Watershed Management Initiative – Phase II

2007-2009

Final Report

Shallow Aquifer Monitoring in the Walla Walla Basin

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In Cooperation with:
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Shallow Aquifer Monitoring Project

Introduction

Overview

Since 2001 the Walla Walla Basin Watershed Council (WWBWC) has been constructing a network of shallow (<250 feet) monitoring wells in the Walla Walla River Valley as part of its long-term efforts to understand the shallow (unconfined) alluvial aquifer. The primary objective of establishing this network is to provide needed data for informed water management in the bi-state basin and help water and fisheries' managers in the basin better understand surface-groundwater interactions as they relate to salmon recovery and groundwater supplies. The monitoring network is also used to track the implementation of artificial aquifer recharge projects currently in operation and provide data for modeling projects.

Well monitoring consists of measuring the static water level (SWL), or the depth to water, water temperature and specific conductivity. The well monitoring network is comprised of two types of monitoring wells: continuous monitoring wells, instrumented with pressure transducers that measure static water level once per hour, and non-continuous wells which are measured manually every three months. Temperature and conductivity measurements are taken quarterly at both types of monitoring wells.

The WWBWC worked with the Oregon Water Resource Department (OWRD) and Washington Department of Ecology (WDOE) to develop protocols for monitoring well location, measurement, and maintenance. Many of the original monitoring wells in the network were established or drilled by OWRD and WDOE. Other partners in the basin such as the Hudson Bay District Improvement Company (HBDIC), The Native Creek Society, and Gardena Farms Irrigation District #13 (GFID#13) have contributed to expanding the monitoring network through direct monitoring and landowner outreach. Many of the dedicated monitoring wells were also established as part of the basin's three shallow aquifer recharge projects. A summary of the established monitoring wells is found in Table 1.

In addition to monitoring well data collection, WWBWC also performed an extensive search for historical records and information about wells in the network. This historical and background information was compiled in 2008 as the Monitoring Well Notebook, which includes water rights, well logs, USGS and OWRD historical SWL data, well GPS coordinates, elevation, maps, and photos of the wells. The Monitoring Well Notebook serves as institutional memory of the monitoring
network and gives insight into historical uses and conditions of the wells and aquifer. It also allows WWBWC to easily share well information with the community and agencies.

Table 1. Summary of wells in the Walla Walla Basin Shallow Aquifer Monitoring Project as of 2009

<table>
<thead>
<tr>
<th>Monitoring Group</th>
<th>State</th>
<th>Number of Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWRD</td>
<td>Oregon</td>
<td>15</td>
</tr>
<tr>
<td>HBDIC Recharge Project</td>
<td>Oregon</td>
<td>4</td>
</tr>
<tr>
<td>Hall-Wentland Recharge Project</td>
<td>Oregon</td>
<td>3</td>
</tr>
<tr>
<td>WWBWC</td>
<td>Oregon</td>
<td>34</td>
</tr>
<tr>
<td>WDOE</td>
<td>Washington</td>
<td>20</td>
</tr>
<tr>
<td>Locher Road Recharge Project</td>
<td>Washington</td>
<td>3</td>
</tr>
<tr>
<td>WWBWC</td>
<td>Washington</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Well Network Monitoring Area

The Walla Walla Valley River Basin is a bi-state system located in northeastern Oregon and southeastern Washington State (Figure 1.) The river basin is approximately 1,760 square miles, with an underlying shallow alluvial aquifer of 200 square miles (Figure 2.) Ninety to ninety-five percent of water rights in the basin are served by the shallow alluvial aquifer, making it a highly important source of water for irrigated agricultural lands as well as domestic and municipal uses.
Figure 1. The bi-state Walla Walla River Basin in northeastern Oregon and southeastern Washington.

Figure 2. The Walla Walla River Basin with the underlying shallow alluvial aquifer.
In addition to supplying water for the basins wells, the shallow alluvial aquifer also feeds the numerous springs, streams, and rivers of the Walla Walla basin. The high connectivity between the aquifer and surface water bodies is important for enhancing base flows and cooling water temperatures for threatened salmonoid species in the river system (Malcolm, et al., 2009; Sophocleous, 2002).

Starting in 2003, the WWBWC and its partners have been building a community-based groundwater monitoring network. This network involves establishing observation wells that measure long-term water levels and provide geologic information. In 2001, only a dozen shallow aquifer wells were monitored in Oregon and Washington. These wells were inadequate to effectively monitor and manage the vast aquifer which supplies thousands of domestic and agricultural wells as well as contributing to base flows for the Walla Walla River. As of 2009, WWBWC and its state and local partners monitor over 100 wells (Figure 3-6.)

The well network includes both urban and rural wells in and around Milton-Freewater, OR, Umapine, OR, Walla Walla, WA, College Place, WA, Lowden, WA, and Touchet, WA (Figure 3.) The wells are owned by a variety of water users, including government agencies (state, county, and city), businesses, and universities within the basin. However, most monitoring wells are irrigation or old domestic wells owned by private land owners. All of the participating well owners do so voluntarily, aiding in the effort to understand and mitigate the decline of the aquifer: a critically important ecological resource to the communities located within the Walla Walla Basin.
Figure 3. Wells located in the Walla Walla Basin (2009) that are monitored as a part of the shallow aquifer monitoring program through multiple agencies including WDOE, ORWD, the City of Walla Walla, and the WWBWC.
Figure 4. Walla Walla City wells that are incorporated into the Shallow Aquifer Monitoring Program run by the WWBWC (2009).
Figure 5. Washington Department of Ecology wells that are incorporated into the Shallow Aquifer Monitoring Program run by the WWBWC (2009). Purple dots indicate WDOE dedicated monitoring wells. Yellow dots indicate Non-dedicated monitoring wells.
Figure 6. Walla Walla Basin Watershed Council wells that monitored as a part of the Shallow Aquifer Monitoring Program (2009).
Methods

Continuous wells
Continuous monitoring wells were instrumented with one of three different pressure transducers (Figure 7) that are suspended in the well below the water level, but not resting on the bottom of the well. The pressure transducers electronically determined and recorded the water pressure (PSI) and water temperature (either °F or °C) once every hour. Transducer data was downloaded quarterly. Manual SWL measurements were made quarterly to verify the pressure transducers’ accuracy.

Non-continuous wells
The shallow groundwater alluvial aquifer well network includes many non-continuous or quarterly monitoring wells. These wells were not instrumented with pressure transducers, but rather SWL data was collected quarterly. SWL was measured with an e-tape (Model 800, engineering tape, Waterline Envirotech Ltd, www.waterlineusa.com). SWL was measured to an established measurement point and then adjusted for top of grade.
Manual Sampling (Temperature and Conductivity)

Temperature and conductivity were measured at each well on a quarterly basis. Some wells did not have access points for collection of water for temperature and conductivity. Water samples were taken at times of transducer download or SWL measurement. Temperature and conductivity values were determined using a handheld conductivity meter (YSI 30, www.ysi.com). Pump condition (on or off) was also determined, if applicable, during each visit. A summary of continuous and non-continuous monitoring wells is shown in Table 2. Further details regarding transducer downloading, deployment, maintenance, and quarterly data collection can be found in Appendix A.

<table>
<thead>
<tr>
<th>Well Type</th>
<th>State</th>
<th>Number of Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>OR</td>
<td>31</td>
</tr>
<tr>
<td>Non-continuous w/ temperature and conductivity</td>
<td>OR</td>
<td>10</td>
</tr>
<tr>
<td>Non-continuous w/o temperature and conductivity</td>
<td>OR</td>
<td>15</td>
</tr>
<tr>
<td>Continuous</td>
<td>WA</td>
<td>25</td>
</tr>
<tr>
<td>Non-continuous w/ temperature and conductivity</td>
<td>WA</td>
<td>11</td>
</tr>
<tr>
<td>Non-continuous w/o temperature and conductivity</td>
<td>WA</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>94</td>
</tr>
</tbody>
</table>
Data Processing and Analysis
Most of the loggers used by WWBWC are absolute (non-vented) loggers, therefore continuous transducer data was compensated for atmospheric pressure using data from dedicated barometric transducers located at the WWBWC office in Milton-Freewater, OR. The data was converted from PSI to feet of water and subtracted from the estimated logger cable length. This gave a depth to water value for each data point from the transducer data. The estimated logger cable length was determined by taking the manual SWL measurement plus the water pressure (barometrically compensated) recorded by the transducer. The estimated logger cable length was determined every time the pressure transducer was changed or the cable length adjusted.

SWL data was plotted both continuously and year by year to show changes in the depth to water in a particular well. The graphs also show any mistakes in data entry, data analysis, or in logger data collection.
**Results**

**Historic Wells**

Seven of the wells monitored in the shallow aquifer are historic wells with data going back to 1949 for most of them and 1933 for one well. These wells can be used to see long term trends in the Walla Walla basin's shallow alluvial aquifer. All but one of these wells has shown a declining water level (Figures 9-15). One well, GW _17, was historically declining, but since the spring of 2005 has started to recover (Figure 10). Some of the monitored historic wells have gone dry in the recent past. GW_25 has been dry since 2004 (Figure 14) and GW_27 has been dry since 1995 (Figure 15).

![Historic Monitoring Wells (OWRD)](image)

*Figure 8. Historic wells that are monitored by the Walla Walla Basin Watershed Council and OWRD as part of the Shallow Aquifer Monitoring Program run by the WWBWC.*
Figure 9. Static water level measurements in feet below ground surface from manual e-tape measurements for the historic well GW_16 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 10. Static water level measurements in feet below ground surface from manual e-tape measurements and electronic pressure transducers for the historic well GW_17 located in the Walla Walla Basin's shallow alluvial aquifer. Logger data is from a pressure transducer suspended in the well. A) All data shown. B) Data for time period when a pressure transducer was in the well.
Figure 11. Static water level measurements in feet below ground surface from manual e-tape measurements for the historic well GW_18 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 12. Static water level measurements in feet below ground surface from manual e-tape measurements for the historic well GW_19 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 13. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for the historic well GW_20 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 14. Static water level measurements in feet below ground surface from manual e-tape measurements for the historic well GW_25 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 15. Static water level measurements in feet below ground surface from manual e-tape measurements for the historic well GW_27 located in the Walla Walla Basin’s shallow alluvial aquifer.
Recharge Monitoring Wells

The Walla Walla Basin Watershed Council and Hudson Bay Irrigation District Improvement Company operate an aquifer recharge site northwest of Milton-Freewater, OR. This aquifer recharge site has four monitoring wells associated with it and an array of wells in the vicinity that also provide vital data (Figure 16). Three of the four monitoring wells at the recharge site showed rising water levels (Figures 27-29), while one well showed the water level stable or slightly declining (Figures 30). Some of the wells to the southeast of the recharge site showed declining water levels (Figures 24 & 26) while several wells to the southwest and northwest showed rising water levels (Figures 18, 19, 21, 32, & 36).

Figure 16. Wells correlated with recharge events at the Hudson Bay Ditch Improvement Company Aquifer Recharge Site. Included wells were chosen by author based upon proximity to recharge site and hydrographs.
Figure 17. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_15 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 18. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_17 located in the Walla Walla Basin’s shallow alluvial aquifer. Logger data is from a pressure transducer suspended in the well. For new well data please see monitoring well GW_118 (in Appendix C), drilled ~35 feet to the north of the historic observation well, which was abandoned and filled in fall 2009. A) Historic Data shown. B) Data for time period when a pressure transducer was in the well.
Figure 19. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_31 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 20. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_33 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 21. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_34 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 22. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_35 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 23. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_37 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 24. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_39 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 25. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_40 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 26. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_41 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 27. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_45 located at the HBDIC Aquifer Recharge site in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 28. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_46 located at the HBDIC Aquifer Recharge site in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 29. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_47 located at the HBDIC Aquifer Recharge site in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 30. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_48 located at the HBDIC Aquifer Recharge site in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 31. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_58 located in the Walla Walla Basin’s shallow alluvial aquifer.
Figure 32. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_60 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 33. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_61 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 34. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_62 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 35. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_63 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 36. Static water level measurements in feet below ground surface from manual e-tape measurements for GW_64 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 37. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_65 located in the Walla Walla Basin’s shallow alluvial aquifer.
Individual Wells
Some individual wells in the basin show interesting trends. There are a number of wells that show a decline in water level (See Appendix C for graphs of all wells). GW_14 shows a declining water level over the last 7 seven years (Figure 38). However, there are some wells that show a rising water level. The water level in GW_110 has trended upward in the last three years (Figure 39).
Figure 38. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_14 located in the Walla Walla Basin's shallow alluvial aquifer.
Figure 39. Static water level measurements in feet below ground surface from manual e-tape measurements and pressure transducer data for GW_110 located in the Walla Walla Basin’s shallow alluvial aquifer.
**Discussion**

The well monitoring network in the Walla Walla Basin shallow alluvial aquifer is becoming larger every year now that the WWBWC manages it. This network is providing valuable information for water issues, both groundwater and surface, in the Walla Walla Basin.

**Continuous and Static Measurements**

More than half of the wells monitored by WWBWC are instrumented with pressure transducers (Table 2). Although this creates a disconnect in the data from a continuous well to a static well, static (non-continuous) wells provide an inexpensive way to monitor a larger part of the aquifer. Static wells allow WWBWC to have information for snap shots of the aquifer which can be used for long term aquifer monitoring. The SWL measurements of the entire well network show the water height of the aquifer spatially over the basin, allowing the WWBWC to track aquifer changes over time.

**Temperature and Conductivity**

Gathering temperature and conductivity data when monitoring wells allows the WWBWC to better understand the hydrologic connections between groundwater and surface water. By knowing the temperature and conductivity we are able to map where groundwater is increasing surface flows and where surface water is recharging the aquifer. Groundwater recharge via surface flows is very evident at a few locations in the basin, namely the HBDIC Aquifer Recharge and the ditches along the Little Walla Walla system. Groundwater-surface water interactions also help to stabilize flows in the river system, which is important for fish passage by allowing adequate flow and lowering water temperature.

**Historic Wells**

Most of the historic wells that the WWBWC monitors have declining water levels. This could be caused by a number of factors. An increasing number of wells and increasing water usage for domestic and agricultural uses could be withdrawing more water than is sustainable for the basin's aquifer. A relatively new change in water management for the basin could also have had an effect on the basin's aquifer. Since the 2001 Civil Penalty Settlement Agreement (Settlement Agreement) between U.S. Fish and Wildlife Service and the three irrigation districts in the Walla Walla basin (Walla Walla River Irrigation District, Hudson Bay Ditch Improvement Co, Gardena Farms Irrigation District #13), 18 cfs has remained in the Walla Walla River during summer months, then in following years the amount was raised to 25 cfs. During the previous ~100 years, the Walla Walla River ran dry during the summer because all of the water was diverted for irrigation uses. This water flowed through the vast array of irrigation ditches in the basin providing groundwater recharge as surface water was lost along the ditches. Since 2001 and the Settlement Agreement, less water has been flowing through the Walla Walla/Gardena/Hudson Bay systems during the
summer causing a reduced amount of groundwater recharge in the ditch system. However, since the decline in the aquifer seems to have started well before the 2001 Settlement Agreement, the reduced recharged from surface flows in the irrigation system does not explain everything. Also, increased efficiency for irrigation districts (piping projects, etc) has reduced the amount of groundwater recharge further from irrigation ditches and canals. Also, many irrigators have started using wells more than they had in the past: supplemental wells, and newly drilled wells.

One of the historic wells, GW_17, has historically shown a decreasing water level; however, over the last 5 years it has started to recover (Figure 18). This recovery correlates with the start of the Hudson Bay Aquifer Recharge site about 1 kilometer to the southeast of the well. This may demonstrate a possible strategy for aquifer stabilization or recovery in the Walla Walla Basin. Creating an array of recharge sites throughout the basin may help to stop or even recover the declining shallow aquifer.

Recharge Monitoring Wells
The HBDIC Aquifer Recharge site has now operated for 5 seasons. The site appears to be recharging a small portion of the shallow aquifer. Many of the wells to the Northwest and Southwest have shown rising water levels. However, wells to the East do not show the same trends. One of the most important wells providing data for the recharge site is GW_17/GW_118. This well is a historic well with data going back to the 1940s. Based upon this data we can see that it has had a declining water level. The water level dropped enough to make the well go dry sporadically during the last decade. However, since the start of the Aquifer Recharge project, this well has started to recover. Since the Aquifer Recharge site was started (Spring 2004), the well has only been dry during summer months (July thru September). Other wells such as GW_31, GW_34, and GW_60 have shown recovering water levels. Unfortunately, most of the wells are declining. It appears as though the HBDIC Aquifer Recharge site only has a limited impact. Specifically it appears as though the recharge water is moving in a north westerly direction away from the recharge site. This will be investigated more with a forthcoming tracer study to understand the speed and direction of the recharge water. From the data it appears like the HBDIC Aquifer Recharge site is only able to affect a limited number of wells. However, this method might be useful in supplementing declining water levels in the shallow aquifer if used in higher numbers and strategically located throughout the basin.

Individual Wells
Some of the wells in the shallow aquifer monitoring system give us an insight into how the shallow alluvial aquifer works. GW_14 is a good example. This well has shown declining water levels over the past 8 years. This pattern was not seen until the Settlement Agreement. This well might not be receiving as much recharge from the irrigation system because a smaller quantity of water is being diverted into the ditch systems. GW_31 has shown rising water levels over the last seven years. The reason for this is not known for sure. It could be due to the HBDIC Aquifer Recharge site to the

48
Southeast or to some other source. GW_34 has also shown rising water levels over the past four years. This may be due to an increased flow in Goodman Spring. The increased flow in Goodman Spring could be due to recharge activities at the HBDIC site. This site has had plenty of recharge opportunities as the spring/canal often overflows its banks and floods the neighboring pasture. The well is right next to the spring/canal and the pasture so it would benefit from recharge from both sites.

**Summary**

Approximately 100 wells were monitored in the Walla Walla Basin shallow alluvial aquifer in 2009, up from only a dozen in 2001. In 2009, 15 new dedicated monitoring wells were established in the Walla Walla Valley. Six were drilled in Oregon and nine were drilled in Washington. These new monitoring wells will help enhance the spatial coverage and the potential for understanding and mitigating aquifer decline and assist in general water management in the bi-state basin.

The importance and usefulness of the Shallow Aquifer Monitoring Project is clear; it is vital to the current and future understanding of groundwater resources, aquifer decline and recharge, surface-groundwater interactions, and base flow in the Walla Walla River. Using the well network WWBWC and partners in the basin have quantitatively illuminated the decline of the shallow aquifer and shown the significant influence and response by the system to aquifer recharge projects. Furthermore, the well monitoring network data is being used to inform decisions on current and future aquifer recharge projects.

This data will also be used in the basin-wide WWBWC/OSU modeling projects which will provide water professionals and communities with a comprehensive tool to manage water in the Walla Walla River Valley in the years to come.

Developing a wide spread shallow aquifer monitoring system through dedicated and non-dedicated wells has been a major accomplishment of this project. Prior to 2001, the bi-state Walla Walla basin only had about a dozen observation wells (Figure 41). As of October 2009, there are more than 25 dedicated monitoring wells in the bi-state well network (Figure 42). There has also been a widespread growth in the grass-roots based non-dedicated wells that are being monitored. More than 20 new non-dedicated monitoring wells have been established with the cooperation of volunteer landowners throughout the basin’s shallow aquifer.

Continuing and expanding the Well Network is important in the future. Establishing more wells, especially to the east of the Walla Walla River and on the Northern and Western edges of the shallow aquifer will be important for completing the picture of how to properly manage the aquifer. It would also be helpful to expand the Well Network from the shallow aquifer down to the basalt.
aquifer with the addition of basalt wells. Monitoring groundwater is critical to measure the impact of a variety of other projects including aquifer recharge and piping ditches/canals and to further understand the interactions between ground and surface water in the Walla Walla basin.

Figure 40. Observation wells in the Walla Walla Basin’s Shallow Aquifer prior to 2001.
Figure 41. Dedicated (purple) and non-dedicated (yellow) wells in the Walla Walla Basin's shallow aquifer as of October 2009. Non-dedicated monitoring wells were established in cooperation with landowners who voluntarily allowed their wells to be monitored.

Finally, the Shallow Aquifer Monitoring Project is successful not only in compiling aquifer data/analysis and expanding the well network, but also in community outreach because it depends on voluntary land owner participation and local support. Many citizens have contributed vital information to the project and also have become more aware of the declining aquifer and other water issues in the Walla Walla Basin.
APPENDIX A

WWBWC Well Monitoring Field Instructions

1.) Before you leave the office
   a. Laptop should be charged
   b. Check battery replacement and logger download schedule
   c. Review “Equipment Needed” (see #2 below)
   d. Review WellNet notebook pages if needed
   e. Review "Procedures" (see #3 below)
   f. Sign out in main office
   g. RECORD your start miles, start time, and the project you will bill

2.) Equipment Needed
   a. General
      i. WELLS KEYS (usually in laptop case)
      ii. Cell phone, GPS, Camera and extra AA batteries
      iii. Flashlight, headlamp and extra batteries
      iv. Hammer, pipe wrench, flathead screw driver, big crescent wrench, blue
cable snips
      v. Socket set
   b. Information and Paperwork
      i. Tatum/clipboard
      ii. Well Field Instructions and Procedures
         1. See: Groundwater Field Instructions and Procedures folder in
            WWBWC WellNet
      iii. Field mmt data sheets and field notebook
         1. Field mmt data sheets saved on laptop on desktop and in “My
            Documents” in “MMT data sheets” folder.
         2. Record data onto hard copy of data sheet or on field laptop
      iv. Blue WellNet notebooks for reference. They contain maps, addresses,
          photos, coordinates, well owner names, etc.
      v. “Well Info” pages/spreadsheet with details for mmt at each well
         1. Also in WellNet notebooks or
      vi. Business cards and pamphlets about WWBWC
   c. Downloading/Logger Equipment
      i. CHARGED Field laptop
      ii. Cables for MiniTroll, LevelTroll, and MicroDiver loggers
      iii. Battery removal tool for MiniTrolls
2.) Equipment Needed (continued…)
   d. Logger Maintenance
      i. U-bolts and copper crimps
      ii. Extra AA lithium batteries
   e. Static and Grab Samples Equipment
      i. E-tape and extra 9V batteries
      ii. Bailers
      iii. Graduated cylinder
      iv. Conductivity/EC meter (w/ thermometer)
   f. Other
      i. Sounding tape
      ii. Mmt tape (meter tape)

3.) Procedures
   a. RECORD THE DATE, TIME, SITE NAME, AND EQUIPMENT INFORMATION
   b. Static mmts
      i. Review well info page for the point at which you should take the static measurement (“mmt_pt”)
      ii. Turn E-tape on to “Test” and make sure it sounds
         1. If it doesn’t buzz, adjust the “Sensitivity” knob
         2. If it still doesn’t buzz, change the batteries
      iii. Turn E-tape to “Buzz”
      iv. Lower E-tape into well slowly, making sure the tape doesn’t come off the sides of the reel
      v. When the tape buzzes, pull the tape up and down until you can determine the exact level.
      vi. TURN THE ETAPE OFF
      vii. RECORD the static level and whether the pump is on or off
   c. Grab Samples
      i. Unlock the bailer and lower it into the well-you may hit bottom or hear it fill
         1. Lower bailer into well ONLY if there is ample space for it.
         2. Do not lower it into wells with vent hole access only
      ii. Reel the bailer back slowly, trying to keep it from banging against the sides of the well
      iii. Empty the bailer contents into the graduated cylinder
      iv. Put the EC/Cond probe into the graduated cylinder
         1. Push the on/off button
         2. Wait for reading to stabilize; RECORD
         3. The reading in degrees C and μs for conductivity
d. Deploying Loggers
   i. Sound well and RECORD or look up well log to find out what well depth is
   ii. Take a static depth and RECORD
   iii. Measure and cut aviation cable to hang logger
       1. Order cable thru acct at Widner Electric/Napa: 938-55118
       2. Cable should be 10-20 feet below the static level, but should not rest on the bottom of the well.
       3. Remember to account for the length of the logger and the cable needed to attach the cable at the surface
       4. RECORD the length of the cable and the logger number
   iv. Attach the cable to the logger using two copper crimps AND a 1/16” U-bolt
       1. Order both thru acct at PGG: 938-5551
       2. Crimp the copper crimps with fencing tool or cable snips
       3. Tighten U-bolt with the socket
   v. Attach the cable at the surface with copper crimps
   vi. Once the logger is started and attached lower it slowly into the well
   vii. Measure the top of ground adjustment (the distance between where you measured the static and the ground) and RECORD
   viii. Take a photo of the well and GPS the coordinates (UTMs) and elevation (ft)

e. Downloading Loggers
   i. Record the time, site name, and logger number
   ii. Follow steps outlined in the procedures for particular brand of logger, saving all downloaded files on the laptop
   iii. Record the status of the hardware and battery
   iv. SHUT DOWN COMPUTER (battery doesn’t last with it on)

f. Office transfer of data
   i. All static mmts, grab samples, download information, TOGs, coordinates, etc go in the “Statics, Grabsamples, Well Info” folder in WWBWC Wells in WellNet
   ii. Update the downloading schedule on the white boards and in the excel worksheet (see above)
   iii. Order needed equipment well in advance
   iv. Report any problems with well, data, or safety to Troy or Bob

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**In-Situ Inc. Level Troll 100 & 300 Download Procedure**

1.) Check download schedule, battery replacement schedules, and consult list of thing to take in field before you leave
2.) Connect download cables to the computer then connect levelTROLL
3.) Click on “Win-Situ 5.0” icon on desktop
4.) Click the connect icon on the bottom right hand part of screen (two yellow cables coming together)
   a. You may be asked to synchronize time. Before doing so, RECORD the logger’s time (difference in time.)
   b. If it does not connect make sure it is using COM5 and all the cables are connected properly, if that doesn’t work close Win-Situ and try again.
5.) Click on the Logging tab (clipboard and pencil icon) at the top
6.) To download
   a. Right click on the most recent test, RECORD test status if not running
      i. Running man icon means test is still running
      ii. Green checkmark means the test was downloaded and stopped
      iii. Red X means the test stopped due to an error
   b. Click “download”
   c. When complete, view the data
   d. Click “file” at top of page and click “Export to CSV”
   e. The file is automatically saved in “My Documents” on laptop
      i. Go to “My Documents”
      ii. Click on the WinSitu folder
      iii. Click on the particular site/well folder you are downloading
      iv. Find the most recent download and copy it
      v. Paste the download into a folder in “My Docs” named for the current date.
7.) Battery and Hardware Check
   a. In the Win-Situ 5.0 window, click the hammer and cog icon at top
      i. Click “Diagnostics”
      ii. RECORD the used battery, used memory, and available memory
      iii. If battery sufficient (compare to available battery), stop and restart.
   b. RECORD the status of the U-bolt, crimpers, cable, and attachment
8.) To Stop
   a. Click the clipboard and pencil icon at top
   b. Right click the log/test you just downloaded, click stop
   c. RECORD stop time
9.) To start a log at a NEW site, follow below steps. To add a new log to existing site, skip to step 9.
   a. Click the “Home” tab at top left of screen
   b. Click the “Site” button (blue and green planet icon)
   c. Click the “New” button (page icon with sunburst)
   d. Enter details for name of site: GW##_PlaceName
      i. Example: GW122_LeeHome
   e. Click “Save”
   f. Follow all steps to add a new log (step 9 below)
10.) Restarting-To “restart” you must add a new log/test
   a. Click New button (page icon with sunburst) at bottom left of “Logging” (clipboard icon) window
   b. Select the correct (current) site name. If this is not a new deployment, the site name should be an option in dropdown menu
   c. Give the new test/log a name with current date: gh_GW##_m-d-y initials.
      i. Example: gh_GW40_10-8-8np
      ii. Click the arrow to continue
   d. Parameters-select C and ftH20 for temp and pressure; click arrow to continue
   e. Logging method-Select “linear;” click arrow to continue
f. Log interval- select 1 hour; click arrow to continue

g. Start/Stop Condition-select “Manual Start;” click arrow to continue

h. Final Screen- check that summary of log setup is correct
   i. If correct, click the checkmark. If not, click the back button to fix

i. In the “Logging” window, right click the new test and click “Start”
   i. RECORD start time

11.) CHECK and deploy/redeploy

   a. CHECK THAT LOGGER IS COLLECTING DATA!
      i. Follow steps 6a-c above

   b. If logger logged temp and pressure measurements, continue to step 11

12.) Close and disconnect

   a. Close Win-Situ 5.0

   b. Disconnect logger from computer and cable

   c. Redeploy logger IF it is running and has enough battery and good U-bolt

   d. TURN OFF COMPUTER

13.) When you return to the office

   a. Put the downloaded data in “My Documents” on the laptop for each day in the
      appropriate hydroshare folder.

   b. When all downloads from a particular folder have been put into “WellNet” or
      “GAUGESPRIMARY,” drag and drop the folder/date on the laptop into the year
      folder.
      i. For example: all folders with 2008 dates whose laptop downloads have been
         copied into hydroshare were finally placed into the “2008 Downloads”
         folder in the laptop’s “My Documents”
Microdivers & Diver Office Software Download Procedure

NEW LOGGER SETUP

NAME ➔ DEFINE SETTINGS ➔ START ➔ CONFIRM START ➔ CLOSE PROGRAM

1.) Open “Diver Office” from the laptop desktop.
2.) Under the “WA Historic Wells” (or other project name) click the logger’s current name. If it has never been used before, it will say “sws”
3.) Fill in the following fields:
   a. Location Type: Regular
   b. Cable Length: Measure (in 10ths of ft) the length of the cable from its attachment point at the ground surface to where it attaches to logger
   c. Top of Casing: Enter the top of ground adjustment. Measure (in 10ths of ft) from the point at which the cable is attached to well to the ground level. This number will be negative if the cable is attached above the ground level and positive if it is attached down in the well below ground level.
   d. Do not select the “Barometer” option unless one has been established
4.) Click “Diver” icon; “Diver” window will appear
5.) Click “Settings” icon in “Diver” window
   a. Logger status should be “STOPPED”
      i. If not, click “Stop” and click “Yes” to continue IF the logger data has already been downloaded and exported
   b. Fill in settings fields as follows:
      i. Name: GW# (fill in # as appropriate)
      ii. Sampling Method: Fixed
      iii. Sampling Interval: 01 Hour
      iv. Pressure Unit: ftH20
      v. Temperature Unit: Celsius
   c. Start/Restart the Diver (see attached instructions)
   d. RECORD the logger serial number, new name, and start/restart date and time
   e. TURN OFF COMPUTER to save battery

CHANGING THE NAME, SETTINGS OF A LOGGER

CONNECT TO DIVER ➔ DOWNLOAD & EXPORT ➔ STOP & RECORD ➔ CHANGE SETTINGS ➔ PROGRAM & RECORD ➔ END

1.) Open “Diver Office” from the laptop desktop.
2.) Click “Diver” icon at top of page
3.) Download and export data (see attached instructions) if need be
4.) Stop logger and RECORD stop date and time
5.) Click “Settings” icon and change settings
6.) Click “Program” to save the settings to the MicroDiver. RECORD settings changes in notebook.

DOWNLOADING MMTS FROM MICRODIVER

CHECK & RECORD ➔ DOWNLOAD ➔ EXPORT ➔ STOP & RECORD

1.) Connect Diver cradle to USB, place Diver in cradle, and cover cradle with hat or something that will keep light out (Diver data read optically; doesn’t work in sun)
2.) Open “Diver Office” from the laptop desktop.
3.) Click the “Diver” icon at top to connect to the logger; new window will appear
4.) Make sure the status of the logger is “STARTED,” shown in green under row of icons. This indicates Diver has been logging data.
5.) RECORD logger serial number in notebook
6.) RECORD number of samples taken and battery power left (%)
7.) Check to make sure the following are correct. If any field is incorrect, RECORD
   a. Sampling Method: Fixed
   b. Sampling Interval: 01 Hour
   c. Pressure Unit: ftH20
   d. Temperature Unit: Celsius
8.) Click the “Data” icon at the top of Diver window to download
9.) Main (old) window will pop up with a graph of pressure and temp data.
10.) Click “Data” icon

11.) Scroll down list of downloaded data and click box to left of your current download (check the “Download Date & Time” field)
12.) Click “Export” icon in this page (“Data”)
13.) Click folder icon to right and browse for location to export data
   a. Click “My Documents”
   b. Click (once) the folder for the current date, or click “Make New Folder” if one doesn’t exist.
   c. Click “OK;” you will be sent back to the “Exported Files” window.
   d. Make sure the “Uncompensated” option is selected in the “Export Files” window.
   e. Click “OK;” a message will appear that says files have been exported successfully
   f. Close “Data” window
14.) Click “Diver” icon
15.) Click “Stop”
   a. IF you have downloaded and exported the data, click “Yes” to continue.
b. RECORD the date and time you stopped the logger

RESTARTING LOGGER AFTER DOWNLOAD AND EXPORT

CHECK & RECORD→RESTART→CONFIRM RESTART & RECORD

→CLOSE PROGRAM & REPLACE DIVER

1.) Open “Diver” window (it should already be open after download)
2.) Click “Settings” in Diver window
   a. CHECK that the following field are correct:
      i. Micro-Diver: STOPPED
      ii. Battery Left: there should be sufficient battery
      iii. Location: correct location in the form of GW#
      iv. Sampling Method and interval: fixed, 01 Hour
      v. Pressure and Temp units: ftH20, Celsius
   b. If any fields are incorrect, change them and then click “Program” icon
3.) Click “Start” icon
   a. Select “Immediate Start” and “Sync Clock” in “Start Diver” window
   b. Click “Start”

4.) To check if Diver is logging data, Click “Data” in Diver window
   a. The main window will appear. Look to make sure one pressure and one temperature reading have been logged
   b. RECORD the date and time the logger was restarted. This can be found by widening the “Date & Time” column in the main window.
5.) IF the Diver is logging, close the program, disconnect logger, TURN OFF COMPUTER, and put back in the well.
In-Situ Minitroll Download and Deployment Procedures

1.) Check download schedule, battery replacement schedules, and consult list of things to take in the field before you leave
2.) Connect download cables to the computer then connect miniTROLL
3.) Click on “Win-Situ 4.0” icon on desktop
4.) Double Click on “COM4-19200”
   a. miniTROLL serial # will appear under “On-Line(1):COM4-19200”
   b. if it doesn’t, connect the cable in the other USB port
5.) Click logger symbol miniTROLL serial # to show tests and info
6.) Under “Tests” info about each test on logger will appear with specific icons:
   a. Red runner icon indicates a test in progress
   b. Red X icon indicates test stopped due to logger or battery failure
   c. Green checkmark icon indicates a completed and stopped test
7.) Download, export, and save logger data (if need be) before you restart. If you are deploying logger for the first time, skip steps 7 and 8.
   a. Download
      i. Click on the active test: it has most recent date
      ii. Click “Extract”
      iii. Click “View”
   b. Export and Save
      i. With the current test’s bin file highlighted on the left, click “File” and “Export to Excel”
      ii. Excel window will appear. Click “Save As”
      iii. Save file in “My Document” in a file with the current date. Create one if one does not exist using the format “9-1-08” for Sept. 1, 2008
      iv. Name the download using the following format:
          gh_SITE_startdate_enddate initials
          1. Well example: gh_GW14_6-20-08_9-23-08np
          2. Surface example: gh_LWJH_6-20-08_9-23-08wl
8.) You can choose to stop the current test after you download or not. If the logger has >6 months of data points on one test, stop the test and start a new one
   a. To redeploy logger without stopping test
      i. Click on the current test and make sure it still says “RUNNING”
      ii. Check measurement interval is 1 hr and battery capacity is 100%
      iii. Close Win-Situ4, disconnect logger, and redeploy
   b. To stop test
      i. Click on current, running test
      ii. IF you have downloaded, exported, and saved test, click “Stop”
      iii. RECORD date and time test stopped
9.) To deploy logger or restart logger on a new test
   a. In order to add a test, you may have to delete an old test. Right click the oldest test and click “Delete”
   b. Click “Tests”
   c. Click “Add”
   d. Fill in name and parameter, click “Next”
      i. Test Name: ghSITE_startdate. Example: gh_GW14_9-23-8
      ii. Parameter: Select temperature and pressure

60
e. Test Wizard: select "Linear" and click "Next"
f. Measurement Interval: select 0day, 1hr, 0min, 0sec, 0hund; click "Next"
g. Start Mode: select "Manual Start," click "Finish"
h. **Click “Start” and then “OK”**
   i. RECORD start time
   ii. Click "Extract" and "View" to confirm test is running
      i. When main window appears, there should be one measurement
10.) RECORD battery capacity
   a. If battery is <100%, do not deploy
   b. Review battery replacement schedule spreadsheet in office.
      
      Logger lithium AA batteries must be replaced every nine months regardless of the battery capacity.

11.) If the test is running click on “Online(1):COM4-19200”
   a. Click "Drop" or just close the program
   b. Disconnect cable and logger, shut down computer, deploy logger
   c. TURN OFF COMPUTER

12.) When you return to the office, put the downloaded data on the laptop for each day in the appropriate hydroshare folder. When all downloads from a particular folder have been put into “WellNet” or “GAUGESPRIMARY,” drag and drop the folder/date on the laptop into the year folder.
   a. For example: all folders with 2008 dates whose laptop downloads have been copied into hydroshare were finally placed into the “2008 Downloads” folder in the laptop’s “My Documents”
# APPENDIX B

**GPS Information**

Below is a table of GPS information for each well monitored by the WWBWC.

<table>
<thead>
<tr>
<th>Well ID</th>
<th>Easting</th>
<th>Northing</th>
<th>Well Elevation in Feet</th>
<th>Well Elevation in Meters</th>
<th>Horizontal Confidence in Meters</th>
<th>Vertical Confidence in Meters</th>
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APPENDIX C

Static Water Level Graphs
Below are static water level graphs for all of the wells that the WWBWC monitors.
Monitoring Well GW_27

Well has been dry since the mid 1990s
Monitoring Well GW_57

Water Level (feet bgs)

Date

Walla Walla Basin Watershed Council
This is not the bottom of the well. Well depth = 100’
Monitoring Well GW_103

This is not the bottom of the well. Depth = 189’
This is not the bottom of the well. Well depth = 200'