Proposal for Hydrogeologic Assessment and Aquifer Characterization at the Luckiamute State Natural Area

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1. INTRODUCTION

This proposal is submitted as part of a long-term collaboration between faculty in the Division of Natural Sciences and Mathematics at Western Oregon University (WOU) and the Luckiamute Watershed Council (LWC). This work dates back to participation in the initial Luckiamute watershed assessment completed in 2004 (Garono et al., 2004). Since then, WOU has provided support to LWC in the form of facilities, student interns, and technical assistance as part of the public service mission of the university. In parallel to this collaboration, WOU faculty and students have extensively utilized the Luckiamute Basin as a local natural laboratory to visit on field trips, support science curricula, conduct research, and engage undergraduate students in multi-disciplinary watershed science. WOU-based Luckiamute studies over the better part of the past decade have covered a wide range of topics including surface water hydrology, geomorphology, environmental chemistry, hydrogeology, botany, plant systematics, environmental quality, stream ecology, and patterns of invasive plant distribution (e.g. Taylor 2002, 2004, 2005, 2006, 2007a, 2007b; Taylor and Dutton, 2009; Taylor et al., 2002; Taylor et al., 2007; Taylor et al., 2009; Noll et al., 2007; Stanley and Taylor, 2009; Dutton and Taylor, 2005).

The purpose of this proposal is to solicit support for a detailed hydrogeologic analysis and aquifer characterization at the Luckiamute State Natural Area (LSNA) property, currently under development by Oregon Parks and Recreation Department (OPRD) and LWC. The LSNA consists of two OPRD parcels (North and South Tracts) totaling ~925 acres near the confluence of the Luckiamute and Willamette Rivers (Figure 1). Based on discussions with Michael Cairns, LWC Project Manager, and attendance at several LSNA planning meetings, it is the author's understanding that LWC is applying for development funds through the Oregon Watershed Enhancement Board's (OWEB) Special Investments Partnership (SIP) and Meyer Memorial Trust. The objectives of the over-arching SIP proposal are multi-fold and include: (1) re-establishment of channel complexity and length in the Willamette River corridor, (2) re-connection of flood plains along the main stem, (3) restoration of site habitat conditions with respect to native plant and animal populations, and (4) development of the LNSA for public recreational use and natural resource education. Project objectives 1 and 2 focus on physical hydrologic connections related to flood frequency and location of low-lying remnant channel features (River Design Group, 2009). Objective 3 focuses on improving floodplain forest function, eliminating non-native plants, re-introduction of native plants, and transformation of existing agricultural lands into prairie habitat (Institute for Applied Ecology, 2009). Objective 4 is a fundamental component of the long-term LNSA master plan developed by OPRD (2009).

2. PROPOSED HYDROGEOLOGIC INVESTIGATION

2A. Statement of the Problem

The concept for a hydrogeologic analysis at the LNSA property is an outgrowth of long-term research interests in the Luckiamute Basin and the linkage with undergraduate Earth Science education at WOU (Taylor, 2006). As the LWC SIP planning discussions progressed during

2009, it became evident to the principal investigator that groundwater conditions in statewide watershed restoration initiatives are significantly underrepresented compared to surface water and biological components. In addition, little detailed information is known about local aquifer properties in the valley margin tributaries along the western (Coast Range) side of the Willamette Valley, including the Luckiamute (K. Wozniak, Oregon Water Resources Department, Personal Communication, 2004). Existing regional groundwater studies focus on high-capacity aquifer units elsewhere in the Willamette Valley, although they include portions of the lower Luckiamute at a generalized scale (Woodward and others, 1998; Gannet and Caldwell, 1998). More detailed work on the hydrogeology and groundwater quality of the Dallas-Monmouth area was conducted by Gonthier (1983) and Caldwell (1993); however their work has not been extended south into the Luckiamute. It should be emphasized that while the general hydrogeologic conditions of the Luckiamute study area are known, detailed aquifer analyses at the scale of the LNSA property are lacking.

Water budget analysis indicates that 61% of the total annual rainfall (avg. = 1894 mm; 1.23×10^9 m^3) is accounted for as runoff in the Luckiamute, whereas 39% is consumed in the form of evapotranspiration and groundwater flow (Waichler et al., 1997). In addition, groundwater accounts for a significant portion of the total Willamette Basin water budget, and is important for maintaining summer surface flows and modulating stream temperatures (Conlon et al., 2005). Given the importance of the groundwater component in sustaining dry-season flows, and in turn as an influence on variability of local soil-moisture conditions, the paucity of knowledge regarding aquifer conditions at the LNSA site is a glaring omission with respect to hydrologic and biologic restoration initiatives. The technical specifications for rectifying this fundamental knowledge gap are presented below.

2B. Geologic Setting

Gannet and Caldwell (1998) and Woodward et al. (1998) delineated the principle hydrostratigraphic units in the Southern Willamette Basin. In ascending order these include: (1) basement confining unit (BCU), (2) Willamette confining unit (WCU), (3) Willamette aquifer (WAq), and (4) Willamette Silt (WS). The lowermost unit is represented by indurated bedrock, while the latter three are comprised of unconsolidated alluvium and valley-fill sediments. Alluvial-fill thickness in the lower Luckiamute and Ash Creek sub-basins ranges up to 30 m (100 ft) with most localities in the 12 to 24 m (40 to 80 ft) range. Luckiamute alluvial-fill thickens to the east towards the center of the Willamette Valley, and thins upstream to a minimum near the communities of Falls City and Pedee (Caldwell, 1993; Gannett and Caldwell, 1998).

As part of a regional aquifer analysis by the U.S. Geological Survey, O'Connor et al. (2001) mapped the surficial deposits of the Willamette Valley at a scale of 1:250,000. Their work covered a portion of the lower Luckiamute, including the LNSA property (Figure 2). Based on the O'Connor et al. (2001) work and historic drilling records available from the Oregon Water Resources Department (OWRD), a framework aquifer model for LNSA can be derived as follows. The northern and southern tracks of the property are located in the floodplain environment of the Willamette River, with surficial deposits mapped as Qg1 and Qalc, coarser-grained alluvium and floodplain deposits respectively, both less than 12,000 years in age. Qg1 and Qalc comprise part of the Willamette Aquifer (WAq) hydrostratigraphic unit of Woodward et al. (1998). The overlying Willamette Silt (Ws) was mapped by the O'Connor group as Qff2 (Missoula flood deposits, 12,000-13,500 years old) and occurs west of the LSNA property

(Figure 2). Thus the site aquifer system is composed of coarser-grained alluvial sediments which have been stripped of Missoula flood silts by erosional fluvial processes in the past 12,000 years. The Basement Confining unit is represented by outcrops of unit Tm underlying hillslopes north and south of LSNA (Figure 2). These strata are comprised of older, Tertiary marine sedimentary rocks that are known to be associated with low permeability and high levels of total dissolved solids, thus serving as the bane of rural well owners living within their proximity (Caldwell, 1993; Gonthier, 1983).

Evaluation of OWRD drilling records for 12 domestic wells southwest and east of LNSA indicate that abundant groundwater is located in the Qg1 and Qalc units (WAq) at depths ranging between 30 and 60 feet, with spot readings of static water levels recorded at 7 to 20 ft below land surface. While a general aquifer model can be derived from available documents, details of the water table configuration, seasonal water level fluctuations, aquifer characteristics, and groundwater-surface water connections at the LSNA property are unknown.

2C. Project Objectives and Outcomes

Knowledge of LSNA aquifer properties, combined with seasonal surface-water inundation patterns (River Design Group, 2009) and high resolution LIDAR elevation models (Maden, 2007) would provide the requisite understanding of site hydrology necessary for proper enhancement of floodplain connectivity (SIP Project Objectives 1 and 2 from section 1 above) and ecological restoration (SIP Project Objective 3). To this end, action items for the proposed LSNA hydrogeologic investigation are summarized as follows:

(1) Drilling and installation of three 2-in monitoring wells at the LNSA south tract to determine aquifer properties and seasonal water table configuration (Figure 2);

(2) Drilling and installation of four 2-in monitoring wells at the LNSA north tract to likewise compliment outcomes in item 1 above (Figure 2);

(3) Conduct public outreach and attain private landowner access to the existing domestic wells, southwest and east of the LNSA site to augment outcomes in items 1 and 2 above (Figure 2);

(4) Survey well locations and casing elevations relative to established bench mark controls and site monuments, and tied to river stage elevations;

(5) Characterize aquifer hydraulic properties (e.g. specific capacity, drawdown-recovery curves, hydraulic conductivity, transmissivity, storativity) using drilling data and pump tests as logistically feasible;

(6) Collect a set of 12 monthly measurements of groundwater levels at the proposed LNSA monitoring wells and surrounding private domestic wells;

(7) Develop seasonal groundwater contour maps and flow models from water level data collected in item 6 above;

(8) Combine monthly water-table data with surface inundation patterns and LIDAR elevation models to establish seasonal trends in ground-surface water connectivity and site soil-moisture conditions;

(9) Capitalize on the results of item 8 above for development of sustainable habitat restoration initiatives, ecological applications, and floodplain enhancements; and

(10) Leverage the applied scientific components of the LNSA groundwater study for greater long-term use in public outreach, water resource education, and university training of future natural resource professionals.

The above hydrogeologic action items and project outcomes are directly aligned with the overarching objectives of the planned SIP proposal currently under development for OWEB and Meyer Memorial Trust.

2D. Budget and Timeline

The following is a budget breakdown for proposed hydrogeologic investigation at the LNSA site.

I.	Drilling Costs for 2-inch PVC Monitoring Wells (~50 ft depth avg., 20 ft screen)		
	a. Hollow-stem auger drilling:	$1300 / hole	
	b. Well construction materials:	$ 900 / well	
	c. Flush mount locking covers:	$ 350 / well	
	d. OWRD Start Card / Permit:	$ 250 / well	
	Unit Cost:	$2800 / well	
	Total Drilling Cost: 7 wells x $2800 / well		$19,600
II.	Driller mobilization fee		$ 750
III.	Well Development and Pump Testing		
	a. 3-Person WOU Student Team		$ 600
	b. Equipment rental		$ 300
IV.	Contracted Well Surveying		$ 800
V.	Monthly Water Level Monitoring		
	a. 2-Person WOU Student Team (2 students x 8 hrs/day x 1 day/mo x 12 mo x $10/hr)		$ 1950
VI.	WOU Field Mobilization / Vehicle Use		$ 350
VII.	Quarterly Map Compilation, Data Synthesis, Reporting		
	a. 1 Student Research Assistant (3 days/quarter x 8 hrs/day x $10/hr x 4 quarters)		$ 950
	PROJECT TOTAL:		**$ 25,300**

Drilling and well installation will be completed over the course of several days. Well development and pump testing is likely to be completed over the span of one week, depending on property logistics and private well access. Water level monitoring and quarterly data compilation is scheduled to occur over the course of one year, as detailed above. Project match (50%) will be leveraged through a combination of donated WOU staff time, faculty salary, laboratory facilities and in-kind services. The use of paid student technicians will greatly enhance the undergraduate education mission in the Division of Natural Sciences and Mathematics at Western Oregon University.

2E. Project Justification

The LSNA groundwater study proposed herein, combined with River Design Group's proposed inundation study and LIDAR elevation models will provide a comprehensive framework in which to evaluate seasonal fluctuations in groundwater levels, sustainability potential for habitat restoration, and seasonal flood zonation. These data will also form the empirical basis for any future hydrologic modeling studies. Presently, there are scant scale-appropriate field data upon which to frame a site hydrologic model, especially in terms of the groundwater component. In addition to the scientific objective, there is also a significant outreach and education component that will be leveraged by the project, in collaboration with WOU, OPRD, and LWC. The groundwater portion of the water budget is generally underrepresented in existing OWEB initiatives. This project affords the chance to greatly expand the vision of water resource education in the State of Oregon.

The intimate hydrologic connection between river channel, floodplain, and groundwater has been the focus of a multitude of studies in the past decade. This groundwater connection is important for maintaining surface flows throughout the year and for modulating river temperatures during the hot season, both of which are critical for plant, fish, and amphibian habitat. The overarching objectives of the LWC SIP proposal not only involve floodplain connectivity, but also ecological restoration based on adaptive plant management relative to soil moisture and water availability. Any ecological design, wetlands restoration, and/or biological engineering application on the LSNA property that does not first include an accurate seasonal assessment of the site hydrologic conditions (ground- and surface water) is potentially limited and unsustainable. The existing regional hydrologic data are at too coarse a spatial and temporal scale to be effectively applied to site-specific design. The overarching SIP/LSNA development project is significantly in need of detailed, empirical data on hydrologic conditions (surface and groundwater), carefully measured over a full spectrum of the seasons. A biocentric, floodplain restoration plan without a fundamental, data-driven understanding of the physical geologic and hydrologic framework upon which the habitat is established, significantly increases the risk of design failure. The hydrogeologic analysis, combined with other proposed site assessment techniques described herein, will greatly increase the probability of long term success with respect to sustainable ecological restoration at the LSNA facility.

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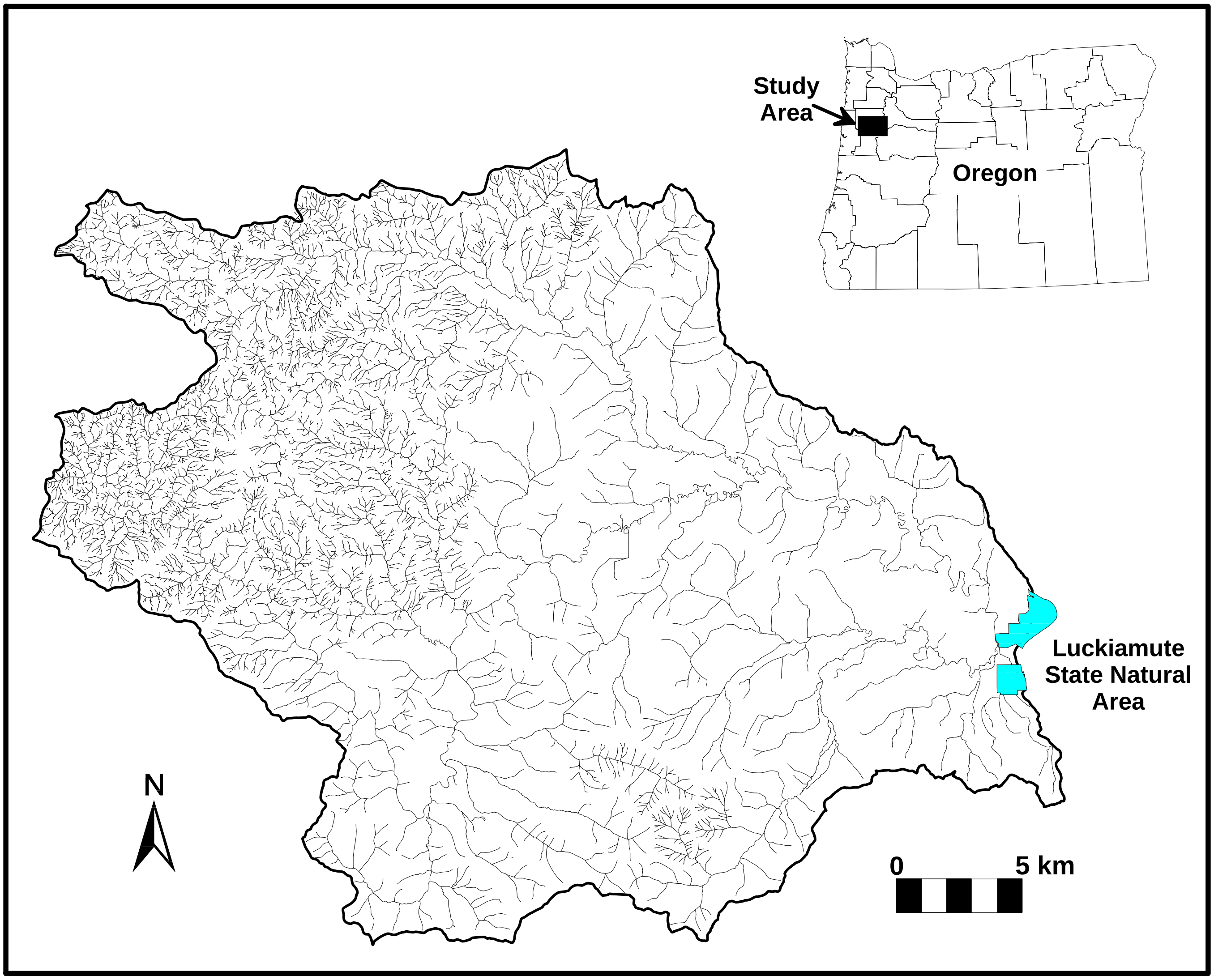

Figure 1. Location map of the Luckiamute Watershed and the Luckiamute State Natural Area.

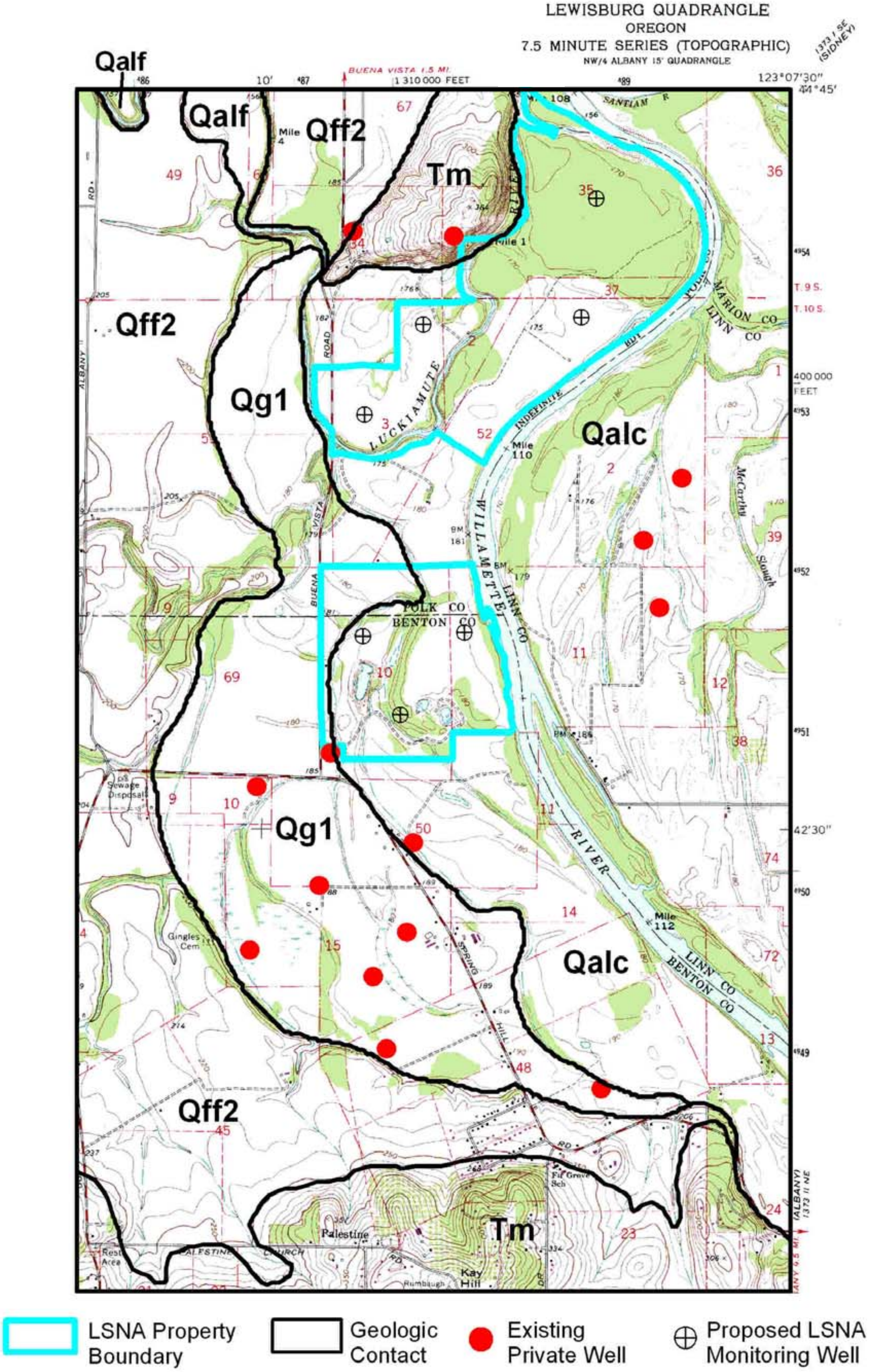

Figure 2. Geologic map of the Luckiamute State Natural Area (Note: "ka" = age of material in thousands of years; after O'Connor et al., 2001).

Geologic Units:
Qalc - Willamette floodplain deposits (<12 ka)
Qalf - Alluvium of smaller tributaries (<12 ka)
Qg1 - Sand, gravel, fans, braid plains (<12 ka)
Qff2 - Missoula flood silts (13.5 - 12 ka)
Tm - Teriary marine sedimentary rocks (Spencer Fm)