WATER RESOURCES DEPARTMENT

MEMO SEPT. 27 ,20 16

TO: **Application G-** 18336

FROM: **GW:** WOZNIAK & ORLOWSKI
(Reviewer's Name)

SUBJECT: Scenic Waterway Interference Evaluation

☐ YES
The source of appropriation is within or above a Scenic Waterway
☒ NO

☐ YES
Use the Scenic Waterway condition (Condition 7J)
☒ NO

☐ Per ORS 390.835, the Groundwater Section is **able** to calculate ground water interference with surface water that contributes to a Scenic Waterway. The calculated interference is distributed below.

☐ Per ORS 390.835, the Groundwater Section is **unable** to calculate ground water interference with surface water that contributes to a scenic waterway; **therefore, the Department is unable to find that there is a preponderance of evidence that the proposed use will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway.**

DISTRIBUTION OF INTERFERENCE

Calculate the percentage of consumptive use by month and fill in the table below. If interference cannot be calculated, per criteria in 390.835, do not fill in the table but check the "unable" option above, thus informing Water Rights that the Department is unable to make a Preponderance of Evidence finding.

Exercise of this permit is calculated to reduce monthly flows in _____ Scenic Waterway by the following amounts expressed as a proportion of the consumptive use by which surface water flow is reduced.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

PUBLIC INTEREST REVIEW FOR GROUNDWATER APPLICATIONS

TO: Water Rights Section Date **September 27, 2016**

FROM: Groundwater Section **Karl Wozniak & Dennis Orlowski**
Reviewer's Name

SUBJECT: Application G- **18336** Supersedes review of _____
Date of Review(s)

PUBLIC INTEREST PRESUMPTION; GROUNDWATER

OAR 690-310-130 (1) *The Department shall presume that a proposed groundwater use will ensure the preservation of the public welfare, safety and health as described in ORS 537.525.* Department staff review groundwater applications under OAR 690-310-140 to determine whether the presumption is established. OAR 690-310-140 allows the proposed use be modified or conditioned to meet the presumption criteria. **This review is based upon available information and agency policies in place at the time of evaluation.**

A. GENERAL INFORMATION: Applicant's Name: **Davidson** County: **Marion**

A1. Applicant(s) seek(s) **1.65** cfs from **2** well(s) in the **Willamette** Basin, **Mission Creek & Champoeg Creek** subbasins

A2. Proposed use **Irrigation (131.7 acres)** Seasonality: **March 1 – October 31**

A3. Well and aquifer data (**attach and number logs for existing wells; mark proposed wells as such under logid**):

Well	Logid	Applicant's Well #	Proposed Aquifer*	Proposed Rate(cfs)	Location (T/R-S QQ-Q)	Location, metes and bounds, e.g. 2250' N, 1200' E fr NW cor S 36
1	Proposed	2	Alluvium	1.65	4S/2W-31 NW/NW	415' S & 1170' E fr NW cor S31
2	Proposed	3	Alluvium	1.65	4S/3W-36 NE/NW	350' S & 2780' W fr NE cor S36

* Alluvium, CRB, Bedrock

Well	Well Elev ft msl	First Water ft bls	SWL ft bls	SWL Date	Well Depth (ft)	Seal Interval (ft)	Casing Intervals (ft)	Liner Intervals (ft)	Perforations Or Screens (ft)	Well Yield (gpm)	Draw Down (ft)	Test Type
1	170				300	30	0-300		200-300			
2	160				300	30	0-300		200-300			

Use data from application for proposed wells.

A4. **Comments:** Well construction in table A3 reflects proposed construction. POAs at these same locations were recently approved for an amendment of GR-1378 (T-12127).

Well numbers 1 and 2 on table A3 correspond respectively to 'Proposed Well 2' (east) and 'Proposed Well 3'(west) on groundwater application map; note that there is not a 'Proposed Well 1' indicated on the application map.

A5. ☒ **Provisions of the** Willamette Basin rules relative to the development, classification and/or management of groundwater hydraulically connected to surface water ☐ **are**, *or* ☒ **are not**, activated by this application. (Not all basin rules contain such provisions.)
Comments: The wells will produce from a confined aquifer so the pertinent rules (OAR 690-502-240) do not apply.

A6. ☐ **Well(s) #** _____, _____, _____, _____, _____, tap(s) an aquifer limited by an administrative restriction.
Name of administrative area: _____
Comments: The wells do not fall into an administrative area.

B. GROUNDWATER AVAILABILITY CONSIDERATIONS, OAR 690-310-130, 400-010, 410-0070

B1. **Based upon available data**, I have determined that groundwater* for the proposed use:

a. ☐ **is** over appropriated, ☒ **is not** over appropriated, *or* ☐ **cannot be determined to be** over appropriated during any period of the proposed use. * This finding is limited to the groundwater portion of the over-appropriation determination as prescribed in OAR 690-310-130;

b. ☐ **will not** *or* ☐ **will** likely be available in the amounts requested without injury to prior water rights. * This finding is limited to the groundwater portion of the injury determination as prescribed in OAR 690-310-130;

c. ☐ **will not** *or* ☐ **will** likely to be available within the capacity of the groundwater resource; or

d. ☒ **will, if properly conditioned**, avoid injury to existing groundwater rights or to the groundwater resource:
   i. ☒ The permit should contain condition #(s) **7c, large water-use reporting**;
   ii. ☐ The permit should be conditioned as indicated in item 2 below.
   iii. ☐ The permit should contain special condition(s) as indicated in item 3 below;

B2. a. ☐ **Condition** to allow groundwater production from no deeper than _____ ft. below land surface;

b. ☐ **Condition** to allow groundwater production from no shallower than _____ ft. below land surface;

c. ☒ **Condition** to allow groundwater production only from the **alluvial** groundwater reservoir ~~between approximately _____ ft. and _____ ft. below land surface~~;

d. ☐ **Well reconstruction** is necessary to accomplish one or more of the above conditions. The problems that are likely to occur with this use and without reconstructing are cited below. Without reconstruction, I recommend withholding issuance of the permit until evidence of well reconstruction is filed with the Department and approved by the Groundwater Section.

Describe injury –as related to water availability– that is likely to occur without well reconstruction (interference w/ senior water rights, not within the capacity of the resource, etc): _____

B3. **Groundwater availability remarks:** The proposed wells are located on a terrace about 70 feet above the floodplain of the Willamette River. The terrace is underlain by a thick sequence of fine-grained sediments that extends to depths of approximately 1000 feet. The bulk of the sediments are clays and silts that encase a few relatively-thin beds of sand and gravel that do not appear to be continuous over widespread areas. The upper 60-80 feet of sediments are a sequence of graded beds of fine sand, silt, and clay (the Willamette Silt) deposited by a series of Pleistocene glacial floods which inundated the Willamette Valley. The water table occurs at shallow depths within the Willamette Silt, which acts as a leaky confining layer for productive sands and gravel at depth. Sand and gravel beds appear to be less common below depths of 100 feet (see MARI 1450). Well yields are expected to be moderately low (<250 gpm) and well interference is likely to extend over broad areas. However, domestic and irrigation well density is relatively low in the area (Conlon and others, 2005; Gannett and Caldwell, 1998; Swanson and others, 1993).

The Willamette Silt is completely removed by erosion to the west/northwest of the proposed wells in the floodplain of the Willamette River. The floodplain is underlain by 30-40 feet of unconsolidated sands and gravels which host an unconfined aquifer.

Water-level data is sparse in the immediate area but available data indicate that water levels in the fine-grained sequence under the terrace have been stable over time. MARI 2331, a state observation well located about 1.25 miles to the southeast, shows a stable long-term trend and seasonal fluctuations of about 20 feet over the last 50 years. These facts suggest that water levels are stable in the area, but the large proposed rate and the apparent lack of a thick sequence of sand and gravel beds indicate that water-use reporting and water-level measurement conditions are prudent.

C. GROUNDWATER/SURFACE WATER CONSIDERATIONS, OAR 690-09-040

C1. **690-09-040 (1):** Evaluation of aquifer confinement:

Well	Aquifer or Proposed Aquifer	Confined	Unconfined
1	**Alluvium**	☒	☐
2	**Alluvium**	☒	☐

Basis for aquifer confinement evaluation: The shallowest productive water-bearing zones in the area near the proposed well locations are sand or sand/gravel deposits beginning at depths ranging from approximately 60 to 85 ft, corresponding to elevations of about 85 to 100 ft (from MARI 1446 and MARI 1450, respectively). Groundwater level elevations in the area range from approximately 135-140 ft (USGS SIR 2005-5168), which are well above the first encountered water-bearing zones/base of confining units.

Furthermore, the well log for MARI 1446, which is located approximately between the two proposed well locations, states 'flows in winter', indicating flowing artesian conditions for that well in the past.

Finally, in the central Willamette Valley, Conlon and others (2005) report that fine-grained deposits (silt and clay) of 'more than 40 ft' thickness typically create confined conditions in the underlying water-bearing sand/gravel deposits. The well log for MARI 1446 indicates approximately 60 feet of mostly 'clay' beginning near ground surface, and MARI 1450 shows additional thick deposits of 'clay' to at least 245 ft depth (the proposed wells have a planned open interval from 200 to 300 ft).

From the above it is concluded that the low-permeability silt and clay deposits overlying the sand/gravel water-bearing zones create confined aquifer conditions at the proposed well locations.

C2. **690-09-040 (2) (3):** Evaluation of distance to, and hydraulic connection with, surface water sources. All wells located a horizontal distance less than ¼ mile from a surface water source that produce water from an unconfined aquifer shall be assumed to be hydraulically connected to the surface water source. Include in this table any streams located beyond one mile that are evaluated for PSI.

Well	SW #	Surface Water Name	GW Elev ft msl	SW Elev ft msl	Distance (ft)	Hydraulically Connected? YES	NO	ASSUMED	Potential for Subst. Interfer. Assumed? YES	NO
1	1	**Mission Creek**	**140**	**145**	**4100**	☒	☐	☐	☐	☒
1	2	**Willamette River**	**140**	**80-90**	**6800**	☒	☐	☐	☐	☒
2	1	**Mission Creek**	**135**	**145**	**6200**	☒	☐	☐	☐	☒
2	2	**Willamette River**	**135**	**80-90**	**3500**	☒	☐	☐	☐	☒

Basis for aquifer hydraulic connection evaluation:
Mission, Champoeg, and Case Creeks have their headwaters in the terrace underlain by the Willamette Silt. As these stream drainages traverse the terrace toward the northeast, they progressively cut into the Willamette Silt until they intersect the water table, at which point they transition from ephemeral to perennial streams. This is consistent with published water level maps which indicate that groundwater in the alluvial aquifer system flows toward and discharges into the local stream network (Woodward and others, 1998). Local discharge is further illustrated by the seasonal flowing conditions in MARI 1446 and stream seepage investigations in Case Creek (Conlon and others, 2003). These facts indicate that the alluvial aquifer system is hydraulically connected to the local stream network.

The National Hydrologic Dataset and USGS topographic maps indicate that Mission Creek (SW #1) becomes perennial where River Road crosses the creek drainage. The distances in table C2 are measured from the proposed wells to this nearest perennial reach of Mission Creek.

The depletion of local streams on the terrace by the proposed wells will be buffered, but not eliminated, by the low vertical hydraulic conductivity (permeability) of the Willamette Silt and other clays and silts that lie between the deeper sands and gravels and the stream beds. Net impacts will be small at the onset of pumping but will increase with time until a new equilibrium between local recharge and discharge is reached. At this time, depletion is expected to be relatively constant throughout the year.

Water Availability Basin the well(s) are located within: CHAMPOEG CR>WILLAMETTE R – AT MOUTH (Watershed ID 30200708) & WILLAMETTE R> COLUMBIA R- AB MOLALLA R (Watershed ID 182). The wells occur within the Champoeg Creek WAB but will also impact the Willamette WAB.

C3a. **690-09-040 (4):** Evaluation of stream impacts for each well that has been determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water source. Limit evaluation to instream rights and minimum stream flows that are pertinent to that surface water source, and not lower SW sources to which the stream under evaluation is tributary. Compare the requested rate against the 1% of 80% *natural* flow for the pertinent Water Availability Basin (WAB). If Q is not distributed by well, use full rate for each well. Any checked ☒ box indicates the well is assumed to have the potential to cause PSI.

Well	SW #	Well < ¼ mile?	Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
1	**1**	☐	☐			☐	**1.00**	☒	**<<25%**	☒
2	**2**	☐	☐	**MF182**	**1500**	☐	**3830**	☐		☐

C3b. **690-09-040 (4):** Evaluation of stream impacts by total appropriation for all wells determined or assumed to be **hydraulically connected and less than 1 mile** from a surface water source. **Complete only if Q is distributed among wells**. Otherwise same evaluation and limitations apply as in C3a above.

	SW #		Qw > 5 cfs?	Instream Water Right ID	Instream Water Right Q (cfs)	Qw > 1% ISWR?	80% Natural Flow (cfs)	Qw > 1% of 80% Natural Flow?	Interference @ 30 days (%)	Potential for Subst. Interfer. Assumed?
			☐			☐		☐		☐
			☐			☐		☐		☐
			☐			☐		☐		☐
			☐			☐		☐		☐

Comments: The Hunt 2003 stream depletion model (Hunt, 2003) was used to estimate depletion of Mission Creek at 30 days (Well 1, SW #1, Table C3a).

The distance from Well 1 to the nearest perennial reach of Mission Creek is approximately 4100 feet. An aquifer transmissivity (T) of 2040 ft-ft/day and storativity of 0.0001 were used for analytical modeling purposes (pumping test results from nearby wells yielded T values ranging from 706 to 2020 ft-ft/day (MARI 1448, MARI 1352, MARI 1341); the storativity value used for modeling is consistent with published values for similar confined aquifer conditions in the Willamette Basin (Conlon and others, 2005)).

The analytical model results using these key parameter values indicate that stream depletion would be considerably less than 25% after 30 days of pumping (Well 1, SW #1). A sensitivity analysis in which T was varied one order of magnitude lower and higher (204 and 20,400 ft-ft/day, respectively) yielded similar results.

Stream depletion of the Willamette River by Well 2 (Well 2, SW #2, Table C3a) at 30 days was not estimated because of the lack of a readily-available analytical model that can simulate the transition from confined conditions under the terrace to unconfined conditions in the floodplain aquifer.

C4a. **690-09-040 (5):** Estimated impacts on **hydraulically connected surface water sources greater than one mile** as a percentage of the proposed pumping rate. Limit evaluation to the effects that will occur up to one year after pumping begins. This table encompasses the considerations required by 09-040 (5)(a), (b), (c) and (d), which are not included on this form. Use additional sheets if calculated flows from more than one WAB are required.

Non-Distributed Wells													
Well	SW#	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	**1**	**0.03 %**	**0.04 %**	**0.00 %**	**0.00 %**	**0.01 %**	**0.01%**	**0.01%**	**0.01 %**	**0.02 %**	**0.02 %**	**0.02 %**	**0.03 %**
Well Q as CFS		**0.000**	**0.000**	**0.677**	**0.677**	**0.677**	**0.677**	**0.677**	**0.677**	**0.677**	**0.677**	**0.000**	**0.000**
Interference CFS		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
(A) = Total Interf.		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
(B) = 80 % Nat. Q		**37.30**	**51.70**	**22.40**	**10.90**	**6.15**	**3.04**	**2.94**	**1.88**	**1.08**	**1.00**	**10.10**	**47.80**
(C) = 1 % Nat. Q		**0.373**	**0.517**	**0.224**	**0.109**	**0.062**	**0.030**	**0.029**	**0.019**	**0.018**	**0.010**	**0.101**	**0.478**
(D) = (A) > (C)													
(E) = (A / B) x 100		**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**	**0.00 %**

(A) = total interference as CFS; (B) = WAB calculated natural flow at 80% exceed. as CFS; (C) = 1% of calculated natural flow at 80% exceed. as CFS; (D) = highlight the checkmark for each month where (A) is greater than (C); (E) = total interference divided by 80% flow as percentage.

Basis for impact evaluation: Potential depletion of the Willamette River (SW 2) by Well 1 was not estimated because the maximum rate of appropriation is less than 1% of the natural 80% exceedance flows in all months of the year.

Potential depletion of Mission Creek (SW 1) by Well 2 was estimated using the Hunt 2003 stream depletion analytical model (Table C4a). For this application, a maximum permitted diversion rate of 1/80th cfs/ac (0.0125 cfs/ac) and duty of 2.5 ac-ft/ac were assumed (the requested rate of 1.65 cfs equates to the maximum permitted diversion rate (131.7 ac * 0.0125 cfs/ac = 1.65 cfs)). However, because of the inequity between the permitted rate and the duty, the duty would be exceeded after 100.8 days of continuous pumping at the maximum permitted rate. Thus a revised (prorated) pumping rate that reflects continuous pumping throughout the 244-day irrigation period (Mar 1 through Oct 31), but that allows the maximum permitted duty of 2.5 af/acre, was calculated for modeling purposes.

To derive the prorated pumping rate, the number of days to meet the duty (100.8) was divided by the number of days in the irrigation season (244). The resultant proration multiplier of 0.41 was used to reduce the maximum permitted rate such that it meets the duty if applied evenly over the entire irrigation period. For this application, a prorated pumping rate of 0.677 cfs (= 1.65 cfs * 0.41) was used for modeling purposes.

Analytical modeling results for the Well 2/SW 1 scenario, using a prorated pumping rate of 0.677 cfs, show that estimated interference is much less than 25% for the first year of use (including residual effects during the non-pumping Nov-Feb period)).

C4b. **690-09-040 (5) (b) The potential to impair or detrimentally affect the public interest is to be determined by the Water Rights Section.**

C5. ☐ **If properly conditioned**, the surface water source(s) can be adequately protected from interference, and/or groundwater use under this permit can be regulated if it is found to substantially interfere with surface water:

i. ☐ The permit should contain condition #(s)_____;

ii. ☐ The permit should contain special condition(s) as indicated in "Remarks" below;

C6. **SW / GW Remarks and Conditions:** _____

References Used:

Conlon, T.D., Lee, K.K., and Risley, J.R., 2003, Heat tracing in streams in the central Willamette Basin, Oregon, *in* Stonestrom, D.A. and Constantz, Jim, eds., Heat as a tool for studying the movement of groundwater near streams: U.S. Geological Survey Circular 1260, chapter 5, p. 29-34.

Conlon, T.D., Wozniak, K.C., Woodcock, D., Herrera, N.B., Fisher, B.J., Morgan, D.S., Lee, K.K., and Hinkle, S.R., 2005, Ground-water hydrology of the Willamette Basin, Oregon: U.S. Geological Survey Scientific Investigations Report 2005-5168.

Gannett, M.W. and Caldwell, R., 1998, Geologic framework of the Willamette Lowland aquifer system, Oregon and Washington: U.S. Geological Survey Professional Paper 1424-A, 32 p.

Hunt, B., 2003, Unsteady stream depletion when pumping from semiconfined aquifer: Journal of Hydrologic Engineering, January/February, 2003.

Swanson, R.D., McFarland, W.D., Gonthier, J.B., and Wilkinson, J.M., 1993, A description of hydrogeologic units in the Portland basin, Oregon and Washington: U.S.Geological Survey Water-Resources Investigations Report 90-4196, 56p.

Woodward, D.G., Gannett, M.W., and Vaccaro, J.J., 1998, Hydrogeologic framework of the Willamette Lowland aquifer system, Oregon and Washington: U.S. Geological Survey Professional Paper 1424-B, 82 p.

D. WELL CONSTRUCTION, OAR 690-200

D1. **Well #:** _____ **Logid:** _____

D2. **THE WELL does not appear to meet current well construction standards based upon:**

a. ☐ review of the well log;
b. ☐ field inspection by _____;
c. ☐ report of CWRE _____;
d. ☐ other: (specify) _____

D3. **THE WELL construction deficiency or other comment is described as follows:** _____

D4. ☐ **Route to the Well Construction and Compliance Section for a review of existing well construction.**

Water Availability Tables

DETAILED REPORT ON THE WATER AVAILABILITY CALCULATION
Water Availability as of 3/11/2005 for
CHAMPOEG CR > WILLAMETTE R - AT MOUTH

Watershed ID #: 30200708 Basin: WILLAMETTE Exceedance Level: 80
Time: 08:37 Date: 03/11/2005

Month	Natural Stream Flow	CU + Stor Prior to 1/1/93	CU + Stor After 1/1/93	Expected Stream Flow	Reserved Stream Flow	Instream Water Rights	Net Water Available
1	37.30	6.59	0.00	30.70	0.00	0.00	30.70
2	51.70	6.11	0.00	45.60	0.00	0.00	45.60
3	22.40	3.06	0.00	19.30	0.00	0.00	19.30
4	10.90	1.88	0.00	9.02	0.00	0.00	9.02
5	6.15	3.87	0.00	2.28	0.00	0.00	2.28
6	3.04	6.45	0.00	-3.41	0.00	0.00	-3.41
7	2.94	10.60	0.00	-7.65	0.00	0.00	-7.65
8	1.88	8.41	0.00	-6.53	0.00	0.00	-6.53
9	1.08	4.11	0.00	-3.03	0.00	0.00	-3.03
10	1.00	0.30	0.00	0.70	0.00	0.00	0.70
11	10.10	3.74	0.00	6.36	0.00	0.00	6.36
12	47.80	9.46	0.00	38.30	0.00	0.00	38.30
Stor	28100	3910	0	25100	0	0	25100

WILLAMETTE R > COLUMBIA R - AB MOLALLA R
WILLAMETTE BASIN

Water Availability as of 9/6/2016

Watershed ID #: 182 (Map)
Date: 9/6/2016

Exceedance Level: 80%
Time: 1:23 PM

Water Availability Calculation | Consumptive Uses and Storages | Instream Flow Requirements | Reservations | Water Rights | Watershed Characteristics

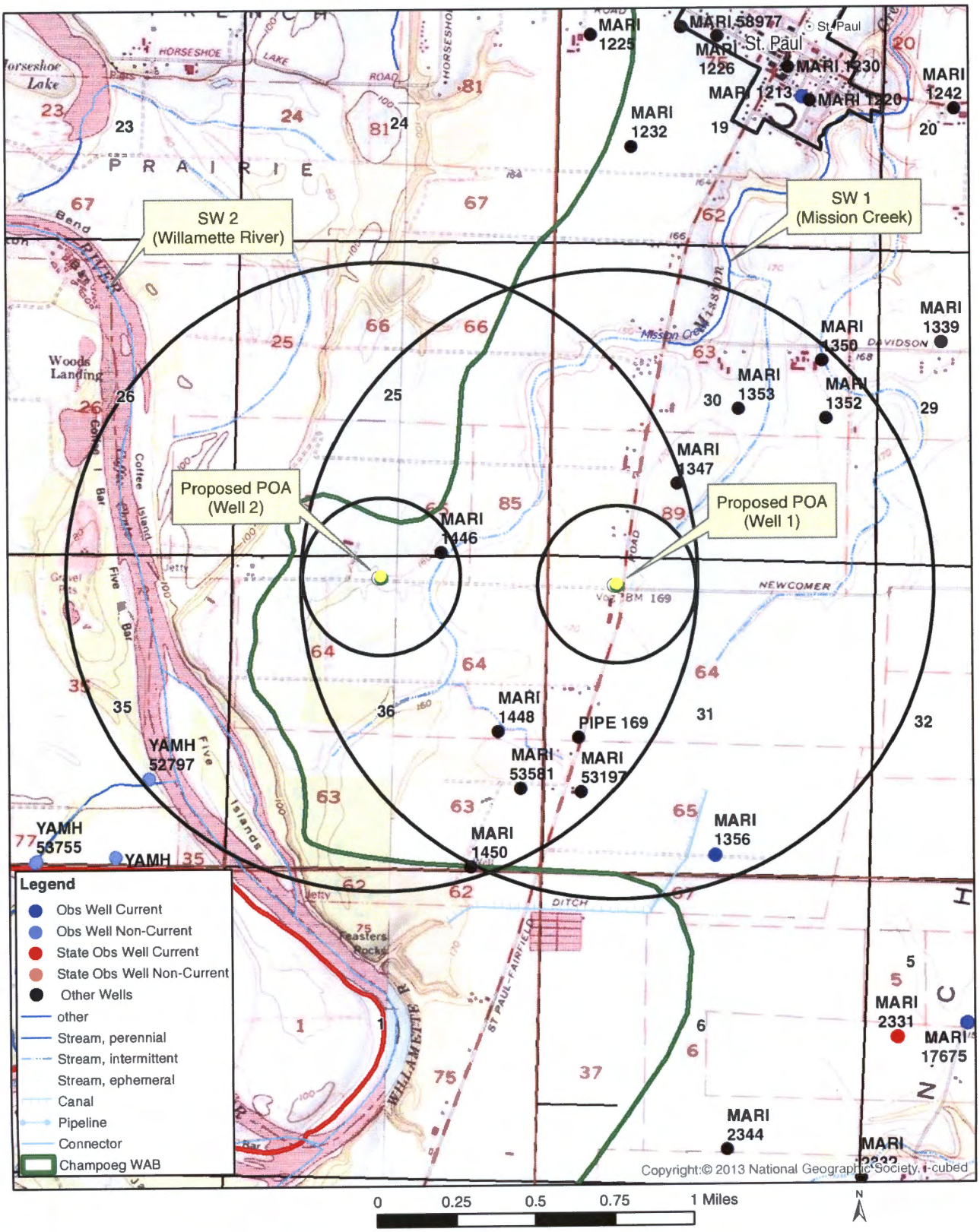
Water Availability Calculation

Monthly Streamflow in Cubic Feet per Second
Annual Volume at 50% Exceedance in Acre-Feet

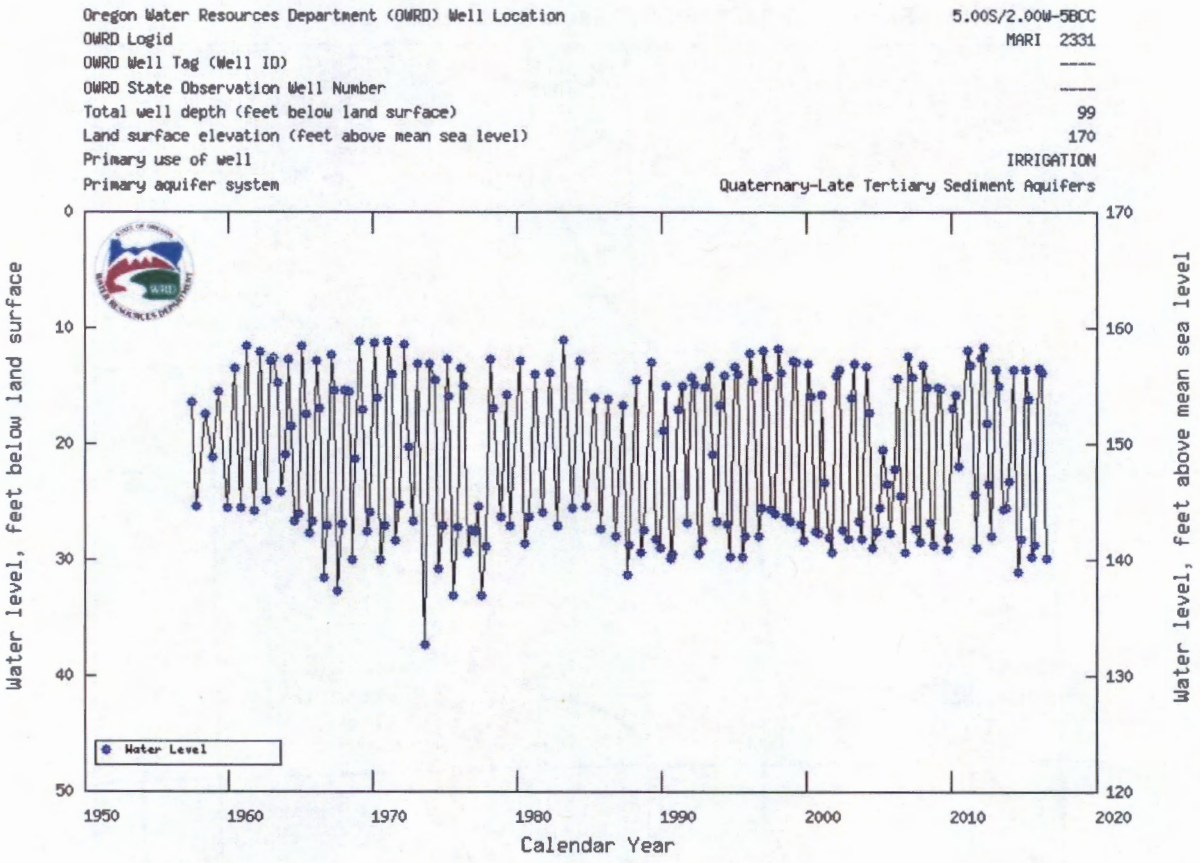
Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	21,400.00	2,290.00	19,100.00	0.00	1,500.00	17,600.00
FEB	23,200.00	7,470.00	15,700.00	0.00	1,500.00	14,200.00
MAR	22,400.00	7,250.00	15,100.00	0.00	1,500.00	13,600.00
APR	19,900.00	6,910.00	13,000.00	0.00	1,500.00	11,500.00
MAY	16,600.00	4,230.00	12,400.00	0.00	1,500.00	10,900.00
JUN	8,740.00	1,970.00	6,770.00	0.00	1,500.00	5,270.00
JUL	4,980.00	1,800.00	3,180.00	0.00	1,500.00	1,680.00
AUG	3,830.00	1,640.00	2,190.00	0.00	1,500.00	686.00
SEP	3,890.00	1,390.00	2,500.00	0.00	1,500.00	996.00
OCT	4,850.00	748.00	4,100.00	0.00	1,500.00	2,600.00
NOV	10,200.00	879.00	9,320.00	0.00	1,500.00	7,820.00
DEC	19,300.00	962.00	18,300.00	0.00	1,500.00	16,800.00
ANN	15,200,000.00	2,250,000.00	13,000,000.00	0.00	1,090,000.00	11,900,000.00

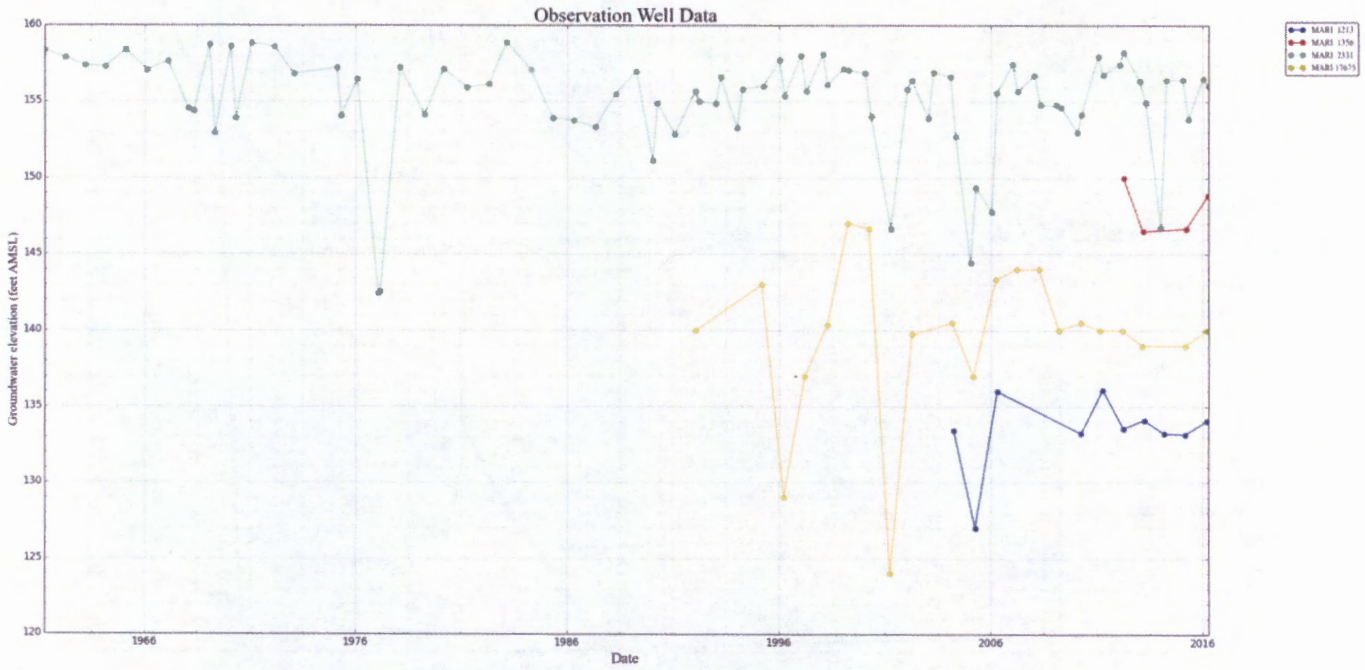
Well Location Map

G-18336 Davidson
T4S/R2W-Sects 30 & 31, T4S/R3W-Sects 25 & 36

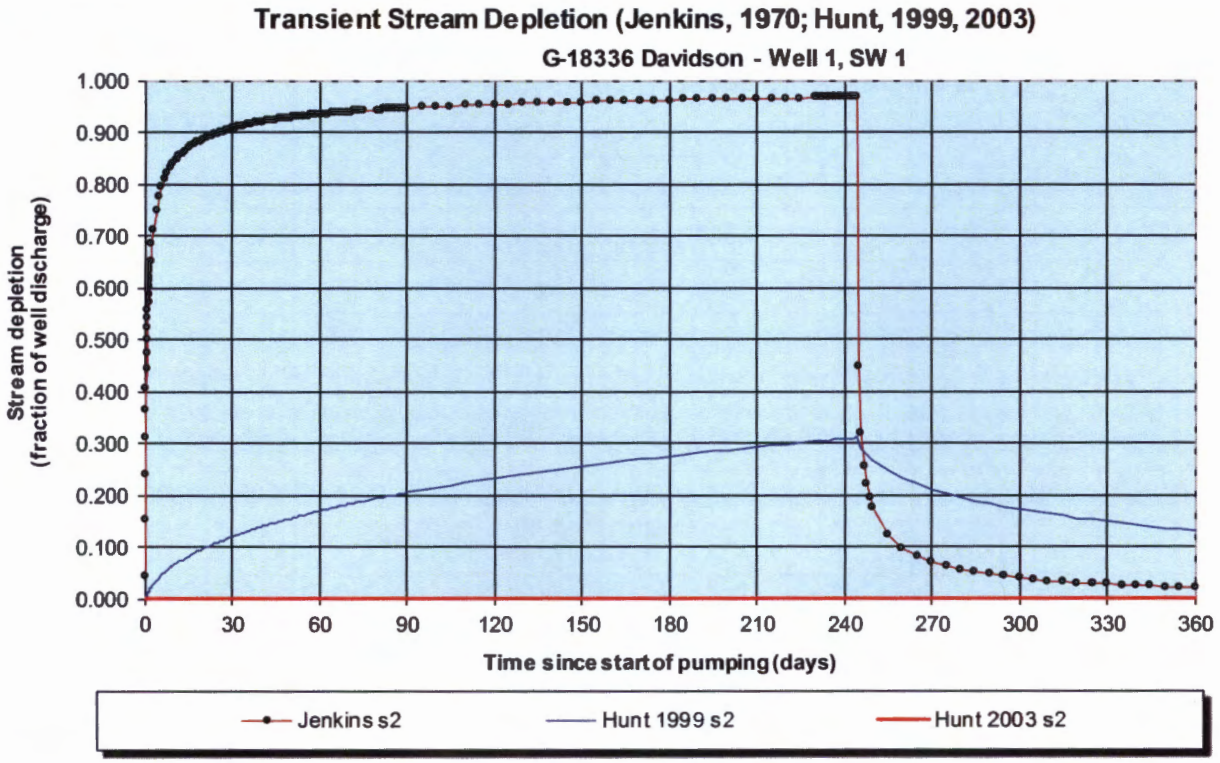


Water-Level Trends in Nearby Wells



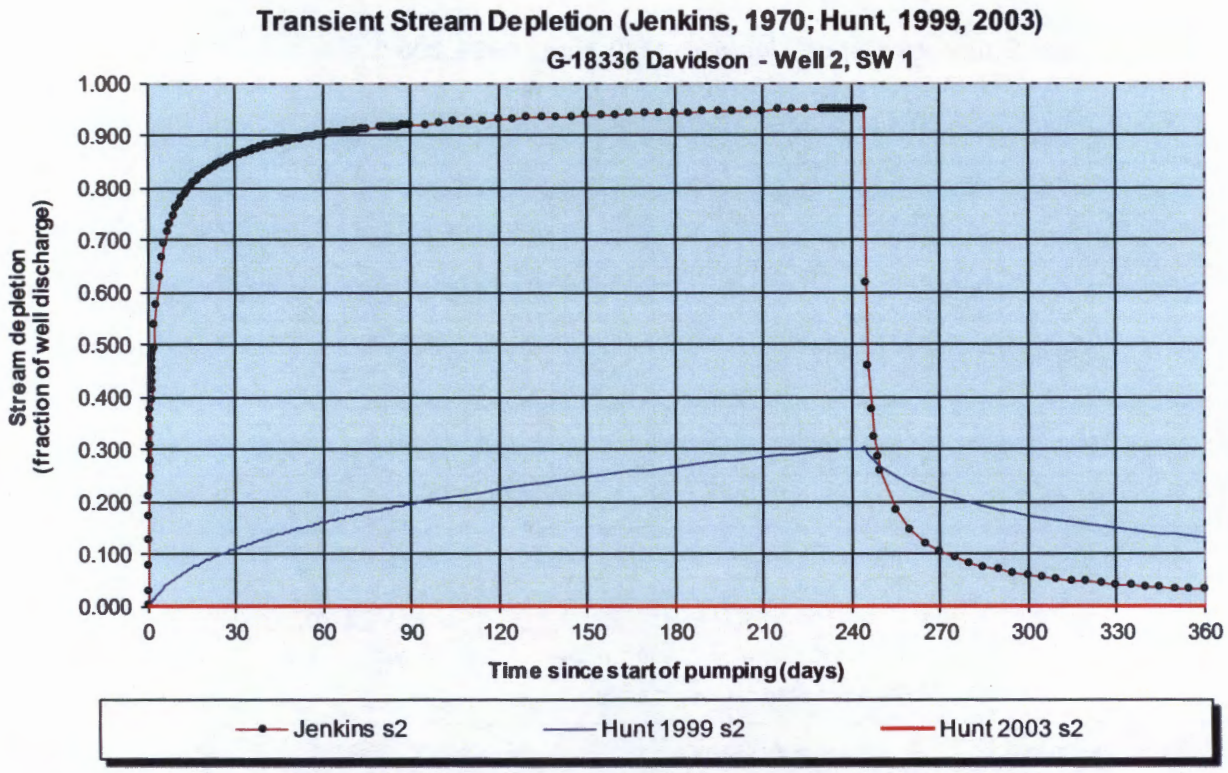


Model Output.



Output for Stream Depletion, Scenerio 2 (s2):	Time pump on (pumping duration) = 244 days											
Days	30	60	90	120	150	180	210	240	270	300	330	360
J SD	90.7%	93.4%	94.6%	95.3%	95.8%	96.2%	96.5%	96.7%	6.9%	3.9%	2.7%	2.1%
H SD 1999	11.9%	16.9%	20.4%	23.1%	25.5%	27.5%	29.2%	30.8%	21.1%	17.2%	14.8%	13.0%
H SD 2003	0.01%	0.02%	0.03%	0.04%	0.05%	0.07%	0.08%	0.09%	0.09%	0.10%	0.11%	0.11%
Qw, cfs	1.650	1.650	1.650	1.650	1.650	1.650	1.650	1.650	1.650	1.650	1.650	1.650
H SD 99, cfs	0.197	0.279	0.336	0.382	0.420	0.453	0.482	0.508	0.349	0.284	0.243	0.215
H SD 03, cfs	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002

Parameters:		Scenario 1	Scenario 2	Scenario 3	Units
Net steady pumping rate of well	Qw	1.65	1.65	1.65	cfs
Time pump on (pumping duration)	tpon	244	244	244	days
Perpendicular from well to stream	a	4100	4100	4100	ft
Well depth	d	300	300	300	ft
Aquifer hydraulic conductivity	K	12	120	1200	ft/day
Aquifer saturated thickness	b	17	17	17	ft
Aquifer transmissivity	T	204	2040	20400	ft*ft/day
Aquifer storativity or specific yield	S	0.0001	0.0001	0.0001	
Aquitard vertical hydraulic conductivity	Kva	0.1	0.1	0.1	ft/day
Aquitard saturated thickness	ba	44	44	44	ft
Aquitard thickness below stream	babs	44	44	44	ft
Aquitard porosity	n	0.2	0.2	0.2	
Stream width	ws	10	10	10	ft
Streambed conductance (lambda)	sbc	0.022727	0.022727	0.022727	ft/day
Stream depletion factor	sdf	8.240196	0.824020	0.082402	days
Streambed factor	sbf	0.456774	0.045677	0.004568	
input #1 for Hunt's Q_4 function	t'	0.121356	1.213563	12.135634	
input #2 for Hunt's Q_4 function	K'	187.277184	18.727718	1.872772	
input #3 for Hunt's Q_4 function	epsilon'	0.000500	0.000500	0.000500	
input #4 for Hunt's Q_4 function	lamda'	0.456774	0.045677	0.004568	



Output for Stream Depletion, Scenerio 2 (s2):						Time pump on (pumping duration) = 244 days						
Days	30	60	90	120	150	180	210	240	270	300	330	360
J SD	85.9%	90.0%	91.9%	92.9%	93.7%	94.2%	94.7%	95.0%	10.4%	5.9%	4.1%	3.1%
H SD 1999	11.0%	16.0%	19.5%	22.3%	24.6%	26.7%	28.4%	30.0%	21.3%	17.3%	14.9%	13.1%
H SD 2003	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%	0.03%	0.03%	0.04%
Qw, cfs	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677	0.677
H SD 99, cfs	0.075	0.108	0.132	0.151	0.167	0.180	0.192	0.203	0.144	0.117	0.101	0.089
H SD 03, cfs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Parameters:		Scenario 1	Scenario 2	Scenario 3	Units
Net steady pumping rate of well	Qw	0.68	0.68	0.68	cfs
Time pump on (pumping duration)	tpon	244	244	244	days
Perpendicular from well to stream	a	6200	6200	6200	ft
Well depth	d	300	300	300	ft
Aquifer hydraulic conductivity	K	12	120	1200	ft/day
Aquifer saturated thickness	b	17	17	17	ft
Aquifer transmissivity	T	204	2040	20400	ft*ft/day
Aquifer storativity or specific yield	S	0.0001	0.0001	0.0001	
Aquitard vertical hydraulic conductivity	Kva	0.1	0.1	0.1	ft/day
Aquitard saturated thickness	ba	44	44	44	ft
Aquitard thickness below stream	babs	44	44	44	ft
Aquitard porosity	n	0.2	0.2	0.2	
Stream width	ws	10	10	10	ft
Streambed conductance (lambda)	sbc	0.022727	0.022727	0.022727	ft/day
Stream depletion factor	sdf	18.843137	1.884314	0.188431	days
Streambed factor	sbf	0.690731	0.069073	0.006907	
input #1 for Hunt's Q_4 function	t'	0.053070	0.530697	5.306972	
input #2 for Hunt's Q_4 function	K'	428.253119	42.825312	4.282531	
input #3 for Hunt's Q_4 function	epsilon'	0.000500	0.000500	0.000500	
input #4 for Hunt's Q_4 function	lamda'	0.690731	0.069073	0.006907	