Walla Walla Basin Watershed Council

WALLA WALLA BASIN AQUIFER RECHARGE STRATEGIC PLAN

January 2013

Walla Walla Basin
Aquifer Recharge Strategic Plan

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List of Abbreviations and Acronyms

acre-feet – volume of water that cover one acre one foot deep in water
AR – aquifer recharge
ASR – aquifer storage and recovery
BGS – below ground surface
cfs – cubic feet per second
COE – US Army Corps of Engineers
CTUIR – Confederated Tribes of the Umatilla Indian Reservation
EC – electrical conductivity
EEP – environmental enhancement project
ELWWR – East Little Walla Walla River
ESA – Endangered Species Act
GFID – Gardena Farms Irrigation District #13
GSI – GSI Water Solutions, Inc.
HBDIC – Hudson Bay District Improvement Company
H-W – Hall-Wentland Aquifer Recharge Site
IWFM – Integrated Water Flow Model
LL – limited license
LWP – local water plan
LWWR – Little Walla Walla River
OSU – Oregon State University
OWRD – Oregon Water Resources Department
RAC – regional advisory committee
SOC – synthetic organic compounds
TDS – total dissolved solids
The River – The Walla Walla River
TKN – total kjeldahl nitrogen
WDOE – Washington Department of Ecology
WLWWR – West Little Walla Walla River
WWBWC – Walla Walla Basin Watershed Council
WWCCD – Walla Walla County Conservation District
WWRID – Walla Walla River Irrigation District
WWWMP – Walla Walla Watershed Management Partnership

Summary

The goal of this document is to summarize aquifer recharge goals, activities, and data for Walla Walla watershed stakeholders so that they may use it while making sustainable water resource decisions for ecological, agricultural, and economic benefit. This document describes the need to stabilize and restore the alluvial aquifer and thus improve low-flow conditions in hydraulically connected streams. Unlike many other aquifer recharge projects being implemented nationally and internationally, Walla Walla alluvial aquifer recharge projects are not currently being implemented for aquifer storage and recovery (commonly referred to as ASR). Although some use of the improved aquifer is likely occurring at wells down gradient of the current aquifer recharge (AR) sites, the primary purpose is for public and regional benefit to restore the aquifer and enhance or support groundwater contributions to instream flow thereby maximizing the resource's potential with multiple benefits for aquatic life, recreational water use, domestic use, and irrigation use.

To meet the goals set forth above for this document, it is subdivided into three main sections as follows:

Section I – Introduction

- A brief introduction to water issues within the Walla Walla Basin.

Section II – Background, Pilot Projects, Water Availability and New Projects

- The background describes the physical, geographic and hydrologic setting of the Walla Walla Valley and watershed, summarizes the results of the alluvial AR pilot projects completed to date, and provides an introduction to hydrologic modeling that has been done to evaluate historical, current and potential future conditions.
- Provides information and data from existing pilot aquifer recharge projects in the valley.
- Summarizes the constraints that are placed on water availability in the valley.
- Introduces potential new projects being considered for aquifer recharge, looking at both how they might operate and what their potential benefits may be.

Section III – Walla Walla Basin Aquifer Recharge Strategy

- This section identifies goals, objectives and actions for implementing aquifer recharge in the Walla Walla Basin.

SECTION I – INTRODUCTION

A Brief History of Water in the Walla Walla Valley

Two hundred years ago, the Walla Walla Basin had healthy populations of salmon, steelhead and bull trout. The Walla Walla River flowed from its headwaters in the Blue Mountains into the Walla Walla Valley and then spread out into a distributary network that delivered winter and spring flows out across the valley floor. This distributary network provided off-channel habitat for fish and other wildlife, but also allowed for a significant amount of water to seep into the soil and recharge the valley's alluvial aquifer system. The alluvial aquifer supplied water to the dozens of springs that emerge on the valley floor and provided cold water returns to the river during summer months, cooling the river and maintaining baseflows.

Through the process of agricultural and urban development, the hydrology of the Walla Walla Basin has been altered from a system that supported diverse wildlife and plants to a system nearly devoid of salmon, reduced populations of steelhead, bull trout and many plant species. By the mid to late 1990s, streams in the Walla Walla Basin had dry reaches during portions of late summer and early autumn, the alluvial aquifer was experiencing significant water level declines, and two fish species (steelhead and bull trout) were listed as threatened under the Endangered Species Act. Irrigators, fishery agencies, the Walla Walla Basin Watershed Council (WWBWC) and many concerned citizens stepped up to address these problems. One of the solutions these parties agreed to was the decision to reduce irrigation withdrawals from the Walla Walla River by 25 cubic feet per second (cfs). This agreement created a wet river from the headwaters to mouth for the first time in a number of years, rehydrating formerly dry reaches of the Walla Walla River in the summer. Irrigators gave up portions of their water rights to leave water instream, creating a flowing river from headwaters to mouth.

To help reduced irrigation water go farther, irrigation efficiency projects were initiated across the valley. Ditches were piped, fields that were flood irrigated were switched to sprinklers and diversion structures were updated to allow for efficient delivery and transfer of water across the valley. However, leaving water in river only fixed a portion of the water problems – the aquifer (groundwater) issues were not being addressed. The declining aquifer has caused problems for the surface water throughout the valley. Spring creeks across the valley started to decline and, in some cases, went completely dry. Overtime, groundwater levels have dropped below the mainstem Walla Walla River in portions of the valley – causing seepage losses. This causes a significant amount, sometimes up to half or more of the water in the river, to soak into the ground. Fixing the water problems in the Walla Walla Basin needs to address more than just surface water left instream. To address that point, in 2004, the WWBWC partnered with the Hudson Bay Ditch Improvement Company (HBDIC) to develop the first alluvial aquifer recharge site in the Walla Walla Valley. The purpose of this aquifer recharge was to simulate the processes of the historic distributary network by allowing winter and spring river water to be spread out across the valley and recharge the aquifer (groundwater). Currently, the WWBWC is working to expand its alluvial aquifer recharge program in the Walla Walla Basin from three sites to over a dozen in the upcoming years. Combined, these multiple aquifer recharge projects are estimated to have the potential to put over 20,000 acre-feet (over 6.5 billion gallons) of water into the aquifer during a single recharge season (November 1st – May 31st).

SECTION II – BACKGROUND, PILOT PROJECTS, WATER AVAILABILITY AND NEW PROJECTS

Background

Geography

The Walla Walla River (River) system is a bi-state watershed located in northeast Oregon and southeast Washington (Figure 1). The River's headwaters are located in the Blue Mountains, the crest of which defines the eastern extent of the watershed. The mainstem Walla Walla River and its primary tributaries, Mill Creek and the Touchet River, are the three primary surface channels of the system. They coalesce within the Walla Walla Valley from which the Walla Walla River then flows draining to the Columbia River (Figure 2). The Walla Walla Valley is a topographic depression defined by highlands on all sides, including the Blue Mountains on the east, the Horse Heaven Hills on the south, the Palouse Slope on the north, and Nine Mile Hill on the west, where the Horse Heaven Hills and the Palouse Slope converge. The focus of this document is the Walla Walla River Valley, which includes the mainstem Walla Walla River and its branches north of Milton-Freewater, its three upper forks (North Fork Walla Walla River, South Fork Walla Walla River and Mill Creek), the small streams that flow intermittently off the Horse Heaven Hills onto the valley floor (Dry Creek and Pine Creek), and the lowermost reach of the Touchet River (Figure 2).

Geology

Over several million years, faulting of the Columbia River basalt created the basin in which the Walla Walla Valley is found. With this faulting, the basalt bedrock which underlies the valley was down-dropped to depths of as much as 800 feet below current ground surface (Figure 3). As the basin floor dropped, sediments deposited by the Walla Walla River, Mill Creek, the Touchet River and the smaller tributary streams filled the valley.

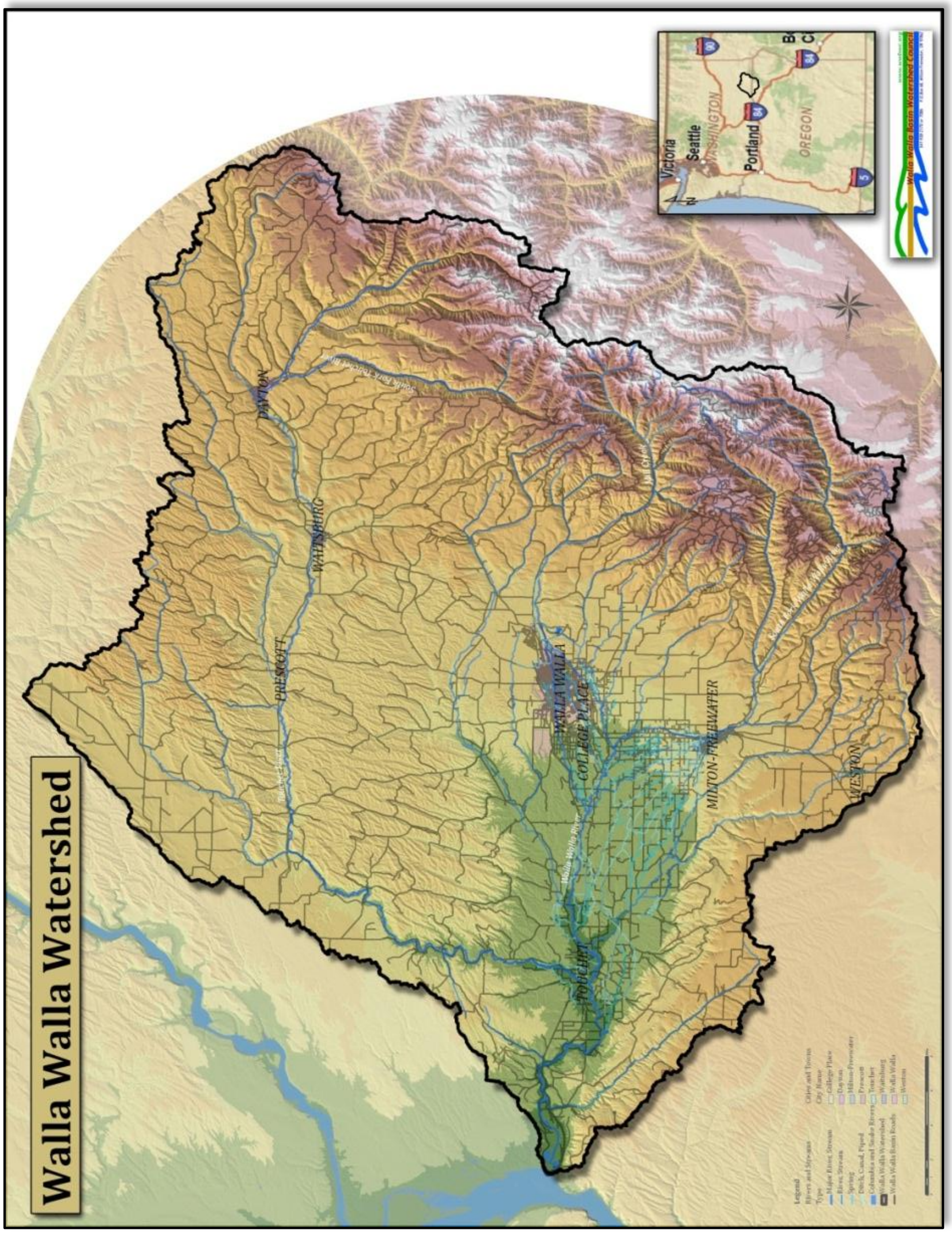


Figure 1 - The Walla Walla Basin in northeast Oregon and southeast Washington.

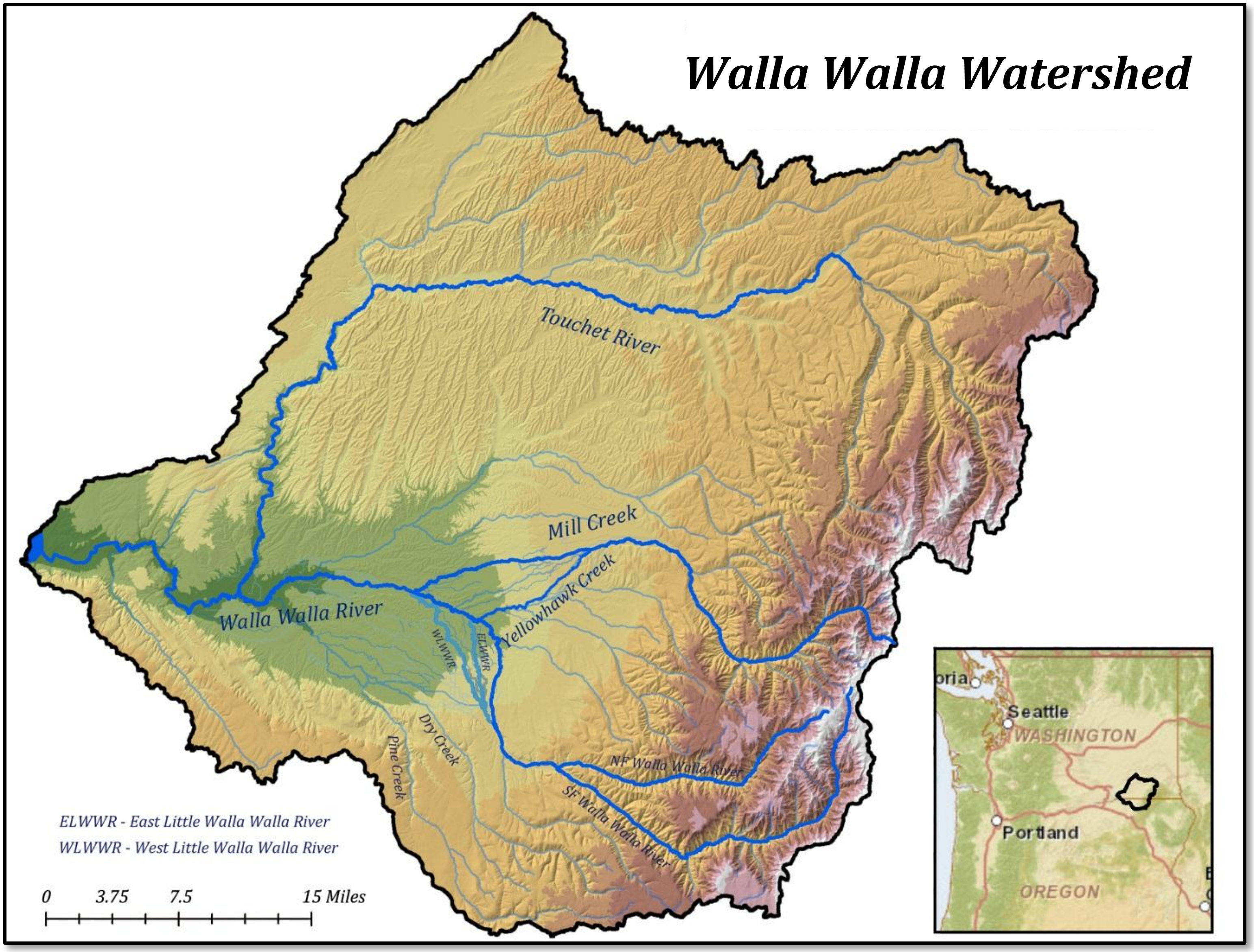


Figure 2 – The Walla Walla River and its tributaries and distributaries.

These sediments range in age from the Miocene-Pliocene Epochs to recent, covering a time span of over 8,000,000 years. The older deposits consist of pebble to cobble gravel and conglomerate, sand, weakly consolidated siltstone and claystone (GSI, 2007). More recent deposits of the Missoula Floods and wind-blown loess form a thin veneer covering these older sediments and basalt.

The sedimentary strada overlying the basalt in the basin are divided into five geologic units, designated the: (1) Quaternary fine unit, (2) Quaternary coarse unit, (3) Mio-Pliocene upper coarse unit, (4) Mio-Pliocene fine unit, and (5) Mio-Pliocene lower coarse unit. More information about basin geology can be found in Newcomb (1965) and several subsequent investigators (Fecht and others, 1987; Busacca and MacDonald, 1994; Waitt and others, 1994; GSI, 2007). Figures 3 -7 portray the basic distribution of these sediments throughout the valley.

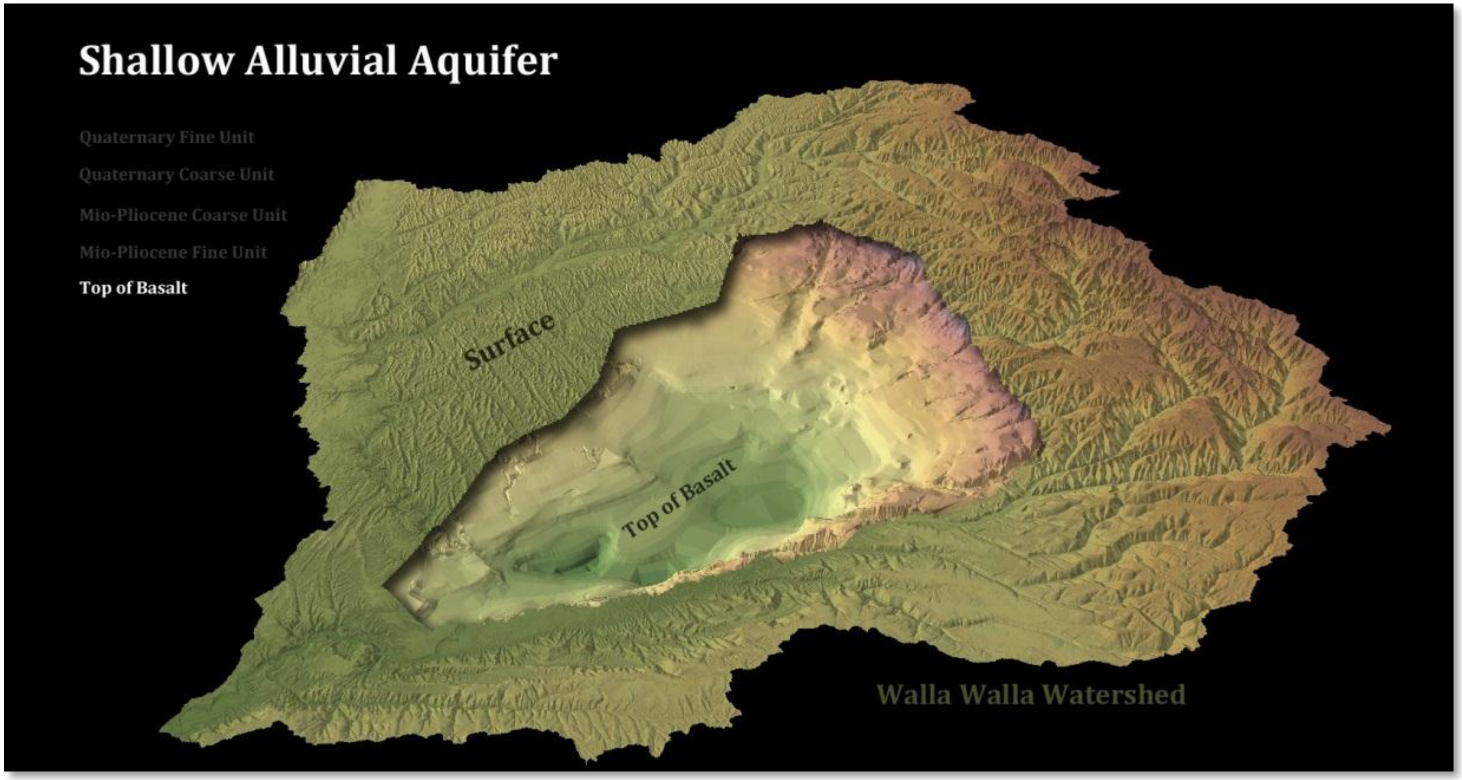


Figure 3 - 3-D illustration showing the top of basalt in the Walla Walla Valley.

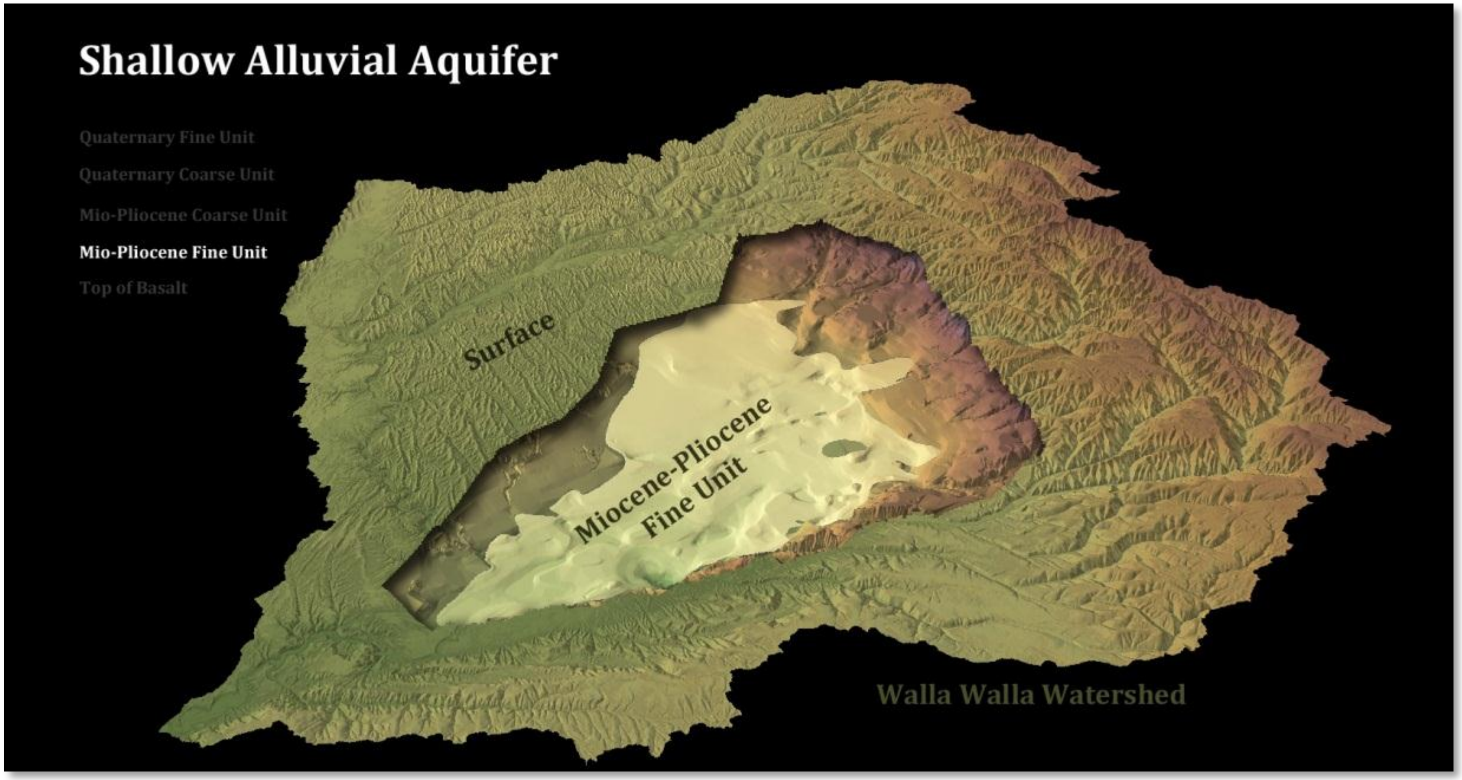


Figure 4 - 3-D illustration showing the top of the Mio-Pliocene Fine Unit in the Walla Walla Valley.

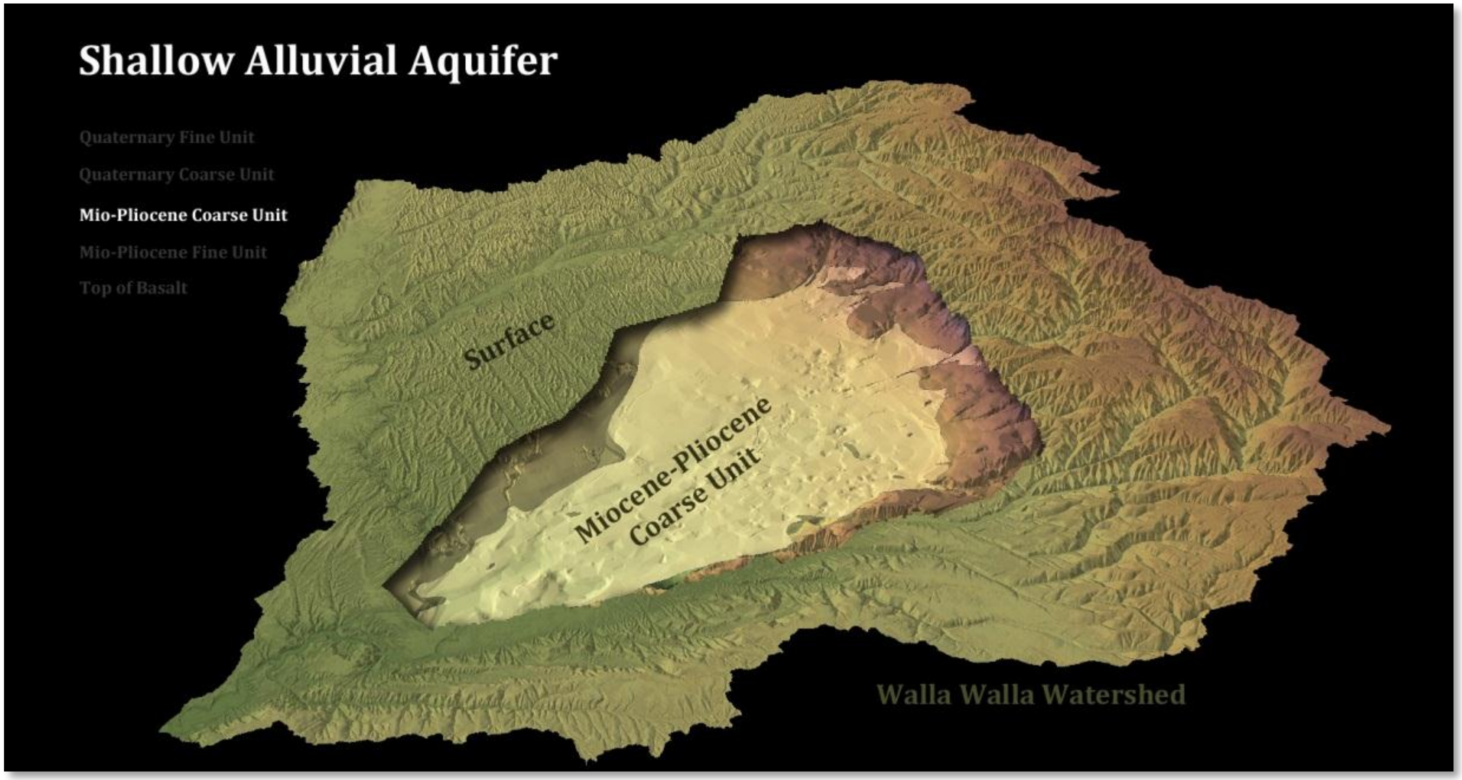


Figure 5 - 3-D illustration showing the top of the Mio-Pliocene Coarse Unit in the Walla Walla Valley.

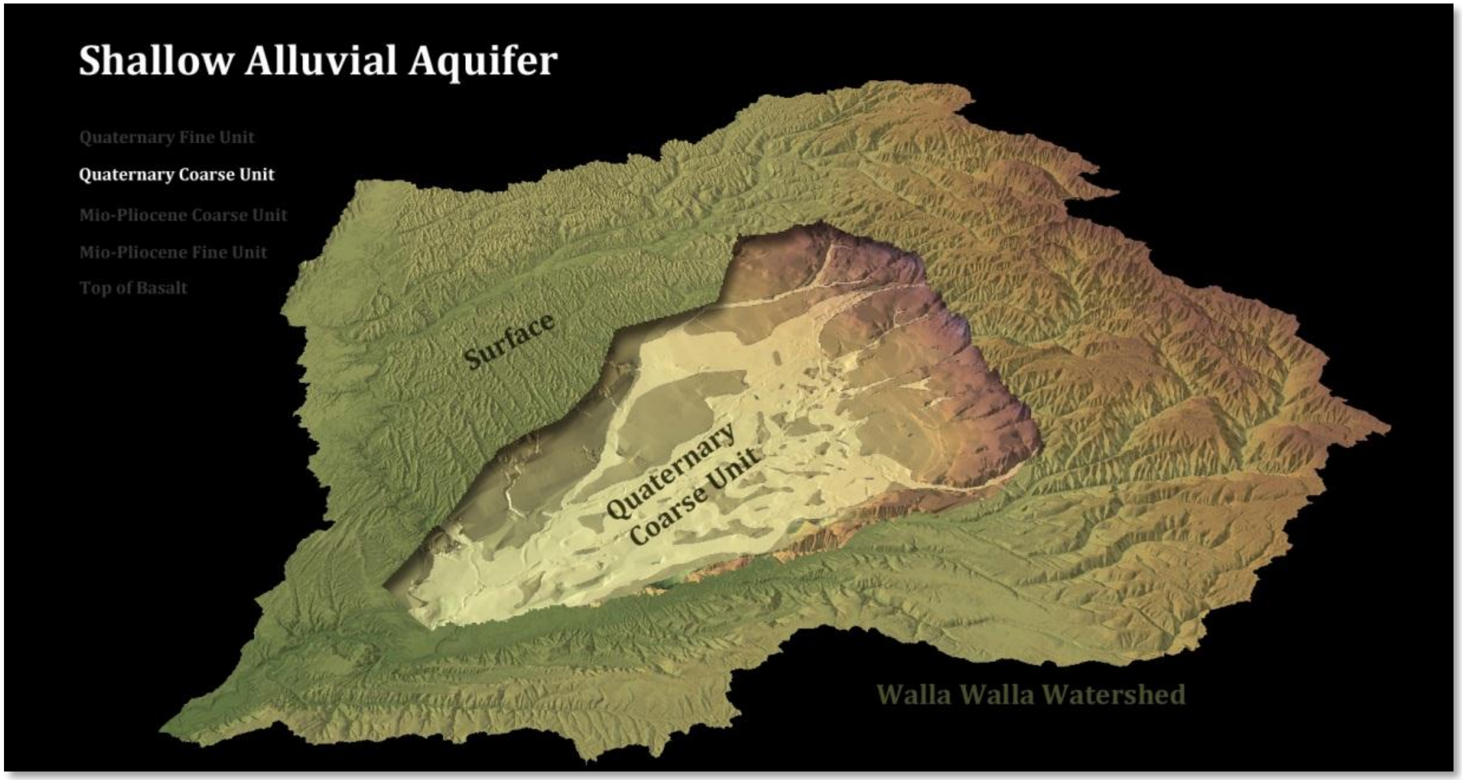


Figure 6 - 3-D illustration showing the top of the Quaternary Coarse Unit in the Walla Walla Valley.

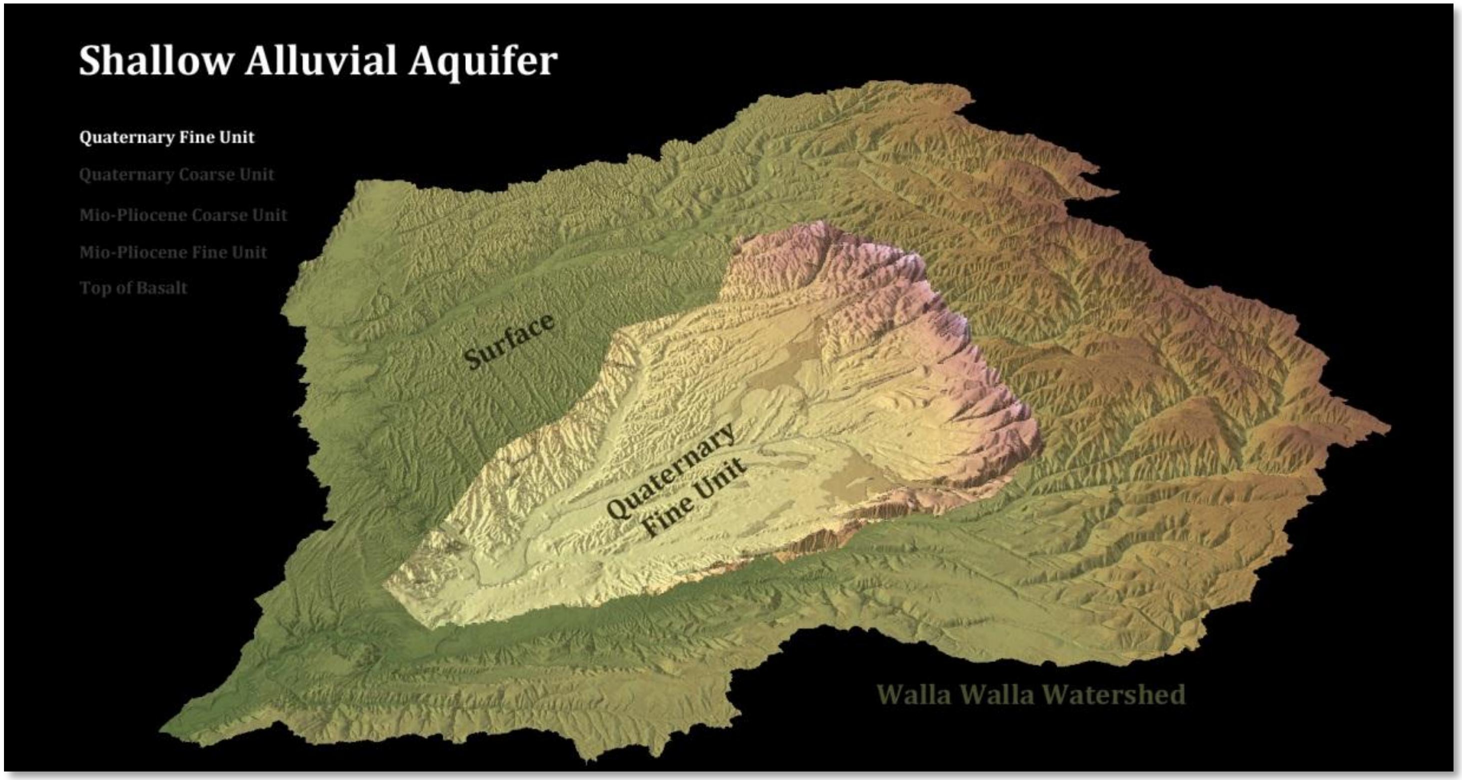


Figure 7 - 3-D illustration showing the top of the Quaternary Fine Unit in the Walla Walla Valley.

Hydrology

Walla Walla Valley hydrology is largely defined by a distributary river system and an underlying alluvial aquifer system hosted by the sediments overlying basalt. Surface waters entering the Walla Walla Valley effectively change regime from steep sided canyons in the headwaters portion of the watershed to a system of distributary and coalescing streams on the valley floor. With this, shallow groundwater systems see a regime change from localized, saturated valley deposits and confined basalt aquifers controlled by the geologic structure of the Columbia River basalt to the more widespread, thick alluvial aquifer system immediately underlying the valley floor. Depth to basalt beneath the base of the canyon floors in the highland areas upstream of the cities of Walla Walla and Milton-Freewater is typically less than 60 feet, with 30 feet more commonly observed. The following sections explore basin hydrology further.

Groundwater

Groundwater in the Walla Walla Basin occurs in two principal aquifer systems: (1) the unconfined to confined suprabasalt sediment (alluvial) aquifer system and (2) the underlying confined basalt aquifer system (Newcomb, 1965). The basalt aquifer system is regional in character, having limited hydraulic connection to the Walla Walla River except in the canyons of the Blue Mountains. The balance of this section focuses on the alluvial aquifer system because of its high degree of hydraulic connection with streams on the valley floor.

The alluvial aquifer system, or alluvial aquifer, is primarily hosted by the Mio-Pliocene strata (upper coarse, fine and lower coarse units) and the Quaternary coarse unit (Figures 4-6). Beneath the Walla Walla Valley floor the alluvial aquifer system is hosted by sediments up to 800 feet thick. The majority of the productive portions of the alluvial aquifer system are hosted by the Mio-Pliocene coarse unit although, at least locally, it is hosted in the overlying Quaternary coarse unit. The alluvial aquifer is generally characterized as unconfined, but it does, at least locally, display evidence of confined conditions. Variation between confined and unconfined conditions within the aquifer system is probably controlled by sediment lithology (e.g., facies – coarse versus fine) and induration (e.g., cementation, compaction). Groundwater movement into, and through, the alluvial aquifer also is inferred to be controlled by sediment lithology and induration. Generally, the deeper portions of the alluvial aquifer unit are more likely to exhibit confined conditions relative to the shallower portions of the aquifer.

Preferential groundwater flow within the gravel aquifer is inferred to largely reflect the distribution of coarse sedimentary strata. General groundwater flow direction can be inferred from the alluvial aquifer water table map (Figure 8) and is illustrated on Figure 9. The preferential groundwater flow paths shown on Figure 9 are inferred from aquifer thickness and the distribution of the gravel and conglomerate strata thought to host the bulk of the alluvial aquifer system (GSI, 2007). Figure 9 also shows an offset between modern stream paths and inferred modern groundwater flow pathways. The streams are following topographic lows while groundwater is inferred to follow the structural axis of the basin, basically flowing down the portion of the basin where alluvial sediments are thickest. This offset is thought to be due to the relatively recent addition (geologically speaking) of the Touchet Beds, Missoula Cataclysmic Flood deposits that filled the structural lows. As a result, as the modern stream system was reestablished following the end of the Pleistocene (Ice Age), stream erosion followed a path other than that of the structural (fold) axis of the basin.

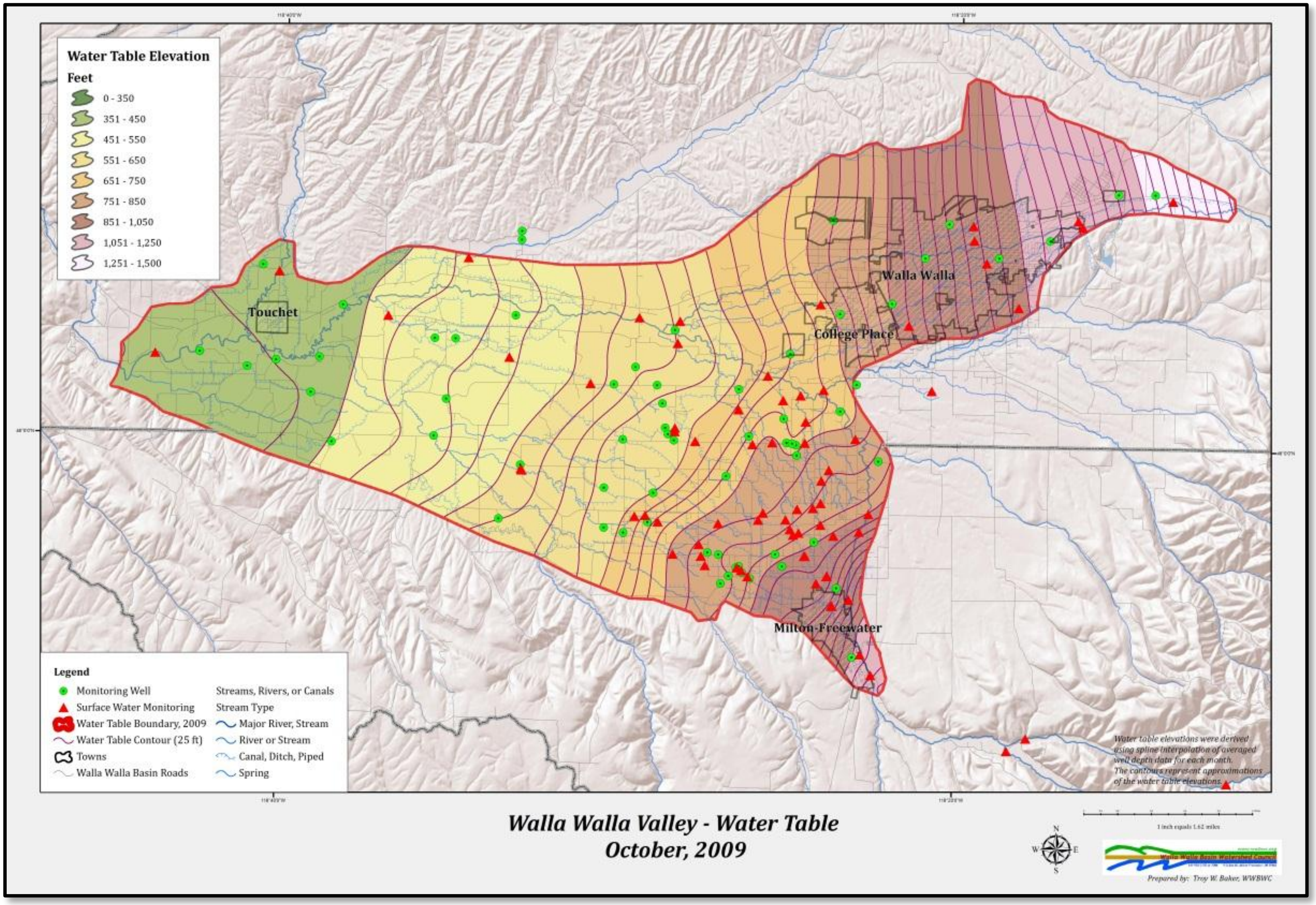


Figure 8 - Water table contours for the alluvial aquifer in October 2009.

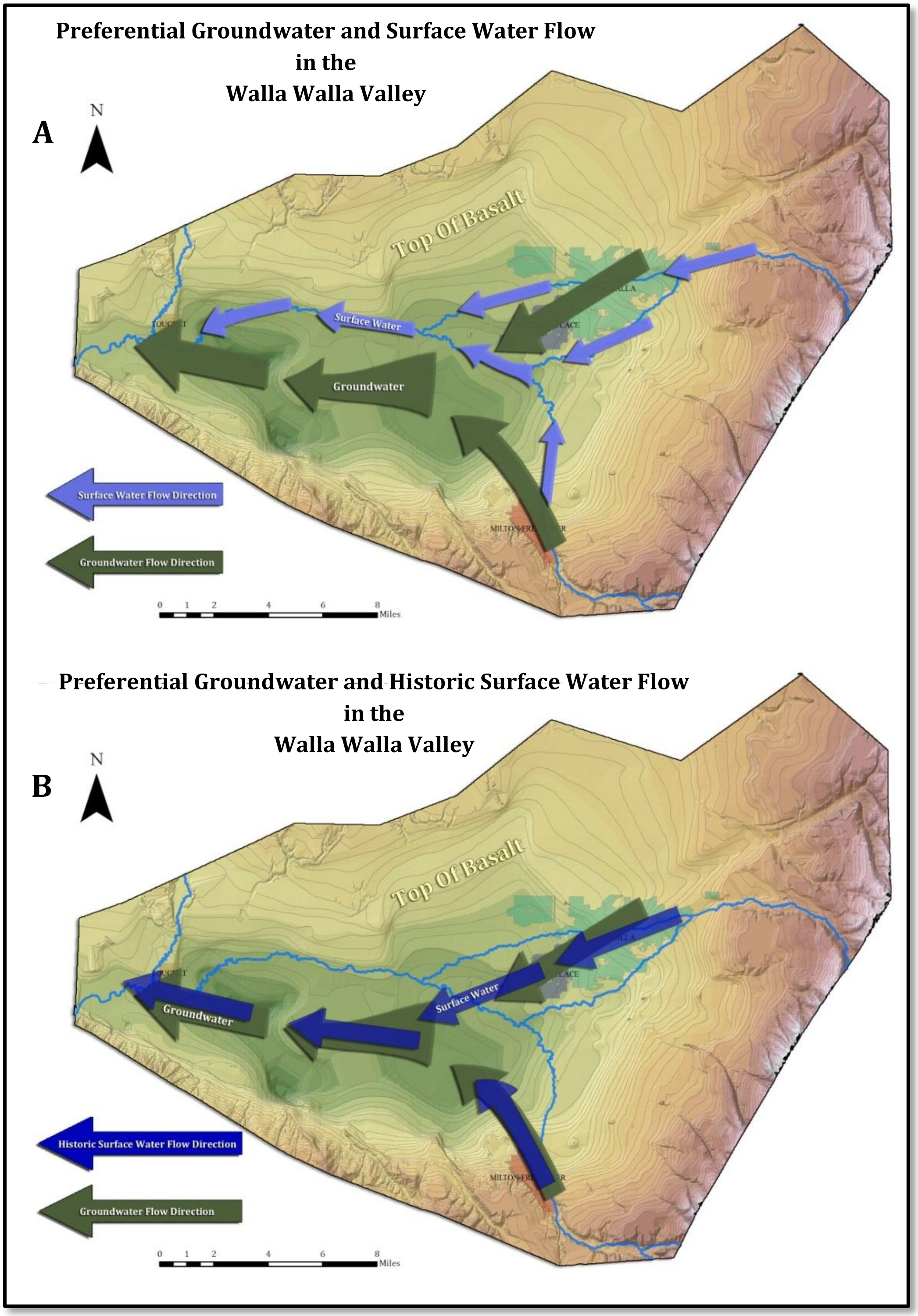


Figure 9 - Illustrations showing current and historic surface and groundwater flow directions. A – Current groundwater and surface water flow directions. Groundwater follows the historic surface water flow directions, but surface water flow direction has been changed by deposits from the Missoula (Ice Age) Floods. B – Historic (pre Missoula Floods) groundwater and surface water flow directions. Groundwater and surface water follow the same flow direction.

Surface Water

The surficial hydrology of the Walla Walla Basin generally is defined by streams confined to steep-walled canyons in the foothills surrounding the valley, a distributary stream system as these streams exit the highlands and flow out onto the valley floor, and then, as the streams flow west, they coalesce into the main Walla Walla River channel. The distributary system formed as streams leaving the highlands entered the valley, went from higher to lower gradient and, as a consequence, deposited coarse sediment loads and formed a series of low angle, coalescing alluvial fans. Upon the alluvial fans in and around the cities of Walla Walla and Milton-Freewater these natural distributary channels still exist in part or in whole to this day. These channels are known today as the East Little Walla Walla River, West Little Walla Walla River, Mud Creek, Yellowhawk Creek, and Garrison Creek. Prior to the development of water resources in the valley, these distributary channels, with other (un-named) channels, served as high water channels that conveyed high amounts of energy and water across the alluvial fan and away from the mainstem Walla Walla River and Mill Creek. The channels run for several miles, accumulating spring flow, before returning back to the River further down the valley (Figure 10).

Prior to the Missoula floods and deposition of the Touchet Beds on the valley floor, the ancestral Walla Walla River and ancestral Mill Creek are inferred to have flowed down the axis of the valley, defined where the alluvial strata and the alluvial aquifer are thickest. These two ancestral streams may have converged in the area along Stateline Road, near to or potentially west of the Locher Road AR site (Figure 23). The deposition of enormous amounts of sediment (the Touchet Beds) to the valley during the Pleistocene (Ice Age) Missoula Floods likely influenced the current positions of the Walla Walla River and Mill Creek, including displacing their confluence to the area seen today, which is inferred to be north and east of the pre-Missoula Flood confluence area. Since the end of the Pleistocene, approximately 10,000 to 12,000 years ago, these two streams (and their tributaries) have been removing the Touchet Beds from the valley and returning valley hydrology to a much older, early Pleistocene (at least 1,000,000

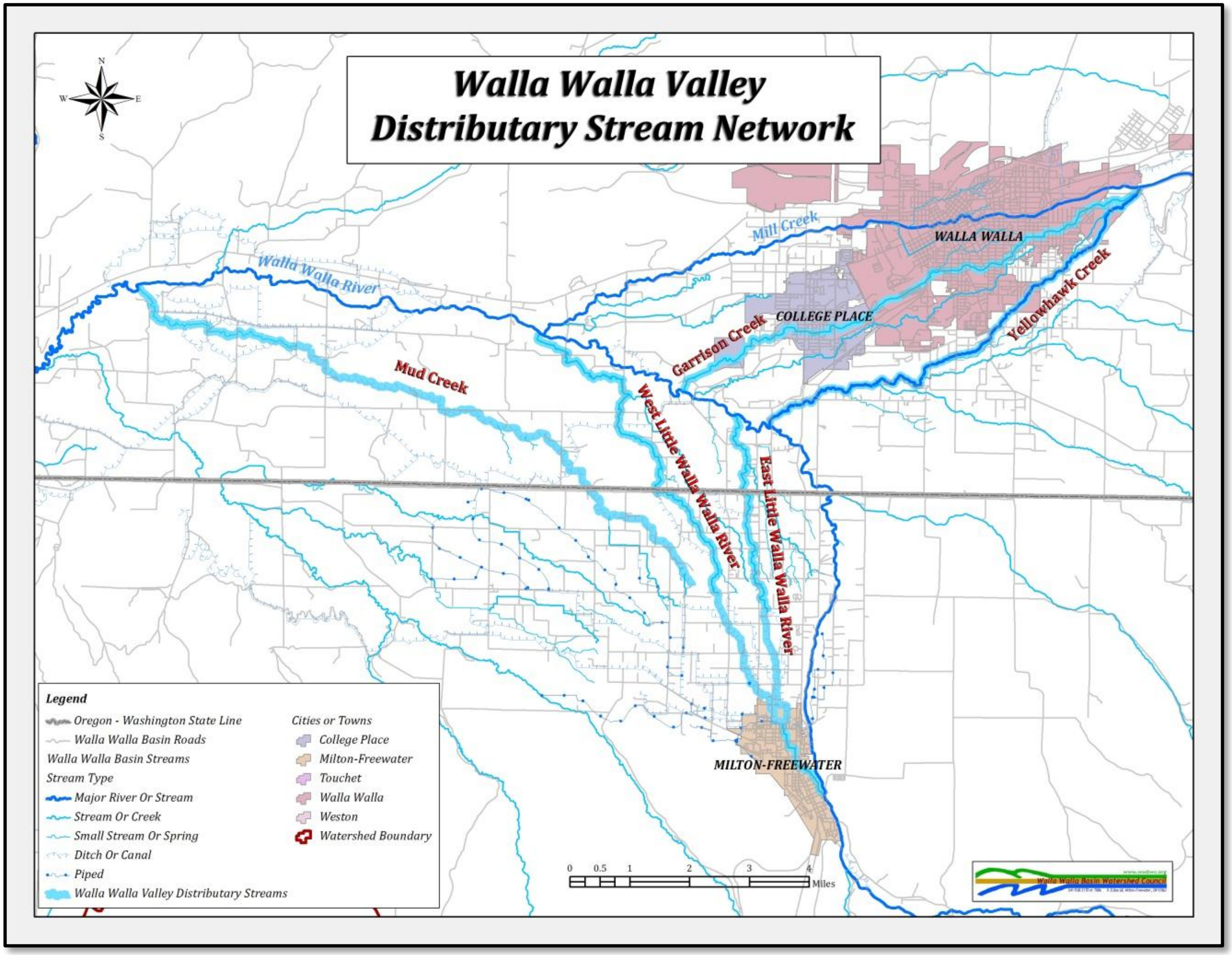


Figure 10 – Map of the distributary stream networks of the Walla Walla River and Mill Creek. Historically these stream networks conveyed winter and spring high flows across the valley's alluvial fans allowing for reduced flood pressure on the mainstem rivers, provided off-channel habitat and provided recharge to the alluvial aquifer system.

years ago) condition. With these events, the primary axes of basin wide groundwater flow and surface water flow are now somewhat disconnected. Figure 9 illustrates these differences.

Surface Water/Groundwater Interaction and Continuity

In recent decades the management and development of surface water resources has led to installation of flow control devices (irrigation head gates) at the head of the distributary channels. Over time, the management of the distributary network has become less natural. High flows during the winter and spring no longer have free access to the distributary network. This, along with the development of groundwater resources and the channelization of the valley's rivers and creeks, has created a declining alluvial aquifer condition.

Generally, the 'spreading out' of water across the alluvial fans via distributary channels (Figure 10), coupled with the high hydraulic conductivity of the underlying coarse sediment, function as a primary groundwater recharge mechanism for the entire alluvial aquifer. This seasonally recharged aquifer system in-turn feeds the valley's springs, spring creeks and larger streams. This cycling of surface water to groundwater recharge, followed by later discharge in springs and as stream base flow creates a delay in discharge of these waters from the valley. Depending on local conditions, this delay can range from days to months, and even years (Jiménez, 2012).

The declining alluvial aquifer, coupled with high connectivity between surface water and groundwater, has created stream reaches where high seepage loss occurs and significant volumes of surface water drain to the aquifer (Figure 11). In recent years, the listing of steelhead and bull trout as threatened under the Endangered Species Act and the reintroduction of spring chinook salmon within the watershed, has led to out-of-court agreements between irrigators and Federal fishery agencies. As a result of these agreements, local irrigators are leaving a portion of their legal water rights instream as bypass water year round. For example, per civil agreement, Oregon irrigators leave 25 cfs instream (bypass) throughout the year. However, depending on the water-year and a number of other factors, it is not unusual to only have 40-50% of the bypass water flow remain in the river above ground to the Oregon-Washington state line. The Pepper Bridge gauge shows that even with the 25 cfs reduction in irrigation withdrawals in Oregon, less than 20 cfs typically reaches the gauge downstream in Washington (Figure 12).

Spring fed creeks across the valley, sourced by springs discharging from the alluvial aquifer, have seen declining discharge since the earliest hydrogeologic studies were conducted by Piper (acting on behalf of the US Supreme Court) in the 1930s, Newcomb in the 1960s and Barker and MacNish in the 1970s. Water level declines in the alluvial aquifer since the 1930s and 1940s (Figures 13 & 14) are consistent with the general decline of the related springs (Figure 15). These trends lead one to conclude that there has generally been decreasing groundwater-sourced baseflow over the past several decades contributing to the Walla Walla River and other surface bodies during critical low-flow periods. This loss of groundwater baseflow to streams affects not only the amount of flow in the river but also leads to increased surface water temperature as the colder temperature baseflow is lost.

WWBWC riverbed seepage analyses compiled since 2002 provide additional insight into the nature of surface water and groundwater continuity and interconnections in the valley. Figure 16 portrays different gaining and losing reaches on the Walla Walla River between Pepper Bridge and Beet Road. Major losing reaches along this portion of the River overlie deeper portions of the aquifer. In these areas, cross cutting/high conductivity sediments remove water from the surface water system through seepage and transport it in a more westerly to south-westerly direction, along the main axis of the valley fill sediments. Without groundwater pumping this water is inferred to flow west toward the center of the valley, eventually reentering the River in the lower end of the valley, where the basalt uplands of Nine Mile Hill and the Horse Heaven Hills come together and pinch-out the alluvial sediments and alluvial aquifer and, as a result, force alluvial aquifer groundwater to discharge to the Walla Walla River.

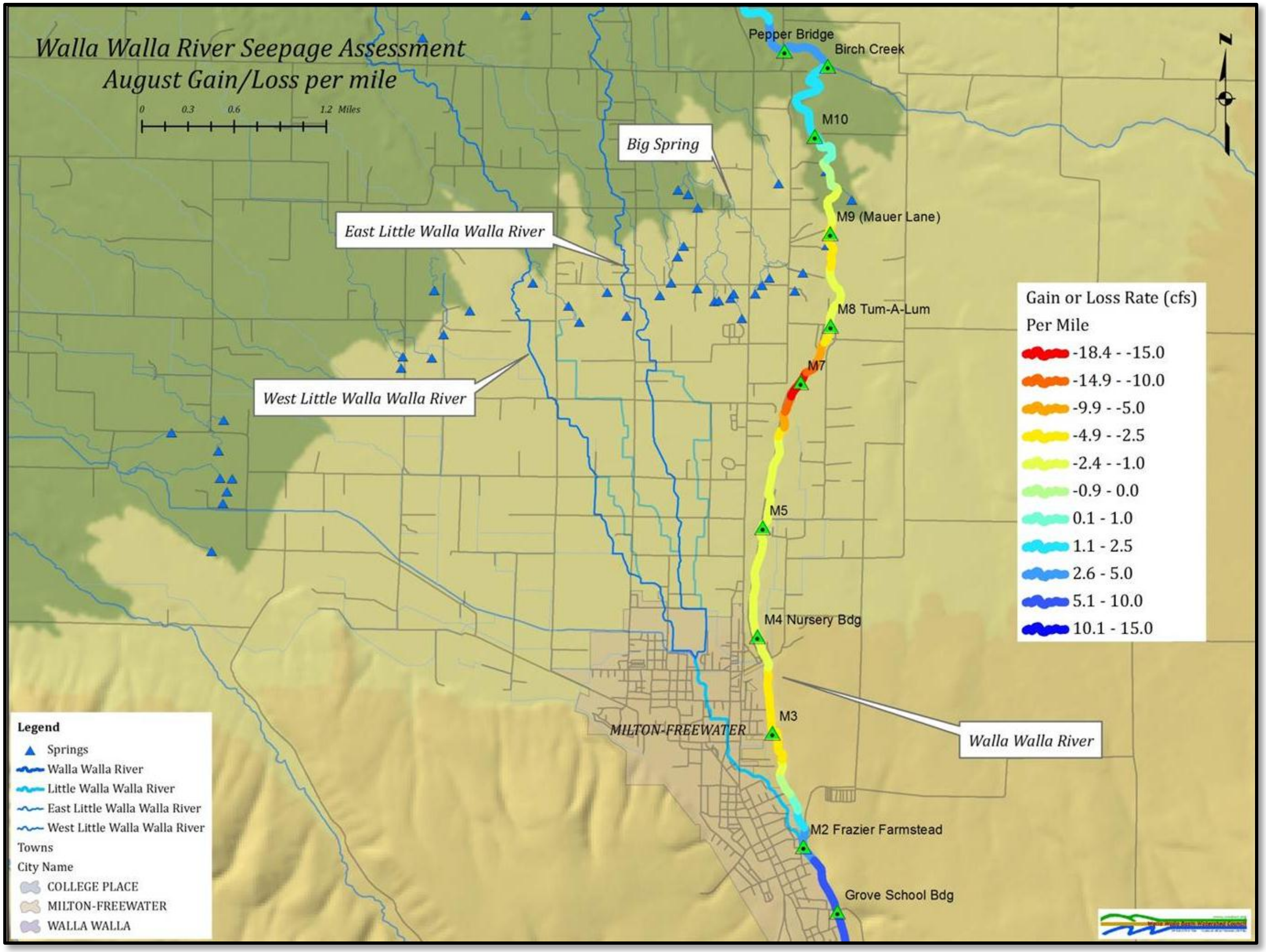


Figure 11 - Results from the water budget analysis of the Walla Walla River in August 2009. Color indicates rate of gain or loss of water in cfs (cubic feet per second). Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

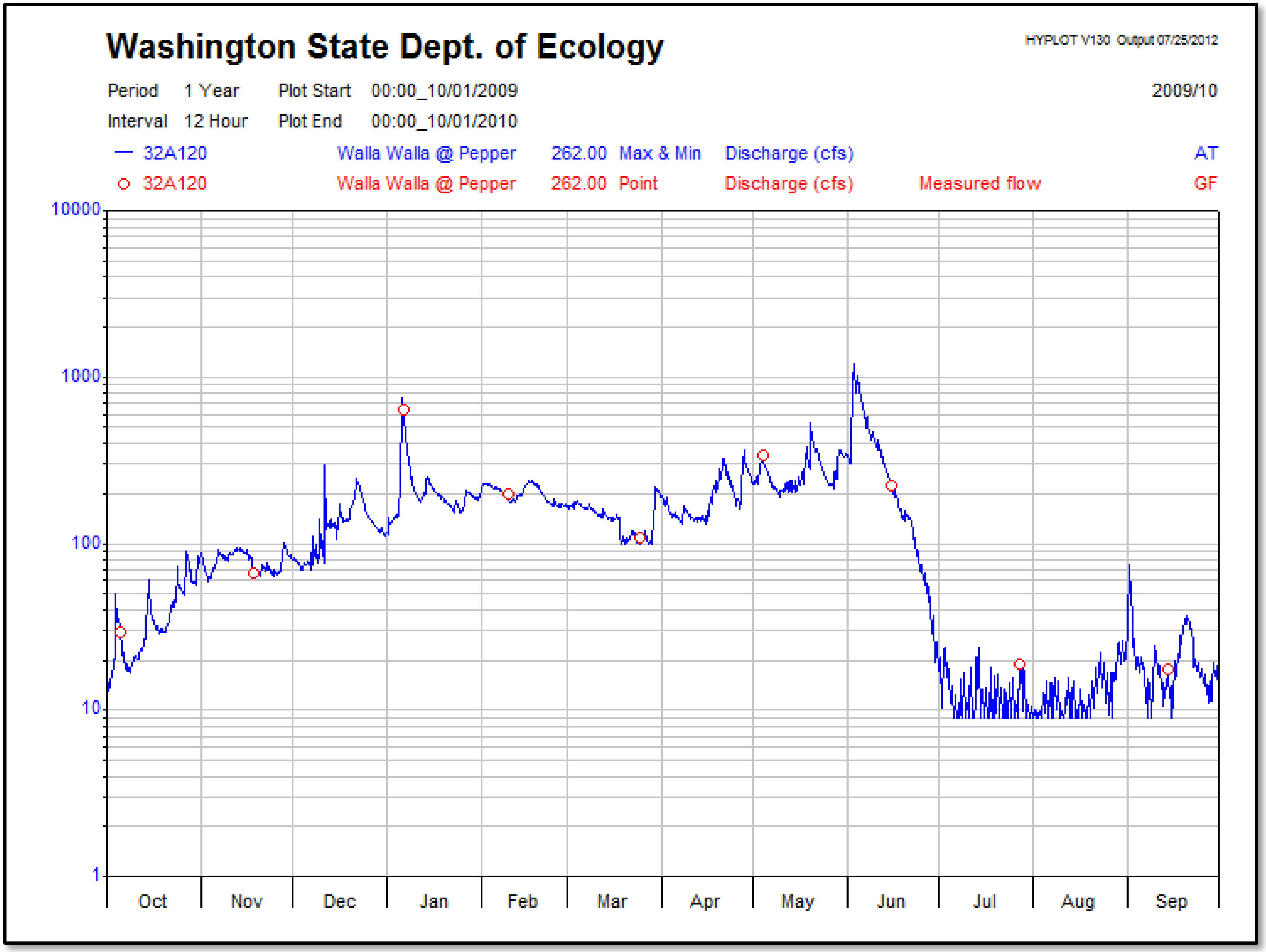


Figure 12 - Walla Walla River discharge measured at the WA Department of Ecology's Pepper Bridge gauge station for the water year 2009-2010.

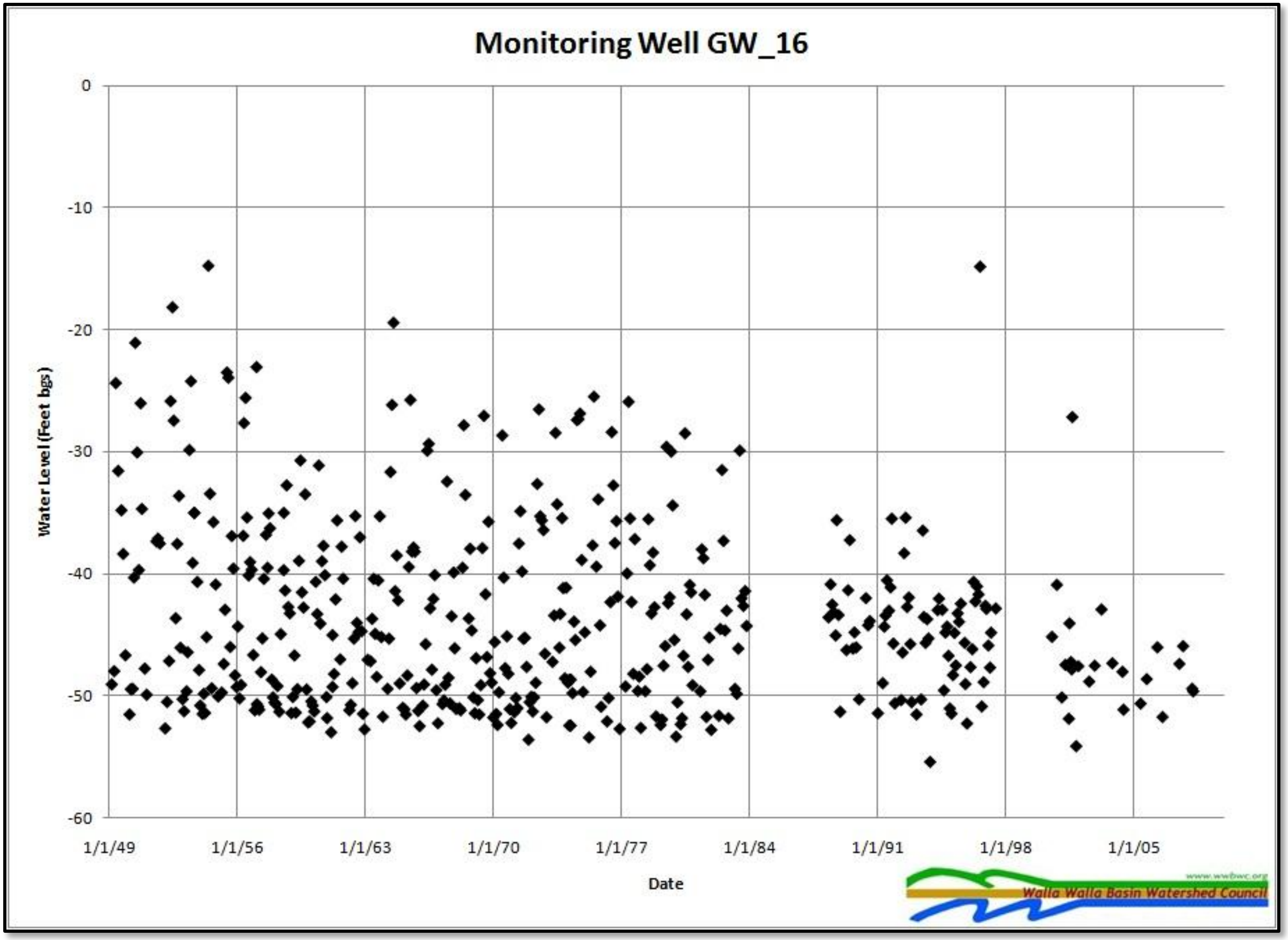


Figure 13 - Hydrograph for GW_16. This hydrograph shows the long-term decline in the alluvial aquifer within the Walla Walla Valley.

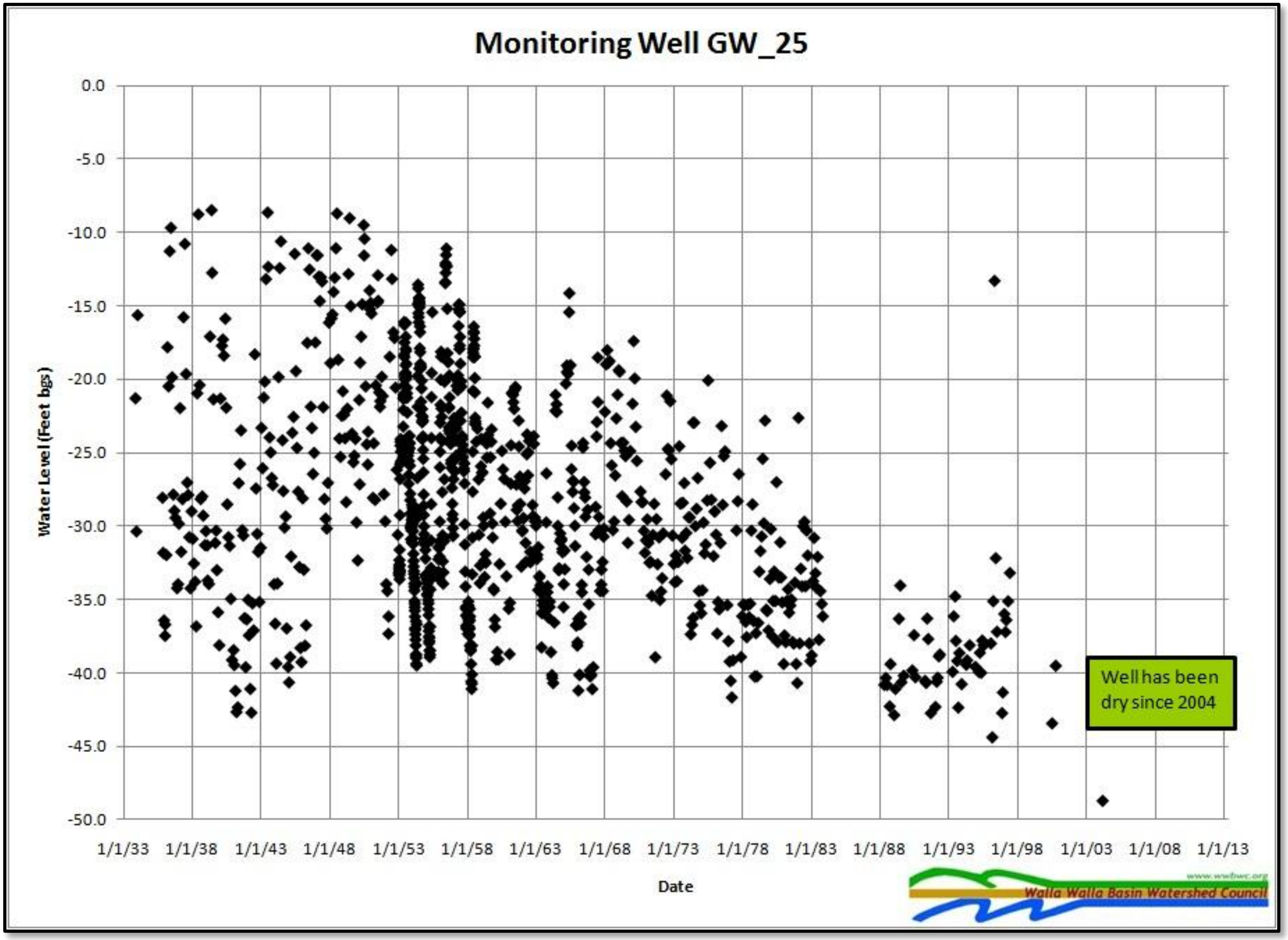


Figure 14 - Hydrograph for GW_25. This hydrograph shows the long-term decline in the alluvial aquifer within the Walla Walla Valley.

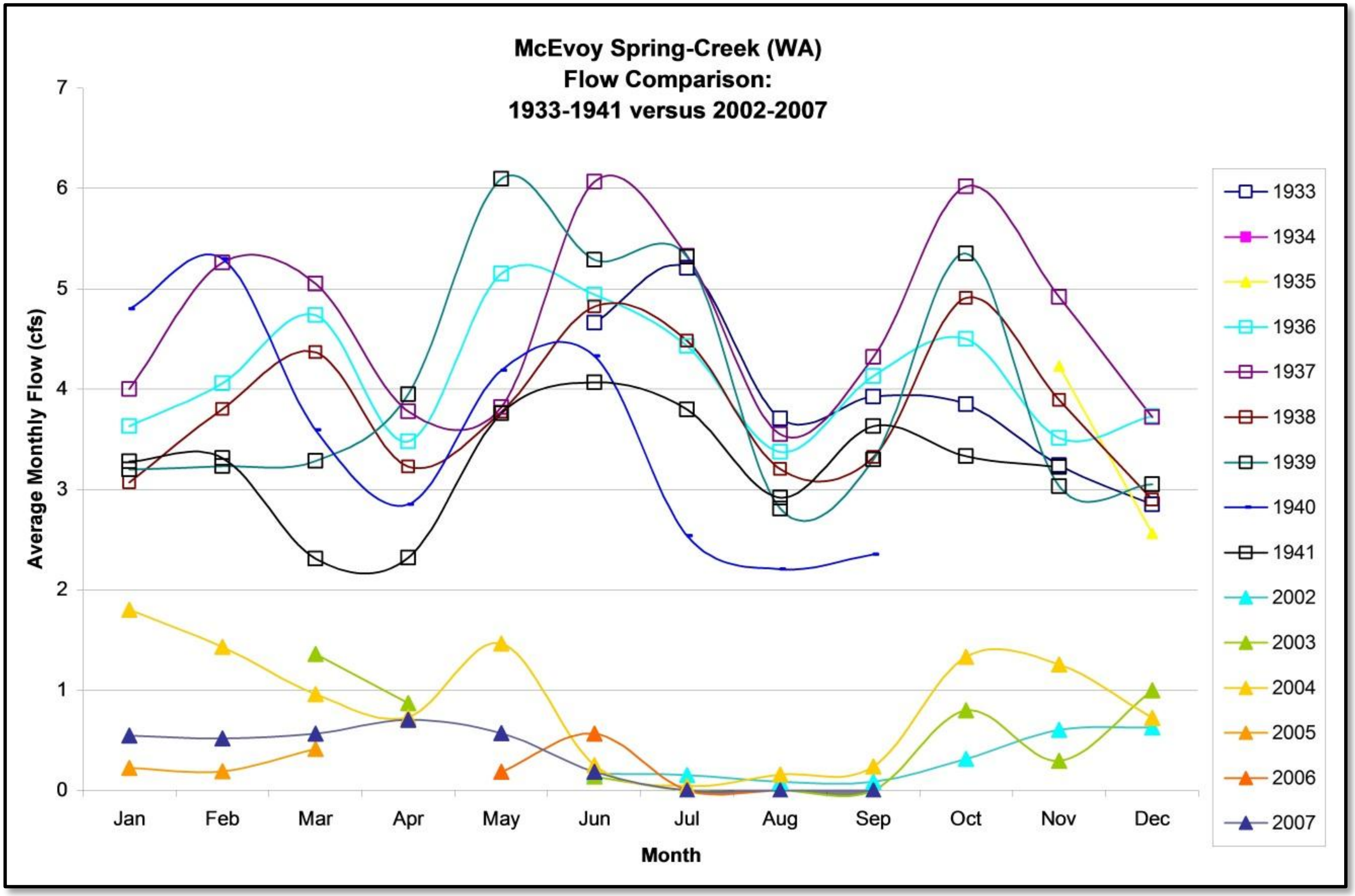


Figure 15 - Hydrograph for McEvoy Spring Creek located just north of the WA-OR state line. Hydrograph shows the decline in spring performance over the last 80 years.

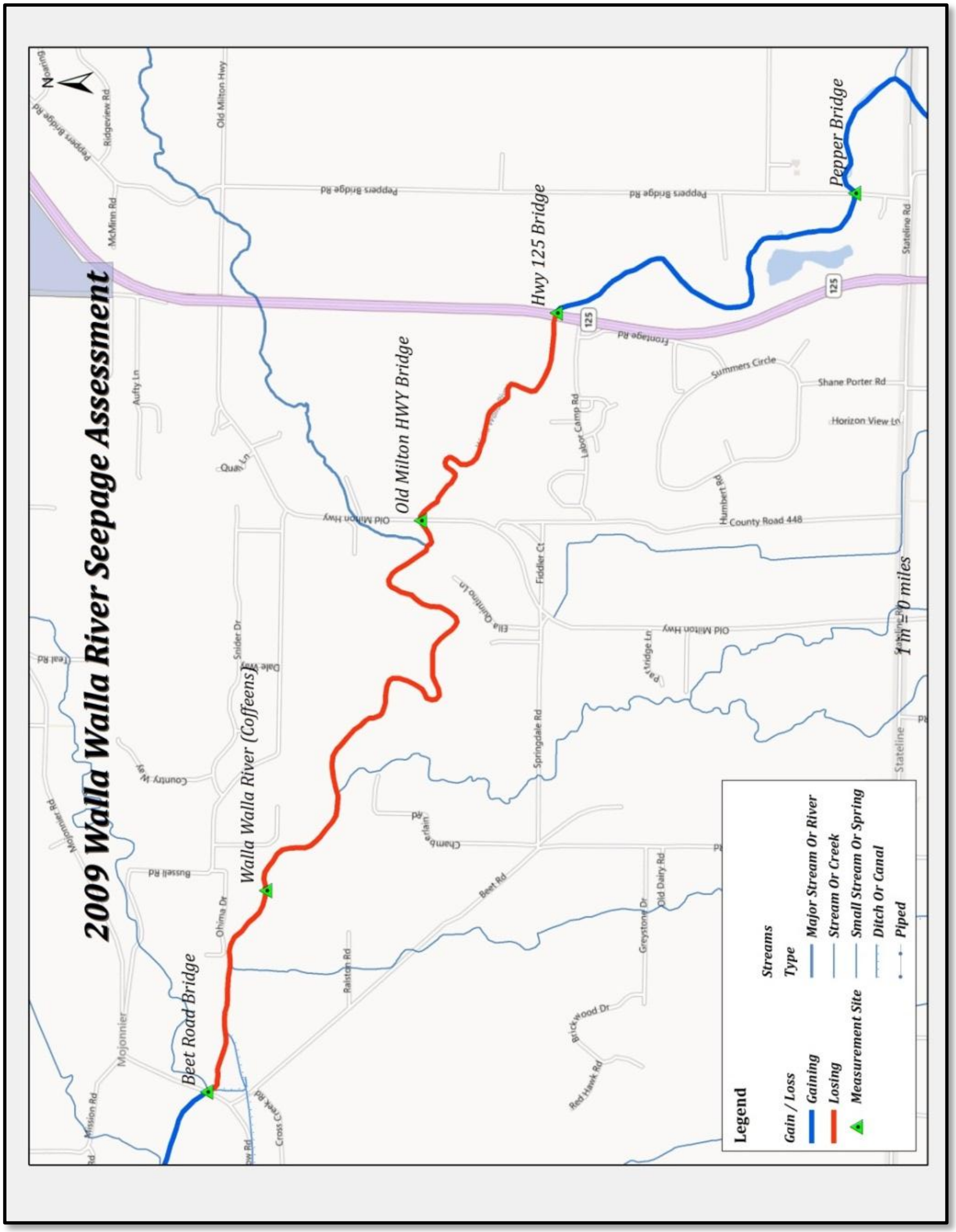


Figure 16 - Results from the water budget analysis of the Walla Walla River in August 2009. Color indicates gain (blue) or loss (red) of water. Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

Figure 17 highlights areas in the valley where significant groundwater level declines are readily apparent. These include the Eastside sub-basin, Section 34 area, SW Umapine area, Lowden area and the Lower Touchet River area. Groundwater level declines in each of these areas are summarized as follows:

- In the Eastside sub-basin well documented water level declines (Figure 14) likely are a significant factor controlling the seepage loss in the nearby mainstem Walla Walla River within the lower levee section, or Tum-a-lum reach. Portions of the eastside sub-basin have experienced 35 feet or more of groundwater declines since the 1940s. The recent piping of the open ditch system within the eastside orchard district in 2002 has removed the main seasonal recharge mechanism for the aquifer.
- The Section 34 area has seen groundwater declines for decades (Figure 13) which have increased in recent years (since the settlement agreement) because of a heavier reliance on groundwater to supplement reduced irrigation water sourced from the Walla Walla River (Figure 36).
- The area south and west of the town of Umapine has experienced groundwater decline over the past several years (Figure 18).
- Figure 19 illustrates a hydrograph from well GW_107, along the middle section of the River. This region, the Lowden area, sees some of the lowest mid-summer stream flows in the River and includes seepage losses that further degrade the stream flow condition (Figure 20).
- Similarly, in the lower Touchet River area, where recent piping of irrigation conveyance systems has been done, groundwater levels are declining. Well GW_126 (Figure 21) illustrates the declining trend of the alluvial aquifer near the town of Touchet in recent years. In addition to this monitoring well, recent seepage loss studies conducted by the WWBWC have shown the Touchet River losing up to 15 cfs within its lower reach during the summer (Figure 22).

The state of the aquifer within the Mill Creek alluvial fan is not as hydraulically stressed as the Walla Walla River alluvial fan in Oregon. Additionally, the depth to basalt below the Mill Creek alluvial fan and the aquifer is not as thick as in Oregon and has not been as extensively developed. For these reasons, the health of the Mill Creek alluvial fan and the connected springs within the City of Walla Walla have not been as negatively affected by decades of water development.

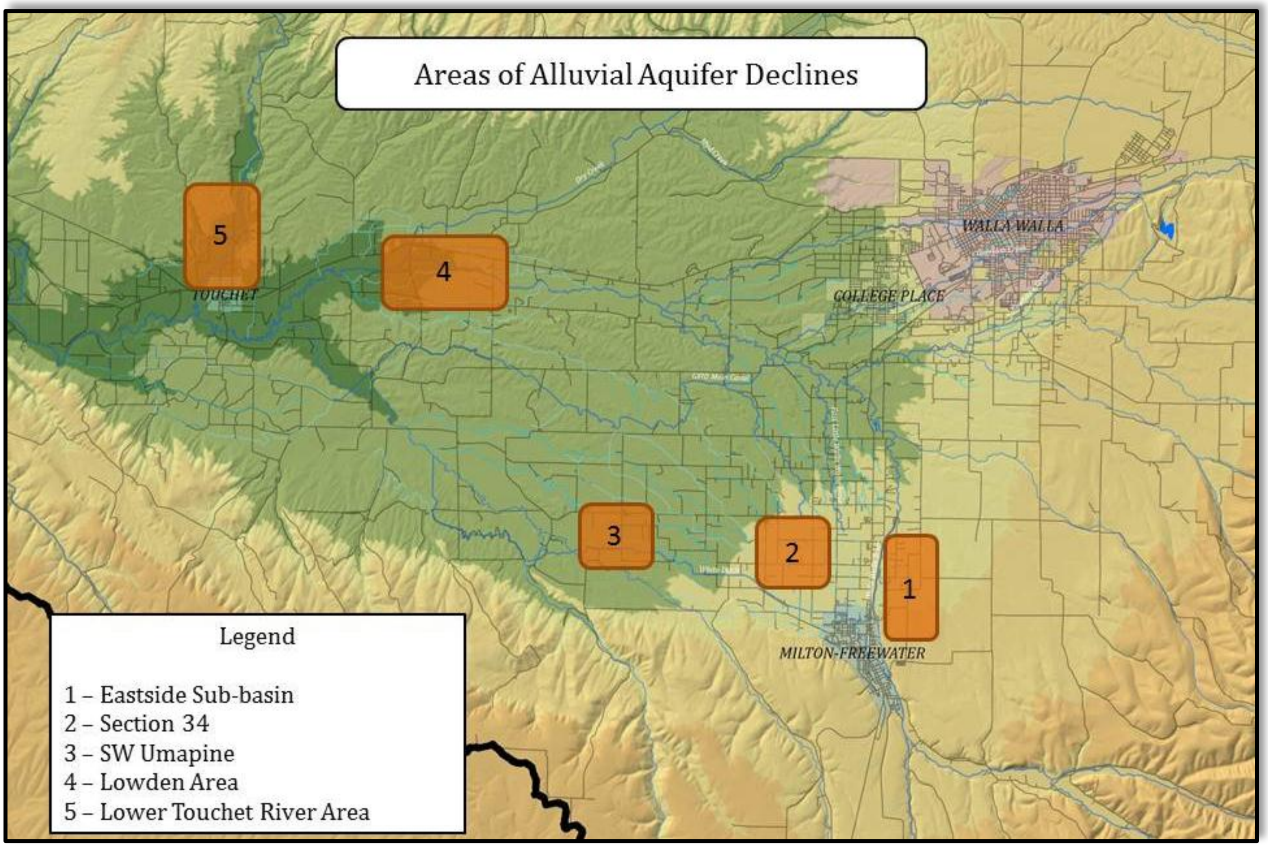


Figure 17 - Map of the Walla Walla Valley showing areas with significant groundwater declines in the alluvial aquifer.

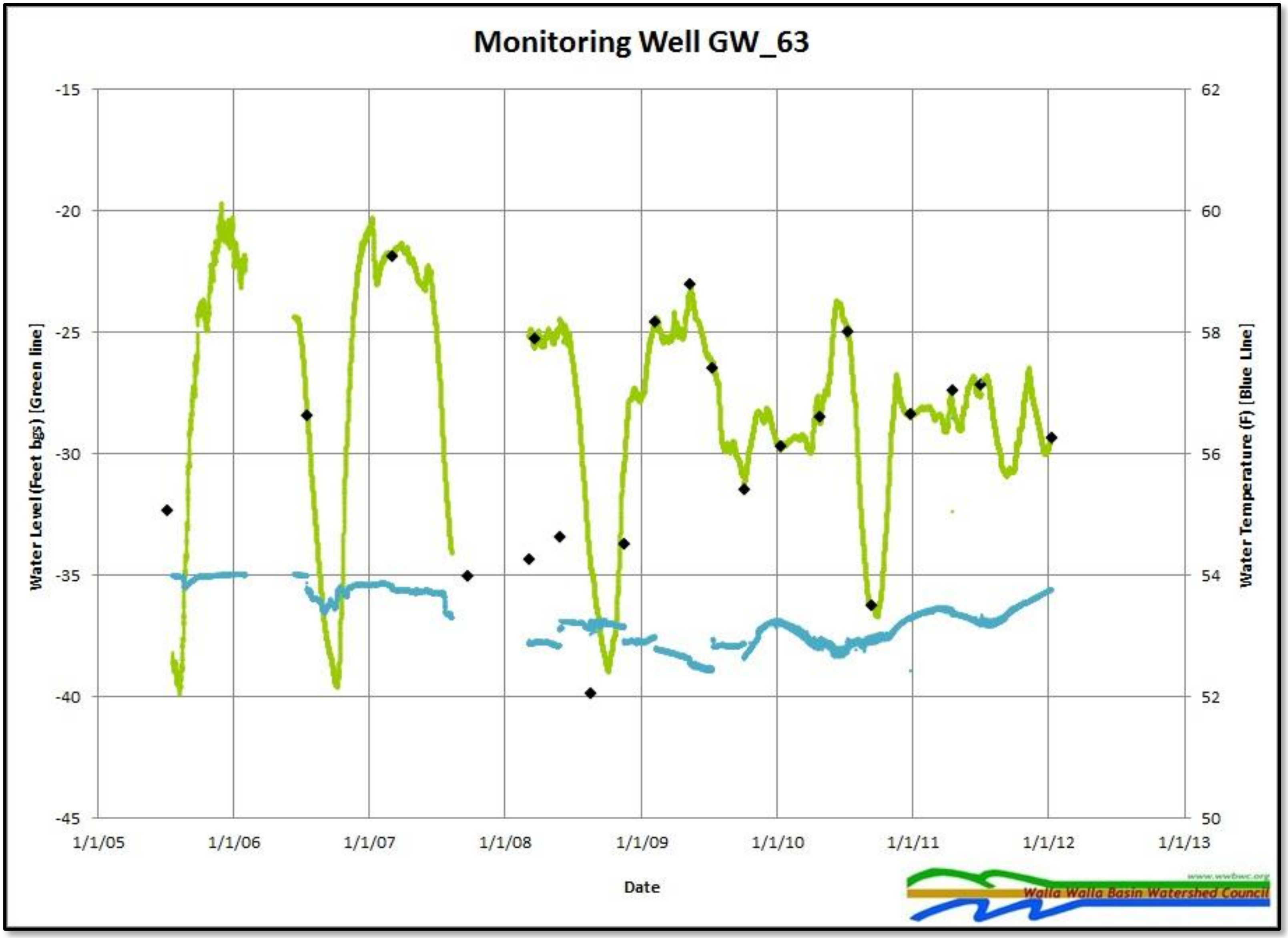


Figure 18 - Hydrograph for GW_16. This hydrograph shows the declines in the alluvial aquifer in the area southwest of Umapine, OR.

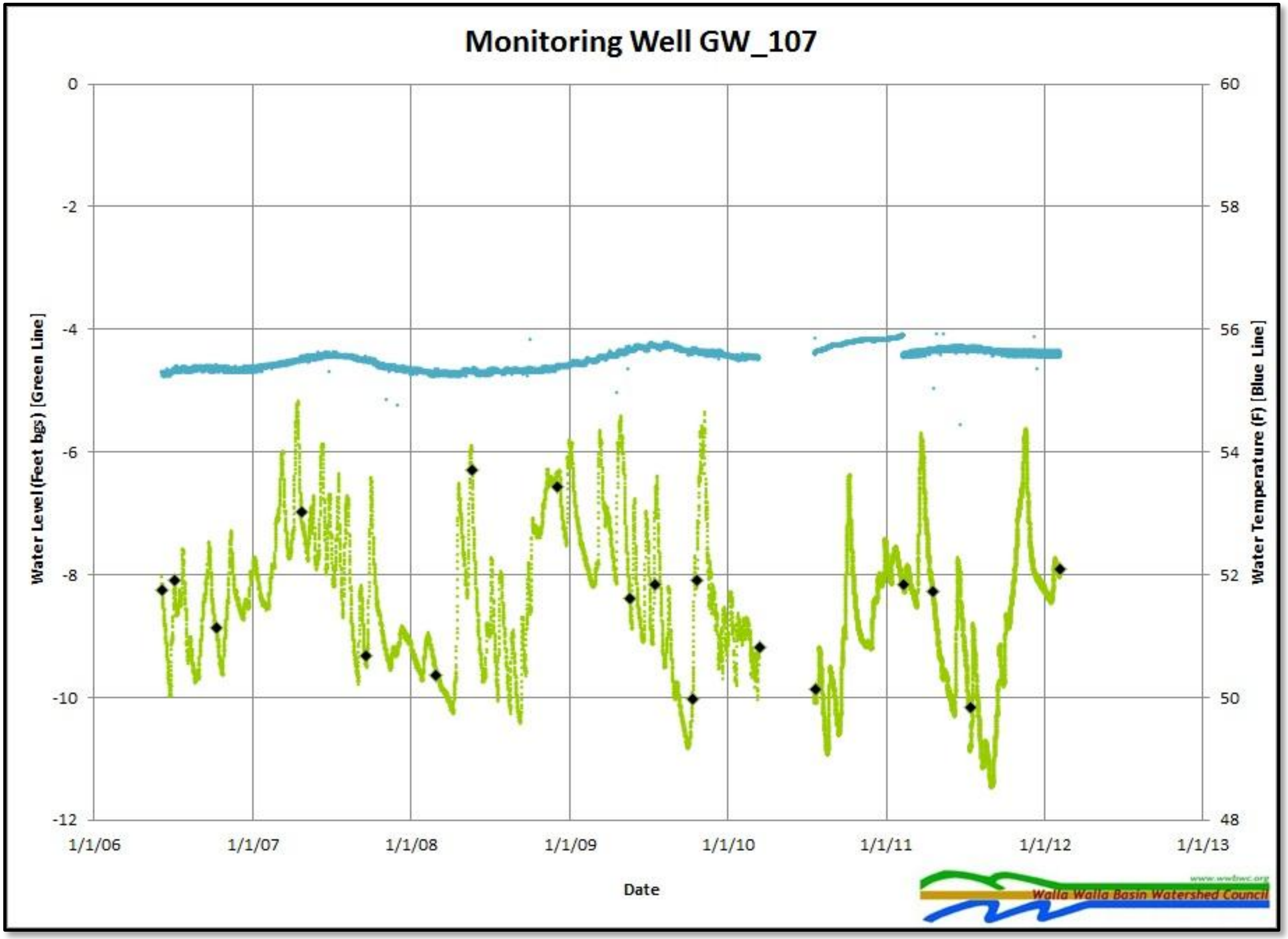


Figure 19 - Hydrograph for GW_107. This hydrograph shows the declines in the alluvial aquifer in the area near Lowden, WA. The decline in the hydrograph is visible in the low water levels dropping from year to year.

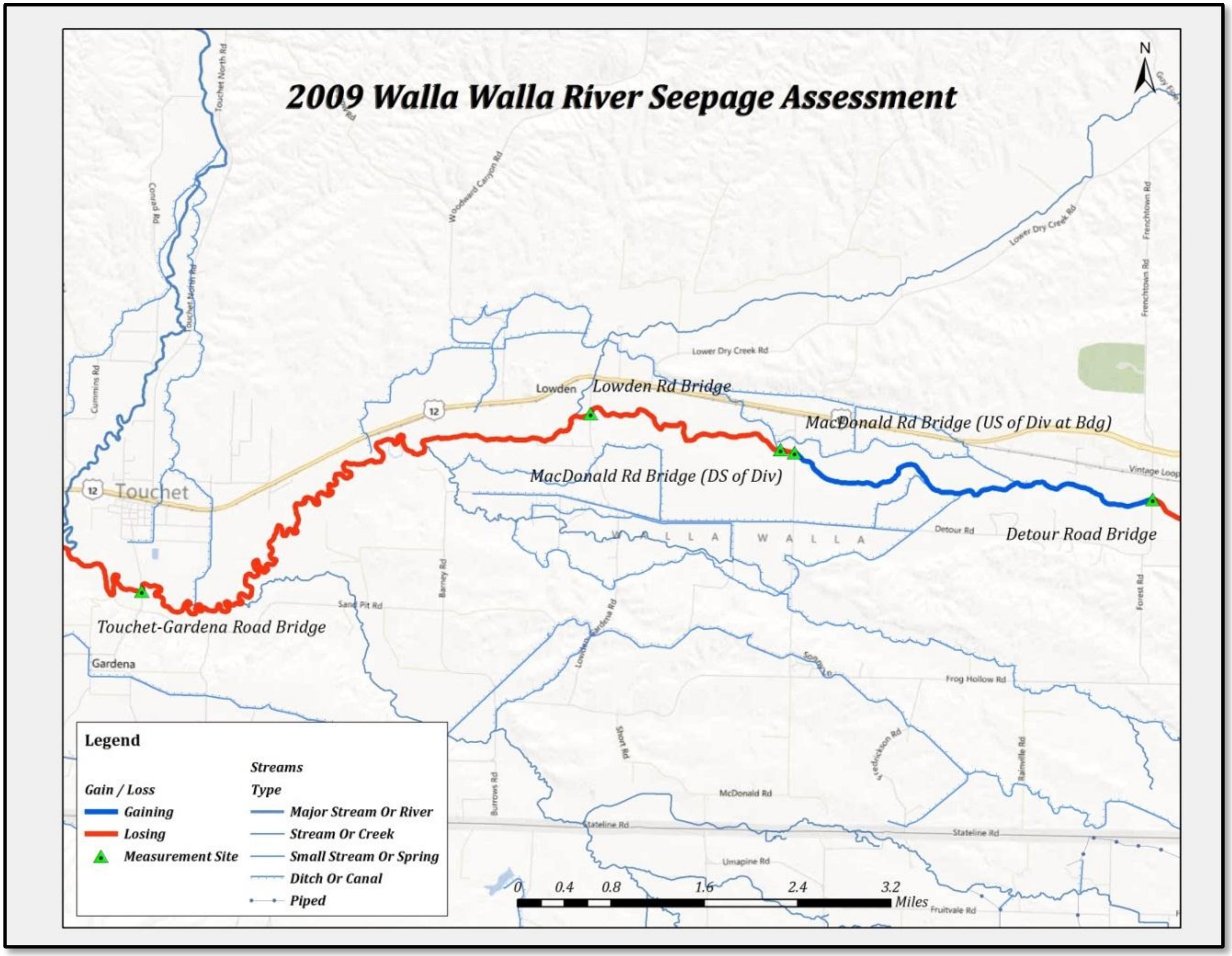


Figure 20 - Results from the water budget analysis of the Walla Walla River in August 2009. Color indicates gain (blue) or loss (red) of water. Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

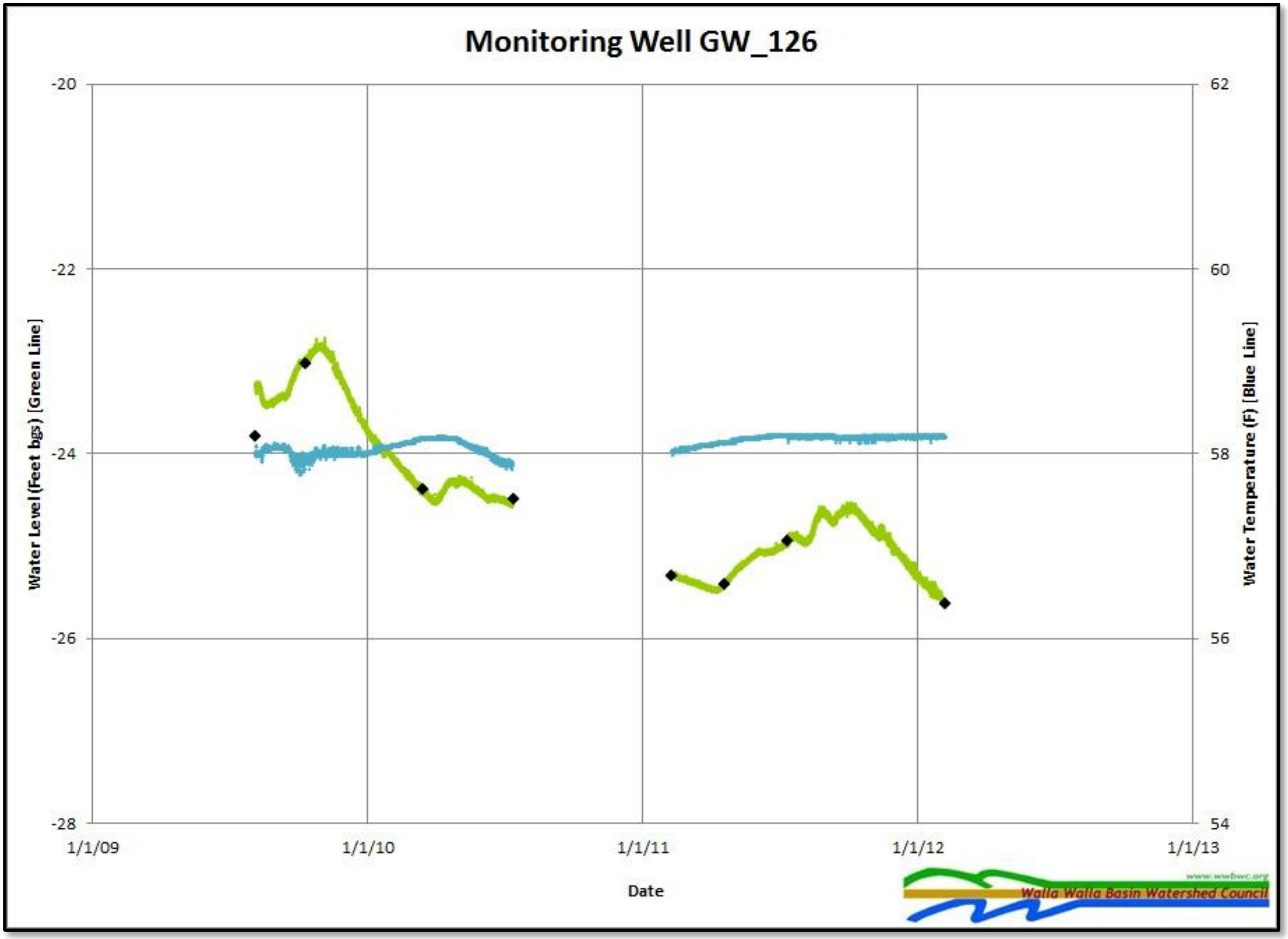


Figure 21 - Hydrograph for GW_126. This hydrograph shows the declines in the alluvial aquifer in the area north of Touchet, WA.

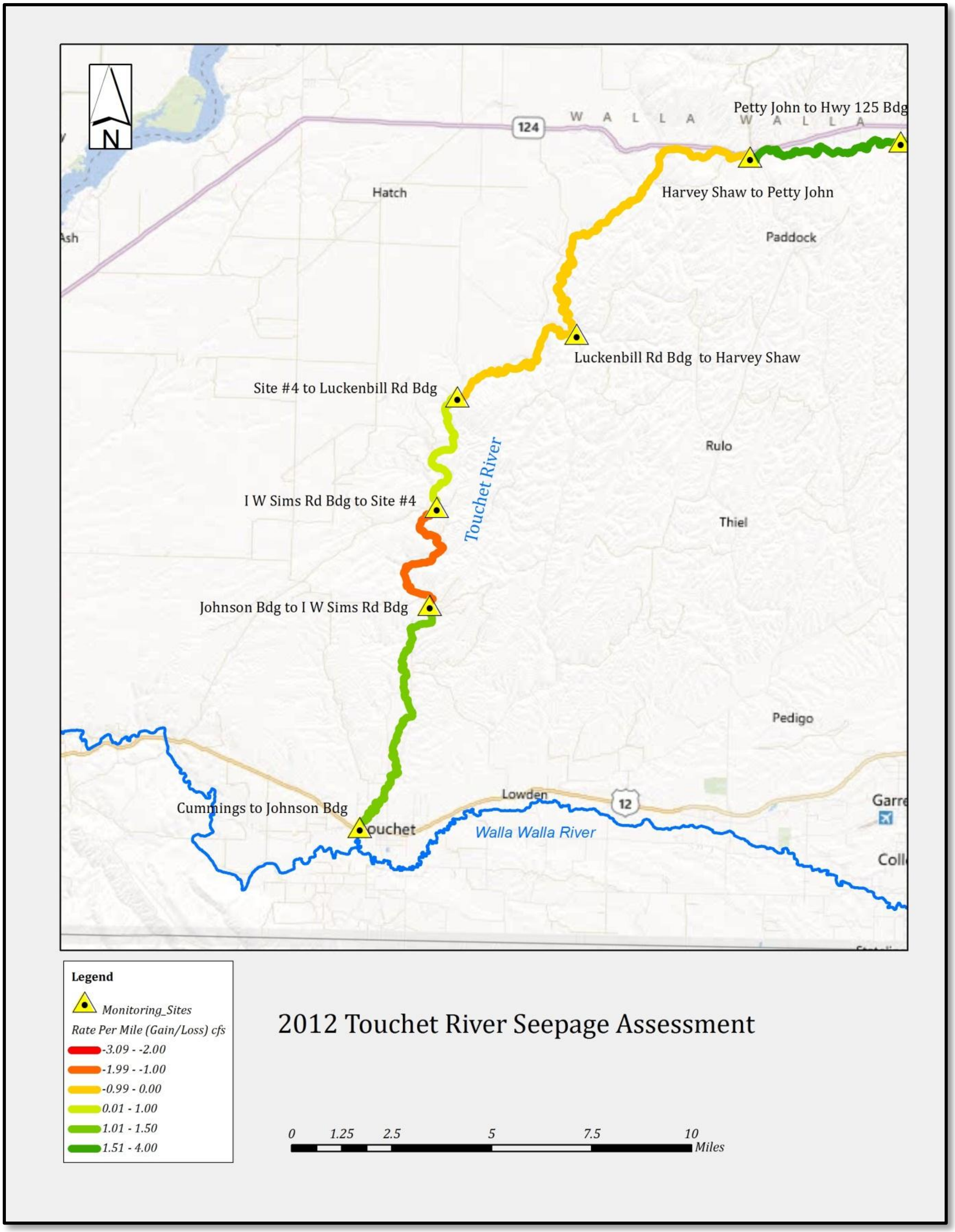


Figure 22 - Results from the water budget analysis of the Walla Walla River in August 2012. Color indicates rate of gain or loss of water in cfs (cubic feet per second). Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

Water Quality

Water quality in the Walla Walla Valley is generally good. Richerson and Cole (2000), focusing on just a few parameters, including nitrate, showed that water quality in the Walla Walla River and up gradient portions of the alluvial aquifer system was good. In addition, they showed that while there was a down gradient reduction in water quality in the alluvial aquifer, this reduction is small and that seepage from surface water sources (such as canals) appears to reduce parameter concentrations in groundwater samples they collected (i.e. recharge water derived from surface sources improved groundwater quality).

Groundwater quality monitoring data collected to date at three active AR sites, Hulette Johnson, Locher Road, and Stiller Pond and at the inactive Hall-Wentland site support the notion that water quality in the basin is generally good. Observations drawn from these data include the following:

- With respect to nutrient type constituents, including nitrate-N, total Kjehldahl nitrogen, phosphate, and ortho-phosphate groundwater concentrations are low, and in the vicinity of AR sites one sees further reduction in groundwater concentrations by AR water.

- Other parameters, such as total dissolved solids, chloride, and electrical conductivity also commonly show evidence of down gradient reductions resulting from AR activity that again is interpreted as evidence of dilution of these parameters in groundwater by AR water.

- The SOC (Synthetic Organic Compounds – i.e. pesticides, etc.) data available for these sites show SOC detections are sporadic, not systematic, and at very low concentrations.

All of these observations also suggest very little degradation of groundwater quality in the basin, again indicative of generally good water quality. Furthermore, water quality data collected for all of the AR projects conducted to date show that the alluvial aquifer (at least its upper portions) and surface water in the Walla Walla Valley display a high degree of geochemical similarity and, as a result, are interpreted to have a high degree of hydrologic continuity.

Pilot Projects

Starting in 2004, the WWBWC, in partnership with Hudson Bay District Improvement Company (HBDIC), Gardena Farms Irrigation District #13 (GFID), the Walla Walla River Irrigation District (WWRID), and the Walla Walla County Conservation District (WWCCD) have created four aquifer recharge (AR) pilot projects within the valley to help mitigate for aquifer declines and improve baseflow to the surface water system (Figure 23). The results of these projects are summarized in the following sections.

Sites

Hulette Johnson

The HBDIC Hulette Johnson AR site (Hulette Johnson site – Figure 23), formerly known as the Hudson Bay site, has been operating since 2004. The Hulette Johnson site has grown in three phases since operations began. The initial 2 phases are described extensively in the final report for the first limited license (WWBWC, 2010). It currently has the capacity for approximately 16 to 17 cfs of infiltration into approximately 3 acres of infiltration basins and infiltration galleries. Per the Oregon Water Resources Departments (OWRD) Limited License for this site, water allocated to this project is sourced from the Walla Walla River using an irrigation diversion and canal delivery system that originates in the town of Milton-Freewater. The license requires a minimum flow amount to remain in the mainstem Walla Walla River (Table 1), water quality testing, and monitoring of local surface water and groundwater hydrology.

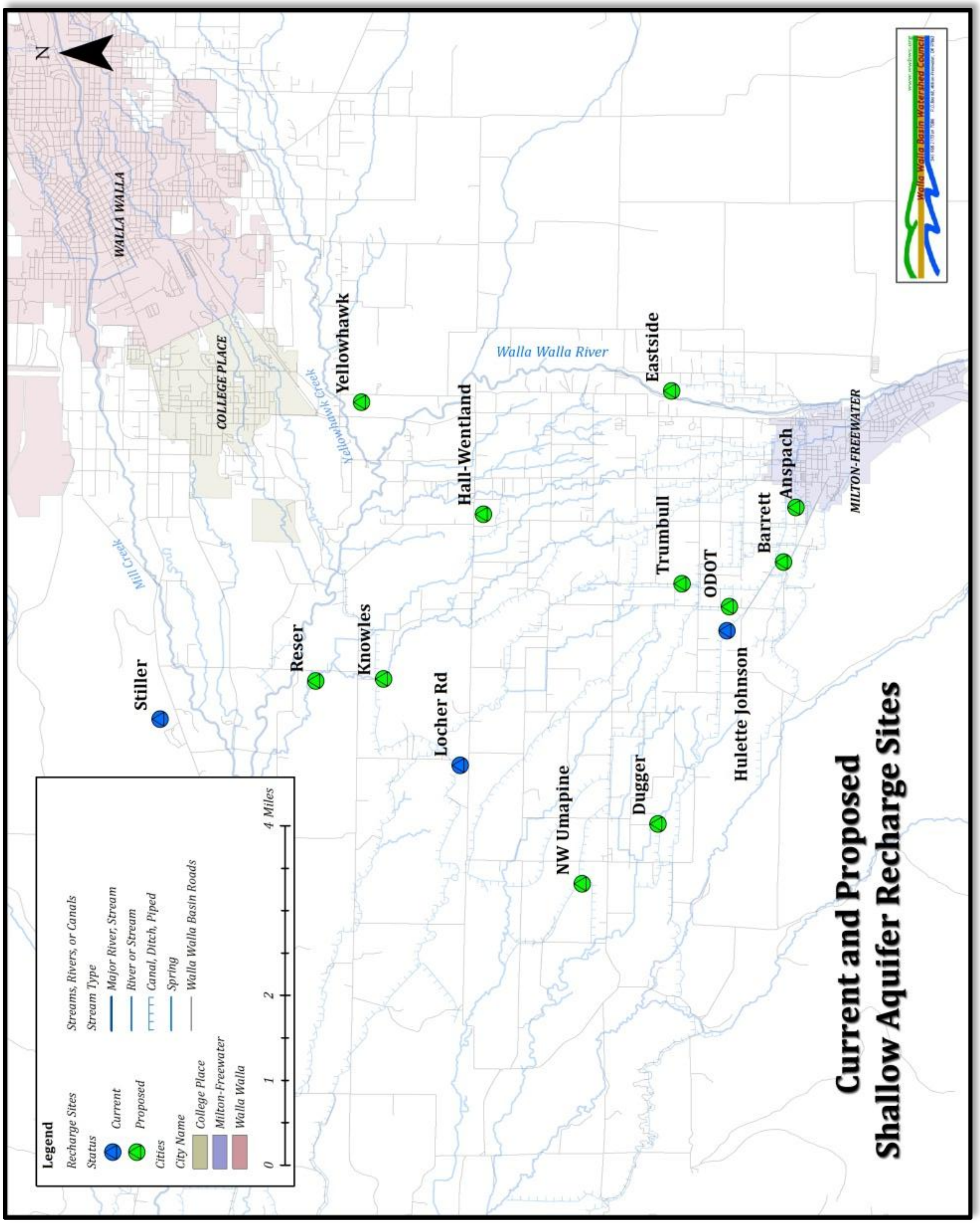
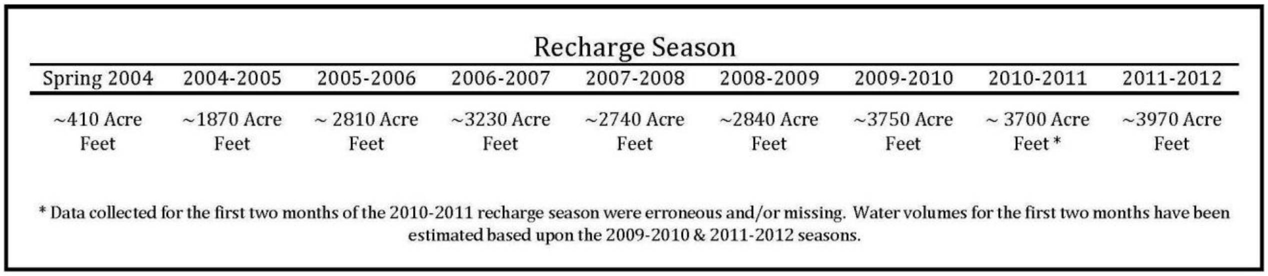


Figure 23 - Current and proposed aquifer recharge sites in the Walla Walla Valley.

Table 1 - Water volume recharged during each recharge season at the Hulette Johnson AR site. A typical recharge season starts in November and goes until May 15th of the following year. Water volumes are in acre-feet.



Recharge Season								
Spring 2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
~410 Acre Feet	~1870 Acre Feet	~ 2810 Acre Feet	~3230 Acre Feet	~2740 Acre Feet	~2840 Acre Feet	~3750 Acre Feet	~ 3700 Acre Feet *	~3970 Acre Feet

* Data collected for the first two months of the 2010-2011 recharge season were erroneous and/or missing. Water volumes for the first two months have been estimated based upon the 2009-2010 & 2011-2012 seasons.

Alluvial aquifer recharge at the Hulette Johnson site has resulted in improvements to both the surface water and groundwater systems as seen in down gradient monitoring locations. Wells GW_31, GW_34, and GW_35, which range from 0.5 to approximately 3.75 miles from the Hulette Johnson site (GW_35 = 0.5 miles, GW_31 = 2.75 miles and GW_34 = 3.75 miles), show rising water levels and decreasing temperatures (Figures 24-26). Annual recharge and discharge cycles are apparent in the hydrographs, with much of the winter and spring periods displaying elevated water levels interpreted to reflect aquifer recharge and recovering water levels. Summer and fall periods show lower water levels occurring when recharge is not occurring and with seasonal discharge to surface water and withdrawals by wells. Most important to note is the general recovery from one year to the next. Seasonal high and seasonal low water levels both are generally higher than in preceding years. This signifies increased aquifer storage in this region carrying over to the following year. The gradual rise in aquifer levels in down gradient monitoring locations represents the water table being nearer to the surface than previous years – indicating a recovering aquifer.

The reactivation of Johnson Spring Creek is interpreted to be directly related to the recovery of the groundwater system. After being dry for decades Johnson Spring Creek began to see seasonal flows in 2005 (Figure 27). These seasonal flows are interpreted to be a direct result of aquifer restoration from AR activity at the Hulette Johnson site. Johnson Spring Creek flows to Swartz Creek, Pine Creek, and ultimately the Walla Walla River.

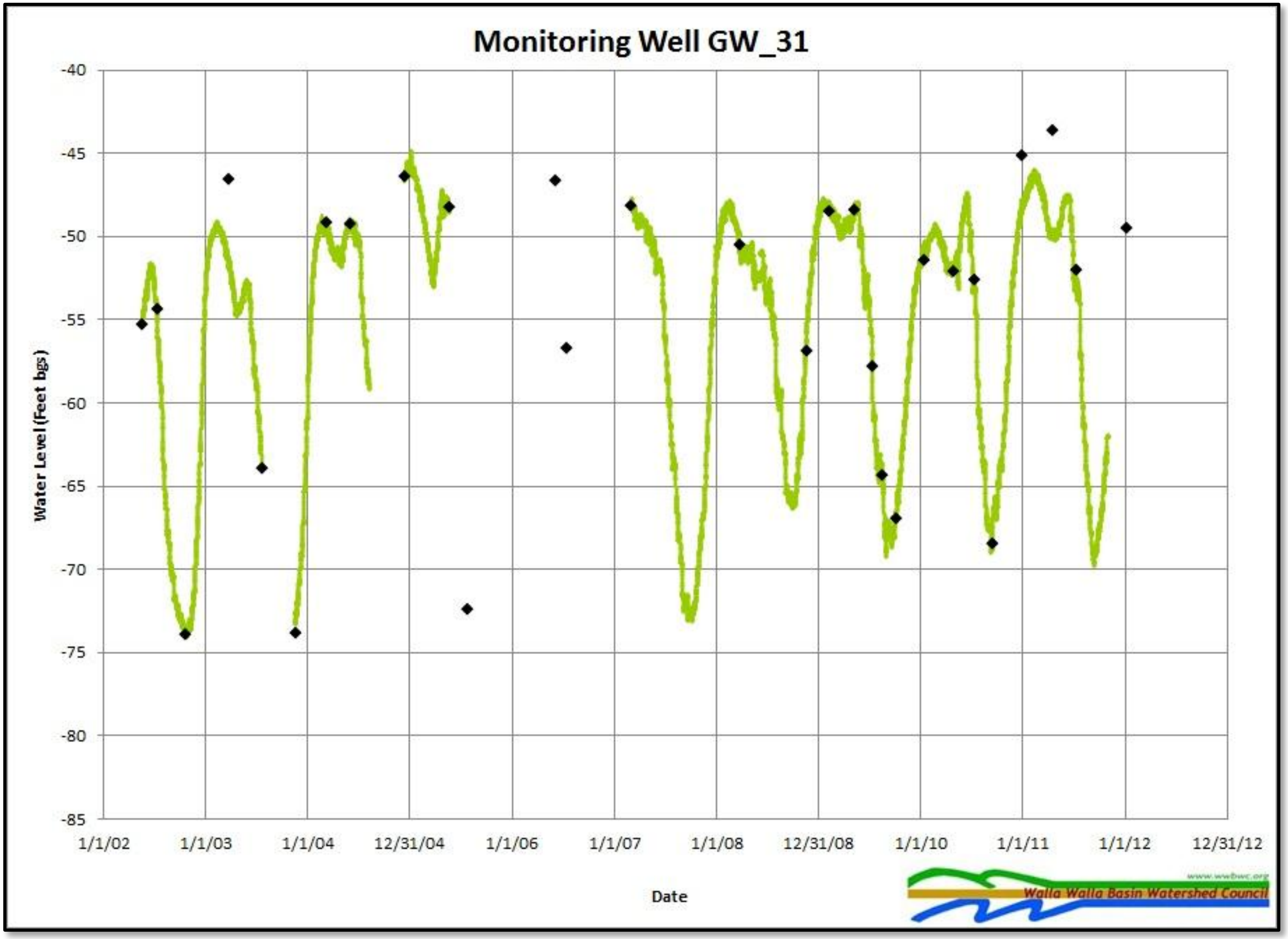


Figure 24 - Hydrograph for GW_31. GW_31 is ~2.75 miles down-gradient of the H. Johnson AR site.

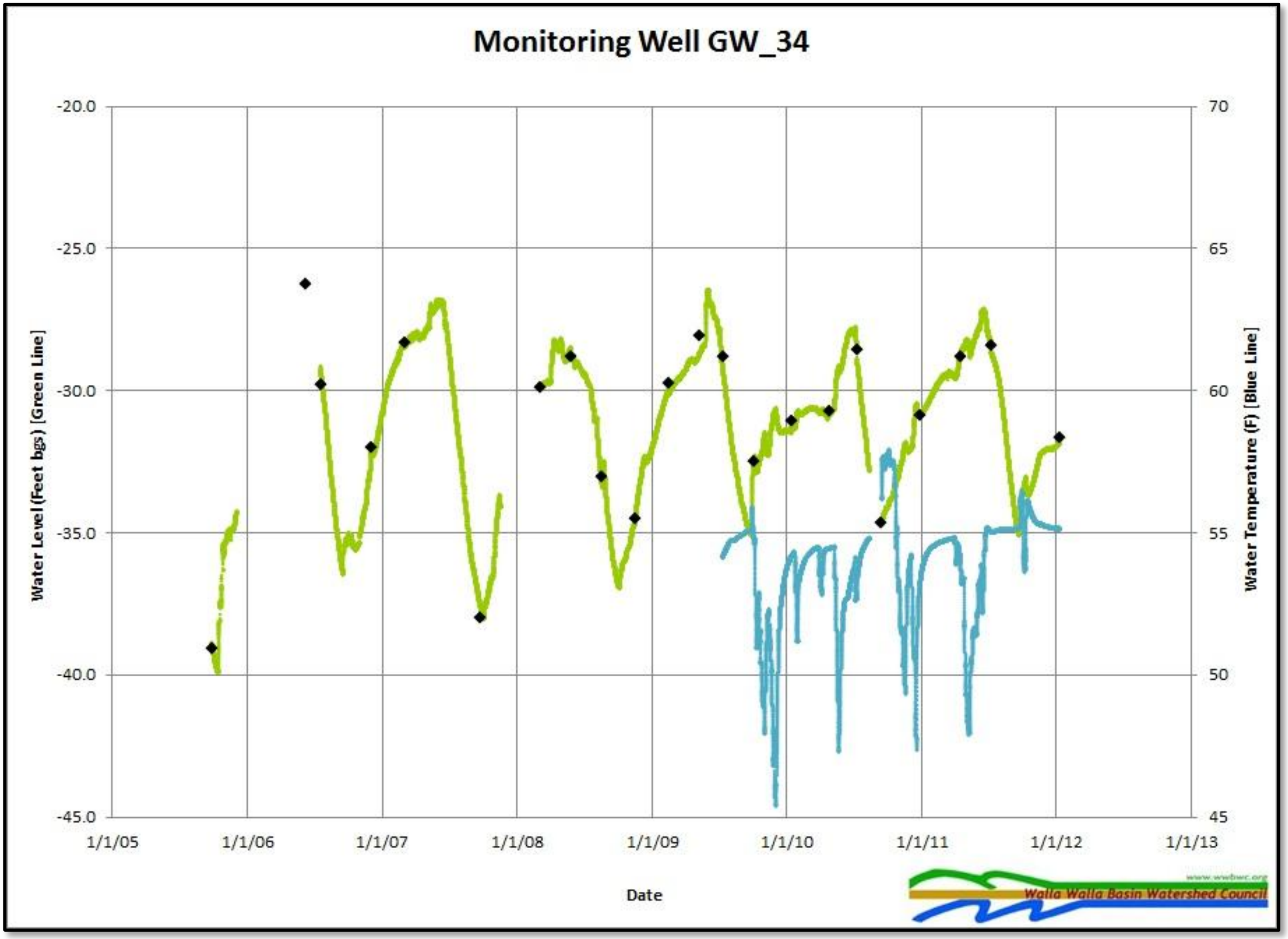


Figure 25 - Hydrograph for GW_34. GW_34 is ~3.75 miles down-gradient of the H. Johnson AR site.

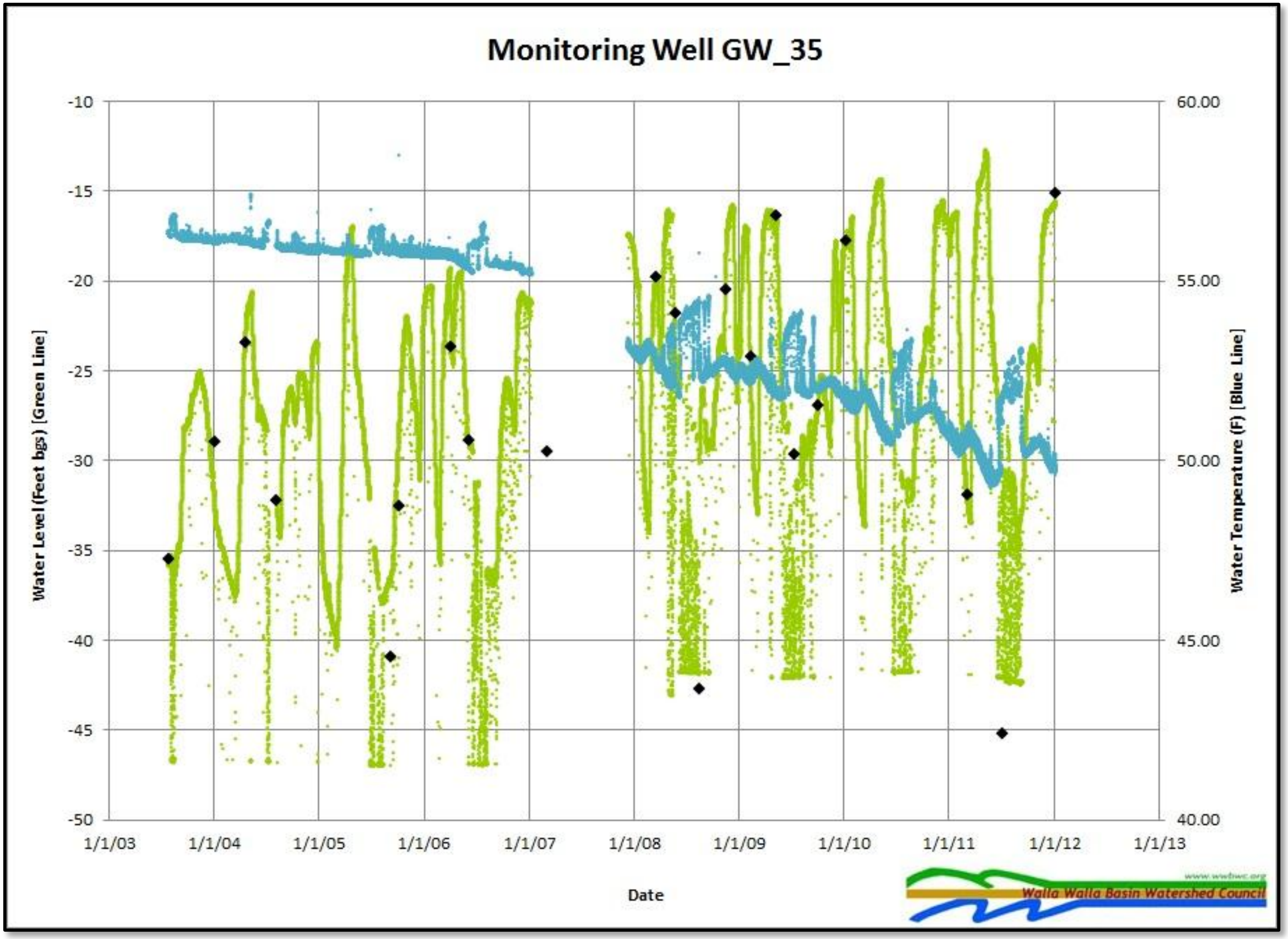


Figure 26 - Hydrograph for GW_35. GW_35 is ~0.5 miles down-gradient of the H. Johnson AR site.

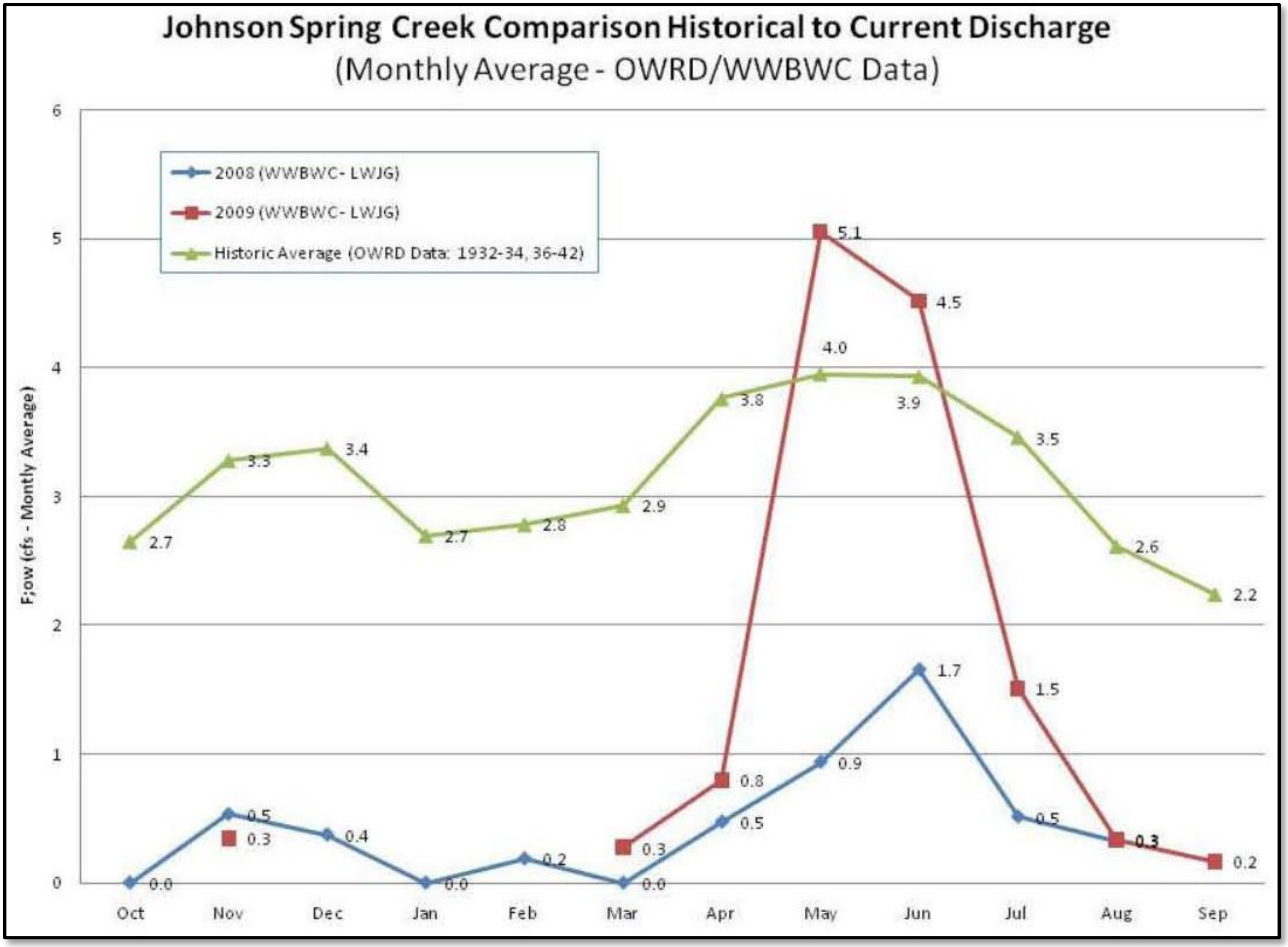
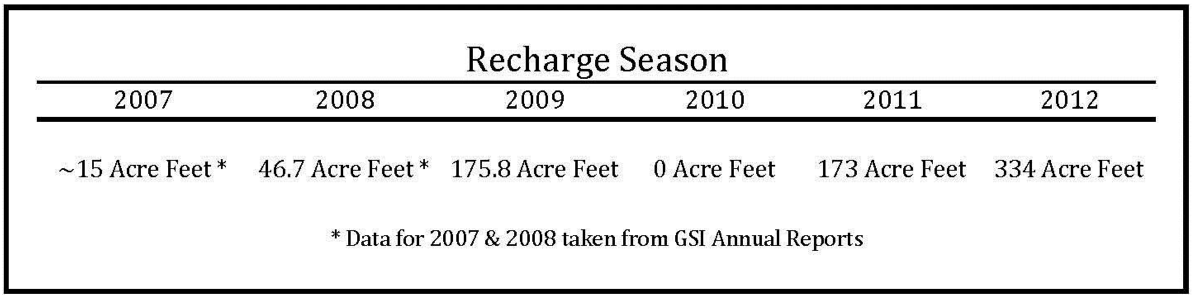


Figure 27 - Johnson Spring Creek hydrograph comparing historic discharge values to recent discharge values. Historically Johnson Spring Creek had 2-4 cfs flowing all year. By the late 1970s Johnson Spring Creek had dried up. After the Hulette Johnson AR site was constructed and started operating in the spring of 2004, Johnson Spring Creek started to flow again after being dry for more than 25 years.

Locher Road

The Locher Road site, located at the intersection of Stateline Road and Locher Road, is a former gravel quarry that has been operated by GFID as an AR site since 2007 (Figure 23). From 2007 through 2011, approximately 1/3 acre of the 4+ acre site was utilized for recharge. The site did not operate during the 2010 AR season. In late 2011, the site was reconstructed to allow infiltration over a 2.5 acre portion of the site. Recharge rates at the site increased from approximately 1.3 cfs to 3.5 cfs. Total recharge volumes are listed in Table 2. The Locher Road site has operated under successive two-year temporary use authorizations issued by Washington Department of Ecology (WDOE) with requirements similar to those of the OWRD limited license.

Table 2 - Water volume recharged during each recharge season at the Locher Road AR site. A typical recharge season starts in December or March and goes until the end of May. Water volumes are in acre-feet.



Recharge Season					
2007	2008	2009	2010	2011	2012
~15 Acre Feet *	46.7 Acre Feet *	175.8 Acre Feet	0 Acre Feet	173 Acre Feet	334 Acre Feet

* Data for 2007 & 2008 taken from GSI Annual Reports

In addition to the temporary use authorization, in 2010 the Walla Walla Watershed Management Partnership (WWWMP), a locally led organization that co-manages Walla Walla Basin water resources with the State of Washington, passed a Local Water Plan (LWP) that allows GFID to utilize up to 5 cfs of its existing water right for AR (WWWMP, 2010). This authorization, like the temporary use authorization, is governed by the maintenance of minimum instream flows in the river (measured at the Detour Road gauging station), water quality testing, and hydrologic monitoring in local wells and surface water points.

Groundwater improvements resulting from Locher Road site AR operation can be seen in onsite wells GW_70 and GW_72 (Figure 28 and 29) and offsite wells GW_110 and GW_122 (Figure 30 and 31). Hydrographs for these wells all show generally higher seasonal peaks and lows occurring since the advent of recharge operations at the site. As with the Hulette Johnson site, these higher water levels are interpreted to reflect increased storage in the aquifer around the Locher Road site.

Direct improvements to the surface water hydrology as a result of the Locher Road project are more difficult to discern. Mud Creek is the local surface water body; however local water table elevations are ten feet or more below this stream. Because the site lies within the central portion of the valley, recharge water likely contributes primarily to aquifer recovery and storage building. Surface water augmentation or base-flow enhancement of the hydrologic system as a result of the Locher Road AR project may be delayed by several years as groundwater storage is rebuilt. Once this is accomplished, recharge water will likely migrate through the shallowest part of the hydrologic system and play a direct role in enhancing surface water flow (GSI, 2007a, 2008a & 2009a).

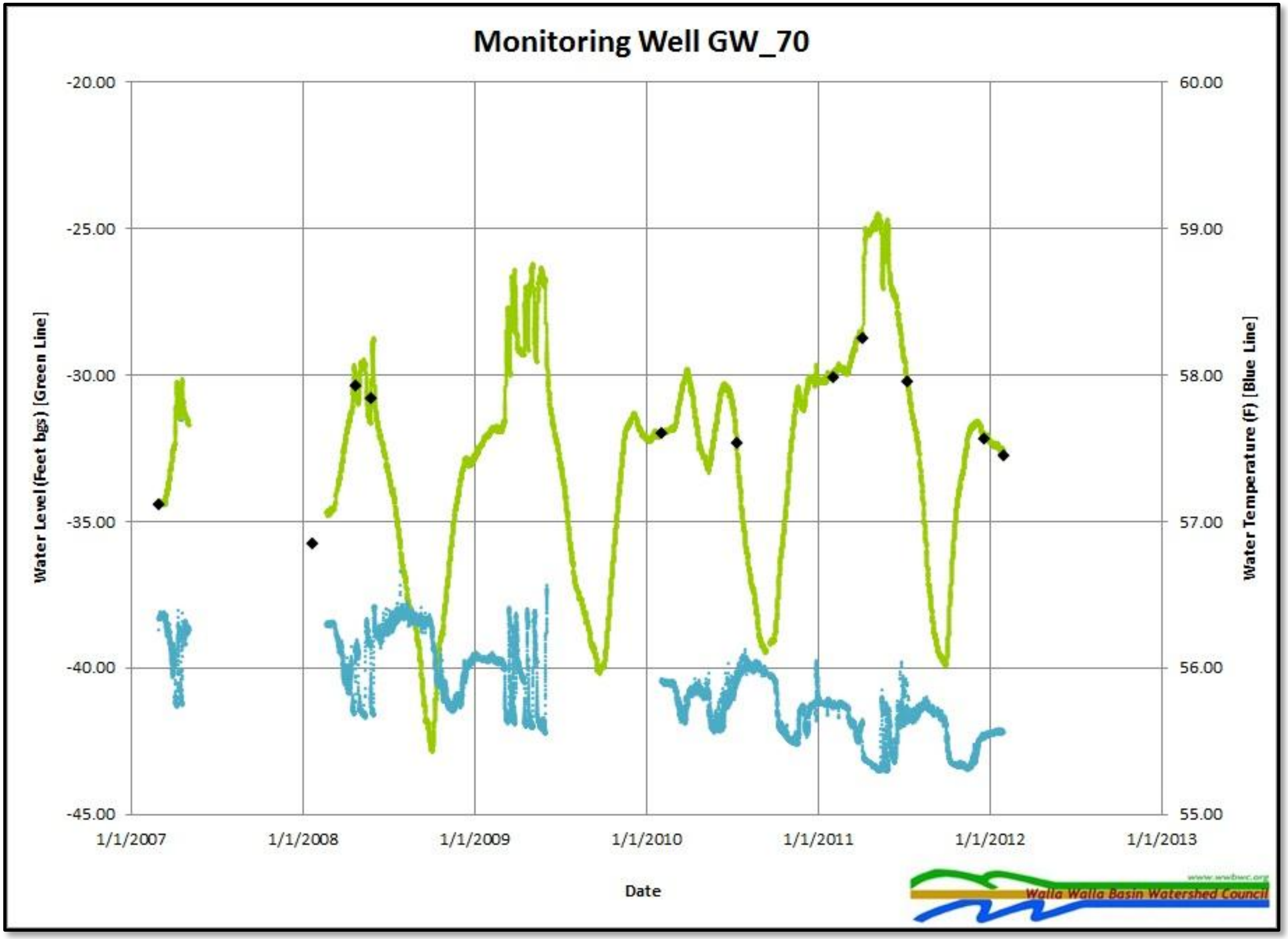


Figure 28 - Hydrograph for GW_70, a monitoring well at the Locher Road AR site.

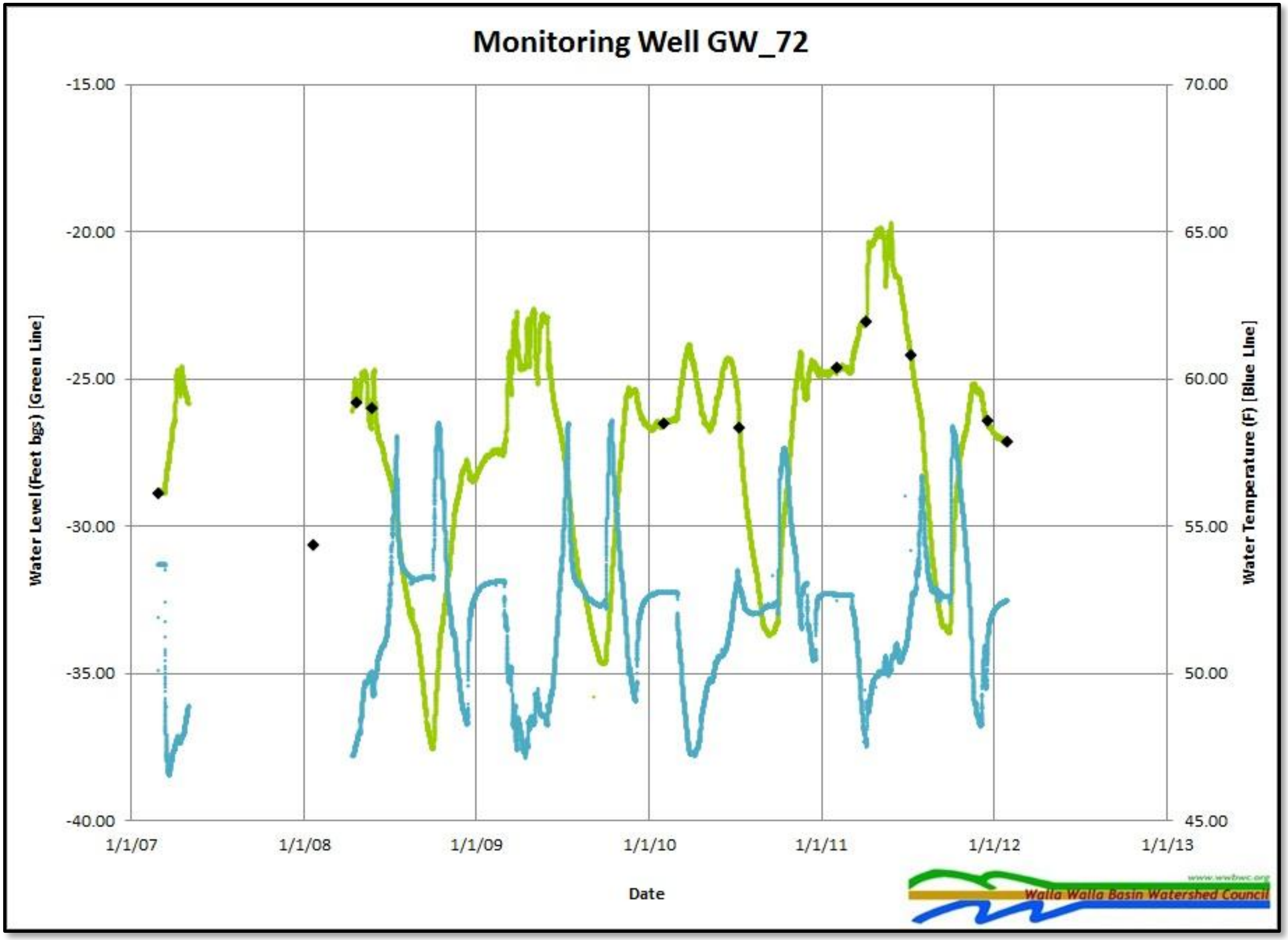


Figure 29 - Hydrograph for GW_72, a monitoring well at the Locher Road AR site.

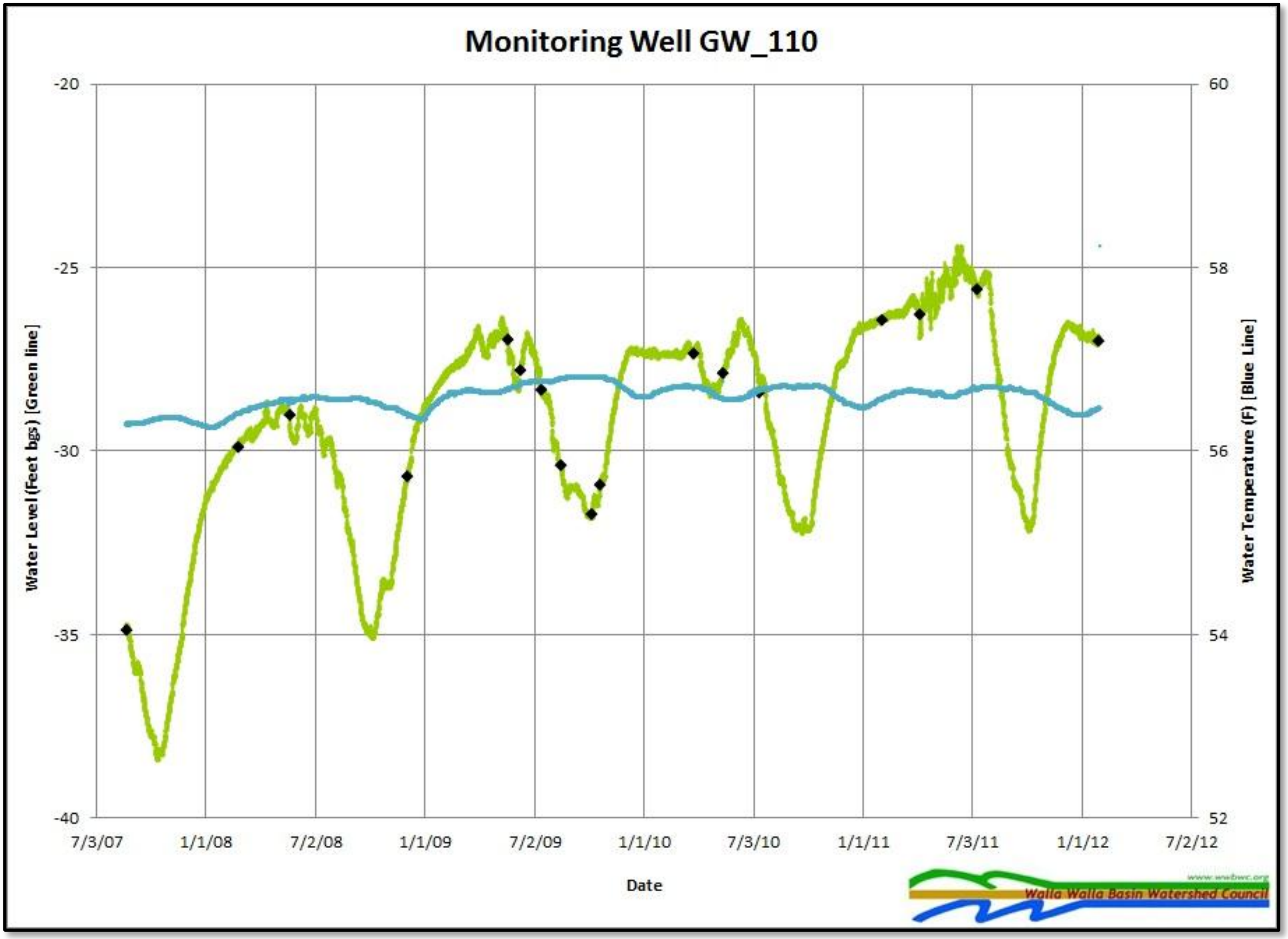


Figure 30 - Hydrograph for GW_110, a monitoring well down-gradient of the Locher Road AR site.

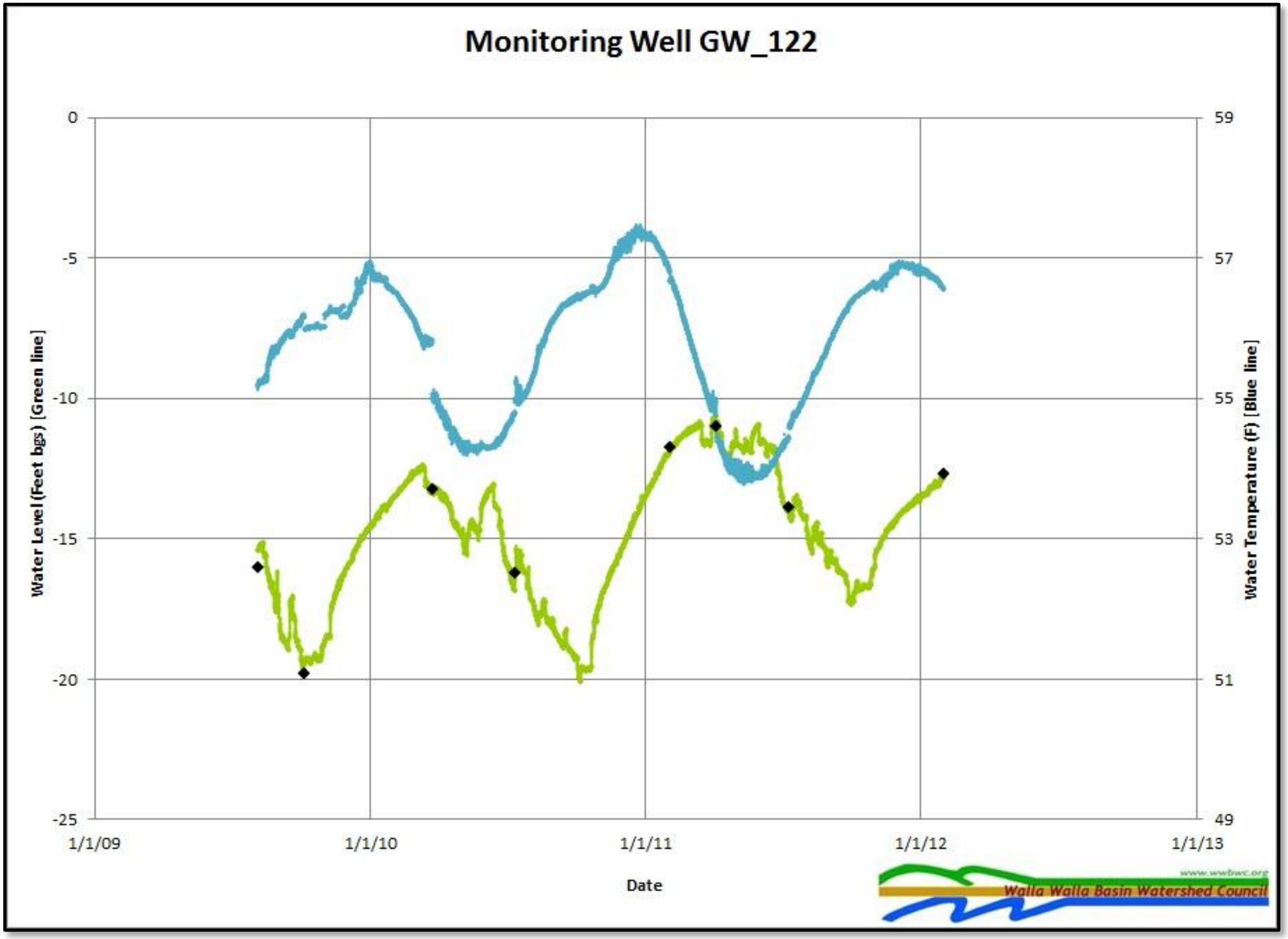


Figure 31 - Hydrograph for GW_122, a monitoring well down-gradient of the Locher Road AR site.

Hall-Wentland

The formerly operated Hall-Wentland Site (H-W Site – Figure 23) functioned through discharge of surface water to a pasture where it was allowed to infiltrate to the underlying alluvial aquifer. The only site improvement done for the project focused on the water delivery system (ditches) through which water reached the H-W Site. Ditches, trenches, and other structures that might have facilitated infiltration of water into the ground were not dug at the H-W Site in any of the four AR seasons.

During the four years of site operation, 2006 through 2009, water volumes delivered to it ranged from 16 acre-feet/year to 179 acre-feet/year (GSI, 2009a). Water level data recorded by pressure transducer-dataloggers in the three on-site monitoring wells indicate the alluvial aquifer system responded rapidly to the delivery of water to the H-W Site. The water level data collected for the project also showed that the alluvial aquifer in the vicinity of the H-W Site responded to factors other than those related to H-W Site AR operations. In some instances, off-season rises and falls in water level were at least as great, and as sustained, as those resulting from AR operations. Although these off-site influences on water level were not directly evaluated, likely phenomena influencing alluvial aquifer water level other than H-W AR include: (1) ditch operations, especially in unlined, leaky ditches, (2) well pumping, and (3) seasonal precipitation and run-off variation.

Source water and groundwater quality samples were collected and analyzed for field parameters, basic water quality constituents, and SOCs periodically before, during, and after each AR season. The data collected to date indicate that no discernible impact to local groundwater quality has occurred as a result of the H-W AR project. These data do however show that surface water and groundwater in the project area are very similar geochemically and that they display a high degree of hydraulic connection. Given that connection and the water quality data collected during operations, any impact on groundwater quality by surface water occurs regardless of the presence or absence of H-W AR operations (Kennedy/Jenks, 2006; GSI 2007b, 2008b & 2009b).

Stiller Pond

The most recent site added to the basin's AR efforts is the Stiller Pond site (Figure 23). In 2012 the WWBWC and the WWCCD partnered to develop the Stiller Pond AR site in Washington. This site is currently authorized under a Local Water Plan with the WWWMP to recharge up to 32 acre-feet of its existing water right via a dry pond located on the Schwenke property, within the lower Mill Creek drainage. Additional authorization for an Environmental Enhancement Project (EEP) currently is being reviewed by WDOE. If approved, this additional authorization would allow approximately 900 acre-feet of water to be diverted from Mill Creek to the Stiller Pond for AR.

Final build-out and operation of the site is awaiting issuance of the EEP. Like the Locher Road and the Hulette Johnson sites, this authorization will require minimum instream flow to be met at a Walla Walla River gauging station (Detour Road) and additional hydrologic monitoring and water quality analysis (GSI, 2012).

Lessons Learned and Observations

This section briefly explores additional observations drawn from the multiple AR projects that the WWBWC has conducted in the Walla Walla Basin. These include the influence of recharge sourced groundwater mounds, impacts on water migration, and groundwater quality impacts.

Groundwater Mounds

Data collected from these sites and evaluated by the WWBWC indicate that recharge creates local groundwater mounds. These mounds result in an environment where seepage loss of local surface water is minimized to varying degrees as the hydraulic gradient between surface water and groundwater decreases. By creating a groundwater mound, groundwater moving from up-gradient to down-gradient is forced to move in a different direction around the mound and slow down. The mound acts as a hydraulic dam. This deflection and rise, or build up, in the water table allows water to occupy a portion of the aquifer that did not have water in it prior to the project. This water mounding and forced lateral movement of groundwater up-gradient of the site is effectively a secondary benefit to the aquifer as a result of the project, with the primary benefit going to the aquifer and surface water bodies down-gradient of the AR site.

The groundwater mounds created by recharge operations are critical to slow the migration of recharge water that enters the valley up-gradient of them. Many future AR sites will be sited up-gradient of the H. Johnson and Locher Road projects. However, without the input of these AR sites (and potentially other future sites located off the alluvial fan) to supply recharge water to the central portion of the valley, much of the water supplied to the newer AR sites in the upper portion of the valley will rapidly move to the central valley and aquifer to fill the groundwater sink located where the alluvial aquifer is thickest. Allowing the groundwater sink to be supplied by the Hulette Johnson and Locher Road sites allows groundwater up-gradient of these sites to flow to another portion of the groundwater system and potentially activate shallow groundwater features such as springs or to supply baseflow to the River or minimize a known losing reach of the Walla Walla River.

Water Migration

It is critical to understand the potential difference between local groundwater flow direction versus local surface water flow direction. Understanding the potential benefit of current and future AR activities is dependent upon understanding where the recharge water migrates. Additionally, groundwater migration within the gravel aquifer is very dynamic. Tracer studies conducted in 2010 at the Hulette Johnson site (Jiménez, 2012) revealed varying groundwater velocities, with higher velocities being as much as 250 feet per day in the shallow unconsolidated gravels while velocities in the underlying partially cemented gravels were as low as approximately 10 feet per day or less.

Groundwater monitoring of the Hulette Johnson and Locher Road sites show recharged groundwater traveling to areas of the valley where the aquifer is the deepest. In the case of the Hulette Johnson site, AR water can be seen travelling north-northwest until it reaches the center of the valley. At this point, AR water appears to take a more westerly trend and travel down the valley, toward lower Gardena, versus continuing northwest toward the Walla Walla

River (Figure 32). Locher Road recharge water appears to travel down-gradient along the deepest/thickest portion of the alluvial gravel fill. This water appears to move due west, through the central portion of the valley, toward lower Gardena (Figure 32).

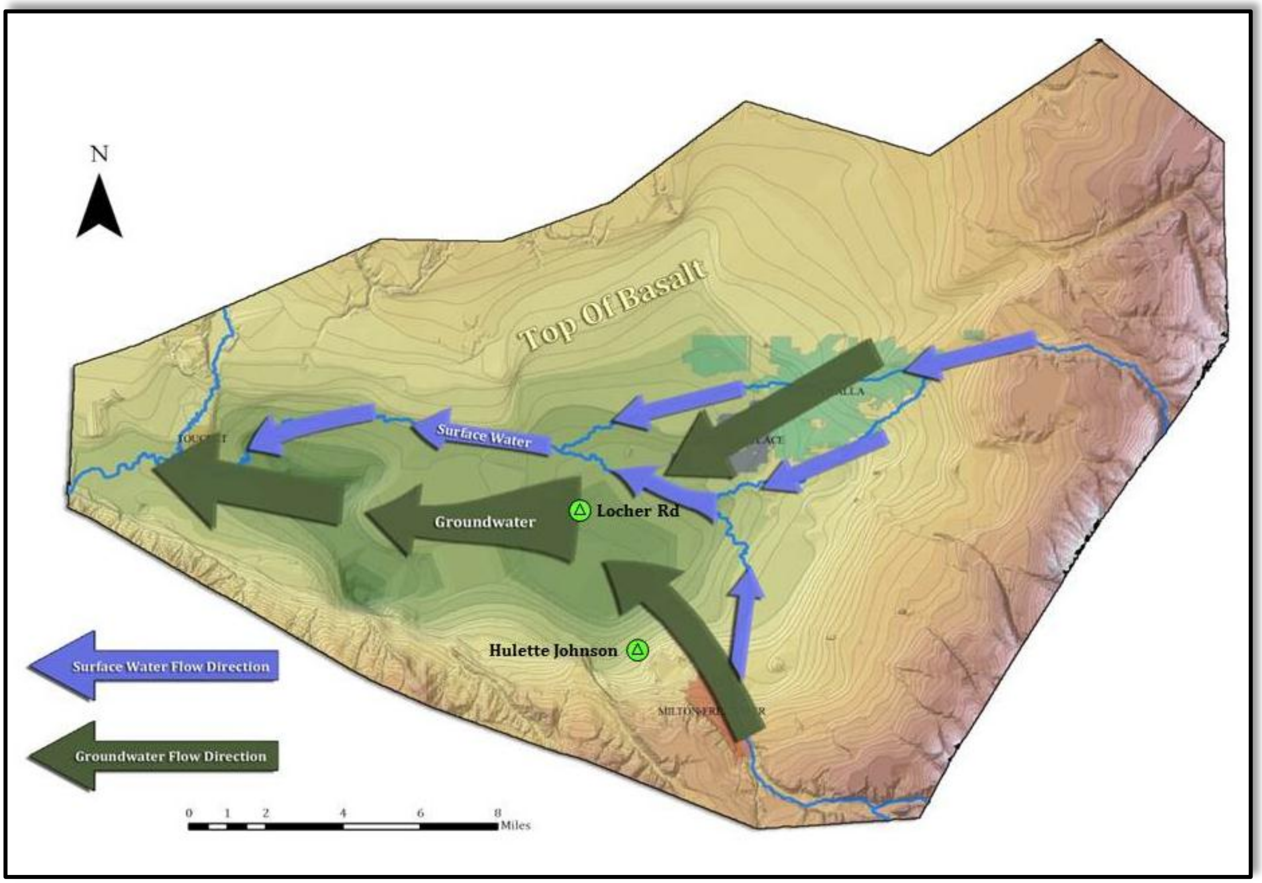


Figure 32 - Groundwater flow direction from the Hulette Johnson and Locher Road AR sites.

Water Quality Impacts

The Hulette Johnson AR site, Locher Road AR site, and the now inactive Hall-Wentland site have undergone extensive water quality monitoring during operation. This monitoring demonstrated that contaminants are not being introduced to the aquifer through AR operations and that groundwater degradation is not occurring as a result of these projects.

Recently the WWBWC and GSI reviewed the water quality data collected from each site. The report (GSI, 2012a) concludes that groundwater degradation has not occurred as a result of AR activity at these sites. In several cases parameters in the groundwater system improved as a result of AR activity. A summary of their draft findings is included in the following:

- *With respect to nutrient type constituents, including nitrate-N, TKN, phosphate, and ortho-phosphate the groundwater changes we see generally show down gradient declines in constituent concentrations, which we interpret to reflect dilution of groundwater concentrations by AR water.*
- *Other parameters, such as TDS, chloride, and EC also commonly show evidence of down gradient reductions through AR sites that we again interpret as evidence of dilution of these parameters in groundwater by AR water.*
- *The SOC data available for these sites is interpreted to show that AR operations have essentially no influence on SOCs present in groundwater. Based on what we reviewed SOC detections are sporadic, not systematic, and at very low concentrations. With that observation, we interpret the few detections to result from background conditions reflective of activities other than AR operations.*
- *In addition to these observations, the Hall-Wentland data is instructive as it shows the importance of natural leakage from surface waters (which typically are the same waters these AR sites use for source water) influencing local groundwater chemistry.*

The water quality data collected over several AR seasons from four different sites are interpreted to have not resulted in alluvial aquifer water quality degradation. Field parameters and major ion hydrochemical trends seen in monitoring well data commonly show reduced concentrations, indicating dilution of groundwater concentrations by AR operations. A few anomalies did occur in these trends, but low source water concentrations versus high monitoring well concentrations strongly suggest that AR operations were not the cause of these anomalies. There were no significant SOC detections from any site. Of the SOC detections seen in the data sets, SOC concentrations are low enough to be considered background levels and/or these detections were instances of localized transient introduction to the water table from an unaltered ground surface AR site (specifically HW). (GSI, 2012a)

Based on these findings revising groundwater monitoring requirements related to AR activities seems to be warranted.

Current water quality monitoring requirements (constituents and sample frequency) results in costs upwards of $20,000 per year for the Hulette Johnson and Locher Road AR sites. Given that funding for these projects is typically derived from capital (construction) programs and not on-going appropriations, these costs are not supportable in the long-term with available funding. Given the water quality findings to date, the WWBWC and its partners are exploring real-time programmatic monitoring efforts, focused primarily on remote sensors deployed in source water systems. These sensors will be selected to screen for parameters indicative of the types of contaminants that monitoring conducted to date suggests are most likely (although of low probability). Data collected by these sensors would be transmitted by radio to the WWBWC office where it would be reviewed by WWBWC and regulatory staff. In the event that a parameter exceeded its determined trigger value, recharge operations would be shut down until the source water returned to normal (below the trigger value). By shutting down an AR site, the contaminant of concern would never be introduced to the groundwater system by AR activity.

IWFM Modeling

Beginning in 2007, Oregon State University (OSU) partnered with the WWBWC to develop a hydrologic model for the Walla Walla Valley. The Integrated Water Flow Model (IWFM) model developed by California Water Resources to evaluate surface water and groundwater hydrology and interaction was selected for this effort. The IWFM possesses the benefit of analyzing thousands of points of hydrologic data, applying changes to water management practices within the model, and analyzing the output of these changes years into the future. Oregon State University utilized WWBWC and agency monitoring data to build the IWFM model for a portion of the Walla Walla alluvial aquifer (Figure 33).

Model calibration was based upon groundwater and surface water data collected during the 2007 through 2009 water years (Jiménez, 2012). The model was refined through validation with 2010 water year data (Scherberg, 2012). Based upon preliminary model output, storage volume of the alluvial aquifer is estimated to be declining by approximately 5,000 acre-feet per year. This volume represents the average yearly rate at which the alluvial aquifer is declining. This loss of groundwater storage results from increased well pumping and decreased seepage from surface water bodies. This is in turn manifested by diminished or lost spring performance, reduced groundwater input to surface water, and diminished well capacity, to name a few.

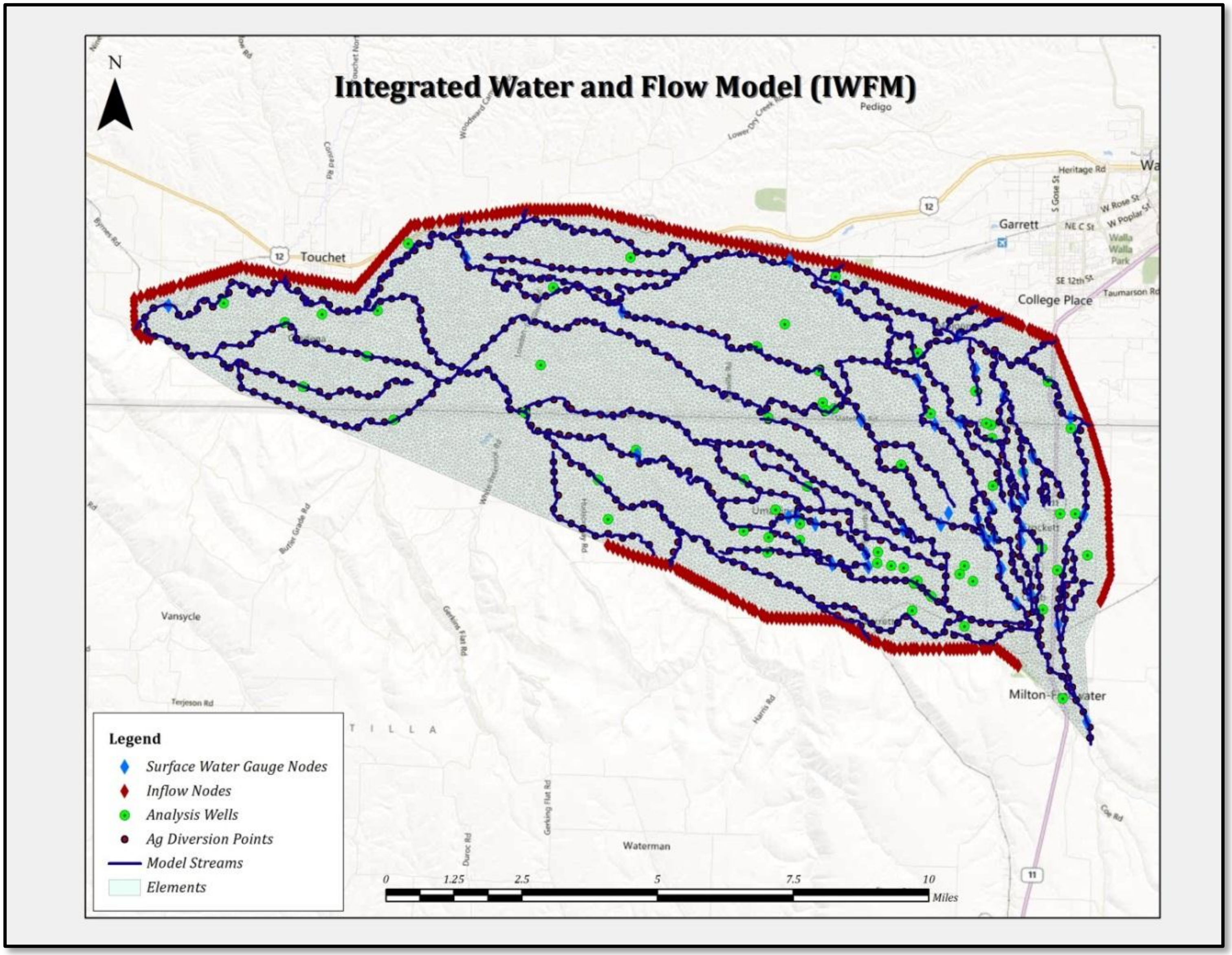


Figure 33 - Map showing the boundaries, stream segments, groundwater wells and surface gauges incorporated into the Walla Walla Valley IWFM model.

By understanding the aquifer's average annual loss in storage to be 5,000 acre-feet per year, the overall mitigation need becomes more defined. To reverse the average annual loss of storage in the alluvial aquifer, more than 5,000 acre-feet of additional water would need to be recharged to, and remain in, the aquifer annually. Alternatively, groundwater pumping would need to be reduced by over 5,000 acre-feet per year. A combination of increased recharge and reduced groundwater pumping could also be used. The model offers the ability to evaluate these types of scenarios and assess potential mitigation impacts from various recharge and pumping project options.

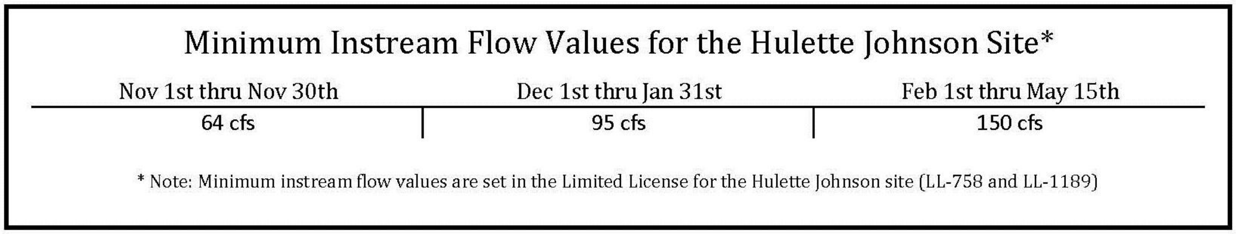
To that end, the model is currently being developed to analyze other changes in water management practices to the hydrologic system. These management changes to be modeled include the anticipated installation of additional AR sites and augmented distributary flow during the winter and spring. Alternatively, if the fishery needs of the CTUIR and Federal agencies suggest increased flow is potentially beneficial to the River, the model could evaluate the impacts of increasing bypass flows. Changes from open canal irrigation to closed pipe irrigation systems also are being modeled. The model will serve as a tool to simulate future hydrologic impacts of current and anticipated water management changes. Such a tool can assist water resource managers in setting realistic goals of improvement and defining mitigation plans.

Water Availability

Current Water Availability

Water availability for AR remains one of the most difficult components to determine. Current methods utilized by both Oregon (Hulette Johnson) and Washington (Locher Road) rely on minimum instream values at specific gauging stations. The Oregon Limited License for the Hulette Johnson site (LL1189) currently states up to 50 cfs can be diverted for AR from the Walla Walla River at the Little Walla Walla Diversion between November 1st and May 15th, given minimum flows in the Walla Walla River are present. These minimum instream values (Table 3) are measured at a gauging station located below Nursery Bridge in Milton-Freewater and maintained by HBDIC and the WWBWC.

Table 3 - Minimum instream flow values, measured below Nursery Bridge that must be met before water can be diverted for the Hulette Johnson aquifer recharge site.



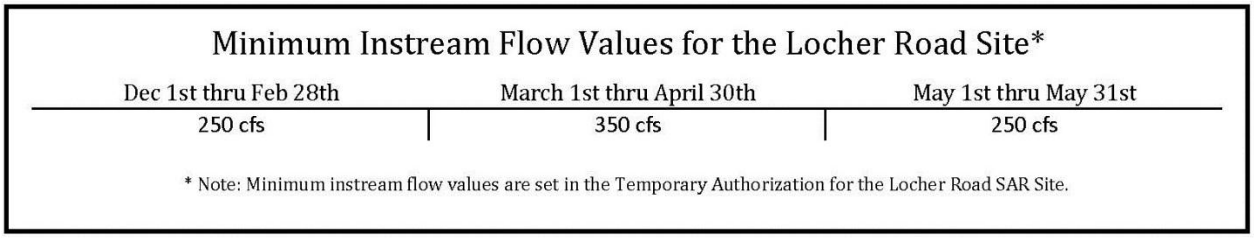
Minimum Instream Flow Values for the Hulette Johnson Site*

Nov 1st thru Nov 30th	Dec 1st thru Jan 31st	Feb 1st thru May 15th
64 cfs	95 cfs	150 cfs

* Note: Minimum instream flow values are set in the Limited License for the Hulette Johnson site (LL-758 and LL-1189)

In a similar manner, the Locher Road site is permitted to divert up to 20 cfs for AR, from the Burlingame Diversion, between December 1st and May 31st, given a different set of minimum flows in the Walla Walla River are present (Table 4). These minimum instream values are measured at a gauging station located at Detour Road and maintained by the WDOE.

Table 4 - Minimum instream flow values, measured at WDOE's gauge at Detour Road, that must be met before water can be diverted for the Locher Road aquifer recharge site.



Minimum Instream Flow Values for the Locher Road Site*

Dec 1st thru Feb 28th	March 1st thru April 30th	May 1st thru May 31st
250 cfs	350 cfs	250 cfs

* Note: Minimum instream flow values are set in the Temporary Authorization for the Locher Road SAR Site.

Current Flows

Based upon the current minimum instream flow values being utilized for the Hulette Johnson site and the Locher Road site, the amount of water available for additional projects can be discerned by plotting the average diversion flow values (irrigation, recharge and other uses) against average Walla Walla River flow at the respective gauging stations. Figures 34 and 35 show the average flows recorded since 2000 for the upper Walla Walla River, near Milton-Freewater (Oregon), and since 2007 for Detour Road (Washington) respectively. Analysis of the average flow over the past 12 years at Milton-Freewater and 6 years at Detour Road reveals how much additional water may be available for AR. Based upon the minimum flow required for the period of November 1st through May 15th in Oregon (upper Walla Walla River flow) and December 1st through May 31st in Washington (Detour Road), approximately **80 cfs** could be made available for AR in Milton-Freewater Oregon (Figure 34) and approximately **20 cfs** could be made available for AR in Washington (Figure 35). Currently, the Hulette Johnson site utilizes approximately 20 cfs for AR and the Locher Road site utilizes approximately 4 cfs.

10% of 2-Year High Flow

Additional policy toward the development of water availability in the winter and spring is currently being considered under Oregon regulation. *White Paper: Peak and Ecological Flow; a Scientific Framework for Implementing Oregon HB 3369* sites a basic methodology currently being use in California to set limits on surface water withdrawal during the winter and spring to preserve ecological flow (Norris, 2010). The report outlines a basic threshold of 10% of an average 2-year high flow event as the maximum diversion rate from a surface water body during the winter and spring. The US Army Corp of Engineers (COE) in previous studies have calculated the 2-year high flow event to be approximately 1,200 cfs near the town of Milton-Freewater (USACOE, 1969). Limiting winter-spring diversion to 10% of the 2-year high flow event would result in a maximum available diversion of 120 cfs during the winter and spring. This policy is continuing to be developed in Oregon.

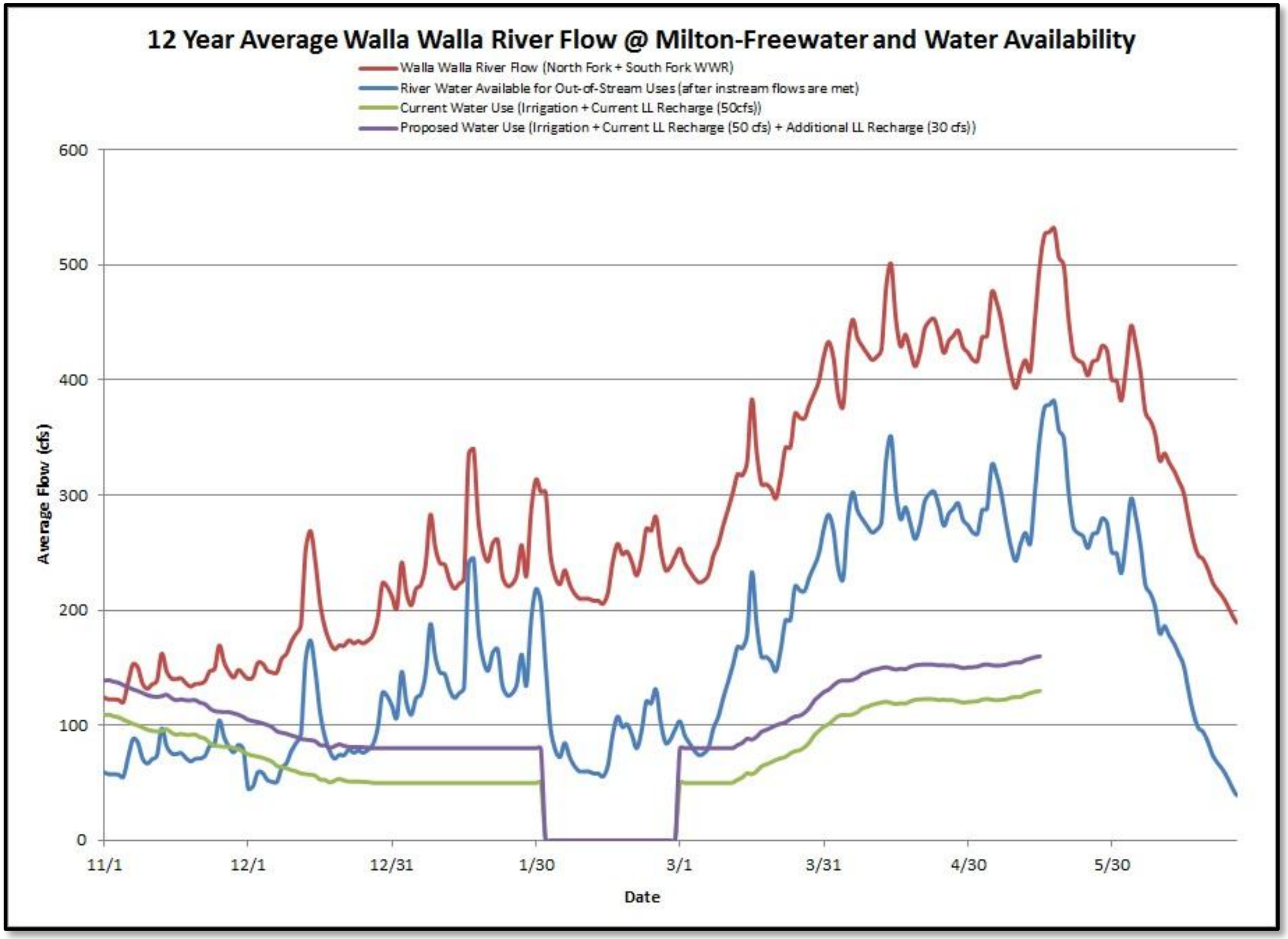


Figure 34 - Water availability analysis for the Walla Walla River at Milton-Freewater, OR (Note – Couse Creek flows have not been included in this analysis. Couse Creek typically is flowing during most, if not all, of the recharge season). Red line indicates Walla Walla River 12 year average discharge at Milton-Freewater, OR. Blue line indicates the amount of water, after instream minimum flows have been satisfied, that can be used for out of stream uses (irrigation, AR, etc.). Green line indicates current diversion flow value (irrigation and maximum AR water currently allowed under LL1189). Purple line indicates proposed increase in AR water use (existing 50 cfs + additional 30 cfs for a total of 80 cfs for AR). Anytime the green or purple lines are below the blue line there is enough water in the river to satisfy instream minimum flows, irrigation water use and AR water.

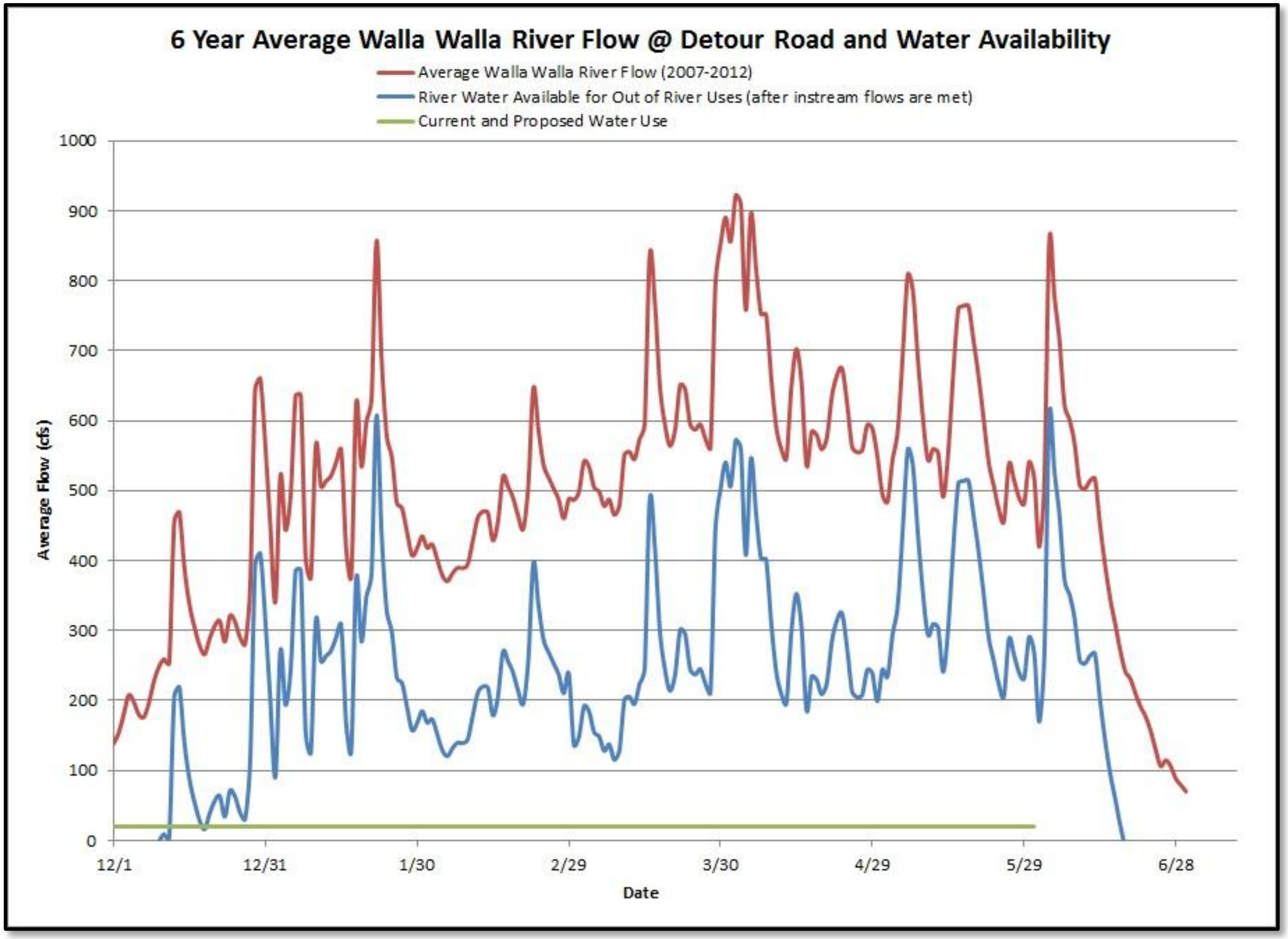


Figure 35 - Water availability analysis for the Walla Walla River at Detour Road, WA. Red line indicates Walla Walla River 6 year average discharge at Detour Road, WA. Blue line indicates the amount of water, after instream minimum flows have been satisfied, that can be used for out-of-stream uses (irrigation, AR, etc.). Green line indicates proposed AR water use (20 cfs for AR). Anytime the green line is below the blue line there is enough water in the river to satisfy instream minimum flows and AR water.

Walla Walla River is a Distributary River

Generalized criteria and methodologies that treat each watershed relatively alike have created extensive discussion. The Walla Walla River system is relatively unique when contrasted with other river systems in the Pacific Northwest. The Walla Walla River is primarily a distributary river system that once, very naturally, diverted winter and spring water into alternative channels. Estimating 30% of the mainstem River flow was naturally diverted to distributary channels during the winter and spring would not be unreasonable. Ecological flow protection during the winter and spring ensures the continuation of channel forming events and annual flow cycles needed for aquatic health. However, in the Walla Walla River, channelization with levees and flow control devices at the head of distributaries have, by and large, left too much water instream during the winter and spring. Since the construction of the Milton-Freewater municipal levee in the late 1940s, significant down-cutting of the riverbed has occurred. Regions within the levee have incurred over 15 feet of loss of riverbed or down-cutting. Water (flow) energy present within the levee section exceeds the energies the River was originally flowing over and being built upon. These higher energies result in riverbed movement, displacement and removal and are a result of channelizing the River and management practices that prevent water from accessing distributaries. This not only degrades fish habitat and impacts fish passage, it also lowers the local water table, impacting summer base flows.

The degradation of the Walla Walla River through this practice, over decades, can only be mitigated through practices that simulate this river system's natural processes, such as distributary function/flow. These processes can be mimicked through the use of AR, reactivating the distributary river system, levee setbacks and other projects. The WWBWC and its basin partners are proposing to develop 100 cfs of AR projects (80 cfs in Oregon and 20 cfs in Washington) while meeting current instream flow minimums (Tables 3 and 4) for AR and additionally remain under the 120 cfs maximum outlined in the draft criteria being reviewed in Oregon. Considering the Walla Walla River system is a distributary river system, allowing the development of AR and enhanced distributary function is consistent with the needs of the overall hydrologic and ecological systems. Allowing all water to stay in the mainstem will only lead to further riverbed degradation and declines in water levels in the underlying alluvial aquifer and related negative impacts on surface water health. The Walla Walla River is a diffuse river system. It is because of this difference from many other rivers, where single channel systems are more typical, that unique consideration toward the Walla Walla River's winter and spring hydrology is warranted.

Making Water Available

Winter and spring peak flow in the Walla Walla River commonly exceeds 1000 cfs. The basic aim of AR is to maximize the distribution of water during these periods of extended high flow. When practiced, the process and distribution of water during these times mimics the natural distributary function of the hydrologic system. The aquifer is dependent on winter and spring recharge, in the form of surface water seepage and to a lesser degree on direct precipitation, to recover from seasonal depletion during the summer and fall. Without the distribution of water during the high flow period, aquifer replenishment during the winter and spring is limited to the mainstem channel and seepage loss in any irrigation canal operating at that time. Given the spatial nature of the valley with its underlying gravel aquifer, relying upon the channelized mainstem river to be the primary recharge source will not be adequate. Water left in the channelized mainstem will travel rapidly out of the valley and only provides recharge to a limited portion of the alluvial aquifer. Some regions close to the River recover significantly, while others regions away from the river are slow to experience significant seasonal recovery.

In addition to the normal recharge sites supplied by the 80/20 cfs distribution, an additional category of projects could be designed to access the highest flows seen in the River (>800 to 1,000 cfs). These projects would only operate during the highest periods by moving large quantities of water to larger surface retention features where infiltration can occur over the following days and weeks once river flow has subsided.

In addition, future recharge projects could be supplied using water conserved from irrigation efficiency (piping) projects. Considering that piping of irrigation canals around the valley limits the overall recharge component to the hydrologic system, utilizing or re-allocating some of the conserved water to AR when water is available would be a mechanism to create additional water availability for AR.

Oregon Regulations

Since it was formally initiated in 2004 in the Walla Walla Valley, AR has been developed under several regulatory mechanisms. In Oregon, AR has always been developed under a Limited License Application. HBDIC has held two limited licenses (LL758 and LL1189) since 2004 and has applied for a new license to include several of the sites discussed earlier (Hulette Johnson, Barrett, Anspach, Trumbull, NW Umapine, Dugger Creek and ODOT – Figure 23). In addition to HBDIC, the WWRID is a second irrigation district within Oregon and serves patrons on much of the Walla Walla River alluvial fan in and around the City of Milton-Freewater. In many ways the Ford and Crockett irrigation systems within the WWRID represent the upper West Little Walla Walla River (WLWWR) and East Little Walla Walla River (ELWWR). Additionally, the WWRID serves the eastside sub-basin, on the east side of the mainstem River. The WWRID is interested in developing additional AR sites within its service area. Unlike HBDIC however, which hold an additional temporary water right (Limited License) for AR, the WWRID is seeking to allow AR within its district through the classification of AR as a beneficial use under Oregon regulation. Organizational structure of the WWRID does not allow for conveyance of water within its district, unless it is going toward beneficial use (irrigation, stockwater, or crop temperature control) under Oregon regulation. In the past, the Regional Advisory Committee (RAC) has met to discuss similar issues. Similar to Washington’s Local Water Plan process, where additional applications of an existing water right can be considered, the RAC could potentially consider allowing a portion of the WWRID patrons’ water rights to be utilized for AR, with similar instream flow minimum requirements. This would accelerate the development of AR within critical areas of the upper portion of the valley. The development of AR within the eastside sub-basin and within the upper LWWR network is critical to minimizing seepage loss within the Tum-a-lum reach of the mainstem River and in the upper/middle reach, where the mainstem River and distributaries come together.

Washington Regulations

In Washington, similar to a limited license, a temporary use authorization or temporary water right can be issued for an Environmental Enhancement Project (EEP). AR authorized under this regulation is primarily developed through WDOE, but requires approval by the local, Washington based, WWWMP. Water rights issued under this regulation represent a new temporary water right for AR only. Similar to a limited license, these rights are seasonal (winter and spring) and require instream flow minimums to be met while operating. In addition to the EEP, a Local Water Plan (LWP) can be developed through the WWWMP. LWPs allow for additional uses or increased flexibility for existing water rights if an overall benefit is apparent. The Stiller Pond AR site was developed under a LWP utilizing an existing water right. In addition to the EEP for the Locher Road site, GFID is authorized to divert 5 cfs of its existing water right for AR, with seasonal and flow restrictions, under its LWP.

When considering the overall need for AR necessary to achieve aquifer restoration, the EEP/LL process (creating new temporary water rights) and the LWP/meeting of the RAC process (utilizing existing water rights) are both needed. The EEP/LL process allows for larger scale effort to be made for AR, while the LWP/RAC process can facilitate AR to take place at a smaller scale with existing water rights. In many ways utilizing the LWP/RAC process results in additional emphasis on local decision making and can be less administratively intensive to local and state regulators.

New Projects and Long-Term Benefits

Given the in the alluvial aquifer, reduced spring flow, and high seepage loss of the surface water hydrology, it has become apparent that a sustainable solution is necessary to meet the needs of the irrigation community as well as the ecological needs for a successful recovery of ESA-listed Steelhead, Bull Trout, and reintroduced Spring Chinook Salmon. Augmenting groundwater levels through aquifer recharge with abundant winter and spring surface water flow is a critical component to the overall success and sustainability of the valley’s ecological, agricultural, and economic needs.

Proposed Projects

The WWBWC is working with basin partners and irrigation districts to develop sites that mitigate for areas of known groundwater decline and reduced hydrologic functionality. Figure 17 highlights areas of the valley where this degradation is apparent. In Oregon, hydrologic declines are noted in the entire Walla Walla alluvial fan, with the exception of the western portion where the Hulette Johnson site is active. In Washington, declining groundwater levels are being seen in the west-central valley from the Lowden area to the mouth of the Touchet River.

New AR projects

Currently, the WWBWC and basin partners are building on what has been learned through pilot AR projects and basin groundwater and surface water monitoring. Several new sites are currently being developed in Oregon and Washington. Figure 23 illustrates the location of the current and future sites the WWBWC intends to develop in the near term. These sites incorporate a combination of water management methods to accomplish and enhance seasonal AR in the valley. Compared to the Hulette Johnson site, these sites are generally smaller in scale and will receive smaller volumes of water.

The WWBWC is seeking to develop over 60 cfs for AR at locations in Oregon over the next two to three years. The WWBWC is developing and constructing AR projects at the Anspach and Trumbull Lane sites (Figure 23). These new projects constitute a potential addition of ~4 cfs of AR on the Walla Walla alluvial fan, near Milton-Freewater. Additionally, these two sites have the potential to mitigate groundwater declines in the ‘Section 34’ area of the orchard district in Oregon (Figure 17). This sub-region of the alluvial fan has experienced significant groundwater declines for decades (Figure 14 & 36). In recent years this has led to the drilling and use of basalt groundwater resources as an alternative to the declining alluvial aquifer. Use of the basalt aquifer is typically more expensive, as it requires more power to pump water from a greater depth.

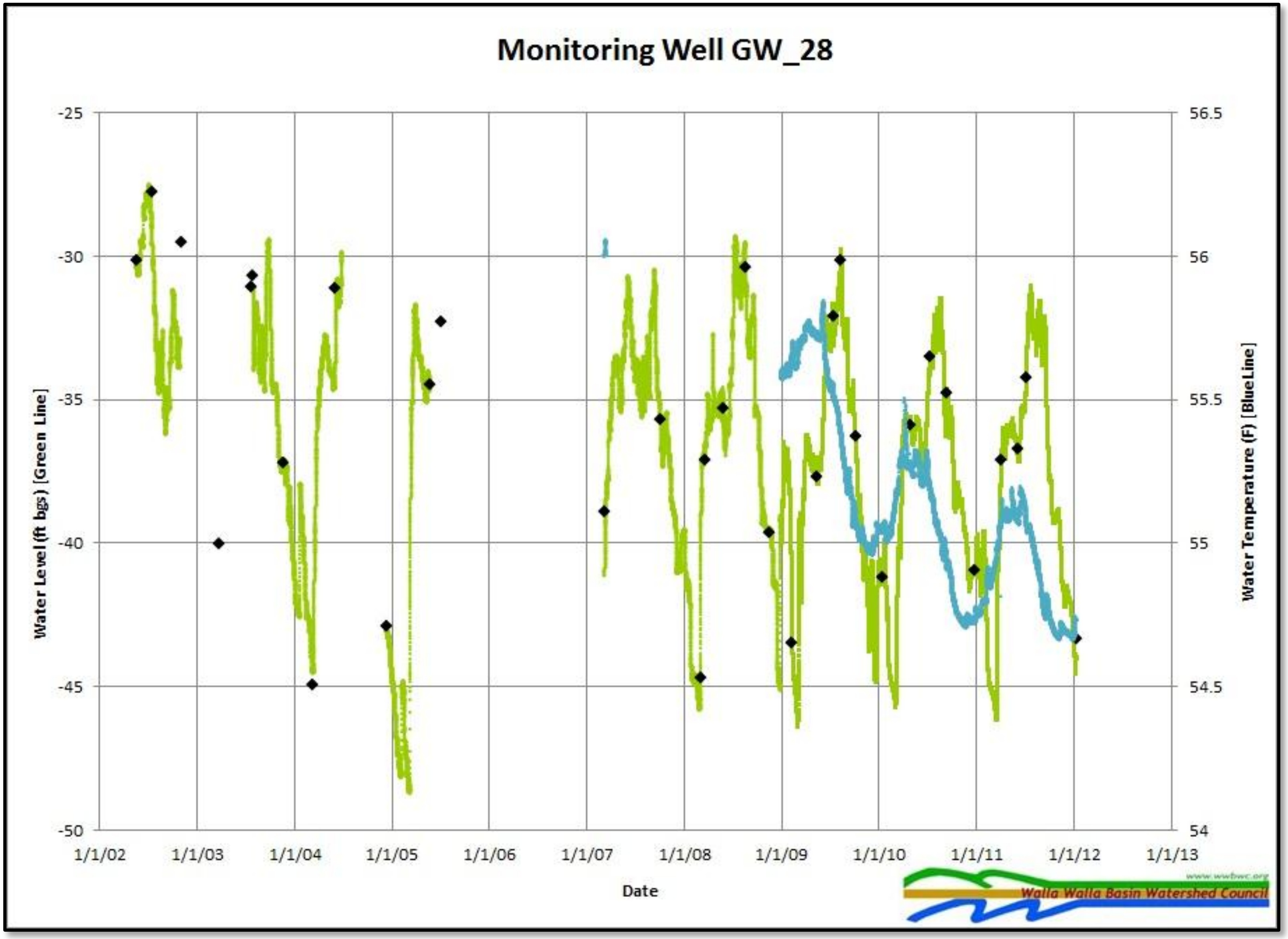
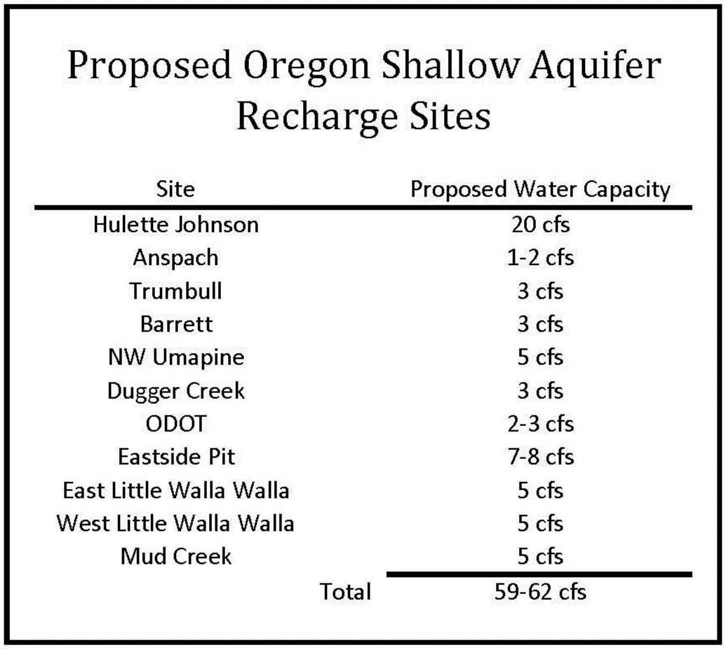


Figure 36 - Hydrograph for GW_28. This hydrograph shows the declines in the alluvial aquifer in the area around Section 34 in Oregon

In addition to the Anspach and Trumbull Lane sites, the WWBWC is working with landowners near the town of Umapine, along upper Dugger Creek, along the Little Walla Walla River spring branch system, and within the eastside sub-basin. Figure 23 illustrates the location of these sites. A summary of water allocation for proposed Oregon AR sites is presented in the following table:

Table 5 - Proposed near-term Oregon aquifer recharge sites.



Proposed Oregon Shallow Aquifer Recharge Sites

Site	Proposed Water Capacity
Hulette Johnson	20 cfs
Anspach	1-2 cfs
Trumbull	3 cfs
Barrett	3 cfs
NW Umapine	5 cfs
Dugger Creek	3 cfs
ODOT	2-3 cfs
Eastside Pit	7-8 cfs
East Little Walla Walla	5 cfs
West Little Walla Walla	5 cfs
Mud Creek	5 cfs
Total	59-62 cfs

Of the approximate 62 cfs of AR capacity at these sites, ~53 cfs would be diverted to sites on the alluvial fan and approximately 8 cfs of recharge would take place down-gradient of the alluvial fan and the spring branch system. Having the majority of sites on the coarsest alluvial sediments maximizes the potential to mimic the natural distributary (flood plain) process and restore a more natural hydrologic condition. Much like the Hulette Johnson site, these sites will potentially reactivate small streams and spring creeks but also contribute to aquifer storage. The NW Umapine site and the Dugger Creek site are down-gradient of the alluvial fan and will serve to accelerate aquifer storage in the central portion of the aquifer and bolster small surface water bodies such as Dugger Creek and Swartz Creek and mitigate for groundwater declines in the vicinity of the town of Umapine. This configuration of sites constitutes a balanced approach to restoring healthy aquifer conditions over the long-term (over several years or more) while activating dormant ecological pathways in the form of springs, spring creeks, and distributary channels in the short-term (within weeks/months).

A region of focus for recharge on the alluvial fan system is the eastside sub-basin. AR for this portion of the aquifer can only come from the River itself (through seepage), through deep percolation of precipitation and excess irrigation water, or through a managed AR program. Long-term trends in the groundwater data suggest the first two options are not adequate (Figure 14). Recovery of the aquifer in the eastside sub-basin is dependent upon the establishment of AR projects in the area. Until this can be accomplished significant seepage loss in the Tum-a-lum reach can be expected to continue.

Additional benefit to the Tum-a-lum reach will be realized through the development of AR projects on the alluvial fan itself (west of the River) in and around the city of Milton-Freewater and surrounding orchards. Recovering this area will increase spring flow to the down-gradient springs and spring creeks as well as prevent recharge water near the River from migrating toward the west.

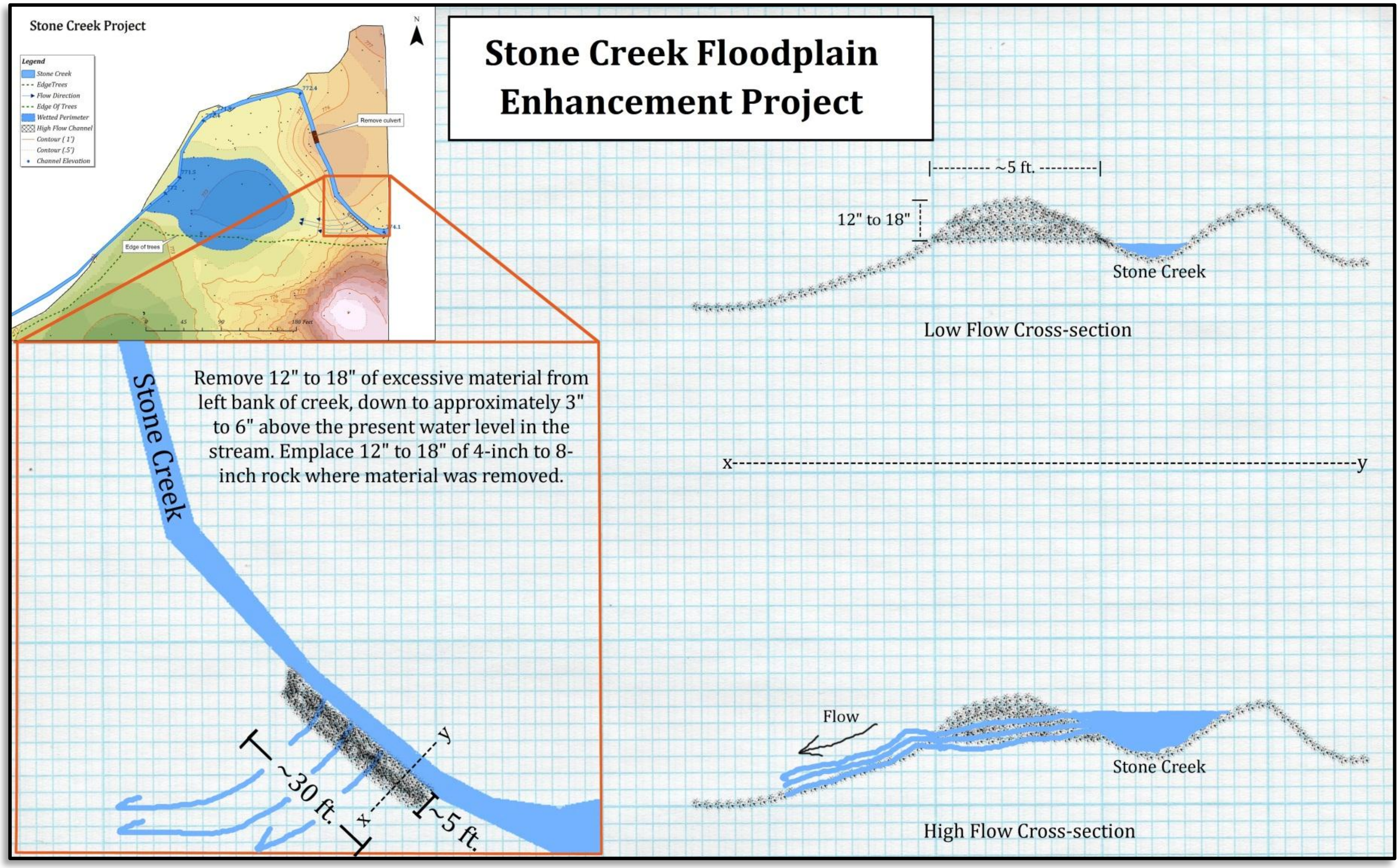
Groundwater declines in the Umapine area (Figure 17) have not been influenced by the Hulette Johnson AR site, as the recharge water appears to travel east of town and north of town. As mentioned previously, preferential flow is likely controlling the direction of flow for recharge water in the area. Recovery of groundwater levels in the area south and west of Umapine is dependent upon water coming from the Dry Creek and Dugger Creek drainage areas.

In Washington, the WWBWC is working with the WWCCD and basin partners to develop up to 20 cfs of AR projects. Currently the Locher Road site can accept approximately 3.5 to 4 cfs for AR. Future improvements may allow this site to accept up to 5 cfs. The Stiller Pond site can accept approximately 2 cfs for AR (this could be increased to 4 cfs with an EEP). The WWBWC and basin partners plan to develop up to 5 cfs of AR projects within the middle reach of the River, near the town of Lowden. This area exhibits an immediate need for AR projects to minimize or reverse seepage loss in this reach (Figure 20). Recent piping of an open ditch irrigation system and the potential for future piping projects further necessitates AR in this area. The WWBWC is working to develop up to 5 cfs of AR projects along the Touchet East/West irrigation system to mitigate for aquifer declines in the lower Touchet River region (Figure 17). Historical groundwater data beyond several years is not available for these areas. Similar to the Eastside sub-basin, piping of an open canal system has recently occurred in this area. Without the reconciliation of recharge lost to piping, aquifer declines should be expected. The WWBWC is working with the WWCCD and other basin partners to implement aquifer recharge in these areas where piping has occurred.

The WWBWC is discussing possible options with the WWCCD, GFID, and area landowners to develop AR projects prior to the piping of the upper Burlingame Canal. The WWBWC is currently working with two landowners on the lower West Little Walla Walla River system (Figure 23) to establish two AR sites that will also restore additional wetland habitat to the lower WLWWR. The Reser and Knowles locations can utilize winter/spring recharge water from the WLWWR, with flow augmentation from the mainstem River in Oregon or through diversion from the GFID Burlingame Canal.

A past attempt to create an AR project on the Mill Creek alluvial fan proved problematic, with water from a pilot project emerging on a commercial property. Further, overfilling Bennington Lake causes water to emerge at or near the surface in close proximity to residential areas. For this basic reason, AR augmentation within the Mill Creek alluvial fan should mainly be left for projects similar to the WWBWC Stone Creek project. This project is small in scale (approximately 10 to 20 gallons per minute (gpm) diverted) but does not require a water right, EEP, or local water plan to develop. It seeks to enhance flood plain function by allowing high water to access the streams floodplain through a roughened channel (Figure 37). This site is passive, does not require ongoing maintenance and only diverts water to the adjoining wetland when water in Stone Creek is abundant. Natural topography at the site allows water to form a shallow pool off-channel and return water to the stream once the pool reaches capacity. Through the augmentation of distributary channels in Washington such as Yellowhawk Creek and Garrison Creek and the installation of projects similar to the Stone Creek project along these distributaries and spring creeks, passive AR can be accomplished on the Mill Creek alluvial fan.

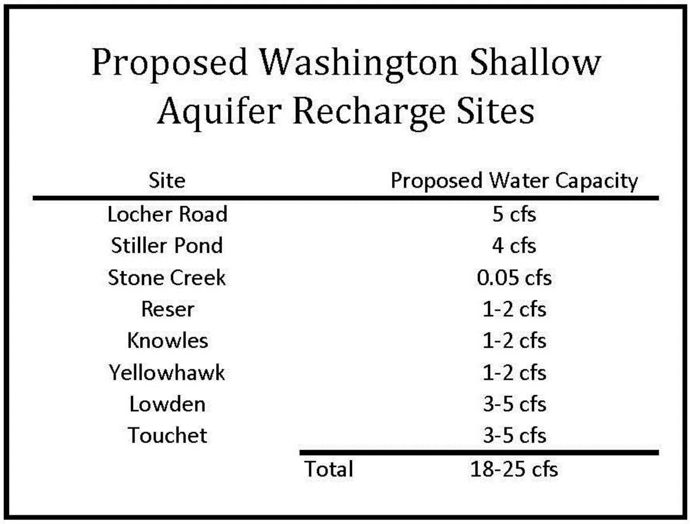
In Washington, the existing and proposed sites result in nearly 20 cfs of AR water. In addition to these sites, focus is being placed upon restoring the aquifer in the Washington portion of the Little Walla Walla River system. GFID continues to seek funding to continue the piping of its irrigation system. Recent studies by the WWBWC indicate that, during the spring/summer irrigation season, approximately 10 - 12 cfs can be lost through ditch seepage in the upper Gardena Farms Canal, which represents more than 2,000 acre-feet of recharge to the alluvial aquifer (WWBWC, 2012a). Without the installation of AR projects in conjunction with the continued piping, groundwater declines will continue and likely worsen.



Remove 12" to 18" of excessive material from left bank of creek, down to approximately 3" to 6" above the present water level in the stream. Emplace 12" to 18" of 4-inch to 8-inch rock where material was removed.

Figure 37 - Illustration showing the design for the Stone Creek Floodplain Enhancement Project.

Table 6 - Proposed near-term Washington aquifer recharge sites.



Proposed Washington Shallow Aquifer Recharge Sites

Site	Proposed Water Capacity
Locher Road	5 cfs
Stiller Pond	4 cfs
Stone Creek	0.05 cfs
Reser	1-2 cfs
Knowles	1-2 cfs
Yellowhawk	1-2 cfs
Lowden	3-5 cfs
Touchet	3-5 cfs
Total	18-25 cfs

Distributary Function

Figure 10 highlights the location of the valley's distributary channels. Part of the solution to utilize AR as a water management tool will look to distributary function as a method to mimic a natural process and enhance seepage to the underlying aquifer during the winter and spring. Allocating additional water to distributary channels during the high flow season will account for hundreds if not a thousand acre-feet of AR. Figure 38 illustrates the historical gauge data (October through April) from the Little Walla Walla Diversion since the 1930s. Since the 1950s water has slowly been allocated back to the mainstem river during the winter and spring. During recent decades, water volumes being diverted down the Little Walla Walla River system have been reduced by approximately 20,000 acre-feet during the winter and spring months. Assuming 25% of this water would have been lost to seepage, a value measured in several canal systems in the valley, it is reasonable to assume up to 5,000 acre-feet of annual recharge is lost by this change in water management (Corps of Engineers, Walla Walla River Basin Feasibility Study Project Review Plan).

The past presence of a variety of aquatic and non-aquatic animals is well documented by the residents of the lower Little Walla Walla River system and its spring branches (Lewis, 2012). Reactivating the Little Walla Walla River system through the diversion of water from the mainstem Walla Walla River during the winter and spring timeframe will boost spring flow and ultimately baseflow to the River during the summer. Additionally, with the reactivation of the LWWR system during the winter and spring, these smaller water bodies will provide valuable off-channel habitat for fish during strong freshet events.

Dual Purpose Sites

In recent years, during periods of low spring flow and reduced snowpack, the need for a low flow response plan has become apparent. There have been times during the past 10 years where flows in the Walla Walla River have been insufficient for salmonids migrating to upper portions of the watershed or out of the basin. The primary mechanism in the past to avoid loss of fish has been to perform instream rescues and transport fish upstream to a location with sufficient flow. In early 2012 the WWWMP passed a preliminary low flow response plan (WWWMP, 2012) to facilitate the ability for the Washington half of the valley to respond to these conditions and facilitate fish passage during these critical times. Through this plan, preliminary partnerships have been arranged with local water users to allow for the release of stored water or bypass of potential irrigation water. The plans sets a threshold of a minimum 50 cfs left instream (amongst additional criteria) during the winter and spring to increase fish migration into and out of the basin.

This plan sites a need to put water instream and requires a relatively short response time. As a result of this need, the WWBWC has been discussing the possibility of expanding the valley's surface storage potential through the utilization of existing gravel pits. As an example, the Locher Road site is a former gravel quarry that in recent years has been primarily utilized for AR through surface infiltration. Figure 39 is a generalized diagram showing how this site could be converted to a dual purpose site, where surface water storage and AR can be accomplished at the same location.

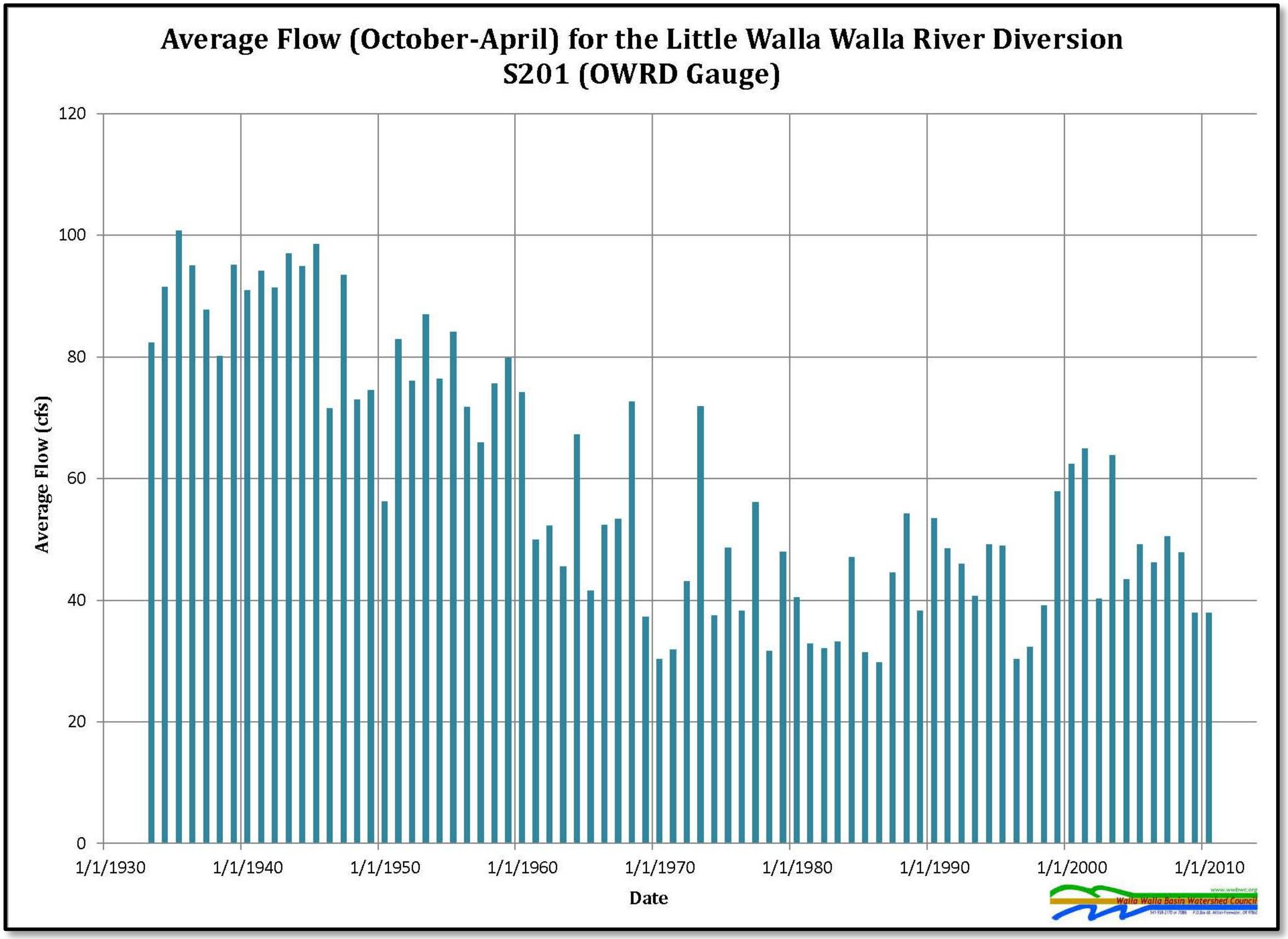


Figure 38 - Hydrograph showing average diversion flow, October through April, at Cemetery Bridge in Milton-Freewater, OR. This diversion controls how much water goes down the Little Walla Walla System.

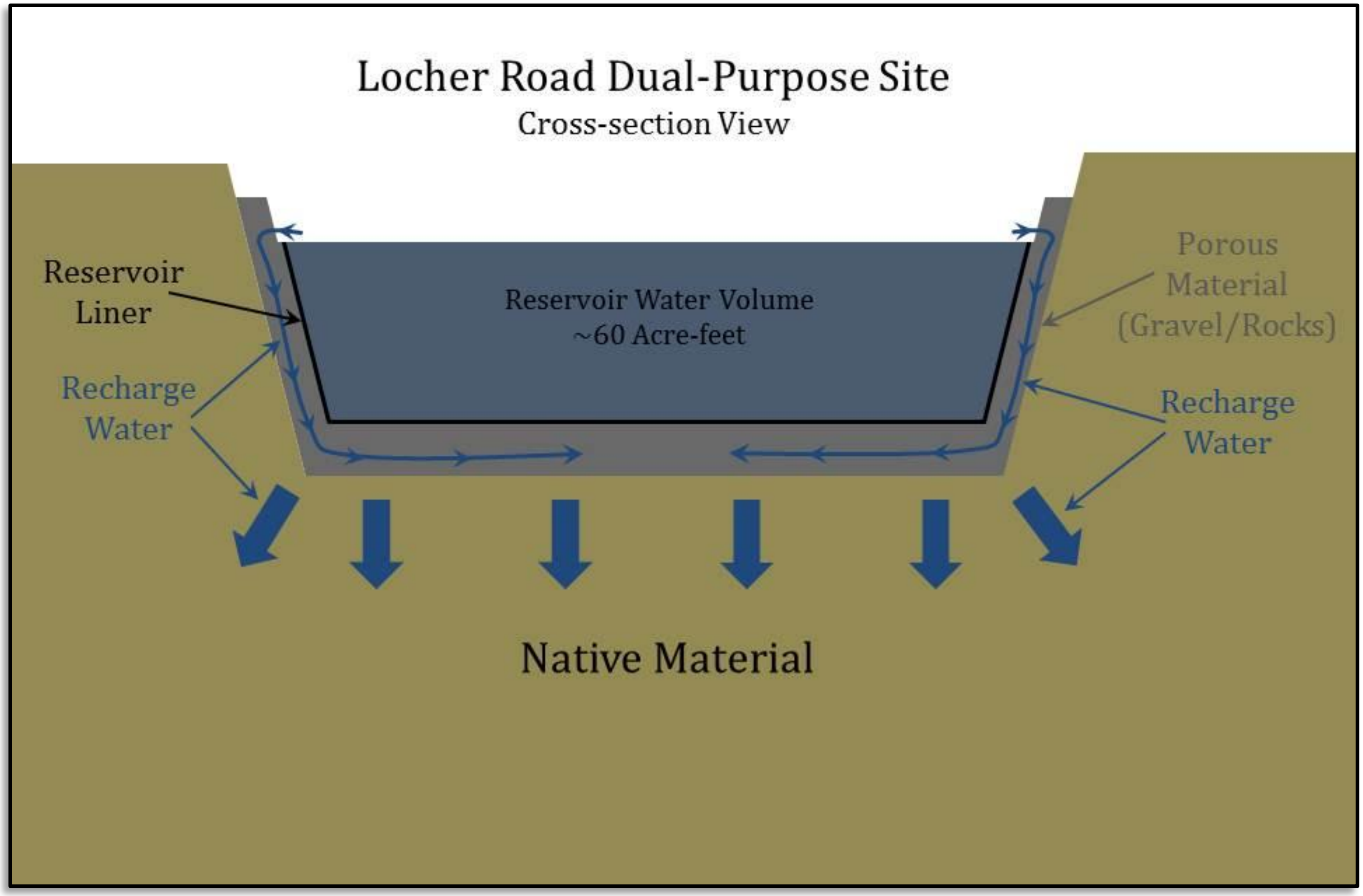


Figure 39 - Illustration of the Locher Road Dual-Purpose Site design. A similar design could be used at other gravel quarries in the valley.

Due to the relatively shallow water table in the alluvial aquifer and relatively high hydraulic conductivity of the aquifer, groundwater mounding beneath the AR site becomes the controlling factor for infiltration rates at most AR sites in the valley. This is different than many other locations around the country where ASR or AR is taking place. Typically, infiltration rate is controlled by surface area because the water table is deeper and does not ‘connect’ with the water within the AR site as it does in the Walla Walla Basin. Based on local conditions and lessons learned through the monitoring of AR projects in the Walla Walla Valley, a lined gravel pit with a high porosity fill between the liner and surrounding sediments can create a site that holds 60 to 70 acre-feet of water and function as an AR site with a capacity of 4 to 5 cfs. Water diverted in the winter can be used to fill the reservoir. The site will funnel the overflow from the reservoir to the backside of the liner and into the underlying aquifer.

The WWBWC is seeking funding to design and construct dual purpose functionality at the Locher Road and Stiller Pond sites. These two sites could enable the availability of 100 acre-feet of water almost immediately. During periods of low flow, 10 cfs could be bypassed or left instream for 5 days by utilizing water stored in these two potential dual purpose sites.

A similar project is being considered in Oregon, within the Eastside sub-basin. An existing gravel pit, located in this region has a capacity of nearly 100 acre-feet. This location is critical for AR development to reduce seepage loss in the Tum-a-lum reach. The addition of a possible surface water storage component is advantageous to this critical reach as well. The two Washington dual purpose sites and the Eastside gravel pit site would provide approximately 200 acre-feet of ‘flexible’ water. In a low flow response scenario, 200 acre-feet of stored water could provide 20 cfs of instream flow to the Walla Walla River for 5 days.

Potential Benefits

Due to the high hydraulic conductivity of the aquifer, groundwater can migrate rapidly, and the higher water levels seen near the River during periods of high flow can fall within a few days or a couple of weeks. Balanced, more widespread distribution of water minimizes the migration of water from the aquifer in and around the River to depleted areas. Balanced distribution allows AR to occur in areas where groundwater is depleted and essentially prevents 'taking' groundwater from other areas. Balanced distribution could help reduce the amount of riverbed seepage that further depletes the limited surface flows available for fish passage and fish habitat each summer in the Walla Walla River.

Several down-gradient monitoring wells at the Hulette Johnson site show increased aquifer storage, which represents water that is filling void space in the sediments. Areas where storage is building indicate that groundwater input is exceeding withdrawal (or discharge) and water is staying within the aquifer for at least one year or more. Once these regions reach a certain recovery, and water storage in that portion of the aquifer has been maximized, AR water (now groundwater) that would have continued to build storage in the past must find another hydrologic outlet further down-gradient or in the shallow surface water system, thus creating baseflow or spring flow.

A broad distribution of water during the winter and spring AR season minimizes the effect of groundwater sinks. Sinks are areas where groundwater depletion has occurred and/or high conductivity sediments in the aquifer create a preferential flow path into the area. Both of these conditions allow groundwater to move into these areas freely, if available. Projects designed to supply regions of the aquifer where groundwater depletion has occurred will begin to fill the sinks and regain the hydrologic potential of these regions.

Approximately 100 cfs of recharge, conducted for 110 days between November 1st and May 31st roughly equates to over 20,000 acre-feet of recharge. Current work being completed on the Integrated Water Flow Model (IWFM), which models groundwater and surface water migration through much of the valley, indicates the gravel aquifer is losing approximately 5,000 acre-feet per year of storage (Scherberg, 2012; Jiménez, 2012). To stabilize this trend, recharge must increase beyond its current practice and potentially be developed to the full 80 cfs potential in Oregon and 20 cfs in Washington. Results from tracer analysis at the Hulette Johnson site indicates half to two-thirds of the AR water put into the site leaves the valley within a year. Evidenced by the rejuvenation of Johnson Spring Creek and the down-gradient waterways it feeds. However, as shown in the earlier well hydrographs, storage building is also evident. The ability for AR water to address storage declines versus more short-term ecological benefit (activation of spring creeks) is dependent on the location, proximity to springs, depth to water, and a number of other factors. Considering that up to two-thirds of the water recharged into the Hulette Johnson site leaves the valley within one year, instituting an aquifer recharge program that enables 20,000 acre-feet of recharge to occur in a given year may be warranted. If this pattern exists at other current and future sites as well, 20,000 acre-feet of recharge would equate to 6,000 to 7,000 acre-feet of storage recovery yearly. According to IWFM, this would not only stabilize the aquifer decline but would also result in modest recovery.

The WWBWC places a high priority on measuring the effectiveness of current and proposed sites through hydrologic monitoring of the valley's surface water and groundwater system (Figure 40). Many of the monitoring locations have been active for 5 to 10 years, providing considerable background data that will be needed to properly measure the overall benefit of AR to the alluvial aquifer and the connected surface water bodies.

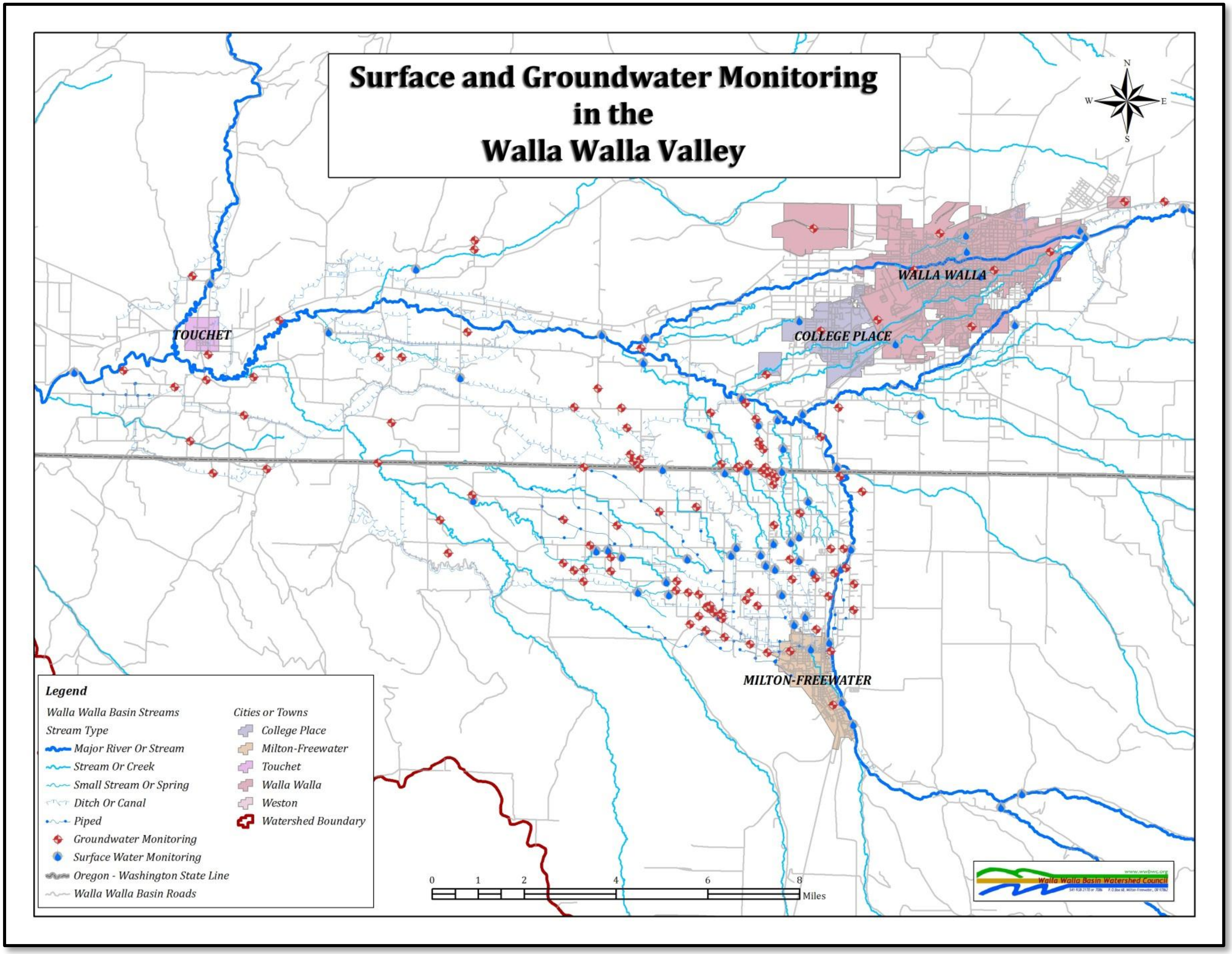


Figure 40 - WWBWC surface and groundwater monitoring network in the Walla Walla Valley.

Conclusions

Through years of hydrologic monitoring of the Walla Walla Valley and the successful initiation of AR as a water management tool, the WWBWC and basin partners have learned how critical seasonal recharge is to the health of the entire Walla Walla River system. The physical nature of recharge is integrated into the entire alluvial system and occurs every day throughout the year in portions of the valley's hydrology. Studies have cited the transition of surface water to groundwater to surface water as a common cycle found in river systems. In the Walla Walla Valley large quantities of surface water seep into the alluvial aquifer in the winter and spring and reemerge weeks to months later as surface water again.

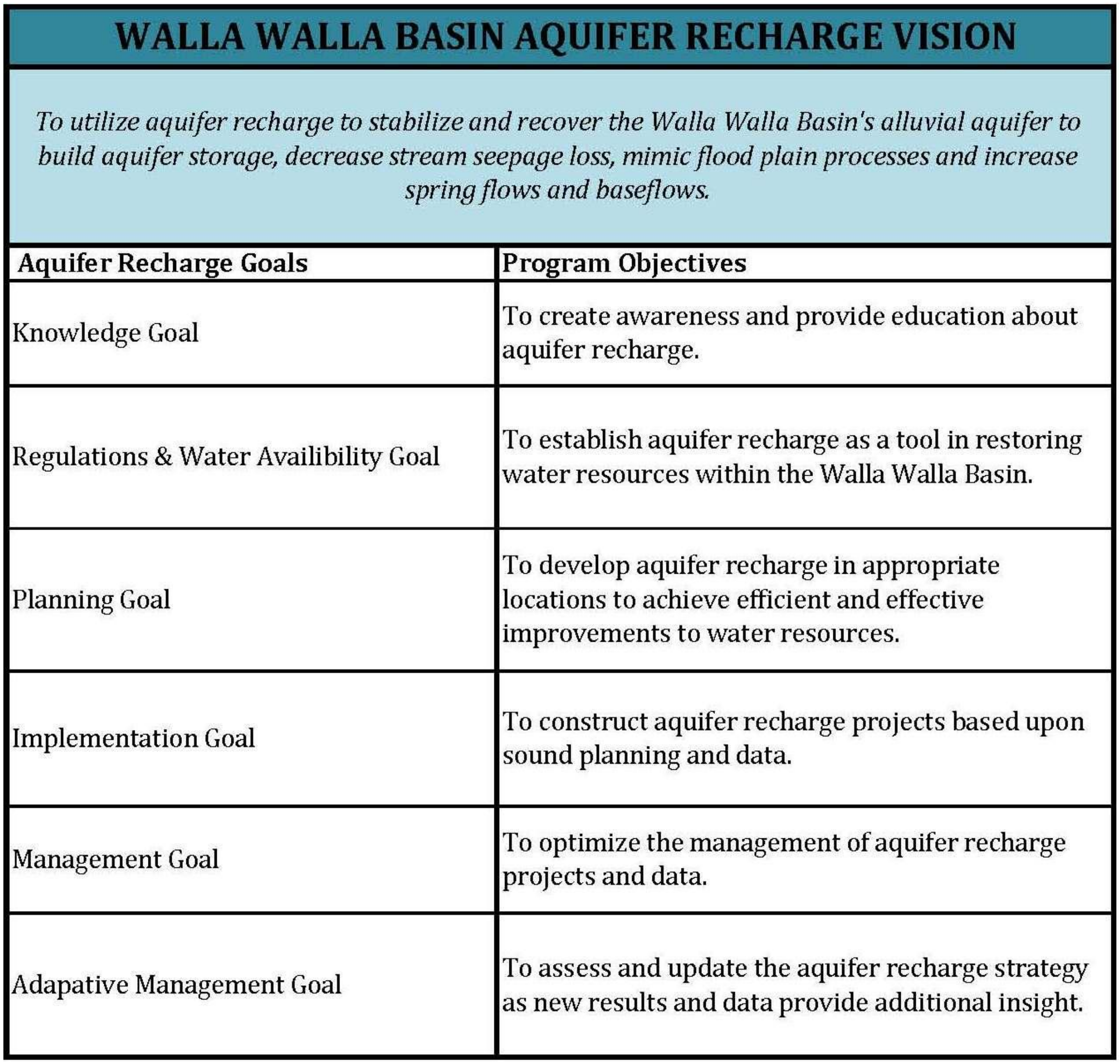
Based upon data collected for decades, long-term declines in the aquifer are known. Declines are simply a reduction in aquifer elevation and overall storage. Aquifer declines have resulted in reduced output of alluvial springs across the valley, increased seepage loss from surface water bodies, and reduced groundwater input to the surface water bodies.

Declines in the aquifer and associated surface water performance are attributed to the change in management of the valley's distributary channels, the channelization of the Walla Walla River system, the lining and increased efficiency of the valley's irrigation canals, and the development of the alluvial aquifers' groundwater resources. These four activities effectively reduce the amount of water recharging the alluvial aquifer and increase the usage from the alluvial aquifer on an annual basis. IWFM estimates the alluvial aquifer is losing approximately 5,000 acre-feet per year under present conditions.

To reduce or reverse the annual loss in groundwater storage within the alluvial aquifer, the WWBWC and basin partners have initiated several AR pilot projects. These projects have shown the ability to increase groundwater storage and thus groundwater input to surface water bodies such as springs. The effects of these projects are relatively localized, and additional projects are needed to benefit the entire alluvial system. Water quality monitoring of AR sites has shown improvements to groundwater quality. Additionally, under present water availability criteria there appears to be approximately 80 cfs of water available in Oregon and

20 cfs available in Washington for AR in the winter and spring. Over the next three years the WWBWC and its basin partners will be seeking support to develop AR to this capacity in the valley, with emphasis on regions in and around the Walla Walla River and Mill Creek alluvial fans. The ultimate goal of diverting up to 100 cfs for AR will be to reverse the predicted loss of storage determined through IWFM modeling. Reversing the loss of storage within the alluvial aquifer will minimize seepage loss in the valley's rivers and streams, increase spring performance and related groundwater input to surface water features, and allow groundwater resources of the alluvial aquifer to continue to be used as a sustainable resource with a secondary or alternative-use benefit to surface water.

The benefit of current and future AR projects will be measured by continued monitoring at more than 100 groundwater and 60 surface water sites throughout the valley. The majority of these monitoring locations are maintained by the WWBWC and compliments the WWBWC's annual seepage loss studies. Through this data, its interpretation, and integration into IWFM, the effectiveness of managed AR can be measured and future water management decisions or modification can be made with a more comprehensive understanding.



WALLA WALLA BASIN AQUIFER RECHARGE VISION

To utilize aquifer recharge to stabilize and recover the Walla Walla Basin's alluvial aquifer to build aquifer storage, decrease stream seepage loss, mimic flood plain processes and increase spring flows and baseflows.

Aquifer Recharge Goals	**Program Objectives**
Knowledge Goal	To create awareness and provide education about aquifer recharge.
Regulations & Water Availibility Goal	To establish aquifer recharge as a tool in restoring water resources within the Walla Walla Basin.
Planning Goal	To develop aquifer recharge in appropriate locations to achieve efficient and effective improvements to water resources.
Implementation Goal	To construct aquifer recharge projects based upon sound planning and data.
Management Goal	To optimize the management of aquifer recharge projects and data.
Adapative Management Goal	To assess and update the aquifer recharge strategy as new results and data provide additional insight.

Goal 1 - Knowledge

Management Objective: To create awareness and provide education about aquifer recharge.

Situation Assessment

The concept and success of artificial aquifer recharge (AR) is well established and accepted within the hydrogeology/hydrology community. Many irrigators also understand the process and benefits of aquifer recharge. Although the WWBWC and others have been presenting and talking about aquifer recharge, the general public in the Walla Walla Basin is not well informed about its process and potential benefits. Much of the outreach and education in the past has been targeted outside of the basin and to academic or agency personnel.

Strategic Approach:

The strategic approach will aim to: **1** - Make this strategic plan and other documents accessible for agency and public use; **2** - Continue to spread awareness and information regarding aquifer recharge; **3** - Educate people and students about artificial recharge; **4** - Promote exisiting aquifer recharge projects to increase awareness and education.

Actions	*Priority*
Make the strategic plan accessible	
Post on the WWBWC website, distribute to basin partners, and release it to the media including local newspapers.	1
Continue to spread awareness and information	
Present information to local civic groups, local governments, landowners and water professionals.	1
Produce information on aquifer recharge including reports, pamphlets, posters and newspaper articles. Billboards at existing sites can inform people that aquifer recharge is occuring and its purpose/benefits.	2
Educate people about artificial recharge	
Give talks describing recharge and give updates on existing and proposed projects at local events including civic groups, government meetings, and agency/organization meetings.	1
Give aquifer recharge presentations to local schools including high schools and colleges/universities.	2
Promote existing aquifer recharge projects	
Provide and distribute data on project performance and benefits derived from aquifer recharge	1

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

Goal 2 - Regulations & Water Availability

Management Objective: To establish aquifer recharge as a tool in restoring water resources within the Walla Walla Basin.

Situation Assessment

Aquifer recharge has been occuring in the Walla Walla Basin for almost ten years under the Limited License (LL) framework in Oregon and the Environmental Enhancement Project (EEP) framework in Washington. The Limited License framework provides a 5 year temporary water right which can be renewed. Currently, on the Oregon side there is no framework to allow for a long-term or permenant aquifer recharge water right. The Environmental Enhancement Project framework is still relatively new in Washington and its functionality and long-term ability to allow aquifer recharge is unknown. Currently, both Oregon and Washington require instream minimum flows to be satisfied before water can be diverted for use at aquifer recharge projects. On the Oregon side, instream minimum flows are typically satisfied from mid-late November through May. Early November river flows occasionally limit aquifer recharge operations but only temporarily. On the Washington side, instream minimum flows are typically satisfied from December through May with occasional gaps in aquifer recharge operations. Except for 2010, when the Locher Road AR site did not run due in part to limited instream flows, instream minimum flow requirements have not severely limited aquifer recharge operations. However, since aquifer recharge started in the basin, there has not been a series of bad water years or drought.

Strategic Approach:

The strategic approach will aim to: **1** - Create an alternate permanent framework for aquifer recharge in Oregon; **2** - Continue using the EEP framework in Washington for aquifer recharge projects

Actions	*Priority*
Create an alternate permanent framework for aquifer recharge in Oregon	
Work with interested parties to develop a new permenant framework for aquifer recharge.	1
Convene the Rules Advisory Committee to look at revising the Basin Program to address limitations to developing aquifer recharge.	2
Continue using the EEP framework in Washington	
Work with Washington Department of Ecology to develop the EEP process for aquifer recharge in the Walla Walla Basin.	1
Develop and implement new aquifer recharge projects that utilize the EEP framework and test its ability to operate aquifer recharge in the long-term.	2

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

Goal 3 - Planning

Management Objective: To develop aquifer recharge in appropriate locations to achieve efficient and effective improvements to water resources.

Situation Assessment

Much of the background work for developing aquifer recharge sites has focused on siting and designing projects in the Walla Walla Basin. Based upon four pilot projects that have run for a combination of over 15 recharge seasons, valley partners and the WWBWC have developed multiple aquifer recharge designs and have studied what limits infiltration and/or recharge rates at various locations throughout the valley. Geology grids have been developed to help site aquifer recharge projects. An extensive surface water and groundwater monitoring network has been established by the WWBWC to develop trends across the valley to better understand where aquifer recharge should occur. WWBWC worked with OSU to develop the IWFM numeric surface water/groundwater model for a portion of the Walla Walla Valley to further understand how aquifer recharge can be used to stabilize and restore water resources.

Strategic Approach:

The strategic approach will aim to: 1 - Utilize historic and collected data to develop aquifer recharge sites in appropriate locations; 2 - Utilize the surface water / groundwater model to run aquifer recharge scenarios.

Actions	*Priority*
Use data to develop aquifer recharge sites	
Locate appropriate areas for aquifer recharge based upon geology, depth to water and other characteristics.	1 and 2
Work with state agencies to aquire a water right for new aquifer recharge sites	1 and 2
Find landowners that are willing to have a aquifer recharge project on their property	1, 2 and 3
Work with valley partners to develop additional recharge opportunities	1, 2 and 3
Utilize the model to run scenarios	
Continue development and refinement of the IWFM model	1
Create and run aquifer recharge scenarios that include new and proposed recharge sites	1
Create and run aquifer recharge scenarios to determine long-term responses to varying amounts of aquifer recharge	1 and 2
Work with basin partners to run additional model scenarios	2

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

Goal 4 - Implementation

Management Objective: To construct aquifer recharge projects based upon sound planning and data.

Situation Assessment

Four pilot projects have already been implemented and another two are under construction and awaiting approval of the limited license. Two additional sites are ready for construction once the limited license is approved. New sites within the Hudson Bay District Improvement Company (HBDIC) are moving forward with few hurdles. Development of aquifer recharge projects within the Little Walla Walla system and within Eastside are hampered by an inability to deliver recharge water to the sites. Limited flows in the lower Little Walla Walla River system (below the irrigation districts) have limited the ability of an existing site to run and will likely limit future sites. In the Eastside area, limitations to aquifer recharge site implementation include a current inability to deliver recharge water to sites, an inadequate diversion structure, and water capacity and distribution of its pipeline.

Strategic Approach:

The strategic approach will aim to: 1 - Continue to implement aquifer recharge within the Hudson Bay District Improvement Company; 2 - Overcome current obstacles to implementing aquifer recharge within the Little Walla Walla system and Eastside; 3 - Work on implementing aquifer recharge within the Little Walla Walla system and Eastside

Actions	***Priority***
Continue to implement projects in the HBDIC system	
Construct additional planned projects in the HBDIC system once a new Limited License is approved	1
Install aquifer recharge projects within the HBDIC system to mitigate for future ditch piping projects	2
Overcome obstacles to implementing aquifer recharge in the LWW system and Eastside	
Work to change the Basin Program to allow aquifer recharge and storage to be a beneficial use.	1
Develop new ways to deliver water, especially down the LWW and Eastside systems.	1 and 2

Work to implement projects in the LWW system and Eastside	
Continue working with the Walla Walla River Irrigation District and other partners to allow delivery of recharge water within the LWW system and Eastside	1
Construct aquifer recharge projects	1 and 2

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

Goal 5 - Management

Management Objective: To optimize the management of aquifer recharge projects and data.

Situation Assessment

Existing recharge projects are typically operated by the irrigation district where the site is located. This allows the site to be run in coordination with the rest of the irrigation system and operations can be optimized to allow for more recharge water to be delivered. The Hulette Johnson site has a network of sensors installed to allow for remote data collection and observation. Water levels in each pond are monitored with a pressure transducer and an alarm email can be sent out if the water levels are either too high or too low. Inflow and outflow rates are also monitored to optimize site operations. Data from existing recharge sites are available on the WWBWC's website (www.wwbwc.org) and included in the annual report for each site. Management of the data is done according to the WWBWC's standard operation procedures. Data are incorporated into the WWBWC's monitoring database for analysis, storage and distribution.

Strategic Approach:

The strategic approach will aim to: 1 - Manage projects using standard operating procedures; 2 - Develop near real-time data collection for recharge sites to allow for optimized operations; 3 - Maintain good communication between recharge project operators (irrigation districts) and WWBWC.

Actions	*Priority*
Manage projects using standard operating procedures	
Create and implement standard operating procedures for aquifer recharge operations	1
Revise standard operating procedures	2 and 3
Develop near real-time data collection for all recharge sites	
Test ability of near real-time data collection on a pilot project	1
Seek grant funding to install and operate additional near real-time data sites for current and future recharge projects	1 and 2
Maintain good communication between recharge partners	
Provide updates to the boards of partnering organizations.	1
Create and distribute annual reports for aquifer recharge operations	1 and 2
Develop and maintain current information regarding the aquifer recharge program on the WWBWC website for easy access and distribution	1 and 2

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

Goal 6 - Adaptive Management

Management Objective: To assess and update the aquifer recharge strategy as new results and data provide additional insight.

Situation Assessment

The current aquifer recharge strategy is based upon four pilot projects that have operated intermittently (except the Hulette Johnson site) over the last 8 years. After creating and operating new aquifer recharge sites for 3-4 years, more data will be available for reassessing the direction of the aquifer recharge program. Reassessment will look at where the program is in comparision to program goals, where we think we should be and adjust the program and strategy to continue to improve the aquifer recharge program and achieve the program goals.

Strategic Approach:

The strategic approach will aim to: 1 - Reassess the strategic plan every 3-5 years; 2 - Determine if the program's direction is still in line with its goals.

Actions	*Priority*
Reassess the strategic plan every 3-5 years	
Work with program partners to reassess the strategic plan	3
Determine if the program's direction is still in line with its goals	
Use data gathered from operating sites to determine groundwater improvements	2
Use gathered data to help inform new project locations and areas that need additional focus	2
After reassessment, determine if program goals have changed (either in time or in outcome) and discuss potential changes to the aquifer recharge program	3

Priority: 1 = Immediate, 2 = Within 2 years, 3 = Within 5 years

References

Busacca, A.J. and MacDonald, E.V., 1994. Regional sedimentation of Late Quaternary loess on the Columbia Plateau – sediment source areas and loess distribution pattern. From Lasmanis, R. and Cheney, E.S., eds., *Regional geology of Washington State*. Washington Department of Natural Resources, Division of Geology and Earth Resources Bulletin 80, p. 181-190.

Fecht, K.R., Reidel, S.P., and Tallman, A.M., 1987. Paleodrainage of the Columbia River system on the Columbia Plateau of Washington State – A Summary. From Shuster, J.E., ed., *Selected papers on the geology of Washington State*. Washington Department of Natural Resources, Division of Geology and Earth Resources Bulletin 77, p. 219-248.

GSI, 2007. Geologic Setting of the Miocene (?) to Recent Suprabasalt Sediments of the Walla Walla Basin, Southeastern Washington and Northeastern Oregon. Consulting Report for the Walla Walla Basin Watershed Council and Washington Department of Ecology, 143 p.

GSI, 2007a. Results of the First Season of Shallow Aquifer Recharge Testing at the Locher Road Site, Walla Walla County, Washington. Consulting Report for Gardena Farms Irrigation District #13 and Washington Department of Ecology, 175 p.

GSI, 2007b. Project Completion Report for Shallow Aquifer Recharge Testing at the Hall-Wentland Site, Umatilla County, Oregon and Walla Walla County, Washington. Consulting Report for Walla Walla County Watershed Planning Department, Washington Department of Ecology, Walla Walla River Irrigation District, and Oregon Water Resources Department, 214 p.

GSI, 2008a. Results of the 2008 Shallow Aquifer Recharge Season at the Locher Road Site, Walla Walla County, Washington. Consulting Report for Gardena Farms Irrigation District #13 and Washington Department of Ecology, 161 p.

GSI, 2008b. Annual Report for the Spring 2008 Recharge Season, Hall-Wentland Shallow Aquifer Recharge Site, Umatilla County, Oregon and Walla Walla County, Washington. Consulting Report for Walla Walla Basin Watershed Council and Walla Walla River Irrigation District, 210 p.

GSI, 2009a. Results of the 2009 Shallow Aquifer Recharge Season at the Locher Road Site, Walla Walla County, Washington. Consulting Report for Gardena Farms Irrigation District #13 and Washington Department of Ecology, 166 p.

GSI, 2009b. Annual Report for the Spring 2009 Recharge Season, Hall-Wentland Shallow Aquifer Recharge Site, Umatilla County, Oregon and Walla Walla County, Washington. Consulting Report for the Walla Walla Basin Watershed Council and Walla Walla River Irrigation District, 175 p.

GSI, 2012. Results of the 2012 Alluvial Aquifer Recharge Season at the Stiller Pond Site, Walla Walla County, Washington. Consulting Report for the Walla Walla Basin Watershed Council and Walla Walla County Conservation District, 67 p.

GSI, 2012a. Review of Previously Collected Source Water and Groundwater Quality Data from Alluvial Aquifer Recharge Projects in the Walla Walla Basin, Washington and Oregon. Consulting Report for the Walla Walla Basin Watershed Council, 70 p.

Jiménez, A. C.P., 2012. Managed Artificial Aquifer Recharge and Hydrological Studies in the Walla Walla Basin to Improve River and Aquifer Conditions. Oregon State University: Water Resources Engineering, Ph.D. Dissertation.

Kennedy/Jenks, 2006. Results of the First Season of Shallow Aquifer Recharge Testing at the Hall-Wentland Site, Umatilla County, Oregon and Walla Walla County, Washington. Consulting Report for HDR, Inc., 90 p.

Lewis, R., 2012. West Little Walla Walla River Habitat Assessment. Little Walla Walla Rivers Working Group for Walla Walla Basin Watershed Council.

Newcomb, R.C., 1965. Geology and ground-water resources of the Walla Walla River Basin, Washington and Oregon: Washington Department of Conservation, Division of Water Resources. Water Supply Bulletin 21, 151 p, 3 plates.

Norris, B.F., 2010. White Paper: Peak and Ecological Flow; a Scientific Framework for Implementing Oregon HB 3369. Prepared by Peak and Ecological Flow Technical Advisory Committee, Oregon Water Resources Department, 99 p.

Richerson, P. and Cole, D., 2000. April 1999 Milton-Freewater groundwater quality study. Oregon Department of Environmental Quality, State-Wide Groundwater Monitoring Program, 17 p.

Scherberg, 2012. The Development of a Hydrological Model of the Walla Walla Basin Using Integrated Water Flow Model. Oregon State University: Water Resources Engineering, M.S. Thesis.

USACOE, 1969. Milton-Freewater Levees, Walla Walla River, Oregon. Design Memorandum No. 1 – Repair and Restoration. May 22, 1969.

Waitt, R.B., Jr., O'Conner, J.E., and Benito, G., 1994. Scores of gigantic, successively smaller Lake Missoula floods through Channeled Scabland and Columbia valley. From Swanson, D.A. and Haugerud, R.A., eds., *Geologic field trips in the Pacific Northwest*. Seattle, Washington, University of Washington Department of Geological Sciences, vol. 1, p 1k.1 – 1k.88.

WWBWC, 2010. Aquifer recharge as a water management tool – Hudson Bay recharge testing site report (2004-2009). Report for Hudson Bay District Improvement Company and Oregon Water Resources Department.

WWBWC, 2012. 2012 Walla Walla Basin Seasonal Seepage Assessments Report – Walla Walla River, Mill Creek, Touchet River, and Yellowhawk Creek.

WWBWC, 2012a. Seepage Gain/Loss Analysis of the Gardena Farms Canal, Gardena Farms Irrigation District #13 – Spring/Summer 2012.

WWWMP, 2010. Gardena Farms Irrigation District #13 Local Water Plan Agreement. Walla Walla Watershed Management Partnership Local Water Plan LWP-10-01.

WWWMP, 2012. Critical Low Flow Plan – For the Walla Walla Basin. Prepared by the Walla Walla Watershed Management Partnership.

Appendix A

Decision Matrix & Project Development Tables

www.wwbwc.org
Walla Walla Basin Watershed Council
541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

Shallow Aquifer Recharge Program
Decision Matrix

Note: Each characteristic can be rated 1 = fair, 2 = good or 3 = excellent

Site Name	Proximity to Problem Areas	Geology	Depth to Water	Project Size	Distance from Dom. Wells	Willing Landowner	Anticipated Benefits	Water Delivery System & Volume	Cost	Total
H. Johnson										
Anspach										
Barrett										
Trumbull										
NW Umapine										
Dugger Creek										
ODOT										
Eastside										
Hall-Wentland										
Locher Road										
Stiller Pond										
Knowles										
Reser										
Yellowhawk										

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Aquifer Recharge Program

Project Development Process

Step	Task Description	Lead	Start	Finish
1	Preliminary Site Visit			
2	Landowner (LO) Converstation			
3	Detailed Topographic Survey - Data			
4	Detailed Topographic Survey - Basemaps			
5	Geology Investigation			
6	Depth to Water Modeling			
7	Initial Design Concepts			
8	Recharge Area Designation			
9	Create Site Plan Data			
10	Initial Site Plan Drawings			
11	Test Pits - Number, Location & Specs			
12	Add Test Pits to Site Plan			
13	LO Permission for Test Pits, Infiltration Test & Site Design			
14	LO Coordination and Agreement			
15	Contractor for Test Pits			
16	Prepare Site for Test Pits			
17	Excavate Test Pits and Record Data			
18	Infiltration Test - Determine Water Source			
19	Infiltration Test - Water Conveyance			
20	Infiltration Test - Develop Schedule			
21	Conduct Infiltration Test			
22	Gather Data for Infiltration Test			
23	Evaluate Infiltration Test and Test Pits Data			
24	Backfill Test Pits			
25	Decision Point - Proceed or Stop			
26	Permanent Water Delivery System Design Options			
27	Complete Draft Site Plan for Project			
28	Review Site Plan with LO and Partners			
29	Finalize Site Plan for Project			
30	Collect Any Preliminary Monitoring Data			
31	Develop Monitoring Plan for Project			
32	Agencies and Partners Review Monitoring Plan			
33	Revise Monitoring Plan as Necessary			
34	Complete Application for Project Water Right			
35	Submit Application and Monitoring Plan			
36	Select Construction Contractor for Project			
37	Develop Construction Schedule			
38	Project Construction			

Summary Table for Aquifer Recharge Projects

Site Location	Bundle	Location	Recharge Amount (at site)	Limited License / LWP / EEP	Characterization - HydroGeo	Design Type	Designs	Water Management, Delivery & Operations	Water Quality Plan	Monitoring Plan	Limiting Factors	Anticipated Benefits	WWBWC Staff Lead and Partners
HBDIC - H. Johnson	HB-1	T6N R35E S33 NE-Q SW/SE-QQ	~15-18 cfs	Under current license #LL-1189	Completed - See HBDIC Report from 2010	Combination of infiltration basins and infiltration galleries	Phase I, II, III Designs	Water is delivered from the White Ditch and is managed by HBDIC with the exception of the infiltration galleries which are managed by the WWBWC.	2008-2009 WQ Plan	Well and surface monitoring networks around the project.	None at this point	Restoration of spring flows, espcially in Johnson Creek, along with increased groundwater levels. Filling the declined aquifer to increase spring flows and increase groundwater discharge to surface bodies.	WWBWC -Steven; GSI - Limited License and Water Quality Plan
Barrett	HB-1	Oregon T6N R35E S34 SE-Q SW-QQ	3 cfs	LL	Depth to water is around 30-35 feet according to a well on the southeast corner of the property (GW_62). Well log from near-by well shows the following: Soil/Large cobbles 0-20', Loose cobbles and clay 20-45', Clay and gravel 45-48', Loose gravel and clay 48-70'	Infiltration gallery	Draft Designs complete	HBDIC - Water will be delivered from the Barrett pipeline into an infiltration gallery. HBDIC will be responsible for turning water into the site. Because flooding is not an issue with the infiltration gallery, water management should be minimal during operations.	Completed	Upgrade GW_62 existing well and possibly fill in hand-dug portion for safety.	Finalizing the landowner agreement and obtaining the Limited License. Designs all almost completed.	Improve groundwater levels in an area of the shallow aquifer that has seen severe declines and could potentially help reduce groundwater gradient from the WWR and LWW systems. Also will help to raise regional groundwater levels to address the general decline in the aquifer reducing negative groundwater/surface interactions (seepage loss)	WWBWC - Steven; GSI - Limited License & HydroGeo; Berny Hewes - Designs; Contractor - HBDIC
Trumbull	HB-1	Oregon T6N R35E S27 SW-Q NW/SW-QQ	3 cfs	LL	Depth to water is 45 feet or greater just to the east of this site (GW_117). Stratigaphy for near by monitoring well.	Infiltration gallery	Completed	HBDIC - Water will be delivered from the Hyline pipeline into an infiltration gallery. HBDIC will be responsible for turning water into the site. Because flooding is not an issue with the infiltration gallery, water management should be minimal during operations.	Completed	We have two upgradient wells but no good down gradient wells. Develop groundwater network around Triangle Station to help capture groundwater response to artificial recharge. Spring and surface flows in Mud Creek may be enhanced by this project. Reassess surface monitoring at Mud Creek springs and farther down stream.	Timing of grant money, getting designs done so construction can be finished before August 31st (now probably pushed to the end of Sept or Oct)	Improve groundwater levels in an area of the shallow aquifer that has seen severe declines and will increase spring flows in the Mud Creek system around Triangle Station. Also will help to raise regional groundwater levels to address the general decline in the aquifer reducing negative groundwater/surface interactions (seepage loss)	WWBWC - Steven; GSI - Limited License & HydroGeo; Berny Hewes - Designs; Contractor - Premiere
NW Umapine	HB-1	Oregon T6N R 34E S24 SE-Q SW-QQ	5 cfs	LL	Depth to water is 25-30 feet according to well just north of the project site (GW_34). Depth to gravel estimated to be ~15-25 feet.	Infiltration pond that will hopefully infiltrate 5cfs	Draft Designs complete	HBDIC - Water will be delivered from the Richardz pipeline down to the basin. Basin is very large and only a portion of it will be used as the infiltration area. Potential for flooding will be very limited. HBDIC will manage water to the site by the turn out from the Richardz pipeline.	Completed	We have one well to the north of the proposed site, but nothing to the northwest or west for some distance. Surface flows in Swartz creek may increase due to this project.	Finalizing the landowner agreement and obtaining the Limited License. Designs all almost completed.	Improve groundwater levels in the area and help mitigate for lost recharge water from the Richardz Pipeline. Will help springs in the Little Mud Creek and Swartz Creek areas. Also will help to raise regional groundwater levels to address the general decline in the aquifer reducing negative groundwater/surface interactions (seepage loss)	WWBWC - Steven; GSI - Limited License & HydroGeo; Berny Hewes- Designs; Contractor - HBDIC
Anspach	HB-1	Oregon T5N R35E S2 NW-Q NW-QQ	1-2 cfs	LL	Depth to water varies from ~15-35 feet depending on season (irrigation/non-irrigation). According to well just west of the project: well dug to 34', brown cement gravel 34-40', med gravel 40-47', brown cement gravel 47-80'	Infiltration gallery	Complete	HBDIC - One of two options: 1 - Water would be delivered down the Pleasantview canal, but managed by HBDIC. 2 - Water would be diverted from the HBDIC canal just west of where it crosses Old Milton Highway/Lamb Street. Water would flow through a pipeline either along the north or south edge of the proptery to the south of the canal and then turn south to deliver water to the project property. HBDIC would be in charge of turning water to the site. Because it would be a closed infiltration gallery design there would be very little risk of flooding and should have low operational needs.	Completed	Have existing well at the southeast edge of the property. Drill a dedicated monitoring well somewhere north and/or west of the infiltration gallery. Continue monitoring GW_27 which has been dry for a couple decades. Surface water enhancements would be limited to do lack of historic streams/springs in the area.	Water supply - WWRID cannot deliver recharge water. Can HBDIC deliver water down the Pleasantview Canal? HBDIC deliver water from the White Ditch - Elevations concerns? Timing of grant money, getting designs done so construction can be finished before August 31st (now probably pushed to the end of Sept or Oct)	Improve groundwater levels in an area of the shallow aquifer that has seen severe declines and could potentially help reduce groundwater gradient from the WWR and LWW systems. Also will help to raise regional groundwater levels to address the general decline in the aquifer reducing negative groundwater/surface interactions (seepage loss)	WWBWC - Steven; GSI - Limited License & HydroGeo; Fazio - Designs; Contractor - HBDIC
Dugger Creek	HB-1	Oregon T6N R35E S30 SE-Q NW-QQ	3 cfs	LL	Depth to water is typically around 20 feet. From well drilled on property: top soil and clay 0-11', cement gravel brown 11-86'	Infiltration basin or infiltration galleries	N/A	Water would be diverted off the White Ditch to feed the project	Completed	Unknown	This project is tied to the piping of the White Ditch	Increase spring flows and reduce seepage loss by increasing groundwater levels in the Dugger Creek system. Will also help address the general decline in the regional aquifer by increase local groundwater levels and refilling the regional aquifer.	WWBWC - Steven; Unknown - Likely HBDIC
ODOT-Prunedale	HB-1	Oregon T6N R 35E S34 NW-Q	1-2 cfs	LL	Depth to water tyipcally around 40 feet. Site is just east of existing H. Johnson recharge site. GW_45, a monitoring well at the H. Johnson site showed the following: sand silt w/ gravel 0-2' Gravel w/ some sand 2-22', Silty Gravel 22-40', Gravel w/ sand 40-62', silty sand 62-72'	Infiltration basin	Preliminary Designs Completed	Water will be diverted of the HBDIC system	Completed	Unknown	Land is owned by ODOT. Discussions regarding purchase/donation of land.	Improve groundwater levels in an area of the shallow aquifer that has seen severe declines and could potentially help reduce groundwater gradient from the WWR and LWW systems. Also will help to raise regional groundwater levels to address the general decline in the aquifer reducing negative groundwater/surface interactions (seepage loss)	WWBWC - Steven; Unknown - Likely HBDIC
Little Walla Walla System	LL-1	Oregon	15 cfs - 5 cfs down the ELWW, 5 cfs down the WLWW, 5 cfs down Mud Creek	LL or Minimum instream flow	Historic distributary stream channels. Seepage analysis of both the East and West Little Walla Walla River systems suggest significant areas where passive recharge could be used to restore groundwater levels and improve spring performance.	None, passive recharge through channel bed seepage loss.	None needed unless culverts/canal improvements need to be done.	Unknown - possible turned out and managed by a combination of OWRD/ODFW.	None needed - existing stream	Develop more groundwater monitoring in the LWW area focusing on expanding our data logging coverage. More wells in the area between Cobb Rd and Sunnyside as well as farther north near Ferndale Rd. Increase well coverage in the lower East and West LWW systems. Continue monitoring surface locations throughout the WWRID and to the north in the spring branches. Look at surface sites on the lower end of the LWW system to gather better data.	Installation of Measuring Devices to allow water to be tailed into the lower LWW system. Getting an instream minimum flow requirement for the LWW during recharge months.	Provide passive recharge and instream minimum flows for increased recharge, habitat, and flow for aquatic animals and plants. Will address loosing sections of the LWW system as well as increase groundwater levels to reduce seepage loss from the mainstem WWR.	WWBWC - Steven; OWRD, ODFW, WWRID?
Hall-Wentland	LL-1	Oregon T6N R35E S14 NW-Q NW&SW-QQ	1-2 cfs	LL	Already done by GSI during initial recharge efforts in the late 2000's	Field Flooding Recharge	None needed unless modifications to the turn out structure needs to be done or modifications to the ditch system.	Unknown - possible turned out and managed by a combination of OWRD/ODFW. May require a minimum by-pass in the East LWW for the site to run like in the past?	N/A	Monitoring network good to the north, but water may be moving directly west and we have limited monitoring sites in that direction.	Getting enough water down the ELWW to allow for adequate recharge volumes	Increase groundwater levels in the lower LWW system and potentially help recover and increase spring flows in McEvoy spring and surrounding springs/creeks. Will also help raise groundwater levels to reduce seepage loss in the mainstem WWR and LWW system.	WWBWC - Steven; GSI - Limited License
Eastside Pit	ES-1	Oregon T6N R35E S36 NE-Q NW-QQ	5-10 cfs	LL	To be completed	Infiltration Basin within the existing pit	N/A	Water will be deliveried through the Eastside pipeline	N/A	N/A	Environmental concerns about the pit, water delivery through the eastside pipeline (owned by WWRID), landowner permission	Provide cool groundwater discharge to the Tumalum reach of the WWR helping to increase flows and reduce temperature. Recharge the eastside regional aquifer that has seen extreme (up to ~50 feet) declines. Restore groundwater levels to help reduce seepage loss from the Tumalum reach. Potentially create an alternate source of irrigation water by pumping from the recharge groundwater to allow for increased in-stream flows during critical fish migration periods or during critical low flow periods.	WWBWC - Steven; WWRID; Consulting Firm
Peterson / Redmond	ES-1	Oregon T6N R 36E S31 ???	1-2 cfs	LL	To be completed	Infiltration basin	N/A	Water will be deliveried through the Eastside pipeline	N/A	N/A	Water supply - WWRID cannot deliver recharge water. Permission from landowners	Provide cool groundwater discharge to the Tumalum reach of the WWR helping to increase flows and reduce temperature. Recharge the eastside regional aquifer that has seen extreme (up to ~50 feet) declines. Restore groundwater levels to help reduce seepage loss from the Tumalum reach. Potentially create an alternate source of irrigation water by pumping from the recharge groundwater to allow for increased in-stream flows during critical fish migration periods or during critical low flow periods.	WWBWC - Steven; WWRID; Consulting Firm
Yellowhawk	MC-2	Washington T6N R35E S12 NW-Q NW-QQ/S1 SW-Q SW-QQ	1-3 cfs	LWP/EEP	To be completed	Infiltration basin	N/A	Water would be diverted off Yellowhawk Creek into either a ditch or pipe towards the SW corner of the property.	N/A	GW_129 is an upgradient well that will be useful. Do other downgradient wells within the Mill Creek/WWR triangle. Mouth of Yellowhawk is currently monitored.	Geology may limit success of project. Delivering water from Yellowhawk Creek may be expensive, espcially depending upon geology.	Mitigate potential groundwater declines from pumping in the area. Provide cool groundwater returns to lower Yellowhawk Creek or the Walla Walla River.	WWBWC - Steven; WWWMP; GSI; John Wariner
Knowles	WLWW or GFID	Washington T6N R35E S8 NE-Q SE-QQ	1-1.5 cfs	LWP/EEP	To be completed	Infiltration basin / wetlands	N/A	Water would be diverted off WLWW to feed the project. Any overflow would spill back into WLWW.	N/A	N/A	Enough water in the WLWW to feed the system.	Increase groundwater returns in the WLWW increase flow and decreasing water temperatures. Help mitigate for the piping of the Burlingame Canal by replacing lost canal seepage. Create wildlife habitat in an area that already has CREP.	WWBWC - Steven; Little Walla Walla Working Group
Reser	WLWW or GFID	Washington T6N R35E S5 SE-Q NE/SE-QQ	2 cfs	LWP/EEP	To be completed	Infiltration basin / berms / wetlands	N/A	Water would be diverted off WLWW to feed the project. Any overflow would spill back into WLWW.	N/A	N/A	Enough water in the WLWW to feed the system.	Increase groundwater returns in the WLWW and WWR increasing flow and decreasing water temperatures. Help mitigate for the piping of the Burlingame Canal by replacing lost canal seepage.	WWBWC - Steven; Little Walla Walla Working Group

Site Location	Bundle	Location	Recharge Amount (at site)	Limited License / LWP / EEP	Characterization - HydroGeo	Design Type	Designs	Water Management, Delivery & Operations	Water Quality Plan	Monitoring Plan	Limiting Factors	Anticipated Benefits	WWBWC Staff Lead and Partners
Stiller Pond	MC-1	Washington T7N R35E S29 SW-Q SW-QQ	4 cfs	EEP/LWP	See GSI report on Stiller Pond	Infiltration pond	Complete	Water would be diverted from Mill Creek and deliveried to site through existing pipeline.	GSI - In Progress	Underdevelopment with GSI	Getting the EEP completed and adopted by WDOE.	Increase groundwater levels north of Mill Creek leading to increase groundwater returns to Mill Creek and/or the Walla Walla River. Increased groundwater returns will help increase flow and reduce water temperatures in a reach of the WWR that has historically had low flow and high temperatures.	WWBWC - Steven; WWCCD - Greg K; GSI
Gardena Creek Gravels	GFID	Washington T6N R33E S15 NW-Q NE-QQ	1 cfs	LWP/EEP	Gravels found at 10 feet bgs. May provide a local water storage area that will help spread recharge out. Needs to be investigated more.	Infiltration basin / gravel-filled hole	N/A	Water divertd of the north lateral and then sent into one of the lateral ditches coming down the hill	N/A	GSI	Extent of gravel beds may limit amount of recharge.	Provide a source of groundwater recharge to mitigate LWP that could result in increased groundwater pumping to leave water instream. Also could increase groundwater returns to lower WWR.	WWBWC - Steven; GFID - Stuart; GSI - Kevin Lindsey
Locher Pit	GFID	Washington T6N R35E S18 NE/SE-Q	3.5-5 cfs	LWP/EEP	See GSI reports on Locher Road	Infiltration basin	Complete	GFID controls diversion off the Burlingame Canal into Locher pit.	Completed - Revisons underway regarding WQ monitoring	Completed - Revisons underway regarding WQ monitoring	Required instream by-pass flows limits when site can run. GFID canal doesn't turn on until March limiting SAR during winter months.	Increase groundwater levels leading to increased groundwater discharges to springs, including Mud Creek, and filling the declined shallow aquifer.	WWBWC - Steven; GFID - Stuart; GSI - Kevin Lindsey