Establishing the Maine Groundwater Level Monitoring Network

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Maine Geological Survey

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Introduction

Groundwater resources are vital to the people and economy of Maine. Half of Maine residents get their domestic water from a private groundwater well. Industry relies heavily on readily available and renewable groundwater resources: the agricultural sector uses billions of gallons of groundwater annually for irrigation and food processing; both small and large manufacturing relies on extracted groundwater; and the growing bottled water industry markets groundwater from dozens of sites around the state. In addition, most public community water systems draw their supplies from a groundwater source.

Before very recently, most readily available information about long-term groundwater levels in Maine was from a network of 19 wells maintained by the United States Geological Survey (USGS). In 2016, the Maine Geological Survey (MGS) began a project with the USGS to add 32 additional wells to the National Groundwater Monitoring Network (NGWMN), and in late 2017 began serving data to the network.

The NGWMN, a product of the Federal Advisory Committee on Water Information and the USGS, is a compilation of selected groundwater monitoring wells from Federal, State, and local groundwater monitoring networks across the United States (SOGW, 2013). The scale of the network focuses on USGS Principal and Major Aquifers. The NGWMN Data Portal provides access to groundwater and well data in a web-based mapping application available at https://cida.usgs.gov/ngwmn/. Available data include groundwater levels, water quality, aquifer lithology, and well construction. The goal of the NGWMN is to provide information needed for the observation and management of groundwater supplies to meet the current and future water needs of humans and other ecosystems.

In 2016, MGS was awarded funding from the USGS to become a new data provider to the NGWMN. The goal of the project was to establish the Maine Groundwater Level Monitoring Network and connect it with the NGWMN, in order to include groundwater level monitoring data collected by the State of Maine in the national network. The project took place in two phases. In Year 1, MGS worked to set up a local monitoring network and link it with the NGWMN to become a "new data provider". In Year 2, MGS maintained and improved the network and linkages with the NGWMN in the capacity of an "existing data provider."

Year 1: New Data Provider

Overview of Work

The Maine Groundwater Monitoring Network was created in 2017 by a selection of 32 wells at 22 unique site locations (Figure 1). The wells were selected based on their geographic distribution around the state, distance from existing USGS wells, long records of greater than ten years, and representation of Maine's principal aquifers. Of the 32 wells, 11 wells are completed in the New England Crystalline-Rock Aquifer, 4 wells in the New England Carbonate-Rock Aquifer, 12 wells in Sand and Gravel Aquifers, and 5 wells in Other Aquifers (either marine deposits or till). Further objectives in monitoring long-term groundwater wells include to

improve access to groundwater level information that represents background conditions unaffected by anthropogenic activities, and to provide information about long-term changes to groundwater due to climate change.

Work in Year 1 involved collecting and evaluating data about wells that are currently monitored in Maine, selecting and classifying sites into appropriate subnetworks and categories, building a database and interface for our local groundwater monitoring network, connecting this database with the NGWMN Portal using web services, and documenting data collection practices and the outcomes of the project.
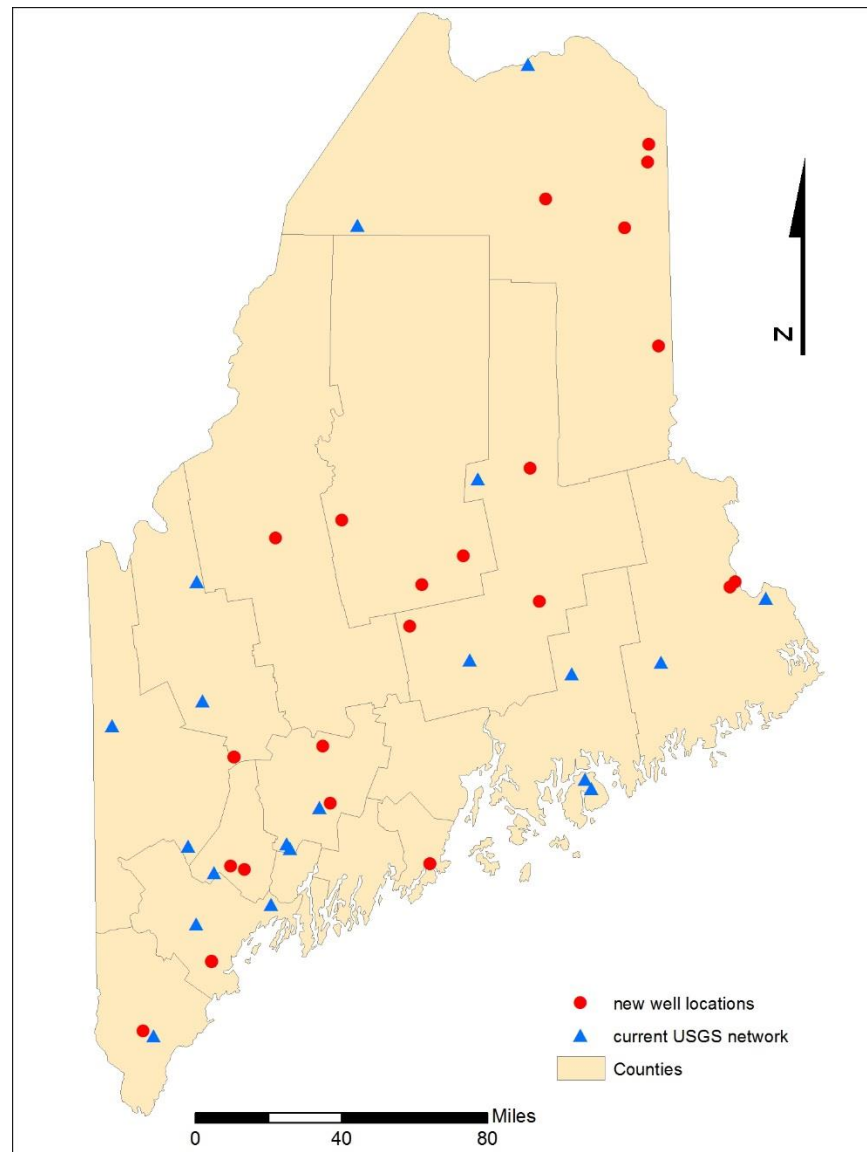

Figure 1. Current NGWMN wells in the State of Maine. Blue triangles represent pre-existing USGS wells, while red circles are wells added in 2017 from Maine's EGAD database.

Preexisting Water-Level Networks and Data

The Maine Department of Environmental Protection (MEDEP), a sister agency to the Maine Geological Survey (MGS), maintains the Environmental and Geographic Analysis Database (EGAD), which is used to manage all environmental information, including groundwater levels and groundwater quality information, at numerous permitted and remediated sites throughout Maine. This database contains over 59 million records. Geologists at MGS have in the past used EGAD to extract groundwater level information from selected background wells.

While EGAD was originally designed to store site and water quality information for potential and actual sources of contamination to groundwater in Maine, it now also includes biological and surface water sampling sites, with a broad range of data types including physical, chemical, biological and spatial. It is MEDEP's most comprehensive database of environmental information. Unlike groundwater monitoring networks in some other states, data collected for the wells in EGAD are primarily used to address environmental needs rather than for groundwater level or background quality monitoring. Data from more than 23,000 wells are stored in EGAD, a subset of which are background wells intended to capture ambient groundwater levels and qualities, unaffected by anthropogenic activities. EGAD includes well sites in all of Maine's three principal aquifer systems.

Site Selection Criteria and Processes

Initial Selection and Evaluation of Wells

In years before the establishment of the NGWMN, MGS worked with the MEDEP to identify a subset of wells within EGAD that serve as background wells at remediation sites and had records covering 10 years or more. Over 1900 wells at 138 sites were identified, and a selection of these was made based on the quality of the record and the absence of pumping influence in the wells. This initial selection included wells at 44 sites across Maine.

The selection process in 2016 began with the initial list of background wells at 44 sites, and then screened these for quality of the record (few missing measurements or outliers), the absence of pumping or active environmental remediation work, a lack of chemical contamination in the background well, and practical concerns such as ease of access. During this task, the knowledge of individual project managers and geologists at MEDEP was vital to help identify appropriate wells at each site. The subsequent list was further refined by MGS geologists considering the spatial distribution of points across the state and the distribution and number of wells in each principal aquifer and in the various depositional units of unconsolidated aquifers. The proximity to existing USGS monitoring wells was also considered.

Documentation of Required Data Elements

The refined list of wells was then subjected to an extensive search for documented information about each well. Although the EGAD database does contain fields for many of the required NGWMN data elements, many of them had not been filled in by MEDEP project managers prior to the start of this project. It was therefore necessary to find and consult paper

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documents from the MEDEP archive and storage buildings, including site plans, drilling logs, surveys, and consultant reports, to gather all the existing data that was pertinent to the NGWMN. Required data elements are described in Table 6.1.1.1 of the NGWMN Framework Document (SOGW, 2013). Potential monitoring wells that still lacked vital data elements after the search was complete were discarded from further consideration. Researching and documenting these data elements was by far the most time-intensive task in Year 1 of this project, and vertical datum determination and verification was perhaps the most difficult component of this step, since many wells and depth measurements were recorded with incorrect or inconsistent vertical datums and measuring point elevations.

Subnetwork and Monitoring Category Assignment

The candidate sites were classified into subnetworks and monitoring categories using guidance from the NGWMN Framework Document (SOGW, 2013) and Tip Sheets (https://cida.usgs.gov/ngwmn/learnmore.jsp). All 32 wells selected for the Maine Groundwater Monitoring Network were placed in the NGWMN Background Subnetwork (little or no documented anthropogenic effect) because anthropogenic effects on the groundwater level could be ruled out at all the selected sites. Any potential sites that had nearby industrial groundwater withdrawals or pump and treat operations were excluded from consideration, and the ten-year records at all the selected wells show no indications of anthropogenic effects. Furthermore, because large-scale groundwater withdrawals are uncommon in Maine and aquifers are generally small and discontinuous, pumping effects are typically highly localized, compared to other states with more extensive and heavily utilized aquifers.

The monitoring category in the NGWMN is based on the frequency of measurement. Water level wells in aquifers with small withdrawals are recommended to be measured once per quarter for the Trend Monitoring Category, while wells in the Surveillance Monitoring Category are recommended to be measured at least once every three years (Table 4.5.1.1 in SOGW, 2013). All the wells in the Maine network were placed into the Trend Category, even though some are not currently measured quarterly (see below), because most were measured quarterly in past years, and we are hoping to increase the frequency to quarterly in 2019 and beyond.

Quality Assurance and Quality Control Processes

Field Techniques for Water Level Measurement

Sites in EGAD are primarily for environmental purposes at permit or remediation sites, and as such, most monitoring information is collected by certified professionals employed by consulting firms. The MEDEP imposes strict collection protocols and quality protocols are subject to periodic reviews by MEDEP staff.

Collection requirements are established in Chapter 405, Solid Waste Management Rules: Water Quality Monitoring, Leachate Monitoring, and Waste Characterization, which specifies the following:

(2) **Sampling, Handling and Analysis of Ground Water**. The ground water monitoring program must include consistent sampling procedures that are designed to ensure monitoring results that provide an accurate representation of ground water quality at all monitoring wells installed at a solid waste facility. The approved sampling protocol must be followed throughout the monitoring period of the facility so that data acquired can be compared over time and accurately represent changes in ground water quality. The following procedures must be followed during purging and sampling of monitoring wells, and the handling and analysis of the collected samples:

(a) **Prior to purging**. Prior to purging the well, static water level must be measured to the nearest 100th of a foot using standard techniques. If a protocol other than low flow sampling is used, well depth must be measured at least annually or more often if suspended solids in the sample suggest that the well integrity has been impaired….

Additionally, each site has a Quality Assurance Project Plan at DEP that specifies data collection protocols. Most water-level measurements are made using the electric-tape method.

Database Quality Control and Verification

Data that appear in the Maine Groundwater Monitoring Network is controlled for quality at several levels before being published to the NGWMN. Data that go into the network come both from the DEP's EGAD database and MGS information sources, since EGAD doesn't store all the information necessary to populate the NGWMN. Additional tables for elevations, aquifer information, and lithology in the MGS database are populated manually by MGS geologists. Drop-down lists are provided for fields that have domains in the database to ensure accurate data entry.

Quality control of the data is performed on the combined data in the MGS database, using a custom design of the Microsoft Access user interface. New data that is routinely imported from the EGAD database is automatically flagged for review by MGS geologists, who can then flag it for release to the NGWMN. Data that are obviously erroneous or appear anomalous can be excluded or modified, and are typically reported to DEP project managers for review and potential correction within the EGAD database. No data in EGAD is ever deleted or modified directly by MGS staff. Other data not directly available from EGAD can be entered or updated as it becomes available to MGS. Data that have been checked for quality and flagged for release to NGWMN are then uploaded to ArcServer and published via web services (see section on Database Design, below).

Final quality control is performed on MGS's contribution to the NGWMN by downloading data directly from the Data Portal at https://cida.usgs.gov/ngwmn/. The downloaded comma-separated value files are imported into a custom spreadsheet, cross-checked with the expected internal values, plotted, and visually inspected for accuracy.

Minimum Data Elements and Monitoring Frequencies

Data elements from the Maine Groundwater Monitoring Network that are provided to the NGWMN through ArcServer web services are listed in Table 1. The data elements include all those described in the NGWMN Tip Sheet on Minimum Data Requirements.

Table 1. Data elements provided to the NGWMN through web services. Each database table is available through a separate ArcServer feature class.

Field Name	Description	Database Table
AgencyCd	Agency identifier code (MEGS)	all
SiteNo	Unique site identification number	all
AgencyNm	Agency name (Maine Geological Survey)	SITE_INFO
SiteName	Site name	SITE_INFO
DecLatVa	Site lattitude	SITE_INFO
DecLongVa	Site longitude	SITE_INFO
HorzDatum	Horizontal reference datum	SITE_INFO
HorzMethod	Horizontal location method	SITE_INFO
HorzAccuracy	Horizontal location accuracy	SITE_INFO
AltVa	Ground surface elevation	SITE_INFO
AltUnits	Code for unit of measure associated with the AltVa field	SITE_INFO
AltUnitsNm	Name of unit of measure associated with the AltVa field	SITE_INFO
AltDatumCd	Vertical reference datum code	SITE_INFO
AltMethod	Vertical location method	SITE_INFO
AltAccuracy	Vertical location accuracy	SITE_INFO
WellDepth	Depth of the well below ground surface	SITE_INFO
WellDepthUnits	Code for unit of measure associated with the WellDepth field	SITE_INFO
WellDepthUnitsNm	Name for unit of measure associated with the WellDepth field	SITE_INFO
NatAquiferCd	USGS code for U.S. Principal Aquifer	SITE_INFO
NatAqfrDesc	USGS name of U.S. Principal Aquifer	SITE_INFO
LocalAquiferCd	USGS code for local aquifer	SITE_INFO
LocalAquiferName	Name or description of local aquifer	SITE_INFO
CountryCd	Abbreviation for country	SITE_INFO
CountryNm	Name of country	SITE_INFO
StateCd	FIPS code for state	SITE_INFO
StateNm	Name of state	SITE_INFO
CountyCd	FIPS code for county	SITE_INFO
CountyNm	Name of county	SITE_INFO
SiteType	Type of groundwater site (Well or Spring)	SITE_INFO
AquiferType	Type of aquifer (Confined or Unconfined)	SITE_INFO
LithologyID	Code for the type of lithology or geology of the unit	LITHOLOGY
LithologyDescription	Description of the type of lithology or geology of the unit	LITHOLOGY
ObservationMethod	Method for classifying lithology or geology of the unit	LITHOLOGY
LithologyDepthFrom	Beginning depth of the lithologic unit	LITHOLOGY
LithologyDepthFromUnit	Name of unit of measure associated with the LithologyDepthFrom field	LITHOLOGY
LithologyDepthTo	Ending depth of the lithologic unit	LITHOLOGY
LithologyDepthToUnit	Name of unit of measure associated with the LithologyDepthTo field	LITHOLOGY
ScreenDepthFrom	Beginning depth of screened interval	SCREEN
ScreenDepthFromUnit	Name of unit of measure associated with the ScreenDepthTo field	SCREEN
ScreenDepthTo	Ending depth of screened interval	SCREEN
ScreenDepthToUnit	Name of unit of measure associated with the ScreenDepthFrom field	SCREEN
holeSize	Size of the openings in the screen	SCREEN
holeSizeUnit	Name of unit of measure associated with the holeSize field	SCREEN
ScreenMaterial	Screen type or material	SCREEN
ScreenDiameter	Internal diameter of the screen	SCREEN
ScreenDiameterUnit	Name of unit of measure associated with the ScreenDiameter field	SCREEN

Table 1 continued.

Field Name	Description	Database Table
CasingDepthFrom	Beginning depth of cased interval	CASING
CasingDepthFromUnit	Name of unit of measure associated with the CasingDepthFrom field	CASING
CasingDepthTo	Ending depth of cased interval	CASING
CasingDepthToUnit	Name of unit of measure associated with the CasingDepthTo field	CASING
CasingMaterial	Casing type or material	CASING
CasingDiameter	Internal diameter of casing	CASING
CasingDiameterUnit	Name of unit of measure associated with the CasingDiameter field	CASING
Time	Date and time of the water-level measurement	WATERLEVEL
Original Parameter	Original parameter code for the water-level measurement	WATERLEVEL
Original Direction	Direction with respect to land surface of original water-level measurement	WATERLEVEL
Original Unit	Original unit of measure associated with the 'Original Value' field	WATERLEVEL
Original Value	Original value of water-level measurement	WATERLEVEL
OriginalMeasuringPointAlt	Elevation of the measuring point from which the original measurement was taken	WATERLEVEL
OriginalMeasuringPointDatum	Vertical reference datum of the original measuring point elevation	WATERLEVEL
Water Depth Below Land Surface Feet	Water-level value represented as depth to water below land surface in feet	WATERLEVEL
Observation Method	Observation method associated with the original water-level measurement	WATERLEVEL
Measurement Accuracy	Accuracy of water-level measurement	WATERLEVEL

Sites with Missing Data Elements

At the current time, there exist a number of information gaps at network sites, wherein some data elements required for the NGWMN are unknown. These data gaps were described in the funding proposal to the NGWMN submitted in November 2017, titled "Information Gap Filling and Continuing Operations for the Maine Groundwater Level Monitoring Network", and are summarized in Table 2. Gaps at the listed wells include land surface and measuring point altitudes, latitude and longitude, well depth, casing diameter, casing length and material, screen length and dimensions, and lithology. The proposed gap-filling project was funded as of September 2018 and is currently in progress.

Table 2. Information gaps at current MGS network sites.

SiteNo	Gap 2				Gap 3			Gap 4	
	depth unknown	casing diameter unknown	casing stickup in doubt	Casing material unknown	screen interval unknown	screen material unknown	screen diameter unknown	Aquifer unknown	lithology unknown
39412		X							
39413		X							
39414		X							
39415		X							
39870			X		X	X	X		X
39939				X		X	X		X
39954						X	X		
39965				X	X	X	X	X	X
40005						X	X		
40412						X	X		
40460		X		X		X	X		X
40496						X	X		
40568				X		X	X		
40775				X		X	X		X
40966				X		X	X		
40967				X		X	X		
40973				X		X	X		X
41155		X		X		X	X		
41176		X		X		X	X		X
41259				X		X	X		
41260				X		X	X		X
41675				X		X	X		
41901							X		
42037		X							
42147		X		X	X	X	X		X
48169			X			X	X		
52215	X	X	X	X	X	X	X		X
66131		X		X		X	X		
66132		X		X		X	X		
66134		X		X		X	X		
66408						X	X		
66409						X	X		

Sites that do not meet frequency specifications of Table 4.5.1.1

A number of sites do not meet the suggested sampling frequency for water-level sites specified in Table 4.5.1.1 of the NGWMN Framework Document. Table 4.5.1.1 indicates that trend water-level monitoring wells in aquifers with small or no withdrawals (the case at all of Maine's sites) should be measured quarterly. Nine wells in Maine's network (39939, 40460, 40568, 41176, 66131, 66132, 66134, 66408, and 66409) have been measured only twice per year in recent years, but have longer records that include quarterly measurements. An additional five wells (40966, 40967, 40973, 41155, and 42037) have only been measured once in recent years. We intend to return all these wells to quarterly sampling beginning in 2018 by having MGS geologists take measurements to supplement those already scheduled by DEP contractors.

Database Design and Web Services Infrastructure

Databases, Connections, and Servers

Data that appear in EGAD are housed in an Oracle database by MEDEP. The Maine Groundwater Monitoring Network data are stored in a Microsoft SQL Server database at MGS. The MGS Director of Earth Resources Information administers the enterprise geodatabase at MGS in close coordination with the Maine Office of Information Technology (OIT) and the Maine Office of GIS (MEGIS). OIT manages the hardware, software, licenses, network access, security, backups and disaster recovery for MGS in accordance with IT industry best practices and established state policy. All related file information is stored on network file storage arrays provided by OIT.

EGAD groundwater level data, along with some site, location, casing, and screen data, is extracted from the MEDEP Oracle database and loaded into the MGS database using a linked server object and a stored procedure. This data can be extracted and loaded at any time by MGS geologists. Since EGAD doesn't store all the information necessary to populate the NGWMN, there are additional tables for elevations, aquifer information, and lithology in the MGS database that can be populated manually from reports or field observations by MGS geologists.

Maine Groundwater Monitoring Network data that are flagged for release to the NGWMN are then made available to a service in ArcServer using a stored procedure that replicates the appropriate data from the MGS database. There are five feature classes, Site_Info, Screen, Lithology, Casing and Water_Level, in the service that adhere to the NGWMN Data Protocol. This service provides a map service, Web Feature Service (WFS), Web Map Service (WMS) and KML service for accessibility by different users with different needs. All data served through the ArcServer web services and published to the NGWMN are public records, and any privacy concerns are avoided by not using business or landowner names as identifiers.

Web Services Description

The Maine Groundwater Monitoring Network data web service is publicly available at https://gis.maine.gov/arcgis/rest/services/mgs/NGWMN/MapServer. From this REST service endpoint, the data for each of the feature classes can be queried and returned in several different formats – JSON, GeoJSON, HTML, KMZ – to name a few. See the full documentation of the ArcGIS REST API for all available options.

As an example of the REST querying capabilities, the request https://gis.maine.gov/arcgis/rest/services/mgs/NGWMN/MapServer/0/1?f=pjson can be issued to return a JSON formatted list of all attributes and the geometry of the first feature in the Site Info feature class.

```
{
 "feature": {
  "attributes": {
   "OBJECTID": 1,
   "AgencyCd": "MEGS",
   "SiteNo": 39412,
   "AgencyNm": "Maine Geological Survey",
   "SiteName": "MW-501A, Jay, ME",
```

```
  "DecLatVa": 44.497602000000001,
  "DecLongVa": -70.241508999999994,
  "HorzDatum": "WGS84",
  "HorzMethod": "CAD",
  "HorzAccuracy": "WITHIN 3M",
  "AltVa": "564.4",
  "AltUnits": 1,
  "AltUnitsNm": "Feet",
  "AltDatumCd": "MSL",
  "AltMethod": "site report",
  "AltAccuracy": "within 3m",
  "WellDepth": "251.7",
  "WellDepthUnits": 1,
  "WellDepthUnitsNm": "Feet",
  "NatAquiferCd": "N600NECRSN",
  "NatAqfrDesc": "New England crystalline-rock aquifers",
  "LocalAquiferCd": "BEDROCK",
  "LocalAquiferName": "Bedrock",
  "CountryCd": "US",
  "CountryNm": "United States of America",
  "StateCd": "23",
  "StateNm": "Maine",
  "CountyCd": "07",
  "CountyNm": "Franklin",
  "WlSysName": "EGAD",
  "WlSnFlag": 1,
  "WlSnDesc": "Yes",
  "WlBaselineFlag": 1,
  "WlBaselineDesc": "Yes",
  "WlWellChars": 1,
  "WlWellCharsDesc": "Background",
  "WlWellType": 2,
  "WlWellTypeDesc": "Trend",
  "WlWellPurpose": 1,
  "WlWellPurposeDesc": "Dedicated Monitoring/Observation",
  "QwSnFlag": 0,
  "QwSnDesc": "No",
  "SiteType": "WELL",
  "AquiferType": "confined",
  "LithDataProvider": "MEGS",
  "ConstDataProvider": "MEGS"
 },
 "geometry": {
 "x": -70.241509429999951,
 "y": 44.497602070000028
 }
 }
}
```

A more practical example is writing a query with parameters. The request
https://gis.maine.gov/arcgis/rest/services/mgs/NGWMN/MapServer/4/query?where=SiteNo%3D
39870+AND+OriginalDirection%3D%27down%27&outFields=*&returnGeometry=true&f=geo
json asks the service to return all the Water Level records for SiteNo 39870 where the
OriginalDirection field is set to 'down'. Again, all fields in the attribute table including the
geometry will be returned. Below is a subset of the returned GeoJSON file.

```
{"type":"FeatureCollection","crs":{"type":"name","properties":{"name":"EPSG:4326"}},"features":[{
"type":"Feature","id":48,"geometry":{"type":"Point","coordinates":[-
```

```
68.592103999999949,45.65040300000004]},"properties":{"OBJECTID":48,"AgencyCd":"MEGS","SiteNo":398
70,"Time":1116929160000,"OriginalParameter":"16589","OriginalDirection":"down","OriginalUnit":"Fe
et","OriginalValue":"10.81","OriginalMeasuringPointAlt":"435.73","OriginalMeasuringPointDatum":"M
SL","WaterDepthBelowLandSurfaceFeet":"7.81","ObservationMethod":"unknown","MeasurementAccuracy":"
unknown","DataProvidedby":"MEGS","PARAMETER_SEQ":4256563}},{"type":"Feature","id":49,"geometry":{
"type":"Point","coordinates":[-
68.592103999999949,45.65040300000004]},"properties":{"OBJECTID":49,"AgencyCd":"MEGS","SiteNo":398
70,"Time":1122888360000,"OriginalParameter":"16589","OriginalDirection":"down","OriginalUnit":"Fe
et","OriginalValue":"13.79","OriginalMeasuringPointAlt":"435.73","OriginalMeasuringPointDatum":"M
SL","WaterDepthBelowLandSurfaceFeet":"10.79","ObservationMethod":"unknown","MeasurementAccuracy":
"unknown","DataProvidedby":"MEGS","PARAMETER_SEQ":4256565}}]}
```

Year 2: Existing Data Provider

Description of Work

During Year 2 of the project, MGS continued to work internally and with DEP project managers and NGWMN technical staff to maintain and improve the Maine Groundwater Monitoring Network and its linkages with the national network. Our goals were to keep the list of sites in the network current and ensure that new data were added as they became available, to verify that monitoring data were entered into the database according to standard operating and quality control procedures, and to ensure that the connection between the State's database and the NGWMN Portal continued to operate correctly and that all web services were consistently available. During the early part of Year 2, we worked with NGWMN technical staff to improve the connections between our databases and correct minor errors in web services (see next paragraph). We also used resources during the year to improve our internal database user interface, in order to make error checking and quality control processes smoother and more efficient.

Updates made to Web Services

No major changes were made to the web services infrastructure during Year 2. In November 2017, we worked with NGWMN technical staff to solve a minor issue in which water levels were being shown incorrectly with 10 decimal places of precision, a result of a known bug in ESRI's ArcServer software. As a result of this work, on November 30 we updated our ArcServer service to publish double data types as properly rounded numbers in text fields, working around the bug. The NGWMN Portal was updated with the correct precision the following week.

Updates made to Database Design

No major changes were made to the underlying database infrastructure or design during Year 2.

Experience Serving Data to the NGWMN Portal

After the initial effort with USGS staff to link our database with the NGWMN, and after the correction of the precision issue described above, serving data to the portal has been free

from problems. Our web services have been consistently available, and updates to our published data have been typically flowing to the NGWMN and appearing in the Portal on a nightly basis.

Future Changes to Databases or Web Services

We do not anticipate any future database upgrades or changes that would affect availability in the next 2-3 years.

<u>**References**</u>

Subcommittee on Ground Water (SOGW), 2013, A national framework for ground water monitoring in the United States: Advisory Committee on Water Information, US Department of the Interior, accessed October 29, 2018, at http://acwi.gov/sogw/ngwmn_framework_report_july2013.pdf.