WWBWC Alluvial Aquifer AR Program Hydrologic Setting, Site Descriptions, and Proposed Surface Water and Groundwater Monitoring Plan

Supporting Materials for Limited License Application

AUGUST 2020

Walla Walla Basin Watershed Council
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1.0 INTRODUCTION AND PROGRAM GOALS

This document, and supporting appendices, was prepared to fulfill certain requirements in Oregon Administrative Rules (OAR) 690-350-0110 through 0130 in support of an application for an artificial recharge (AR) Limited License. The aquifer recharge program described herein will be administered and managed by the Walla Walla Basin Watershed Council (WWBWC), Hudson Bay District Improvement Company (HBDIC), Fruitvale Water Users Association (FWUR), and Walla Walla River Irrigation District (WWRID).

The AR program described herein includes seventeen aquifer recharge sites in the Walla Walla Basin of Northeastern Oregon. The recharge sites included in this project are referred to as Anspach, Barrett, Chuckhole, East Trolley Lane, Fruitvale, Gallagher, Johnson, LeFore Road, Locust Road, Miller Road, Mud Creek, North Sunquist, NW Umapine, Ringer Road, Ruby Lane, Triangle Road, and Trumbull (Figure 1). More than one recharge structure is present at some of these sites. All but three of these sites are active under Limited License LL1621, which will be superseded by the Limited License issued in response to this application. The sites not yet active are North Sunquist, Ruby Lane, and Miller Road. Upon issuance of the proposed Limited License operations at the three new sites will begin.

The general goal of the proposed aquifer recharge program is to reduce the degradation of the shallow alluvial aquifer for the benefit of people, the environment and wildlife. Specific goals of the program include: (1) stopping and reversing the groundwater level declines observed in the shallow alluvial aquifer system in portions of the basin; (2) reducing the hydraulic gradient away from streams and creeks in the valley to reduce surface water seepage, especially during dry summer months, and (3) increasing flows in spring creeks sourced in the alluvial aquifer.

This document includes the following:

- A summary of surface water hydrology and groundwater hydrogeology (Chapter 2).
- Descriptions of current and proposed new AR sites (Chapter 3).
- The proposed source water and groundwater monitoring plan (Chapter 4). The monitoring plan describes the proposed approaches to conduct water quality sampling to assess the quality of the source water and groundwater, monitor groundwater elevations and surface water discharge, and provide annual reports of the results.
- Shallow aquifer well information (Appendix A).
- WWBWC monitoring program standard operating procedures (Appendix B).
- More detailed description of Walla Walla Basin hydrogeologic setting than is presented in Chapter 2 (Appendix C).
- Aquifer recharge site designs (Appendix D).

With respect to ongoing work, in 2019 the WWBWC began working on a project under an Oregon Water Resources Department Water Conservation, Reuse, & Storage Grant. That project, entitled Enhancing the Reliability of the Alluvial Groundwater Supply in the Walla Walla Basin, is scheduled for completion in December 2021. Because it will not be completed until the end of 2021 there are no findings or conclusions from it used in this limited license application and its supporting documents.

2.0 HYDROLOGIC SETTING

2.1 SURFACE HYDROLOGY

The Walla Walla River system is a bi-state watershed located in northeast Oregon and southeast Washington (Figure 2). The headwaters are located in the Blue Mountains, the crest of which defines the eastern extent of the watershed. The Walla Walla River, Mill Creek and the Touchet River are the three primary streams in the system. They coalesce within the Walla Walla Valley then flow to the Columbia River. This report focuses on the Oregon portion of the basin, including the Walla Walla River and its distributary network, especially where they flow onto and across the Milton-Freewater alluvial fan.

At Milton-Freewater, the Walla Walla River exits a steep-walled canyon in the foothills surrounding the valley. Historically the river divided into a distributary stream system on an alluvial fan on the valley floor, and then, as the distributary streams flowed west, they coalesced into the main Walla Walla River. A similar pattern existed in the Mill Creek distributary system in Washington. Today the river and the distributaries are controlled and channelized. The distributary 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, the distributary channels conveyed large amounts of energy and water across the alluvial fan. The distributary channels and associated overbank areas provided habitat for aquatic species, recharge to the alluvial aquifer system, and cooler water to the Walla Walla River in the form of springs and subsurface inflows to the river resulting from recharge to the aquifer. A headgate installed in the Little Walla Walla River in the 1930’s shunted wintertime flows away from the Little Walla Walla River into the Walla Walla River, significantly reducing the system’s complexity. Then, in the 1950’s, seven miles of levees were constructed along the Walla Walla River to protect the Milton-Freewater area from flooding, severing the connection between the river and the floodplain and underlying alluvial aquifer. Increasing development led to increasing reliance on the alluvial aquifer as a source of water for irrigation and drinking.

In recent years, the listing of steelhead and bull trout as threatened under the Endangered Species Act and the reintroduction of spring chinook salmon led to out-of-court settlement agreements between irrigators and federal fishery agencies to enhance flows in the Walla Walla River. Since 2003, HBDIC and the Walla Walla River Irrigation District leave 25 to 27 cfs of their water rights in the river – roughly one-quarter of their typical summertime diversions during the 1990’s – further de-watering the Little Walla Walla River.

2.2 HYDROGEOLOGY

Groundwater in the Walla Walla basin occurs in two principal aquifer systems: (1) the unconfined to confined 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, primarily in the canyons of the Blue Mountains. The alluvial aquifer system is the focus of the AR program because of its high degree of hydraulic connection with streams on the valley floor. Preferential groundwater flow within the alluvial aquifer is inferred to largely reflect the distribution of coarse sedimentary strata. General groundwater flow direction is from east to west based on contoured groundwater elevations in the alluvial aquifer

(Figure 3). He following pages provide a summary of alluvial aquifer hydrogeology. For more details of area hydrogeology, the reader is referred to Newcomb (1965), GSI (2007, 2009a, 2009b) and WWBWC (2010), other citations as presented herein, and the more detailed review in Appendix C.

2.2.1 HYDROSTRATIGRAPHY

Following the terminology in GSI (2007) five alluvial sediment hydrostratigraphic units are mapped in the project area, the Quaternary fine unit, Quaternary coarse unit, Mio-Pliocene upper coarse unit, Mio-Pliocene fine unit, and Mio-Pliocene lower coarse unit. The Quaternary units are less than 1,000,000 years old while the Mio-Pliocene units probably range in age from 10,000,000 to 3,000,000 years old. The characteristics of these units are summarized below and described in more detail in Appendix C.

2.2.1.1 QUATERNARY FINE UNIT

Newcomb (1965) and several subsequent investigators (Fecht and others, 1987; Busacca and MacDonald, 1994; Waitt and others, 1994) described a variety of Quaternary aged fine (clay, silt, fine sand dominated) units in the Walla Walla Basin. Above elevations of approximately 1150 to 1200 feet above mean sea level (msl), these strata consist predominantly of loess. Isolated hills found on the valley floor and much of the upland area north of the Walla Walla River consist predominantly of Missoula flood deposited silt and sand referred to as the Touchet Beds. Reworked flood deposits and loess form local accumulations of fine strata across the valley floor near major streams. These strata are grouped into a single unit referred to as the Quaternary fine unit. The thickness of this unit varies greatly, depending on local topography, depth of stream incision, and original depositional patterns.

2.2.1.2 QUATERNARY COARSE UNIT

Uncemented and nonindurated sandy to gravelly strata is found in the shallow subsurface beneath much of the Basin. These gravely deposits are basaltic, moderately to well bedded, have a silty to sandy matrix, and contain thin, local silt interbeds. These uncemented and nonindurated basaltic gravels generally are equivalent to Newcomb's (1965) younger alluvial sand and gravel and are referred to currently as the Quaternary coarse unit. This sequence of uncemented gravel is interpreted to record stream deposition in the Walla Walla Basin by streams draining off the adjacent Blue Mountains. These streams are inferred to include the ancestral courses of the modern stream drainage. Based on stratigraphic relationships the Quaternary coarse unit predates, is contemporaneous with, and post-dates Missoula flood deposits. Given this, the Quaternary coarse unit probably ranges in age from a few years old to as old as 1 million years or more.

2.2.1.3 MIO-PLIOCENE UPPER COARSE UNIT

The Mio-Pliocene upper coarse unit consists of a sequence of variably cemented sandy gravel, with a muddy to sandy, silicic to calcic matrix. This unit underlies much of the Walla Walla Basin. Field reconnaissance reveals thin, localized, discontinuous caliche at the top of these strata at some locations. Based on physical characteristics displayed by analogous strata in rare outcrops, field reconnaissance, and a small number of borehole log descriptions these strata are predominantly basaltic in composition and typically have a slight too strong red, red brown, and yellow brown color. The Mio-Pliocene upper coarse unit generally is continuous beneath the entire Basin, being absent only in a few, relatively small areas. Isopach data for this unit shows that it varies greatly in thickness, ranging from just a few feet thick to over 500 feet thick.

2.2.1.4 MIO-PLIOCENE FINE UNIT

The Mio-Pliocene upper coarse unit generally is underlain by fine deposits variously described as silt, clay, sandy clay, and sandy mud having blue, green, gray, brown, and yellow colors. These strata are designated the Mio-Pliocene fine unit. This unit is thickest in the northeastern, north, central, and western Basin where it can range between 300 and 500 feet thick. These areas generally are located north and west of areas of thickest accumulation of the overlying Mio-Pliocene upper coarse unit. Depositional, erosional, and structural factors similar to those that are interpreted to affect the overlying unit also are interpreted to have had a role in controlling Mio-Pliocene fine unit distribution.

2.2.1.5 MIO-PLIOCENE BASAL COARSE UNIT

The basal coarse unit consists of arkosic-micaceous sand and silt in the basal portion of the Mio-Pliocene section directly overlying basalt. These strata form an interval several tens of feet to over 100 feet thick. This unit, with its distinctive arkosic mineralogy, is very different petrographically from other strata comprising the Mio-Pliocene sequence in the Basin. Because of this distinctive mineralogy, this unit is inferred to have been deposited by the ancestral Salmon-Clearwater River, which entered the Basin from the north.

2.2.1.6 TOP OF BASALT

The alluvial sequence overlies the Columbia River Basalt Group (CRBG) beneath the entire basin area. The top of the CRBG, while irregular, forms the base of the alluvial sequence, and it generally appears to dip downwards off the highlands surrounding the Basin, in to the center of the Basin. Given this, the top of basalt in the Basin ranges from the ground surface around the basin margins, to a depth of over 800 feet near the center of the basin.

2.3.2 ALLUVIAL AQUIFER HYDROGEOLOGY

Most of the alluvial aquifer is hosted by Mio-Pliocene strata, although the uppermost part of the aquifer is found, at least locally, 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.

2.3.2.1 AQUIFER PROPERTIES

Given the physical properties of the Quaternary course unit (non-indurated sand and gravel) versus those of the Mio-Pliocene upper coarse unit (e.g., finer matrix and the presence of naturally occurring cement), the Mio-Pliocene upper coarse unit probably has generally lower permeability and porosity than the Quaternary coarse unit. Consequently, alluvial aquifer groundwater flow velocities are inferred to be less where the water table lies within the Mio-Pliocene strata and/or the gradients are higher than where it lies within the younger, more permeable Quaternary strata.

In addition, where the Quaternary coarse unit is saturated, this uncemented, high permeability gravel and sand may form preferred pathways for groundwater movement and areas of increased infiltration capacity in the shallow parts of the alluvial aquifer system.

Basin-wide estimates of the hydraulic properties of alluvial aquifer system were made by Barker and MacNish (1976) as part of their effort to produce a digital model of this aquifer system. This modeling work used estimated hydraulic conductivity of $1.5x10^{-4}$feet/second to $7.6x10^{-3}$ feet/second and transmissivity of 10,000 $feet^2$/day to 60,000 $feet^2$/day for the entire alluvial aquifer system.

Recent work by Northwest Land & Water, Inc. (NWLW, 2019) provides additional insight into hydrogeologic conditions in the area east of the Walla Walla River. Based on pumping and slug tests they report hydraulic conductivity of approximately 210 to 610 feet/day, transmissivity of approximately 2,400 to 16,600 $feet^2$/day, and a storativity ranging from approximately 0.01 to 0.005 in the shallow parts of the alluvial aquifer in the eastside area. NWLW (2019) also provides calculated hydraulic diffusivity ranging from 300 to 200,000 $feet^2$/day in that same area.

2.3.2.2 GROUNDWATER LEVEL AND FLOW DIRECTION

Recent efforts by the WWBWC have begun to build a picture of alluvial aquifer water level conditions in the eastern and southern Walla Walla Basin. Based on these efforts the following basic observations relative to alluvial aquifer water level and flow direction can be made:

- West of the Walla Walla River groundwater flow in the alluvial aquifer system generally is from east to west. Locally this flow may converge towards the Walla Walla River and other streams where the alluvial aquifer water table is higher than the stream. Where this occurs, streams are, in part, fed by groundwater discharge. However, along many reaches of the Walla Walla River and other streams in the Basin, the alluvial water table may at least locally be below the bed of the stream during some or all of the year. When and where this occurs, such stream reaches probably lose water to the alluvial aquifer, thus acting as a recharge source for groundwater.
- East of the Walla Walla River groundwater flow direction is generally from the south to the north and northwest (NWLS, 2019), parallel to and towards the Walla Walla River.
- Water level within the alluvial aquifer varies seasonally. Barker and MacNish (1976, p. 25) determined that the month of January was the time of year when this aquifer is under the smallest amount of pumping stress and that water table most reflect unmodified conditions. In some portions of the Basin, seasonal changes in the water table elevation can be as great as 50 feet (Newcomb, 1965; Pacific Groundwater Group, 1995).

Groundwater level declines have been ongoing for many years, although recent AR efforts have reversed these trends at least locally near existing sites, in particular the Johnson site (WWBWC, 2010 and WWBWC, 2014b). Out of 11 long-term state observation wells, all had downward trends and three were completely dry by 2009. Declines at GW_16 and GW_19 illustrate long-term trends in portions of the aquifer.

Because of the interconnectedness between the alluvial aquifer and the streams in the basin, declining groundwater levels result in decreased groundwater contributions to the Walla Walla River and other surface waters, including during critical low-flow periods. The loss of groundwater to streams affects not only the amount of flow in the river but also leads to increased surface water temperature during the low-flow periods, affecting aquatic species and the stream ecosystem. Historically, the estimated yield from 57 mapped springs on the Milton-Freewater and Mill Creek alluvial fans was 50,000 ac-ft (Oregon State Water Resources Board, 1963), or 69 cfs on an annual basis. In contrast, in 2017 the annual discharge from five of the largest springs sourced in the Milton-Freewater alluvial fan was 15.5 cfs (WWBWC, 2019). Flows at McEvoy and Dugger springs were 4-6 cfs and 8-10 cfs, respectively, during summers in the 1930's; by 2009 both springs were dry for portions of the year. However, even under altered modern conditions, groundwater still provides a cooling function to the river.

2.3.2.3 ALLUVIAL AQUIFER WATER QUALITY

Historical water quality data available include a groundwater quality report prepared by Richerson and Cole (2000) and source water and groundwater quality reporting done for AR program (GSI, 2009a, 2009b; WWBWC, 2014, 2015, 2016, 2017, 2018) sites. Based on Richerson and Cole (2000), the Johnson site data (WWBWC, 2010), and groundwater quality data collected from other AR sites in the Walla Walla Basin:

- Nitrate-N, TKN, phosphate, and orthophosphate concentrations measured in groundwater have not been significantly affected by AR activities. In addition, the groundwater down gradient of AR sites generally show declines in constituent concentrations, which are interpreted to reflect dilution of ambient groundwater concentrations by lower concentration AR water.
- Other parameters, such as TDS, chloride, and electrical conductivity also commonly show evidence of down gradient reductions attributed to AR activities. These trends are interpreted as evidence of dilution of these parameters in groundwater by AR water.
- Ammonia, copper, iron, and zinc concentrations in also do not show effects that can be linked to previous AR activities. In fact, source water concentrations of these constituents are very low and are interpreted to not be affecting groundwater at all.

Box plots (Figure 4) comparing historical source water to groundwater concentrations show that source water (surface water) collected in the canal system feeding the AR sites displays significantly lower constituent concentrations than is seen in the alluvial aquifer.

3.0 AQUIFER RECHARGE SITES

The 14 existing and 3 proposed new AR sites (Figure 1, Tables 1 and 2) are intentionally distributed across the Milton-Freewater alluvial fan. The spacing is intended to mimic, to the extent possible given land ownership and water delivery infrastructure, the floodplain process of recharge to the aquifer that has been lost because of stream channelization and flood control. Table 2 lists estimates of recharge volumes and conveyance losses between the point of diversion and the recharge sites.

The remainder of this section summarizes the physical layout and operation of the existing (Section 3.1) and proposed new (Section 3.2) AR sites. In addition, purpose-built monitoring wells (monitoring wells) and existing wells in the vicinity of each site are noted. Physical details of these wells are presented in Appendix A. The use of these wells for water quality monitoring and/or water level monitoring are noted in Appendix A, in the following descriptions, and in the monitoring plan presented in Chapter 4.

3.1 EXISTING AR SITES

3.1.1 ANSPACH

The Anspach site consists of two infiltration galleries constructed in 2012 and the fall/winter of 2015. The site is located northwest of Milton-Freewater, OR, east of Winsap Road and north of County Road in NW ¼, NW ¼, Sec. 30, T6N, R35E (Figures 1 and 5). Recharge rates for the combined galleries have ranged from 0.1 to 3.5 cubic feet per second (cfs). The site was built in a field that had been an apple orchard before siting fallow for at the 14 years prior to construction. Recharge source water is diverted from the Hudson Bay District Improvement Company (HBDIC) White Ditch canal west of its intersection with the Old Milton Highway/Lamb Street. At a weir structure, water is diverted south through a pipeline to the project. HBDIC and the WWBWC manage the diversion of recharge water from the canal to the recharge site. There are two wells onsite (GW_135 and GW_141). GW_135 is an abandoned irrigation well located at the up-gradient, southeastern corner of the site and GW_141 is a monitoring well at the up-gradient, northeastern corner of the site. Another abandoned irrigation well (GW_23) is located generally down gradient of, and west southwest of, the site. GW_135 and GW_23 have been adapted for use in the WWBWC water level monitoring network.

3.1.2 BARRETT

The Barrett site is an infiltration gallery constructed in January 2014. The site is located approximately 1.5 miles northwest of Milton-Freewater, OR between County Road and Chuckhole Lane in SW ¼, SE ¼, Sec. 34, T6N, R35E (Figures 1 and 6). Average recharge rates have been 0.7 to 1.8 cfs. The site was built in a field that has been fallow since the early 1990s. Recharge source water is delivered from the Barrett pipeline to the infiltration gallery. HBDIC manages the diversion of water to the site. One well, GW_62, is in the immediate vicinity of this site, located up-gradient of the facility. Another existing well, GW_150, is located down-gradient of the site. These wells are water wells adapted for use in the WWBWC water level monitoring network.

3.1.3 CHUCKHOLE

The Chuckhole site is located approximately one-mile northwest of Milton-Freewater, OR near the south end of Chuckhole Lane in SW ¼, NE ¼, Sec. 3, T5N, R35E (Figures 1 and 7). The site consists of two basins -- a sediment trap basin and an infiltration basin. The site was constructed in the fall of 2015 and began operations in WY2017. Average recharge rates have been lower than expected, less than 0.5 cfs. This site was constructed in a vacant corner of a vineyard; the corner had not been utilized for at least 20 years. The adjacent field has been cultivated as a vineyard for approximately 10 years and before that it was apple orchard (at least to the early 1990s). Recharge source water is delivered from the Milton Pipeline into the project. The landowner is responsible for operating the diversion into the site. Existing wells in the area include GW_23, GW_62, and GW_169. GW_23 and GW_62 are existing wells adapted for use in the WWBWC water level monitoring network. Well GW_62 is a monitoring well installed up-gradient of the site.

3.1.4 EAST TROLLEY LANE

The East Trolley Lane site is an infiltration gallery constructed in late 2013 and first operated in November 2017. The site is located east of Trolley Lane and approximately 0.5 miles south of the Oregon/Washington border in SW ¼, SE ¼, Sec. 15, T6N, R35E (Figures 1 and 8). Average recharge rates have been 0.5 cfs due to limited water availability. The infiltration gallery was built between an apple orchard and the county road. This field has been used as an apple orchard since at least the early 1990s. Recharge water is delivered down the Ford branch to the West Little Walla Walla River and then diverted down the Trolley Lane pipeline to the project. WWBWC staff operates the diversion into the Trolley Lane site. A monitoring well, GW_151, is located immediately north (down-gradient) of the infiltration gallery.

3.1.5 FRUITVALE

The Fruitvale recharge site is located approximately 3.5 miles northwest of Milton-Freewater, OR near the intersection of Sunquist Road and Fruitvale Road in NE ¼, NW ¼, Sec. 21, T6N, R35E (Figures 1 and 9). The site is an infiltration gallery with an average recharge rate of 0.2 cfs. The Fruitvale site was constructed in the fall of 2015 and began operations in WY2017. The site was constructed in an existing wheat/alfalfa field. The land has historically (since the early 1990s) been in a wheat/alfalfa rotation; however, there have been times when a portion of the land was planted in corn. Recharge source water is delivered from the Fruitvale ditch. The landowner is responsible for operating the diversion into the site. There are two wells in the area, GW_33, a water well adapted for use in the WWBWC water level monitoring network, and GW_171, a monitoring well.

3.1.6 GALLAGHER

The Gallagher recharge site is located approximately 0.75 miles southeast of Umapine, OR in SE ¼ and SW ¼ of Sec. 30, T6N, R35E (Figures 1 and 10). The site has an infiltration gallery and an infiltration basin. The site has not yet operated except for a few days in WY2019. Based on the first few trial days, the expected recharge rate is 0.5 cfs. The site consists of land that has been fallow, used as a pasture, or used for farm equipment storage since the 1990s. This site is connected to the White ditch and fed from the HBDIC system. The landowner and WWBWC jointly manage the diversion for this site. There are three wells in the area. Two of the wells, GW_36 and GW_66 are existing water wells used to monitor water levels in the WWBWC water level monitoring network. The other well, GW_119, is a monitoring well used for water quality and water level monitoring.

3.1.7 JOHNSON

The Johnson site consists of 10 infiltration basins and 3 infiltration galleries. The site is located approximately 2.5 miles northwest of Milton-Freewater, OR between County Road and Prunedale Road in SE ¼, SW ¼, Sec. 33, T6N, R35E (Figures 1 and 11). The original site was constructed and began operating in 2004 and expanded in subsequent years. Average recharge rates for the fully expanded site have been 12 to 15 cfs. The site was constructed on ground that had been fallow since at least the mid-1990s but historically was used to grow cherry tree starts. Recharge source water is delivered to the site from the White Ditch. Water delivery and infiltration basin operation is managed by the HBDIC. The infiltration galleries are managed by the WWBWC. There are 6 wells on or very near the site, including: 1 up-gradient well (GW_40), one mid-site well (GW_45), and 4 down-gradient wells (GW_46, GW_47, GW_48, and GW_118). Wells GW_45, GW_46, GW_47, and GW_48 are monitoring wells drilled and constructed as part of original site construction and have been used at various times for water quality monitoring. GW_118 is also a monitoring well. All wells are included in the basin-wide WWBWC water level monitoring network.

3.1.8 LeFore Road

The LeFore Road site is an infiltration gallery located immediately northeast of Milton-Freewater, OR and north of LeFore Road in NE ¼, SW ¼, Sec. 36, T6N, R35E (Figures 1 and 12). The site was constructed in October 2014. The first and only year of operation to-date was WY2018. Site operations will resume under the proposed new limited license. The average recharge rate was 0.7 cfs. The site was built between an existing apple and cherry orchard, and the land it is on has been utilized as apple/cherry orchards since at least the early 1990s. Recharge source water is delivered from a private pressurized pipeline into the infiltration gallery. WWBWC and the landowner are responsible for operating the diversion into the site. There are two monitoring wells in the immediate area. GW_152 is immediately up-gradient of the site and GW_160 is down-gradient of the site.

3.1.9 Locust Road

The Locust Road recharge site is located approximately 1.0 mile north of Milton-Freewater, OR in SE ¼, NE ¼, of Sec. 35, T6N, R35E (Figures 1 and 13). The site is an infiltration gallery constructed in the fall of 2016. In WY2018, its first year of operation, the average recharge rate was 0.6 cfs. The site consists of land that has been used as a cherry orchard since at least the early 1990s. Recharge source water is delivered from the East Branch Crockett ditch into the infiltration gallery. The landowner is responsible for operating the diversion into the site. There are two wells in the area, GW_14 and GW_116. GW_14 is an existing water well used to monitor water levels and GW_116 is a monitoring well built in 2009. These wells are used for water level monitoring in the WWBWC water level monitoring network.

3.1.10 Mud Creek

The Mud Creek site is located approximately 2.5 miles northwest of Milton-Freewater, OR between State Route 332 and Triangle Road in NW ¼, NW ¼, Sec. 27, T6N, R35E (Figures 1 and 14). The site consists of one infiltration basin with average recharge rates of 0.1 to 0.3 cfs. The site was constructed in the fall of 2015 in a pasture and began operating in WY2017. The land has been in pasture grass since at least the early 1990s. Recharge source water is delivered from the Fruitvale ditch into the infiltration basin. The Fruitvale Water Users Association is responsible for operating the diversion into the site. Existing wells in the area include an existing water well up-gradient of the site, GW_117, and a monitoring well installed near the site (GW_170).

3.1.11 NW UMAPINE

The NW Umapine site is an infiltration basin constructed in 2013. The site is located approximately 0.5 miles northwest of Umapine, OR and the intersection of Umapine-Stateline Road with State Road 332 in SW ¼, SE ¼, Sec. 24, T6N, R34E just (Figures 1 and 15). Average recharge rates are 1 to 1.9 cfs. The site was constructed in a pasture, which had been used as pasture for at least the last 5 years. Prior to that it was farmed with a wheat/alfalfa rotation. Recharge source water is diverted from the Richartz pipeline to the basin. HBDIC manages the diversion of water to the site by a turn out from the Richartz pipeline. There is a monitoring well (GW_144) on the site and several other wells in the area of it. Wells in the area of the site include GW_34, GW_36, GW_66 and GW_119, all of which are part of the WWBWC water level monitoring network. GW_119 is a monitoring well.

3.1.12 RINGER ROAD

The Ringer Road site consists of two infiltration galleries. One uses perforated pipes and the other uses storm water chambers. The site is located west of Ringer Road, just south of the community of Umapine in SW ¼, NE ¼, Sec. 25, T6N, R34E (Figures 1 and 16). The first infiltration gallery was constructed in late 2013 and began operating in WY2018 while the second infiltration gallery was constructed and began operating in the fall of 2018. The average recharge rate during the first year of operation of the newer gallery was 2.4 cfs. Both galleries were built along the edge of and under a portion of a field that has had a wheat/alfalfa rotation since the 1990s. Water is delivered to this project in one of two routes. The primary route is down the HBDIC's Richartz canal and then into Dugger ditch via the pipeline overflow. The secondary route is down the White ditch, into Dugger Creek and then into Dugger ditch. WWBWC is responsible for operating the diversion at this site. Wells in the general area of the site include GW_36, GW_66, GW_119 and GW_144. GW_119 and GW_144 are monitoring wells that are part of the WWBWC water level monitoring network. The remaining wells are water wells adapted for use in the water level monitoring network.

3.1.13 TRIANGLE ROAD

The Triangle Road site is located approximately 3.5 miles northwest of Milton-Freewater, OR in NE ¼, NW ¼, Sec. 27 T6N, R35E (Figures 1 and 17). The site is an infiltration basin with a recharge design capacity of 1 cfs. The site was constructed in the fall of 2016. The average inflow rate during the first year of operation, WY2018, was 0.9 cfs. The site was built on land that has been an orchard lane/fruit box storage area. Historically the land has been utilized as an orchard since the early 1990s with a few years of fallow ground. Recharge source water is delivered from the Fruitvale ditch into the basin. The Fruitvale Water Users Association is responsible for operating the diversion into the site. Wells in the vicinity of the site include two monitoring wells (GW_170 and GW_171) down-gradient of this site, one monitoring well is up-gradient of the site (GW_117), and another monitoring well cross-gradient to the site (GW_143).

3.1.14 TRUMBULL

The Trumbull site is an infiltration gallery constructed in late 2012 and operational since 2013. The site is located approximately 2.5 miles northwest of Milton-Freewater, OR between the Umapine Highway and Trumbull Road in NW ¼, SW ¼, Sec. 27, T6N, R34E (Figures 1 and 18). The average recharge rate is 0.8 to 2.1 cfs. The site was built in a fallow field that has since been converted to a vineyard. Historically this land was utilized as cherry/apple orchards. The current vineyard is approximately 50 yards away from the infiltration gallery. Recharge source water is delivered to the site from the HBDIC Canal. HBDIC manages the diversion of water to the site.

There are no monitoring wells located at the site, however, an existing purpose-built monitoring well (GW_117) that is included in the WWBWC water level monitoring network is located approximately 0.3 miles east and up-gradient of the site. Two monitoring wells, GW_142 and GW_143, are located approximately 0.3 to 0.75 miles to the west and northwest of the Trumbull site, respectively. These locations are generally down gradient of the site.

3.2 PROPOSED NEW SITES

3.2.1 MILLER ROAD

The Miller Road site is located immediately north of Miller Road and east of Eastside Road, at the head of an apple orchard (Figures 1, 19, and 20). The site consists of one infiltration gallery. The expected average recharge rate is 1 cfs. The site was constructed in 2019 but has not yet operated, pending approval of the limited license. Existing wells in the area include GW_160, located at the recharge site, GW_152 up-gradient of the recharge site, and GW_162 and GW_163 down-gradient of the site.

The site is underlain by approximately 160 to 180 feet of alluvial strata overlying basalt. The upper half of this sequence is interpreted to be higher permeability sand and gravel, the lower half of the alluvial sequence is interpreted to be lower permeability older strata, and the water table at the site is expected to be approximately 60 to 80 feet below ground surface (NWLW, 2019). A geologic cross-section of the site is shown on Figure 21.

3.2.2 NORTH SUNQUIST

The North Sunquist site is an infiltration basin located approximately 4.5 miles northwest of Milton-Freewater, OR in NE ¼, NE ¼, Sec. 20, T6N, R35E (Figures 1, 22, and 23). The design was intended to recharge 1 cfs. The site was constructed in 2018 but has not yet operated, pending submittal and approval of the LL. The site is built on land that has been a pasture. The source water is from the Fruitvale ditch. The Fruitvale Water Users Association is responsible for operating the site. Figure 22 shows the expected layout of the site.

The site is underlain by approximately 730 feet of alluvial strata overlying basalt. The upper 250 feet of this sequence is interpreted to predominantly be higher permeability sand and gravel, the lower 480 feet of the alluvial sequence is interpreted to be lower permeability older strata. A geologic cross-section of the site is shown on Figure 24.

3.2.3 RUBY LANE

The Ruby Lane site will be located immediately south of Ruby Lane and approximately 0.1 miles east of Highway 339, northwest of Milton-Freewater in the SW ¼ NE ¼ Sec. 26 T6N R35E (Figure 1). The site is planned to be an infiltration gallery with a recharge capacity of approximately 1 cfs. The location of the gallery is an unused pasture which was last used for livestock. Recharge water will be delivered by the Walla Walla River Irrigation District through the West Crockett branch of the East Little Walla River.

The site is underlain by approximately 560 feet of alluvial strata overlying basalt. The upper 250 feet of this sequence is interpreted to predominantly be higher permeability sand and gravel, the lower 310 feet of the alluvial sequence is interpreted to predominantly be lower permeability older strata. A geologic cross-section of the site is shown on Figure 25.

4.0 MONITORING PLAN

Water quality data previously collected in support of earlier AR efforts have shown that these AR activities have not degraded alluvial groundwater quality (GSI, 2009a, 2009b, 2012, WWBWC 2010, 2014-2019) and have often improved water quality. Given these observations, the dispersed nature of the individual AR sites, and the common source water for the proposed AR program, the monitoring approach described herein focuses on evaluating the effects of each recharge season on water quality using a dispersed but integrated monitoring network that builds on the results of previous AR activities.

This section describes proposed water quality and water level monitoring to be performed in support of the AR program. All monitoring will follow the WWBWC Watershed Monitoring Program Standard Operation Procedures provided in Appendix B.

4.1 WATER QUALITY

4.1.1 HISTORICAL WATER QUALITY MONITORING

Water quality monitoring for the WWBWC AR program has historically been done to track source water quality and groundwater quality changes in response to AR. Source water quality has been monitored at several locations throughout the canal/pipe system supplying water to the AR sites. Groundwater quality has been monitored in monitoring wells throughout the project area. Some of these wells are close to AR facilities and some are more distant. These data (GSI 2012; WWBWC 2014, 2015, 2016, 2017, 2018, 2019) collected as part of the WWBWCs ongoing AR efforts were evaluated to provide a context for the monitoring efforts proposed herein and are attached in Appendix E.

These data indicate post-recharge groundwater concentrations are less than pre-recharge in 64% of the samples (Table 3). Where constituent concentrations are higher after the recharge season, measured source water concentrations in the corresponding recharge season are less than those measured in groundwater (GSI 2012; WWBWC 2014, 2015, 2016, 2017, 2018, 2019). Of the samples in which post-recharge groundwater concentrations were greater than pre-recharge, source water concentrations were greater than in groundwater in 14, or 1.2% of the samples. Of these 14 samples, 10 were for iron, in which source water was greater than groundwater by an average of 0.15 mg/L. The other four samples were for calcium, nitrate, and potassium, with average increases of 0.1, 0.4, and 0.1 mg/L, respectively. Based on these data the observed elevated concentrations result from activities other than AR.

These historical groundwater quality data also show increasing constituent concentrations in the downgradient direction, from east to west, across the project area. Because source water quality is largely unchanged from up gradient to down gradient (WWBWC 2014, 2015, 2016, 2017, 2018, 2019), the cause of the observed increases in down gradient groundwater quality, such as are seen in monitoring wells GW_119, GW_144, GW_171 and GW_151, are interpreted to be other than the AR program. These data also show that for most of the analyzed constituents, source water concentrations are usually less than groundwater concentration, both up gradient of and down gradient of AR site (Figure 4).

4.1.2 Proposed Programmatic Water Quality Monitoring Approach

The water quality monitoring program proposed herein for the multi-site AR program will compare source water quality data with groundwater quality data to assess the impacts on the entire AR program area. Water quality will be evaluated through measuring field parameters and obtaining grab samples for lab analyses of basic water quality constituents (cations, anions, metals, etc.) and synthetic organic compounds (SOC). However, based on the water quality data collected to-date the water quality monitoring program proposed herein differs from the previous AR efforts.

These changes are summarized below and described further in the following sections.

- Several constituents are dropped from the previous list because they are not being detected.
- There are several changes to laboratory analytical technique because of inherent problems in the previously used techniques.
- Fewer groundwater quality monitoring locations are proposed because:
    - Fifteen years of accumulated water quality monitoring data does not show degradation of native groundwater quality resulting from the AR program, and
    - Several groundwater monitoring wells are so distal from any AR facility that any observed water quality change that may occur cannot be tied to a specific AR facility because of intervening land uses.

4.1.3 Water Quality Sampling Locations

4.1.3.1 Groundwater Locations

Groundwater quality monitoring will be conducted at monitoring points located to evaluate overall AR program impacts on up-gradient and down-gradient water quality for the multi-site AR program. Data from these wells, when combined with the source water data collected at the five locations named in the following section, will be used to interpret water quality impacts of the entire AR program. The proposed ground water monitoring locations fall into the following basic categories:

- Monitoring well GW_141 will provide up-gradient groundwater quality information for the program area west of the Walla Walla River.
- Monitoring wells GW_46 and GW_170 will provide groundwater quality information for the area west of the Walla Walla River generally encompassing the middle of the program area.
- Monitoring wells GW_144, GW_171, and GW_151 will provide down-gradient groundwater quality information for the program area west of the Walla Walla River.
- Monitoring wells GW_152 (up-gradient) and GW_160 (down-gradient) will provide groundwater quality information for the Eastside program area.

Refer to Figure 26 for groundwater quality monitoring locations and Table 4 for the characteristics of these wells.

Three previously sampled groundwater monitoring wells (GW_117, GW_119, and GW_169) are not included in the proposed AR program. GW_117 is dropped from the program because it is essentially downgradient from GW_141 with no intervening AR facilities. GW_119, which is upgradient of several recharge sites is dropped from the program because it displays anomalously high concentrations of many constituents that do not reflect any of the measured source water concentrations, nor is it similar to the next set of wells upgradient of it with no intervening recharge site. These other wells are at the Johnson site and one of them (GW-46) provides good coverage for water downgradient of that recharge site. With no intervening recharge site between it and GW-_119, yet the strikingly different water quality at GW_119 monitoring at this later well is not reflecting MAR program conditions but something unrelated. GW_169 is dropped from the program because it is next to the basalt bluffs west of Milton-Freewater and likely is not reflective of any other portion of the AR program.

4.1.3.2 SURFACE WATER LOCATIONS

Source water quality sampling will be conducted at five locations (Table 5) within the canal and pipeline recharge water conveyance system, as follows:

- Source water monitoring location WQ-1 is in the White Ditch canal up-stream of the diversion to the Anspach site. Samples from this location represent source water diverted to the Anspach, Barrett, Chuckhole, Locust Road, and Ruby Lane sites. This location is also representative of the source water delivered to the Chuckhole site from the Milton pipeline. Additionally, this location is up-stream of all recharge sites and is considered representative of incoming source water conditions.
- Source water monitoring location WQ-2 is at the Duff Weir (White Ditch & Hudson Bay Canal split) upstream of the diversion for the Johnson, Gallagher, Ringer Road, and Trumbull sites.
- Source water monitoring point WQ-3 is at the Huffman-Richartz Weir (start of Huffman & Richartz pipelines) upstream of the NW Umapine and Ringer Road sites.
- Source water monitoring point WQ-4 is at the Fruitvale Weir upstream of the Mud Creek, Fruitvale, Triangle Road, North Sunquist and East Trolley Lane sites.
- Source water monitoring point WQ-5 is at the Eastside diversion upstream of the LeFore Rd and Miller Rd sites.

Refer to Figure 27 for source water quality sampling locations.

4.1.4 WATER QUALITY PARAMETERS

The water quality parameters proposed in this application are based on previous and on-going AR operations in the Walla Walla basin that use similar source water. These parameters are considered to be most representative of the potential for AR degradation of alluvial aquifer groundwater quality, based on recharge water sources, adjacent land use and a review of AR data collected to date at several sites in the Walla Walla Basin as cited previously in this document.

4.1.4.1 FIELD PARAMETERS

Field parameters will continue to include temperature, specific conductance, pH, and dissolved oxygen. Table 6a lists these parameters and their associated sample matrix, analytical method, and sampling frequency.

4.1.4.2 INORGANIC AND METAL PARAMETERS

Proposed inorganics and metals for laboratory analysis are calcium, iron, magnesium, nitrate-N, phosphorus, potassium, sodium, and sulfur. Ammonia-N, copper, manganese, and zinc (previously sampled) are not proposed for inclusion in the new application because the previously collected data has normally been very low to non-detect. Table 6b lists these parameters, their associated sample matrix, analytical methods, and sampling frequency. In addition, Table 6b lists the SOC's to be sampled and analyzed for in monitoring wells GW_144 and GW_171 at the end of season sampling event (typically in mid-May).

4.1.5 WATER QUALITY SAMPLING SCHEDULE

Recharge source water and groundwater samples will be collected at monitoring points described above twice each recharge season. The first sampling event will occur before or within one (1) week of the start of recharge operations (Typically in early November). The second sampling event will occur within one (1) week after termination of each recharge season (typically in mid-May). During the second sampling event SOC sampling will also be done. This is the same timing as has been used in previous work on the AR program.

4.1.6 SAMPLING PROCEDURES & EQUIPMENT (EXTRACTED FROM WWBWC'S SOP)

4.1.6.1WATER QUALITY SAMPLING (GROUNDWATER)

Groundwater sampling will be conducted utilizing the following equipment and procedures. The general overview of groundwater sampling includes gathering equipment, measuring the initial water level, installing a submersible pump in the well, purging the well at a low flow rate, collecting and labeling all required samples and delivering them to the lab or shipping company.

Note: this procedure is modified from:

Marti, 2011. Standard Operating Procedure for Purging and Sampling Monitoring Wells. Washington State Department of Ecology – Environmental Assessment Program. EAP078.

Equipment

- Sampling field data sheets (see below) or field notebook
- Chain of Custody form
- Water level measuring equipment (e-tape)
- Water quality meters and probes (Temperature, Specific Conductance, pH & Dissolved Oxygen)
- Submersible pump
- Pump controller
- Tubing and connectors
- Sample bottles/containers
- Cooler
- Ice
- Deionized water
- Non-phosphate soap
- Nitrile or latex gloves
- First aid kit
- Well keys
- Camera
- Paper towels or clean rags
- Plastic sheet for keeping equipment clean
- Buckets (5-gallon or similar for purge volumes)
- 1 liter container (for purge volumes)

- Socket set
- Screwdriver(s)

Purging and Sampling

1. Check well for any changes or potential hazards.
2. Make sure equipment has been cleaned and decontaminated (see below for details). Spread plastic or other material if needed to keep equipment clean.
3. Wear clean disposable gloves (latex or Nitrile) while performing purging and sampling. If gloves become contaminated or dirty replace with new gloves.
4. Make sure field water quality meters are calibrated according to the manufacturer's instructions.
5. If well is equipped with a pressure transducer, note how it is installed and its position to replace it after sampling. Remove the pressure transducer from the well. Note the time the pressure transducer was removed from the well on the data sheet or in the field notebook.
6. Measure the static water level in the well (see Groundwater Level and Temperature protocol below for details).
7. Measure the depth of the well or refer to the well log to determine the depth of the well.
8. Calculate the length of the water column. Calculate the volume of water in the well using the following values: 2" well = 0.1631 gallons per linear foot, 4" = 0.6524 gallons per linear foot (Equation used for water volume calculation – Volume (gal/ft) = πr^2 (7.48 gal/ft^3) where r is the radius of the well and 7.48 is the conversion factor).
9. Install the submersible pump into the well. Be sure to slowly lower the pump into the well and through the water to avoid stirring up particulates. Place the pump in the middle of the screen section of the well (refer to well log to determine the open interval for pump placement).
10. Once the pump is installed correctly re-measure the static water level to monitor during purging.
11. Start purging. Set the pump controller to the desired pumping rate (~1 liter/minute). See notes from previous sampling for pumping rate.
12. Ideally, wells should be purged and sampled at flow rates at or less than the natural flow conditions of the aquifer in the screen interval to avoid drawing down the water level in the well. Use water level measurements to help adjust pumping rates to prevent well drawdown. Purging should not cause significant drawdown (considered to be 5% of the total height of the water column). If drawdown is significant, reduce pumping rate until water levels stabilize at an appropriate level.
13. Record pumping rate on the data sheet or field notebook.
14. Discharge evacuated water as far as possible from the wellhead and work area.
15. During purging and sampling water flow should be smooth and consistent without bubbles in the tubing.
16. Once pumping rate has been determined and flow has stabilized, start collecting field parameters (water temperature, specific conductance, pH and dissolved oxygen) at regular intervals. The measurement interval will depend upon the pumping rate (typically 2-5 minutes between measurements).

17. Record field parameters, water level measurement, and estimated amount of water purged. Note any changes in purged water's appearance (clear, turbid, odor, etc.).
18. Continue purging well until field parameters stabilize. Parameters should be considered to be stabilized when 3 consecutive measurements fall within the following ranges (see Table 6a):
19. Collect samples once field parameters have stabilized. Do not stop or change pumping rate during the final phase of purging and sampling.
20. Collect most sensitive analytes first (i.e. organics) followed by less sensitive analytes (i.e. nutrients). This order can be modified if using sulfuric or nitric acid preservatives to prevent contamination of sulfate and/or nitrogen samples.
21. Collect any duplicate or quality control samples (see below for details).
22. Place samples in an ice-cooled cooler for delivery to the lab or shipping company. Make sure samples do not freeze during transport.
23. Complete chain of custody form. Record sample date and time, final water level and estimated total purge volume on the data sheet or in the field notebook. Also record any comments or observations regarding the purging and sampling process.
24. Replace pressure transducer if the well was equipped with one. Note re-install time on the data sheet or in the field notebook.
25. Clean sampling equipment for next sampling event.

Decontamination

All non-disposable field equipment that may potentially come in contact with any soil or water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted prior to each sampling event. In addition, the sampling technician shall decontaminate all equipment in the field as required to prevent cross-contamination of samples collected in the field. The procedures described in this section are specifically for field decontamination of sampling equipment.

At a minimum, field-sampling equipment should be decontaminated following these procedures:

- Wash the equipment in a solution of non-phosphate detergent (Liquinox® or equivalent) and distilled or deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene and/or plastic tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex, plastic, or equivalent gloves during all washing and rinsing operations.
- Rinse twice with distilled or deionized water.
- Dry the equipment before use, to the extent practicable.

Sample containers, quantification or detection limits, and holding times for each parameter are listed in Table 7.

4.1.6.2 WATER QUALITY SAMPLING (SURFACE WATER)

Surface water sampling will be conducted utilizing the following equipment and procedures.

Note: this procedure is a modified from:

Anderson, 2011. Standard Operating Procedure for Sampling of Pesticides in Surface Waters. Washington State Department of Ecology – Environmental Assessment Program. EAP003.

Equipment

- Sampling field data sheets (see below) or field notebook
- Chain of Custody form
- Water quality meters and probes (Temperature, Specific Conductance, pH & Dissolved Oxygen)
- Sample bottles/containers
- Cooler
- Ice
- Deionized water
- Diluted Bleach solution
- Non-phosphate soap (Liquinox or similar)
- Nitrile gloves
- First aid kit
- Camera
- Paper towels or clean rags
- Plastic sheet for keeping equipment clean
- Screwdriver(s)

Sampling

1. Check for any changes or potential hazards.
2. Make sure equipment has been cleaned and decontaminated (see below for details). Spread plastic or other material if needed to keep equipment clean.
3. Wear clean disposable gloves (Nitrile) while performing purging and sampling. If gloves become contaminated or dirty replace with new gloves.
4. Make sure field water quality meters are calibrated according to the manufacturer's instructions.
5. Collect required field water quality parameters and record on data sheet. Also note weather conditions
6. Fill out labels on each sample bottle with all necessary information.
7. Samples will be collected using the "Grab Sample" method described in EAP 003.
8. Take sample bottles and sampling equipment to the sample site and put on nitrile gloves.
9. Carefully collect samples by filling each container with water from the site. Note marked fill lines or preservatives to prevent over or under filling of the sample bottle.
10. Collect any duplicate or quality control samples (see below for details).
11. Place samples in an ice-cooled cooler for delivery to the lab or shipping company. Make sure samples do not freeze during transport.
12. Complete chain of custody form. Record sample date and time on the data sheet or in the field notebook. Also record any comments or observations regarding the sampling process.
13. Clean and disinfect sampling equipment for next sampling event.

Decontamination

All non-disposable field equipment that may potentially come in contact with any soil or water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted prior to each sampling event. In addition, the sampling technician shall decontaminate all equipment in the field as required to prevent cross-contamination of samples collected in the field. The procedures described in this section are specifically for field decontamination of sampling equipment.

At a minimum, field-sampling equipment should be decontaminated following these procedures:

- Wash the equipment in a solution of non-phosphate detergent (Liquinox® or equivalent) and distilled or deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene and/or plastic tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex, plastic, or equivalent gloves during all washing and rinsing operations.
- Rinse twice with distilled or deionized water.
- Dry the equipment before use, to the extent practicable.

Sample containers, quantification or detection limits, and holding times for each parameter are listed in Table 7.

4.1.7 WATER QUALITY SAMPLING DATASHEET

See Appendix A.

4.2 WATER LEVEL MONITORING

Water level monitoring for the AR program will be done to identify groundwater level changes in response to AR activities. Water level data will be collected from two sets of wells, those assigned to the AR program and those belonging to the WWBWC basin wide program. Of the water level monitoring wells assigned to the AR program some, like the water quality monitoring wells, are close to specific AR facilities and others are distant. As such, some facilities may not have a nearby well, some will have only an upgradient well, and some will have a downgradient well.

The WWBWC basin wide program is used to track water level conditions over a much larger area of the Basin. Data from these wells have utility in understanding the effects of AR on the groundwater system in addition to other effects, such as pumping, gaining/losing reaches, precipitation, irrigation, to name a few. This effort is reflected in the monitoring network as other WWBWC work that will benefit AR evaluation, but without it being mandated as part of compliance with the LL. If necessary, and based on available funding, geographic gaps in this other monitoring well network effort will be filled from time-to-time. While this work is not required for the AR program, the resulting data can still be used in any analysis of AR effects.

Together AR program wells and basin wide program wells provide year-round data for analysis of groundwater changes during recharge activities and for longer term analysis of groundwater recovery (i.e. changes to groundwater storage). Appendix A lists wells in both programs to be used WWBWC's overall monitoring efforts. For these wells their locations (GPS coordinates) Well ID Tag #'s and UMAT numbers (when available) are listed. Groundwater level data will be provided to OWRD in digital format with the written annual report. Additional groundwater level data can be found on the WWBWC's website.

4.3 FLOW MONITORING LOCATIONS

Flow Monitoring will be done in the canals or pipelines feeding each individual AR site to determine the volumes of water delivered to each AR site during operations. Each aquifer recharge site will have either a rated intake structure (such as the Johnson site) or have a flow meter installed at the diversion from the irrigation canal (such as the Anspach site). Water volume delivered to each site will be collected and stored by the WWBWC and reported to OWRD in a written annual report and submitted to OWRD's electronic reporting system. WWBWC may also conduct flow monitoring in the canals to estimate seepage losses during aquifer recharge operations. A total diversion from the Walla Walla River (in acre-feet) will be included in the annual report. Surface water measurement locations are shown on Figure 27.

4.4 SPRING MONITORING

Spring flows increase when the volume of water in the aquifer increases. While groundwater elevation data typically represent conditions in a very small area surrounding each well, the area influencing each spring's discharge is spatially larger. Thus, monitoring the yield of springs sourced in the alluvial aquifer can provide a relatively inexpensive alternative to drilling expensive groundwater monitoring wells. To supplement the groundwater elevation data, the following spring locations will be monitored to characterize long-term changes in groundwater volumes:

- Walsh/Lewis Spring (S-221).
- Mud Creek Spring (S-303).
- Little Mud Creek Spring (S-405).
- Schwartz Creek Spring (S-411).
- Big Spring (S-233).

4.5 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

4.5.1 FIELD RECORDS

All field notes, analytical results and other pertinent data associated with the program should be maintained in a secure location and be archived for at least a five-year period. Maintaining records will also facilitate tracking of environmental trends for the program.

4.5.2 DATA VALIDATION

Data validation for both field and lab QA/QC can be performed using a checklist. All pertinent information with respect to QA/QC will be checked. The following items will be included in the checklist:

- ♦ Completeness of field data sheets and observation
- ♦ Completeness of chain-of-custody
- ♦ Holding times for all constituents
- ♦ Completeness of laboratory quality controls

4.5.3 SPECIFIC QA/QC GUIDANCE

One field duplicate will be obtained once per season. Field duplicates are two samples collected at the same time and location and analyzed in the same batch.

One field blank will be obtained once per season. Field blanks will be transfer blanks created using deionized water with sample bottles filled at the monitoring site.

4.6 REPORTING

Primary reporting for this monitoring plan will focus on annual reports completed following the end of each recharge season. The goals of the annual reports will be to: (1) report water quantity diverted and quantity delivered to each recharge site, (2) analyze the data to evaluate how trends related to AR operations are influencing groundwater quality and quantity and (3) based on the results of that analysis provide recommendations (if any) for adjustments to the monitoring program and AR operations. In addition to the written annual report, monitoring data collected under this monitoring plan will be provided to OWRD and ODEQ with the annual report.

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Table 1. Location and type of recharge sites.

Site Name	GPS Coordinates	Section, Township & Range	Site Type
Anspach	45.945540, -118.411043	NW ¼, NW ¼, Sec. 30, T6N, R35E	Gallery
Barrett	45.948009, -118.421811	SW ¼, SE ¼, Sec. 34, T6N, R35E	Gallery
Chuckhole	45.941074, -118.419149	SW ¼, NE ¼, Sec. 3, T5N, R35E	Basin
East Trolley Lane	45.993006, -118.423812	SW ¼, SE ¼, Sec. 15, T6N, R35E	Gallery
Fruitvale	45.987780, -118.444852	NE ¼, NW ¼, Sec. 21, T6N, R35E	Gallery
Gallagher	45.967480, -118.485502	SE ¼ & SW ¼ of Sec. 30, T6N, R35E	Gallery & Basin
Johnson	45.956690, -118.439271	SE ¼, SW ¼, Sec. 33, T6N, R35E	Gallery & Basin
LeFore Road	45.951187, -118.377397	NE ¼, SW ¼, Sec. 36, T6N, R35E	Gallery
Locust Road	45.957360, -118.392845	SE ¼, NE ¼, Sec. 35, T6N, R35E	Gallery
Miller Road (new)	45.954925, -118.378132	SE ¼, NE ¼, Sec. 36, T6N, R35E	Gallery
Mud Creek	45.973630, -118.430493	NW ¼, NW ¼, Sec. 27, T6N, R35E	Basin
North Sunquist (new)	45.989705, -118.455241		Basin
NW Umapine	45.979884, -118.503350	SW ¼, SE ¼, Sec. 24, T6N, R34E	Basin
Ringer Road	45.971370, -118.496996	SE ¼, NW ¼, Sec. 25, T6N,R33E	Gallery
Ruby Lane (new)	45.971061, -118.400318	SW ¼, NE ¼, Sec. 26, T6N, R35E	Gallery
Triangle Road	45.973104, -118.425618	NE ¼, NW ¼, Sec. 27 T6N, R35E	Basin
Trumbull	45.962171, -118.428849	NW ¼, SW ¼, Sec. 27, T6N, R34E	Gallery

Table 2. Expected recharge rates, volumes, and conveyance losses

Site Name	Expected Maximum Recharge Volume (ac-ft/year)	Expected Recharge Rate (cfs) (assumes a 120-day recharge season)	Calculated Conveyance Loss
Anspach	660	2.78	< 4,500 ac-ft/year
Barrett	383	1.61	
Chuckhole	25	0.1	
East Trolley Lane	52	0.2	
Fruitvale	51	0.2	
Gallagher	16	0.1	
Johnson	4500	19.1	
LeFore Road	78	0.32	
Locust Road	56	0.24	
Miller Road	*<100*	*0.42*	
Mud Creek	45	0.18	
NW Umapine	499	2.09	
North Sunquist	*<100*	*0.42*	
Ringer Road	111	0.46	
Ruby Lane	*<100*	*0.42*	
Triangle Road	103	0.43	
Trumbull	421	1.77	
Estimated Totals	**<7,350**	**<30.1**	**< 4,500 ac-ft/year or 6 cfs**

NOTE: Italicized recharge rates are estimates because the site has not operated yet.

Table 3. Historical pre- and post-recharge water quality comparisons.

Constituent	total # samples	# samples post>pre	# samples source water > gw	% samples source water > gw	Avg dif (mg/L)
Calcium	61	32	1	3	0.1
Copper	37	1	0	0	n/a
Iron	61	11	10	91	0.15
Magnesium	61	33	0	0	n/a
Manganese	61	2	0	0	n/a
Nitrate	61	31	1	3	0.4
Phosphorus	37	9	0	0	n/a
Potassium	61	33	2	6	0.1
Sodium	61	39	0	0	n/a
Sulfur	37	12	0	0	n/a
Zinc	37	2	0	0	n/a
sum	*575*	*205*	*14*	--	--

Table 4. Groundwater quality sampling locations

Monitoring ID	Well ID Tag #	Well Log #	GPS Coordinates	Proximity to sites
GW_141	97758	UMAT 57169	45.945663, -118.408360	**Program upgradient (west of Walla Walla River)**
GW_46	63869	UMAT 55114	45.957821, -118.441180	**Program mid-gradient (west of Walla Walla River)**
GW_170	N/A	N/A	45.973074, -118.428844	**Program mid-gradient (west of Walla Walla River)**
GW_144	97761	UMAT 57172	45.980159, -118.506767	**Program down-gradient (west of Walla Walla River)**
GW_171	N/A	N/A	45.991032, -118.444754	**Program down-gradient (west of Walla Walla River)**
GW_151	111667	UMAT 57435	45.994728, -118.423728	**Program down-gradient (west of Walla Walla River)**
GW_152	111668	UMAT 57434	45.951427, -118.376960	**Up-gradient (east of Walla Walla River)**
GW_160	*111671*	N/A	45.954846, -118.378992	**Down-gradient (east of Walla Walla River)**

Table 5. Source water quality sampling locations.

Monitoring ID	GPS Coordinates	Source Water Monitoring Sites
WQ-1 Zerba	45.947580, -118.408015	Anspach, Barrett, Chuckhole, Locust Rd, Ruby Lane,
WQ-2 Duff	45.951665, -118.428920	Gallagher, Johnson, Ringer Rd, Trumbull
WQ-3 Huffman-Richartz	45.976577, -118.475888	Ringer Rd, NW Umapine
WQ-4 Fruitvale	45.971173, -118.414991	East Trolley Lane, Fruitvale, Mud Creek, North Sunquist, Triangle Rd
WQ-5 Eastside	45.945233, -118.383753	LeFore Rd, Miller Rd

Table 6a. Field water quality parameters.

Parameter	Sample Matrix	Analytical Method	Frequency
Water Temperature	Surface Water & Groundwater	YSI 30 / Orion 5-Star	1 x Pre & 1x Post Operations
Specific Conductance	Surface Water & Groundwater	YSI 30 / Orion 5-Star	1 x Pre & 1x Post Operations
pH	Surface Water & Groundwater	Orion 5-Star	1 x Pre & 1x Post Operations
Dissolved Oxygen	Surface Water & Groundwater	Orion 5-Star	1 x Pre & 1x Post Operations

Table 6b. Surface water and groundwater quality parameters, analytical methods, and frequency.

Analyte	Analytical Methods	Sampling Occurrence
Calcium	Ag Manager (Unibest)	One time pre-operations and one time post-operations
Iron	Ag Manager (Unibest)	
Magnesium	Ag Manager (Unibest)	
Nitrate-N	EPA 300.0	
Phosphorus	Ag Manager (Unibest)	
Potassium	Ag Manager (Unibest)	
Sodium	Ag Manager (Unibest)	
Sulfur	Ag Manager (Unibest)	
Synthetic Organic Analytes (Groundwater only)		
Azinphos-methyl	EPA Method 8141B	One time post-operations @ GW_144 & GW_171
Chlorphyrifos	EPA Method 8141B	
Diuron	EPA Method 532	
Malathion	EPA Method 8141B	

Table 7. Sample containers, quantitation or detection limits, and holding times.

Analyte	Method	Sample containers	Quantitation* or detection limits	Preservation	Holding times
Calcium	Eco-tracker	Unibest capsule	0.31 mg/L	Refrigerate	˜ 3 days
Iron	Eco-tracker	Unibest capsule	0.05 mg/L	Refrigerate	˜ 3 days
Magnesium	Eco-tracker	Unibest capsule	0.27 mg/L	Refrigerate	˜ 3 days
Nitrate-N	EPA 300.0	HDPE	0.1 mg/L	Cool to 4˚ C	48 hours
Phosphorus	Eco-tracker	Unibest capsule	0.02 mg/L	Refrigerate	˜ 3 days
Potassium	Eco-tracker	Unibest capsule	0.18 mg/L	Refrigerate	˜ 3 days
Sodium	Eco-tracker	Unibest capsule	0.17 mg/L	Refrigerate	˜ 3 days
Sulfur	Eco-tracker	Unibest capsule	0.02 mg/L	Refrigerate	˜ 3 days
Azinphos-methyl	EPA Method 8141B	Amber glass	0.3 ug/L*	Cool to 4˚ C	7 days
Chlorphyrifos	EPA Method 8141B	Amber glass	0.3 ug/L*	Cool to 4˚ C	7 days
Diuron	EPA Method 532	Amber or clear glass bottles	0.06 ug/L*	Cool to 6˚ C; cupric sulfate; Tris buffer	14 days
Malathion	EPA Method 8141B	Amber glass	0.3 ug/L*	Cool to 4˚ C	7 days