

**FINAL TECHNICAL REPORT**

**Network  
Maintenance and Improvements  
in Support of the  
NGWMN**

**USGS Cooperative Agreement G21AC10477  
(\$42,264)  
*11/1/2021 - 10/31/2023***

**Prepared by**

**NC Department of Environmental Quality  
Division of Water Resources  
Ground Water Management Branch  
512 N. Salisbury St  
Raleigh, NC 27604**

**December 5, 2023**

**Mark Durway, NC DEQ Hydrogeologist  
mark.durway@deq.nc.gov  
Tel (919) 707-9018**

**Nat Wilson, Independent Hydrogeologist  
gnatwilsonnc@gmail.com**

## **Overview of Work Planned and Accomplished**

In 2021, the US Geological Survey (USGS) awarded the NC DEQ Division of Water Resources (DWR) a \$42,264 grant in support of the National Ground-Water Monitoring Network (NGWMN) for performance period 11/1/2021 to 10/31/2023 (USGS Cooperative Agreement G21AC10477). Funding from this grant covered work under NGWMN Objectives 2A, 2B, and 6. In summary, Objectives 2A and 2B consisted of providing water level (WL) and water quality (WQ) data to the NGWMN, including developing new web services, and Objective 6 consisted of purchasing and replacing water level loggers and barometric pressure loggers on 12 NGWMN wells. In summary, all planned work objectives were either met or exceeded.

## **Detailed Description of Work Accomplished**

Work accomplished over the two-year grant period has equaled or exceeded all goals and expectations. GWMB's web services advancements under this grant have been so successful that discussion has begun about adding DWR's data to the EPA-USGS Water Quality Portal.

Goals and accomplishments for each objective are summarized in the following table.

<b>Objective - Description of Work</b>	<b>Goal</b>	<b>Actual</b>	<b>Accomplished</b>
2A - serve WL data	635 wells	655 wells	Exceeded goal
2B - serve WQ data (basic)	535 wells	616 wells	Exceeded goal
2B - serve WQ data (advanced)	264 wells	326 wells	Exceeded goal
2B - serve WQ data (advanced + PFAS)	Unspecified	127 wells	No goal set
6 - buy and replace loggers	12 wells	12 wells	Met goal

Note: WL data under Objective 2A consisted of daily groundwater levels, lithology and construction details for each well. Basic WQ data under Objective 2B consisted of pH, chloride, specific conductance, and salinity. Advanced WQ data under Objective 2B consisted of organic and inorganic chemical data, and when available, data for per- and polyfluoroalkyl substances (PFAS).

## **Description of Work to Support the NGWMN as a Data Provider**

Under Objective 2A, DWR proposed that outside services be used to maintain existing water level web services for NGWMN wells in accordance with Framework and Tip Sheet requirements. Nat Wilson, former groundwater program manager with DWR, was retained to implement work under this objective. No in-kind services were required for Objective 2A.

Under Objective 2B, DWR proposed that outside services be used to expand existing water-quality web services in accordance with Framework and Water-Quality Web

Services Tip Sheet requirement. Basic WQ services already being provided for most NGWMN wells consisted of pH, chloride, specific conductance, and salinity. With funding from this grant, inorganic and organic chemical data and per- and polyfluoroalkyl substances (PFAS) were added, as indicated in the preceding section. Under Objective 2B, DWR proposed that web services for all required data fields and metadata be developed, tested for accuracy and speed, and used to add water quality data to the NGWMN for selected wells. Well locations and details for WQ data added under this objective are provided on the NGWMN website. Nat Wilson, former groundwater program manager with DWR, was retained to implement work under this objective. No in-kind services were required for Objective 2B.

Under Objective 6, DWR proposed the purchase of 12 non-telemetry water-level loggers and 12 barometric pressure loggers for wells which have been in service as persistent water-level wells for at least five years. These loggers were needed because the maximum service life of the existing equipment and internal batteries had been nearly reached. The twelve wells are listed in the NGWMN Well Registry and meet Framework and Tip Sheet requirements including the Populating the Well Registry and Minimum Data Requirements Tip Sheets. The new water-level loggers are used for collecting hourly groundwater levels and the barometric pressure loggers are used for data correction. Equipment purchase under Objective 6 benefits the NGWMN by providing persistent, regional water-level data and minimizing data gaps. Agency in-kind services match for this objective consisted of salary and expenses for DWR staff responsible for operation of the North Carolina groundwater monitoring network.

### **Methods Used for Data Collection**

DWR data collection and other work for this grant project was performed by personnel whose qualifications are provided in the grant proposal. Water levels were obtained using dedicated Onset or Solinst data loggers which are routinely calibrated with water level tapedowns. Telemetry systems, equipped on some wells, are also monitored remotely on a continuous basis. Logger battery life is routinely monitored to assure that logger failure does not occur between data collection events.

Water quality analytical data was collected using US EPA and industry-recommended sampling protocol to prevent cross contamination and ensure wells were properly purged and sampled. Typically, wells were purged by peristaltic pump and tested by multimeter to determine when water quality parameters had stabilized, at which low-flow or other appropriate sampling technique was performed. Basic water parameters consisting of pH, chloride, specific conductance, and salinity were measured using a multimeter or test strips. Advanced analytical data consisting of organic and inorganic analyses, including PFAS, was obtained from samples collected using lab-specified containers, preservatives, hold times and submitting samples to a certified lab for analysis.

**Procedures Used to Quality Assure Data**

Before adding data to NGWMN databases or the well registry, data is quality assured by DWR staff. The two data types collected by DWR for this grant project consisted of water levels and water quality analyses.

Water levels were acquired hourly or at other regular intervals by data loggers, validated, and downloaded to the appropriate DWR database. Accuracy of locational data is assured soon after wells are constructed or acquired using survey grade GPS equipment to determine latitude, longitude, and altitude. Accuracy and geodetic reference systems used by DWR are state plane coordinates and latitude/longitude (<0.05 ft), altitude (<0.1 ft), horizontal datum (NAD83), and altitude datum (NAVD88).

Water quality data was quality assured and certified by the analytical lab used for analysis. Accuracy of test strip data is approximate and results can vary by user.

**Table of New Wells Added to the NGWMN During Grant Period**

New wells added to the NGWMN during the two-year grant period from 11/1/21 to 10/31/23 are listed in the following table.

NGWMN ID	Well Name	Date Added	Principal Aquifer	Depth (ft)
W 29D11	Chinquapin Elementary School	2/12/2022	Surficial	34
W 29D12	Chinquapin Elementary School	2/12/2022	NACP	800
W 29D13	Chinquapin Elementary School	5/5/2022	NACP	465
U 34B10	Turkey	5/5/2022	Surficial	39
U 34B11	Turkey	5/5/2022	NACP	142
U 34B12	Turkey	5/5/2022	NACP	260
U 34B13	Turkey	5/5/2022	NACP	335
U 34B14	Turkey	5/5/2022	NACP	446
U 37D1	Pondberry Bay	5/5/2022	Surficial	38
U 37D2	Pondberry Bay	5/5/2022	NACP	360
U 37D3	Pondberry Bay	5/5/2022	NACP	199
D 7F3	Maple	8/31/2022	Castle Hayne	760
D 7F2	Maple	8/31/2022	NACP	200
D 7F1	Maple	8/31/2022	Surficial	30
BB 45M2	Marietta	8/31/2022	NACP	552

NGWMN ID      for full ID, precede value in each cell with NCDWR:  
 NACP            Northern Atlantic Coastal Plain aquifer system  
 ft                feet

## **Web Service Updates During Grant Period**

The maintenance of web services and the well registry under Objectives 2A and 2B required upkeep of software designed to process and store raw data. Regular updates were required to MariaDB and PHP, which are the primary software packages of the DWR Ground Water Management Branch (GWMB). Also, DWR security software, such as Cloudflare, have timeout and content standards which affect and require changes to underlying code.

Under Objective 2A, web service improvements were made to many scripts used to upload and perform integrity checks on groundwater level data. These changes led to alteration and improvement of some scripts which form GWMB's public web pages, especially associated with automated real time data used in mapping applications on GWMB's map interface.

One aspect of GWMB's automated data collection program involves Solinst monitoring equipment and software at each well and new software at the server. An effort was made to allow staff to update the data collection process as defined at the server through a set of administrative scripts. These scripts limit the need for an IT employee with direct server access.

GWMB's web services use Plotly to graph individual and multiple water levels associated with DWR's multi-well monitoring stations. This interface allows users to adjust the time frame of the plot and select which wells are viewable. It also allows users to reset the plot to show all data over the water level history of a site or to plot one or more wells on a second y-axis to highlight water level changes.

Under Objective 2B, web service improvements were made to provide the NGWMN with organic and inorganic chemical data, and when available, PFAS data. A series of alterations were made to scripts associated with public display of groundwater quality data. Intermediate database tables were created to index the data collected and stored in a separate database to the groundwater level data base. Finally, the web service script was adapted to perform the required query which brings together all groundwater quality data collected by GWMB.

### **Description of Problems Encountered in Serving Data to the NGWMN Portal**

Water quality web services modifications included minor adjustments to the units returned to avoid the Greek letter mu, which is not represented on the portal, and to improve the consistency of data presented on the portal. In particular, the Greek letter mu was changed to u, as in ug/l, also referred to as micrograms per liter.