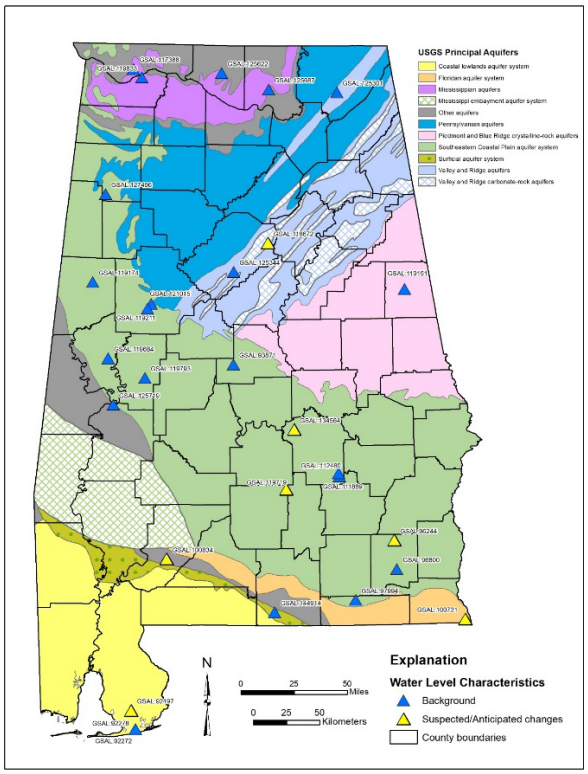
ALABAMA WELL AND DATA MAINTENANCE FOR THE U.S. GEOLOGICAL SURVEY NATIONAL GROUNDWATER MONITORING NETWORK FINAL REPORT

Open-File Report 2301

by

Ann C. Arnold



Submitted by Geological Survey of Alabama In partial fulfillment of

U.S. Geological Survey Award G20AC00378

Tuscaloosa, Alabama

2023

GEOLOGICAL SURVEY OF ALABAMA
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CONTENTS

FIGURES

.

BACKGROUND INFORMATION

DESCRIPTION OF AGENCY AND PURPOSE OF MONITORING

The Geological Survey of Alabama (GSA) has provided services and information to Alabama and its citizens as a natural resource data gathering and research agency since its establishment in 1848 (GSA, 2018). As part of its mission, the GSA explores and evaluates the mineral, water, energy, biological, and other natural resources of the State of Alabama, and conducts basic and applied research in these fields (GSA, 2018). Natural resource investigations of both groundwater and surface water began in 1898 when the GSA, in cooperation with the U.S. Geological Survey (USGS), began a systematic evaluation of the state's water resources (Johnston, 1933). For the past several decades, the GSA has published many reports related to both the groundwater and the surface water resources of the state.

The GSA Groundwater Assessment Program (GSA-GAP) has two ongoing monitoring programs: real-time and periodic. Data from the real-time network is used by the GSA and other state entities such as the Drought Monitoring and Impact Group (MIG) of the Alabama Drought Assessment and Planning Team (ADAPT) to make informed decisions about current groundwater conditions. Semi-annual water levels collected for the periodic monitoring program are used to create snapshots of specific aquifers that have been impacted by pumping, land use, and/or drought stressors. Collected data from the networks are made available to the public and to other state agencies through online portals: https://gsa.state.al.us/gsa/groundwater/realtime and https://gsa.state.al.us/gsa/groundwater/periodic. These programs are described in a publication entitled *An Assessment of Groundwater Resources in Alabama, 2010-2016 (*GSA, 2018), which contains a compilation of aquifer characteristics and groundwater wells monitored across the state. Alabama utilizes the major regional aquifer physiography to delineate groundwater flow regimes across the state as described in a report by the Advisory Committee on Water Information Subcommittee on Ground Water (SOGW, 2013), entitled *A National Framework for Ground-Water Monitoring in the United States*.

The GSA began systematically installing real-time monitoring equipment in wells throughout the state in 2010 to monitor and assess groundwater levels and to provide data on groundwater responses to water use, land use changes, and natural stressors. Beginning in 2020, this data was made available to the National Groundwater Monitoring Network (NGWMN) operated by the USGS. Water-level data from the periodic network was made available to the NGWMN starting in 2022. The NGWMN is a national database of vetted groundwater quality data presented in the same format to facilitate scientific research and the discernment of large-scale groundwater patterns. Providing the GSA-GAP groundwater monitoring network data through the NGWMN portal to view readily alongside adjacent states can reveal regional aquifer conditions within the southeastern region of the United States. This knowledge has the potential to lead to a better understanding of groundwater conditions, support water management decisions, and provide insight about groundwater responses to climatic changes in the region.

OVERVIEW OF WORK

EXISTING MONITORING NETWORKS REPORTING TO THE NGWMN

The GSA-GAP has been actively monitoring groundwater conditions in eight of the principal aquifer systems established by the USGS (2003) in the state since the early 1950s through a network of observation wells. Initially, this network was operated in conjunction with the USGS; however, currently the GSA-GAP has full responsibility for maintenance and operation of the network. Real-time data collection began in 2010, with the installation of the first equipment in some of the observation wells used for periodic monitoring. Since 2010, the GSA-GAP has focused on expanding the network, which now includes 30 well sites to monitor daily water-level changes across the state. The current real-time network incorporates wells in which water levels are recorded every two hours and reported twice daily to the GSA-GAP server.

Approximately 450 wells across the state are monitored in the periodic network. The total number of wells varies because of changes in property ownership, which can limit access to a well, and/or changes in the condition of a well, which may limit its usefulness for monitoring purposes. Prior to 2020, every well in the network was

sampled yearly in the Spring and Fall. In 2020, due to a reduction in field staff the sampling schedule was changed to alternating years, with the same bi-yearly schedule.

WELL SITE SELECTION FOR THE NGWMN

The purpose of the NGWMN is to provide a national overview of long-term trends across regional aquifer systems. As such, wells are selected to differentiate between the effects of short-term and long-term hydrologic stressors to the aquifers. As a data provider to the NGWMN, the GSA-GAP staff selected wells from the current water-level monitoring programs to meet the requirements of the NGWMN after reviewing the criteria for inclusion into the USGS catalog as trend wells and surveillance wells.

TREND WELL NETWORK

Trend monitoring, as described in Section 4.5.1 of the SOGW (2013) report, is designed to look at long-term and seasonal water-level variations at frequent measuring intervals for a limited number of wells across the state. The GSA-GAP staff selected trend wells from the state's real-time network, which derives water-level elevation data from the principal aquifer systems identified in Alabama. Twenty-nine wells in Alabama's real-time network were established as trend-monitoring wells, and the daily average water-level elevation data are currently being served to the NGWMN program online at cida.usgs.gov/ngwmn. Trend well locations are shown in figure 1.

SURVEILLANCE WELL NETWORK

Surveillance monitoring as described in Section 4.5.1 of the SOGW (2013) report, is designed to periodically "tie together" the trend monitoring well data, providing greater spatial coverage to fill in spatial gaps between trend wells that are monitored on a more frequent basis. The frequency of measurements made in Alabama's surveillance wells is semi-annual, which provides an extensive snapshot of overall aquifer conditions in the state when combined with trend well data. The selection process and locations for the trend wells are described in detail in a previous report to USGS (Arnold, 2020). Currently, there are 172 surveillance monitoring wells serving water level data to the USGS NGWMN (figure 2).

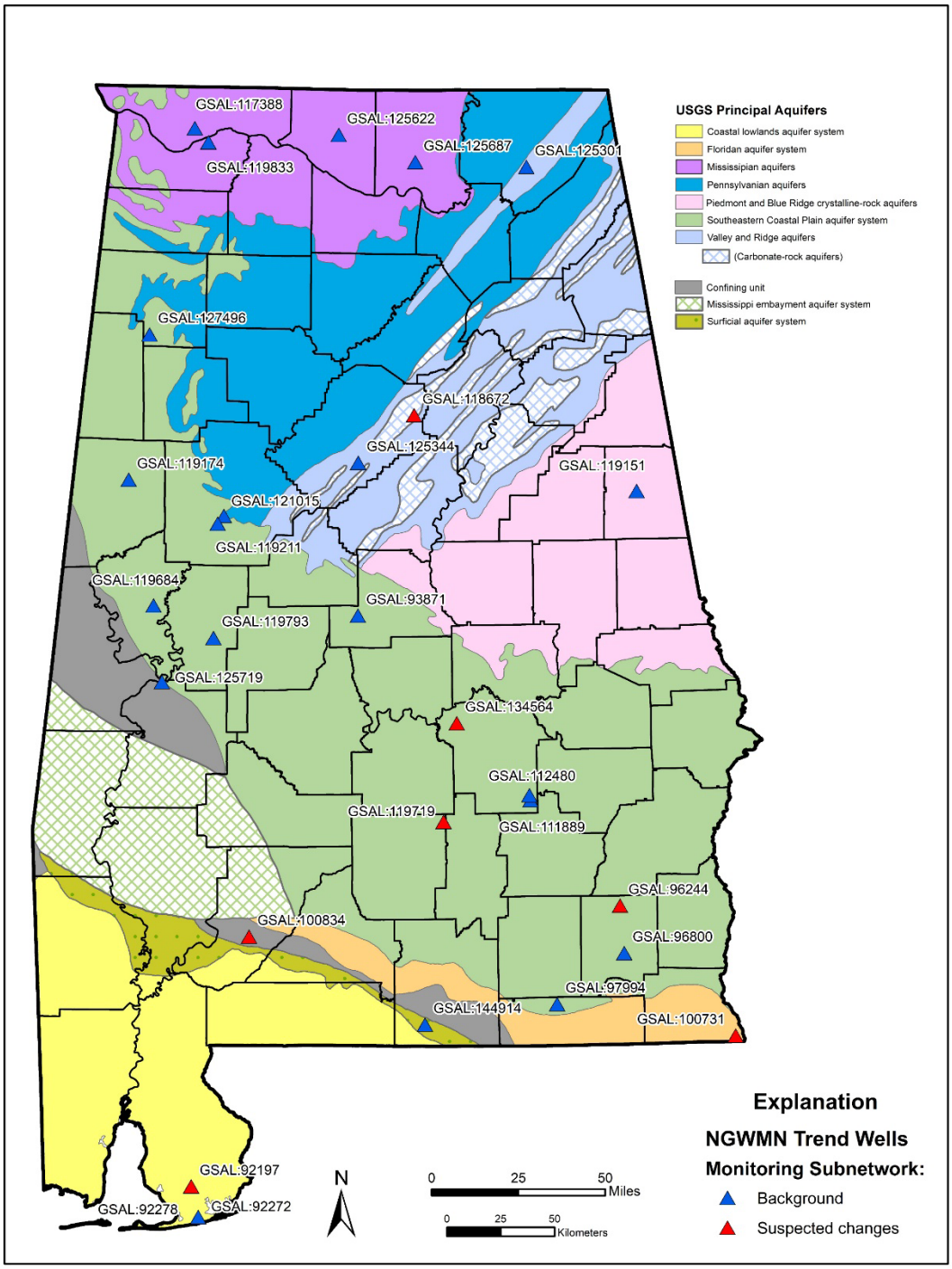


Figure 1. Location of NGWMN trend monitoring wells in Alabama. USGS Principal Aquifer map modified from USGS (2003).

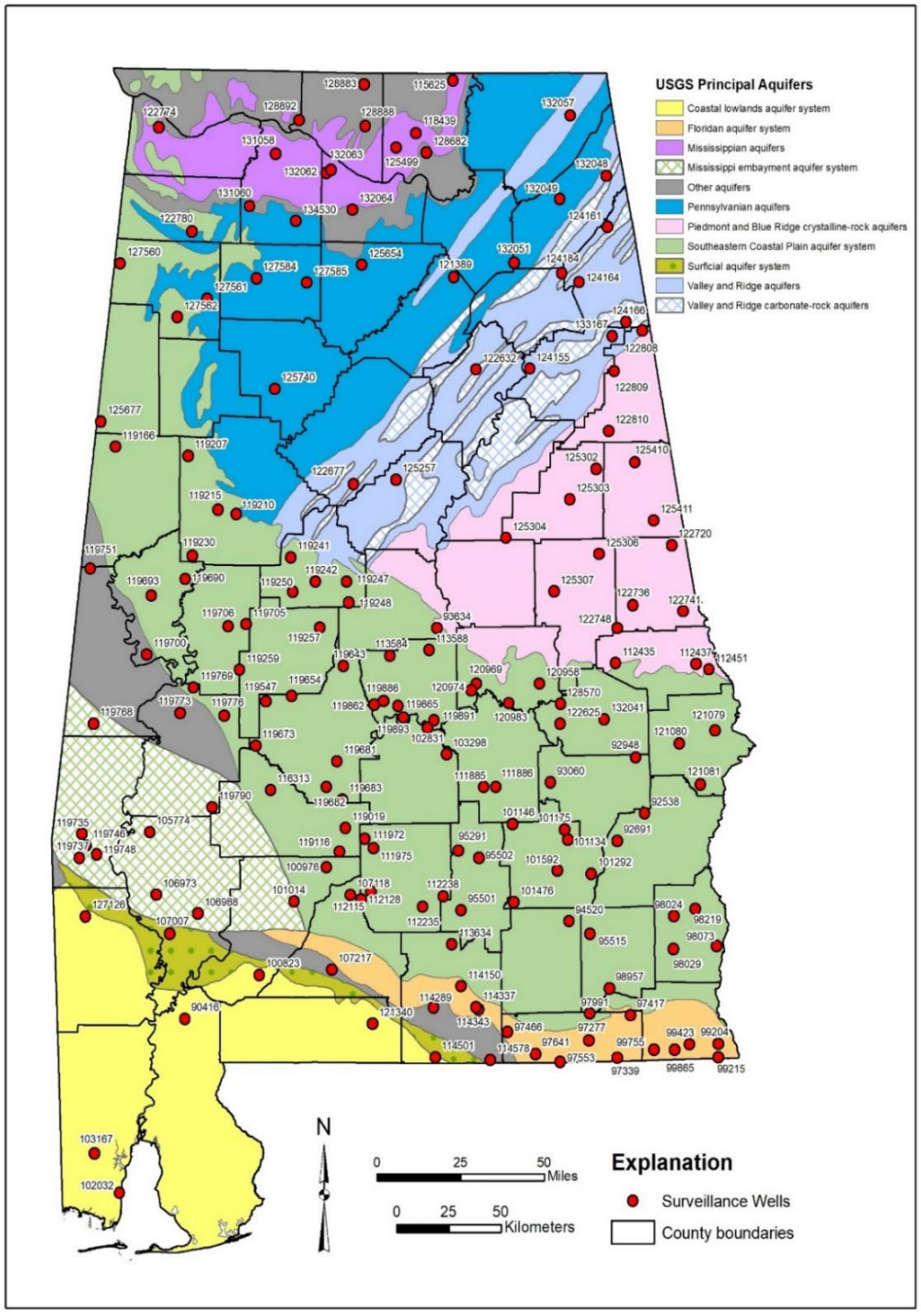


Figure 2. Location of NGWMN surveillance monitoring wells in Alabama. USGS Principal Aquifer map modified from USGS (2003).

TASKS PERFORMED FOR THE CURRENT PROJECT

The major tasks performed for this contract included tasks under work Objectives 2 and 4, as defined by the USGS NGWMN. The Objective 2 task of supporting persistent data service to the USGS NGWMN was provided for the two-year contract period. The Objective 4 task of well maintenance and repairs was accomplished as needed on wells identified under USGS award G20AC00378.

OBJECTIVE 2 TASKS: SUPPORT PERSISTENT DATA SERVICES

Technical support for the electronic formatted data available on the GSA website and served to the USGS NGWMN portal is provided on an ongoing basis, as described in the sections below.

DATA MANAGEMENT PROCEDURES

Minimum data elements for each well required for upload to the NGWMN registry are:

- Agency name.
- Unique site number and name.
- Location information including state, county, latitude and longitude with the horizontal datum and method used, and accuracy.
- Altitude in specified units with the vertical reference datum and method used and accuracy.
- Well depth in specified units.
- The national aquifer designation and local aquifer name.
- The type of groundwater well and aquifer type.
- Whether the site is in a water level (WL) subnetwork and the WL subnetwork name from which the data is uploaded.
- Whether the well meets the criteria for WL baseline (five years of data), well type, well characteristics, well purpose, and well purpose notes.
- Whether the well is part of the water quality (QW) subnetwork.

- The URL to the specified data on the data provider's website.

Water-level elevations for the 29 real-time trend network wells are measured by pressure transducers and recorded on a data logger every two hours. These data are transmitted to a GSA-GAP dedicated computer each day, and the daily average water-level elevation for each trend monitoring well is served to the USGS NGWMN portal each evening.

Periodic water-level data for the 172 surveillance monitoring wells are manually entered and stored in Excel spreadsheets on the GSA-GAP data server and uploaded to the Risk Based Data Management System (RBDMS) database. The data is copied and stored on a separate data back-up storage device each evening. The updated data is served once per day to the USGS portal. All of the data served to the USGS NGWMN portal is available online at cida.usgs.gov/ngwmn.

WEB SERVICES FOR THE NGWMN SURVEILLANCE WELLS

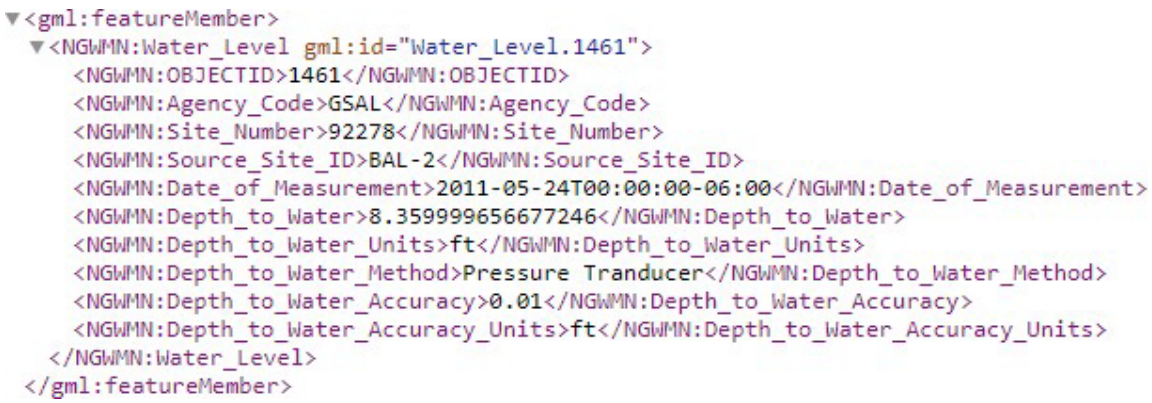
The GSA web services were developed using ArcGIS Server as the service provider. Pertinent well data were aggregated and extracted from the agency's two water databases via SQL queries. Query results are loaded into three tables in a NGWMN geodatabase where each table represents a web service (water levels, construction data, and lithology). These tables are loaded into a map in ArcGIS Pro and published to the ArcGIS Server as a REST WFS web service. Each web service returns XML formatted data by accepting a unique well identifier as a parameter in the service URL. Data from these web services are maintained from a scheduled task that executes a Python script to update the source data for each web service from the parent databases. This task executes on a nightly basis to consume data received daily from the agency real-time monitoring network.

WATER-LEVEL SERVICE

Water levels for a well can be retrieved by accessing the water-level service and passing the unique site number as a URL parameter. As an example, in the web service URL below, USGS NGWMN Site Number 92278 is queried. When the matching record is accessed, a XML formatted document returning required elements is returned. The

query and response shown below depicts a water-level record. A complete water-level measurement includes the date of measurement, depth-to-water, units, method for measuring, and the accuracy.

https://map.gsa.state.al.us/arcgis/services/NGWMN/**Water_Levels**/MapServer/WFSSer
ver?&service=WFS&request=GetFeature&typename=NGWMN:Water_Level&outputFormat=GML3&filter=<ogc:Filter><ogc:PropertyIsEqualTo><ogc:PropertyName>Site_Number</ogc:PropertyName><ogc:Literal>**92278**</ogc:Literal></ogc:PropertyIsEqualTo></ogc:Filter>.



CONSTRUCTION SERVICE

The construction service, which contains casing and screen information, can also be accessed via passing a unique site number inside the URL, as follows:

https://map.gsa.state.al.us/arcgis/services/NGWMN/**Construction**/MapServer/WFSSer
ver?&service=WFS&request=GetFeature&typename=NGWMN:Construction&outputFormat=GML3&filter=<ogc:Filter><ogc:PropertyIsEqualTo><ogc:PropertyName>Site_Number</ogc:PropertyName><ogc:Literal>**92278**</ogc:Literal></ogc:PropertyIsEqualTo></ogc:Filter>.

For both casing and screen information, the web service returns tops, bottoms, diameters, construction materials, and units for each casing and screen. The service also supplies well depth and well depth units. The features described by this query are illustrated as follows:

```
▼<gml:featureMember>
  ▼<NGWMN:Construction gml:id="Construction.7113">
      <NGWMN:OBJECTID>7113</NGWMN:OBJECTID>
      <NGWMN:Agency_Code>GSAL</NGWMN:Agency_Code>
      <NGWMN:Site_Number>92278</NGWMN:Site_Number>
      <NGWMN:Source_Site_ID>BAL-2</NGWMN:Source_Site_ID>
      <NGWMN:Well_Depth>130</NGWMN:Well_Depth>
      <NGWMN:Well_Depth_Units>ft</NGWMN:Well_Depth_Units>
      <NGWMN:Casing_Depth_Top>0</NGWMN:Casing_Depth_Top>
      <NGWMN:Casing_Depth_Top_Unit>ft</NGWMN:Casing_Depth_Top_Unit>
      <NGWMN:Casing_Depth_Bottom>100</NGWMN:Casing_Depth_Bottom>
      <NGWMN:Casing_Depth_Bottom_Unit>ft</NGWMN:Casing_Depth_Bottom_Unit>
      <NGWMN:Casing_Material/>
      <NGWMN:Casing_Diameter>4</NGWMN:Casing_Diameter>
      <NGWMN:Casing_Diameter_Unit>in</NGWMN:Casing_Diameter_Unit>
      <NGWMN:Screen_Depth_Top>100</NGWMN:Screen_Depth_Top>
      <NGWMN:Screen_Depth_Top_Unit>ft</NGWMN:Screen_Depth_Top_Unit>
      <NGWMN:Screen_Depth_Bottom>130</NGWMN:Screen_Depth_Bottom>
      <NGWMN:Screen_Depth_Bottom_Unit>ft</NGWMN:Screen_Depth_Bottom_Unit>
      <NGWMN:Screen_Material/>
      <NGWMN:Screen_Diameter>4</NGWMN:Screen_Diameter>
      <NGWMN:Screen_Diameter_Unit>in</NGWMN:Screen_Diameter_Unit>
    </NGWMN:Construction>
  </gml:featureMember>
```


LITHOLOGY SERVICE

Similar to the web services described in prior sections, lithologic information can be obtained by passing the same unique identifier from the previously mentioned services as a parameter to the web service URL, as follows:

https://map.gsa.state.al.us/arcgis/services/NGWMN/**Lithology**/MapServer/WFSServer?
&service=WFS&request=GetFeature&typename=NGWMN:Lithology&outputFormat=GML3&filter=<ogc:Filter><ogc:PropertyIsEqualTo><ogc:PropertyName>Site_Number</ogc:PropertyName><ogc:Literal>**92278**</ogc:Literal></ogc:PropertyIsEqualTo></ogc:Filter>

The lithology web service provides the lithologic ID, description, top and bottom of the unit, and the observation method. All lithologic observations were determined from drilling records reviewed by geologists on staff in the GSA-GAP. Where necessary, these depths were correlated with available electrical logs. The features described by the lithologic query are illustrated as follows:

```
▼<gml:featureMember>
 ▼<NGWMN:Lithology gml:id="Lithology.7151">
    <NGWMN:OBJECTID>7151</NGWMN:OBJECTID>
    <NGWMN:Agency_Code>GSAL</NGWMN:Agency_Code>
    <NGWMN:Site_Number>92278</NGWMN:Site_Number>
    <NGWMN:Source_Site_ID>BAL-2</NGWMN:Source_Site_ID>
    <NGWMN:Lithology_ID>Tm</NGWMN:Lithology_ID>
    <NGWMN:Symbol_Lithology/>
    <NGWMN:Lithology_Description>Miocene Series undifferentiated</NGWMN:Lithology_Description>
    <NGWMN:Lithology_Depth_Top>80</NGWMN:Lithology_Depth_Top>
    <NGWMN:Lithology_Depth_Top_Unit>ft</NGWMN:Lithology_Depth_Top_Unit>
    <NGWMN:Lithology_Depth_Bottom>133</NGWMN:Lithology_Depth_Bottom>
    <NGWMN:Lithology_Depth_Bottom_Unit>ft</NGWMN:Lithology_Depth_Bottom_Unit>
    <NGWMN:Observation_Method/>
  </NGWMN:Lithology>
 </gml:featureMember>
```


OBJECTIVE 4 TASKS: WELL REPAIRS AND MAINTENANCE

The following wells that provide water-level data for the NGWMN trend network were identified prior to the project as needing repairs or further work:

- GSAL 125301 (JAC-2)
- GSAL 125344 (JEF-1)
- GSAL 118672 (JEF-2)
- GSAL 125687 (MAD-2)
- GSAL 125719 (MAG-1)
- GSAL 125622 (LIM-4)

The necessary repairs were approved for the project and the well maintenance work was conducted by the GSA staff, where possible, and is documented in the following sections.

TREND WELL GSAL 125301 (JAC-2) IN JACKSON COUNTY

Trend well GSAL 125301 (JAC-2), located in southeast Jackson County (figure 1), required maintenance to repair broken well housing hardware (figure 3). The locking hasp as well as the “bracket” opposite the locking hasp had broken free of the cover presumably due to rust and failure of the weld that held it in place.

Figure 3. Trend well GSAL 125301 (JAC-2) prior to repairs.

The original design used a rod or “stud” that slides through a hole in the bracket and secures the side of the cover opposite the locking hasp. The original rod was mounted too low, making it difficult to install the cover and putting additional stress on the bracket. Repairs performed during November 2022 consisted of removing the old rod and welding a new one approximately 1 inch higher. A new locking hasp was also welded to the cover. The cover was fitted, checked for ease of removal and replacement, and a new lock was installed (figure 4).

Figure 4. Trend well GSAL 125301 (JAC-2) after repairs. Photo illustrates cover secured by new hasp and lock.

TREND WELL GSAL 125344 (JEF-1) IN JEFFERSON COUNTY

Trend well GSAL 125344 (JEF-1), located in south Jefferson County (figure 1), needed repairs to the hinges and lock hasp attached to the well cover to secure the equipment and insure it was free from tampering (figure 5).

Figure 5. Trend well GSAL 125344 (JEF-1) prior to repairs. Photo illustrates broken hinges and lock hasp.

The damaged steel hinges and lock hasp were cut free of the steel door and frame using a 90° angle grinder, and the steel surfaces were prepared for welding using a wire

wheel to remove surface rust. Three hinges were welded to the cover's steel frame and door connecting the two, and a lock hasp was welded on the opposite side of the door and frame to allow the structure to be secured with a padlock (figure 6). Steel handles were also welded to the door which allow it to be grasped and lifted. The work was performed on January 24, 2022.

Figure 6. Trend well GSAL 125344 (JEF-1) after repairs. Photo illustrates three new hinges, lock hasp, and handles installed during repairs.

TREND WELL 118672 (JEF-2) IN JEFFERSON COUNTY

Trend well GSAL 118672 (JEF-2) is located in northeast Jefferson County (figure 1). The well house at the site was demolished by the City of Trussville, which owns the well, due to vandalism concerns. The existing wellhead has a new locking cap on the cover and is enclosed in a fenced area with a lock (figure 7). Installation of a new well

house would have required anchoring it to the concrete pad. This was deemed unnecessary by the City of Trussville since the well is secured behind a locked fence. Therefore, the well house was not replaced.

Figure 7. Trend well GSAL 118672 (JEF-2) showing secure location.

TREND WELL GSAL 125687 (MAD-2) IN MADISON COUNTY

Trend well GSAL 125687 (MAD-2) is located in a public recreational park that is situated in southern Madison County (figure 1), a fast-growing suburban area of Huntsville. The well housing was struck by a large mower during maintenance of the site by the City that caused damage to the housing and the concrete pad surrounding the base of the wellhead and permanently damaging the installed monitoring equipment (figure 8).

The wellhead was rebuilt by reducing the 6-inch diameter metal casing to 4-inch diameter schedule 40 PVC using a PVC reduction collar. The monitoring wellhead was enclosed in a 14-inch PVC surface casing and a locking cap installed. Four 1.5-inch

PVC pipes were placed as guard posts at each corner of the approximately 4-foot square concrete pad for additional protection. The new concrete pad with guard posts and a new pressure transducer were installed at the site in June 2022 (figure 9).

Figure 8. Trend well GSAL 125687 (MAD-2) prior to repairs.

Figure 9. Trend well GSAL 125687 (MAD-2) after repairs. Photo illustrates PVC surface casing, locking cap, and guard posts installed during repairs.

TREND WELL GSAL 125719 (MAG-1) IN MARENGO COUNTY

Trend well GSAL 125719 (MAG-1) is located in northwest Marengo County (figure 1) near the Demopolis municipal water supply tank. The well was originally installed with a flush mount that could not accept the pressure transducer mounting collar currently used by the GSA (figure 10). Repairs consisted of pouring a concrete pad around the base of the well to seal the surface. A 4-inch PVC casing was attached to the metal well casing that supports the mounting collar and pressure transducer (figure 11). Work was completed and the well restored to service in April 2021.

Figure 10. Trend well GSAL 125719 (MAG-1) prior to repairs.

Figure 11. Trend well GSAL 125719 (MAG-1) after repairs. Photo illustrates 4-inch PVC casing and mounting collar installed during repairs.

TREND WELL GSAL 125622 (LIM-4) IN LIMESTONE COUNTY

Trend well GSAL125622 (LIM-4) was installed in a municipal parking lot in Athens, Alabama (figures 1 and 12). The City of Athens improved the parking lot for their facilities and paved over the well site (figure 13).

Figure 12. Trend well GSAL 123622 (LIM-4) in city of Athens, Alabama, prior to the city of Athens parking lot improvement project.

During the construction process, the well was buried, and the existing monitoring equipment was destroyed. Requests were made by GSA to obtain permission from the City of Athens to locate GSAL 123622, excavate it, repair the well, and return it to service. These requests were denied. As a result, the well has been removed from the GSA real-time network, and will be removed from data served to the NGWMN. Historic water level data for the well through Spring 2016 is available on GSA's website. The GSA staff are looking for a suitable replacement well in the area.

Figure 13. Former site of trend well GSAL 123622 (LIM-4) in Athens, Alabama. The improved parking lot now covers the well site.

SUMMARY

The major project goals for USGS NGWMN Objectives 2 and 4 work tasks were accomplished in a timely manner and within budget constraints. The Objective 2 task of supporting persistent data service to the USGS NGWMN was accomplished for the two-year project period. Some minor modifications to the computer software system was required to keep connected and insure that updated water level information is served to the NGWMN data portal. Objective 4 tasks of well repairs were completed at four well sites: GSAL 125301 (JAC-2), GSAL 125344 (JEF-1), GSAL 125687 (MAD-2), and GSAL 125719 (MAG-1). The installation of a new well housing at the GSAL 118672 (JEF-2) site was not deemed necessary by the owner because the security of the site is maintained. GSAL 125622 (LIM-4) was removed from the GSA-GAP NGWMN

programs because the well was destroyed and further access to the site was denied by the owner. A suitable replacement well is being pursued in the area at this time.

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