GSI Water Solutions, Inc.

June 27, 2011

Jen Woody
Hydrogeologist
Oregon Water Resources Department
158 12th Street NE
Salem Oregon 97310

Subject: Request for a 5-Year Time Extension and Modifications for ASR Limited License #005

Dear Jen:

On behalf of the City of Tigard (City), this letter requests a 5-year time extension for the Aquifer Storage and Recovery (ASR) Limited License #005. The current ASR Limited License #005 authorizing ASR testing at five wells in the Columbia River Basalt Group (CRBG) aquifer will expire December 14, 2011. In summary the following are requested in this memorandum:

- A 5-year time extension for the modified Limited License #005.
- Modification of ASR Limited License #005 Condition 9 to allow for well-field sampling approach.
- Modification of ASR Limited License #005 Condition 11(B) to allow for concurrent withdrawal of stored ASR water debited against the ASR account and native groundwater under the City's existing groundwater rights.
- An increase in maximum storage volume of 25% from the current 400 million gallons (MG) to 500 MG.
- Modifications to ASR well names and locations as described in Table 1. Specifically, the following modifications are requested:
    - Change the name of ASR 4 to ASR 3, and a minor adjustment of the location to Township 2 South, Range 1 West, Section 9, SW ¼ NE ¼, 1,770 feet south and 1,500 feet west from the NE corner of Section 9.
    - Change the name of ASR 3 to ASR 4, and change the location to Township 2 South, Range 1 West, Section 10, NW ¼ SW ¼, 25 feet south and 500 feet east from the northwest corner of the southwest ¼ of Section 10. This is the location of the existing City-owned Well 4.
    - Change the location of ASR 5 to Township 2 South, Range 1 West, Section 5, SW ¼ SE ¼, 770 feet north and 1,870 feet west from the southeast corner of Section 5.

We understand that certain criteria must be met in order to grant an extension and the above modifications; a discussion of those points is provided below:

Rationale for Time Extension and Requested Modifications

5-Year Time Extension

The City is requesting an extension of ASR Limited License #005 to continue evaluating the feasibility of expanding its ASR program in the Cooper Mountain-Bull Mountain area. The City has not finalized the total number of proposed ASR wells that it would like to develop and the exact locations of future ASR wells are not established. As shown in Figure 1, the City has two operational ASR wells: ASR 1 located at the Canterbury facility east of Bull Mountain and ASR 2 located on the western end of Bull Mountain. ASR 3 was drilled and completed in 2007 and is located west of ASR 2, along Bull Mountain Road (about 1,450 feet west of ASR 2). It is anticipated that ASR 3 will be brought on-line in 2013. A pilot test work plan for ASR 3 is provided as Attachment A. As part of its current testing program, the City continues to monitor the response of the basalt aquifer to ASR activities. The ongoing monitoring and testing are key to helping the City define additional areas to explore for ASR expansion. Through the extension of the limited license, the City would be able to better define the extent of its ASR program, before applying for a full-scale ASR operational permit.

Modification of Condition 9

Because ASR 3 is located in close proximity to ASR 2 and completed in the same interflows of the basalt aquifer, it is our opinion that there is one water source for both ASR 2 and ASR 3, and that the receiving aquifer is essentially one unit (single injection bubble). This concept is consistent with the ASR rules OAR 690-350-001 (2), which states that *a limited license application may propose ASR testing for a single well or same-aquifer wells in a wellfield*. The area of Bull Mountain hosting ASR 2 and ASR 3, in our opinion, is a same-aquifer system with both wells in a single ASR wellfield. In summary, because ASR 2 and ASR 3 are completed in the same aquifer and are in close proximity to each other (approximately 1,450 feet apart), the City is requesting permission to use a well-field sampling approach for these two wells. Under this approach, ASR compliance water samples would come from either of these two wells and would not come from both of them. This approach has been applied at Beaverton's Sorrento ASR wellfield, which was approved by Oregon Water Resources Department (OWRD). No adverse consequences have resulted from the well-field sampling approach at Beaverton.

Modification of Condition 11(B)

Because the City has native groundwater rights, it would be in its best interest, and also would allow the City to better manage its ASR program, if the City were able to account for withdrawal of water from its ASR wells as native groundwater, a draft from the ASR account, or some combination of these two options. The amount of native groundwater withdrawn and ASR water recovered as monthly totals would be reported to OWRD in the annual ASR report.

To date, the City's ASR program has been very successful. Since 2006 when ASR 2 was brought on-line, a maximum of 341 MG were stored with no adverse impacts identified as a result of ASR activities. Since the start of ASR pilot testing, the ambient aquifer water level measured before the start of each successive ASR cycle has steadily increased until the City increased native groundwater production during 2008 and 2009. The present aquifer level, however, remains approximately 30 feet higher than historic levels observed during the early 1970s before the establishment of the Cooper-Bull Mountain Critical Groundwater Area. Figure 2 shows groundwater elevation at observation wells monitored by the City demonstrating a general rising water level trend since the start of ASR by the City in 2002. As shown in Figure 3, historic aquifer water levels, native groundwater production by the City, and precipitation trends, indicate that this general rise in water level could be related to a multitude of factors, but may be primarily related to: 1) a reduction in native groundwater pumping by the City of Beaverton, the City of Tigard, and Tualatin Valley Water District (TVWD) and 2) accumulation of residual stored ASR water required by Limited License Condition 11(A). Additional factors that may have affected the observed water level rise, but occurred prior to 2002, include: 1) a reduction in domestic groundwater pumping as the region has urbanized and residents have been served by the municipal water systems and 2) a reduction in groundwater pumping related to gravel mining activities in the region.

Based on previous discussions OWRD, GSI Water Solutions, Inc. (GSI) understands that the reason Condition 11B was added to ASR Limited License #005 was to ensure that the regional aquifer hosting the ASR wells would not be adversely affected. When the program began, little information was available about how the aquifer would respond to ASR activities. Since the limited license was issued in 2002, data collected as part of the ASR program have shown that the CRBG basalt aquifer hosting the City's ASR wells has not been adversely affected, regardless of the amount of native groundwater withdrawn under the City's rights after the ASR storage account has been depleted. Specifically, the water levels in the aquifer remain well above the historic levels observed during the early 1970s. Modifying Condition 11B would not allow the City to increase its native groundwater withdrawal; it would only alter the timing of the native groundwater withdrawal. Based on what has been observed to date, GSI believes that changing the timing of the native groundwater withdrawal will not negatively impact the aquifer. Therefore, we believe the restrictions described in Condition 11B are no longer necessary.

Modifying Condition 11B will benefit the City because the City will be able to pump native groundwater early in the recovery season and, consequently, will preserve its ASR storage account for times when there is a need to pump at higher rates. The maximum ASR pumping rates established in ASR Limited License #005 are higher than the maximum rates of the City's native groundwater rights. The limited license authorizes a combined maximum rate of over 8,750 gallons per minute (gpm) or 1,750 gpm per well, while the City's groundwater rights are limited to a combined maximum rate of 1,634 gpm. Currently, the City purchases nearly 90 percent of its water from wholesale water providers that primarily supply surface water. During periods of high demand, the City depends on its ASR wells and native groundwater wells to supplement its supply. Modifying Condition 11B to permit the City to withdrawal from its ASR account in concert with its native groundwater rights will allow the City to rely less on costly surface water supply to meet peak season demands thereby providing a significant benefit to the City, its customers, and other surface

water users in the basin. A precedent was set for this modification request when OWRD approved a similar modification request for the City of Beaverton and TVWD ASR Limited License #002.

At present, Condition 11B states:

> *Any water withdrawn from an ASR well identified in this limited license shall first be debited against the quantity available in the aquifer by virtue of ASR storage. When ASR storage is depleted at an ASR well, any water withdrawn from an ASR well shall be considered a draft on natural ground water, requiring separate or additional authorization. This limited license does not authorize withdrawal of more water than was injected.*

GSI proposes modifying the language in Condition 11B to state:

> *Any water withdrawn from an ASR well identified in this limited license shall either be considered a draft on natural groundwater under existing groundwater rights or debited against the quantity available in the aquifer by virtue of ASR storage. This limited license does not authorize withdrawal of more water than was injected and any water withdrawn that is considered a draft on natural groundwater requires separate or additional authorization. Simultaneous withdrawals of natural groundwater and stored water may occur, but at no time shall the total withdrawal rate exceed that which is authorized in this limited license. The licensee shall report the amount of native groundwater withdrawn and ASR water recovered as monthly totals.*

If Condition 11B were modified as proposed, the City could withdrawal water from an ASR well up to the authorized rate of 1,750 gpm and a percentage of the withdrawal, up to the rate authorized by the City's groundwater rights (1,634 gpm), could be considered a draft on natural groundwater. For example, the City could withdrawal water at ASR 1 and ASR 2 at a rate of 1,750 gpm each (as authorized by ASR Limited License #005) and account for 1,250 gpm at each well as a draft on the quantity available in the aquifer by virtue of ASR storage and 500 gpm at each well as a draft on native groundwater (as authorized by the City's groundwater rights), thereby preserving the ASR storage account to allow longer periods of withdrawal.

Increase of Maximum Storage Volume

The City is requesting an increase in maximum storage volume to plan for population growth, the possibility of future drought years, and an increase in economic activity. The maximum storage volume authorized in Limited License #005 is 400 MG of water. During year 2009 through 2010, a maximum of 341 MG were stored using ASR 1 and ASR 2 without a loss of stored water or adverse impacts to the aquifer system. The City's ASR 3 is scheduled to be brought on-line in 2013 with an anticipated storage volume of 150 MG, or a total storage of 491 MG when combined with the volume stored at ASR 1 and ASR 2 during year 2010. Consequently, more available storage than is currently authorized in Limited License #005 is required before ASR 3 can be brought on-line.

Additionally, it is anticipated that the City may add two more ASR wells (ASR 4 and ASR 5) during the next 5 years. While it is anticipated that future ASR wells may be capable of storing 150 MG, the current intent is not to store more than 500 MG cumulatively. Rather, the intent of bringing additional ASR wells on-line beyond ASR 3 is to allow the City to adjust the injection volume at each well to allow for operational flexibility and redundancy in its system. To accommodate future ASR expansion plans at this time, we request that the renewed ASR limited license be modified to allow for a maximum storage volume of 500 MG (an increase of 25%). If future ASR expansion is successful and the City's demand projections increase, a request to increase the storage volume beyond 500 MG may be made to OWRD in the next renewal and/or ASR permit application.

Modifications to ASR Well Names and Locations

Table 1 outlines the requested ASR well name and location modifications.

Table 1
Modifications to ASR Well Names and Locations
City of Tigard ASR Limited License #005

Current Well Name (1)	**Current Well Location** (1)	**Requested Well Name**	**Requested Well Location**
ASR 3	T2S R1W Section 10, NW 1/4 NW 1/4	ASR 4	T2S R1W Section 10, NW 1/4 SW 1/4, 25 feet south and 500 feet east from the NW corner of the southwest 1/4 of Section 10 (2)
ASR 4	T2S R1W Section 9, SW 1/4 NE 1/4	ASR 3	T2S R1W Section 9, SW 1/4 NE 1/4, 1,770 feet south and 1,500 feet west from the NE corner of Section 9
ASR 5	T2S R1W Section 4, NW 1/4 SE 1/4		T2S R1W Section 5, SW 1/4 SE 1/4, 770 feet north and 1,870 feet west from the SE corner of Section 5

Notes:
No change is requested for the well name of ASR 5
(1) As listed in ASR Limited License #005
(2) This is the location of the existing City of Tigard Well 4

<u>Change the Name of ASR 4 to ASR 3 and Minor Location Adjustment</u>

The City would like to change the name of ASR 4 to ASR 3, and move the location slightly to the northeast. ASR Limited License #005 describes the anticipated location of ASR 4 (now to be called ASR 3) as Township 2 South, Range 1 West, Section 9, SW ¼ NE ¼, 2270 feet south and 1560 feet west from the NE corner of Section 9. The City would like to move the location to Township 2 South, Range 1 West, Section 9, SW ¼ NE ¼, 1,770 feet south and 1,500 feet west from the NE corner of Section 9. ASR 3 and ASR 4 were not yet sited at the time the previous limited license renewal request was submitted in November, 2006. The exact location of ASR 3 changed when the well was sited for drilling in 2007. The ASR 4 well location described in ASR Limited License #005 is in close

proximity to the existing ASR 3 location. As such, the name change of ASR 4 to ASR 3 and a minor adjustment (i.e., within an adjacent ¼ ¼) to the location is requested for inclusion in ASR Limited License #005.

As previously mentioned, ASR 3 was drilled and tested in 2007. ASR 3 is completed in the CRBG and is located adjacent to the City's proposed 3 MG reservoir located on Bull Mountain Road. Based on aquifer test data, it was recommend that ASR 3 be designed to pump at a minimum rate 1,400 gpm and that it be designed to inject at a rate of up to 1,000 gpm. Based on a sustained specific capacity of approximately 7.5 gpm/ft (as observed during a 5-day pump test at 1,200 gpm) and 266 feet of available drawup, the target storage is 150 MG. A schematic as-built of ASR 3 and geology encountered during drilling are shown in Figure 4. It is anticipated that ASR 3 will be equipped with a line shaft turbine pump with a variable frequency drive and a recharge control valve (downhole control valve). Other primary equipment will include: (1) a bi-directional flow meter and a continuous downhole water level sensor connected to the City's telemetry system, (2) a pump-to-waste option, and (3) an onsite hypochlorite disinfection system. A preliminary floor plan and wellhead design are presented in Attachment B.

Change the Name of ASR 3 to ASR 4 and Modify the Location

Preliminary findings from a cursory assessment of the suitability of the City's Well 4 for ASR development conducted by GSI were positive. As such, the City would like to change the location of ASR 4 (previously ASR 3) to the location of Well 4. Specifically, the City would like to change the name of ASR 3 to ASR 4, and modify the location to Township 2 South, Range 1 West, Section 10, NW ¼ SW ¼, 25 feet south and 500 feet east from the northwest corner of the southwest ¼ of Section 10.

Figure 5 shows the geology and well construction information for Well 4 based on OWRD well logs (WASH 11590 and WASH 11591 included in Attachment C). Well 4 is completed in the CRBG aquifer to a total depth of 925 feet below ground surface (bgs) and may penetrate four or more possible interflow zones within the CRBG. The rapid water level response in Well 4 to injection and recovery operations at ASR 2 during the past few years suggests that Well 4 may be completed in the same water bearing zones as ASR 2. The static water level in Well 4 has ranged from roughly 220 to 280 feet bgs in recent years in response to the City's current ASR operations. The available water quality data for Well 4 does not indicate any water quality concerns for use of the native groundwater at this well for use as a potable source. If no major retrofit of Well 4 it needed for ASR operation, the design and construction of ASR 4 will be similar to that of ASR 1. Otherwise, Well 4 will be retrofitted to have a similar design and construction to that of ASR 2. Schematic diagrams showing the two possible well designs are shown in Figure 6 and a preliminary floor plan and wellhead design are presented in Attachment B. However, the details of the future well design for ASR 4 will be dependent on well performance, hydraulic capacity of the aquifer, and the configuration of the City's water distribution system.

Modify the Location of ASR 5

The City would like to change the location of ASR 5 to the Cach site located at Township 2 South, Range 1 West, Section 5, SW ¼ SE ¼, 770 feet north and 1,870 feet west from the southeast corner of Section 5. The Cach site (parcel next to Cach property) is the anticipated site for the City's next reservoir. The site has ample room for hosting an ASR pump station and pump to waste facility. In addition, the Cach site is host to an existing relatively deep domestic well and is located in an area that appears favorable for ASR exploration (hydrogeology of this area has been shown to support an ASR system and there is ample available headroom). For these reasons, the City would like the Cach site to host ASR 5.

Figure 7 provides a general cross section through Bull Mountain and the cross section line is shown on Figure 8. The domestic well on the Cach site is shown on the cross section. This well is completed to 530 feet bgs (about 10 feet msl). The Cach well is a small diameter (6-inch) well that most likely is open hole. The surface seal for this well is unknown. A site visit showed that the well is completed with a submersible pump and is currently used to serve the well owner with domestic and irrigation water. The yield is low and no pump test data or detailed well log are available. The well is located away from the owner's house and he is amenable to having the City test the well, with the understanding that the well owner would want to continue to use the well for domestic needs after the City is done testing the well. Ideally the well could be deepened in order to test the full basalt section in this area. The surface seal may have to be upgraded to current well construction standards if the well were deepened. Assuming the Cach well could be deepened, this would save the City substantial test well drilling costs since the well is already 530 feet deep. Attachment C includes the only available log for the well (deepening log). Assuming testing at the Cach well is positive, a new ASR well (ASR 5) would be drilled nearby on City-owned land. The design and construction of ASR 5 likely will be similar to that of ASR 2. A schematic diagram showing the well design is shown in Figure 6 (20-inch well with liner assembly) and a preliminary floor plan and wellhead design are presented in Attachment B. However, the details of the future well design for ASR 5 will be dependent on well performance, hydraulic capacity of the aquifer, and the configuration of the City's water distribution system.

Amount of Time Requested

Because the City has not finalized the total number of proposed ASR wells that it would like to develop and the exact locations of future ASR wells are not established, the City would like to request an extension to its ASR limited license. Through the extension of its ASR limited license, the City's ASR program will be better defined before applying for a full-scale ASR operational permit. Consequently, the City would like to request a 5-year extension to ASR Limited License #005.

Compliance with the Terms and Conditions of the Current Limited License

Several terms and conditions are defined in ASR Limited License #005, such as groundwater monitoring and water quality sampling. The City has complied with the terms of the limited license and they have worked in good faith to report ASR pilot testing data to the Department on a regular

basis. The City has never received a notice from the Department that they are out of compliance with the terms of the license. Specifically, the following have been completed to comply with the terms and conditions of the license:

- Changes to the preliminary locations and names of ASR wells outlined in the Limited License have been requested in writing to OWRD.
- The maximum injection and recovery rate has not exceeded 1,750 gpm which complies with the terms of the license.
- Condition 1 – This letter requests an extension.
- Condition 2 – The City has notified OWRD verbally and in writing prior to injection and recovery each year.
- Condition 3 – The City has kept record of the injection and recovery volumes and has reported the data to the Department in the year-end reports.
- Condition 4 – Any proposed modifications to the Limited License have been submitted to the Department in writing.
- Condition 5 – The City understands that the Limited License does not receive a priority date like a water right.
- Condition 6 – The City completed a UIC registration and has complied with all state and local permits with regard to injecting, recovering and pumping to waste.
- Condition 7 – The Department received an ASR work plan prior to the start of ASR 1 and ASR 2 pilot testing and they have received addendums that outlined proposed changes to the monitoring plan. The ASR work plan for ASR 3 is included as an attachment to this letter.
- Condition 8 – Injected water and recovered water have met all state and federal drinking water standards, with no exceedence of regulatory screening levels.
- Condition 9 – The City continues to collect water quality samples in compliance with the terms outlined in the condition and continues to ensure that the water delivered to its customers meets all federal and state drinking water standards.
- Condition 10 – The City has maintained a detailed monitoring plan to measure the response in the regional aquifer due to ASR activities. Changes in the points of monitoring have been made from time-to-time (new points added and others dropped based on data trends) and the Department has been notified of the changes.
- Condition 11 – The City has recovered up to 95 percent of the stored volume each year. However, using its existing water rights, the City has continued to pump native groundwater after the ASR account has been depleted, as needed. Yearly reporting to the

OWRD has documented the amount of recovered water; both ASR water and native groundwater. A request to modify condition 11b is outlined in this letter.

- Condition 12 – Yearly ASR reports have been submitted to the Department since the start of ASR pilot testing.
- Condition 13 – No injuries to existing groundwater users have been reported since the start of ASR activities.
- Condition 14 – The recovered water has been put to beneficial municipal use as described in Permit S-46423 or as described in ORS 538.420.
- Condition 15 – The City has met periodically with the Department to review the status of the City's ASR project.
- Condition 16 - The Department has not suggested additional conditions to the Limited License since its issue date.
- Condition 17 – The City has kept the public informed of the ASR program through their Consumer Confidence Report and through other presentations, publications and community meetings. In addition, the City has posted information about its ASR program on the City's official Web site.
- Condition 18 – No adverse effects have been observed, such as new seeps or landslide activation since the start of ASR operations. The City modified the Tigard High School well because the static water level in this well was approaching the ground surface. The City also has worked with one landowner and OWRD to properly abandon an undocumented well that has shown a response to ASR activities. Overall, the City continues to monitor for adverse affects resulting from ASR activities based on the approach and monitoring outlined in the approved ASR work plans.
- Condition 19 – A running account of the amount of recovered ASR water has been submitted to the Department yearly.

Thank you for considering this request and please do not hesitate to call me at 503 239-8799 if you have questions.

Regards,

Larry G. Eaton, RG
Principal Hydrogeologist

Ted Ressler, RG
Project Hydrogeologist

Rachael Peavler
Staff Hydrogeologist

Cc John Goodrich, Jennifer Joe, and Aaron Beattie –- City of Tigard

FIGURE 1

Limited License Map
City of Tigard ASR
Limited License #005

Tigard Area

City of Portland Bull Run POD

Overview Map
0 0.5 1 2 3 4
1 inch equals 1.1 miles, NOT TO OWRD STANDARD SCALE

LEGEND

- Observation Well
- Planned ASR Well and Current Observation Well
- ASR Well
- Planned ASR Well
- Points of Diversion (PODs)
- Focus_Areas
- Major Roads
- Watercourses
- Waterbodies

Obs Well 3
ASR 5 - Cash Site
Obs Well 2
ASR 3
ASR 2
ASR 1
Obs Well 1
ASR 4 - Obs Well 4
Obs Well 5
Tigard High School

Tigard Area
0 0.25 0.5 0.75 1
2 inches equals 1 mile

City of Portland
Bull Run POD (ORS 538.420)

City of Portland Bull Run POD
0 0.25 0.5 0.75
2 inches equals 1 mile

POINTS OF DIVERSIONS
City of Portland POD Bull Run (ORS 538.420) Located 660 feet North, 670 feet West from the SE corner of Section 26, Township 1 South, Range 5 East (W.M.).
Latitude: 45.414192, Longitude: -122.78499

OBSERVATION WELLS
Obs Well 1 Located 1,650 feet South, 50 feet West from the NE corner of Section 10, Township 2 South, Range 1 West (W.M.)
Latitude: 45.414192, Longitude: -122.78499
Obs Well 2 Located 560 feet South, 1,200 feet East from the NW corner of Section 10, Township 2 South, Range 1 West (W.M.)
Latitude: 45.41609, Longitude: -122.800626
Obs Well 3 Located 2,610 feet South, 2,620 feet East from the NW corner of Section 4, Township 2 South, Range 1 West (W.M.)
Latitude: 45.425837, Longitude: -122.815563
Obs Well 5 Located 970 feet North, 1,330 feet West from the SE corner of Section 8, Township 2 South, Range 1 West (W.M.)
Latitude: 45.406672, Longitude: -122.833619
Tigard High School Located 130 feet South, 1,100 feet West from the NE corner of Section 14, Township 2 South, Range 1 West (W.M.)
Latitude: 45.403864, Longitude: -122.768546

PLANNED ASR WELL AND CURRENT OBSERVATION WELL
ASR 4 - Obs Well 4 Located 25 feet South, 500 feet East from the NW corner of the SW quarter of Section 10, Township 2 South, Range 1 West (W.M.)
Latitude: 45.411319, Longitude: -122.803261

ASR WELLS
ASR 1 Located 1,550 feet South, 50 feet East from the NW corner of Section 11, Township 2 South, Range 1 West (W.M.)
Latitude: 45.414418, Longitude: -122.784572
ASR 2 Located 1,725 feet South, 25 feet East from the NW corner of Section 10, Township 2 South, Range 1 West (W.M.)
Latitude: 45.413749, Longitude: -122.80529

PROPOSED ASR WELLS
ASR 3 Located 1,770 feet South, 1,500 feet West from the NE corner of Section 9, Township 2 South, Range 1 West (W.M.)
Latitude: 45.413662, Longitude: -122.811067
ASR 5 - Cash Site Located 770 feet North, 1,870 feet West from the SE corner of Section 5, Township 2 South, Range 1 West (W.M.)
Latitude: 45.420593, Longitude: -122.833006

MAP NOTES:
Projection: Oregon State Plane North
Date: May 23, 2011
Data Sources: OWRD, METRO

N

GSI Water Solutions, Inc.

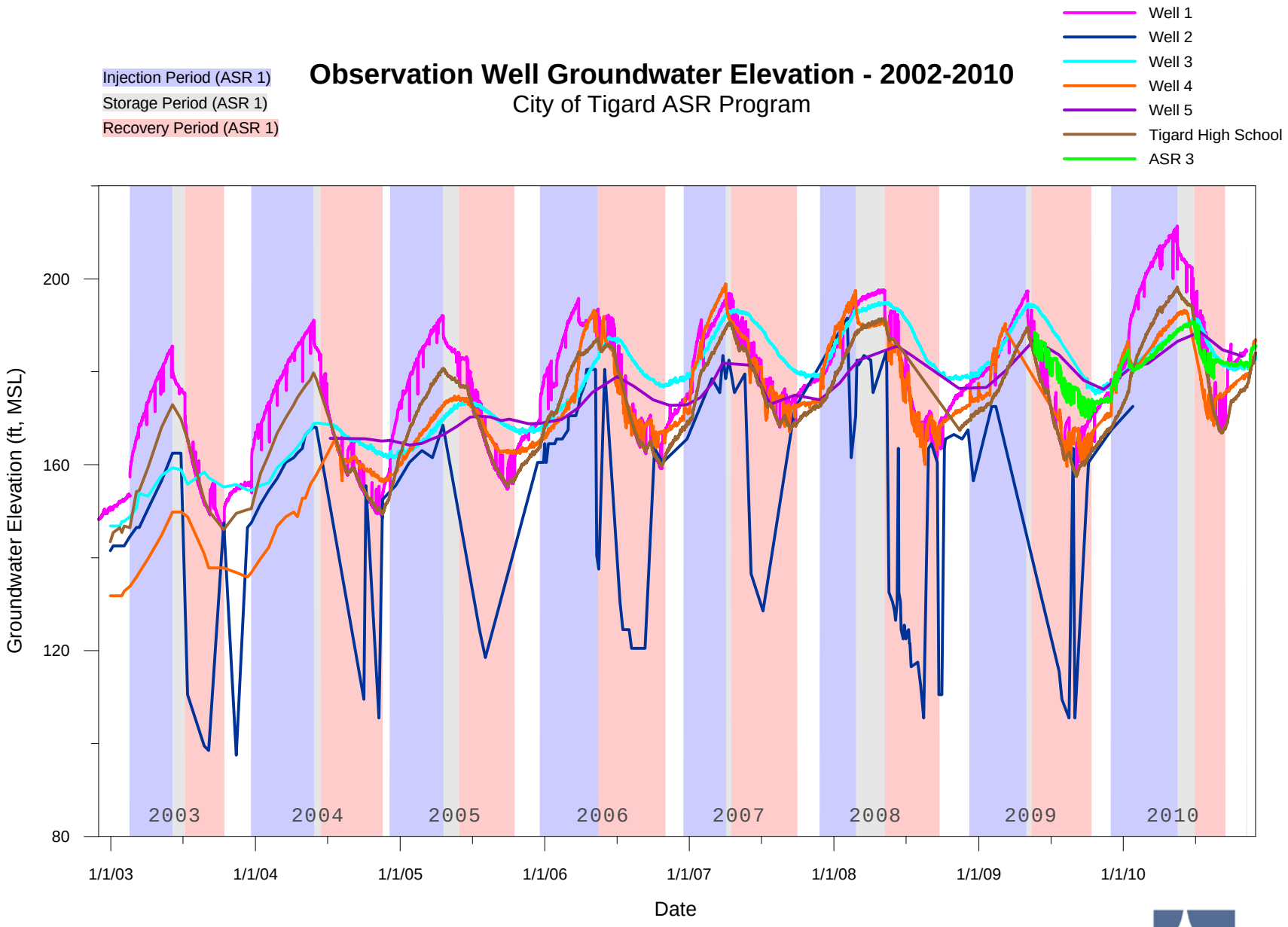


Figure 2

P:\Portland\103 - Tigard\ASR Tracking\Output Plots\Obs_Well_Elev.grf

GSI Water Solutions, Inc.

Aquifer Water Level, Native Groundwater Pumping, and Precipitation

City of Tigard ASR Program

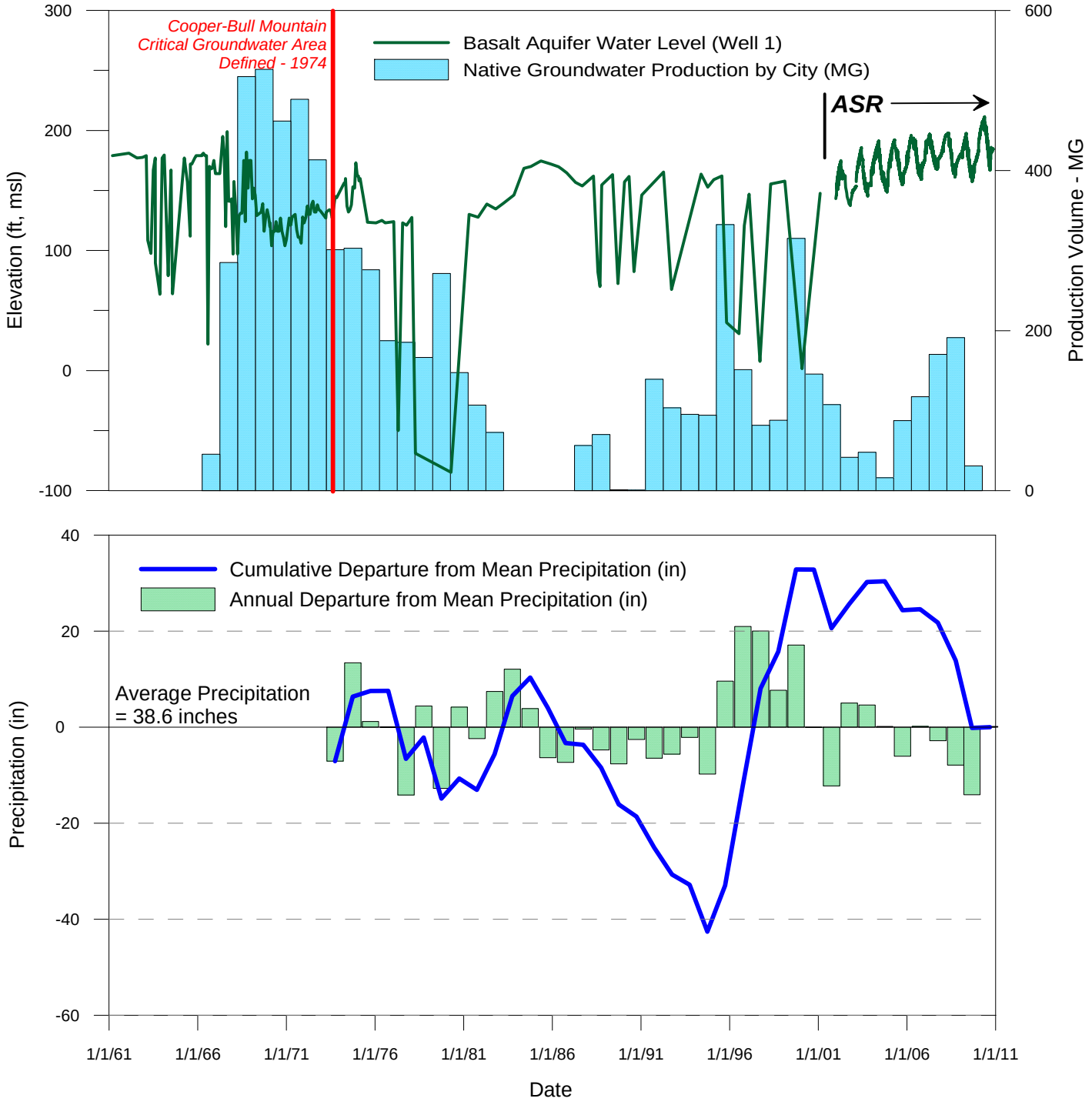
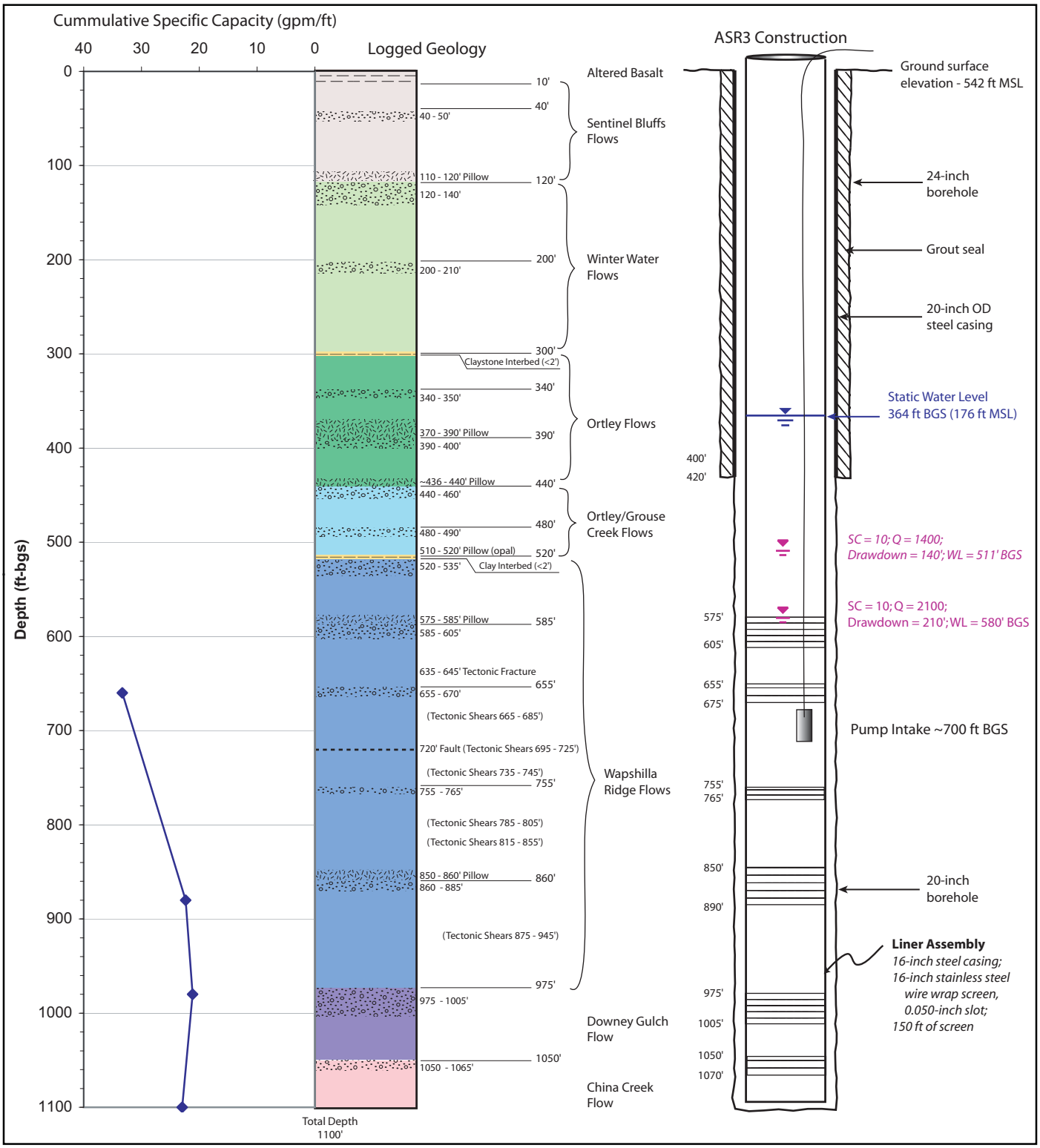


Figure 3

P:\Portland\103 - Tigard\ASR Tracking\Precipitation Analysis\WL_Q_Precip.grf

GSI Water Solutions, Inc.



LEGEND

- Flow Top
- Interior Flow Basalt
- Claystone
- Pillow Basalt

Notes:

bgs= below ground surface

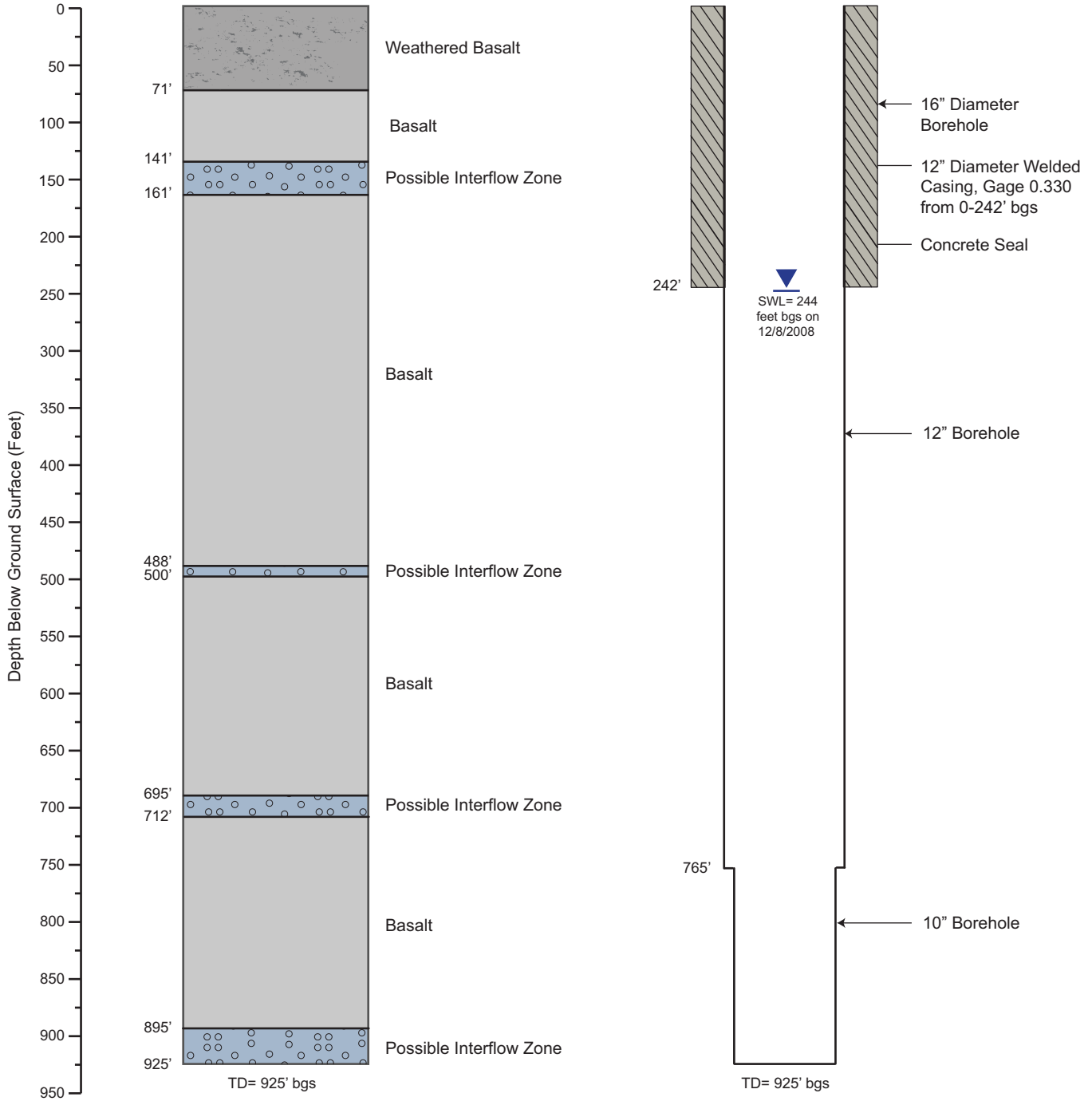
msl = mean sea level

FIGURE 4

Schematic As-Built of ASR 3
City of Tigard ASR Limited License #005

GSI Water Solutions, Inc.

P:\Portland\103 - Tigard\016 - 2010-2011 ASR Support\Figures



Notes:

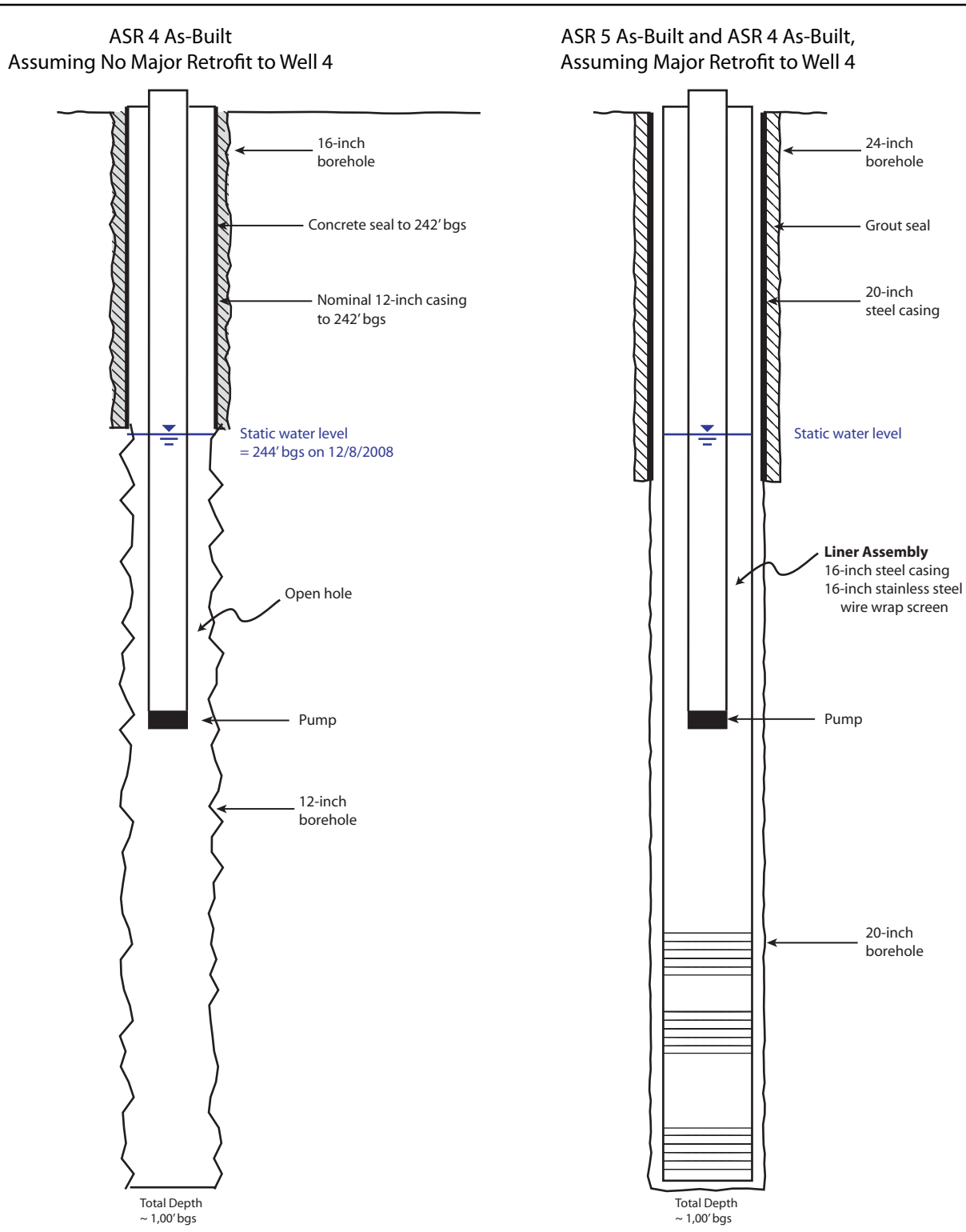
bgs= below ground surface
SWL= static water level
gpm= gallons per minute
TD= total depth

Geology and well construction information from WASH 11590 and WASH 11591.

FIGURE 5

Schematic As-Built of Well 4
City of Tigard ASR Limited License #005

GSI Water Solutions, Inc.



Notes
bgs - Below Ground Surface

FIGURE 6

Potential As-Builts for ASR 4 and ASR 5

City of Tigard ASR Limited License #005

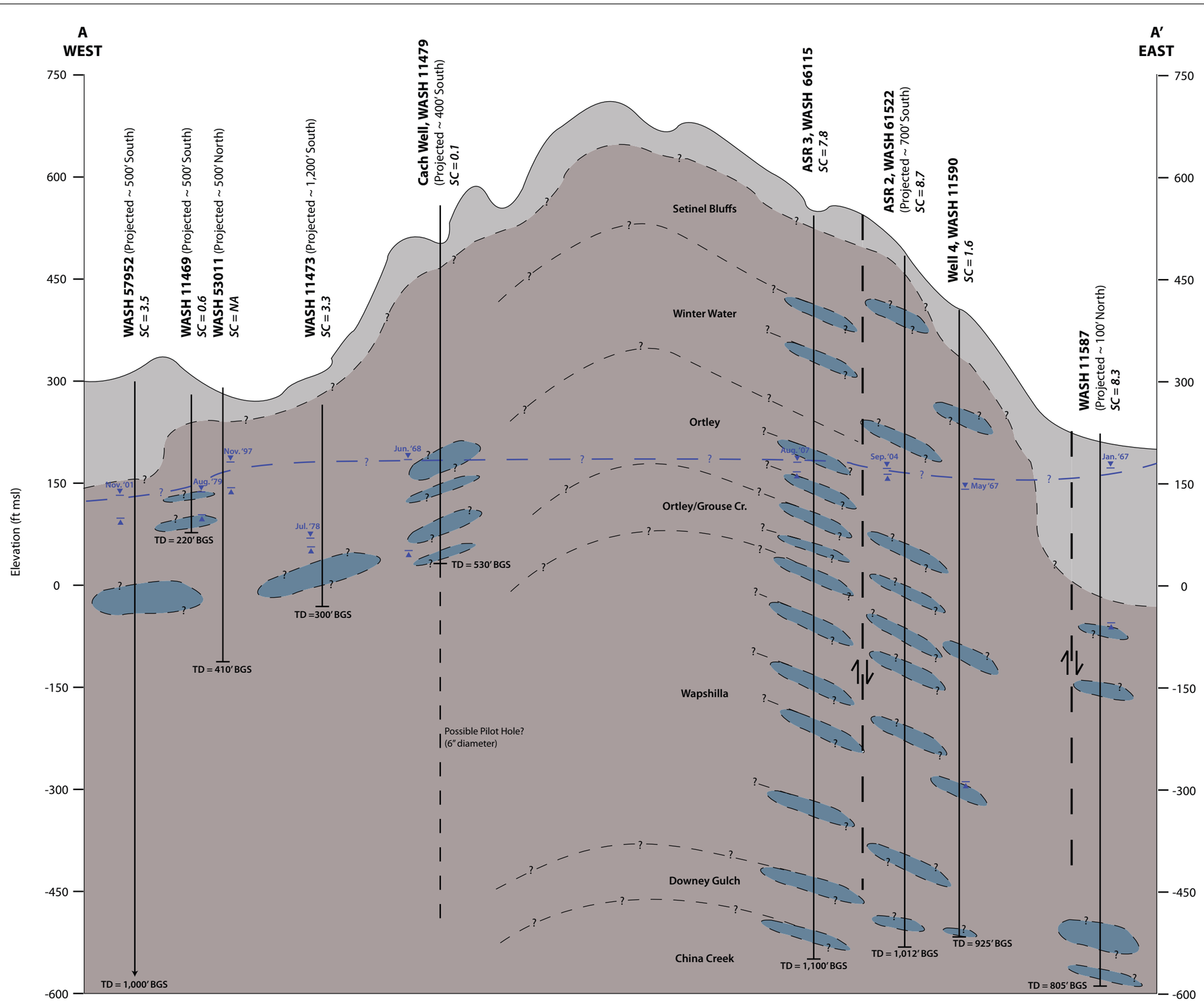
GSI Water Solutions, Inc.

P:\Portland\103 - Tigard\016 - 2010-2011 ASR Support\Figures

FIGURE 7

Cross Section A-A'

City of Tigard ASR Limited License #005



LEGEND

- Weathered Basalt
- Basalt
- Interflow
- Well
- Fault
- Jan. '67 — SWL and Date
- Depth of First Water

NOTES

BGS - Below Ground Surface
TD - Total Depth
SWL - Static Water Level
SC - Specific Capacity

SCALE

150'

0 — 1,500'

Vertical Exaggeration = 10X

GSI Water Solutions, Inc.

P:\Portland\103 - Tigard\016 - 2010-2011 ASR Support\Figures

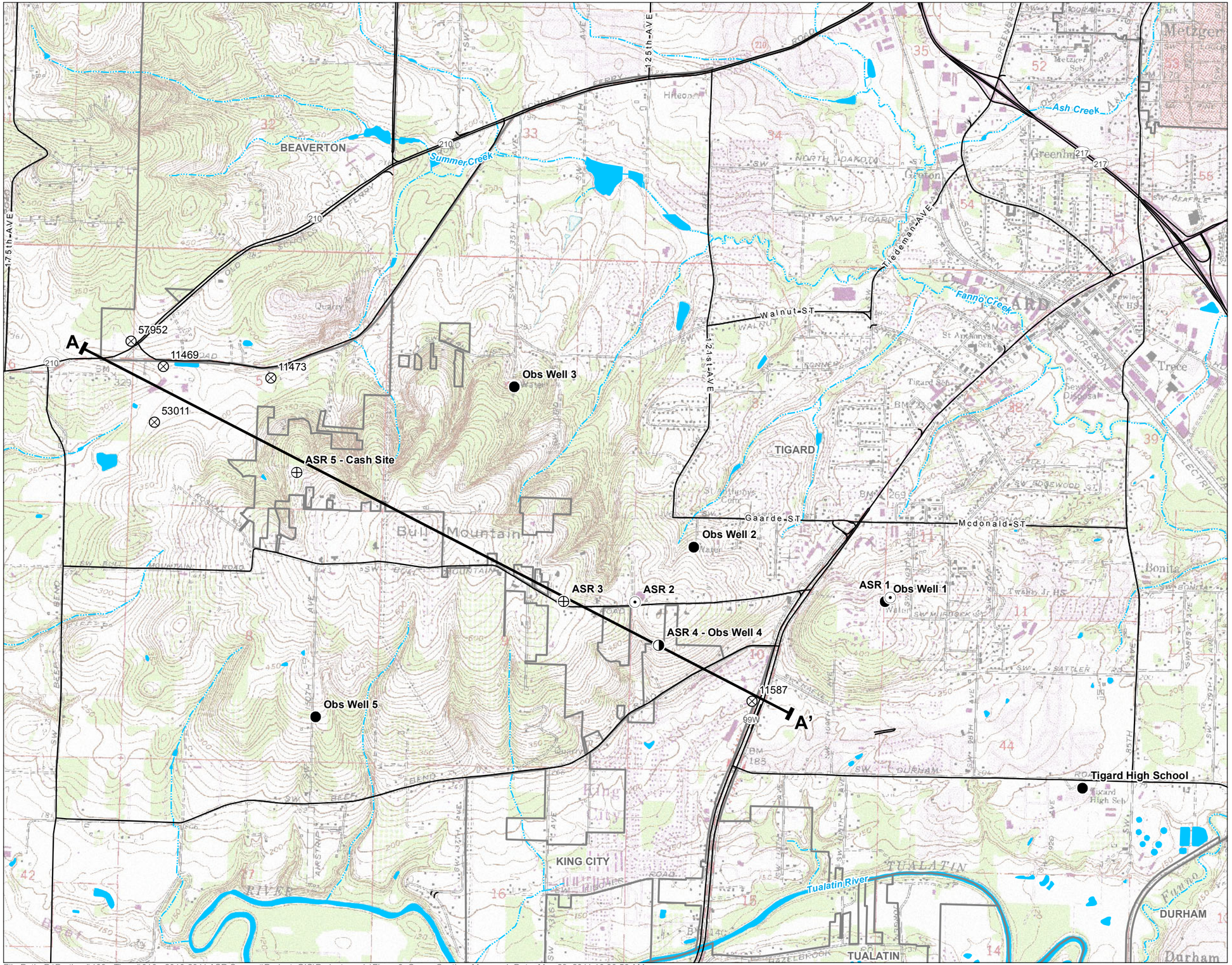


FIGURE 8

Cross Section Map

City of Tigard ASR Limited License #005

LEGEND

Wells

- Observation Well
- Planned ASR Well and Current Observation Well
- ASR Well
- Planned ASR Well

Other Data

- Cross Section Line
- City Limits
- Major Roads
- Watercourses
- Waterbodies

N

0 1,000 2,000 3,000

Feet

MAP NOTES:
Date: May 23, 2011
Data Sources: ESRI

GSI Water Solutions, Inc.

File Path: P:\Portland\103 - Tigard\016 - 2010-2011 ASR Support\Project_GIS\Project_mxds\Figure8_Cross_Section_Map.mxd, Date: May 23, 2011 10:30:56 AM

Attachment A

Pilot Test Work Plan for the City of Tigard ASR 3 Well, City of Tigard Aquifer Storage and Recovery Project, ASR Limited License #005

GSI Water Solutions, Inc.

TECHNICAL MEMORANDUM

Pilot Test Work Plan for the City of Tigard ASR 3 Well, City of Tigard Aquifer Storage and Recovery Project, ASR Limited License #005

PREPARED FOR: Jennifer Woody, Oregon Water Resources Department

PREPARED BY: Larry Eaton, RG, LHG – GSI Water Solutions, Inc.
Ted Ressler, RG, CWRE – GSI Water Solutions, Inc.
Rachael Peavler – GSI Water Solutions, Inc.

CC John Goodrich – City of Tigard
Aaron Beattie – City of Tigard
Robert Murchison, PE – City of Tigard

DATE: April 18, 2011

Summary

This technical memorandum outlines a detailed pilot testing work plan for ASR 3 that will be implemented under the City of Tigard's (City) current aquifer storage and recovery (ASR) Limited License #005. The primary objective of pilot testing ASR 3 is to collect sufficient data to confirm the feasibility of using ASR 3 and to develop full-scale ASR operational criteria. Data collected as part of the ASR 3 work plan will be used by the City to apply for an ASR operational permit with the Oregon Water Resources Department (OWRD). General details of the plan include:

ASR 3

Injection: 1,000 gallons per minute typically from November to May (complies with ASR Limited License #005)
Target storage volume: 150 million gallons (complies with ASR Limited License #005 after modification is approved)
Recovery: Up to 1,400 gallons per minute typically from July to October (complies with ASR Limited License #005)
Water Level Monitoring: Same observation well network monitored for ASR 1 and ASR 2. Goal of the water level monitoring is to collect sufficient data to track the dynamic response of the regional basalt aquifer to ASR activities.
Water Quality Sampling: Single wellfield sample collected at ASR 2 or ASR 3 that is representative of source and recovered water (refer to the 5-year time extension and modification request for ASR Limited License #005 to which this work plan is attached). Water samples will be tested for a suite of constituents similar to what is outlined in the approved work plans for ASR 1 and ASR 2. The goal of the

water quality sampling plan is to ensure that recovered water meets drinking water standards before delivering to City residences and to collect sufficient water quality samples to track the potential water quality changes of injected, stored, and recovered water as it relates to taste, quality, and the potential clogging of the ASR wells.

Introduction

This technical memorandum presents a work plan for operating the City's ASR 3 well under the City's approved ASR Limited License #005. Specifically, the work plan for ASR 3, the City's newest ASR well, includes details associated with pilot testing the well. The ASR 3 work plan mirrors the approved work plans for ASR 1 and ASR 2 previously submitted to the OWRD as part of the City's overall ASR program. However, because of the close proximity of ASR 3 to ASR 2 (approximately 1,450 feet) and the similar depth of completion, the City has requested a modification of ASR Limited License #005 to allow for a well-field sampling approach for ASR 2 and ASR 3 (refer to the 5-year time extension and modification request for ASR Limited License #005 to which this work plan is attached). All other elements of this work plan (e.g., recovery rate) comply with the requirements of ASR Limited License #005 after slight modifications as requested in the letter to which this work plan is attached.

Background

The City began ASR pilot testing under ASR Limited License #005 in January 2002. The City currently operates two wells, ASR 1 and ASR 2, for ASR operations under the City's limited license. As required by condition of the City's limited license, a pilot testing work plan for each well was submitted to OWRD prior to each well being placed into service.

ASR 1 has been an operational ASR well since 2002. To-date, a maximum of 145 MG has been stored in the basalt aquifer at ASR 1. Pilot testing results to-date have been generally favorable; however, because of high water levels observed at one of the ASR monitoring wells (the Tigard High School well, WASH 11707/67285), the City decided to not immediately plan any further storage volume increases at ASR 1. Instead, the City's ASR expansion focused on Bull Mountain where preliminary testing at a test well (subsequently completed as ASR 2) indicated that the basalt aquifer below Bull Mountain was favorable for ASR and capable of hosting one or more ASR wells (see Figure 1).

ASR 2 was brought on-line for ASR operations in March 2006. To date, a maximum of 291 MG has been stored in the basalt aquifer at ASR 2. Pilot testing results from ASR 2 have been favorable and suggested that the aquifer could support an additional ASR well in close proximity to ASR 2. Additional testing at a test well drilled approximately 1,450 feet west of ASR 2 also suggested favorable conditions for an ASR well. The test well was subsequently completed as ASR 3 and it is the City's intent to bring ASR 3 on-line for ASR operations by 2013. In accordance with the modified ASR Limited License #005, which assumes a 25% increase in the allowable storage (as requested in the letter to which this work plan is attached), the combined storage volume of the three ASR wells will be a maximum of 500 MG.

This work plan presents the designs for the wellhead piping and controls to be constructed at the wellhead and the specific details of the proposed ASR pilot testing program for ASR 3.

Anticipated ASR 3 Design

It is anticipated that ASR 3 will be equipped with a line shaft turbine pump with a variable frequency drive and a recharge control valve (downhole control valve). Other primary equipment will include: (1) a bi-directional flow meter and a continuous downhole water level sensor connected to the City's telemetry system, (2) a pump-to-waste option, and (3) an onsite hypochlorite disinfection system. Attachment A includes preliminary floor plan and select mechanical ASR 3 wellhead drawings. The anticipated operational service date for ASR 3 is 2013.

Pilot Testing Objective

The purpose of the pilot testing is to confirm ASR feasibility and to develop criteria for full-scale ASR operation at ASR 3. The primary objectives of the pilot test at ASR 3 are to:

- Evaluate the wellhead operation and response to ASR activities.
- Evaluate the dynamic response of the aquifer to injection and recovery.
- Evaluate the long-term performance of the well and determine what frequency of back flushing and redevelopment are necessary.
- Evaluate the optimal injection and recovery rates for the well assuming operation of the City's other ASR wells.
- Continue to evaluate the chemical compatibility of the receiving and injected water.

The data collected during ASR pilot testing at ASR 3 will be used in combination with the data collected from the pilot testing of the City's other ASR wells to develop a long-term ASR operational plan for the City.

Pilot Test Program and Approach

This section presents the specific details of the proposed ASR pilot testing program for ASR 3 and presents the designs for the wellhead piping and controls to be constructed at the wellhead. The ASR pilot testing program for ASR 3 will include several components: pilot testing rates and volumes, water level monitoring, and water quality monitoring. Details associated with each element are outlined below.

Pilot Testing Rates and Volumes

Typically, ASR pilot testing would include an injection period (typically November to May), a relatively short duration storage period (typically June), followed by a recovery period (typically July through October). These elements combined are referred to as a 'cycle'. The anticipated specifications for a single ASR cycle at ASR 3 are outlined in Table 1 below.

Table 1. Anticipated specifications for a single ASR cycle at ASR

Injection Rate	Injection Period[1]	Target Injection Volume[2]
1,000 gpm	November – May	150 MG

Storage Period
June

Recovery Rate	Recovery Period[1]	Maximum Recovery Volume[3]
2,100 gpm	July – October	142.5 MG

[1] The start, stop, and duration of the injection and recovery periods in a given year are dependent on the water supply and demand conditions and operational restrictions experienced by the City; hence, these time estimates are an approximation.
[2] Total combined target storage volume for ASR 1, ASR 2, and ASR 3 is 500 MG. Assumes ASR Limited License #005 is modified as requested in the letter to which this work plan is attached.
[3] Based on Limited License #005, only 95 percent of the volume injection may be recovered in any one given injection cycle (year).
Abbreviations: gpm = gallons per minute, MG = million gallons.

Water Level Monitoring

A network of observation wells was established early in the City's ASR program and largely has remained unchanged. This same network of observation wells, as outlined below, is proposed for pilot testing ASR 3. Figure 1 shows the location of the observation wells relative to the City's ASR wells. The goal of the water level monitoring is to track the dynamic response of the basalt aquifer to ASR activities.

Proposed Monitoring Well and Data Collection Network

- ASR 1 – transducer (1 hour readings)
- ASR 2 – transducer (1 hour readings)
- ASR 3 – transducer (1 hour readings)
- Well 1 – transducer (1 hour readings)
- Well 2 – manual (monthly)
- Well 3 – transducer (1 hour readings)
- Well 4 – transducer (1 hour readings)
- Well 5 – manual (monthly)
- Tigard High School – transducer (1 hour readings)

Water Quality Monitoring

The goal of the water quality program is to ensure that recovered water from the ASR wells meets all drinking water standards and is of high quality. In addition, the water quality program is designed to test for potential changes in injected, stored and recovered water as it relates to taste, quality, and the potential for clogging the ASR wells.

In principal, the proposed water quality monitoring plan for ASR 3 follows the prescribed requirements outlined in the City's ASR limited license; however, the City has requested a modification of ASR Limited License #005 to allow for a well-field sampling approach for ASR 2 and ASR 3 (refer to the 5-year time extension and modification request for ASR Limited License #005 to which this work plan is attached). In summary, because ASR 3 is located in close proximity to ASR 2 and completed in the same interflows of the basalt aquifer, it is our opinion that there is one water source for both ASR 2 and ASR 3, and that the receiving aquifer is essentially one unit (single injection bubble). This concept is consistent with the ASR rules OAR 690-350-001 (2), which states that *a limited license application may propose ASR testing for a single well or same-aquifer wells in a wellfield*. The area of Bull Mountain hosting ASR 2 and ASR 3, in our

opinion, is a same-aquifer system with both wells in a single ASR wellfield. Table 2 presents a proposed water quality sampling program for future ASR cycle testing that includes ASR 2 and ASR 3. The ASR compliance water samples for the ASR wellfield will be collected at either ASR 2 or ASR 3. The water quality parameters to be included in the planned water quality monitoring program are those presented in our December 17, 2003 memorandum to OWRD (Attachment B).Attachment C includes a Quality Assurance and Quality Control (QA/QC) program for the ASR sampling program.

Table 2. Proposed Water Quality Sampling
Sampling point: Either ASR 2 or ASR 3 wellhead

Water type	Progress Period[1]	Analysis[2]	Comments
Receiving Water	Prior to injection	FP, GC, DBP, Radon	If carryover of stored water occurs, this sample will not represent native groundwater
Source Water	Approximately 30 days prior to injection	FP, GC, DBP, SDWA	
Source Water	35-50% of injection	FP, GC	
Source Water	70-100% of injection	FP, GC, DBP	
Stored Water	Mid-point of storage (variable)	FP, GC, DBP, Radon	Well purged and representative sample of stored water collected
Recovered Water	Approximately 30 days prior to recovery[3]	FP, GC, DBP, SDWA, Radon	
Recovered Water	30-50% of recovery	FP, GC	
Recovered Water	70-100% of recovery	FP, GC, DBP, Radon	

[1] Additional samples may be collected during injection and recovery for testing of geochemical constituents to track the temporal variation in recovered water and to better understand mixing between source water and native groundwater.

[2] FP = Field parameters: pH, temperature, dissolved oxygen, oxygen reduction potential, conductivity
GC = Geochemical constituents
PWB = City of Portland Water Bureau
DBP = Disinfection by-products (including residual chlorine)
SDWA = Safe Drinking Water Act parameters (DHS, DEQ, MML, Federal MCL, SMCL)

[3] The first recovered water sample (collected approximately 30 days prior to recovery) may serve as the 'stored water' sample depending on the length of the storage period for a given ASR cycle.

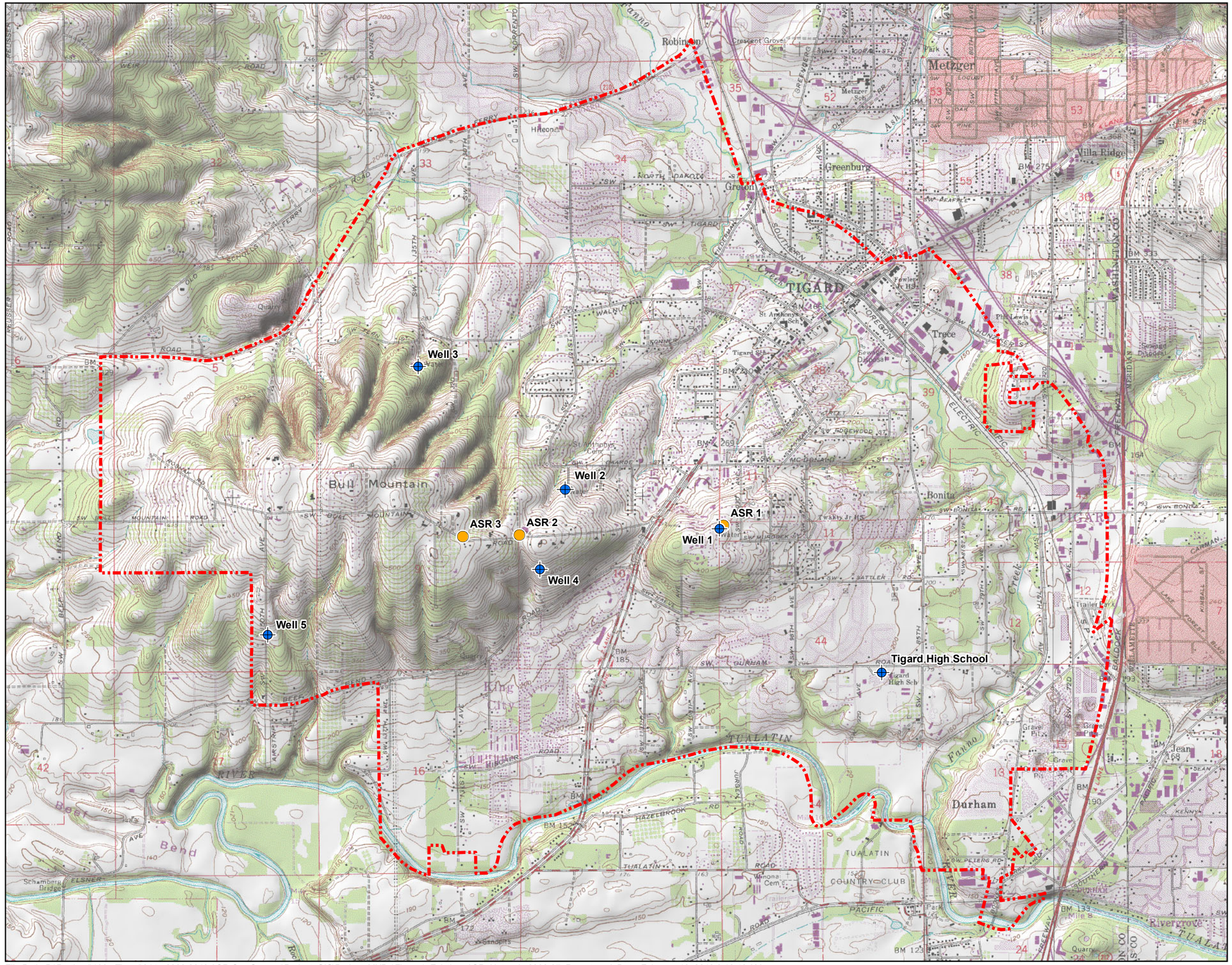


FIGURE 1

Existing ASR Network

City of Tigard

LEGEND

- City of Tigard ASR Well
- ASR Observation Well
- City of Tigard Water Service Area Boundary

N

Scale
1:30,000

0 1250 2500 3750 5000
Feet

MAP NOTES:
Projection: Universal Transverse Mercator, Zone 10 North
Datum: North American Datum of 1983
Date: February 16, 2010
Data Sources: City of Tigard, USGS

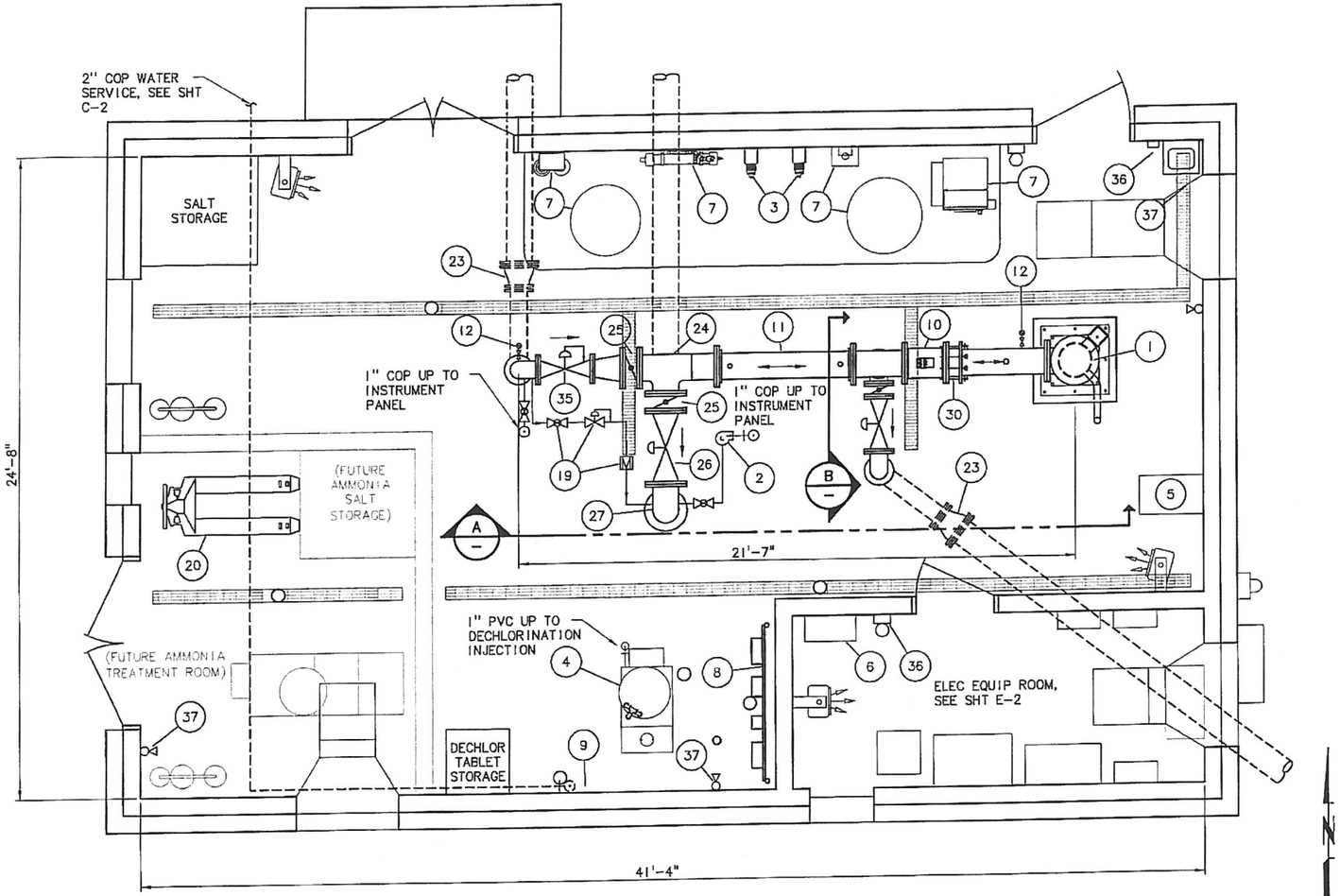
GSI Water Solutions, Inc.

File Path: P:\Portland\103 - Tigard\014 - 2009-2010 ASR Ops Supoort\Project_GIS\Project_MXDs\Figure1_Existing_ASR_Network_2006-07_Report.mxd, Date: February 16, 2010 9:10:40 AM

Pilot Test Work Plan for the City of Tigard ASR 3 Well

Attachment A

Preliminary Floor Plan and Wellhead Design



WELL HOUSE FLOOR PLAN

SCALE: 3/8"=1'-0"

MECHANICAL SCHEDULE

1. P201, DEEP WELL OLS VERT TURBINE PUMP W/PUMP BASE, SEE SPECS & SHT M-2 DETS
2. P202, SAMPLE PUMP
3. P203 & P204, HYPOCHLORITE FEED PUMPS, SEE DET 5, SHT M-2
4. DU201, TABLET DECHLORINATION UNIT, INCLUDES P205
5. P206, HYDRAULIC PUMP FOR CONTROL OF DOWNHOLE ASR VALVE, FCV201
6. CONTROL PANEL FOR DOWNHOLE ASR VALVE, FCV201
7. OHG201, ONSITE HYPOCHLORITE GENERATOR, 24 PPD, W/TRANSFORMER, CONTROL PANEL, BRINE TANK, WATER SOFTENER, ELECTROLYTIC CELLS, STORAGE TANK & BLOWER. VENT CELLS & STORAGE TANK THROUGH ROOF
8. WATER QUALITY INSTRUMENT PANEL FOR ATU201, ACD201, AFC201, APH201 & TT201
9. PW/NPW MANIFOLD, SEE DET 1, SHT M-4
10. 12" MAGNETIC FLOW METER
11. 12" STATIC MIXER
12. PRESS GAUGE & SAMPLE STATION, SEE DET 3, SHT M-3
13. 2" DEEP WELL VERT TURBINE PUMP AIR VALVE ON 2" WELD-O-LET W/BV & COP TO DRAIN
14. 12" WS FLGxPE SPL
15. 12"x8" WS TEE, FLGS AS SHOWN
16. 8" WS 90° BEND, FLGS AS SHOWN
17. 8" FLG BFV
18. FV202, 8" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE-STYLE, PRESSURE SUSTAINING DIAPHRAGM VALVE
19. 2" COP BYPASS W/VALVES & WATER METER- ALIGN BENEATH MAIN PIPING TO MAINTAIN ACCESS TO BFV'S & DIAPHRAM VALVES
20. PALLET JACK
21. 8" DI FLGxPE SPL
22. 8" DI MJ 90° BEND W/ RESTRAINED JOINTS & THRUST BLOCK
23. 12"x8" DI MJ RDCR
24. 12" WS TEE, FLGS AS SHOWN
25. 12" FLG BFV
26. FV204, 12" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE STYLE DIAPHRAGM VALVE
27. 12" WS 90° BEND, FLGxFLG
28. 12" FLG SILENT CV, GLOBE STYLE
29. 12" WS FLGxPE SPL
30. RESTRAINED FCA, SIZE PER PIPE
31. 12" WS FLGxPE SPL
32. 12" DI FLGxPE SPL
33. 12 DI MJ 90° BEND W/ RESTRAINED JOINTS & THRUST BLOCK
34. 12"x8" WS RDCR, FLGxFLG
35. FV203, 8" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE-STYLE, PRESSURE REDUCING DIAPHRAGM VALVE
36. 10 POUND FIRE EXTINGUISHER
37. HOSE BIB, SEE DET 6, SHT M-3

NOTE:

1. FOR HVAC AND PLUMBING PLAN AND EQUIPMENT SCHEDULE, SEE SHEET M-4.

NO.	DATE	BY	REVISION

NOTICE
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

AS DESIGNED
BAH DRAWN
JLH CHECKED

REGISTERED PROFESSIONAL ENGINEER 59853 OREGON JULY 9, 1981 ANDREW SZATKOWSKI
EXPIRES 6-30-06

MSA Murray, Smith & Associates, Inc. Engineers/Planners
121 S.W. Salmon, Suite 900 Portland, Oregon 97204
PHONE 503-225-9010 FAX 503-225-9022

CITY OF TIGARD OREGON

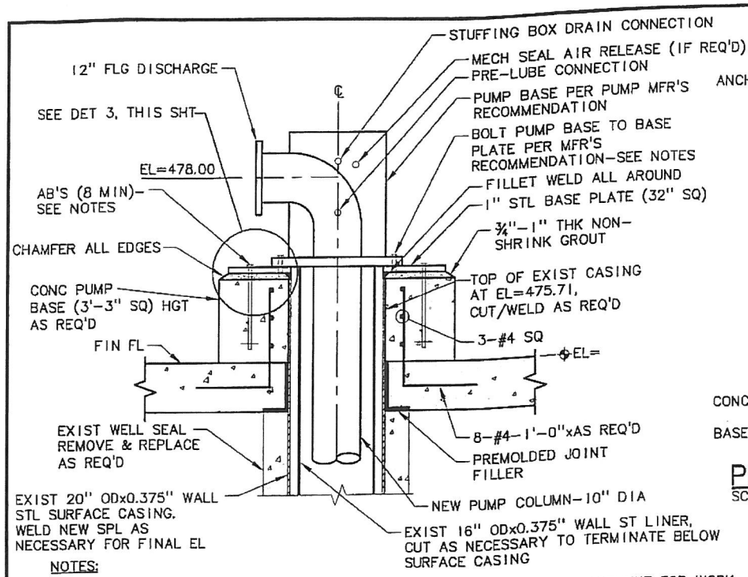
ASR 2 WELL HOUSE

MECHANICAL FLOOR PLAN AND SECTIONS

PROJECT NO.: 03-0603.204 | SCALE: AS SHOWN | DATE: MARCH 2005

SHEET M-1

G:\03\0603\204\CAD\03-0603-204-OR-M-1.dwg M-1 3/29/05 09:14 (hcm)



NOTES:

1. COMPLY WITH ALL REQUIREMENTS OF OREGON WATER RESOURCES DEPARTMENT FOR WORK ON EXISTING WELL.

2. FURNISH AND INSTALL BRASS OR COPPER FITTINGS, PIPING AND VALVING AS REQUIRED TO PROVIDE AIR RELEASE AND DRAIN. TYPICAL EACH PUMP.

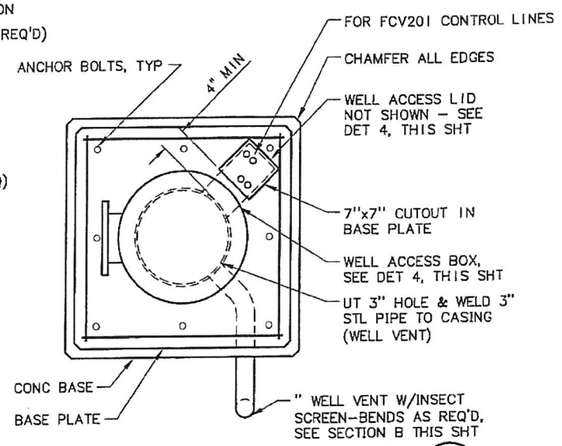
3. ROUTE AIR RELEASE AND DRAIN PIPING TO TRENCH DRAIN. HOLD OUTLET PIPING 6-INCHES OFF FLOOR.

4. ANCHOR BOLTS TO BE ⅞" MINIMUM GALVANIZED STEEL WITH HEX NUTS (8 REQUIRED). LENGTH AND EMBED PER MANUFACTURER REQUIREMENTS.

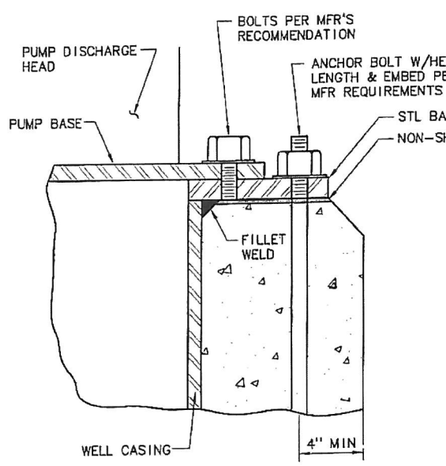
5. PUMP BASE BOLTS TO BE HEX HEAD BOLTS WITH LOCK WASHER, LENGTH AS REQUIRED.

6. WELL VENT AND WELL ACCESS PORTS NOT SHOWN FOR CLARITY. SEE PLAN VIEW OF PUMP BASE, DETAIL 2 THIS SHEET.

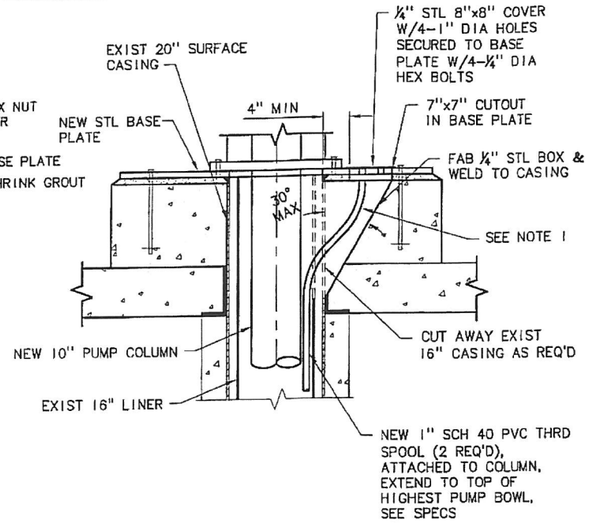
DEEP WELL VERTICAL TURBINE PUMP BASE DETAIL
SCALE: NTS — 1 / M-1



PLAN VIEW - PUMP BASE
SCALE: NTS — 2 / -



PUMP BASE EDGE DETAIL
SCALE: NTS — 3 / -



NOTES:

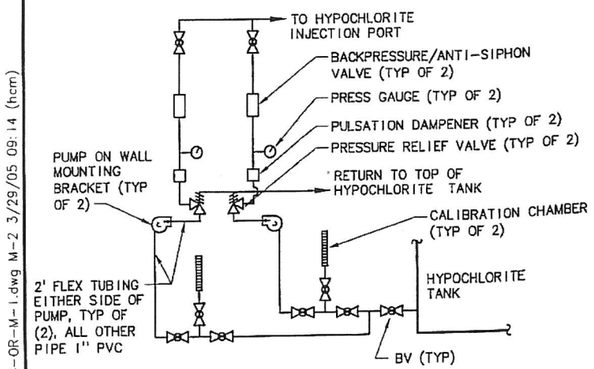
1. HEAT PVC AND FORM LONG RADIUS CURVES CAPABLE OF PASSING LEVEL TRANSMITTING AND LEVEL SENSING PROBES.

2. PROVIDE AND INSTALL 1" CAP ON SPARE HOLE IN COVER.

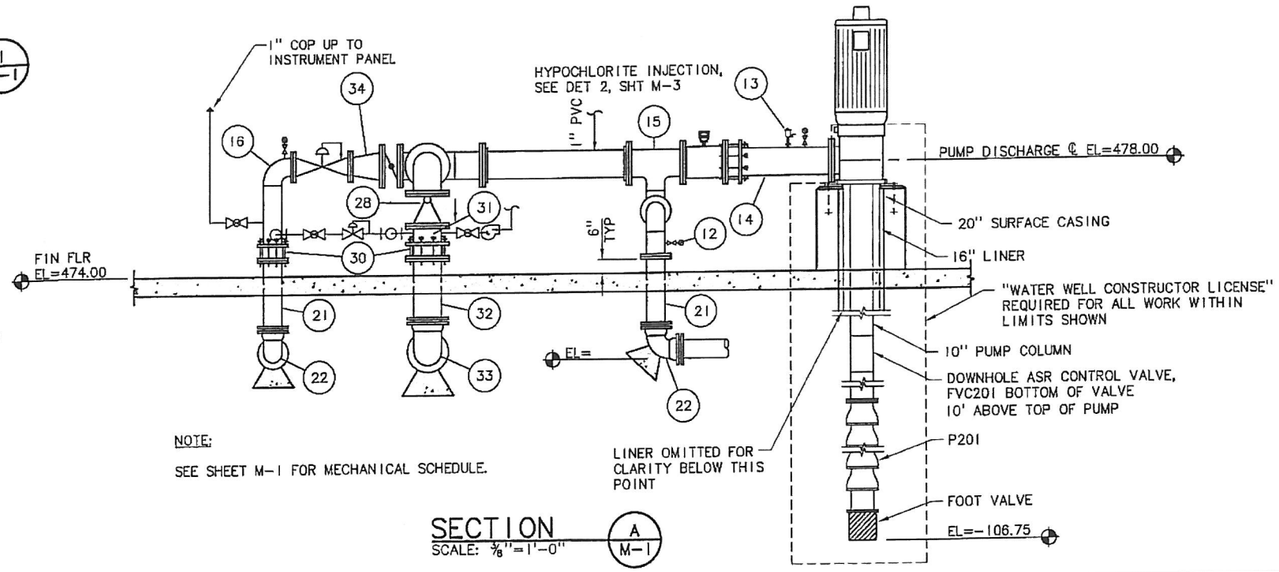
3. INSTALL GROMMET AND CABLE/CONDUIT SUPPORT ON 1" HOLES IN COVER PER TRANSDUCER AND DOWN HOLE CONTROL VALVE SUPPLIER REQUIREMENTS.

4. GRIND ALL INTERIOR EDGES OF ACCESS BOX, BASE PLATE OPENING AND COVER PLATE SMOOTH AND ROUND.

WELL ACCESS BOX
SCALE: NTS — 4 / -



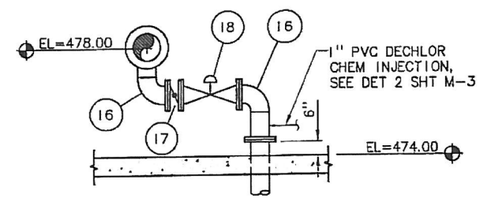
HYPOCHLORITE FEED DETAIL
SCALE: NTS — 5 / M-1



NOTE:

SEE SHEET M-1 FOR MECHANICAL SCHEDULE.

SECTION
SCALE: ⅜"=1'-0" — A / M-1



NOTE:

1. SEE MECHANICAL SCHEDULE ON SHT M-1 FOR KEY NOTES.

SECTION
SCALE: ⅜"=1'-0" — B / M-1

NO.	DATE	BY	REVISION

NOTICE: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

AS DESIGNED | BAH DRAWN | JLH CHECKED

REGISTERED PROFESSIONAL ENGINEER 59893 OREGON JULY 9, 1991 ANDREW SZALKOWSKI — EXPIRES 6-30-06

MSA Murray, Smith & Associates, Inc. Engineers/Planners
121 S.W. Salmon, Suite 900 Portland, Oregon 97204 PHONE 503-225-9010 FAX 503-225-9022

CITY OF TIGARD OREGON

ASR 2 WELL HOUSE

MECHANICAL DETAILS - 1

PROJECT NO.: 03-0603.204 | SCALE: AS SHOWN | DATE: MARCH 2005

SHEET M-2

19 of 29

G:\03\0603\204\CAD\03-0603-204-OR-M-1.dwg M-2 3/29/05 09:14 (hcm)

Pilot Test Work Plan for the City of Tigard ASR 3 Well

Attachment B

Water Quality Parameters

Groundwater Solutions Inc.
3758 SE Milwaukie Ave. Portland, Oregon 97202
ph:503.239.8799 fx:503.239.8940 e:groundwatersolutions.com

December 17, 2003

Mr. Donn Miller
Oregon Department of Water Resources
725 Summer Street NE, Suite A
Salem, OR 97301-1271

Subject: Updated Water Quality Testing Requirements for ASR Projects

Dear Donn,

Over the past several years the federal and state Drinking Water Quality testing requirements have undergone several changes. These changes impact the required list of testing parameters for our ASR projects. This letter is intended to clarify the current list of the required water quality parameters that is based upon the current federal and state testing requirements. Table 1 includes current updated drinking water quality parameters as well as the typical additional ASR parameters. Prior to our adopting Table 1 for our ASR projects, we would appreciate input from OWRD, DHS, and DEQ. However in order to start this year's injection cycle for the Beaverton and Tigard ASR projects, we began using updated analyte list. If changes are needed we will collect these additional parameters at that time.

Table 1 is based on the most recent federal and state water quality testing requirements, which includes:

- **Oregon Department of Health –Drinking Water Program** (OAR 333-061-0030, 0031 & 0036, Community & Non-Transient Water Systems Routine Chemical Monitoring)
- **Environmental Protection Agency** (EPA 816-F-03-016: National Primary Drinking Water Standards)
- **Oregon Department of Environmental Quality** (OAR 340-40-0090)

Recent changes to the drinking water requirements include elimination and inclusion of the following water quality parameters:

Eliminated Parameters:

- Chloroform – May 2000
- Unregulated Synthetic Organic Compounds (SOC)
- Unregulated Volatile Organic Compounds (VOC)
- Unregulated Contaminant Monitoring Regulations (UCMRs) - Jan. 2001 through Dec 2003

New Parameters:

- Uranium, Combined Radium 226/228 and Beta Photon Emitters (effective Dec. 8, 2003);
- Disinfectant By-Products (effective Jan. 2001 and Jan. 2004),

It is our intention to continue to monitor water quality standards and regulations and modify our drinking water quality testing parameter list to reflect the current rules and laws and update this table as necessary.

This updated analyte list (Table 1) will be used on the following ASR projects:

- Beaverton
- Tigard
- Tualatin
- Salem
- Baker City
- Madison Farms
- McCarty Ranch

Thank you for any insight you may be able to provide. If you have any comments, do not hesitate to contact us at 503-239-8799.

Sincerely,
Groundwater Solutions, Inc.

Bruce Brody-Heine
Senior Hydrogeologist

Enclosed: Table 1

Cc. Dennis Nelson (Oregon DHS)
Phil Richerson (DEQ – Eastern Region)
Rodney Wieck (DEQ – Northwest Region)

Table 1
Summary of Native Groundwater and ASR Source Water Quality Testing Parameters

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL
Bacteriological	Fecal Coliforms/E.Coli				
	Total Coliform	<1/100 ML	CFU/100 ml	MML	
Disinfection By-Products					
THM	Chloroform (Trichloromethane)	None	mg/L	URC	0.0005
THM	Bromodichloromethane	None	mg/L	None	0.0005
THM	Dibromochloromethane	None	mg/L	None	0.0005
THM	Bromoform (Tribromomethane)	None	mg/L	URC	0.0005
	Total Trihalomethanes	0.08	mg/L	MCL, MML	--
HAA	Monochloroacetic Acid	None	mg/L	None	0.002
HAA	Dichloroacetic Acid	None	mg/L	None	0.001
HAA	Trichloroacetic Acid	None	mg/L	None	0.001
HAA	Monobromoacetic Acid	None	mg/L	None	0.001
HAA	Dibromoacetic Acid	None	mg/L	None	0.001
	Total Haloacetic Acids	0.06	mg/L	MCL	
	Chlorite (only for plants using chlorine dioxide)	1	mg/L	MCL	
	Bromate (only for plants using ozone)	0.01	mg/L	MCL	NT
Field Parameters	Temperature	None	Celsius	None	NA
	Conductivity	None	mS/cm	None	NA
	Dissolved Oxygen	None	mg/L	None	NA
	pH	6 - 8.5	Units	SMCL	NA
	Turbidity	1	NTU	MCL, MML	NA
	ORP	None	mV	None	NA
Geochemical	Bicarbonate	None	mg/L	None	2
	Calcium	None	mg/L	None	0.1
	Carbonate	None	mg/L	None	2
	Chloride	250	mg/L	SMCL	1
	Hardness (as CaCO3)	250	mg/L	SMCL	4
	Magnesium	None	mg/L	None	0.05
	Nitrate as N	10	mg/L	MML	0.5
	Nitrite as N	1	mg/L	MCL	0.01
	Total Nitrate-Nitrite	10	mg/L	MML	--
	Potassium	None	mg/L	None	0.1
	Silica	None	mg/L	None	0.2
	Sodium	20	mg/L	URC, SMCL	0.05
	Sulfate	250	mg/L	URC, SMCL	5
	Total Alkalinity	250	mg/L	SMCL	2
	Total Dissolved Solid	500	mg/L	SMCL	0.7
	Total Organic Carbon	None	mg/L	None	0.5
	Total Suspended Solids	None	mg/L	None	2
Metals	Aluminum	0.05	mg/L	SMCL	0.05
	Antimony	0.006	mg/L	MCL	0.001
	Arsenic	0.05	mg/L	MCL, MML	0.002
	Barium	1	mg/L	MCL, MML	0.05
	Beryllium	0.004	mg/L	MCL	0.0005
	Cadmium	0.005	mg/L	MCL, MML	0.001
	Chromium	0.05	mg/L	MCL, MML	0.002
	Copper	1.3	mg/L	MCL, MML	0.005
	Iron (Total)	None	mg/L	None	0.05
	Iron (Dissolved)	0.3	mg/L	SMCL	0.05
	Lead	0.015	mg/L	MCL, MML	0.001
	Manganese (Total)	None	mg/L	None	0.002
	Manganese (Dissolved)	0.05	mg/L	SMCL	0.002
	Mercury	0.002	mg/L	MCL, MML	0.0004
	Nickel	0.1	mg/L	MCL	0.004
	Selenium	0.01	mg/L	MCL, MML	0.002
	Silver	0.05	mg/L	MML, SMCL	0.005
	Thallium	0.002	mg/L	MCL	0.0006
	Zinc	5	mg/L	SMCL	0.01
Miscellaneous	Odor	3	TON	SMCL	1 ton
	Color	15	ACU	SMCL	5 color units
	Methylene Blue Active Substance	0.5	mg/L	SMCL	0.05
	Corrosivity (Langelier Saturation Index)	Non-Corrosive	mg/L	SMCL	--
	Asbestos	7	MFL	MML	--
	Cyanide (as free cyanide)	0.2	mg/l	MCL	
	Fluoride	2	mg/L	MCL, MML, SMCL	0.5
Radionuclides	Combined Radium 226/228	5	pCi/L	MCL, MML	
	Uranium [1]	0.03	mg.L	MCL	
	Gross Alpha	15	pCi/L	MCL, MML	1.79
	Beta/Photon emitters [2]	4	mrem/yr	MCL	
	Gross Beta	50	pCi/L	MML	2.83
	I - 131 [3]	3	pCi/L	MML	--
	Sr-90 [3]	8	pCi/L	MML	--
	Tritium 3	20000	pCi/L	MML	--
	Radon		pCi/L	None	--

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL
Synthetic Organic Compounds (SOCs)					
Regulated SOCs	2,4,5-TP (Silvex)	0.01	mg/L	MCL, MML	0.0004
	2,4-D	0.07	mg/L	MCL, MML	0.0002
	Alachlor (Lasso)	0.002	mg/L	MCL	0.0004
	Atrazine	0.003	mg/L	MCL	0.0002
	Benzo(a)Pyrene	0.0002	mg/L	MCL	0.00004
	BHC-gamma (Lindane)	0.0002	mg/L	MCL, MML	0.00002
	Carbofuran	0.04	mg/L	MCL	0.001
	Chlordane	0.002	mg/L	MCL	0.0004
	Dalapon	0.2	mg/L	MCL	0.002
	Di(2-ethylhexyl)adipate *(adipates)*	0.4	mg/L	MCL	0.001
	Di(2-ethylhexyl)phthalate *(phthalates)*	0.006	mg/L	MCL	0.001
	Dibromochloropropane (DBCP)	0.0002	mg/L	MCL	0.00002
	Dinoseb	0.007	mg/L	MCL	0.0004
	Dioxin	3x10-8	mg/L	MCL	
	Diquat	0.02	mg/L	MCL	0.0004
	Ethylene Dibromide (EDB)	0.00005	mg/L	MCL	0.00001
	Endothall	0.1	mg/L	MCL	0.01
	Endrin	0.0002	mg/L	MCL, MML	0.00002
	Glyphosate	0.7	mg/L	MCL	0.01
	Heptachlor	0.0004	mg/L	MCL	0.00004
	Heptachlor Epoxide	0.0002	mg/L	MCL	0.00002
	Hexachlorobenzene (HCB)	0.001	mg/L	MCL	0.0001
	Hexachlorocyclopentadiene	0.05	mg/L	MCL	0.0002
	Methoxychlor	0.04	mg/L	MCL, MML	0.0002
	Polychlorinated Biphenyls (PCBs)	0.0005	mg/L	MCL	0.0002
	Pentachlorophenol	0.001	mg/L	MCL	0.00008
	Picloram	0.5	mg/L	MCL	0.0002
	Simazine	0.004	mg/L	MCL	0.0001
	Toxaphene	0.003	mg/L	MCL, MML	0.001
	Vydate (Oxamyl)	0.2	mg/L	MCL	0.002
Volatile Organic Compounds (VOCs)					
Regulated VOCs	1,1,1-Trichloroethane	0.2	mg/L	MCL, MML	0.0005
	1,1,2-Trichloroethane	0.005	mg/L	MCL	0.0005
	1,1-Dichloroethylene	0.007	mg/L	MCL, MML	0.0005
	1,2,4-Trichlorobenzene	0.07	mg/L	MCL	0.0005
	1,2-Dichlorobenzene (o)	0.6	mg/L	MCL	0.0005
	1,2-Dichloroethane (EDC)	0.005	mg/L	MCL, MML	0.0005
	1,2-Dichloropropane	0.005	mg/L	MCL	0.0005
	1,4-Dichlorobenzene (p)	0.075	mg/L	MCL, MML	0.0005
	Benzene	0.005	mg/L	MCL, MML	0.0005
	Carbon Tetrachloride	0.005	mg/L	MCL, MML	0.0005
	Chlorobenzene (monochlorobenzene)	0.1	mg/L	MCL	0.0005
	cis-1,2-Dichloroethylene	0.07	mg/L	MCL	0.0005
	Ethylbenzene	0.7	mg/L	MCL	0.0005
	Dichloromethane (methylene chloride)	0.005	mg/L	MCL	0.0005
	Styrene	0.1	mg/L	MCL	0.0005
	Tetrachloroethylene	0.005	mg/L	MCL	0.0005
	Toluene	1	mg/L	MCL	0.0005
	trans-1,2-Dichloroethylene	0.1	mg/L	MCL	0.0005
	Trichloroethylene	0.005	mg/L	MCL, MML	0.0005
	Vinyl chloride	0.002	mg/L	MCL, MML	0.0005
	Total Xylenes	10	mg/L	MCL	0.0005

NOTE
mg/L = milligram per liter
MDL = Method Detection Limit
ND = Not detected at concentrations greater than the MDL
NT = Analyte not tested
MCL = Federal maximum contmainant level for drinking water
MML = DEQ's maximum measurable levels for groundwater
SMCL = Federal secondary maximum contaminant levels for drinking water
UCMR = EPA unregulated contaminant monitoring regulations for drinking water
Samples are unfiltered unless noted (i.e., dissolved)
1 = Combined Radium 226/228 and Uranium required after December 2003
2 = Only need to analyze if in a vunerable area per OAR 333-61-0036, 6(b)(A) (i.e., near man-made radioactive sources, such as nuclear facilities - currently only selected systems along Columbia River classified as vunerable)
3 = These compounds would be analyzed if Gross Alpha or Beta exceed an MCL.

likely not required for ASR unless specifically requested (generally depends upon the location of project within state)

Pilot Test Work Plan for the City of Tigard ASR 3 Well

Attachment C

Quality Assurance and Quality Control (QA/QC)

Quality Assurance and Quality Control Plan

Introduction

This quality assurance and quality control (QA/QC) plan describes water sampling QA/QC procedures that will be performed during the City of Tigard ASR pilot testing program. The purpose of the QA/QC plan is to obtain water quality data that are valid representations of the water quality at each sampling location.

Field QA/QC

QA/QC procedures that will be used in the field during the ASR pilot testing program include field equipment calibration, field record keeping, and chain-of-custody documentation. No duplicate samples will be collected in the field. If lab testing results indicate that a parameter has an unexpectedly high concentration approaching the Maximum Contaminant Level (MCL) or Maximum Measurable Level (MML), injection or pumping will be stopped and the location will be resampled as soon as possible. Each element of the Field QA/QC is described below.

Field Equipment Calibration

Field meters require calibration to ensure accurate and precise measurement of field parameters. The field meters will be calibrated prior to each sampling event and subsequently operated in a manner consistent with the manufacturer's recommendations.

Field Record Keeping

The sampling technician will record field observations and measurements during sampling. The following information will be recorded on the form for each sampling point:

- Time of day and date
- Name of person performing the sampling
- Location of sampling point
- Field parameter values (pH, temperature, and conductivity) collected during sampling
- Appearance of sample
- Thermal and chemical preservation (if any)

If groundwater samples are collected from wells, the following additional information will be recorded:

- Depth to groundwater
- Field parameter values collected during purging intervals
- Purging time and volume of water purged

Sample Labels

A sample label will be secured to each water sample container. The following information will be included on the sample labels:

- Project location

- Sample number (e.g., well ID# and date)
- Name of person collecting the sample
- Date and time of sample collection
- Type of preservative (if any)

Chain-of-Custody

A chain-of-custody form will be used to track possession of each sample and document the requested analyses. The following procedure will be used regarding chain-of-custody records.

1. After collecting the samples, the sampling technician will complete the chain-of-custody form.

2. The chain-of-custody record will accompany the samples from the field to the laboratory.

3. Each individual having samples in his/her custody must ensure that the samples are not tampered with and that the chain-of-custody record is completed upon sample transfer.

4. A copy of the completed forms will be retained in the project files.

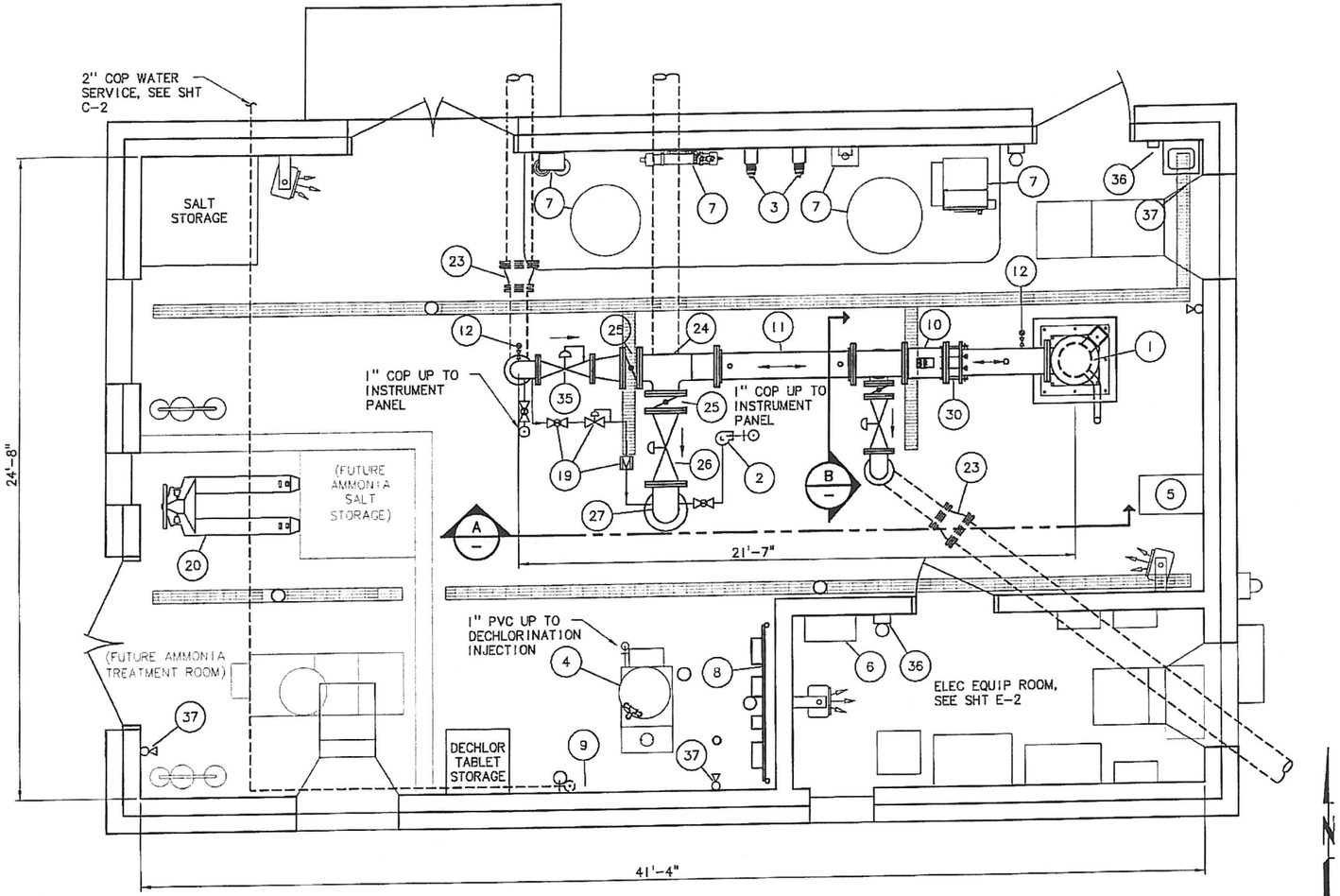
Laboratory Quality Assurance Program

Samples collected during the pilot testing program will be analyzed by an analytical laboratory certified by the Drinking Water Laboratory Certification Program (DWLCP) or the Oregon Environmental Laboratory Accreditation Program (ORELAP). DWLCP is in the process of being phased out and replaced by ORELAP, which is recognized by the U.S. Environmental Protection Agency's National Environmental Laboratory Accreditation Program (NELAP) to accredit environmental testing laboratories to national standards as adopted by the National Environmental Laboratory Accreditation Conference (NELAC).

The analytical laboratory will use trip blanks, method blanks, spikes, duplicates, surrogates, and control samples in each analytical batch containing the City's samples being analyzed or at a frequency of at least one in every 20 samples, depending upon the analysis being performed. The results from these procedures will accompany the sample test results. A copy of the analytical laboratory's quality assurance manual is available upon request.

Attachment B

Preliminary Floor Plan and Wellhead Design



WELL HOUSE FLOOR PLAN

SCALE: 3/8"=1'-0"

MECHANICAL SCHEDULE

1. P201, DEEP WELL OLS VERT TURBINE PUMP W/PUMP BASE, SEE SPECS & SHT M-2 DETS
2. P202, SAMPLE PUMP
3. P203 & P204, HYPOCHLORITE FEED PUMPS, SEE DET 5, SHT M-2
4. DU201, TABLET DECHLORINATION UNIT, INCLUDES P205
5. P206, HYDRAULIC PUMP FOR CONTROL OF DOWNHOLE ASR VALVE, FCV201
6. CONTROL PANEL FOR DOWNHOLE ASR VALVE, FCV201
7. OHG201, ONSITE HYPOCHLORITE GENERATOR, 24 PPD, W/TRANSFORMER, CONTROL PANEL, BRINE TANK, WATER SOFTENER, ELECTROLYTIC CELLS, STORAGE TANK & BLOWER. VENT CELLS & STORAGE TANK THROUGH ROOF
8. WATER QUALITY INSTRUMENT PANEL FOR ATU201, ACD201, AFC201, APH201 & TT201
9. PW/NPW MANIFOLD, SEE DET 1, SHT M-4
10. 12" MAGNETIC FLOW METER
11. 12" STATIC MIXER
12. PRESS GAUGE & SAMPLE STATION, SEE DET 3, SHT M-3
13. 2" DEEP WELL VERT TURBINE PUMP AIR VALVE ON 2" WELD-O-LET W/BV & COP TO DRAIN
14. 12" WS FLGxPE SPL
15. 12"x8" WS TEE, FLGS AS SHOWN
16. 8" WS 90° BEND, FLGS AS SHOWN
17. 8" FLG BFV
18. FV202, 8" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE-STYLE, PRESSURE SUSTAINING DIAPHRAGM VALVE
19. 2" COP BYPASS W/VALVES & WATER METER- ALIGN BENEATH MAIN PIPING TO MAINTAIN ACCESS TO BFV'S & DIAPHRAM VALVES
20. PALLET JACK
21. 8" DI FLGxPE SPL
22. 8" DI MJ 90° BEND W/ RESTRAINED JOINTS & THRUST BLOCK
23. 12"x8" DI MJ RDCR
24. 12" WS TEE, FLGS AS SHOWN
25. 12" FLG BFV
26. FV204, 12" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE STYLE DIAPHRAGM VALVE
27. 12" WS 90° BEND, FLGxFLG
28. 12" FLG SILENT CV, GLOBE STYLE
29. 12" WS FLGxPE SPL
30. RESTRAINED FCA, SIZE PER PIPE
31. 12" WS FLGxPE SPL
32. 12" DI FLGxPE SPL
33. 12 DI MJ 90° BEND W/ RESTRAINED JOINTS & THRUST BLOCK
34. 12"x8" WS RDCR, FLGxFLG
35. FV203, 8" ELECTRICALLY CONTROLLED, HYDRAULICALLY OPERATED, GLOBE-STYLE, PRESSURE REDUCING DIAPHRAGM VALVE
36. 10 POUND FIRE EXTINGUISHER
37. HOSE BIB, SEE DET 6, SHT M-3

NOTE:

1. FOR HVAC AND PLUMBING PLAN AND EQUIPMENT SCHEDULE, SEE SHEET M-4.

NO.	DATE	BY	REVISION

NOTICE
0 ½ 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

AS DESIGNED
BAH DRAWN
JLH CHECKED

REGISTERED PROFESSIONAL ENGINEER 59853 OREGON JULY 9, 1981 ANDREW SZATKOWSKI
EXPIRES 6-30-06

MSA Murray, Smith & Associates, Inc. Engineers/Planners
121 S.W. Salmon, Suite 900 Portland, Oregon 97204
PHONE 503-225-9010 FAX 503-225-9022

CITY OF TIGARD OREGON

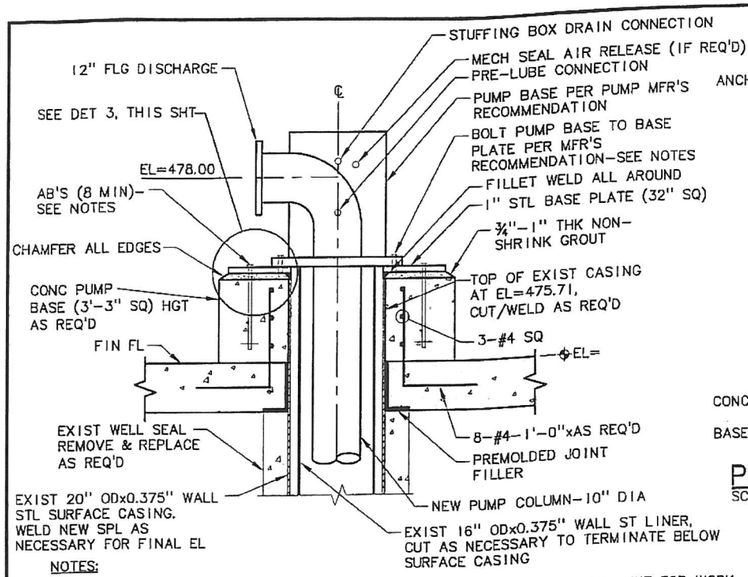
ASR 2 WELL HOUSE

MECHANICAL FLOOR PLAN AND SECTIONS

PROJECT NO.: 03-0603.204 | SCALE: AS SHOWN | DATE: MARCH 2005

SHEET M-1

G:\03\0603\204\CAD\03-0603-204-OR-M-1.dwg M-1 3/29/05 09:14 (hcm)



NOTES:

1. COMPLY WITH ALL REQUIREMENTS OF OREGON WATER RESOURCES DEPARTMENT FOR WORK ON EXISTING WELL.

2. FURNISH AND INSTALL BRASS OR COPPER FITTINGS, PIPING AND VALVING AS REQUIRED TO PROVIDE AIR RELEASE AND DRAIN. TYPICAL EACH PUMP.

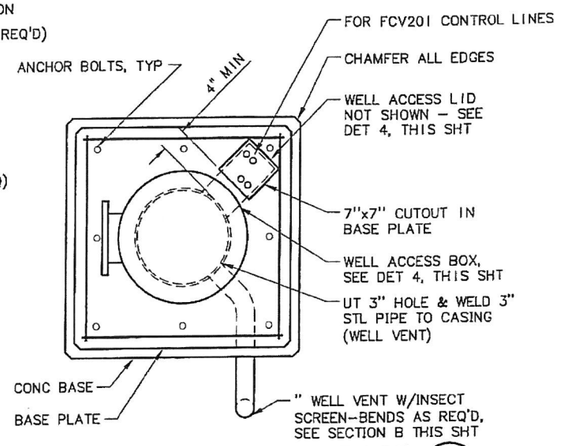
3. ROUTE AIR RELEASE AND DRAIN PIPING TO TRENCH DRAIN. HOLD OUTLET PIPING 6-INCHES OFF FLOOR.

4. ANCHOR BOLTS TO BE ⅞" MINIMUM GALVANIZED STEEL WITH HEX NUTS (8 REQUIRED). LENGTH AND EMBED PER MANUFACTURER REQUIREMENTS.

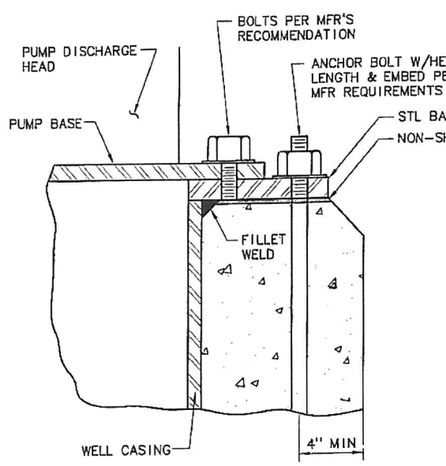
5. PUMP BASE BOLTS TO BE HEX HEAD BOLTS WITH LOCK WASHER, LENGTH AS REQUIRED.

6. WELL VENT AND WELL ACCESS PORTS NOT SHOWN FOR CLARITY. SEE PLAN VIEW OF PUMP BASE, DETAIL 2 THIS SHEET.

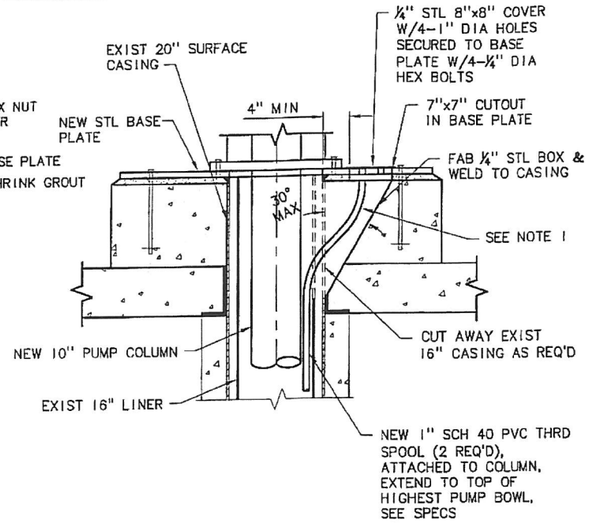
DEEP WELL VERTICAL TURBINE PUMP BASE DETAIL
SCALE: NTS — 1 / M-1



PLAN VIEW - PUMP BASE
SCALE: NTS — 2 / -



PUMP BASE EDGE DETAIL
SCALE: NTS — 3 / -



NOTES:

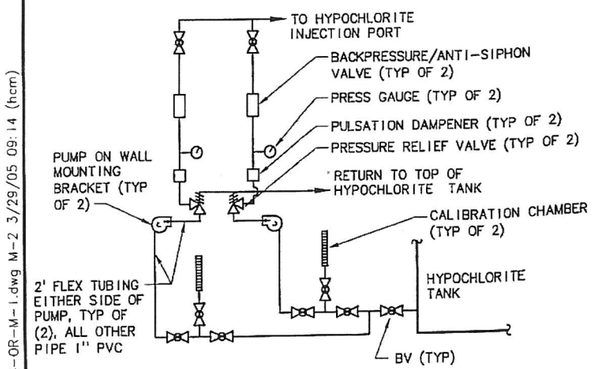
1. HEAT PVC AND FORM LONG RADIUS CURVES CAPABLE OF PASSING LEVEL TRANSMITTING AND LEVEL SENSING PROBES.

2. PROVIDE AND INSTALL 1" CAP ON SPARE HOLE IN COVER.

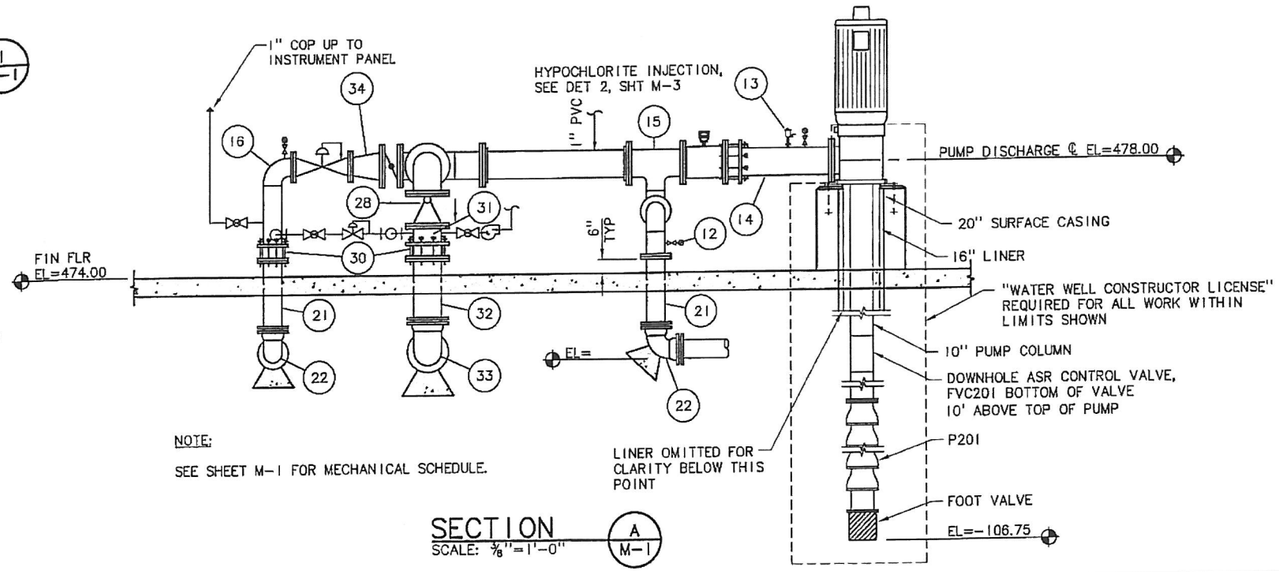
3. INSTALL GROMMET AND CABLE/CONDUIT SUPPORT ON 1" HOLES IN COVER PER TRANSDUCER AND DOWN HOLE CONTROL VALVE SUPPLIER REQUIREMENTS.

4. GRIND ALL INTERIOR EDGES OF ACCESS BOX, BASE PLATE OPENING AND COVER PLATE SMOOTH AND ROUND.

WELL ACCESS BOX
SCALE: NTS — 4 / -



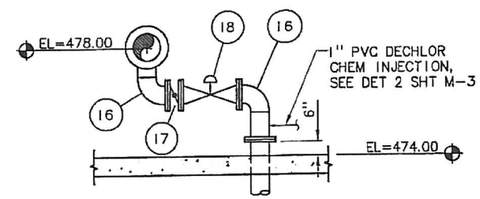
HYPOCHLORITE FEED DETAIL
SCALE: NTS — 5 / M-1



NOTE:

SEE SHEET M-1 FOR MECHANICAL SCHEDULE.

SECTION
SCALE: ⅜"=1'-0" — A / M-1



NOTE:

1. SEE MECHANICAL SCHEDULE ON SHT M-1 FOR KEY NOTES.

SECTION
SCALE: ⅜"=1'-0" — B / M-1

NO.	DATE	BY	REVISION

NOTICE: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

AS DESIGNED | BAH DRAWN | JLH CHECKED

REGISTERED PROFESSIONAL ENGINEER 59893 OREGON JULY 9, 1991 ANDREW SZALKOWSKI — EXPIRES 6-30-06

MSA Murray, Smith & Associates, Inc. Engineers/Planners
121 S.W. Salmon, Suite 900 Portland, Oregon 97204 PHONE 503-225-9010 FAX 503-225-9022

CITY OF TIGARD OREGON

ASR 2 WELL HOUSE

MECHANICAL DETAILS - 1

PROJECT NO.: 03-0603.204 | SCALE: AS SHOWN | DATE: MARCH 2005

SHEET M-2

19 of 29

G:\03\0603\204\CAD\03-0603-204-OR-M-1.dwg M-2 3/29/05 09:14 (hcm)

Attachment C

OWRD Well Logs

WASH 011590

RECEIVED
OCT 27 1966
STATE ENGINEER
SALEM, OREGON

2/1w-10 (E M)

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Please type or print)

State Well No. ~~Well No. 4~~
State Permit No.

(1) OWNER:
Name Tigard Water District
Address 8841 S.W. COMMERCIAL ST.
TIGARD OREGON 97223

(2) LOCATION OF WELL:
County WASHINGTON Driller's well number #4
¼ NW ¼ Section 10 T. 2S R. 1W W.M.
Bearing and distance from section or subdivision corner
North of S.W. Bend West of S.W. Pacific Highway near the King City Development

Well #4

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☒ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(6) CASING INSTALLED:
Threaded ☐ Welded ☒
2½" Diam. from ..... ft. to ..... ft. Gage .....
..." Diam. from ..... ft. to ..... ft. Gage .....
12" Diam. from 0 ft. to 242 ft. Gage .330

(7) PERFORATIONS:
Perforated? ☐ Yes ☒ No
Type of perforator used
Size of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

(8) SCREENS:
Well screen installed? ☐ Yes ☐ No
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... Set from ..... ft. to ..... ft.
Diam. ..... Slot size ..... Set from ..... ft. to ..... ft.

(9) CONSTRUCTION:
Well seal—Material used in seal Cement, sand & gravel
Depth of seal 242 ft. Was a packer used? no
Diameter of well bore to bottom of seal 16 in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth .....
Was a drive shoe used? ☐ Yes ☒ No
Was well gravel packed? ☐ Yes ☒ No Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off

(10) WATER LEVELS:
Static level 257 ft. below land surface Date
Artesian pressure lbs. per square inch Date

(11) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom?
Yield: 250 gal./min. with 33 ft. drawdown after 8 hrs.
" 303 " 60 " 8 "
" 360 " 173 " 8 "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 56 Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG:
Diameter of well below casing 12"
Depth drilled 725 ft. Depth of completed well 725 ft.
Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Clay, brown w/grey rock	0	25
Clay & broken rock	25	71
Rock, black	71	103
Rock, brown soft	103	111
~~Rock~~, red black	111	141
Clay, red	141	146
Rock, brown soft	146	161
Rock, black hard	161	210
Rock, blue	210	242
Rock, brown	242	320
Rock, red	320	360
Rock, brown	360	389
Rock, red	389	421
Rock, brown	421	429
Rock, blue	429	436
Clay, brown	436	438
Rock, brown	438	460
Rock, blue	460	488
Rock, black, softer	488	500
Rock, blue	500	585
Rock, blue, hard	585	688
Rock, black, coarse	688	695
Rock, brown, reddish(w.brg)	695	712
Basalt, grey, hard	712	725

Work started Feb. 1st. 1966 Completed Aug. 9 1966
Date well drilling machine moved off of well Aug. 15 1966

(13) PUMP:
Manufacturer's Name .....
Type: ..... H.P. .....

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME HAAKON BOTTNER DRILLING COMPANY
(Person, firm or corporation) (Type or print)
Address 3424 S.E. 17th. AVENUE
PORTLAND, OREGON 97236
Drilling Machine Operator's License No. 246 & 380
[Signed] Haakon Bottner
(Water Well Contractor)
Contractor's License No. 109 Date ....., 19....

(USE ADDITIONAL SHEETS IF NECESSARY)

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

G-3301 NC

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

RECEIVED JAN 5 1968 STATE ENGINEER SALEM, OREGON

State Well No. 2/1W-10
State Permit No. Deepening

Well #4 WASH

011591

(1) OWNER:
Name TIGARD WATER DISTRICT
Address 8841 S.W. COMMERCIAL ST
TIGARD, OREGON 97223

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☒ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED:
Threaded ☐ Welded ☐
..... " Diam. from ..... ft. to ..... ft. Gage .....
..... " Diam. from ..... ft. to ..... ft. Gage .....
..... " Diam. from ..... ft. to ..... ft. Gage .....

PERFORATIONS:
Perforated? ☐ Yes ☒ No.
Type of perforator used
Size of perforations in. by in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... Set from ..... ft. to ..... ft.
Diam. ..... Slot size ..... Set from ..... ft. to ..... ft.

(8) WATER LEVEL: Completed well.
Static level 268 ft. below land surface Date
Artesian pressure lbs. per square inch Date

(9) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Bottner Drilling
Yield: 230 gal./min. with 142 ft. drawdown after 1 hrs.
" 265 " " 209 " " 8 "
" 305 " " 259 " " 7 "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☐ Yes ☒ No

(10) CONSTRUCTION:
Well seal—Material used .....
Depth of seal ..... ft.
Diameter of well bore to bottom of seal ..... in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth .....
Was a drive shoe used? ☐ Yes ☐ No
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

(11) LOCATION OF WELL:
County Washington Driller's well number
¼ N.W. ¼ Section 10 T. 2S R. 1W W.M.
Bearing and distance from section or subdivision corner

(12) WELL LOG:
Diameter of well below casing 12" to 765'--10" from 765 to bottom
Depth drilled 197 ft. Depth of completed well 925 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
Basalt, black hard	725	746	
" gray, softer	746	761	
" black, hard	761	798	
" brown, soft	798	802	
" black, hard	802	837	
Clay, white	837	839	
Rock, gray Mdm. hard	839	846	
Basalt, black, hard	846	895	
" , black, softer	895	906	
Rock, black w/ clay seams	906	914	
Rock, black broken caving	914	925	

Work started May 8 1967 Completed Sept. 26 1967
Date well drilling machine moved off of well Sept. 29 1967

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] H. Bottner Date ....., 19.....
(Drilling Machine Operator)
Drilling Machine Operator's License No. 246, 463, 431

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME HAAKON BOTTNER DRILLING COMPANY
(Person, firm or corporation) (Type or print)
Address 3424 S.E. 17th th. AVENUE PORTLAND, ORE.
[Signed] Haakon Bottner
(Water Well Contractor)
Contractor's License No. 109 Date Oct. 31, 1967

(USE ADDITIONAL SHEETS IF NECESSARY)

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

WASH 011479

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

RECEIVED
JUL 2 1968
STATE ENGINEER
SALEM, OREGON

State Well No. 2/1W-5K
Permit No.

(1) OWNER:
Name G. C. CACH
Address 15170 SW SUNRISE LANE - TIGARD ORE.

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☒ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☒ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED:
Threaded ☐ Welded ☐
" Diam. from NONE ft. to ft. Gage
" Diam. from DEEPENING OF ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS:
Perforated? ☐ Yes ☒ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WATER LEVEL: Completed well.
Static level 368 ft. below land surface Date 6-24-68
Artesian pressure lbs. per square inch Date

(9) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? OPERATOR
Yield: 10 gal./min. with 162 ft. drawdown after 1 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 53° Was a chemical analysis made? ☐ Yes ☒ No

(10) CONSTRUCTION:
Well seal—Material used
Depth of seal ft.
Diameter of well bore to bottom of seal in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth
Was a drive shoe used? ☐ Yes ☐ No
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(11) LOCATION OF WELL:
County WASH Driller's well number 81
NW ¼ SE ¼ Section 5 T. 2S R. 1W W.M.
Bearing and distance from section or subdivision corner

(12) WELL LOG:
Diameter of well below casing 6
Depth drilled 165 ft. Depth of completed well 530 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
SOFT GRAY BASALT	365	393	
HARD GRAY BASALT	393	415	
SOFT RED & BROWN BASALT	415	425	
BROWN BROKEN BASALT	425	432	
HARD GRAY BASALT	432	458	
BROWN & GRAY BROKEN BASALT	458	482	
HARD GRAY BASALT	482	510	
BROWN WEATHERED (WATER)	510	522	368
GRAY BASALT & MUD SEAMS	522	530	

Work started 6-21 1968 Completed 6-24 1968
Date well drilling machine moved off of well 6-24 1968

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Raymond A. Bucher Date 6-24, 1968
(Drilling Machine Operator)
Drilling Machine Operator's License No. 305

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME B & S Drilling Co
(Person, firm or corporation) (Type or print)
Address RT 3 BOX 271A SHERWOOD ORE.
[Signed] Raymond A. Bucher
(Water Well Contractor)
Contractor's License No. 404 Date 6-24, 1968

(USE ADDITIONAL SHEETS IF NECESSARY)