GEOENGINEERS

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Memorandum

To:	Greg Ferguson, Sea Springs Company
From:	Joel W. Purdy, LG, LHG and James A. Miller, PE, LG, LHG
Date:	January 27, 2011
File:	9301-006-01
Subject:	Summary of Phase 1 Drilling for Well 2 at the George Property

INTRODUCTION

This memorandum summarizes the results of the Phase 1 drilling program for the first test well (Well 2) drilled at the George property. Well 2 is located approximately 150 feet from the south (right) bank of the Wenatchee River, downstream of Lake Wenatchee, near the proposed surface water intake for the hatchery. The drilling project has been separated into two phases. Phase 1 included drilling Well 2 to total depth. Phase 2, scheduled for later in 2011, will include design and placement of a well screen in Well 2, pumping tests in Well 2, and possibly drilling a second test well (Well 1) at the proposed hatchery site.

PHASE 1 SUMMARY

A GeoEngineers hydrogeologist was on site during the drilling of Well 2 from a depth of 18 feet to the total depth of 216.5 feet. The following is the summary of Phase 1 drilling based on our field notes:

- The air-rotary drilling rig was mobilized by Tumwater Drilling on January 11, 2011.
- Drilling began with the placement of the temporary 12-inch surface seal casing to a depth of 18 feet.
- On January 12, drilling continued below the surface seal casing with 8-inch diameter casing.
- The total depth of 216.5 feet was reached on January 13.
- The following is a brief description of the materials encountered during the drilling of Well 2:
  - 0 - 14 feet – Gray sandy gravel
  - 14 - 97 feet – Gray silt
  - 97 - 165 feet – Gray silty fine to medium sand
  - 165 - 167 feet – Light gray fine to coarse sand with occasional gravel
  - 167 - 173 feet – Gray silty fine to medium sand
  - 173 - 182 feet – Gray gravel with fine to coarse sand
  - 182 - 190 feet – Gray silty fine sand (no samples)
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  - 210 - 214 feet – Gray medium to coarse sand with larger gravel
  - 214 - 216.5 feet – Gray fine-grained sedimentary bedrock
- All formations were water-bearing below the base of the silt encountered from 14 to 97 feet.

- Sand and gravel heaved approximately 50 feet up inside the 8-inch casing when it was left overnight with the casing drilled to about 177 feet.
- Air-lift testing of the George Well 1 was conducted at 193, 200 and 205 feet. At each depth of these depths, we estimate that the well was producing roughly 150 gallons per minute through an open-bottom casing.
- The static water level in Well 1 was estimated to be approximately 14 feet based on observations during drilling. A true static water level could not be obtained because the casing was driven about 0.75 feet into the bedrock, shutting off the water entry to the well.
- The thick section of silt between the depths of 14 feet and 97 feet will function as an aquitard and separate the shallow water table aquifer from the deeper aquifer that overlies bedrock. The deep aquifer is expected to behave as a confined aquifer during aquifer testing.
- A surface seal has been placed from 0 to 18 feet using bentonite hole-plug chips and the well casing was capped.

RECOMMENDATIONS

We believe that the materials from 190 to 214 feet have good water production potential, with the best zones below about 199 feet where the materials are slightly coarser. The potential production rate for an 8-inch-diameter well is estimated to be 200 to 300 gpm or greater. Based on the results of Phase 1 drilling, we recommend that Well 2 be screened and tested. If approved, the following Phase 2 work will be completed:

1. GeoEngineers will conduct grain-size testing on Well 2 soil samples obtained between the depths of 184 and 214 feet.
2. We will design the slot size and length of a screen to be placed between 190 and 214 feet based on the results of the grain-size tests. The screen will likely be about 20 feet long.
3. We will provide the screen design to Tumwater Drilling, who will submit the screen order to a qualified screen manufacturer.
4. Tumwater Drilling will install and develop the screen in Well 2. We will be on-site during the screen placement and development.
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6. We will provide a report that provides the results of the drilling and testing of Well 2.

Potentially, a second well (Well 1) will be drilled on the George property during Phase 2, depending on the results for Well 2.

JWP:JAM:tt

George Water Supply System Description and Impact Analysis

Prepared by: Greg Ferguson, Sea Springs Co.

February, 2011

Table of Contents

List of Figures

1. Introduction

The proposed design for the George Hatchery includes both ground and surface (Wenatchee River) supplies. Water requirements are shown in Figures 1-1 and 1-2 below. Groundwater would be used primarily for holding adults and incubating eggs. A small quantity would also be used to control icing at the proposed surface water intake.

Groundwater withdrawal from two proposed wells would be returned to the river at discharge location 2 (see Figure 1-3). It would not flow through the disconnected side channel.

Surface water withdrawal would be pumped from the river and delivered by pipeline to the hatchery. After passing through the hatchery, water would be discharged into the existing side channel (discharge location 1). Some of the water would enter the shallow groundwater aquifer and some would re-enter the Wenatchee 3,800 ft downstream of the withdrawal location.

Period	Ground *cfs*	Surface *cfs*	Total *cfs*
Aug	0.0	2.8	2.8
Sep	3.6	3.5	7.1
Oct	3.4	4.0	7.4
Nov	0.6	4.5	5.1
Dec	0.6	2.5	3.0
Jan	0.5	2.5	3.1
Feb	0.5	2.6	3.1
Mar	0.0	3.3	3.3
Apr	0.0	0.8	0.8
May	0.0	1.1	1.1
Jun	0.0	1.6	1.6
Jul	0.0	2.2	2.2

Figure 1-1. Design Water Flow Table

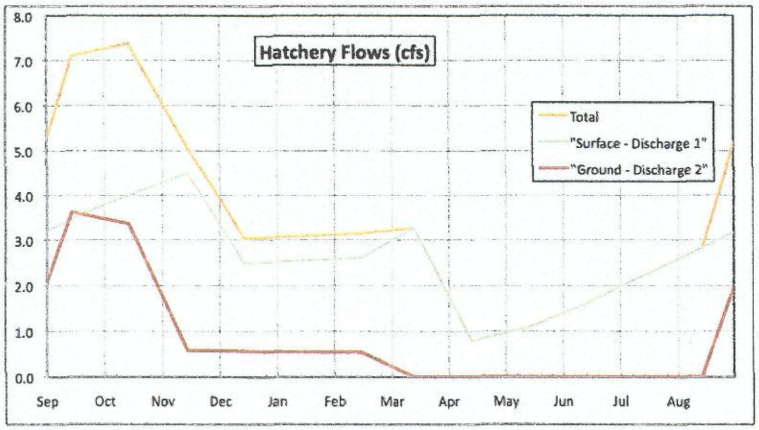

Figure 1-2. Design Water Flow Plot

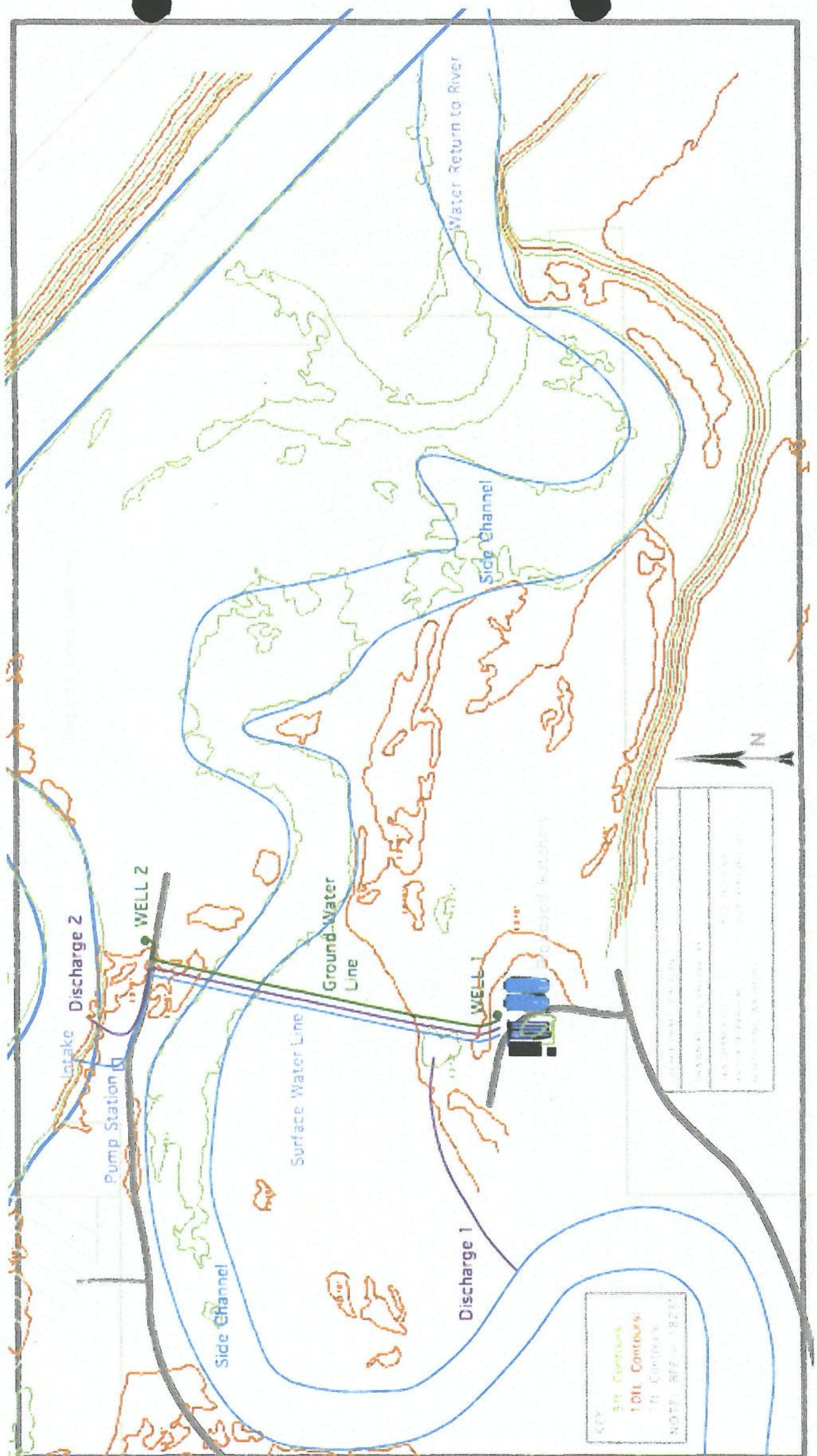

Figure 1-3. George Hatchery Site Plan

2. Withdrawal Impacts - General

The hatchery operation would be water-balance neutral; there is no net loss of water. However, potential consumptive impacts occur between the withdrawal and return locations and to a deep, confined aquifer.

Water is exchanged between the river and the aquifers underlying the site. Pumped groundwater is returned directly to the river after flowing through the hatchery and surface water infiltrates into the ground in the side channel.

During the river low flow period in early fall, the surface and ground water withdrawal amounts are roughly equal. The amount of surface water pumped from the river is replaced by groundwater discharged 100' downstream of the removal location. Surface water is returned to the side channel where some would enter the shallow aquifer (minus evaporation losses).

At other times of the year, more surface water than groundwater is used. Since some of that water would infiltrate into the ground within the side channel, there is a net loss to the river and a net gain to the aquifer. This may be a benefit to river conditions during low flow periods if some of this recharged groundwater contributes to river base flows.

The habitat benefits of adding water to the side channel have not yet been evaluated. The Yakama Nation is considering habitat projects for the property that include re-watering this side channel. Impact evaluations will be conducted as these plans are developed.

The overall impact to river flows of hatchery operations is positive or neutral during low flow conditions and as discussed in the sections below, is negligible during other times of the year.

3. Infiltration

Preliminary estimates have been made of the amount of infiltration to the groundwater aquifer that may occur as hatchery water passes through the side channel. GeoEngineers performed the estimate and used the following assumptions:

- Half of the 20 acre side channel is inundated.
- The average water depth will be 0.5 ft.
- The vertical infiltration rate is 0.26 ft/day (from the Washington Department of Ecology Stormwater Manual for loam soil).

- Groundwater mounding effects were not modeled.

Figure 3-1 below shows the results of the infiltration estimate applied to the amount of flow discharged from the hatchery into the side channel. Note that during April and May, it is estimated that all water will infiltrate to the aquifer.

Period	Hatchery Discharge *cfs*	% Infiltrated	Discharge to River *cfs*
Aug	**2.8**	50%	1.4
Sep	**3.5**	62%	2.2
Oct	**4.0**	67%	2.7
Nov	**4.5**	72%	3.2
Dec	**2.5**	50%	1.2
Jan	**2.5**	50%	1.2
Feb	**2.6**	51%	1.3
Mar	**3.3**	61%	2.0
Apr	**0.8**	100%	0.0
May	**1.1**	100%	0.0
Jun	**1.6**	13%	0.2
Jul	**2.2**	36%	0.8

Figure 3-1. Surface Water Discharge

Some field measurements were made that demonstrated higher infiltration rates than the applied value (0.26 ft/day value) used in the calculations. However, tests were not comprehensive enough to be used. More thorough field tests will be completed in the spring of 2011 and the infiltration estimates will be revised.

Water is lost to evaporation and is gained through precipitation in the side channel. GeoEngineers estimates that annual precipitation (1,017,000 cubic ft per year) is nearly the same as evaporation (1,051,000 cubic ft per year). These values are all much smaller than the annual hatchery flow to the side channel (82,529,000 cubic ft per year) and do not impact the evaluation analysis.

Recharge flow estimates, from the aquifer to the river, have not been made. It is expected that during river low flow conditions there would be an increased net movement of water from the shallow aquifer to the river. Infiltration of surface water in the side channel would contribute to Wenatchee River base flows.

4. Withdrawal Impacts – Groundwater

4.1. Well 2 Test Drilling Results

A test well was drilled in January, 2011 at well site 2. Pump tests have not yet been performed on the completed well but a layer of material from 190 ft to bedrock at 214 ft was found which has good production potential. Details are provided in the following Memorandum from GeoEngineers:

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Pumping large quantities from the confined, deep aquifer could result in net depletion and a lowering of the water table. A static water level monitoring program would help monitor this potential impact.

4.2. Potential Impacts on Other Users

An evaluation of the impact of hatchery groundwater withdrawals on the aquifer and on surface flows was completed for the Mid-Columbia Coho Restoration Project (MCCRP) Draft Environmental Impact Statement (GeoEngineers, 2010). The following is quoted from that report:

"GROUNDWATER LEVELS

There is potential for localized impacts to groundwater levels due to groundwater withdrawals at the George site. Based on existing information on the source aquifer, the drawdown cone, defined by drawdown greater than 1 foot, would reach approximately 500 to 1,500 feet depending on aquifer characteristics and the degree of confinement of the source aquifer. There are no known wells within 1,500 feet of the proposed well sites."

A map of ground and surface water rights and claims (Figure 4-1) confirms that the closest claim, #6 on the map, is over 1,500 ft upstream of George Well 2. There is no depth information available for the claim but it is a domestic well that is likely shallow.

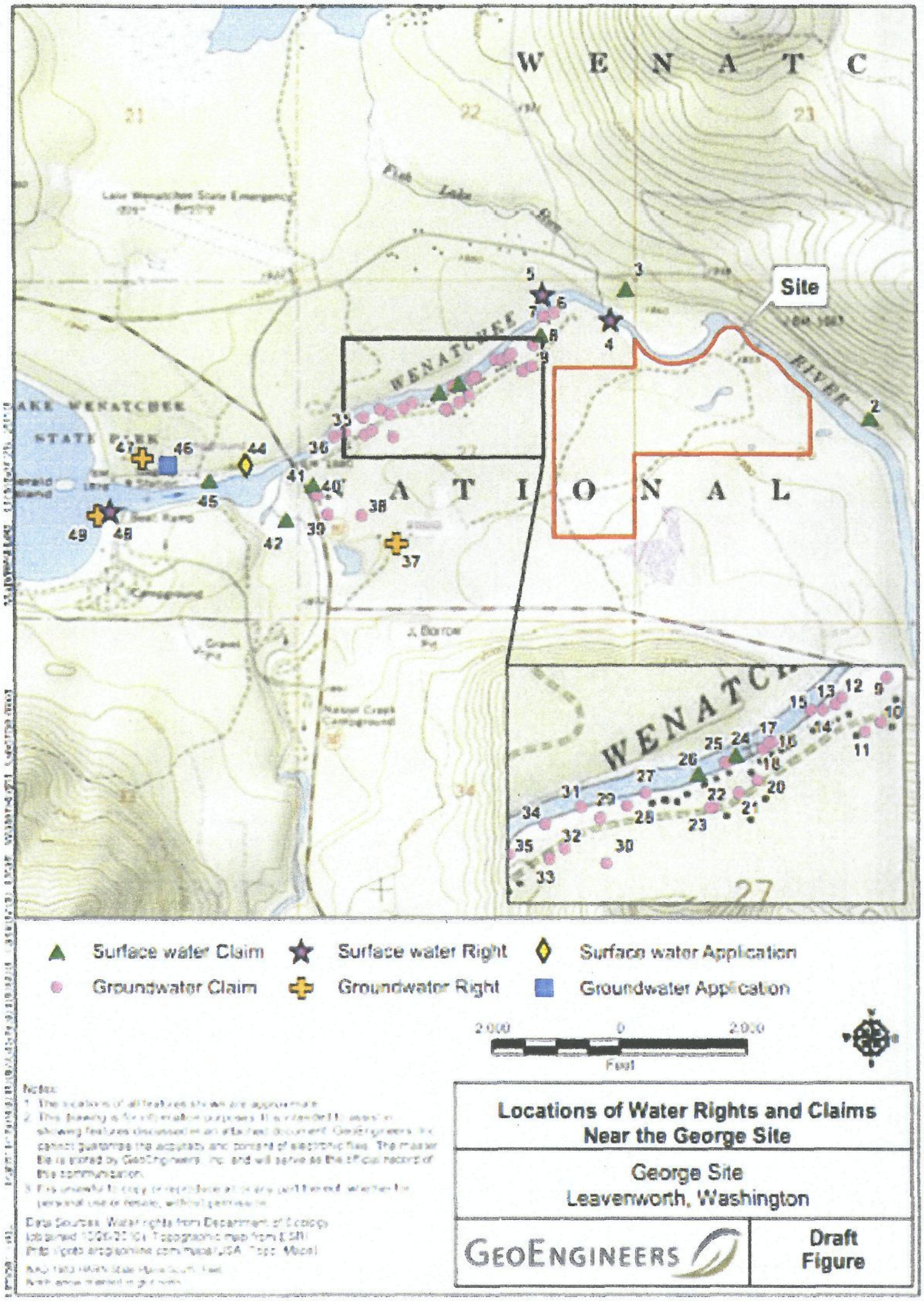

Figure 4-1. Water Rights Map

Map ID	Control #[1]	Owner	Qi (gpm)	Qi (cfs)	Qa (afy)	Acres	Purpose[2]
1	S4-025735CL	Washington DNR	--	0.01	1	--	ST
2	S4-025736CL	Washington DNR	--	0.01	1	--	ST
3	S4-033726CL	Harold Dunnagan	10	--	2	--	DG
4	S4-26882C	Harold Dunnagan	--	0.01	0.25	--	DS
5	S4-23169C	Washington DNR	--	0.5	6	--	DM, RE
6	G4-024455CL	Chelan County PUD No. 1	5	--	5	--	DG
7	G4-024455CL	Chelan County PUD No. 1	5	--	5	--	DG
8	S4-115912CL	Walter S. Glerup	10	--		--	NR
9	G4-024453CL	Chelan County PUD No. 1	5	--	5	--	DG
10	G4-024456CL	Chelan County PUD No. 1	5	--	5	--	DG
11	G4-001899CL	Cyril Smith	450	--	1.6	--	DG
12	G4-024452CL	Chelan County PUD No. 1	5	--	5	--	DG
13	G4-024451CL	Chelan County PUD No. 1	5	--	5	--	DG
14	G4-024450CL	Chelan County PUD No. 1	5	--	5	--	DG
15	G4-024448CL	Chelan County PUD No. 1	5	--	5	--	DG
16	G4-024449CL	Chelan County PUD No. 1	5	--	5	--	DG
17	G4-116449CL	Clarence Shea	--	--	--	--	DG
18	G4-083715CL	W.D. Kinsinger	--	--	--	--	DG
19	--	--	--	--	--	--	--
20	G4-024457CL	Chelan County PUD No. 1	5	--	5	--	DG
21	G4-024458CL	Chelan County PUD No. 1	5	--	5	--	DG
22	G4-155637CL	Austin Kimball	--	--	--	--	DG
23	G4-155638CL	Austin Kimball	--	--	--	--	DG
24	S4-147979CL	Harold Martret	10	--	2	--	DG
25	G4-085092CL	R. Wayne Hunter	--	--	--	--	DG
26	S4-077512CL	Harold Magnuson	--	--	--	--	DG
27	G4-024450CL	Chelan County PUD No. 1	5	--	5	--	DG
28	G4-024446CL	Chelan County PUD No. 1	5	--	5	--	DG
29	G4-059785CL	James Price	--	--	--	--	DG
30	G4-040526CL	Ruth Kriewald	--	--	--	--	DG
31	G4-072997CL	Leota Case	--	--	--	--	DG
32	G4-155639CL	Austin Kimball	--	--	--	--	DG
33	G4-138747CL	Edward Pekola	--	--	--	--	DG
34	G4-078426CL	Fred Ernst	--	--	--	--	DG
35	G4-151298CL	Joseph Weber	--	--	--	--	DG
36	G4-081084CL	Gustav Olson	--	--	--	--	DG
37	G4-30851C	Chelan County PUD No. 1	10	--	1	--	DG
38	G4-092314CL	Eugene Ertsgaard	--	--	--	--	DG
39	G4-082883CL	Westley Kriewald	--	--	--	--	DG
40	G4-086598CL	Elgin Kriewald	--	--	--	--	DG
41	S4-122355CL	F. Gilbert Lieser	--	--	--	--	DG
42	S4-067102CL	Washington DNR	--	0.01	1	--	ST
Map	**Control #[1]**	**Owner**	**Qi**	**Qi**	**Qa**	**Acres**	**Purpose[2]**
43	--	--	--	--	--	--	--
44a	S4-35272A	Chelan County PUD No. 1	--	0.01	0.24	--	FS
44b	S4-	Chelan County PUD No. 1	--	0.01	0.5	--	FS
45	S4-067101CL	Washington DNR	--	0.01	1	--	ST
46a	G4-35182A	Mark Peterson/Alpine Water District	--	0.99	500	--	MU
46b	G3-*22138C	Washington Parks	100	--	--	--	DM
46c	CS4-	Kahler Glenn Comm. Assn./Brown Road Water	--	0.12	11	--	MU
47a	CS4-SWC1390	USFS Okanogan	--	0.2	142.81	--	MU
47b	CS4-	USFS Okanogan	--	0.012	8.57	--	MU
48	S4-*19974C	Washington DNR	--	0.13	32	--	DM
49	G4-*08388C	Washington DNR	40	--	32	--	DM

[1] Control Number key-- Beginning codes: C = Change, S = Surface Water; G = Ground Water; Ending codes: CL = Claim, A = Application, P = Permit, C = Certificate

[2] Purposes: ST = Stock Watering, DG = Domestic General, DS = Domestic Single, DM = Domestic Multiple, RE = Recreation and Beautification, NR = ? (most likely a typo for IR), FS = Fish Propagation, MU = Municipal

Figure 4-2. Water Rights Map Key

The nearest groundwater certificate G4-30851C (#37 on the water right map) is controlled by Chelan County PUD No. 1 and is 1 mile from George wells 1 and 2. The well log indicates it was drilled to 124 feet in 1992.

It is unlikely that the George wells will impact other water claims or rights due to the distances that they are from the site and because the George wells would be withdrawing from a deeper aquifer.

4.3. Potential Impacts on Surface Water

The hatchery groundwater withdrawal impact report (GeoEngineers, 2010) also stated:

"SURFACE WATER FLOWS

There is potential for localized impacts to streamflows from groundwater withdrawals due to the potential that the source aquifer is in hydraulic continuity with surface water (Wenatchee River). A change in groundwater levels would result in a reduction in streamflow, the magnitude of which is dependent upon the degree of hydraulic continuity between aquifer and surface water. This minor reduction in streamflow will be completely offset and balanced by return flows from the hatchery.

Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to streamflow within the Wenatchee River basin."

Subsequent to this report, the George test Well 2 was constructed and productive materials were found in a deep aquifer. The thick layer of silt above this productive layer limits the impact of groundwater withdrawal on river flows.

5. Withdrawal Impacts – Surface Water

The impact of hatchery surface water withdrawals was also studied for the MCCRP Environmental Impact Statement (Cramer Fish Sciences, 2010). The study concluded that a 4.7 cfs withdrawal had negligible effect on ESA listed fish habitat. The report states:

"The Wenatchee River provides spawning and/or rearing habitat for ESA listed spring Chinook salmon, steelhead, and bull trout (Appendix 9 of the EIS). We

evaluated potential impacts of hatchery surface water withdrawals on microhabitat availability for ESA listed fish using the PHABSIM methodology. This approach was chosen to enable direct comparison to flow effects quantified for the George hatchery site.

Wenatchee River mean discharge below Lake Wenatchee ranges between 200 cfs and 8,000 cfs annually (Figure 14). A total of 8 [now 7.4 cfs] cfs of water would be supplied to the George hatchery via ground and surface water sources. Surface water, approximately 4.7 [now 4.5 cfs] cfs, would be withdrawn from the Wenatchee River and piped to the hatchery. Hatchery discharge would be returned to the river 3,800 feet downstream of the withdrawal via a historic side channel that maintains hyporheic (subsurface) connectivity to the main stem. Discharged hatchery water would travel 5,600 feet before reaching the main stem, and some water would likely be lost to the ground depending on the river's flow stage. For simplicity, we assumed that returned flows would be equivalent to the amount of surface flow withdrawn; thus, our study reach was defined by the upstream withdrawal and downstream discharge locations (Figure 15).

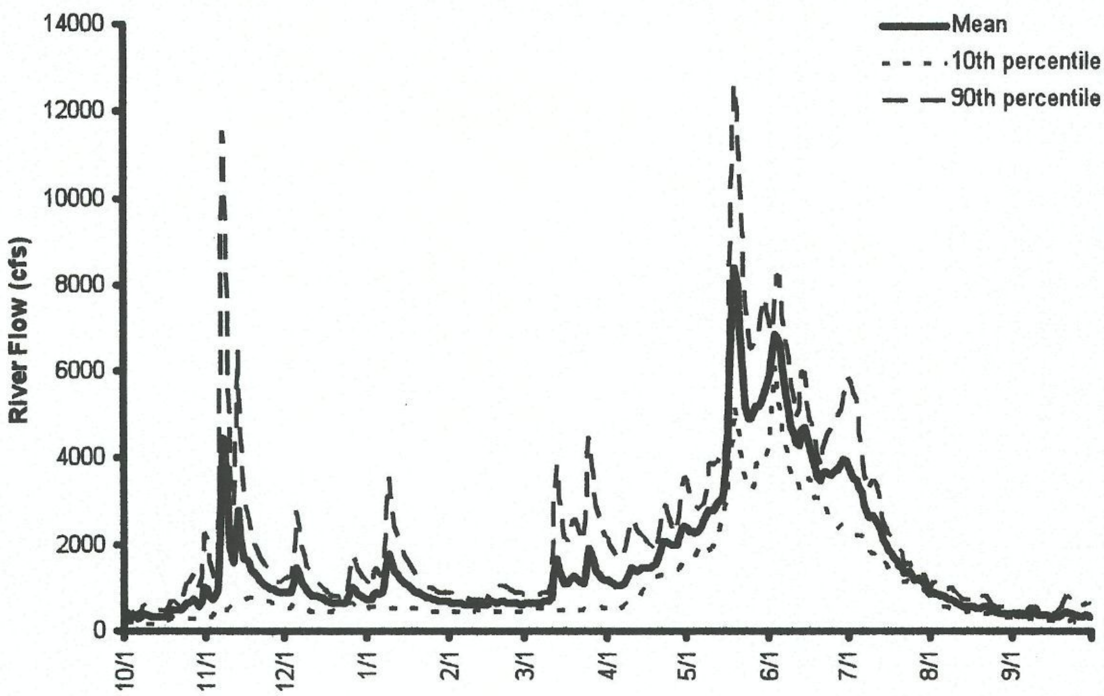

Figure 14. Wenatchee River discharge below Lake Wenatchee, water years 2005-2010. Washington Department of Ecology stream gage 45A240.

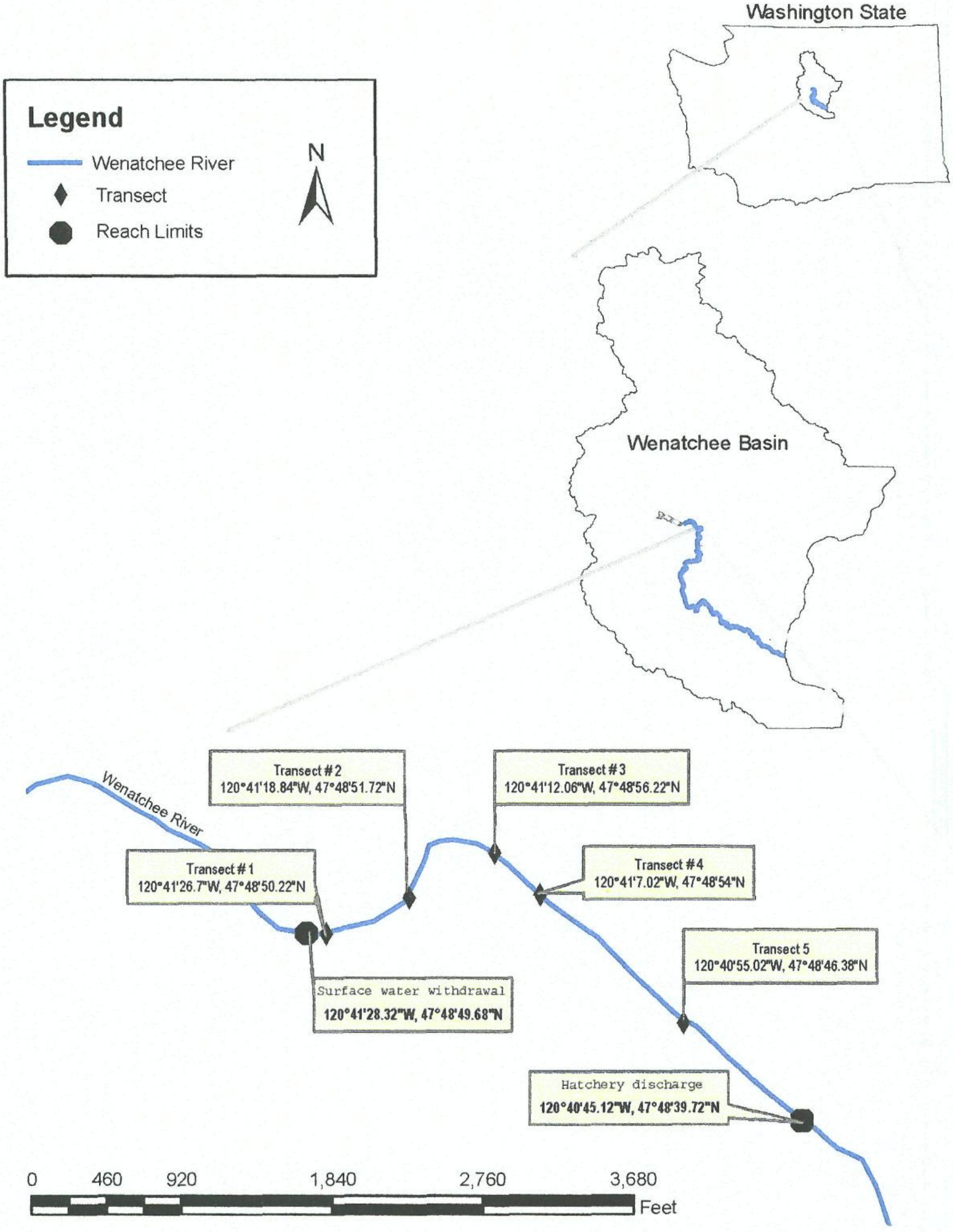

Figure 15. Map of the study reach adjacent to the George hatchery site. The reach was defined by the locations of surface water withdrawal and discharge. Locations of data collection transects are provided for reference.

The majority of the study reach was comprised of glide habitat (~60%), followed by pool (~30%) and riffle (~10%) habitat types. Stream substrate in pools was *composed of equal proportions of fines, gravel, and cobble with a small amount of boulder. Riffles had primarily gravel and cobble substrate. Glides were composed of near equal parts of fines, gravel and cobble. In-stream wood complexity was judged to be fair throughout the reach, and a total of 69 pieces of large wood were counted. Following completion of the stream habitat survey, five transects were selected in locations representative of the observed habitat composition within the study reach (Figure 15). Channel profile and water velocity data were collected at each transect in October 2010 and used to define the hydraulic characteristics of the study reach at base flows.*

Field data was used to parameterize the IFG4 hydraulic model following the "one-velocity" method described by Milhous (1984). Habitat Suitability Criteria recommended by the State of Washington (WDFW and WDOE 2004) for steelhead, spring Chinook salmon and bull trout were coupled with IFG4 program output to simulate relative changes in microhabitat availability across a range of flows. Figure 16 provides PHABSIM results across the range of flows simulated. Note that simulations were not completed for flows above 450 cfs and, therefore, our analysis was limited to low flow periods. The effect of flow withdrawals on WUA was expected to be greatest during the low flow season. Results of comparisons between the no-withdrawal and 4.7 cfs withdrawal scenarios are presented in Table 7. We caution readers not to overuse the absolute values presented in Table 7 because the difference in flow between the two scenarios is small and PHABSIM analyses are most useful for evaluating a broad range of flows. Specific values are provided in Table 7 to demonstrate that the relative change in weighted useable area (WUA) was extremely small (less than 1.5%) for all species and life-stages. Thus, a 4.7 cfs flow change during low and extreme low flows in the Wenatchee River had negligible effects on WUA simulated for spring Chinook, steelhead and bull trout.

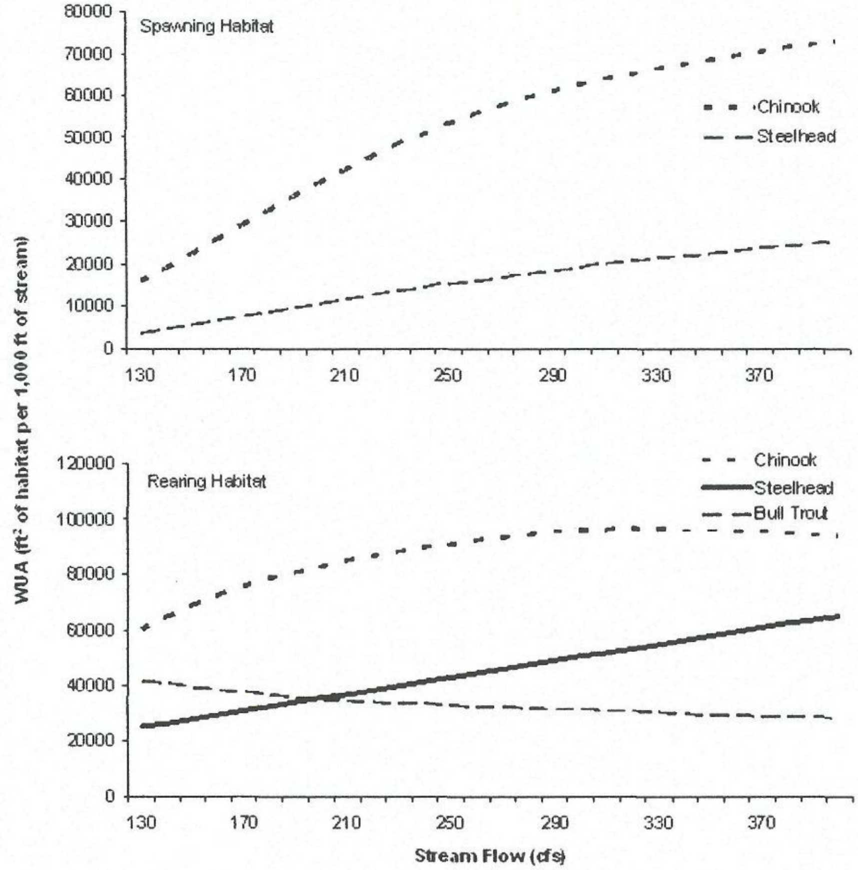

Figure 16. Estimated weighted useable area for spawning and rearing habitat as a function of fall stream flow in the Wenatchee River study reach.

Table 7. Estimated percent of weighted usable area for ESA listed species in the Wenatchee River study reach under low flow and extreme low flow conditions. Low flows for the study reach were calculated from available WDOE stream gauge data. Values are provided for current conditions and conditions expected if flows are reduced by 4.7 cfs.

Species	Lifestage	Timing	Flow type	Flow (cfs)	% of WUA	- 4.7cfs % of WUA
Chinook	Spawning	Aug-Sep	Extreme low	136	13.2%	12.1%
			Mean low	263	37.5%	36.7%
	Rearing	All year	Extreme low	136	44.8%	43.4%
			Mean low	263	62.4%	62.0%
Steelhead	Spawning	Mar-May	Extreme low	136	3.2%	2.9%
			Mean low	263	11.0%	10.7%
	Rearing	All year	Extreme low	136	18.5%	18.0%
			Mean low	263	30.1%	29.6%
Bull trout	Rearing	All year	Extreme low	136	28.2%	28.6%
			Mean low	263	22.1%	22.2%

6. Acronyms

Abbreviation	Definition
cfs	cubic feet per second
EIS	Environmental Impact Statement
MCCRP	Mid-Columbia Coho Restoration Project
PHABSIM	Physical Habitat Simulation System
Q	Flow
WUA	Weighted Usable Area
WDOE	Washington Department of Ecology
WDFW	Washington Department of Ecology

7. References

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