

Groundwater Conditions at the Leavenworth National Fish Hatchery, Leavenworth, Washington



U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region Boise, Idaho In cooperation with:



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Groundwater Conditions at the Leavenworth National Fish Hatchery, Leavenworth, Washington

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In cooperation with the U.S. Fish and Wildlife Service

Cover Photo: Leavenworth Hatchery Channel by K. Didricksen.



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Executive Summary

The Leavenworth National Fish Hatchery (Hatchery) depends on groundwater from 7 production wells that supplement the surface water supply from Icicle Creek. Groundwater is also used to adjust the temperature of surface flows to meet fish production targets. Extended production from the shallow wells is dependent on aquifer recharge that is sustained by diverting Icicle Creek flows into the man-made Hatchery channel.

From 1940 to 2005, Hatchery operations directed most creek flows into the Hatchery channel, which helped recharge the aquifer but limited flow into the historic channel of Icicle Creek. Since 2006, operations were changed to improve fish passage and habitat in the historic channel. The gates at the control structure are currently open most of the year and the Hatchery channel usually remains dry. For two weeks at a time the gates are partially closed and water is diverted into the Hatchery channel. Although these recharge periods help well production temporarily, a two week period has not been sufficient to significantly improve well capacity.

A groundwater flow model was developed in the mid-1990's by GeoEngineers using MODFLOW96 software. The model simulates groundwater flow conditions in the shallow sand and gravel aquifer beneath the site. At the time of model development, water was diverted to the Hatchery channel on a regular basis so the GeoEngineers model simulated this source of recharge to the aquifer. In order to update the model for current Hatchery operations, features within the model were changed to represent current conditions and the absence of continuous recharge from the Hatchery channel.

In October 2009, Hatchery management adjusted the control structure gate and diverted water into the Hatchery channel to promote aquifer recharge. During that two week period, water levels were measured in Hatchery wells to monitor the aquifer response to the induced recharge. The test results were incorporated into the updated groundwater model and the model was recalibrated. During calibration, the parameters of riverbed conductance, hydraulic conductivity and storativity of the aquifer were adjusted to match simulated observations to measured observations over time. Following calibration, predictive simulations (scenarios) were run with the updated model to represent pumping conditions and the effect of induced aquifer recharge by diverting water into the Hatchery channel for various time durations. The purpose of these simulations was to determine the aquifer response to various combinations and duration of recharge to help manage groundwater use at the Hatchery.

A total of 8 predictive scenarios were run with the updated model. The pumping schedule for the production wells remained the same for all of the scenarios while the seasonal water level conditions and the presence or absence of water in the Hatchery channel were varied.

Results from the scenario model runs show that the presence of water in the Hatchery channel is of primary importance to extended pumping from the Hatchery production wells. Recharge from the canal raises aquifer water levels and maintains higher levels, even during well pumping. Without that source of induced recharge, water levels quickly fall and some wells are forced to stop pumping as the water levels drop to the pump intake elevations. A cycled diversion to the Hatchery channel, consisting of 15 days with water in the Hatchery channel followed by 15 days without water, allows full extended pumping from all of the production wells. If water is diverted to the channel for only 15-days (then the channel is dry for the remaining 45 days of the 60-day simulation) the wells with relatively shallow pump settings are forced to shut-off after about 42 to 58 days of pumping, depending on the seasonal water level conditions.

1 Introduction

1.1 Purpose and Scope

The purpose of this report is to:

- 1) Update the available groundwater information for the Hatchery with current data.
- 2) Describe the changes made to a numerical groundwater flow model of the site.
- 3) Document the modeling results in order to evaluate the groundwater supply capacity under various recharge conditions.

1.2 Background

The Hatchery has used groundwater as a supplemental source of water since about 1940. Groundwater is used periodically to enhance water quantities and adjust the temperature of surface flows to meet fish production targets (USFWS, 2009a). A flow control structure, known as "Structure No. 2", is located at RM 3.8 on Icicle Creek, and was designed to divert flow into a man-made channel, called the "Hatchery channel" (Figure 1-1). The Hatchery channel was built in the late 1930's so a portion of Icicle Creek could be used to accommodate Hatchery fish production. Diverting flow into the Hatchery channel protected those in-creek Hatchery operations, particularly during high flow events. The Hatchery channel is about 5 feet higher than the historic channel of Icicle Creek and parallels the historic channel for 1 mile, before rejoining the creek at RM 2.8. Production wells for the Hatchery are located just west of the Hatchery channel and benefit from increased recharge provided by diverting water into the channel.

From 1940 to 2005, Hatchery operations directed most creek flows into the Hatchery channel (the gates at Structure No. 2 were regularly closed), which limited flow into the historic channel of Icicle Creek. Since 2006, operations were changed to improve fish passage and habitat in Icicle Creek. The gates at Structure No. 2 are fully open most of the year and the Hatchery channel remains dry. Since operation changes, the restriction of flow in the Hatchery channel reduces recharge to the shallow alluvial aquifer and reduces pumping capacity of the Hatchery's production wells.

1.3 Use of Groundwater at the Hatchery

The Hatchery needs between 1,060 gallons per minute (gpm) and 6,590 gpm of groundwater during its fish production cycle (Sverdrup 2000). The largest demand is in June (6,590 gpm)¹ to supply cool water to the holding adults and again in December (6,110 gpm), when young salmon fry begin to feed. Groundwater use continues throughout the winter months in order to temper cold surface water used on yearling salmon in outdoor ponds (USFWS, 2009a). The groundwater is also used to cool surface water in the summer months as surface water temperatures begin to rise.

Since 2006, the gates at Structure 2 are not closed for more than two weeks at a time in order to maintain higher flows in the historic channel of Icicle Creek. However, the two week period of diversion into the Hatchery channel has not been sufficient to significantly improve well capacity. Without aquifer recharge from the Hatchery channel, well production is substantially reduced (USFWS, 2009a).

The timing and quantity of surface water needed to maintain recharge to the aquifer in order to support the production wells needs to be known to optimally manage the water supply at the Hatchery.

¹ Quantities listed are from hatchery records from 10/1998 - 09/1999. In 2008, pumping rates were less than 4,600 gpm all year (personal communication, F. Wurster)



Figure 1-1: Location of Hatchery features.

1.4 Water Rights

Table 1-1 lists the water rights that have been issued by the State of Washington for the Hatchery.

Certificate	Source	Purpose of	Priority Date	Amount
Number	Source	I ut pose of	I Horney Date	Amount
1824	Jaiola Crook	Fish	3/26/12	$42 \mathrm{ofs}$
1024	ICICIE CIEEK	Dranastian	3/20/42	42 018
		Propagation		
1825	Snow and	Fish	3/26/42	16,000 AF
	Nada Lakes	Propagation		
3103-A	Groundwater	Fish Culture	10/16/57	1200 gpm/
(well 1)				1120 AF
Claim # 016379	Groundwater	Fish Culture	6/1940	900 gpm/
(well 2)				730 AF
Claim # 016378	Groundwater	Fish Culture	8/1939	700 gpm/
(well 3)				570 AF
G4-27115C	Groundwater	Fish	10/20/80	3900 gpm/
(well 4: 800		Propagation		5257 AF
gpm, well 5:				
1500 gpm, well				
6: 1200 gpm,				
well 7: 400				
gpm)				

Table 1-1: Water rights for the Hatchery.

A water right to divert water from the Wenatchee River to supplement Icicle Creek flow was abandoned in the 1980's (personal communication, F. Wurster).

2 Hydrogeologic Setting

Unconsolidated sediments of glaciofluvial and river origin underlie the Hatchery site and consist of interbedded gravel, sand, silt and clay. Granite bedrock underlies the sediments and forms a north-northeast trending trough beneath the site. Bedrock is encountered at depths ranging from about 190 feet in the south to 320 feet in the central part of the Hatchery. The unconsolidated sediments are stratified (layered) and comprise two aquifers; a shallow unconfined aquifer of sand and gravel that extends over most of the valley and a deeper confined aquifer of more limited extent.

The shallow aquifer has a maximum thickness of about 200 feet near well 4, in the central part of the site, but is typically 80 to 100 feet thick in other areas. The deep aquifer is about 30 to 50 feet thick and is limited to the north-central part of the site, near wells 5 and 6. The deep, sand and gravel aquifer is confined by overlying layers of silt and clay. Since the clay layers are not continuous, the aquifer is likely semi-confined or leaky and is probably influenced by stresses (pumping) and recharge in the overlying unconfined aquifer.

Drill logs for the Hatchery wells indicate that the shallow aquifer is stratified with layers and stringers of silt and clay interspersed with sand and gravel. Several test wells have been drilled onsite that have not encountered productive aquifer materials or have limited exposures of the aquifer. Hydraulic conductivity probably varies significantly in the horizontal and vertical directions due to the stratification of the aquifer.

2.1 Aquifer Properties

During 1994, constant rate pumping tests were conducted in each of the 7 production wells and a 24-hour constant rate test was conducted with all 7 wells pumping simultaneously (GeoEngineers, 1995). Transmissivity and hydraulic conductivity values for the shallow and deep aquifers were calculated using data obtained during the individual aquifer tests (GeoEngineers, 1995). The transmissivity of the shallow aquifer ranged between 25,000 ft²/d (square feet per day) and 85,000 ft²/d. The calculated transmissivity of the deeper aquifer was about 6,000 ft²/d. Based on aquifer thicknesses of the shallow aquifer ranging from 80 to 200 feet and assuming homogeneous conditions in the aquifer, the hydraulic conductivity ranges from 283.5 ft/d (feet per day) to 425.2 ft/d. The hydraulic conductivity of the deep aquifer is about 142 ft/d.

The calculated storativity values determined from the aquifer test data ranged between 0.005 and 0.02 for the shallow aquifer and between 1 x 10^{-5} and 5 x 10^{-4}

for the deep aquifer (GeoEngineers, 1995). The storativity values for the shallow unconfined aquifer are lower than typical for sand and gravel aquifers, and may be related to the stratification of the glaciofluvial and alluvial aquifer materials.

Well interference drawdown of as much as 3.5 feet (additional water level drawdown) was observed during the individual pumping tests in the shallow aquifer (GeoEngineers, 1995). During the tests, water flowing in the Hatchery channel was actively recharging the shallow aquifer, which prevented excessive drawdown in the wells. Current conditions of no water flowing in the Hatchery channel results in greater drawdown and more interference between the wells.

2.2 Groundwater Temperature

The Hatchery staff monitored well water temperature in selected wells during water year 2009 (USFWS, 2009b). Water in the shallow aquifer averages about 48° F to 49° F (degrees Fahrenheit) in wells 4a and 7, with a range from 43.2° F to 53.4° F. Water temperature in well 5, in the deep aquifer, averages 52.8° F. Well 6, completed in both aquifers, has a composite temperature averaging 50.1° F.

The lowest water temperature recorded for well 7 (43.2° F) occurred in May, 2009 and the highest water temperature (53.4° F) was recorded in November, 2008. Surface water temperatures are generally lowest in mid-winter and highest in the summer. The lag time of several months between high and low temperatures in the surface water of Icicle Creek and the groundwater temperature in well 7 is probably a result of the travel time of groundwater flow through the aquifer.

3 Seepage Monitoring

During September 2009, the Bureau of Reclamation (Reclamation) Pacific Northwest Regional drill crew was at the Hatchery to drill investigative boreholes to provide design level geologic information for repairs to various structures at the site. During that time, water resource specialists from Reclamation and the U.S. Fish and Wildlife Service (USFWS) were discussing data needs to better monitor the hydrologic conditions and groundwater use at the Hatchery. The Hatchery was planning to divert water into the Hatchery channel for a span of two weeks in early October to recharge the aquifer (and increase capacity of their production wells). It was decided to have four shallow observation wells drilled by the Reclamation drill crew and use the wells to monitor water seepage from the Hatchery channel into the shallow aquifer. Well data from the new observation wells are tabulated in Table 3-1. All of the available well logs and well construction schematics from the Hatchery site are included in Appendix B. The location of the wells and other features of the Hatchery site are shown on Figure 1-1.

The purpose of the seepage monitoring was to determine the temporal and spatial response within the shallow aquifer to the addition of water in the Hatchery channel. This information was then used to update and adjust calibration parameters within an existing MODFLOW groundwater flow model, developed in 1994 by GeoEngineers (1995). It has long been understood that water-flow in the Hatchery channel provides recharge to the shallow aquifer and Hatchery production wells, but operations at the Hatchery have changed since the flow model was developed and the model needed to be updated to reflect current Hatchery operations prior to using the model to run new predictive scenarios.

Well Number	Northing	Easting	Elevation of MP (top PVC)	Depth of Completed Well (feet)
OW-09-1	1678875.015	200668.731	1149.981	37.0
OW-09-2	1679510.438	201404.146	1149.709	42.0
OW-09-3	1679758.376	202309.673	1152.622	48.0
OW-09-4	1679741.378	201341.592	1149.076	42.0

Table 3-1: Well data for new observation wells at the Hatchery

Survey datum NAD83, projection State Plane Washington North, vertical datum NAVD88.

Each of the new observation wells was completed with 2-inch diameter, Schedule 40 PVC piezometer pipe that had a 5-foot length of slotted pipe (0.020-inch slot) at the bottom. From September 29 to October 23, the wells were equipped with Instrumentation Northwest PT2X pressure transducers with dedicated data loggers for hourly monitoring of water levels.

In addition, two In-Situ Level Troll 500 transducers were placed in the Hatchery channel to monitor water levels. Locations of the channel transducers are shown on Figure 1-1. Hatchery personnel measured water levels daily in 5 of the production wells (wells 1, 2, 3a, 4a, and 7) and in wells 9, 10 and TW2. Only production well 5 was pumped during the 2-week time period. The hydrographs of the field data from each of the monitored wells are included in Appendix C.

The flow control gate at Structure No. 2 was partially closed beginning September 30 to divert a portion of the flow from Icicle Creek into the Hatchery channel. The gate was again adjusted to the full open position beginning on October 13. Observed flows and gate measurements are included in Appendix C.

3.1 October 2009 Monitoring Results

As shown in the graphs of the well response data (included in Appendix C), water levels in the shallow aquifer responded almost immediately to recharge from the Hatchery channel. Aquifer water levels in the Hatchery area were raised about 6 feet during the 2 week recharge period. Accordingly, as the diversion of surface water to the channel ended, groundwater levels quickly declined (in OW-3 the water level declined about 4 feet in the first 4 days). This response indicates high conductivity in the shallow aquifer. It also indicates that temporarily recharging the aquifer by diverting water to the Hatchery channel has only short-term benefits to increasing well capacity.

4 Groundwater Modeling

Groundwater modeling was used in this study to incorporate the new data acquired during the seepage monitoring and to evaluate possible Hatchery water management plans.

4.1 Previous Modeling Work

In the mid-1990's, GeoEngineers developed a 3-dimensional, numerical groundwater flow model, utilizing the USGS MODFLOW96 software, to simulate groundwater conditions in the shallow aquifer beneath the site (GeoEngineers, 1995). The shallow aquifer was simulated as a single, isotropic, unconfined layer. The model did not include the deeper, confined aquifer. The model consists of a 45 by 45 cell grid (2,025 cells total) that are 100 feet on each side.

Hydrologic features, such as production wells and streams (represented by MODFLOW river features) were included in the model. Production wells 1, 2, 3A, 4, 6, and 7 each occupy a separate cell; well 5 was not simulated because it is completed in the deeper confined aquifer. The Hatchery channel, Icicle Creek, and two ditches (Wenatchee Channel², a.k.a. onsite ditch, and the Icicle Irrigation District canal) were included, as well as areas that receive surface irrigation within the model domain.

Model input parameters, such as hydraulic conductivity and storativity, were determined from the pump testing program that GeoEngineers conducted during 1994. The measured parameters were used as starting points and then were manually adjusted during calibration of the model to match observed water level conditions. Following calibration of the steady state simulations, transient conditions were simulated to calibrate to the pumping test data and to run predictive scenarios for various pumping operations. In each case, and under high and low water conditions, the model simulated water flowing in the Hatchery channel. The results of the scenarios and a full description of the model development are included in Appendix E of the GeoEngineers (1995) report.

 $^{^{2}}$ During the 1990's, water in the Wenatchee channel was excess spill from a mixing chamber in the Hatchery pipeline.

4.2 Current Model Updates

Adjustments were made to the GeoEngineers model (Version 1) to incorporate new data from the seepage monitoring and to represent current water operations and management practices. When the original model was developed, surface water was regularly diverted to the Hatchery channel and the onsite ditch (Wenatchee Channel), so these features were incorporated as sources of recharge. Since operations of Structure No. 2 were modified, both channels are dry except during periods of high flows and during 2-week periods when water from Icicle Creek is temporarily diverted to the Hatchery channel. The more recent activity was incorporated into a new version (Version 2) of the GeoEngineers model. The Version 2 model also used an updated version of the modeling software, MODFLOW2000.

High resolution LiDAR data (2006) were incorporated to improve the accuracy of ground surface and channel bottom elevations. The results of HEC-RAS modeling (Knutson, 2009) were used to provide river stage and bottom elevations at various locations along Icicle Creek using the flow rates observed during the October 2009 seepage monitoring. Water depths for the Hatchery channel were stage values recorded by pressure transducers. Since the seepage monitoring occurred during the non-irrigation season, areal recharge due to irrigation was not included during the recalibration. In addition, no precipitation occurred during the monitoring period, so areal recharge due to precipitation was not included.

Hydraulic conductivity, storativity, river conductance, and general head boundary conductance values were adjusted during the recalibration of the model. The calibration model was a time-dependent simulation with a 12-hour stress period, meaning that the water levels in the Hatchery channel and Icicle Creek were adjusted every 12 hours. Water level observations were recorded in wells 1, 2, 3a, $4a^3$, and 7 during the seepage monitoring and were used during the calibration process. The parameters were adjusted to also calibrate the model to the observed water level response in the 4 new observation wells (OW-1 through OW-4) monitored during the seepage monitoring. The model matched the observed water levels to within 10 percent of the total change in head, 13.5 feet, which is generally considered well calibrated. Figure A-6 in Appendix A shows the modeled versus observed head values. A perfect match between modeled and observed would graph along a straight line, with an R-squared value of 1. The modeled versus observed values in this model plot along a line with an R-squared value of 0.78, which is considered good. A detailed description of the model development and calibration is included in Appendix A.

³ A new pump well, well 4a, was drilled near original pump well 4 in January 2009 but well 4a has a lower well yield (about 500 vs 850 gpm) and the pump intake is at a higher elevation, which limits the available drawdown. The model uses well 4a in the pumping scenarios.

4.3 Scenarios

Predictive simulations were run with the Version 2 model to represent pumping conditions and the effect of induced aquifer recharge by diverting water into the Hatchery channel for various time durations. The purpose of these simulations was to determine the aquifer response to various combinations and duration of recharge to help manage groundwater use at the Hatchery.

Previous studies at the Hatchery (GeoEngineers, 1995) recommended a pumping schedule based on the well characteristics such as specific capacity, available drawdown and well interference effects observed during the pumping tests. Their schedule was developed under the condition of full Hatchery channel flow, so it reflected a different recharge condition than what exists currently. The recommended schedule was modified slightly to compensate for the changed condition and is shown in Table 4-1.

Table 4-1:	Recommended schedule for production well pumping (modified from
GeoEngine	eers, 1995)

Discharge (gpm)	Constant Pump Wells	Cycled Pump Wells ¹
Up to 3,000	Wells 1, 4a and 6	Wells 2, 3A, and 7
4,000 ²	Wells 1, 4a, 5, and 6	Wells 2, 3A and 7

1. Pumping cycle of 15 days on, 15 days off is intended to allow water levels to recover after extended periods of pumping.

2. Maximum sustainable flow rate from the existing production wells in late summer and fall was estimated in 1995 to be about 6,000 gpm. Without artificial recharge from the Hatchery channel, those rates are significantly decreased. This combination of wells (including well 5) was not modeled because well 5 is completed in the deeper aquifer.

Each of the scenarios was run under simulated high water level conditions (to represent late spring and early summer) and low water level conditions (to represent late summer through winter). The high water level condition was represented by increasing the general head boundary (GHB) elevation to 1147.0 feet (from 1140.0 feet) and by simulating a high flow rate in Icicle Creek (2100 cfs). The low water level condition matched the calibrated, non-irrigation season condition.

The simulated pumping rates for wells 1, 2, 3A, 4A, 6, and 7 are 800, 600, 400, $500, 400^4$, and 300 gpm, respectively. These rates were common discharge rates for the wells during 2008 and 2009. Well 5, which is capable of producing up to 1100 gpm, but is normally pumped at about 900 gpm, was not included in the model simulations since it is completed in the deeper, confined aquifer. During periods of high demand, the combination of well 5 with the other production wells would produce more than 4,000 gpm.

⁴ Well 6 pumps about 700 to 800 gpm but draws from both the shallow and deep aquifer. A reduced amount of discharge was simulated in the model scenarios to represent only that portion that is from the shallow aquifer.

Distributed recharge (from precipitation and applied on-farm irrigation) was not included in the model. The water level conditions (high or low) and Hatchery channel conditions for the model scenarios are listed in Table 4-2.

Scenario	High or Low Water Conditions	Full or Dry Hatchery Channel	Wells Pumping for full 60- day duration	Wells Pumping for 15-day alternate cycles ¹
1	High	Dry	1, 4A, 6	2, 3A, 7
2	Low	Dry	1, 4A, 6	2, 3A, 7
3	High	Full	1, 4A, 6	2, 3A, 7
4	Low	Full	1, 4A, 6	2, 3A, 7
5	High	Cycle: Full – 15 days, Dry – 15 days	1, 4A, 6	2, 3A, 7
6	Low	Cycle: Full – 15 days, Dry – 15 days	1, 4A, 6	2, 3A, 7
7	High	Cycle: Full - 15 days, Dry - 45 days	1, 4A, 6	2, 3A, 7
8	Low	Cycle: Full - 15 days, Dry - 45 days	1, 4A, 6	2, 3A, 7

Table 4-2:	Conditions	for	Model	Scenarios
1 abic 7-2.	Containing	101	mouci	Scenarios

1- well 2 pumps for 15 days while wells 3 and 7 are allowed to recover, then wells 3 and 7 pump for 15 days while well 2 recovers.

During the 60 day model simulation, it was possible for the water levels to drop below the pump intake elevation because MODFLOW does not account for the intake depth. When this occurred, a second version of the scenario was run with the well turned off when the water level in the well reached 5 feet above the intake depth. Only the second version of the scenario is shown in the results below; however, the times (in days) at which the water level elevations dropped below the water level cut-off elevation (WLCO) are noted. Table 4-3 lists the pump intake elevations used to control the pumping of wells in the model scenarios.

Well Number	Intake Depth	Pump Intake Elevation	Water Level Cut-off Elevation (pump intake + 5 ft)
1	70	1078	1083
2	70	1078	1083
3a	55	1096.3	1101.3

 Table 4-3: Pump intake elevations used in model scenarios

4a	60	1091.3	1096.3	
6	103	1048.3	1053.3	
7	75	1073.7	1078.7	

4.3.1 Scenario 1 results

Figure 4-1 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 1 (high water levels, dry channel). Arrows on the data line for well 3a explain the water level fluctuations seen on the scenario graphs; they are due to the 15-day cycling on/off of wells 2, 3a, and 7. In scenario 1, the water level in well 3a dropped below the WLCO elevation after 36 days.



Figure 4-1: Plot of water level elevation in pumping wells under scenario 1 conditions.

With the channel dry, the overall water surface elevation declines under pumping conditions.

4.3.2 Scenario 2 results

Figure 4-2 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 2 (low water levels, dry channel). In scenario 2, the water level in well 3a reached the WLCO elevation after 30 days and in well 4a after 37 days. Extended pumping from these wells is limited by water supply and by the shallow placement depth of the pump in well 4a. The available drawdown in original well 4 is significantly greater, since the pump intake is about 30 feet lower in well 4 than in well 4a.



Figure 4-2: Plot of water level elevation in pumping wells under scenario 2 conditions.

The water surface elevation declines overall as a result of the pumping conditions and it has not yet reached an equilibrium condition at day 60. The water surface declines faster in the low water condition than in the high water condition (scenario 2 vs. scenario 1). The pumps have a similar localized effect on the water surface elevation near the pumping wells. Without the addition of recharge from the Hatchery channel to maintain a higher water level in the aquifer, the pumping wells with shallow pump settings are not sustainable for extended pumping periods.

4.3.3 Scenario 3 results

Figure 4-3 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 3 (high water levels, full channel). In scenario 3, the water level elevations remained above the WLCO elevations for all wells.



Figure 4-3: Plot of water level elevation in pumping wells under scenario 3 conditions.

With a full channel, the overall water level in the shallow aquifer increases. After about 50 days, the water surface elevation in the pumped wells nearly reaches equilibrium, indicating that pumping can continue for extended periods.

4.3.4 Scenario 4 results

Figure 4-4 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 4 (low water levels, full channel). In scenario 4, the water level elevations remained above the pump intake elevations for all wells.



Figure 4-4: Plot of water level elevation in pumping wells under scenario 4 conditions.

As in scenario 3, the full channel provides recharge to the shallow aquifer and the overall water level increases. After about 50 days, the water surface elevation in the pumped wells nearly reaches equilibrium. The addition of recharge from the Hatchery channel is much more important than seasonal water level conditions in determining the ability to pump from the shallow aquifer.

4.3.5 Scenario 5 results

Figure 4-5 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 5 (high water levels, cycling water into the Hatchery channel every 15 days). In scenario 5, the water level elevations remained above the WLCO elevations for all wells.



Figure 4-5: Plot of water level elevation in pumping wells under scenario 5 conditions.

When water is diverted to the channel, the overall water surface elevation increases, even during well pumping, but the water level declines sharply when the channel is empty. The amount of water in the channel has a larger impact on the aquifer water level than the drawdown effects from pumping the wells.

4.3.6 Scenario 6 results

Figure 4-6 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 6 (low water levels, cycling water into Hatchery channel every 15 days). In scenario 6, the water level elevations remained above the WLCO elevations for all wells.



Figure 4-6: Plot of water level elevation in pumping wells under scenario 6 conditions.

When the channel is full, the overall water surface elevation increases and it declines sharply when the channel is empty. The amount of water in the channel has a larger impact on the aquifer water level than the pumping effects from the wells. These periodic recharge events allow pumping from the wells during the entire simulation period.

4.3.7 Scenario 7 results

Figure 4-7 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 7 (high water levels, water in Hatchery channel for only 15 days). In scenario 7, the water level in well 3a reached the WLCO elevation after 51 days and in well 4a after 58 days.



Figure 4-7: Plot of water level elevation in pumping wells under scenario 7 conditions.

Water diverted to the Hatchery channel for the first 15 days of this scenario supports a raised water level in the aquifer. When water is no longer diverted to the channel, the water level drops steeply and the final water levels (at 60 days) are similar to those in scenario 1 that diverts no water to the channel.

4.3.8 Scenario 8 results

Figure 4-8 shows a plot of the water level elevation in the pumping wells under the conditions described for scenario 8 (low water levels, water in Hatchery channel for only 15 days). In scenario 8, the water level in well 3a reached the WLCO elevation after 42 days and in well 4a after 55 days. The low seasonal water conditions reduced the time available to pump wells 3a and 4a, as compared to scenario 7 with high water level conditions. As in the other scenarios in which water is not diverted to the Hatchery channel, the aquifer cannot support extended pumping of the production wells without the addition of recharge from the Hatchery channel.



Figure 4-8: Plot of water level elevation in pumping wells under scenario 8 conditions.

Scenario	High or Low Water	Full or Dry	Number of days wells can pump during 60-day model simulation ¹		
	Conditions	Hatchery Channel	Well 3a	Well 4a	Wells 1, 2, 6, 7
1	High	Dry	36	С	С
2	Low	Dry	30	37	С
3	High	Full	С	С	С
4	Low	Full	С	С	С
5	High	Cycle: Full – 15 days, Dry – 15 days	С	С	С
6	Low	Cycle: Full – 15 days, Dry – 15 days	С	С	С
7	High	Cycle: Full - 15 days, Dry - 45 days	51	58	С
8	Low	Cycle: Full - 15 days, Dry - 45 days	42	55	С

Table 4-4:	Summary	of Scenario	Results
\mathbf{I} abit $\mathbf{T}^{-}\mathbf{T}_{0}$	Summary	or occutatio	ICourto

1 - At the day listed, the modeled water level elevation drops to 5 feet above the pump intake elevation (see table 4-3) and the pump is turned off for the remainder of the simulation period. C = continuous pumping (wells 2 and 7 cycle on/off every 15 days during simulation period) This page intentionally left blank.

5 Conclusions and Recommendations

The Hatchery depends on groundwater from 7 production wells that supplement the surface water supply from Icicle Creek. Groundwater is also used to adjust the temperature of surface flows to meet fish production targets.

Unconsolidated sediments of glaciofluvial and river origin underlie the Hatchery site and consist of interbedded gravel, sand, silt and clay. The unconsolidated sediments are stratified (layered) and comprise two aquifers; a shallow unconfined aquifer that extends over most of the valley and a deeper confined aquifer of more limited extent. All but one of the Hatchery's production wells pump from the shallow unconfined aquifer. Well 5 is completed in the deeper aquifer and well 6 is screened in both aquifers.

From 1940 to 2005, Hatchery operations directed most creek flows into the Hatchery channel, a man-made channel built in the late 1930's so that a portion of Icicle Creek could be used to accommodate Hatchery fish production. It has long been understood that water flow in the Hatchery channel provides recharge to the shallow aquifer. Since 2006, operations were changed to improve fish passage in Icicle Creek. The gates at the diversion control structure are kept open most of the year and the Hatchery channel is usually kept dry. Under current operations, the gates are partially closed at the control structure for two weeks at a time, allowing water into the Hatchery channel. Although these recharge periods help well production temporarily, a two week period has not been sufficient to significantly improve well capacity.

Groundwater monitoring during October 2009 helped quantify the aquifer response to induced recharge by diverting water into the Hatchery channel. The purpose of the monitoring was to determine the temporal and spatial response within the shallow aquifer to the addition of water in the Hatchery channel. The test results were used to update and adjust calibration parameters within an existing MODFLOW groundwater flow model that was developed by GeoEngineers (1995). Other updates to the model were also completed to better represent current Hatchery conditions.

Following calibration, predictive simulations were run with the updated model to represent pumping conditions and the effect of induced aquifer recharge by diverting water into the Hatchery channel for various time durations. The purpose of these simulations was to determine the aquifer response to various combinations and duration of recharge to help manage groundwater use at the Hatchery. Each simulation was run for 60-days.

A total of eight predictive scenarios were run with the updated (Version 2) model. The pumping schedule for the production wells remained the same for all of the scenarios while the seasonal water level conditions and the presence or absence of water in the Hatchery channel was varied.

Results from the scenario runs show that the presence of water in the Hatchery channel is of primary importance to extended pumping from the Hatchery production wells. Recharge from the channel raises aquifer water levels and maintains higher levels, even during well pumping. Without recharge from the channel, water levels quickly fall and some wells are forced to stop pumping as the water levels drop to the pump intake elevations. A cycled diversion of 15 days of water in the channel followed by 15 days without water, allows pumping from all of the production wells for the 60 day simulation. If water is diverted to the channel for only 15 days, and the channel is dry the remaining 45 days, the wells with relatively shallow pump settings are forced to shut off after 42 to 58 days of pumping, depending on the seasonal water level conditions.

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Appendix A: Version 2 Model and Scenario Development

The Version 2 groundwater model of the Hatchery used the GeoEngineers model (Version 1 model) as a starting point to develop an upgraded model of the system. The cell size, number of cells, and location of the boundary conditions remained the same. Recharge and stream conditions were changed to represent the current conditions at the Hatchery. The model was recalibrated to develop refined hydraulic conductivity and storativity distributions, which was recommended by GeoEngineers (1995).

A.1 Model Parameters

LiDAR elevation data (Watershed Sciences, 2007) with an accuracy of +/- 0.04 meters (1.6 inches) was incorporated into Version 2 because it provides a more accurate representation of the top elevation of the model. Figure A-1 shows the new elevations that are used in the model.

Appendix A



Figure A-1: Map of ground surface elevations used in model extracted from LiDAR.

Version 2 was calibrated using a time-dependent model that simulated the seepage monitoring performed in October 2009. Since the monitoring was performed during the non-irrigation season, the off-site irrigation ditch (Icicle Canal) was removed from the model and no recharge from the application of irrigation water or precipitation was simulated. The GeoEngineers model simulated the on-site ditch (Wenatchee Channel) but that feature was removed from the version 2 model since water was not flowing in the ditch during the calibration time period. The effect of calibrating the model to a period without recharge from precipitation or irrigation represents a "worst-case" groundwater condition; when there is additional recharge from precipitation or irrigation, the results from pumping would be less severe and there would be less water level

drawdown. The general head boundary locations were left the same as those in the GeoEngineers model. Figure A-2 shows the location of the surface features that were used in the calibration process.



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A.2 Model Calibration

The model was calibrated to match observations that were recorded during the 2009 seepage monitoring using PEST (Doherty, 2008), an automated parameter estimation software. GeoEngineers (1995) suggested, in the recommendations section of their report, that an automated calibration procedure be attempted to better refine the hydraulic conductivity distribution in the model.

Pilot points and Tikhonov regularization (Tikhonov 1963a, 1963b) were applied to the PEST calibration scheme. Pilot points are a way to characterize the spatial distribution of parameters (such as hydraulic conductivity) within the grid that eliminates the need for lumping the parameter into piecewise homogeneous zones. Parameters are estimated at the pilot points and are then interpolated to the remaining cells (in this case, the pilot points are interpolated using kriging). Since the pilot points are at discreet locations, PEST has the ability to make large changes at each point to best match an observation, which can lead to large variations in a parameter over short distances. Tikhonov regularization constrains the PEST calibration process so that PEST does not calculate unrealistic parameters simply to meet the observations. It has been argued that using pilot points with Tikhonov regularization calculates the most unique parameter distribution possible and reduces uncertainty in the model results (Fienen and others, 2009).

The locations of the pilot points were selected based on the criteria that at least one pilot point should be between any two observations. The remaining pilot points were placed to minimize the number, but to evenly cover the remaining area. Pilot points were used for both horizontal hydraulic conductivity and storativity. In addition to pilot points, hydraulic conductivity targets were used to assist the PEST calibration. The targets were measured values in wells 1, 2, 3A, 4A, and 6.

Figure A-3 shows the hydraulic conductivity distribution calculated during the calibration process.


Figure A-4 shows the storativity distribution calculated during the calibration process.

Appendix A



The model calibrated conductances for four separate river reaches: Icicle Creek upstream of Structure No. 2, Icicle Creek between Structure No. 2 and the confluence of Icicle Creek and Hatchery Channel, Icicle creek downstream of the confluence, and the Hatchery Channel. The conductance values are shown in Table A-1.

Table A-1: Table of calibrated conductances for river reaches i	in model.
River Reach	Conductance (ft ² /d)
Icicle Creek u/s of Structure No. 2	500
Icicle Creek between Structure No. 2 and Channel confluence	500
Icicle Creek d/s of confluence	1290
Hatchery Channel	8203

Figure A-5 shows the hydrographs of the observed versus the simulated water levels.





Figure A-5: Plots of observed versus simulated water levels.

The model was calibrated to within 10% of the total change in observed water levels within the model domain. A model is considered well calibrated if it is within 10%. Figure A-6 shows a plot of the simulated versus observed values with an R-squared value of 0.78.



Figure A-6: Observed versus simulated values.

A.2.1 Calibration Uniqueness

Models are simplified representations of complex natural systems that can never match reality perfectly. In any modeling endeavor, it is important to examine the uncertainty related to the model and its calibration so as to understand the applicability and limitations of the model.

In the case of the Version 2 LNFH groundwater model, utilizing pilot points and Tichonov regularization provides a unique solution with reduced uncertainty.

A.3 Scenarios

Six scenarios were run to show the consequences of proposed operations at LNFH. The scenarios are described in the main text of this report. All of the scenarios used the same pumping schedule (Section 4, Table 4-1). The seasonal water conditions (high or low) and Hatchery channel operations were varied. Each scenario was run for 75 days: 15 days to allow the water levels to adjust to the water condition type and 60 days applying the well pumping schedule.

Scenario 1 – High water conditions with dry channel

This scenario represented high water conditions (such as during spring and early summer) with no water flowing in the Hatchery channel through the entire 75 day simulation. To simulate high water conditions, the calibrated model simulated a general head boundary elevation at 1147 feet. In addition, Icicle Creek was simulated with high flow of 2100 cfs. The HEC-RAS model was used to develop water surface elevations at the 2100 cfs flow rate, which were then fed into the MODFLOW model. The wells begin pumping at day 15 of the simulation to allow the system to equilibrate with respect to the high water conditions before applying the pumping stress. Scenario results are shown in Section 4-3.

Scenario 2 – Low water conditions with dry channel

This scenario represented low water conditions (such as late summer through winter) with no water flowing in the Hatchery channel through the entire 75 day simulation. The general head boundary elevation was set at 1140 feet to simulate low water conditions. Icicle Creek had a minimum flow of 50cfs.

Scenario 3 – High water conditions with full channel

This scenario is similar to Scenario 1, except that the Hatchery channel is simulated to have three feet of water in it, simulating full conditions.

Scenario 4 - Low water conditions with full channel

This scenario is similar to Scenario 2, except that the Hatchery channel is simulated to have three feet of water in it.

Scenario 5 – High water conditions with 15 day cycle of water in Hatchery channel

The scenario is similar to Scenarios 1 and 3 except the water in the Hatchery channel is cycled full for 15 days, then empty 15 days. The cycle repeats twice in the 75 day simulation period.

Scenario 6 – High water conditions with 15 day cycle of water in Hatchery channel

The scenario is similar to Scenarios 2 and 4 except the water in the Hatchery channel is cycled full for 15 days, then empty 15 days. The cycle repeats twice in the 75 day simulation period.

Scenario 7 – High water conditions with 15 day full channel

The scenario is similar to Scenarios 1 and 3 except the water in the Hatchery channel is cycled full for 15 days, then empty 45 days.

Scenario 8 – High water conditions with 15 day full channel

The scenario is similar to Scenarios 2 and 4 except the water in the Hatchery channel is cycled full for 15 days, then empty 45 days.

Appendix A References

- Doherty J., 2008, PEST, Model Independent Parameter Estimation. User manual, 5th ed., Brisbane, Australia, Watermark Numerical Computing. <u>http://www.pesthomepage.org/files/pestman.pdf</u> (accessed February 1, 2009)
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Appendix B: Well logs and construction schematics for wells at **Leavenworth National Fish Hatchery**

			Well C	onstruction I	Details				Static W	ater Level
Well Number	Date Drilled	Drilled Depth (ft)	Completion Depth (ft)	Diameter (inches)	Perforated Casing or Screened Depth (ft)	Pump Inlet Depth (ft)	Source Aquifer	Status of well	Date	Depth (ft)
1	(04/58)?	80	80	12	40-80	70	Shallow	Active	28.5	5/5/09
2	1940	94	94	12.5	20-90	77	Shallow	Replaced by 2A		
2A	07/91	206	203	20	70-90		Shallow	Active	24.0	5/5/09
3		103	103	12	$20-92^5$	75	Shallow	Replaced by 3A	25.8	5/5/09
3A	06/91	120	98	16	63-98	55 ⁶	Shallow	Active	30.8	9/30/09
4	10/76	324	237	16	60-69 95-225 ⁷	92	Shallow	Active	38.75	8/25/09
4A	10/08	333	105	16	64-94	60	Shallow	Active	29.04	7/8/09
5	07/79	290	279	14	249-279	120	Deep	Active	17.0	5/5/09
5A	02/78	300	300	14	250-300		Deep	Collapsed during pumping test		
5B	10/76	286	280	16			Deep	Pumped excessive sand during pumping test		

Table B-1: Summary of Well Information for Hatchery Wells

⁵ Screen is filled with sand to a depth of 92 ft.

⁶ Pump inlet depth is estimated
⁷ Screen is filled with sand to a depth of 101 ft.

Appendix B

6	12/76	195	170	14	102-112 150-170	103	Shallow and Deep	Active	35.44	7/8/09
7	11/76	192	110	14	72-82 92-110	75	Shallow	Active	24.5	5/5/09
8	10/76	278	278 ⁸	1.5				Obser. Well		
9	11/76	213	205	16	80-105 115-136 180-200		Shallow	Collapsed during pumping test, used as obser. well	17.7	9/30/09
10	2/95	110	104	12	75-100		Shallow	Not Pumped	38.15	9/30/09
11	2/95	278	278	16			Shallow	Decommissioned		
TW-1	9/94	276						Abandoned		
TW-2	11/94	150					Shallow	Used as obser. well	34.75	9/30/09
TW-3	1/95	145					Shallow	Cased well near well 10		

⁸ Collapsed or filled with sand to a depth of 56 ft.

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FEATURE Leavamwohn National Firth Hatcherg - Repain LGCATION North Side - Diverso Canad Beschar 92700 FINISHER, 17/26/00 DEPTH AND ELEY OF WATER LEVEL MID DATE MEASURED 32 7 9/29/2009							DEPTH 490 TO BEDRUCH	NotEnc	E 1,879 ounterex	9,7564	STATE Westington GROUND FLEVATION 1152.6 ANGLE FROM NORIZONTAL 90 AZIMUTH HOLE LOGGED BY StatmaClidndison REVIEWED BY D Bonnett			
NOTES	OBPTH	M, RECOVERY	1.45	NG.	mas	LASSFICATION	USCS LAW	BEOLOBICJMIT	GRAPHIC	-00 ECOMPLETION	CLASSIFICATION AND PHYSICAL CONDITION			
All elevations measured from ground surface and are same as driller reported. PLIRPOSE OF HOLE: Drilled hole to install plexometer for monitoring seepage from the diversion canal. DRILL SETUP: Set up on the access road on the north side of the diversion canal. DRILLER: Chris Peterson DRILLING EOUIPMENT: Ingersol Rand T2W truck mounted rolary drill rig with ODEX casing advancer system. DRILLING METHODS: 0.0 to 49.0°; Advanced Gener 0.0, Intreaded steel casing advancer system (down-hole hammer; and diversion canal. DRILLING METHODS: 0.0 to 49.0°; Advanced Sectivate hammer; and termove cuttings. DRILLING CONDITIONS: 0.0 to 49.0°; Moderately hard to soft and fast with DRILLING CORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 6° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 6° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 6° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 6° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 6° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 09/27 8° 49.0° 49.0° FLUD RECORD: 2009 CS Depth Depth Date S2 Hole CS 00/10 49.0°; Drilled with at. CASING RECORD: 2009 CS Depth Depth Date S2 Hole CS 00/10 49.0°; Drilled CS 00/10 49.0°; Dri	5 10 10 10 10 10 10 10 10 10 10 10 10 10	teide como	ng Deur Sur Ch Sur Ch	gradion zdľada	SPg BOTTI USEP SIDS-A Data Manufie Proton Engineer Inducive Peter	EMOFY 6 mail: many (name	KOLE GIR BI	Ogd2			0.0 to 49.0 QUATERNARY GLACIAL DRIFT- OUTWASH SUBUNIT (Ggd2) Pleistocene deposits associated with alpine glaciation. The unit consists of outwash deposits composed of medium to coarse sand and gravel with cobbles and scattered boulders. 0.0 - 49.0 'S AND AND GRAVEL. Description based on drilling conditions and cuttings returned. BOTTOM OF HOLE: 49.0 FEET			

FEATURE Leavanworth Notione LOCATION North Side - Diversi BEGUN 92/08 FINISHED 5 DEFT/LAND BLEV OF WATER LEVEL //ID DATE MEASURED	GEOLC I Fish Hatchery - Repairs on Canal I/26/09 32 /* 9/29/2009	COORDINATES A TOTAL DEPTH 10 DEPTH 10 BEDROO	ILL HULL I Basin Finglect (202,309.7 E 1) V V. Not Encounte	879,7564	STATE Weshindrox GROUND ELEVATION 1152.6 ANGLE FROM HOBI/OPTIAL 90 AZIM/JH HOLE LOGGED BY Stolma/Didnokson REVIEWED BY D. Gornelt.		
NOTES	Retra Recovery In IC	JASSFICATION	BEOLODICUNIT BRAFHIC	ICLE CONFLETION	CLASSIFICATION AND PHYSICAL CONDITION		
DRILLING TIME: Drilling 10 nrs. Maving; 5 nrs. (Travel lims not included) HOLE COMPLETION: Placed #3 silica sand from 48.0-430. Installed 2-inch. schedule 40 PVC riser and sloted-pips plezometer from 0.0-48 or. vilh sloted (0.02°, section from 43.0-48.0. Filige sand (#6 silica sand) sand was placed from 46.0 to 38.0 feel (5.0° above sinited section). Bentonile chips (surface seal) were placed from 0.0 to 38.0°. A protective sleel sland pipe alaced from 0.0 to 38.0°. A protective sleel sland pipe valced in all the surface, slick up is approximately 24-inches. Developed well by flushing with clear waler upon completion.							
COMMENTS							

SPT SELO	NDULY HASSY D	MMU 6281	BEOLOSICUMT	O P C C C C C C C C C C C C C C C C C C	CLASSIFICATION AND PHYSICAL CONDITION 0.0 to 43.0 QUATERNARY GLACIAL DRIFT- OUTWASH SUBUNIT (Qgd2) Pleistocene deposits associated with ajpine glaciation. The unit consists of outwash deposits composed of medium to coarse sand and gravel with cobbles and scattered boulders. 0.0 - 8.0: SAND AND GRAVEL. Description based or drilling conditions and cuttings returned. 8.0 - 43.0° SAND, GRAVEL AND COBBLES. Description based on drilling conditions and cuttings returned. BOTTOM OF HOLE: 43.0 FEET
	SPg		ale all a set a second and a second		0.0 to 43.0 QUATERNARY GLACIAL DRIFT - OUTWASH SUBUNIT (Qgd2) Pleistocene deposits associated with alpine glaciation. The unit consists of outwash deposits composed of medium to coarse sance and gravel with cobbles and scattered boulders. 0.0 - 8.0°. SAND AND GRAVEL. Description based or drilling conditions and cuttings returned. 8.0 - 43.0°. SAND, GRAVEL AND COBBLES. Description based on drilling conditions and cuttings returned. BOTTOM OF HOLE: 43.0 FEET
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	ng Ce ugnition USEIT Suit Clear anno 10	BOTTOM OF HOLE BOTTOM OF HOLE	BOTTOM OF HOLE BOTTOM OF HOLE BOTTOM OF HOLE Stat Clearing and Annuals Stat Clearing and Annuals Stat Clearing and Annuals Clearing cond Fabron, metanoled Petrolary (1980)	Ing De uggintion USER 5005-A6 BOTTYDM OF HOLE BOTTYDM OF HOLE Sol Charge agriculture (Your Languer) Sol Charge agriculture (Your Languer)	Ing Designation USEPP SIDS-R6 Sol Chaptication (VisepP SIDS-R6 Sol

FEATURE Levelstwoom National LOCATION Couts Side - Diversin BEGUN 2020/04 FNIGHED 172 DEFTH AND ELEV OF WATER LEVEL AND DATE MEASURED	Fish Halchery - Repain n Canol 31/Up 30/ 10/01/2/004	PROJECT COORDINA TOTAL DES DEPTHTO	Columbia Bosin P TES N 201,341 TH 43-0 BEDROCH, NotE	raject 5. E 1,87 nocuntern	STATE Weshington GROUND ELEVATION 11491 ANGLE FROM HORIZONTAL 90 AZIMU HOLE LUGGED BY StamaDidnokson REVIEWED BY D Bennelt.		
NOTES	JEETT-A S RELOVIERY IPT	TELO	ISCS UMM EELOTICUMT	3RAPHIC	ICLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION	
DRILLING TIME: Drilling 8 hrs. Moving: 2 hrs. (Travel lime not included) HOLE COMPLETION: Placed #8 silica sand from 42.0-43.0: Installed 2-inch, schedule 40 PVC riser and sibited-pipe plezometer from 0.0-42.0: with slotted (0.02") section from 37.0-42.0: Filter sand (#8 silica sand) sand was placed from 42.0 to 33.0 feel (5.0° above slotted section). Bentonite chois (surface seal) were placed from 0.0 0.33.0°. A protective sleel slandpipe with a locking cover was cemented in at the surface, slick up is approximately 24-inches. Developed well by flushing with clear water upon completion.							
EOMMENTS							

. . . $\frac{1200}{14} = 35.7$ $473^{22} = 120 400001$

Well#1

24/7-23601

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A - 1



LEAVENWORTH NATIONAL FISH HATCHERY FIGURE 3

epartment of Ecology Second Copy—Owner's Copy				
hird Copy-Driller's Copy	STATE OF	Water Right Permit No		\rightarrow
OWNER: Name DEPT OF	FISH & WILDLIFE	Address ICICLE RD		Y
I OCATION OF WELL: County CH	IELAN	N/W x No x sec 26 To	LN.R.	17.W.M
a) STREET ADDDRESS OF WELL (or ne	arest address)_1CICLE	RD		
B PROPOSED USE: Domestic	Industrial 🗌 Municipal 🗌	(10) WELL LOG or ABANDONMENT PROCEDU	RE DESC	RIPTION
DeWater	Test Well D hother	Formation: Describe by color, character, size of material an	d structure,	, and show
1) TYPE OF WORK: Owner's number of w	rell 2 A	thickness of aquifers and the kind and nature of the material in ea with at least one entry for each change of information.	ach stratum	penetrate
Abandoned D New well 25 Me	ethod: Dug 🗌 Bored 🗌	MATERIAL	FROM	TO
Deepened Reconditioned	Cable 🖄 Driven 🗌 Rotary 🗌 Jetted 🗌	GAND	0	3
	inchos	SANDA BOULDERS	3	12
Drilled feet Depth of co	incres.	LARGE GRAVEL-SANDEL WATER	25	50
		COARSE SAND - LG. GRAVE	50	65
Casing installed: 24 · Diam fro	m () # to & () #	COANSE SAND-LG COBBLES	65	85
Welded B QO Diam. fro	om_0tt. to_203tt.	SUT-SAND BLACK	111	123
Liner installed U Threaded U Diam. fro	omft. toft.	SILT - BOULDERS, BLACK	123	126
Perforations: Yes No		BLACK SILT	126	140
Type of perforator used		BLACK SILT W/ SILT STOLE LAY.	140	180
SIZE of perforations	in. by in.	BLACK SILT, COBISLED	180	200
perforations from	ft. toft.	GRANITE, HARD	200	200
perforations from	ft. to ft.	· · · · · · · · · · · · · · · · · · ·		
Screens: Yes No			1	
Manufacturer's Name				
Diam Slot size	Model No	the second s		
Diam Slot sizefr	omft. toft.			
Gravel packed: Yes No Size o	f gravel			
Gravel placed from	ft. toft.		-	1
Surface seal: Yes No No	at depth?ft.		1	
Material used in seal	TON ITE			
Did any strata contain unusable water? Yes	_ No 2		1.10	
I ype of water?				
7) PUMP: Manufacturer's Name			1	
Type:	Н.Р			
(8) WATER LEVELS: Land-surface el	evation ft		10	
Static level ft. below to	op of well Date n.			1
Artesian pressure lbs. per	square inch Date			
Artesian water is controlled by	(Cap, valve, etc.))	West started 12/3/9/ 19 Completed 7	122	19 9
9) WELL TESTS: Drawdown is amount w	ater level is lowered below static level	Work started	1	
Yield: gal./min. with	ft. drawdown after hrs.	WELL CONSTRUCTOR CERTIFICATION:	etruction	of this we
		and its compliance with all Washington well co	nstruction	standard
Recovery data (time taken as zero when pumi	p turned off) (water level measured	knowledge and belief.	a are true	to my De
from well top to water level) Time Water Level Time Wate	r Level Time Water Level	A DALL DALL LUK POL	/	
		(PERSON, FIRM, OR CORPORATION)	(TYPE	OR PRINT)
		Address RT 5 BOX1010 EL	LENS	BURG
Date of test				779
Bailer test cal (min with	ft drawdown after bre	(Signed) CULLIORILLER	No//	10
Airtest gal./min. with stem set a	t ft. for hrs.	Contractor's Registration		
Artesian flow g.p.	.m. Date	No. MIKE DOC 1331 Gate		, 19
Temperature of water Was a chemical	analysis made? Yes No	(LISE ADDITIONAL SHEETS IF NECE	SSARY)	<i></i>

Appendix B



Start Card No.

in and First Co	by with	ATER W	ELL REPORT Start Card No.		
acond Copy-Owner's C Third Copy-Drillar's Cop	юру У	STATE OF	WASHINGTON Weter Right Permit No.		
(1) OWNER: Name_	U.S. FISH & WIL	DLIFE	Address 911ND E. 11TH AV PORT	LAND	OR
LOCATION OF	WELL: Courts Management	CHELAN	NW NE	21.	17
(2a) STREET ADDDR	ESS OF WELL (or nearest addre	LEAVENWOR	TH NATIONAL FISH HATCHERY	<u> </u>	17
(3) PROPOSED US	E: Domestic Industrial	□ Municipal □ □ Other 🕅	(10) WELL LOG OF ABANDONMENT PROCEDU	JRE DES	CRIPT
(4) TYPE OF WOR	K: Owner's number of well 7	5A	thickness of aquifers and the kind and nature of the material in with at least one entry for each change of information.	each stratur	n penetr
Abandoned D N	lew well K Method: Dug	Bored	MATERIAL	FROM	то
. D F	eepened Cat leconditioned Rot	ble 🔬 Driven 🗌 ary 🗃 Jetted 🗌	sand & gravel cobbles & boulders	0	10
5) DIMENSIONS: Drilled 120	Diameter of well16 feet. Depth of completed we	inches. ell98ft	Sand &gravel lagge coobles	10	30
6) CONSTRUCTION	N DETAILS:	6.5	sand silt w/gravel	20	25
Casing installed: Welded	Diam. from 2	<u>ft. to</u> <u>65</u> <u>ft</u> .	sandw/large gravel	25	30
Liner installed	Diam. trom	ft. toft.	W/ TALEE BLAVET	1-2	1-0
Perforations: Yes Type of perforator use	□ _{N°} ⊠		Sand w/large gravel	30	35
SIZE of perforations _	in. by	in.	med coarse sand	35	40
Pe	rforations from ft rforations from ft	t. to ft.	Sand	40	45
P•	rlorations from ft	t. to ft.			
Screens: Yes X	JOHNSON		sand w/some gravel	45	50
Type <u>304</u> S	ot eize 60 from 63.	_ Model No ft. to93ft.	med coarse sand & gravel	50	60
Gravel packed: Ye	ot size <u>40</u> from <u>93</u>	tt. to98tt.	coarse sand small gravel	60	75
Gravel placed from		tt.	med_coarse_sand_small_grave	1 75	80
Surface seal: Yes	No To what depth? cement grout	<u>∠∪</u> "	coares sand small gravel	80	85
Did any strata contain u Type of water?	nusable water? Yes No X	pth of strate	fine sand trace small grave	1 85	90
Method of sealing strat	• off		fine sand small gravel	90	Q F
) PUMP: Manufactur	er's Name		Survey States		,,,
B) WATER LEVELS	Land-surface elevation	H.P tt.	fine sand some large grave	95	100
Static level 77 2	ft. below top of well Date	•_3/27/91	fine sand	100	1-20
Artesian wat	er is controlled by				
WELL TESTS: D	rawdown is amount water level is low	velve, etc.))	Work started 10/15/90 19. Completed1	/91	19_
Was a pump test mede?	Yes No If yes, by whom	* WELLS WAD	WELL CONSTRUCTOR CERTIFICATION		
Yield: _650_ gal.	/min. with26 ft. drawdowr	n after hrs.	I constructed and/or accept responsibility for cons	truction of	this w
•••			and its compliance with all Washington well con Materials used and the information reported above	struction s are true to	my b
Recovery data (time tak from well top to water le	en as zero when pump turned off) (wa vel)	ater level measured	knowledge and belief.		
Time Water Level	Time Water Level 1 ECOVERY	Time Water Level	NAME DI TERICH DRILLING (PERSON, FIRM, OR COMPORTION)	(TYPE OF	PRINT
			Address P.O. BOX 3840 WENATCHE	Ç	
Date of test	AK.	10-	(Signed) Sharin Mind License h	115	2
Bailer test 9	al./min. with ft. drawdow	mafter hrs.	(WELL DRILLER)		
Artesian flow	g.p.m. Date	n. for hrs.	No. DLETRD*101LH Date5/13/92	2	. 19_
Temperature of water	Was a chemical analysis made?	Yes No	(USE ADDITIONAL SHEETS IF NECESS	SARY)	

PORATION) (TYPE OR PRINT) WENATCHEE License No. 1152



original and First Copy with partment of Ecology cond Copy — Owner's Copy	WATER WE	LL REPORT	pucation No	
rd Copy — Driller's Copy	STATE OF W	Person Pe	rmit No	
OWNER: Nome Leavenworth-Fi	sh Hatcherv	Address 500 NE Multhomah Stre	et: Portland	OR
OCATION OF WELL	Chelan	Set y SE y se	23 - 24 -	17Emy
COCATION OF WELLE: County	corner	n//N	Weiter I and I and the first of the	distan.
aring and distance from section or subdivision	comer			. Wir
) PROPOSED USE: Domestic [] Inc	iustrial XX Municipal	(10) WELL LOG:	2-985 	
Irrigation 🗌 Te	st Well 🛛 Other 🗌	Formation: Describe by color, character, size show thickness of aquifers and the kind and	of material and stri nature of the mater	icture, and
TYPE OF WORK: Owner's number	of well 4	MATERIAL	Jor each change of	Jormanies
New well Metho	d: Dug 🛛 Bored 🗍	Lange nocks 2%-5"	2	F
Deepened	Cable Driven	Gravels & sands		-10
Reconditioned	RotaryAN Jetted []	linconsolidated gravel	10	20
) DIMENSIONS: Diameter of v	well	Gravel & rocks	20	31
Drilled 324 ft. Depth of comple	ted well 250 ft.	Gravel & Large rocks	31	47.
CONSTRUCTION DETAILS.		Gravel & rocks	47	50~
Contraction Definition	0 20	Gravel & rocks	50	75
Casing installed:O" Diam. from	0 # to 237.5#	Pea_gravel & sands	75	112
Welded	ft. to ft.	_Gravel_Coarse	112	181
		Gravels & sands	181	245
Perforations: Yes XX No D Slott	ed Pine	<u>Clays & gravels</u>	245	312
Type of perforator used	in. by in.	Quartzite in rock	312	318
perforations from95	ft. to115ft.	Uuartz, white & gray gran		364
perforations from165				
perforations from	п. ю п.	1		1 A.
Screens: Yes XX No [•		
Manufacturer's NameUOP_John	son			1 State 120
Type Wirewrap	5-165 175-225			
Diam				
	1/4 2/08			
Gravel packed: Yes MX No Size	e of gravel $\frac{1}{4} = \frac{3}{8}$			
Gravel placed from	11. 00			
Surface seal: Yex No D To wh	at depth?			-
Material used in seal		· · ·		· ·
Did any strata contain unusable wa	h of strata	1.		-
Method of sealing strata off				
T) DIUMP.				
() FUME: Manufacturer's Name	НР		the state	
Туре:				
3) WATER LEVELS: Land-surface e above mean se	a level 48 ft.	per letter		
atic level	well Date 2-21-4	tecened 1-18-10		
rtesian pressurelbs. per square	inch Date			
Artesian water is controlled by	(Cap, valve, etc.)			
) WELL TESTS: Drawdown is an	nount water level is		10.2	/
as a pump test made? Yes No T If yes, b	y whom?	Work started	npleted	
eld 2000 gal./min. with 85 ft. draw	vdown after 3 hrs.	WELL DRILLER'S STATEMEN	Т:	
		This well was drilled under my ju	irisdiction and thi	is report
		true to the best of my knowledge an	id belief.	
ecovery data (time taken as zero when pump measured from well top to water level)	turned off) (water level		IN THE	
Time Water Level Time Water Level	Time Water Level	NAME LATNE WESTERN COMPAN (Person, firm, or corpora	tion) (Type or	print)
				27
		Address P. U. BUX 33b POSES	AKEL WA 988	
·····			DICTOMON	
Date of test	wdown after hre	[Signed]	Driller)	

TIGE ADDIMIONAL OTIBERED TE MECECCABV







I

File Original and First Copy with Department of Ecology	WATER WE	II. PEPOPT	Application No		
Second Copy - Owner's Copy Third Copy - Driller's Copy	WALLS WE		Barrett Ma		
US Department	of Interior		Fertult Nd		
(1) OWNER: Name Leavenworth	Fish Hatchery	Address 500 NE Multa	mah Street; Por	tland	,OR
(2) LOCATION OF WELL: County	helan	- SH 4	И 1 Sec. 23 т. 24		7E w
aring and distance from section or subdivision of	corner		うじ・		
(3) PROPOSED USE: Domentic I Indi	ustrial 🕅 Municipal 🛛	(10) WELL LOG:			
Irrigation 🗌 Tes	Well Other	Formation : Describe by color, ci	aracter, size of material a	and stru	cture.
		show thickness of squifers and stratum penetrated, with at least	the kind and nature of the it one entry for each cha	materi	al in e
(4) TYPE OF WURK: (if more than one)		MATERIA	L	FROM	TO
Despend	Cable [] Drives []	Sand & gravel		0	5
Reconditioned []	Botary Jotted	Sand & silt		5	13
(5) DIMENSIONS:		_Fine & course sand	& gravel_some	13	20
Drilled	ed well	cobbles & stene	s	-	
		Course sand fine	to medium grave	120	55
(6) CONSTRUCTION DETAILS:		Gray silt & very t	ine grain sand	55	119
Casing installed: Diam. from	0 n to 250 n	Fine & course sand	1 fine to mod	117	223
Threaded []]4" Diam. from	.210. n. to	ium orav oravel	a Line Ly mese	223	224
Weided a	п	Grav silt & fine o	ray sand	224	240
Perforations: yes 🗆 No 🗘		Gray fine to cours	e sand &		
Type of perforator used		gravel stones &	cobbles		
perforations from		(263-2643 sand	stone boulder)	240	270
perforations from	ft. to ft.	<u>Gray fine to cours</u>	e sand & fine		
perforations from	ft. to ft.	gravel		270	275
Screens: Ta & No		Medium to course s	and & fine to		
Menufecturer's Neme UPO Joh	nson	laver of rock A	" to 1' thick	275	296
Type Stathless Steel M	odel No	Regalt	LU I LINCK	286	200
Diam	249. R. to				2.30
Gravel packed: Yes (). No Size o	d gravel: <u>8-12</u>				
	10				
Surface seal: Yes (X No [] To what	depth?247 ft.				
Material used in seal					
Type of water? Depth	of strata				
Method of scaling strata off					
7) PUMP: Manufacturer's Name Layne	Bowler				
Type: 12 THC	н.р. 250				
8) WATER LEVELS. Land-surface elev	ation				
tatic level 14 the below two of mean sea 1	evel				
rtesian pressure	th Date				
Artesian water is controlled by	Can value ate)				
DI WELL TESTS: Drawoown is amou lowered below stati	ic level	Work started1	Completed		
as a pump test made? Yes (X No () If yes, by a leid: 1500 cal/min. with 70 at desired	nomt Layne	WELL DRITTERS STA	TEMENT.		
" 1050 " 53 "	2.5 -	White well commission of STA			
- 750 - 40 -	2 -	true to the best of my know	vledge and belief.		repor
ecovery data (time taken as sero when pump tu	uned off) (water level				
Time Water Level Time Water Level	Time Water Level	NAME LAYNE WEST	ERN COMPANY		
3 28 6 26	10 25	(Person, firm,	or corporation) (Ty	pe or pi	int)
4 27 7 26	29 25	Address P.O. Box 3			
2 2/ 8 26	69 20		d (mtt		
Date of test		[Signed] UNVI~	L. LOM	JHA	
rtestan flow gam. Date		A747		L.	-
mperature of water Was a chemical ensive	in mades Yes Cl. He Cl.	Lionna No. OTOD	Data SUL		. 19.



LEAVENWORTH NATIONAL FISH HATCHERY FIGURE 7

Becond Copy — Owner's Copy Third Copy — Driller's Copy		Permit No.	
U.S. Department	of Interior		
(1) OWNER: Name Leavenworth - F	ish HatcheryAddres 500 NE	Multhomah Street; Portland	d, Q
(2) LOCATION OF WELL: County Che	lan	NW & SE & Bec 23 T 24 N. R	11e
aring and distance from section or subdivision corr	ner		-
(3) PROPOSED USE: Domestic [] Indust:	rialy Municipal [(10) WELL LO	G:	
Irrigation [] Test W	Yell Other Describe	by color, character, size of material and str ulters and the kind and nature of the mate	victure,
(A) TYPE OF WORK. Owner's number of v	stratum penetrated, i	ofth at least one entry for each change of	forma
(4) AITE OF WORK: (If more than one)		MATERIAL FROM	T
Deepened D	Cable D Driven DMedian brow	n sand O	
Reconditioned []	Notary I Jetted I Boulder, sa	nd gravel 10	
(5) DIMENSIONS	14 -Sand & grav	el: 1 ·	+ 4
Defiled 300 the Depth of completed	well 170 B Sand & fine	silt & clay 89	+1
	Stity, clay	- sand 159-	+-20
(6) CONSTRUCTION DETAILS:	Large grave	1, Doulders 246-	30
Casing installed: _24_" Diam. from	0	t	+
Threaded14 Diam. from	0 n. w .300 n.		+
Welded Diam. from			+
Perforations: Yes CI NoYY			+
Type of perforstor used			1
SIZE of perforations		1	
perforations from	ft. 10		T
nerforations from	ft. to ft		
Screens: Yes Dy No [] (IOP .]onbson			-
Manufacturer Name Cor Contrison			
Diam 14" Slot size 50 from 2	50 n w _300 n		
Diam Slot size			
Gravel necked:	1/4"-3/8"		
Gravel placed from	300		+
	20		+
Surface seal: Yes No To what de	nont		
Material used in seal		· · · · · · · · · · · · · · · · · · ·	+
Type of water?	strate	···· †	1
Method of sealing strate off.			1
(7) PUMP - Manufacture -	Der letter		
Type:	HP revid 1-1	18-80	
(8) WATER LEVELS: Land-surface elevet	25		
Static levelft. below top of well	Date		
Artesian pressure			
(Ca	p, valve, etc.)		+
(1) WELL TESTS: Drawdown is amount	water level is		
Was a nump test made? Yes YV No C If yes hy wh	om? F. Lubdon Work started	19_II. Completed	
Yield: 1500 gal/min. with ft. drawdown	after hrs. WELL DRILLE	B'S STATEMENT:	
н н р	This well was a	drilled under my jurisdiction and thi	s repo
- Well Collapsed in Short Time	- true to the best of	f my knowledge and belief.	
Recovery data (time taken as zero when pump turn	ved off) (water level	COTTON COMPANY THE	
Time Water Level Time Water Level Ti	me Water Lavel NAME LAYNE-	ILSIEKN CUMPANY, INC.	print'
		and and or curpersons (Type or	0027
	Address P.U. Bo	JX 330; MOSON LAME, NA 9	003/
	((// //	1 (a matrix	
Date of test	[Signed]	LE LE LAXUIN	
manter and delemin with deservice	anar are	(WOULDILLE)	

3 ()----

(USE ADDITIONAL SHEETS IF NECESSARY)

.,

1) OWNER man_lawymoth Fish Hardry Address_500. NE Multinomah. Street; Portland; Orielan 1) OWNER man_lawymoth Fish Hardry Address_500. NE Multinomah. Street; Portland; Orielan 1) OWNER man_lawymoth Fish Hardry Address_500. NE Multinomah. Street; Portland; Orielan 1) OWNER man_lawymoth Fish Hardry Address_500. NE Multinomah. Street; Buscher Multinomah. Street; Portland; Orielan 3) PROPOSED USE: Demesic Industrial (Municipal Industrial (Multinomah. Street; Buscher Multinomah. Street; Buscher Mul	U.S. Department Uf Interfor	ASHINGION Permit N	lo	
JOCATION OF WELL: Comp. Chelan JW2, 55, 10 Sec 23, 724, 10 FEGE Wa and datases from section or infloridatio corrier Image and the section of infloridation corrier Image and the section corrier base of corrier correction and the section of infloridation correction	1) OWNER: Name Loavonworth-Fish Hatery	Address 500 NE Multhomah Street;	Portland	OR
and datases from section or indefinition corrier (10) WELL LOG: b) PROPOSED USE: Determination [] of determination of the section of the sectin sectin section of the section of the sectin section	NOCATION OF WELL: country Chelan	Aledy SEY so 23	24	16
3) PROPOSED USE: Domestic Industrial XX Municipal Infragation Test Well Other Infragation Test Well Infragation Test Well Infragation Test Well Other Infragation Test Well Infragation Test Vell Infragation Infragation Test Vell Infragation Test Test Vell	og and distance from section or subdivision corner		UN R.	
9) PROPOSED USE: Description 1) TYPE OF WORK: Created in Description by color, character, site of matteria control control and control in the control internation of the control internatint of the			1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -	uterta ta
Impacts Tree Will Other Impacts Description (a) TYPE OF WORK: Create number of well of the complete of the complete of the complete of well of the complete of the) PROPOSED USE: Domestic I Industrial XX Municipal I	(IV) WELL LOG:		一族教教
6) TYPE OF WORK: Correct number of well spectrations and an user of portion and an usere of portion and an usere of portion and an user of portion and	Irrigation Test Well Other	Formation: Describe by color, character, size of mat show thickness of aquifers and the kind and nature	of the materi	cture, an al in eac
New will Benedic Die Diese Die Depensei Cohie Dietwein Roderykä Jetted 30 DIMENSIONS: Diameter of will 300 16" Index and the state of the	1) TYPE OF WORK: Owner's number of well 5. 58?	stratum penetratea, with at least one entry for each	ch change bi	Current
Despend Cable C Driven D Dip-Sol1-Salady	New well Method: Dug Bored			
INDENSIONS: Dimense of weil 3016" Gravels 4. Saids Gravels 4. Saids SD DIMENS(10)NS: Dimense of weil 3016" Gravels 4. Saids Gravels 4. Saids SD ONSTRUCTION DETAILS: Gravels 4. Saids Gravels 4. Saids Gravels 4. Saids Casing installed: 30 - Diam. from G. to 20.5 ft Gravels 4. Saids Gravels 4. Saids Perforations: Yes Diam. from ft to _ ft Gravels 4. Saids Gravel 2. Saids Sizz of perforations from ft to _ ft Gravel 1. large, some Clay 2257 2278 Sizz of perforations from ft to _ ft Gravel 1. large, some Clay 2260 2860 Gravel packed: Yes Yes Gravel 1. large, some Clay 2260 2860 Gravel packed: Yes Model No. ft ft Gravel packed: Yes Yes Mainterver Name Diam. ft ft ft ft ft ft ft Orared packed: Yes Mid L. Cellenth 20.5 ft ft <t< td=""><td>Deepened Cable Driven</td><td></td><td></td><td>Acada (A Saa Saffara a Sa</td></t<>	Deepened Cable Driven			Acada (A Saa Saffara a Sa
5) DIMENSIONS: Diameter of well 30x16 ^m incher Dettied 286 n. Depti of completed well 276.11 n. Gravel 5 d. sands Gravel 5 d. sands Gravel 5 d. sands Gravel 4 s.and Gravel 4 s.ands Gravel 4 s.ands Gra	Reconditioned [] Rotary/A Jetted []	-Unconsolitated gravel	A Shares	
Defined 250	b) DIMENSIONS: Diameter of well 30x16" inches.	Gravels a Saints	C P	
a) CONSTRUCTION DETAILS: Casing installed: 30 - 'ohm. from 0 r. to 20.5 r. three the state of 0 for 'ohm. from 0 r. to 20.5 r. three the state of 0 for 'ohm. from r. to 0 r. to 20.1 r. three the state of 0 for the	Drilled 280 ft. Depth of completed well 2/0.11 ft.	Enavola 2 anda		376
0: Construction Distriction 0: n to 20.5 n Casing installed: 30. * 0km. from 0 n. to 20.5 n Fared = 0ck, gravel 242 252 Perforations: Yes [] Nogg Fared = 0ck, gravel 252 252 Preforations: Yes [] Nogg Fared = 0ck, gravel 252 252 Gravel perforations from n. ft to n n n 10 262 286 Gravel packed: Yes gX No [] Model No. 10<	CONSTRUCTION DETAILS.	Gravel & sands	176	210
Classing installed: .30 * burn, from	Optime installed: 20 0 20 E	Gravel large some clay	210	276
Interested Internation	Casing installed: $\underline{30}$ " Diam. from $\underline{10}$ ft. to $\underline{20}$ ft.	Hard rock_ gravel	245	259
Interview Comparison Compari	Welded	Hard rock	25	51.7
Perforations: vs □ Ngg Type of perforations from ft io the perforations from ft io ft is perforation perforation perforations from ft io ft is perforation perforation perforation ft is perforatis perforatis perforatis perforation ft is perforation ft is perfo		Gravel	257	278
Type of perforations inclusted in. by in perforations from if. to in. the interval in perforations from if. to in. the interval	Perforations: Yes NXX	Granite	278	279
Size or perforations from ft. to ft. perforations from ft. to ft. menufacturer's Name LOP Model No. Type Menufacturer's Name 14. to ft. Diam Side isse from ft. to ft. Olam Side isse from ft. to ft. Gravel packed: yeigk No jt. ft. to ft. Material used in seal. Nealt. Coment. Model Properties jt. jt. Did any strata contain unuable water? Yeight of stata. jt. jt. Method of sealing strata off Did all ft. Did all follow of of stata. jt. Method of sealing strata off jt. jt. jt. jt. Type of water? Date Method is anount water level is a pump test madel yea with low of the level is a pump test madel yea with low of the level is onound water ferel is onound water level is a pump test madel yea withe level is onound water level is a pump test	Type of perforator used	Granite	279**	280
performions from ft to ft Screens: vexX No UOP_Johnson ft Manutacturer's Name UOP_Johnson ft Type Mileting for Name Model No. Diam	Size of perforations in. by in.		280	286
	perforations from ft. to ft.		-672	
Screens: yes/X No □ Manufactury: Name 100 Johnson Type Miget Partial District Diam. Slot size Diam. Slot size Type Model No. Gravel paced for model to the total total total total number water 20.75. Gravel paced for model number water 20.75. Material used in seal NGAL Competition 20.75. Type of water Depth of strata Method of sealing strata off. 25. Type: HP. By WATER LEVELS: Landown sense stevel. Lick level 10.12. Material used water is confile objet. 25. Material used in season water is confile objet. 25. Material text material season as acondin water is con	perforations from ft. to ft.			
Maintacturer is Nome UOP_lohnson Type Wide WTap Maintacturer is Nome Image: State is is is from fit to fit Gravel packed is size from fit to fit fit Gravel packed is size from fit to fit fit Gravel packed is size from fit fit to fit Gravel packed is size from fit fit Gravel packed is size from fit fit Gravel packed from fit fit Surface seal: yes KX No log fit Size of gravel: 1/48/753/28/ Matterial used in seal Neat Cetterint fit Did any strata contain unusable water? Yes log NoW NoW Type: manufacturer's Name Type: HP Type: how to devel for destrata Type: anufacturer's Name Type: HP Type: Land-surface elevation Artesian pressure Bok per square inch Date Artesian water is controlled by (Cap, valve, etc.) (Cap, valve, etc.) (Cap, valve, etc.) (D) Date of test fill fill drawdown atter & 3 hre """"""""""""""""""""""""""""""""""""	Screens: Youry No D			1 mart
Type WILEWID Model No. Diam. Stot size from ft. to ft. Diam. Stot size from ft. to ft. Gravel placed from 0 size of gravel: ft. to ft. Gravel placed from 0 size of gravel: ft. to ft. Gravel placed from 0 size of gravel: ft. to ft. Gravel placed from 0 size of gravel: ft. to ft. Gravel placed from 0 size of gravel: ft. to ft. Material used in seal. Neal Cell Celler no ft. ft. Material used in seal. Neal Cell Celler no ft. ft. Type: Material of distata ft. ft. ft. ft. Type: HP ft. ft. ft. ft. ft. B) WATER LEVELIS: land-surface elevation ft. ft. ft. ft. atic level I.o. ft. ft. ft. ft. ft. ft. B) WELL TEST	Manufacturer's Name UOP Johnson			
Diam. Slot size from ft. to ft. Diam. Slot size from ft. to ft. Gravel packed: yes gx No Size of gravel: 1/20-753/26" Gravel packed: yes gx No Size of gravel: 1/20-753/26" Gravel packed: yes gx No Size of gravel: 1/20-753/26" Gravel packed: yes gx No To what depth? 26.5 - ft. Material used in seal. Next and NoXI Type: Depth of strata NoXI Method of sealing strata off Size of gravel: 25.5 - ft. Type: HP Proc. 1/2-15-80 Side level 1/0 ft. bolow for wold bate. 25.5 - ft. Artesian water is controlled by (Cap. valve, etc.) 25.5 - ft. P) WELL TESTS: Drawdown is amount water level is lower stata level	TypeWTREWTapModel No		- 1 42	
Diam. Slot size from ft. to ft. Gravel packed: yes fX No Size of gravel: 1/14/2753/28" Gravel packed: yes fX No The of gravel: 1/14/2753/28" Gravel packed: yes fX No The of gravel: 1/14/2753/28" Gravel packed: yes fX No To what depth? 26.5 ft. Material used in scal Ne31. Comment Depth of strata No/X1 Type: Depth of strata Did any strata contain unusable water? Yes No/X1 No/X1 Provide: Image: Strata off. 7) PUMP: Manufacturer's Name Provide: Provide:<	Diam Slot size from ft. to ft.			3
Gravel packed: Yes by No Size of gravel: 1/10-53/8" Gravel placed from O nt. to 280 ft. Gravel placed from O nt. to 280 ft. Surface seal: Yes KX No To what depth? 20.5 ft. Material used in seal Neat Cement. Did any strate contain unusable water? Yes NoVX NoVX Type of water? Depth of strata Method of sealing strate off Depth of strata 7) PUMP: Manufacture's Name Proce Cetter Type: HP 8) WATER LEVEIS: Land-surface elevation attrice elevation from word of a subore mean sea level. 25 ft. reside level (C ft. below top of well Date Cetter) 25 ft. Artesian water is controlled by (Cap, valve, etc.) 9) WELL TESTS: Drawdown is amount water level is insource to below static level is a a pump test made? Yes XN O The yes, by whon ff. F. Luhdorff Comercial and your state level is a a pump test made? Yes XN O The yes, by whon ff. F. Luhdorff Comercial and your state level is nover dealow static level is insource at the state of the best of my knowledge and belief. "" "" "" "" "" "" "" "" "" "" "" "" "" "" "" ""	Diam	· · · · · · · · · · · · · · · · · · ·		
Sufface seal: Yes fX No □ To what depth? _20.5_ ft Material used in seal. Neal C.CEMENT. Did any strata contain unusable water? Yes □ NoVX Type of water?	Gravel packed: Yes EX No Size of gravel: 1/40753/8" Gravel placed from XX 0 ft. to 280 ft.			
Did any strate contain unusable water? Yes NoWX Type of water?Depth of strataMethod of sealing strata offMethod of strata strate of sealing strata offMethod of strata sealing strata offMethod of strata sealing strata offMethod of strata sealing strata offMethod wethod offMethod off	Material used in seal Neat Cement		1.	
Type of water? Depth of strata Method of sealing strata off 7) PUMP: Manufacturer's Name Type: HP B) WATER LEVELS: Land-surface elevation above mean sea level	Did any strata contain unusable water? Yes 🗌 NoXXX			
Method of sealing strata off 7) PUMP: Manufacturer's Name Type: HP B) WATER LEVELS: above mean sea level 25 ft. atic level 10 ft. below top of well Date.19/12/91/ Artesian water is controlled by (Cap, valve, etc.) B) WELL TESTS: Drawdown is amount water level is lowered below static level (Cap, valve, etc.) B) WELL TESTS: Drawdown is amount water level is lowered below static level (Cap, valve, etc.) B) WELL TESTS: Drawdown is amount water level is lowered below static level (Cap, valve, etc.) B) WELL TESTS: Drawdown atter 8.3 hrs. " " " " " " " " " " " " " " " " " " "	Type of water? Depth of strata	3		
7) PUMP: Manufacturer's Name	Method of sealing strata off			
HP B) WATER LEVELS: Land-surface elevation above mean sea level 25 fit atic level	7) PUMP: Manufacturer's Name	· · · · · · · · · · · · · · · · · · ·		
8) WATER LEVELS: Land-surface elevation above mean sea level	Туре: Н.Р	- Ora fellera		· ·
above mean sea level atic level	B) WATER LEVELS: Land-surface elevation	muld to the So		•••
Tritesian pressure Ds. per square inch Date Artesian water is controlled by (Cap, valve, etc.) (Cap, valve, etc.) Drawdown is amount water level is (B) WELL TESTS: Drawdown is amount water level is (as a pump test made? Yes (X) No [] If yes, by whom E.E.Luhdorff """"""""""""""""""""""""""""""""""""	above mean sea level ft.	- 1CV/0 1-11-10		
Artesian water is controlled by (Cap, valve, etc.) 9) WELL TESTS: Drawdown is amount water level is lowered below static level as a pump test made? Yes XX No I If yes, by whom E.E.Luhdorff (1500 gal/min. with t. drawdown after 8.3 hrs. Work started 9-21	rtesian pressurelbs. per square inch Date			
9) WELL TESTS: Drawdown is amount water level is lowered below static level ias a pump test made? Yes XX No I if yes, by whom E.E.Luhdorff Work started 9-21	Artesian water is controlled by			
B) WELL TESTS: Drawdown is amount water level is lowered below static level is low	(Cap, Valve, etc.)			· · ·
as a pump test made? Yes XX No 1 If yes, by whom E.E.Luhdorf fC. Constant to you completed 10012 1000 and the state of the	WELL TESTS: Drawdown is amount water level is lowered below static level	Work started 9-21 19 76 Completed	10-12	19 7
Image: Second state in the state of the state of the state in the state of the state in the	as a pump test made? Yes 🕸 No 🗆 If yes, by whom E. E. Luhdorff			
PUMPED EXCESSIVE SAND " " "PUMPED EXCESSIVE SAND " " "scovery data (time taken as zero when pump turned off) (water level " Time Water Level Time Water Level Time Water Level Time Water Level Time Water Level Time Water Level Date of test 10-12-76 Biler test gal/min. with testan flow g.p.m. Date Imperature of water Was a chemical analysis made? Yes □ No □	teld: 1500 gal./min. with ft. drawdown after 8.3 hrs.	WELL DRILLER'S STATEMENT:		_
PUTIF ED EACESSIVE SAND covery data (time taken as zero when pump turned off) (water level measured from well top to water level Time Time Top Time Top Time Top		This well was drilled under my jurisdict	ion and this	report
Dete of test 10-12-76 Balar test gal/min. with The state of water the water level Time Top Time Water Level Time Top Time Top Time Top Time Top Time Top Top Top	FUMPED EAGEDIVE DAND	and the best of my knowledge and bene	•••	
Time Water Level Time Address P. 0. Box 336; Mos State Mos State Mos State Mos State Mos State Mos State Mos St	measured from well top to water level)	NAME LAYNE-WESTERN COMPANY T	NC	
Date of test 10-12-76 Bate of test 10-12-76 Siler test gal/min. with ft. drawdown after hrs. rtestan flow gp.m. Date Imperature of water Was a chemical analysis made? Yes No 0733 Date Date Date 01		(Person, firm, or corporation)	(Type or p	rint)
Date of test 10-12-76 iller test gal/min. with t. drawdown after hrs. rtesian flow g.m. Date mperature of water Was a chemical analysis made? Yes No I License No. 0733 Date Deu, Mar., 197	Time Water Level Time Water Level Time Water Level	P.O. Box 336. Mosor and	WA 98	837
Date of test10-12-76	Time Water Level Time Water Level Time Water Level	Addmong 1.00 DUA JULA HUSES INC	.,	
aller testgal/min. withft. drawdown afterhrs. [Signed]	Time Water Level Time Water Level Time Water Level	Address 100 DOX 0000 HOSES LONE		
tesian flow	Time Water Level Time Water Level Time Water Level	Address () WOD () ()	MAL	
emperature of water Was a chemical analysis made? Yes No License No	Time Water Level Time Water Level Time Water Level Date of test <u>10-12-76</u> iller test <u>gal/min</u> , with <u>ft</u> . drawdown after hrs.	[Signed]	DA	
I	Time Water Level Time Water Level Date of test 10-12-76 üler test gal/min. with ft. drawdown after hrs.	[Signed]	DA	.70

File Original and First Copy with Department of Ecology Second Copy Owner's Copy	WATER WI	ELL REPORT	Application No.	
Third Copy - Driller's Copy	STATE OF	WASHINGTON	Permit No.	
(1) OWNER: Non Longerth	T Interior	500 NE Multan	mah St., Portland, C	P
(1) OTTALIN: NAME_LOGVORUOFLO-	Chalas	Address		A
(2) LOCATION OF WELL: County.	Cheran		58 K Sec. 23 T. 24 N. R.	17E.,
aring and distance from section or subdivisi	on corner	NU 2	16	/
		(10) WELL LOG		
(3) PROPUSED USE: Domentic	industrial X Municipal	(IV) WELLE 100.		
Irrigation []	Test Well Other	show thickness of aquifers and	laracter, size of material and stri the kind and nature of the mater	ial in
(A) TYPE OF WORK. Owner's numb	er of well with lo	stratum penetrated, with at leas	it one entry for each change of	forme
(1) III S OF WORKS. (if more than	one)	MATERIA	L FROM	T
	Cable Driven D	Sand & Gravel		22
Beconditioned []	Rotary Jetted	Coarse Sand	22	39
		Gravel 3/8	39	52
(5) DIMENSIONS: Diameter of	d well 20 inches	Gravel	52	70
Drilled	pleted well170ft.	Coarse Sand Gravel	70	115
A CONCEPTION DEBAT		Clay	115	130
(0) CONSTRUCTION DETAILS:	-	Sand & Gravel	130	1140
Casing installed: 14 Diam. tro	m 0_ n to _170_ n.	Coarse Sand Small G	rave] 140	1171
Threaded	mQ tt. to25 tt.	Boulders	149	111
Welded []	m	Cuanito	177	110
Perforations:				1122
Type of performant und				+
SIZE of perforations	_ in. by in.			+
perforations from		·		+
perforations from				+
perforations from				+
Sereen to an an an an				+
Manufacturer's Name				+
TypeSlotted_nine	Model No.	j		+
Diam Blot size fro	m102 n. to .112_ n.			+
Diam	m150 ft to _170_ ft.			+
Connel marked	1/4 2/0			+
Citaves packed. Yes C. No. 1 St	170 a			+
				+
Surface seal: Yes No D. To w	that depth?25ft			+
Material used in seal	el pipe - cemente	l		+
Did any strate contain unusable	water? Yes 🗋 No 💭			+
Type of water?	ement			
method or sealing strata out				+
(7) PUMP: Manufacturer's Name				+
Туре:	¥P			+
(.) WATED I FUELC. Land and	elevation			+
(0) WALLER LEVELS; above mean a	the level			
Static level	t well Dete 12=20=/6			+
Arterian pressure	uch Uave			
Arveniau water is controlled by	(Cap, valve, stc.)			
(a) WFLL TESTS. Drawdown is a	mount water level is	1		L
lowered below	static level	West started		
was a pump test mader Yerking No [] If yes,	whom atter A	WELL DRILLER'S STA	TEMENT	
и и		true to the best of my know	der my jurisdiction and this wiedse and belief.	repor
Recovery data (time taken as take when sum	n turned off) (mater laural			
measured from well top to water level)	· ····································	NAME LAYNE-WESTER	IN COMPANY THE	
Time Water Level Time Water Leve	I Time Water Level	(Person, firm,	or corporation) (Type or p	rint)
			Mosee LAke HA OO	227
		Address P.U. DUX 33	A THE REAL PROPERTY AND A DESCRIPTION OF	17 <i>1</i>
			1 mar Vainada	
Date of test	and an attack	[Signed] William		
rear with an	woown atter	1- 22		



FIGURE 8

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epartment of Ecology With WATI	R WELL REPORT	pplication No.	
dird Copy — Driller's Copy STA	TE OF WASHINGTON P	ermit No	
U.S. Department of Inter	ior 500 NE Multhomah Stre	at. Dontland	4 OD
Owners Name eavenworth - Fish Hatch	ery Address JUU NE FUI LUDUAN JUL	EL. FUI LIANU	•UK
LOCATION OF WELL: County Lingian	- Si 4 Sec	ZJ_T_24.N. R.	17E.w.m
Aring and distance from section or subdivision corner	NWND	20	1
B) PROPOSED USE: Domestic I Industrial & Mu	nicipal [] (10) WELL LOG:	\mathbf{V}) (
Irrigation [] Test Well [] Ot	er D Formation: Describe by color, character, size	of material and stru	cture, an
	show thickness of aquifers and the kind and stratum penetrated, with at least one entry	for each change of	ial in eac formation
4) TYPE OF WORK: Owner's number of well 7 #8	MATERIAL	TROM	TO
New well 🔯 Method: Dug	Bored D Large Boulders		13
Reconditioned [] Botary A	letted D Large rock gravel	13	29
	Gravel	29	30
5) DIMENSIONS: Diameter of well23	inches. Large rock & gravels	30	78
Drilled 196 ft. Depth of completed well 11	Gravel	-78	136
CONSTRUCTION DETAILS	Clay Streaks & gravel	136	145
Contraction Distributes	Gravel	145	161
Casing installed: Diam. from ft. to	30 # Gravel (clay traces)	161	184
Welded	the Gravel	184	186
	Hard rock (granite quart	z) 186	192
Perforations: Yes 🖄 No 🗆			-
Type of perforator used			
SIZE of perforations in. by		· · ·	
perforations from ft. to	ft.	1 20 A.	·
Sereense			1
Norma UPO Johnson			
Type Wire wran Model No			
Diam. 14 Slot size 50 trom 72 tt. to .	.82 ft.		1
Diam14 Slot size	<u>10_ n.</u>		
Gravel nacked ver & No D Size of gravel			1
Gravel placed from ft. to			
Surface seal: Yesy No To what depth?	I n.		1
Material used in seal			
Type of water?			1
Method of sealing strata off			1.1
7) DIIMD.		and the second second	
() FUNE: Manufacturer's Name			1.1.1
туре:		14 M	
8) WATER LEVELS: Land-surface elevation above mean sea level			
tatic level12tt. below top of well Date	1-76		
rtesian pressurelbs. per square inch Date			
Artesian water is controlled by	2.)		1
	10		1
9) WELL TESTS: Drawdown is amount water level lowered below static level	Work started	apleted	
as a pump test made? Yes No If yes, by whom 2. L.L	NOCLI CO.		
" 1025 " "		.	
	This well was drilled under my ju	risdiction and this	report
ecovery data (time taken as zero when numn turned of) (m	ter level		
measured from well top to water level)	NAME LAYNE-WESTEDN COMDAN	IV	
Time Water Level Time Water Level Time Wat	(Person, firm, or corporat	tion) (Type or)	print)
	Address P.O. Box 3360 24	The A Dover	
	Address I. J. Address	in purer	
/ Date of text		ACTION	
aller test	hrs. [Signed]	XUX WULK	
rtesian flow		Dr. Ir	~



LEAVENWORTH NATIONAL FISH HATCHERY FIGURE 9

- -

le Originel and First Copy with	WATER WI	LL. REPORT	Application No.	
kind Copy Owner's Copy Aird Copy Driller's Copy	STATE OF	VASHINGTON	Permit No	19-2 [
I) OWNER: Name Leavenworth - FI	sh Hatchery	Address 500 NE Multnomah	Street; Portland	OR
OCATION OF WELL County C	helan di secondaria mer	<u></u>	sec_23_ т_24 мся1	7 6 % .M.
PROPOSED USE: Domestic II Indus	triel 📋 Municipel 🗋 Well 🔲 Other 👾 XX	(10) WELL LOG: Tormation L Describe by color, charact	er, size of material and stre	ciure and
) TYPE OF WORK: Orneral munder of	wei 199 g1	strutum penetrated with at least one	entry for each change info	ormation.
Dependent Offer	Cable	Sint		13) 60-
DIMENSIONS	9+7/8 toches well 278 1			(280- 171
) CONSTRUCTION DETAILS:	0 278	Clay & sands	250	250
Casing insulice: **** piam from Threaded []* Diam from Welded []* Diam. from	0 n to 20 n n to 20 n	Quartz & sand	276	278
Perforations: Yest No Slots		- Cooks like the	il Ra	
SIZE of perforations in. perforations from	by in. 	WEN Maple	it phay	
perforations from	ft. to ft.			a Angalan Part
Manufacturer's Name Mo	del No		3.55	
Diam Siot aize from Diam Siot aize from	ft. to ft.	<u> </u>		
Gravel placed from28ft.	to			
Surface seal: YesXX No To what of Material used in seal	depth?	x		
Type of water? Depth o Method of sealing strata off	of strata	is in the second second		
() PUMP: Manufacturer's Name Type:		no lettro		
b) WATER LEVELS: Land-surface elev. above mean sea la atic level 26.10 ft. below top of we	ation 25 ft. evel	herd 1-18-80		
tesian pressurelbs. per square inc. Artesian water is controlled by((h Date Cap, valve, etc.)			
)) WELL TESTS: Drawdown is amoun lowered below stati	nt water level is c level whom?	Work started 10-13 , 197	c. Completed /D - 21	2, 197
eld: gal./min. with ft. drawdou	wn after hrs. "	WELL DRILLER'S STATE This well was drilled under	MENT: my jurisdiction and this	report i
covery data (time taken as zero when pump tu measured from well top to water level)	rned off) (water level	LAYNE-WESTERN CO	MPANY, INC.	
Time Water Level Time Water Level	Time Water Level	(Person, firm, or c P.O. Box 336; Mo	orporation) (Type or p)ses Lake, WA 98	print) 837
Date of test	·····	[Signed] UML	Catalians	-
uler test	own afterhrs. ds made? Yes 🗌 No 🗍	License No. 0733	(Well Driller) Date Del 14	, 1979

(USE ADDITIONAL SHEETS IF NECESSARY)

	ILS Department of Interior	Termit A	.0	
(1)	OWNER: Name Leavenworth Fish Hatchery	Address 500 NE Multhomah Street;	Portland	OR
)	LOCATION OF WELL: County Chelan	- 8 4 5 4 5 23	- 24 -	TEW
ari	ing and distance from section or subdivision corner			
(9)	DRODOGED MOR	(10) WELL LOG	There was a start of the	
(3)	PROPUSED USE: Domestic Industrial [] Municipal	(IU) WELL LOG:		16. C
	Irrigation Test Well Other	Formation: Describe by color, character, size of main show thickness of aquifers and the kind and nature	of the materi	cture an
(4)	TYPE OF WORK: Owner's number of well	stratum penetrated, with at least one entry for each	h change of	ormatio
• •	New well D Method: Dug D Bored	MATERIAL	TROMS	#TO:
	Deepened Cable Driven	lop set L-sand		\$20 ^{**}
	Reconditioned	Sand & gravel	3201	26-93 1
(5)	DIMENSIONS: Diameter of well 30"x16"	Laving, sand & gravel	- 52	63
(-)	Drilled 213 ft. Depth of completed well 213 ft	Sand & gravel		160
		Sand & gravel	160	205
(6)	CONSTRUCTION DETAILS:	Bottliders	205	207.7
	Casing installed: 30 Diam. from ft. to ft.	Granite hard Quartzite	207	213
	Threaded Diam. from ft. to ft.		100 A	\$ 7.2°
	Welded Diam. from ft. to ft.	Based on depth to be drock,	1.000	
	Perforations:	- this -		the en
	True of performance used	- cull invell #9-		
	SIZE of perforations in, by in,			
		- on original wither	45	
	perforations from ft. to ft.	- C		
	perforations from ft. to ft.	- "me" -	56 A.S.	
	Screens: Yes YY No []		3.0.C	
	Manufacturer's Name UOP Jonhson		2.200	
	TypeWirewrapModel No			14 · · · · ·
	Diam. 10 115-120			
;	$\frac{1}{122} - \frac{1}{122} - \frac{1}{131} - \frac{1}{136} - \frac{1}{180} - \frac{200}{180}$		1.577	
	Gravel packed: Yest No D Size of gravel: 1/4-3/8"			
	Gravel placed from0 ft. to205 ft.			
	Surface cool			
	Surface seal: Yes YY No To what depth?	h. V.		
	Did any strata contain unusable water? Yes Nd M			
	Type of water? Depth of strata			
	Method of sealing strata off			
(7)	PUMP: Manufactures's Name			
(.,	Type: HP			
(8)	WATER LEVELS: Land-surface elevation above mean sea level ft.			122
Static	level ft. below top of well Date 11-2-76			
Artesi	an pressure			
	(Cap, valve, etc.)		1.1	1
(9)	WELL TESTS. Drawdown is amount water level in		•	
	lowered below static level	Work started		
wasa Yield•	400 gal/min with 50 th drawdown attan	WELL DRILLER'S STATEMENT	1 1 and 1	
	" " " "	WILL DIVIDUALS STATEMENT:		
	Well Callapsed "	This well was drilled under my jurisdicti	on and this	report
Recov	ery data (time taken as zero when pump turned off) (water level	and bene		
m	easured from well top to water level)	NAME LAYNE-WESTERN COMPANY. II	NC.	
1.111	water Level 11me water Level Time Water Level	(Person, firm, or corporation)	(Type or p	rint)
		Addama P.O. Box 336; Moses Lake	, WA 9883	7
		Address		
Da	te of test	I WINK (a (m this	74	
Bailer	test	[Signed].UAUU	<u>. r</u>	
Irtesi	an flowg.p.m. Date	(wear Driller)	. *	-
STATE OF WASHINGTON Water Right Permit No. Water Right Permit No. OWNER: Name_US_Fish + Wildlift Address 9/1/ N.E. 11 ^{-Th} + e Port 16.11 ^{-Th} OWNER: Name_US_Fish + Wildlift Address 9/1/ N.E. 11 ^{-Th} + e Port 16.11 ^{-Th} Chi & I/a III OWNER: Name_US_Fish + Wildlift OWNER: Output OWNER: County_Chi & I/a OWNER: Name_US_Fish + I/a OWNER: Output OWNER: Output<	CR 97 N. R 17 RIPTION			
---	--			
Image: Section of Well: County	<u>сле 97.</u> ч. в <u>17</u> Пртіон			
27 LOCATION OF WELL: County	N. R 17			
2a) STREET ADDRESS OF WELL (or nearest address) L Caves worth Fish Hatchery 3) PROPOSED USE: Domestic Industrial Municipal (10) WELL LOG or ABANDONMENT PROCEDURE DESCI				
3) PROPOSED USE: Domestic Industrial Municipal (10) WELL LOG or ABANDONMENT PROCEDURE DESCI	IPTION			
Innation				
DeWater Test Well Other Formation: Describe by color, character, size of material and structure, and show: DeWater De	hickness of aqu			
4) TYPE OF WORK: Owner's number of well #: (6)	One entry lot			
Abandoned New well C Method: Dug Bored MATERIAL FR	ом то			
Deepend Cable & Driven Silly Saudy Could's	5			
neconditioned notary Jeted Skyld, Cravelset (Cb) - 5	30			
i) DIMENSIONS: Diameter of well 12 inches. Carrs Science 30	. 40			
Drilled 110 feet. Depth of completed well 104 ft. Said & Grave 44	1 50			
$\frac{1}{2}$ CONSTRUCTION DETAILS: $\frac{5\alpha n \xi}{2}$	70			
Cooler location 12 Day ton to 2 ton 25 MICC SULL 70	110			
Perforations: Yes No 🖄				
Type of perforator used				
SIZE of periorations in. by in.				
perforations from ft. to ft.				
periorations from ft. to ft.				
perovations from ft. to ft.				
Screens: Yes 🛛 No 🗌				
Manufacturer's Name				
Type 55 Model No.				
$\lim_{t \to \infty} \frac{d\mathcal{O}}{dt} = \int_{t}^{t} \int_{t}^{t}$				
Diam. <u>(C)</u> Slot size <u>10</u> from <u>50</u> ft. to <u>75</u> ft.				
Gravel packed: Yes No Size of gravel				
Gravel placed fromft. toft.				
Surface seal: res () NO () Iowhat depth? ft.				
Type of water?				
Method of sealing strata off				
') PUMP: Manufacturer's Name				
Туре:				
WATER LEVELS: Land-surface elevation				
Static level 3 5 / or emean sea level t.				
Artesian pressure bis, per source inch Date				
Artesian water is controlled by				
(Cap, valve, etc.) Work Started /-23-96, 19 Convoluted J-224	-0 10			
) WELL TESTS: Drawdown is amount water level is lowered below static level	, 19			
Was a pump test made? Yes 📋 No 🖄 If yes, by whom? WELL CONSTRUCTOR CERTIFICATION:				
Yield:gal./min. withft. drawdown afterhrs. I constructed and/or accept responsibility for construction of the	nis well and			
" " compliance with all Washington well construction standards. Ma	terials used			
" " " the information reported above are true to my best knowledge an	d belief.			
Recovery data (time taken as zero when pump turned off) (water level measured from well NAME Holf Dr.//ing Tric				
top to water level) (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT Time Water Level Time Water Level Time Water Level)			
Address & 621 Tect Re & Porally	10A9			
	FO.			
(Signed) <u>Liceact</u> (Liceacted) Licease No	54			
Date of test				
Bailer testgal./min. withft. drawdown afterhrs. Contractor's				
Airtestgal./min. with stem set atft. forhrs. No. HOCTTINO810J Date 3-14	. 19			
Artesian flow				
Temperature of water Was a chemical analysis made? Yes L No L (USE ADDITIONAL SHEETS IF NECESSARY	5			



	Start Card No.	6349
File Or sinal and First Copy with Desc into 16 Ecology Second Copy — Owner's Copy State OF W/		ABV 292
Current C Fish with 11110	Water Right Permit No.	<u> </u>
OWNER: Name () FIST & COTATION Address	iss III NEIT GIT TON and CR	27232-4181
2) LOCATION OF WELL: County Chelq 11	- <u>NUU 1/4 SE 1/4 Sec 23 T. Z</u>	5 N.R/7 W
(2a) STREET ADDRESS OF WELL (or nearest address)	Fish Hacthery	
(3) PROPOSED USE: Domestic Industrial Municipal	(10) WELL LOG or ABANDONMENT PROCEDURE	ESCRIPTION
📋 Irrigation	Formation: Describe by color, character, size of material and structure, and and the kind and nature of the material in each stratum penetrated with	d show thickness of aquife
(4) TYPE OF WORK: Owner's number of well (If more than one) //	change of information.	at least one entry for ea
Abandoned 2 New well & Method: Dug Bored D	MATERIAL	FROM TO
Deepened Cable Driven	Srown Sawal	0 12
(5) DIMENSIONS: Diameter of well (6 inches	Brand Gard Cont	18 55
Drilled 278 feet. Depth of completed well ft.	Gray Sill (wet)	55 261
	Gray Silt up Cabs.	261 274
Casing installed: "Diam from it to it	Granite Bed North	274 278
Welded Diam. from ft. to ft.		· · · · · · · · · · · · · · · · · · ·
Threaded Diam, fromft. to ft.		
Perforations: Yes No		
Type of perforator used		
SIZE of perforations in. by in.		
perforations from ft. to ft.		
perforations from ft. toft.		
Screens: Yes No 🗵		
Manufacturer's Name		
Type Model No	Abandonal with	
Diam Slot size trom tt. to tt.	Benonite a plea Grows.	
	from 218-20'	
Gravel placed from		
Material used in sealR to the north of T		
Did any strata contain unusable water? Yes No		
Type of water? Depth of strata		
Method of sealing strata off		
(7) PUMP: Manufacturer's Name		
Туре: Н.Р		
(8) WATER LEVELS: Land-surface elevation above mean sea level ft.		
Static level ft. below top of well Date		
Artesian water is controlled by		
(Cap, valve, etc.)	Work Started, 19. Completed	
(9) WELL TESTS: Drawdown is amount water level is lowered below static level		,
Yield: gal./min. with ft. drawdown after brs	WELL CONSTRUCTOR CERTIFICATION:	
	I constructed and/or accept responsibility for construction compliance with all Washington well construction standar	on of this well, and ds Materials used a
¹¹ ¹¹ ¹¹ ¹¹	the information reported above are true to my best knowle	dge and belief.
Recovery data (time taken as zero when pump turned off) (water level measured from well	NAME Holt Drukting In	X
top to water level) Time Water Level Time Water Level Time Water Level	(PERSON, FIRM, OR CORPORATION) (TYPE	OR PRINT)
	Address 10621 lodd Ru	E
	(Signed) Wade Torente Lice	nse No. 5,97
Date of test	(WELL DRILLER)	
Bailer testgal./min. withft. drawdown afterhrs.	Contractor's Begistration	
Airtestgal./min. with stem set atft. forhrs.	No HOLT YTY 88705 Date 3-1	4 . 19 9
Artagion flow		

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Appendix C: Seepage Monitoring Data



Figure C-1: Hydrograph of water level response in OW-1 and upstream transducer in hatchery channel



Figure C-2: Hydrograph of water level response in OW-2 and upstream transducer in Hatchery channel



Figure C-3: Hydrograph of water level response in OW-3 and downstream transducer in hatchery channel



Figure C-4: Hydrograph of water level response in OW-4 and upstream transducer in Hatchery channel



Figure C-5: Hydrograph of water level response in monitoring wells and downstream transducer in Hatchery channel

Flow in Icicle Crk.						
	Structure No. 2	Historic Channel	Water Elev. u/s of			
Date/Time	Gate Opening (ft)	(cfs)	Structure No. 2			
9/29/09 17:00	5	47	1128.6			
9/30/09 8:45	5	52	1128.6			
9/30/09 9:45	5	52	1128.6			
9/30/09 10:37	03	46	1129.3			
9/30/09 15:03	0.3	53	1129.8			
10/1/09 7:20	0.3	54	1129.9			
10/1/09 10:37	0.3	54	1129.9			
10/1/09 12:40	0.3	55	1129.9			
10/1/09 14:40	0.3	55	1129.9			
10/2/09 8:40	0.3	54	1129.9			
10/2/09 11:50	0.3	64	1130 7			
10/2/09 15:10	0.3	69	1131.1			
10/3/09 9:10	0.3	87	1133.0			
10/3/09 16:00	0.4	108	1132.4			
10/4/09 9:30	0.4	99	1131.6			
10/4/09 15:20	0.3	78	1132.0			
10/5/09 7:50	0.0	79	1132.0			
10/5/09 11:50	0.23	64	1132.6			
10/5/09 14:00	0.23	64	1132.6			
10/6/09 9:30	0.26	90	1132.5			
10/6/09 13:00	0.26	90	1132.5			
10/7/09 10:20	0.26	0	1130.0			
10/7/09 10:20	0.26	59	1129.9			
10/7/09 12:10	0.20	58	1120.0			
10/7/09 13:20	0.20	56	1120.0			
10/7/09 16:20	0.06	14	1131.0			
10/8/09 8:10	0.00	19	1133.1			
10/8/09 12:30	0.00	18	1133.1			
10/8/09 12:00	0.00	18	1133.1			
10/8/09 15:45	0.00	47	1133.0			
10/0/09 13:45	0.10	40	1133.0			
10/9/09 12:10	0.10	40	1131.7			
10/9/09 13:20	0.10	40	1131.7			
10/10/09 15:20	0.10		1130.8			
10/11/09 16:25	0.10	38	1130.0			
10/12/09 16:00	0.16	30	1131.0			
10/12/09 10:00	0.10	30	1131.4			
10/13/09 13:35	0.10	70	1131.0			
10/13/09 13:35	0.31	68	1130.8			
10/13/09 14:00	0.46	95	1130.5			
10/17/09 14:40	0.40	95 50	1128.6			
10/14/09 11:20	0.40	50	1120.0			
10/14/09 12.20	0.40		1120.7			
10/14/09 14.30	0.40	49	1120.0			
10/15/09 9.40	<u> </u>	90 75	1129.0			
10/17/00 7:20	<u> </u>	70	1120.0			
10/17/09 7.20	<u> </u>	92	1120.9			
10/10/09 7.23	3	10	1120.0			

Table C-1: Gate and flow measurements at Structure No. 2 during Oct. 2009 seepage monitoring (personal communication, F. Wurster)

10/19/09 9:00	3	197	1129.6
10/20/09 9:08	3	139	1129.2
10/22/09 8:50	3	116	1129.1
10/22/09 15:30	3	124	1129.1

Note: Values in red are estimated