Project Completion Report for Shallow Aquifer Recharge Testing at the Hall-Wentland Site, Umatilla County, Oregon and Walla Walla County, Washington

Hydrogeologist 742

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Summary

This report presents the results of the second season of shallow aquifer recharge (SAR) testing at the Hall-Wentland Site which began on December 22, 2006 and ended on April 15, 2007. Testing at the Site is permitted under a Limited License granted by the Oregon Water Resources Department to Walla Walla River Irrigation District. SAR testing utilized water in the East Little Walla Walla River, a portion of which was diverted towards the Site via Wells Ditch. As in the first season, water was not diverted from the Walla Walla River for the project. An estimated 190 to 250 acre-feet of water was diverted from Wells Ditch towards the Site. Most of this water was delivered to the Site in the last 6 weeks of the test season. Increased flow to the Site followed reconfiguration of the diversion weir that resulted in a reduction in fish screen plugging which repeatedly reduced flow to the Site.

Based on data collected before, during, and after testing, water levels in on-site monitoring wells began to rise within a few hours after the start of testing. Down gradient effects extended several miles north, at least as far north as well MC-3, and may extend all the way to the Walla Walla River. Water table rise in response to testing is interpreted to have extended at least 0.5 miles up gradient. Based on the field and basic water quality parameters measured to-date, SAR testing at the Site are interpreted to have had no negative effect on groundwater quality in the Site area. This data does suggest a high degree of hydraulic continuity between local surface and groundwater, with surface water bodies in the immediate Site area, generally loosing water to the underlying shallow alluvial aquifer system. A few synthetic organic compounds (SOC's) were detected intermittently before and during the test. However, the timing of these detections suggests that they were not caused by the test activity and the measured concentrations represent background concentrations related to off site activities.

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1.0 INTRODUCTION

Shallow aquifer recharge (SAR) is one of several water resource management strategies being explored by water resources stakeholders in the Walla Walla Basin of southeastern Washington and northeastern Oregon (Figure 1). One of the locations where SAR is being tested is known as the Hall-Wentland Site (H-W Site). The H-W Site is located in the SE ¼, NE ¼, Section 14, T6N, R35E, on private property south of Stateline Road in Oregon (Figures 1 and 2).

SAR testing at the H-W Site is being done under Oregon Water Resources Department (OWRD) Limited License 915 issued to Walla Walla River Irrigation District (WWRID) in the fall of 2005. The H-W Site SAR work is being funded by Washington Department of Ecology (Ecology) through grants awarded to the Walla Walla County (Washington) Watershed Planning Department. Work described in this report was done under Grant No. G0600312. SAR testing done at the H-W Site under Limited License 915 can be conducted seasonally (with several stipulations and conditions) between November and April of the succeeding calendar year. This license expires in April 2010.

Under Limited License 915, the first SAR test season at the H-W Site began in early March 2006 and ended in mid-April 2006. The results of this first test season are described in Kennedy/Jenks (2006). That report also describes background conditions interpreted for the H-W Site prior to the start of testing in early 2006, H-W Site physical conditions, and the regulatory constraints under which testing can be conducted. That information will not be repeated in this report. Instead, this report focuses on describing the results of the recently completed second test season, which started in late December 2006 and ended in mid-April 2007. Topics and information presented in this report include the following:

- A timeline listing the major events associated with the 2006/2007 recharge season.
- Site modifications and changes relative to the first test season.
- Rates and volumes of water delivered to the H-W Site from the source water, which was, as is in the first season, ambient flow from the East Little Walla Walla River (ELWW) delivered to the H-W Site via Wells Ditch. For the second test season water was not diverted from the mainstem of the Walla Walla River for testing.
- Alluvial aquifer water levels, before, during, and after the second test season.
- Results of groundwater and surface water quality monitoring before, during, and after the second test season.
- Comparisons between conditions observed in the first and second test seasons.
- Summary and recommendations.

In addition, this report is accompanied by appendices that contain data and information collected during the course of the 2006/2007 test season. These appendices are as follows:

- Appendix A. Field notes.
- Appendix B. Water quality data.
- Appendix C. A copy of an independently produced strategy report entitled: *Hall-Wentland Recharge Project Long-Term Implementation Strategy*. This strategy report, produced by Fountainhead for Walla Walla County (the County), is included herein per GSI Water Resources, Inc. (GSI) contract with the County. Our inclusion of the Fountainhead report in no way implies or warrants agreement with, or an endorsement of, the Fountainhead report by GSI.

For the second recharge season the Walla Walla County Watershed Planning Department contracted to GSI (formerly Groundwater Solutions, Inc.) to conduct testing, compile data, interpret test results, and prepare this report. Because the Limited License holder for this project is WWRID, GSI worked with Walla Walla County staff and WWRID staff (and stakeholders), to make sure both parties were satisfied with test operations, monitoring, and activities. The project team included:

- Kevin Lindsey, Ph.D., L.Hg. (GSI) – project manager and hydrogeologist (Washington).
- Terry Tolan, R.G. (GSI) – hydrogeologist (Oregon).
- Jon Travis (GSI) – geologic and report production support.
- John Fazio, PE (Fazio Engineering) – project engineer.
- Tom Page (Independent land owner) – Site operator and local point of contact.

The basic site layout for the 2006/2007 test season was very similar to that of the preceding test season (Figure 3).

2.0 2006/2007 TIMELINE

The project timeline presented here lists the main project activities and actions for the 2006 through 2007 recharge season. Notes and documents describing many of these actions and events are attached to this report in the Appendix A.

- 03 October 2006; Initial water quality sampling event. Field and basic groundwater parameters collected. Results in Appendix B.
- 31 October 2006; Water quality sampling event. Field, basic, and synthetic organic compound (SOC) parameters collected for both groundwater and source water. Results in Appendix B.
- Late November 2006; Small ramp flumes installed at the Wells Ditch diversion

and in the branch ditch leading onto the H-W Site. Gated culverts installed in the pump sump pit on the H-W Site.

- 01 December 2006; Transducers installed in the ramp flumes.
- 06 December 2006; Project team met with Oregon Department of Fish and Wildlife (ODFW) staff on-site to get approval of the fish screen planned for use during testing. Approval granted.
- 21 December 2006; Second test season begins.
- 27 December 2006; Water quality sampling event. Field and basic parameters collected. Results in Appendix B.
- January and February, 2007; Test ongoing, but fish screen repeatedly plugged by fine suspended solids and vegetation. Site visited every 1 to 2 days to clean screen. Flow to H-W Site commonly less than 0.4 cubic feet per second (cfs).
- 02 March 2007; Reinstall weir boards (and associated transducer) in the Wells Ditch diversion structure for the H-W Site. This was done to collect weir flow data to compare to ramp flume data at the request of OWRD staff.
- March and early April, 2007; Test ongoing with weir boards installed. Fish screen plugging significantly reduced and flow to site generally exceeds 0.7 cfs.
- 12 April 2007; Water quality sampling event. Field, basic, and SOC parameters collected. Results in Appendix B.
- 15 April 2007; Test season ends. Fish screen and weir boards used to control the test are removed. Wells Ditch and branch ditch return to normal irrigators use.
- 7 May 2007; Post-test water quality sampling. Field and basic parameters collected. Results in Appendix B.
- Late June; Second season report prepared.

3.0 ON-SITE WORK

Work done on-site for the 2006-2007 test season focused primarily on changing the physical layout of the way water was delivered to the H-W Site and how flow through the delivery system was measured. This work was done to address several of the recommendations in the report written describing the results of the first test season (Kennedy/Jenks, 2006). This on-site work included: (1) installing a ramp flume at the Wells Ditch diversion, (2) replacing the branch ditch weir with a ramp flume, and (3) installing gated culverts in the pump sump pit on-site. Each of these modifications is described further below.

3.1 Diversion Ramp Flume

In the first test season the volume of water diverted from Wells Ditch was measured using a 3-foot rectangular weir, staff gauge, and transducer (Figure 4). However, to function properly, water needed to be backed up against the weir to generate the approximately one-foot drop required for proper functioning of the weir. This resulted in some water spilling out of Wells Ditch upstream of the weir, inundating a small portion (several hundred square feet) of pasture adjacent to Wells Ditch. For the second test season the project team decided to attempt to reduce or eliminate this ponded water by replacing the measurement weir with a calibrated, 3.5 cfs EZFlow ® portable ramp flume.

The ramp flume (and an associated transducer) was installed in the branch ditch which transports water to the H-W Test site immediately downstream of the Wells Ditch diversion structure and fish screen (Figure 5). With ramp flume installed, several boards were removed from the weir, eliminating the back up of water above the diversion structure and removing the spill over out of Wells Ditch. Unfortunately, with the removal of the weir boards we found that the fish screen rapidly plugged with suspended organic debris. We surmised that this was because, with the boards gone, the Wells Ditch gradient was high enough above the fish screen to deliver fine suspended debris to the fish screen, thus plugging it. In this configuration the fish screen needed to be manually cleaned every 1 to 2 days. Flow through the screen and to the H-W Site, when the fish screen was plugged, generally was less than 0.4 cfs.

During preparation for the 2006-2007 recharge season, OWRD staff requested that at some point during the season we collect water level data and calculate flow concurrently for both the weir and the ramp flume. Doing this required reinstallation of the weir boards. The concurrent operation of the weir and flume was done between 02 March 2007 and 19 March 2007. With this configuration, even though some water spilled out of Wells Ditch up stream of the weir, we observed that fine debris settled out of the water column before it reached the fish screen.

3.2 On-Site Ramp Flume

For the first test season, flow and volume delivered to the H-W Site was measured using a rectangular 3-foot weir, the on-site weir (Figure 6), similar to that installed at the Wells Ditch diversion. Flow measurements collected using the on-site weir generally were found to be unsatisfactory because the gradient across it was so low that water commonly back-flooded across it, inundating it and generating water levels in the weir not representative of actual flow conditions (Kennedy/Jenks, 2006). For the 2006/2007 test season we attempted to address this by installing a Nu-Way 3.5 cfs EZFlow ® portable ramp flume in place of the rectangular weir (Figure 7).

In conjunction with installation of the on-site ramp flume, the ditch down stream of it was cleaned by removing vegetation and mud. This was done in an attempt to increase the gradient between the flume and the pump sump pit and get water level measurements and flow measurements more indicative of actual flow conditions than we were able to collect in the first test season.

3.3 Gated Culverts

In the first test season water was diverted onto the H-W Site from the delivery ditch and/or the pump sump pit via breaks manually dug into the ditch and pit bank. Water was allowed to flow freely through these breaks onto the H-W Site. For the 2006/2007 test season two gated culverts were installed in the edge of the pump sump pit. One culvert leads from the pit onto the Hall pasture, the other from the pit onto the Wentland alfalfa field (Figure 8). Flow into either, or both, portions of the H-W Site was then controlled by opening and closing the culvert gates. For the 2006/2007 we estimate that over 75 percent of the total water delivered to the H-W Site was directed onto the Wentland alfalfa field.

4.0 WATER VOLUME USED IN 2006/2007 TEST SEASON

The water volume delivered to the H-W Site during the 2006/2007 test season was calculated from the staff gauge readings and transducer data collected at the two ramp flumes. Transducer data also was collected from the existing rectangular Wells Ditch diversion weir between 02 March 2007 and 19 March 2007, in the same way it was done for the previous seasons testing (Kennedy/Jenks 2006). Hydrographs for the two ramp flumes are shown on Figure 9.

Transducer data for the two ramp flumes was calibrated to the “0” flow mark on both ramp flumes by using a correction factor. For the Wells Ditch diversion ramp flume the correction was done by subtracting 4.62 inches from transducer measured water depth data. The on-site ramp flume correction was done by subtracting 0.93 inches from transducer water depth data. Following the correction for water depth, transducer data was converted to flow using the equation for the flumes:

$$Q = 0.07106\ (h)^{1.615}$$

where,

Q = flow in cfs,

and

h = depth of water (in inches) across the ramp flume measurement sill.

Based on the calculations described above approximately 253 acre-feet of water was diverted from Wells Ditch to the branch ditch (Figure 10). Average calculated instantaneous flow through the Wells Ditch diversion ramp flume, before installing the weir boards, was 0.80 cfs. Average calculated instantaneous flow through the ramp flume, after installing the weir boards on 02 March 2007 was 1.60 cfs.

Calculated flow through the diversion ramp flume was checked against calculated flow through the Wells Ditch diversion weir during the period of 02 March 2007 to 19 March 2007. Hydrographs for this event are shown in Figure 11. For this period a total of approximately 34.4 acre-feet of water is calculated to have flowed through the weir with a calculated average instantaneous flow of approximately 1.0 cfs. The total flow volume calculated for the diversion flume over this same period was approximately 44.6 acre-feet with a calculated average instantaneous flow of approximately 1.8 cfs.

Total flow for the entire test period through the on-site ramp flume was calculated to be approximately 97.0 acre-feet (Figure 10). The calculated instantaneous average flow through the on-site ramp flume before installing the weir boards was 0.24 cfs. After installing the weir boards it is calculated to have been approximately 0.74 cfs.

Clearly there are some discrepancies in calculated flow data through the diversion ramp flume when compared to the diversion weir and when compared to the on-site ramp flume. Calculated instantaneous flow through the diversion ramp flume averages 0.4 cfs higher than those calculated for the weir. Total calculated flow through both structures was approximately 22 percent higher in the ramp flume. Comparing flow data from the diversion ramp flume to the on-site ramp flume, one again sees a significant difference between calculated total flows. Based on the calculated flows, we see an apparent loss in total calculated flow in the branch ditch of approximately 60 percent.

Other observations relevant to better understanding calculated flows onto the H-W Site during the 2006/2007 recharge season include the following:

- The differences between the diversion weir and the diversion ramp flume are greatest at higher flows, and generally decrease as flows decrease.

- During operations, the water surface above (up stream) of the weir, where the transducer was installed was generally less turbulent than the water surface above the ramp flume, where that transducer was installed.

- Similar turbulent conditions were observed when comparing the two ramp flumes. Flow through the diversion ramp flume generally was more turbulent than through the on-site ramp flume.

- Flow surges through the diversion flume were common when it was cleaned. These flow surges may have, at least on some occasions, generated calculated flows higher than normal.

Given these observations, determining the volume of water diverted from Wells Ditch towards the Site proved to be more problematic than anticipated. The volume diverted to the Site could be as high as approximately 253 acre-feet, as calculated from the diversion flume data. Alternatively, it could have been as low as 195 acre-feet (or less) based on the overestimation possibly associated with the diversion ramp flume when that data is compared to flow calculations generated from diversion weir data. In addition, the volume of water actually arriving at the Site appears to be open to question. If flow calculated through the on-site flume is accurate (e.g., 97 acre-feet), over 50 percent of the water diverted from Wells Ditch was lost to the ground through seepage from the branch ditch. Visual observations suggest this flow loss is unlikely and that data collection problems were encountered with the on-site flume during the 2006/2007 recharge season, just as they were with the previous season. This problem is likely due to the low gradient in the branch ditch and the difficulty in having the unimpeded flow through the measurement structure needed to collect representative water depth data for calculating flow.

5.0 WATER LEVELS IN ALLUVIAL AQUIFER

As was done in the previous season we tracked water levels in on-site monitoring wells HW-1, HW-2, and HW-3 and 14 off-site water supply wells. Water levels in the monitoring wells were collected using a digital transducer, in the off-site wells using an e-tape.

5.1 Transducer Data from Monitoring Wells

Water level data collected from each of the three monitoring wells is summarized below and shown in Figure 12. This summary generally focuses on water levels observed before, during, and after testing.

Water level in well HW-1, at the north end of and down gradient of the Site, generally declined in the three months prior to the start of testing, reaching a low of approximately 735.5 feet above mean sea level (amsl) just prior to the start of testing. It then rose to its first high of approximately 736.2 feet on 10 January 2007. Water level in the well declined during most of February but began to rise again after 02 March 2007, the day the weir boards at the diversion were installed. On 15 April 2007, the day of the test shutdown, HW-1 had a water level of approximately 738.1 feet, which continued to rise to a high of approximately 739.2 feet on 19 April 2007. Water levels begin to fall after 19 April 2007 and continued to fall until the end of data collection 04 May 2007. The final water level measurement is above the pretest level.

Water level in well HW-2, positioned up gradient of the Site, experience more and greater fluctuation than either HW-1 or HW-3. Because of problems with the transducer, data collection in HW-2 began approximately one month before the start of testing. During that time water level fluctuated between approximately 748 and 749.8 feet amsl. Within less than 1 day of the start of testing on 22 December 2007, water level rose from a pre-test low of 747.9 feet amsl to a high of approximately 753.3 feet amsl on 30 December 2007. Like HW-1, water level remained relatively stable in January 2007 before falling in February. After installing the weir boards 02 March 2007 at the diversion, water level in well HW-2 began to rise, reaching a high of approximately 757.9 feet one day after the end of the test. Water levels begin to fall after 16 April 2007 and continued to fall until the end of data collection on 04 May 2007. The final post test water level was still higher than any pretest level.

Well HW-3 is, like HW-1, located down gradient of the Site and it displayed water level changes similar to those seen in HW-1. In the several months prior to the start of testing water level in HW-3 generally fell, reaching a pre-test low on 22 December 2007 of approximately 732.8 feet amsl. It then rose to its first high of approximately 735.5 feet on 10 January 2007. Water levels fell during most of February but began to rise again after the weir boards were installed at the diversion on 02 March 2007. On the day of the test shutdown HW-3 had a water level of approximately 735.9 feet. Water level continued to rise to a high of approximately 736.5 feet on 19 April 2007. Water levels began to fall after 19 April 2007 until the end of data collection 04 May 2007. The final water level is still above pre-test levels.

All three monitoring wells display water level changes interpreted to be in response to testing. All wells appear to show a response to the pretest shutdown of Wells Ditch and the branch ditch, a rise corresponding to the start of testing, and a decline in response to the shutdown of the test. Monitoring well water levels also showed a response to the decrease in branch ditch flow during February 2007, due to plugging of the fish screen until 02 March 2007 when weir boards were installed at the Wells Ditch diversion.

5.2 Manually Measured Water Supply Wells

Manually measured water levels were collected from 14 wells on a monthly to weekly basis (Figure 13). Water level data was collected from wells MC-1 through MC-10 during the first and the second (2006/2007) recharge seasons. Three new wells, designated MC-11, MC-12, and MC-13, were added to the manually measured wells for the 2006/2007 recharge season. Wells MC-11, MC-12, and MC-13 are located west of the H-W Site along Stateline Road (Figure 2), generally in a down gradient to cross gradient orientation with respect to groundwater flow in the H-W Site area. Of the other wells, MC-10 is located up gradient of the H-W Site and wells MC-1 through MC-6 are located down gradient from the H-W Site. Wells MC-7, MC-8, and MC-9 are located near the H-W Site, with MC-7 and MC-9 generally transverse gradient to the H-W Site and MC-8 essentially on-site.

Based on the water level data collected for the 2006/2007 recharge season, the off-site manually measured wells generally appear to fall into three basic groups. Water levels displayed by the manually measured wells are shown on Figure 13, and summarized below:

- The first group of wells (MC-1, MC-2, MC-7, MC-9, and MC-10) displays two water level highs, early and late in testing, separated by decreased water levels during the mid-test period. The two peaks generally occur early in testing, in January 2007, and late in testing, in March/April 2007. These peaks are separated by a drop in water levels, centered on February 2007, which generally corresponds to the period during the test when flow to the site was lowest because of fish screen plugging. Water levels in all of the wells in this group fell soon after the end of testing in mid-April.

- Another group of wells consists of the three wells located west of the H-W Site, MC-11, MC-12, and MC-13, and one well north of the H-W Site, MC-4. The highest water levels recorded in these wells appear late in, or soon after the end of, the test season. All of these wells seem to display relatively stable water levels for the month following the end of testing.

- The final group of wells, which includes MC-3, MC-5, MC-6, and MC-8, show late and post-test water level highs, similar to all the MC wells, followed by a drop in water level. However, the data for these wells is notable in that they all lack data for January 2007, limiting our ability to determine if the early test water level high followed by the mid-test water level decrease (as seen in wells MC-1, MC-2, MC-7, MC-9, and MC-10), occurred in this group of wells.

Based on the data collected during the 2006/2007 test season, it is possible that all the manually measured wells responded to the test. All of the wells show high water levels at, or following, the end of the test, and most of them show water level decreases following the end of testing. These level changes could reflect the spread and subsequent collapse of the groundwater mound generated by the test. In addition, at least 5 of the wells show water level increases followed by decreases early in the test which could reflect the start of testing, followed by decreased recharge during the period when flow to the Site was restricted by repeated fish screen plugging.

Three of the four wells that showed relatively stable water levels following the end of testing, MC-11, MC-12, and MC-13, might also be seeing influences other than the test. These could include: (1) seepage from nearby Walsh Creek sustaining water level in the aquifer and/or (2) increased flow through lower Wells Ditch following the end of testing sustaining these higher levels and postponing or stopping a post-test water level drop. The cause of apparent stable post-test water level in well MC-4, which is located down gradient of the H-W Site and is near wells that show post-test water level decreases, is unknown.

6.0 WATER QUALITY

6.1 Field and Basic Water Quality

Field and basic water quality data was collected twice prior to testing from the three monitoring wells, HW-1, HW-2, and HW-3. The first sampling event was on 03 October 2007 and the second was on 31 October 2007. The branch ditch was sampled once prior to testing on October 31. This was done to better characterize background water quality conditions prior to testing. Water quality data was also collected from the three monitoring wells and surface water during testing and after testing. Samples were collected on 27 December 2007 following the beginning of testing, on 11 April 2007 before the end of testing, and on 07 May 2007 following the end of testing. Sample analysis results are shown in Table 1, summarized below, and included in Appendix B.

Pre-test field pH for source water was 7.33. Pre-test up gradient groundwater ranged from 5.95 to 6.24 and down gradient groundwater ranged between 6.23 and 6.84. During testing source water pH increased as the test continued. Up gradient groundwater ranged from 6.79 to 6.96 during testing, increasing as testing continued. Down gradient groundwater during testing had a pH ranging from 6.57 to 6.96, which generally increased as testing continued. Following the end of testing pH fell in source water, but continued to increase in the wells.

Pre-test field electrical conductivity (EC) for source water was 1370 micro Siemens per centimeter (mS/cm). In pre-test groundwater, both up and down gradient, EC was between 1430 and 1570 mS/cm. During testing EC in source water increased following the start of testing and decreased later in the test. Up gradient groundwater EC generally decreased during the course of testing. Down gradient groundwater showed little change from pretest levels and was relatively unchanged over the course of testing. Following the end of testing all wells show a decline in electrical conductivity and while source water did not change.

Nitrate-N in source water prior to testing was 0.870 milligrams per liter (mg/l). Concentrations in pre-test groundwater ranged from 0.470 to 0.910 mg/l. During testing nitrate-N concentration in source water first increased then decreased to below pre-test levels later in testing. Nitrate-N in all monitoring wells generally increased slightly over the course of testing. Following the end of testing, nitrate-N increased in all wells and source water.

Nitrite-N concentrations were below the minimum detection limit (MDL) of 0.0023 mg/l during pre-test sampling events in both the monitoring wells and surface water. During and following testing nitrite-N concentrations were at, or below, the MDL.

Hardness in pre-test source water was 53.6 mg/l. Concentrations in pre-test up gradient groundwater were approximately 63.0 mg/l and down gradient groundwater ranged from 59.4 to 67.9 mg/l. Hardness increased at all sampling locations following the start of testing, ranging from 87.20 to 98.70 mg/l. Later in the testing season hardness concentration fell at all sampling locations and following testing it continued to fall.

Total dissolved solids (TDS) concentration in pre-test source water was 92 mg/l. There was relatively no difference between up and down gradient TDS concentrations in pre-test groundwater, with all values ranging from approximately 100 to 130 mg/l. TDS in source water and groundwater remained relatively unchanged following the start of testing. Following testing TDS in all wells and surface water fell with up gradient groundwater showing the greatest decline.

Chloride concentration in pre-test source water was 2.190 mg/l. In groundwater pre-test chloride concentrations were at, or below, the MDL of 0.297 mg/l for the 03 October 2007 sampling event. Chloride concentrations increased in wells HW-1 and HW-2 but stayed at, or below, the MDL in HW-3 in the 31 October 2007 pre-test sampling event. Following the start of testing chloride concentrations in source water and well HW-1 fell to, or below, the MDL. Concentrations in well HW-2 fell from 1.900 to 0.600 mg/l following the start of testing, and in HW-3 rose from at or below the MDL to 2.800 mg/l. Following testing chloride increased in well HW-1 and source water and decreased in wells HW-2 and HW-3.

Pre-test soluble reactive phosphorus (SRP) concentration in source water was 0.150 mg/l. In groundwater, pre-test SRP was lowest in well HW-3. The highest pre-test groundwater SRP was measured in well HW-2 in the second pretest sampling event (31 October 2007). Following the start of testing SRP increased in source water from 0.150 to 0.250 mg/l, but fell in both up and down gradient wells.

For all sampling event chemical oxygen demand (COD) was almost always at, or below, the MDL of 8.0 mg/l. The one exception was seen in source water which had a COD of 15 mg/l in the 11 April 2007 sampling event.

For the 2006/2007 season, source water and groundwater generally appear to show similar field and basic water quality conditions. Parameter concentrations generally increased and decreased together, although not always by the same amount. These data generally suggest surface water and groundwater throughout the vicinity of the Site display a high degree of continuity. Given the depth to groundwater described earlier, this continuity generally is restricted to surface water bodies leaking into and recharging the shallow alluvial aquifer.

6.2 SOC Water Quality

Samples for SOC analysis were collected during the 31 October 2006 and 11 April 2007 sampling events. Analysis results are provided in Table 2 and both sampling events are summarized as follows:

- No SOC's were detected in surface water.

- Two SOC's, di-n-butyl phthalate and dimethyl phthalate, were detected in pre-test groundwater analysis (31 October 2007). Dimethyl phthalate was detected in well HW-3 at a concentration of 3 micrograms per liter (ug/l) and di-n-butyl phthalate was detected in up gradient well HW-2 and down gradient well HW-3 at concentrations of 1.1 ug/L and 0.9 ug/L respectively.

    - Di-n-butyl phthalate and dimethyl phthalate are manufactured chemicals commonly used in plastic, paint, glue, and other household products.

- During testing (11 April 2007) di-n-butyl phthalate was again detected, this time in all three monitoring wells at concentrations of 0.7 ug/l, 0.5 ug/l, and 0.6 ug/l in wells HW-1, HW-2, and HW-3, respectively.

- Malathion also was detected during testing (11 April 2007) in all three monitoring wells at concentrations of 0.4 ug/l in HW-1, 0.3 ug/l in HW-2, and 0.4 ug/l in HW-3.

    - Malathion is a general use pesticide commonly used in mosquito control.

The SOC data is interpreted to indicate a very small number of these compounds are found in local groundwater. However, inconsistent occurrence, both temporally and spatially, and low concentrations suggest the detections represent intermittent background conditions and that Site operation has an extremely low potential to contribute to the presence of these compounds in groundwater as a result of testing.

7.0 FIRST AND SECOND TEST SEASON COMPARISONS

This section presents a simple qualitative comparison between data collected and observations made during the first test season (spring 2006) and the recently completed second season (winter/spring 2006/2007). In particular:

- The second aquifer recharge season was able to begin much earlier than the first season.

- During the first season most water was delivered to the Hall portion of the H-W Site, during the second season most water was delivered to the Wentland portion of the Site.

- Water level in the first season in HW-1 and HW-3 experienced maximum rises of approximately 9 feet and 2.5 feet, respectively (Figure 14). During the second season water level rose approximately 2.5 feet and 2.0 feet in wells HW-1 and HW-3, respectively.

- Water levels observed in HW-2 for the second season are similar to those seen during the first season. At the start of both seasons the water level began to rise within a few hours of the start of testing. Water levels in HW-2 during both test seasons show larger responses than the other wells. It also responded quickly to the end of testing, with water level dropping soon after the end of the tests.

- Water level changes measured in the first season and the just completed second season in off-site wells MC-1 through MC-10 continue to suggest the effects of recharge can be seen some distance form the Site, and that shallow alluvial aquifer water level does rise in response to recharge at the Site. These water level rises do appear to migrate to the north along the valley of McEvoy Spring Creek. The rise in water level seen in MC-10 suggests that propagation of recharge effects extend at least 0.5 miles up gradient in both seasons.

- Both field and basic water quality constituents for source water and groundwater during the second season appear to be much like the first season. There were concentration fluctuations in many constituents, but no discernable trends that occur, other than the apparent close degree of hydrologic continuity between surface water and groundwater suggested by similar chemistry and changes.

- SOC's in both seasons saw intermittent detections of phthalates. This suggests phthalates may be present as part of the general background groundwater chemistry. Malathion was detected this season, but not last season.

8.0 SUMMARY AND RECOMMENDATIONS

8.1 Summary

This report presented the results of the second season of shallow aquifer recharge testing at the Hall-Wentland Site. Testing was done to continue to evaluate the feasibility of using SAR to help restore depleted shallow sediment aquifer groundwater levels and improve flow in spring creeks and streams. Testing at the Hall-Wentland Site is permitted under a Limited License granted by the Oregon Water Resources Department. The license authorizes testing for a total of five years, and specifies a recharge season each year extending from November of one calendar year to April of the following year.

The test event discussed in this report began on 22 December 2006 and ended on 15 April 2007. SAR testing utilized ambient stream flow in the East Little Walla Walla River. Water was diverted from this stream to the H-W Site via Wells Ditch. Calculating the total water flow diverted to the H-W Site proved to be more problematic than anticipated. Based on the data collected for the just completed recharge season, between approximately 250 and 190 acre-feet of water probably was diverted from Wells Ditch towards the Site. However, based on the on-site ramp flume measurements, as little as approximately 100 acre-feet may have reached the Site. The reasons for these discrepancies are not clear, but may include inaccurate measurements at the diversion ramp flume, problems similar to those encountered in the previous season which were related to low gradients through the measurement structures resulting in impeded flow and collection of inaccurate data, and/or repeated plugging of the fish screen. Low gradients are also interpreted to have contributed to repeated fish screen plugging in the 2006/2006 recharge season.

We started the test season with several weir boards removed from the diversion structure for the Site. Unfortunately, with the boards removed, stream gradient through the ditch was high enough to carry suspended debris up to, lodge against, and plug the fish screen. The boards were reinstalled on March 2, 2007, at which point ponding occurred and stream gradient above the weir decreased, allowing debris to fall out of suspension before reaching the screen. With this, flow through the diversion increased.

The shallow aquifer beneath the Site did respond to SAR testing by rising approximately 8.8 feet in HW-2 during testing. Based on data collected during testing, water levels in on-site monitoring wells began to rise within a few hours after the start of testing. We do not know exactly how far the water table response extends from the Site. Based on data collected at well MC-10 effects extend approximately 0.5 miles up gradient of the Site. Down gradient effects extend through the off-site wells at least as far north as MC-3, if not all the way to MC-1, MC-2, and the Walla Walla River. Following the end of testing water levels continued to rise a few days, before beginning to fall. At the end of data collection on 04 May 2007, 6 days short of a full month after testing ended, water levels were still above pre-test levels in December 2006.

Based on the field and basic water quality parameters measured to-date, SAR activities at the H-W Site are interpreted to have had no negative effect on groundwater quality in the Site area. This data does suggest a high degree of hydraulic continuity between local surface and groundwater, with surface water bodies in the immediate H-W Site area, generally loosing water to the underlying shallow alluvial aquifer system. A few SOC's were detected intermittently before and during the test. However, the timing of these detections suggests that they were not caused by the test activity and the measured concentrations represent background concentrations related to off site activities.

8.2 Recommendations

Based on the results of the second test season described in this report, we have several recommendations for changes to Site operation and testing for the 2007/2008 and 2008/2009 recharge seasons. These include:

- Install and instrument 3 new shallow aquifer monitoring wells near the Site. One of these wells should be located east of the Site. A second well should be located to the south, up gradient of the Site, if a suitable location can be found. The third well should either be placed to the east of the Site or further down gradient than the existing down gradient shallow aquifer monitoring wells.

- Conduct one or more infiltration tests on the Site to better constrain on-site infiltration rates as another way to get at the amount of water delivered to the Site.

- Install fiber optic transducers in at least 2 of the off site manually measured water wells to collect better off site water level data.

- Add additional water wells to the manually measured water well network, possibly further up gradient.

- Discontinue use of the diversion flume, returning to using the weir structure to measure flow and calculate water volume diverted from Wells Ditch towards the Site.

- Conduct an aquifer test in at least one of the existing off-site wells. If done, the selected well should be open to the majority of the Mio-Pliocene upper coarse unit, be accessible for the installation of a digital transducer, and be as close to the H-W Site as we can get. Such a test would require the cooperation of the well owner. This test would generate aquifer property data currently lacking.

- Revisit with Oregon Department of Fish and Wildlife staff the need for a fish screen at the Site. If that agency still requires one, we recommend replacing the fish screen used in the first 2 seasons with one that is self-cleaning.

- Following the end of the 2007/2008 recharge season, prepare an interim report outlining basic work activities and results for that season. Following the end of the 2008/2009 recharge season prepare a final report will focus on summarizing all data collected since the beginning of the project, analyze test performance, and make recommendations for future operations.

Longer term recommendations, all requiring additional funding. These include:

- Expand the size and capacity of the ELWW and Wells Ditch system.

- Address WWRID concerns (with physical structures and/or regulatory exclusions) regarding false fish attraction issues to the introduction of Walla Walla River water to the ELWW and Wells ditch system.

9.0 REFERENCES CITED

Kennedy/Jenks, 2006, Results of the First Season of Shallow Aquifer Recharge Testing at the Hall-Wentland Site, Umatilla County, Oregon and Walla Walla County, Washington. Consultants report prepared for HDR, Inc., 23 June 2006, 35 p., 5 tables, 34 figures, 4 Appendices.

Tables

Sample ID	Date	Lab No.	pH	Temp. C	Electrical Conductivity (mS/cm)	Turbidity (NTU)		NO_3-N (mg/L)		NO_2-N (mg/L)	Hardness (mg/L)	TDS (mg/L)		Cl (mg/L)		Soluble Reactive Phosphorous (mg/L)		COD (mg/L)	Total Coliform (per 100ml)	E-Coli (per 100ml)
MDL -->								0.084		0.0023	0.11	21.1		0.297		0.0433		8.0		
Surface	2/2/2006	80603	7.29	10.0	1027	14.40		0.206		0.0300	50.42	100.0		18.700		0.197		14	present	present
Surface	2/22/2006	80884	7.21	9.5	1044	10.80		0.620			48.90	108.0		6.200		0.146		23	present	present
Surface	3/3/2006	81009	6.94	9.7	1144	26.50		0.940	<	0.0023		160.0	<	0.297	<	0.043		820	present	present
Surface	4/12/2006	81717	7.29	14.9	1300	16.10		0.610	<	0.0023	51.50	66.0		6.000		0.100		14	present	present
Surface	10/31/2006	85494	7.33	8.7	1370	27.40		0.870	<	0.0023	53.60	92.0		2.190		0.150	<	8		present
Surface	12/27/2006	86255	7.42	6.8	1530	8.36		1.130	<	0.0023	89.80	92.0	<	0.297		0.250	<	8	absent	
Surface	4/11/2007	87722	8.89	14.9	1100	5.68		0.290	<	0.0023	55.00	92.5		2.500		0.06		15	present	present
Surface	5/7/2007	88149	8.59	15.9	1100	6.51		0.600	<	0.0023	38.60	50.0		4.500		0.090	<	8	present	present

Sample ID	Date	Lab No.	pH	Temp. C	Electrical Conductivity (mS/cm)	Turbidity (NTU)		NO_3-N (mg/L)		NO_2-N (mg/L)	Hardness (mg/L)	TDS (mg/L)		Cl (mg/L)		Soluble Reactive Phosphorous (mg/L)		COD (mg/L)	Total Coliform (per 100ml)	E-Coli (per 100ml)
HW-1	2/2/2006	80600	6.67	10.3	1120	0.10		0.566		0.0200	57.75	110.0		25.000		0.224	<	8	absent	absent
HW-1	2/22/2006	80881	6.48	7.0	1000	0.34		1.690			55.00	98.0		9.400		0.139		9	present	present
HW-1	3/2/2006	81006	6.59	12.2	1178	0.15		0.680		0.0500	58.90	170.0		5.000		0.100		404	absent	absent
HW-1	3/9/2006	81156	6.62	11.3	1142	0.13		1.210	<	0.0023	62.00	112.0		5.000	<	0.043	<	8	absent	absent
HW-1	4/12/2006	81714	6.39	9.8	1400	0.12		1.420	<	0.0023	60.10	72.0		5.000		0.170	<	8	present	present
HW-1	5/10/2006	82240	6.55	12.0	1413	0.10		0.990	<	0.0020	59.30	116.0	<	0.200		0.150	<	10	absent	absent
HW-1	10/3/2006	85052	6.43	12.8	1440	0.50		0.750	<	0.0023	62.80	136.0	<	0.297		0.11	<	8	absent	
HW-1	10/31/2006	85491	6.84	12.2	1560	0.23		0.910	<	0.0023	64.40	108.0		2.100		0.13	<	8		absent
HW-1	12/27/2006	86252	6.57	12.1	1590	0.13		0.710	<	0.0023	90.00	108.0	<	0.297		0.12	<	8	absent	
HW-1	4/11/2007	87719	6.90	12.9	1540	0.12		0.800	<	0.0023	83.30	115.0		0.500		0.090	<	8	absent	absent
HW-1	5/7/2007	88146	7.32	13.3	1520	0.89		1.140	<	0.0023	56.70	76.7		5.000		0.130	<	8	present	absent

Sample ID	Date	Lab No.	pH	Temp. C	Electrical Conductivity (mS/cm)	Turbidity (NTU)		NO_3-N (mg/L)		NO_2-N (mg/L)	Hardness (mg/L)	TDS (mg/L)		Cl (mg/L)		Soluble Reactive Phosphorous (mg/L)		COD (mg/L)	Total Coliform (per 100ml)	E-Coli (per 100ml)
HW-2	2/2/2006	80601	6.60	14.0	1434	6.82		0.390		0.0210	72.41	126.0		25.000		0.208	<	8	present	absent
HW-2	2/22/2006	80882	6.60	13.1	1441	1.23		0.930			77.00	128.0		7.800		0.114		19	present	absent
HW-2	3/3/2006	81007	6.74	12.8	1506	0.02		0.720		0.0500	77.50	166.0		5.000		0.100		743	absent	absent
HW-2	3/9/2006	81157	6.78	12.5	1470	0.71		0.950	<	0.0023	82.00	126.0	<	0.297	<	0.043	<	8	absent	absent
HW-2	4/12/2006	81715	6.30	13.4	1400	12.50		1.690	<	0.0023	63.00	82.0		5.000		0.120	<	8	present	present
HW-2	5/10/2006	82241	6.65	13.4	1708	4.53		1.710	<	0.0020	71.90	132.0	<	0.200		0.130	<	10	present	present
HW-2	10/3/2006	85053	5.95	18.0	1450	0.61		0.470	<	0.0023	63.10	130.0	<	0.297		0.090	<	8	absent	
HW-2	10/31/2006	85492	6.24	15.1	1570	2.23		0.740	<	0.0023	62.90	114.0		1.900		0.200	<	8		absent
HW-2	12/27/2006	86253	6.79	14.4	1370	4.12		0.780	<	0.0023	87.20	90.0		0.600		0.130	<	8	present	
HW-2	4/11/2007	87720	6.96	11.3	1370	0.83		0.810	<	0.0023	69.00	108.0		2.700		0.050	<	8	present	absent
HW-2	5/7/2007	88147	7.02	10.8	1360	1.67		0.850	<	0.0023	48.70	53.3		1.500		0.120	<	8	present	present

Sample ID	Date	Lab No.	pH	Temp. C	Electrical Conductivity (mS/cm)	Turbidity (NTU)		NO_3-N (mg/L)		NO_2-N (mg/L)	Hardness (mg/L)	TDS (mg/L)		Cl (mg/L)		Soluble Reactive Phosphorous (mg/L)		COD (mg/L)	Total Coliform (per 100ml)	E-Coli (per 100ml)
HW-3	2/2/2006	80602	6.53	12.4	1193	0.16		0.391		0.0170	60.38	108.0		31.200		0.083	<	8	absent	absent
HW-3	2/22/2006	80883	6.64	12.3	1181	0.14		0.900			62.70	106.0		15.600		0.107		14	absent	absent
HW-3	3/3/2006	81008	6.48	13.0	1223	0.12		0.700	<	0.0023	60.80	158.0	<	0.297	<	0.043		615	absent	absent
HW-3	3/9/2006	81158	6.86	12.4	1178	0.20		0.920	<	0.0023	64.00	96.0		8.000	<	0.043		13	absent	absent
HW-3	4/12/2006	81716	6.52	13.2	1500	0.05		1.020	<	0.0023	62.60	88.0		5.000		0.100	<	8	absent	absent
HW-3	5/10/2006	82242	6.45	13.2	1447	16.90		1.020	<	0.0020	62.20	144.0	<	0.297		0.160	<	10	present	present
HW-3	10/3/2006	85054	6.32	13.2	1430	0.20		0.700	<	0.0023	67.90	122.0	<	0.297		0.080	<	8	absent	
HW-3	10/31/2006	85493	6.76	12.7	1430	3.17		0.760	<	0.0023	59.40	98.0	<	0.297		0.090	<	8		absent
HW-3	12/27/2006	86254	6.8	12.5	1470	2.44		1.120	<	0.0023	98.70	94.0		2.800		0.060	<	8	absent	
HW-3	4/11/2007	87721	6.96	13.1	1490	0.27		0.870	<	0.0023	78.90	105.0		3.000	<	0.043	<	8	absent	absent
HW-3	5/7/2007	88148	7.07	13.2	1480	0.11		1.160	<	0.0023	56.80	76.7		2.000		0.07	<	8	absent	absent

Table 1. Field and basic water quality results for the first and second recharge seasons.

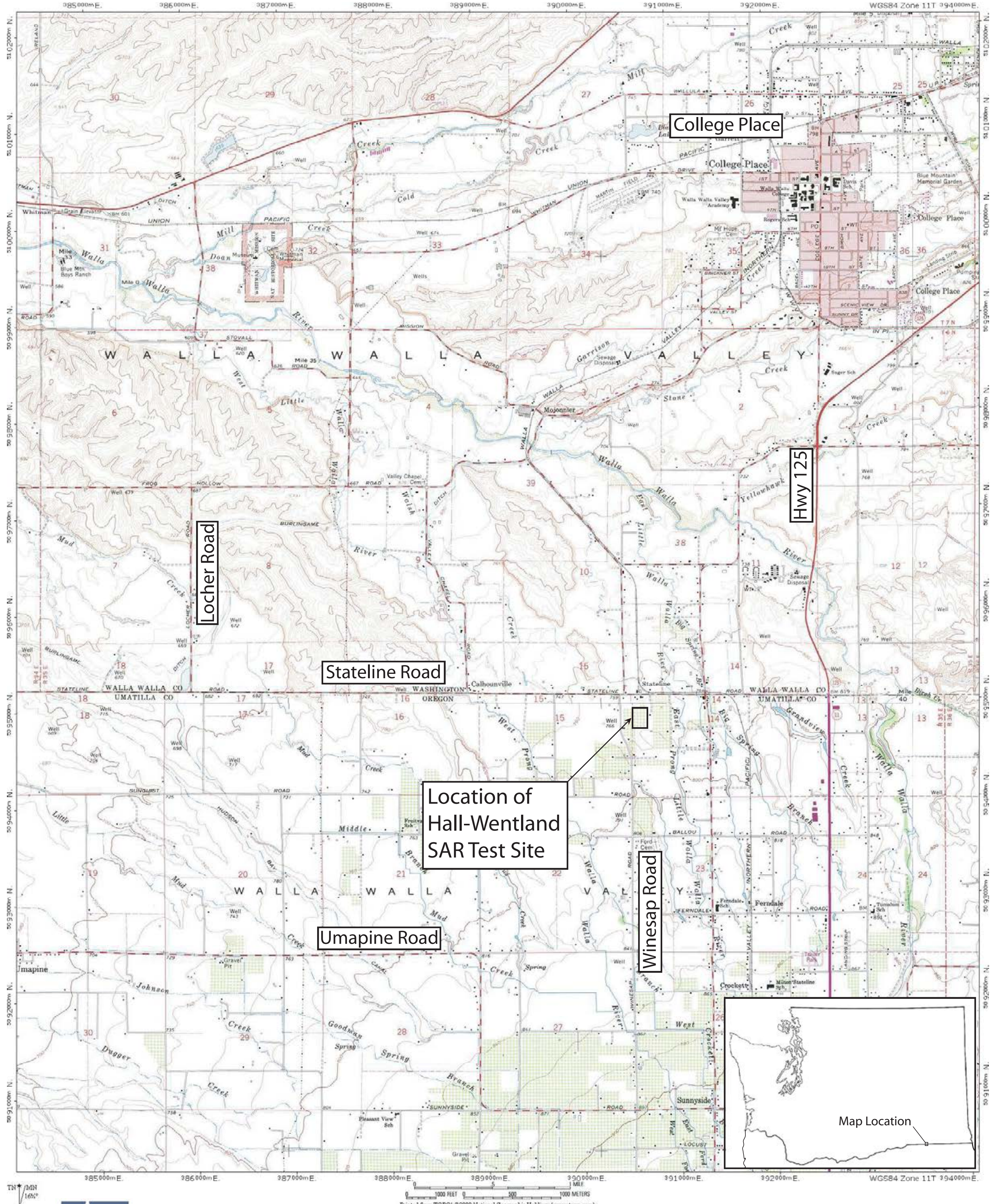
Date	10/31/2006	10/31/2006	10/31/2006	10/31/2006
Well ID	HW-1	HW-2	HW-3	Surface
Chemical				
Carbamates in Drinking water				
Carbofuran	ND	ND	ND	ND
Oxymal	ND	ND	ND	ND
3-Hydroxycabofuran	ND	ND	ND	ND
Aldicarb	ND	ND	ND	ND
Aldicarb sulfone	ND	ND	ND	ND
Aldicarb sulfoxide	ND	ND	ND	ND
Carbaryl	ND	ND	ND	ND
Methomyl	ND	ND	ND	ND
Propoxur (Baygon)	ND	ND	ND	ND
Methiocarb	ND	ND	ND	ND
Synthetic Organic Compounds				
Endrin	ND	ND	ND	ND
Lindane (BHC-Gamma)	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND
Alachlor	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND
Chlordane Technical	ND	ND	ND	ND
Di(ethylhexyl)-Adipate	ND	ND	ND	ND
Di(ethylhexyl)-phthalate	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND
Heptachlor Epoxide A&B	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND
Hexachlorocyclo-Pentadiene	ND	ND	ND	ND
Simazine	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND
Butachlor	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND
Metolachlor	ND	ND	ND	ND
Metribuzin	ND	ND	ND	ND
Propachlor	ND	ND	ND	ND
Bromacil	ND	ND	ND	ND
Prometon	ND	ND	ND	ND
Terbacil	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND
EPTC	ND	ND	ND	ND
4,4-DDD	ND	ND	ND	ND
4,4-DDE	ND	ND	ND	ND
4,4-DDT	ND	ND	ND	ND
Cyanazine	ND	ND	ND	ND
Malathion	ND	ND	ND	ND
Trifluralin	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND
Benz(A)anthracene	ND	ND	ND	ND
Benzo(B)fluoranthene	ND	ND	ND	ND
Benzo(G,H,I)peryene	ND	ND	ND	ND
Benzo(K)fluoranthene	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND
Dibenzo(A,H)anthracene	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND
Indeno(1,2,3-CD)pyrene	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND
Benzyl Butyl Phthalate	ND	ND	ND	ND
Di-N-Butyl Phthalate	ND	**1.1BQ**	**0.9**	ND
Diethyl Phthalate	ND	ND	ND	ND
Dimethyl Phthalate	ND	ND	**3**	ND
Toxaphene	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND
Herbicides in Drinking Water				
2,4-D	ND	ND	ND	ND
2,4,5-TP (Silvex)	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND
Dalapon	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND
Picloram	ND	ND	ND	ND
Dicamba	ND	ND	ND	ND
2,4 DB	ND	ND	ND	ND
2,4,5 T	ND	ND	ND	ND
Bentazon	ND	ND	ND	ND
Dichlorprop	ND	ND	ND	ND
Actiflorfin	ND	ND	ND	ND
Dacthal (DCPA)	ND	ND	ND	ND
3,5-Dichlorobenzoic Acid	ND	ND	ND	ND
Velpar (hexazinone)	ND	ND	ND	ND
Bronate (bromoxynil)	ND	ND	ND	ND
Gramoxone (paraquat)	ND	ND	ND	ND

Table 2. SOC results for the 2006/2007 recharge season.

Date	4/11/2007	4/11/2007	4/11/2007	4/11/2007
Well ID	HW-1	HW-2	HW-3	Surface
Chemical				
Carbamates in Drinking water				
Carbofuran	ND	ND	ND	ND
Oxymal	ND	ND	ND	ND
3-Hydroxycabofuran	ND	ND	ND	ND
Aldicarb	ND	ND	ND	ND
Aldicarb sulfone	ND	ND	ND	ND
Aldicarb sulfoxide	ND	ND	ND	ND
Carbaryl	ND	ND	ND	ND
Methomyl	ND	ND	ND	ND
Propoxur (Baygon)	ND	ND	ND	ND
Methiocarb	ND	ND	ND	ND
Synthetic Organic Compounds				
Endrin	ND	ND	ND	ND
Lindane (BHC-Gamma)	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND
Alachlor	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND
Chlordane Technical	ND	ND	ND	ND
Di(ethylhexyl)-Adipate	ND	ND	ND	ND
Di(ethylhexyl)-phthalate	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND
Heptachlor Epoxide A&B	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND
Hexachlorocyclo-Pentadiene	ND	ND	ND	ND
Simazine	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND
Butachlor	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND
Metolachlor	ND	ND	ND	ND
Metribuzin	ND	ND	ND	ND
Propachlor	ND	ND	ND	ND
Bromacil	ND	ND	ND	ND
Prometon	ND	ND	ND	ND
Terbacil	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND
EPTC	ND	ND	ND	ND
4,4-DDD	ND	ND	ND	ND
4,4-DDE	ND	ND	ND	ND
4,4-DDT	ND	ND	ND	ND
Cyanazine	ND	ND	ND	ND
Malathion	**0.4**	**0.3**	**0.4**	ND
Trifluralin	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND
Benz(A)anthracene	ND	ND	ND	ND
Benzo(B)fluoranthene	ND	ND	ND	ND
Benzo(G,H,I)peryene	ND	ND	ND	ND
Benzo(K)fluoranthene	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND
Dibenzo(A,H)anthracene	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND
Indeno(1,2,3-CD)pyrene	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND
Benzyl Butyl Phthalate	ND	ND	ND	ND
Di-N-Butyl Phthalate	**0.7**	**0.5KK**	**0.6**	ND
Diethyl Phthalate	ND	ND	ND	ND
Dimethyl Phthalate	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND
Aroclor 1221	ND	ND	ND	ND
Aroclor 1232	ND	ND	ND	ND
Aroclor 1242	ND	ND	ND	ND
Aroclor 1248	ND	ND	ND	ND
Aroclor 1254	ND	ND	ND	ND
Aroclor 1260	ND	ND	ND	ND
Aroclor 1016	ND	ND	ND	ND
Herbicides in Drinking Water				
2,4-D	ND	ND	ND	ND
2,4,5-TP (Silvex)	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND
Dalapon	ND	ND	ND	ND
Dinoseb	ND	ND	ND	ND
Picloram	ND	ND	ND	ND
Dicamba	ND	ND	ND	ND
2,4 DB	ND	ND	ND	ND
2,4,5 T	ND	ND	ND	ND
Bentazon	ND	ND	ND	ND
Dichlorprop	ND	ND	ND	ND
Actiflorfin	ND	ND	ND	ND
Dacthal (DCPA)	ND	ND	ND	ND
3,5-Dichlorobenzoic Acid	ND	ND	ND	ND
Velpar (hexazinone)	ND	ND	ND	ND
Bronate (bromoxynil)	ND	ND	ND	ND
Gramoxone (paraquat)	ND	ND	ND	ND

Table 2 (continued)

Figures



GSI Water Solutions, Inc.

Figure 1. Area and regional setting.

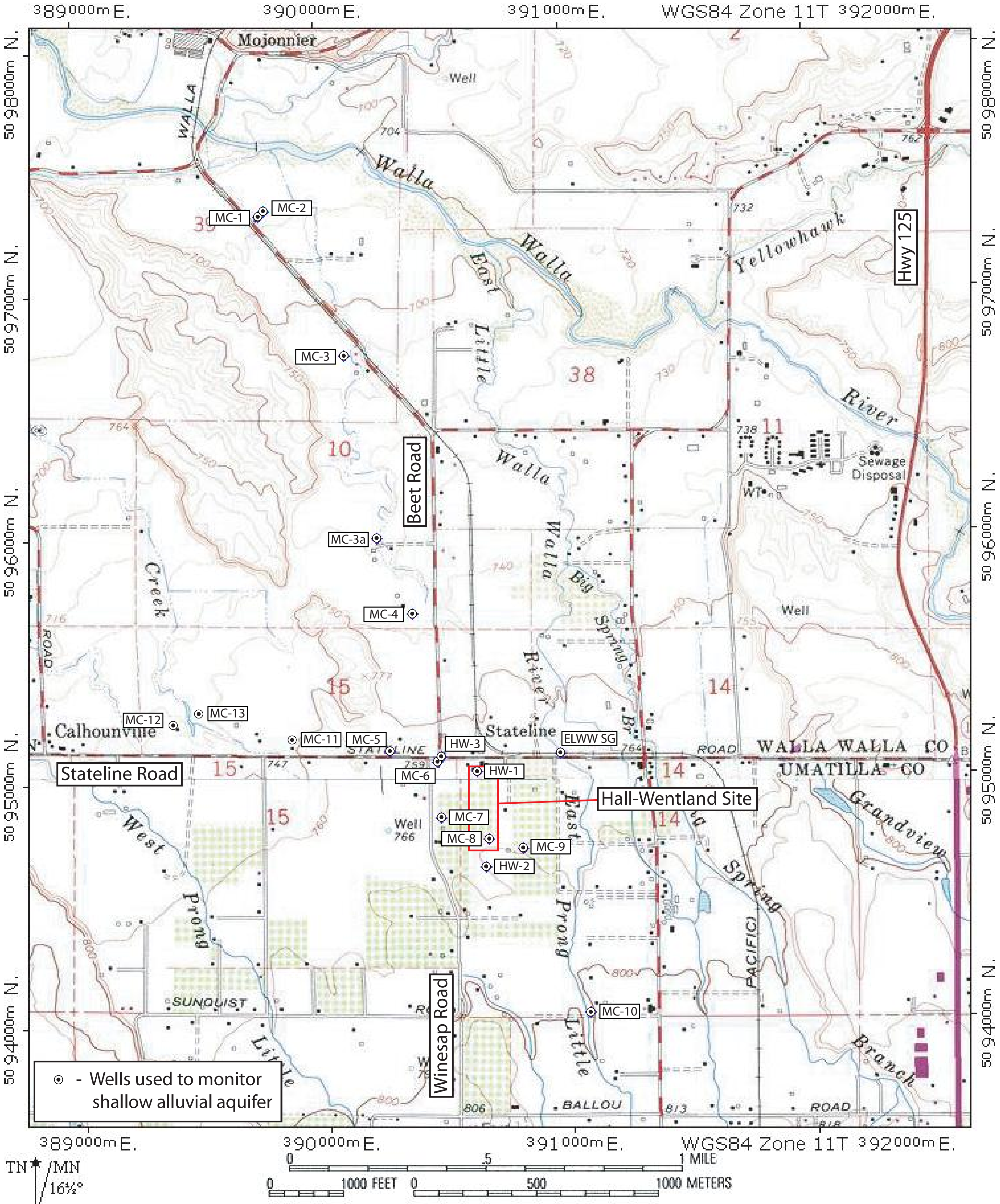


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Figure 2. Local setting, including location of off-site wells used for water level monitoring and onsite wells used for water level and water quality monitoring.

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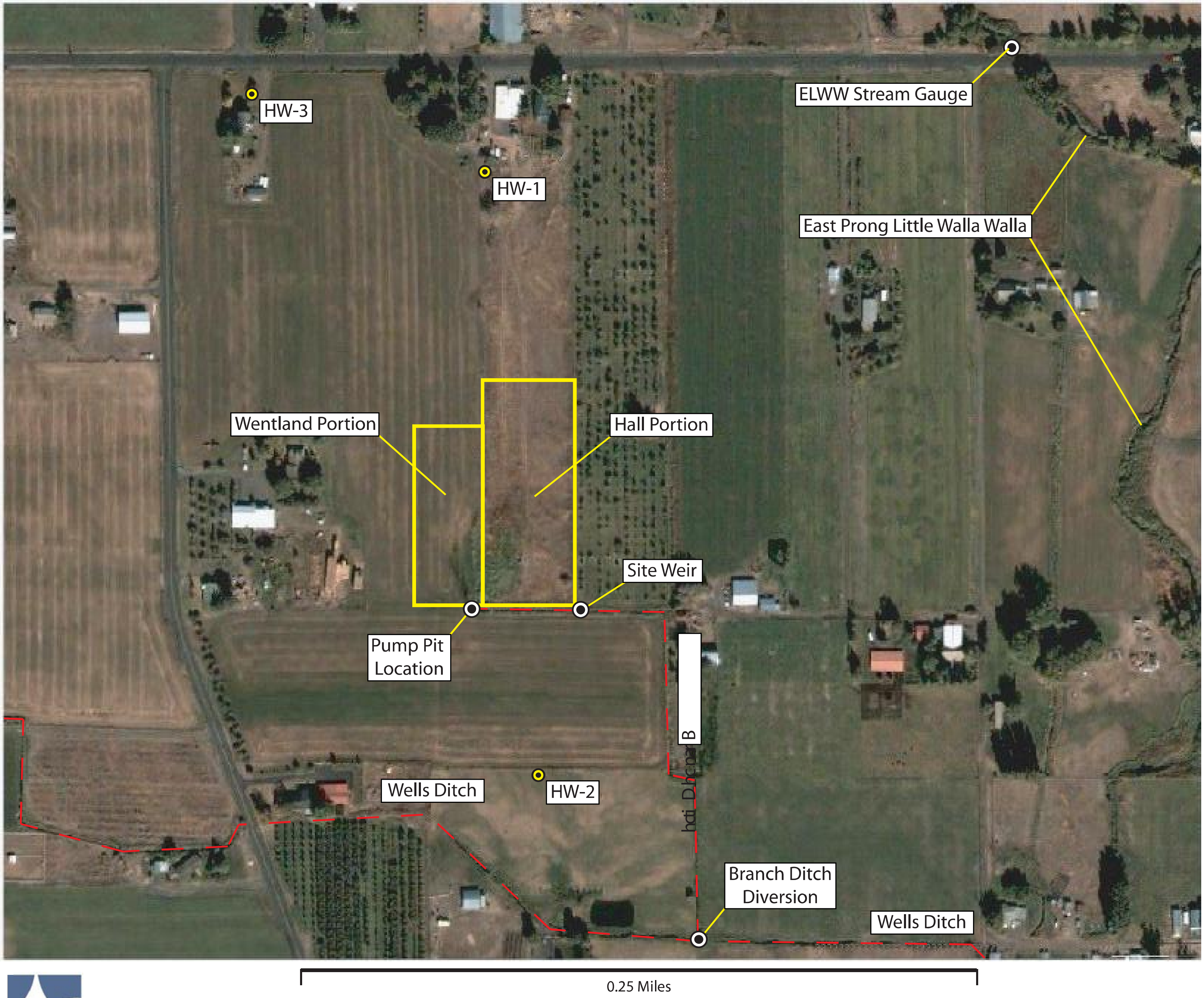

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Figure 3. Local setting, showing ditches, site boundaries, and location of water quality monitoring wells.

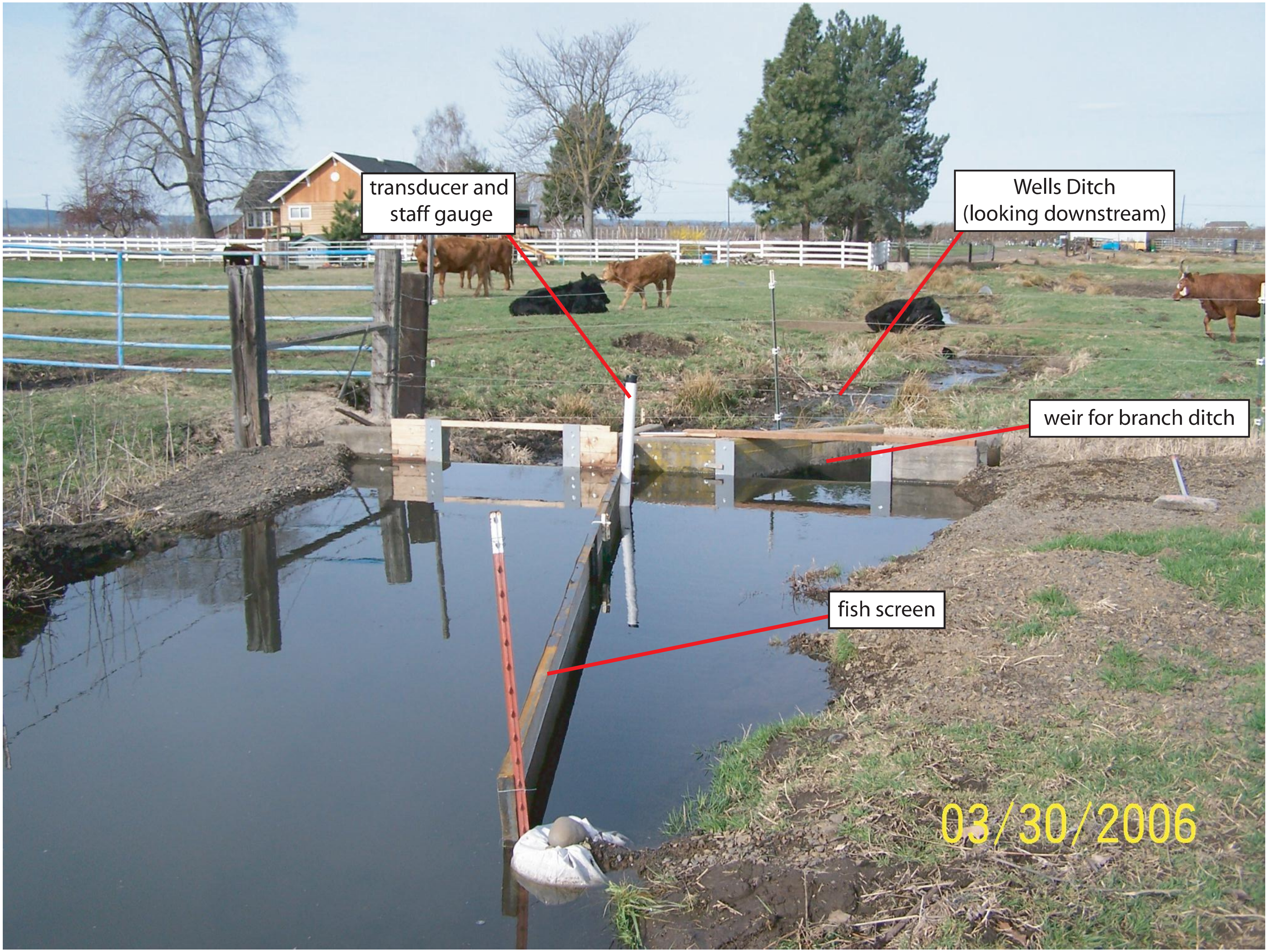

Figure 4. Photograph of the fish screen at the branch ditch diversion off Wells Ditch.
This configuration shows weir installed.

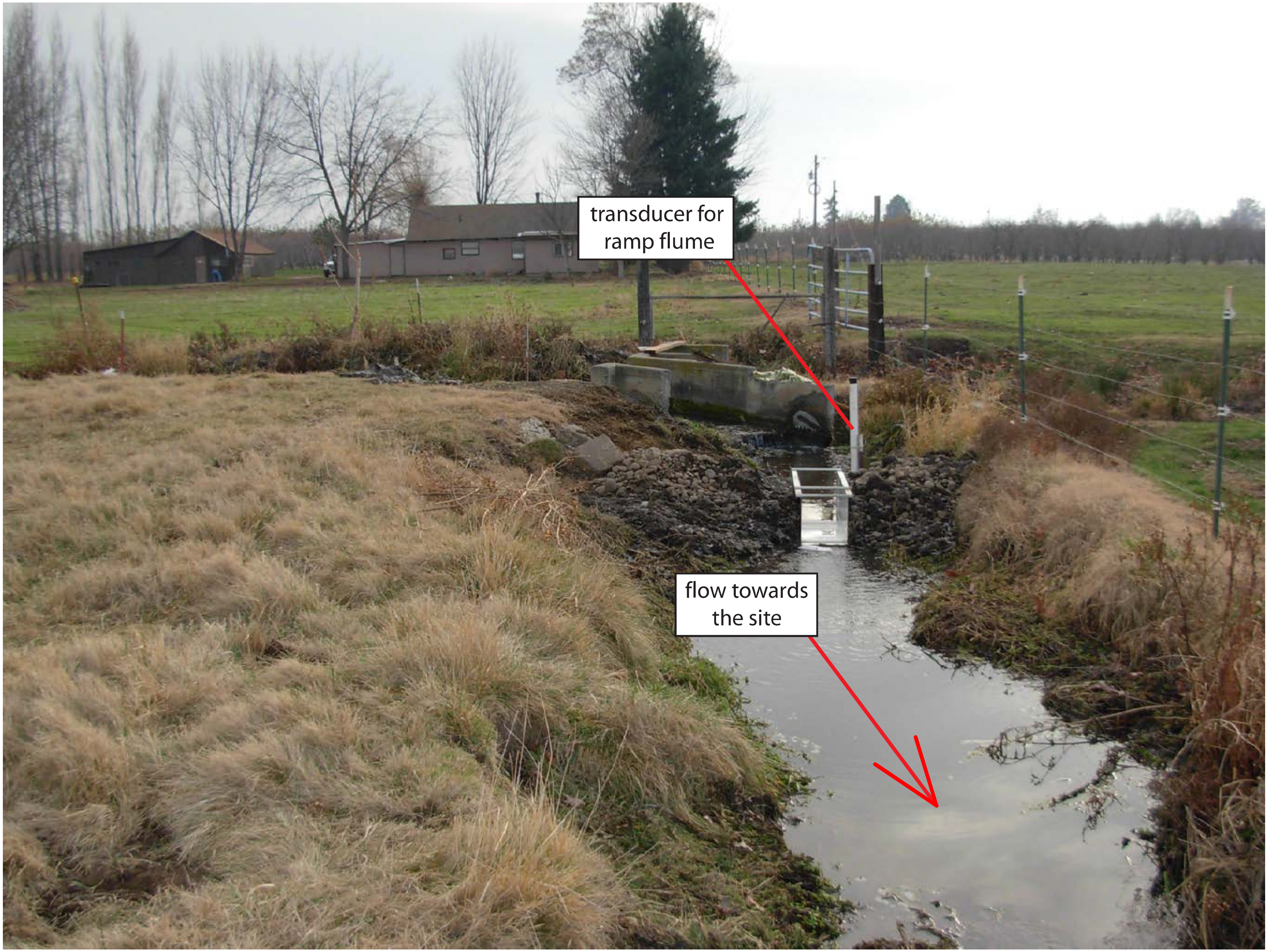

Figure 5. Photograph of branch ditch ramp flume just below the diversion off Wells Ditch.

Figure 6. Photograph of the on-site branch ditch measurement weir used during the 2006 recharge season. Notice the small drop across the weir.

Figure 7. Photograph of the on-site ramp flume that replaced the on-site weir for the 2006/2007 recharge season. View is towards the Site.

Figure 8. Photograph of the gated culvert used to control flow from the pump sump pit to the Hall portion of the Site.

Hall-Wentland Surface Water Monitoring

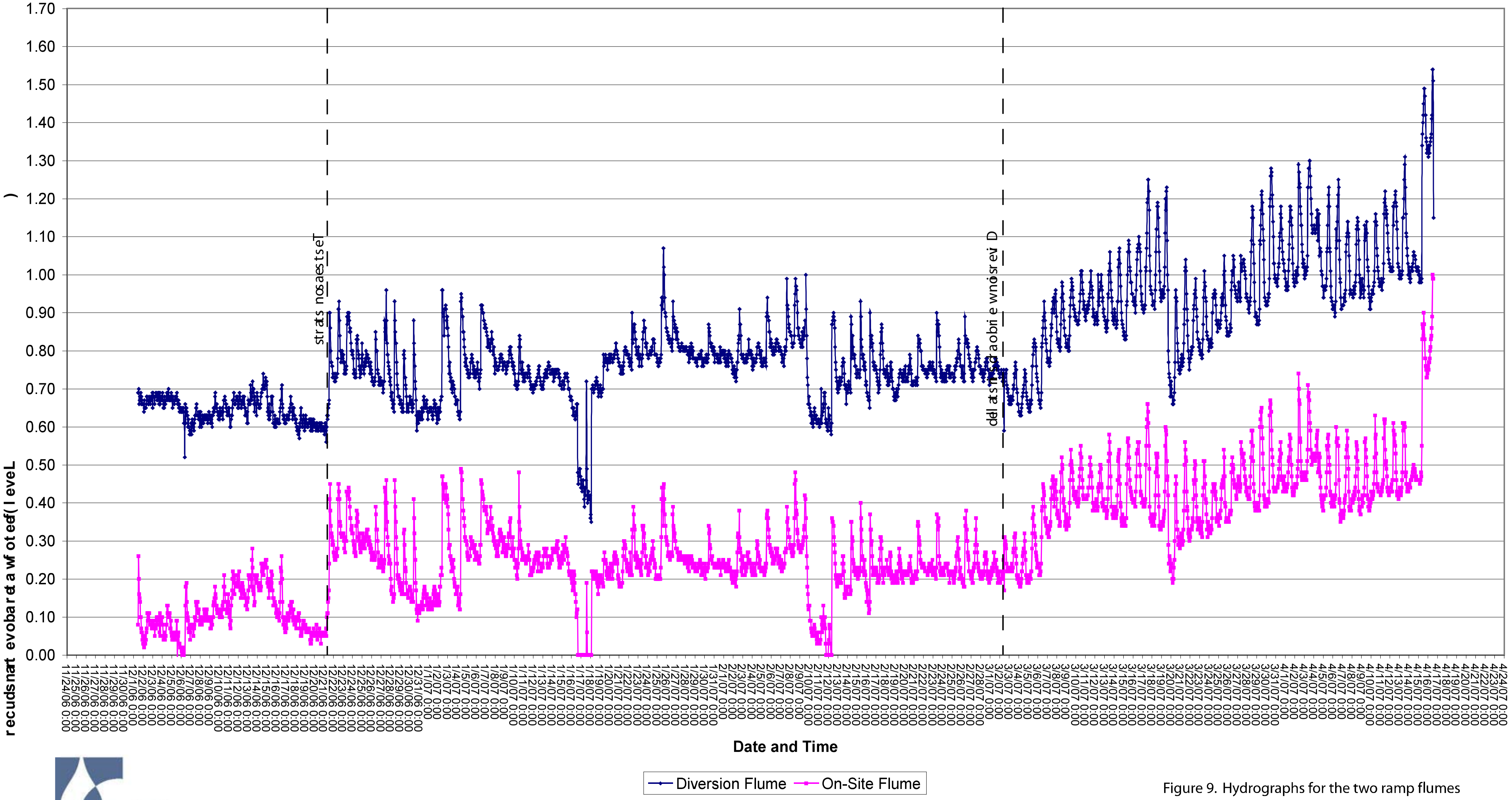

Figure 9. Hydrographs for the two ramp flumes showing water levels recorded during the 2006/2007 recharge season.

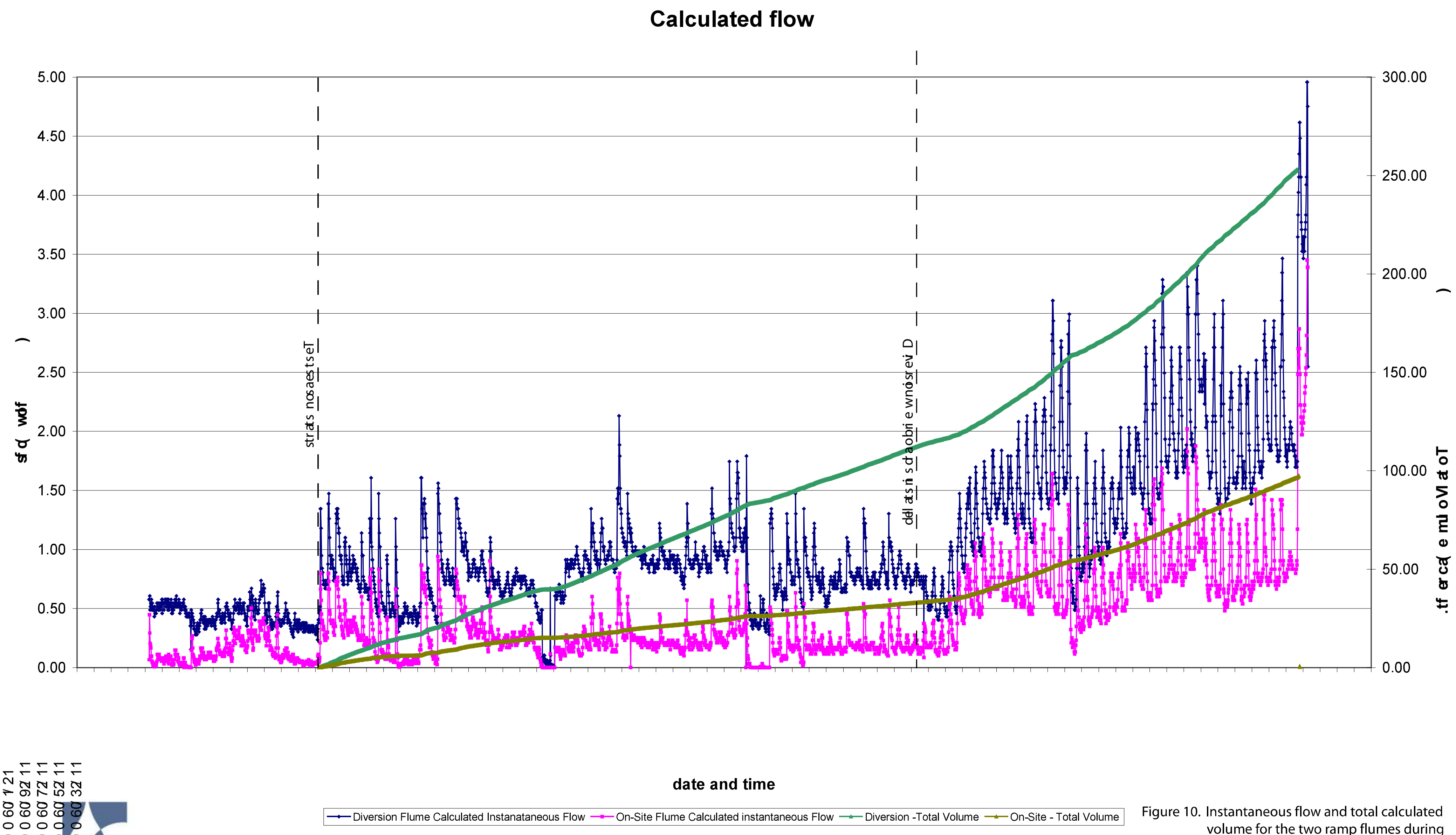

Figure 10. Instantaneous flow and total calculated volume for the two ramp flumes during the 2006/2007 recharge season.

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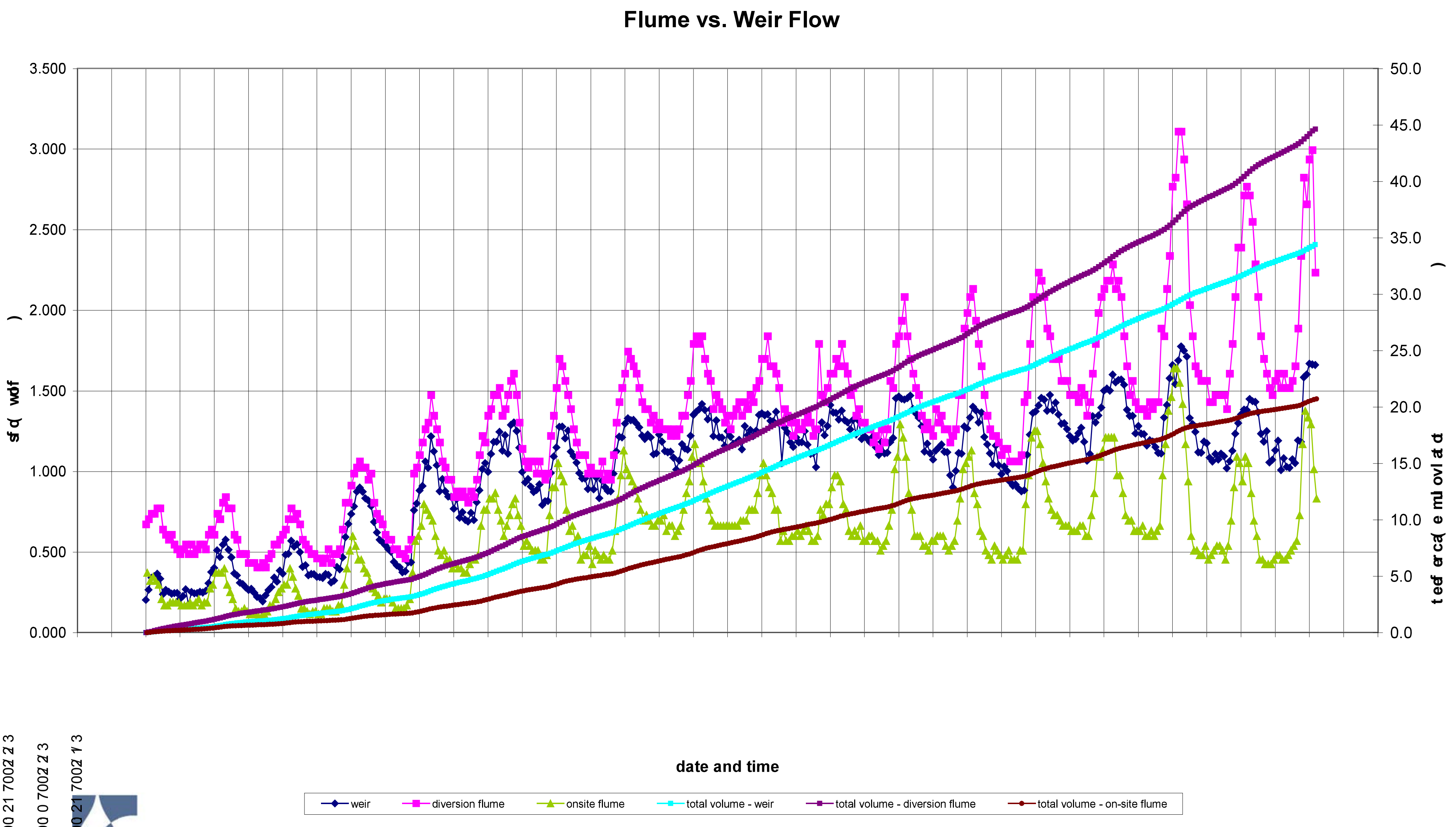

Figure 11. Comparison between calculated flows through both ramp flumes and the diversion weir.

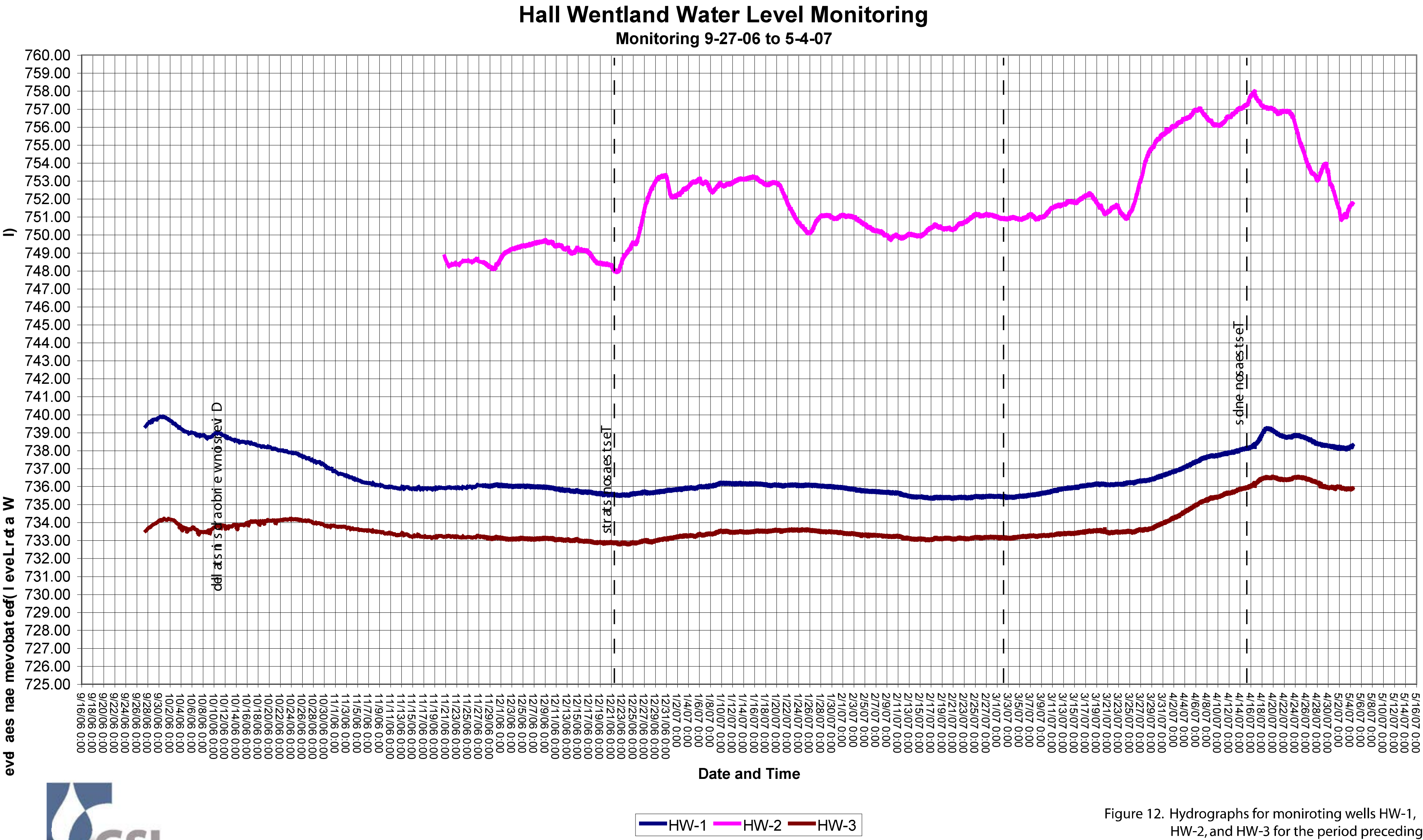

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Figure 12. Hydrographs for moniroting wells HW-1, HW-2, and HW-3 for the period preceding, during, and following the 2006/2007 recharge season.

Page Monitoring Well Levels

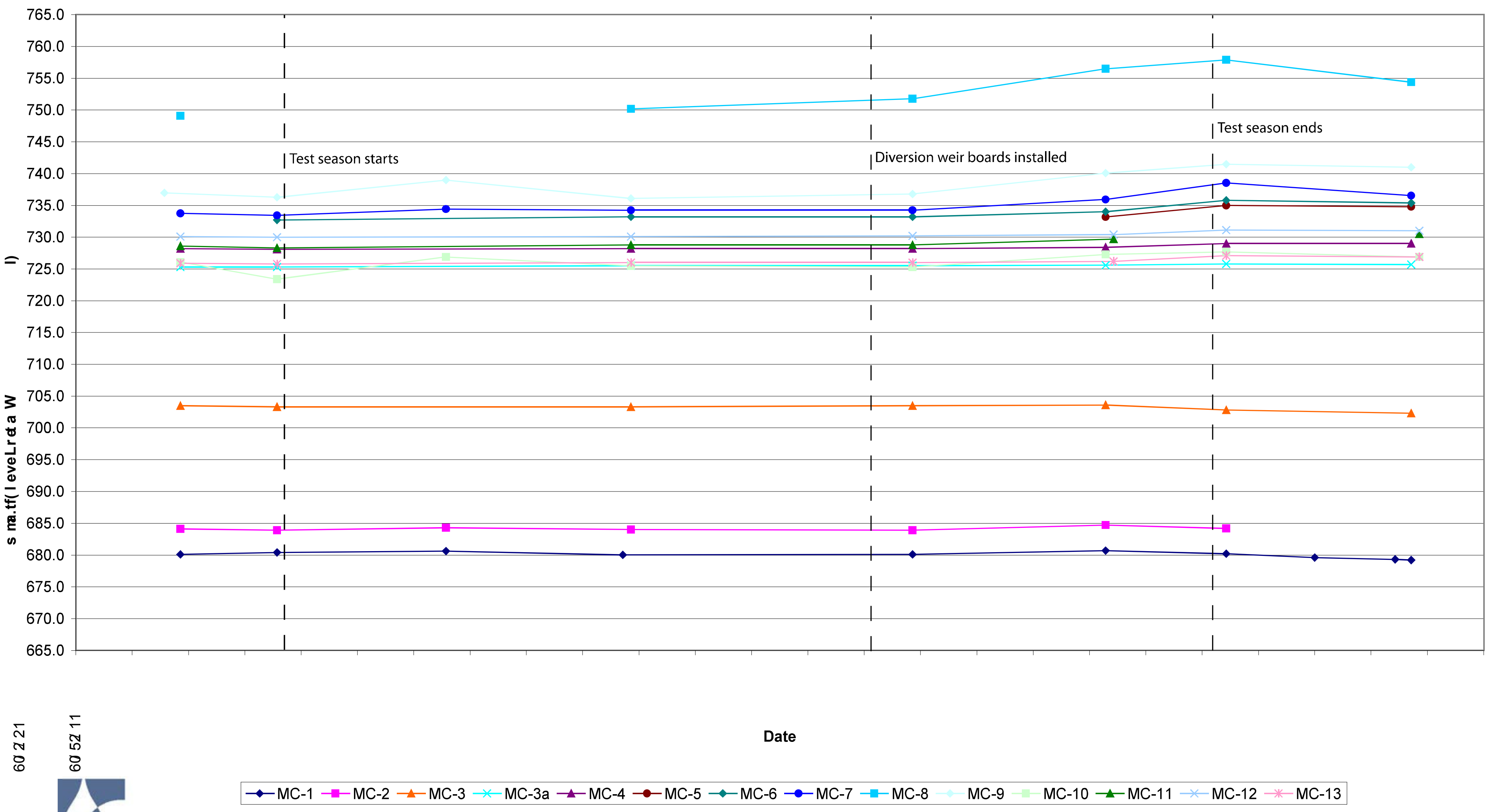

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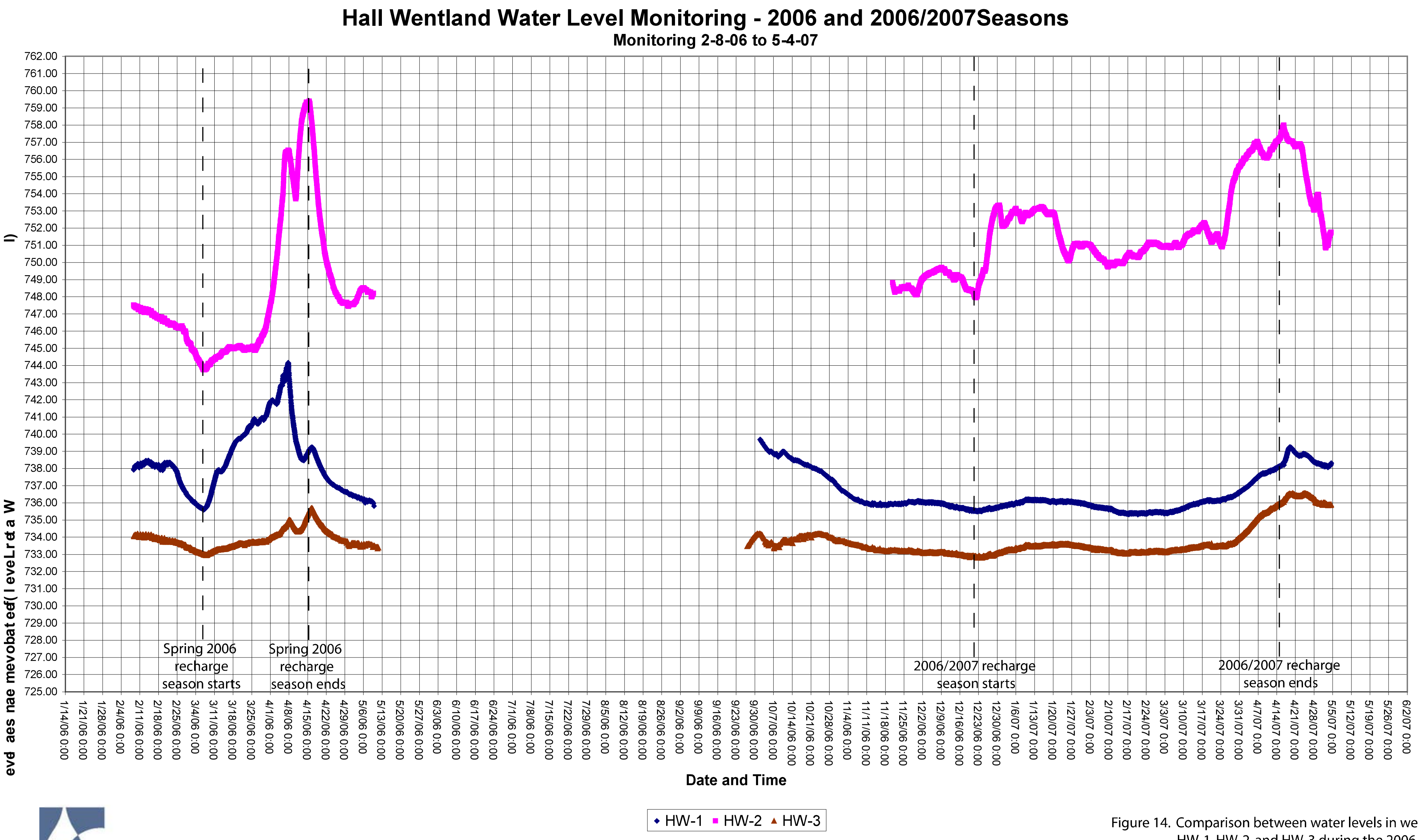
Figure 13. Hydrograph for the manually measured off-site wells for the period preceding, during, and following the 2006/2007 season.



Hall Wentland Water Level Monitoring - 2006 and 2006/2007Seasons

Monitoring 2-8-06 to 5-4-07

Figure 14. Comparison between water levels in wells HW-1, HW-2, and HW-3 during the 2006 and 2006/2007 recharge seasons.

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