

ADWR'S GROUNDWATER SITE INVENTORY WEB APPLICATION; A USEFUL TOOL FOR ARIZONA'S HYDROLOGISTS

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ABSTRACT

In a continuing effort to make groundwater data available to water professionals in Arizona, the Arizona Department of Water Resources has created a web application that allows users to search, view, and download all Groundwater Site Inventory (GWSI) data. The web application consists of five distinct web pages that interact with each other: a search wizard page, a map page, a well information page, a hydrograph page, and an automated well hydrograph page. The search wizard page allows the user to search for GWSI records by individual well identification numbers or by spatial filters such as basin, subbasin, township, or U.S. Geological Survey 7.5-minute topographical quadrangle. The map page also provides a way to search for GWSI wells and provides users the ability to create custom spatial views of the GWSI data. Individual well data can be viewed on either the well information page or the hydrograph pages. The well information page displays all the data that has been captured for an individual GWSI well such as location, well depth, perforation depths, water levels, etc. The hydrograph pages allow the user to view graphically water level data for individual wells. These hydrograph pages are interactive, providing the user the ability to customize the depth to water (y-axis) and date (x-axis) ranges. In addition, the web application allows the user to send an email, with links to the user designated GWSI well hydrograph or well information pages. ADWR plans to produce a similar application for its Wells Registry database.

Key words: Arizona, groundwater, water level, Internet, web, application

INTRODUCTION

The Arizona Department of Water Resources (ADWR) has two main databases related to wells and water levels in Arizona: the Groundwater Site Inventory (GWSI) and Well Registry (Wells55) databases. GWSI originated in 1941 with the U.S. Geological Survey (USGS), who provided the Arizona portion of it to ADWR soon after it formed in 1980. The ADWR GWSI database is currently the main repository for groundwater data from wells and springs in Arizona, with over 43,900 sites. GWSI contains field verified data collected by personnel from ADWR's Hydrology Division, the USGS, and the City of Tucson. Today, GWSI stores both water levels taken manually, and water levels recorded automatically by transducers and shaft encoders maintained by both ADWR and the City of Tucson. GWSI has over 217,600 manual water levels and over 1,320,000 automated water levels. ADWR's Basic Data Unit annually adds to this large depository of data, visiting approximately 5,000 wells each year collecting manual measurements (ADWR, 2009b). Approximately 1,700 of the GWSI sites visited each year are index wells, which are wells that ADWR visits annually for long term water level monitoring (ADWR, 2009b). ADWR also maintains 117 automated wells, which typically collect four water levels daily; while the City of Tucson maintains 126 automated wells (ADWR, 2009c).

Today, the data in ADWR's GWSI are utilized by a variety of people, including state and federal agencies, municipalities, cities, water providers, consultants, well drillers, developers, real estate planners, as well as the general public (ADWR, 2009b). Many of these groups include water professionals, who need to analyze groundwater conditions. In the past, these data were provided to the public on a CD or DVD in a Microsoft Access database and an ESRI GIS Shapefile. These data were typically updated on an annual basis. The problem with this method was that recent water levels were not readily available to the public and were also in a proprietary format that required specialized software. Now, all this information is available through ADWR's new web application on a real-time basis, meaning that the application interacts directly with ADWR's GWSI database (ADWR, 2009a). We hope that hydrologists who work in Arizona find this application to be a useful tool. The remainder of this paper describes how someone would use this application.

THE APPLICATION

Using ESRI's ArcGIS Server technology, ADWR created a web application that allows anyone with an internet connection the ability to search, view, and download GWSI data (available at <http://gisweb.azwater.gov/waterresourcedata>). This application works best with Windows Internet Explorer 7, but is compatible with many other web browsers. The GWSI

web application is built with 5 distinct web pages that users can interact with to view the GWSI data. These pages are a search wizard page, a map page, a well information page, a hydrograph page, and an automated well hydrograph page.

The search wizard page walks a user through a short series of questions to help them narrow their search for GWSI records. They can either choose to search by individual well identification numbers or by spatial filters such as basin, subbasin, township, or USGS 7.5-minute topographical quadrangle. If they proceed with a spatial search, they can further narrow their search by well type (Index or Automated Wells). If the user has a question at anytime during the wizard process, they can click on the **Help** button. After walking through the search wizard questions, search results are displayed in a table that includes the following columns: Site ID, Local ID, Reg. ID, DTW, WL Elev, WL Date Data Type, Well Depth, Case Dia., Water Use, Drill Date, LatNad27, and LongNad27. Once the results table is displayed, the user has different options, through the toolbar, to interact with the GWSI data (Figure 1). The toolbar buttons are: **Well Info**, **Hydrograph**, **Auto Site Hydrograph**, **Map**, **Data Export**, **Water Level Export**, and **Auto Water Level Export**. To use the **Well Info** button, the user must select a record in the results table (by clicking anywhere on that record's row), and then click the **Well Info** button. This action opens a new well information page that displays all the information for that particular well (Figure 2). To use the **Hydrograph** button, the user must select a record in the results table, and then click the **Hydrograph** button. This action opens a Hydrograph page that displays all the manual water level measurements taken at that particular well (Figure 3). The **Auto Site Hydrograph** button is very similar to the **Hydrograph** button, except that the new window includes both the manual and automated water level measurements for that well. The **Map** button opens a new window with the GWSI interactive map, which is zoomed into the area of the well selected before hitting the **Map** button (Figure 4). The remaining three buttons provide different options for exporting GWSI Data to Extensible Markup Language (XML) files, which can be opened in Microsoft Excel. XML files are simple, text based files that can easily transfer over the internet, as compared to binary files, such as Microsoft Excel (.xls) files. The user can quickly convert the XML based download file to a binary file by opening the downloaded file and using the "Save As" option. The **Data Export** button exports all the records in the search results table. The GWSI site X and Y coordinates are included in this data export, so that the user can incorporate these data in their own mapping software. The **Water Level Export** button exports all the manual water levels for the wells in the search results table, while the **Auto Water Level Export** exports water levels from automated wells.

The map page allows users to view the GWSI Data spatially. In addition to GWSI data, the map page includes many other spatial features such as roads, rivers, cities, basins, and watersheds to help the user navigate around Arizona on the interactive map. The map pages also includes a **Map Contents** bar on the left hand side of the map where the user can toggle on or off in the map layers (Figure 4). Also, at scales larger than 1:500,000, the map's default background is an aerial photo layer (flown in 2007), but the user can toggle the background to a USGS topographical map layer by using the **USGS Topo** button. This toggle button is located in the upper right hand corner of the map (Figure 4). The user can change the scale of the map with either the **Zoom** buttons or by a drop-down **Map Scale** tool found in the toolbar above the map. The user can also use the **Map Identify** button to discover information about a particular site on the map. If the map identify tool is selected, and the user clicks on a GWSI site on the map, summary information is provided in a pop-up window (Figure 5). Also, included are two buttons above the pop-up window's result table. The **Hydrograph** button opens a new hydrograph page with manual water level measurements for this site. The **Well Info** button opens a new well information page with all the details for this site. The same results are also available as a "map tip" when the user hovers over a GWSI site at or below 1:40,000 scales. Finally, the user can use the **Print** button to print a copy of the map they are currently viewing in the map page.

The well information page is the best place for a GWSI application user to see all the data for an individual GWSI site. These data are organized under 9 different tabs labeled **General**, **Water Levels**, **Construction**, **Remark**, **Owner**, **Pump**, **Water Quality**, **Spring**, and **Photo**. The **General** tab contains basic site information such as location, site use, and water use information. The **Water Levels** tab displays a **Standard Water Levels** sub-tab which lists all the manual water levels collected for this particular GWSI site (Figure 6). If the site is an automated well, an **Automated Water Levels** sub-tab is also activated displaying all water levels collected by a transducer or shaft encoders. Both sub-tabs contain an **Export Water Levels** button that allows the user to export the results in that particular sub-tab to an XML file. The **Construction** tab contains any well construction information such as completion date, boring and casing completion data, and perforation depths. The **Remark** tab stores any comments or notes taken at the time water level measurements were collected, as well as any logs recorded in the GWSI database. The **Owner** tab stores any well ownership information recorded by field staff needing to contact information for permission to collect water levels. Note that this information may not be the same as the owner information in the ADWR Well Registry (Wells55) database, since the Well Registry data are reported by the owner. The **Pump** tab stores any information collected about the pump attached to any GWSI well. **Pump** tab information can include pump type, power type, and pump discharge. During field collection, some GWSI sites are measured for basic water quality parameters, including specific conductance, fluoride, temperature, pH, alkalinity, and dissolved oxygen. These data can be found under the **Water Quality** tab. If a GWSI site is a spring instead of a well, the **Spring** tab is activated and spring

information are displayed, such as the spring name, type, and permanence. Finally, the **Photo** tab contains any photos taken by field staff (Figure 7).

With all the data on the well information page, it may be easy to overlook the toolbar at the top of the page. This toolbar helps the user navigate to other parts of the application from this page. The toolbar is similar to that found in the search wizard page, containing the following buttons: **Search** , **Hydrograph** , **Auto Site Hydrograph** , **Map** , **Data Export** , **GWSI Help** , and **Email** . The **Search** button opens a pop-up window that allows a user to search for another GWSI site by individual well identification number. Once entered, this new site's data are displayed in the well information page. The **Hydrograph**, **Auto Site Hydrograph**, and **Map** buttons provide the same functionality as their equivalent buttons on the search wizard page. The **Data Export** button on the well information page downloads all the data for the particular GWSI site displayed into a multiple-worksheet Excel file in XML format (Figure 8). The **GWSI Help** button opens a .pdf copy of ADWR's GWSI database handbook, which describes every field provided on the well information page and data download. Finally, the **Email** button gives the user the capability to send an email through the application to any valid email address with a custom message and a link to the specific GWSI site well information page that the user was viewing.

The hydrograph and automated hydrograph pages allow the user to view graphically water level data for individual wells (Figure 3). Both hydrograph pages provide the same basic functionality and look very similar, except that the hydrograph page only displays manual water level measurements, while the automated hydrograph page displays both the manual measurements and the automated water level measurements. The other difference between the two hydrograph pages is that the later can only display up to 5 years of water levels at a time, due to the volume of automated water level data that must be processed. Both hydrograph pages display some basic information about the GWSI site above the hydrograph image. The hydrograph image is interactive in a few different ways. The first is that the user can hover the mouse over any manual water level measurement and a small pop-up window displays the Depth to Water, Water Level Elevation, Measurement Date, and any Remarks if they exist (Figure 9). Water level remarks are any conditions noted at the time the water level measurement was taken that might cause the water level measurement to not reflect static water level. These can include cascading water, well injecting, obstruction, and pumping remarks. Another feature of the hydrograph pages is that the user can interactively remove any water levels on the hydrograph that have remarks for them. This is done in the **Measurement Remarks** slide out tab on the left hand side of the hydrograph (Figure 10). To utilize the slide-out tab, the user must hover the mouse over the slide-out tab they want to open. Once the **Measurement Remarks** tab is open, the user can either uncheck only those remarks they want to remove, or they can click the **No Remarks** button to clear all remarks. Then the user must click the **Refresh** button and the hydrograph image is redrawn with those water levels with remarks removed for it. The hydrograph page also provides the user the ability to customize the depth to water (y-axis) and date (x-axis) ranges with the **Set x-axis** and **Set y-axis** slide-out windows (Figure 11). Once open the user can make changes and then click the **Refresh** button to refresh the hydrograph image. Above the hydrograph and GWSI site information is the hydrograph page toolbar, which has the following buttons: **Well Info** , **Map** , **Reset Graph** , **Auto Site Hydrograph**, and **Email** . The **Well Info** and **Map** buttons do the same tasks as described on the search wizard page. The **Reset Graph** button refreshes the hydrograph to its original (default) display. When the user is viewing the hydrograph page the **Auto Site Hydrograph** button is available to open the automated hydrograph page for the same well. If the user has the automated hydrograph page open, a **Hydrograph** button is shown, which allows the user to open the hydrograph page to display only the manual water level measurements. The **Email** button is available for the user to send an email through the application, similar to the email button on the well information page, except the email sent using this button includes a link to the specific hydrograph that the user is viewing. This link opens up the respective hydrograph page to its default display.

CONCLUSION

The GWSI web application provides a useful tool not only for ADWR staff, but also to a variety of public users. We feel that with the quick search and download capabilities, that it is especially useful to water professionals who need field verified data with which to analyze past and present water level conditions. Now that the GWSI data are available on a real-time basis through the web, application users can avoid using dated data which up until this point were only available on a DVD from ADWR. ADWR plans to produce a similar application for its Wells Registry database, which houses all the data related to registered wells in Arizona. Although not field verified, the Well Registry database also has good information on wells in Arizona.

REFERENCES

ADWR, 2009a, "ADWR Water Resource Data." Found on the Internet:

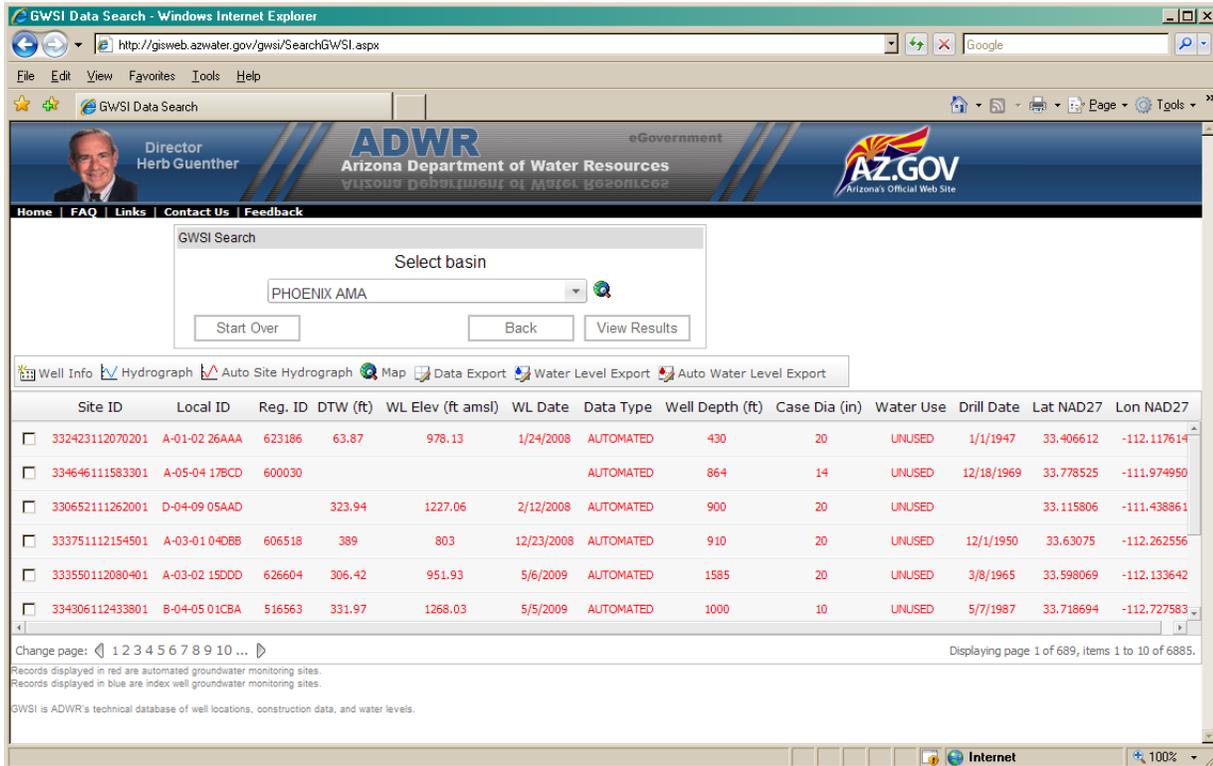
<http://gisweb.azwater.gov/waterresourcedata>

ADWR, 2009b, "Basic Data Unit." Found on the Internet:

http://docushare.azwater.gov/dsweb/Get/Document-3233/BasicData_FactSheet.pdf

ADWR, 2009c, "Hydrology Basic Data Unit." Found on the Internet:

<http://www.azwater.gov/AzDWR/Hydrology/BasicDataUnit/default.htm>



GWSI Search

Select basin

PHOENIX AMA

Start Over Back View Results

Well Info Hydrograph Auto Site Hydrograph Map Data Export Water Level Export Auto Water Level Export

Site ID	Local ID	Reg. ID	DTW (ft)	WL Elev (ft amsl)	WL Date	Data Type	Well Depth (ft)	Case Dia (in)	Water Use	Drill Date	Lat NAD27	Lon NAD27
332423112070201	A-01-02 26AAA	623186	63.87	978.13	1/24/2008	AUTOMATED	430	20	UNUSED	1/1/1947	33.406612	-112.117614
334646111583301	A-05-04 17BCD	600030				AUTOMATED	864	14	UNUSED	12/18/1969	33.778525	-111.974950
330652111262001	D-04-09 05AAD		323.94	1227.06	2/12/2008	AUTOMATED	900	20	UNUSED		33.115806	-111.438861
333751112154501	A-03-01 04DBB	606518	389	803	12/23/2008	AUTOMATED	910	20	UNUSED	12/1/1950	33.63075	-112.262556
333550112080401	A-03-02 15DDD	626604	306.42	951.93	5/6/2009	AUTOMATED	1585	20	UNUSED	3/8/1965	33.598069	-112.133642
334306112433801	B-04-05 01CBA	516563	331.97	1268.03	5/5/2009	AUTOMATED	1000	10	UNUSED	5/7/1987	33.718694	-112.727583

Change page: 1 2 3 4 5 6 7 8 9 10 ...

Displaying page 1 of 689, items 1 to 10 of 6885.

Records displayed in red are automated groundwater monitoring sites.
Records displayed in blue are index well groundwater monitoring sites.

GWSI is ADWR's technical database of well locations, construction data, and water levels.

FIGURE 1. Example of GWSI search wizard page results.

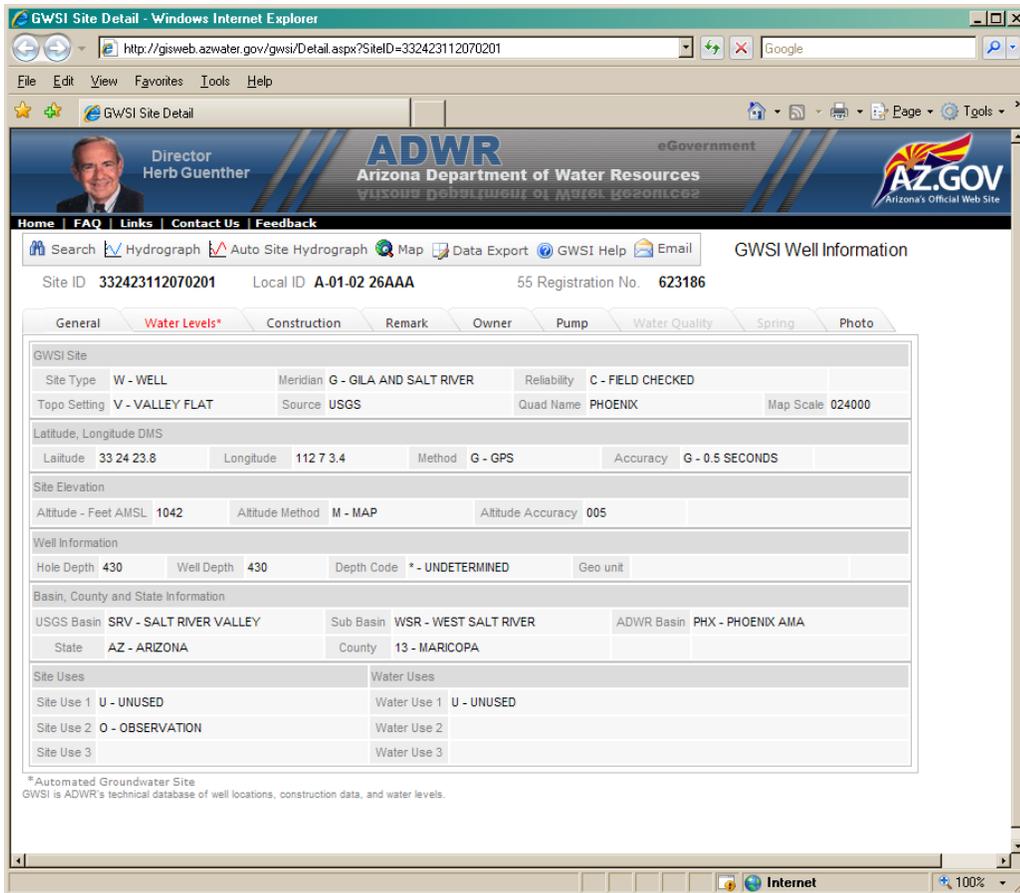


FIGURE 2. Example of GWSI well information page

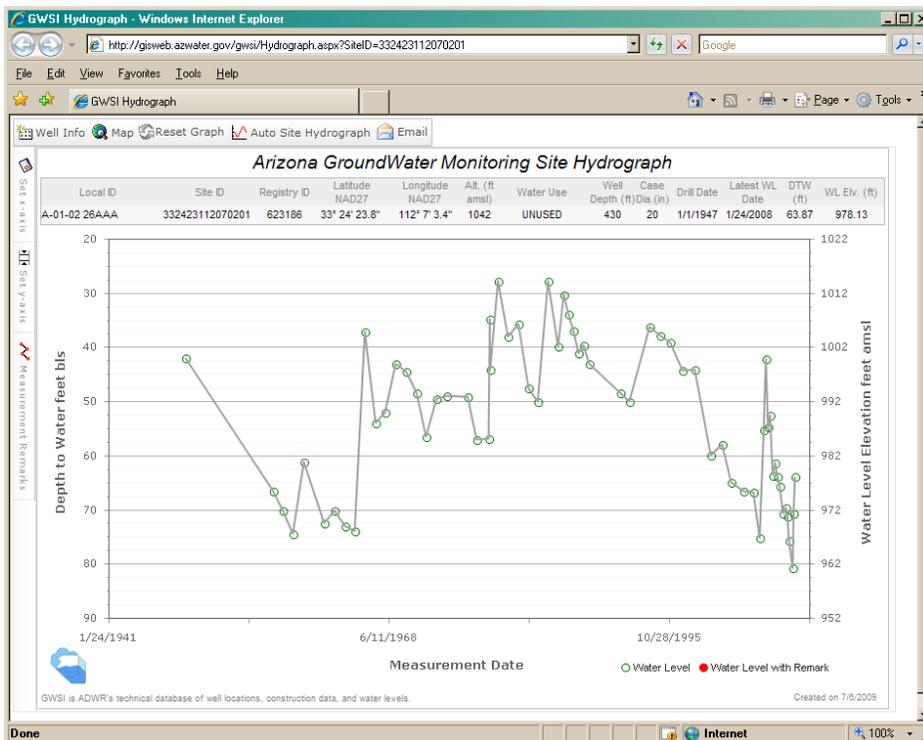


FIGURE 3. Example of hydrograph page, showing manual water level measurements for a particular well.

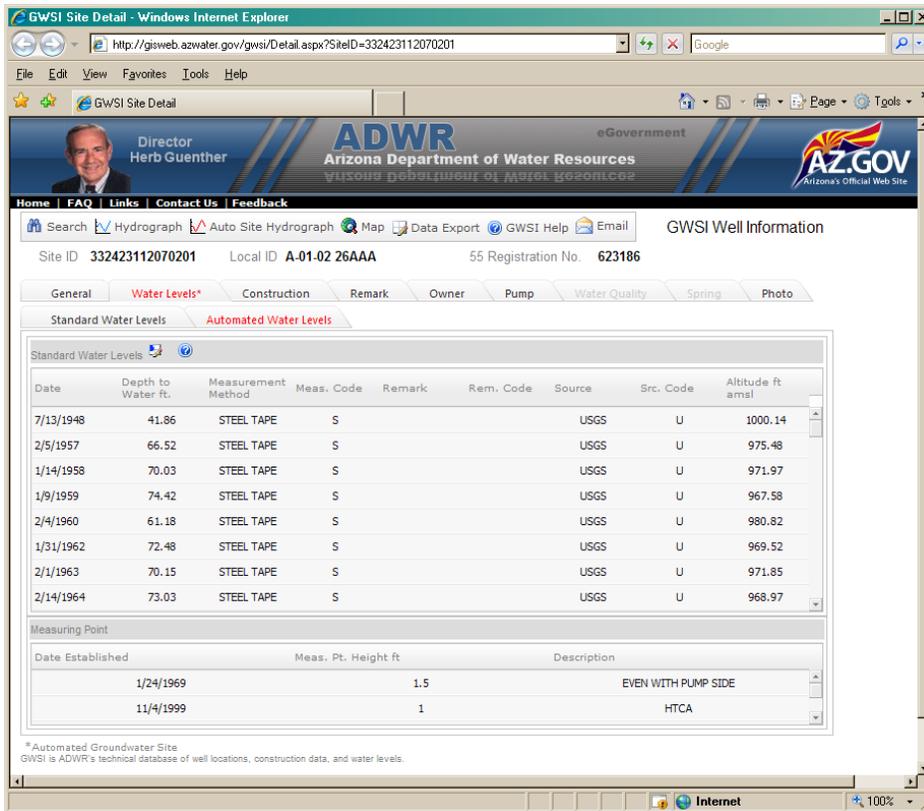


FIGURE 6. Example of GWSI well information page, showing the **Water Levels** tab for an automated water level well.

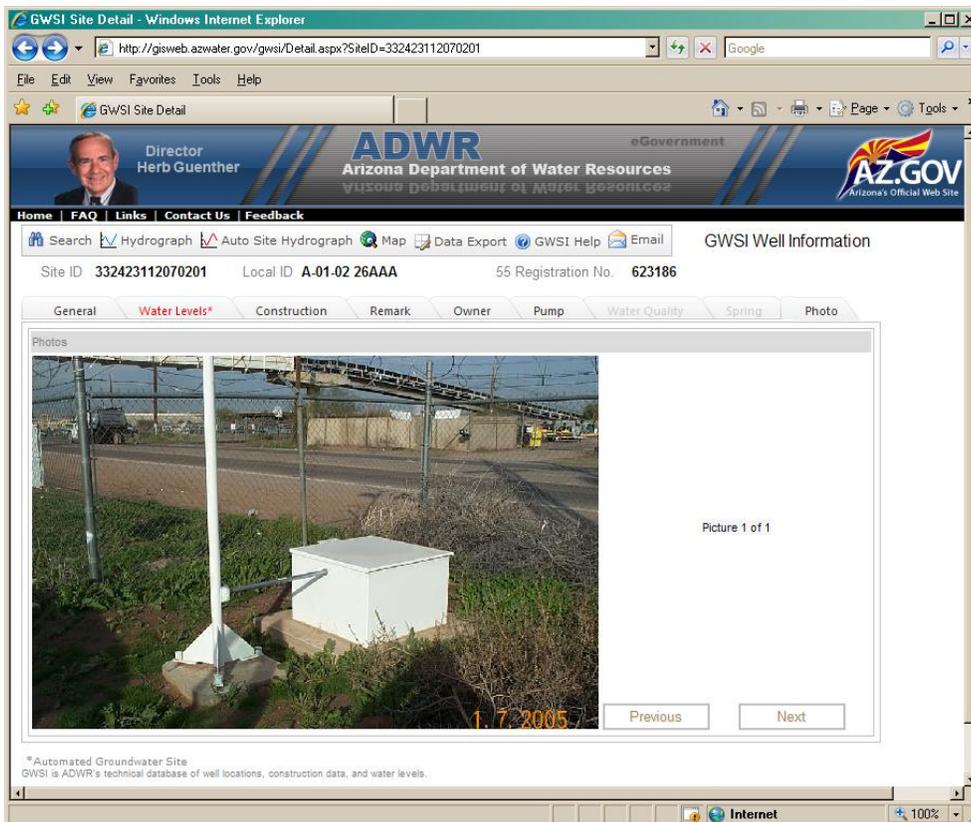


FIGURE 7. Example of GWSI well information page, showing the **Photo** tab.

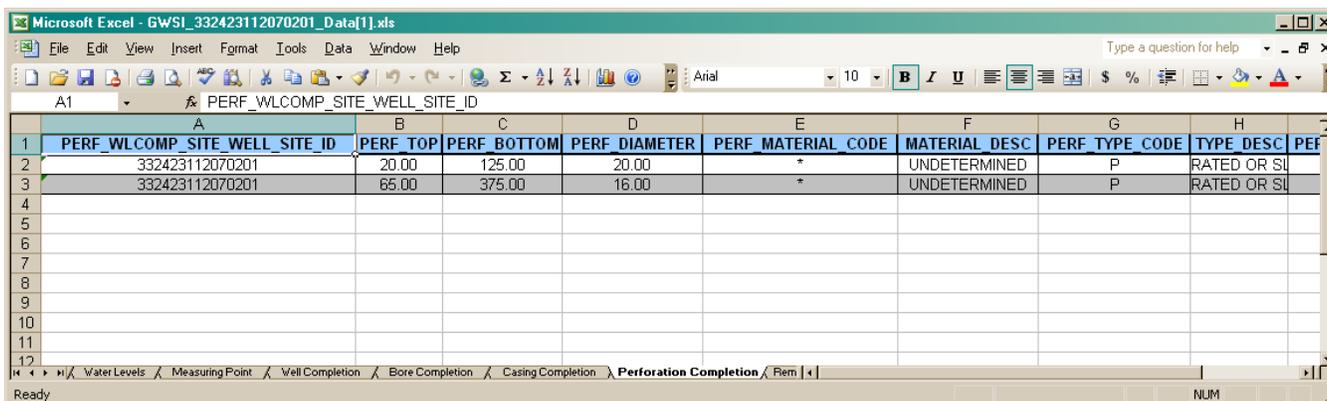


FIGURE 8. Example of downloaded data from well information page for GWSI site 332423112070201. Note the multiple worksheet tabs along the bottom of the Excel file.

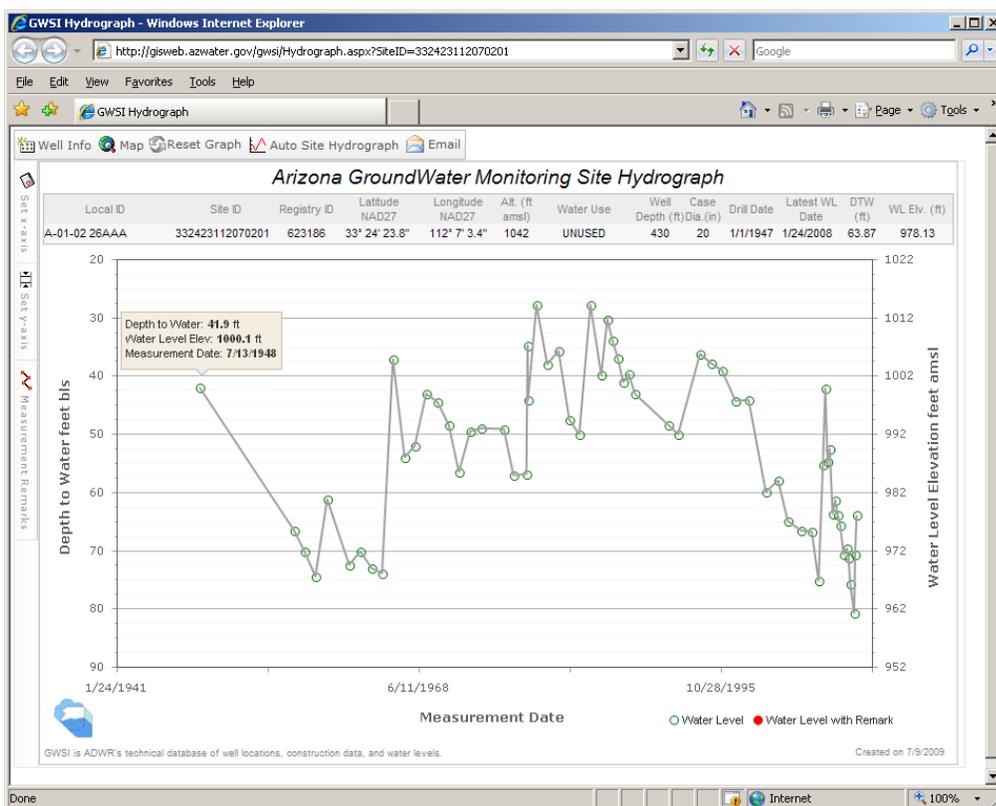


FIGURE 9. Example of hydrograph page, showing the hydrograph image interactive pop-up window.

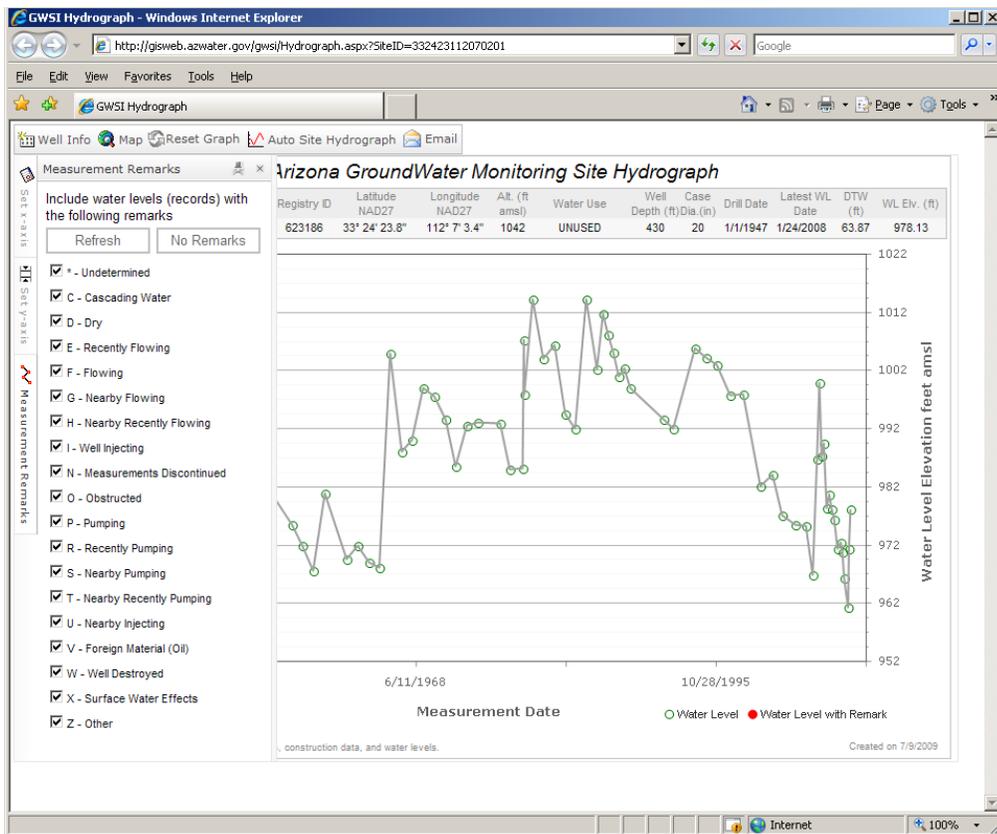


FIGURE 10. Example of hydrograph page, showing the **Measurement Remarks** slide-out window.

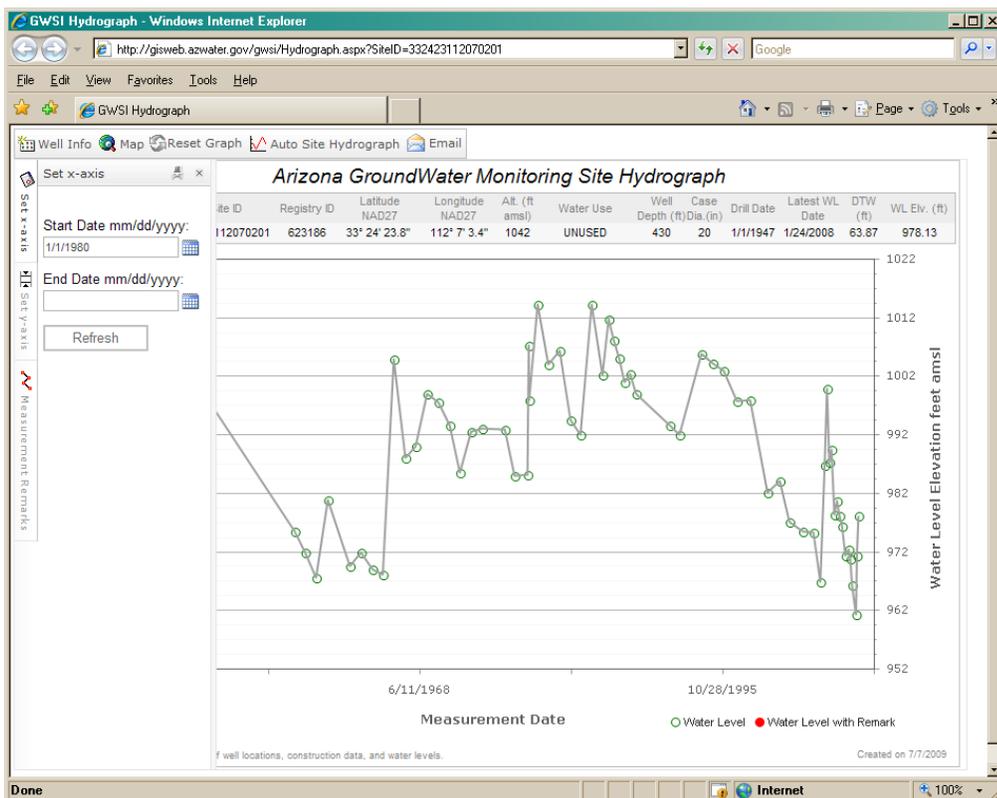


FIGURE 11. Example of hydrograph page showing interactive **Set x-axis** slide-out tab (Date).