Water Years 2014 & 2015

Washington Walla Walla Basin Aquifer Recharge Report

FINAL VERISION

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Washington Walla Walla Basin Aquifer Recharge Report

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Walla Walla Basin Watershed Council

2015

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EXECUTIVE SUMMARY

This report summarizes operations at the two operating aquifer recharge (AR) sites in the Washington portion of the Walla Walla Basin, the Locher Road Aquifer Recharge (Locher Road) site and Stiller Pond Aquifer Recharge (Stiller Pond) site during Water Years 2014 (WY2014 – October 1 2013 to September 30 2014) and 2015 (October 1 2014 to September 2015). It also summarizes the two new sites that have not operated yet, Last Chance Road and WA Mud Creek. Data include recharge amounts, supporting groundwater level, groundwater quality, source water quality and soil quality data.

For Water Year 2014, water for the Locher Road site was sourced from the Walla Walla River at Gardena Farms Irrigation District #13's (GFID) main diversion just upstream of Mojonnier Road. The water was delivered down the Gardena Farms Canal to the Locher Road site. A total of 256.48 acre-feet of water were delivered to the Locher Road site. Water for the Stiller Pond site was sourced from Mill Creek at a private diversion located downstream of Wallula Road. The water was delivered down a pipeline to the Stiller Pond site. A total of ~300 acre-feet were delivered to the Stiller Pond site. The total amount of water diverted for the two aquifer recharge sites during WY2014 was ~556.48 acre-feet (~181.2 million gallons).

For Water Year 2015, water for the Locher Road site was sourced from the Walla Walla River at Gardena Farms Irrigation District #13's (GFID) main diversion just upstream of Mojonnier Road. The water was delivered down the Gardena Farms Canal to the Locher Road site. A total of 36 acre-feet (11.7 million gallons) of water were delivered to the Locher Road site. Water for the Stiller Pond site was sourced from Mill Creek at a private diversion located downstream of Wallula Road. The water was delivered down a pipeline to the Stiller Pond site. A total of 214 acre-feet (69.7 million gallons) were delivered to the Stiller Pond site. The total amount of water diverted for the two aquifer recharge sites during WY2015 was ~250 acre-feet (81.5 million gallons).

Water level and water quality data were collected in accordance to the approved monitoring plan with the exception of soil samples were collected after shutdown at the Stiller Pond site instead of before start up (WWBWC, 2012). Down-gradient groundwater monitoring wells in the vicinity of the recharge sites responded to recharge activities, with groundwater elevations increasing and decreasing as recharge operations began and ended.

Groundwater and surface water quality data collected during aquifer recharge activities do not indicate any potential water quality concerns or that AR activities are degrading groundwater quality. Source water being delivered to the AR sites was of acceptable quality and likely resulted in some observed improvement in groundwater quality over the recharge seasons.

INTRODUCTION

The Walla Walla Basin Aquifer Recharge program has been in existence since 2004. The first pilot project, the Hulette Johnson site, was started in Oregon in the spring of 2004. The program expanded in 2006 with the addition of the Hall-Wentland site just south of the Oregon-Washington state line. The first site in Washington, Locher Road, started in 2007. For a more in-depth background to the aquifer recharge program and the Walla Walla basin's hydrology and geology, please see the Walla Walla Basin Aquifer Recharge Strategic Plan (available at www.wwbwc.org).

HYDROLOGIC SETTING

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). This report focuses on the portion of the River system that comprises the Walla Walla River mainstem and Mill Creek, especially where they flow onto and across the area referred to in the balance of this report as the Walla Walla Valley (Figure 4).

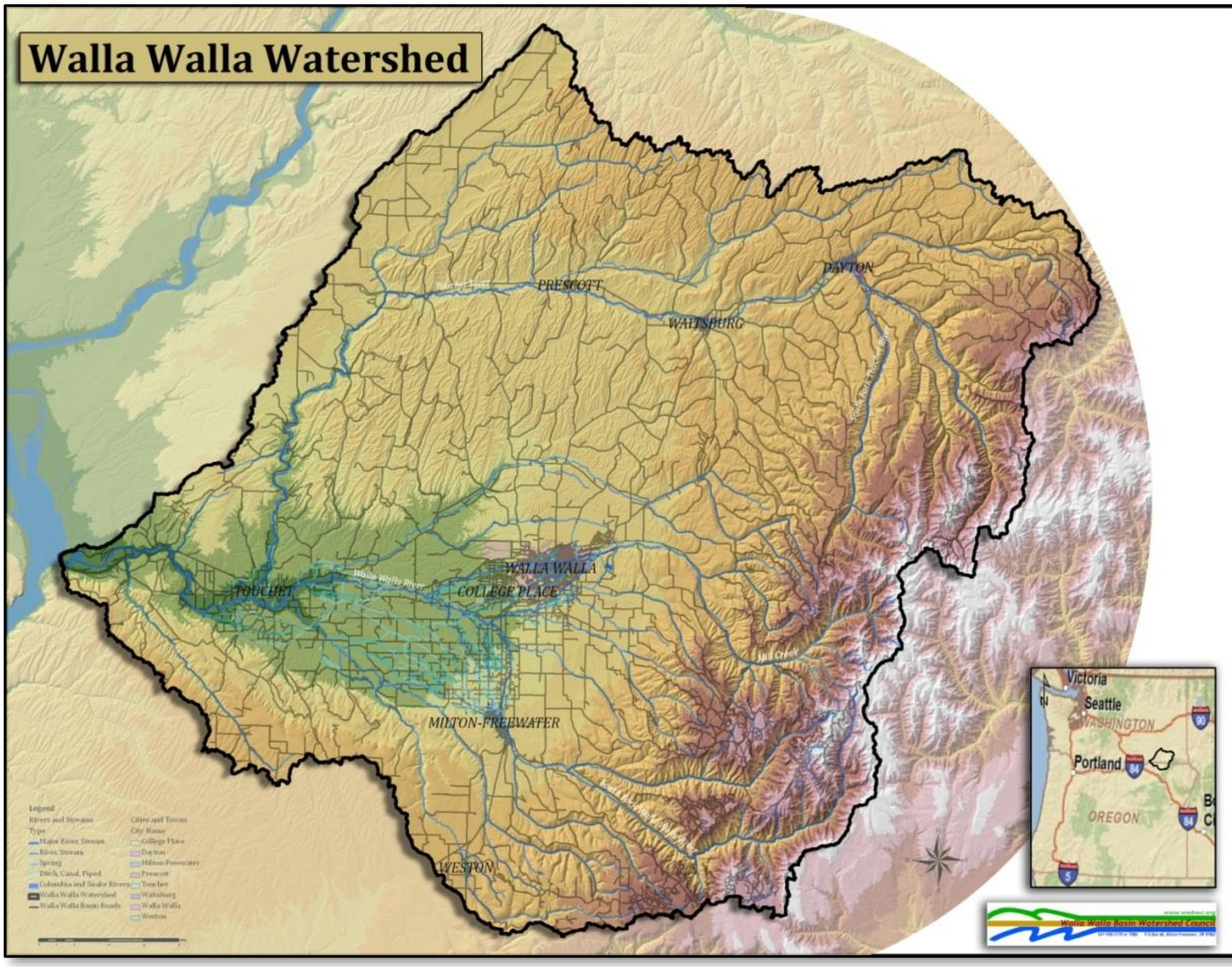


Figure 1 - The Walla Walla Watershed in Northeast Oregon and Southeast Washington.

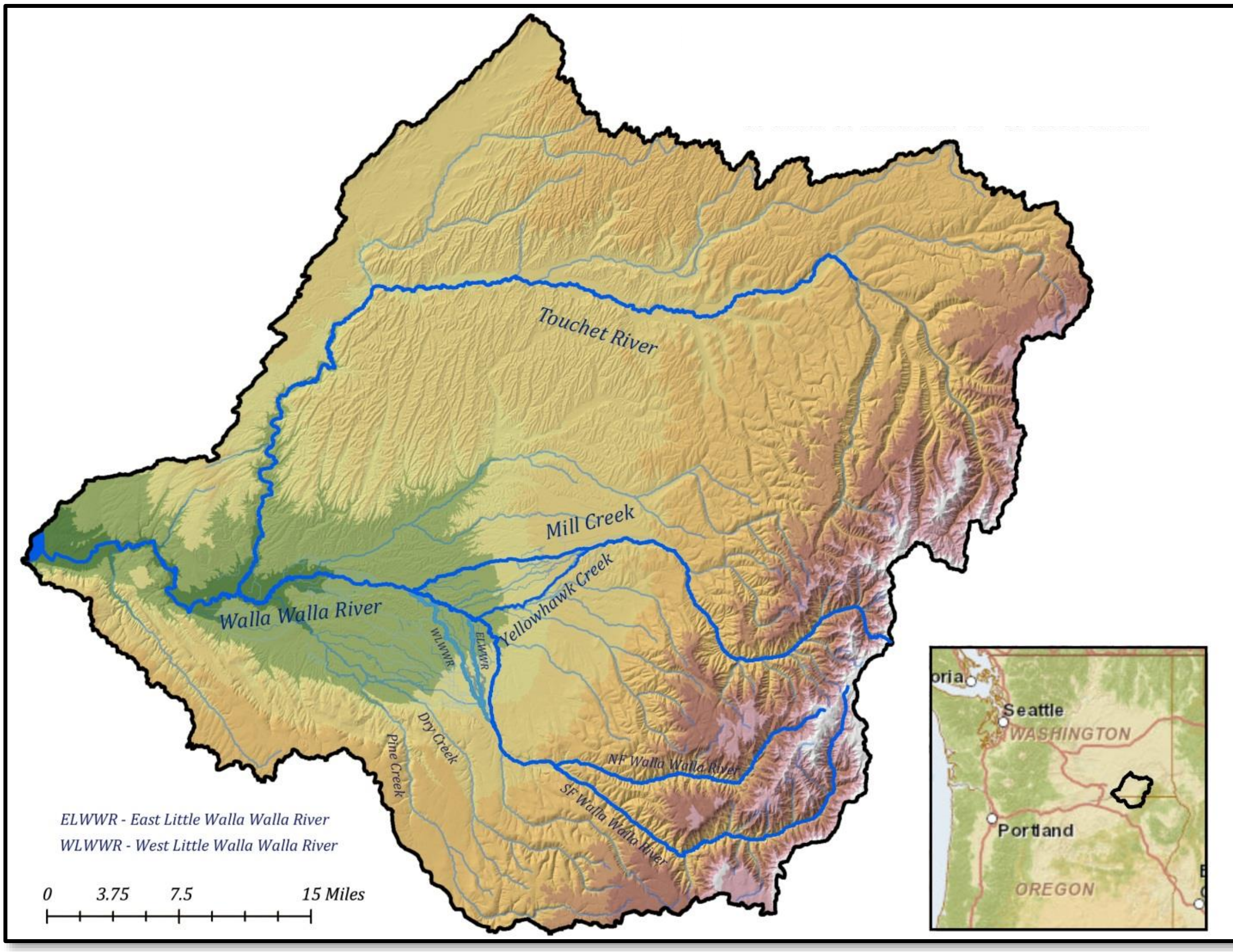


Figure 2 - The Walla Walla River and its major tributaries and distributaries.

Walla Walla Basin 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. Beneath the valley floor the top of basalt often is hundreds of feet deep below overlying alluvial sediments.

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, primarily in the canyons of the Blue Mountains. The alluvial aquifer system is the focus of the aquifer recharge program because of its high degree of hydraulic connection with streams on the valley floor.

The alluvial aquifer system, or alluvial aquifer, is found within a sequence of continental clastic sediments overlying the top of basalt (the Mio-Pliocene strata (upper coarse, fine and lower coarse units) and the Quaternary coarse unit). Beneath the Walla Walla Valley floor these sediments, and the alluvial aquifer system is 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. 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 3).

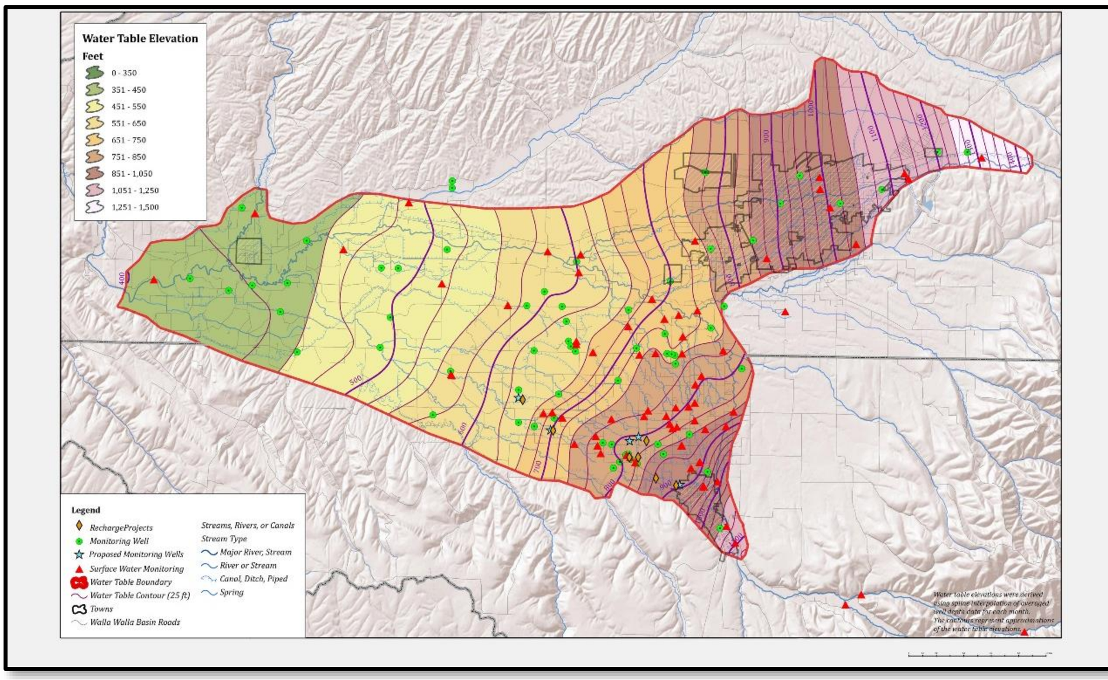


Figure 3 - Water table contours for the alluvial aquifer system.

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 4).

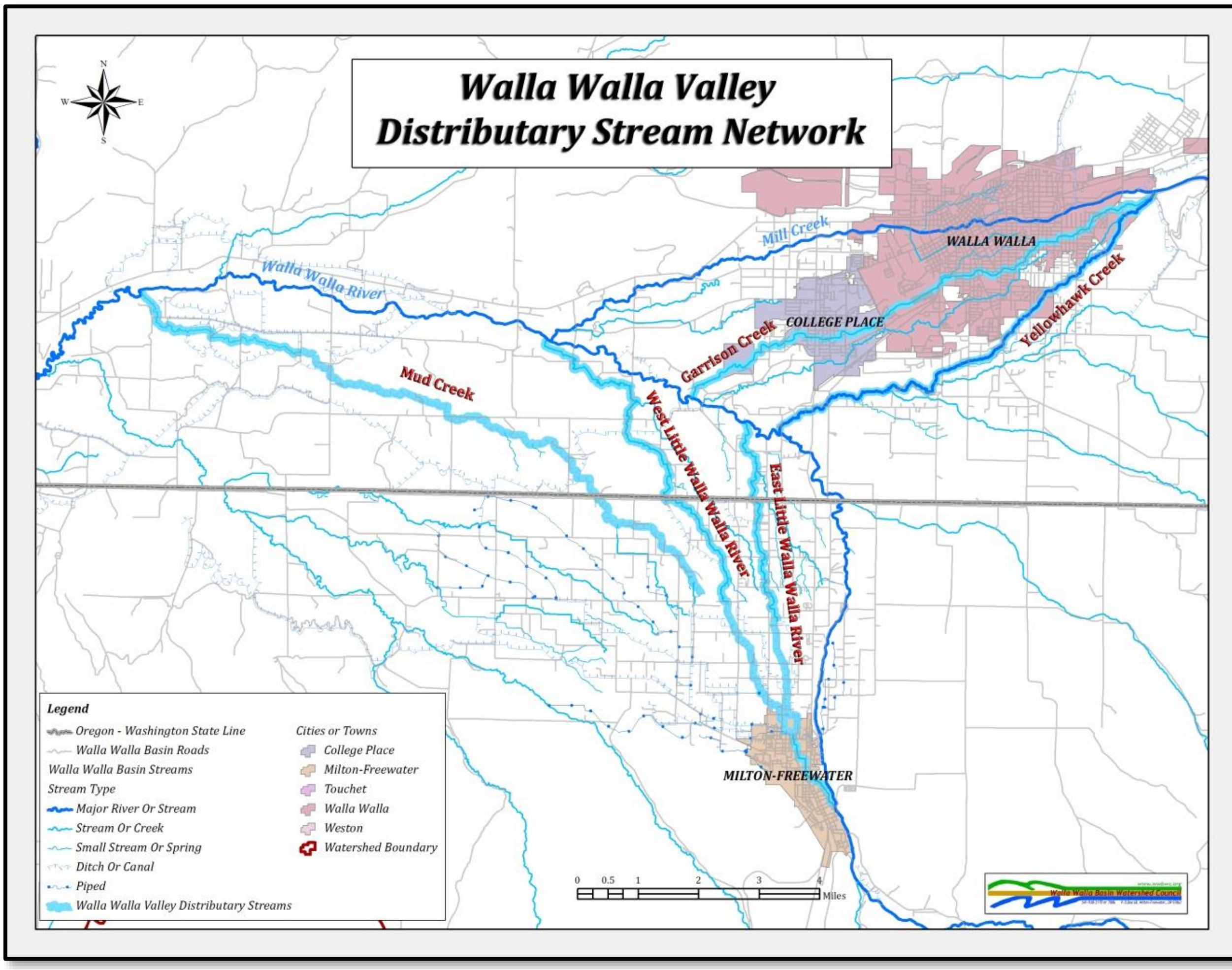


Figure 4 - Map of the distributary stream networks of the Walla Walla River and Mill Creek. Historically these stream networks conveyed winter and spring high flows across the valley's alluvial fans allowing for reduced flood pressure on the mainstem rivers, provided off-channel habitat and provided recharge to the alluvial aquifer system.

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 and the adjacent floodplains. 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 and adjacent floodplains, 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 alluvial groundwater, has created stream reaches where high seepage loss occurs and significant volumes of surface water drain to the aquifer (Figure 5 & 6). 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, Gardena Farm Irrigation District #13 (GFID) irrigators leave 18 cfs instream (bypass) throughout the year. However, depending on the water-year and a number of other factors, it is not unusual to have a significant portion (40-50%) of the bypass water seep into the underlying aquifer.

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 7 & 8) are consistent with the general decline of the related springs (Figure 9). 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 cold groundwater derived baseflow is lost.

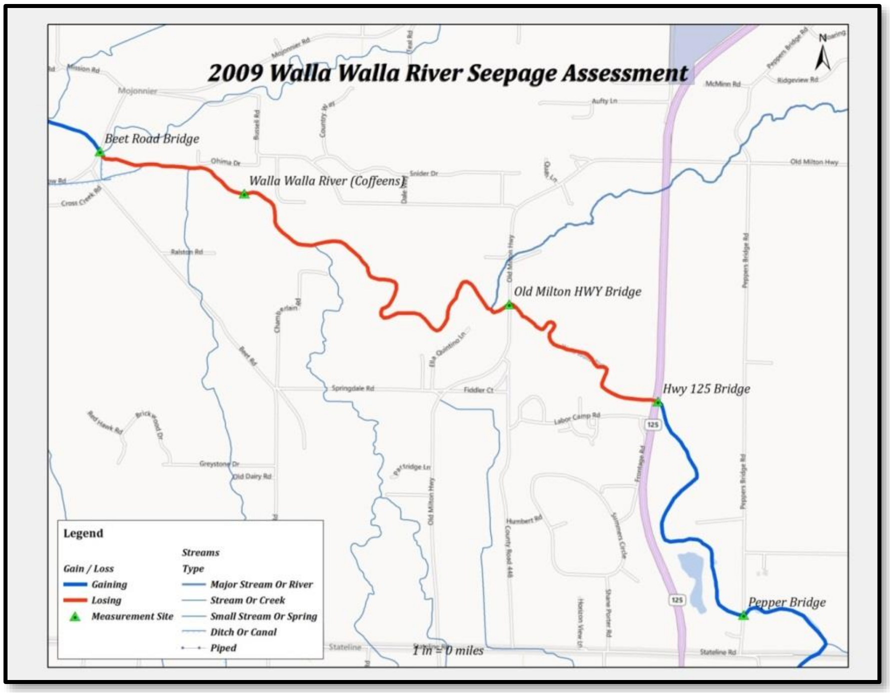


Figure 5 - Results from the water budget analysis of the Walla Walla River in August 2009. Color indicates a given reach as either gaining or losing. Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

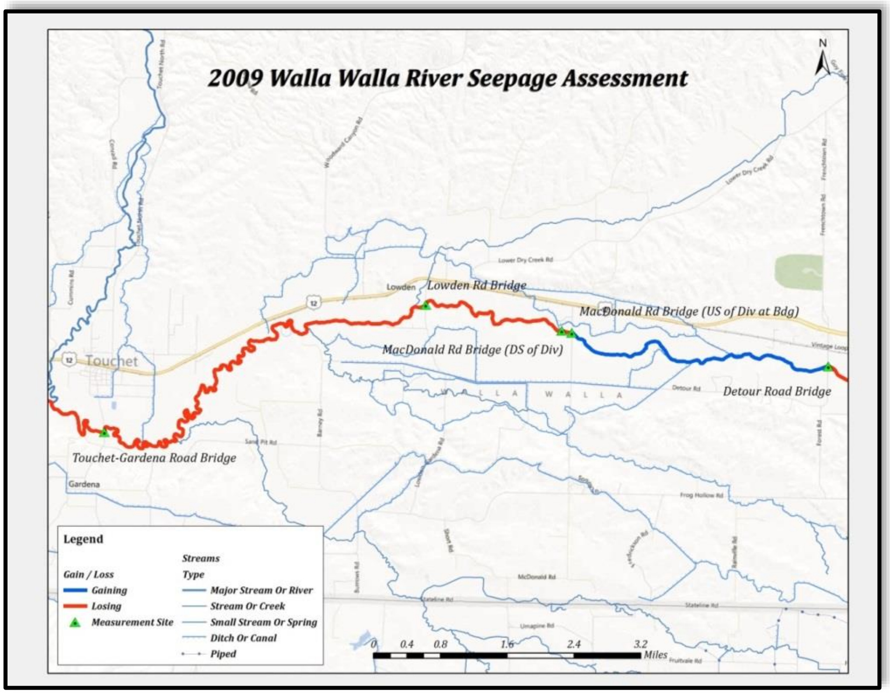


Figure 6 - Results from the water budget analysis of the Walla Walla River in August 2009. Color indicates a given reach as either gaining or losing. Gains indicate groundwater discharging to the river and losses indicate surface water seeping into the ground (see WWBWC, 2012 for details).

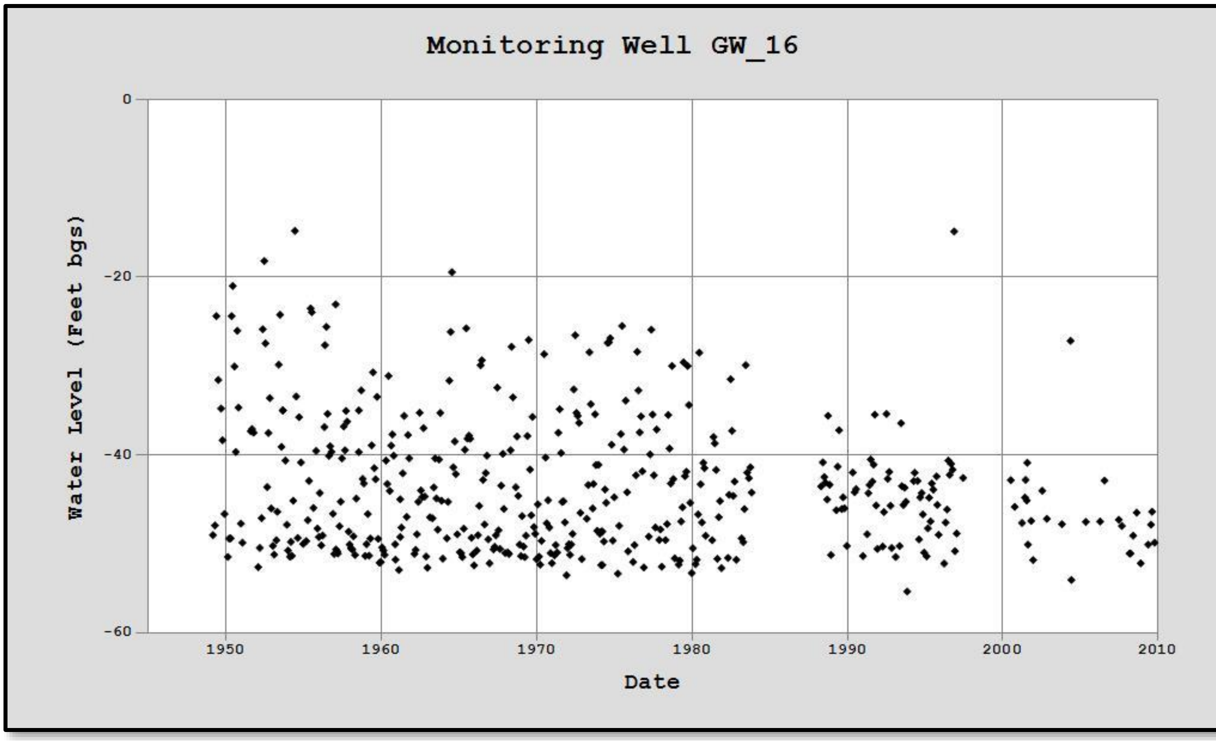


Figure 7 - Hydrograph for Monitoring Well GW_16 showing the long-term decline in the alluvial aquifer system in the Walla Walla Basin.

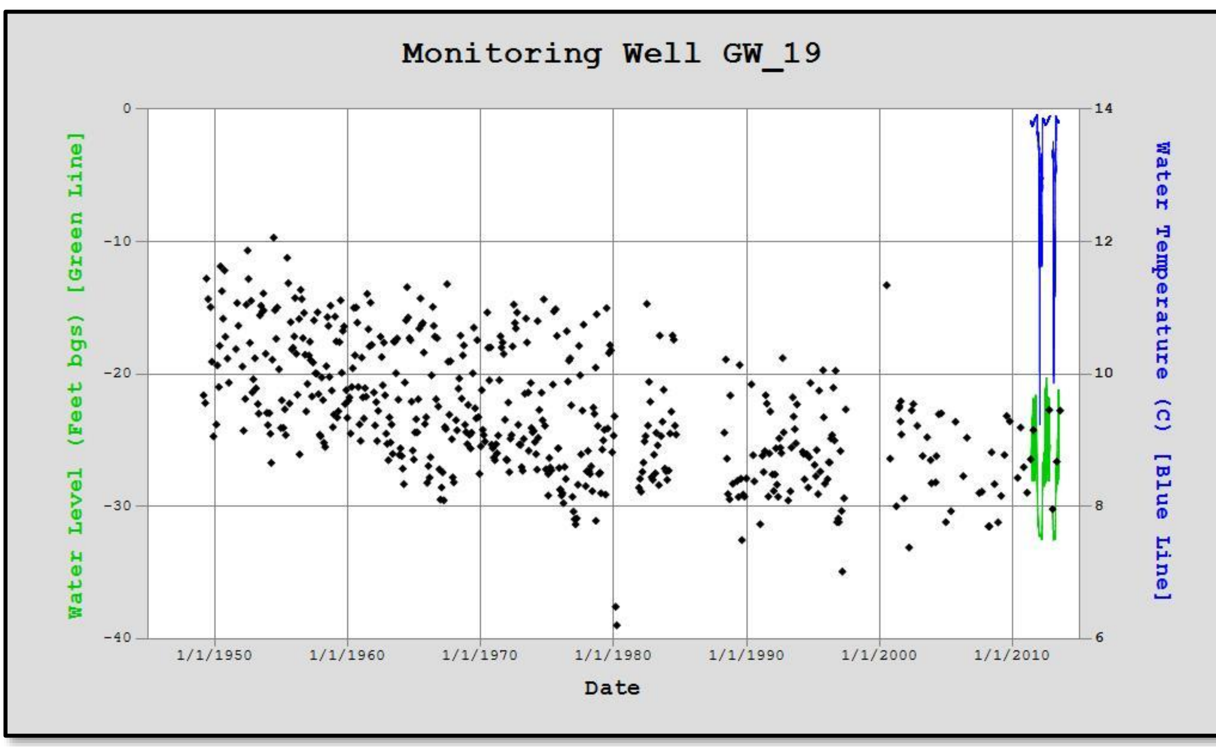


Figure 8- Hydrograph for Monitoring Well GW_19 showing the long-term decline in the alluvial aquifer system in the Walla Walla Basin.

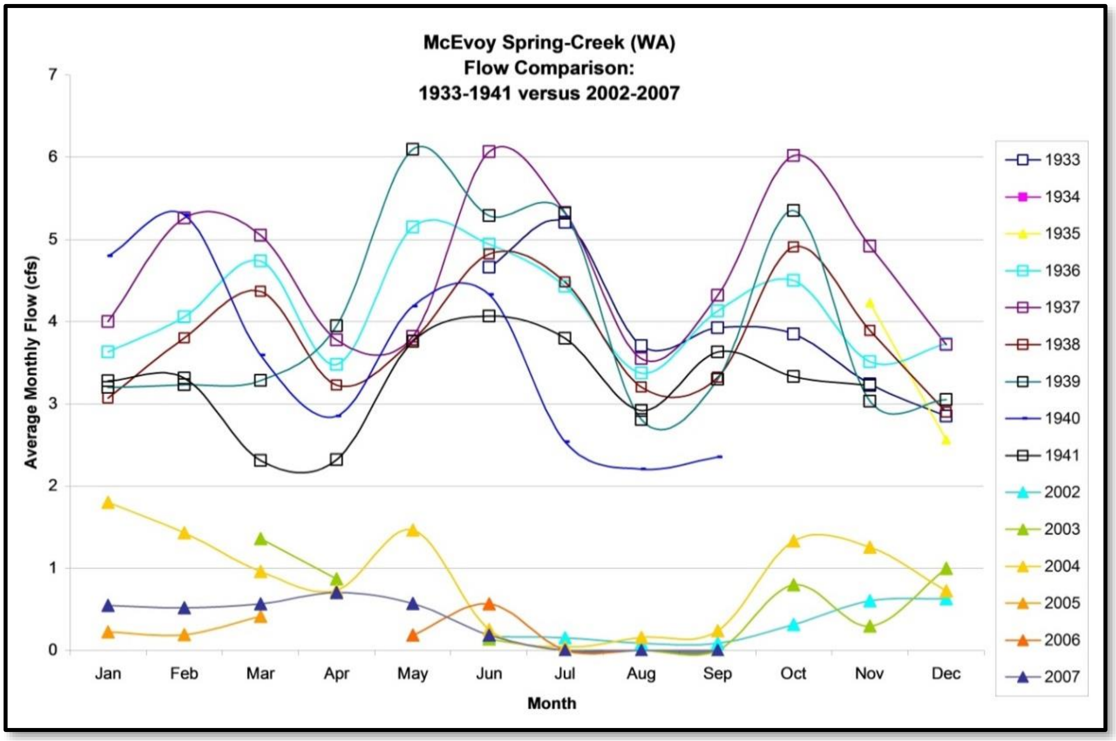


Figure 9 - Hydrograph for McEvoy Spring Creek located just north of the WA-OR state line. Hydrograph shows the decline in spring performance over the last 80 years.

Aquifer Recharge Sites

Locher Road

The Locher Road site (Figure 10), located at the intersection of Stateline Road and Locher Road, is a former gravel quarry that has been operated by GFID as an aquifer recharge (AR) site since 2007. From 2006-2007 through the end of the 2010-2011 season, approximately 1/3 acre of the 4+ acre site was utilized for recharge. In late 2011, the site was reconstructed to allow infiltration over a 2.5 acre portion of the site (Figures 11-15). Inflow volume rates at the site increased from approximately 1.3 cfs to 3.5 cfs. Total recharge volumes for each season are described below in the results section.

The Locher Road site has operated under successive one and two-year temporary use authorizations issued by WADOE. In addition to the temporary use authorizations, 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.

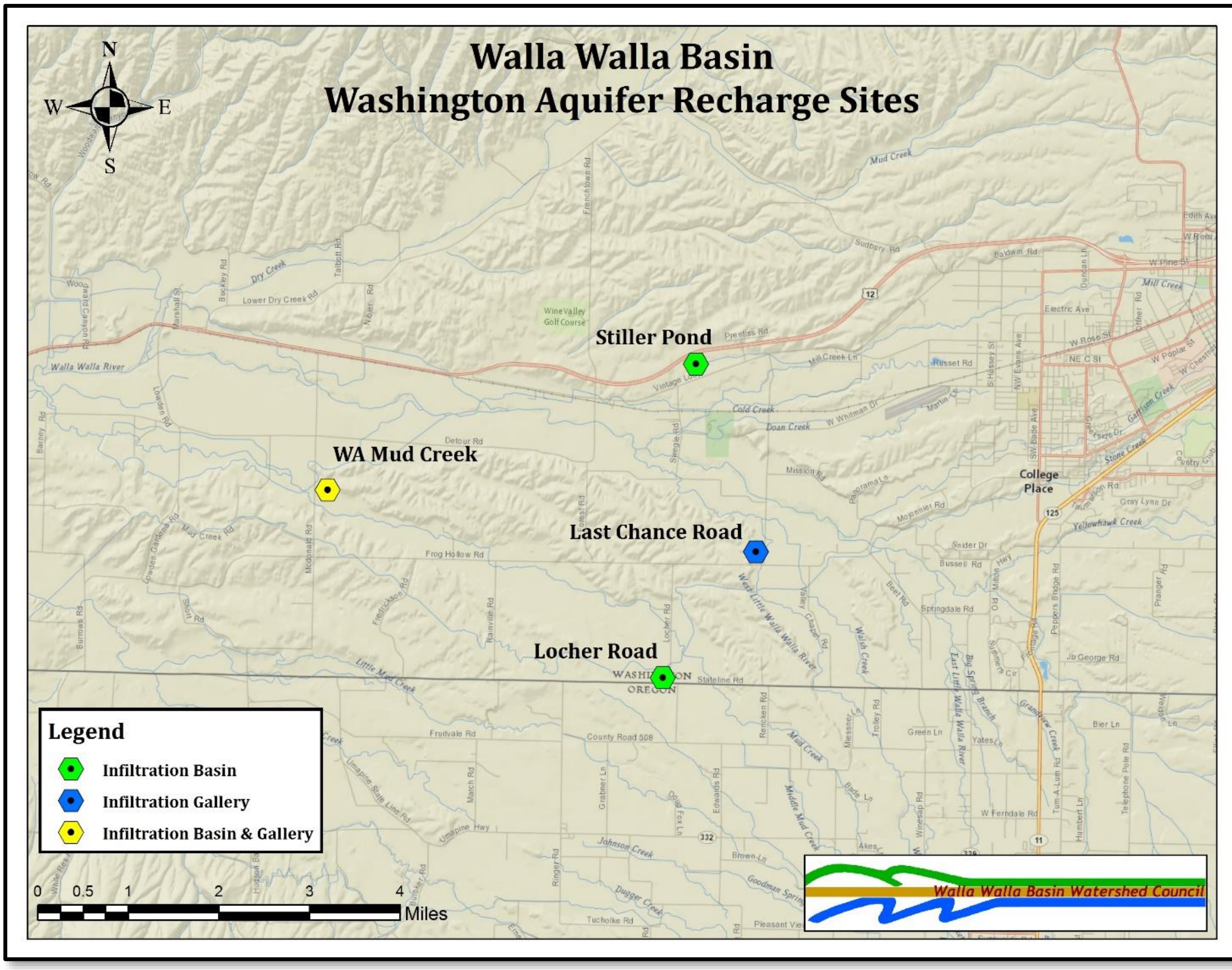


Figure 10 – Walla Walla Basin Washington Aquifer Recharge Sites.

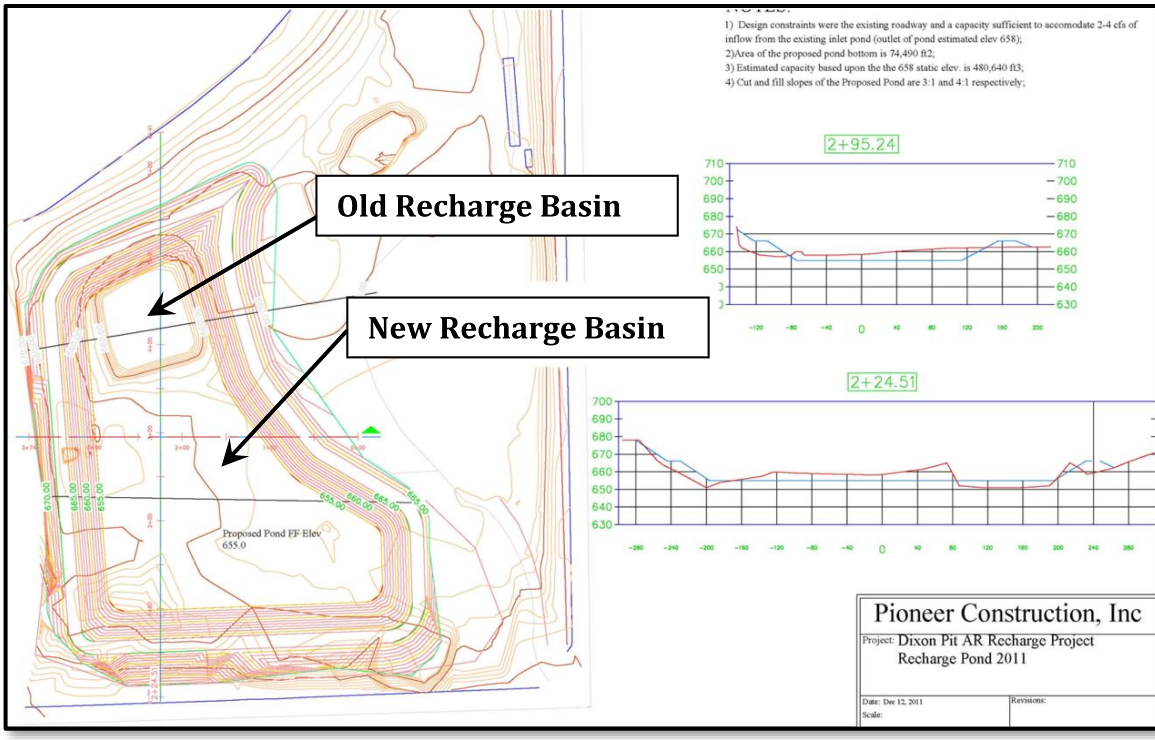


Figure 11 - Preliminary design for expansion of the Locher Road site's main recharge basin in late 2011.

Figure 12 - Photo during expansion of the Locher Road site's main recharge basin, December 2011.

Figure 13 - Photo of the completed expansion of the Locher Road site's main recharge basin, December 2011.

Figure 14 - Photo of the Locher Road aquifer recharge site during operations.

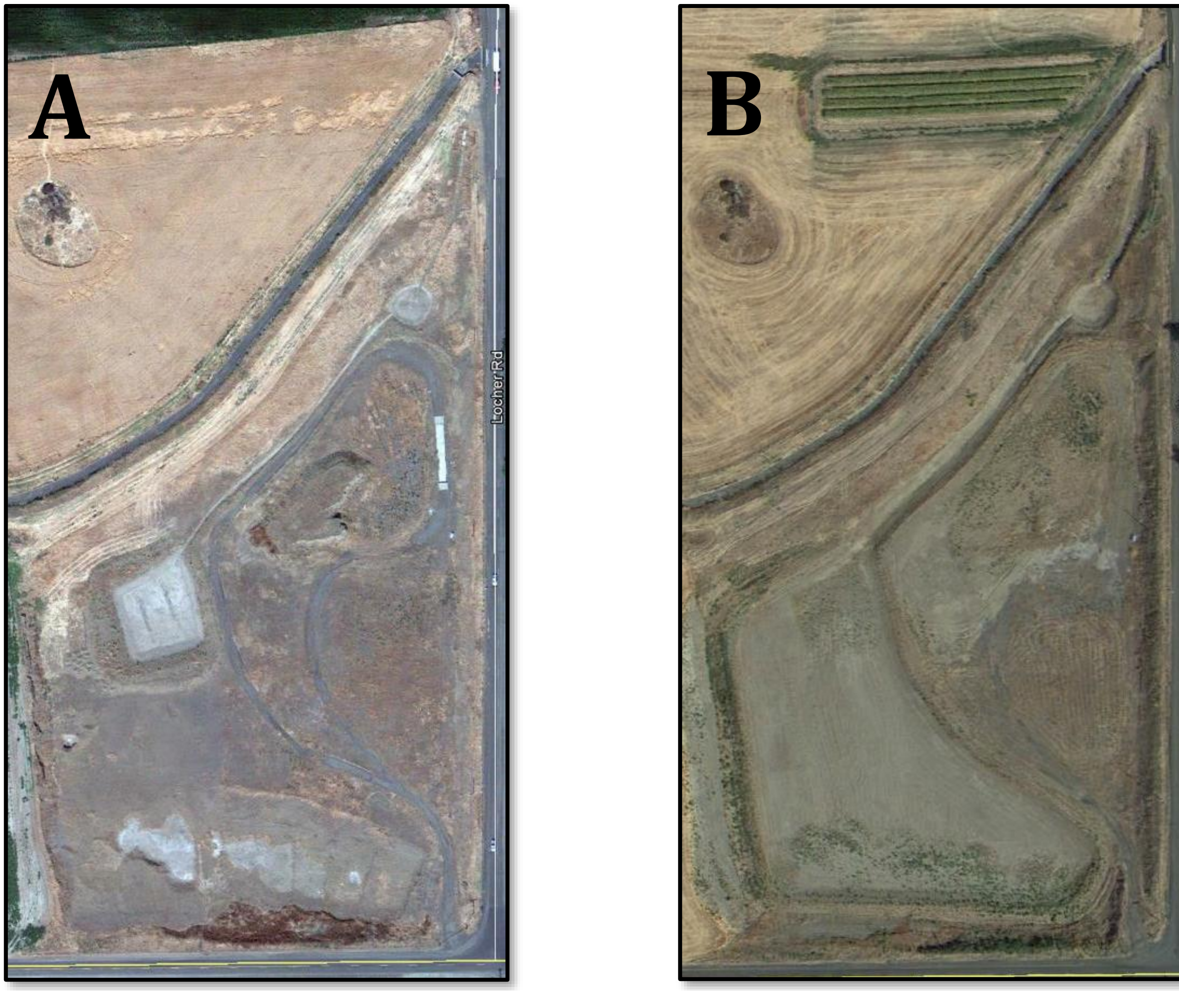


Figure 15 - Aerial photographs showing the Locher Road site before (A) and after (B) the expansion that occurred in December 2011. The diversion and settling pond were not changed. During the expansion work, the ditch from the diversion flume to the settling pond was reinforced with additional rock and the main recharge basin was expanded from approximately 1/3 of an acre to approximately 2.5 acres.

STILLER POND

In 2012 the WWBWC and the Walla Walla County Conservation District (WWCCD) partnered to develop this AR site (Figure 10 & 16). This site is currently operated under a Local Water Plan with the Walla Walla Watershed Management Partnership (WWWMP) to recharge up to 32 acre-feet of the landowners 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) was issued in early 2014. This additional authorization allows for diversion of up to 991 acre-feet of water from Mill Creek to the Stiller Pond for AR.

In its current configuration the Stiller Pond site can recharge approximately 1-2 cfs depending upon other demands from the diversion system. Future plans include a new diversion structure and larger pump to allow the delivery of up to approximately 4 cfs to the site. Like the Locher Road site, this authorization requires minimum instream flow to be met at two gages on Mill Creek and at the WADOE Walla Walla River gauging station at Detour Road and additional hydrologic monitoring and water quality analysis (GSI, 2012 and WWBWC, 2013).

Figure 16 - Stiller Pond Aquifer Recharge site during operations.

LAST CHANCE ROAD

The Last Chance Road site was constructed in June 2015 (Figure 10, 17 and 18). The site did not operate during the 2015 recharge season, but is ready for future operations. The site includes two recharge features, an infiltration gallery and a new open ditch along the hillside. The project also installed a fish screen on the diversion from the West Little Walla Walla River. This site is currently permitted under a Local Water Plan with the Walla Walla Watershed Management Partnership (WWWMP) to recharge up to 250 acre-feet per year from November 1-May 30. Minimum instream flows (1 cfs) for the site will be measured at the WWBWC's gauge on the West Little Walla Walla River at Swegle Road (S-227). In its current configuration, the Last Chance Road site can recharge up to 1 cfs of water from the West Little Walla Walla River. If the site continues to operate, an Environmental Enhancement Project permit may be sought for the site (WWWMP, 2014).

Figure 17 - Infiltration gallery area for the Last Chance Road Aquifer Recharge site.

Figure 18 - Irrigation ditch, fish screen and intake (back left) for the Last Chance Road Aquifer Recharge site.

WA Mud Creek

The WA Mud Creek site is currently being designed and will be constructed in the fall of 2015 (Figure 10). The site will encompass two recharge areas with water delivered via two separate irrigation ditches. The first recharge area will be supplied by the Gardena Farms Canal on the south side of the property. Water from this canal will feed into an infiltration gallery in a draw up-gradient of Mud Creek. The second recharge area will be supplied by the Lowden #2 ditch on the northern side of the property. Water from this ditch will feed into an infiltration pond within an existing pasture. The pasture will be reconfigured to enhance infiltration as much as possible. This site is currently permitted under a Local Water Plan with the Walla Walla Watershed Management Partnership (WWWMP) to recharge up to 783.7 acre-feet per year from November 1-May 30. The designed recharge areas are estimated to recharge approximately 1.5-2 cfs between the two sites. If the site continues to operate, an Environmental Enhancement Project permit may be sought for the site (WWWMP, 2014a).

Water Year 2014 Recharge Season Results

Locher Road

Overview

During the WY2014 recharge season, the Locher Road site operated under the Local Water Plan authorization because the temporary authorization had expired. The site operated from early April until late May. Minimum in-stream bypass flows did not prevent the site from operating during the WY2014 season until the last part of May (Figure 19).

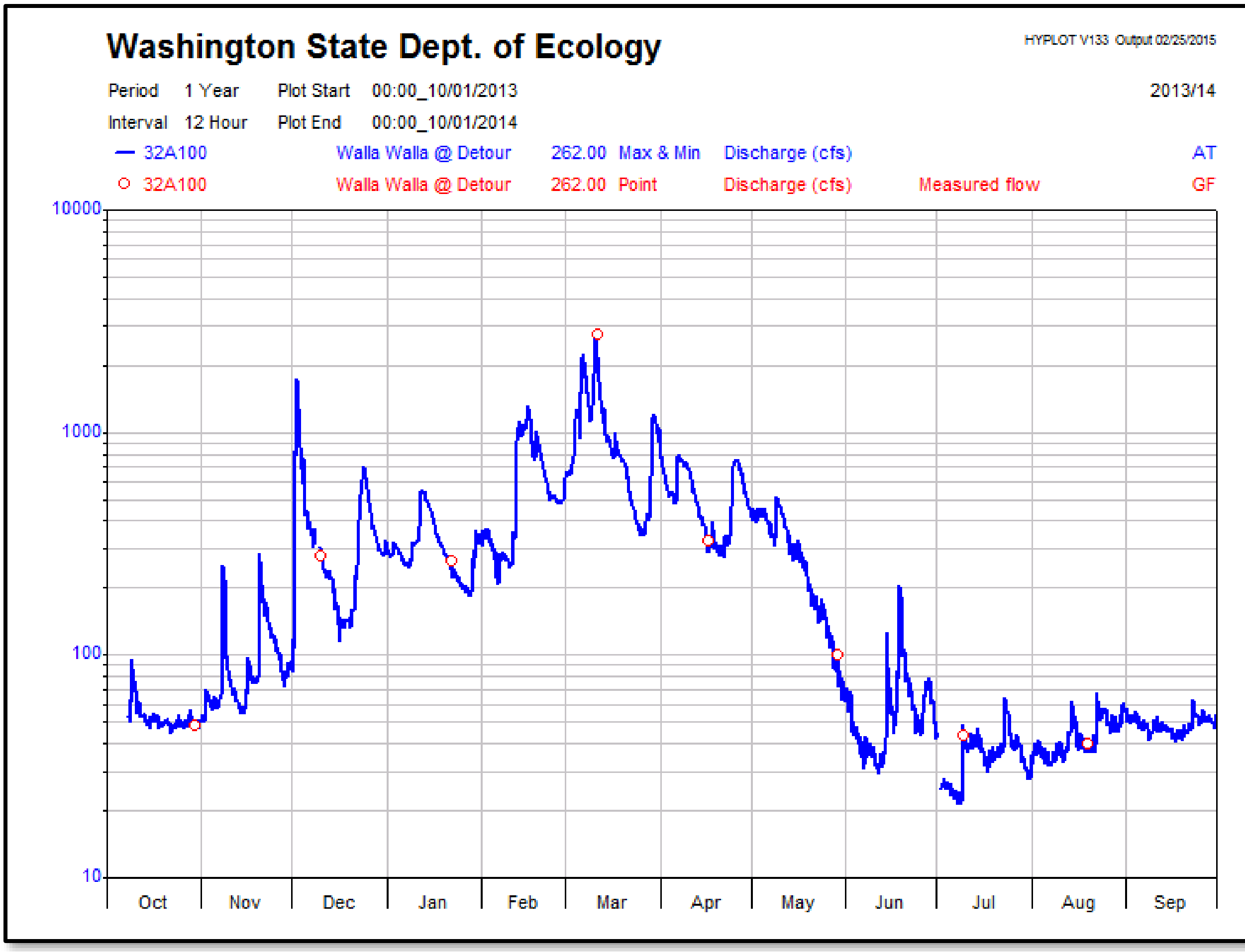


Figure 19 – Water Year 2014 hydrograph for Washington Department of Ecology's Walla Walla River at Detour Road (32A100) gage.

Alluvial Well Responses

Groundwater monitoring (Figure 20) at the Locher Road site includes four "on-site" monitoring wells (GW_57, GW_70, GW_71 and GW_72), three down-gradient monitoring wells (GW_108, GW_110 and GW_122) and two down-gradient irrigation wells. The four on-site wells surround the site with GW_70 up-gradient, GW_72 and GW_57 immediately down-gradient of the site and GW_71 farther down-gradient. Wells 70, 71 and 72 are shallow alluvial aquifer monitoring wells that were drilled in 2005 to monitoring site operations and aquifer response while well 57 was drilled in 1972-73 to be fully open to the entire gravel sequence. The "on-site" monitoring wells all show a similar response to canal and recharge operations (Figures 21-24). Water levels rise in early October with the start of the Gardena Farms Canal for fall irrigation. The canal was turned off in early-mid December. Starting in early December water levels show neutral to declining conditions until the canal turned on again in early March. Water levels increase due to canal operations through late March and early April. Recharge operations start in mid-April and water levels respond with a sharp increase until recharge operations stop in late May. Water levels decrease after recharge and continue to decline after the Gardena Farms Canal is shut down in early July. Down-gradient wells do not show the same rapid response to canal or recharge operations (Figures

25-27). One of the offsite, distal, monitoring wells, GW_108, also show the influence of nearby groundwater pumping on alluvial aquifer water levels during and after recharge operations.

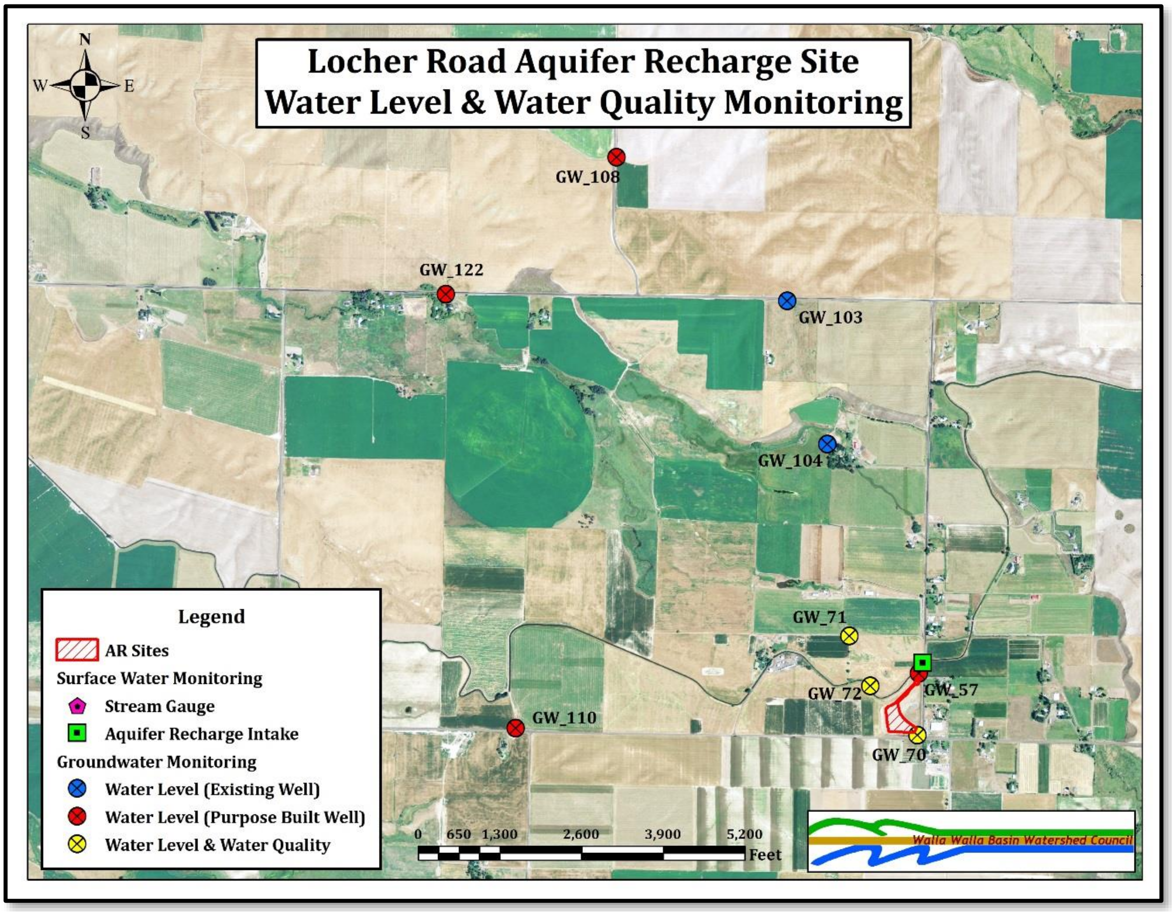


Figure 20 – Map showing groundwater monitoring sites for the Locher Road Aquifer Recharge Site.

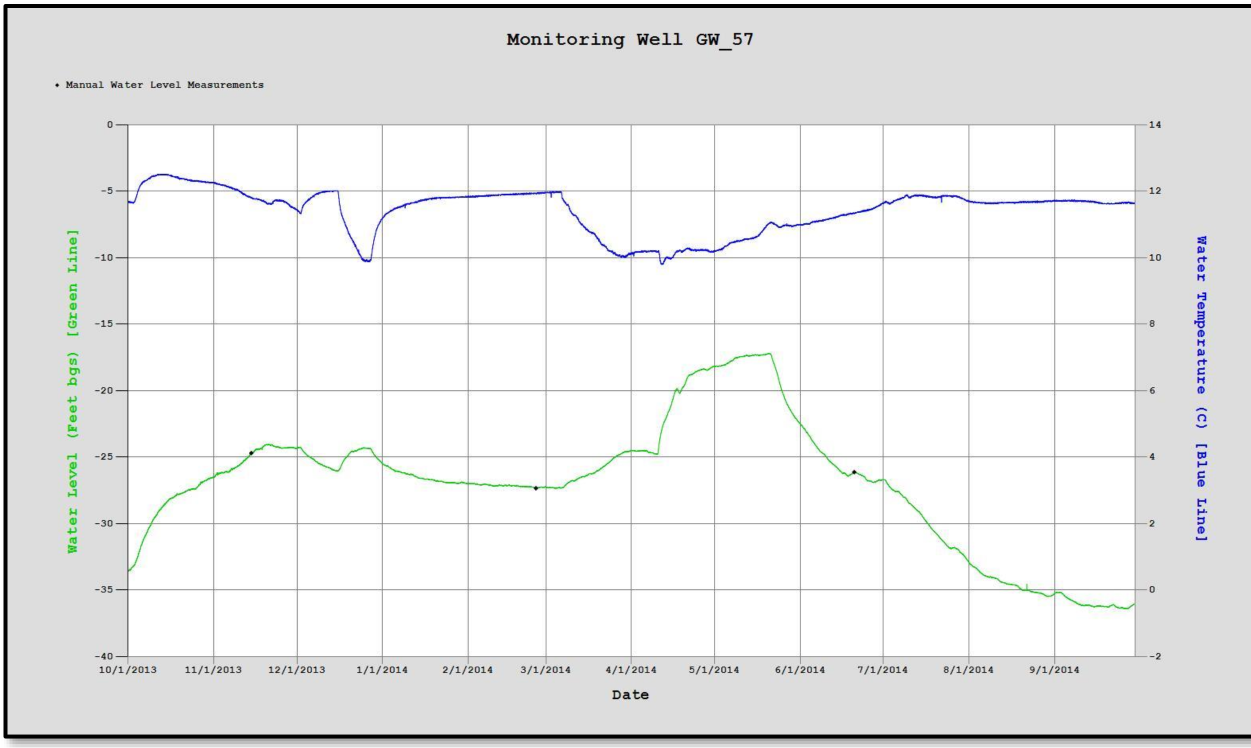


Figure 21 - Hydrograph for GW_57 during the WY 2014 recharge season.

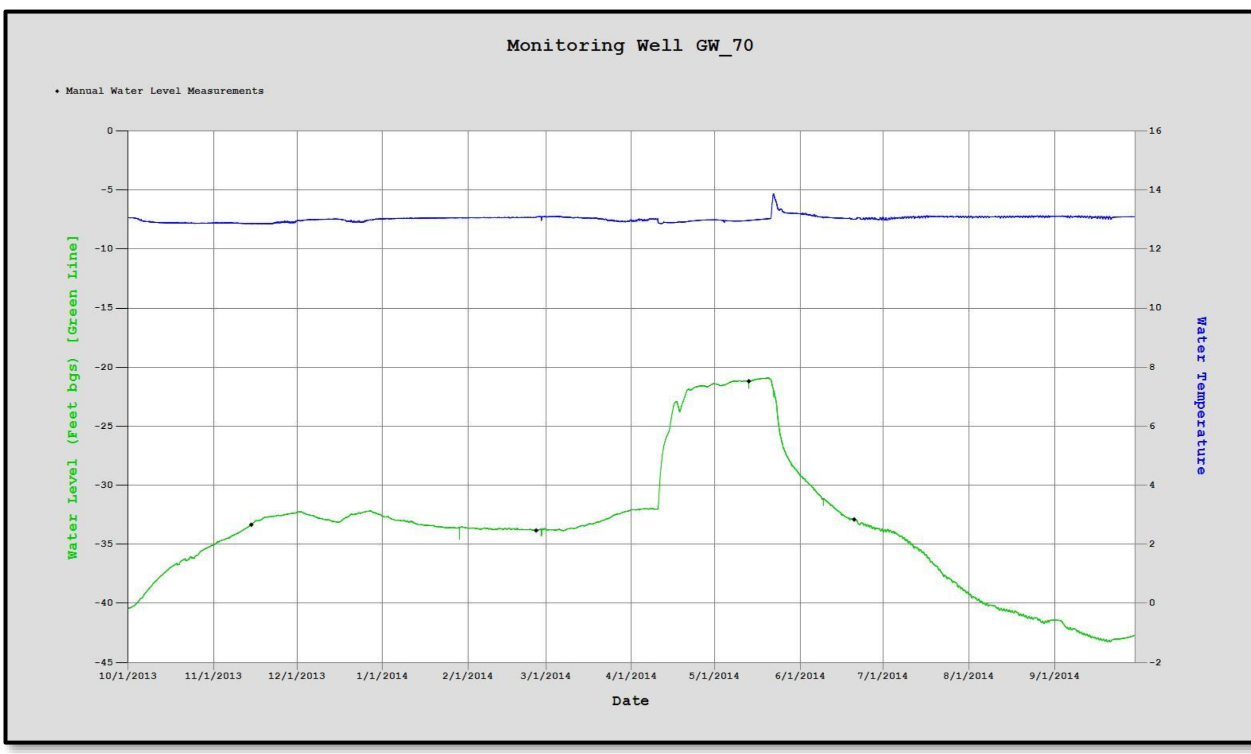


Figure 22 - Hydrograph for GW_70 during the WY 2014 recharge season.

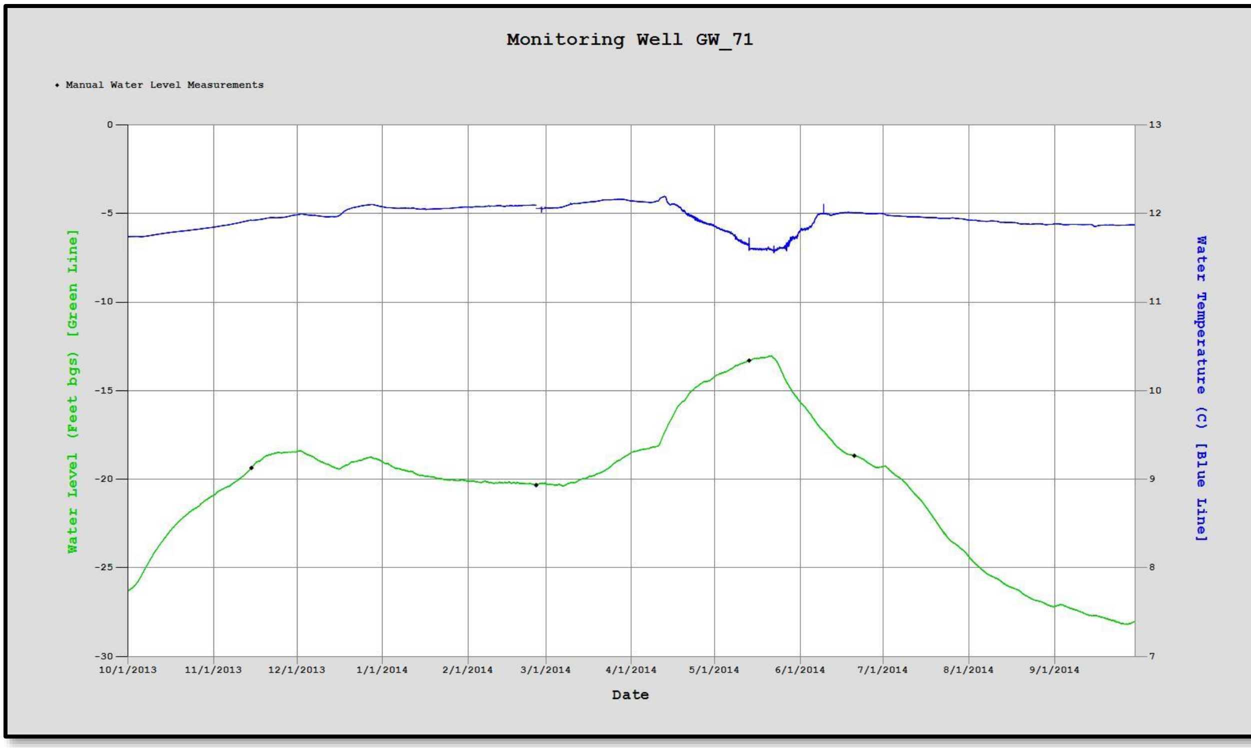


Figure 23 - Hydrograph for GW_71 during the WY 2014 recharge season.

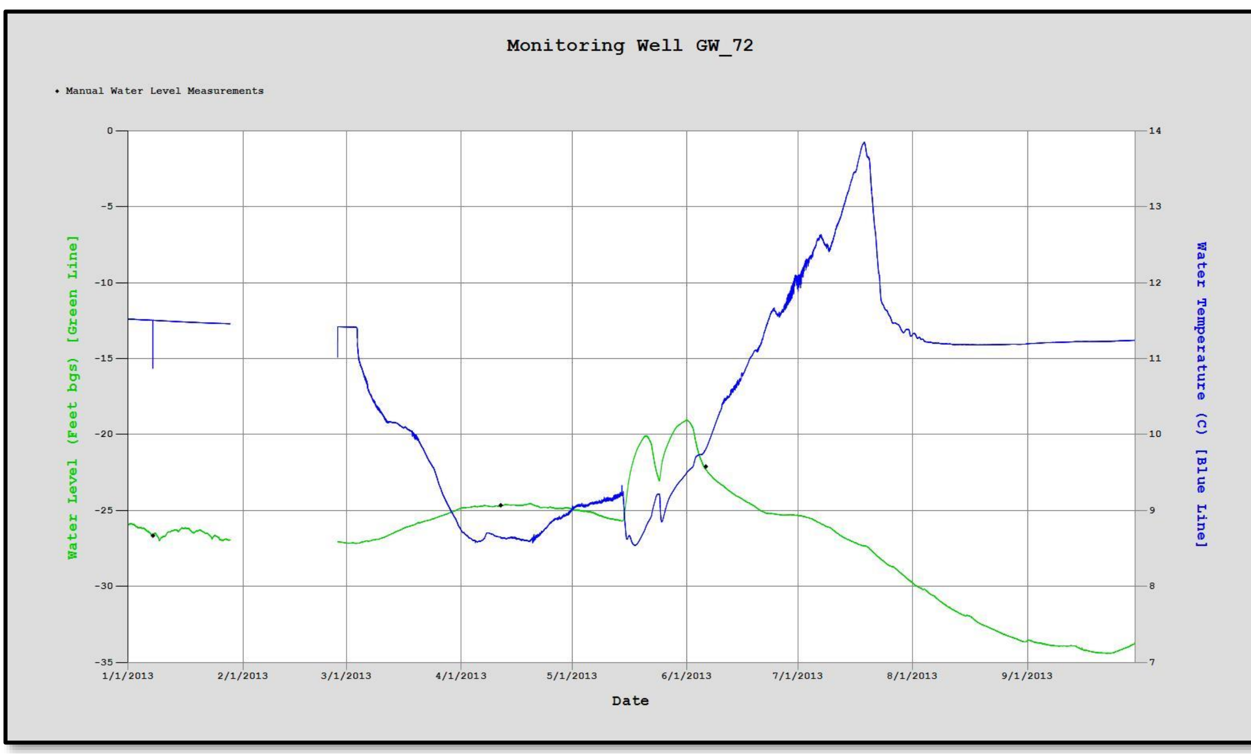


Figure 24 - Hydrograph for GW_72 during the WY 2014 recharge season.

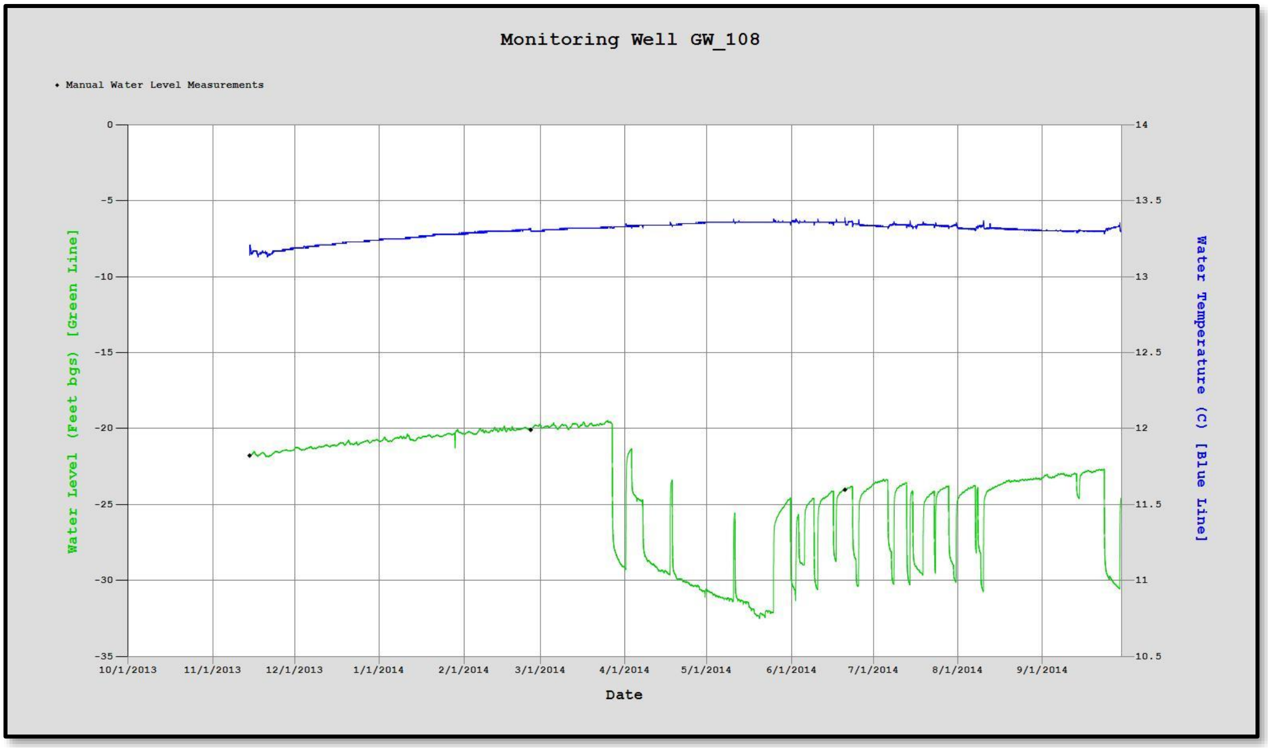


Figure 25 - Hydrograph for GW_108 during the WY 2014 recharge season. Note drawdowns during April-September from potential influence of nearby pumping well(s).

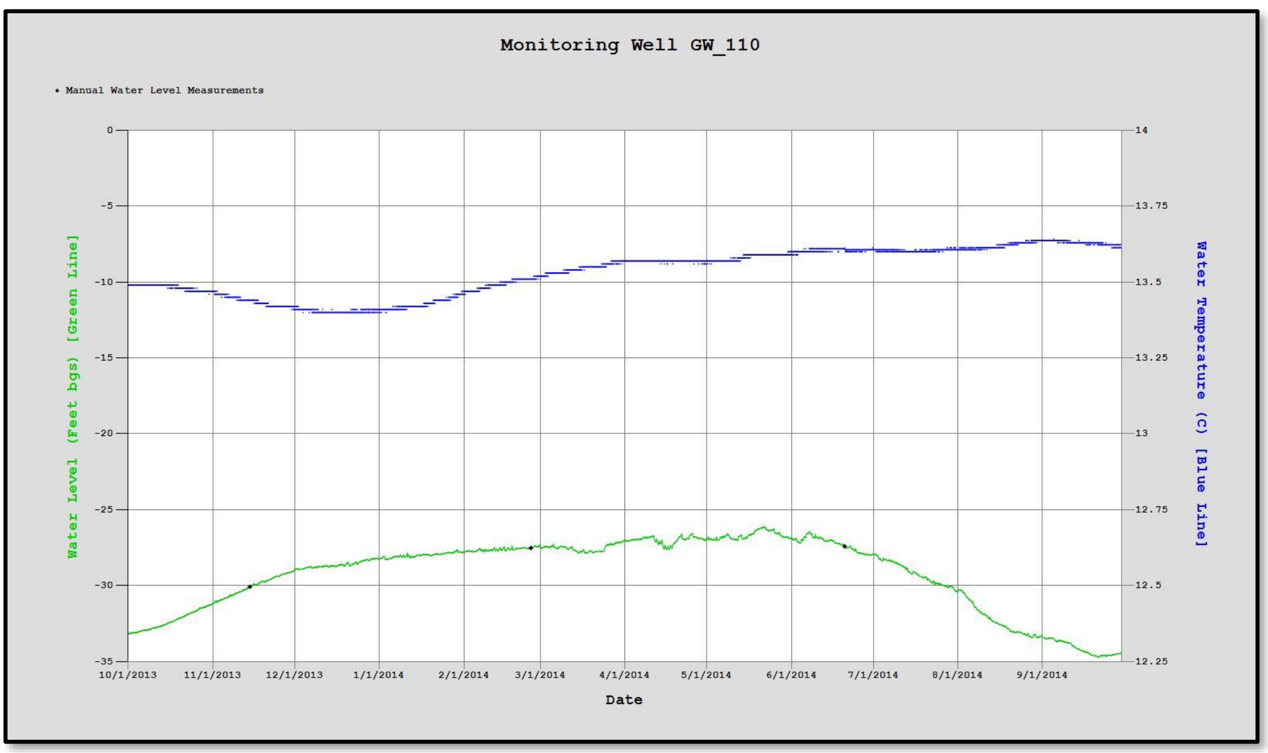


Figure 26 - Hydrograph for GW_110 during the WY 2014 recharge season.

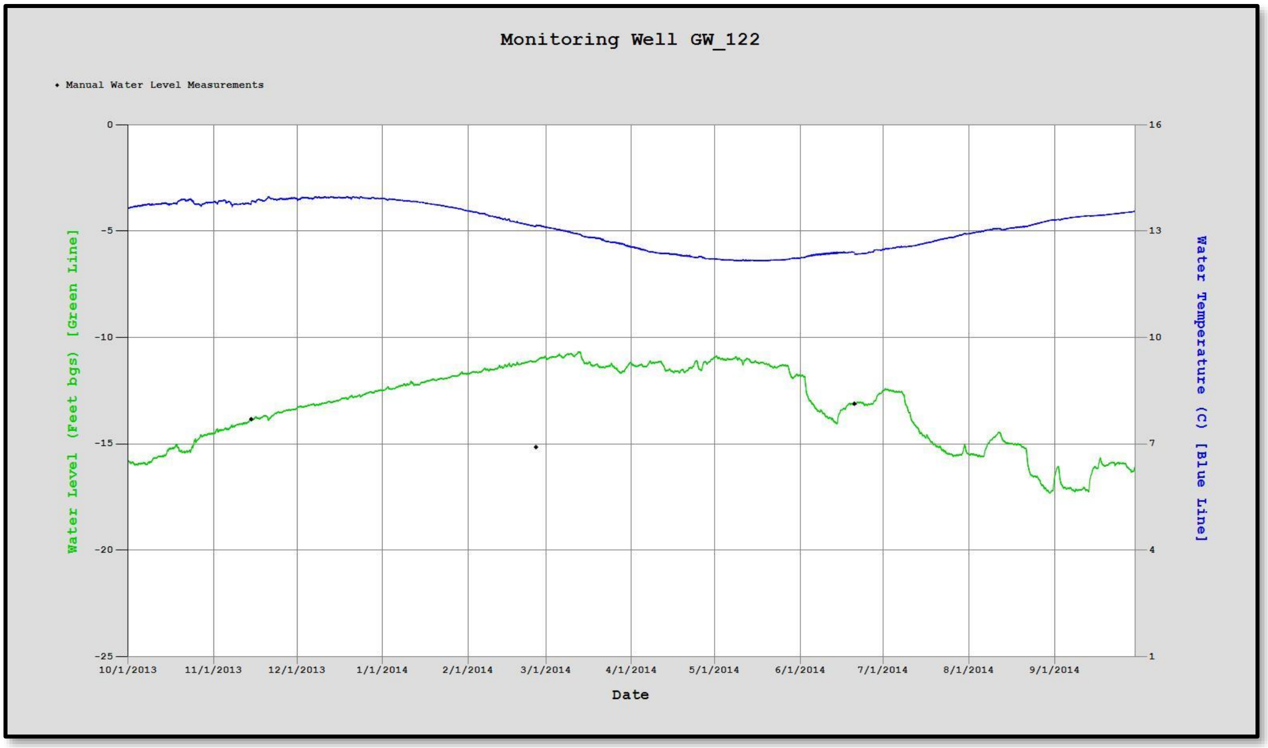


Figure 27 - Hydrograph for GW_122 during the WY 2014 recharge season.

Water Quality

Full water quality data and laboratory QA records can be found in Appendix B.

Source Water

Sample Parameter	February 27th, 2014	May 13th, 2014	June 9th, 2014
pH	7.40	7.54	7.78
Nitrates (mg/L)	0.35	0.19	0.65
Calcium (mg/L)	7.5	7.5	13.2
Total Dissolved Solids (TDS) (mg/L)	86	68	105
Chloride (mg/L)	0.9	0.89	2.06
Total DCPA (Dacthal) (µg/L)	0.12	0.16	0.67
Polychlorinated Biphenyls (pg/L)	32.9	68.5	1490

Up-gradient Well (GW_70 – L1)

Sample Parameter	February 27th, 2014	May 13th, 2014	June 9th, 2014
pH	7.17	6.95	6.87
Nitrates (mg/L)	6.72	0.25	3.31
Calcium (mg/L)	37.8	9.8	23.4
Total Dissolved Solids (TDS) (mg/L)	273	95	174
Chloride (mg/L)	6	1.10	3.31
Total DCPA (Dacthal) (µg/L)	ND	0.10	ND
Polychlorinated Biphenyls (pg/L)	713	1110	1120

Mid-gradient Well (GW_72 – L3)

Sample Parameter	February 27th, 2014	May 13th, 2014	June 9th, 2014
pH	7.24	6.88	6.76
Nitrates (mg/L)	3.23	1.41	0.86
Calcium (mg/L)	17.5	10.6	11.1
Total Dissolved Solids (TDS) (mg/L)	147	101	98
Chloride (mg/L)	2.4	0.95	1.67
Total DCPA (Dacthal) (μg/L)	ND	0.04	ND
Polychlorinated Biphenyls (pg/L)	681	699	1130

Down-gradient Well (GW_71 – L2)

Sample Parameter	February 27th, 2014	May 13th, 2014	June 9th, 2014
pH	7.12	6.62	6.82
Nitrates (mg/L)	3.45	22	10
Calcium (mg/L)	24	53.3	34.3
Total Dissolved Solids (TDS) (mg/L)	190	373	250
Chloride (mg/L)	4.3	4.63	4.03
Total DCPA (Dacthal) (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	710	1120	984

Soil Quality

Full soil quality data and laboratory QA records can be found in Appendix B.

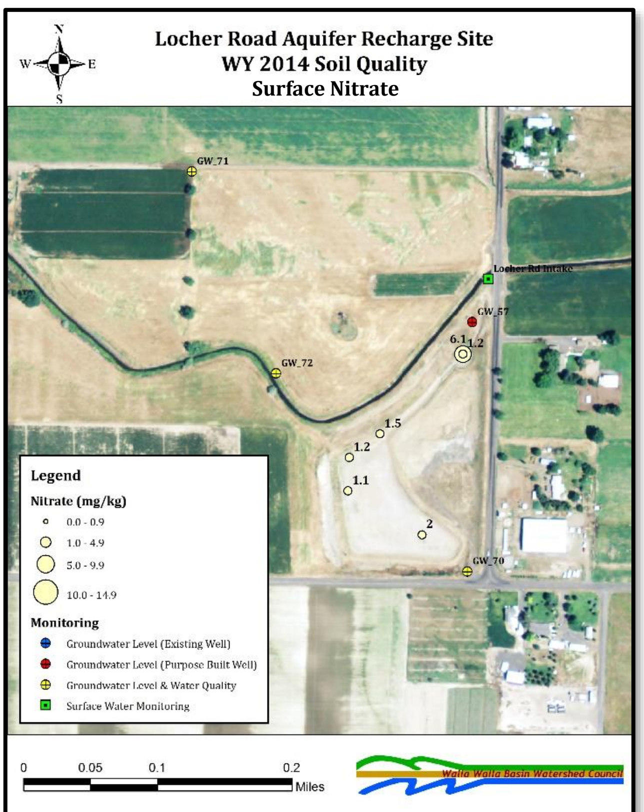


Figure 28 – Surface soil nitrate values at the Locher Road site during the WY2014 recharge season.

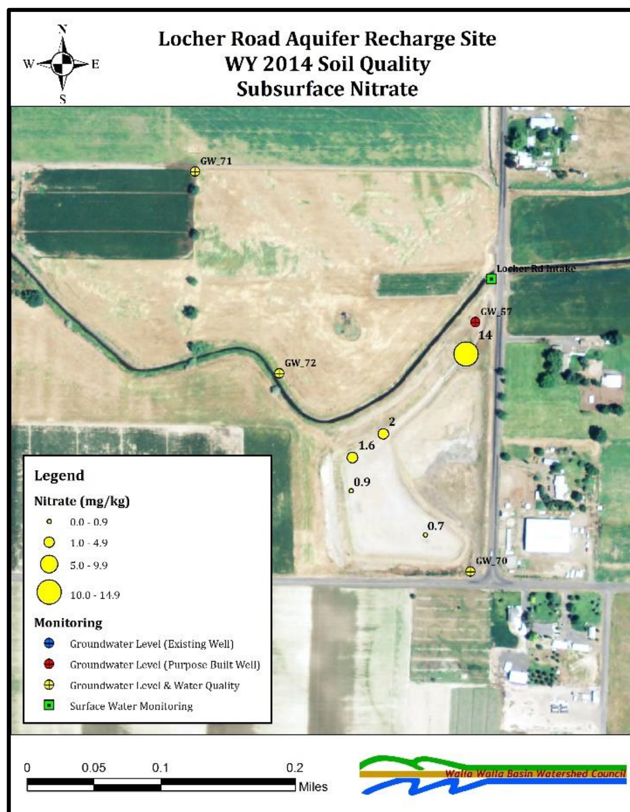


Figure 29 - Surface Subsurface (~1' below ground surface) soil nitrate values at the Locher Road site during the WY2014 recharge season.

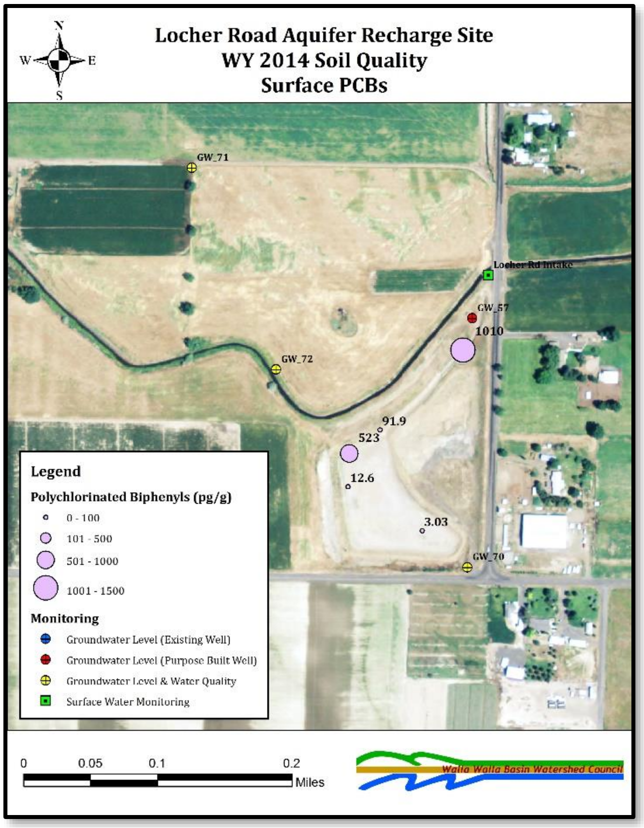


Figure 30 – Surface soil Polychlorinated Biphenyls (PCBs) values at the Locher Road site during the WY2014 recharge season.

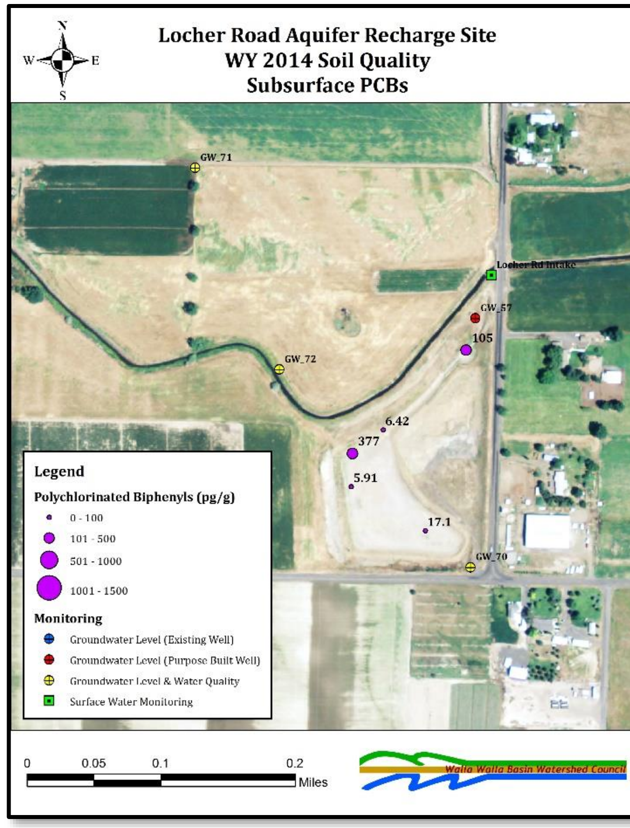


Figure 31 - Subsurface (~1' below ground surface) soil Polychlorinated Biphenyls (PCBs) values at the Locher Road site during the WY2014 recharge season.

Stiller Pond

Overview

The WWCCD operated the Stiller Pond Aquifer Recharge site during the WY2014 recharge season. WWBWC staff collected monitoring data, including water quality samples. The Stiller Pond site operated under the WWWMP Local Water Plan LW-10-02 which allows 32 acre-feet to be recharged to the shallow alluvial aquifer and the EEP temporary authorization for up to 991 acre-feet. Minimum in-stream flows did not prevent the site from operating during the WY2014 season until the last part of May (Figure 19). Mill Creek was monitored at two locations, above the site at Wallula Road (Figure 32) and below the site at Swegle Road (Figure 33). During the WY2014 recharge season ~300 acre-feet of water was delivered to the site.

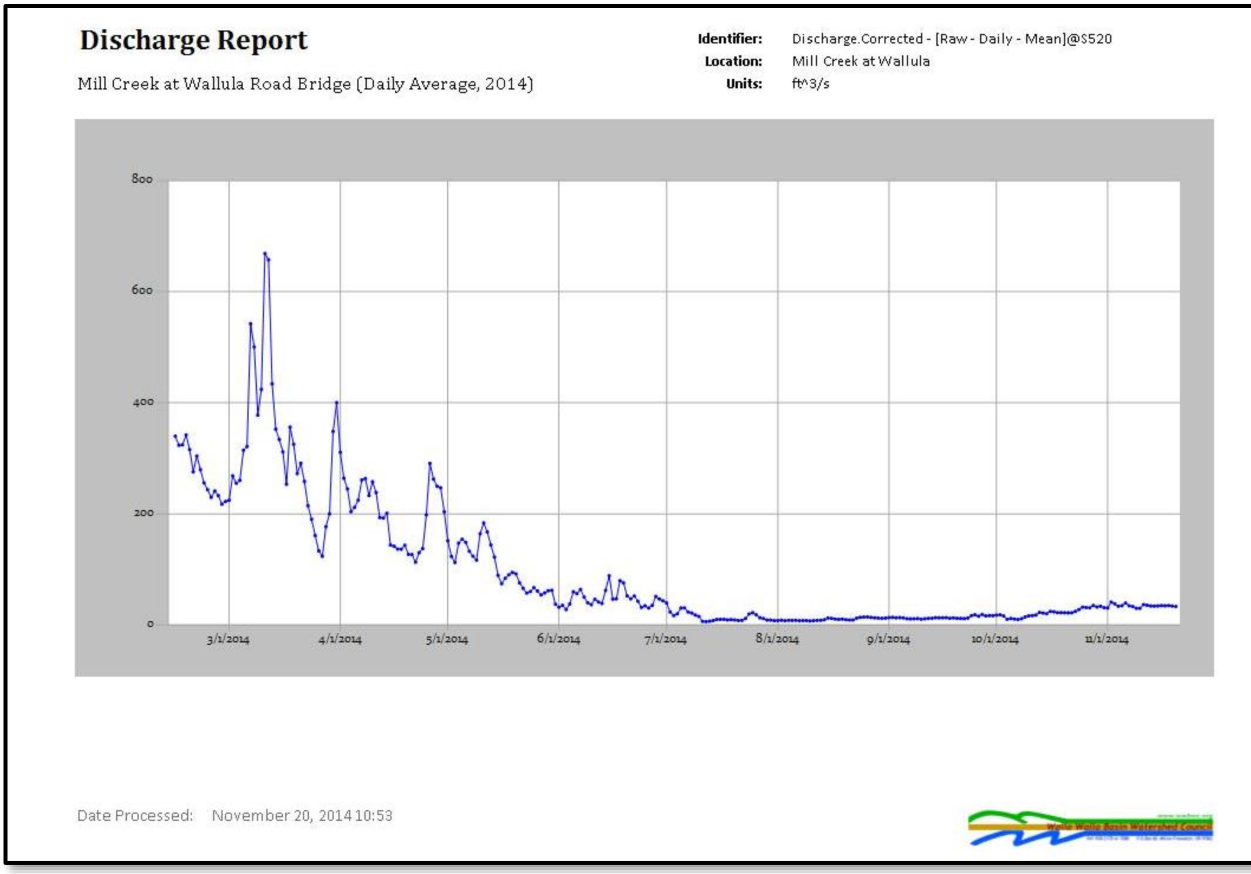


Figure 32 - Water Year 2014 hydrograph for WWBWC's Mill Creek at Wallula Road (S520) gage.

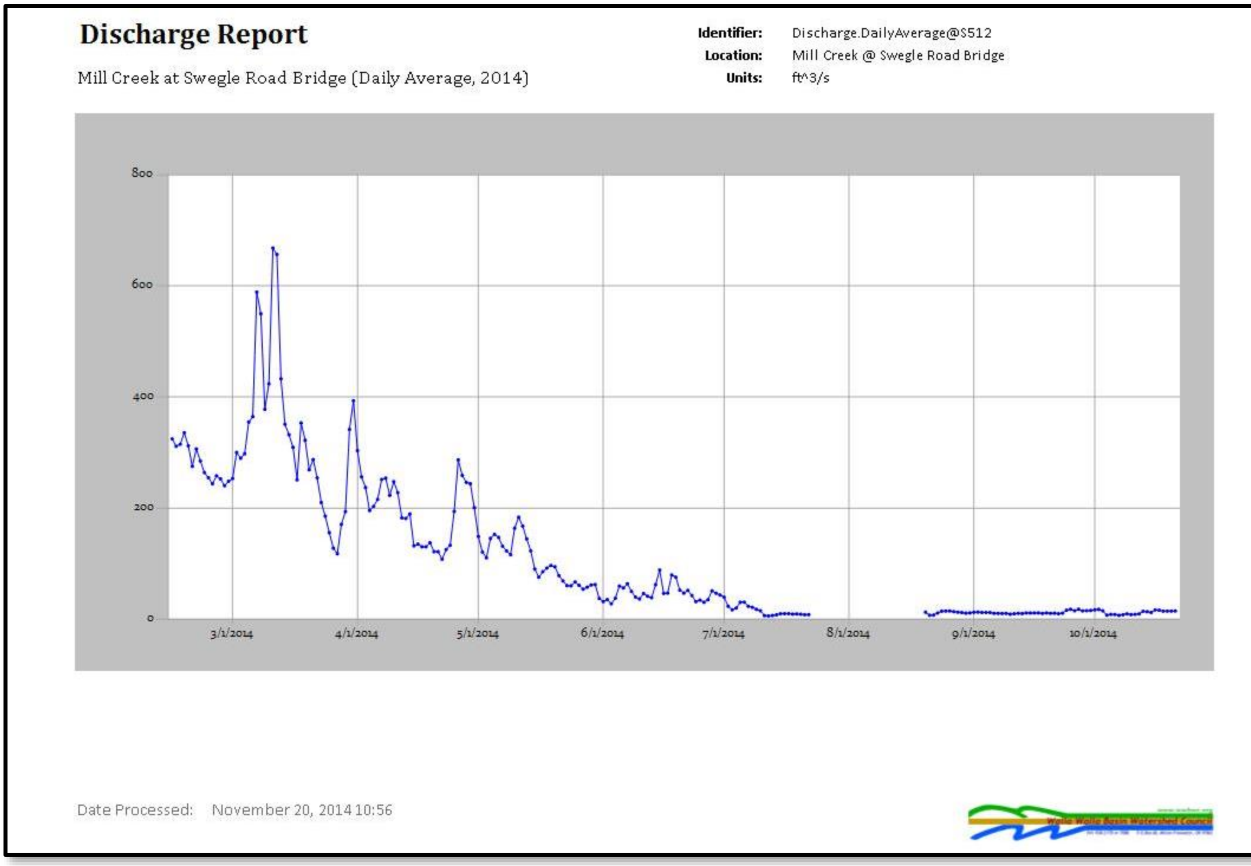


Figure 33 - Water Year 2014 hydrograph for WWBWC's Mill Creek at Swegle Road (S512) gage.

ALLUVIAL WELL RESPONSES

Groundwater monitoring (Figure 34) at the Stiller Pond site includes four on-site monitoring wells (GW_136, GW_145, GW_146 and GW_147). The four on-site wells surround the site with GW_147 up-gradient, GW_136 immediately down-gradient of the site and GW_145 and GW_146 farther down-gradient. All of the on-site wells are purpose-built monitoring wells. GW_145, GW_146 and GW_147 were installed just prior to the start of WY2014 recharge operations therefore they lack any pre-operation water level data. All of the on-site wells show a similar response during and after recharge operations (Figures 35-38). Water levels start to rise in early March coinciding with the start of recharge operations. Water levels appear to plateau starting in late April or early May. After recharge operations end in late May, water levels start to decline. The up-gradient well, GW_147, shows water levels responses to near-by pumping, however the overall water level trend is similar to down-gradient wells (Figure 38). Yearly low water levels during WY 2014 did not dip as low as they did during WY2013 (see Appendix A).

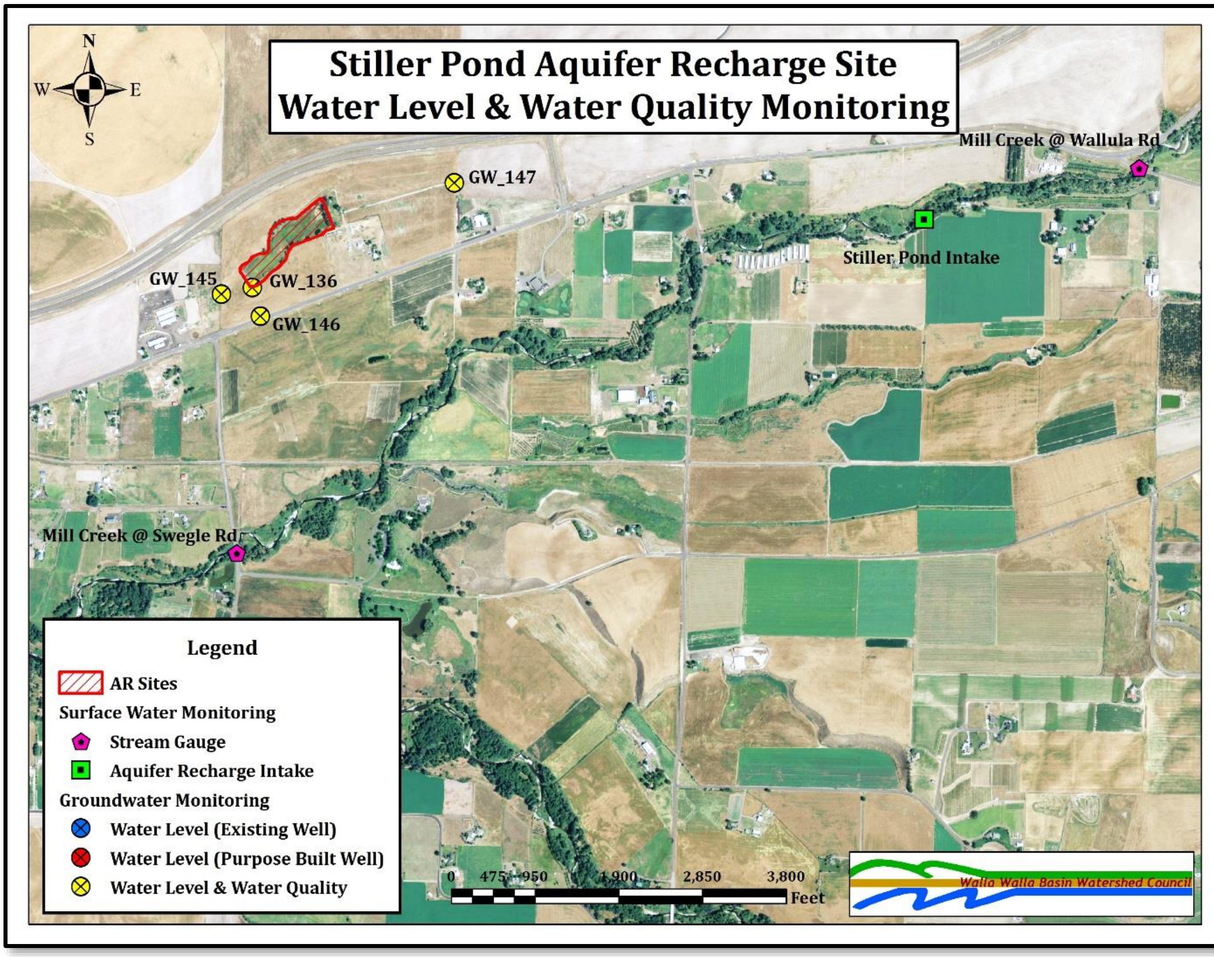


Figure 34 - Map showing groundwater and surface water monitoring sites for the Stiller Pond Aquifer Recharge Site.

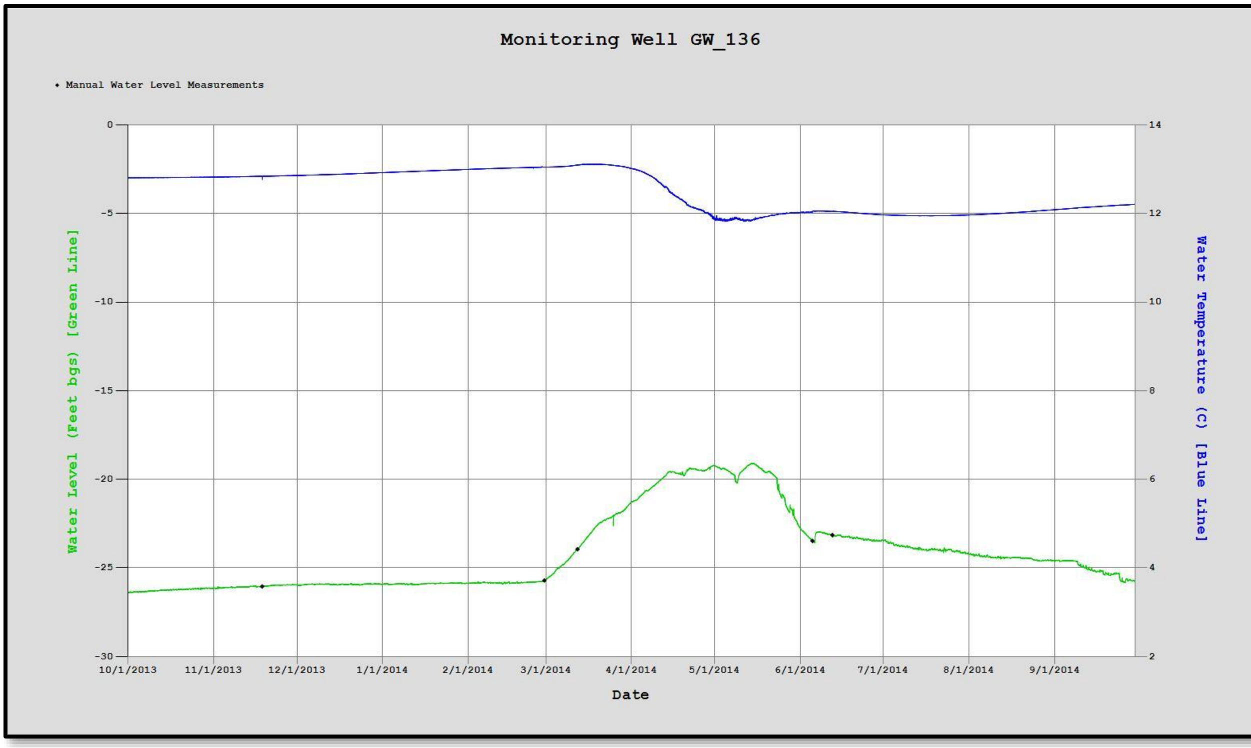


Figure 35 - Hydrograph for GW_136 during the WY 2014 recharge season.

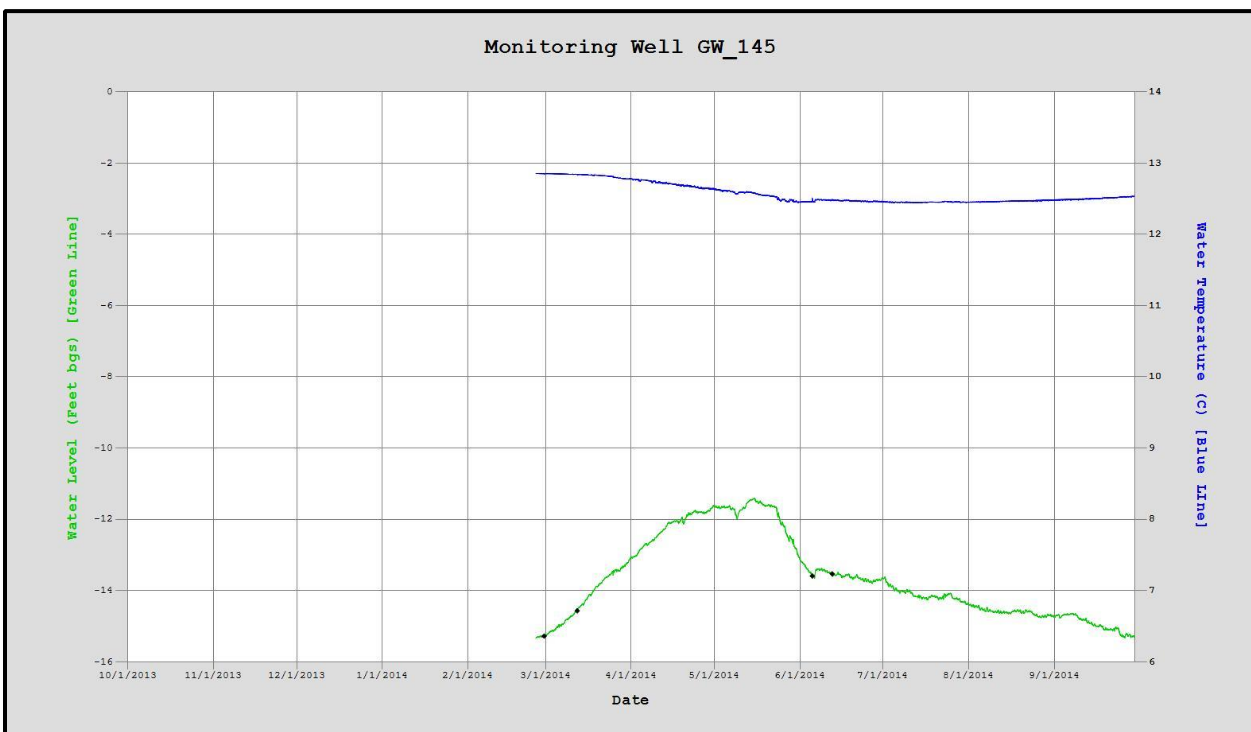


Figure 36 - Hydrograph for GW_145 during the WY 2014 recharge season.

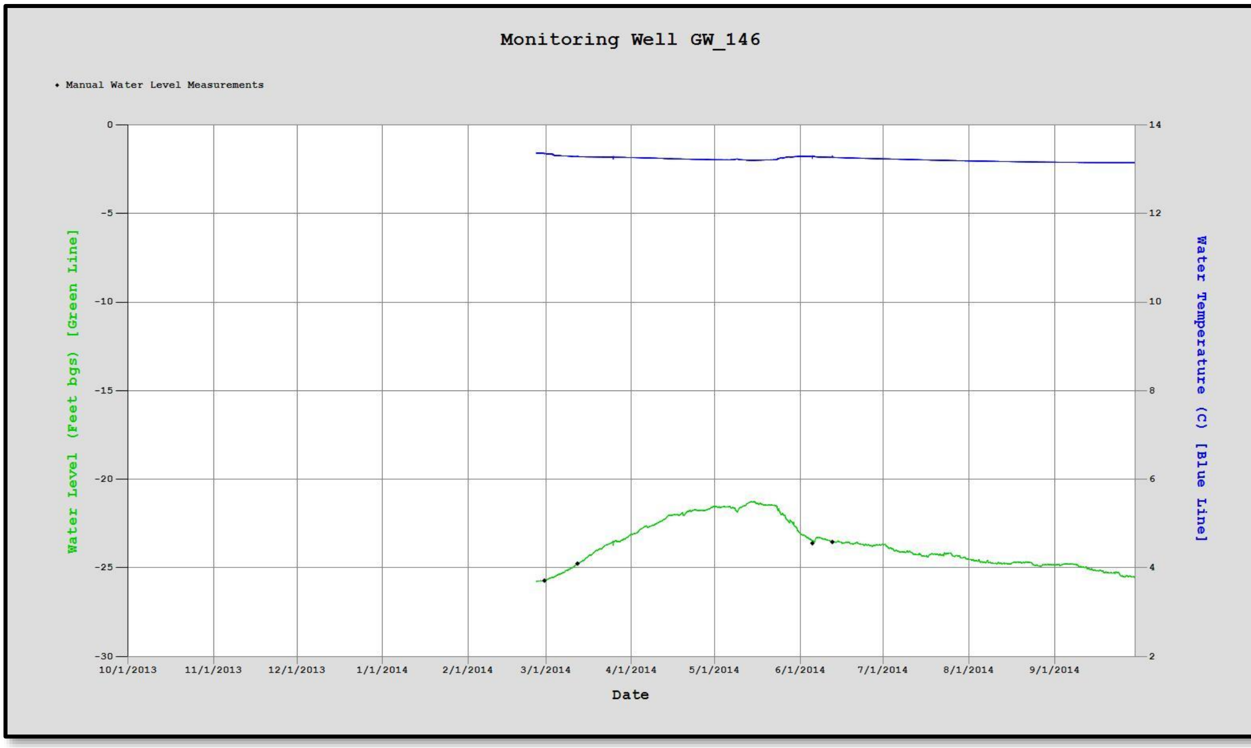


Figure 37 - Hydrograph for GW_146 during the WY 2014 recharge season.

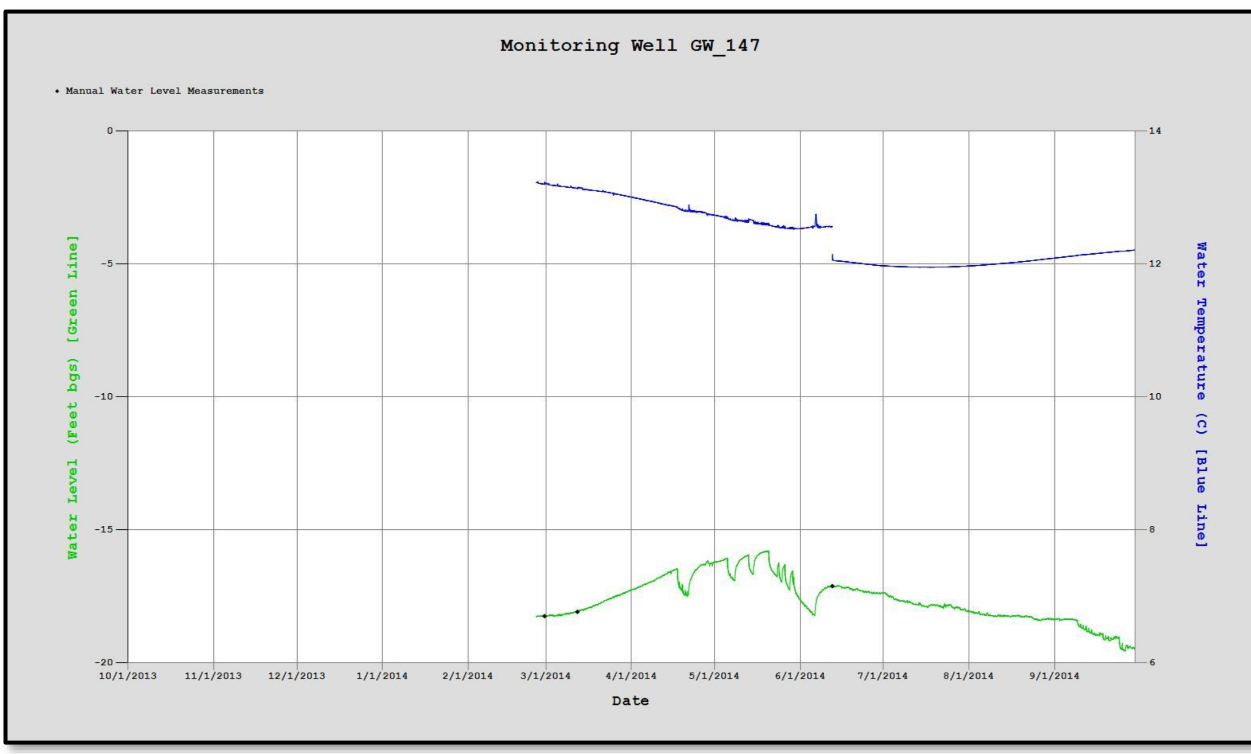


Figure 38 - Hydrograph for GW_147 during the WY 2014 recharge season.

Water Quality

Full water quality data and laboratory QA records can be found in Appendix B.

Source Water

Sample Parameter	February 26th, 2014	March 25th, 2014	June 5th, 2014
Nitrate (mg/L)	0.44	0.9	1.12
Calcium (mg/L)	7.0	8.6	13.5
Total Dissolved Solids (mg/L)	95	84	113
Chloride (mg/L)	2.88	2.9	7.28
Total DCPA (µg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	56.5	78.2	139

Up-gradient Well (GW_147)

Sample Parameter	February 25th, 2014	March 25th, 2014	June 5th, 2014
Nitrate	6	5.94	5.50
Calcium (mg/L)	44.2	45.1	43.7
Total Dissolved Solids (mg/L)	315	300	293
Chloride (mg/L)	32	32	30
Total DCPA (µg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	634	703	1050

Mid-gradient Well (GW_136)

Sample Parameter	February 25th, 2014	March 25th, 2014	June 5th, 2014
Nitrate	13	3.34	0.48
Calcium (mg/L)	66.4	49.2	39.7
Total Dissolved Solids (mg/L)	460	270	211
Chloride (mg/L)	40	15	4.29
Total DCPA (µg/L)	0.84	0.15	ND
Polychlorinated Biphenyls (pg/L)	674	734	1050

Down-gradient Well (GW_145)

Sample Parameter	February 25th, 2014	March 25th, 2014	June 5th, 2014
Nitrate	10	11.63	6.77
Calcium (mg/L)	61.8	62.5	56.7
Total Dissolved Solids (mg/L)	394	416	372
Chloride (mg/L)	36	39	28
Total DCPA (µg/L)	0.09	0.11	ND
Polychlorinated Biphenyls (pg/L)	734	817	1210

Down-gradient Well (GW_146)

Sample Parameter	February 25th, 2014	March 25th, 2014	June 5th, 2014
Nitrate	18	16.71	10
Calcium (mg/L)	70.5	70.1	57.8
Total Dissolved Solids (mg/L)	560	510	456
Chloride (mg/L)	47	47	34
Total DCPA (µg/L)	4.37	3.9	ND
Polychlorinated Biphenyls (pg/L)	858	1100	1430

SOIL QUALITY

Full soil quality data and laboratory QA records can be found in Appendix B.

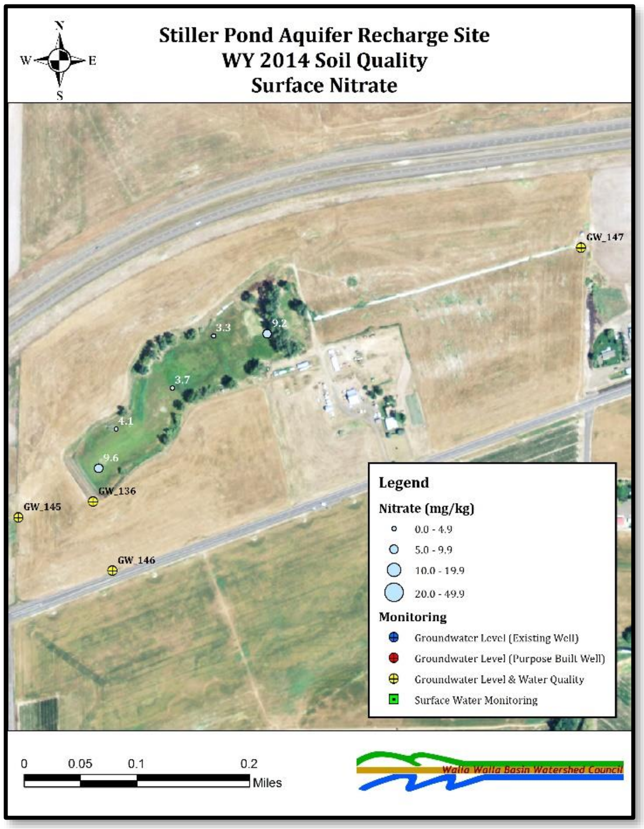


Figure 39 – Surface soil nitrate values at the Stiller Pond site during the WY2014 recharge season.

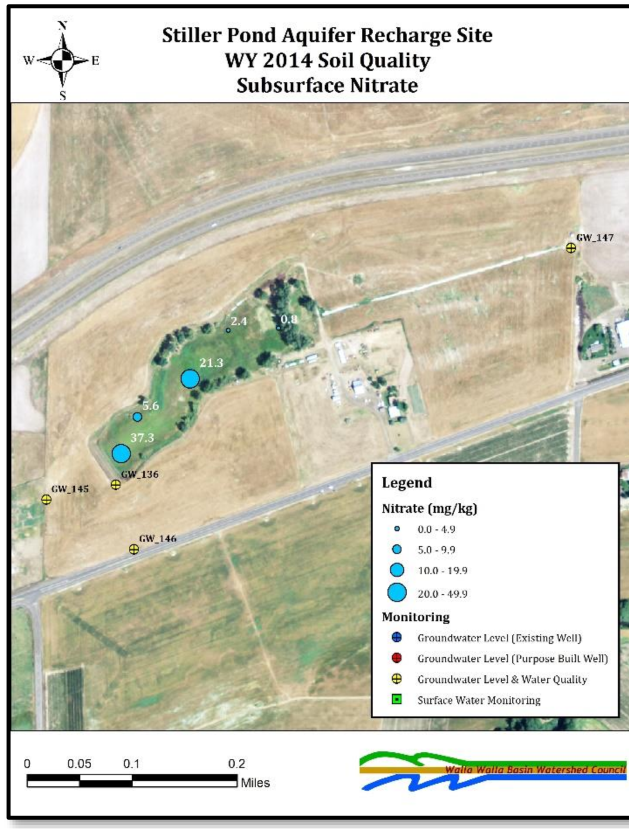


Figure 40 - Subsurface (~1' below ground surface) soil nitrate values at the Stiller Pond site during the WY2014 recharge season.

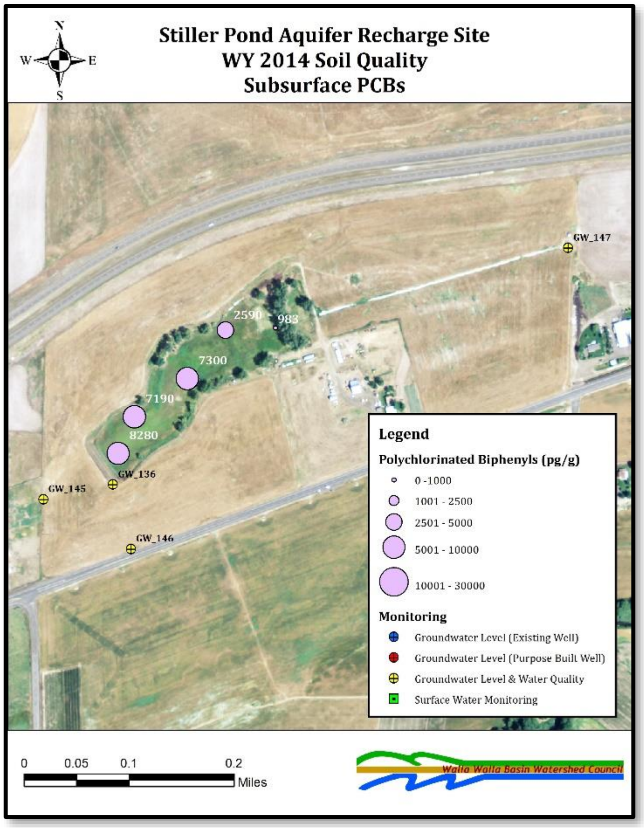


Figure 41 – Surface soil Polychlorinated Biphenyls (PCBs) values at the Stiller Pond site during the WY2014 recharge season.

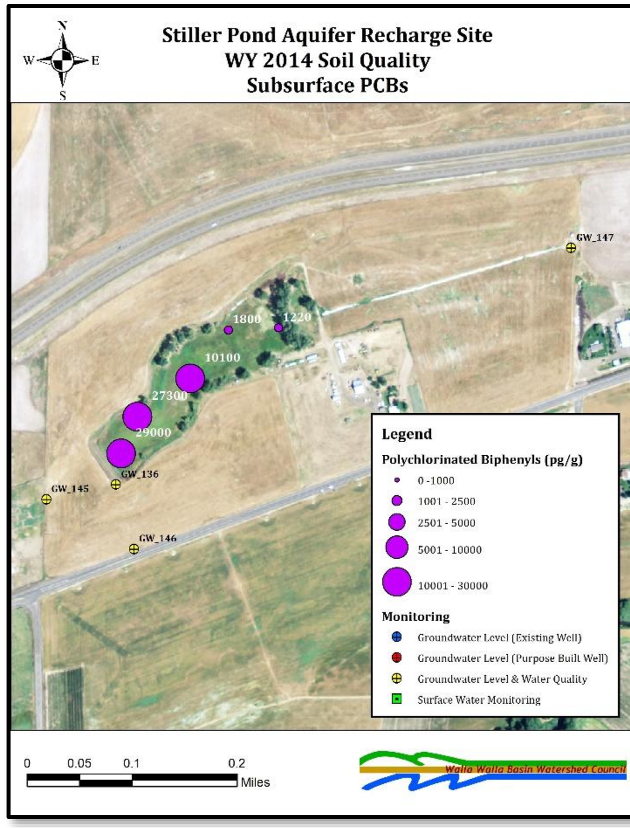


Figure 42 - Subsurface (~1' below ground surface) soil Polychlorinated Biphenyls (PCBs) values at the Stiller Pond site during the WY2014 recharge season.

WATER YEAR 2015 RECHARGE SEASON RESULTS

LOCHER ROAD

OVERVIEW

During the WY2015 recharge season, the Locher Road site operated under the Local Water Plan authorization because the temporary authorization had expired. The site operated from almost two weeks during April. A total of 36 acre-feet was delivered to the site. Minimum in-stream bypass flows prevented the site from operating during March, some of April and all of May (Figure 43).

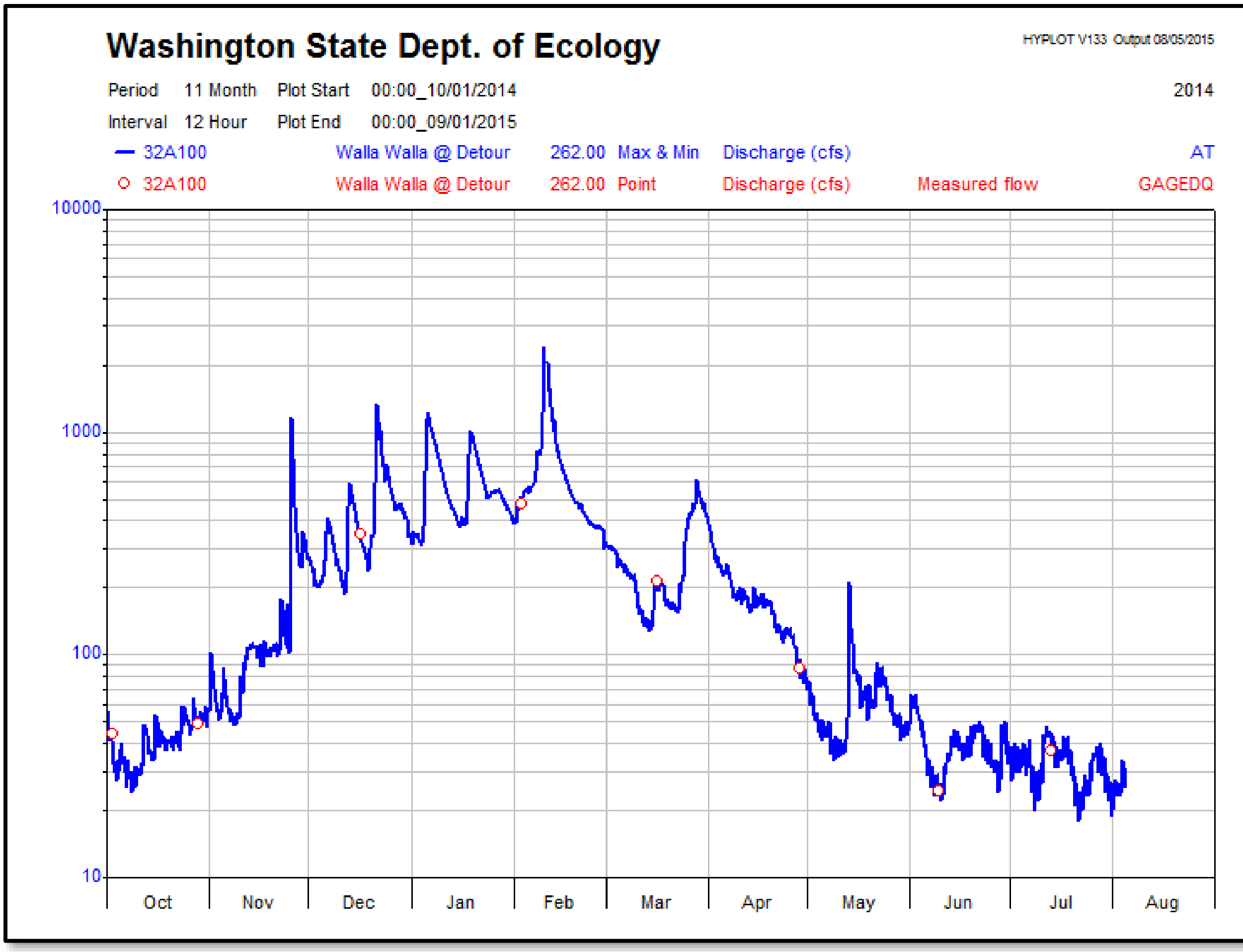


Figure 43 – Partial Water Year 2015 hydrograph for Washington Department of Ecology's Walla Walla River at Detour Road (32A100) gage.

Alluvial Well Responses

The "on-site" monitoring wells all show a similar response to canal and recharge operations (Figures 44-47). Water levels rise in early October with the start of the Gardena Farms Canal for fall irrigation. The canal was turned off in early-mid December. Starting in early December water levels show neutral conditions until the canal turned on again in early March. Water levels slowly increase due to canal operations through late March and early April. Recharge operations start in mid-April and water levels respond with a sharp increase until recharge operations stop in late April. Water levels decrease after recharge and return to pre-recharge levels. Down-gradient wells do not show the same rapid response to canal or recharge operations (Figures 48-50). One of the offsite, distal, monitoring wells, GW_108, also shows the influence of nearby groundwater pumping on alluvial aquifer water levels before, during and after recharge operations.

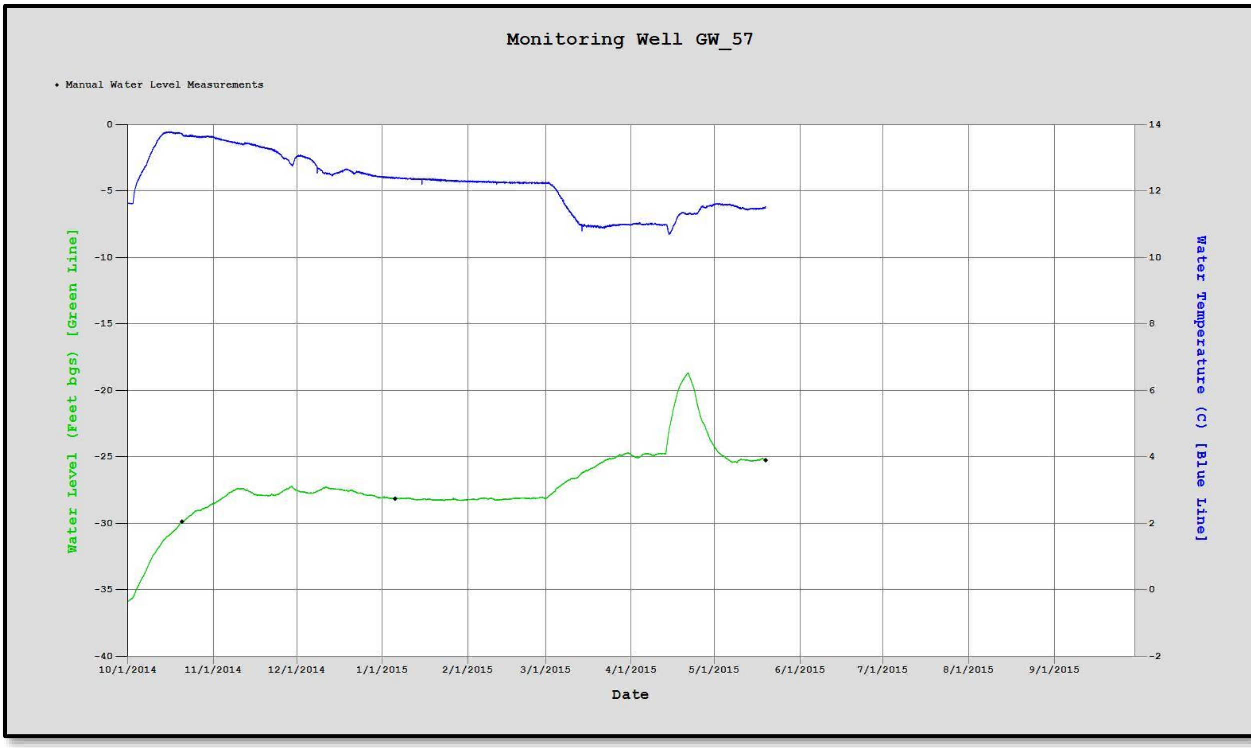


Figure 44 - Hydrograph for GW_57 during the WY2015 recharge season.

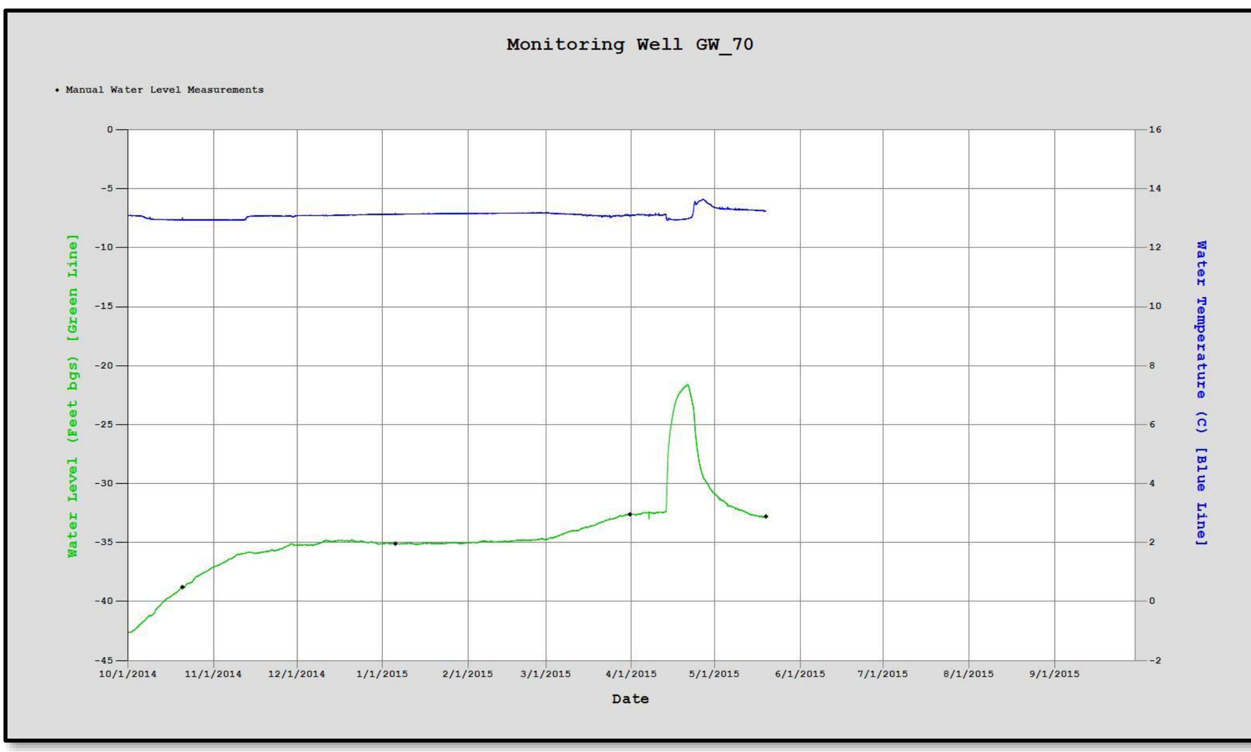


Figure 45 - Hydrograph for GW_70 during the WY2015 recharge season.

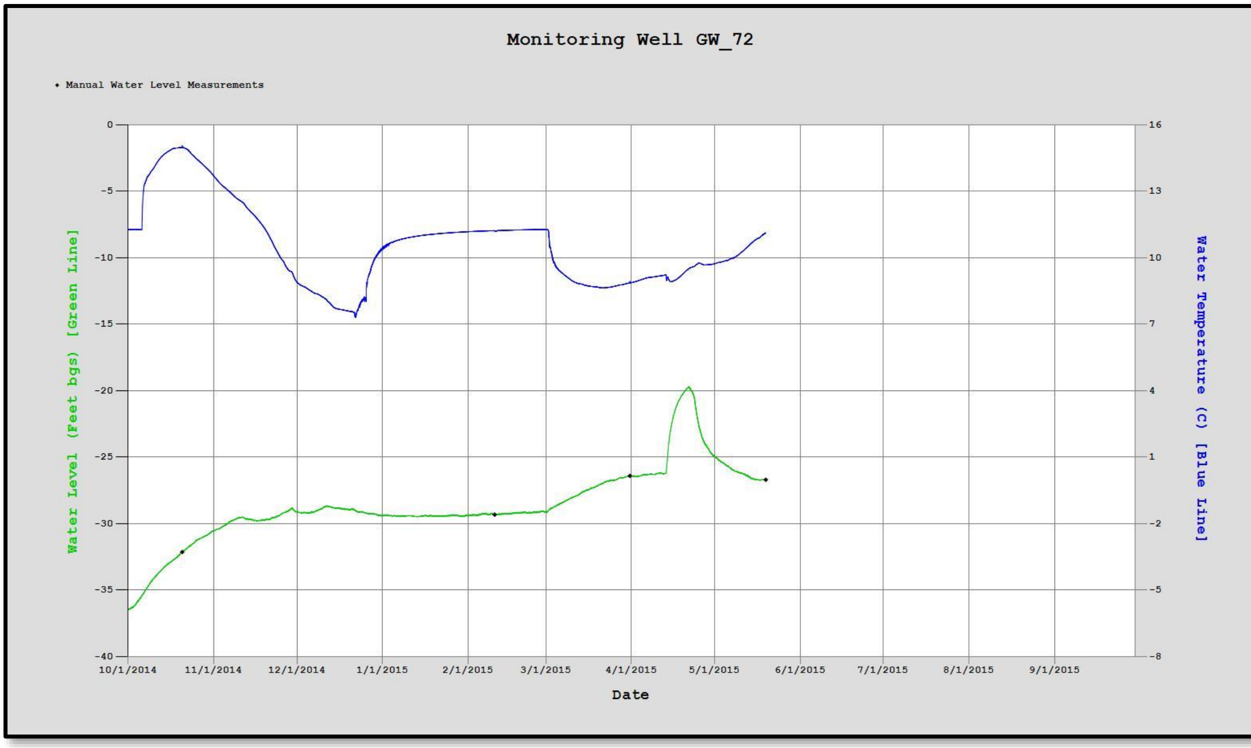


Figure 46 - Hydrograph for GW_71 during the WY2015 recharge season.

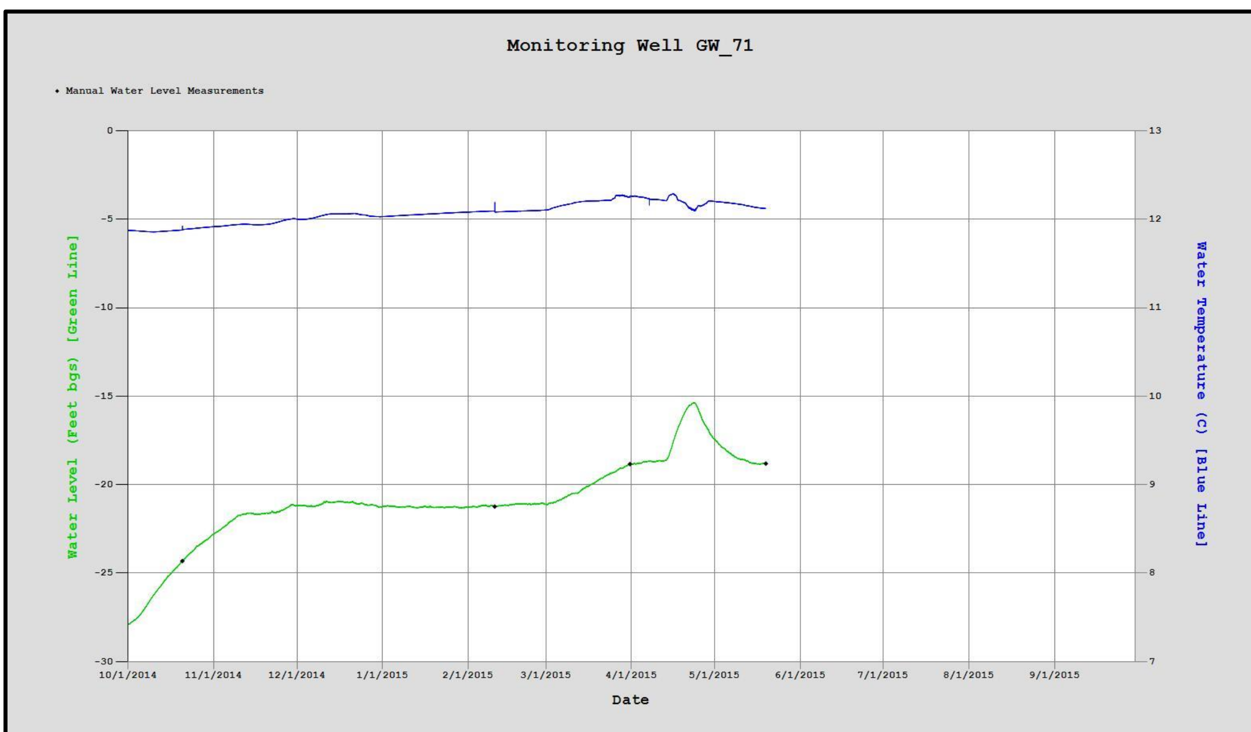


Figure 47 - Hydrograph for GW_72 during the WY2015 recharge season.

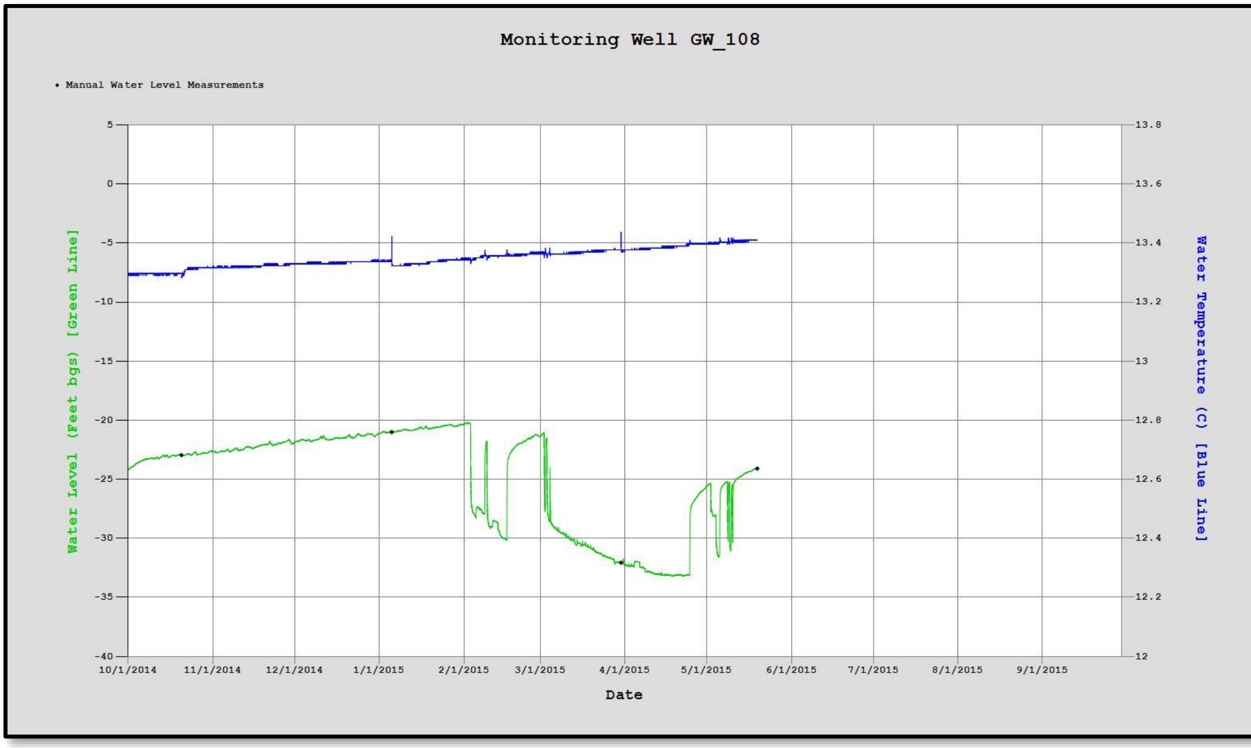


Figure 48 - Hydrograph for GW_108 during the WY2015 recharge season.

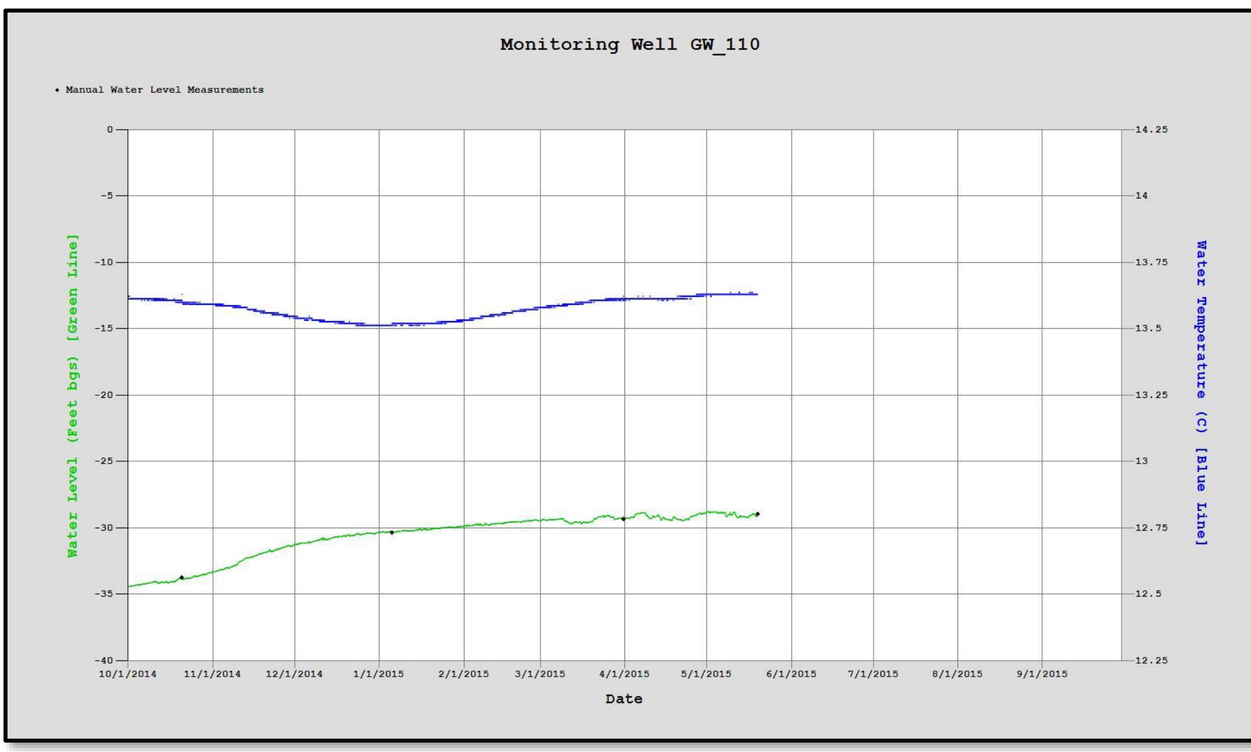


Figure 49 - Hydrograph for GW_110 during the WY2015 recharge season.

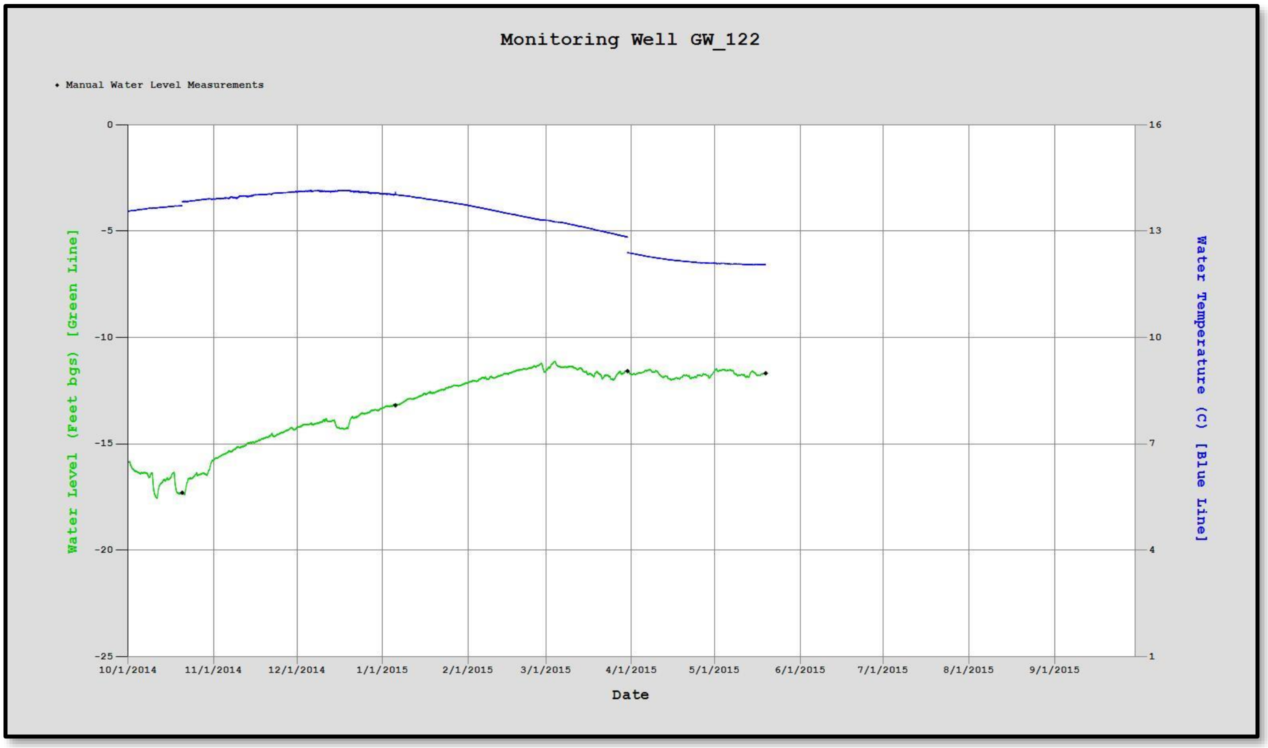


Figure 50 - Hydrograph for GW_122 during the WY2015 recharge season.

WATER QUALITY

Full water quality data and laboratory QA records can be found in Appendix B. Note that PCBs and chlorinated pesticides were removed from the parameters list for WY2015 (Kuttel, 2015).

SOURCE WATER

Sample Parameter	April 7th, 2015	May 20th, 2015
pH	7.36	7.50
Nitrates (mg/L)	0.34	0.56
Calcium (mg/L)	8.2	11.9
Total Dissolved Solids (TDS) (mg/L)	82	106
Chloride (mg/L)	1.4	2.2
Total DCPA (Dacthal) (μg/L)	0.3	ND

UP-GRADIENT WELL (GW_70 – L1)

Sample Parameter	April 7th, 2015	May 20th, 2015
pH	6.90	6.90
Nitrates (mg/L)	6.56	5.62
Calcium (mg/L)	31.5	29.2
Total Dissolved Solids (TDS) (mg/L)	247	233
Chloride (mg/L)	5.9	5.2
Total DCPA (Dacthal) (μg/L)	ND	ND

Mid-gradient Well (GW_72 – L3)

Sample Parameter	April 7th, 2015	May 20th, 2015
pH	6.88	6.83
Nitrates (mg/L)	0.89	1.07
Calcium (mg/L)	9.0	12.0
Total Dissolved Solids (TDS) (mg/L)	86	111
Chloride (mg/L)	1.5	2.1
Total DCPA (Dacthal) (μg/L)	0.07	ND

Down-gradient Well (GW_71 – L2)

Sample Parameter	April 7th, 2015	May 20th, 2015
pH	6.80	6.82
Nitrates (mg/L)	5.10	6.66
Calcium (mg/L)	24.1	26.3
Total Dissolved Solids (TDS) (mg/L)	197	228
Chloride (mg/L)	5.04	5.3
Total DCPA (Dacthal) (μg/L)	ND	ND

Soil Quality

Full soil quality data and laboratory QA records can be found in Appendix B. Note that PCBs and chlorinated pesticides were removed from the parameters list for WY2015 (Kuttel, 2015).

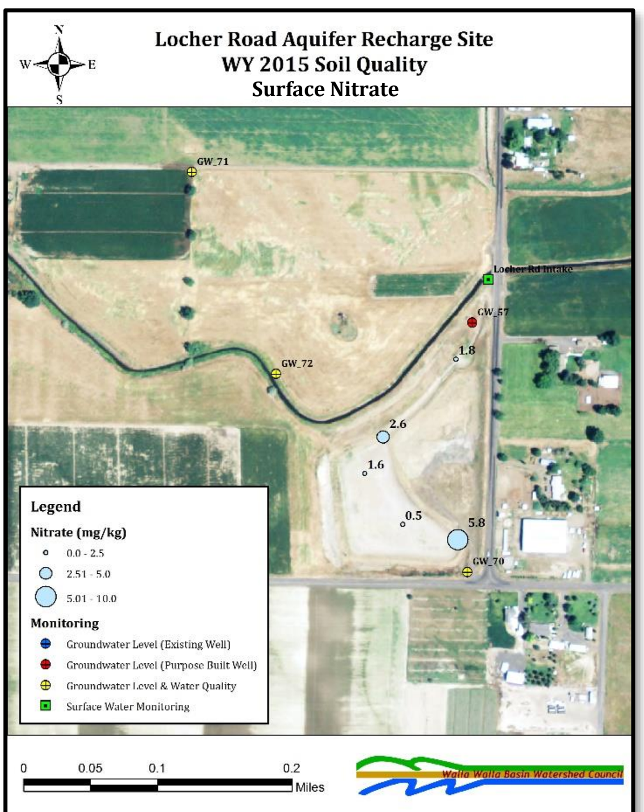


Figure 51 – Surface soil nitrate values at the Locher Road site during the WY2015 recharge season.

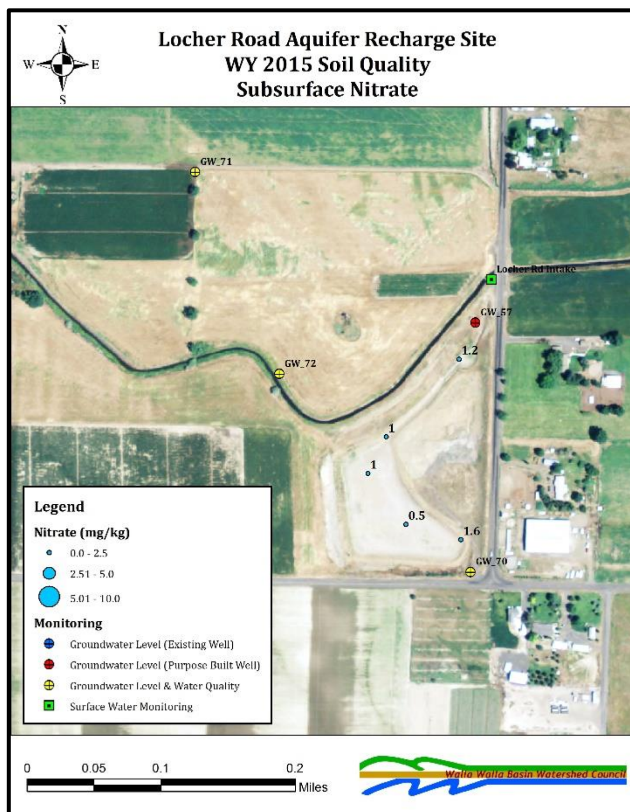


Figure 52 - Surface Subsurface (~1' below ground surface) soil nitrate values at the Locher Road site during the WY2015 recharge season.

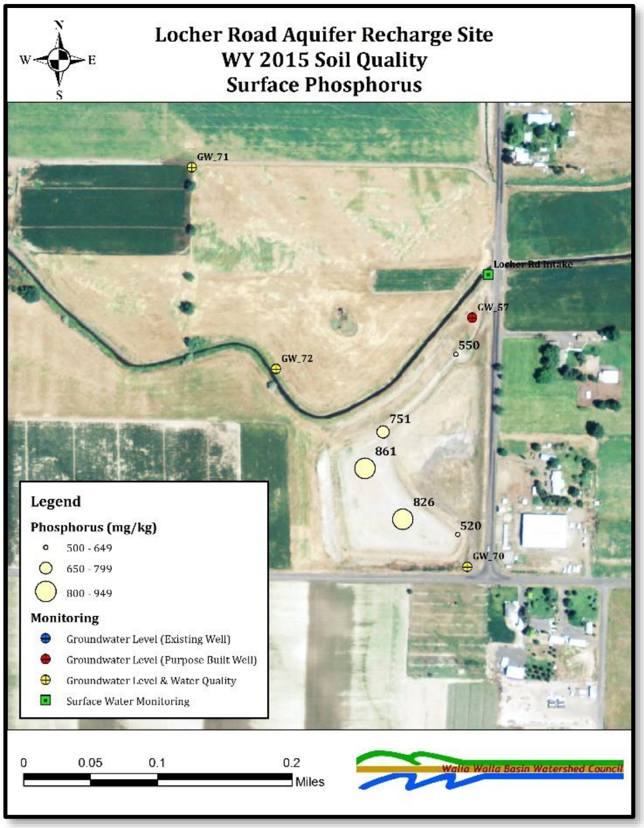


Figure 53 – Surface soil Phosphorus values at the Locher Road site during the WY2015 recharge season.

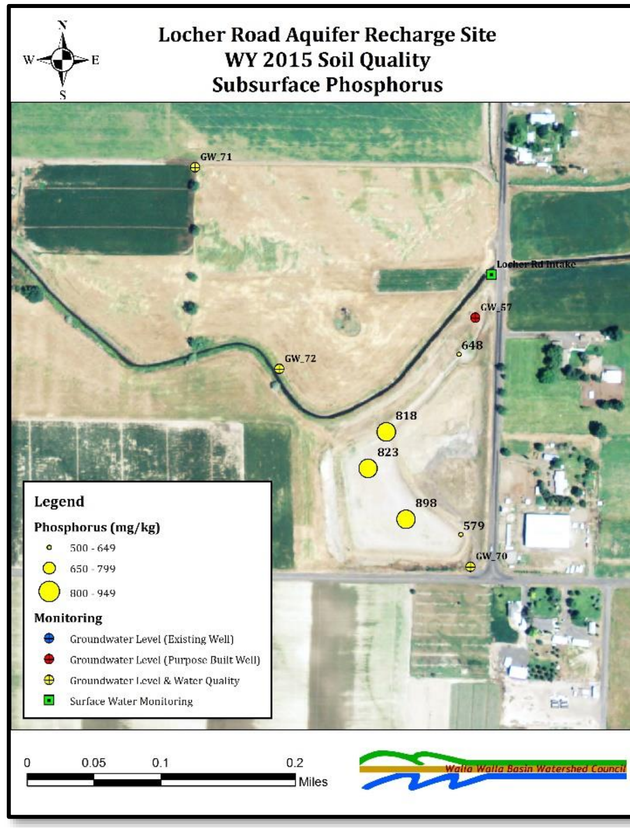


Figure 54 - Subsurface (~1' below ground surface) soil Phosphorus values at the Locher Road site during the WY2015 recharge season.

STILLER POND

OVERVIEW

The WWCCD operated the Stiller Pond Aquifer Recharge site during the WY2015 recharge season. WWBWC staff collected monitoring data, including water and soil quality samples. The Stiller Pond site operated under the WWWMP Local Water Plan LW-10-02 which allows 32 acre-feet to be recharged to the shallow alluvial aquifer and the EEP temporary authorization for up to 991 acre-feet. Minimum in-stream flows prevented the site from operating during a significant portion of the WY2015 season (Figure 43). Mill Creek was monitored at two locations, above the site at Wallula Road (Figure 55) and below the site at Swegle Road (Figure 56). During the WY2015 recharge season 214 acre-feet of water was delivered to the site.

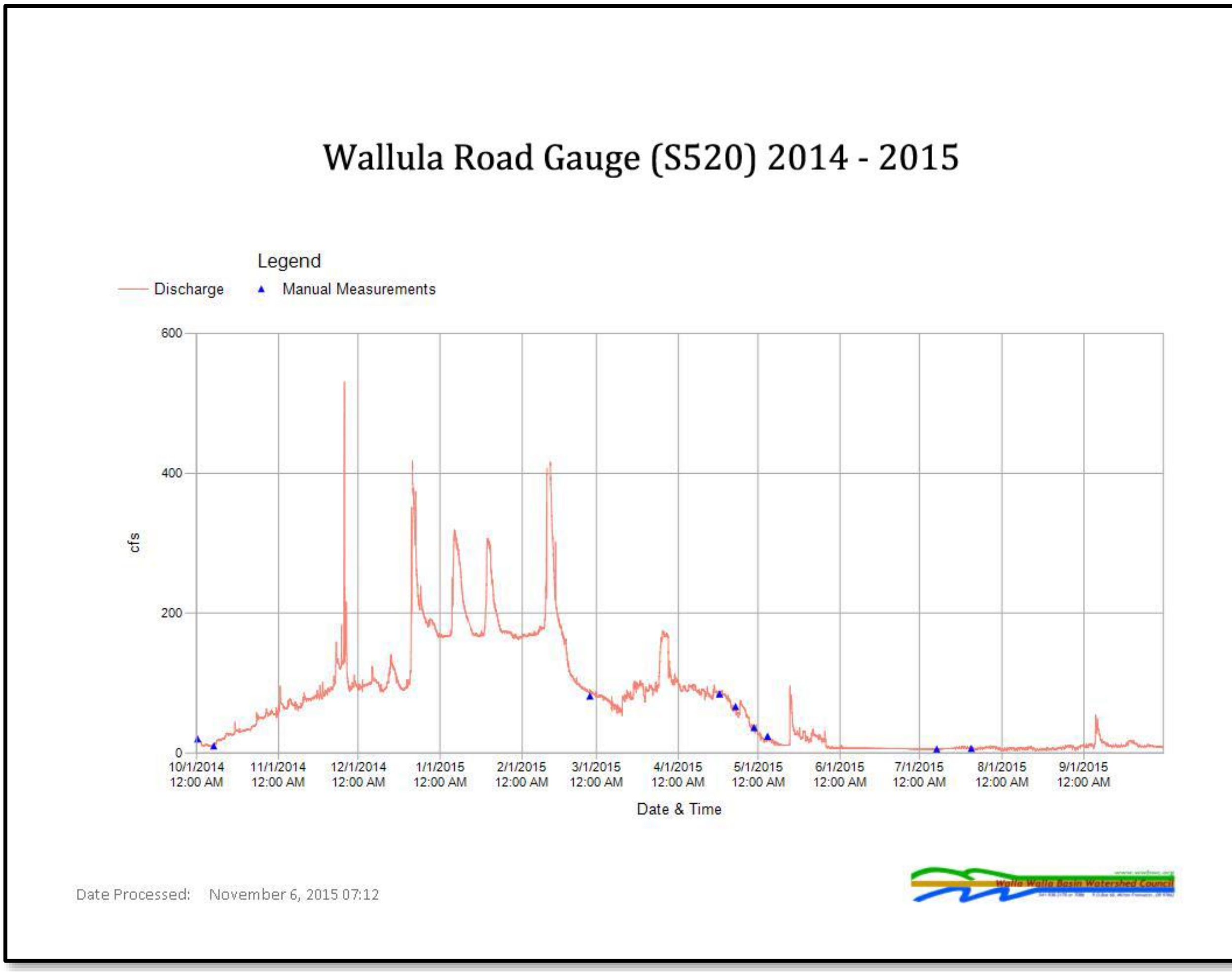


Figure 55 - Water Year 2015 hydrograph for WWBWC's Mill Creek at Wallula Road (S520) gage.

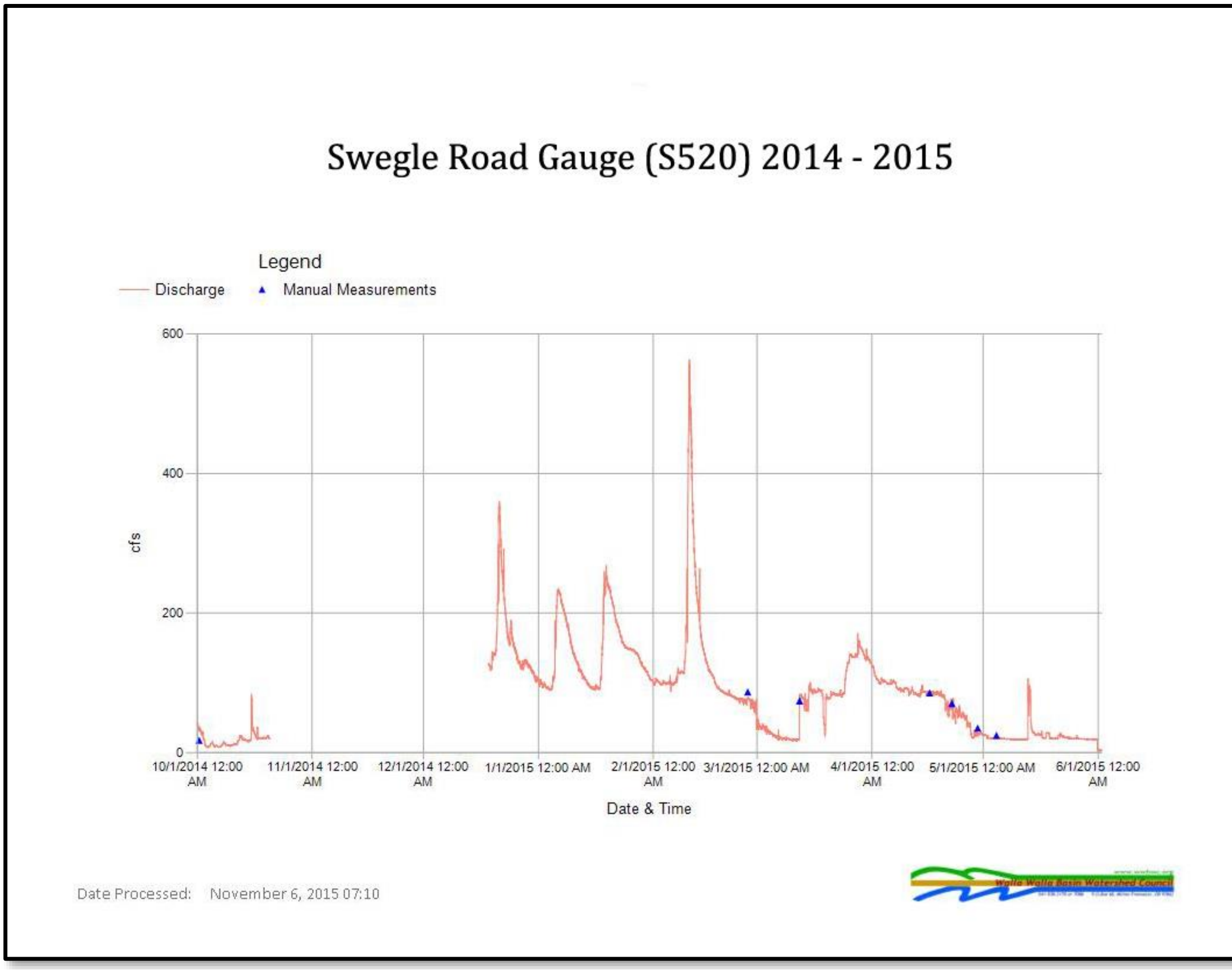


Figure 56 - Water Year 2015 hydrograph for WWBWC's Mill Creek at Swegle Road (S512) gage.

ALLUVIAL WELL RESPONSES

Groundwater monitoring (Figure 34) at the Stiller Pond site includes four on-site monitoring wells (GW_136, GW_145, GW_146 and GW_147). All of the down-gradient, on-site wells show a similar response during and after recharge operations (Figures 57-59). Water levels start to rise in mid-December coinciding with the start of recharge operations. Water levels decline during short periods of shut down during January and March. After recharge operations end in April, water levels start to decline. The up-gradient well, GW_147, shows water levels responses to near-by pumping in May, however the overall water level trend is similar to down-gradient wells with water levels increasing from December to April and starting to decline in late-April/May (Figure 60).

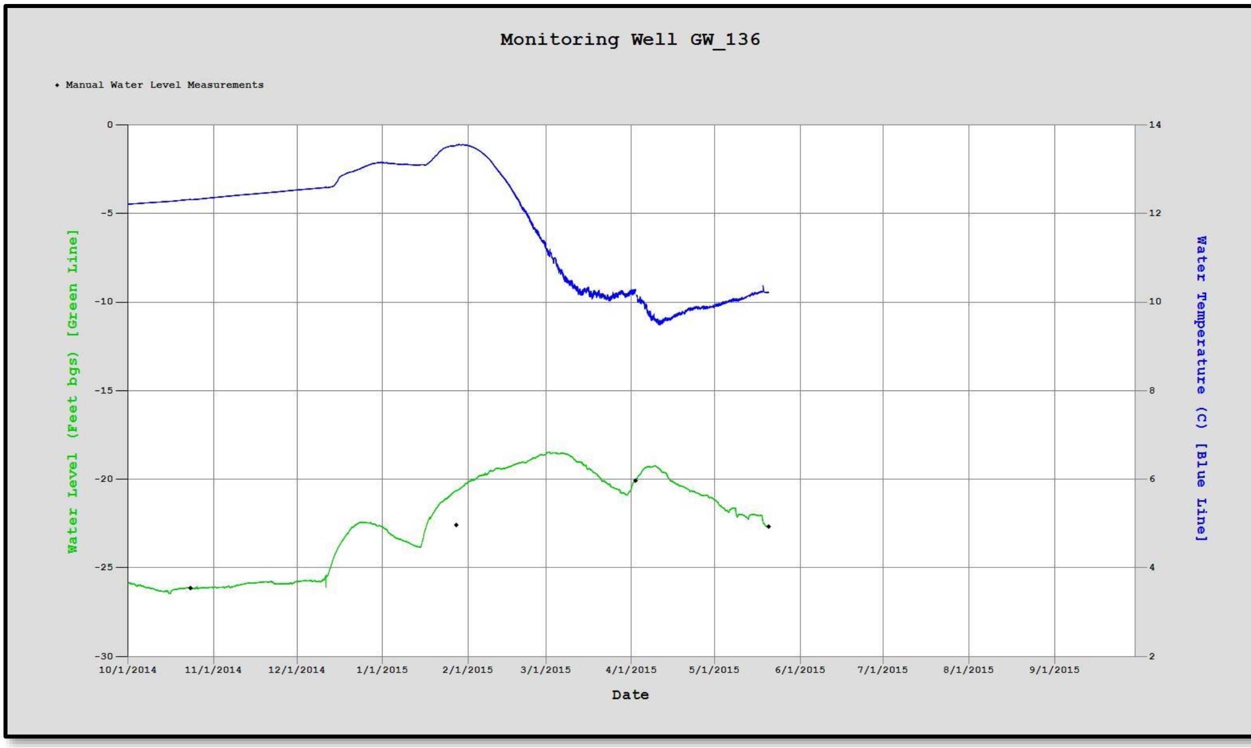


Figure 57 - Hydrograph for GW_136 during the WY2015 recharge season.

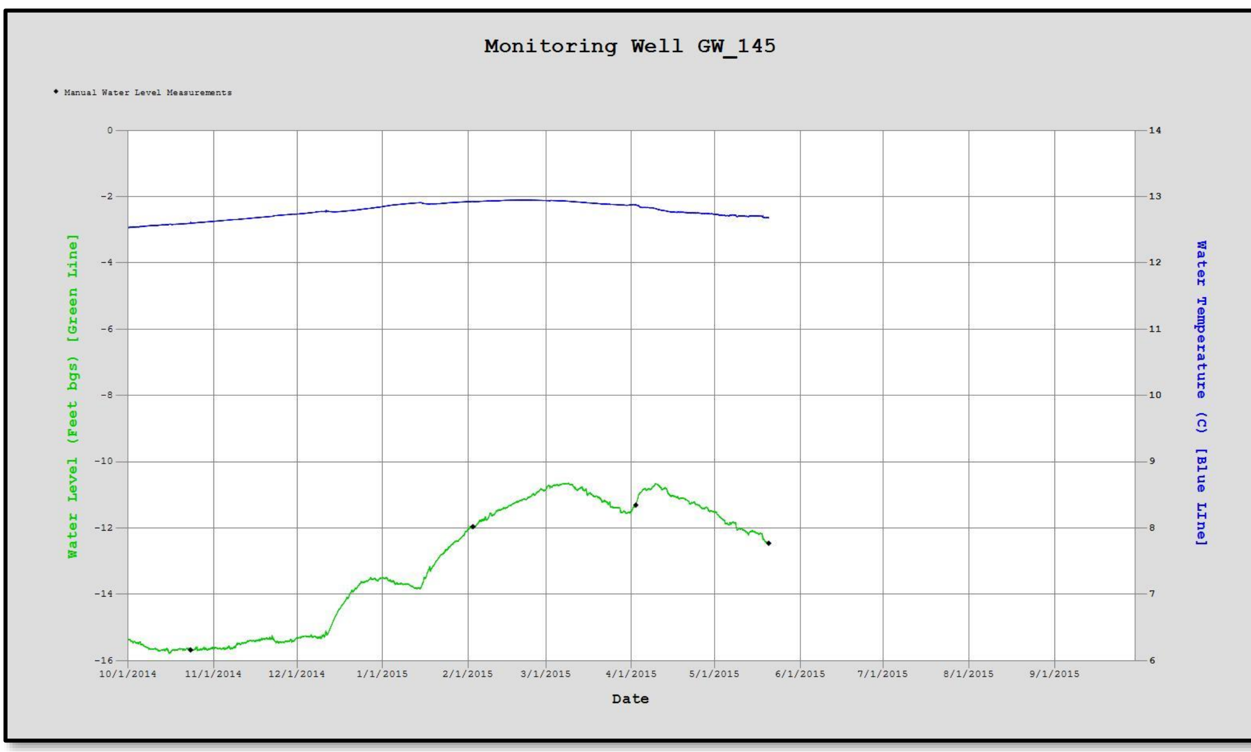


Figure 58 - Hydrograph for GW_145 during the WY2015 recharge season.

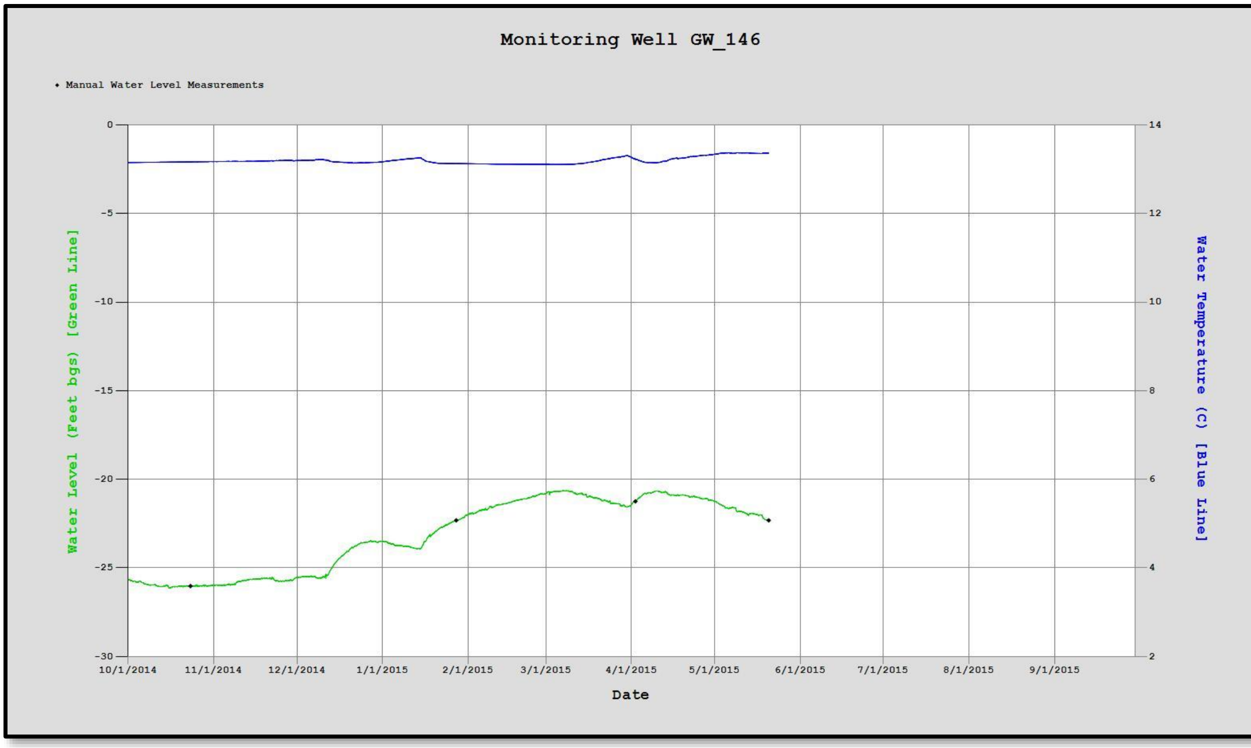


Figure 59 - Hydrograph for GW_146 during the WY2015 recharge season.

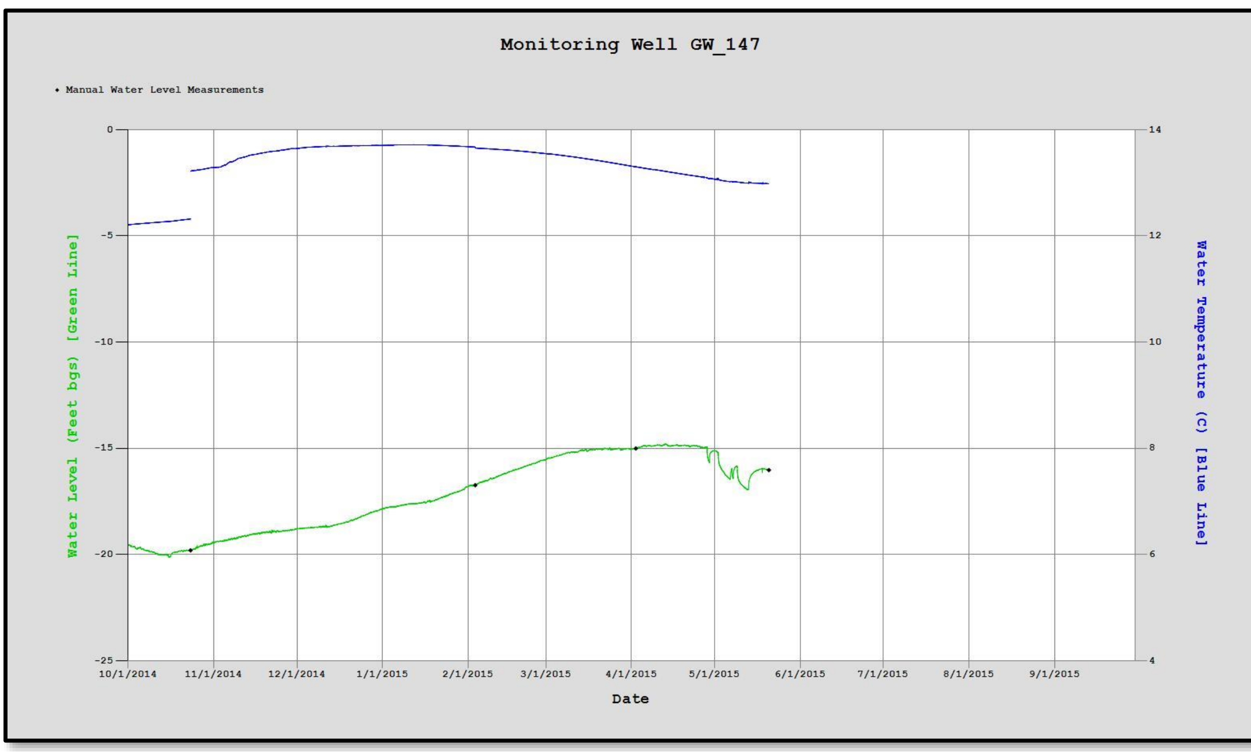


Figure 60 - Hydrograph for GW_147 during the WY2015 recharge season.

Water Quality

Full water quality data and laboratory QA records can be found in Appendix B.

Source Water

Sample Parameter	December 11th, 2014	March 2nd, 2015	May 18th, 2015
Nitrate (mg/L)	1.08	1.22	1.07
Calcium (mg/L)	8.3	10.6	12.8
Total Dissolved Solids (mg/L)	99	100	115
Chloride (mg/L)	4.57	5.09	6.5
Total DCPA (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	73.2	14.1	106

Up-gradient Well (GW_147)

Sample Parameter	December 11th, 2014	March 2nd, 2015	May 18th, 2015
Nitrate	5.22	4.44	4.28
Calcium (mg/L)	38.9	39.8	36.1
Total Dissolved Solids (mg/L)	292	286	279
Chloride (mg/L)	28	26	25.4
Total DCPA (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	692	938	985

Mid-gradient Well (GW_136)

Sample Parameter	December 11th, 2014	March 2nd, 2015	May 18th, 2015
Nitrate	6.86	0.59	1.1
Calcium (mg/L)	52.1	33.7	34.7
Total Dissolved Solids (mg/L)	361	178	217
Chloride (mg/L)	27	2.95	7.2
Total DCPA (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	839	845	848

Down-gradient Well (GW_145)

Sample Parameter	December 11th, 2014	March 2nd, 2015	May 18th, 2015
Nitrate	4.54	3.05	2.98
Calcium (mg/L)	45.6	48.4	51.1
Total Dissolved Solids (mg/L)	338	329	378
Chloride (mg/L)	23	20	29.4
Total DCPA (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	693	1190	938

Down-gradient Well (GW_146)

Sample Parameter	December 11th, 2014	March 2nd, 2015	May 18th, 2015
Nitrate	14	5.94	9.73
Calcium (mg/L)	59.2	44.7	52.7
Total Dissolved Solids (mg/L)	516	350	508
Chloride (mg/L)	41	24	37.5
Total DCPA (μg/L)	ND	ND	ND
Polychlorinated Biphenyls (pg/L)	809	858	982

Soil Quality

Full soil quality data and laboratory QA records can be found in Appendix B.

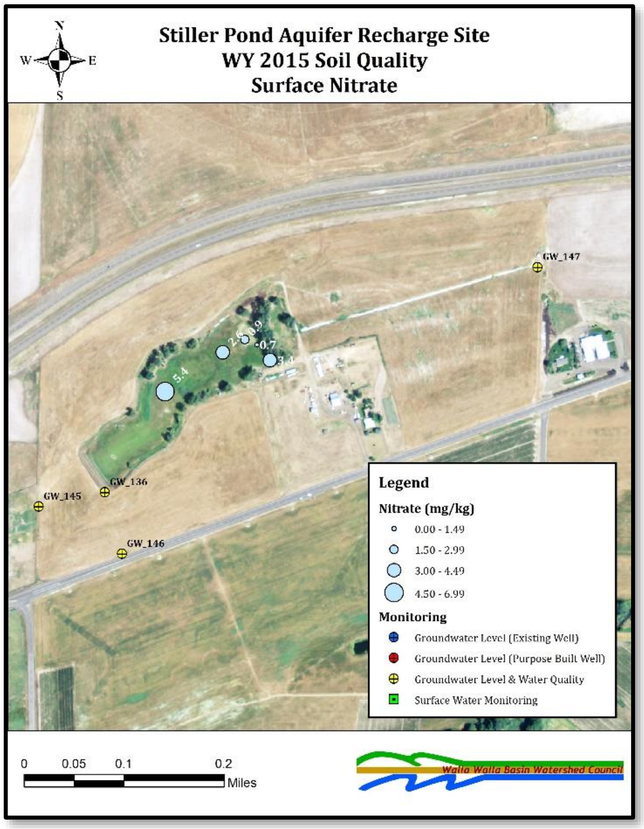


Figure 61 – Surface soil nitrate values at the Stiller Pond site during the WY2015 recharge season.

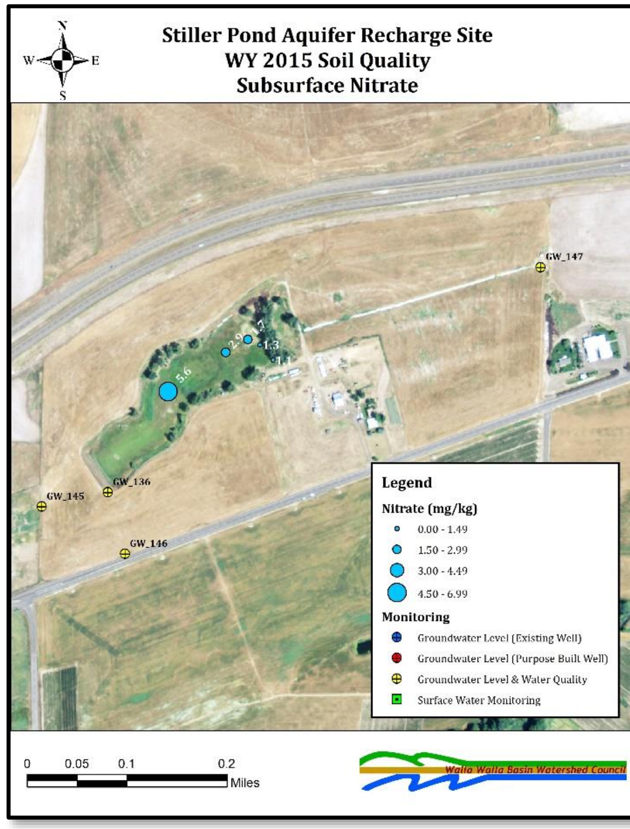
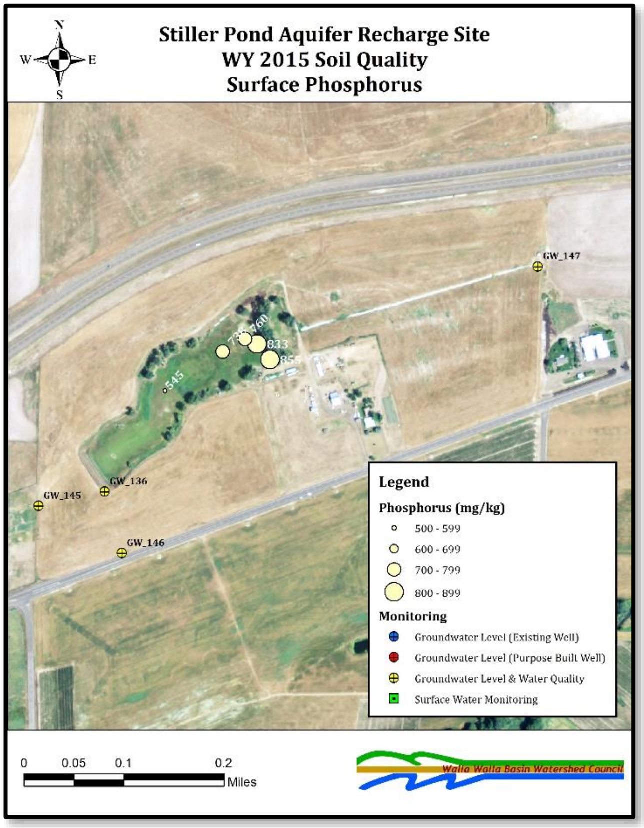


Figure 62 - Subsurface (~1' below ground surface) soil nitrate values at the Stiller Pond site during the WY2015 recharge season.



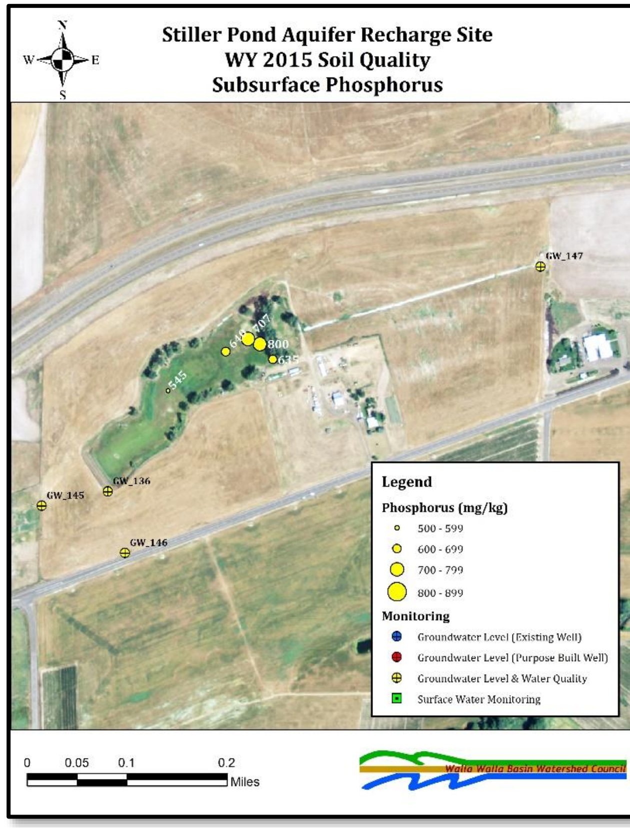
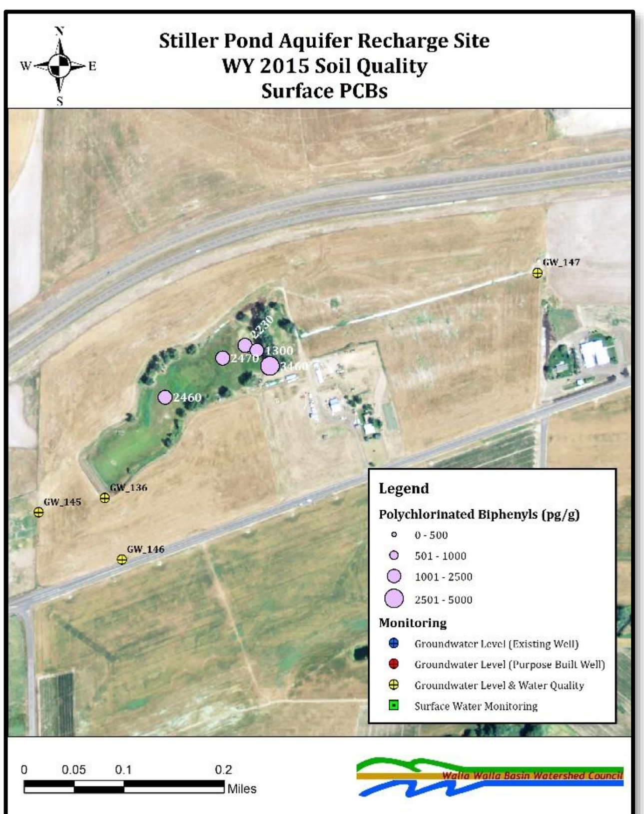


Figure 63 – Surface soil phosphorus values at the Stiller Pond site during the WY2015 recharge season.

Figure 64 - Subsurface (~1' below ground surface) soil phosphorus values at the Stiller Pond site during the WY2015 recharge season.



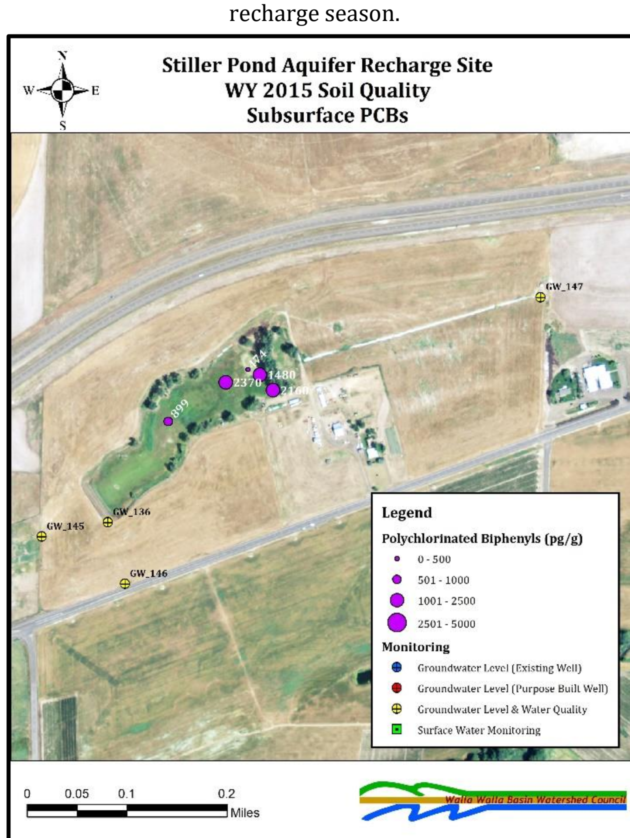


Figure 65 – Surface soil Polychlorinated Biphenyls (PCBs) values at the Stiller Pond site during the WY2015 recharge season.

Figure 66 - Subsurface (~1' below ground surface) soil Polychlorinated Biphenyls (PCBs) values at the Stiller Pond site during the WY2015 recharge season.

LAST CHANCE ROAD

OVERVIEW

The Last Chance Road site did not operate during the WY2015 recharge season. The site was constructed in June 2015 and is ready for future recharge operations. Polychlorinated biphenyls (PCBs) samples were collected for both water and soil to establish pre-operation baselines. Nitrate and phosphorus were also analyzed in the soil samples (Figure 67).

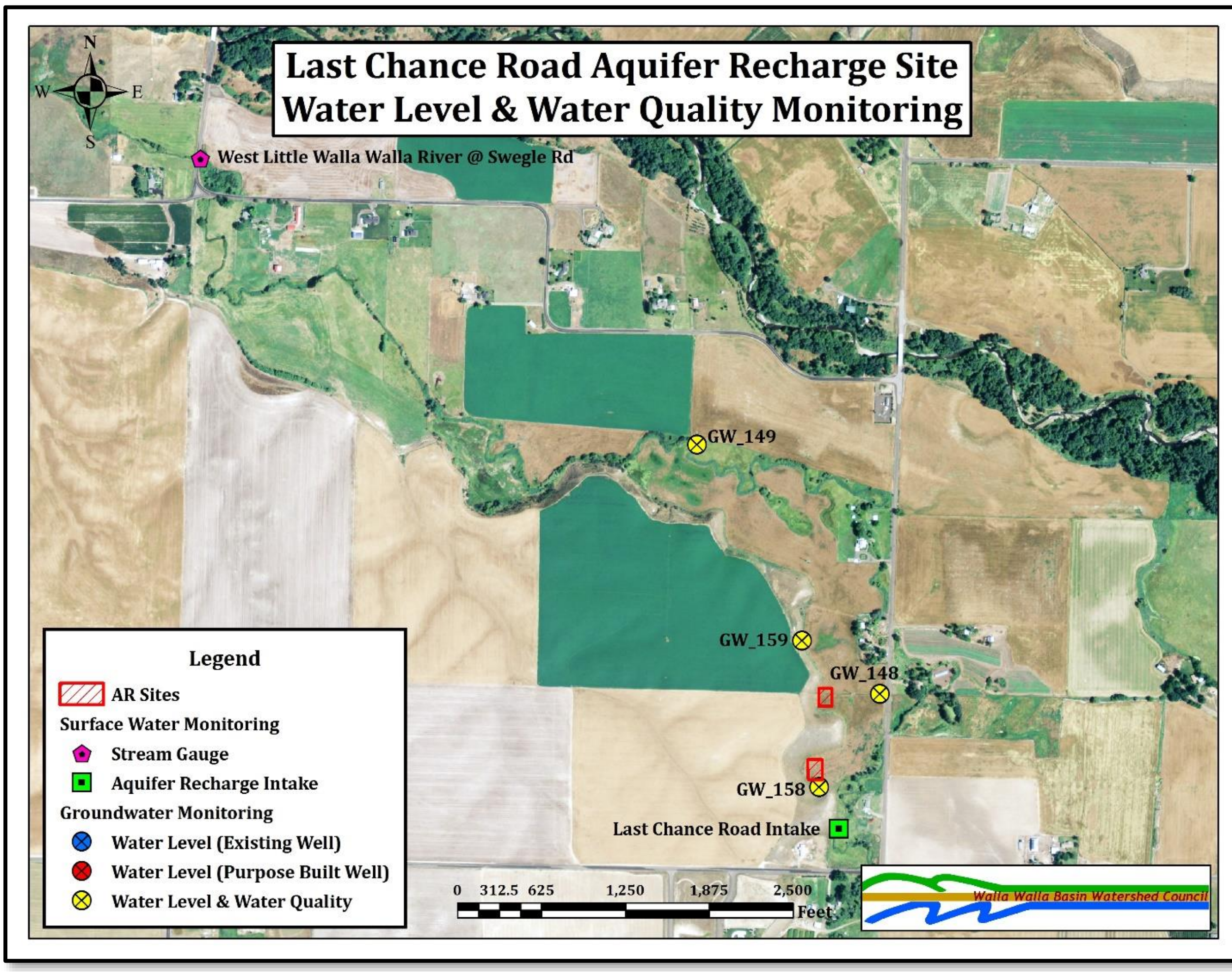


Figure 67 - Map showing groundwater monitoring sites for the Last Chance Road Aquifer Recharge Site.

WATER QUALITY

Full water quality data and laboratory QA records can be found in Appendix B.

SOURCE WATER (RECHARGE INTAKE)

Sample Parameter	May 20th, 2014
Polychlorinated Biphenyls (pg/L)	59.4

Source Water (West Little Walla Walla River @ Swegle Road)

Sample Parameter	May 20th, 2014
Polychlorinated Biphenyls (pg/L)	87.2

Mid-Gradient Well (GW_148)

Sample Parameter	May 20th, 2014
Polychlorinated Biphenyls (pg/L)	1030

Down-Gradient Well (GW_149)

Sample Parameter	May 20th, 2014
Polychlorinated Biphenyls (pg/L)	1680

Soil Quality

Full soil quality data and laboratory QA records can be found in Appendix B.

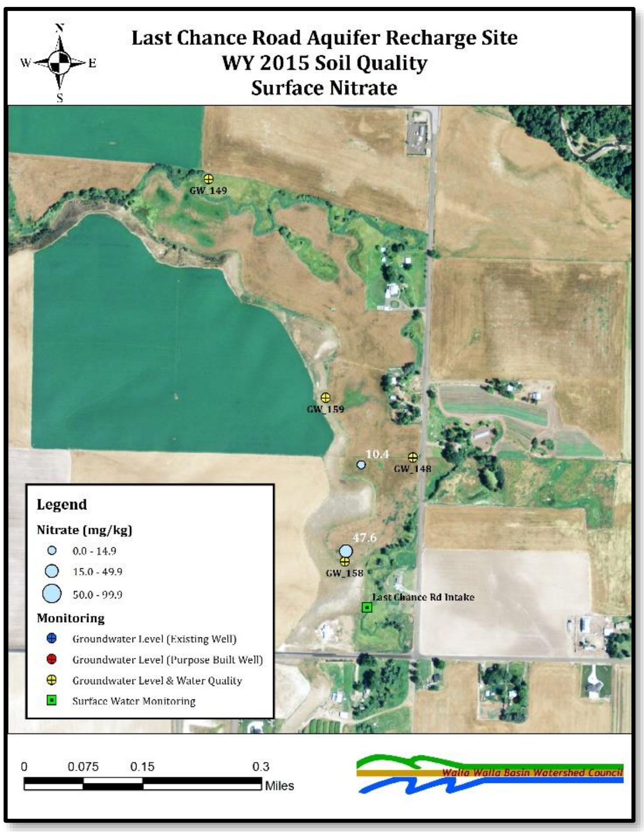


Figure 68 – Surface soil nitrate values at the Last Chance Road site during the WY2015 recharge season.

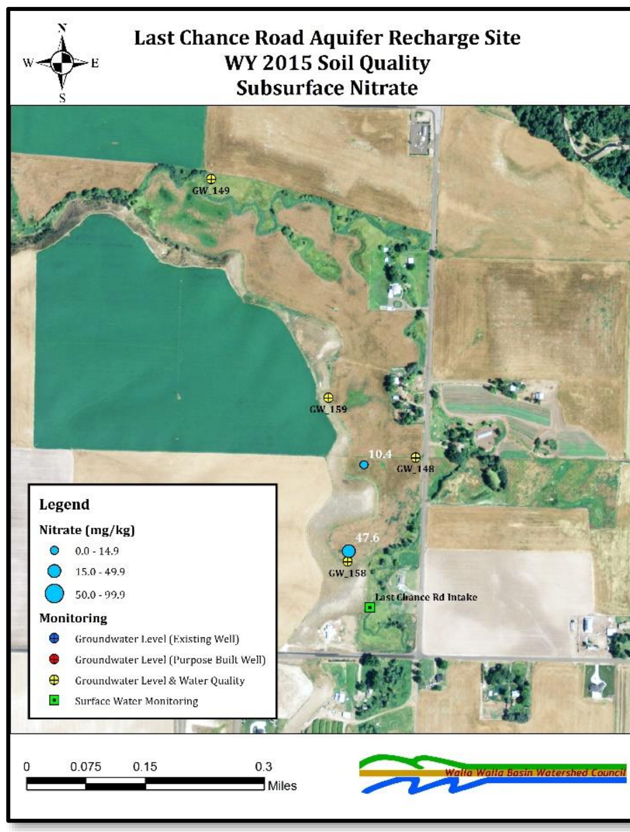


Figure 69 - Subsurface (~1' below ground surface) soil nitrate values at the Last Chance Road site during the WY2015 recharge season.

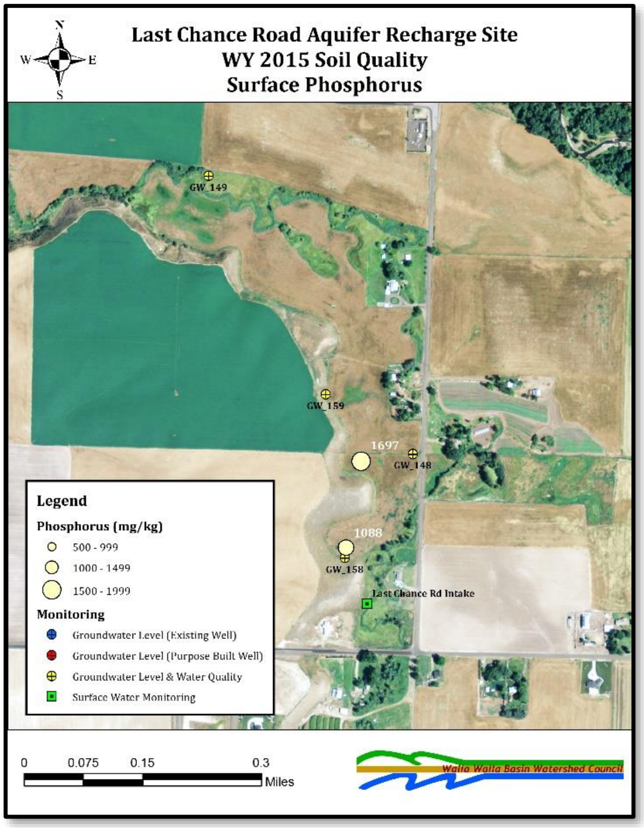


Figure 70 – Surface soil phosphorus values at the Last Chance Road site during the WY2015 recharge season.

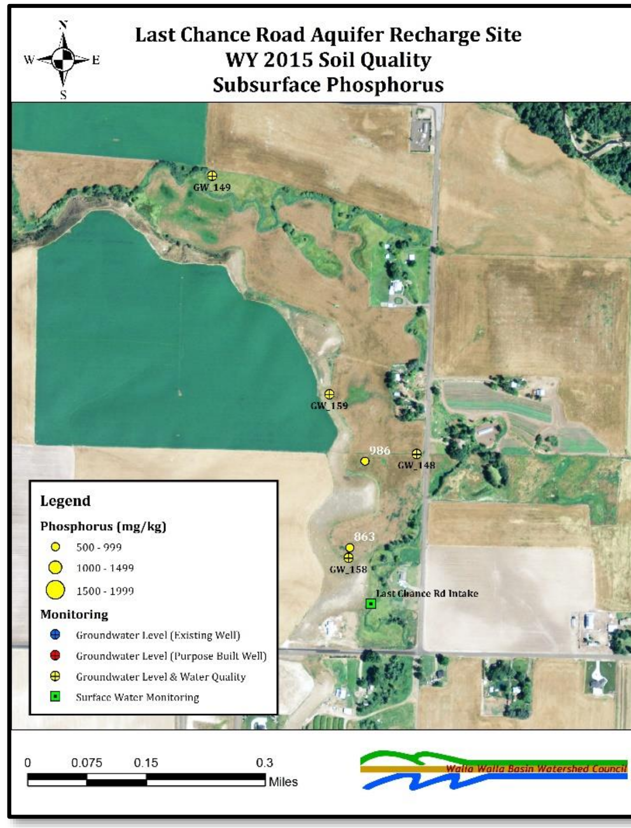
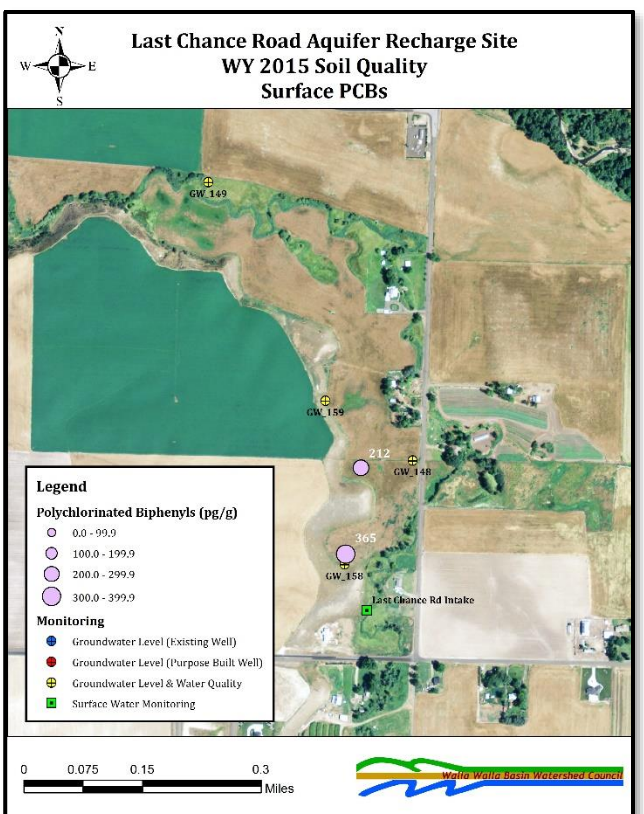


Figure 71 - Subsurface (~1’ below ground surface) soil phosphorus values at the Last Chance Road site during the WY2015 recharge season.



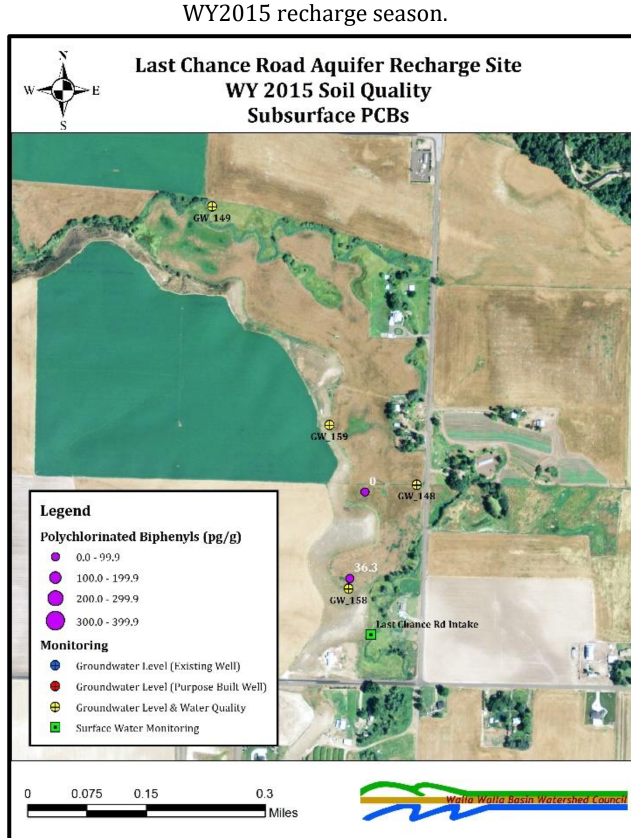


Figure 72 – Surface soil Polychlorinated Biphenyls (PCBs) values at the Last Chance Road site during the WY2015 recharge season.

Figure 73 - Subsurface (~1' below ground surface) soil Polychlorinated Biphenyls (PCBs) values at the Last Chance Road site during the WY2015 recharge season.

WA Mud Creek

Overview

The WA Mud Creek site did not operate during the WY2015 recharge season (Figure 74). The site will be constructed in the fall of 2015 and will be ready for future recharge operations. Polychlorinated biphenyls (PCBs) samples were collected soil to establish pre-operation baselines. Nitrate and phosphorus were also analyzed in the soil samples.

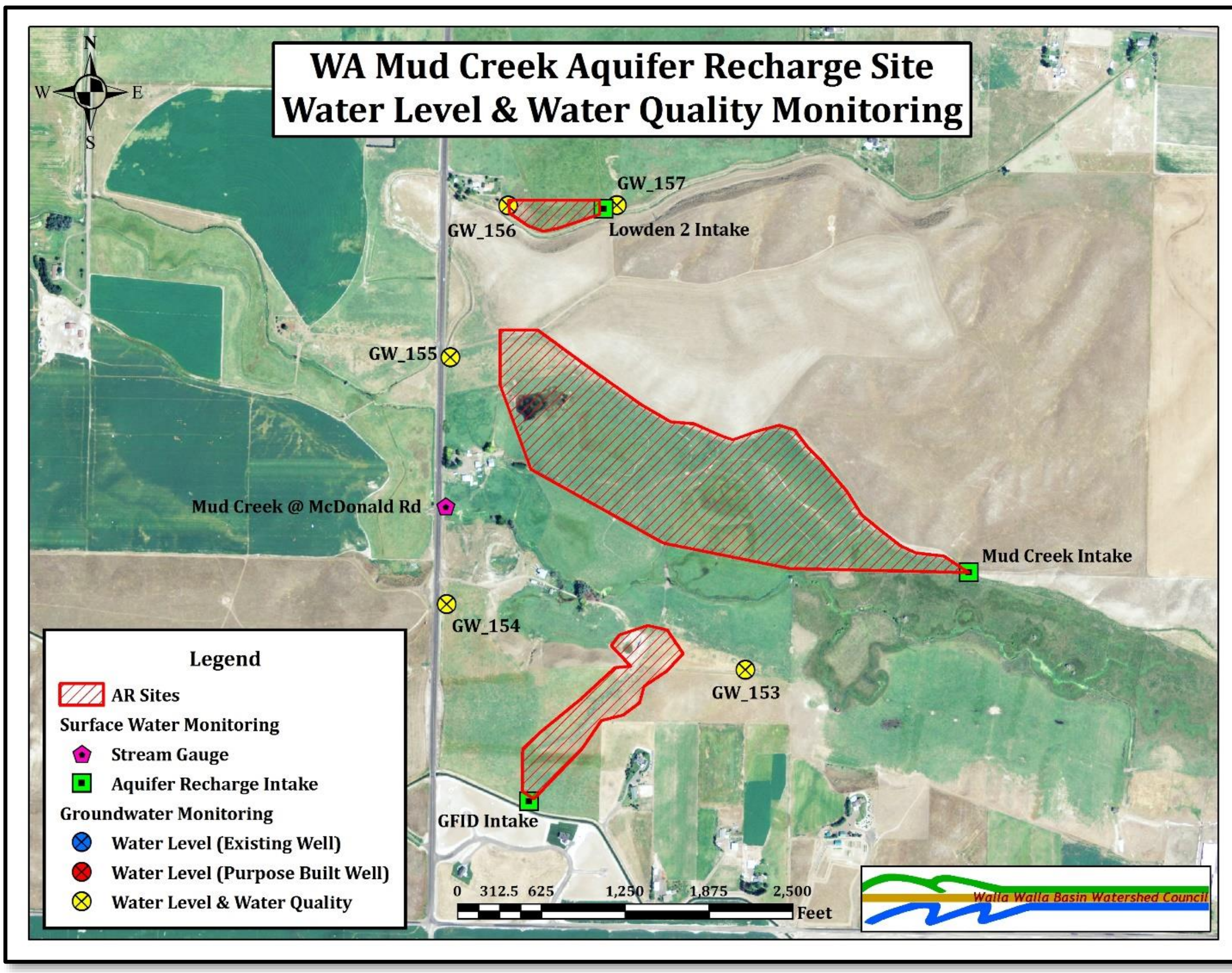


Figure 74 - Map showing groundwater monitoring sites for the WA Mud Creek Aquifer Recharge Site.

Soil Quality

Full soil quality data and laboratory QA records can be found in Appendix B.

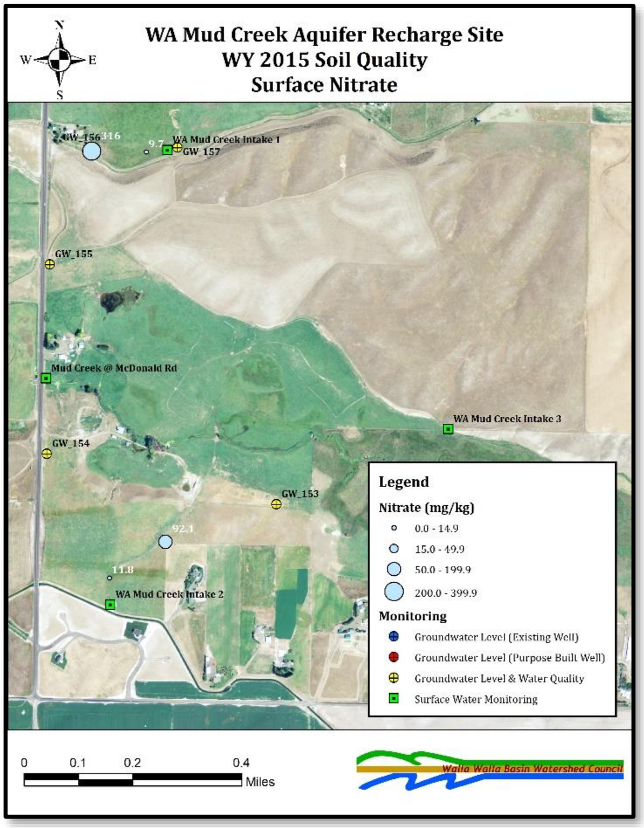


Figure 75 – Surface soil nitrate values at the WA Mud Creek site during the WY2015 recharge season.

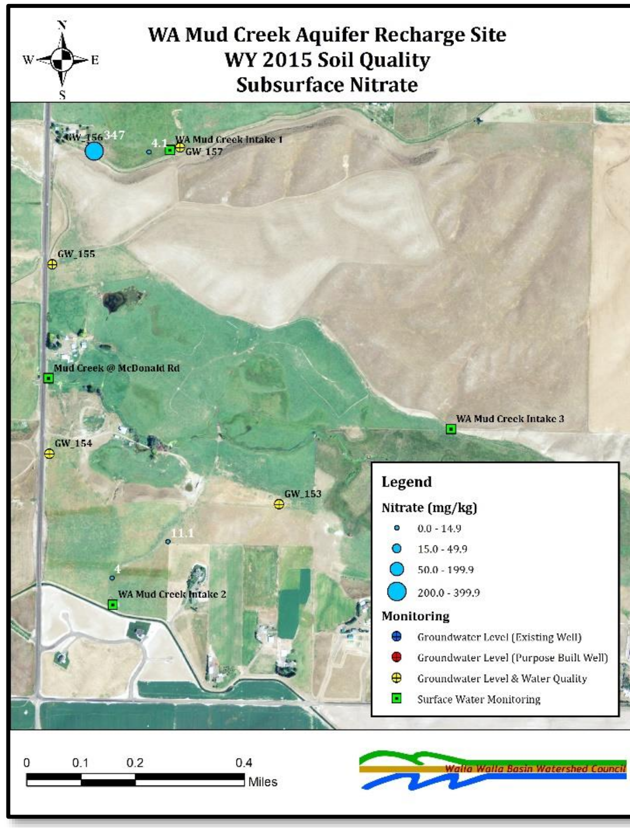
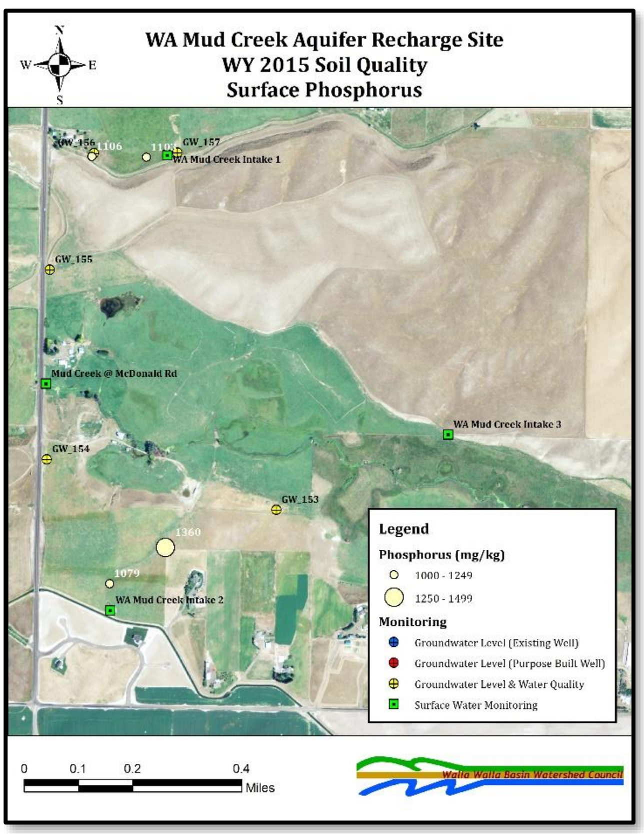


Figure 76 - Subsurface (~1' below ground surface) soil nitrate values at the WA Mud Creek site during the WY2015 recharge season.



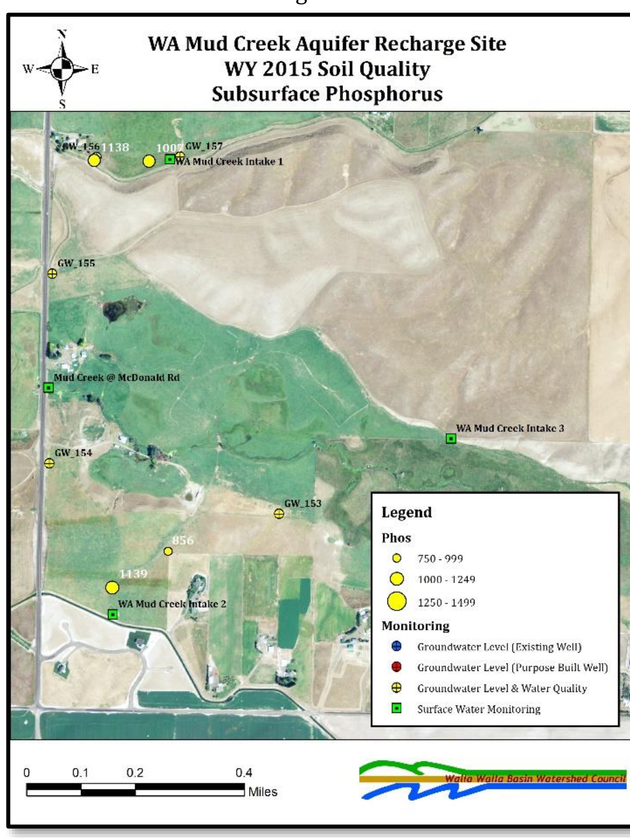


Figure 77 – Surface soil phosphorus values at the WA Mud Creek site during the WY2015 recharge season.

Figure 78 - Subsurface (~1’ below ground surface) soil phosphorus values at the WA Mud Creek site during the WY2015 recharge season.

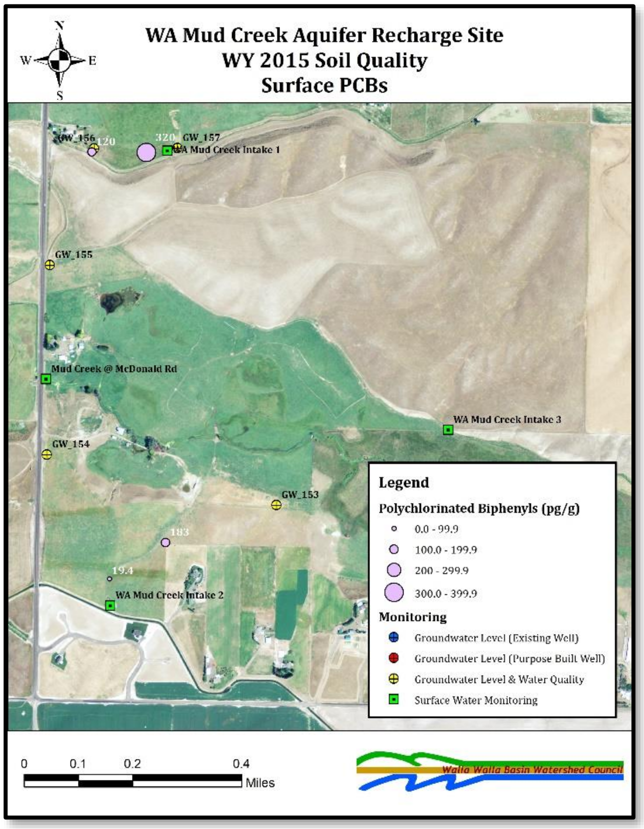


Figure 79 – Surface soil Polychlorinated Biphenyls (PCBs) values at the WA Mud Creek site during the WY2015 recharge season.

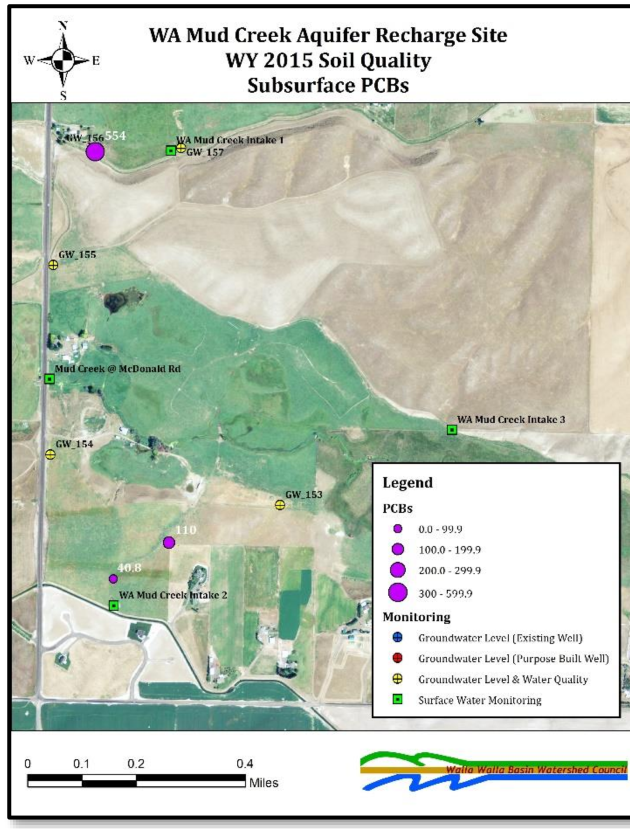


Figure 80 - Subsurface (~1’ below ground surface) soil Polychlorinated Biphenyls (PCBs) values at the WA Mud Creek site during the WY2015 recharge season.

SUMMARY AND DISCUSSION

WATER LEVEL AND QUANTITY

The AR program summarized here simulates floodplain function and processes that have been lost due to irrigation and urban development and channelization of the river and stream channels for flood control and other uses. With continued AR activities at the Locher Road and Stiller Pond sites we anticipate that increasing alluvial aquifer water levels could lead to the types of spring flow increases and increased groundwater inputs to streams and rivers that have been observed in recent years resulting from Oregon AR activities elsewhere in the valley. Also, the addition of the Last Chance Road and WA Mud Creek sites will likely increase spring and stream flows in the West Little Walla Walla River and Mud Creek respectively.

Over the course of the WY2014 recharge season, the aquifer recharge program in the Washington portion of the Walla Walla Basin put ~556.48 acre-feet (~181.2 million gallons) of winter/spring run-off water into the shallow alluvial aquifer at the Locher Road site (256.48 acre-feet) and Stiller Pond (~300 acre-feet) AR sites. Water levels in the alluvial aquifer at both sites responded to AR activities. More data will need to be collected, especially at the Stiller Pond site, in order to establish trends and ongoing improvements to the alluvial aquifer system or surface water system.

During the WY2015 recharge season, the aquifer recharge program in the Washington portion of the Walla Walla Basin put ~250 acre-feet (~81.5 million gallons) of winter/spring run-off water into the shallow alluvial aquifer at the Locher Road site (36 acre-feet) and Stiller Pond (214 acre-feet) AR sites.

The Locher Road site wells indicate improving groundwater levels from the start of the project in 2007 until approximately 2011-12. Water levels in the area start to show a yearly decline starting in the summer of 2012. These decreasing water levels coincide with the last phase of the Hyline piping project on the Oregon side of the border that was completed in 2012. Water levels around the Locher Road site have dropped approximately 1 foot per year since 2012 (Appendix A). Water levels in the area rise during recharge operations, however the volume of water added to the alluvial aquifer does not appear to be sufficient to overcome the regional deficit. Unless volumes are increased (both at the Locher Road site and in Oregon), this declining water level pattern is expected to continue. Piping of the Gardena Farms Canal (source water for Locher Road) would most likely increase the rate of decline in water levels in the area without proper mitigation.

Trends and impacts due to recharge operations at the Stiller Pond site cannot yet be inferred due to limited data. Most of the wells near the site have just over two years of data and a single well has about four years of data. Additional years of operation and data collection will be needed to further evaluate the influence of this site both on groundwater and surface conditions.

WATER QUALITY

As mentioned previously in this report and in GSI, 2012a, aquifer recharge program operations do not appear to have degraded groundwater quality (Appendix B).

> *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).*

Water and soil quality data was reviewed by WADOE staff "based upon two year of results of water quality monitoring data at the Locher Road SAR site, Ecology has concluded that operation of the site is not contaminating groundwater with PCBs and chlorinated pesticides" (Kuttel, 2015). A similar review process will occur with the Stiller Pond site after the WY2015 recharge season.

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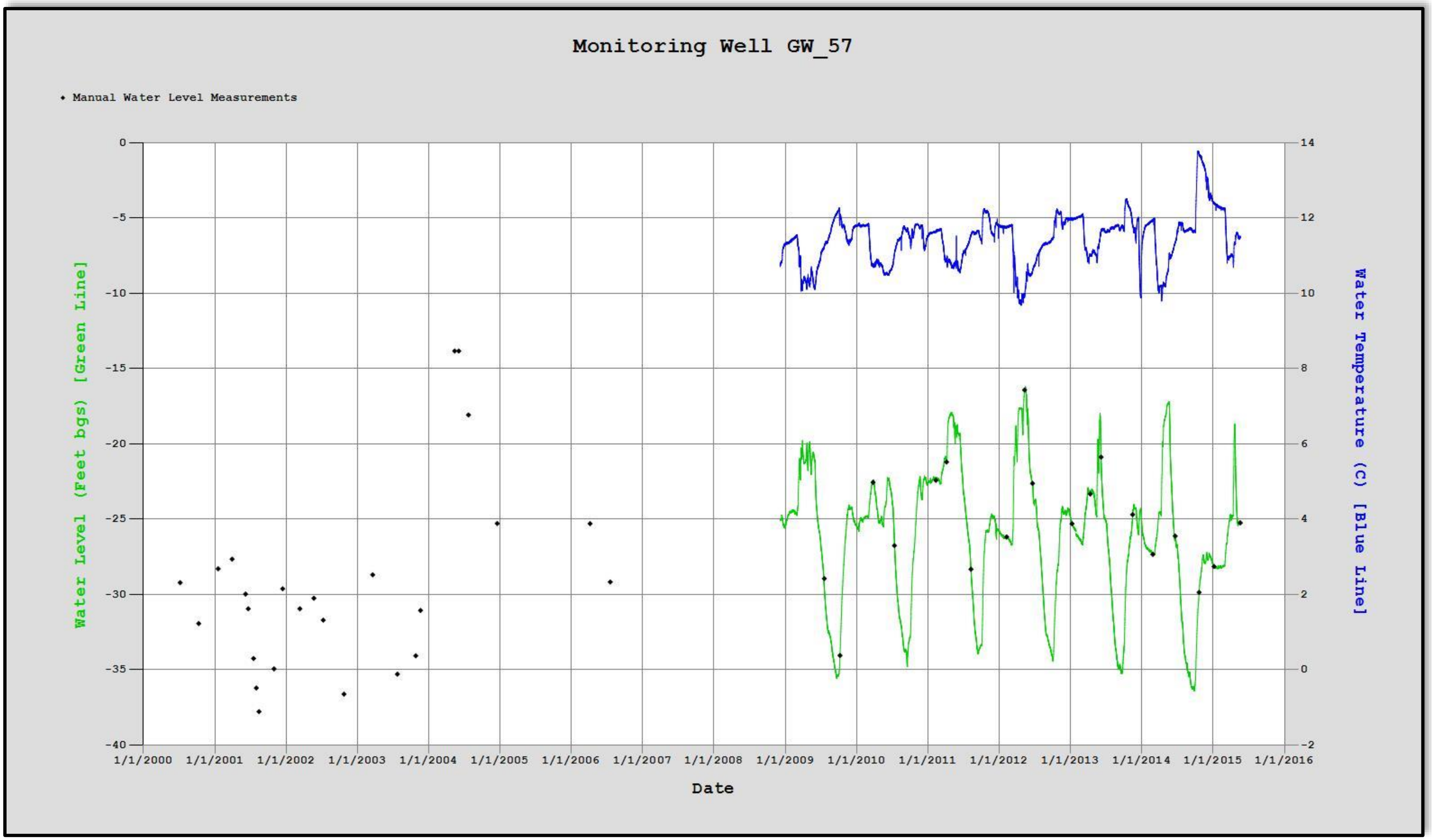
WWWMP, 2014a. Hassler Local Water Plan Agreement. Walla Walla Watershed Management Partnership Local Water Plan LWP 14-01. www.wallawallawatershed.org.

APPENDIX A - MONITORING WELL HYDROGRAPHS, INCLUDING ALL AVAILABLE DATA, FOR THE LOCHER ROAD AND STILLER POND AQUIFER RECHARGE SITES



Monitoring Well GW_57
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
Date
0
-5
-10
-15
-20
-25
-30
-35
-40
14
12
10
8
6
4
2
0
-2
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
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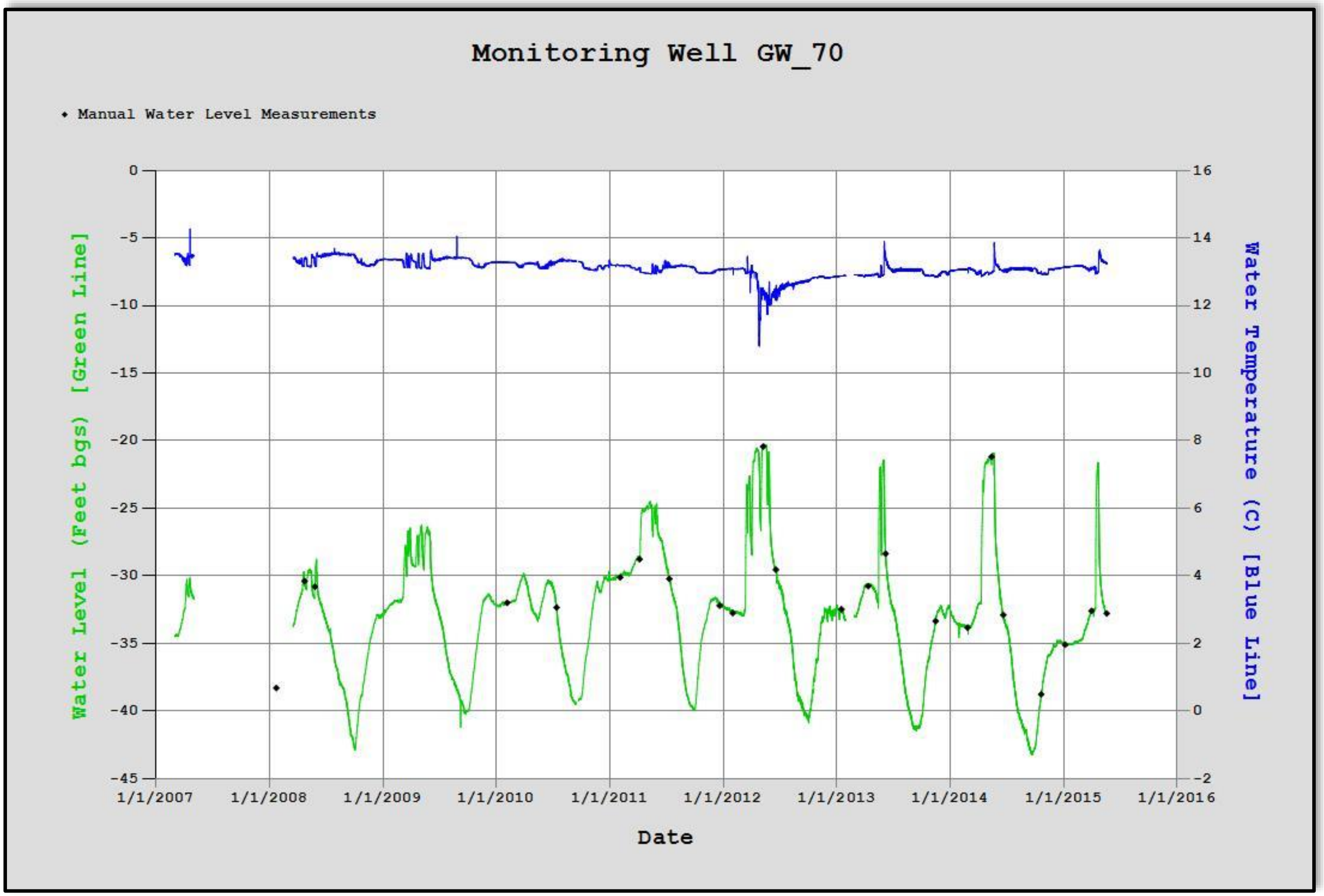
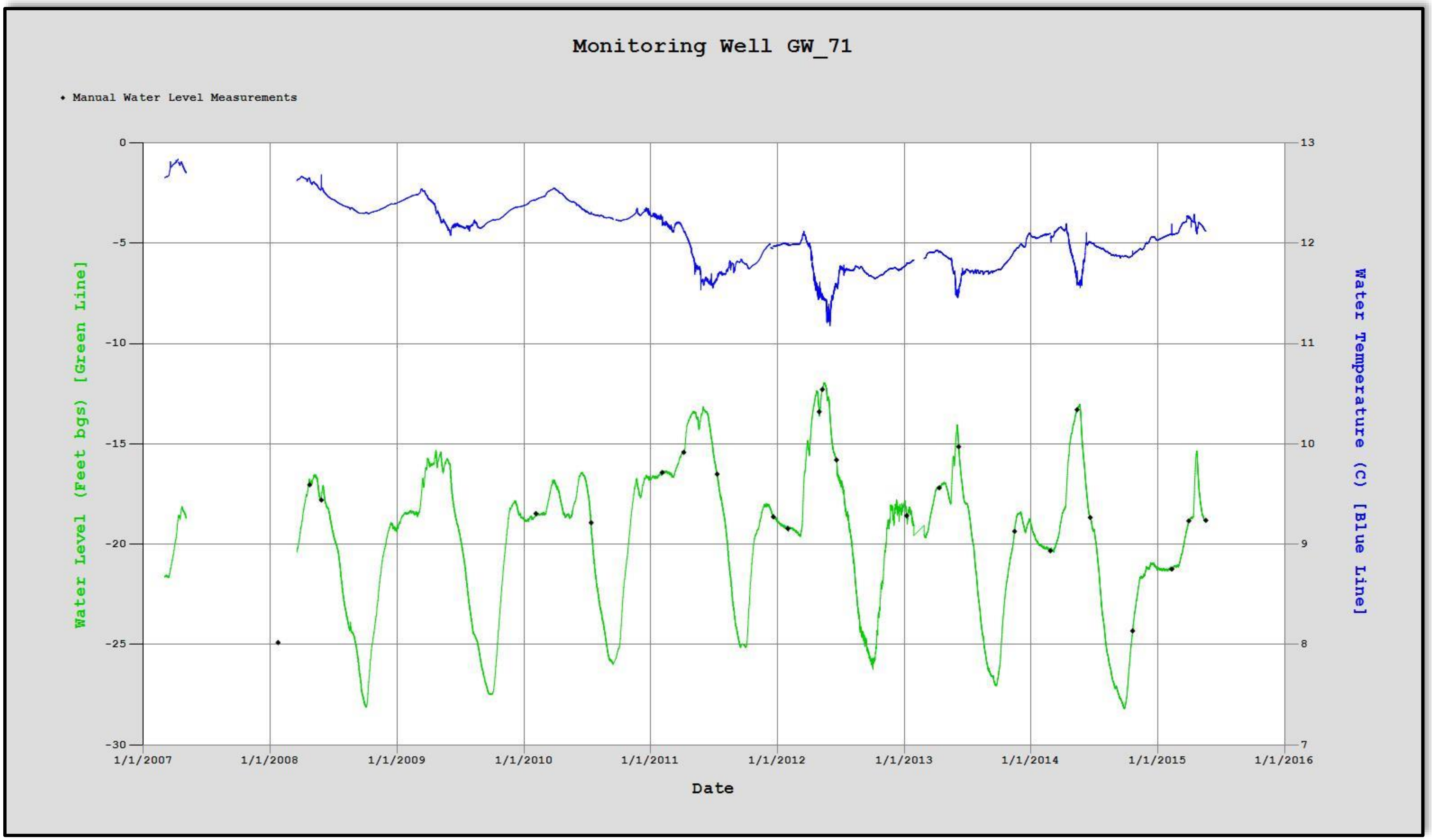
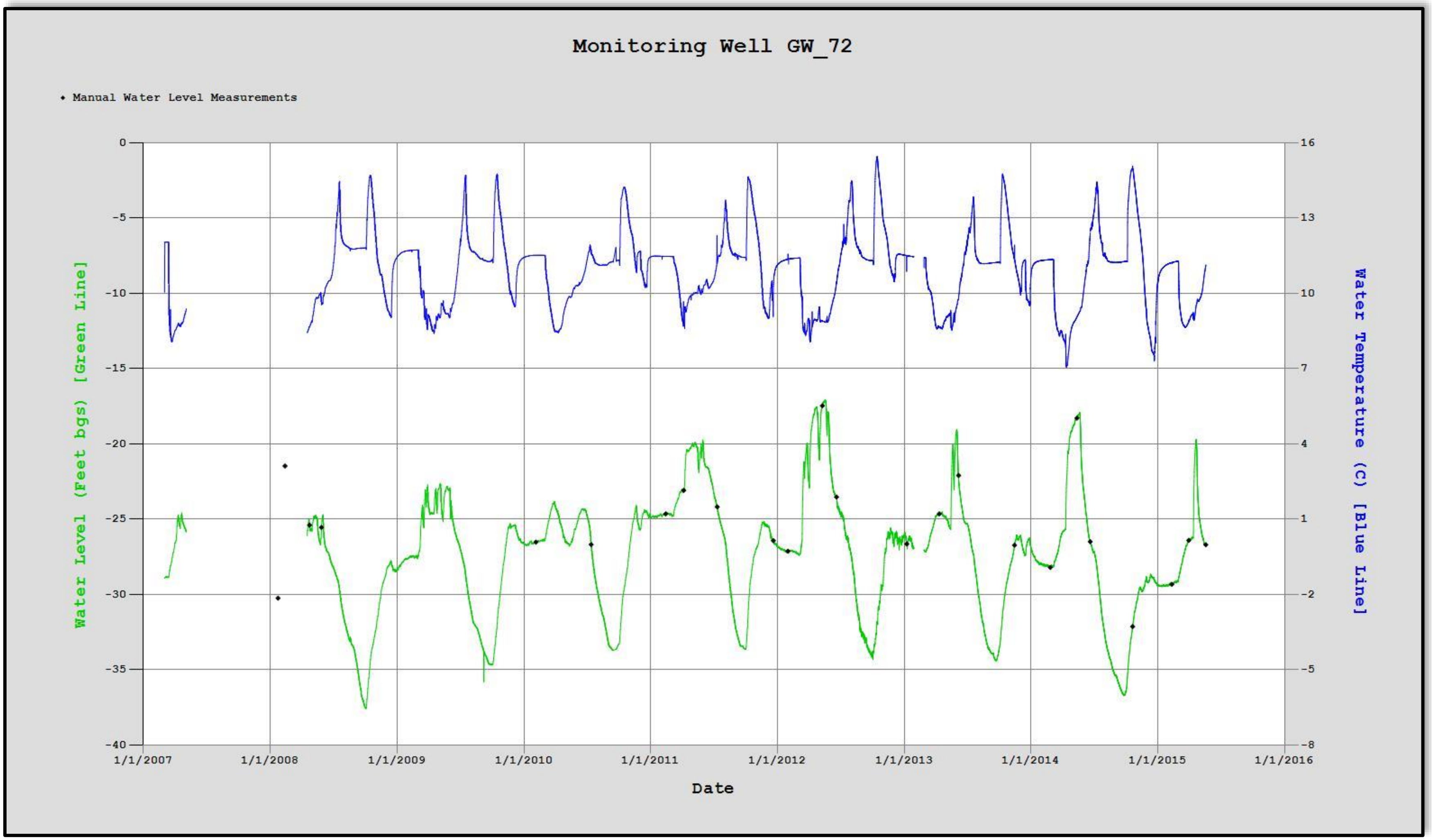
1/1/2013
1/1/2014
1/1/2015
1/1/2016



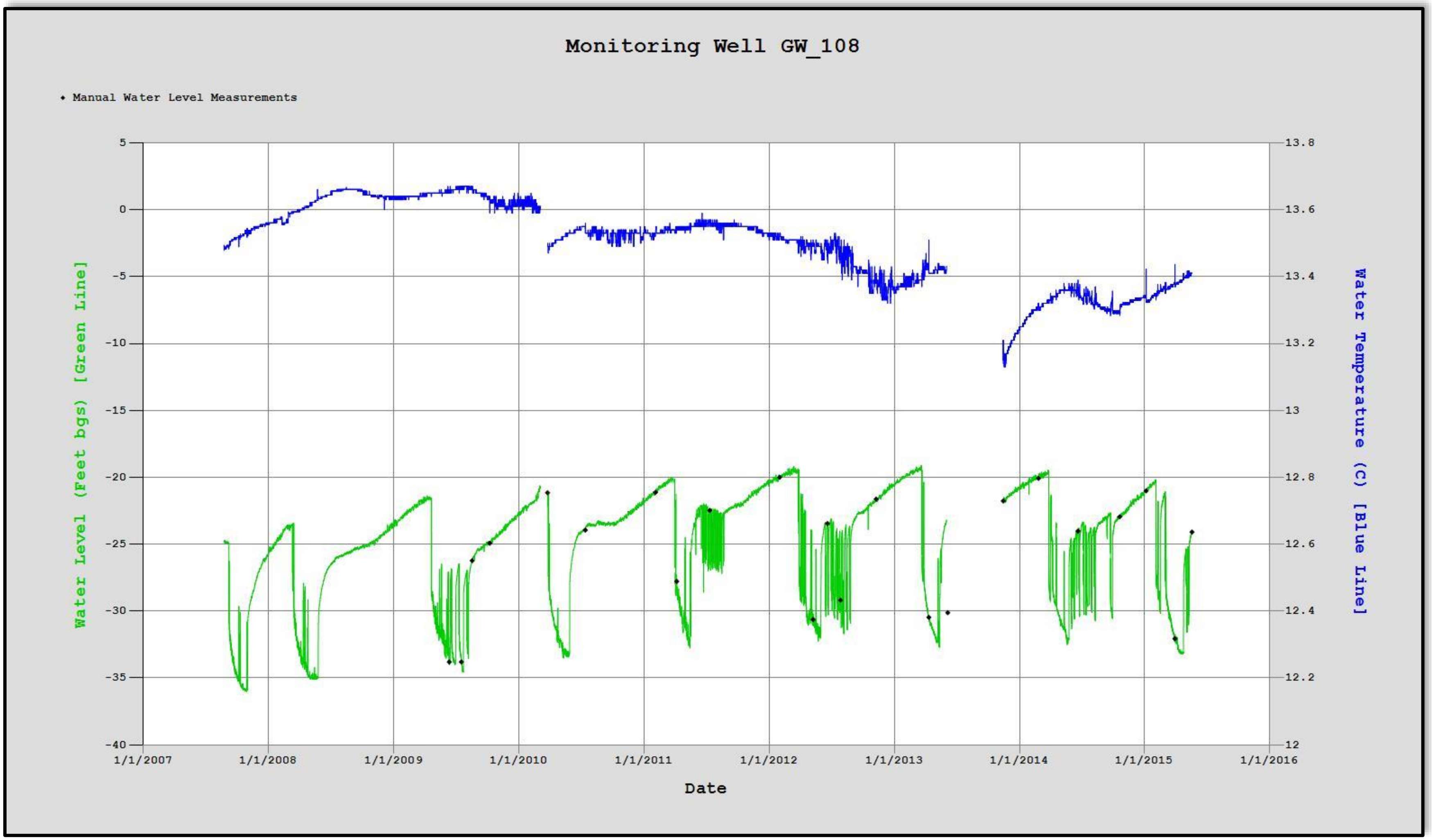
Monitoring Well GW_70
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
16
14
12
10
8
6
4
2
0
-2
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
Date



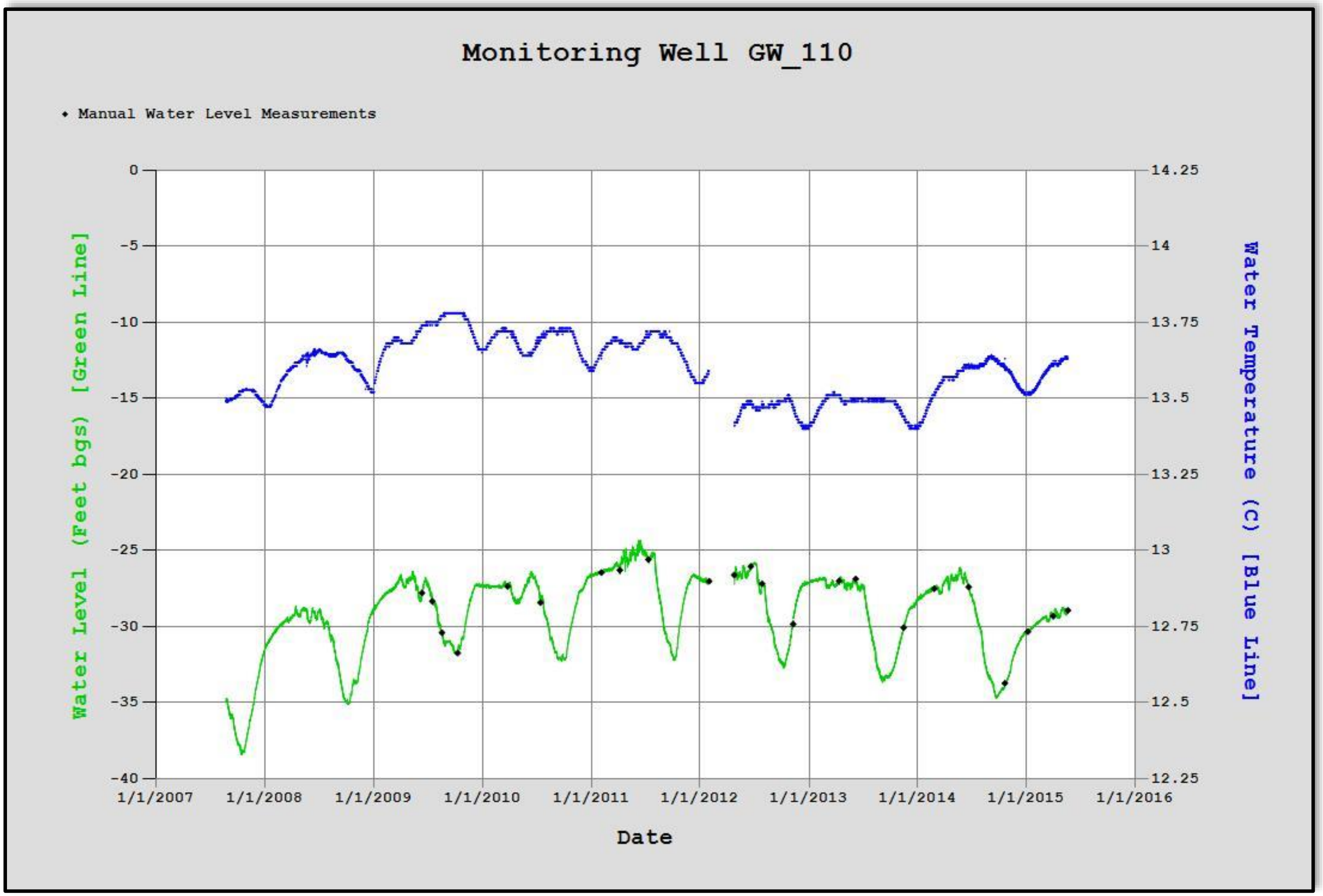
Monitoring Well GW_71
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
Date
0
-5
-10
-15
-20
-25
-30
13
12
11
10
9
8
7
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016

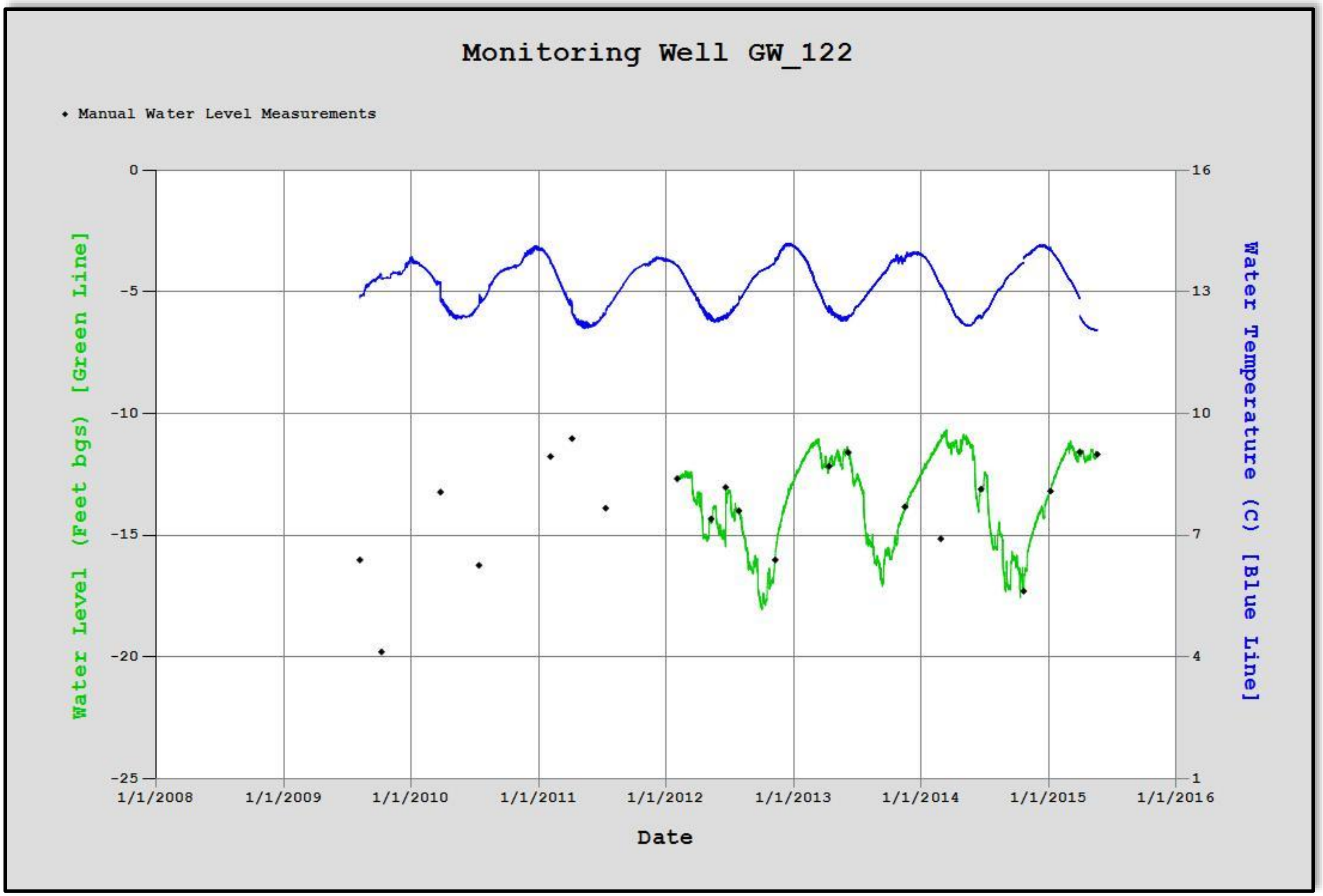


Monitoring Well GW_72
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
-30
-35
-40
16
13
10
7
4
1
-2
-5
-8
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
Date

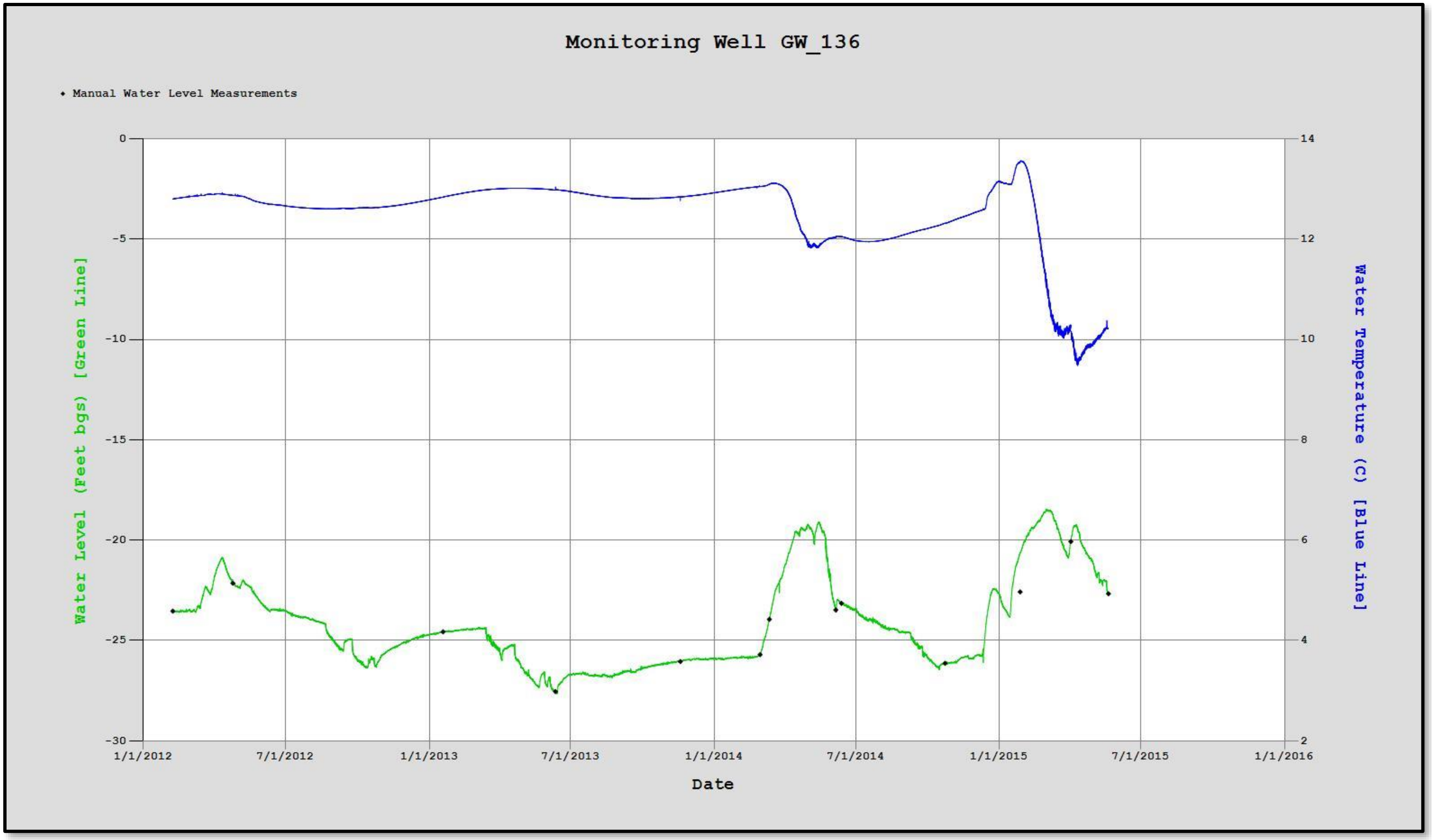


Monitoring Well GW_108
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
5
0
-5
-10
-15
-20
-25
-30
-35
-40
13.8
13.6
13.4
13.2
13
12.8
12.6
12.4
12.2
12
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
Date

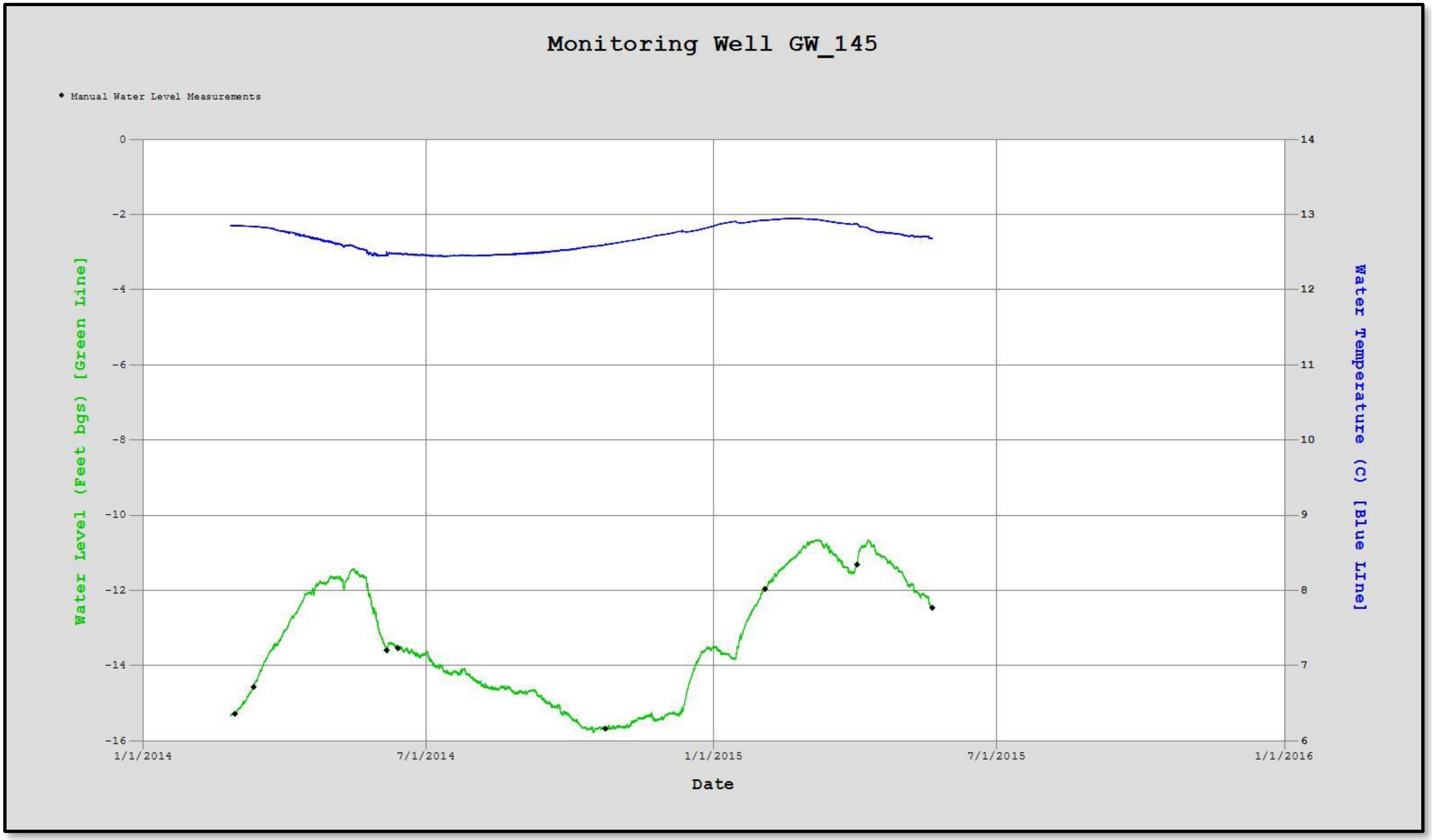

Monitoring Well GW_110
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
-30
-35
-40
14.25
14
13.75
13.5
13.25
13
12.75
12.5
12.25
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
Date



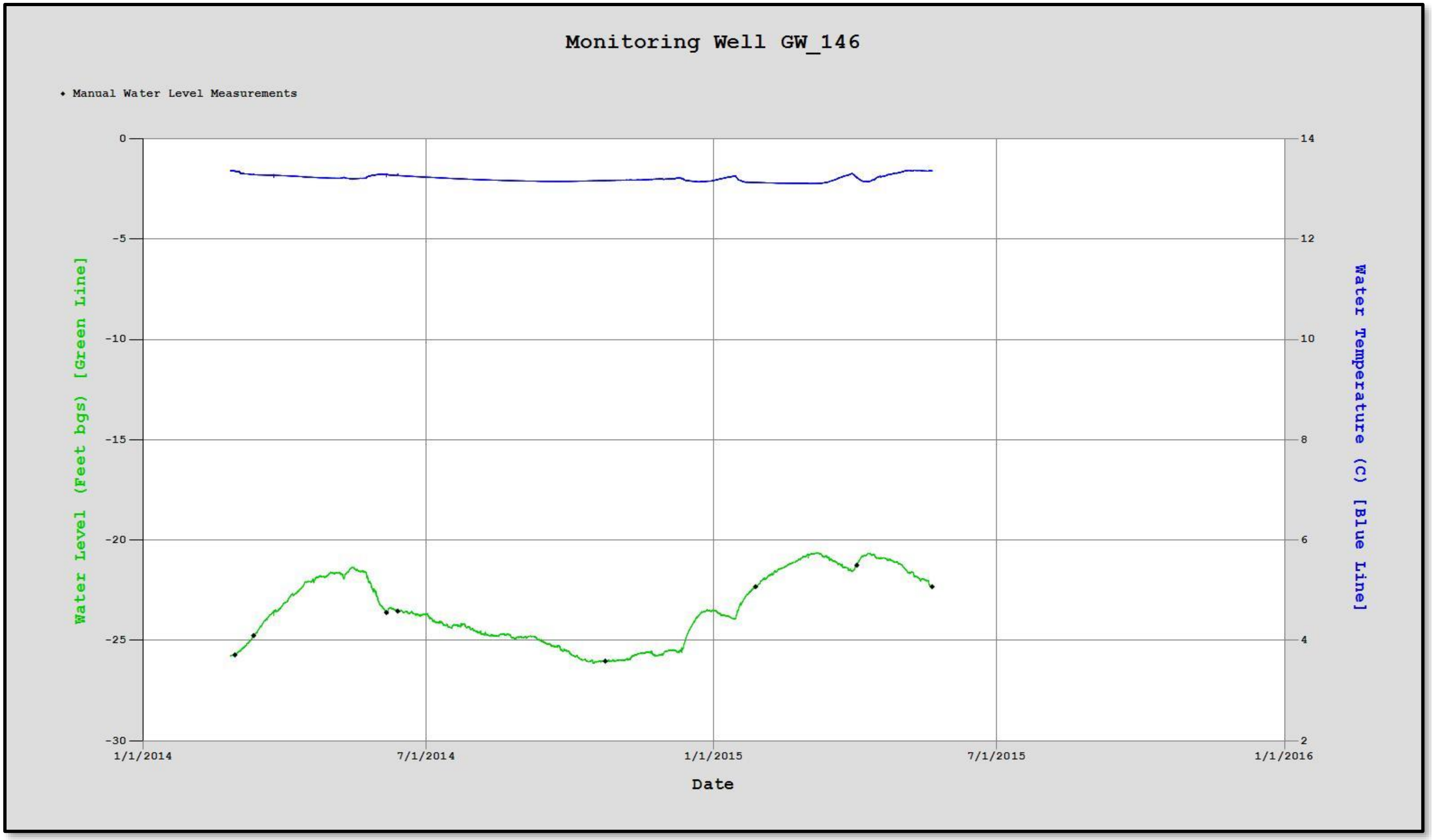
Monitoring Well GW_122
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
16
13
10
7
4
1
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
Date



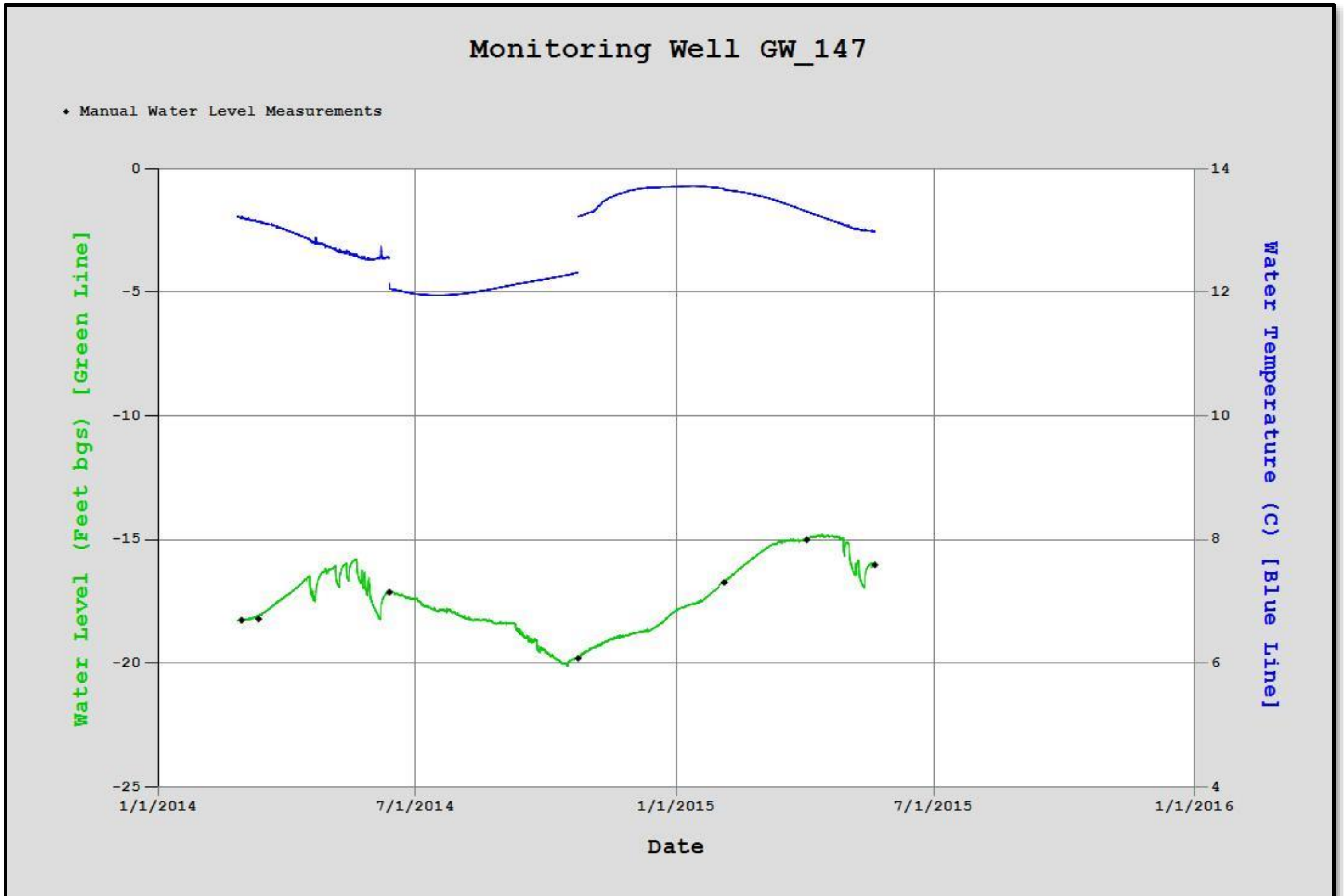
Monitoring Well GW_136
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
-30
14
12
10
8
6
4
2
1/1/2012
7/1/2012
1/1/2013
7/1/2013
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016
Date



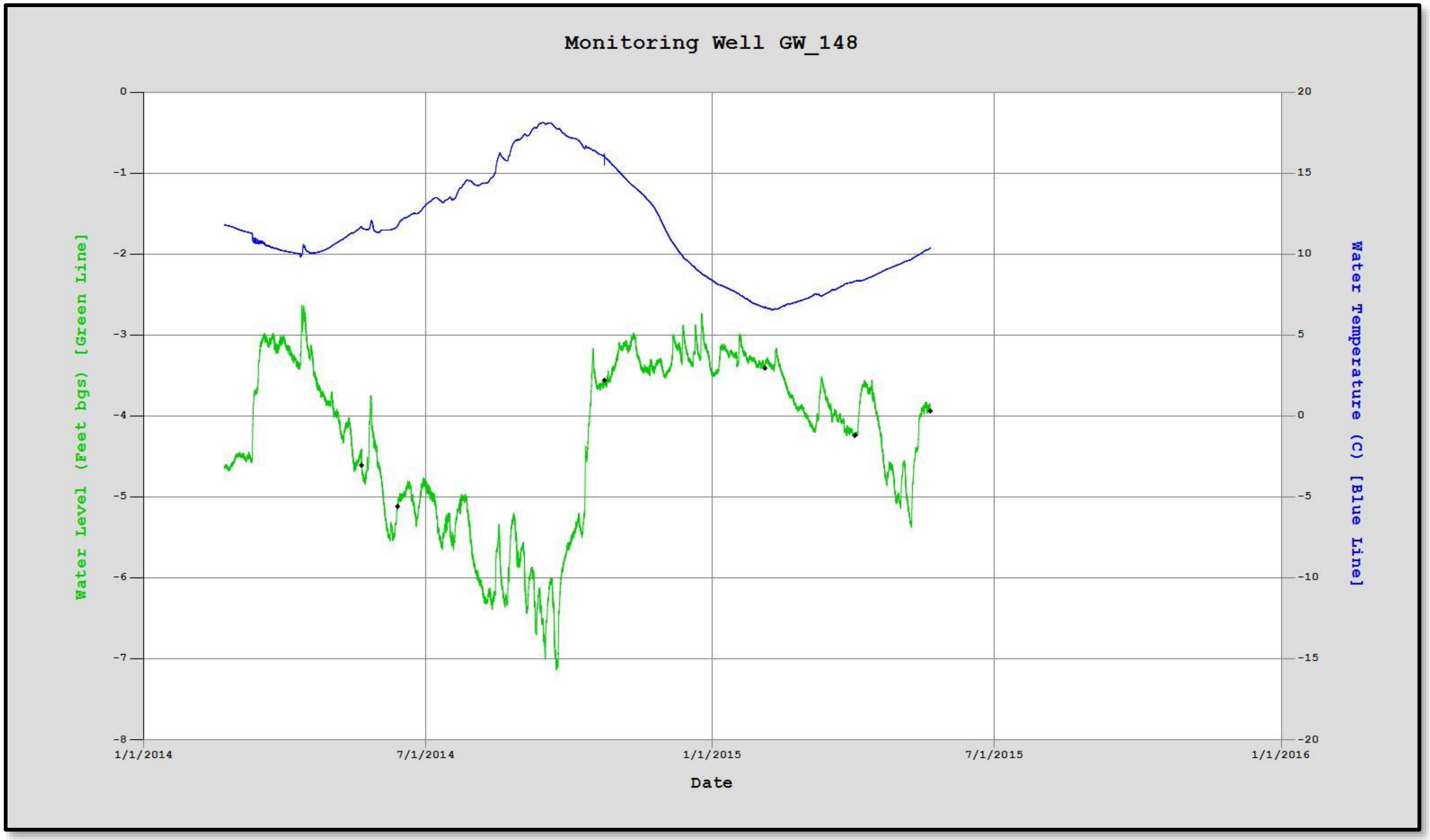
Monitoring Well GW_145
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue LIne]
0
-2
-4
-6
-8
-10
-12
-14
-16
14
13
12
11
10
9
8
7
6
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016
Date

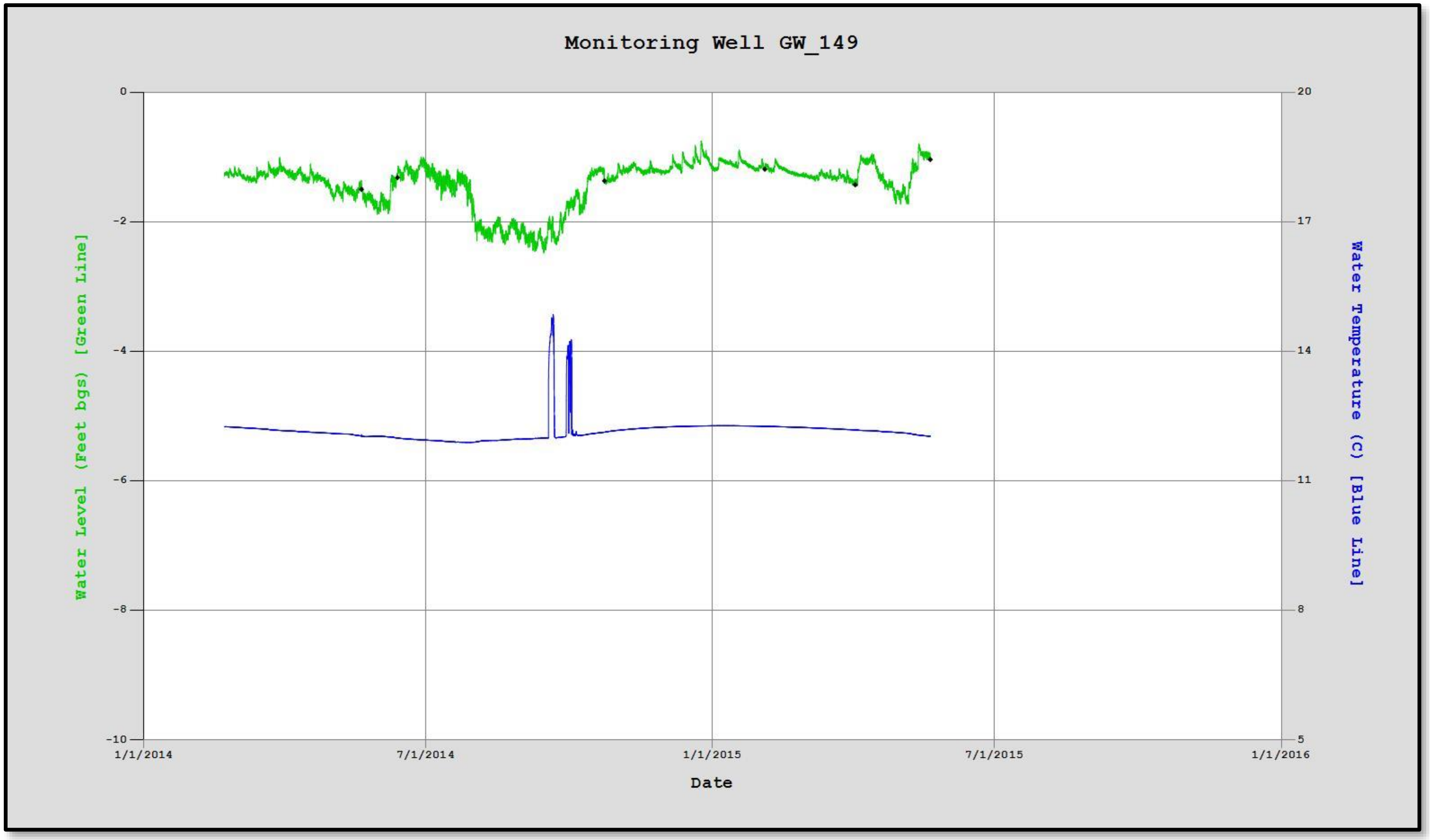


Monitoring Well GW_146
Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
-30
14
12
10
8
6
4
2
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016
Date



Monitoring Well GW_147
• Manual Water Level Measurements
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
0
-5
-10
-15
-20
-25
14
12
10
8
6
4
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016
Date


Monitoring Well GW_148
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
Date
0
-1
-2
-3
-4
-5
-6
-7
-8
20
15
10
5
0
-5
-10
-15
-20
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016



Monitoring Well GW_149
Water Level (Feet bgs) [Green Line]
Water Temperature (C) [Blue Line]
Date
0
-2
-4
-6
-8
-10
20
17
14
11
8
5
1/1/2014
7/1/2014
1/1/2015
7/1/2015
1/1/2016

APPENDIX B - WATER & SOIL QUALITY RESULTS FOR WY2014

LOCHER ROAD – WY2014

Stiller Pond – WY2014

Locher Road – WY2015

STILLER POND 2015

LAST CHANCE ROAD – PRE-OPERATIONS SAMPLING

WA Mud Creek – Pre-operations Sampling

APPENDIX C - WALLA WALLA BASIN AQUIFER RECHARGE WATER QUALITY AND WATER LEVEL MONITORING QUALITY ASSURANCE PROJECT PLAN