Groundwater & Environmental Consultants

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Technical Review Memorandum

To: Washington Department of Ecology
From: Mark Yinger, LHG, Hydrogeologist
Date: February 3, 2012
Re: Aspect Consulting Report - Husum/BZ Corner Subarea Rezone

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I. Introduction.

This memorandum presents an expert review of the disclosure and analysis presented in a report prepared for Klickitat County by Aspect Consulting for the rezone of hundreds of acres of land along the White Salmon River and its tributaries which authorizes a significant increase in residential development density on lands along the White Salmon River. I was retained to provide a peer review of the Aspect report by Ralph Bloemers, Crag Law Center (Portland, Oregon) and present expert testimony in an appeal of a Mitigated Determination of Non-significance filed by the Friends of the White Salmon River, Friends of the Columbia Gorge and Citizens for Common Sense on the White Salmon.

The Aspect Consulting report (the "Aspect report" or the "report") was prepared by Erich Miller and Jay Chenault (the "authors", 2009) and is on file with Klickitat County. I understand it has been shared with the Department of Ecology but do not know the extent to which it has been carefully peer-reviewed. The report presents an analysis of the impacts on water resources from rezoning these lands along the White Salmon River. To aid your understanding of the extent and nature of the proposed rezone, this technical memorandum includes two detailed maps as exhibits, and a map showing the hypothetical drainfield. The following is link to the Aspect report; http://friendsofthewhitesalmon.org/wordpress/wp-content/uploads/AspectFinal-Report-11-4-09-2.pdf

II. Analysis.

The Aspect report contains serious errors and miscalculations. Most notably the report mischaracterizes the relationship between the shallow Quaternary aquifer and the underlying Columbia River Basalt (CRB) aquifer and misrepresents the potential nitrate pollution of groundwater due to septic systems by grossly over sizing drainfields so as to dilute the effluent. The report also relies heavily on proposed mitigation to address the significant impacts, specifically stating that new residential users in the Husum area and to the south of there would hook up to the Fordyce Water Association community

water system even though this system is already over-tapped and it is not likely to be expanded.

A. The Basin is Generally Unconfined or Leaky, Not Bounded or Confined.

Aspect assumes the hydraulic continuity between the shallow Quaternary basalt and gravel aquifer "is limited by a single massive basalt flow" (Aspect Report p. 29). This assumption is erroneous and unsupported. The report repeatedly states that withdrawals from the CRB aquifer are "entirely consumptive, with the return flows contributing to the alluvial sediments and Quaternary volcanics aquifer." The report presents the claim that there is no return flow to the CRB aquifer, that there is a very limited hydraulic connection between the CRB and shallow Quaternary aquifers. Readily available data demonstrates this is incorrect. The water levels in the wells shown on the cross-sections in the Aspect report indicate a downward vertical gradient with water flowing from the shallow Quaternary aquifer into the CRB aquifer.

B. The Aspect Report Ignores Significant Risk to Fordyce Water System.

I have personally conducted tests and analysis on the water systems in this basin for over 18 years. In 1994, I conducted tests on the Fordyce Water Association system wells and observed firsthand how the pumping of the deeper aquifer directly affects the upper shallow aquifer (Yinger, 1995). During a pump test of Fordyce Well #2, completed in the CRB aquifer, the water levels in Fordyce Well #1, completed in the shallow Quaternary aquifer, and a nearby exempt well went down significantly. The pump test of this water supply well in the deeper CRB aquifer revealed measurable interference with wells in the shallow Quaternary aquifer. The shallow Quaternary aquifer serves as the source bed for the water pumped from Fordyce Well #2 in the deeper CRB aquifer.

Because the Aspect report ignores the hydraulic connection between the shallow Quaternary aquifer and the CRB aquifer, it fails to disclose and identify the critical aquifer recharge area surrounding the Fordyce Well #1. The Aspect report does not even state that Fordyce Well #1 relies on a Critical Aquifer Recharge Area, let alone attempt to identify the location of the recharge area for this public water system (Aspect report p. 24). This is a critical omission. The identification of a critical aquifer recharge area for the Fordyce well is needed to protect this important public water supply from interference and contamination.

C. Impacts on Seeps, Springs and White Salmon River Tributaries.

The report discusses the impacts of increased and diffuse groundwater use. Aspect report at 21-22. This discussion is infected by the incorrect characterization of the hydraulic connections between the CRB aquifer, the shallow Quaternary aquifer, and surface waters. The Aspect report does not present information on how much of the return flow actually recharges the CRB aquifer. The Aspect report at least identifies increased pumping of the CRB aquifer as a "potential significant impact" but then

wrongly assumes that the CRB and shallow Quaternary aquifers have limited hydraulic connection due to a single massive basalt flow and that the CRB aquifer is divided into blocks by faults that impede groundwater flow. As a result the authors ignore two important impacts:

(1) lowering the water level in the shallow Quaternary aquifer from increased pumping in the CRB aquifer will affect wells in the shallow aquifer and vice versa – which risks pitting users of the shallow Quaternary aquifer against those in the deeper CRB aquifer and risks significant costs to all users,

(2) reduced discharge from the shallow Quaternary aquifer to White Salmon River tributaries, seeps, and springs. The Aspect report does not identify these potentially significant impacts, and therefore, there is no way that these impacts are mitigated in the County's MDNS.

As discussed above, the Aspect report contains no evidence that CRB fault blocks of hydrologic significance are found north of the Buck Creek fault. In fact, groundwater is present in a leaky system, not compartmentalized by faults that impede groundwater flow. While the Aspect Report makes contrary claims, the cross-section B-B' (Figure 2.3) in the Aspect report actually confirms that there is no significant water level change across the fault just south of BZ Corner. In the discussion on pages 24 and 25, the report again overstates the nature of the fault blocks and assumes that other wells in the CRB aquifer will have remote recharge areas and long travel times.

The report states that the proposed rezone could have a probable significant impact on tributary streams. I agree. However, the report then suggests that mitigation is "drilling wells so that they are not in hydraulic continuity with the tributary streams." I disagree. There is no location on the planned lots along these tributaries where a landowner could drill a new well so the well is not in hydraulic continuity with the tributaries. See Aspect Report at 32.

The flow in Rattlesnake Creek and other named and unnamed tributaries is very low in the late summer to early fall. An increase in groundwater withdrawals will very likely have a significant impact on flow and thus temperature in these fish bearing tributaries.

D. Flaws in Discussion of Water Use.

The Aspect reports presents an analysis under the title "water use by aquifer." This analysis is flawed because it is based again on unfounded assumptions. The first paragraph on page 32 again repeats the claim that there will be no significant impact on the shallow Quaternary aquifer from the pumping of wells in the CRB aquifer. However, pumping in the CRB aquifer would lead to declining water levels in the

shallow Quaternary aquifer and reduced groundwater discharge from the shallow aquifer to area streams, particularly tributaries of the White Salmon River.[1]

The Aspect report admits that groundwater pumping has the potential to have significant impacts on tributary streams. However, the mitigation Aspect offers: "locate wells in areas not in hydraulic continuity with tributary streams" is not reasonable and capable of being accomplished.

The last sentence in the first paragraph of page 34 again understates the impact to the water quality of tributaries. In fact, wells in the vicinity of the tributaries will reduce stream flows and this will cause a rise in water temperatures during the low flow period of summer and fall. Stream flow volume reduction will increase stream temperature. The streams will heat up for two reasons; 1) groundwater is much cooler than the stream and any reduction in groundwater discharge to a tributary stream will increase water temperature of the stream, and 2) reduced flow means shallower streams and shallower streams heat up quicker.

E. Water Quality Impacts to the White Salmon River Basin.

The report presents an evaluation of the impact on groundwater quality due to nitrate concentrations in discharges from sewage drainfields. This presentation is fundamentally flawed, and therefore, should be disregarded. Aspect used a grossly oversized drainfield when applying Ecology's simple mass balance mixing model to estimate nitrate concentration in groundwater downgradient of a hypothetical community septic drainfield in the Husum RC area.

The Aspect report authors assume the drainfield is the same size as the lot, even in RC zoning where a community sewage treatment system is required for build out at the allowed density. This modification from a default 1,000 square foot drainfield per residence to up to an 87,000 square foot drainfield per residence is a gross misuse of the model and without any foundation in science.

The values below are from Aspect's Table 3.5 (size and area are in square feet):

Lot size	5,000	43,560	87,300
Total area of drainfield	2,000,000	2,003,760	2,007,900
Number of homes	400	46	23
Area of drainfield per home	5,000	43,560	87,300

[1] Aspect report, page 32 second paragraph, fourth sentence. There is no evidence that BZ Corner area lies within a separate fault bounded aquifer from Husum. From a hydrologic perspective fault blocks are only significant if there are evidenced changes in hydraulic head from one fault bounded block to the next. In the NW-SE cross-section, the Aspect report plots static water levels and the cross-section shows no big changes in water levels across the fault just south of BZ Corner. If a fault barrier to groundwater flow was present in the area, then the cross-section would show significantly higher groundwater levels north of the fault, on the up-gradient side.

The Aspect report presents artificially low nitrate concentrations. Instead of using a default 1,000 square foot drainfield per residence the Aspect report uses a grossly oversized drainfield that has the result of exponentially increasing dilution of the septic effluent by infiltrating rainfall. The Aspect report presents arbitrary and capricious, clearly erroneous data and conclusions regarding the proposed rezone's impact on water quality.

The report failed to base the nitrate modeling on site specific hydrogeologic parameters, namely hydraulic conductivity and groundwater gradient. The drainfield discharge is to the uppermost aquifer, which is in the fine-grained Bretz Flood sediments (also known as the Missoula Flood sediments). Both the effluent flow through the vadose zone and effluent mixing with groundwater in the saturated zone will be within the Bretz Flood fine-grained sediments.

While there are no wells located in the low permeability flood sediments, Aspect derived its figure for hydraulic conductivity, which is a key component of the model, based on analysis of specific capacity of water wells completed in the Quaternary volcanics and underlying gravels. As a consequence, the hydraulic conductivity values used in their modeling are far too high. The logs for three wells to the north of the hypothetical drainfield, at approximately the same elevation, penetrate starting from just below the surface, 71 to 79 feet of the Bretz Flood sediments. The sediments are described as clay, clayey sand and sand. Of particular interest is that in two of the well logs quicksand and caving-sand are described starting at 17 and 29 feet beneath the surface. These conditions are strong indicators of saturated conditions. Further, Aspect appears to ignore the published geologic maps and their own cross-sections which show the entire area of the drainfield and from the drainfield to river to be underlain by Bretz Flood fine-grained sediments. The Bretz Flood sediments have been extensively studied in the Willamette Valley and consist of many layers of very fine sand, clayey-sand, and clay. The low hydraulic conductivity of the clay-rich layers plays a dominant role in the flow of groundwater and thus limits groundwater flow.

Using the information in the logs of the nearby wells the depth to groundwater beneath the drainfield is estimated to be 30 feet. Assuming the Bretz Flood sediment aquifer discharges to the White Salmon River then the hydraulic gradient would be approximately 0.035 (70 foot drop over 2,000 feet). This gradient is much shallower than that used in the Aspect report. The great majority of the wells in the area are completed in the gravels beneath the Quaternary volcanics. The water levels in these wells are not indicative of the watertable in Bretz Flood sediments.

The consequence of Aspect's errors is serious because it significantly underestimates the increase of nitrate concentration in groundwater due to septic drainfields. Without a sewage treatment plant Ecology's nitrate non-degradation standard of 2 milligrams per liter (mg/l) will be exceeded under all zoning densities, and by a significant amount. That is probably why expansion of the RC zoning requires the development of a community waste water treatment system.

On November 29th I was in the Husum area specifically to examine the Bretz Flood sediments. The sediments are exposed in road cuts of Spring Road and Lower Spring Road (northwest of Husum). I would classify the majority of the exposed material as lean clay (CL). There are also likely to be layers of elastic silt (MH). These are old road cuts that are steep and are not significantly eroded. In the USDA's Engineering Field Handbook the range of hydraulic conductivity for CL is 0.003-0.00003 ft/d and for MH 0.3 to 0.003 ft/d. For the nitrate loading modeling I would use 0.003 to 0.0003 ft/day.

The USGS groundwater hydrology study of the Willamette basin (2005) contains a table that is a compilation of hydraulic conductivity values for the Willamette Silt. The silt is strongly anisotropic with vertical conductivity generally three-orders of magnitude less than the horizontal conductivity. Horizontal conductivities cited range from 1 to 0.01 ft/d horizontally and vertical from 0.7 to 0.00004 ft/d.

During my site visit, I observed a small stream and wetland just to the west of the Husum RC area. Based on the elevation of the stream and wetland I am comfortable with my above estimation that the watertable in the area of the hypothetical drainfield would be approximately 30 feet beneath the surface.

F. Undisclosed Impacts, Unmitigated Impacts.

As discussed above, pumping the CRB aquifer will lower the water level in the shallow Quaternary aquifer in which many domestic wells are completed and are proposed to be located with this proposed rezone. The increased pumping will also reduce groundwater discharge to the White Salmon River and tributaries. Because the Aspect report understates and ignores these impacts, there is no consideration of feasible alternatives or feasible mitigation.

Again the impact to tributary stream flow is recognized as a significant impact (bottom page 38). Pumping either aquifer in the vicinity of the tributaries will reduce groundwater discharges to the tributaries. The impact may be particularly significant during the low flow period in late summer and fall. The mitigation offered of locating wells in aquifers not hydraulically connect to tributaries is not possible. In any case the mitigation described is so vague as to be not feasible to implement.[2]

[2] The report recognizes additional pumping of the CRB aquifer within the fault block in which the City of White Salmon wells are located as a significant impact. The report presents aquifer storage and recovery (ASR) and completion of future exempt wells in the shallow quaternary aquifer as mitigation options. ASR is expensive but feasible for the City of White Salmon, whether the basin can support it remains to be determined. However, the completion of new wells in the shallow Quaternary aquifer to mitigate for declining water level in the CRB aquifer will not work as discussed as increased pumping of the shallow aquifer fault reduces recharge to the CRB aquifer.

The standard is to first identify the impact, and then assess whether there is reasonable and capable of being accomplished mitigation for the impact. Under water quality mitigation (page 39) nitrate loading is identified as a significant impact. As discussed above it is actually of much greater significance than Aspect has portrayed. In the Husum RC area and adjoining RR-1area, under either alternative, a community sewer and treatment system is the only practical mitigation. In areas underlain the Bretz Flood sediments, which is most of the proposed large RR-2 area south of Husum, on-site septic systems will have to be capable of efficient nitrate removal (currently not required in the area).

The significant cost of a sewer and treatment system makes it most feasible where the population density is high, in other words more connections over a small area. The higher density development allowed in RC areas encourages this kind of development over the highly dispersed approach in the proposed Rezone.

Monitoring for nitrate is also presented as a mitigation option. However, monitoring is not mitigation for this particular impact. By the time nitrate levels are detected at a concentration that is recognized as significant what are you going to do? It will be very hard to go back and require residents to retrofit or upgrade their existing on-site septic systems. This has been and continues to be a major problem for the La Pine area in south Deschutes Count and for other communities. Monitoring is not a legitimate mitigation option.

III. Conclusion.

In summary the most significant issues are:

A) Increased pumping and water withdrawals in the deeper CRB aquifer (Columbia River Basalt) will lower the water levels in the shallow Quaternary aquifer and reduce groundwater discharges to area springs, seeps, and tributaries.

B) The rezone authorizes significant levels of new development which will require the use of new individual exempt wells in the vicinity of tributaries to the White Salmon River. These new wells will be in hydraulic continuity with the springs, seeps, and streams, and will lead to reduced discharges of cool groundwater to these surface waters. The decrease discharge of groundwater will lead to significant increases in the water temperature of tributary streams, particularly during low-flow periods in summer and fall.

C) The Nitrate concentrations in the area's groundwater will increase significantly, far more than the Aspect report discloses. The Aspect report contains erroneous assumptions regarding drainfield size, hydraulic conductivity, and groundwater gradient. The grossly oversized drainfields result in inappropriate dilution of the septic effluent by percolating rainfall. The state's anti-degradation standard will likely be exceeded for all zoning densities, particularly in the areas which are underlain by the Bretz Flood sediments. The proposed large expansion of RR-1 and RR-2 zoning

in the vicinity of Husum and to the south are underlain in large part by the Bretz Flood sediments, and water moves far more slowly through these sediments than claimed in the Aspect report.

References:

Chennault, J.W. and Miller, E.W., 2009, Hydrologic Report Husum/BZ Corner Subarea, prepared for Klickitat County Planning Department.

Conlon, T.D., Wozniak, K.C., Woodcock, D., Herrera, N.B., Fisher, B.J., Morgan, D.S., Lee, K.K., and Hinkle, S.R., 2005, Ground-Water Hydrology of the Willamette Basin, Oregon: U.S. Geological Survey Scientific Investigations Report 2005-5168, 83 p., 1 plate.

Yinger, Mark, 1995, Aquifer Hydraulic and Water Testing Related to Fordyce #2, prepared for Fordyce Springs, Inc.

Exhibit List

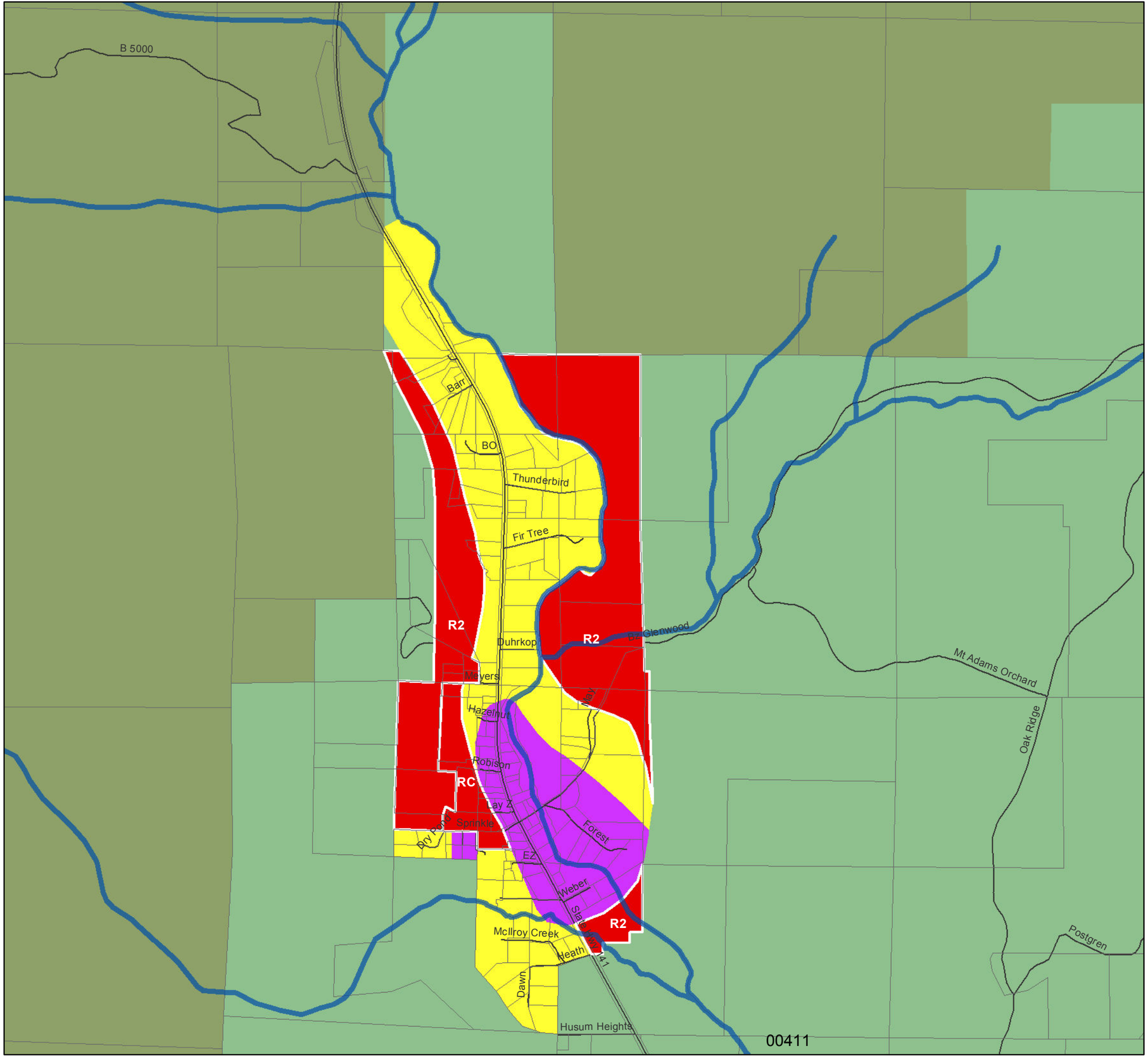
1. Maps of Proposed Rezone
2. Map of Proposed Drainfield

Proposed County Zoning

BZ Corner

**Prepared by Joanna Malaczynski for Crag Law Center
on behalf of Friends of the White Salmon River,
Friends of the Columbia River Gorge,
Citizens for Common Sense on the White Salmon**

Data Source: Klickitat County



Klickitat CO Parcels

Proposed 2 Acre Density

EXISTING ZONING

Forest Resource

Resource Lands

Rural Center

Rural Residential 2

N

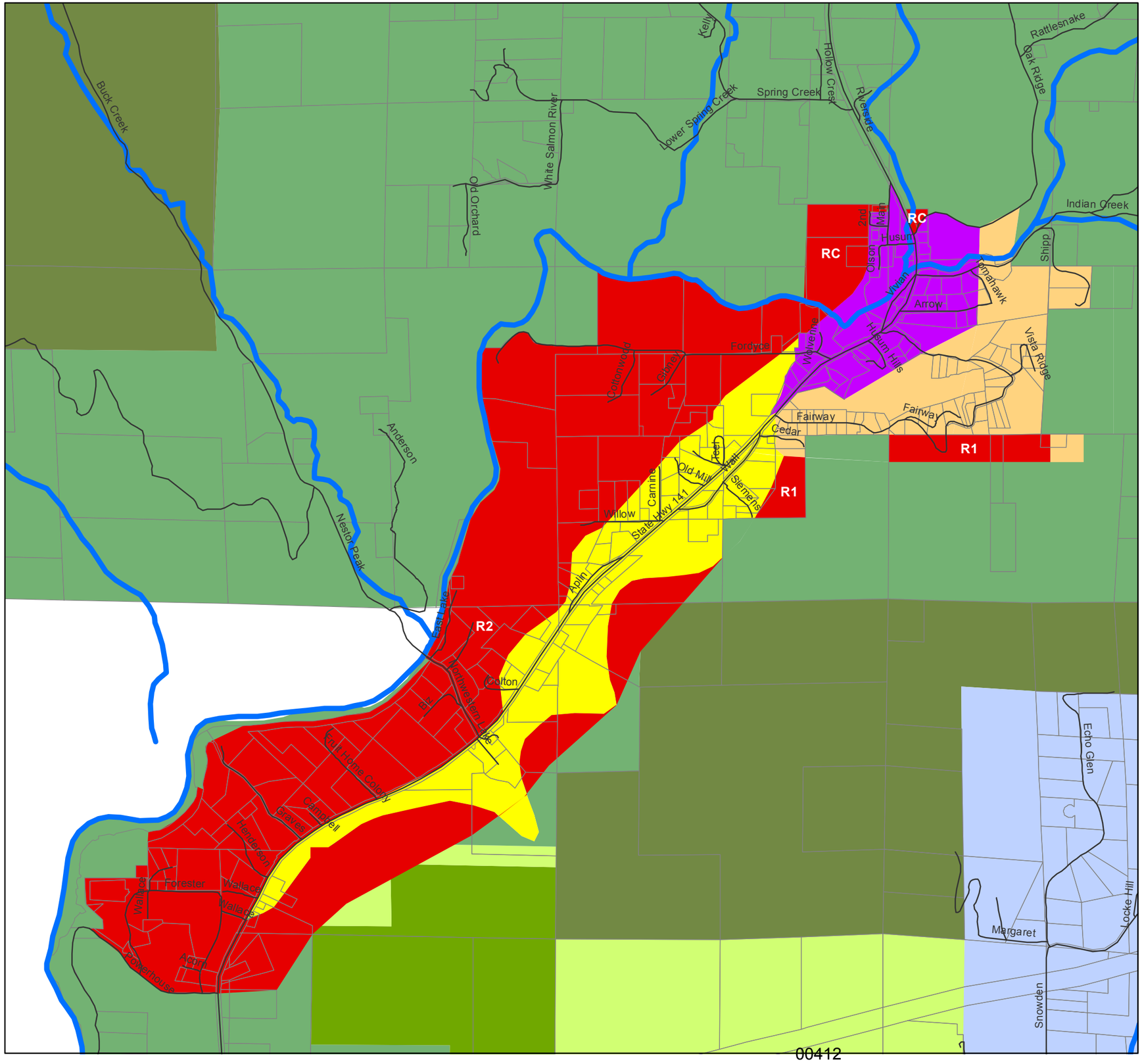
0 1,000 2,000 3,000 4,000 Feet

Proposed County Zoning

Husum

Prepared by Joanna Malaczynski for Crag Law Center on behalf of Friends of the White Salmon River, Friends of the Columbia River Gorge, Citizens for Common Sense on the White Salmon

Data Source: Klickitat County



Klickitat CO Parcels

Proposed 2 Acre Density

EXISTING ZONING

- Extensive Agriculture
- Forest Resource
- General Rural
- Open Space
- Resource Lands
- Rural Center
- Rural Residential 1
- Rural Residential 2

0 1,000 2,000 3,000 4,000 Feet

N

Proposed Septic Drainfield (2 million square foot area)

Husum

Prepared by Joanna Malaczynski for Crag Law Center on behalf of Friends of the White Salmon River, Friends of the Columbia River Gorge, Citizens for Common Sense on the White Salmon

Data Source: Klickitat County

- Proposed 2 million sq. ft septic drainfield
- Klickitat CO Parcels
- Proposed 2 Acre Density

EXISTING ZONING

- Extensive Agriculture
- Forest Resource
- General Rural
- Open Space
- Resource Lands
- Rural Center
- Rural Residential 1
- Rural Residential 2

0 1,000 2,000 3,000 4,000 Feet

N

Mark Yinger Associates

Selected Water Resource Projects

Bickleton, Washington, Groundwater Source Investigation

Water produced by private and public wells in the community of Bickleton has nitrate concentrations that exceed safe drinking water standards. This project involved investigating the extent of the nitrate impact and defining a target aquifer for of new community water system well that would be free of nitrate impact. Several sites for new wells were identified.

City of Mosier, Oregon, Water System Improvements

Mark Yinger was a sub-consultant to Berger/ABAM Engineering. The first phase of the project involved identifying, evaluating, and ranking all potential groundwater resources culminating in a recommendation to site a new production well. Phase two involved developing specifications for a new well and for the repair of commingling Well #3. The new well construction involved inspection of drilling, construction, and testing of the new well. Commingling Well #3 was successfully repaired.

Crooked River Environmental Flows Literature Review and Summary Report

Mark Yinger was a member of team of scientist put together by WPM, Inc. to make an assessment of flow conditions and develop a recommendation for environmental flows in the Crooked River below Bowman Dam. The study area includes the City of Prineville, Oregon. Mark Yinger was responsible for evaluating historical and current groundwater / surface interactions. This project included a comprehensive compilation and review of the pertinent literature and data.

Crystal Springs Zone of Contribution Definition

This study defined the boundary of the recharge area for Crystal Springs. Crystal Springs supplies water for a major portion of Hood River County, Oregon. The study involved detailed hydrogeologic mapping in a setting of complex volcanic geology, stream flow measurements and a water balance. The boundary was certified by the Oregon Department of Human Services and Health establishing a source water protection area.

Skamania County Public Utility District #1, Carson Water System

Mark Yinger worked as a sub-consultant to Wallis Engineering. The objective was to explore for a new groundwater source for the Carson Water System that would eventually replace the current source a diversion on Bear Creek. The project involved hydrogeologic mapping, conceptual modeling, and geophysical surveys to define locations for two test wells. Neither well encountered productive enough aquifers. Based on these results the district proceeded to test an existing well and eventually acquired the well and constructed a new water transmission line. Mark Yinger is currently assisting the PUD with Phase I evaluation of two water right applications. This work involves the defining the source water body which includes the source aquifer and connected surface waters. This will be followed by identifying all senior applications in the defined source water body.

National Golf Courses Inc./Multnomah County Drainage District No.1, Oregon

Mark Yinger assisted National Golf Courses Inc. with a change in point of diversion for a golf course irrigation water right. The change was from a diversion on the Columbia Slough, a tributary of the Columbia River, to a new well. The work involved a review of the area hydrogeology, area well logs, production well specifications, and a pumping test.

Skamania County Public Utility District #1, Underwood Water District

Mark Yinger conducted a study to define a location for a new production well needed to augment water supply during periods of low flow from Shaddock Spring. A well was designed, installed and tested. A hydrogeologic assessment supported the use of the new well as and alternate point of diversion for water rights associated with the spring. The geologic setting can be characterized as Quaternary basaltic lavas and cinders filling a deep canyon eroded in Grande Ronde Basalt.

WRIA 29, Wind/White Salmon Watershed Assessment

A comprehensive Level I description and assessment of the hydrogeology and groundwater resources of the WRIA 29 region. This region includes Wind, Little White Salmon and White Salmon Rivers. Level II assessment work involved a study of the lower Wind River basin and a groundwater monitoring plan for the entire WRIA-29 region.

City of Hood River: Potable springs characterization

This study defined the geologic features controlling the occurrence of several large springs (13 million gallons per day) to guide redevelopment intended to improve spring water capture and sanitation. This extensive study involved: detailed hydrogeologic mapping, seismic refraction surveys, self potential surveys, VLF surveys, stream channel and spring flow measurements, and tracer testing.

A buried channel was identified beneath a talus slope of an andesite flow approximately 300 feet up gradient of the current collectors. The self-potential survey and tracer testing confirmed water flow in the channel and its connection to the springs. A conceptual hydrogeologic model was developed to define the zone of contribution for the springs.

City of White Salmon: Critical aquifer recharge area definition

This study involved hydrogeologic mapping in the City of White Salmon's Buck Creek Watershed area. The objective was to define recharge areas for aquifers contributing to the base-flow of the drainage basin. The study established that a significant portion of the recharge area is located outside the topographic watershed boundary. The boundary of the newly defined recharge area was used to negotiate new land use zoning for long term water quality and quantity protection.

City of White Salmon: Ground water resource portion of comprehensive plan

This regional study was conducted to inventory and rank potential groundwater sources for future development. The City had relied on a watershed that at times failed to provide adequate quality water. This study identified and ranked four potential aquifers for development.

Limmeroth Ranches, Eightmile Creek Drainage, The Dalles, Oregon: Irrigation well

This project involved a hydrogeologic investigation for the purpose of selecting the location for a new irrigation well, and a long term pumping test of the well. A fault was identified and mapped that offsets very permeable zones within the Columbia River basalts resulting in a much greater hydraulic head in up gradient of the fault. The new well is a very productive well.

City of White Salmon: Drinking water wells

This project involved the selection of locations for two production wells and two observation wells for the City of White Salmon, Washington. The work included well design, bid specifications and construction monitoring. The combined production rate is approximately 2,400 gallons per minute. The project also include long term pumping tests, groundwater/surface water interaction and well interference studies, and technical support for water right changes. Finally, wellhead protection zones were defined for the production wells.

Fordyce Springs Incorporated: Aquifer test and wellhead protection

This project involved the management of a long term pumping test of a new potable water well for a new rural public water system in Washington State. Draw down at three existing domestic wells and the flow from one spring were monitored during the pumping. The draw down and recovery at the pumping well was digitally monitored. This information was analyzed to determine the transmissivity of the aquifer. The analysis of time-draw down data for the pumped well and the observed small decline of water levels in the domestic wells indicated that the deeper aquifer is a semi-confined leaky aquifer. A wellhead protection area was delineated.

City of Mosier: Drinking water well

Mark Yinger conducted a study to evaluate well capacity, interference, and commingling of artesian aquifers within the Wanapum Basalt.

Bonneville Hot Springs Resort: Geothermal wells

This project involved hydrogeologic mapping, conceptual hydrogeologic modeling, and seismic surveys to select locations for geothermal wells.

OSU Agricultural Extension Services and USDA: Monitoring well network

This project involved specifying well locations and construction for two monitoring well networks situated along the Grande Ronde River. The monitoring wells are to be used to evaluate the long tern impact of experimental agricultural practices on groundwater quality.

Condit Dam Decommissioning – Evaluation of Impacts to Area Water Wells

This is a current project for PacifiCorp and their consultant Kleinfelder. The work involves monitoring groundwater level declines in response to the draining of Northwestern Lake and using the data to project the trend of the groundwater decline.