Attachment 8

DRIFT CREEK SITE A, NEAR SILVERTON OR

RUNOFF YIELD ANALYSIS

(UPDATE #1)
May 2010

Proposed Drift Creek Reservoir Site

Report Prepared for

East Valley Irrigation District
Mount Angel, OR

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RUNOFF YIELD ANALYSIS FOR DRIFT CREEK SITE A NEAR SILVERTON, OREGON (ADDENDUM #1)

1. Introduction

A hydrologic yield analysis report was prepared in February 2007 to provide estimates of the October through April run-off volume that could be expected a potential project site located on Drift Creek, a tributary of the Pudding River. It contains a review of existing hydro-meteorological records at nearby streams, and development of synthesized mean monthly discharges with probability of occurrence. The report recommended actual discharge measurements at the proposed project site to enhance the reliability of the runoff volume estimates.

Following the subsequent stream flow gauging that took place in 2008 and 2009, this hydrologic addendum examines the significance of those new data on the runoff estimates covered in the February 2007 report. It also takes into account data provided by the Oregon Department of Water Resources (ODWR) on water availability data for the 50 and 80% exceedance levels and applicable irrigation and fisheries water rights.

Furthermore, to provide a general preliminary idea on how the project could be operated year-round, daily inflows to the proposed reservoir were developed for the dry year, average year, and wet year. A reservoir routing model was then set up to test how the runoff would be stored at the project and released downstream on a daily time step during those three years, subject to applicable inflow, storage availability, protected water rights during the off-season, and newly identified ecological flow triggers. The model's outputs could be refined as more data are available and later used to support the project's feasibility.

2. New Information of Relevance

The hydrologic update relies on the following new sets of information:

- Daily stream flow data collected by Marion Soil and Water Conservation District (Marion SWCD) and the U.S. Geological Survey (USGS) for Drift Creek (2 stations) and six nearby streams. Initial MSWC District data were received in early February 2010 with final numbers coming in late in April 2010. USGS data were readily available from the Internet;
- Latest mapping by Harvest Geographics, Inc. that yields a drainage area of 25.15 square mile drainage area for Drift Creek at its confluence with the Pudding River. This number is in line with the 24.8 square mile area adopted by Marion SWCD for the lower Drift Creek gauging site on Hibbard Road. Both numbers were used to support a request to OWDR to revise the 17.91 square mile number it previously used

for Drift Creek at its mouth. OWDR did agree to upgrade that drainage area from 17.91 square miles to 25.25 square mile area in early April 2010 (see Figure 1);

- Storage volume, surface area, and elevation data developed by Stuntzner Engineering, Inc. in January 2010 for the proposed project site near the intersection of Victor Point Road and Fox Road;
- Ecological and flushing flows recommended in their report, "Determination of Appropriate Channel Maintenance Flows", by Ellis Ecological Service in March 2010; and
- OWDR's revised Drift Creek flow availability data made available in April 2010.

The new information listed above will be described in more details in the following sections.

Figure 1. Drift Creek Watershed Boundary

3. Drift Creek's October 2008-September 2009 Stream Flows

Prior to 2008, Drift Creek was an ungauged stream with no known flow data. While annual or seasonal runoff volume could be roughly estimated from data recorded at nearby streams, it was difficult to predict how this stream's runoff hydrograph would look like. Actual stream flow measurements were then initiated for the first time at two sites on Drift Creek in 2008 by Marion SWCD.

The upper site, controlling a drainage area of 15.4 square miles, is located at Victor Point Road Crossing (near the intersection of Victor Point Road and Fox Road), Latitude 44 55 27 and Longitude 122 45 21. The lower site, with a drainage area of 24.8 square miles, is at the Hibbard Road bridge-crossing near the confluence of Drift Creek with Pudding River. The drainage areas at both sites were mapped by Marion SWCD.

Measured discharges at the project site finalized in early May 2010 are listed in Table 1.1 (daily flows) and Table 1.2 (monthly flows). Corresponding hydrographs are plotted on Figures 2.1 (daily flows) and 2.2 (monthly flows). The lower site's data are listed in Appendix.

Table 1.1 2008-09 Drift Creek Daily Discharge (in cfs) at Victor Point Road Bridge

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.5	0.7	17	275	22	91	60	22	11	3.0	0.23	0.16
2	0.5	0.7	19	500	21	92	81	39	10	2.7	0.23	0.17
3	1.0	1	20	267	21	86	80	39	9.8	2.3	0.23	0.19
4	5.0	6	19	181	20	74	72	40	10	2.0	0.22	0.19
5	4.0	5	19	173	19	77	64	70	13	2.0	0.23	0.49
6	3.8	3.3	17	159	23	71	56	98	12	1.8	0.25	0.90
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	0.40
9	4.0	3.5	17	163	22	60	44	89	9.3	1.7	0.42	0.29
10	3.0	4	16	132	22	58	45	75	8.8	1.8	0.34	0.30
11	2.8	5	15	115	25	54	38	65	8.7	1.8	0.30	0.29
12	2.6	22	17	96	24	50	35	59	8.4	2.0	0.39	0.27
13	2.5	130	26	84	25	46	44	53	7.9	3.0	0.50	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	0.30	0.73
16	2.0	40	17	57	23	92	35	46	6.8	1.6	0.29	3.70
17	1.6	34	17	50	23	84	35	40	6.5	1.2	0.26	1.70
18	1.8	28	28	44	22	73	33	36	6.2	0.92	0.20	0.83
19	1.3	23	25	39	21	66	30	37	6.2	0.78	0.18	0.43
20	1.0	24	24	35	20	60	27	33	6	0.73	0.17	0.32
21	1.0	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	0.20
25	0.6	21	50	27	126	61	21	21	4	0.4	0.13	0.19
26	0.6	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	0.6	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	------
TOTAL	56.6	684.7	1494	3158	1090	2043	1192	1412	217	42.0	7.3	14.7
MEAN	1.83	22.82	48.19	101.9	38.93	65.90	39.73	45.55	7.24	1.35	0.24	0.49
MAX	4	130	215	500	156	92	81	128	13	3	0.5	3.7
MIN	.5	0.7	17	23	19	46	20	11	3.1	0.20	0.13	0.15
AC-FT	11.2	1,360	6,090	6,110	2,160	4,050	2,360	2,800	432	83	14	29

*****Final Record******* 05/04/10 rmh

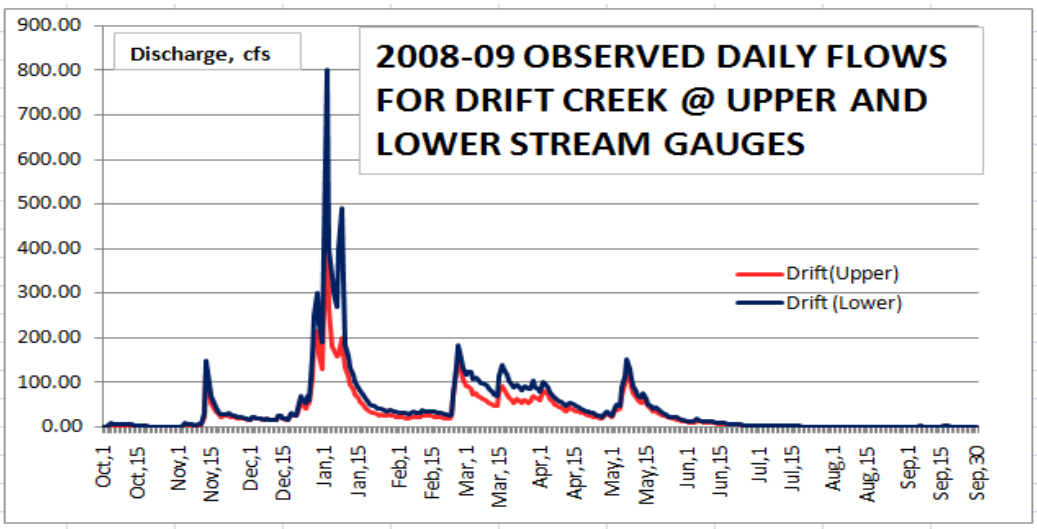

Figure 2.1 Daily Flow Hydrographs for Drift Creek Upper and Lower Stream Gauges

Table 1.2. 2008-09 Drift Creek Monthly Discharge (in cfs) at Victor Point Road Bridge

Station	OCT 08	NOV 08	DEC 08	JAN 09	FEB 09	MAR 09	APR 09	MAY 09	JUN 09	JUL 09	AUG 09	SEP 09
Drift/Victor	1.83	22.82	48.19	101.9	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49
Drift/Lower	3.1	27.4	60.8	170.0	50.4	98.7	50.1	54.5	9.0	1.8	0.6	0.9

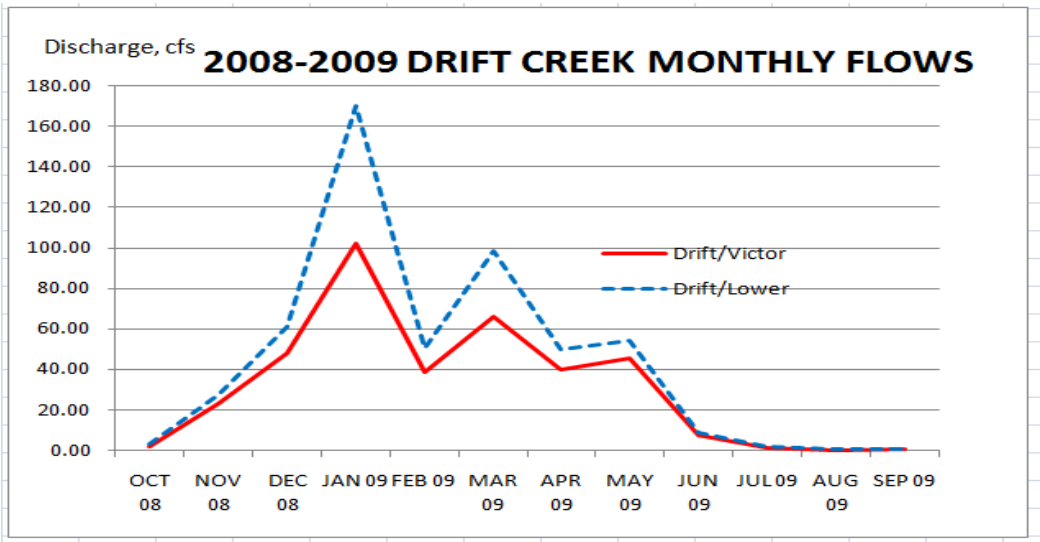

Figure 2.2 Monthly Flow Hydrographs for Drift Creek Upper and Lower Stream Gauges

As shown in Figures 2.1 and 2.2, the shapes of the hydrographs and the magnitude of the discharges for the two sites look very similar as expected. There is also a very good correlation between the daily flows at those sites. See Table 2 and Figures 3.1 (daily flows) and 3.2 (monthly flows).

Table 2. Statistical Correlation between 2008-09 Flows at Upper and Lower Drift Creek Sites

	Correlation Equations	Statistical Correlation Indicator R^2
Monthly Flows	Y=0.5701X^1.0681	0.9928
Daily Flows	Y=0.5838X^1.0644	0.9801

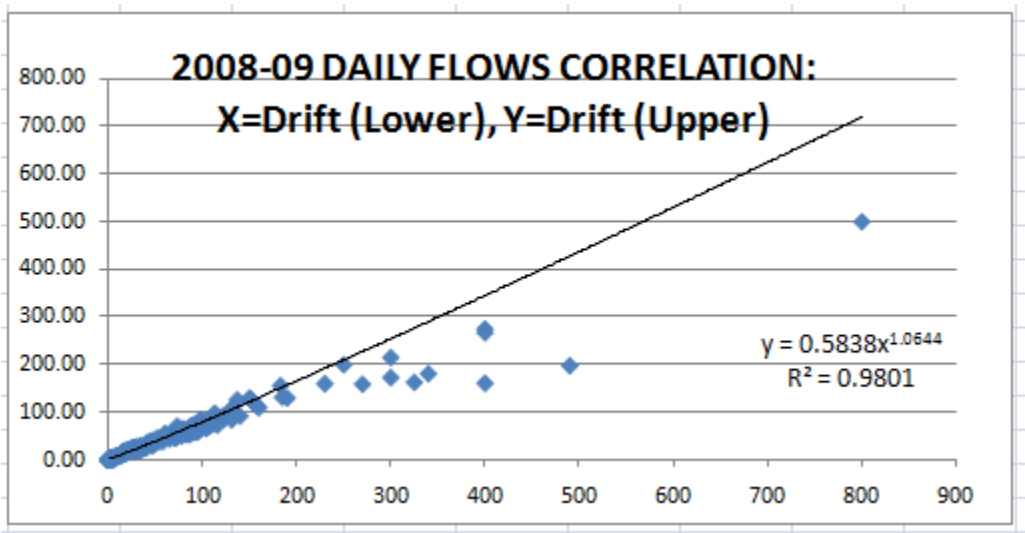

Figure 3.1 Correlation between Daily discharges at both Drift Creek Stream Gauges

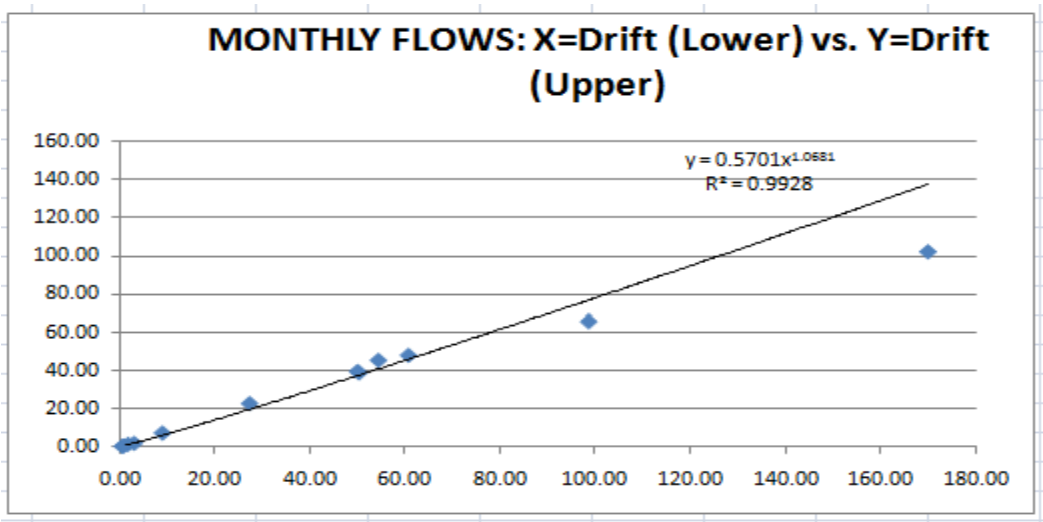

Figure 3.2 Correlation between Monthly Flows at Both Drift Creek Stream Gauges

There seems to be some a close relationship between Drift Creek runoff and rainfall recorded at the Salem Airport. Since most of the Drift Creek watershed lies below Elevation 2000 feet mean sea level, snow-melt runoff probably occurs only during high flow years. Monthly rainfall data recorded at Salem during 2008-09 are listed in Table 3

(along with monthly Drift Creek (Upper) flows), and plotted on Figure 4.

Table 3. 2008-09 Salem Airport Monthly Rainfall (“) and Upper Drift Cr. Runoff (cfs)

Month	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Salem Rain(inch)	0.96	3.59	6.02	3.56	2.9	3.03	1.35	3.03	1.39	0.68	0.18	1.2
Runoff Drift A	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	.24	.49

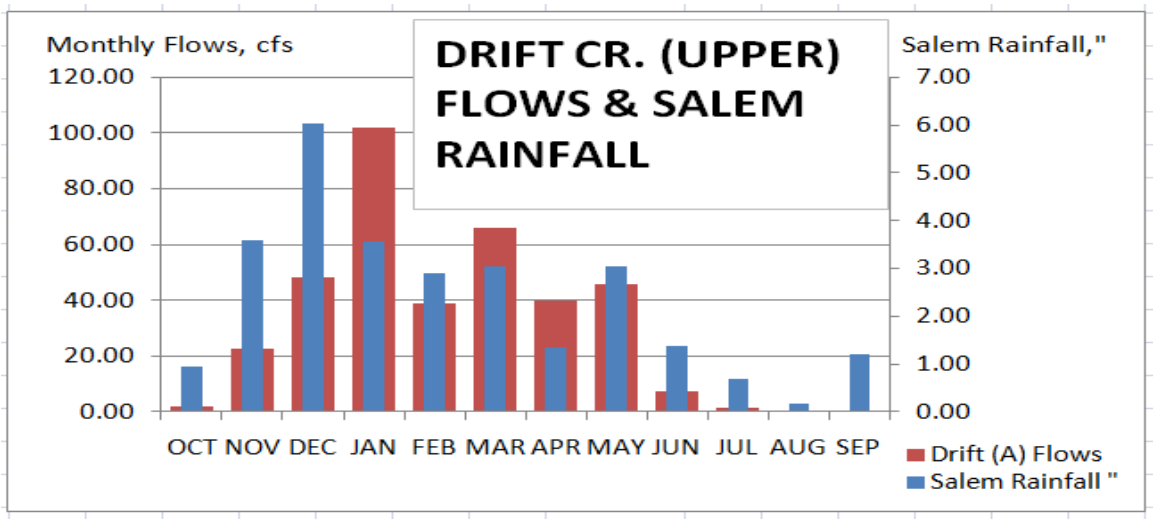

Figure 4. 2008-09 Monthly Salem Rainfall and Monthly Upper Drift Creek Flows

4. 2008-09 Flow Data at Nearby Streams

The 2008-09 daily flow data collected by the U.S. Geological Survey and Marion SWCD at nearby streams including Pudding River, Zollner Creek, and Silver Creek are listed in Table 4 in the more condensed form of monthly flows. Drift Creek data are reinserted back for easy reference.

Table 4. 2008-09 Observed Mean Monthly Discharges, in cfs

Streams= Gages=	Zollner Mt. Angel	Pudding Woodburn	Pudding Aurora	Drift Upper	Drift Lower	Silver Silverton
Drainage (DA)	15.0	314.0	479.0	15.8	24.8	47.9
DA Ratio	0.97	20.39	31.10	1.00	1.57	3.11
OCT08	0.9	74.2	132.6	1.83	3.1	25.7
NOV08	16.7	556.7	767.8	22.8	27.4	217.6
DEC08	122.7	821.8	1110.1	48.19	60.8	199.6
JAN09	362.0	2237.5	2977.0	101.87	170.0	413.5
FEB09	19.0	562.9	830.1	38.9	50.5	164.0

MAR09	27.6	1146.9	1810.3	65.9	98.7	345.0
APR09	8.6	727.0	1174.8	39.7	50.1	222.3
MAY09	9.8	710.0	1117.8	45.5	54.5	215.5
JUN09	1.1	148.2	247.3	7.3	9.0	43.1
JUL09	0.3	39.0	57.8	1.4	1.8	15.7
AUG09	0.3	15.6	21.6	0.2	0.6	8.6
SEP09	0.3	20.2	36.9	0.5	0.9	6.7
Oct-Sep Runoff	48.1	591.0	860.5	31.2	47.8	156.8
Runoff Ratio	1.36	16.67	24.27	1.00	1.53	4.20

Daily flow hydrographs for all the streams listed above are plotted in Figure 5 to highlight their fairly uniform shapes.

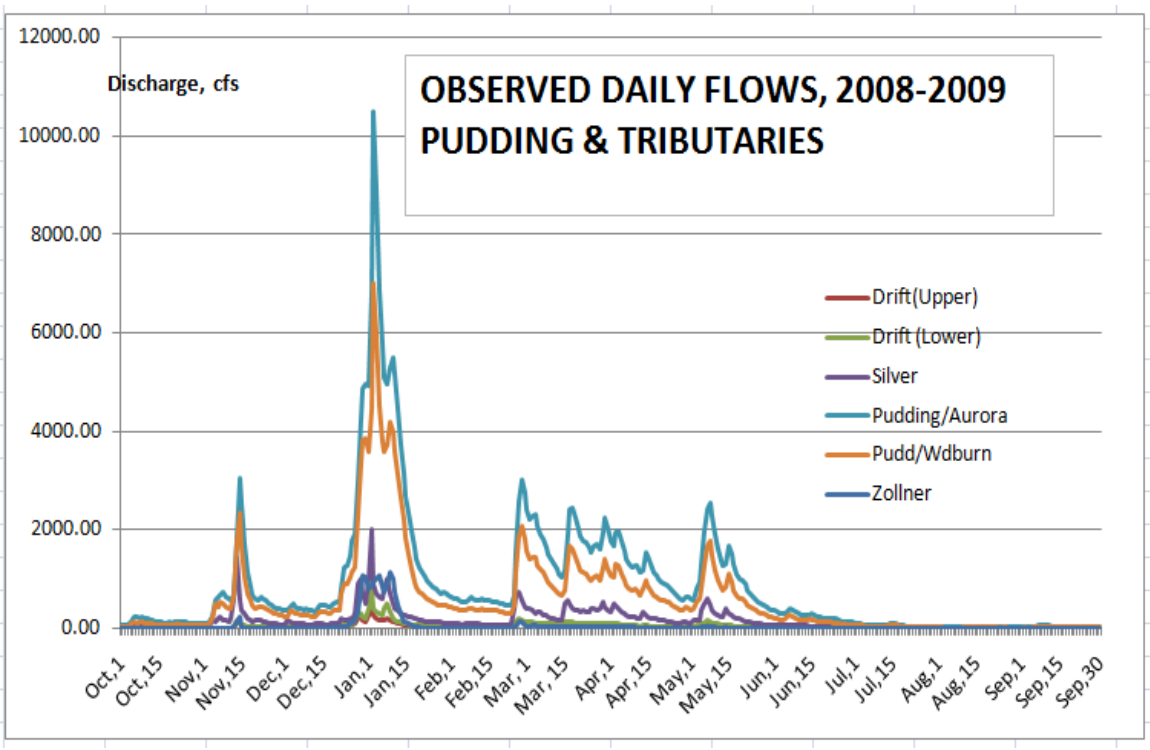

Figure 4. Hydrographs of Daily 2008-09 Discharges at Drift Creek and Nearby Streams

This generally close relationship, especially in terms of runoff peaking, is further reflected in the numerical values of the statistical correlation indicators R^2 computed for the 2008-2009 discharges, both daily and monthly. Many of the R^2 values are close to 1, which is a sign of high correlation between the numbers involved. Regression equations and R^2 values are listed in Table 5.1 (Daily Flows) and 5.2 (Monthly Flows). Data scatter plots for each stream gauging site are shown in Figures 5.1 through 5.4, and Figure 6.1 through 6.4.

Table 5.1 2008-09 **Daily** Discharge Correlation

Stream and Location, X	Regression Equation (power series)	Correlation Indicator R^2	Comments
Silver nr. Silverton	Y=0.0357 X^1.3006	0.8929	
L. Abiqua nr. Scotts Mills			No 08-09 data
Zollner nr. Mt. Angel	Y=2.8684X^0.8737	0.7473	
Pudding nr. Mt. Angel			No 08-09 data
Pudding nr. Woodburn	Y=0.0095X^1.2654	0.9183	
Pudding nr. Aurora	Y=0.0052X^1.2631	0.9316	

Figures 5.1 through 5.4 provide a graphic representation of the daily discharge correlation.

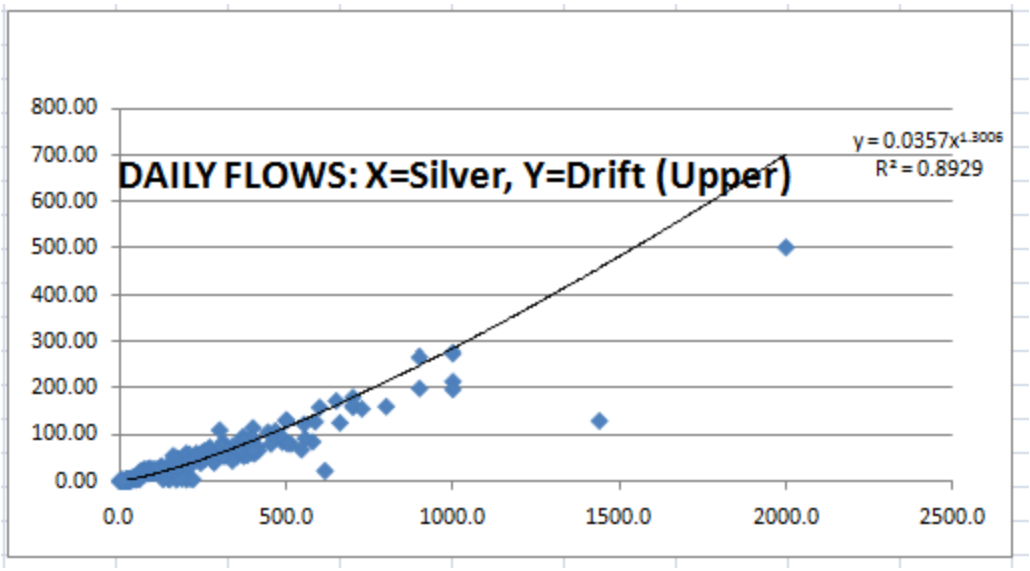

Figure 5.1. X=Silver Creek

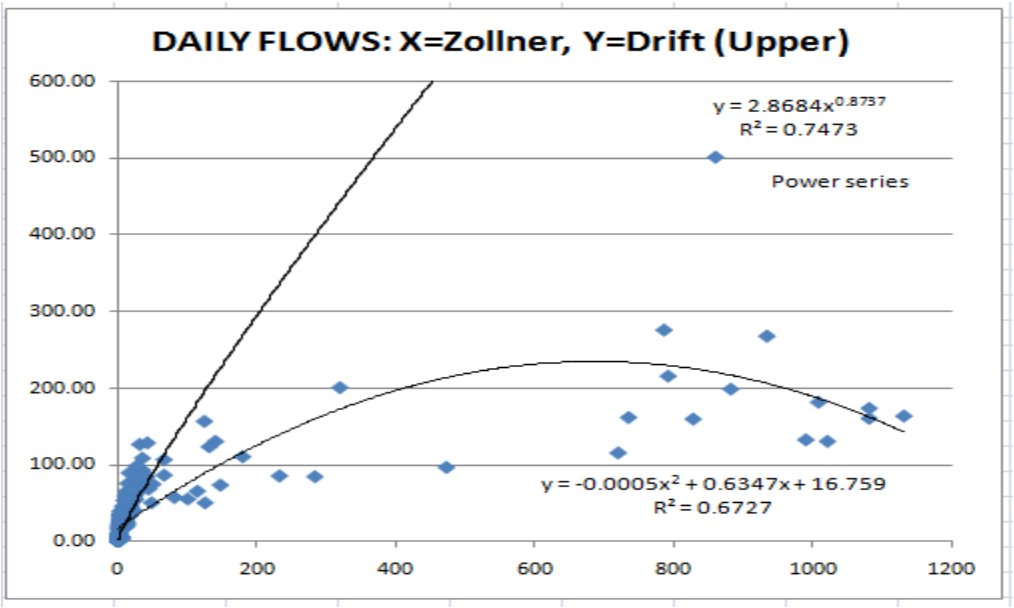

Figure 5.2 X=Zollner Creek

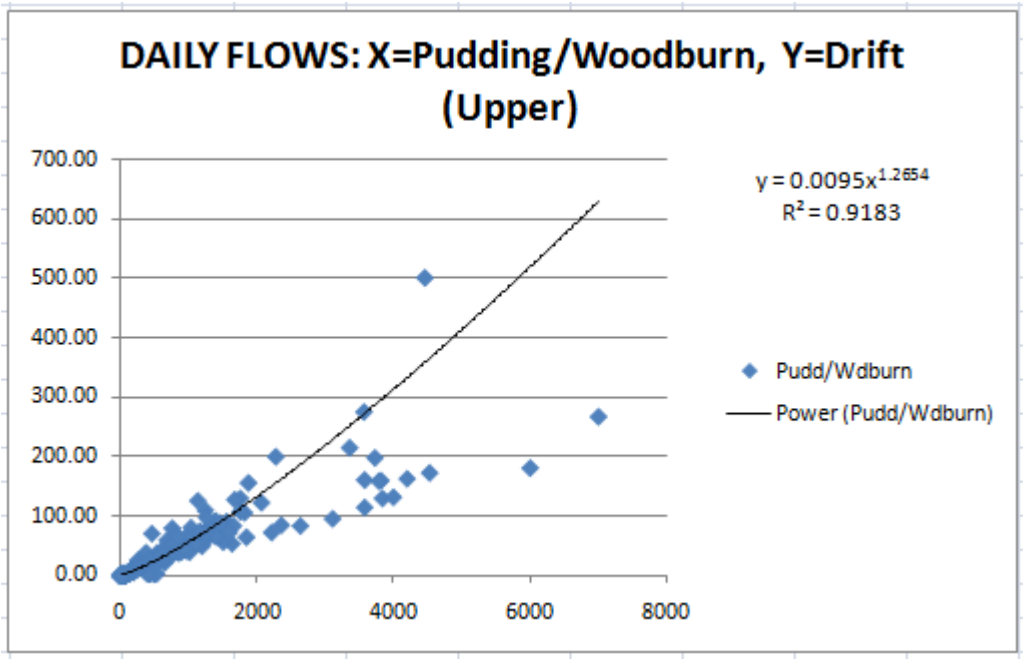

Figure 5.3 X=Pudding near Woodburn

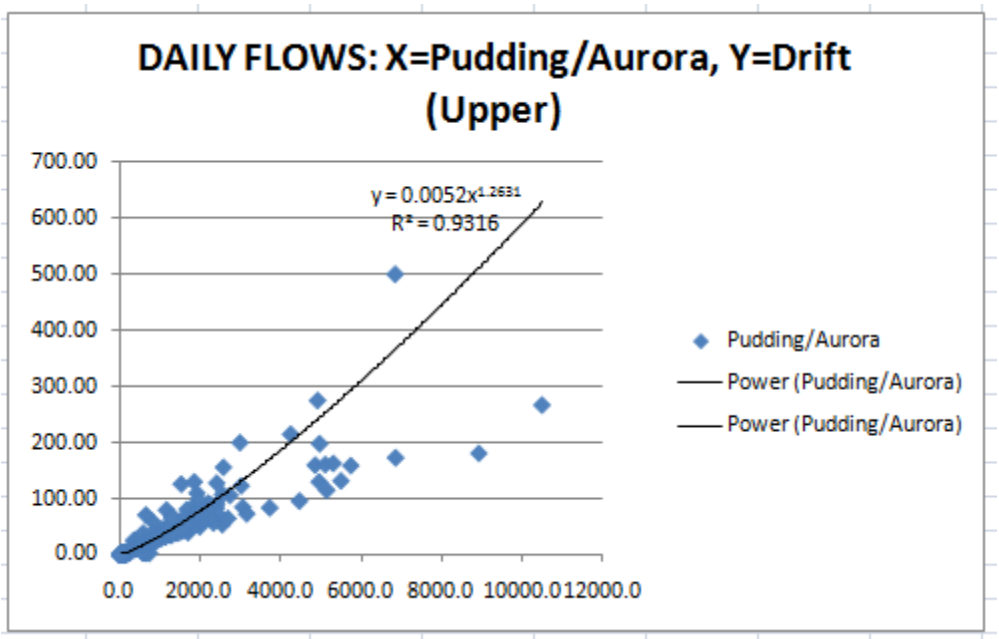

Figure 5.4 X=Pudding near Aurora

Table 5.2 2008-09 **Monthly** Discharge Correlation

Stream and Location, X	Regression Equation (power series)	Correlation Indicator R^2	Comments
Silver nr. Silverton	Y=0.025 X^1.3775	0.9681	
L. Abiqua nr. Scotts Mills			No 08-09 data
Zollner nr. Mt. Angel	Y=2.711X^0.8157	0.8558	
Pudding nr. Mt. Angel			No 08-09 data
Pudding nr. Woodburn	Y=0.0114X^1.2331	0.9855	
Pudding nr. Aurora	Y=0.0063X^1.26	0.9734	

Figures 6.1 through 6.4 provide a graphic representation of the monthly discharge correlation.

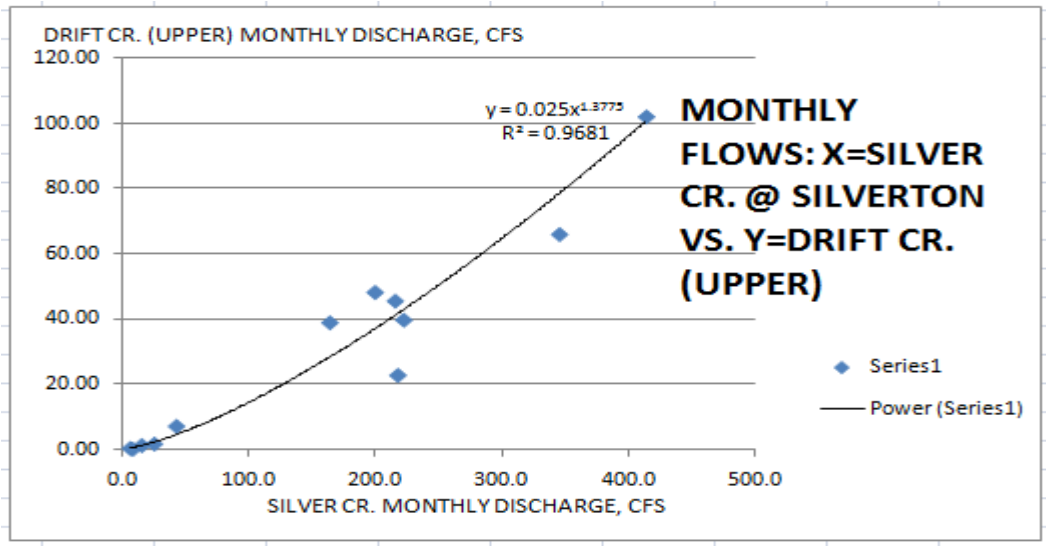

Figure 6.1 X= Silver Cr.

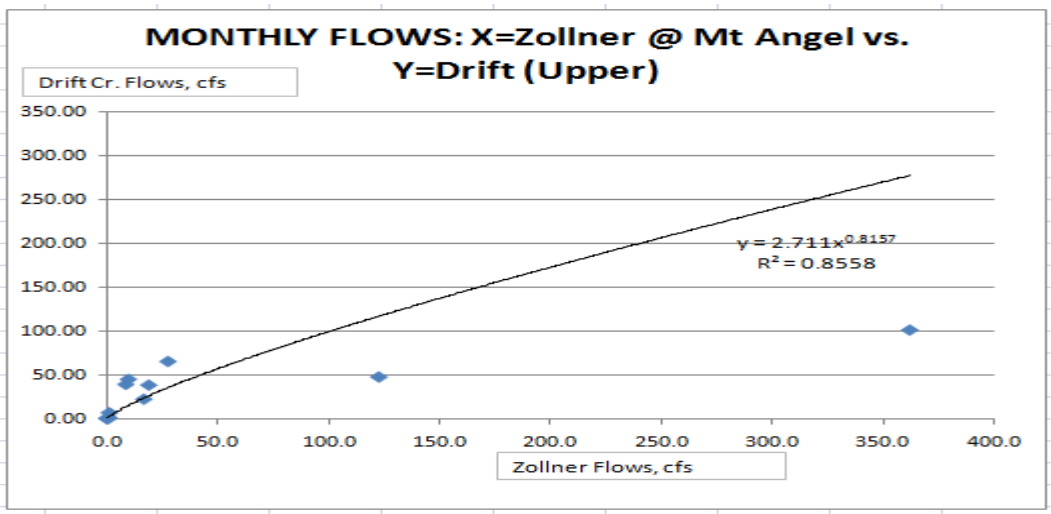

Figure 6.2 X=Zollner Cr.

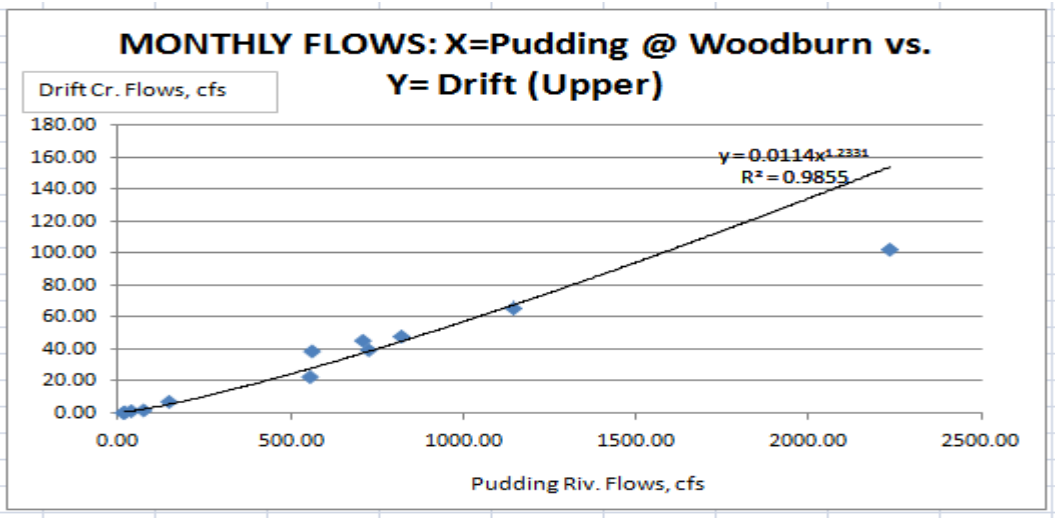

Figure 6.3 X= Pudding River near Woodburn

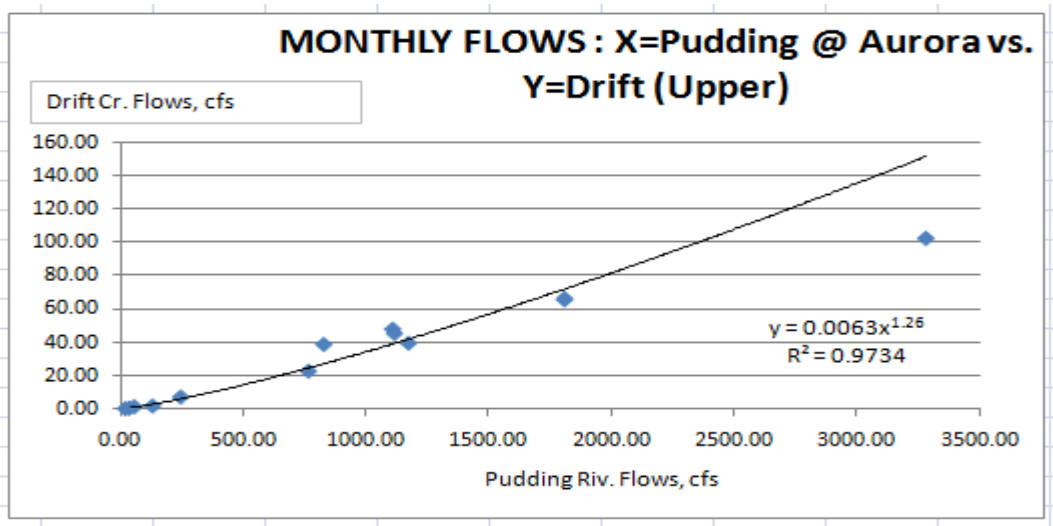

Figure 6.4 X=Pudding River near Aurora

5. Practical Observations Based on 2008-09 Data

Based on the R^2 statistical indicators listed in Tables 5.1 and 5.2, the ranking of the gauging sites that could be used to generate more flow data for Drift Creek is as follows:

- Pudding River near Woodburn
- Pudding River near Aurora
- Silver Creek near Silverton
- Zollner Creek near Mt. Angel

Of the two Pudding River sites, the one near Aurora has by far the longer period of records of the two sites: 49 years of actual flows and 28 years of additional reconstituted flows between 1963 and 1993. Considering that their R^2 values are not that much

different, the data Aurora site is more advantageous to use because they cover a longer period of records and, hence, reflect a wider range of run-off conditions.

Table 6 contains the 2008-09 and 1928-2008 mean monthly discharges of the Pudding River near Aurora. It shows that the October 2008 - September 2009 average annual discharge of 860 cfs (622,842 acre-feet) is definitely lower than the October 1928 – September 2008 average annual discharge of 1237 cfs.

Table 6. Pudding River at Aurora Mean Monthly Discharges (cfs)

Years	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	An-nual
2008-2009	133	768	1110	2977	830	1810	1175	1118	247	58	22	37	860
1928-2008	324	1410	2480	2840	2680	2070	1530	868	426	145	67	92	1237

Review of the 2008-09 stream flow data leads to the following observations:

(1) The shape of the hydrographs of all four streams is generally very similar.
(2) The statistical indicators R^2 for the correlation between Drift Creek both daily and monthly discharges and the corresponding discharges of the other three streams are fairly high –all above 0.7473. The highest R^2 applies to the correlation between Drift Creek discharges and Pudding River discharges.
(3) The year was a dry year for Drift Creek and Pudding River, but appears to be an average year for Silver Creek. This is reflected in the lower-than-expected R^2 value for Silver Creek. See Figure 7.1.
(4) Runoff for Zollner Creek is mostly concentrated on January, a pattern not observed for any of the other three streams. See Figure 7.2.
(5) Runoff for all four streams was primarily driven by rainfall.
(6) Rainfall recorded at the Salem Airport reasonably matches the shape of the hydrographs, especially the timing of the peak discharges.
(7) As expected for a dry year, there were no detectable snowmelt impacts. This is to be expected, as most of Drift Creek watershed lies below elevation 2000 feet.

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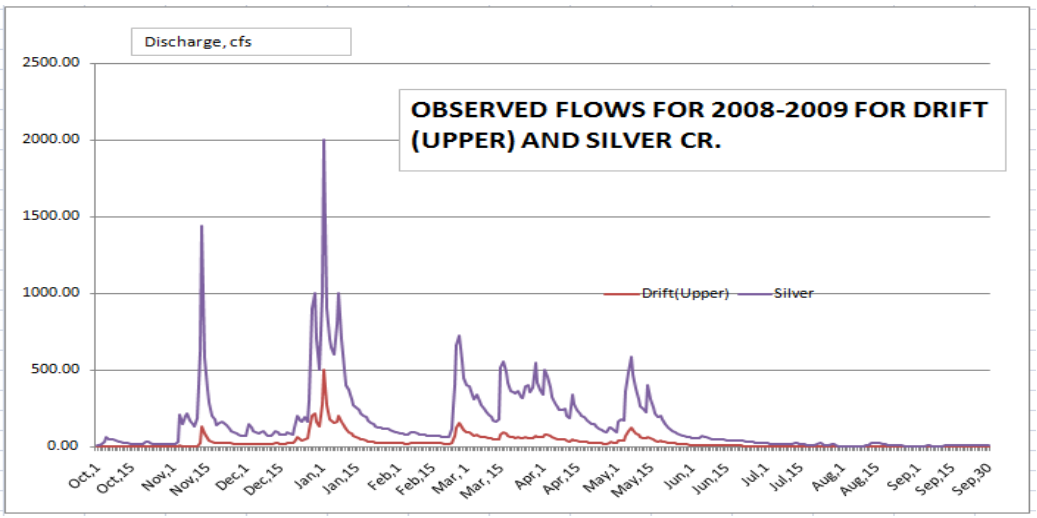


Figure 7.1 2008-09 Daily Discharge Hydrographs for Silver Cr. and Drift Cr. (Upper)

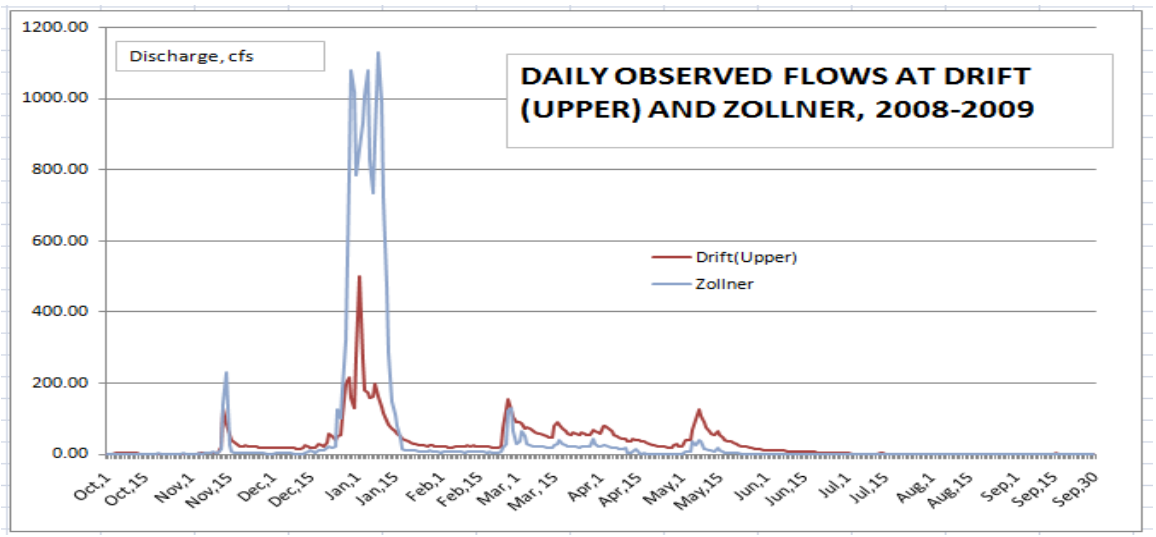


Figure 7.2 2008-09 Daily Discharge Hydrographs for Zollner Cr. and Drift Cr. (Upper)

The 2008-09 stream flow data move Drift Creek from the list of ungauged watersheds and provide for the first time a real picture of how the runoff is shaped during the year, including how the timing of its peak discharge is related to the peak rainfall recorded at Salem. However, these measurements only reflect one of the many possible runoff conditions that can take place in the basin. Therefore, since 2008-09 was a dry year, any practical conclusions reached so far would be more applicable to years with similarly dry rainfall-runoff conditions than years with heavier precipitations and snowfall.

An important number to note is the October-April runoff volume. In 2008-09, that volume was 19,271 acre-feet for Drift Creek at the project site and 532,336 acre-feet for Pudding River near Aurora, a volume ratio of 19,271/532,336=0.0362. By comparison,

the drainage area ratio for those sites is [15.4 sq. mi. /479 sq. mi.]= 0.03215, which reflects greater precipitation over Drift Creek. The 19,000-20,000 acre-foot runoff volume range is probably what can be expected at the project site in the future during low flow years.

6. Building Stream Flow Reconstitution Capability

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, was absent. The 2008-09 stream flow measurements now provide at least one full hydrologic year 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 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.

A. Monthly Flows Reconstitution

The two procedures used to reconstitute the 2008-09 monthly stream flows at the project site include the following:

(1) Multiply the monthly Pudding River flows near Aurora by a factor of 0.036, which is the ratio of the 22,630 acre-feet annual runoff for Drift Creek at the project site divided by the 622,842 acre-feet annual runoff for Pudding River at Aurora. (Note that the reverse of 0.036 is 622,842/22,630=27.52).
(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.

Table 7 summarizes the results of the two procedures when applied to 2008-09 monthly flows. The results of a third procedure involving daily rainfall-runoff model application to be described later in the report are also attached in the table for reference purposes.

Table 7. Reconstitution of 2008-2009 Drift Creek Monthly Flows

Method	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Vol (aft)
Rev.1(w/27.52)	4.8	27.9	40.3	108.2	30.2	65.8	42.7	40.6	9.0	2.1	0.8	1.3	22,630
Rev2(Regress	3.0	27.2	43.3	150.1	30.0	80.2	46.5	43.7	6.5	1.0	0.3	0.6	26,244
Model Calc	2.5	20.6	53.0	103.3	39.4	75.1	25.4	38.3	10.6	3.0	0.7	4.7	22,867
Observed	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49	22,630

Figure 8 shows the monthly flow hydrographs generated by the two procedures for 2008-09, along with the observed 2008-09 monthly flow hydrograph.

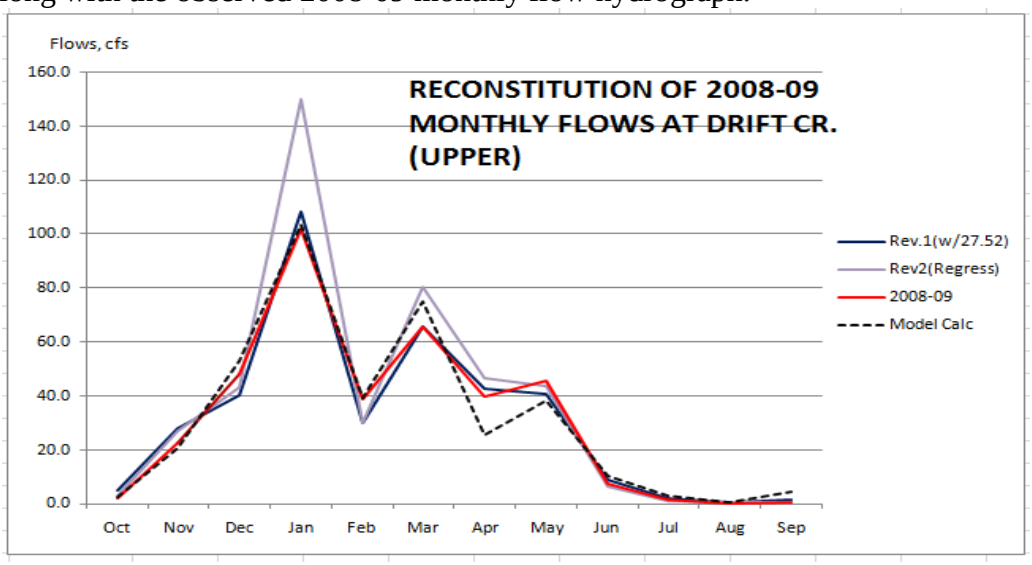


Figure 8. Reconstituted 2008-09 Monthly Hydrographs for Drift Creek (Upper)

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 2008-09 daily flows recorded at Pudding River near Aurora: Y=0.005X^1.2782. The results, after conversion from daily into monthly averages, are shown in Table 8. The hydrographs for the 2008-09 observed flows, along with the regression-based hydrograph, are shown in Figure 9.

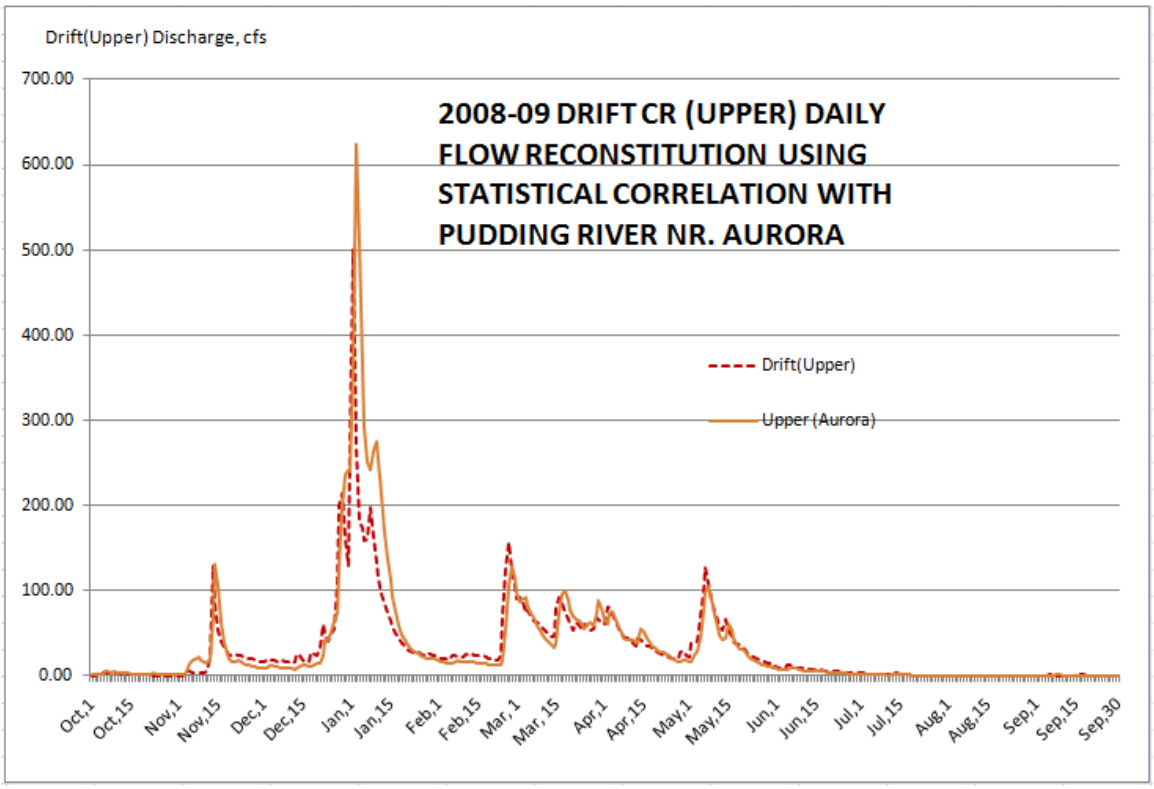


Figure 9. Reconstituted 2008-09 Daily Flow Hydrograph Using Regression Equation

Table 9. Regression-based Reconstitution of 2008-09 Drift Creek (Upper) Daily Flows

Station	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 AF
Drift/Victor	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49	22,630
Recon.	2.54	25.22	42.97	158.47	27.57	68.30	40.03	38.60	5.57	0.90	0.26	0.51	24,957

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. The main model 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.

The observed and SSARR model-reconstituted daily flow hydrographs, using precipitation data at Salem, are shown in Figure 10. The previous hydrograph generated by a regression equation using data for Pudding River near Aurora is also shown for comparison purposes. Table 10 provides the summary results in terms of monthly flow values.

Table 10. Model-based Reconstitution of 2008-09 Drift Creek (Upper) Daily Flows

Station	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 AF
Drift/Victor	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49	22,630
Model	3.13	21.73	83.74	73.00	54.89	63.16	24.27	34.61	9.67	2.90	0.71	7.27	22,852

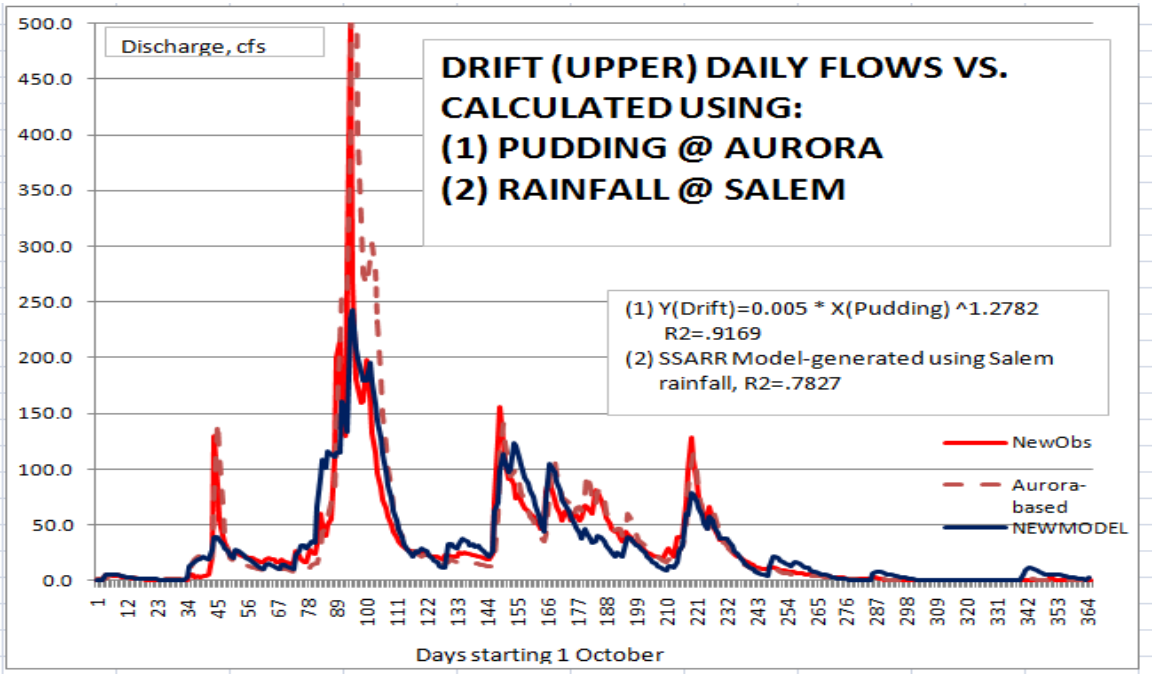


Figure 10. 2008-09 Daily Flows Reconstitution

The relationship between the 2008-09 observed and model-generated daily discharges for Drift Creek at the project site is illustrated in Figure 11. The R^2 value of 0.84 could be misleading because it refers to a polynomial regression equation (as opposed to a power series equation used for Pudding River), due to the presence of too many zero flow values.

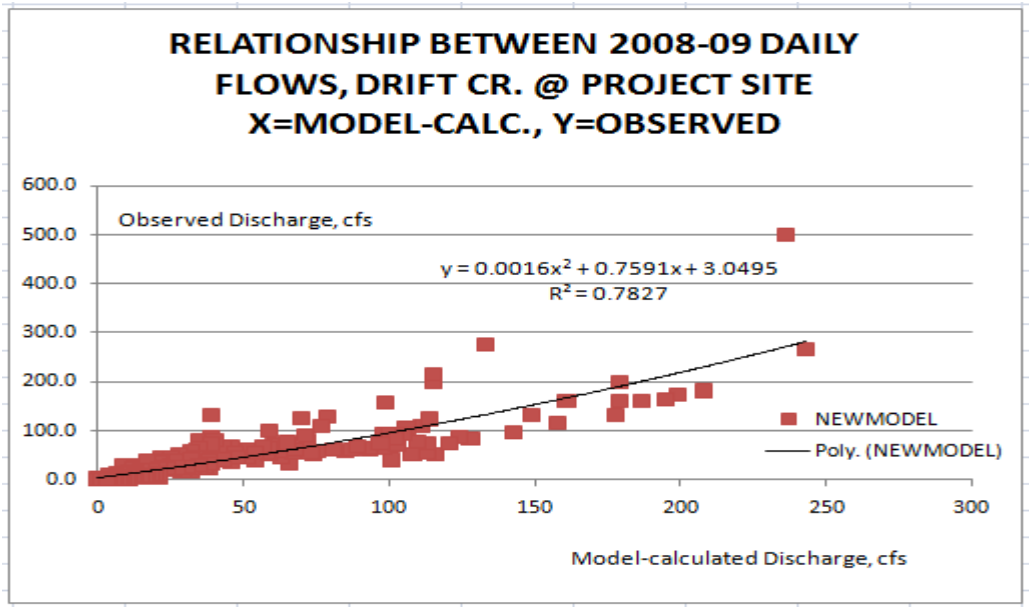


Figure 11. 2008-09 Observed vs. Model-Calculated Daily Flows

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 accommodate other runoff conditions. 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. Therefore, any wet year data extrapolation based on 2008-09 alone will have to be treated with caution.

7. Identifying Representative Low, Average and High Runoff 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.

Table 11 shows the observed annual (October-September) runoff volumes of the Pudding River at Aurora ranked from highest to lowest for the 47 years between 1928 and 2009. See also Figure 12.

Table 11. 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			25	847,532	2002-03	
2	1,447,386	1995-96			26	839,022	1934-35	
3	1,437,398	1955-56			27	835,282	1963-64	
4	1,304,908	1950-51			28	806,562	1946-47	
5	1,254,722	1942043			29	802,527	1954-55	
6	1,190,121	1937-38			30	799,099	1959-60	
7	1,159,557	1960-61			31	789,243	1961-62	
8	1,127,442	1953-54			32	788,919	2003-04	
9	1,115,792	1949-50	hi		33	743,883	1936-37	lo
10	1,095,130	1947-48			34	734,391	1941-42	
11	1,069,919	2005-06			35	721,816	1956-57	
12	1,020,183	1932-33			36	711,335	1939-40	
13	1,007,579	1948-49			37	695,169	1944-45	
14	985,724	1931-32			38	687,904	1935-36	
15	974,484	1994-95			39	622,842	**2008-09**	
16	959,376	1952-53			40	596,992	1929-30	
17	959,325	1945-46			41	586,594	1938-39	
18	956,901	1951-52			42	559,244	1930-31	
19	956,679	2006-07			43	554,344	1928-29	
20	955,863	2007-08			44	525,012	1993-94	
21	952,064	1962-63			45	513,563	1943-44	
22	946,422	1958-59			46	502,791	1940-41	
23	916,004	1957-58	av		47	500,823	2004-05	
24	867,553	1933-34			Ave.=1-47	891,487		

The mean annual (October-September) runoff volume for those 47 years is 891,487 acre-feet (aft). Mean average corresponds to the 50% exceedance level. The 891,487 aft number is about the same as the runoff volume recorded for the year ranked 23th out of 47 (50% of the 47 years of records): 1957-58 water year

The annual (October-September) runoff volume that is exceeded 80% of the 47 years (about 38 years) corresponds to the volume ranked 38th, which is about 687,904 acre-feet and occurred in 1935-36.

The annual (October-September) runoff volume that is exceeded 20% of the time (rank 9th out of 47) corresponds to 1,115,792 acre-feet and occurred in 1949-50.

Therefore, water years 1957-58, 1935-36 and 1949-50 can be used as average, low, and high water years respectively for Pudding River at Aurora. Based on the 2008-09 stream

flow measurements, those same years will also be treated as average, low, and high water years respectively for Drift Creek at the project site as well.

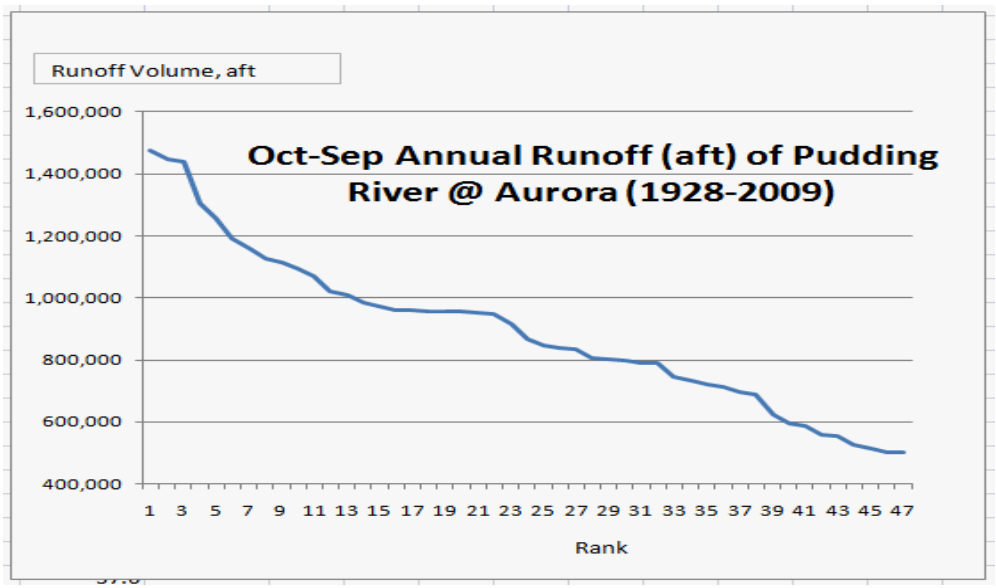


Figure 12. Ranking of Annual Runoff Volume of Pudding Riv. @ Aurora, 1928-2009

In 2008-09, the annual runoff volume was 22,630 acre-feet for Drift Creek at the project site and 622,842 acre-feet for Pudding River at Aurora -- a runoff volume ratio of 22,630/622,842=0.0363. This ratio will be used to produce the estimated annual runoff volumes for the average, low, and high flow years as shown in Table 12.

Table 12. Projected Drift Cr. (Upper) Annual October-September Runoff Volume Using Straight Multiplier

Flow Years	Representative Hydrologic Years	Observed Oct-Sep. Runoff Vol. (aft), Pudding @ Aurora	Multi-plier	Projected Oct-Sep. Runoff Vol. (aft), Drift Cr. @ Victor Point Rd.
High	1949-50	1,115,792	0.0363	40,540
Average	1957-58	916,004	0.0363	33,281
Low	1935-36	687,904	0.0363	24,994

Likewise, in 2008-09, the annual October-April runoff volume at the project site was 19,271 acre-feet for Drift Creek at the project site and 532,336 acre-feet for Pudding River at Aurora -- a runoff volume ratio of 19,271/532,336=0.0362. This ratio will be used to produce the estimated **October-April** runoff volume for the average, low, and high flow years as shown in Table 13.

Table 13. Projected Drift Cr. (Upper) **October-April** Runoff Volume

Flow Years	Representative Hydrologic Years	Observed Oct-Apr. Runoff Vol. (aft), Pudding @ Aurora	Multiplier	Projected Oct-Apr. Runoff Vol. (aft), Drift Cr. @ Victor Point Rd.
High	1949-50	1,008,572	0.0362	36,512
Average	1957-58	851,445	0.0362	30,823
Low	1935-36	585,279	0.0362	21,188

Note: the average October-April runoff volume predicted in February 2007 (Table 5) was 31,800 acre-feet, which is relatively close to the 30,823 acre-feet shown above for the average flow year.

8. Estimated Flow Hydrographs for Representative Flow Years

Table 14 contains projected monthly flows for the three representative years based on Pudding River stream flows. The monthly shape of the runoff for those years is illustrated in Figure 13.

Table 14. Projected Representative Monthly Flows for Drift Creek (Upper Site) Using Straight Multiplier

Hydro Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
PUDDING/Aurora													Vol (aft)
High(1949-50)	245.0	699.7	2004.0	4735.0	4263.0	3310.0	1638.0	990.8	471.5	143.4	78.7	77.5	1,115,792
Ave(1957-58)	153.1	404.8	2959.0	2982.0	4384.0	1459.0	2011.0	567.4	305.5	95.2	33.9	60.0	916,004
Low(1935-36)	135.9	318.7	668.3	4352.0	1773.0	1428.0	1002.0	858.9	489.3	191.2	68.5	79.9	687,904
2008-09	132.6	767.8	1110.1	2977.0	830.1	1810.3	1174.8	1117.8	247.3	57.8	21.6	36.9	622,842
Runoff Ratio	0.0363	27.5228											
Hydro Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
DRIFT/Upper													Vol (aft)
High(1949-50)	8.9	25.4	72.8	172.0	154.9	120.3	59.5	36.0	17.1	5.2	2.9	2.8	40,541
Ave(1957-58)	5.6	14.7	107.5	108.3	159.3	53.0	73.1	20.6	11.1	3.5	1.2	2.2	33,282
Low(1935-36)	4.9	11.6	24.3	158.1	64.4	51.9	36.4	31.2	17.8	6.9	2.5	2.9	24,994
2008-09	1.83	22.82	48.19	101.87	38.93	65.90	39.73	45.55	7.25	1.35	0.24	0.49	22,630
Monthly Ratio	72.6	33.6	23.0	29.2	21.3	27.5	29.6	24.5	34.1	42.7	91.8	75.2	

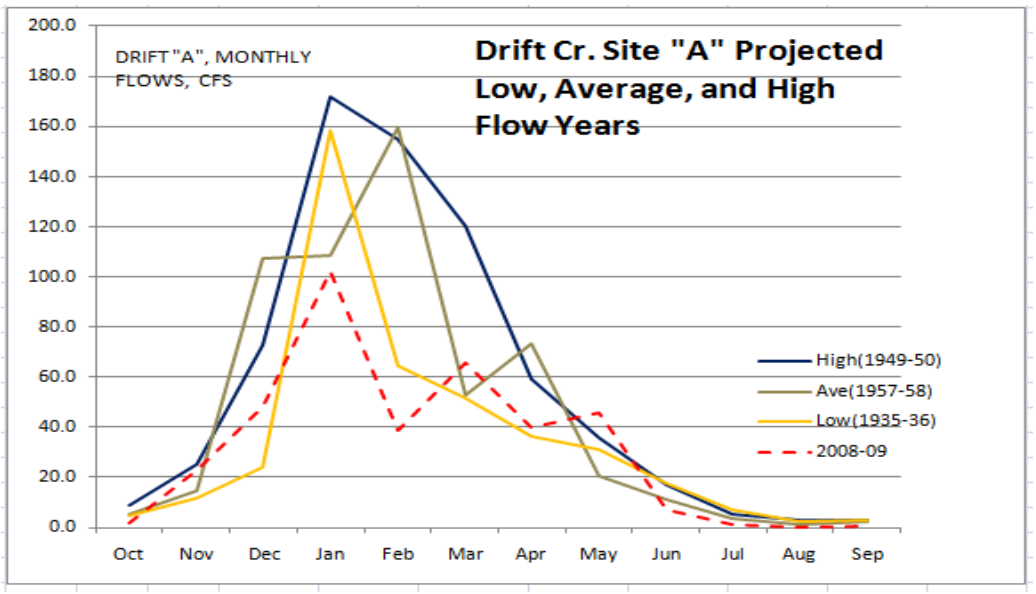


Figure 13. Monthly Flow Hydrographs of Projected Representative Flow Years for Drift Creek

The next step is to generate daily flows for those three years, using either a statistical regression equation or rainfall and/or snow-based modeling tools.

Table 14 shows the results obtained through regression, and Figure 14 contains the daily flow hydrographs for those three years.

Table 14. Regression-based Mean Monthly Flows for Representative Flow Years

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Ann.Vol (AF)
Average 1957-58	3.2	12.0	151.0	141.9	228.7	56.9	89.8	18.9	7.7	1.8	0.5	1.0	42,259
Low 1935-36	2.8	8.4	21.6	235.0	77.2	55.7	34.9	28.2	13.8	4.2	1.1	1.4	29,349
High 1949-50	5.9	25.0	85.6	256.6	221.8	160.2	65.0	34.2	13.2	2.9	1.3	1.4	52,152

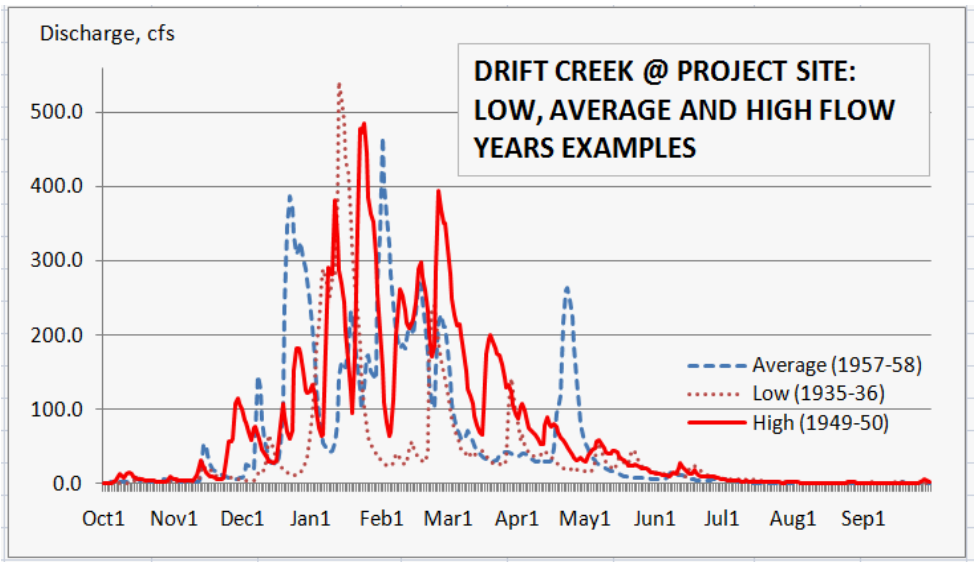


Figure 14. Hydrograph of Projected Daily Flows During Representative Years
(Data saved at Avelohi_Flows_Aurora.xls)

Daily discharge reconstitution for the three representative years using the rainfall-runoff SSARR model based on Salem rainfall data has not yet been performed as rainfall and 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

9. 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. Those original estimates will now be updated based on the relationships established between actual monthly discharges of the Pudding River near Aurora and those of Drift Creek at the project site based on the 2008-2009 stream flow measurements. The procedure includes the steps listed below and is further illustrated by numbers shown in Table 14:

- Compiling existing historical October-April runoff volumes for Pudding River near Aurora over the entire 1928-2009 period of record
- Multiplying the Pudding River data by a factor of 0.0362 (runoff volume ratio defined earlier) to produce the corresponding October-April runoff volumes for Drift Creek at the project site
- Performing the statistical frequency analysis to produce an updated frequency curve for the October-April runoff volume

The accuracy of the new 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 one year 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 a good option.

Table 15. Details of Statistical Frequency Calculation

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	-0.20602	0.04244
2	1929-30	506,791	18,346	4.26354	18.17775	-0.17359	0.03014
3	1930-31	498,485	18,045	4.25636	18.11661	-0.18077	0.03268
4	1931-32	904,509	32,743	4.51512	20.38632	0.07799	0.00608
5	1932-33	840,124	30,413	4.48305	20.09776	0.04592	0.00211
6	1933-34	798,321	28,899	4.46089	19.89951	0.02375	0.00056
7	1934-35	778,303	28,175	4.44986	19.80123	0.01272	0.00016
8	1935-36	585,279	21,187	4.32607	18.71489	-0.11106	0.01233
9	1936-37	616,209	22,307	4.34844	18.90890	-0.08870	0.00787
10	1937-38	1,122,245	40,625	4.60880	21.24100	0.17166	0.02947
11	1938-39	539,529	19,531	4.29072	18.41031	-0.14641	0.02144
12	1939-40	648,682	23,482	4.37074	19.10337	-0.06639	0.00441
13	1940-41	419,148	15,173	4.18108	17.48140	-0.25606	0.06556
14	1941-42	613,602	22,212	4.34660	18.89289	-0.09054	0.00820
15	1942-43	1,147,435	41,537	4.61844	21.32996	0.18130	0.03287
16	1943-44	451,846	16,357	4.21370	17.75526	-0.22343	0.04992
17	1944-45	550,657	19,934	4.29959	18.48647	-0.13754	0.01892
18	1945-46	894,637	32,386	4.51036	20.34331	0.07322	0.00536
19	1946-47	734,364	26,584	4.42462	19.57726	-0.01251	0.00016
20	1947-48	957,349	34,656	4.53978	20.60959	0.10265	0.01054
21	1948-49	909,843	32,936	4.51767	20.40939	0.08054	0.00649
22	1949-50	1,008,572	36,510	4.56242	20.81563	0.12528	0.01570
23	1950-51	1,237,781	44,808	4.65135	21.63508	0.21422	0.04589
24	1951-52	862,064	31,207	4.49425	20.19827	0.05712	0.00326
25	1952-53	811,270	29,368	4.46787	19.96190	0.03074	0.00095
26	1953-54	1,025,958	37,140	4.56984	20.88342	0.13271	0.01761
27	1954-55	674,511	24,417	4.38770	19.25189	-0.04943	0.00244
28	1955-56	1,353,423	48,994	4.69014	21.99743	0.25301	0.06401
29	1956-57	648,236	23,466	4.37044	19.10076	-0.06669	0.00445

30	1957-58	851,445	30,822	4.48887	20.14991	0.05173	0.00268
31	1958-59	834,219	30,199	4.47999	20.07030	0.04286	0.00184
32	1959-60	637,122	23,064	4.36293	19.03517	-0.07420	0.00551
33	1960-61	1,056,599	38,249	4.58262	21.00039	0.14549	0.02117
34	1961-62	660,499	23,910	4.37858	19.17197	-0.05855	0.00343
35	1962-63	780,119	28,240	4.45087	19.81024	0.01374	0.00019
36	1963-64	743,346	26,909	4.42990	19.62401	-0.00723	0.00005
37	1993-94	473,466	17,139	4.23400	17.92673	-0.20313	0.04126
38	1994-95	890,685	32,243	4.50843	20.32597	0.07130	0.00508
39	1995-96	1,288,619	46,648	4.66883	21.79800	0.23170	0.05369
40	1996-97	1,373,397	49,717	4.69650	22.05716	0.25937	0.06727
41	2002-03	759,339	27,488	4.43914	19.70600	0.00201	0.00000
42	2003-04	685,310	24,808	4.39460	19.31247	-0.04254	0.00181
43	2004-05	381,407	13,807	4.14010	17.14041	-0.29703	0.08823
44	2005-06	1,000,928	36,234	4.55911	20.78550	0.12198	0.01488
45	2006-07	908,008	32,870	4.51680	20.40147	0.07967	0.00635
46	2007-08	831,396	30,097	4.47852	20.05711	0.04138	0.00171
47	2008-09	532,336	19,271	4.28489	18.36032	-0.15224	0.02318
			N=	47.00000			
			S(X)=	208.54521		0.00000	0.88033
			M=	4.43713			
			S(X^2)=		926.22299	S^2=	0.01914
			[S(X)^2]/N		925.34266	S=	0.13834
			S(x^2)=		0.88033		

Pn	0.25	1	10	50	90	99	99.75
k (N=46)	2.97	2.44	1.32000	0	-1.32	-2.44	-2.97
Log(V)=	4.84800	4.77468	4.61974	4.43713	4.25452	4.09959	4.02627
Vol, aft	70,468	59,521	41,661	27,360	17,968	12,576	10,622

Both the statistical runoff volume estimates made in 2007 (based on **78** years of observed **and synthesized** Pudding River runoff between 1928 and **2005**) and the current estimates numbers (based on **47** years of observed Pudding River runoff between 1928 and **2009**) are listed in Table 16 for the same frequency of occurrence. The new estimates are lower than the previous ones, but still look favorable with respect to the 12,000 acre-foot storage volume target used for the project. They also match OWRD water surface availability data. See next section.

Table 16. Statistical October-April Runoff Volume Estimates, in aft, using 47 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 (new)	70,468	59,521	41,661	27,360	17,968	12,576	10,622

Vol (old)	98,736	82,429	58,384	38,522	25,417	18,002	15,029

The updated October-April runoff volume frequency curve for Drift Creek at the project site based on 2008-09 stream flow gauging is shown in Figure 15. Compared to the curve developed in 2007, this frequency curve is shifted downward. With just one year of data used in the updating, it is difficult to determine for sure if this trend is permanent and in the right direction, and how much of the move is affected by a runoff multiplier based on a dry year like 2008-09.

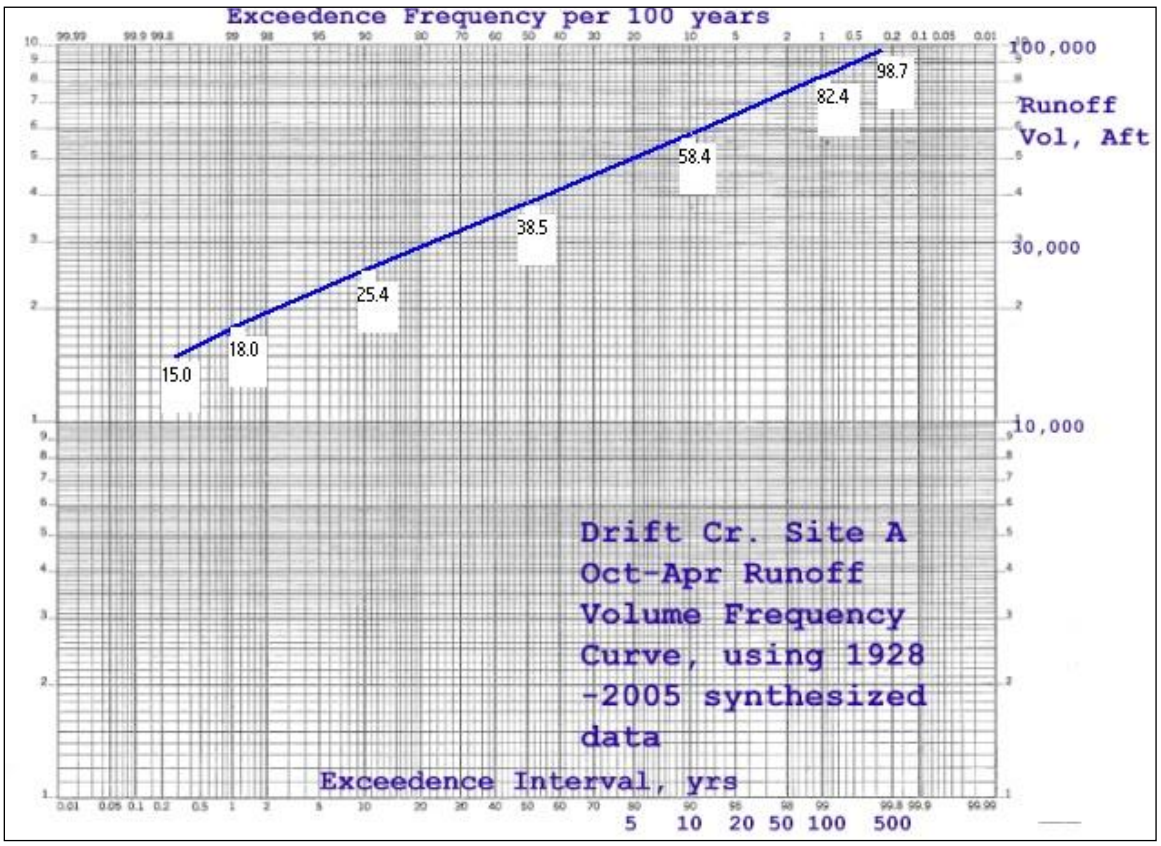


Figure 15. Current and Previous "A" October-April Runoff Volume Frequency Curves (GRAPHIC TO BE UPDATED)

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 81 years between 1928 and 2009, including 47 years of observed flows and 34 more years of synthesized flows using rainfall and snow data at Salem. The same 0.0362 multiplier was used to convert Pudding River flows into Drift Creek flows. The results are summarized in Table 17 still showing slightly smaller October-April runoff volumes than the previous estimates. Details of the calculation are listed in the Appendix.

Table 17. Statistical October-April Runoff Volume Estimates, in aft, using 81Years of Pudding River Observed and Synthesized Data

Pn	0.25	1	10	50	90	99	99.75
k (N=81)	2.92	2.4	1.30000	0	-1.3	-2.4	-2.92
Log(V)=	4.83778	4.76288	4.60446	4.41723	4.23000	4.07157	3.99668
Vol, aft	68,829	57,926	40,220	26,134	16,981	11,791	9,923

10. Water Availability

OWDR makes water availability data for Drift Creek at its confluence with the Pudding River for the 50% and 80% exceedance levels at the following address: http://apps2.wdr.state.or.us/apps/wr/wrinfo. 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 the 24.8 sq. mi. area used by Marion Water and Conservation Service for a Drift Creek stream gauging site near Silverton.

Following contacts by members of the project team, OWDR 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 square miles, and previous ins-tream flow requirements remain unchanged. It is believed that OWDR still treats Drift Creek as an ungauged stream, applies the same calculation procedures as used before, and probably has not seen and accounted for the 2008-09 discharge measurements. The procedures are posted at http://www1.wrd.state.or.us/pdfs/reports/SW02-002.pdf.

The revised water availability data provided by WRD are listed in Table 15 for the 50% and 80% exceedance levels.

Table 15. Revised Water Availability Data for Drift Creek at Its Mouth, in cfs

a) 50% Exceedance (New)

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	149.00	2.26	147.00	0	40	107.00
FEB	133.00	2.01	131.00	0	40	91.00
MAR	108.00	0.02	108.00	0	40	68.00
APR	68.10	0.04	68.10	0	40	28.10
MAY	32.70	0.22	32.50	0	30.1	2.38
JUN	41.90	0.44	41.50	0	13.6	27.90
JUL	18.30	0.77	17.50	0	3	14.50
AUG	8.40	0.61	7.79	0	2	5.79
SEP	4.65	0.30	4.35	0	2	2.35
OCT	7.56	0.02	7.54	0	5.26	2.28

NOV	61.10	0.92	60.20	0	40	20.20
DEC	138.00	2.09	136.00	0	40	95.90
50%STO	46,300	581	45,700	0	17,800	27,900

Average 64.2

b) 80% Exceedance (New)

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	67.30	2.26	65.00	0	40	25.00
FEB	74.90	2.01	72.90	0	40	32.90
MAR	66.80	0.02	66.80	0	40	26.80
APR	48.80	0.04	48.80	0	40	8.76
MAY	24.20	0.22	24.00	0	30.1	-6.12
JUN	11.50	0.44	11.10	0	13.6	-2.54
JUL	5.51	0.77	4.74	0	3	1.74
AUG	3.34	0.61	2.73	0	2	0.73
SEP	3.09	0.30	2.79	0	2	0.79
OCT	4.27	0.02	4.25	0	5.26	-1.01
NOV	23.70	0.92	22.80	0	40	-17.20
DEC	65.80	2.09	63.70	0	40	23.70
ANN50%	46,300	581	45,700	0	17,800	27,900

Average 33.3

It should be noted that the 50% exceedance flows should be about the same as the long term average flows. The following paragraphs document how the actual numbers fit with that expectation.

Table 15 shows an OWDR-calculated 50% exceedance natural stream flow volume of 39,817 acre-feet for the October-April runoff volume of Drift Creek at its mouth. By comparison, the observed October 2008-April 2009 runoff volume of Drift Creek at the lower gauging station is 27,847 acre-feet. This station controls a drainage area of 25.45 square miles –about the same size as the 25.25 square mile area used by OWDR in the water availability calculation. This runoff volume is less than the 39,819 acre-feet used by OWDR for the 50% exceedance level, which makes sense because 2008-09 was a dry year and, therefore, should have less runoff than an average year.

Likewise, for Drift Creek at the project site which controls a drainage area of 15.4 square miles, the October 2008-April 2009 runoff volume was measured at 19,271 acre-feet. The equivalent runoff volume for Drift Creek at the lower gauging site, with a drainage area of 25.45 square miles, was measured at 27,847 acre-feet. To go from 19,271 to 27,847 requires an adjustment factor of 0.692. If the same 0.692 factor is applied to OWDR's water availability calculation results, the 50% exceedance runoff volume for Drift Creek at the project site would have been 39,819*0.692= 27,555 acre-feet. This 50% excedance volume is greater than the 19,271 acre-feet measured in the 2008-09 dry year for Drift Creek at the project site, which again makes sense.

With specific reference to the critical 12,000 acre-feet runoff volume targeted for storage at the proposed project during October through April, the "net water available" for that period estimated by OWRD is 24,699 acre-feet for the 50% exceedance level, and only 5,904 acre-feet for the 80% exceedance level. This points to the 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.

11. Ecological and Channel Maintenance Flows

A recent 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 instream 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 bypass all flows up to ODFW's in-stream flow water right and all flows above the 2-year flood peak of 630 cfs.

12. Reservoir Modeling

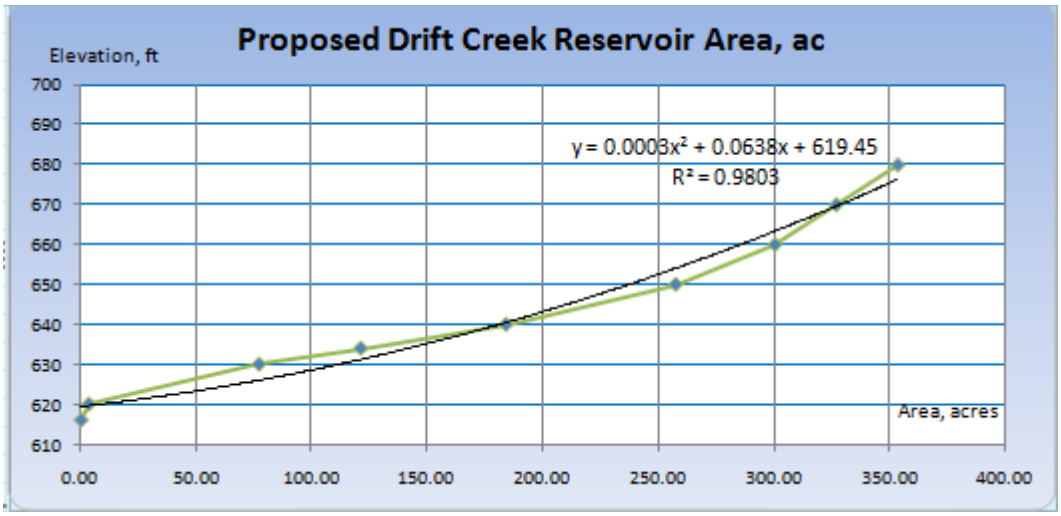
There is a need to test how the proposed reservoir would best operate under various inflow conditions to meet all the flow requirements mentioned above and still be able to store enough water for irrigation purposes. Because the project would basically operate alone, for a single purpose, and in a not too complicated small watershed (see Figure 16), a simple reservoir regulation model, coded name RES4DRIFT, was developed using the Quick-Basic programming language.

Figure 16. Satellite Contour Map of the Proposed Project Site

RES4DRIFT uses the reservoir storage information prepared by Stuntzner Engineering, including storage elevation, volume, and surface area. See Table 16 and Figure 17.

Table 16. Drift Creek Reservoir Storage and Area

El.	Dam Height	Area, ac	Vol, AF
616	0.00	0.40	0
620	4.00	3.66	8
630	14.00	77.24	413
634	18.00	121.27	810
640	24.00	184.04	1,726
650	34.00	257.39	3,933
660	44.00	300.37	6,722
670	54.00	326.81	9,857
680	64.00	353.49	13,259



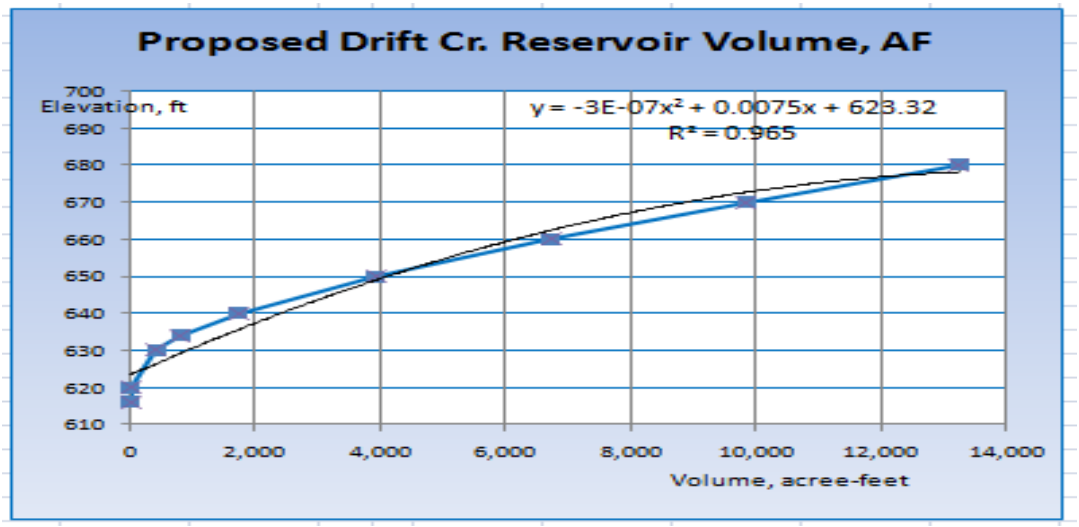


Figure 17. Storage Project Volume and Area

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 water rights, irrigation, storage, ecological and flushing flow requirements summarized in Table 17.

Table 17. Project Release Requirements, in cfs

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Storage	2.25	2.01	0.01	0.01							0.92	2.09
Irrigation			0.01	0.03	0.22	0.44	0.76	0.61	0.30	0.02		
Water R.	40	40	40	40	30.1	13.6	3	2	2	5.26	40	40
Total	42.25	42.01	40.02	40.04	30.23	14.04	3.76	2.61	2.30	5.28	40.92	42.09
Flushing*	630	630	630	630	630	630	630	630	630	630	630	630

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

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 18 and Figure 18

A sample model output is shown in Table 18 and Figure 18.

Table 18. Sample Model Output

SUMMARY RESULTS OF RESERVOIR SIMULATION
Average Flow Year (1957-58) Based on Pudding at Aurora

I	DAY	MON	INFLOW	Starting Elevation	Min.Requ'd Flow	Viol-ation	Outflow	Final Elev.	Storage
1	1	10	1.1	620.00	5.28	1	1.1	620.00	8
2	2	10	1.1	620.00	5.28	1	1.1	620.00	8
3	3	10	1.3	620.00	5.28	1	1.3	620.00	8
4	4	10	1.7	620.00	5.28	1	1.7	620.00	8
5	5	10	2.3	620.00	5.28	1	2.3	620.00	8

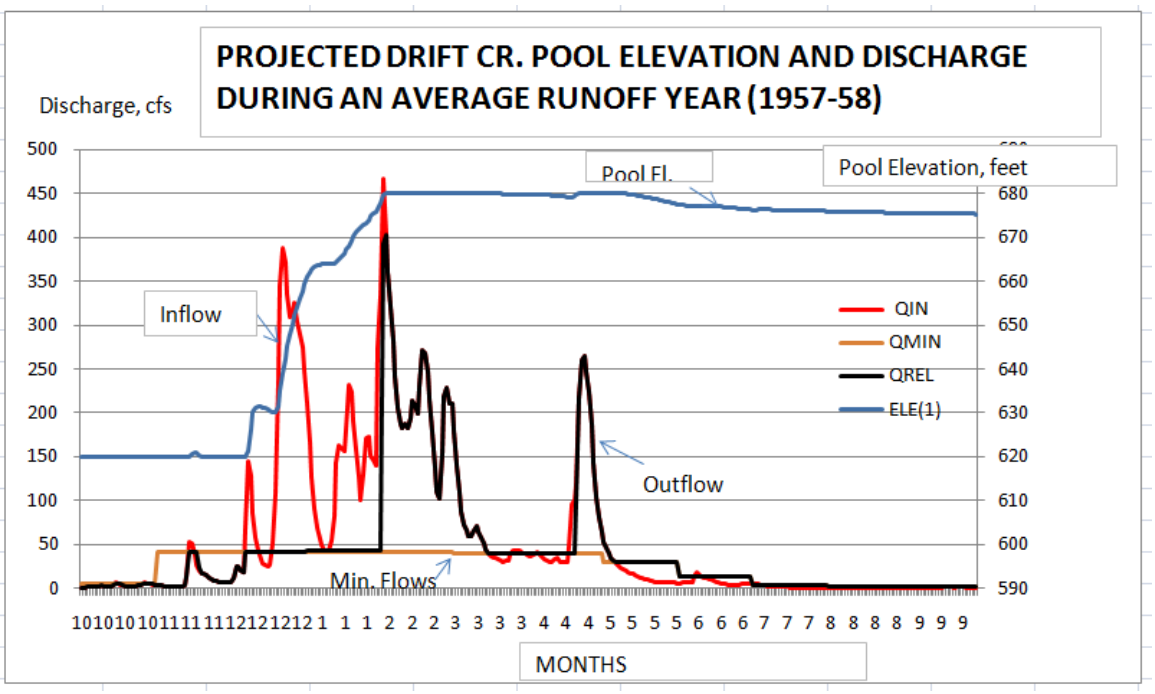


Figure 18. Sample Model Graphical Output

RES4DRIFT model is all set to go as more reliable flow data are available, along with up-to-date information on contemplated irrigation withdrawals after the storage season. It is flexible enough to accommodate any changes in reservoir characteristics and can test the feasibility of meeting additional use of the stored water on a daily basis.

13. Conclusions

This hydrologic yield update complements an earlier report prepared in February 2007document in the light of more recent stream flow data collected for Drift Creek. 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 about two years stretching from October 2008 to September 2009. It is a also worth noting that 2008-09 was a dry water year; it covers the lower side of the expected runoff at the project and still leaves open questions on the higher side of that runoff.

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 stream gauging sites under consideration, Pudding River near Aurora has by far the longest period of records --47 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 equation to generate up to 81 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 which procedure would lead to the more reliable set of results because of the actual data limitation.

More recent additional data of relevance to the project and discussed in this report are data on natural water availability, in-stream water rights, ecological and channel maintenance flows. Since OWRD is still using procedures developed for ungauged streams to create natural stream flow for the 50% and 80% exceedance frequencies, it is likely that those data will need to be reviewed in the next few years.

While waiting for more data covering a wide range of runoff conditions to come in, both the regression and modeling tools have been developed to move along both paths. A representative set of low, average and high flow years has also been developed, along with computer modeling capabilities to generate daily runoff data and to simulate daily reservoir operation.

With the new information obtained, the likelihood to see an October-April runoff volume of 12,000 acre-feet still remains reasonably good. The 50% exceedance value for that volume still ranges between 26,000 and 27,000 acre-feet. With about 15,000 acre-feet allocated to water rights and other uses, the net runoff volume that can be stored is still between 11,000 and 12,000 acre-feet. This is admittedly a low range estimate due to the

nature of the 2008-09 data used in the analysis. OWRD equivalent volume number is 24,700 acre-feet.

A P P E N D I X

Available Hydromet Data (more recent numbers are in **bold**)

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

** No Incomplete data have been used for statistical calculation

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**			
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

USGS 14202000 PUDDING RIVER AT AURORA, OR 00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1928-10-01 -> 2008-11-30)											
	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**			
Mean of	**2,839**	**2,637**	**2,067**	**1,526**	**873.7**	**422.5**	**140.5**	**65.3**	**91.0**	**323.9**	**1,408**	**2,451**

monthly Discharge												

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

Observed October-April Runoff Volume (AF) for Pudding River near Aurora

Hydro Year=	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Oct-Apr Vol (aft)
1928-29	162.0	605.2	1273.0	1875.0	1066.0	1097.0	1752.0	757.1	470,330
1929-30	68.5	81.5	1907.0	962.2	3868.0	1073.0	682.9	828.4	506,791
1930-31	123.4	460.5	573.4	1464.0	956.7	1652.0	3086.0	327.2	498,485
1931-32	204.6	1780.0	2593.0	3304.0	2010.0	3312.0	1754.0	743.7	904,509
1932-33	161.3	1613.0	2168.0	3574.0	2263.0	2937.0	1262.0	1361.0	840,124
1933-34	295.5	699.7	5170.0	3633.0	864.4	1325.0	1142.0	695.5	798,321
1934-35	355.4	1975.0	2842.0	2992.0	1535.0	1996.0	1217.0	551.1	778,303
1935-36	135.9	318.7	668.3	4352.0	1773.0	1428.0	1002.0	858.9	585,279
1936-37	66.1	78.9	662.4	766.5	3563.0	2100.0	3239.0	901.5	616,209
1937-38	305.1	3039.0	3904.0	3670.0	2990.0	3121.0	1668.0	682.1	1,122,245
1938-39	120.3	888.6	1204.0	1853.0	2679.0	1702.0	638.3	241.9	539,529
1939-40	149.7	151.0	1679.0	1353.0	3532.0	2491.0	1477.0	671.6	648,682
1940-41	205.1	1110.0	1863.0	1885.0	831.5	598.5	456.3	638.3	419,148
1941-42	298.2	1138.0	3408.0	1719.0	2277.0	916.2	498.4	929.1	613,602
1942-43	78.1	3098.0	4624.0	3768.0	3916.0	1035.0	2713.0	720.4	1,147,435
1943-44	543.8	783.8	1130.0	1463.0	1466.0	1047.0	1120.0	474.4	451,846
1944-45	70.9	373.2	435.9	1517.0	2466.0	2527.0	1879.0	1623.0	550,657
1945-46	108.2	1801.0	2955.0	3488.0	2507.0	3000.0	1028.0	466.5	894,637
1946-47	353.0	2006.0	3452.0	1572.0	1999.0	1421.0	1448.0	322.5	734,364
1947-48	1774.0	2482.0	1518.0	3664.0	2311.0	2454.0	1730.0	1416.0	957,349
1948-49	295.3	1508.0	3661.0	1209.0	5600.0	2067.0	1086.0	1081.0	909,843
1949-50	245.0	699.7	2004.0	4735.0	4263.0	3310.0	1638.0	990.8	1,008,572
1950-51	1170.0	4643.0	3239.0	4853.0	3208.0	2624.0	887.2	703.1	1,237,781
1951-52	914.4	1497.0	3283.0	2241.0	3474.0	1905.0	1130.0	618.3	862,064
1952-53	63.8	104.3	792.7	5576.0	3743.0	2142.0	1179.0	1171.0	811,270
1953-54	326.7	1770.0	4772.0	3721.0	3375.0	1506.0	1656.0	418.0	1,025,958
1954-55	390.6	1028.0	1808.0	1895.0	1255.0	1795.0	3054.0	1193.0	674,511
1955-56	1036.0	3039.0	5704.0	5722.0	2127.0	3115.0	1630.0	682.1	1,353,423
1956-57	331.8	755.7	1421.0	1108.0	1872.0	3945.0	1361.0	658.7	648,236
1957-58	153.1	404.8	2959.0	2982.0	4384.0	1459.0	2011.0	567.4	851,445
1958-59	103.3	1846.0	1874.0	4017.0	3067.0	1716.0	1347.0	1061.0	834,219
1959-60	578.6	515.3	879.6	1374.0	2789.0	2543.0	2037.0	1820.0	637,122
1960-61	142.4	2775.0	1883.0	2006.0	5550.0	4235.0	1264.0	1214.0	1,056,599
1961-62	258.6	776.9	2880.0	1322.0	1242.0	2589.0	1882.0	1454.0	660,499
1962-63	461.1	2163.0	2302.0	819.2	2458.0	1548.0	3355.0	2192.0	780,119
1963-64	185.3	1940.0	1289.0	4513.0	1840.0	1656.0	939.9	687.7	743,346
1993-94	79.5	99.1	1114.0	2050.0	1590.0	1741.0	1225.0	375.3	473,466
1994-95	346.5	2557.0	2957.0	3017.0	3335.0	1595.0	1123.0	812.2	890,685

1995-96	520.0	2233.0	4323.0	3888.0	6948.0	1988.0	1867.0	1552.0	1,288,619
1996-97	606.6	3387.0	6090.0	4643.0	2875.0	3728.0	1446.0	727.9	1,373,397
2002-03	86.6	255.4	1383.0	2565.0	2973.0	3116.0	2345.0	1034.0	759,339
2003-04	93.3	393.6	2705.0	3364.0	2884.0	1296.0	727.5	469.7	685,310
2004-05	428.9	617.0	1579.0	758.5	496.7	824.6	1620.0	1132.0	381,407
2005-06	185.4	1476.0	2559.0	6873.0	2506.0	1507.0	1515.0	527.8	1,000,928
2006-07	85.3	3454.0	3554.0	2814.0	2001.0	2166.0	1035.0	500.0	908,008
2007-08	424.7	1005.0	3051.0	3524.0	2371.0	1992.0	1387.0	1092.0	826,694
2008-09	132.6	767.8	1110.1	2977.0	830.1	1810.3	1174.8	1117.8	826,694
Average	323.9	1,408.4	2,451.2	2,839.2	2,636.8	2,067.1	1,525.9	873.7	

OCT-APR RUNOFF VOLUME STATISTICAL FREQUENCY FOR DRIFT CREEK AT PROJECT SITE –BASED ON 81 YEARS OF FLOWS OF PUDDING RIVER NEAR AURORA (47 YEARS OF OBSERVED FLOWS + 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	-0.20602	0.04244
2	1929-30	506,791	18,346	4.26354	18.17775	-0.17359	0.03014
3	1930-31	498,485	18,045	4.25636	18.11661	-0.18077	0.03268
4	1931-32	904,509	32,743	4.51512	20.38632	0.07799	0.00608
5	1932-33	840,124	30,413	4.48305	20.09776	0.04592	0.00211
6	1933-34	798,321	28,899	4.46089	19.89951	0.02375	0.00056
7	1934-35	778,303	28,175	4.44986	19.80123	0.01272	0.00016
8	1935-36	585,279	21,187	4.32607	18.71489	-0.11106	0.01233
9	1936-37	616,209	22,307	4.34844	18.90890	-0.08870	0.00787
10	1937-38	1,122,245	40,625	4.60880	21.24100	0.17166	0.02947
11	1938-39	539,529	19,531	4.29072	18.41031	-0.14641	0.02144
12	1939-40	648,682	23,482	4.37074	19.10337	-0.06639	0.00441
13	1940-41	419,148	15,173	4.18108	17.48140	-0.25606	0.06556
14	1941-42	613,602	22,212	4.34660	18.89289	-0.09054	0.00820
15	1942-43	1,147,435	41,537	4.61844	21.32996	0.18130	0.03287
16	1943-44	451,846	16,357	4.21370	17.75526	-0.22343	0.04992
17	1944-45	550,657	19,934	4.29959	18.48647	-0.13754	0.01892
18	1945-46	894,637	32,386	4.51036	20.34331	0.07322	0.00536
19	1946-47	734,364	26,584	4.42462	19.57726	-0.01251	0.00016
20	1947-48	957,349	34,656	4.53978	20.60959	0.10265	0.01054
21	1948-49	909,843	32,936	4.51767	20.40939	0.08054	0.00649
22	1949-50	1,008,572	36,510	4.56242	20.81563	0.12528	0.01570
23	1950-51	1,237,781	44,808	4.65135	21.63508	0.21422	0.04589
24	1951-52	862,064	31,207	4.49425	20.19827	0.05712	0.00326

25	1952-53	811,270	29,368	4.46787	19.96190	0.03074	0.00095
26	1953-54	1,025,958	37,140	4.56984	20.88342	0.13271	0.01761
27	1954-55	674,511	24,417	4.38770	19.25189	-0.04943	0.00244
28	1955-56	1,353,423	48,994	4.69014	21.99743	0.25301	0.06401
29	1956-57	648,236	23,466	4.37044	19.10076	-0.06669	0.00445
30	1957-58	851,445	30,822	4.48887	20.14991	0.05173	0.00268
31	1958-59	834,219	30,199	4.47999	20.07030	0.04286	0.00184
32	1959-60	637,122	23,064	4.36293	19.03517	-0.07420	0.00551
33	1960-61	1,056,599	38,249	4.58262	21.00039	0.14549	0.02117
34	1961-62	660,499	23,910	4.37858	19.17197	-0.05855	0.00343
35	1962-63	780,119	28,240	4.45087	19.81024	0.01374	0.00019
36	1963-64	743,346	26,909	4.42990	19.62401	-0.00723	0.00005
37	1964-65	766,851	27,760	4.44342	19.74398	0.00629	0.00004
38	1965-66	721,428	26,116	4.41690	19.50902	-0.02023	0.00041
39	1966-67	657,317	23,795	4.37648	19.15361	-0.06065	0.00368
40	1967-68	708,640	25,653	4.40913	19.44046	-0.02800	0.00078
41	1968-69	1,012,349	36,647	4.56404	20.83045	0.12691	0.01611
42	1969-70	874,116	31,643	4.50028	20.25250	0.06315	0.00399
43	1970-71	1,047,283	37,912	4.57877	20.96516	0.14164	0.02006
44	1971-72	873,458	31,619	4.49995	20.24956	0.06282	0.00395
45	1972-73	470,469	17,031	4.23124	17.90339	-0.20589	0.04239
46	1973-74	1,259,453	45,592	4.65889	21.70526	0.22176	0.04918
47	1974-75	707,696	25,619	4.40856	19.43536	-0.02858	0.00082
48	1975-76	786,755	28,481	4.45455	19.84300	0.01742	0.00030
49	1976-77	197,929	7,165	3.85522	14.86270	-0.58191	0.33862
50	1977-78	668,444	24,198	4.38377	19.21747	-0.05336	0.00285
51	1978-79	418,772	15,160	4.18069	17.47814	-0.25645	0.06576
52	1979-80	757,077	27,406	4.43785	19.69450	0.00072	0.00000
53	1980-81	597,766	21,639	4.33524	18.79431	-0.10189	0.01038
54	1981-82	926,194	33,528	4.52541	20.47934	0.08828	0.00779
55	1982-83	1,012,188	36,641	4.56397	20.82982	0.12684	0.01609
56	1983-84	740,659	26,812	4.42833	19.61008	-0.00881	0.00008
57	1984-85	612,787	22,183	4.34602	18.88788	-0.09111	0.00830
58	1985-86	597,101	21,615	4.33476	18.79011	-0.10238	0.01048
59	1986-87	678,463	24,560	4.39023	19.27416	-0.04690	0.00220
60	1987-88	599,374	21,697	4.33641	18.80442	-0.10073	0.01015
61	1988-89	529,715	19,176	4.28275	18.34195	-0.15438	0.02383
62	1989-90	550,087	19,913	4.29914	18.48260	-0.13799	0.01904
63	1990-91	606,560	21,957	4.34158	18.84934	-0.09555	0.00913
64	1991-92	544,536	19,712	4.29474	18.44475	-0.14240	0.02028
65	1992-93	727,869	26,349	4.42076	19.54313	-0.01637	0.00027
66	1993-94	473,466	17,139	4.23400	17.92673	-0.20313	0.04126
67	1994-95	890,685	32,243	4.50843	20.32597	0.07130	0.00508
68	1995-96	1,288,619	46,648	4.66883	21.79800	0.23170	0.05369
69	1996-97	1,373,397	49,717	4.69650	22.05716	0.25937	0.06727

70	1997-98	787,841	28,520	4.45515	19.84834	0.01802	0.00032
71	1998-99	758,191	27,447	4.43849	19.70017	0.00136	0.00000
72	1999-00	726,590	26,303	4.42000	19.53638	-0.01713	0.00029
73	2000-01	381,814	13,822	4.14056	17.14424	-0.29657	0.08795
74	2001-02	867,323	31,397	4.49689	20.22201	0.05976	0.00357
75	2002-03	759,339	27,488	4.43914	19.70600	0.00201	0.00000
76	2003-04	685,310	24,808	4.39460	19.31247	-0.04254	0.00181
77	2004-05	381,407	13,807	4.14010	17.14041	-0.29703	0.08823
78	2005-06	1,000,928	36,234	4.55911	20.78550	0.12198	0.01488
79	2006-07	908,008	32,870	4.51680	20.40147	0.07967	0.00635
80	2007-08	831,396	30,097	4.47852	20.05711	0.04138	0.00171
81	2008-09	532,336	19,271	4.28489	18.36032	-0.15224	0.02318

		X	X^2	x	x^2
N=	81.00000				
S(X)=	357.79536			-1.61234	1.65943
M=	4.41723				
S(X^2)=			1582.09057	S^2=	0.02074
[S(X)^2]/N			1580.46323	S=	0.14402
S(x^2)=			1.65943		

Pn	0.25	1	10	50	90	99	99.75
k (N=81)	2.92	2.4	1.30000	0	-1.3	-2.4	-2.92
Log(V)=	4.83778	4.76288	4.60446	4.41723	4.23000	4.07157	3.99668
Vol, aft	68,829	57,926	40,220	26,134	16,981	11,791	9,923

(TABLE TO BE UPDATED WITH FINAL NUMBERS)

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

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 CUBIC FEET PER SECOND WATER YEAR OCT 2008 TO SEP 2009

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.96	.68	17	370E	30	119	81	25	14	3.7	.67	.23
2	.96	.86	21	590E	30	125	102	45	13	3.1	.61	.25
3	1.5	2.1	21	420E	29	126	99	50	12	2.7	.46	.21
4	8.2	7.9	19	352	29	109	90	48	13	2.4	.43	.18
5	7.2	6.0	18	333	28	114	80	88	18	2.4	.43	.73
6	7.2	4.5	18	302	32	110	72	116	15	2.3	.49	1.6
7	6.5	4.6	17	298	34	99	66	158	14	1.9	.73	1.7
8	7.2	3.7	18	352	32	99	60	135	13	1.7	.79	1.3
9	18	4.6	17	233	31	97	56	111	12	1.9	.87	.96
10	14	4.9	16	182	32	94	59	93	11	2.0	.88	.79
11	12	6.2	16	151	37	87	49	80	11	2.0	.64	.79
12	10	31	17	126	35	79	46	71	11	2.6	.82	.71
13	7.9	175	26	109	37	72	55	65	10	3.9	.86	.47
14	5.8	107	30	94	35	71	54	78	10	3.4	.82	.52
15	4.6	70	31	83	35	118	49	62	9.0	2.8	.86	.51
16	3.5	53	28	74	34	145	46	52	7.9	2.3	.87	2.2
17	2.5	43	26	65	34	135	44	46	7.8	1.9	.77	2.6
18	2.1	33	36	59	31	119	42	41	7.6	1.5	.76	1.7
19	1.6	28	42	53	30	106	38	43	7.6	1.4	.54	1.2
20	1.3	29	45	49	28	96	35	40	7.3	1.3	.47	1.0
21	1.1	29	175E	44	28	88	34	35	6.6	1.3	.40	.79
22	1.2	31	228E	42	25	95	31	31	6.0	1.2	.44	.72
23	.86	29	155E	39	29	92	30	28	5.4	1.3	.25	.52
24	.68	27	135E	36	74	84	27	25	5.0	1.1	.41	.44
25	.62	24	165E	38	142	89	25	23	4.4	.98	.56	.39
26	.58	23	135E	35	194	93	24	23	4.4	1.0	.56	.40
27	.61	21	400E	33	160	86	23	23	3.9	.76	.43	.41
28	.62	21	580E	37	136	85	30	21	4.1	.52	.27	.54
29	.61	18	480E	35	------	105	34	19	3.6	.17	.44	1.4
30	.64	18	400E	33	------	92	29	17	3.8	.61	.34	1.2
31	.63	------	300E	31	------	85	------	15	------	.65	.49	------
TOTAL	131.17	856.04	3,632	4,698	1,431	3,114	1,510	1,707	271.4	56.79	18.36	26.46
MEAN	4.23	28.5	117	152	51.1	100	50.3	55.1	9.05	1.83	.59	.88
MAX	18	175	580	590	194	145	102	158	18	3.9	.88	2.6
MIN	.58	.68	16	31	25	71	23	15	3.6	.17	.25	.18
AC-FT	260	1,700	7,200	9,320	2,840	6,180	3,000	3,390	538	113	36	52

CAL YEAR 2008	TOTAL	7,693.21	MEAN	21.0	MAX	580	MIN	.58	AC-FT	15,260		
WTR YEAR 2009	TOTAL	17,452.22	MEAN	47.8	MAX	590	MIN	.17	AC-FT	34,620		

e=estimate

******Provisional********* 11/3/09 rmh