,936	$ 4,651	$ 12
2017	$ 893,854	$ 736,994	$ 156,860	$ 15,686	$ 5,272,120	$ 158,164	$ (16,990)	$ (45)
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 893,854	$ 658,664	$ 235,190	$ 23,519	$ 4,711,914	$ 94,238	$ 117,433	$ 313
2014	$ 893,854	$ 677,387	$ 216,467	$ 21,647	$ 4,883,772	$ 97,675	$ 97,145	$ 259
2015	$ 893,854	$ 696,671	$ 197,183	$ 19,718	$ 5,034,854	$ 100,697	$ 76,768	$ 205
2016	$ 893,854	$ 716,535	$ 177,319	$ 17,732	$ 5,164,523	$ 103,290	$ 56,297	$ 150
2017	$ 893,854	$ 736,994	$ 156,860	$ 15,686	$ 5,272,120	$ 105,442	$ 35,732	$ 95
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 893,854	$ 658,664	$ 235,190	$ 11,760	$ 4,711,914	$ 141,357	$ 82,073	$ 219
2014	$ 893,854	$ 677,387	$ 216,467	$ 10,823	$ 4,883,772	$ 146,513	$ 59,130	$ 158
2015	$ 893,854	$ 696,671	$ 197,183	$ 9,859	$ 5,034,854	$ 151,046	$ 36,278	$ 97
2016	$ 893,854	$ 716,535	$ 177,319	$ 8,866	$ 5,164,523	$ 154,936	$ 13,517	$ 36
2017	$ 893,854	$ 736,994	$ 156,860	$ 7,843	$ 5,272,120	$ 158,164	$ (9,147)	$ (24)

Table C.26: **Processed Vegetable Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Processed Vegetables (600 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 902,792	$ 658,664	$ 244,128	$ 24,413	$ 4,720,853	$ 141,626	$ 78,090	$ 208
2014	$ 911,820	$ 677,387	$ 234,433	$ 23,443	$ 4,910,677	$ 147,320	$ 63,669	$ 170
2015	$ 920,938	$ 696,671	$ 224,267	$ 22,427	$ 5,088,844	$ 152,665	$ 49,175	$ 131
2016	$ 930,148	$ 716,535	$ 213,613	$ 21,361	$ 5,254,806	$ 157,644	$ 34,608	$ 92
2017	$ 939,449	$ 736,994	$ 202,455	$ 20,246	$ 5,408,000	$ 162,240	$ 19,970	$ 53
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 902,792	$ 658,664	$ 244,128	$ 24,413	$ 4,720,853	$ 94,417	$ 125,298	$ 334
2014	$ 911,820	$ 677,387	$ 234,433	$ 23,443	$ 4,910,677	$ 98,214	$ 112,776	$ 301
2015	$ 920,938	$ 696,671	$ 224,267	$ 22,427	$ 5,088,844	$ 101,777	$ 100,063	$ 267
2016	$ 930,148	$ 716,535	$ 213,613	$ 21,361	$ 5,254,806	$ 105,096	$ 87,156	$ 232
2017	$ 939,449	$ 736,994	$ 202,455	$ 20,246	$ 5,408,000	$ 108,160	$ 74,050	$ 197
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 902,792	$ 658,664	$ 244,128	$ 12,206	$ 4,720,853	$ 141,626	$ 90,296	$ 241
2014	$ 911,820	$ 677,387	$ 234,433	$ 11,722	$ 4,910,677	$ 147,320	$ 75,391	$ 201
2015	$ 920,938	$ 696,671	$ 224,267	$ 11,213	$ 5,088,844	$ 152,665	$ 60,388	$ 161
2016	$ 930,148	$ 716,535	$ 213,613	$ 10,681	$ 5,254,806	$ 157,644	$ 45,288	$ 121
2017	$ 939,449	$ 736,994	$ 202,455	$ 10,123	$ 5,408,000	$ 162,240	$ 30,092	$ 80

Table C.27: **Processed Vegetable Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Processed Vegetables (600 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 920,669	$ 658,664	$ 262,005	$ 26,201	$ 4,738,730	$ 142,162	$ 93,643	$ 250
2014	$ 948,289	$ 677,387	$ 270,902	$ 27,090	$ 4,965,023	$ 148,951	$ 94,861	$ 253
2015	$ 976,738	$ 696,671	$ 280,067	$ 28,007	$ 5,198,990	$ 155,970	$ 96,091	$ 256
2016	$ 1,006,040	$ 716,535	$ 289,505	$ 28,951	$ 5,440,845	$ 163,225	$ 97,329	$ 260
2017	$ 1,036,221	$ 736,994	$ 299,227	$ 29,923	$ 5,690,810	$ 170,724	$ 98,580	$ 263
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 920,669	$ 658,664	$ 262,005	$ 26,201	$ 4,738,730	$ 94,775	$ 141,030	$ 376
2014	$ 948,289	$ 677,387	$ 270,902	$ 27,090	$ 4,965,023	$ 99,300	$ 144,511	$ 385
2015	$ 976,738	$ 696,671	$ 280,067	$ 28,007	$ 5,198,990	$ 103,980	$ 148,081	$ 395
2016	$ 1,006,040	$ 716,535	$ 289,505	$ 28,951	$ 5,440,845	$ 108,817	$ 151,738	$ 405
2017	$ 1,036,221	$ 736,994	$ 299,227	$ 29,923	$ 5,690,810	$ 113,816	$ 155,488	$ 415
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 920,669	$ 658,664	$ 262,005	$ 13,100	$ 4,738,730	$ 142,162	$ 106,743	$ 285
2014	$ 948,289	$ 677,387	$ 270,902	$ 13,545	$ 4,965,023	$ 148,951	$ 108,406	$ 289
2015	$ 976,738	$ 696,671	$ 280,067	$ 14,003	$ 5,198,990	$ 155,970	$ 110,094	$ 294
2016	$ 1,006,040	$ 716,535	$ 289,505	$ 14,475	$ 5,440,845	$ 163,225	$ 111,804	$ 298
2017	$ 1,036,221	$ 736,994	$ 299,227	$ 14,961	$ 5,690,810	$ 170,724	$ 113,541	$ 303

Table C.28: **Processed Vegetable Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Processed Vegetables (600 acres)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 938,546	$ 658,664	$ 279,882	$ 27,988	$ 4,756,607	$ 142,698	$ 109,196	$ 291
2014	$ 985,474	$ 677,387	$ 308,087	$ 30,809	$ 5,020,085	$ 150,603	$ 126,676	$ 338
2015	$ 1,034,747	$ 696,671	$ 338,076	$ 33,808	$ 5,312,060	$ 159,362	$ 144,907	$ 386
2016	$ 1,086,485	$ 716,535	$ 369,950	$ 36,995	$ 5,634,360	$ 169,031	$ 163,924	$ 437
2017	$ 1,140,809	$ 736,994	$ 403,815	$ 40,382	$ 5,988,913	$ 179,667	$ 183,766	$ 490
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 938,546	$ 658,664	$ 279,882	$ 27,988	$ 4,756,607	$ 95,132	$ 156,762	$ 418
2014	$ 985,474	$ 677,387	$ 308,087	$ 30,809	$ 5,020,085	$ 100,402	$ 176,877	$ 472
2015	$ 1,034,747	$ 696,671	$ 338,076	$ 33,808	$ 5,312,060	$ 106,241	$ 198,027	$ 528
2016	$ 1,086,485	$ 716,535	$ 369,950	$ 36,995	$ 5,634,360	$ 112,687	$ 220,268	$ 587
2017	$ 1,140,809	$ 736,994	$ 403,815	$ 40,382	$ 5,988,913	$ 119,778	$ 243,655	$ 650
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Payment Capacity**
2013	$ 938,546	$ 658,664	$ 279,882	$ 13,994	$ 4,756,607	$ 142,698	$ 123,190	$ 329
2014	$ 985,474	$ 677,387	$ 308,087	$ 15,404	$ 5,020,085	$ 150,603	$ 142,080	$ 379
2015	$ 1,034,747	$ 696,671	$ 338,076	$ 16,904	$ 5,312,060	$ 159,362	$ 161,810	$ 431
2016	$ 1,086,485	$ 716,535	$ 369,950	$ 18,498	$ 5,634,360	$ 169,031	$ 182,422	$ 486
2017	$ 1,140,809	$ 736,994	$ 403,815	$ 20,191	$ 5,988,913	$ 179,667	$ 203,957	$ 544

Table C.29: **Grass and Wheat Payment Capacity**

Representative Farm:	Grass and Wheat (2000 acres: 640 Wheat and 1360 Grass)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,759,238	$ 1,217,196	$ 542,042	$ 54,204	$ 11,632,534	$ 348,976	$ 138,862	$ 69
2014	$ 1,759,238	$ 1,253,712	$ 505,526	$ 50,553	$ 12,086,695	$ 362,601	$ 92,373	$ 46
2015	$ 1,759,238	$ 1,291,323	$ 467,915	$ 46,792	$ 12,501,470	$ 375,044	$ 46,079	$ 23
2016	$ 1,759,238	$ 1,330,063	$ 429,175	$ 42,918	$ 12,875,658	$ 386,270	$ (12)	$ (0)
2017	$ 1,759,238	$ 1,369,965	$ 389,273	$ 38,927	$ 13,208,021	$ 396,241	$ (45,895)	$ (23)
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,759,238	$ 1,217,196	$ 542,042	$ 54,204	$ 11,632,534	$ 232,651	$ 255,187	$ 128
2014	$ 1,759,238	$ 1,253,712	$ 505,526	$ 50,553	$ 12,086,695	$ 241,734	$ 213,240	$ 107
2015	$ 1,759,238	$ 1,291,323	$ 467,915	$ 46,792	$ 12,501,470	$ 250,029	$ 171,094	$ 86
2016	$ 1,759,238	$ 1,330,063	$ 429,175	$ 42,918	$ 12,875,658	$ 257,513	$ 128,744	$ 64
2017	$ 1,759,238	$ 1,369,965	$ 389,273	$ 38,927	$ 13,208,021	$ 264,160	$ 86,185	$ 43
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,759,238	$ 1,217,196	$ 542,042	$ 27,102	$ 11,632,534	$ 348,976	$ 165,964	$ 83
2014	$ 1,759,238	$ 1,253,712	$ 505,526	$ 25,276	$ 12,086,695	$ 362,601	$ 117,649	$ 59
2015	$ 1,759,238	$ 1,291,323	$ 467,915	$ 23,396	$ 12,501,470	$ 375,044	$ 69,475	$ 35
2016	$ 1,759,238	$ 1,330,063	$ 429,175	$ 21,459	$ 12,875,658	$ 386,270	$ 21,447	$ 11
2017	$ 1,759,238	$ 1,369,965	$ 389,273	$ 19,464	$ 13,208,021	$ 396,241	$ (26,431)	$ (13)

Table C.30: **Grass and Wheat Payment Capacity (1% Farm-Gate Price Increase)**

Representative Farm:	Grass and Wheat (2000 acres: 640 Wheat and 1360 Grass)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,776,831	$ 1,217,196	$ 559,635	$ 55,964	$ 11,650,126	$ 349,504	$ 154,168	$ 77
2014	$ 1,794,599	$ 1,253,712	$ 540,887	$ 54,089	$ 12,139,648	$ 364,189	$ 122,609	$ 61
2015	$ 1,812,545	$ 1,291,323	$ 521,222	$ 52,122	$ 12,607,730	$ 378,232	$ 90,868	$ 45
2016	$ 1,830,671	$ 1,330,063	$ 500,608	$ 50,061	$ 13,053,350	$ 391,601	$ 58,947	$ 29
2017	$ 1,848,977	$ 1,369,965	$ 479,012	$ 47,901	$ 13,475,452	$ 404,264	$ 26,847	$ 13
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,776,831	$ 1,217,196	$ 559,635	$ 55,964	$ 11,650,126	$ 233,003	$ 270,669	$ 135
2014	$ 1,794,599	$ 1,253,712	$ 540,887	$ 54,089	$ 12,139,648	$ 242,793	$ 244,005	$ 122
2015	$ 1,812,545	$ 1,291,323	$ 521,222	$ 52,122	$ 12,607,730	$ 252,155	$ 216,945	$ 108
2016	$ 1,830,671	$ 1,330,063	$ 500,608	$ 50,061	$ 13,053,350	$ 261,067	$ 189,480	$ 95
2017	$ 1,848,977	$ 1,369,965	$ 479,012	$ 47,901	$ 13,475,452	$ 269,509	$ 161,602	$ 81
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,776,831	$ 1,217,196	$ 559,635	$ 27,982	$ 11,650,126	$ 349,504	$ 182,149	$ 91
2014	$ 1,794,599	$ 1,253,712	$ 540,887	$ 27,044	$ 12,139,648	$ 364,189	$ 149,653	$ 75
2015	$ 1,812,545	$ 1,291,323	$ 521,222	$ 26,061	$ 12,607,730	$ 378,232	$ 116,929	$ 58
2016	$ 1,830,671	$ 1,330,063	$ 500,608	$ 25,030	$ 13,053,350	$ 391,601	$ 83,977	$ 42
2017	$ 1,848,977	$ 1,369,965	$ 479,012	$ 23,951	$ 13,475,452	$ 404,264	$ 50,798	$ 25

Table C.31: **Grass and Wheat Payment Capacity (3% Farm-Gate Price Increase)**

Representative Farm:	Grass and Wheat (2000 acres: 640 Wheat and 1360 Grass)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,812,016	$ 1,217,196	$ 594,820	$ 59,482	$ 11,685,311	$ 350,559	$ 184,779	$ 92
2014	$ 1,866,376	$ 1,253,712	$ 612,664	$ 61,266	$ 12,246,610	$ 367,398	$ 183,999	$ 92
2015	$ 1,922,367	$ 1,291,323	$ 631,044	$ 63,104	$ 12,824,514	$ 384,735	$ 183,204	$ 92
2016	$ 1,980,038	$ 1,330,063	$ 649,975	$ 64,998	$ 13,419,501	$ 402,585	$ 182,392	$ 91
2017	$ 2,039,439	$ 1,369,965	$ 669,474	$ 66,947	$ 14,032,066	$ 420,962	$ 181,565	$ 91
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,812,016	$ 1,217,196	$ 594,820	$ 59,482	$ 11,685,311	$ 233,706	$ 301,632	$ 151
2014	$ 1,866,376	$ 1,253,712	$ 612,664	$ 61,266	$ 12,246,610	$ 244,932	$ 306,465	$ 153
2015	$ 1,922,367	$ 1,291,323	$ 631,044	$ 63,104	$ 12,824,514	$ 256,490	$ 311,449	$ 156
2016	$ 1,980,038	$ 1,330,063	$ 649,975	$ 64,998	$ 13,419,501	$ 268,390	$ 316,587	$ 158
2017	$ 2,039,439	$ 1,369,965	$ 669,474	$ 66,947	$ 14,032,066	$ 280,641	$ 321,885	$ 161
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,812,016	$ 1,217,196	$ 594,820	$ 29,741	$ 11,685,311	$ 350,559	$ 214,520	$ 107
2014	$ 1,866,376	$ 1,253,712	$ 612,664	$ 30,633	$ 12,246,610	$ 367,398	$ 214,633	$ 107
2015	$ 1,922,367	$ 1,291,323	$ 631,044	$ 31,552	$ 12,824,514	$ 384,735	$ 214,756	$ 107
2016	$ 1,980,038	$ 1,330,063	$ 649,975	$ 32,499	$ 13,419,501	$ 402,585	$ 214,891	$ 107
2017	$ 2,039,439	$ 1,369,965	$ 669,474	$ 33,474	$ 14,032,066	$ 420,962	$ 215,038	$ 108

Table C.32: **Grass and Wheat Payment Capacity (5% Farm-Gate Price Increase)**

Representative Farm:	Grass and Wheat (2000 acres: 640 Wheat and 1360 Grass)							
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,847,200	$ 1,217,196	$ 630,004	$ 63,000	$ 11,720,496	$ 351,615	$ 215,389	$ 108
2014	$ 1,939,560	$ 1,253,712	$ 685,848	$ 68,585	$ 12,354,979	$ 370,649	$ 246,614	$ 123
2015	$ 2,036,538	$ 1,291,323	$ 745,215	$ 74,522	$ 13,047,054	$ 391,412	$ 279,282	$ 140
2016	$ 2,138,365	$ 1,330,063	$ 808,302	$ 80,830	$ 13,800,368	$ 414,011	$ 313,461	$ 157
2017	$ 2,245,284	$ 1,369,965	$ 875,319	$ 87,532	$ 14,618,777	$ 438,563	$ 349,224	$ 175
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (10%)**	**Net Worth/Equity**	**Return to Equity (2%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,847,200	$ 1,217,196	$ 630,004	$ 63,000	$ 11,720,496	$ 234,410	$ 332,594	$ 166
2014	$ 1,939,560	$ 1,253,712	$ 685,848	$ 68,585	$ 12,354,979	$ 247,100	$ 370,164	$ 185
2015	$ 2,036,538	$ 1,291,323	$ 745,215	$ 74,522	$ 13,047,054	$ 260,941	$ 409,752	$ 205
2016	$ 2,138,365	$ 1,330,063	$ 808,302	$ 80,830	$ 13,800,368	$ 276,007	$ 451,464	$ 226
2017	$ 2,245,284	$ 1,369,965	$ 875,319	$ 87,532	$ 14,618,777	$ 292,376	$ 495,412	$ 248
Year	**Gross Income**	**Annual Farm Costs**	**Net Income**	**Return to Management (5%)**	**Net Worth/Equity**	**Return to Equity (3%)**	**Total Payment Capacity**	**Per-Acre Grass/Wheat Payment Capacity**
2013	$ 1,847,200	$ 1,217,196	$ 630,004	$ 31,500	$ 11,720,496	$ 351,615	$ 246,889	$ 123
2014	$ 1,939,560	$ 1,253,712	$ 685,848	$ 34,292	$ 12,354,979	$ 370,649	$ 280,906	$ 140
2015	$ 2,036,538	$ 1,291,323	$ 745,215	$ 37,261	$ 13,047,054	$ 391,412	$ 316,543	$ 158
2016	$ 2,138,365	$ 1,330,063	$ 808,302	$ 40,415	$ 13,800,368	$ 414,011	$ 353,876	$ 177
2017	$ 2,245,284	$ 1,369,965	$ 875,319	$ 43,766	$ 14,618,777	$ 438,563	$ 392,990	$ 196

SECTION 6.0
WETLAND DELINATION

Under Reconnaissance I investigations Schott and Associates, Ecologists and Wetlands Specialists, completed the “Jurisdictional Wetland Determination and Delineation of Drift Creek Reservoir” and submit it and an application to the Division of State Lands in December 2009.
A copy of the delineation is available as an appendix item to the earlier grant. A total of 9.91 acres of wetlands were found within the reservoir footprint, primarily in a cow pasture at the lower end of the reservoir site. In addition 7.02 acres of open water habitat would be impacted.

Since the submittal of the application, there was change in the rules for review and the approval was delayed while additional information was sought by the agency from the consultant for the District. In March of 2011 a specific list of questions was provided to Schott and Associates to supplement the earlier application. Agency staff indicated that once the review was accomplished, staff would visit the site and make a final determination. Since that time Schott and Associates has continued to request a response from the agency after submitting the information requested in March of 2011. Although a final review was to be received in June of 2013, no information or contact has been received. The District has expected a response but does not have one at the time this report is filed.

SECTION 7.0
WATER SUPPLY

Background

The East Valley Water District (District) proposes to store approximately 12,000 acre feet (a.f.) of surface water from Drift Creek in its Drift Creek Dam and Reservoir project. To accommodate-date that need, the district will require two water rights, one for storage of surface water from Drift Creek prior to project construction; and then a second right for withdrawal of irrigation water supply after the structure is complete and ready to be filled. Current groundwater rights held by a number of the districts' water users are limited in scope due to the two Groundwater Limited Areas within the District boundaries. It is imperative to achieve a new water supply for both primary and supplemental irrigation uses.

Source Documents

Reconnaissance I investigations relied on several studies to determine an adequate water supply: *Preliminary Storage and Pool Elevation Analysis, Runoff Yield Analysis,* and *Determination of Appropriate Ecological and Channel Maintenance Flows for Drift Creek Downstream of the Proposed Dam.* Reconnaissance II investigations provide an update for the *Runoff Yield Analysis,* along with two studies relative to fishery needs, as referenced in the list of attachments.

Water Right Analysis

The District has continued to monitor and measure flows at a stream gauge installed four years ago. The hydrologic study updated as a part of Reconnaissance II by Dr. Tanovan has incurporated those flow measurements in the runoff yield analysis. The analysis confirms that 12,000 acre feet should be generally be available to the district during the storage season.

Water Availability

Dr. Tanovan reviewed the Oregon Water Resources Department's (OWRD) water availability records for Drift Creek and verified the information through a series of discussions with OWRD staff earlier in the process and worked with the Department staff to change the size of the drainage area of the watershed in the water availability record as verified by Dr. Tanovan's report. Water availability for a storage project is based on water being available at a 50% exceedance factor. In reviewing the department's water availability data, Dr. Tanovan factored in existing current uses which have an earlier priority date than the water right to be requested for the District for storage purposes. The existing consumptive rights are for small amounts of irrigation and related pond storage for agriculture use and equate to only 586 a.f. annually. There is an existing instream water right with a priority date of October 18, 1990. The water availability quantification developed by Dr. Tanovan includes those instream rights as measured at the lower end of the stream reach as required by the certificate.

Currently the Willamette Basin plan requires that storage in October would necessitate a request to the Water Resources Commission to classify storage use for that month. The District has decided at this time not to make that request in its pursuit of the water right

for storage.

Pass Through Flows
The pass-through flows have three components:

- Existing consumptive rights for agriculture purposes
- Existing instream water rights
- Peak and ecological flows

The consumptive rights have an earlier priority than the proposed storage project and will be passed-through to honor that priority. The instream water right also has an earlier priority and will be passed-through to accommodate the right (as naturally available).

As part of the water right approval process, the Oregon Department of Fish and Wildlife (ODFW) reviews water right applications to determine from their analysis whether additional peak and ecological flows may be needed for the fishery resource. The Ecological and Channel Maintenance Flows (ECFM) report completed by Ellis Ecological Services, Inc. under Reconnaissance I studies, based on flow monitoring, habitat analysis and fishery inventory, relates that 630 cfs is the estimated 2-year peak recurrence flow for Drift Creek at the proposed dam site. The analysis was based on ODFW's "Calculating Channel Maintenance/Elevated Instream Flows when Evaluating Water Right Applications for Out-of-stream and Storage Water Rights", a guidance document published in September 2007. The ECFM report states that the flow available from the existing instream water right will be adequate to support fish migration. The peak and ecological flow need is already incorporated in the existing instream right.

Water Right Application
The District submitted a water right application for surface water storage on February 21, 2013. The Water Resources Department assigned the application R-87871 as the application reference number. The application requests up to 12,000 acre feet of water from Drift Creek and unnamed tributaries to be stored in a reservoir for the purpose of irrigation, supplemental irrigation and flow augmentation as required. Storage would occur between October 1 and April 30 of each year. As a special district formed under Oregon Revised Statutes Chapter 545, it is not necessary for the District to provide engineering plans and specifications prior to permit issuance, but the District has continued to cooperative update the Department on the status of the project design. The statutes also allow a public entity, such as the District, to request Issuance of a permit before obtaining easements or other authorizations relative to lands affected by the project [ORS 573.211(6)] prior to beginning to fill the reservoir, such documents will be required to substantiate access.

The District is working with the Oregon Department of Fish and Wildlife to secure a fish passage waiver to meet the Department's fish passage requirements. Refer to Section 9 of this document for studies relative to that issue.

The District, as part of its application, has requested the ten year period allowed to districts under ORS 537.248 to seek the ability to complete construction of the reservoir within a ten year period from issuance of the permit.

GSI Water Solutions prepared the application on behalf of the District. A map of the

water right footprint was provided as a supporting document to the application as well as a land use information form signed by Marion County. A list of affected landowners was provided. Following the submittal of the application, the District awaited a letter from Marion County Public Works Department confirming that the county made a determination pursuant to Chapter 17.115 of the Marion County Code on the uses allowed in an Exclusive Farm Use (EFU) zone, in which the project site is located. MCC 17.136.040(L) permits "irrigation reservoirs, canals, delivery lines and those structures and accessory operational facilities, not including parks or other recreational structures and facilities, associated with a district as defined in ORS 540.505."

As East Valley Water District is an irrigation district formed under ORS Chapter 545, the District qualifies to site a reservoir on EFU zoned lands. The county's determination is based on ORS 215.283(1)(t) and remains in effect so long as any permits issued remain in effect, including the water right application. Upon receipt of this final document, the Water Resources Department can complete its review and list the application for public notice for a period of 60 days. During that period agencies and the public may comment.

Balancing Needs

In 1987 when the instream water rights legislation was enacted, the legislation set guidelines for balancing instream water rights with future water needs and the ability to store water for economic development. The value of storage projects is codified in the state's water storage policy, adopted by the Water Resources Commission in 1992. The OWRD, as part of its Integrated Water Resource Strategy approved in 2012, proposes adding storage infrastructure. The Drift Creek storage site is listed under the OWRD's "Potential Water Storage Opportunities" in the recently released Oregon's Integrated Water Resources Strategy.

Alternative Water Supply Analysis

As reported in Reconnaissance I, extensive review of other water alternatives occurred since 1994, including potential use of reclaimed water from the City of Salem facilities, groundwater recharge, use of stored water in the federal reservoirs on the Willamette and three other potential storage sites. Progress on each option was reported in the earlier grant report. Since that last report no other potential sources have been identified.

GSI Water Solutions, Inc.

February 21, 2013

Tim Wallin
Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, OR 97301

Subject: Application for a Permit to Store Water in a Reservoir for East Valley Water District

Dear Tim:

Enclosed please find an Application for a Permit to Store Water in a Reservoir and the required attachments filed on behalf of East Valley Water District (District). Also enclosed is a check for the amount of $13,580 for the application and recording fees. The application fee was computed as follows based on a request to store 12,000 acre-feet:

- $ 700 - Base application fee
- $ 500 - Fee for first 20 acre-feet at $25/acre-foot
- $11,980 - Fee for remaining 11,980 acre-feet at $1/acre-foot
- $ 400 - Permit Recording fee

The District had a pre-application conference with Oregon Water Resources Department (Department) staff on September 10, 2012. As discussed during that meeting, the District is requesting to store up to 12,000 acre-feet from Drift Creek and unnamed tributaries to Drift Creek in a reservoir for irrigation, supplemental irrigation and flow augmentation as may be required for the approval of this irrigation reservoir by the Department. The District intends to store water from October 1 to April 30 of each year. It is anticipated that the reservoir will inundate approximately 384 acres when filled.

East Valley Water District is a district formed pursuant to ORS Chapter 545 and, accordingly, is not required to submit engineering plans and specifications prior to permit issuance. As work on this reservoir project proceeds, the District will continue to work cooperatively with the Department to provide necessary information as it becomes available.

In addition, since the District is a "public corporation," the District requests that the Department issue a permit prior to the District obtaining easements or written authorization permitting access to lands affected by the reservoir project, as provided under ORS 537.211(6). The District will submit the necessary authorizations to the Department prior to filling the reservoir. The District

1600 Western Blvd., Suite 240 Corvallis, OR 97333 P: 541.753.0745 F: 541.754.4211 info@gsiwatersolutions.com www.gsiwatersolutions.com

will also submit the legal description for the property involved with the application at that time, as we have previously discussed with Department staff.

Further, the District intends to work with staff of the Oregon Department of Fish and Wildlife (ODFW) to obtain a fish passage waiver. The District will provide the Department with information regarding this effort as it proceeds.

Finally, the District is requesting ten years from permit issuance to begin and complete construction and to perfect the water right, as is allowed for districts under ORS 537.248.

GSI Water Solutions, Inc. is a representative of the District for the purposes of this water right application, and communications regarding this application should be sent to the District and to me.

Please do not hesitate to call if you have any questions or need additional information. My telephone number is 541-753-0745.

Sincerely,

Adam Sussman
Principal Water Resources Consultant

Enclosures

Cc: Dave Bielenberg, East Valley Water District

1600 Western Blvd., Suite 240 Corvallis, OR 97333 P: 541.753.0745 F: 541.754.4211 info@gsiwatersolutions.com www.gsiwatersolutions.com

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem Oregon 97301-1271
(503) 986-0900
www.wrd.state.or.us

Application for a Permit to Store Water in a Reservoir

(Standard Review)

Standard Review Process (ORS 537): You must use this form for any reservoir storing more than 9.2 acre-feet and with a dam more than 10 feet high.

Use a separate form for each reservoir. However, to obtain authorization for multiple reservoirs, multiple forms may be combined into one application if filed at the same time.

Please type or print in dark ink. If your application is found to be incomplete or inaccurate, we will return it to you. A summary of review criteria and procedures that are generally applicable to these applications is available at www.wrd.state.or.us/OWRD/PUBS/forms.shtml

1. APPLICANT INFORMATION

Applicant: East Valley Water District (First) _____ (Last)

Mailing Address: P.O. Box 1046

Mt. Angel (City) OR (State) 97362 (Zip)

Phone: _____ (Home) (541) 873-2710 (Work) _____ (Other)

Fax: _____ E-Mail Address*: _____

* By providing an e-mail address, consent is given to receive all correspondence from the department electronically. (paper copies of the final order documents will also be mailed.)

I(We) make application for a permit to construct a reservoir and store the following described waters of the State of Oregon. The name of the reservoir is Drift Creek Reservoir.

2. SOURCE OF WATER for the proposed use: Drift Creek and unnamed tributaries,

a tributary of Pudding River.

Is the proposed use an enlargement of an existing dam/reservoir? ☐ Yes ☑ No

If the reservoir is not in channel of a stream, state how it is to be filled:

The proposed reservoir will be in channel.

For Department Use

App. No._____ Permit No._____ Date_____

3. DAM HEIGHT AND COMPOSITION

The maximum height of the structure will be approx. 70.0 feet above streambed or ground surface at the centerline of the crest of the dam.

*Note: If your dam height is greater than or equal to 10.0' above land surface **AND** your reservoir will store equal to or greater than 9.2 acre-feet, engineered plans and specifications must be approved prior to storage of water.*

The dam will be (check one): ☐ Earthfill ☐ Concrete ☐ Flash board ☐ Other

If "other" give description:

The Applicant is a district, so plans and specifications are not required before a permit is issued. The Applicant will work cooperatively with the Department to provide the necessary plans and specifications as they become available.

4. PRIMARY OUTLET WORKS

Describe the location and the dimensions of the outlet conduit through the dam:

The Applicant is a district, so plans and specifications are not required before a permit is issued. The Applicant will work cooperatively with the Department to provide the necessary plans and specifications as they become available.

NOTE: Most dams across a natural stream channel will need an outlet conduit having a minimum diameter of 8 inches or greater.

5. EMERGENCY SPILLWAY

Describe the location and the dimensions of the spillway channel:

The Applicant is a district, so plans and specifications are not required before a permit is issued. The Applicant will work cooperatively with the Department to provide the necessary plans and specifications as they become available.

6. THE USE(s) of the impounded water will be:

The Applicant will store water from October 1 through April 30 for irrigation, supplemental irrigation, and flow augmentation as may be required for the approval of this irrigation reservoir by OWRD.

7. THE AMOUNT OF WATER to be stored is: 12,000 acre-feet.

The area submerged by the reservoir, when filled, will be approximately 384 acres.

8. PROJECT SCHEDULE: (List **Month** and **Year**)

Proposed date construction work will begin: within 10 years of permit issuance

Proposed date construction work will be completed: within 10 years of permit issuance

Proposed date water use will be completed: within 10 years of permit issuance

Is this project fully or partially funded by the American Recovery and Reinvestment Act? (Federal stimulus dollars) No

9. PROPERTY OWNERSHIP

Do you own all the land where you propose to divert, transport, and use water?

☐ Yes *(Please check appropriate box below then skip to section 10)*

☐ There are no encumbrances

☐ This land is encumbered by easements, rights of way, roads or other encumbrances *(please provide a copy of the recorded deed(s))*

☑ No *(Please check the appropriate box below)*

☐ I have a recorded easement or written authorization permitting access.

☑ I do not currently have written authorization or an easement permitting access.

☐ Written authorization or an easement is not necessary, because the only affected lands I do not own are state-owned submersible lands, and this application is for irrigation and/or domestic use only (ORS 274.040).

You must provide the legal description of: (1) the property from which the water is to be diverted, (2) any property crossed by the proposed ditch, canal or other work, and (3) any property on which the water is to be used as depicted on the map.

List the names and mailing addresses of all affected landowners:

See Attachment C

10. WITHIN A DISTRICT

☑ Check here if the point of diversion or place of use are located within or served by an irrigation or other water district.

Irrigation District Name East Valley Water District (Applicant)	Address	
City	State	Zip

11. MAP REQUIREMENTS The Department cannot process your application without accurate information showing the source of water and location of water use. You must include a map with this application form that clearly indicates the township, range, section and quarter/quarter section of the proposed reservoir location and place of use. The map must provide tax lot numbers. See the map guidelines sheet for detailed map specifications.

12. SIGNATURE

By my signature below I confirm that I understand:

- I am asking to use water specifically as described in this application.
- Evaluation of this application will be based on information provided in the application packet.
- I cannot legally use water until the Water Resources Department issues a permit to me.
- If I get a permit, I must not waste water.
- If development of the water use is not according to the terms of the permit, the permit can be canceled.
- The water use must be compatible with local comprehensive land use plans.
- Even if the Department issues a permit, I may have to stop using water to allow senior water right holders to get water to which they are entitled.

I certify that the information I have provided in this application is an accurate representation of the proposed water use and is true and correct to the best of my knowledge:

Applicant: [illegible] Board Chair 1/10/201_
Signature *(If more than one applicant, all must sign.)* Date

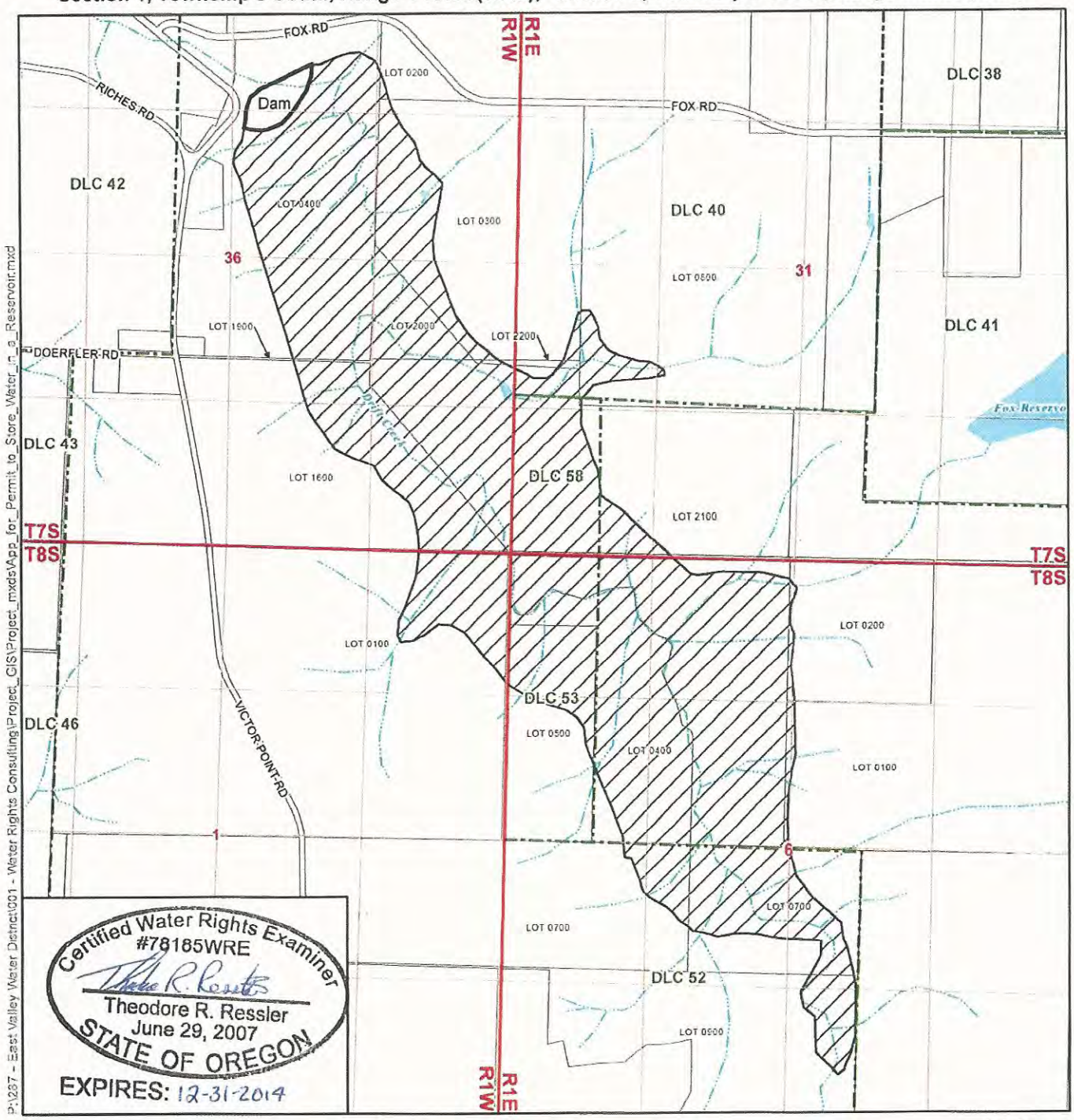
Before you submit your application be sure to:

- Answer each question completely.
- Attach a legible map that includes township, range, section, quarter/quarter and tax lot.
- Include a Land Use Information Form or receipt stub signed by a local official.
- Include the legal description of all the property involved with this application. You may include a copy of your deed land sales contract or title insurance policy to meet this requirement.
- Include a check payable to the Oregon Water Resources Department for the appropriate amount. The Department's fee schedule can be found at www.wrd.state.or.us or call (503) 986-0900.

Attachment A
Map
East Valley Water District Application for a Permit to Store Water in a Reservoir

Application for a Permit to Store Water in a Reservoir
In the Name of: East Valley Water District

Section 36, Township 7 South, Range 1 West (W.M.); Section 31, Township 7 South, Range 1 East (W.M.); Section 1, Township 8 South, Range 1 West (W.M.); Section 6, Township 8 South, Range 1 East (W.M.)



Certified Water Rights Examiner
#78185WRE
Theodore R. Ressler
June 29, 2007
STATE OF OREGON
EXPIRES: 12-31-2014

Legend

- Proposed Dam
- Proposed Reservoir
- Tax Lots
- Existing Waterbodies
- Existing Watercourses

Data Sources
Marion County GIS, Oregon Geospatial Data Clearinghouse

Disclaimer
This map was prepared for the purpose of identifying the location of a water right only and it is not intended to provide legal dimensions or location of property ownership lines.

N

Scale
0 330 660 1,320
1 inch equals 1,320 feet

GSI Water Solutions, Inc.

Location Description for Proposed Dam

Proposed Dam
Located 3,990 feet North and 355 feet East from the S1/4 corner of Section 36, Township 7 South, Range 1 West (W.M.)

Attachment B
Land Use Information Form

East Valley Water District Application for a Permit to Store Water in a Reservoir

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

NOTE TO APPLICANTS

In order for your application to be processed by the Water Resources Department (WRD), this Land Use Information Form must be completed by a local government planning official in the jurisdiction(s) where your water right will be used and developed. The planning official may choose to complete the form while you wait, or return the receipt stub to you. Applications received by WRD without the Land Use Form or the receipt stub will be returned to you. Please be aware that your application will not be approved without land use approval.

This form is NOT required if:

1) Water is to be diverted, conveyed, and/or used only on federal lands; **OR**
2) The application is for a water right transfer, allocation of conserved water, exchange, permit amendment, or ground water registration modification, and <u>all</u> of the following apply:
   a) The existing and proposed water use is located entirely within lands zoned for exclusive farm-use or within an irrigation district;
   b) The application involves a change in place of use only;
   c) The change does not involve the placement or modification of structures, including but not limited to water diversion, impoundment, distribution facilities, water wells and well houses; <u>and</u>
   d) The application involves irrigation water uses only.

NOTE TO LOCAL GOVERNMENTS

The person presenting the attached Land Use Information Form is applying for or modifying a water right. The Water Resources Department (WRD) requires its applicants to obtain land-use information to be sure the water rights do not result in land uses that are incompatible with your comprehensive plan. Please complete the form or detach the receipt stub and return it to the applicant for inclusion in their water right application. You will receive notice once the applicant formally submits his or her request to the WRD. The notice will give more information about WRD's water rights process and provide additional comment opportunities. You will have 30 days from the date of the notice to complete the land-use form and return it to the WRD. If no land-use information is received from you within that 30-day period, the WRD may presume the land use associated with the proposed water right is compatible with your comprehensive plan. Your attention to this request for information is greatly appreciated by the Water Resources Department. If you have any questions concerning this form, please contact the WRD's Customer Service Group at 503-986-0801.

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

Applicant(s): East Valley Water District, Attn: Dave Bielenberg

Mailing Address: P.O. Box 1046

City: Mt. Angel State: OR Zip Code: 97362 Daytime Phone: 541-873-2710

A. Land and Location

Please include the following information for all tax lots where water will be diverted (taken from its source), conveyed (transported), and/or used or developed. Applicants for municipal use, or irrigation uses within irrigation districts may substitute existing and proposed service-area boundaries for the tax-lot information requested below.

Township	Range	Section	¼ ¼	Tax Lot #	Plan Designation (e.g., Rural Residential/RR-5)	Water to be:			Proposed Land Use:
7S	1W	36	E 1/2	See		☒ Diverted	☒ Conveyed	☒ Used	____
7S	1E	31	SW 1/4	attached	____	☒ Diverted	☒ Conveyed	☒ Used	____
8S	1W	1	NE NE	map	____	☒ Diverted	☒ Conveyed	☒ Used	____
8S	1E	6	all			☒ Diverted	☒ Conveyed	☒ Used	

List all counties and cities where water is proposed to be diverted, conveyed, and/or used or developed:

Marion County

B. Description of Proposed Use

Type of application to be filed with the Water Resources Department:

☒ Permit to Use or Store Water ☐ Water Right Transfer ☐ Permit Amendment or Ground Water Registration Modification
☐ Limited Water Use License ☐ Allocation of Conserved Water ☐ Exchange of Water

Source of water: ☐ Reservoir/Pond ☐ Ground Water ☒ Surface Water (name) Drift Creek and unnamed tributaries

Estimated quantity of water needed: 12,000 ☐ cubic feet per second ☐ gallons per minute ☒ acre-feet

Intended use of water: ☐ Irrigation ☐ Commercial ☐ Industrial ☐ Domestic for _____ household(s)
☐ Municipal ☐ Quasi-Municipal ☐ Instream ☒ Other Storage

Briefly describe:

Water from Drift Creek and unnamed tributaries will be stored in the proposed irrigation reservoir to provide water for irrigation, supplemental irrigation, and flow augmentation as may be required for the approval of this irrigation reservoir by OWRD.

Note to applicant: If the Land Use Information Form cannot be completed while you wait, please have a local government representative sign the receipt at the bottom of the next page and include it with the application filed with the Water Resources Department.

See bottom of Page 3. →

For Local Government Use Only

The following section must be completed by a planning official from each county and city listed unless the project will be located entirely within the city limits. In that case, only the city planning agency must complete this form. This deals only with the local land-use plan. Do not include approval for activities such as building or grading permits.

Please check the appropriate box below and provide the requested information

☐ Land uses to be served by the proposed water uses (including proposed construction) are allowed outright or are not regulated by your comprehensive plan. Cite applicable ordinance section(s): _____.

☑ Land uses to be served by the proposed water uses (including proposed construction) involve discretionary land-use approvals as listed in the table below. (Please attach documentation of applicable land-use approvals which have already been obtained. Record of Action/land-use decision and accompanying findings are sufficient.) **If approvals have been obtained but all appeal periods have not ended, check "Being pursued."**

Type of Land-Use Approval Needed (e.g., plan amendments, rezones, conditional-use permits, etc.)	Cite Most Significant, Applicable Plan Policies & Ordinance Section References	Land-Use Approval:	
Administrative Review	Marion County Code 17.136.040 (4)	☐ Obtained ☐ Denied	☐ Being Pursued ☑ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued

Local governments are invited to express special land-use concerns or make recommendations to the Water Resources Department regarding this proposed use of water below, or on a separate sheet.

Name: Joe Fennimore Title: Principal Planner

Signature: Joe Fennimore Phone: (503) 566-5038 Date: 1/4/13

Government Entity: Marion County Planning Division
5155 Silverton Rd. NE
Salem, OR 97305

Note to local government representative: Please complete this form or sign the receipt below and return it to the applicant. If you sign the receipt, you will have 30 days from the Water Resources Department's notice date to return the completed Land Use Information Form or WRD may presume the land use associated with the proposed use of water is compatible with local comprehensive plans.

Receipt for Request for Land Use Information

Applicant name: _____

City or County: _____ Staff contact: _____

Signature: _____ Phone: _____ Date: _____

Marion County
OREGON

PUBLIC WORKS

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Sam Brentano
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OPERATIONS

PARKS

PLANNING

SURVEY

June 10, 2013

East Valley Water District
Attn: Dave Bielenberg
P. O. Box 1046
Mt. Angel, OR 97362

Re: Proposed Reservoir on Drift Creek

Dear Sir:

This letter is in response to your request for a determination pursuant to chapter 17.115 of the Marion County Code (MCC) on the uses allowed in an Exclusive Farm Use (EFU) zone. MCC 17.136.040(L) permits "Irrigation reservoirs, canals, delivery lines and those structures and accessory operational facilities, not including parks or other recreational structures and facilities, associated with a district as defined in ORS 540.505."

ORS 540.505 defines district to mean "an irrigation district formed under ORS chapter 545, a drainage district formed under ORS chapter 547, a water improvement district formed under ORS chapter 552, a water control district formed under ORS chapter 553 or a corporation organized under ORS chapter 554."

Based on the information provided, the East Valley Irrigation District is a district formed under ORS chapter 545. The district intends to place an irrigation reservoir, canals delivery lines and associated structures and accessory operational facilities, but not parks or other recreational structures or facilities in an EFU zone. Therefore, the proposed use is permitted outright in the EFU zone without further planning review.

This determination is based on ORS 215.283 (1)(t) and remains in effect as long as any permits issued, including those issued by the State of Oregon, based upon this determination remain in effect, pursuant to MCC 17.115.090.

If you have any questions regarding this determination, please contact me at (503) 588-5038.

Joe Fennimore
Principal Planner

Attachment C
Affected Landowners

East Valley Water District Application for a Permit to Store Water in a Reservoir

Affected Landowners

Tax Lot	Landowner's Name	Address	City	State	Zip Code
071W3600400	DOMINICK,NORBERT V & Gail K	1116 VICTOR POINT RD NE	SILVERTON	OR	97381
071W3600200	QUALEY,ROBERT B	15256 FOX RD SE	SILVERTON	OR	97381
071W3600300	QUALEY,ROBERT B	15256 FOX RD SE	SILVERTON	OR	97381
071E3100800	JAQUET,KATHLEEN ET AL	PO BOX 44	MOCLIPS	WA	98562
071W3602000	QUALEY,ROBERT B	15256 FOX RD SE	SILVERTON	OR	97381
071W3601900	JACQUET,BRUCE P	14752 DOERFLER RD SE	SILVERTON	OR	97381
071W3601600	RUE, JOEL & DONNA	1316 VICTOR POINT RD SE	SILVERTON	OR	97381
	DARBY, MERLIN & MARVIN	493 GOUNTAIN COURT	KEIZER	OR	97303
071W3602100	JAQUET,BRUCE P	14752 DOERFLER RD SE	SILVERTON	OR	97381
071W3602200	JAQUET,BRUCE P	14752 DOERFLER RD SE	SILVERTON	OR	97381
081E0600100	FOX LAND COMPANY LLC	16364 FOX RD SE	SILVERTON	OR	97381
081W0100100	LIERMAN,ROBERT	1985 VICTOR POINT RD SE	SILVERTON	OR	97381
081E0600200	FOX LAND COMPANY LLC	16364 FOX RD SE	SILVERTON	OR	97381
081E0600400	FOX LAND COMPANY LLC	16364 FOX RD SE	SILVERTON	OR	97381
081E0600500	PETERS,TODD F	4742 LIBERTY RD #173	SALEM	OR	97302
081W0100700	PETERS,TODD F	4742 LIBERTY RD #173	SALEM	OR	97302
081E0600700	FOX,FLOYD T JR	16364 FOX RD SE	SILVERTON	OR	97381
081E0600900	FRERES TIMBER INC	PO BOX 276	LYONS	OR	97358

SECTION 8.0
LAND USE

Location of Site

The East Valley Water District intends to site the Drift Creek Dam and Reservoir project on Drift Creek, a tributary to the Pudding River. The intended reservoir site is located approximately six miles southeast of Silverton in Marion County, Oregon. The project will encompass approximately 340 acres of land. A series of maps are provided in Reconnaissance I reports. The site lies in a natural valley which is 1,000 feet wide on the southeast side and narrows to approximately 100 feet wide to the northwest. A small east-west trending ridge feature, which crests at an elevation of approximately 665 feet, is present along the southwestern side of the valley. This ridge will become the left abutment of the project.

The Drift Creek Reservoir will be located in parts of the following sections:

- Township 7 South, Range 1 West, Willamette Meridian, Sections 23, 26 and 36
- Township 7 South, Range 1 East, Willamette Meridian, Section 31
- Township 8 South, Range 1 West, Willamette Meridian, Section 1 Township 8 South, Range 1 East, Willamette Meridian, Section 6

The proposed project will require the submittal of an application for development to the Marion County Planning Division.

Zone

The entire project site is comprised of larger ownerships in an unincorporated area of Marion County zoned as “Exclusive Farm Use” (EFU). Chapter 17.136 of the county’s comprehensive plan defines uses permitted in the EFU zone. Section 17.136.040 of the county’s ordinances lists among outright permitted uses: “irrigation canals, delivery lines and those structures and accessory operational facilities associated with a district as defined in ORS 540.505.” The citation defining districts includes irrigation districts organized under Chapter 545 of the Oregon Revised Statutes. East Valley Water District is an irrigation district organized in 2002 under that statute and therefore qualifies. (See Section 7, water right application and letter of confirmation of the county’s determination of the District status dated June 10, 2013.)

County Administrative Application

A use proposed for this section of the zoning ordinance is considered “outright”, or a sub(1) use, versus requiring a conditional use permit or higher level of approval under the new statute. Outright uses can be addressed with an “administrative” application. No hearing is required for an outright use. Once issued the permit will expire two years from the date of the final decision. An extension may be granted for up to 12 months.

East Valley Water District is in the process of acquiring an administrative permit for the development of the reservoir.

Land Use Information Form

The Oregon Water Resources Department requires a Land Use Information Form signed by Marion County to be submitted along with the water right application and other supporting documents. The intent of the LIAC is to signify that the applicant may eventually gain approval from the county if county procedures, as defined by the ordinances, are met for use in the applicable zone. (See form in Section 7 as part of the water right application, signed by Marion County and dated January 13, 2013.)

Overlay Zones

The county has developed two overlay zones that also must be addressed by an applicant under this process if the site falls into either overlay.

Geologically Hazardous Areas Overlay Zone
Marion County, in compliance with Land Use Goal 7 (Areas Subject to Natural Disasters and Hazards), reviews applications to assure the property site does not fall within the Geologically Hazardous Areas Overlay Zone. The intent of the zone is to protect areas where there are slide hazards or excessive slope areas. Development permits for uses within the overlay zone require a supplementary geological assessment, engineering geology report or geotechnical report.

Floodplain Overlay
Marion County's Floodplain Program provides for an overlay zone intended to promote safety and minimize public and private losses due to flood conditions. The county's program is developed in coordination with the Federal Emergency Management Act (FEMA).

A portion of the reservoir site, near the dam, is included within the floodplain overlay zone. As a result, East Valley will be required to submit a floodplain application, which includes a site plan developed to county specifications and documentation describing the land use proposal. Additional submittals will be required to assist in determining whether the proposal meets the applicable criteria. Such information includes floodproofing and anchoring data, certification by a registered professional engineer or architect demonstrating that any proposed encroachments into the floodway will not result in any increase in flood levels during major floods, identification of unusual terrain features, and statements or drawings or photos of the proposed external appearance of the proposed activity.

The Drift Creek Dam and Reservoir Project will likely have either no impact or a positive impact on the floodplain. The dam will positively impact the downstream floodplain by reducing effects of upstream creek inflows from large storms. A more detailed assessment will be developed as part of the final design work and a submittal will be made to the county. While the county ordinances allow mitigation for impact, there does not appear to be a need for mitigation as a negative impact is not expected.

SECTION 9.0
FISH PASSAGE

Background

The Reconnaissance I report included an environmental effects summary completed by Ellis Ecological Services, Inc. That report indicated that 3.22 miles of Drift Creek would be inundated by development of the proposed reservoir as well as 0.25 miles of Fox Creek. The earlier report described the gravels available for habitat in these streams and described the electrofishing testing and identification of the fish species sited within the reaches affected by the proposed project. That report also describes the habitat along Drift Creek; no unique habitat was identified within the reach. In summary, the reach of stream that would be inundated by the reservoir is of generally low quality for rearing or spawning of anadromous or resident salmonids. The slow-moving water and its lack of shade during the summer results in warming to levels unsuitable for rearing of cold-water fish species.

The District's preliminary investigations into the feasibility of providing fish passage at the proposed Drift Creek Dam indicate it is unlikely that a functional fish passage facility can be constructed to meet the Oregon Department of Fish and Wildlife (ODFW) or National Marine Fisheries Service (NMFS) fish passage criteria. It was concluded that the District would likely apply for a fish passage waiver for the project, requiring a net improvement in fish habitat for areas accessible to migratory native fish upstream of the dam site.

Consultation Process for the Fish Passage Waiver

Under this second phase of the grant the project consultation continued between the District's consultants Cramer Fish Sciences and Ellis Ecological Services with ODFW District Fish Biologist Todd Alsbury and the Department's Fish Passage Coordinator, Greg Apke, including meetings in the field. The District, in its earlier studies, provided the baseline information needed for a waiver if one would be identified as necessary later in the project review. The ODFW biologists agree in principle that the Drift Creek Dam project may be appropriate for applying the Fish Passage Waiver process available through approval by the Fish and Wildlife Commission.

Potential Mitigation

Work under Reconnaissance II included a thorough evaluation of all potential fish passage options for the proposed dam. That analysis was led by Ellis Ecological Services and it reviewed

- fish passage facilities at existing irrigation dams;
- new developments in fish passage facilities at dams with fluctuating water levels;
- availability of water for a fish passage facility; and
- analysis of fish passage water quality on downstream water temperature conditions.

The District's consultants and the ODFW biologists need to concur on the amount and quality of habitat that would be lost by the reservoir's development as this agreement would set the bar for benefit to fishery resources that must be provided through the mitigation plan.

Simulation of Potential Cutthroat Trout Production in the Drift Creek Watershed

Cramer Fish Sciences prepared a report in June 2013 titled "Simulation of Potential Cutthroat Trout Production in the Drift Creek Watershed, Pudding River Basin." Cramer used an existing simulation model developed to determine the capability of present habitat conditions in Drift Creek that would support native salmonids and determine what factors limited production. The tool provides a prediction for trout production to then develop a framework for integrating that information to quantify the factors. The model has been published in peer-reviewed science journals and was recently applied under contract to the U.S. Army Corps of Engineers to estimate fish benefits on Beaver Creek in the Sandy River Basin. Conditions in Beaver Creek are similar to those in Drift Creek so the model was well suited for obtaining estimates of potential production under both present and alternative future conditions.

Cutthroat trout is the only native salmonid species found in Drift Creek. Habitat surveys conducted throughout Drift Creek identified that salmonid production is strongly limited by three specific conditions:

- lack of spawning gravel;
- low summer flows; and
- high water temperatures that approach lethal levels during the heat of the day.

In recognition of the conditions and the need to mitigate for the loss of spawning habitat, the District may reserve a portion of the stored water to increase summer base flow. In addition, the multiport outflow as described in the Portland State University water quality modeling study will enable release of cooler water throughout the summer.

To estimate the carrying capacity of the watershed to support a fish species, it was necessary to define how the habitat would be used. The habitat and its features were measured, a projection was made as to how the measurements would change across seasons, and then the habitat preferences of each fish life stage was overlaid to determining the carrying capacity. The documentation of the study, as carried out by Cramer Fish Sciences, is detailed in the attachment identified for this section of the report.

The analysis determined that in addition to the limiting factors already referenced above, gravel suitable for cutthroat spawning habitat strongly limits cutthroat production. Suitable spawning areas are limited to reach 5 of the main stream of Drift Creek and reach 4 of the West Fork. (Refer to the map that is appended to the study to identify those reaches.) Flows drop to under 2 cfs in late summer at the Victor Point gauge and those low flows contribute to the high temperatures.

The conclusion of the model effort shows that the project should support maximum production of cutthroat that is about double (846 spawners) that for the present potential (473 spawners). Production gains above the dam would likely accrue without gravel

addition. Gains below the dam would be dependent upon the amount of spawning gravel added. Temperatures below the dam would improve substantially with the release of cooler water and remain in the optimal range in all but the very lowermost reach. Releasing a minimum of 2 cfs, compared to the exiting minimum of .5 cfs would cool the stream by 6 to 10 degrees Centigrade in the first 3 reaches below the dam. Watershed councils could build upon that benefit by providing further restoration of fish production potential by creation of spawning habitat to take advantage of the surplus rearing capacity. Improved rearing habitat would provide opportunities for ESA-listed steelhead to establish themselves in the stream.

Fish Passage Waiver Application

Ellis Ecological Services has prepared the draft fish passage waiver for the project and a copy is provided in the attachments. The application details habitat conditions, upstream and downstream passage and provides potential barrier that might be removed as well as providing photos of some areas that might be restored.

CRAMER FISH SCIENCES®
Oregon • California • Washington • Idaho • Alaska

REPORT:

SIMULATION OF POTENTIAL CUTTHROAT TROUT PRODUCTION IN THE DRIFT CREEK WATERSHED, PUDDING RIVER BASIN

Submitted to:

East Valley Water District

Prepared by:

Steve Cramer[1] and Mark Teply[2]

1-Cramer Fish Sciences
600 NW Fariss Rd,
Gresham, OR 97030

2-Cramer Fish Sciences
4405 7th Ave SE, Suite 306
Lacey, WA 98503

Submittal Date: June 26, 2013

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Introduction

The Drift Creek Simulation Model for potential production of cutthroat trout was developed to determine the capability of present habitat conditions in Drift Creek for supporting native salmonids, and what the factors were that limited that production. The model was used as a tool to identify what information would be needed from the Drift Creek watershed to predict trout production, to then provide a framework for integrating that information, and finally to quantify where and what the factors were that limited production in the watershed.

We used an existing model to translate habitat measurements into estimates of the maximum number of adult cutthroat trout that could be produced in Drift Creek under average environmental conditions. The model has been developed by Cramer Fish Sciences and partial versions have been published in peer-reviewed science journals. The present version of the model was recently applied under contract to the US Army Corps of Engineers to estimate fish benefits for loss or gains in fish passage at road crossings over Beaver Creek, a tributary to the Sandy River (Cramer et al. 2012). Many of the conditions in Beaver Creek are similar to those in Drift Creek, so the model was well suited for obtaining accurate estimates of cutthroat production potential under present and alternative future conditions in Drift Creek.

We parameterized the model specifically for coastal cutthroat trout, because cutthroat were the only native salmonid species found in Drift Creek. A small number of juvenile Coho salmon were captured, but they were not historically present in the Willamette Basin above Willamette Falls until it was laddered. Drift Creek is located in the Pudding River subbasin (Figure 1) in the mid Willamette Valley upstream of Willamette Falls. Coho were stocked by the Oregon Department of Fish and Wildlife (ODFW) into nearby Butte, Abiqua and Silver Creeks beginning in 1958 (Runyon et al., 2006). Coho salmon stocking ended in 1998, but Coho continue to return and spawn in Pudding River tributaries (Wevers et al., 1992). Coho salmon have been observed in Drift Creek during the last several years (Wayne Hunt, ODFW, personal communication, Salem, 2005, cited in Runyon et al., 2006), and three juvenile Coho were collected in Fox Creek by Ellis Ecological Services in June 2006. Fox Creek is a small tributary of Drift Creek within the proposed reservoir footprint. Coho spawning was also observed in Fox Creek by landowners in November 2009. ESA-listed steelhead are native to the Pudding River Subbasin, but Drift Creek is not listed as a steelhead-bearing stream by Streamnet, and extensive sampling by Ellis Ecological Services in 2005, 2006 and 2009 did not identify any steelhead or rainbow trout.

It was readily apparent from the habitat surveys throughout the Drift Creek watershed that salmonid production was strongly limited by two conditions; the lack of spawning gravel (Table 1) and high water temperatures that approached lethal levels during the heat of the day. Further, the limited amount of gravel suitable for spawning within the main stem was contained principally in the stream reach that would be inundated by the reservoir. In recognition of the need to mitigate for this loss of spawning habitat, the project proponents have changed their plans for reservoir operations, and have reserved a portion of the stored water to increases summer base flow. Additionally, they have proposed a multiport outflow structure that will enable release of cool water throughout the summer. In order to determine whether this investment in more and cooler water in the summer mitigated for reduced

spawning habitat, Cramer Fish Sciences was retained to develop and apply a model that could use measurements of the stream habitat conditions to predict the stream's capacity for salmonids. Sampling data from Ellis Ecological Services indicated that cutthroat trout were the only native salmonid present in the watershed, so the model was specifically tailored to the life history attributes and habitat preferences of coastal cutthroat trout.

Table 1. Substrate composition in different portions of the Drift Creek watershed, as determined during stream surveys by Ellis Ecological Services.

	Fines	Gravel	Cobble	Boulder	Bedrock
Mainstem	6%	1%	43%	14%	37%
East Fork	1%	4%	64%	2%	29%
West Fork	28%	8%	35%	5%	21%

Modeling Productive Capacity for Cutthroat Trout

Model Overview

The model was constructed to use available information known to influence carrying capacity for either spawning or rearing. Habitat needs for these two life stages differ. Data inputs to the model were the measurements of habitat features in Drift Creek that determined the maximum density of fish supportable. Habitat features that determined spawning capacity were gravel availability, area defended per spawning pair, and minimum depth for spawning. Habitat features that determined rearing capacity were channel unit composition, surface area, depth, substrate, cover, and temperature. Habitat measurements were scaled to flows in March for spawning, and to summer base flow for rearing.

We used habitat surveys completed by Ellis Ecological Services (2010) for the required inputs on channel morphology. Those surveys were designed to characterize existing habitat conditions prior to development of the proposed Drift Creek Dam at River Mile (RM) 6.5 on Drift Creek (Figure 2). Habitat surveys of the lower 6.5 miles of Drift Creek, between the dam site and the confluence of Drift Creek with the Pudding River, were completed in 2009. Surveys within the 2.3-mile footprint of the proposed reservoir were completed in conjunction with fish surveys in 2006. The East Fork of Drift Creek upstream to an impassible falls at RM 1.5 and the West Fork of Drift Creek upstream to the upper limit of potential fish migration at RM 4.5 were surveyed in 2010.

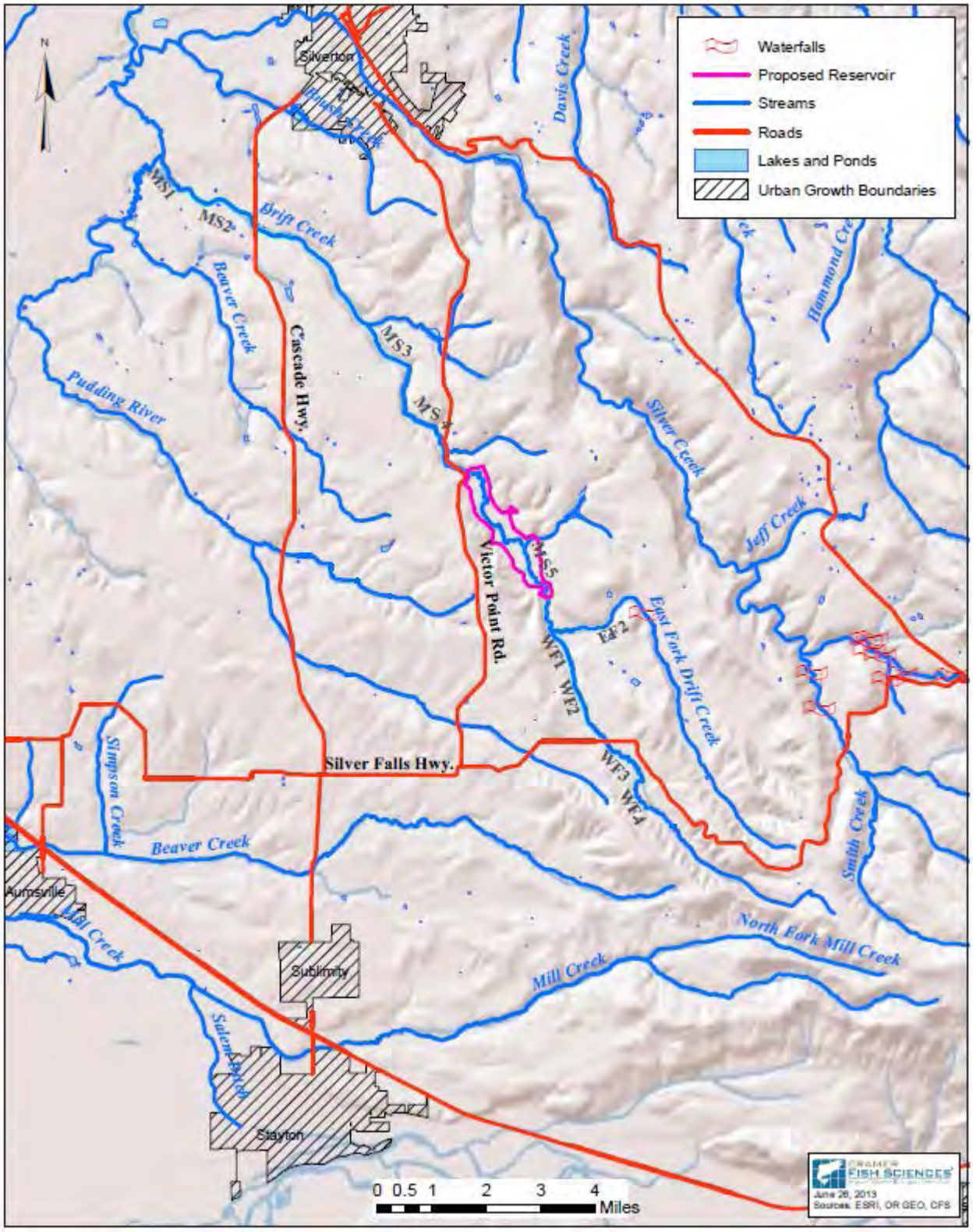

Figure 1. Map of the Drift Creek watershed and project location.

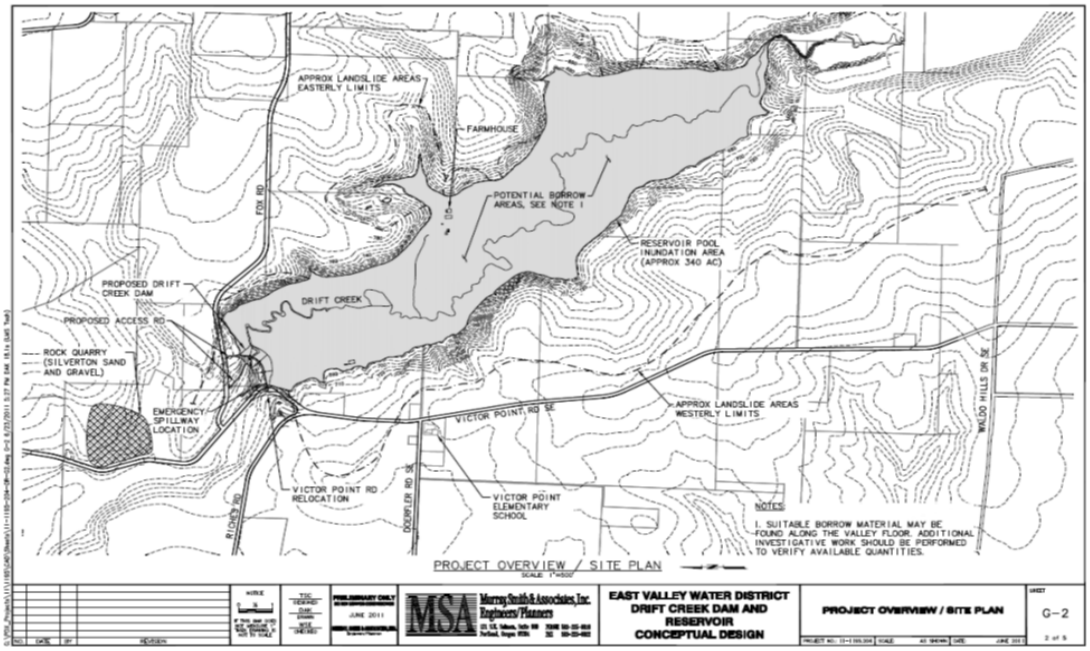

Figure 2. Proposed Drift Creek Reservoir at river mile 6.5 near Victor Point Road.

The typical channel morphologies used to describe habitat are riffles, runs (or glides) and pools. Definitions of these channel units are as follows:

pool: a unit with no surface turbulence, except at the inflow, and has depth extending below the plane of the streambed
riffle: a unit with discernible gradient and surface turbulence
glide: a unit that has relatively uniform velocity down the channel, little surface turbulence, and no depth below the plane of the streambed

The Unit Characteristic Method (UCM) that we used to predict stream carrying capacity for salmonids based on habitat measurements has been published in the peer-reviewed scientific journal (Cramer and Ackerman 2009a). The key principles underlying this method are:

1. Salmonids exercise strong and repeatable preferences for a suite of habitat features they will use, and these preferences determine the type of channel unit in which they choose to reside.
2. These preferences have repeatable patterns of change between life stages and in response to extremes in environmental variation.
3. The suite of habitat features available is related to the type of channel unit (e.g. pool, riffle, glide, etc.), and differs between these channel unit types.
4. Therefore, densities of salmonid use follow consistent differences between types of channel units.
5. Habitat capacity for a particular life stage of salmonid can be predicted as the product of the expected density of fish supportable in a particular channel unit, multiplied by the surface area of the unit, and then summed with such products for all channel units in the stream.

REPORT – Simulation of Potential Cutthroat Trout Production

While Cramer and Ackerman (2009a) describe the general utility of the UCM for understanding population function of salmonids in streams, Cramer (2001) provides specific relationships for application of the UCM to cutthroat trout. We extended the UCM model to account for habitat's influence on capacity to support spawning, and we incorporated survival rates during each life stage. Survival rates in a reservoir environment differ from those in a stream, so we incorporated anticipated changes in fish survival into a calculation of fish effects expected from scenarios with Drift Creek Dam in place. Predicted effects were accumulated across all life stages and translated into the common currency of adult-equivalent change in fish production the watershed could produce under average conditions. Adult-equivalents are the expected number of returning adults that would result in the absence of fishing. For example, if it takes 100 hundred fry to produce one adult, then 100 fry are one adult equivalent.

Conceptual Model of Fish Use

In order to estimate carrying capacity of a watershed to support a fish species, we first had to describe how the species could be expected to use the habitat. Patterns of habitat use in streams by fish (which we refer to as habitat preferences) determine the proportion of available habitat that is suitable for fish use at a given life stage. So, we measured the amount of available habitat and its features, we projected how these measurements would change across seasons, and then we overlaid the habitat preferences of each fish life stage with the amount of habitat each fish would need to determine the habitat carrying capacity for that life stage.

Production of cutthroat trout, steelhead, and Coho salmon is most often limited by the capacity for juvenile rearing (Cramer and Ackerman 2009a; Quinn 2005), but factors constraining production can vary between stream reaches, and migration can enable fish to overcome some of these limitations by moving to another stream reach. The life stages we will refer to are defined as follows:

Fry	Juveniles in their first 30 days of life prior to establishing territories. Maximum fork lengths of fry are assumed to be ≤35mm for cutthroat .
Juveniles	Juveniles rearing and defending territories. Fork lengths assumed for cutthroat are assumed to be 35 to 120 mm for fish rearing in streams
Adults or spawners.	Fish that have reached maturity and are capable of spawning in the spring

In our modeling, we directly estimate carrying capacity within Drift Creek, and we assume that suitable rearing habitat is not available outside the watershed in the Pudding or Willamette rivers at the points directly downstream of Drift Creek. Temperatures in these downstream areas tend to reach lethal levels for Cutthroat during summer. We assume that juveniles will disperse within the Drift Creek watershed to fill available habitat, but we assign extra mortality during the act of migrating between reaches, because migrating fish expose themselves to ambush predators such as larger trout, birds, and mammals.

Cutthroat spawn in the late winter into spring, emerge as fry in late spring to early summer, and typically rear through one or two summers in their natal area before a portion migrate to larger water bodies downstream, including rivers, lakes, and the ocean. Rearing capacity for parr in the summer is typically the limiting factor (Cramer and Ackerman 2009a). Given the limited rearing opportunities in Drift Creek during summer, many age-0 and age-1 juveniles would be expected to disperse by early summer to

find rearing opportunities. Some cutthroat trout mature as early as age-2, and all are mature by age-4. None are assumed to survive past age-5 in small streams such as Drift Creek.

Relationships of Fish Use to Habitat Features

Carrying capacity is a function of the types of habitat features for which fish consistently exercise preference and how well those preferences can be satisfied by the types of habitat that are available in a given stream. We now turn to describing the functional relationships that describe how fish use of a stream at each life stage is affected by specific habitat features.

Spawning Habitat Preferences

There is sufficient commonality of preferred spawning habitat features across anadromous salmonid species that we were able to use the same generalized model to predict spawner carrying capacity for all species. However, the distribution of spawning in a basin is influenced by where the juvenile life histories of a species can be supported, so we will also point out influences on spawner distribution under our separate description of the rearing capacity model.

Salmonids show broad overlap in the range of depths, velocities, and substrate composition they choose to spawn in (Burner 1951; Kondolf and Wolman 1993; Keeley and Slaney 1996) and studies have generally revealed that predictable differences in preferred spawning habitat are related to the size of the spawning fish rather than its species. Fish of different species but similar size would tend to spawn in the same type of habitat. Larger fish tend to spawn in deeper, faster water with larger diameter substrate than their smaller cohorts choose (Keeley and Slaney 1996). The data presented by Kondolf (2000) show that salmonids can spawn in gravels with median diameters up to 10% of their body length, although movement of such large particles would also likely correspond to spawning in water velocities at the maximum of the observed range.

Gradient and flow are key factors that drive where spawnable size substrate will settle out. Researchers consistently report that trout and salmon most frequently spawn in pool tailouts and heads of riffles below a pool (Bjornn and Reiser 991; Mull and Wilzbach 2007; Keeley and Slaney 1996), because these are the zones where fish preferences for depth, velocity and substrate most frequently are met in combination.

Measurements of depth, velocity, and substrate size at spawning redds lead to the conclusion that minimum depth and velocity are the factors that limit use of appropriate sized gravels. Keeley and Slaney (1996) concluded that across a range of salmon species, water flows greater than 10 cm/sec velocity and 10 cm deep were the minimum amounts of water fish would spawn in. Numerous researchers have reported that cutthroat trout generally spawn in first and second order streams (DeWitt 1954; Edie 1975; Magee et al. 1996) where stream widths are 1-10 ft and gradient is 2-6%. The substrate size they use is small gravel.

Where minimum depth, velocity and appropriate substrate sizes occur, salmonids also need a minimum amount of territory in which to construct and defend their redd. The most widely cited study for determining spawning territory size is that of Burner (1951) who measured characteristics for a large

number of redds for several salmon species in the Lower Columbia basin. Burner found that inter-redd spacing was proportional to redd size, which in turn was proportion to spawner size. Burner concluded that the total average area necessary for a pair of spawning fish was about four times the area of the average redd. Keeley and Slaney (1996) reviewed 33 studies of microhabitat selected at spawning by 13 species of salmonids, and concluded that available data continued to support Burner's conclusion; territory size for spawning salmonids is roughly four times that of the redd area. Accordingly, we used Burner's estimates for area needed per spawning pair in our model.

The amount of fine sediment mixed with the gravels can have a strong effect on egg survival. Even when depth, velocity and substrate criteria preferences are satisfied, egg survival is reduced when fines compose more than 25% of the substrate. Bjornn and Reiser (1991) summarized research showing that egg survival begins to decline at 25% fines in otherwise suitably-sized gravel, and approaches zero when fines exceed 55%. Thus, we scaled egg capacity to decline directly proportional to this survival effect wherever a suitable gravel patch had fines greater than 25%.

Spawner Carrying Capacity

We followed the following list of steps to estimate spawning capacity.

1. Exclude units with less than 10 cm depth. Assume depth of pool tailout is 1/3 of pool max depth
2. Pool spawnable area is the tail out, and is assigned length equal to one channel width (area upstream of tailout is assumed unsuitable)
3. Glide spawnable area is assumed to be half of the glide area with suitable substrate
4. Riffle spawnable area is the full area of the riffle with suitable substrate.
5. Spawnable area in each unit is multiplied by the scalar for fines exceeding 25%
6. Qualifying suitable area is summed across all units
7. Area required per spawning pair is 0.5 m^2
8. Redd capacity = qualifying suitable area/(4 * avg redd area)

Rearing Habitat Preferences

Stream carrying capacity for salmonids rearing in freshwater can be predicted from a sequence of cause-response functions that describe fish preferences for macro-habitat features. The channel unit (e.g., pool, glide, and riffle) is a useful stratum for quantifying rearing capacity for salmonids, and is a hydrologically meaningful unit for predicting the response of stream morphology to watershed processes. Thus, channel units are the natural link between habitat-forming processes and habitat requirements of salmonids. Maximum densities of juvenile salmonids that can be supported in a channel unit are related to availability of preferred habitat features including velocity, depth, cover, and substrate. Within channel unit types, maximum densities of salmonid parr will shift predictably as availability of cover from wood and boulders increases.

We used average densities of cutthroat trout specific to each channel unit type as was determined by ODFW from sampling in coastal streams of Oregon where habitats fully populated with fish (Table 2). In nearly all of these streams, anadromous salmon and steelhead were also present, so competition among

species likely resulted in lower densities than might be found where cutthroat trout are the only species present.

Table 2. Average density of cutthroat parr (> 90 mm) in different habitat types in the summer and winter in 30 streams of the Oregon Coast. Standard errors shown in parentheses.(Johnson et al. 1993)

	Summer			Winter		
Habitat type	Units Samples	Fish Density (fish/sq m)		Units Samples	Fish Density (fish/sq m)	
Pools						
Trench	5	0.12	(0.05)	3	0.00	(0.00)
Beaver Pond	1	0.04		1	0.01	
Mid-channel Scour	19	0.16	(0.04)	12	0.02	(0.01)
Plunge	28	0.22	(0.04)	15	0.07	(0.02)
Lateral Scour	107	0.16	(0.02)	22	0.07	(0.02)
Dam	2	0.12	(0.01)	4	0.05	(0.02)
Backwater	5	0.02	(0.01)	0		
Glides	70	0.04	(0.01)	21	0.01	(0.01)
Riffles	57	0.01	(0.00)	17	0.00	(0.00)
Rapids	76	0.02	(0.00)	22	0.01	(0.00)
Cascades	3	0.00		1	0.06	

As salmonids grow, territory size of salmonids increases exponentially with fish length, such that the demand for territory to support surviving members of a cohort increases at least through their first year of life. Changing habitat preferences and space demands, juxtaposed against shrinking habitat availability with the onset of summer low flows often results in a bottleneck to rearing capacity in wadable streams for salmonids greater than age 1. Habitat factors within each channel unit that affect its capacity to support rearing salmonids are described below.

Influence of Depth

Densities within each unit type are strongly influenced by depth and cover. Combined observations from several experiments indicate that steelhead exercise habitat preferences in the priority order of depth first, velocity second, and cover third. Parr of all salmonid species strongly avoid areas with depths <0.2 m, and a variety of studies show that parr densities increase as unit depths increased up to at least 1 m. Cramer and Ackerman (2009a) showed similarly that cutthroat use tended to increase as depth increased. Heggenes et al. (1991) found that cutthroat trout strongly preferred deeper areas in both summer and winter. Larger cutthroat trout occupied the deeper pools. At the Hinkle Creek study, Berger and Greswell (2009) found that the drop in survival during the autumn period was correlated only with maximum pool depth; survival decreased as pool depth decreased.

Influence of Cover

A study by Johnson et al. (1993) was able to quantify the benefit of cover by assigning a cover complexity score to the pools in which fish were sampled. Parr density in pools for both steelhead and cutthroat increased about three fold as woody debris complexity increased from none to high complexity. Boulders provide a form of cover in streams, particularly in riffles. Steelhead and spring Chinook show strong preference to hold adjacent to much faster velocities, and their densities in boulder dominated riffles,

where they held behind boulders, are several times greater than in riffles dominated by other substrate types.

Influence of Substrate

Substrate embeddedness with fines is a key factor that influences both the production of invertebrate drift and the cover for juvenile salmonids. Hawkins et al. (1983) found that increasing percentages of fines in riffles across reaches in 13 coastal streams of Oregon was correlated to reduced production of both invertebrates and juvenile salmonids. Bjornn and Reiser (1991) summarize data from several studies on the effects of fines, and show that rearing densities decline as fines rise above 10% of the substrate in riffles. The measurement of fines in riffles is used as an index for the effect on fish in the entire reach rather than just in riffles.

Overwinter Habitat

Coho have a strong tendency to seek off-channel and protected habitats during winter; their area required for winter habitat is often the factor limiting their carrying capacity (Nickelson 1998). In contrast to coho, Chinook and steelhead do not seek off channel habitat for winter, and have a strong tendency to enter interstices of cobble and boulder substrates within the same channel types they occupy during summer (Hartman 1965; Bustard and Narver 1975; Hillman et al. 1987; Bjornn and Reiser 1991). Cutthroat trout use both off channel habitat and subtrace interstices within the channel. Related to these preferences, summer rearing habitat usually determines the carrying capacity for cutthroat, yearling Chinook, and steelhead, in contrast to the usual winter habitat limitation for coho.

Stream Temperature

We found several studies of fish assemblages in streams spread over a broad geographic area that showed salmon and trout were consistently found at highest densities where stream temperatures in summer were near their physiological optimum of 12 to 16°C (Huff et al. 2005; Ott and Marret 2003; Waite and Carpenter 2000). These studies showed that salmonids still persisted, but at lower densities, in stream reaches with temperatures above this range. Although densities declined with increasing temperature, we did not find consistent evidence that mortality rate of rearing fish increased until temperatures reached incipient lethal levels.

In order to scale down the rearing capacity as temperatures reaches stressful levels (> 16°C) we used the function derived by Cramer et al. (2012) from ODFW snorkel counts of juvenile salmon rearing in coastal streams. Consistent with the ODFW data, the function suggests that juvenile rearing densities are highest at MWAT (maximum of weekly average temperatures) between 14-16°C (Figure 3). The logistic function is set to yield a scalar of 0.95 at MWAT = 16°C and 0.05 at MWAT = 23°C (Figure 3). Additionally, we also assumed that in small streams with limited summer flow, there would be thermal stratification in pools over 1 m deep, so the function for those deep pools differed slightly from shallow pools (Figure 3). This function is:

Equation 3: $Ts_i = \frac{1}{1+e^{-a-bT_i}}$

Where:

Tsi = Temperature scalar for capacity for reach *i*
a = intercept of logit(*Tsi*) = 19.63;
b = slope of logit(*Tsi*) = -0.98;
T = MWAT for reach *i*
This scalar is then multiplied by the habitat capacity for rearing in the reach.

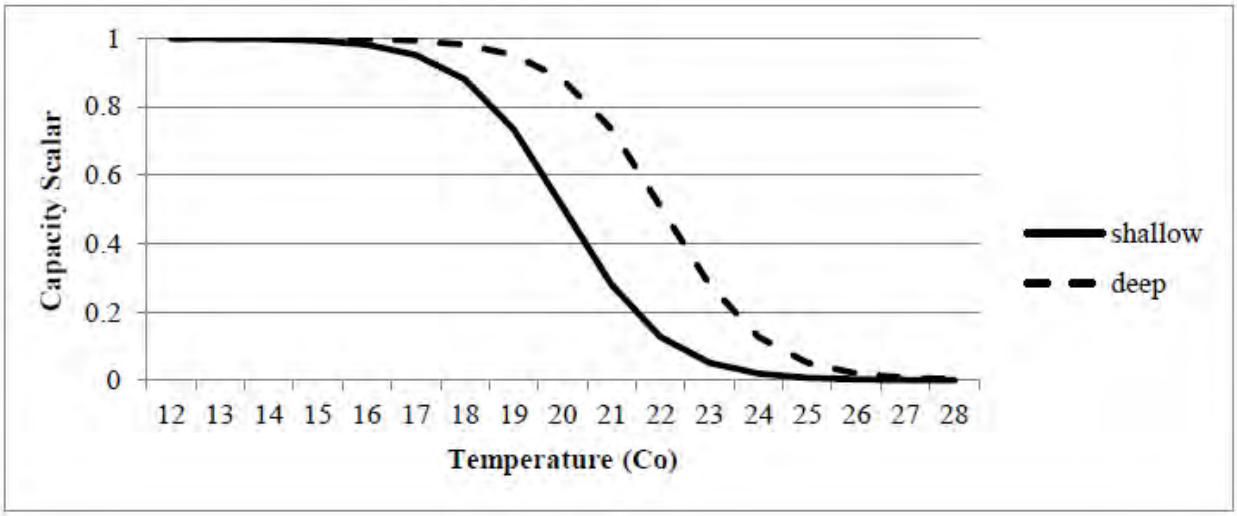

Figure 3. Effect of temperature on rearing capacity for cutthroat trout. Temperature is expressed as the summer maximum of the 7-day running average. Dashed line applies to pools >1m deep, which we assume thermally stratify and provide a thermal refuge at depth that is 2°C cooler than surface flow.

Rearing Capacity Prediction

We assumed that carrying capacity at the emergent fry life stage was not a bottleneck to production, and we did not calculate its carrying capacity. Cutthroat trout have life histories that include rearing through the summer, so we assumed their carrying capacity is most limited by the late summer base-flow period. This has been confirmed by the studies of Berger and Greswell (2009). Although coho production has been shown to be most limited by overwintering habitat (Nickelson 1998) that has generally not been true for steelhead and Chinook (Cramer and Ackerman 2009a).

The UCM predicts a stream's carrying capacity under average conditions by multiplying fish density by surface area in each unit, and then adjusts for differences between stream reaches in factors that influence food supply, as described in the section below. The general form of the predictor for a given species in a specific stream reach is:

$$\text{Capacity}i = (\Sigma\ \text{area}k \cdot \text{den}j \cdot \text{chnl}jk \cdot \text{dep}jk \cdot \text{cvr}jk)$$

Where;
i = stream reach. "Reach" is a sequence of channel units that compose a geomorphically homogenous segment of the stream network,
j = channel unit type,

k = individual channel unit,
area = area (m^2) of channel unit *k*,
den = standard fish density (fish/m^2) in unit type *j*,
dep = depth scalar with expected value of 1.0,
cvr = cover scalar with expected value of 1.0,
chnl = discount scalar for unproductive portions of large channels with expected value of 1.0. In Drift Creek, channel width always resulted in a scalar of 1.0.

We used scalars to represent the proportionate change in standard fish densities that would occur if habitats differed from the standard in their depth, cover, substrate, or nutrients. We used the functions described by Cramer and Ackerman (2009b), for steelhead, and applied them to cutthroat trout (Figure 4).

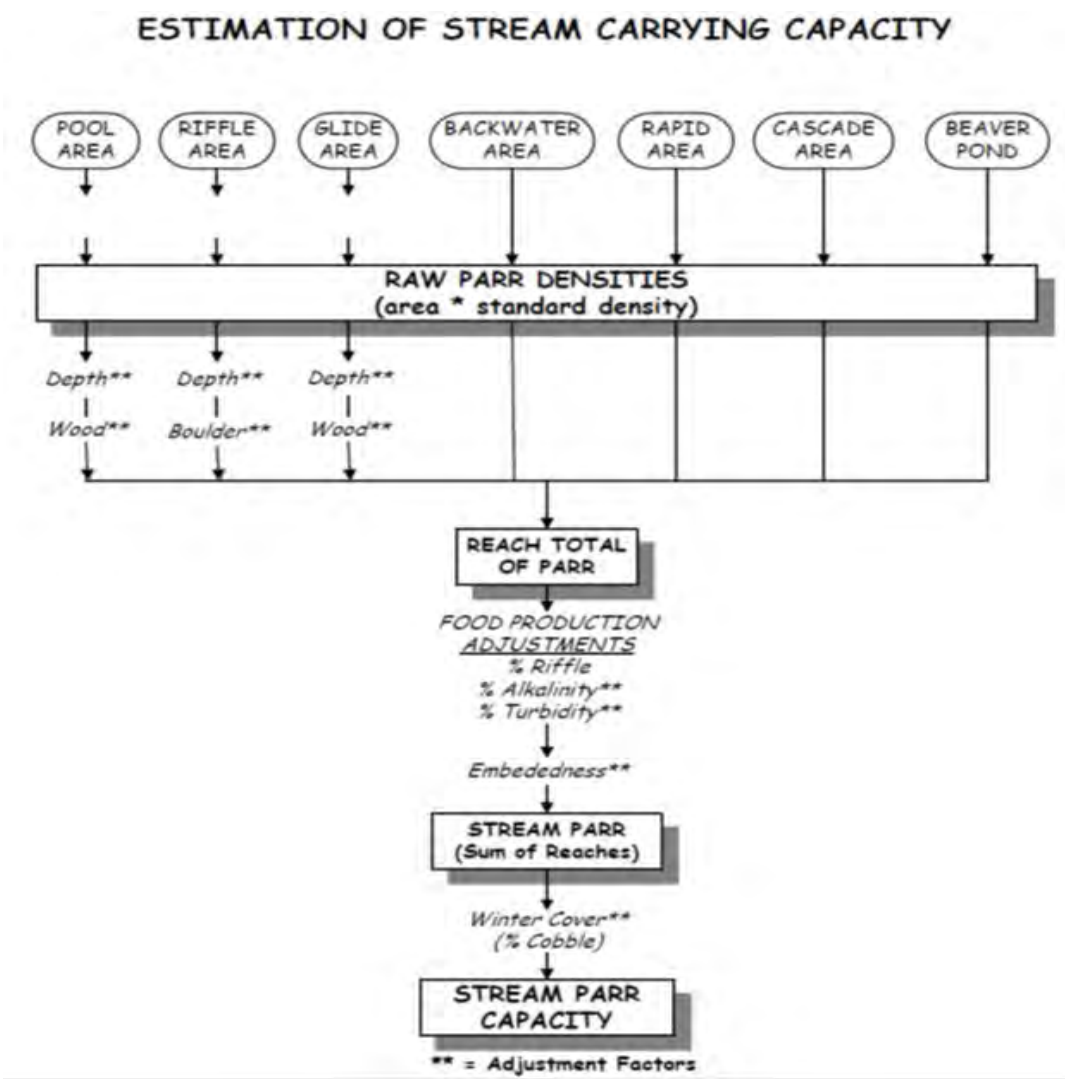

Figure 4. Schematic of the calculation sequence applied in the Unit Characteristic Method (UCM) to estimate carrying capacity for age-1 salmonids (parr). Adapted from Cramer et al. (2013)

Predicted Width and Depth Change at Higher Flow

Stream dimensions were measured while flows were at their lowest of the year, so we needed to predict how both the width and depth of each channel unit would increase at the higher flows during late winter for spawning capacity or during summer for rearing capacity. We applied basic relations for hydraulic geometry to predict these differences. Leopold and Madock (1953) described trends in average channel width and depth as simple power functions of river discharge:

W = aQb

D = cQf

V = kQm

where

W is average channel width;

D is depth; V is velocity;

Q is discharge;

b, f and m are exponents for the increase in width, depth, and velocity, respectively, with increase in discharge;

a, c and k are coefficients for the respective power functions.

These relationships also have the property that the sum of the exponents must equal unity (b + f + n = 1), and so must the product of the coefficients (ack = 1). Rosenfeld et al. (2007) describes the use of these hydraulic geometry relations to predict how characteristics of fish habitat change with flow. Rosenfeld et al. (2007) point out that pools are deeper and slower than riffles during low flow conditions, so exponents for width and depth of pools and riffles differ from each other (Figure 5). Velocity increases more rapidly and depth more slowly in pools than in riffles as flow increases, such that depth and velocity of the two unit types converge at bankfull flow (Figure 5). Width, on the other hand tends to change at a similar rate between unit types. Rosenfeld et al. used exponents for depth change of f = 0.22 in pools and f = 0.46 in riffles to represent typical values estimated from stream field studies (Figure 5), and we used those values to estimate the rate of depth change with increasing flow in Drift Creek. We used the width exponents estimated by Hogan and Church (1989) for a coastal stream in British Columbia.

We used the hydraulic geometry equations to calculate channel unit widths and depths in February-March, the season of adult salmon spawning. We then calculated the ratio of width in February-March to that which we measured at low flow in September (e.g. February-March width/Sept width), and repeated the process for depths. These ratios of width or depth in one season to that at base flow in September were used as expansion factors (scalars) for each channel unit to determine their dimensions in February-March. The value of Q for each of these seasons was 2.7 cfs in September, 58 cfs for February-March. These were the flows measured at Victor Point Rd (near proposed dam site) during the 2009-2010 water year, which was an average flow year. Flows were converted to m^3/sec before we applied the hydraulic geometry equations, because the exponents were determined from flows expressed in metric flow units. We compared our scaled width and depth values to measurements taken at 72 different sites in the Oregon Coastal Range and found that our values fell within the range of observed values in the field (Romer et al. 2008).

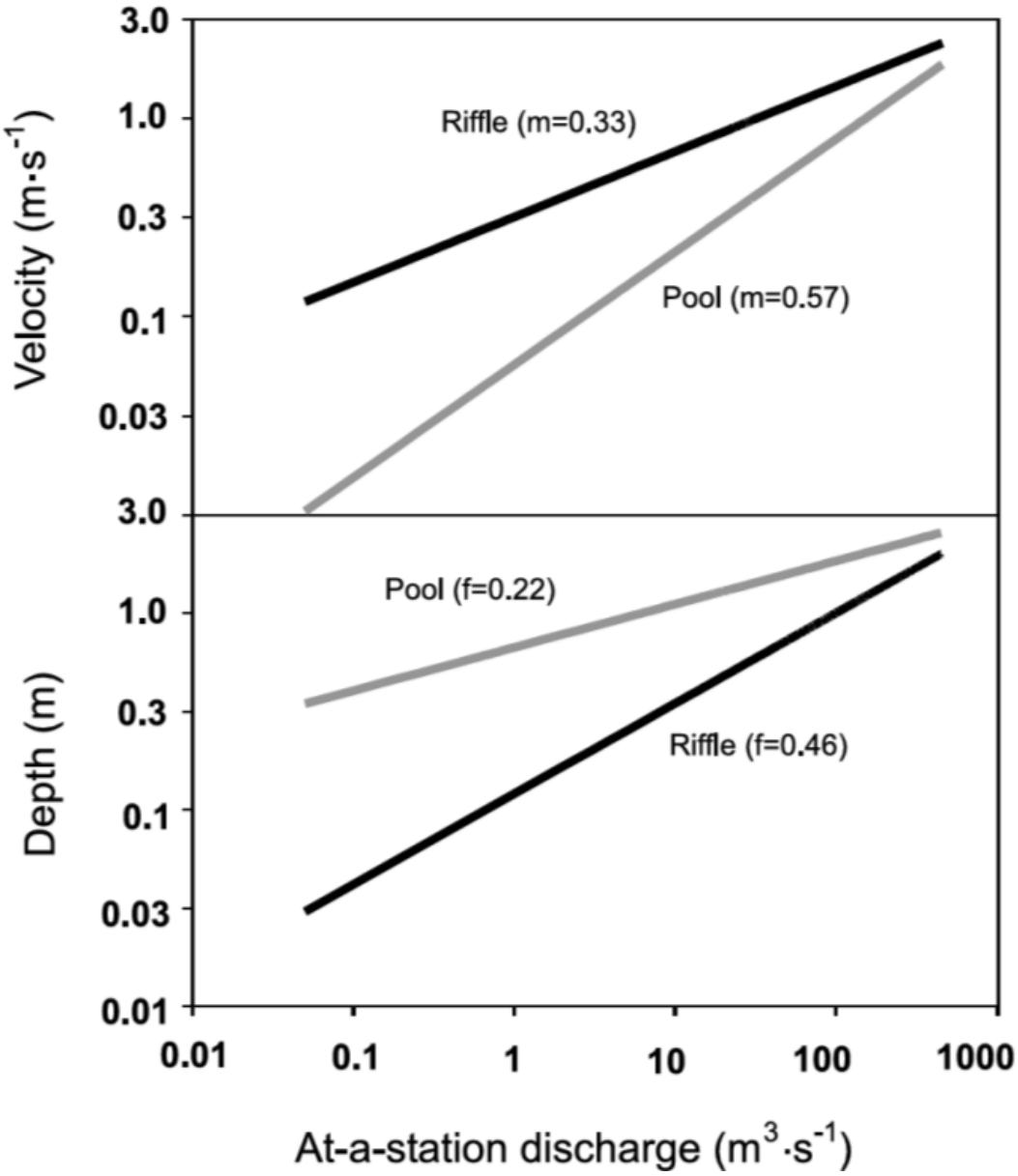

Figure 5. Contrasting rates of change in velocity and depth between pools and riffles in response to increasing flow for a stream with mean annual flow of 3 m3/sec. From Rosenfeld et al. (2007).

The predicted effect of 58 cfs flow in February-March (spawning season) compared to the 2.7 cfs during September was that pools would average 96% deeper and 79% wider than in September, and riffles would average 400% deeper and 63% wider than in September. These changes together would considerably increase the area of those channel units containing suitable spawning, although simulations under existing conditions show that lack of spawning habitat is a key factor constraining production. These increases in depth and area also indicate that area for rearing would be much greater during other seasons of the year compared to that at base flow.

Estimated Production Potential for Drift Creek

Here we describe how data on habitat availability, carrying capacity, and life history parameters are integrated in a simulation model to estimate the maximum number of adult cutthroat the Drift Creek watershed can produce under average conditions. We previously described how carrying capacity can be estimated, and now we describe the expected survival of eggs and fish from one life stage to the next. With values for carrying capacity and survival, we can then predict the number of adult cutthroat the watershed is capable of producing.

Life Stage Survival Rates

We derived best available estimates for life-stage survival rates through review of published scientific literature and fish agency reports. The values we used and the primary source from which they were derived are summarized in Table 3.

Table 3. Fecundity and life-stage survival values used to calculate potential production of juveniles through each life-history pathway to estimate the average number of adult equivalents produced.

Life History Parameter	Value	Source
Fecundity	150 eggs/Adult 1000 eggs/Adult	Resident cutthroat trout (Nicholals 1978; Moring & Youker 1979) Adfluvial cutthroat trout (Nicholals 1978; Moring & Youker 1979)
Egg to spring Fry Survival	15%	Cutthroat fry do not migrate, so estimation of their survival is difficult Lister and Walker 1966 estimated average Chum egg-to-fry survivals ranging from 5.0% to 17.0% under natural varying flow, and of 25% when flows were stabilized.
Fry to fall Parr Survival	38.6%	Johnson and Cooper 1995. Average across 10 broods of steelhead in Snow Creek, WA
Annual Survival Age 1-5	33%	Coastal cutthroat; Hinkle Creek (Berger and Greswell 2009)
Proportion Maturing	Age 2 = 25% Age 3 = 60% Age 4 = 100% Age 5 = 100%	Willamette cutthroat trout (Moring & Youker 1979)

Estimation of Adult Equivalent Production

The predicted number of juveniles that could be produced through each life-history pathway were accumulated across all life stages and translated into the common currency of the predicted number of adults they would produce under average conditions. Survivals applied in this process are summarized in Table 4. The assignment of fish to different life history pathways was influenced by the distribution of spawners among reaches and the carrying capacity limitations that their offspring encountered. Adults were assigned to spawn in all suitable redd capacity for their species in all reaches where such capacity occurred. Redd capacity was estimated using the data collected during our field surveys, but with depth and width values scaled up to those at the higher flows in February-March, as described previously. The equations used to scale depth and width of the different habitat unit types are described in Table 4. The

number of redds supported was then multiplied by fecundity values to calculate the number of eggs that would be produced within each reach. Eggs were assigned a fixed survival to the fry stage. During the fry to age-1 parr stage, fish were assumed to distribute into available habitat, including the reach immediately upstream, and up to three reaches downstream. All fish that moved outside their natal reach were assigned an extra 10% mortality as a cost of migration that exposes them to predation risk.

Table 4. Functions used to scale fish densities based on specific habitat features. Abbreviations are L = length, W = width, D = depth. All measurements are in meters, and flow measurements in cfs. Depths measured are the maximum in pools and the mean in riffles and glides.

Redd Capacity Scalars		
Pool Length	If L > 4*W: L = 4*W	Cramer 2001. Derived from Sandy and Clackamas Basin surveys
Pool Depth	Measured Depth *(Feb-Mar Flow$^{0.22}$/September Flow$^{0.22}$)	Exponent values from Rosenfeld et al. 2007
Glide Depth	Measured Depth * (Feb-Mar Flow$^{0.33}$/September Flow$_{0.33}$)	Exponent midway between that for pools and riffles by Rosenfeld et al. 2007
Riffle Depth	Measured Depth * (Feb-Mar Flow$^{0.46}$/September Flow$^{0.46}$)	Exponent values from Rosenfeld et al. 2007
Pool Width	Measured Width *(Feb-Mar Flow$^{0.19}$/September Flow$_{0.19}$)	Exponent values from Hogan and Church 1989
Glide / Riffle Width	Measured Width*(Feb-Mar Flow$^{0.16}$/September Flow$^{0.16}$)	Exponent values from Hogan and Church 1989
Parr Capacity Scalars		
Pool Depth	If D is <0.10: 0.0*D	Beecher et al. 1993. Puget Sound steelhead habitat preference
Pool Depth	If *D* is 0.10 – 0.80: (0.30* *D* – 0.027)/0.17	Dambacher 1991. Steelhead parr
Pool Depth	If D is >0.80: 0.22/0.17	Bisson et al. 1988. Steelhead parr
Riffle Depth	If D is <0.1: 0.0*D	Beecher et al. 1993. Puget Sound steelhead habitat preference?
Riffle Depth	If D is 0.10 – 0.16: (0.5*D – 0.050)/0.03	Bovee 1978
Riffle Depth	If D is 0.16 – 0.30: (0.29*D – 0.017)/0.03	D. B. Lister and Associates, unpublished data, steelhead and Chinook parr
Riffle Depth	If D is 0.30 – 0.80: (0.25*D – 0.003)/0.03	D. B. Lister and Associates, unpublished data, steelhead and Chinook parr
Riffle Depth	If D is 0.80 – 0.90: 0.20/0.03	D. B. Lister and Associates, unpublished data, steelhead and Chinook parr
Riffle Depth	If D is 0.90 – 1.50: (–0.32*D + 0.485)/0.03	Conner et al. 1995. Steelhead parr
Riffle Depth	If D is >1.50: 0	Conner et al. 1995. Steelhead parr
Reach Scalar for fines	If % Fines in Riffles < 10: 1.0	Bjornn et al. 1977
Reach Scalar for fines	If % Fines in Riffles ≥ 10: 1.11 – 1.1 * % Fines	Bjornn et al. 1977

Pools and Glides	If wood complexity = 1: 0.58	Johnson et al. 1993. Oregon coast streams
Pools and Glides	If wood complexity = 2: 1.00	Johnson 1985. Washington rivers. Steelhead
Pools and Glides	If wood complexity = 3: 1.42	Johnson et al. 1993. Oregon coast streams
Pools and Glides	If wood complexity = 4 or 5: 1.84	Johnson et al. 1993. Oregon coast streams
Riffles	If % Boulder < 25: 1.0	Johnson 1985. Washington rivers. Steelhead
Riffles	If % Boulder is 25 – 75: 1 + 12 * (% Boulder – 0.25)	Johnson 1985. Washington rivers. Steelhead
Riffles	If % Boulder > 75: 7.0	Johnson 1985. Washington rivers. Steelhead

Limiting Factors and Potential Remediation

Existing Production Potential

The survey data obtained by Ellis Ecological reveals that salmonid production is strongly constrained by three factors, (1) a paucity of spawning gravel, (2) low summer flows, and (3) high summer temperatures. After the observed habitat measurements were input to our model, simulations with the model made it possible to examine the extent of limitation each of these factors posed to cutthroat production.

Spawning Capacity

The paucity of gravel suitable for cutthroat spawning habitat strongly limits cutthroat production. Suitable areas for spawning were only found in main stem reach 5 (MS5) and West Fork reach 4 (WF4) (Table 5). Even with rearing habitat severely restricted by low flows and high temperatures, the spawning habitat capacity is not sufficient to support enough spawning pairs to fully seed the stream's rearing capacity. This can be seen by comparing the number of age-2 fish in the spring within each reach to the age-2 carrying capacity for each reach. We see in Table 5 that there are fewer age-2 fish available than there is carrying capacity in every reach of the mainstem.

Low Summer Flow

Low flow in the summer is a major limiting factor in the watershed, with flows dropping under 2 cfs in late summer at the Victor Point gauge. Low flows contribute to the high temperatures that we analyze separately, but also cause riffles to become too shallow to support any cutthroat during late summer (Table 6). At such low flows, only the pool and some glides are capable of supporting juveniles through the summer, and both the size and depth of these channel units are restricted. Habitat conditions during low flow have been described by Ellis Ecological Services (2010).

Table 5. Simulated potential for cutthroat trout production in the Drift Creek watershed under existing conditions. Total AEQ (adult equivalent) spawners are the sum of spawners across ages for the specified reach.

		Redd Capacity	Eggs	Fry	Parr	Age 1	Age 1 - Redist.	Age 2 - Spring	Age 2 Carrying Capacity	Age 2 - Fall	Age 3	Age 4	Age 5	Total AEQ Spawners
Fecundity								50			100	150	150	
Survival Rates				0.15	0.386	0.3321		0.33			0.33	0.33	0.33	
% Mature								0.25			0.6	1	1	
Near the Mouth	MS1	-	-	-	-	-	-	-	16	-	-	-	-	-
Cascade Hwy	MS2	-	-	-	-	-	-	-	36	-	-	-	-	-
Canyon	MS3	-	-	-	-	-	209	69	82	69	23	8	2	41
Out of Canyon	MS4	-	-	-	-	-	209	69	74	69	23	8	2	41
Proposed Reservoir	MS5	1,193	108,719	16,308	6,295	2,091	1,406	464	519	464	153	51	17	275
Farmland	EF1	-	-	-	-	-	247	81	18	18	6	2	1	27
Forested	EF2	-	-	-	-	-	38	12	12	12	4	1	0	7
Fisher Farm	WF1	-	-	-	-	-	114	37	39	37	12	4	1	22
Fisher Forest	WF2	-	-	-	-	-	114	37	30	30	10	3	1	20
Beaver Activity	WF3	-	-	-	-	-	114	37	25	25	8	3	1	18
Upstream	WF4	432	39,368	5,905	2,279	757	114	37	39	37	12	4	1	22
	Total	1,625	148,087	22,213	8,574	2,848	2,563	846	890	762	251	83	27	473

Table 6. Mean depths (cm) for different channel unit types during late summer in different portions of the Drift Creek wastershed. Data from stream surveys by Ellis Ecological Services.

	Pool	Glide	Riffle	Rapid
Mainstem	51	27	15	10
East Fork	37	*	5	5
West Fork	40	12	7	5

High Summer Temperatures

Stream temperatures in the summer rise to levels that exceed the preferred range for salmonids, and this further reduces the number of juveniles that will remain in the watershed. The temperature scalar used in the model for this effect was derived from numerous field studies that demonstrate salmonid densities in a given body of water drop at a rate directly proportional to the increase in temperature above the optimum for growth (~16°C). The effect of that scalar at present temperatures in an average water year was to reduce capacity to 29% of that which could be supported in the same habitat if temperatures were within the optimal range of 10-16°C. Temperature records in the Drift Creek show that MWAT values of 23°C are reached in the main stem during low flow and exceed 20°C in most years.

Production Potential with Reservoir

We simulated what the cutthroat production would be with two scenarios that included a reservoir replacing main-stem reach 5 and a dam that prevented migration between the two forks and the main stem below the dam (MS1 through MS 4). We used outputs from the hydrodynamic temperature model developed by Portland State University (Berger et al. 2012) to determine what the flow and temperature would be at release from the dam. For each scenario, we used model results for an average water year, as represented by WY 2009-2010, and we assumed outflows could be mixed from two withdrawal ports, one at mid level and the other at low level in the reservoir. Outflows were specified to meet minimum in

stream flows at the mouth of Drift Creek, and satisfy temperature standards as nearly as possible at the point of release (Figure 6). Before addressing the downstream effects, we first describe effects of the reservoir on habitat and cutthroat production upstream of the dam. This production above the dam would remain the same for both flow scenarios simulated below the dam.

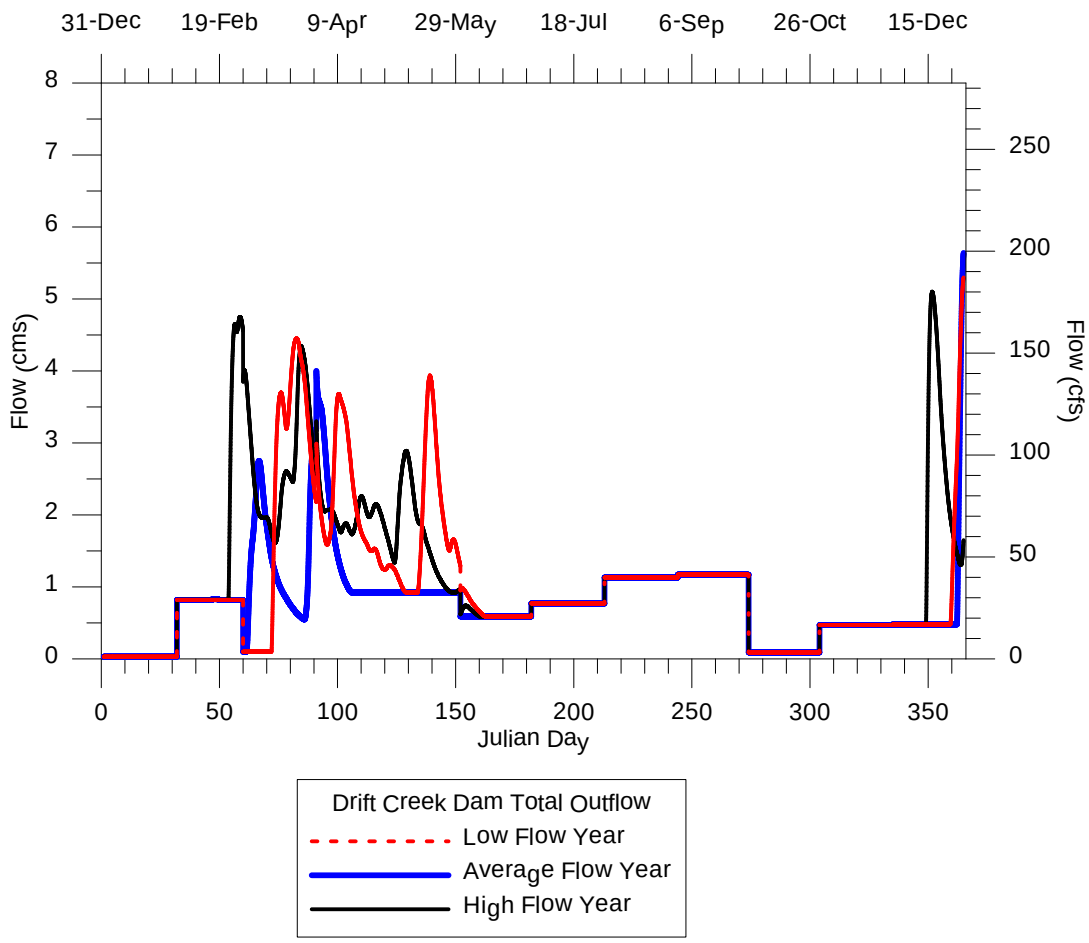

Figure 6. Total reservoir outflows for low, average, and high flow years. Note that the more familiar measure of flow as cfs is plotted on the right-side y axis. From Berger et al (2012)

Production in the Reservoir and Upstream

The proposed Drift Creek Dam would convert all of main-stem reach 5 to a reservoir, and the upper end of the reservoir would be downstream of where the two forks of Drift Creek merge. After a reservoir is created, main stem reach 5 would become reservoir habitat. Modeling of temperature and dissolved oxygen within the reservoir show that it would provide desirable habitat for cutthroat for about 11 months of the year (October through August), but water quality in September would likely limit growth while allowing cutthroat to survive (Figures 7 and 8). The reservoir would be thermally stratified during summer and maintain a cool deep layer through August. Simulations indicate the cool pool would be exhausted in September, and temperatures of 18-20 degrees C would extend from surface to the bottom for a few weeks before seasonal cooling begins. Although a zone of oxygen depletion is likely to develop

at bottom layers of the reservoir in mid summer, a broad range of depths with suitable oxygen levels would remain throughout the year. Studies have shown that cutthroat can fare well with circumstances more challenging than these. Baldwin et al. (2002) tracked acoustically tagged cutthroat trout in Strawberry Reservoir, Utah, and found that trout constrained their use of depths during mid summer when only the meta limnion (10-15 m deep) had a suitable combination of temperature and DO for their survival. Water was too warm at the surface and hypoxic at depth. These fish used a wide range of depths at other times of year. The depth at which hypoxia occurred extended to increasingly shallower depths through August. In early August, fish occupied water that was 9-11°C and DO was 3-3.9 mg/L and the depth range was 11-13m. During mid August, they stayed in the DO range of 3.1 to 6.2 mg/L during day at temperatures of 13-16°C, but moved to near surface at night in water of 18.3C and 9.4 mg/L DO. In August, trout lost or barely maintained weight (Baldwin et al. 2002). These findings and the modeled conditions within Drift Creek Reservoir indicate the reservoir would be well suited to production of an adfluvial life history of cutthroat that would spawn in the West Fork and main stem of Drift Creek entering the reservoir.

A number of studies indicate that coastal cutthroat thrive in reservoirs with suitable water quality. Hooton (1997) noted that several natural adfluvial populations of cutthroat exist in Oregon coastal lakes above barrier falls. These include Grassy (North Nehalem River), Buttermilk (Yaquina River), Slide and Klickitat (Aslee Rivr), and Loon (Umpqua River). These lakes have not received stocking of hatchery trout. Angler catches have been monitored in Slide and Klickitat lakes since 1979, and catches have remained at 2 – 6 trout per angler across years without trend. Hooton (1997) interprets these data to indicate that lakes can sustain harvestable production of coastal cutthroat trout. Hooton (1997) also reported that an abundant adfluvial population of cutthroat trout exists in Bull Run Reservoir and upstream tributaries where no public access is permitted. Adfluvial cutthroat have developed in Fern Ridge Reservoir on the Long Tom River near Junction City. These fish when caught by anglers often exceed 30 cm, while cutthroat that remain in the Long Tom River seldom exceed 20 cm (Hooton 1997). Wild adfluvial cutthroat trout populations are present in Cascade Mountain lakes and reservoirs in the Clackamas, Santiam, McKnezie, and Middle Fork Willamette River subbasins (Hooton 1997).

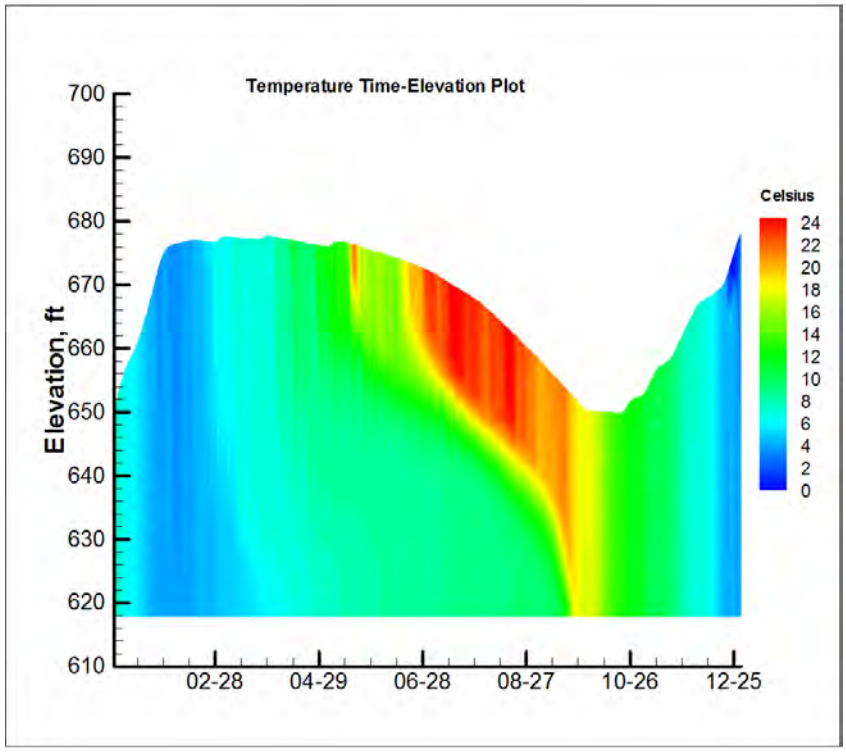

Figure 7. Time-elevation contour plot of predicted temperature in Drift Creek Reservoir for an average flow year with outflows through the mid and low level outlets. From Berger et al. (2012)

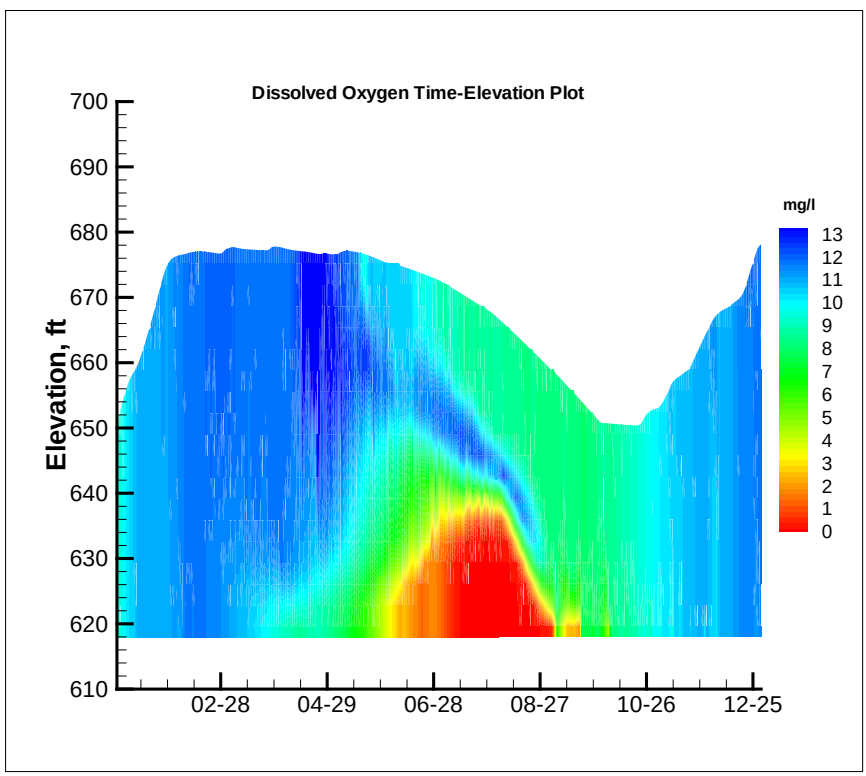

Figure 8. Time-elevation contour plot of predicted dissolved oxygen concentrations in Drift Creek Reservoir for an average flow year with 2 outlets at mid and lower elevations (no mixing). From Berger et al. (2012)

REPORT – Simulation of Potential Cutthroat Trout Production

In order to model how the adfluvial population would perform, we assumed the reservoir rearing capacity exceeded the number of fish that could be supplied by spawning in the stream. We reasoned that a 20-30 m wide strip of habitat suitable for rearing would be created around the reservoir edge, and this edge habitat would support fish densities similar to the least of stream habitat with a meter of depth. Such an area of habitat would vastly exceed the habitat capacity that now exists for rearing, given the existing high temperature limitation. So, we simply set the reservoir capacity at a number (1,000) larger than needed to support the offspring from the full carrying capacity for spawning.

Within reservoirs, cutthroat do not experience the shallow depths and high exposure to predation during fall that is typical for fish in small streams. Additionally, fish in reservoirs usually experience higher over-winter survivals than in streams (no floods to contend with). The data of Berger and Greswell (2009) show that cutthroat survival during moderate and high flow seasons of the year is higher by a factor of about 1.5 compared to that during the fall in Hinkle Creek. We reason that a similar increase in survival would accrue to cutthroat in the reservoir where they would avoid increased predation risk. We assumed annual survival for age 2 and older fish would be 0.33 in the stream and 0.5 in the reservoir.

We assumed that the head of the reservoir would create a deposition zone for gravels in the seasonally inundated area at its head, and that cutthroat would be spawn in these gravels within the natural stream channel. These gravel beds would gradually replace those that presently exist in the upper half of main-stem reach 5. Figure 7 and 8 shows that reservoir drawdown would not begin until mid June, so eggs deposited in these depositional gravels would generally not be dewatered before free-swimming fry emerged. Spawners should average 11-14 inches with the reservoir, versus 6-9 inches now in the stream. Given that the model predicts nearly equal numbers of spawners will result from resident (228) and adfluvial (258) life histories when the reservoir is in place, we assumed spawners in the two spawnable reaches of the West Fork would be a 50:50 mix of resident and adfluvial adults, and have fecundity half way between the 150 and 1,000 eggs assigned to the two rearing types (mean = 575 eggs). This applies only to spawners upstream of the reservoir.

Simulation of these conditions with the reservoir results in combined production from the reservoir and watershed upstream of 629 spawning adult equivalents/brood. This is more than a 60% increase compared to the 391 spawning adult equivalents/brood that are predicted under present conditions without the reservoir. This result is the same for both outflow scenarios, because changes upstream would be inconsequential.

Table 7. Simulated potential for cutthroat trout production in the Drift Creek watershed with Drift Creek Dam in place and a minimum release of 2.0 cfs. Total AEQ (adult equivalent) spawners are the sum of spawners across ages for the specified reach.

		Redd Capacity	Eggs	Fry	Parr	Age 1	Age 1 - Redist.	Age 2 - Spring	Age 2 Carrying Capacity	Age 2 - Fall	Age 3	Age 4	Age 5	Total AEQ Spawners
	Fecundity							50			100	150	150	
	Survival Rates			0.15	0.386	0.3321		0.33			0.33	0.33	0.33	
	% Mature							0.25			0.6	1	1	
Near the Mouth	MS1	-	-	-	-	-	123	41	77	41	13	4	1	24
Cascade Hwy	MS2	-	-	-	-	-	247	81	182	81	27	9	3	48
Canyon	MS3	-	-	-	-	-	247	81	276	81	27	9	3	48
Out of Canyon	MS4	704	64,156	9,623	3,715	1,234	493	163	174	163	54	18	6	97
Proposed Reservoir	MS5	-	-	-	-	-	1,145	567	1,000	567	281	139	69	518
Farmland	EF1	16	1,870	281	108	36	49	16	18	16	5	2	1	9
Forested	EF2	-	-	-	-	-	49	16	12	12	4	1	0	8
Fisher Farm	WF1	470	54,940	8,241	3,181	1,056	146	48	39	39	13	4	1	25
Fisher Forest	WF2	12	1,403	210	81	27	146	48	30	30	10	3	1	22
Beaver Activity	WF3	-	-	-	-	-	146	48	25	25	8	3	1	21
Upstream	WF4	432	50,498	7,575	2,924	971	146	48	39	39	13	4	1	25
	Total	1,634	172,867	25,930	10,009	3,324	2,935	1,157	1,872	1,094	455	196	88	846

Table 8. Simulated potential for cutthroat trout production in the Drift Creek watershed with Drift Creek Dam in place and minimum release of 4.0 cfs. Total AEQ (adult equivalent) spawners are the sum of spawners across ages for the specified reach. Note that age 2 carrying capacity is greater than in Table 7 for the 2.0 cfs release, but production from the available red capacity is not sufficient to fill the rearing capacity under either the 2.0 or the 4.0 cfs releases.

		Redd Capacity	Eggs	Fry	Parr	Age 1	Age 1 - Redist.	Age 2 - Spring	Age 2 Carrying Capacity	Age 2 - Fall	Age 3	Age 4	Age 5	Total AEQ Spawners
	Fecundity							50			100	150	150	
	Survival Rates			0.15	0.386	0.3321		0.33			0.33	0.33	0.33	
	% Mature							0.25			0.6	1	1	
Near the Mouth	MS1	-	-	-	-	-	123	41	123	41	13	4	1	24
Cascade Hwy	MS2	-	-	-	-	-	247	81	183	81	27	9	3	48
Canyon	MS3	-	-	-	-	-	247	81	276	81	27	9	3	48
Out of Canyon	MS4	704	64,156	9,623	3,715	1,234	493	163	174	163	54	18	6	97
Proposed Reservoir	MS5	-	-	-	-	-	1,145	567	1,000	567	281	139	69	518
Farmland	EF1	16	1,870	281	108	36	49	16	18	16	5	2	1	9
Forested	EF2	-	-	-	-	-	49	16	12	12	4	1	0	8
Fisher Farm	WF1	470	54,940	8,241	3,181	1,056	146	48	39	39	13	4	1	25
Fisher Forest	WF2	12	1,403	210	81	27	146	48	30	30	10	3	1	22
Beaver Activity	WF3	-	-	-	-	-	146	48	25	25	8	3	1	21
Upstream	WF4	432	50,498	7,575	2,924	971	146	48	39	39	13	4	1	25
	Total	1,634	172,867	25,930	10,009	3,324	2,935	1,157	1,919	1,094	455	196	88	846

Production Downstream of the Reservoir

We modeled the potential for cutthroat production downstream from the reservoir under two scenarios; one with a minimum release of 2.0 cfs (which includes a ~1.5 cfs supplement for in-stream flows) and one with a minimum release of 4.0 cfs. Without the reservoir, flows in 2008, 2009, and 2010 dropped under 0.5 cfs in Augusts and September at Victor Point Rd (Tanovan 2012). The temperature at release to the stream for these flows is predicted to substantially cool the existing temperature regime at Victor Point during spring and summer, (Figure 9). Under either scenario, the releases would reduce mean daily temperatures to under 18° through the summer, and should provide suitable temperatures for spawning (<13°C) by October 1. No fish are expected to spawn in Drift Creek below the dam in October, and none are presently known to spawn below the dam site at any time.

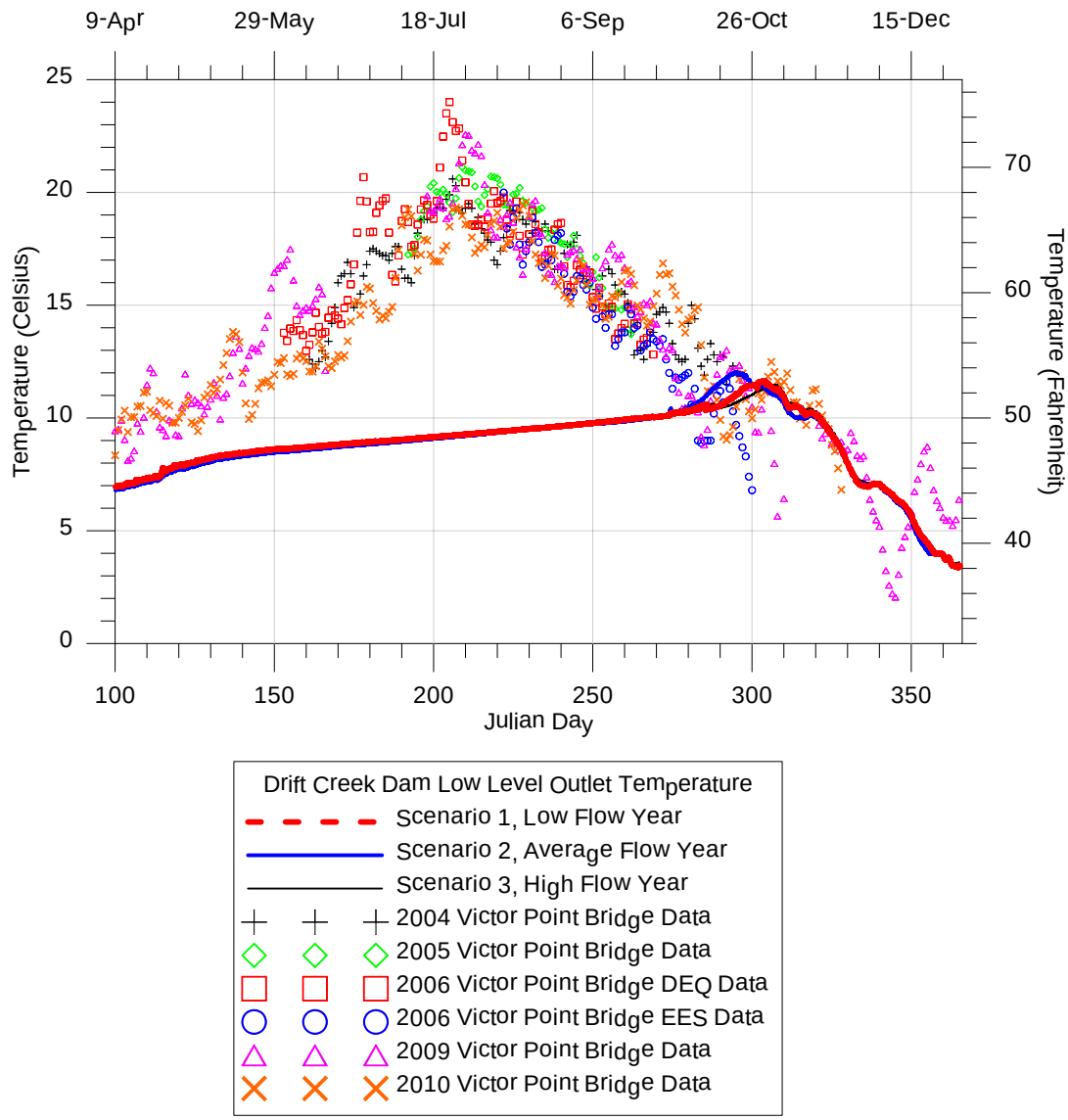

Figure 9. Model predicted dam outflow temperatures of for water released to the stream while irrigation water is released from the mid-level outlet directly to a pipe that delivers water to the East Valley Water. Average daily temperature data measured at Victor Point Bridge were also plotted. From Berger et al. (2011).

The effects of reservoir releases on temperatures downstream of the dam were predicted with the temperature model SNTEMP. Predicted temperatures in downstream reaches are shown in Table 9, including those that would result if all irrigation water were released in stream for downstream delivery via the stream channel. Though irrigation releases via the stream channel would substantially improve flow downstream of the dam, they would result in temperatures at release that are about 8°C higher during mid summer (Table 9) than if irrigation water was delivered via pipes directly from the reservoir. Irrigation water delivered via pipes would be withdrawn from the warm surface layers, while leaving the cooler layers of the reservoir to supply the water for in-stream releases. This separation of the warm and cool water led to the result of much cooler outflows to the stream when irrigation water was withdrawn separately by pipe. We did not simulate how potential trout production would be affected by this tradeoff between the benefits of higher flow versus the limitation of warmer water. Instead, we simulated trout production potential for two release scenarios with irrigation water delivered by pipe. The minimum in-stream flows from those releases of either 2 or 4 cfs are predicted to substantially

improve downstream temperatures. Under both releases, average stream temperatures during the warmest week of the summer would still remain within the optimum range for growth of trout (10-16°C) in three reaches (M2, M3, and M4) of the four reaches below the dam. This is substantially cooler than under present conditions (Table 9).

Table 9. Stream temperatures for Drift Creek main stem below the proposed dam site, as measured under existing average conditions, and predicted for two scenarios of minimum instream flows released from the reservoir.

Reach Name	Present	1.5 cfs release	4.0 cfs release	Irrigation delivered in stream
Near Mouth M1	22.0°	19.2°	16.8°	19.8°
Cascade Hwy M2	21.3°	15.1°	14.8°	19.2°
Canyon M3	20.6°	11.2°	11.7°	18.3°
Above Canyon M4	20.1°	9.7°	9.7°	17.7°

There is no spawning gravel that we know of below the dam, so spawning will be dependent on the amount of spawning habitat we create. The project proposal is to add gravel and gravel capture structures at three sites below that dam to create the equivalent 3,800 ft^2 of suitable spawning in MS4, the first reach below the dam. With that gravel, the simulated production capacity below the dam increased from 82 spawner equivalents before the dam to 217 after the dam. The different outflow scenarios did create slight differences in carrying capacity for rearing below the reservoir, but still produced the same number of adult equivalents. This was the case, because there was more rearing capacity than there was spawning capacity below the dam under either the 2.0 cfs or the 4.0 cfs scenarios. Thus, the available spawning capacity was the limiting factor that determined production. Given the same amount of spawning habitat available in the two outflow scenarios, the production of offspring remained the same.

Conclusion

This model effort shows that, the project as proposed, should support maximum production of cutthroat that is about double (846 spawners) that of the present potential (473 spawners). Production gains above the dam would likely accrue without gravel addition, and gains below the dam would be dependent on the amount of spawning gravel added. Temperatures below the dam would improve substantially and remain in the optimal range for cutthroat growth (10-16°C) in all but the lowermost reach. Reservoir operations with release of a minimum 2 cfs, compared to existing minimums of 0.5 cfs, would cool the stream by 6 to 10°C in the first three reaches below the dam. The water release levels of 2.0 cfs and 4.0 cfs would both provide the same level of fish benefit. In either case, the creation of excess rearing habitat below the dam would create opportunities for watershed councils to propose further restoration of fish production potential by creation of spawning habitat, which would enable their offspring to take advantage of the surplus rearing capacity. The improved rearing habitat would also provide opportunities for ESA-listed steelhead to establish themselves in the stream.

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OREGON DEPARTMENT OF FISH AND WILDLIFE

Fish Passage WAIVER Application

- *Use this form if providing fish passage at the artificial obstruction for which a Waiver is being requested would benefit native migratory fish.*
- *Use the "Fish Passage EXEMPTION Application" if a waiver has already been granted for the artificial obstruction, fish passage mitigation has already been provided for the artificial obstruction , or if there would be no appreciable benefit for native migratory fish if passage were provided at the artificial obstruction.*
- *If you unlock and re-lock this Form, information already entered may be lost in certain versions of MS Word.*

APPLICANT INFORMATION

The Applicant must be the owner or operator of the artificial obstruction for which a Waiver is sought.

ORGANIZATION/APPLICANT: East Valley Water District
CONTACT: David Bielenberg **TITLE:** N/A
ADDRESS: P.O. Box 1046
CITY: Mount Angel **STATE:** OR **ZIP:** 97362
PHONE: 503.873.2713
FAX: 503.873.2710
E-MAIL ADDRESS: bbergdb@bmi.net

SIGNATURE: _____ **DATE:** _____

OWNER (*if different than Applicant*)**:**
CONTACT:
FAX:
E-MAIL ADDRESS:

SIGNATURE: _____ **DATE:** _____
Signature indicates that you understand and do not dispute this request.

CONTACT:
FAX:
E-MAIL ADDRESS:

SIGNATURE: _____ **DATE:** _____
Signature indicates that you understand and do not dispute this request.

APPLICATION COMPLETED BY (*if different than Applicant*)**:** Robert Ellis
TITLE: Principle
ORGANIZATION: Ellis Ecological Services, Inc.
ADDRESS: 20988 Springwater Road
CITY: Estacada **STATE:** OR **ZIP:** 97023
PHONE: 503.631.7809
FAX: 503.631.7851
E-MAIL ADDRESS: rellis@ellisecological.com

SIGNATURE: _____ **DATE:** _____

To Be Completed by ODFW Fish Passage Coordinator

APPLICATION #: **DATE RECEIVED:**

FILE NAME:

APPROVED ☐ **SIGNATURE:** _____ **DATE:** _____

DENIED ☐ **TITLE:**

ARTIFICIAL OBSTRUCTION (*for which a Waiver is being requested*)

1. TYPE OF ARTIFICIAL OBSTRUCTION:

X Dam
☐ Culvert/Bridge
☐ Tidegate
☐ Other (describe):

New X
Existing ☐

2. PLEASE PROVIDE A BACKGROUND AND DESCRIPTION OF THE PROPOSED ACTION TRIGGERING THE NEED TO ADDRESS FISH PASSAGE:

The East Valley Water District (District) is an irrigation district established in 2002 for the benefit of member lands and associated agricultural operations in Marion County and Clackamas County in the general vicinity of Mt. Angel, Oregon. The District's general service area of approximately 15,000 acres extends from just north of Silverton, to just south of Woodburn and Molalla, between the Pudding River on the west and the Cascade Mountain foothills on the east. The District's approximately 75 members are currently served by individual farm wells and direct withdrawals from local surface waters. Limited surface water supplies and lowering groundwater levels make the development of a new surface water source an imperative.

The District is proposing a new water reservoir impoundment on Drift Creek, a tributary to the Pudding River at Drift Creek river mile (RM) 6.5 (Figure 1). The intended reservoir site is located approximately six miles southeast of Silverton in Marion County, and the facility would be the cornerstone of a new surface water supply system for the District. Stored winter water would be released during the summertime months and conveyed downstream to the District's service area via a new raw water pipeline. Supplied water would be used for irrigation purposes and would require the development of a new water distribution piping system for delivery of irrigation water to served members.

The proposed earth-fill dam would be approximately 70 feet high and impound up to 12,000 acre-feet of water. The proposed dam crest would be about 20 feet wide and approximately 850 feet long (Figure 2).

The foot print of the reservoir includes approximately 375 acres of mixed agricultural land (Christmas tree plantations, livestock pasture and grass hay) and a narrow riparian strip along the stream channel. Hydrology studies for the Drift Creek watershed indicate that there is adequate runoff in most years to fill the reservoir during the late fall, winter and early spring months. Temperature modeling conducted by Portland State University engineering staff demonstrated that the reservoir would stratify thermally during the summer and early fall months. Draw-off from the reservoir will be through at least two ports, a bottom port for maintenance of stream flow and temperature and a higher level port connected to the irrigation supply pipeline. Water discharged to Drift Creek would be re-aerated at the base of the dam.

3. PASSAGE WILL NOT BE PROVIDED FOR THE FOLLOWING REASON(S): The district has reviewed all available methods of fish passage for its proposed dam. Reviewed methods include various fish ladder designs and trap-and-haul facilities. Because there will be large fluctuations in the impounded water level and very low summer flows (Figure 3) in Drift Creek, construction of a fishway at the proposed dam that would maintain fish passage and cool water temperatures at all reservoir levels was found to be infeasible. Also, the lowering of the reservoir water level through the summer irrigation season would isolate the ladder entrance above the water surface at some point Trap-and-haul operations require significant attraction flows, which also would not be available during at least part of the migration period for some of the native species present.

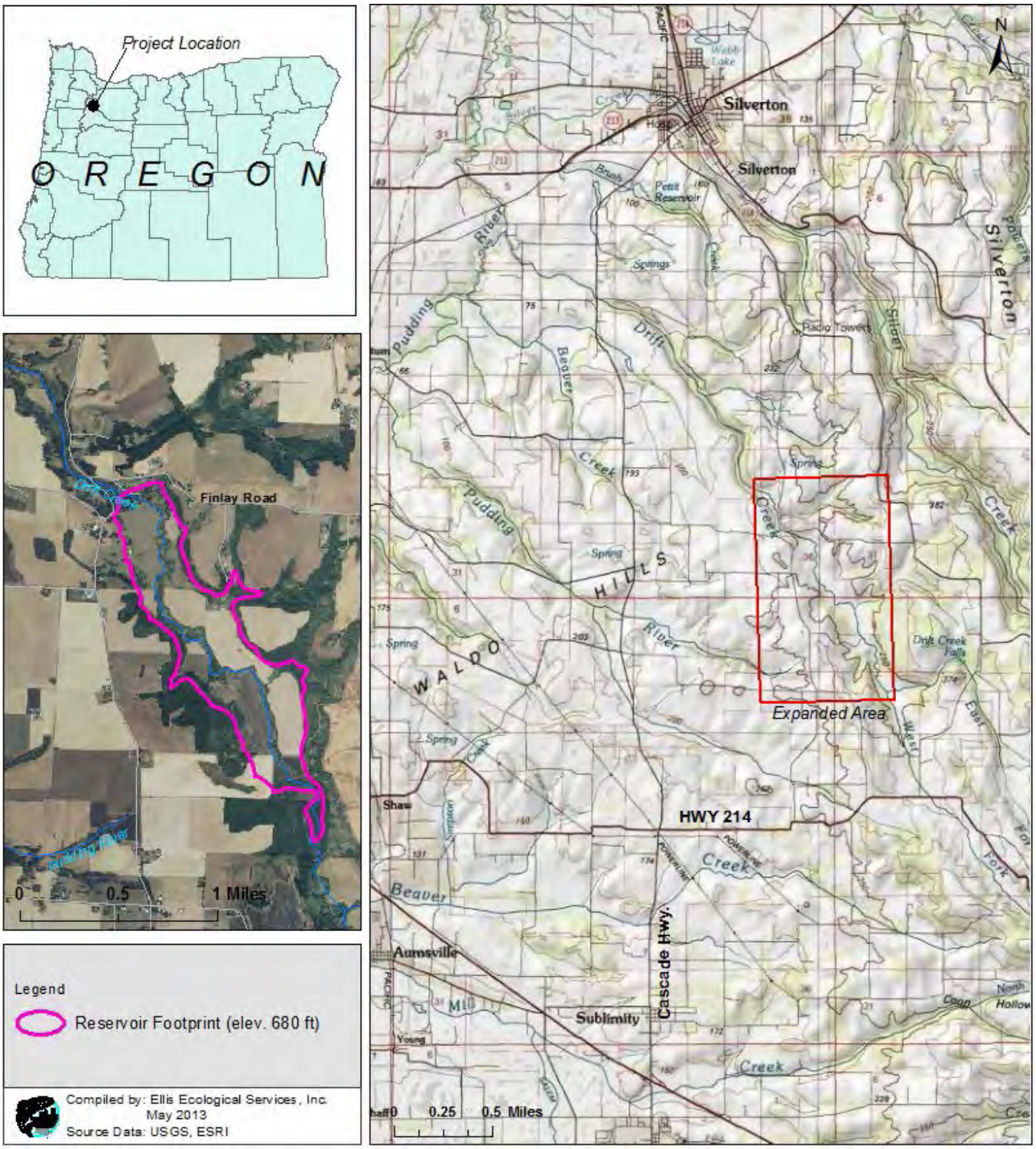


Figure 1. Project Location.

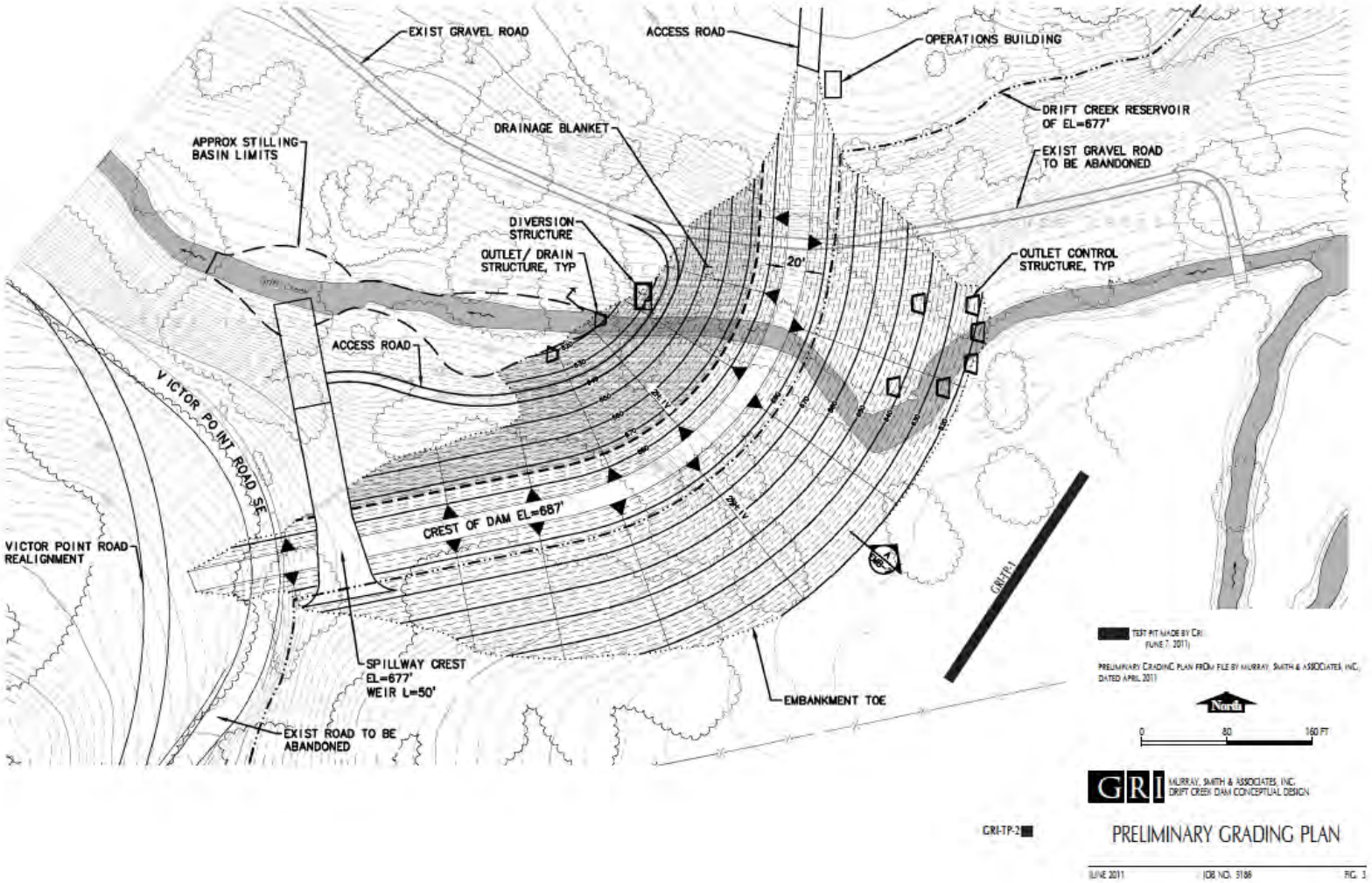


Figure 2. Proposed Drift Creek Dam.

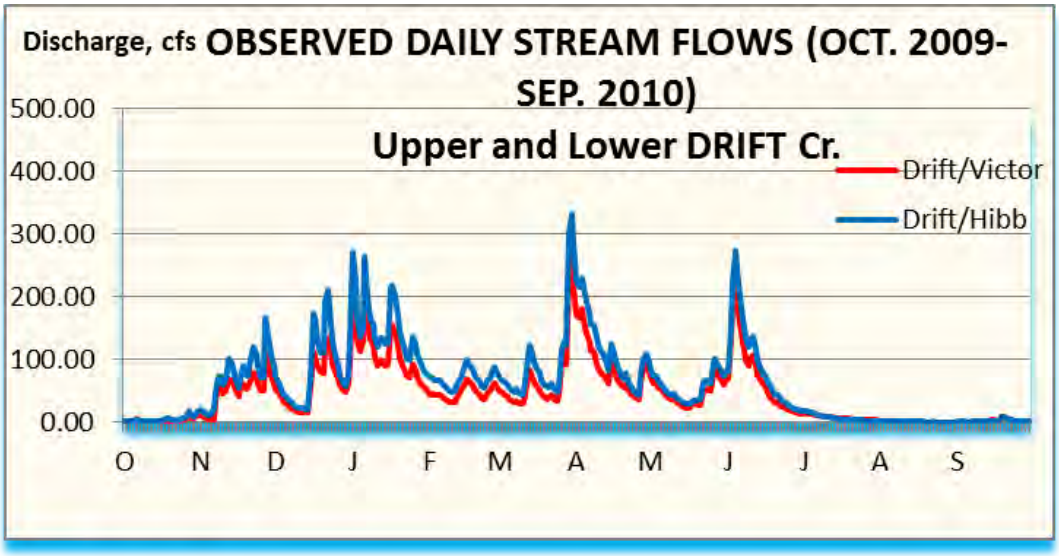


Figure 3. Typical year mean daily flow hydrographs for Drift Creek at Victor Point Road (RM 6.3) and Hibbard Road bridge (RM 0.5) on Drift Creek (from Tanovan 2012, Runoff yield analysis, update #3)

during the summer draw down. Furthermore, ladder flows, when available, would require drawing warmer water from the surface of the reservoir and could contribute to further warming of Drift Creek, which is already temperature limited during summer months. Therefore, if passage were provided it would have to be on a seasonal basis, primarily during the non-irrigation season.

A fish passage waiver that provides a net benefit to migratory native fish species is a better alternative than provision of seasonal fish passage. Presently, Pacific lamprey, cutthroat trout, northern pikeminnow and largescale sucker are the only migratory native fish (as defined by statute) that would be affected by the proposed dam. Coho salmon, while present in Drift Creek in small numbers, are not native to the Willamette River watershed above Willamette Falls. Pacific lamprey adult upstream migration extends into July as does juvenile outmigration. Therefore, if a ladder was operated seasonally, part of the adult and juvenile lamprey migrations would be blocked. In addition, migratory movements of cutthroat trout that may occur at the dam site also would be blocked during the summer months. Largescale sucker typically have difficulties using fish ladders regardless of attraction flow or ladder conditions.

The District's fishery consultants have met with ODFW staff on numerous occasions regarding provision of fish passage at the dam. ODFW staff have emphasized that provision of fish passage is their preference if it is feasible. However, after reviewing the site-specific conditions at the dam site and the general habitat conditions in the Drift Creek watershed through site visits (September 12, 2011 and October 14 and 27, 2011), review of hydrological and water temperature analyses, and consideration of the difficulties in designing a functional fish ladder or trap and haul facility, both the District Biologist (Todd Alsbury) the Fish Passage Coordinator (Greg Apke) agreed that a fish passage waiver with appropriate mitigation (rather than fish passage at the dam) was the preferred alternative.

4. DATE THE TRIGGER ACTION IS SCHEDULED TO BEGIN *(a minimum of two months should be planned for the waiver process after ODFW receives your application; requests that must go before the Commission will take longer)***:** No date has been set for the scheduled trigger action to begin. The initiation of construction will depend on completion of the environmental permitting process and acquisition of funding support for the project.

5. LOCATION

COUNTY: Marion
ROAD CROSSING (if applicable)**:** N/A
RIVER/STREAM: Drift Creek
TRIBUTARY OF: Pudding River
BASIN: Willamette Basin, Molalla/Pudding Subbasin
COORDINATES[a]**:** Longitude: 122.754014°W Latitude: 44.923562°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

6. STREAM DESCRIPTION

6A. BARRIER TABLE (*please provide the following information for barriers, which will help determine the benefit of providing passage at the Artificial Obstruction; indicate measurement units if applicable*)**:**

	DOWNSTREAM					UPSTREAM				
Locations	3	C/N	2	1	AO	1	2	3	E	*example*
Type	D		D	D	D	C	N	N		C
Length	10		10	10		30	20			80 ft
Distance	6.32 mi	6.5 mi	5.05 mi	4.05 mi		4.6 mi	5.24 mi	4.68 mi	12 mi	1,200 ft
Level	3		3	3	5	3	3	5		5

Type = C (culvert/bridge), D (dam), T (tide gate), N (natural; *describe below*), O (other; *describe below*)
Length = length of the barrier in the stream (e.g., culvert's length, dam's width/footprint)
Distance = distance from the Artificial Obstruction (to closest point of other barriers)
Level = amount of passage at the barrier using the following codes:
5 - barrier to all native migratory fish
4 - barrier to some native migratory fish adults and/or species
3 - barrier to some native migratory fish adults and/or species for only part of migration period
2 - barrier to all native migratory fish juveniles
1 - barrier to some native migratory fish juveniles and/or for only part of migration period

LOCATIONS:
AO = the existing or proposed Artificial Obstruction
1,2 = other barriers in the same stream as the Artificial Obstruction
3 = downstream barrier outside the immediate stream in which the Artificial Obstruction is located (*only needed if C/N is a confluence rather than a complete natural barrier*)
E = end of historic native migratory fish use, including all tributaries (i.e., potential range without any artificial barriers in place)
C/N = first downstream confluence or complete natural barrier, whichever comes first

NOTE: The *example* indicates that there is culvert which is 80 feet long, is located 1,200 feet from the Artificial Obstruction in question, and is a complete fish passage barrier.

PLEASE PROVIDE ADDITIONAL DESCRIPTIONS FOR THOSE BARRIERS INCLUDED IN THE BARRIER TABLE OR FOR OTHER BARRIERS AFFECTING NATIVE MIGRATORY FISH MOVEMENT TO OR FROM THE ARTIFICIAL OBSTRUCTION:

6A.1 Upstream Barriers:

1: A concrete culvert under a gravel road crossing of West Fork Drift Creek (RM 0.9) represents a possible partial barrier to fish migration.

2: An unnamed natural falls/cascade (4ft- vertical drop) is located on West Fork Drift Creek just upstream of Drift Creek Road. This is likely passable during higher flow conditions and therefore, represents a partial barrier to migration. Its location coincides with the upper extent of potential Coho distribution according to ODFW best professional judgment.

3: Drift Creek Falls, located on East Fork Drift Creek at East Fork RM 1.5 is approximately 40 feett high and represents a complete barrier to upstream and downstream fish migration for all species.

The location of the upstream barriers is provided on Figure 4.

6A.2 Downstream Barriers:

Numerous partial barriers to fish movement are present downstream of the proposed dam. There are six significant cascades over bedrock. These cascades are not likely barriers to fish movement, although they may inhibit upstream juvenile movement during low flow periods. The largest of the cascades is located at approximately RM 5.9. At this location, the river falls approximately five feet (vertically) over a distance of ten feet (horizontally), through a series of steps. Water depth at the foot of the cascade was 16", but was only one to two inches deep on each of the steps. Because of the shallow water depth over the bedrock steps, this cascade may inhibit upstream juvenile movement.

The more significant barriers to fish movement are man-made and include one irrigation dam and two "push up" dams whose use was not obvious. However, like the irrigation dam, the push up dams were likely constructed to provide a pool from which to draw irrigation water.

1: The pushup dam nearest the proposed dam is located at approximately RM 2.5 (see Figure 5). This dam is constructed of large boulders and is lined on the upstream side with black plastic sheeting, held in place with sandbags. The pool created by the dam was approximately 80 feet long and two to three feet deep. Siltation of the substrate in the pool was apparent. At the time of the survey, the dam was a complete barrier to upstream movement, and likely also inhibited downstream movement of juvenile salmonids.

2: The most downstream push up dam is located at approximately RM 1.5 (see Figure 5). It appeared to have been recently constructed of large boulders, and backfilled with gravel and dirt. The dam spans the entire channel, but for approximately six feet on the left bank (facing upstream) which was blocked with hay bales. At the time of the survey, the push up dam was 3-4 feet in height and was likely at least a partial barrier to juvenile movement (see photos, Attachment 2). The dam impounded an area of water two feet deep on the upstream side.

3: The irrigation dam is located at RM 0.23 (see Figure 5) and consists of a large concrete abutment on either side of the creek. Spanning the creek between these abutments is a steel structure with removable splashboards. At the time of the site visit, 38 inches of vertical splashboards were installed, and the dam has the capacity for an additional 52" of splashboards. During habitat surveys in September, 2009, the dam represented a complete upstream migration barrier, and likely a complete downstream barrier, as only one to two inches of water were flowing over the splashboards in a uniform sheet, and dropping over three feet vertically onto a concrete apron, with only one inch of water. Later in the year (during the upstream coho migration period), the dam had been removed. With splashboards installed, the dam also impounds water up to RM 0.43 in an area with little riparian cover, which results in increased thermal loading.

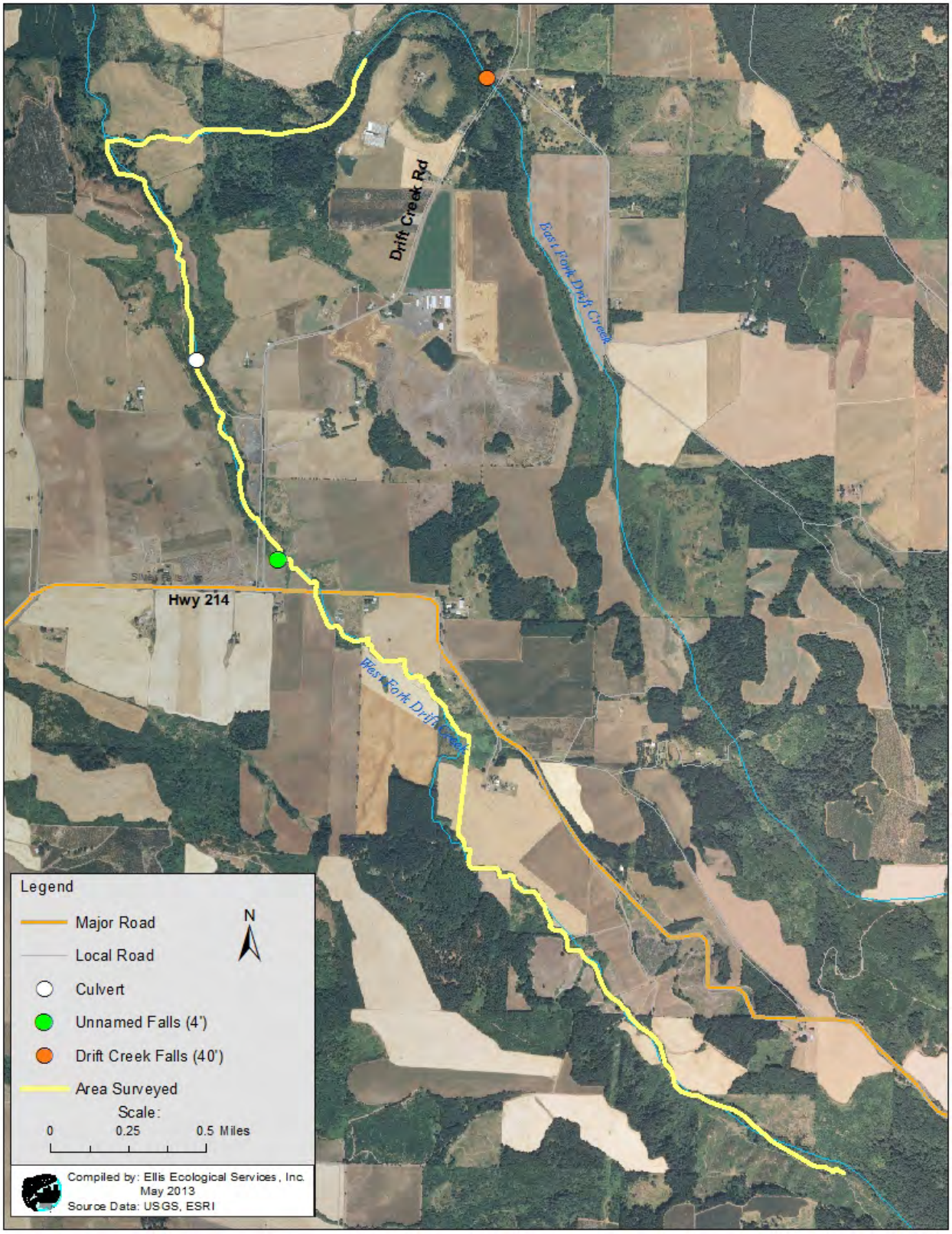


Figure 4. Location of barriers upstream of the Proposed Drift Creek Dam.

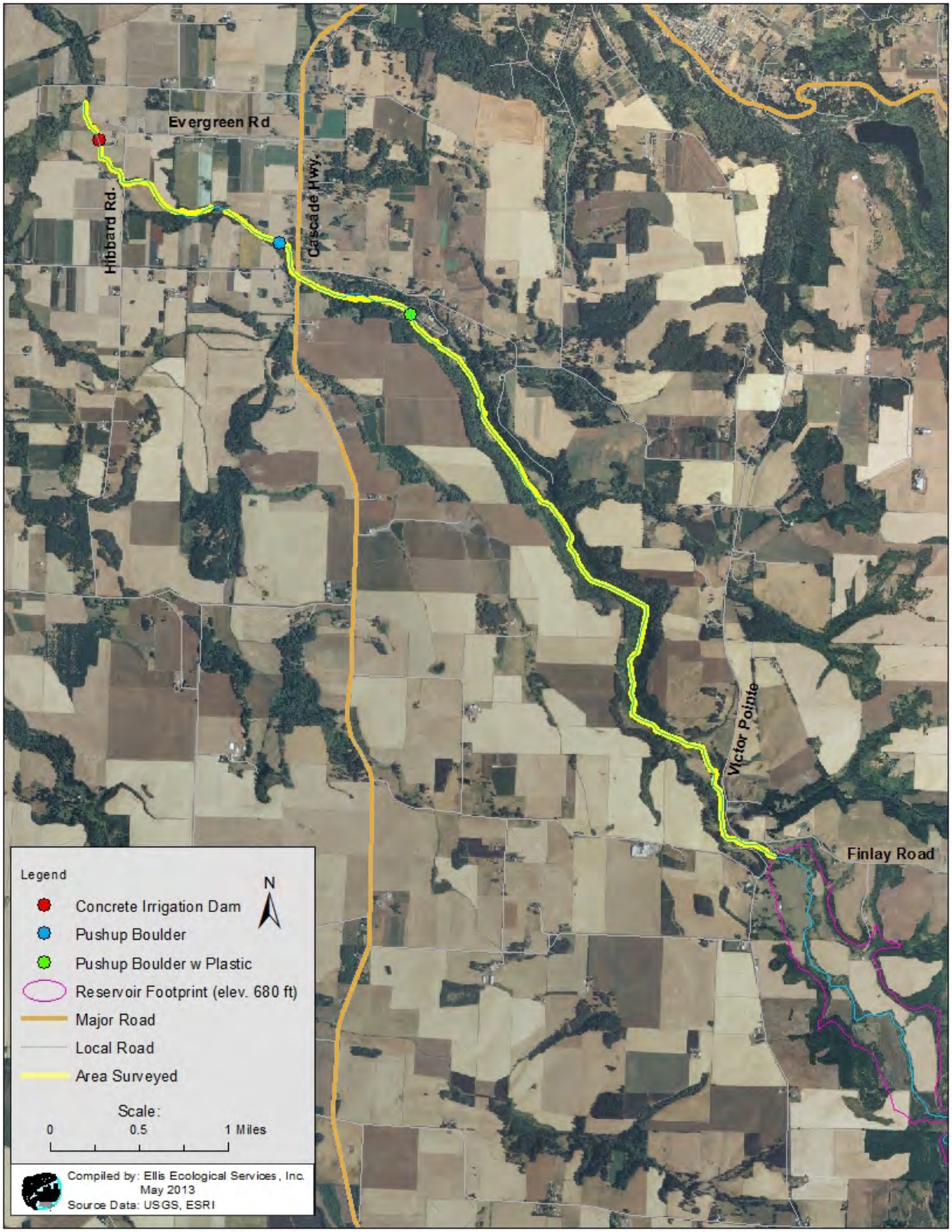


Figure 5. Location of barriers downstream of the proposed Drift Creek Dam

6B. SUMMARY TABLE (*please provide the following information relative to the Artificial Obstruction, which will help determine the benefit of providing passage at it*)**:**

	DOWNSTREAM	**UPSTREAM**
NMF Species Present Currently	cutthroat trout, largescale sucker, northern pikeminnow and Pacific lamprey	cutthroat trout, largescale sucker, northern pikeminnow and Pacific lamprey
NMF Species Present Historically	Possibly UWR steelhead, UWR Chinook salmon (juveniles near mouth) and mountain whitefish	Possibly UWR steelhead and mountain whitefish
Habitat Quality	Fair to poor, see below	Fair to poor, see below
Flows	Summer limited, see below	Summer limited, see below
Water Quality	303(d) Temperature limited in summer	303(d) Temperature limited in summer
Water Right Availability		District has applied for water right for storage of 12,000 acre feet
Land Use/Zoning	Exclusive farm use	Exclusive farm use
NMF = native migratory fish		

PLEASE PROVIDE ADDITIONAL DETAILS REGARDING THE INFORMATION PROVIDED IN THE SUMMARY TABLE (*such as species listed under the state or federal ESA and descriptions of the stream channel and riparian habitat*)**:**

6B.1 Current and historical distribution of native migratory fish

Native Migratory Fish (as defined by ODFW, http://www.dfw.state.or.us/ fish/CRP/migratory.asp) that are, or were historically present in Drift Creek are included on Table 6B1. Upper Willamette River Steelhead and Upper Willamette River Chinook Salmon are both listed as threatened species under the Endangered Species Act and both occur in the Pudding River drainage. Upper Willamette River Steelhead may have historically used Drift Creek for spawning and/or rearing, but none have been observed or captured during fish surveys in recent years, including those conducted by Ellis Ecological Services, Inc (EES) in 2005, 2006 and 2009. Historically, surveys of Drift Creek have consistently found it to be of low value to anadromous fish.

Table 6B1. Native Migratory Fish that are, or could historically have been present in Drift Creek.

Common Name	**Scientific Name**	**Documented presence (yes/no)**
Chinook salmon	*Oncorhynchus tshawytscha*	No
Cutthroat trout	*Oncorhynchus clarki*	Yes
Steelhead/Rainbow Trout	*Oncorhynchus mykiss*	No
Mountain whitefish	*Prosopium williamsoni*	No
Largescale sucker	*Catostomus macrocheilus*	Yes
Pacific lamprey	*Lampetra tridentate*	Yes*
Northern pikeminnow	*Ptychocheilus oregonensis*	Yes
*Only ammocoetes were found, and may have been Western Brook Lamprey		

Neither Drift Creek nor the Pudding River contains summer holding water for adult spring chinook salmon, which essentially precludes their use of Drift Creek. There are no documented reports of spring chinook salmon in Drift Creek. Historical surveys of Drift Creek include ODFW presence/absence surveys conducted in 2002 on the East and West Forks. Table 6B2 indicates the results and the location of the surveys

Table 6B2. Locations and Results of ODFW presence/absence surveys in Drift Creek

Stream	River Mile	Fish Species Present (number collected)
East Fork Drift Creek	0.47	Sculpin spp. (1), cutthroat trout (3), dace spp. (2)
	2.15	Sculpin spp. (1), cutthroat trout (4)
	3.84	None
	10.61	None
West Fork Drift Creek	1.17	Sculpin spp. (6), cutthroat trout (3)
	2.31	Dace spp. (1), cutthroat trout (1)
	3.86	Sculpin spp. (1), unidentified salmonid (1), dace spp. (2)

EES conducted three fish surveys over four years to collect data on current fish populations within various reaches of Drift Creek and its tributaries (available at http://www.oregon.gov/owrd/law/docs/GrantApp/GA0035_09_Attachment17.pdf). Table 6B3 summarizes the catch results for cutthroat trout at all survey sites. Lower Drift Creek (below RM 4) had higher species diversity and generally higher catch rates (all species combined) than the middle and upper reaches of the creek. Native migratory fish found in the lower reach of Drift Creek included small numbers of lamprey ammocoetes (probably Pacific lamprey) and largescale suckers. Two cutthroat trout were collected at RM 3.9 in 2006 but none were collected below RM 4.0 in 2005 or 2009. In a survey reach between RM 6.2 (just below Victor Point Road bridge) and RM 6.5 (dam site) 1 cutthroat trout was collected in 2005, 11 in 2006 and 2 in 2009. A few northern pikeminnow were found throughout mainstem Drift Creek.

Three fish survey reaches within the foot print of the proposed reservoir were electrofished. A total of two cutthroat trout were found within the reservoir foot print in mainstem Drift Creek (RM 6.3 to 9.7). Low to moderate densities (range 0.4 to 4.7 per 100 ft of stream electrofished) of cutthroat trout were found in the East Fork Drift Creek and low densities (range 0.0 to 1.8 per 100 ft of stream electrofished) were found in various sections of the West Fork Drift Creek Lamprey ammocetes and juvenile largescale sucker were found in low numbers in the slow moving water within the proposed reservoir footprint. A few non-native juvenile coho salmon (five) were collected in lower Fox Creek and in mainstem Drift Creek within the reservoir footprint in 2006. Fox Creek is a small tributary which enters Drift Creek from the north about midway through the proposed reservoir footprint. Adult coho were observed spawning in lower Fox Creek in November 2009 by landowners. Fox Creek provides a small section of gravel suitable for coho spawning. Fox Creek also had the highest density of cutthroat trout with 20 fish per 100 ft of stream electrofished in 2006. Much lower densities were found in 2005 and 2009 (Table 6B3). No mountain whitefish were found during the fish surveys, but they have been reported in the Pudding River system (Runyon, 2006).

Steelhead and Chinook salmon, although present in Pudding River tributaries such as Butte, Abiqua and Silver Creeks, were notably absent in the samples taken from Drift Creek. According to the Pudding River Watershed Association's watershed assessment for the Pudding River and its tributaries (Runyon et al. 2006), there have been scattered historical reports of steelhead and salmon in Drift Creek, however, with the exception of a few juvenile coho salmon, none were captured in the surveys conducted by EES in 2005, 2006 and 2009.

6B.2 Habitat Conditions

6B.2.1 Historical

The first recorded survey of Drift Creek was that of Parkhurst et al. (1949). Their surveys on Drift Creek were conducted in 1940. The authors state that Drift Creek is "about 15 miles long, of which only the lower mile contains sufficient spawning area to warrant a detailed survey. About 1 mile above the mouth there is a 2-foot high diversion dam (not present today), which diverts most of the flow during low water stages. There is sufficient spawning area in the lower mile below the diversion dam for about 300 salmon. Above this point there is little suitable spawning area." The authors concluded by stating that, "According to local reports, no salmon have been seen in Drift Creek for many years, and it was considered of little possible value to migratory fish."

Table 6B3. Cutthroat trout sampling results for electrofishing surveys conducted in Drift Creek and its tributaries in 2005, 2006 and 2009.

Stream/Reach	ID	Location	Beginning River Mile	Years Surveyed	Bankfull width (ft)	Cutthroat Trout/100 feet of electrofishing
Drift Creek Below the Dam	R 0.5	Drift Creek at Hibbard Road Crossing	Drift Creek RM 0.4	2009	30	0
	R0.75	Drift Creek at Cascade Highway	Drift Creek RM 1.8	2009	30	0
	R1	Drift Creek midway between Cascade Hwy and Victor Pointe Rd.	Drift Creek RM 3.9	2005 2006 2009	25	0 0.4 0
	R2	Drift Creek upstream and downstream of Victor Pointe Rd (dam site)	Drift Creek RM 6.3	2005 2006 2009	25	0.4 2.2 0.2
Drift Creek in Dam Footprint	R2.5	Drift Creek within the reservoir	Drift Creek RM 6.9	2009	25	0
	R3	Drift Creek within the reservoir	Drift Creek RM 7.8	2005 2006 2009	25	0 0.2 0
	R5	Drift Creek within the reservoir	Drift Creek RM 8.3	2005 2006 2009	20	0 0 0.25
Fox Creek	R4	Fox Creek at confluence with Drift Creek	Drift Creek RM 8.1	2005 2006 2009	5	3 20 2
East Fork	R6.0	East Fork below Drift Creek Rd	East Fork Drift Creek RM 0.29	2006	19	4.7
	R6.5	East Fork below Drift Creek Rd	East Fork Drift Creek RM 0.6	2009	25	0.4
West Fork	0	West Fork below Drift Creek Rd	West Fork Drift Creek RM 0.3	2006	22	1.8
	R7.5	West Fork below Drift Creek Rd	West Fork Drift Creek RM 0.7	2009	20	0.25
	R8	West Fork Drift Creek at Silver Falls Hwy	West Fork Drift Creek RM 1.4	2009		0

Thompson et al. (1960) surveyed from the mouth of Drift Creek upstream nine miles to the junction of the east and west forks. The investigators stated: "The stream gradient is moderate and pools constitute an estimated 35 per cent of the total stream area. The bottom materials are predominantly gravel from pea to grapefruit in size, but badly silted. However, gravel suitable for salmon spawning is present in fair to good quantity."

The first 1.5 miles of the 5-mile long West Fork were also surveyed. The investigators stated that, "The stream gradient is steep and pools constitute an estimated 70 percent of the stream area. The bottom materials are predominantly bedrock and silt. Gravel suitable for spawning is present in meager quantities…The West Fork of Drift Creek appears to have very little potential for salmonids…"

The first 1.8 miles of the 5-mile long East Fork was also surveyed: "The stream gradient is moderate and pools constitute an estimated 40 percent of the total stream area. The East Fork is generally a gravel-bottomed stream, with considerable silt in some areas. There is practically no gravel suitable for spawning in the upper 0.9 mile surveyed but such gravel is present in fair to good quantity in the lower 0.9 mile of the stream(Thompson et al., 1960)." The authors concluded by stating that, "Drift Creek appears to have some potential for silver [coho] salmon and steelhead trout production."

6B.2.2 Current

EES completed habitat surveys on Drift Creek from its mouth to the confluence of the East and West Fork and on the fish accessible portions of the East and West Forks of Drift Creek. Two survey methods were utilized: detailed reach surveys (using ODFW methodology) and general observation of habitat conditions while walking the entire length of the creek beds. A detailed report was prepared and is and is available on line at http://www.oregon.gov/owrd/law/docs/GrantApp/GA0035_09_Attachment14.pdf.

In addition, a GIS analysis was conducted to calculate the number of miles of stream above the proposed dam that could provide habitat for native migratory fish. This analysis indicated that **11.8 miles** of Drift Creek and its tributaries above the proposed dam could provide habitat for native migratory fish. Stream data utilized were from a Marion County GIS database. The stream location and size data was based on USGS quad sheets, updated with City of Salem hydrologic data. Streams were designated permanent, intermittent (defined as containing water for most of the year, or ephemeral (defined as only inundated briefly during the year). The GIS analysis included intermittent and perennial stream reaches, but excluded stream reaches blocked by natural barriers and those with gradients greater than 12%. There were no ephemeral tributary streams observed during the walking surveys that could potentially provide spawning or rearing habitat for migratory fish species.

6B.2.2.1 Downstream of the proposed dam

Although Drift Creek below the proposed dam site offers some salmonid rearing habitat, it appears to be totally lacking in spawning substrate suitable for cutthroat trout. Water temperatures (discussed below) that routinely exceed criteria (OAR 340-41-0028) for streams providing salmon and trout rearing and migration further limit the quality of Drift Creek salmonid habitat. For the purposes of habitat analysis the 6.5-mile reach below the dam site was divided into three sub-reaches based on stream gradient and channel morphological characteristics.

The first sub-reach of Drift Creek upstream of the mouth (RM 0.0 to RM 0.44) is a low-gradient glide with a uniform clay hardpan bottom and straight incised banks. Water depths ranged from 2.5 to 4.0 ft during summer low flows. Riparian vegetation is sparse and dominated by reed canary grass and blackberries. Large woody debris (LWD) was essentially absent from this reach.

The Hibbard Road bridge (RM 0.5) spans a short transitional reach (RM 0.44 to RM 0.70) separating the topographically flat section closest to the mouth from the steadily rising gradient that characterizes the majority of Drift Creek below the proposed dam site. At this location the clay hardpan bottom is replaced with cobble, gravel and bedrock substrate and the previously uninterrupted glide habitat is interspersed with substantial riffled areas. Inspection of the substrate indicated that it was heavily silted and too large to provide suitable spawning habitat for cutthroat trout. Only one small section of pool habitat, the result of a beaver dam at RM 0.62, is present within this area of Drift Creek. The riparian zone ranges from areas one and two trees wide to intact riparian zones extending several hundred feet laterally from the stream bank. However, the majority of the riparian areas in this segment are only a few trees in width. Canopy cover in this zone was greater than 50% and trees consist of cottonwoods and alders, some of which are very large (up to 48" diameter at breast height [dbh]), interspersed with smaller alders and ash and scattered conifers. LWD is sparse, being generally restricted to scattered smaller logs that did not appear to be trapping sediment or otherwise contributing significantly to stream complexity.

Between RM 0.70 and the proposed dam site (RM 6.50) Drift Creek rises 80 feet per mile with a nearly uniform gradient of 1.5%. Substrate consists primarily of cobble, boulder and bedrock, although a few small and widely dispersed patches of coarse gravel were observed. The habitat is dominated by riffles, glides and steps over bedrock. Deep pool habitat is limited and was observed only within a short steep-sided canyon from approximately RM 3.4 to 3.8. Substrate within the pools consists of fine sediments. At approximately RM 1.8 the riparian zone becomes wide, providing good canopy cover over the stream, and primarily deciduous trees. Within the steep-walled canyon, riparian zones are in excess of 500 feet on either side of the river. These conditions extend upstream to approximately RM 5.7. There is a variety of tree sizes represented, and the species mix is predominantly deciduous, but with a significant coniferous component. In many areas within this reach, the stream is covered with low-growing willows and other shrubs. The floor of the valley is broad in many places (in excess of 100 feet wide), with the canyon walls rising steeply on either side. From RM 5.7 upstream to the proposed dam site, the riparian zone is narrower, but still typically several trees wide, often followed by a cleared or grazed terrace, with additional wooded areas on hill slopes beyond. Canopy cover within this reach is also good. There are numerous areas with debris jams on either side of the river consisting of multiple small branches and logs, but large, stream-spanning wood is rare. There is one significant large woody debris jam at approximately RM 6.3, just downstream from the Victor Point Road bridge. The jam was five feet high, and nearly impermeable. Water was flowing primarily under/through, but also around one end of the debris dam.

Four survey reaches for detailed habitat analyses were established in the reach downstream of the proposed dam. Thirteen habitat parameters were rated from low to high quality according to ODFW's rating criteria. Results for each of the parameters were compared against ODFW's criteria for properly functioning stream habitat (Table 6B4). Note that the summary at the bottom of the table indicates that all of the survey reaches had predominately low rankings for most of the habitat indicators.

6B.2.2.2 Reservoir Footprint

Within the footprint of the proposed reservoir (RM 6.5 to RM 9.7), Drift Creek is primarily a slow moving meandering stream, cutting through flat agricultural land. There are a few short riffles in the mid-section of this reach and at the upper end of the reach. Canopy cover is virtually absent within much of the reservoir footprint. This low gradient reach has a predominately silt substrate with occasional exposed bedrock. Reed canary grass and Himalayan blackberries are dominant components of the bank vegetation. Habitat consists primarily of deep, unprotected pools and slow moving runs. Erosive action is evident throughout the reservoir with banks along the lower third being especially unstable. Approximately 30 feet of suitable spawning gravel was observed within Fox Creek, a small tributary to Drift Creek and another 30 feet of gravel within Drift Creek mainstem.

A quarter mile of more robust riparian conditions exist in the upper end of the proposed reservoir footprint as Drift Creek enters a tract of land managed for timber, smaller deciduous trees and native shrubs populate the banks and shade the channel. At this point, the gradient increases and the creek transitions to the cobble and bedrock riffle habitat typical of the areas upstream of the reservoir footprint.

6B.2.2.3 Upstream of the Proposed Reservoir

West Fork Drift Creek provides salmonid habitat for most of its length due to an abundance of pool habitat, LWD, shade and cool water. The exception to this observation includes portions of the creek that have been heavily impacted by agricultural practices. Small, widely dispersed patches of spawning substrate were observed in the upper reaches. There are many private and public road crossings in the lower to mid-section and a falls that could represent a partial barrier during some times of the year.

West Fork Drift Creek consists of four distinct morphological units. The first (most downstream) zone begins at the confluence with East Fork Drift Creek and extends approximately 0.6 miles upstream. This area has relatively flat topography (slope 2%) and is currently farmed for grass seed. The reach is dominated by glide habitat with incised banks and a flat stream bottom. Pool habitat is also relatively abundant. Measured depths ranged from 0.3 feet to 3 feet and widths were generally about 6 feet. Two low water vehicle crossings used to access fields are present within this reach. Figure 6 illustrates the elevation by stream mile of West Fork Drift Creek.

Table 6B4. Habitat rankings for the detailed habitat survey reaches downstream of the dam site.								
Parameter	Reach #							
	Reach 1		Reach 2		Reach 3		Reach 4	
	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking
% pools	0	Low	0	Low	8.82	Moderate	0	Low
Deep pools/km	0	Low	0	Low	0	Low	0	Low
% slackwater pools	0	Low	0	Low	0	Low	0	Low
% secondary channels	0	Low	0	Low	0	Low	1.8	Moderate
% fines in riffles	N/A	Low	2	Moderate	1	Moderate	0	High
% gravel in riffles	N/A	Low	3	Low	3	Low	0	Low
% bedrock in streams	0	High	5	High	21	Moderate	65	Low
Pieces lwd/100 m	4.2	Low	14.1	Moderate	2.8	Low	4.8	Low
Volume lwd/100 m	1.3	Low	1.1	Low	0.8	Low	1	Low
Key pieces of lwd/100 m	0	Low	0	Low	0	Low	0	Low
# conifers >50 cm dbh	0	Low	0	Low	0	Low	0	Low
# conifers > 90cm dbh	0	Low	0	Low	0	Low	0	Low
% shade	42	Low	83	Moderate	65	Low	80	Moderate
Low rankings	12		9		10		10	
Moderate rankings	0		3		3		2	
High rankings	1		1		0		1	

The second morphological unit is defined by a higher gradient (3.2% slope) and largely intact banks. This stream reach is approximately one mile long and terminates at Silver Falls Highway located near RM 1.7. Riffles dominate the mesohabitat during low flow conditions, but chutes, rapids and boulder steps are also abundant. Scattered scour and lateral pools were observed. A small falls, which is likely a seasonal barrier to upstream migration, was noted at approximately RM 1.5.

Above Silver Falls Hwy, the landscape has only a slight gradient (<1% slope). Creek banks are incised with little undercutting. The lower end of this reach is largely uniform, consisting mainly of shallow riffles with widely scattered pools mainly resulting from prolific beaver activity. At approximately RM 2.4 the creek has been confined to a quarter-mile long ditch. The banks are clay and greater than six feet in height. Upstream of this ditch, the creek is incised and sinuous, hidden within thick banks of reed canary grass.

The last morphological unit of West Fork creek begins at approximately RM 3.2 and extends to the termination of perennial flow at RM 4.5. It is defined by a sharp and continued rise in gradient and an increase in active channel

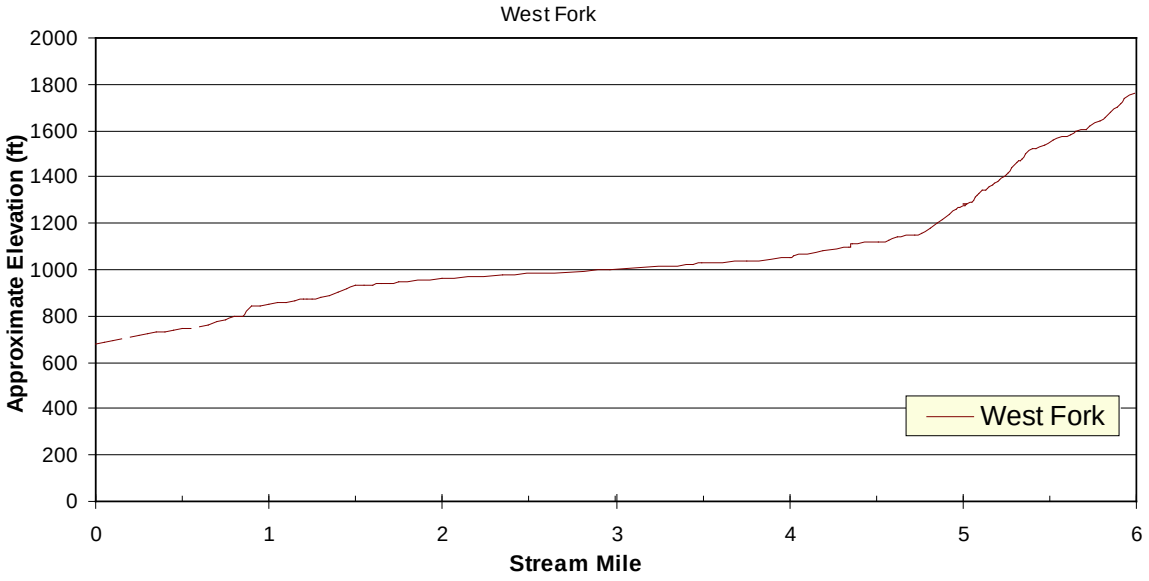


Figure 6. Elevation by stream mile in West Fork Drift Creek.

width. Long riffles separated by steps or cascades over boulders are typical. Banks were generally undercut. Pools, though relatively abundant, decrease in frequency as elevation increases.

Four locations within the West Fork were selected for detailed habitat surveys. Habitat criteria in all reaches received predominately low rankings, the exception being pool habitat, which was present at moderate to high levels in all reaches (Table 6B5). Also, percent shade and bedrock were ranked as moderate to high in all but one reach. Reach 2 received the highest overall ranking within West Fork, scoring moderate to high in five of the 13 habitat rankings. In general, the data collected reinforced the subjective observational data that pool habitat in West Fork Drift Creek was abundant but that significant concentrations of gravel and LWD are in low abundance.

East Fork Drift Creek can be divided into two distinct morphological units based on channel morphology. The entire creek from its mouth to the falls at Drift Creek Road is uniformly sloped (approximately 3.5%). However at RM 0.35 the habitat transitions abruptly. The creek downstream of this point is an incised channel running through a wide flood plain surrounded by agricultural fields. Banks are actively eroding for most of the reach. Habitat is dominated by long glides interspersed with shallow riffles. Pools were scattered throughout the reach. Above RM 0.35 the thickly wooded landscape rises steeply away from the left bank of the creek. The right bank terrace gradually moves closer to the active channel as elevation increases. By the time the creek reaches Drift Creek Road the channel is at the bottom of a steep canyon. Banks throughout this upper reach are largely intact with only occasional evidence of erosion in outer bends. Instream habitat consists mainly of riffles separated by cascades and steps. Scour pools are moderately abundant.

Two detailed habitat reaches were completed. The scores indicate generally low quality habitat throughout (Table 6B5). In the upper reach, shade was robust and moderate amounts of LWD were present. However, substrate, though largely lacking in fines, was predominantly bedrock and no spawning gravels were observed. The lower reaches of East Fork have been impacted by agricultural practices. Shade has been greatly reduced and LWD is nearly absent. Sediment composition is more varied as bedrock gives way to gravel, cobble and more fines. The habitat rankings are in agreement with the subjective observations described in the general habitat description above.

Pebble counts results for the two East Fork survey reaches were fairly similar with median particle size (D50) ranging from just over 50mm in the downstream reach to 60 mm in the upstream reach. Although both counts fall within the range for gravel bed streams (2.5mm to 63.5mm) copious amounts of bedrock were observed in the upper reaches of East Fork and moderate levels of fines were observed in the lower reaches. Additionally, field surveys did not find any suitable spawning gravel beds for coho or steelhead.

Table 6B5. Habitat rankings for the detailed study reaches in West Fork and East Fork Drift Creek.

Parameter	West Fork Reach #								East Fork Reach #			
	Reach 1		Reach 2		Reach 3		Reach 4		Reach 1		Reach 2	
	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking	Value	Ranking
% pools	59	High	11	Moderate	53	High	72	High	44	High	29	High
Deep pools/km	0	Low	0	Low	0	Low	0	Low	0	Low	0	Low
% slackwater pools	0	Low	0	Low	53	High	4	High	0	Low	0	Low
% secondary channels	0	Low	0	Low	0	Low	0	Low	0	Low	0	Low
% fines in riffles	14-16	Moderate	0-5	Low	NA	NA	37	Low	0-5	Moderate	0	High
% gravel in riffles	5-14	Low	8-10	Low	NA	NA	15	Low	5-10	Low	0	Low
% bedrock in streams	2	High	18	Moderate	0	High	44	Low	7	High	56	Low
Pieces lwd/100 m	1.1	Low	25.7	High	4.1	Low	39.9	High	0	Low	13	Moderate
Volume lwd/100 m	0.5	Low	2.9	Low	0.7	Low	11.8	Low	0	Low	1.4	Low
Key pieces of lwd/100 m	0	Low	0	Low	0	Low	0	Low	0	Low	0	Low
# conifers >50 cm dbh	0	Low	122	Moderate	0	Low	0	Low	0	Low	0	Low
# conifers > 90cm dbh	0	Low	0	Low	0	Low	0	Low	0	Low	0	Low
% shade	70	Low	100	High	88	Moderate	100	High	60	Low	100	High
Low rankings	10		8		7		9		10		9	
Moderate rankings	1		3		1		0		1		1	
High rankings	2		2		3		4		2		3	

6B.3 Habitat Effects

Effects of the project on fish habitat would include the conversion of 3.2 miles of currently accessible stream upstream of the proposed dam into a reservoir and the blockage of access to an additional 8.6 miles of stream above the reservoir. The reservoir and areas upstream would be isolated from downstream areas and fish upstream of the dam would consequently lose their ability to migrate downstream in the Drift Creek Mainstem and on to the Pudding River, and then return above the dam. The only anadromous salmonids known to spawn upstream up the dam site are (non-native) coho salmon. No evidence (e.g. larger size adults) was found during the fish surveys that cutthroat presently exhibit adfluvial behavior however, it is likely that the population retains the genetic capacity for adfluvial behavior. The reservoir would inundate the lower end of Fox Creek that currently provides a small amount of spawning habitat for coho salmon and possibly cutthroat trout. There is also a short section of gravel substrate in the mainstem Drift Creek near the confluence of Fox Creek that would be inundated.

Construction of the dam would create reservoir habitat. This habitat is likely to be utilized extensively by largescale sucker, northern pikeminnow, and cutthroat trout – all of which can thrive in lake and reservoir environments. The reservoir would lead to an increase – and likely a significant increase – in food resources for all three species. In addition, the reservoir would provide increased juvenile rearing habitat for all three species and coldwater summer refugia for cutthroat trout. Therefore, habitat would likely be improved for cutthroat trout, northern pikeminnow, and largescale sucker, except that they would be isolated from populations of those species downstream of the dam. The benefits of the reservoir to cutthroat trout will be quantified in a production model discussed below.

The presence of the dam and reservoir would also alter the natural flow of Drift Creek downstream of the dam. Due to storage of water during the late autumn and winter months, many of the high flow events, which typically occur in November, December and January, would be reduced or eliminated. During annual filling, the project would be required to meet the Oregon Department of Fish and Wildlife fish flow water right below the dam but would be able to store water in excess of the instream water right. By reducing the frequency of high flow events, the flow conditions in the creek below the dam would be more predictable, which should improve fish survival. In addition, there presently is little off-channel or within channel winter refuge habitat for native migratory fish species. Therefore, during high flow events fish are likely forced to move downstream and out of the system. With the dam, it is expected that a greater number of fish would be able to reside in lower Drift Creek throughout the winter.

When dams reduce the frequency of high flow events, there can sometimes be detrimental effects on flow-related ecological functions that affect fish habitat and on channel forming and channel maintenance processes. EES conducted an analysis of the effects of dam-related flow modification for lower Drift Creek and the findings were published in a report entitled Determination of Appropriate Ecological and Channel Maintenance Flows for Drift Creek Downstream of the Proposed Dam (http://www.oregon.gov/owrd/law/docs/GrantApp/GA0035_09_Attachment10.pdf). For ecological flows the report considered the life histories and ecological requirements of all of the native migratory fishes potentially present within the lower 6.5 miles of Drift Creek. It was determined from this analysis that if the dam releases maintain compliance with the ODFW instream water right requirements set for the mouth of the stream, ecological flow requirements would be met for all of the native migratory species.

The flushing flow analysis indicated that the majority of the substrate in the streambed downstream from the dam site falls within the coarse bed size category. A small reach of gravel/cobble substrate was identified near the Hibbard Road bridge but pebble counts on this area indicated that it also fell within the coarse bed size category. The short section of stream between the mouth and the lower end of the gavel/cobble section is predominately a silt/clay hardpan that is resistant to scouring. Flushing flows needed to move coarse bed streams are usually provided by a 2-3 year flood event. Based on WRD equations for estimating flood recurrence intervals at the proposed dam site and on modeling of bankfull flows, it appears that the 2-year flood event would be approximately 630 cubic feet per second (cfs). A 2-year flood event could occur during the period of reservoir filling or during the period when the reservoir was full. Presently, guidance with respect to release of a 2-year flood event during filling of the reservoir is not available from the resource agencies. If the 2-year flood event occurred during filling, it would be difficult for the outlets to discharge 630 cfs due to the high, potentially damaging water velocities that would occur under such conditions. Therefore, unless much larger discharge pipes were installed than those proposed, it would be infeasible to discharge a 2-year flood event during reservoir filling. If the 2-year event occurred after the reservoir was full, some supplemental discharge from the outlet pipes would be required since the reservoir would

cause some buffering of the spillway discharge. Such details in managing the 2-year or greater flood releases will need to be worked out during final design of the dam and its controls.

Even in the absence of additional mitigation measures (discussed below), rearing habitat for native migratory fish downstream of the dam would be enhanced by the discharge of cool water and supplementation of flows during the summer low flow period. As will be described below, mitigation within the reach below the dam will include the introduction of spawning substrate suitable for cutthroat trout and coho salmon.

6B.4 Flows

Streamflow data for Drift Creek are limited. The District established a stream gauging station near the Victor Point Road bridge (RM 6.2) in November 2008 and began collecting data on December 4, 2008. Marion County Soil and Water Conservation District (MCSWCD) staff calibrated the gauge and collected data through September 2009. Since that time, the District's consultants have calibrated, maintained and collected data at the Victor Point site through the present. A second gauge monitored by MCSWCD was established earlier in 2008 near the mouth of the creek at Hibbard Road bridge (RM 0.5) and provides comparable flow data to the Victor Point bridge site for the period December 4, 2009 through January 2012 when it was washed out by a flood event. The Hibbard Road gauge was returned to service in April 2013 and has been maintained by MCSWCD since that time. Based on regional precipitation records, the 2008-2009 water year was a low precipitation year and streamflows were close to historic low flow conditions. Monthly flow statistics during the 2008-2009 water year for the lower gage (Hibbard Road) are included on Table 6B6.

The existing ODFW instream water right for fish flows in Drift Creek increases from 3.0 cfs to 5.26 cfs on October 16, then to 20.0 cfs November 1 and to 40.0 cfs on November 16. The proposed project would be required to bypass water until these flow requirements were met. This flow pattern should provide more than sufficient change in flow to stimulate upstream migration of returning adult coho salmon should they be present in the fall and early winter months.

Table 6B6. Discharge statistics for the Hibbard Road Gage in cubic feet per second (cfs).

	2008			**2009**								
Daily discharge	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep
Mean	4.23	28.5	117	152	51.1	100	50.3	55.1	9.05	1.83	0.59	0.88
Max	18	175	580	590	194	145	102	158	18	3.9	0.88	2.6
Min	0.58	0.68	16	31	25	71	23	15	3.6	0.17	0.25	0.18

6B.5 Water Quality

6B.5.1 Temperature

The state of Oregon identifies Drift Creek as being used for salmon and trout rearing, migration and spawning (OAR 340-41-340, Figures 340A and 340B). Based on the temperature criteria outlined in OAR 340-41-0028, the seven-day average maximum temperature of a stream identified for salmon and trout rearing and migration use may not exceed 18.0° C (64.4° F) and during designated spawning periods (October through May) may not exceed 13° C (55.4° F). Drift Creek is identified on Oregon Department of Environmental Quality's (DEQs) 303(d) list as being water quality limited for temperature during the summer because it exceeds temperature criteria for salmon and trout rearing and migration (River Mile 0 to 9.5). Temperature recorders located above the reservoir, near the dam site and near the mouth of Drift Creek indicated that most of the summer temperature increases occur in the low gradient reach where the reservoir would be located. There was little difference in summer mean water temperatures between the thermograph near the dam site and the mouth of the Creek. However, daily maximum temperatures were higher near the mouth with temperatures reaching near lethal levels for salmon and trout.

6B.5.2 Dissolved Oxygen

Drift Creek has no significant sources of oxygen demanding pollutants and has not been identified by DEQ as having any dissolved oxygen problems. Therefore, it can be assumed that existing dissolved oxygen conditions are suitable for the maintenance of cold water fauna except, perhaps, in the lowest reach where low gradient and high water temperature may combine to reduce dissolved oxygen during the summer.

6C. PROVIDE THE SOURCE FOR INFORMATION CONTAINED IN THE BARRIER AND SUMMARY TABLES:

Parkhurst, Z.E., F.G. Bryant and R.S. Nielson. 1949. Survey of the Columbia River and its Tributaries. Part 3. Special Scientific Report – Fisheries, No. 36. US Department of the Interior.

Runyon, J., C. Andrus, and A Stewart. 2006. Pudding River Watershed Assessment Prepared for the Pudding River Watershed Council.

Thompson, Robert N, James B. Haas, Raymond A.Willis, Melvin D. Collins, Roy E. Sams. 1960. *Environmental survey report pertaining to salmon and steelhead in certain rivers of eastern Oregon and the Willamette River and its tributaries.* Oregon Fish Commission. Research Division.

MITIGATION (*attach additional copies of this section if multiple mitigation sites are proposed*)

The District explored multiple options for mitigation including demolition of the degraded dam at Scott's Mills on Butte Creek and upgrade of its associated fish ladder; and three culvert upgrades:

- Scott's Mill's Road impedes access to two miles of a tributary to Butte Creek in the creek's lower reach (MBG, 2003).

- Power's Creek, beneath Power's Creek Loop Road, Abiqua Watershed: blocks five miles of habitat. Willard's Pool Dam is one mile upstream, and may impede migration (MB&G, 2003).

- Culvert beneath Mt. Angel/Scotts Mills Road on an unnamed tributary of Butte Creek may block access to approximately two miles of habitat in the upper watershed, assuming habitat above is adequate (MB&G, 2003).

Each of these projects faced significant uncertainties with regard to ownership, benefit, feasibility and long-term maintenance.

Furthermore, it is always preferable to conduct mitigation as near to the impact as possible. Therefore, it was determined that the preferred mitigation option was habitat enhancement within Drift Creek itself, rather than off-site mitigation.

1. DESCRIBE THE MITIGATION TO BE PROVIDED:

The proposed mitigation addresses the habitat conditions in Drift Creek that are presently limiting for cutthroat trout, largescale sucker, northern pikeminnow and Pacific lamprey. Our analyses to determine the type and quantity of mitigation needed focused on cutthroat trout. Largescale sucker, northern pikeminnow and Pacific lamprey will benefit from the mitigation proposed downstream of the dam and cutthroat trout, largescale sucker and northern pikeminnow populations are expected to expand upstream of the dam through their utilization of the proposed reservoir habitat. .

From the habitat surveys conducted by EES and analysis of existing flow and water temperature conditions in Drift Creek and its tributaries, it is clear that habitat conditions are far from optimal for the watershed's native migratory fish populations. However, without some measure of the present carrying capacity of the habitat and the effect of habitat improvement on carrying capacity, it is difficult to provide clear evidence that a mitigation proposal will provide a "net benefit" to native migratory fishes. This problem was discussed in meetings with Todd Alsbury (District Fish Biologist and Greg Apke (Fish Passage Coordinator). During the meeting held on April 9, 2012, Steve Cramer suggested that the modeling approach that his company (Cramer Fish Sciences) had recently developed and applied to the Beaver Creek drainage near Troutdale, Oregon (Cramer et al. 2012) could be used to estimate carrying capacity for cutthroat trout and benefits to carrying capacity derived from habitat improvements. Todd Alsbury was familiar with the Beaver Creek modeling work and agreed that this would be a reasonable approach to quantify the present carrying capacity and to identify and quantify the mitigation needed for a fish passage waiver for the Drift Creek Dam Project. A brief description of the model, modeling approach and results of the model are presented below. A detailed report on the modeling work is provided in Attachment 1.

1.1 Cramer Fish Sciences Model

The Drift Creek Simulation Model for potential production of cutthroat trout was developed to determine the capability of present habitat conditions in Drift Creek for supporting native salmonids, and what the factors were that limited that production. The model was used as a tool to identify what information would be needed from the Drift Creek watershed to predict trout production, to then provide a framework for integrating that information, and finally to quantify where and what the factors were that limited production in the watershed.

An existing model was used to translate habitat measurements into estimates of the maximum number of adult cutthroat trout that could be produced in Drift Creek under average environmental conditions. The model was developed by Cramer Fish Sciences and partial versions have been published in peer-reviewed science journals. The

present version of the model was recently applied under contract to the US Army Corps of Engineers to estimate fish benefits for loss or gains in fish passage at road crossings over Beaver Creek, a tributary to the Sandy River (Cramer et al. 2012). Many of the conditions in Beaver Creek are similar to those in Drift Creek, so the model was well suited for obtaining accurate estimates of cutthroat production potential under present and alternative future conditions in Drift Creek.

The model was parameterized specifically for coastal cutthroat trout, because cutthroat were the only native salmonid species found in Drift Creek. As discussed previously, a small number of juvnenile coho salmon were captured by EES in Drift Creek, but coho salmon were not historically present in the Willamette Basin above Willamette Falls until it was laddered. ESA-listed steelhead are native to the Pudding River Subbasin, but Drift Creek is not listed as a steelhead-bearing stream by Streamnet, and extensive sampling by EES in 2005, 2006 and 2009 did not identify any steelhead or rainbow trout.

It was readily apparent from the habitat surveys throughout the Drift Creek watershed that salmonid production was strongly limited by two conditions; the lack of spawning gravel and high water temperatures that approached lethal levels during the heat of the day. Further, the limited amount of gravel suitable for spawning was contained principally in the stream reach that would be inundated by the reservoir. In recognition of the need to mitigate for this loss of spawning habitat, the project proponents have changed their plans for reservoir operations, and have reserved a portion of the stored water to increase summer base flow. Additionally, they have proposed a multiport outflow structure that will enable release of cool water throughout the summer. In order to determine whether this investment in more and cooler water in the summer mitigated for reduced spawning habitat, Cramer Fish Sciences was retained to develop and apply a model that could use measurements of the stream habitat conditions to predict the stream's capacity for salmonids. Sampling data from EES indicated that cutthroat trout were the only native salmonid present in the watershed, so the model was specifically tailored to the life history attributes and habitat preferences of coastal cutthroat trout.

1.1.1 Model Approach

The model was constructed to use available information known to influence carrying capacity for either spawning or rearing. Habitat needs for these two life stages differ. Data inputs to the model were the measurements of habitat features in Drift Creek that determined the maximum density of fish supportable. Habitat features that determined spawning capacity were gravel availability, area defended per spawning pair, and minimum depth for spawning. Habitat features that determined rearing capacity were channel unit composition, surface area, depth, substrate, cover, and temperature. Habitat measurements were scaled to flows in March for spawning, and to summer base flow for rearing.

Habitat surveys completed by EES were used for the required inputs on channel morphology. Those surveys were designed to characterize existing habitat conditions prior to development of the proposed Drift Creek Dam at River Mile (RM) 6.5 on Drift Creek. The typical channel morphologies used to describe habitat are riffles, runs (or glides) and pools. Definitions of these channel units are as follows:

> **pool:** a unit with no surface turbulence, except at the inflow, and has depth extending below the plane of the streambed
> **riffle:** a unit with discernible gradient and surface turbulence
> **glide:** a unit that has relatively uniform velocity down the channel, little surface turbulence, and no depth below the plane of the streambed

The Unit Characteristic Model (UCM) that was used to predict stream carrying capacity for salmonids based on habitat measurements has been published in the peer-reviewed scientific articles (Cramer and Ackerman 2009). The key principles underlying this method are:

> 1. Salmonids exercise strong and repeatable preferences for a suite of habitat features they will use, and these preferences determine the type of channel unit in which they choose to reside.
> 2. These preferences have repeatable patterns of change between life stages and in response to extremes in environmental variation.

3. The suite of habitat features available is related to the type of channel unit (e.g. pool, riffle, glide, etc.), and differs between these channel unit types.

4. Therefore, densities of salmonid use follow consistent differences between types of channel units.

5. Habitat capacity for a particular life stage of salmonid can be predicted as the product of the expected density of fish supportable in a particular channel unit, multiplied by the surface area of the unit, and then summed with such products for all channel units in the stream.

While Cramer and Ackerman (2009) describe the general utility of the UCM for understanding population function of salmonids in streams, Cramer (2001) provides specific relationships for application of the UCM to cutthroat trout. The UCM model was extended to account for habitat's influence on capacity to support spawning, and survival rates were incorporated during each life stage. Survival rates in a reservoir environment differ from those in a stream, so anticipated changes in fish survival were incorporated into a calculation of fish effects expected from scenarios with Drift Creek Dam in place. Predicted effects were accumulated across all life stages and translated into the common currency of adult-equivalent change in fish production the watershed could produce under average conditions. Adult-equivalents are the expected number of returning adults that would result in the absence of fishing. For example, if it takes 100 hundred fry to produce one adult, then 100 fry are one adult equivalent.

1.1.2 Conceptual Model of Fish Use

To estimate carrying capacity of a watershed to support a fish species, one must first describe how the species could be expected to use the habitat. Patterns of habitat use in streams by fish (which we refer to as habitat preferences) determine the proportion of available habitat that is suitable for fish use at a given life stage. So, the amount of available habitat was measured as well as its features. How these measurements would change across seasons was then projected. Finally, after the habitat preferences of each fish life stage was overlaid with the amount of habitat each fish would need, carrying capacity for that life stage was estimated.

Production of cutthroat trout, steelhead, and coho salmon is most often limited by the capacity for juvenile rearing (Cramer and Ackerman 2009; Quinn 2005), but factors constraining production can vary between stream reaches, and migration can enable fish to overcome some of these limitations by moving to another stream reach. The life stages referred to in the model were defined as follows:

- **Fry-**Juveniles in their first 30 days of life prior to establishing territories. Maximum lengths of fry are assumed to be ≤35mm for cutthroat .
- **Juveniles-**Juveniles rearing and defending territories. Fork lengths assumed for cutthroat are assumed to be 35 to 120 mm for fish rearing in streams.
- **Adults or spawners-** Fish that have reached maturity and are capable of spawning in the spring

The modeling, directly estimates carrying capacity within Drift Creek, and it was assumed that suitable rearing habitat is not available outside the watershed in the Pudding or Willamette rivers at the points directly downstream of Drift Creek. Temperatures in these downstream areas tend to reach lethal levels for cutthroat trout during summer. It was also assumed that juveniles will disperse within the Drift Creek watershed to fill available habitat, but extra mortality was assigned during the act of migrating between reaches, because migrating fish expose themselves to ambush predators such as larger trout, birds, and mammals. For further details of the model's structure and assumption see Attachment 1.

1.1.3 Modeling Results

The modeling results for existing conditions without the dam are presented in Table 1.1. The carrying capacity of all accessible reaches of Drift Creek for adult equivalent spawners under average conditions is estimated to be 475 adults. The model indicates that key limiting factors downstream of the dam site are high summer water temperatures and lack of suitable spawning substrate. Under present conditions this area is probably seeded from reproduction in the small area of suitable spawning substrate in Fox Creek and possibly the small area of suitable substrate in the reservoir reach. With the dam, these areas will no longer be accessible to adults from the reach below the dam.

Table 1.1. Simulated potential for cutthroat trout production in the Drift Creek watershed under existing conditions. Total AEQ (adult equivalent) spawners are the sum of spawners across ages for the specified reach.

		Redd Capacity	Eggs	Fry	Parr	Age 1	Age 1 - Redist.	Age 2 - Spring	Age 2 Carrying Capacity	Age 2 - Fall	Age 3	Age 4	Age 5	Total AEQ Spawners
Fecundity								**50**			**100**	**150**	**150**	
Survival Rates				**0.15**	**0.386**	**0.3321**		**0.33**			**0.33**	**0.33**	**0.33**	
% Mature								**0.25**			**0.6**	**1**	**1**	
Near the Mouth	MS1	-	-	-	-	-	-	-	16	-	-	-	-	-
Cascade Hwy	MS2	-	-	-	-	-	-	-	36	-	-	-	-	-
Canyon	MS3	-	-	-	-	-	209	69	82	69	23	8	2	41
Out of Canyon	MS4	-	-	-	-	-	209	69	74	69	23	8	2	41
Proposed Reservoir	MS5	1,193	108,719	16,308	6,295	2,091	1,406	464	519	464	153	51	17	275
Farmland	EF1	-	-	-	-	-	247	81	18	18	6	2	1	27
Forested	EF2	-	-	-	-	-	38	12	12	12	4	1	0	7
Fisher Farm	WF1	-	-	-	-	-	114	37	39	37	12	4	1	22
Fisher Forest	WF2	-	-	-	-	-	114	37	30	30	10	3	1	20
Beaver Activity	WF3	-	-	-	-	-	114	37	25	25	8	3	1	18
Upstream	WF4	432	39,368	5,905	2,279	757	114	37	39	37	12	4	1	22
	Total	1,625	148,087	22,213	8,574	2,848	2,563	846	890	762	251	83	27	473

The model was then run assuming 2.0 cfs discharge of cool bottom water from the reservoir during the summer low flow period and the introduction of 3,800 ft^2 suitable spawning gravels in the first mile of stream below the dam. Table 1.2 shows the results of the model with these mitigating measures after the dam is in place. A net increase of 371 spawners is predicted.

The with-dam scenario assumes that cutthroat trout will utilize the relatively shallow edge habitat around the periphery of the reservoir during the late autumn, winter and spring months where food abundance will be high compared to the stream environment. Survival in the reservoir environment is assumed to be somewhat higher than survival of fish that remain in the creek. Also, it is assumed that some new spawning gavel will be deposited at the upper end of the reservoir where water velocity drops off just downstream of the confluence of the East and West Forks. Cutthroat that utilize the reservoir are expected to grow larger and have a higher fecundity than those fish remaining in the stream.

Also, the with-dam scenario will improve both rearing and spawning habitat for cutthroat trout downstream of the dam. The introduction of suitable spawning substrate in a reach that is presently totally lacking of spawning substrate will be a clear benefit. The discharge of cool water from the reservoir during the low flow summer period will keep water temperatures lower throughout the summer and within DEQ recommended limits for cold water fishes (i.e., <64° F) through much of the low flow summer period.

1.2 Recommended Mitigation Based on Model Results.

1.2.1 Temperature improvement and low flow enhancement

Water quality modeling (CE-QUAL-W2) conducted by Portland State University (PSU) staff for the proposed Drift Creek reservoir, demonstrated that the reservoir will stratify during the summer and early autumn. A warm layer of water near the surface (epilimnion) will overlay a cooler layer of water (hypolimnion) near the bottom. By discharging irrigation water from a mid-level outlet and instream water requirements (IWR) from a low level outlet, the model predicted that water leaving the dam will be from 5º C (9º F) to 10 º C (18º F) cooler than existing temperatures at the proposed dam's location (Figure 7).

EES used the Stream Segment Temperature Model Version 1.2.2 (SSTEMP) to model the possible persistence of these lower temperatures as far as the Hibbard Road crossing (RM 7) during the average flow water year 2010 (Tanovan 2011). The model was calibrated by simulating stream temperature for days on which observed flow and temperature data were available for summer months in 2008. The output modeled temperatures were then compared with actual recorded mean daily water temperatures at Hibbard Road for each day in July and August of 2010 (Figure 8). Predicted daily mean temperatures were on average 0.89°F higher than observed temperatures (maximum over estimate was 4.9°F, maximum under estimate was 2.25°F)

Table 1.2. Simulated potential for cutthroat trout production in the Drift Creek watershed with Drift Creek Dam in place and minimum instream release of 2.0 cfs. Total AEQ (adult equivalent) spawners are the sum of spawners across ages for the specified reach.

		Redd Capacity	Eggs	Fry	Parr	Age 1	Age 1 - Redist.	Age 2 - Spring	Age 2 Carrying Capacity	Age 2 - Fall	Age 3	Age 4	Age 5	Total AEQ Spawners
	Fecundity							**50**			**100**	**150**	**150**	
	Survival Rates			**0.15**	**0.386**	**0.3321**		**0.33**			**0.33**	**0.33**	**0.33**	
	% Mature							**0.25**			**0.6**	**1**	**1**	
Near the Mouth	MS1	-	-	-	-	-	123	41	77	41	13	4	1	24
Cascade Hwy	MS2	-	-	-	-	-	247	81	182	81	27	9	3	48
Canyon	MS3	-	-	-	-	-	247	81	276	81	27	9	3	48
Out of Canyon	MS4	704	64,156	9,623	3,715	1,234	493	163	174	163	54	18	6	97
Proposed Reservoir	MS5	-	-	-	-	-	1,145	567	1,000	567	281	139	69	518
Farmland	EF1	16	1,870	281	108	36	49	16	18	16	5	2	1	9
Forested	EF2	-	-	-	-	-	49	16	12	12	4	1	0	8
Fisher Farm	WF1	470	54,940	8,241	3,181	1,056	146	48	39	39	13	4	1	25
Fisher Forest	WF2	12	1,403	210	81	27	146	48	30	30	10	3	1	22
Beaver Activity	WF3	-	-	-	-	-	146	48	25	25	8	3	1	21
Upstream	WF4	432	50,498	7,575	2,924	971	146	48	39	39	13	4	1	25
	Total	1,634	172,867	25,930	10,009	3,324	2,935	1,157	1,872	1,094	455	196	88	846

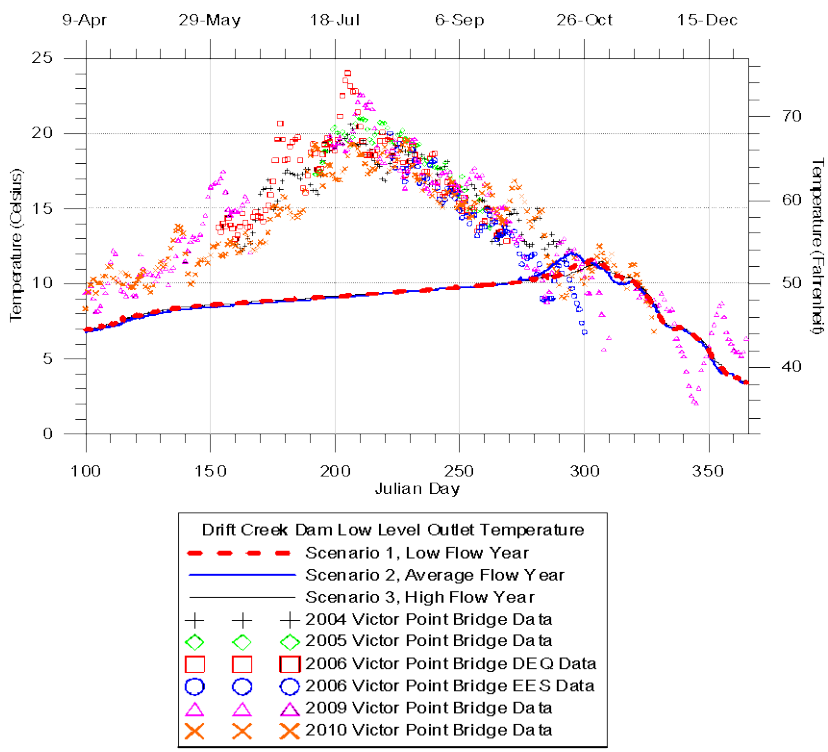


Figure 7. Comparison of existing summer water temperatures at Victor Point Bridge with post dam water temperature under low and average flow conditions (from Berger et al. 2011).

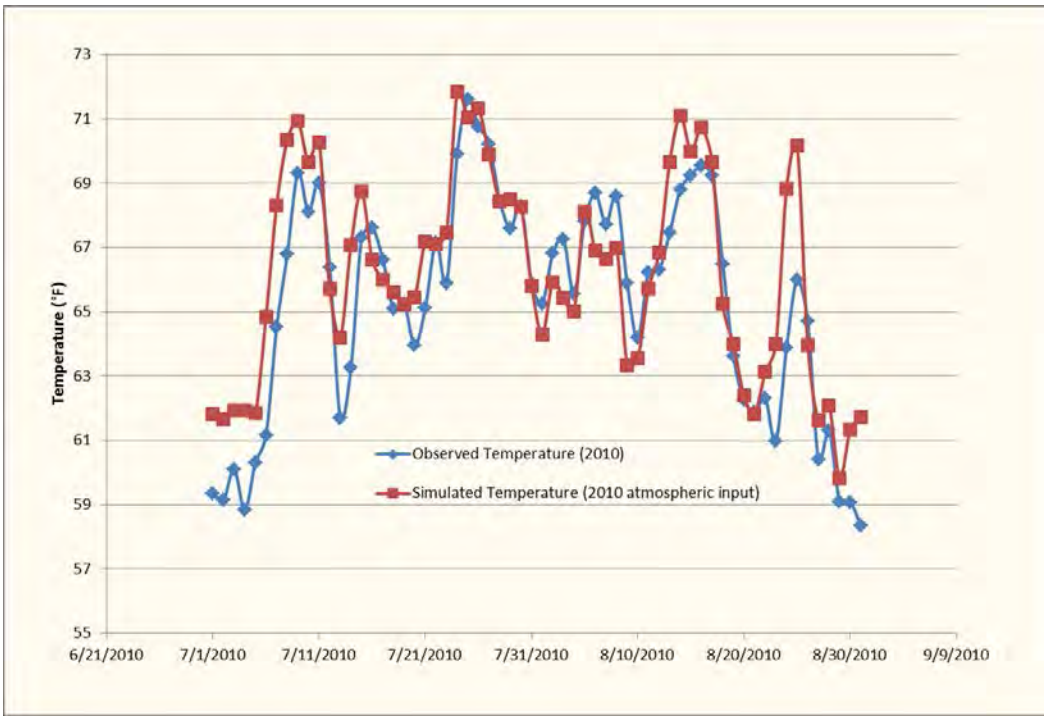


Figure 8. Simulated temperatures at Hibbard Rd compared to observed temperatures

For modeling temperatures under the proposed IWR releases, SSTEMP input temperatures and flow values were derived from PSU's modeled output for average flow year conditions where agricultural flows were withdrawn from the mid-level outlet and IWR flows were withdrawn from the lower outlet. Meteorological data for July 1, 2010 through August 31, 2010 were gathered from an AGRIMET weather station located in Aurora, Oregon.

The most likely operation scenario involves the release of a minimum of 2.0 cfs from the bottom outlet of the dam from July through August. Model results shown in Figure 9 show a general reduction in mean daily temperatures downstream of the proposed dam site through August This reduction in summer temperatures is expected to bring most of the reach of Drift Creek below the dam site into compliance with the DEQ temperature standard during the month of July, which would benefit rearing habitat for cold-water fish species.

Mean daily flows during the critical summer period (July and August) currently fall as low as 0.24 cfs. Discharge from the dam will be a minimum of 2.0 cfs during July and August. These enhanced flows will provide additional critical habitat volume for rearing fish.

1.2.2 Gravel supplementation

Habitat surveys have indicated that Drift Creek has a sediment-starved, bedrock/boulder dominated channel. Therefore, in order to enhance spawning habitat downstream of the dam additional gravel will need to be introduced, monitored and maintained long-term. Under present conditions the stream channel is nearly devoid of structure that will retain gravel. Large boulders and large woody debris are largely absent and the existing substrate is primarily bedrock in the first mile downstream of the dam site. Stream gradient in this reach is about 1.5 percent and therefore, is suitable for stream enhancement structures. Gravel introduction will require instream structure to hold it in place. We will follow the guidance provided in "Guide to Placement of Wood, Boulders and Gravel for Habitat Restoration " (Oregon Department of State Lands et. al., 2010) to design and install appropriate instream structures. These may incluce boulder clusters and/or large woody debris placements. We will work closely with ODFW staff

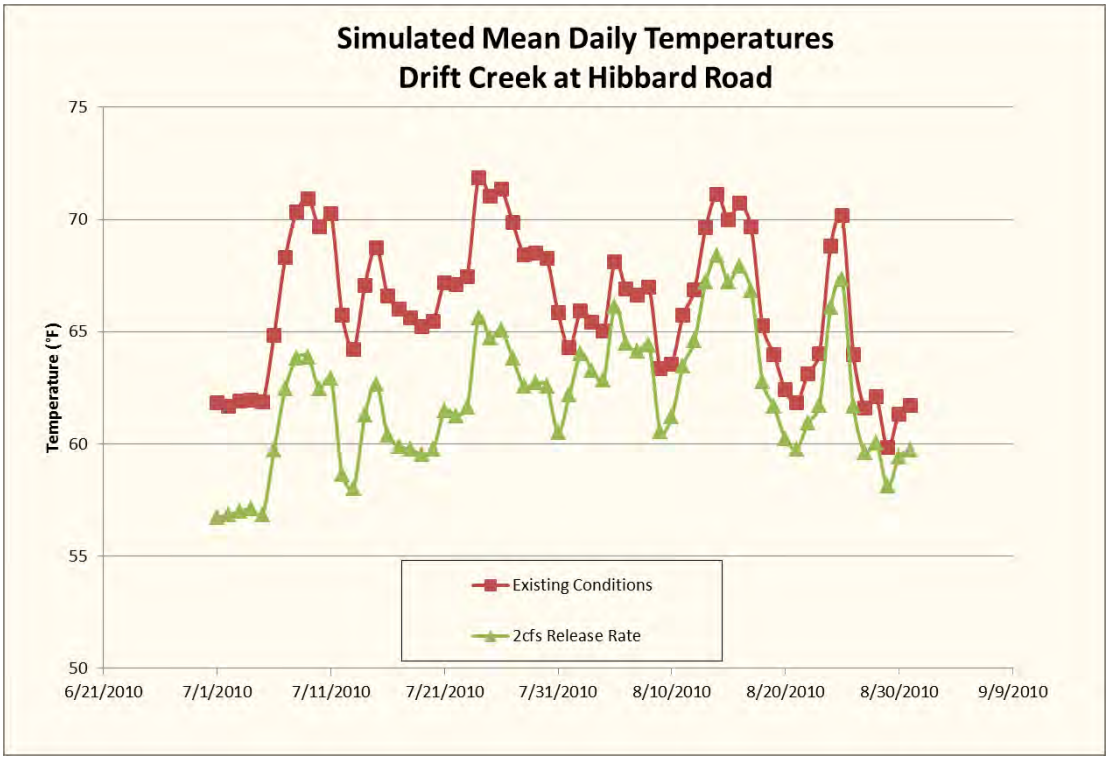


Figure 9. SSTEMP results for proposed IWR releases during average flow year (2010).

throughout the design and implementation phase. Smooth gravel in the appropriate size range for adult cutthroat trout will be purchased and transported to accessible sites within the first mile below the dam site. We anticipate that the reservoir will trap most of the fine sediments reducing the potential for sedimentation of the gravel beds. Enough gravel will be introduced to provide a minimum of 3,800 ft^2 of spawning gravel. Monitoring will be conducted yearly to evaluate the condition of the gravel and its location. Fish sampling will also be conducted yearly during the first five years to evaluate the success of the stream enhancements and to determine whether predicted densities of trout are produced. It is also anticipated that the gravel introduction will provide new spawning habitat for Pacific lamprey as this species typically spawns in gravel based streambeds.

1.3 References

Berger, C., S. Wells, A. McCulloch, and V. Wells. Drift Creek Reservoir Model: Model Development and Scenarios Report. Technical Report EWR-03-11. Water Quality Research Group. Department of Civil and Environmental Engineering. Maseeh College of Engineering and Computer Science Portland State Universit. Portland, Oregon 97201-0751. Prepared for East Valley Water District.

Cramer, S.P.. 2001. The relationship of stream habitat features to potential for production of four salmonid species. S. P. Cramer & Associates, Inc. contract report to Oregon Building Industry Association, Salem, Oregon. Available online at http://www.fishsciences.net/reports/index.php.

Cramer, S., Nicklaus K. Ackerman. 2009. Linking stream carrying capacity for salmonids to habitat features. American Fisheries Society, Series: Symposium, Vol. 71, Page(s): 225-254.

Cramer, S., J. Vaghan, M. Teply and S. Duery. 2012. Potential Gains In Anadromous Salmonid Production From Restoration Of Beaver Creek (Sandy River Basin, Oregon).

Prepared for U. S. Army Corps of Engineers.

Mason, Bruce and Girard. 2003. Historic Salmon Distribution Study in Marion County, Oregon. Completed for the City of Salem.

MB&G: See Mason, Bruce and Girard.

Oregon Department of State Lands, Oregon Department of Forestry, Oregon Watershed Enhancement Board, Oregon Department of Fish and Wildlife. 2010. Guide to Placement of Wood, Boulders, and Gravel For Habitat Enhancement

Quinn, T. 2005. The behavior and ecology of Pacific salmon and trout.

Tanovan. B. 2012. Drift Creek Site A, Near Silverton Or. Runoff Yield Analysis. (Update #3). Prepared for East Valley Water District.

2. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION: Gravel will be introduced immediately below the dam and at other locations within the first mile downstream of the dam. Log/boulder structures will be placed as necessary to retain the gravel within the first one mile below the dam. Details of the mitigation (including specific locations for log structures and dates for installation) have yet to be finalized.

3. OWNER (*if different than Applicant*)**:**

CONTACT:	Don and Allen Mulkey	**TITLE:**			
ADDRESS:	9697 Bates Rd SE				
CITY:	Aumsville	**STATE:**	OR	**ZIP:**	97325
PHONE:	503.749.2728				
FAX:					
E-MAIL ADDRESS:					

CONTACT:	Robert B Qualey	**TITLE:**			
ADDRESS:	1105 E Main St				
CITY:	Silverton, OR	**STATE:**	OR	**ZIP:**	97381
PHONE:	503-875-6153				
FAX:					
E-MAIL ADDRESS:					

4. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED: Mitigation will be completed prior to initial blockage of the stream channel.

5. LOCATION

COUNTY:	Marion	
ROAD CROSSING (if applicable)**:**	N/A	
RIVER/STREAM:	Drift Creek	
TRIBUTARY OF:	Pudding River	
BASIN:	Willamette Basin, Molalla/Pudding Subbasin	
COORDINATES[a]**:**	Longitude: 122.754014°W	Latitude: 44.923562°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

6. STREAM DESCRIPTION

6A. BARRIER TABLE (*please provide the following information for barriers, which will help determine the benefit of the Mitigation site; indicate measurement units if applicable*)**:**

Because the mitigation will be completed in Drift Creek immediately downstream of the dam, barriers present are the same as those listed above in table 6A of the obstruction section.

PLEASE PROVIDE ADDITIONAL DESCRIPTIONS FOR THOSE BARRIERS INCLUDED IN THE BARRIER TABLE OR FOR OTHER BARRIERS AFFECTING NATIVE MIGRATORY FISH MOVEMENT TO OR FROM THE MITIGATION: Same descriptions as provided above.

6B. SUMMARY TABLE (*please provide the following information relative to the Mitigation, which will help determine its benefit*)**:** Because mitigation is occurring in Drift Creek all required information is provided above.

PLEASE PROVIDE ADDITIONAL DETAILS REGARDING THE INFORMATION PROVIDED IN THE SUMMARY TABLE (*such as species listed under the state or federal ESA and descriptions of the stream channel and riparian habitat*)**:** See above for a thorough description of species and conditions currently present in Drift Creek.

6C. PROVIDE THE SOURCE FOR INFORMATION CONTAINED IN THE BARRIER AND SUMMARY TABLES: Same sources as above.

7. DESCRIBE HOW THE MITIGATION RELATES TO ANY EXISTING FISH MANAGEMENT PLANS, INCLUDING THE OREGON PLAN: None known

8. DESCRIBE ANY KNOWN RESTORATION OR LAND USE PLANS WHICH MIGHT HAVE AN IMPACT ON THE MITIGATION *(e.g., is the watershed included within an expanded Urban Growth Boundary or does a Local Comprehensive Plan limit future development in the watershed)***:** There are no known entities considering habitat enhancements in Drift Creek.

9. IF THE MITIGATION ENTAILS PROVIDING PASSAGE AT AN EXISTING ARTIFICIAL BARRIER, WHAT IS THE EXPECTED DATE OF REPLACEMENT OR MAJOR REPAIR FOR THE STRUCTURE IF IT WERE NOT USED AS MITIGATION: N/A

10. DOES THE MITIGATION INCLUDE ANY ACTIVITY THAT IS A REQUIREMENT OR CONDITION OF ANY OTHER AGREEMENT, LAW, PERMIT, OR AUTHORIZATION *(if "Yes", describe)***:** No

11. DESCRIBE HOW THE MITIGATION WILL BE FUNDED *(include a cost estimate, funding sources, and whether funds are currently secured)***:** A preliminary cost estimate for installation of gravel retention structures, appropriate size gravel and its installation is approximately $65,000, which will be funded by the District. Funds are not currently secured. Supplemental flows during the low flow summer period for an average year will represent approximately 76 acre-feet over and above the flow that would be naturally present in the creek at the dam site. The value of the water for fish habitat enhancement includes capital costs, annual maintenance and fees lost for the water. The estimated capital cost to store 12,000 acre feet of water is $60, 000,000. Therefore the initial capital cost per acre foot would be $5000.00 x 76 = $380,000.

The price for an acre-foot of water from the proposed Drift Creek reservoir project is expected to range from $50-$70 per acre foot or from $3,800 to $5,320 per year. The Capital cost for the storage capacity for instream water requirements will be funded through loans and federal grants which have yet to be secured. The annual expense of providing the water for instream use will be included in the operations/maintenance cost of the project and will be shared among the District's water users proportional to their water use.

12. DESCRIBE HOW THE MITIGATION WILL BE EVALUATED, MONITORED, AND MAINTAINED: The existing continuously recording thermographs and discharge stations will continue to be operated to monitor temperature and flow data. An additional continuously recording discharge monitoring station will be established immediately upsteam of the reservoir to monitor input to the reservoir. The District proposes to conduct either spawner surveys of the newly created spawning gravels and/or population surveys of the affected reach for five years post construction and then every five years thereafter along with a survey after any significant (20-year) flood. Concurrent with the spawner or population surveys, the amount and extent of spawning gravels will be surveyed for areal extent and composition and photo-documented annually to determine when additional gravel supplementation may be required. A detailed monitoring plan will be prepared for ODFW approval. An annual monitoring report documenting monitoring activities and results will be prepared by the District's consultants. If the monitoring indicates that predicted benefits to the fish populations are not occurring, remedies will be identified and implemented.

MAP(S)

- *Please attach one or more maps indicating the Artificial Obstruction, Mitigation, the streams on which they are located, and other barriers in those streams. A 7.5 minute USGS quad map is sufficient.*

X -- Map(s) included in the above application.

PHOTOS

- *Please include photographs of the following* (*.JPG files are preferred):*

☐ -- Artificial Obstruction
☐ -- Mitigation Site(s)
X -- up- and downstream habitat at the Artificial Obstruction and Mitigation Site(s) (See Attachment 2)
X -- other barriers up- and downstream of the Artificial Obstruction and Mitigation Site(s) (See Attachment 2)

Please submit this application electronically to the ODFW Fish Passage Coordinator at greg.d.apke@state.or.us and send one signed original paper copy of the application to the ODFW Fish Passage Coordinator at 3406 Cherry Avenue NE, Salem, OR 97303.

ATTACHMENT 1

CRAMER FISH SCIENCES DRIFT CREEK SIMULATION MODEL

ATTACHMENT 2

PHOTO LOG OF BARRIERS

Downstream barrier 1.

Downstream barrier 2.

Downstream barrier 3. Dam is removed during higher flow periods

Upstream barrier 1. Partial barrier at low flow. Photo is taken during higher flow

Upstream Barrier 2. Partial barrier at low flow

Upstream barrier 3. Drift Creek Falls

Typical habitat downstream of the proposed dam (RM 0.1)

Typical habitat downstream of the proposed dam (RM 1.8).

Typical habitat downstream of the proposed dam (RM 3.7).

Typical habitat downstream of the proposed dam (RM 5.6).

Typical habitat in the reservoir footprint.

Typical section of lower West Fork

High gradient reach of West Fork Drift Creek.

West Fork Drift Creek just above Silver Falls Highway.

Upper end of West Fork Creek.

Lower end of East Fork Drift Creek.

Upper end of East Fork Drift Creek.

SECTION 10
CONSERVATION

Growers in the East Valley Water District currently use pressurized systems that use less water than the department prescribes for the area west of the Cascade Mountains on a per acre basis. More recently growers have begun using linear systems that are supported by the Natural Resources Conservation Service (NRCS), but mainly to conserve electricity. The Marion County Soil and Water Conservation District continues to promote the linear systems in the county with federal assistance. Neither the drip or linear systems have led to less water use, according to growers in the District, but they have led to more production as the result of more efficient water use.

While the intent of the reservoir project is not based on the need to provide additional water resources for changes in cropping patterns, some changes do occur based on external factors such as market prices or other economic conditions. The intent of the reservoir project and conveyance system is to replace water rights that have been either withdrawn or diminished because there are two groundwater limited areas within the boundaries of the District. Replacing the groundwater rights that are being depleted by the dropping water table could provide more instream water benefits and perhaps delay the continuation of the water table drop.

If the conveyance decision leads to piping water delivery to major points of diversion within the District, there would then be a savings of water through that conservation project. That consideration could be part of the decision-making process to determine the final choice for the conveyance system. The decision to pipe could also reduce energy consumption.

SECTION 11
EVALUATION OF WATER TRANSMISSION ALTERNATIVES

Black Rock Consulting reviewed past work by Murray Smith and Associates and developed a summary report dated August 12, 2012 that compared and contrasted the two potential alternatives for water supply to the East Valley Water District service area boundary:

- **Live Stream Discharge from Drift Creek Reservoir to Drift Creek and Subsequent Pumping from the Pudding River and Pressurized Pipe Delivery to the District Service Area**
- **Piped Discharge from Drift Creek Reservoir to the District Service Area**

The evaluation by Black Rock Consulting identified a lower-pressure delivery alternative for pumping from the Pudding River to the District service area that would provide initial capital system cost savings and long term pumping cost savings. The estimated total cost of a piping alternative was approximately $40MM and for a pumped solution was $24MM including long term estimated pumping costs.

The evaluation found that there were challenges and benefits to a pumping solution versus a piped conveyance solution.

Live Stream Conveyance and Pumping Benefits:

1) Lower initial cost.
2) Likely staging of initial cost by addition of pumps over time.
3) Likely incremental operating cost over time as patrons/demand and pumps were added.
4) Avoidance of easement and environmental issues that may require mitigation of the dam-to-District pipeline option.
5) Summer irrigation release may be a benefit to Drift Creek and become mitigation for other project impacts.
6) Potential for NRCS program participation/partnership.

Live Stream Conveyance and Pumping Issues/Challenges:

1) Live stream installation will present additional project permitting challenges.
2) Flashy river and flood stages present design and long-term O&M risks and challenges.
3) Pudding River water quality after co-mingling with Drift Creek water may not be as desirable for irrigation as strict Drift Creek water.
4) Quantification and measurement of released flows at the dam verses extracted water at the pump station may be a challenge. The District will not want a net water loss between release volume and extracted volume.
5) River installation will create additional O&M in the river that may present long-term challenges to the District's operations.
6) Long term power rates are uncertain and present financial risk to the District.
7) Long term pump maintenance and O&M.
8) Future regulatory uncertainty regarding screening and other mechanical features on the river.

The Black Rock Consulting evaluation provided a recommendation that the District defer its decision

regarding the delivery method pending these additional study results:

1) Water rights evaluation and application development
2) Fish passage waiver process
3) Water Quality Modeling
4) Hydrologic yield analysis update

These deliverables were compiled during the grant cycle after Black Rock Consulting developed its report. Generally, no particular issues developed during the development of the Water Rights application to the OWRD.

The hydrologic yield analysis update provided essential information that the reservoir would fill in most years and over the latest 10-year cycle, the reservoir could serve every irrigation season modeled.

Portland State University utilized the updated yield analysis to develop additional temperature modeling scenarios to evaluate the potential for meeting DEQ temperature criteria in Drift Creek. Given live stream discharge of irrigation water resources stored during the winter months and by the use of multiple ports on the Reservoir discharge system, PSU found that significant improvements could be made to temperatures in Drift Creek, yet there were a few days each year that temperature criteria may be exceeded.

Ellis Ecological Services developed a temperature model for Drift Creek to evaluate existing creek temperatures and the affects of adding cool reservoir water (1.5 CFS and 4 CFS) during the low flow summer months. Significant cooling was determined, generally bringing the temperatures down to the acceptable range for fishery. Adding this cooler water in critical times and ultimately adding some spawning gravels in conjunction with the benefits of the reservoir resulted in doubling of the cutthroat adult spawner population. Regarding temperature, there was no appreciable benefit of adding 4 CFS versus 1.5 CFS. Live stream conveyance of irrigation water and pumping from the Pudding River was also evaluated and it was determined that the gross cooling effects were less than that of the piping and cool mitigation water release alternative.

Ultimately, the decision as to whether piping or pumping should be pursued is based upon a complex number of variables. The live stream conveyance alternative with pumping presents a lower cost alternative but presents project risks including but not limited to:

1) DEQ temperature criteria exceedance – even if for a few days
2) Any seepage losses that may exist in transmission of water
3) Permitting, construction and installation of diversion measures on the Pudding River
4) Flooding risks with Pudding River diversion
5) Long term power cost escalation
6) Water quality of comingled Pudding River water
7) Future regulatory uncertainty regarding live stream diversions, screening, and weirs

For these reasons, the current version of the Fish Passage Waiver has been prepared based upon a piped delivery alternative with cool water mitigation enhancement to 2.0 CFS at low flow periods during the summer period. Modeling for fish production has also been based upon the piping alternative.

Further coordination with ODFW will be necessary to confirm approach in the Fish Passage Waiver process and with the various agencies to confirm assumptions regarding permitting, etc. to ultimately

determine which approach – Piping or Pumping will be pursued. Each has its challenges and ultimately project funding constraints may play a critical role in the delivery method selection.

Summary Report
Pudding River Pump Station Versus Drift Creek Dam to District Boundary Transmission Pipeline

August 10, 2012

Black Rock Consulting, Bend, Oregon

BACKGROUND

Given recent hydrologic yield work by Dr. Tanovan, water quality modeling by Portland State University, and engagement in the Oregon Department of Fish and Wildlife Fish Passage Waiver process, further review and evaluation of a Pudding River withdrawal system versus dam to District transmission pipeline was considered of value.

Past reports key to this analysis were:

"FINAL REPORT – Technical Memorandum, DRIFT CREEK PROJECT, OVERALL PROJECT PLANNING ASSESSMENT/WATER CONVEYANCE SYSTEM ALTERNATIVE ANALYSIS- February 23, 2007, Murray, Smith & Associates, Inc."

"Technical Memorandum – DRIFT CREEK WATER SUPPLY PROJECT, PRELIMINARY TRANSMISSION PIPELINE ROUTING ANALYSIS, October, 2008, Murray Smith & Associates, Inc."

This Summary Report is intended to provide straight-forward, reconnaissance-level answers, based upon existing and available data, to the questions:

1) What is the scope of a Pudding River intake and transmission pipeline to the District boundary versus a dam to District pipeline?
2) What is the order-of-magnitude cost difference of a Pudding River intake versus a dam to District Transmission Pipeline?
3) What is the long term energy cost consideration?
4) What are some of the potential benefits of a Pudding River intake?
5) What are some of the potential issues regarding a Pudding River intake?
6) What recommendations are there or are there further actions that must occur prior to recommendation to the Distict?

SCOPE OF PUDDING RIVER INTAKE VERSUS DAM TO DISTRICT PIPELINE

Dam to District Pipeline –

In their 2008 report, MSA developed a series of alignment alternatives and performed some level of ground truthing. Black Rock Consulting also visited the MSA suggested alignments in the field along with District representatives. For the purposes of this summary evaluation no major modifications to the MSA

conclusions are recommended although should piping be pursued further in the future, it is recommended that the alignment route be further refined as Black Rock Consulting believes that there may be a less costly and less invasive alignment in reaches of the proposed piping.

In its report (see excerpts attached), MSA developed the route by 5 segments including along Drift Creek, cross-country, road-way portions, and creek crossings, then recommended what it felt to be the best alternatives within each segment. The selected route (see attached) resulted in a total 42-inch pipeline installation cost estimate of $40MM that included 45% ($12.4MM) for engineering, permitting, administration and contingencies. Although this cost estimate was developed in 2008, BRC does not recommend escalation of the cost value as significant cushion is present in the contingency already and recent HDPE pricing received by BRC would support the values used in the MSA estimate.

Pudding River Intake –

In its 2007 report, MSA evaluated several alternatives for conveyance of irrigation water from the proposed Dam including dam to District piping alternatives, Drift Creek diversion and pumping and Pudding River diversion and pumping. From a cost, only, standpoint the Pudding River intake and transmission pipeline to the District boundary was the preferred alternative (see attached report excerpts).

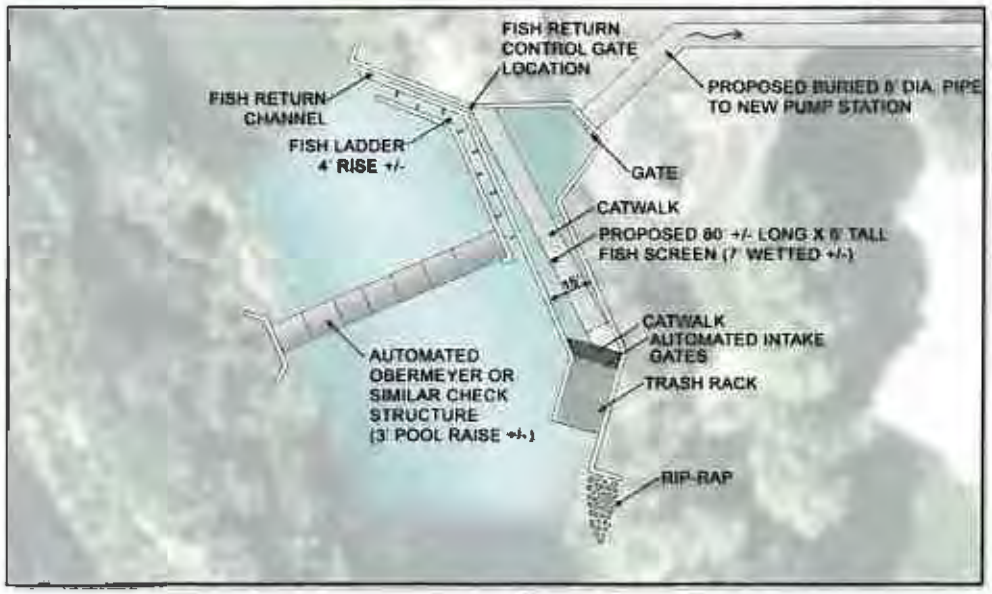
The MSA concept for the Pudding River Intake alternative (Alternative 2 in their 2007 report) included the installation of a live river intake and 3,371 HP pump station and an approximate 11,700 LF, 36-inch diameter pipeline to transmit the water to the edge of the District service area at the intersection of Highway 214 and Downs Road. Their intent was to deliver 50 CFS to the boundary at 150 PSI such that the worst area in the system would still have 50 PSI delivery pressure. This resulted in a system estimated at approximately **$32MM**. Of this, $17MM was for the pump station and pipeline loaded with 45% for engineering, permitting, administration and contingencies, and $15MM was for present worth of power and O&M expenses over a 100-year project design life.

Although this high-pressure delivery approach may be desirable to the patrons, there are significant cost implications to all elements of the system including the pump sizing, the electrical substation sizing, transmission and distribution pipeline wall thickness, valve and gasket ratings, long term O&M, etc.

Black Rock Consulting recently completed a study for another irrigation district that involved a similar live stream intake, obermeyer gates on the river, fish screen and large vertical turbine array, and significant HDPE transmission system. Given this recent experience and costing information it seemed prudent to re-assess the cost of a Pudding River intake system assuming a low-head delivery system and given that the end users must continue private pumping for their on-farm delivery systems as they see fit.

In the following reconnaissance-level cost analysis, Black Rock Consulting assumed the same intake location and transmission pipeline alignment for the river gates, fish ladder, pump station, and fish screen as used by MSA. The following indicates the approximate facility locations:

Below is an exhibit indicating a live river intake. In this case, the similar features to a Pudding River intake would likely be the need for river elevation control (i.e. Obermeyer gates and fish ladder), trash rack and fish screen intake. The difference is that the elevated vertical turbine pump array would be located behind the fish screen and catwalk system and would discharge to a manifold/discharge pipe system.



In reviewing the topography, it appears that there should be additional evaluation of best District service area connection to try to split the flows appropriately and minimize necessary pumping head. For the purposes of this early analysis, we have assumed the same connection location at Downs Road and Highway 214 although we believe some improvement may be made to this should this alternative be pursued further. We have assumed a reduced goal of 50 PSI at the District service area connection point. This would reduce the pipe cost by an estimated $150/LF and the pumping plant horsepower by 48%. We held the same contingency so that we would be comparing apples to apples regarding contingency values on the pipe option verses the pumping option. The resulting cost estimate would be:

Nusom/Downs Road Pipeline (11,700 LF @ $330/LF) =	$3.9MM
Pudding River Intake and 1,800 HP Pump Station=	$5.5MM
Engineering, Permitting, Admin, &C Contingency (45%)=	$4.2MM
TOTAL =	**$13.6MM**

As noted above, MSA also included O&M and power costs by evaluating the project over a 100-year life and bringing those costs back to present worth. Should the District choose to include these real costs in its evaluation of the choices, we recommend using the following MSA and BRC values:

Present Worth of Power Cost=	$6.0MM
Present Worth of O&M/Pump Replacements=	$4.1MM
GRAND TOTAL =	**$23.7MM**

ORDER OF MAGNITUDE COST DIFFERENCE BETWEEN DAM TO DISTRICT PIPELINE AND PUDDING RIVER INTAKE AND TRANSMISSION PIPELINES

As determined above, we estimate the reconnaissance level cost of the dam to District pipeline at $40MM and the Pudding River Intake to be $13.6MM or $23.7MM if long term O&M and power costs are included.

LONG TERM ENERGY COST CONSIDERATION

The long term energy cost is based upon a 50 CFS assumption and 90 full flow operation days. The reality is that the District may choose to commence operations with a reduced pumping capacity and then increase pump installations as patron base/demand grows. Additionally, the irrigation demand regime is not for 50 CFS over three months, therefore the power consumption estimate at $198K per year is likely high. Lastly, the characteristics of the District may change dramatically over a 100-year period. The $6MM present worth power estimate is therefore a conservative estimate of present worth cost over a 100-year period.

POTENTIAL BENEFITS/ISSUES OF A PUDDING RIVER INTAKE

The following list of benefits and issues surrounding a Pudding River intake are based upon excerpted comments from the MSA report and the observations of BRC. This list is likely not exhaustive and additional benefits and/or issues would likely arise as further pursuit of the project were to occur.

Benefits:

1) Significantly lower initial cost.
2) Likely staging of initial cost by addition of pumps over time.
3) Likely incremental operating cost over time as patrons/demand and pumps were added.
4) Avoidance of easement and environmental issues that may require mitigation of the dam-to-District pipeline option.
5) Summer irrigation release may be a benefit to Drift Creek and become mitigation for other project impacts.
6) Potential for NRCS program participation/partnership.

Issues/Challenges:

1) Live stream installation will present additional project permitting challenges.
2) Flashy river and flood stages present design and long-term O&M risks and challenges.
3) Pudding River water quality after co-mingling with Drift Creek water may not be as desirable for irrigation as strict Drift Creek water.
4) Quantification and measurement of released flows at the dam verses extracted water at the pump station may be a challenge. The District will not want a net water loss between release volume and extracted volume.
5) River installation will create additional O&M in the river that may present long-term challenges to the District's operations.
6) Long term power rates are uncertain and present financial risk to the District.
7) Long term pump maintenance and O&M.
8) Future regulatory uncertainty regarding screening and other mechanical features on the river.

RECOMMENDATIONS AND FUTURE ACTIONS

This summary is recommended to be only one piece of decision-making information for consideration by the District. In conjunction with this information, water quality modeling information, fish passage waiver mitigation alternative information, and expectations regarding release flows versus extracted flows should all be considered in the overall decision. The District is currently in process with:

1) Water rights evaluation and application development
2) Fish passage waiver process
3) Water Quality Modeling
4) Hydrologic yield analysis update

We recommend that the District complete this work prior to making a decision regarding piping from dam-to–District or Pudding River intake. Although the Pudding River intake system appears to be significantly less expensive than the pipeline alternative, the District along with its staff should carefully consider the results of the on-going work as well as the benefits versus potential challenges indicated above and others that may arise.

APPLICABLE EXCERPTS FROM:

"FINAL REPORT – Technical Memorandum, DRIFT CREEK PROJECT, OVERALL PROJECT PLANNING ASSESSMENT/WATER CONVEYANCE SYSTEM ALTERNATIVE ANALYSIS- February 23, 2007, Murray, Smith & Associates, Inc."

FINAL REPORT
Technical Memorandum

DRIFT CREEK PROJECT

OVERALL PROJECT PLANNING ASSESSMENT/ WATER CONVEYANCE SYSTEM ALTERNATIVES ANALYSIS

Murray, Smith & Associates, Inc.

February 23, 2007

EAST VALLEY WATER DISTRICT

MARION COUNTY, OREGON

would be unique to each scenario.

Routing a large diameter pipeline the roughly 10-mile distance between the proposed Drift Creek Dam and the District service area will be challenging and expensive. Hydraulic gradeline constraints relative to existing topography would force the upper portion of a prospective pipeline to be routed cross-country along Drift Creek several miles before a routing could be established along exiting roadways. Several creek crossings, highway crossing and railroad crossings will be required along with other special circumstances around or through Silverton and Mt. Angel. Many decisions are required for routing major pipelines, decisions such as routing inside or adjacent to existing roadway right-of-ways, versus routing cross-country. In addition to the property issues, various environmental issues must be considered as well as land use interests, traffic impacts, business impacts and many other issues.

A pumping alternative scenario would avoid much of the complexity associated with a 10-mile long pipeline, but would present its own set of technical challenges. Either a deep stable pool must be found, or an artificial instream diversion structure must be constructed to create a suitable backwater condition for a large capacity river intake. Intake and pump station siting must consider stream channel geomorphology, bank stability, channel stability, fish screening, water rights, permitting, power supply, access and many other issues.

Irrigation Distribution System

The distribution system element of the Drift Creek Project would be relatively straight forward in terms of issues. Pipeline routing would most likely be in or along existing rights-of-way. As many impacted properties would more than likely be District members, "friendly" property acquisition would most likely be the norm.

MSA conducted preliminary conceptual-level system layout planning and hydraulic analysis of the potential District distribution system to determine potential pipe sizes and distribution system hydraulic characteristics. A conceptual layout of potential major piping is shown on *Figure 7.*

The majority of the District service area is situated in relatively flat terrain, where stored water can be delivered through the distribution system layout shown on *Figure 7.* There are some areas that would require booster pumping and/or in-system storage for adequate service due to high elevation, specifically in the southeast portion of the District service area against the Cascade Mountain foothills. For the purpose of conveyance system assessments, trial pipe size and water flow distribution assumptions were established based on aerial mapping assessments, computer based hydraulic modeling and other engineering judgments.

Regulatory and Permitting Interests

There are a variety of regulatory and permitting interested that must be considered relative to each element of the project. While these interests will largely be addressed by others outside

static (no flow) conditions, this elevation differential (or hydrostatic "head") would result in a system pressure of approximately 160 to 180 pounds per square inch (psi). In hydraulic terms, 2.31 feet of water "head" is equivalent to 1.0 psi. Under a flowing condition where hydraulic head and associated water pressure is lost to friction, a 48-inch diameter pipeline delivering 50 cubic feet per second over 10 miles, by gravity (without pumping), would present a residual downstream pressure at the entry point to the distribution system of approximately 165 psi. Due to normal friction losses in the irrigation distribution system, available system pressures would then be reduced as one moves away from the initial transmission pipeline entrance point.

Initial Basic Analysis -- For the purposes of initial comparative analysis, it was agreed with District representatives, that a residual pressure of 150 psi, at the entrance point to the distribution system, under a flow condition of 50 cfs would be a suitable base assumption. It was furthermore agreed that the "entrance point" to the District distribution system would be considered as the intersection of Downs Road and the Southern Pacific Railroad (SPRR) along State Highway 214, midway between Silverton and Mt. Angel. Under this criteria and other assumptions regarding distribution pipeline layouts and sizing, preliminary hydraulic analysis indicated that with a 48-inch diameter transmission pipeline, most of the distribution system service area could be served with an available service pressure of at least 50 psi without booster pumping.

For the purposes of initial comparative analysis, similar performance requirements were applied to comparative stream/river conveyance and pumping based alternatives.

Supplementary Analysis – Following initial analyses and reporting, the District asked that additional supplementary analysis be conducted using lesser stringent criteria, so as to allow other potential concept variations and facilities sizing scenarios to be assessed and considered. An abbreviated analysis and assessment effort was conducted, as a result of this request without the level of reporting being developed as was completed for the initial basic comparative cost analysis. The results of this supplementary analysis are briefly noted herein.

Preliminary Cost Estimates and Comparative Analysis Methodology

The development of the Drift Creek Project represents a major capital undertaking. Each of the three major project elements, the Drift Creek Dam, the stored water conveyance system and the irrigation distribution system, are multi-million dollar propositions. In advance of any construction, is the significant cost of project engineering, environmental assessments, property acquisition and permitting. Following construction are the significant costs of on-going system management, operation and maintenance.

In the past, agriculture benefiting irrigation projects have been eligible for favorable federal funding programs supporting both initial construction and, for pumping based systems, subsidized electrical power costs. It is recognized that such projects today face great competition for available federal and state funding programs. While the District has intended

as a consistent reference, based on recent and historical costing information available from similar local area projects. Such information has been used as the basis for this TM's comparative cost analysis.

The "45 percent" allowance that is then added to basic construction costs to develop estimates of "project costs", as referenced herein, may be generally broken down as follows:

Construction Contingencies	25%
Engineering (Design and Construction Management)	15%
Permitting	2.5%
Administration/Legal/Misc	2.5%
	TOTAL @ 45 %

For purposes of comparing alternatives, the actual value of these factors is not so critical, as long as they are applied consistently. However, acknowledging that this document will likely be used for broader project planning and decision making purposes, MSA has made every effort to develop estimates at a level that may be appropriate for District budgeting.

Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For future reference, the November 2006 ENR CCI of 8655.83 for the Seattle area construction market (the nearest market ENR monitors) may be used in the future to update cost estimates in this report.

Initial comparative cost analysis did not include allowances for water losses (and the cost thereof) associated with in-channel creek/river conveyance. The following discussion addresses this interest.

Open Channel Conveyance Water Loss -- In preliminary review meetings with the District, it was suggested that it may be appropriate to incorporate provisions into the comparative cost analysis that consider the potential for lost water associated with the pumping based Conveyance Alternatives (Alternatives 2 & 3) that rely on reservoir releases and in-stream flow routing for a portion of the conveyance need. While it has been suggested that such potential water loss might be in the range of 25% it is acknowledged that there are several factors that would influence potential water loss with open channel conveyance. These are briefly discussed as follows:

*Stream Channel Seepage~Seepage loss is a function of stream channel subsurface geology, groundwater hydrology, channel flow depth and so forth. It is likely that in the upper reaches of Drift Creek, where the stream channel is flowing on exposed bed rock, water loss due to seepage would be fairly nominal. Lower downstream in the Pudding River, it is likely that over time, silt/clay sediment has, to some extent, sealed the subsurface channel and thus, seepage could be minimal or nominal. Geotechnical engineering evaluations would be important to quantifying the extent to which seepage losses might be relevant.

*Evaporation~Calculations can be conducted to estimate potential evaporation losses. While MSA has not made evaluations or calculations of potential evaporation losses for this system, calculations for other Willamette Valley reservoir based water supply systems have included additional reservoir storage in the range of 3-4% to account for evaporation losses. Note, this estimate does not distinguish between reservoir evaporation and potential conveyance channel evaporation.

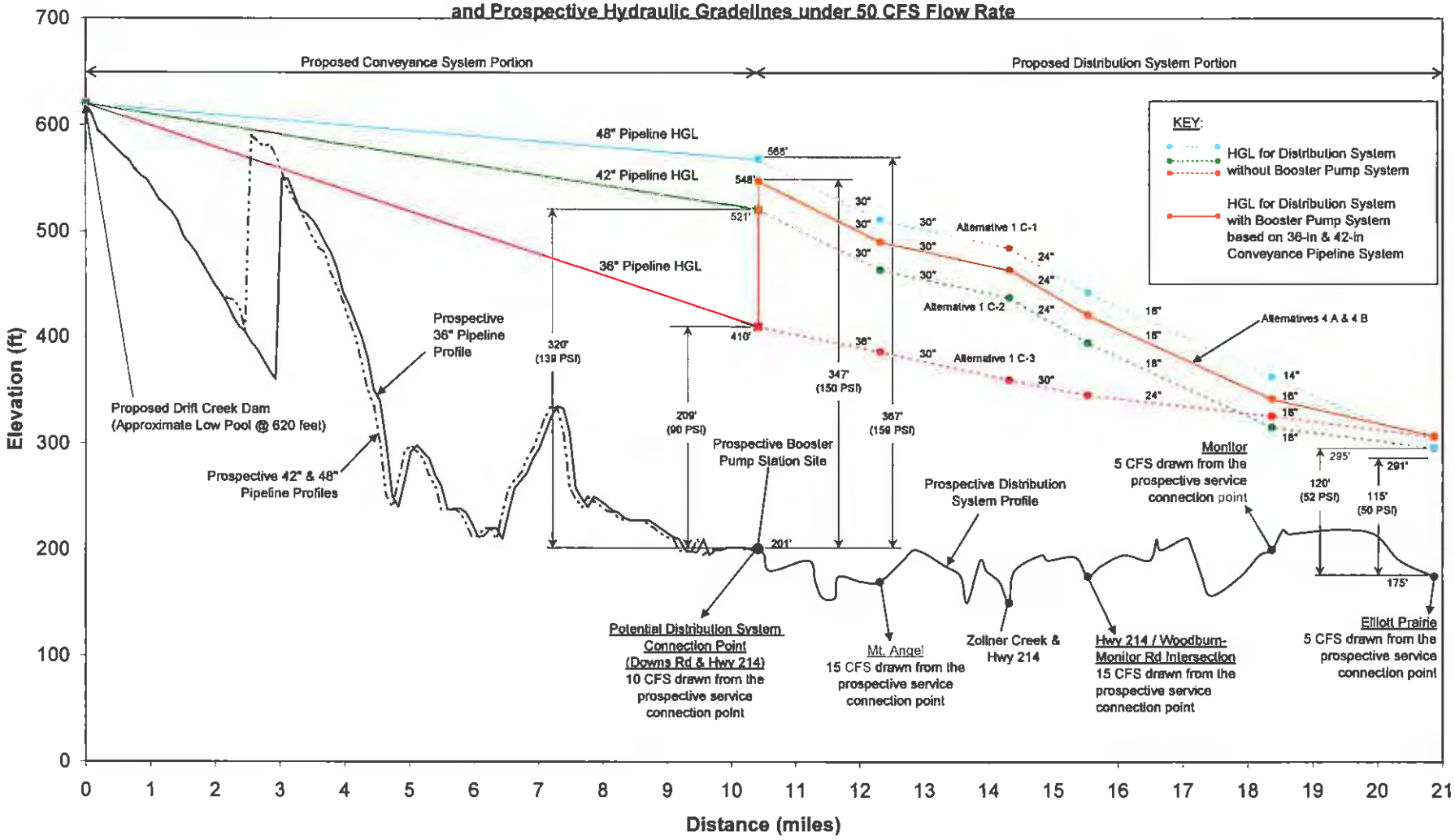
*"Call for Water/Operational" Inefficiencies~In an open channel system, it is necessary to release stored water at the upstream dam/reservoir for creek/river conveyance and recapture at a downstream intake and pumping facility. Depending on the length of this open channel conveyance, many hours of lead/lag time may be involved between the required release of water, and the actual recapture and pumping for use. This lead/lag time, and the difficulty in predicting exactly what the actual pumped demand may be, can lead to direct water loss, as unused water may pass-by the downstream intake/pumping facility. The Barney Reservoir/Hagg Lake/Scoggins Reservoir (BuRec, Tualatin Valley Irrigation District, Joint Water Commission, Clean Water Services) multi-use water supply system has historically estimated lost water due to operational efficiencies in the range of 20%. This system is currently planning for a large diameter raw water pipeline, with it being understood that the pipeline will eliminate this operational loss. Currently, released water from Hagg Lake/Scoggins Reservoir travels about 7 miles from the dam site to the downstream river intake/ pumping station location. For the Drift Creek project, it is possible that greater water demand predictability and reduced water loss may be accomplished with a single irrigation user base.

Assuming it is agreed that some sort of differential cost accounting should be included in the comparative cost estimates that consider both open channel conveyance and piped conveyance, MSA suggests the following: If it is agreed that an approximate lost water factor of 25% might be applicable to the open channel conveyance options relative to the piped alternatives, then a way to account for this in the comparative cost analysis would be to build additional storage capacity into the basic Drift Creek Dam/Reservoir and account for this additional cost in the cost comparisons. Initial analysis estimated a $10 million project cost for 12,000 acre-feet of total gross storage, for a general unit cost of $10 million/12,000 AF=$833/AF. If, out of the total proposed gross reservoir capacity of 12,000 acre-feet, it is assumed that 10,000 net acre-feet of capacity is allocated for irrigation use, then an additional 2,500 AF of gross storage would be needed to make up for the 25% assumed loss (10,000 AF X .25 = 2,500 AF), at an additional project cost of $2 million (2,500 AF X $833/AF = $2 million). To aid in the overall comparisons, Table E.1 was developed as part of supplementary analysis work, adding a column that allows for a varying Drift Creek Dam cost, depending on the conveyance alternative. An updated/revised Table E.1 is included for this purpose and is referenced herein as Table 6.

Analysis Discussion

The Drift Creek Project consists of three major elements—the Drift Creek Dam/Reservoir, the stored water transmission/conveyance system and the irrigation water distribution system.

Chart E
(Copied from Appendix E and Revised February 23, 2007)
Prospective Conveyance and Distribution Pipeline Profiles from Proposed Drift Creek Dam
Into Potential District Distribution System
and Prospective Hydraulic Gradelines under 50 CFS Flow Rate



Alternative 2: Creek/River Conveyance and Downstream Pumping System

System Description -- This alternative involves the potential of transporting stored water by means of natural conveyance channels via Drift Creek and the Pudding River. Summertime reservoir releases would be withdrawn downstream via a new pump station along Pudding River, and transmitted a relatively short distance to the District water distribution system. Preliminary hydraulic analysis indicates that a 36-inch transmission pipeline would be suitable for delivery of a flow of 50 cfs at a pressure of 150 psi. A potential pump station location and pipeline route is shown on *Figure 4*.

Key Considerations -- A pumping alternative scenario would avoid much of the complexity associated with miles of right-of-way acquisition involved with the gravity pipeline transmission system, but would present its own set of technical challenges. Either a deep stable pool must be found, or an artificial instream diversion structure, such as a weir, must be constructed to create a suitable backwater condition for a large capacity river intake. Intake and pump station siting must consider stream channel geomorphology, bank stability, channel stability, fish screening, power supply, access, water rights, permitting, and many other issues. Pump station O&M costs (including electrical power costs) would also be considerably higher than gravity pipeline O&M costs.

MSA conducted preliminary site reconnaissance of four prospective pump station siting options along the Pudding River. Since all of the four sites appeared to be generally similar in nature (e.g., similar topography in relation to the distribution facility site, easy access with adequate space for construction, similar river bed and stream bank characteristics), the prospective pump station site, for the purpose of cost comparison, was chosen as the location where Nusom Road crosses over the Pudding River. Out of the four considered sites, this site is located closest to the target distribution system connection site.

Preliminary Cost Estimates -- Table 2 presents the preliminary capital cost estimates along with operations and maintenance (O&M) cost estimates for the Pudding River pumping alternative. Comparative present worth cost estimates, including annual O&M and power costs and future replacement costs, are also noted.

Table 2
Alternative 2, Pudding River Pump Station Option
Preliminary Comparative Cost Estimate

Description	Estimated Cost
Downs Road Pipeline (11,700 L.F. for 36" Pipeline @ $480/L.F.) [1]	$5.6 million
Pudding River Intake and Pump Station [2]	$6.0 million
Estimated Construction Cost	**$11.6 million**
Engineering, Permitting, Administration & Contingencies (45% of Construction Cost)	$5.2 million
Total Estimated Project Cost	**$16.8 million** (say $17 million)
Estimated Present Worth Value of Annual Pump Station Power Cost (Say $380,000 per year) over 100-year Design Life Period at 3.5% Inflation and 7.0% Gross Discount Rate [3]	$10.9 million
Estimated Present Worth Value of Annual Pump Station O&M Cost (Say $120,000 per year) over 100-year Design Life Period at 3.5% Inflation and 7.0% Gross Discount Rate [5]	$3.5 million
Estimated Present Worth Value of Pump Replacement Cost (Say $320,000 per pump) over 100-year Design Life Period at 3.5% Inflation and 7.0% Gross Discount Rate [4]	$0.6 million
Subtotal Estimated Pump Station Power and O&M Cost	**$15.0 million**
Total Estimated Comparative Cost (100-Year Design Life Basis) (Total Estimated Project Cost + Total Power and O&M Cost)	**$31.8 million**
Comparative Round-up	**$32 million**

1) Includes estimated easement acquisitions costs & access road construction costs
2) Includes estimated cost of pumps, pump station structure, and river intake facility
3) Assumes continuous pumping 3 months/year
4) Includes estimated installation costs & assumes pump replacement every 33 years
5) Includes annual pipeline O&M costs

Benefits and drawbacks of the Alternative 2 pumping based alternative (Pudding River) are outlined below.

Alternative 2 Benefits:

- The least expensive out of the three conveyance system alternatives.
- Involves the least disruption to private properties and the environment.
- Summer-time flow releases into Drift Creek and the Pudding River, may be viewed as an environmental benefit.

Alternative 2 Drawbacks:

- Water supply drawn from the Pudding River is generally expected to be of lesser water quality than is expected from direct withdrawal from the proposed Drift Creek Reservoir or from Drift Creek.
- Pump station O&M and power costs would be much higher than pipeline O&M off-setting initial first-cost savings.
- Natural dissipation (evaporation and infiltration) and potential unauthorized water usage, presents the opportunity for lost water.

Alternative 3: Creek Conveyance/Transmission Pipeline Hybrid Conveyance System

System Description -- This alternative involves the potential of using Drift Creek as a natural conveyance channel part way down the creek (approximately 4.7 miles downstream of the proposed Drift Creek Dam) and withdrawing summertime reservoir releases by means of a new pump station along Drift Creek. The stored water would then be transported via a 36-inch transmission pipeline the rest of the way to the District water distribution facility delivering the required flow of 50 cfs at a pressure of 150 psi. The prospective Drift Creek pump station location and the Cascade Highway/Highway 214 pipeline route is shown on *Figure 5.*

Key Considerations -- Regarding the pumping portion of Alternative 3, similar technical challenges would apply as for the pumping scenario in Alternative 2, such as providing a suitable backwater condition for the intake and considering various environmental and construction issues, e.g., fish screening, bank stability and permitting.

The pipeline portion of Alternative 3 still involves extensive pipeline routing and similar environmental and construction issues as for Alternative 1, such as creek crossings, land use interest, traffic impacts, business impacts and many other issues. However, Alternative 3 avoids the complex upper Drift Creek pipeline construction, and avoids much of the complicated and costly processes of acquiring private property easements along Drift Creek. With the prospective pump station located along the Cascade Highway, pipeline routing north to the District would be either in or along existing roadway right-of-ways.

MSA conducted preliminary site reconnaissance of a prospective pump station site along Drift Creek. This site, situated approximately 4.7 miles downstream from the proposed Drift Creek Dam site and approximately 5.5 miles south of the prospective distribution system connection site, is located where Cascade Highway NE crosses over Drift Creek, near the intersection with Finlay Road NE. This site was identified as a prospective pump station site since it appears to offer the required features for pump station construction, e.g., stable creek channel and bank, easy access with adequate space, available power source for pump station operation and the location along an existing roadway, which would allow for roadway pipeline routing.

Preliminary Cost Estimates -- Table 3 presents preliminary capital cost estimates, along with estimates of operations and maintenance (O&M) costs for the Drift Creek pumping

- Reduced pipeline length, with routing primarily along existing roadway right-of-ways, would reduce the complexity and cost of private property easement acquisition associated with Alternative 1.

Alternative 3 Drawbacks:

- Construction costs would be higher than the Pudding River pumping alternative due to lengthy pipeline construction.
- O&M costs would be the most expensive out of the three alternatives because of the pump station O&M costs combined with pipeline O&M.

Comparative Cost Analysis of Water Conveyance System Alternatives

Table 4 presents preliminary comparative cost estimates of the three key Drift Creek Project water conveyance system alternatives that were initially considered as primary candidates.

Table 4
Comparative Present Worth (PW) Cost Analysis
Conveyance Alternatives
(100-Year Design Life Period)
(Based on Initial Analysis Criteria)

Alternative Description	Project Costs (million $)	O&M Costs (million $)	Total (PW) Costs (million $)	Diversion Point
Alternative I: Gravity Transmission Pipeline System (Routing Option C – 48" Pipeline)	$52	$6	$58	Drift Creek Dam
Alternative II: Pudding River Pump Station System (36" Pipeline System)	$17	$15	$32	Pudding River
Alternative III: Drift Creek Pump Station System (36" Pipeline System)	$30	$15	$45	Drift Creek (~4.7 miles downstream of Drift Creek Dam)

On an initial project cost basis, the Pudding River Pump Station System (Alternative 2) estimated at $17 million, is clearly the lowest cost alternative of the three alternatives considered, with the Drift Creek Pump Station System alternative (Alternative 2), estimated at $30 million, being shown as the second lowest cost. On this same, initial cost comparative basis, the Gravity Transmission Pipeline System (Alternative 1) is by far the highest cost, estimated at $52 million. On a present worth basis, with long term electrical power and O&M costs being considered, Alternative 2, the Pudding River Pump Station System alternative still appears to be considerable lower cost than the Alternative 1, Gravity Transmission Pipeline System alternative ($32 million vs. $58 million), over an assumed 100 year service life. The Drift Creek Pump Station System, with an estimated present worth value of $45 million, has a cost midway between Alternative 1 and Alternative 2.

Summary, Conclusions and Preliminary Recommendations

This preliminary project planning assessment for the proposed Drift Creek Project was prepared to assist the East Valley Water District in establishing overall project direction. Comparative cost estimates for water transmission/conveyance alternatives indicate that a creek/river conveyance and downstream pumping station concept is of significantly lesser cost, both on an initial project cost basis and a present worth cost basis, than a gravity piped water transmission system, considering the present worth value of long term operations and maintenance costs, power costs and future replacement costs for major equipment. It is understood that the District considers a Pudding River Pumping Station system alternative (which this reporting establishes as the lowest apparent cost) to be least desirable from a water quality perspective. It is recommended that this matter be further reviewed by the District in light of apparent costs. In that estimated overall project costs for the least-apparent-cost alternative likely exceed originally anticipated budgets and available funding capabilities, it is expected that the District will pursue outside agency funding and financing assistance. This Technical Memorandum is intended to serve as basic reporting documentation in support of funding/financing discussions with outside agencies.

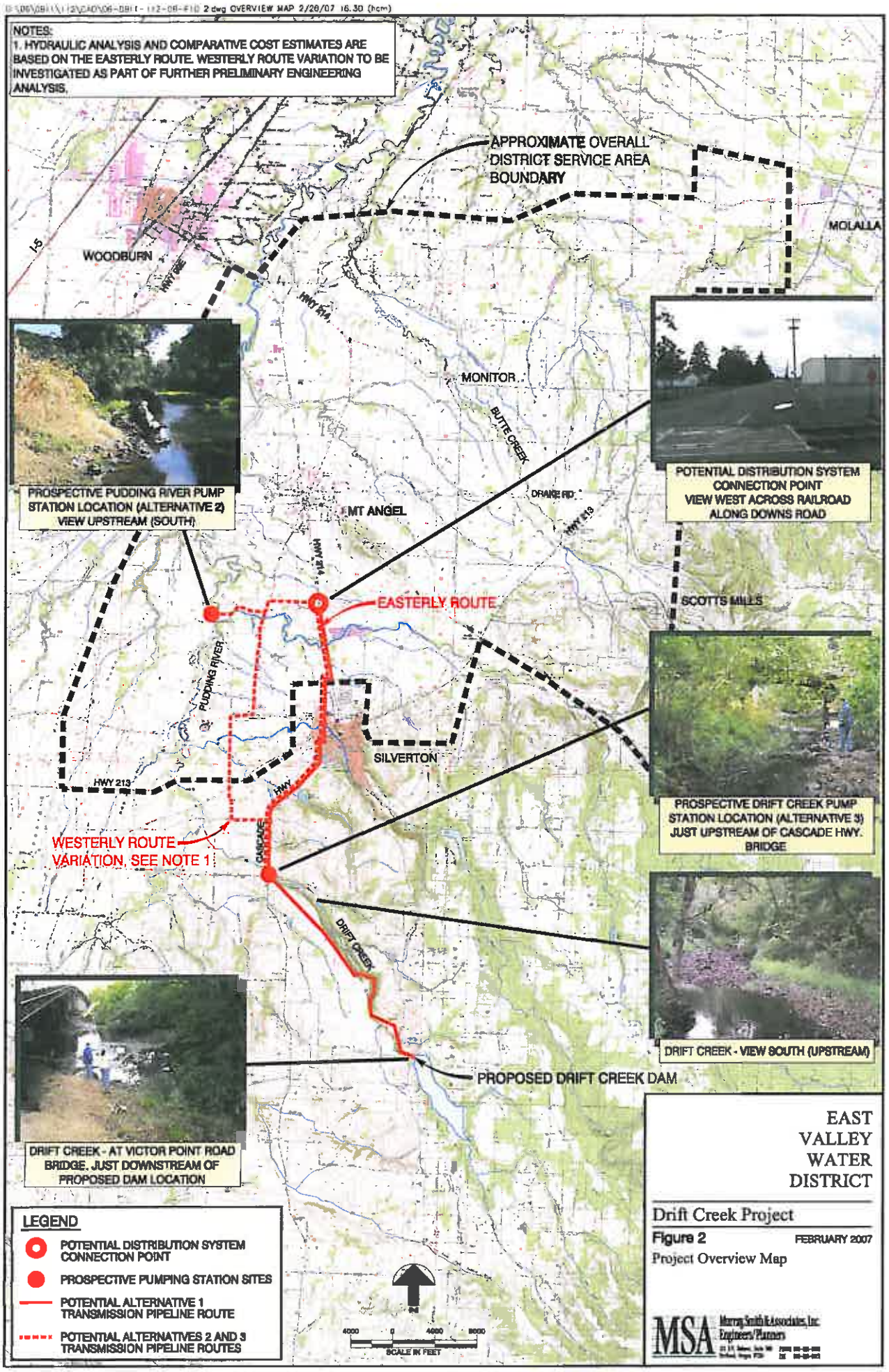
It should be noted that both the piping based and pumping based conveyance alternatives present unique technical and environmental challenges. From a comparative standpoint, it is not judged that the challenges associated with one, overshadow those associated with the other. In particular, hydraulic and geographic constraints dictate that the upper several miles of piping just downstream of the proposed Drift Creek Dam site, will require routing through a narrow creek bottom/canyon with very steep banks. Large diameter pipeline construction will be both technically challenging from a design and construction perspective, and will be disruptive from an environmental and private property perspective. On the other hand, siting, permitting, designing and constructing a large capacity intake and pumping station downstream in either Drift Creek or the Pudding River, will present equally important challenges. It is intended that this preliminary reporting be reviewed with the District's separately retained environmental consultant, and it is recommended that such reviews be undertaken as an important next step. Should such reviews have a bearing on assumptions and analysis presented here-in, it is recommended that this reporting be further updated to reflect such input.

It should also be noted that considerable planning work remains to be done toward the establishment of an irrigation distribution system. Preliminary discussions with District Board representatives indicate a wide range of alternatives that might be considered involving the use of new Drift Creek Project facilities and capacity in combination with existing individual groundwater and surface water rights. Various potential alternatives for distribution system configuration involving various combinations of potential water rights trades have been discussed. With project feasibility confirmed, it is recommended that further decisions on the distribution system be guided by subsequent irrigation distribution system master planning. Such planning should include detailed hydraulic analysis of various system configurations and pipeline layouts to confirm facilities siting, sizing and routing and

to confirm appropriate levels of service to various areas of the District. Preliminary distribution systems layouts shown in Figures 7 and 7.1 are included herein for general reference only.

As project feasibility may be confirmed and District preference for a particular water conveyance alternative may be established, the next step will be to proceed with more comprehensive preliminary engineering and environmental assessments. Such preliminary engineering will better define project concepts, costs, environmental impacts and required mitigation and will lay the essential groundwork then for final designs and permitting. Preliminary engineering will also develop recommendations for proposed project phasing and sequencing and will establish detailed needs for property/easement/right-of-way acquisition.

It is understood that others are addressing the water rights interests for the project. As further project programming is confirmed, it will be important that appropriate actions be taken to secure required water rights for the project.


NOTES:
1. HYDRAULIC ANALYSIS AND COMPARATIVE COST ESTIMATES ARE BASED ON THE EASTERLY ROUTE. WESTERLY ROUTE VARIATION TO BE INVESTIGATED AS PART OF FURTHER PRELIMINARY ENGINEERING ANALYSIS.
APPROXIMATE OVERALL DISTRICT SERVICE AREA BOUNDARY
MOLALLA
I-5
WOODBURN
HWY 99E
HWY 214
MONITOR
BUTTE CREEK
DRAKE RD.
HWY 213
MT ANGEL
HWY 214
PROSPECTIVE PUDDING RIVER PUMP STATION LOCATION (ALTERNATIVE 2) VIEW UPSTREAM (SOUTH)
POTENTIAL DISTRIBUTION SYSTEM CONNECTION POINT VIEW WEST ACROSS RAILROAD ALONG DOWNS ROAD
EASTERLY ROUTE
SCOTTS MILLS
PUDDING RIVER
SILVERTON
HWY 213
HWY
CASCADE
PROSPECTIVE DRIFT CREEK PUMP STATION LOCATION (ALTERNATIVE 3) JUST UPSTREAM OF CASCADE HWY. BRIDGE
WESTERLY ROUTE VARIATION, SEE NOTE 1
DRIFT CREEK
DRIFT CREEK - VIEW SOUTH (UPSTREAM)
PROPOSED DRIFT CREEK DAM
DRIFT CREEK - AT VICTOR POINT ROAD BRIDGE, JUST DOWNSTREAM OF PROPOSED DAM LOCATION
LEGEND
POTENTIAL DISTRIBUTION SYSTEM CONNECTION POINT
PROSPECTIVE PUMPING STATION SITES
POTENTIAL ALTERNATIVE 1 TRANSMISSION PIPELINE ROUTE
POTENTIAL ALTERNATIVES 2 AND 3 TRANSMISSION PIPELINE ROUTES
N
4000 0 4000 8000
SCALE IN FEET
EAST VALLEY WATER DISTRICT
Drift Creek Project
Figure 2
FEBRUARY 2007
Project Overview Map
MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

Alternative 2 Pudding River Pump Station Option Power Cost Calculation

Total Horsepower Input (Hp) for 50 cfs of flow & 150 psi of delivered pressure

$$\frac{\text{Flow (cfs)} * 62.4\,(lb/cf) * \text{Total Dynamic Head}\,(ft)}{550\,(ft\text{-}lb/s\text{-}Hp) * \text{Pump Efficiency}} = \underline{\sim 3{,}371\ \text{Hp}}$$

Flow = 50 cfs
Total Dynamic Head = Static Head + Friction Loss
= [Elevation Difference + 150 psi * 2.31(ft/psi)] + Head Loss in Pipe due to Friction
= 58 ft + 347 ft + 41 ft
= 446 ft
Pump Efficiency = 0.75

Total Annual Power Input (kW-hr)

$$\frac{\text{Total Hp Input}\,(Hp)}{1.341\,(Hp/kW)} * \text{Annual Operation Period}\,(days) * 24\,(hr/day) = \underline{\sim 5{,}429{,}272\ \text{kW-hr}}$$

Annual Operation Period = 90 days

Annual Power Cost ($/yr)

Total Annual Power Input (kW-hr) * Unit Power Cost ($\$/kW-hr$) = **~$380,000 / year**

Unit Power Cost = $\$0.07/kW-hr$

Present Worth Value of Pump Station Power Cost over the Design Life Period ($)

Annual Power Cost ($/yr) * Present Worth Factor for Equal Payment Series = **~$10.9 million**
(Say $11 million)

Present Worth Factor for Equal Payment Series (P/A, i, N) = 28.7613
where: P = Present Worth Value
A = Annual Power Cost = $380,000
i = Real Discount Rate

$$= \frac{\text{Gross Discount Rate (7\%) - Inflation Rate (3.5\%)}}{1 + \text{Inflation Rate (3.5\%)}}$$

= 3.4 %
N = Design Life Period, 100 Years

APPLICABLE EXCERPTS FROM:

"Technical Memorandum – DRIFT CREEK WATER SUPPLY PROJECT, PRELIMINARY TRANSMISSION PIPELINE ROUTING ANALYSIS, October, 2008, Murray Smith & Associates, Inc."

Technical Memorandum

DRIFT CREEK WATER SUPPLY PROJECT

PRELIMINARY TRANSMISSION PIPELINE ROUTING ANAYLSIS

East Valley Water District, Oregon

Murray, Smith & Associates, Inc.
Engineers/Planners

October 2008

pipe" as a consistent reference, based on recent and historical costing information available from similar local area projects. Such information has been used as the basis for this comparative cost analysis.

The "45 percent" allowance that is then added to basic construction costs to develop estimates of "project costs", as referenced herein, may be generally broken down as follows:

Construction Contingencies	25%
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For purposes of comparing alternatives, the actual value of these factors is not so critical, as long as they are applied consistently. However, acknowledging that this document will likely be used for broader project planning and decision making purposes, MSA has made every effort to develop estimates at a level that may be appropriate for District budgeting.

Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. Basic unit cost assumptions referenced herein were originally developed as part of MSA's previous 2007 reporting. Due to recent up and down trends in the construction industry, and to simplify comparisons with prior work, no inflationary adjustments have been made to prior unit cost estimates. This report's comparative estimates do, however, consider updated information of construction conditions and likely material and construction quantities. For future cost estimate updating purposes, the November 2006 ENR CCI of 8655.83 (basis of MSA 2007 reporting) for the Seattle area construction market (the nearest market ENR monitors) may be used as the base year reference.

Comparative Cost Analysis

Table 3 presents comparative cost estimates for each pipeline segment within each reach of the proposed alignments. For this comparative cost analysis, the relative cost of pipeline installation within differing construction constraints such as within the Drift Creek Valley floor versus within a rural public right-of-way or urban environment is considered. Additionally, alternatives to installation within the paved area of the roadway are evaluated. Based on recent field work, installation of the pipe in the shoulder of the road, alongside the pavement, but within the right-of-way may be possible in some areas. In other areas installation of the pipe outside of the right-of-way but within an easement purchased alongside the right-of-way may be possible. The length of each segment is factored in to arrive at a relative cost per alignment.

Alignment 1, of course, is the only available alternative within Reach 1 due to hydraulic constraints. Within Reach 2, Alignment 2B, which leaves the Drift Creek Valley floor and travels cross country, is less costly than Alignment 2A. Alignment 3B initially travels cross country on the northeast side of Drift Creek and then follows Finlay Road partly in the shoulder and partly in an easement adjacent to the right-of-way. Alignment 3B appears to be the least costly alignment within Reach 3 and offers easy access to the pipe for future inspection and maintenance as it lies near the roadway. Within Reach 4, a large portion of the pipe alignment may be located in the shoulder of the road adjacent to the pavement.

In terms of Reach 5, numerous project interests must be considered. Reach 5A is the longest, almost 32,000 linear feet. This rural route looks like a good route in terms of ease of construction but it adds pipe length that comes at an additional dollar cost to the project and a hydraulic performance cost in terms of available residual pressure head at the target connection point. These added "costs" may ultimately not be relevant, though, should the District consider at some point expanding service to the rural area along the route. A portion of Reach 5A is located along Brush Creek Road and requires passing through an apparent wetland area. Construction within a wetland can offer unique challenges in terms of permitting, construction and mitigation costs.

Reach 5B, although the shortest route at approximately 24,000 linear feet, is more challenging and likely more costly to construct as a large portion of the route runs through the developed downtown area. Review of City of Silverton's utility mapping established existing water, gravity sewer and storm water piping to be already located within the James Street right-of-way. The City reportedly intends to add a new pump station and force main in this same roadway corridor. This would further complicate construction of a large diameter District pipeline through this reach.

Alignment 5C.2 offers apparent cost savings over 5B as the alignment has been offset from the congested downtown core. However, a large portion remains within the urban environment and the route is somewhat longer than 5B, causing it to be slightly more costly.

The least costly alignment within Reach 5 appears to be Alignment 5C.1. This route is approximately 15 percent shorter than Route 5A and takes the pipeline cross country or along rural roadways, the least costly method of installation, for almost 75 percent of the pipe length. It should be noted that both alignments 5C.1 and 5C.2 route the pipe very near to the Silverton Wastewater Treatment Plant. An alignment near the treatment plant will require careful consideration during preliminary design to ensure that potential conflicts with existing gravity and pressure sewer lines are properly addressed.

As seen in Table 3, the result of this relative cost comparison would indicate the least costly overall alignment to be 1, 2B, 3B, 4, and 5C.1. Table 4 presents a total comparative project cost estimate applied to this configuration.

Table 4
Preliminary Comparative Cost Estimate for Conveyance System
Based on 42" Diameter Pipeline
Alignments 1, 2B, 3B, 4, 5C.1

	Alignment Description	Estimated Cost
1	Creek Route Pipeline Portion (10,060 L.F. @ $716/linear feet) [1]	$ 7.2 million
2B	Pipeline Cost for Cross-Country Route Portion (3,100 linear feet @ $416/linear feet) [2]	$ 1.3 million
3B	Pipeline Cost for Cross-Country Route Portion (5,700 linear feet @ $416/linear feet) [2]	$ 2.4 million
	Pipeline Cost for Roadway Route Portion (7,540 linear feet @ cost varies)	$ 2.9 million
4	Pipeline Cost for Roadway Route Portion (5,250 linear feet @ cost varies)	$ 1.9 million
5C.1	Pipeline Cost for Cross-Country Route Portion (10,700 linear feet @ $416/linear feet)	$ 4.5 million
	Pipeline cost for Roadway Route Portion (16,100 linear feet @ cost varies)	$ 7.0 million
	Additional Cost for Creek Crossings	$ .4 million
	Estimated Construction Cost	**$27.6 million**
	Engineering, Permitting, Administration & Contingencies (45% of Construction Cost)	$12.4 million
	Total Estimated Project Cost	**$40.0 million**

Notes: 1.) Includes estimated easement acquisition costs & access road construction costs.
2.) Includes estimated easement acquisition costs.

Summary and Conclusions

The water supply challenges facing the Silverton/Mt. Angel farming community have been known for many years. In 2007, the District, assisted by MSA, completed a preliminary engineering evaluation to assess alternative project configurations and assist the District in establishing overall project direction. This project, the District's DRIFT CREEK PROJECT, *Preliminary Transmission Pipeline Routing Analysis*, builds on this prior work and focuses on assessing and better defining potential pipeline routing alternatives. This Technical Memorandum presents a comparative analysis of various pipeline alignment options, considering both non-cost and cost related factors.

Figure 2 provides an overview of the various pipeline alignment alternatives that were considered and evaluated. A more detailed reach-by-reach view of various alternatives is shown in Figures 3.1 through 3.7. Through some reaches, multiple alignment alternatives are available. Through others, for either physical constraint reasons or practicability reasons, only one alignment option is considered. Where a given alignment is

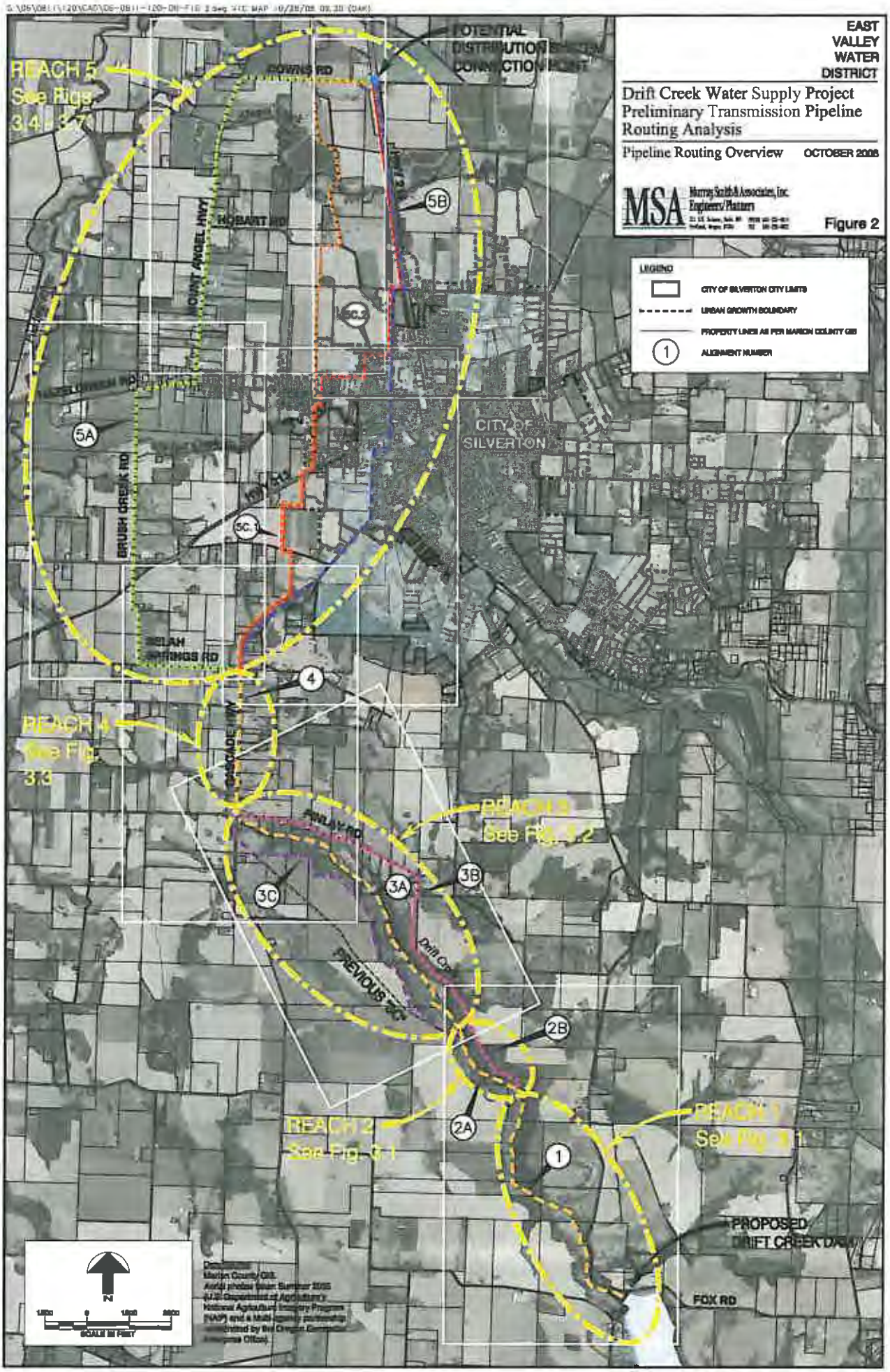
contemplated along an existing roadway, actual pipeline orientation along such alignments may ultimately be inside the existing roadway, inside the roadway right-of-way, along the road shoulder but outside the paved area, or immediately adjacent to the roadway right-of-way in a dedicated private property easement. These determinations will be made as part of more detailed preliminary design work. For this report's illustration purposes, all pipelines shown along public roadways are shown in the center of the right-of-way. Comparative cost estimates considered approximations of the extent of these various orientations within each reach.

While non-cost factors are useful to consider, it is likely that ultimate decisions will be made based on overall best value to the District. This overall value will likely mean the lowest cost alternative that meets all the fundamental performance requirements of the project. Based on this study's comparative assessments, it appears the highest value alignment is that alignment defined by the following reach-by-reach segments: 1, 2B, 3B, 4, and 5C.1. The total comparative project cost based on this configuration, totals $40 million and is presented in Table 4.

At the north end of the project, a westerly "rural" route was considered, along with an easterly "urban" route through the City of Silverton and two versions of a "suburban" route, between the two (2). The westerly "suburban" route that just skirts the westerly edge of Silverton, is the apparent lowest cost alternative through this reach and is thus, recognized as the likely preferred alternative. Should the District ultimately consider irrigation service to rural farm land westerly of Silverton, then the westerly "rural" route could offer attributes and benefits in terms of future customer access to the pipeline that have not been recognized by this study. Such benefits could possibly outweigh the added cost identified in this analysis for this alternative. This alignment alternative (Alternative 5A), ranked the highest within Reach 5, considering only non-cost factors.

It is recommended that the District review this study's assessments and findings. While this report identifies a likely preferred alternative, it is recommended that final alignment decisions be made as part of next step preliminary engineering. It is acknowledged that any of a number of factors could result in the ultimate pipeline alignment shifting somewhat from the "likely preferred alignment" shown and described herein. This report's evaluation matrix and comparative cost estimates have been presented in a form that may be easily updated in the future.

MSA is available to assist with further engineering evaluations and next-step preliminary designs, as future project decisions are made by the District.


EAST VALLEY WATER DISTRICT
Drift Creek Water Supply Project
Preliminary Transmission Pipeline Routing Analysis
Pipeline Routing Overview
OCTOBER 2008
MSA
Figure 2
LEGEND
CITY OF SILVERTON CITY LIMITS
URBAN GROWTH BOUNDARY
PROPERTY LINES AS PER MARION COUNTY GIS
ALIGNMENT NUMBER
REACH 5
See Figs. 3.4 & 3.7
POTENTIAL DISTRIBUTION SYSTEM CONNECTION POINT
DOWNS RD
HOBART RD
MOUNT ANGEL HWY
5B
5C
5A
5C.1
CITY OF SILVERTON
BRUSH CREEK RD
BELAH SPRINGS RD
4
REACH 4
See Fig. 3.3
CASCADE HWY
REACH 3
See Fig. 3.2
3A
3B
3C
Drift Cr.
PREVIOUS ROUTE
2B
2A
REACH 2
See Fig. 3.1
1
REACH 1
See Fig. 3.1
PROPOSED DRIFT CREEK DAM
FOX RD
N
SCALE IN FEET