

**USGS National Groundwater Monitoring Network Cooperative Agreement  
Final Technical Report**

**Award Number:** G16AC00410

**Agency Name:** Missouri Department of Natural Resources, Missouri Geological Survey

**Title:** The Missouri Department of Natural Resources' Missouri Geological Survey proposal to collect well data from existing state observation wells in order to fill gaps in the National Groundwater Monitoring Network database and to add Missouri's groundwater observation wells to the national network.

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## **Background of Proposal**

The Missouri Geological Survey (MGS) has been collecting groundwater level data for over 60 years and is an existing data provider to USGS. Because of this, MGS's proposal was focused on the cleanup and addition of well data which was completed to fulfill two tasks in support of this grant. These tasks were conducted in fulfillment of Objective 3: Filling gaps in information at NGWMN sites and Objective 4: Well maintenance.

At the time of the proposal, MGS operated 172 groundwater observation wells, but had only 145 wells in the NGWMN database. The goals set forth to fulfill Objective 3 were to establish benchmarks at the 145 wells that were in the database and to search existing MGS information for water quality data for these wells. The goal for Objective 4 was to add missing data for the 27 wells that were not in the NGWMN database to increase Missouri's total well count to the 172 wells operated by MGS in addition to verifying that data was complete for the existing 145 wells already in the database.

## **Problems Encountered Completing Grant Deliverables**

At the beginning of the grant period, the MGS Groundwater Level Observation Well network included 172 wells for which MGS proposed to establish benchmarks for 145 of these wells that were currently included in the NGWMN database. Due to budgetary constraints and returning of wells to the original owners, the MGS network was downsized to 148 wells in June 2017. Twenty wells originally in the NGWMN database were eliminated while the remaining 125 were not. An additional four wells that were not previously in the database were also eliminated. Since June 2017, MGS has added one additional well to bring the total number of wells in the observation well network to 149.

Table 1 lists all wells that are currently or were formerly in the observation well network and is divided into three statuses.

1. Eliminated – 24 wells (20 previously in the NGWMN database and four that were not) which were discontinued from use as an observation well.
2. Added to Database – 24 wells which were not previously in the NGWMN database. Information for these wells was provided to USGS to be added to the database.
3. Previously in Database – 125 wells that were part of the original 145 wells in the NGWMN database that are still active.

Per the grant proposal, benchmarks were to be established for the 145 wells previously in the NGWMN database. Six wells where benchmarks were established were eliminated from the network, as previously described, after the benchmark was constructed. An additional six sites had two wells each for which only one benchmark was established at the site. This reduced the number of benchmarks constructed to 133 for wells previously in the database. However, MGS proceeded to construct benchmarks at the remaining network wells that were not previously in the database. Therefore, benchmarks have been established for all 149 wells, at 143 sites, that are currently active.

Due to the elimination of 24 observation network wells, MGS was not able to add data to the NGWMN database for all the missing 26 wells as originally proposed. However, data for the missing 14 wells still in operation, plus the missing data for the remainder of the original 145, has been provided to USGS for entry into the NGWMN database.

## Methods Utilized to Complete Workplan Deliverables

Benchmarks were established according to USGS standards as described in the publication titled *Methods of practice and guidelines for using survey-grade global navigation satellite systems (GNSS) to establish vertical datum in the United States Geological Survey*: U.S. Geological Survey Techniques and Methods, book 11, chap. D1, and illustrated in figure 10 of this publication. Elevations of the benchmarks were determined using a Trimble R8 Model 3 GNSS Receiver. Differential leveling was performed at each site to determine the vertical difference between the benchmark and static water level measuring point (MP) or reference point for the well. Differential leveling was accomplished with an optical level and leveling rod. Details were recorded on a *Benchmark Recovery and Establishment Form* and have been provided to the USGS Central Midwest Water Science Center (CMWSC) to be entered into the National Water Information System (NWIS). Copies of these forms will be available as deliverables for this grants as requested.

Although MGS maintains and operates the NGWMN wells located in Missouri, personnel with the CMWSC edit the well data and associated information shown in the NGWMN portal. Mr. Daryll Pope of the USGS provided MGS with spreadsheets of the wells and information currently in the NGWMN. As of July 31, 2018 there were 141 wells in the “SITE INFO” spreadsheet provided by Mr. Pope. Of these 141 wells, four (Winona, Marion Bottoms, Marshfield and Four Rivers) were eliminated from the MGS network and two (USGS-D1, P2 Potosi Dol and USGS-D1, P3 Bonnetterre Fm) are maintained by CMWSC and are not part of the MGS network. MGS files and records were mined to find any information that was missing for the remaining 135 wells. In addition, 14 wells and associated data were added to the NGWMN “SITE INFO” spreadsheet bringing the total number of MGS wells to 149 as discussed previously.

MGS also edited the “CASING” and “SCREEN” spreadsheets and updated them with appropriate revisions. The “SCREEN” spreadsheet only contains 38 wells as most of Missouri’s observation wells are constructed in consolidated formations and with open hole completions. All 149 current observation wells are included in the “CASING” spreadsheet. Some wells are listed twice since they have multiple strings of casing. Some data in the “SCREEN” and “CASING” spreadsheets is unknown. This information will be collected as part of a current NGWMN grant to conduction downhole video logging of the wells.

All three spreadsheets, “SITE INFO”, “SCREEN” and “CASING”, were sent to Mr. Daryll Pope of the USGS as part of this grant deliverables.

Table 1: NGWMN database status for Missouri observation wells

SITE_NAME	USGS_WELL_ID	STATUS
Akers	372153091322301	Previously in Database
Archie	382835094254301	Eliminated
Arrow Rock	390207092570801	Previously in Database
Asbury Ozark Aquifer	372202094370202	Previously in Database
Asbury Springfield Plateau Aquifer	372202094370201	Previously in Database
Atherton	391236094170201	Previously in Database
Atlas Powder	370600094223501	Previously in Database
Aurora	365645093431601	Previously in Database
Ava	365602092395101	Previously in Database
Babler State Park	383628090411901	Previously in Database
Battle of Athens State Park	403501091420401	Previously in Database
Bee Hollow Conservation Area	393640092303901	Eliminated
Big Spring	365654091001301	Previously in Database
Big Sugar Creek State Park	363721094173801	Eliminated
Billings	370354093325901	Previously in Database
Bixby	373955091065901	Previously in Database
Blackwater	385853092592801	Eliminated
Bourbon	380900091153901	Previously in Database
Branson	363855093134701	Previously in Database
Butterfield - Ozark Aquifer	364453093543602	Previously in Database
Butterfield - Springfield Plateau Aquifer	364453093543601	Previously in Database
Cainsville	402657093470201	Previously in Database
California	383707092311701	Added to Database
Camdenton	380038092442701	Previously in Database
Cardwell - Alluvial Aquifer	360252090173201	Previously in Database
Cardwell - McNairy Formation	360252090173202	Previously in Database
Carrollton	392045093302401	Previously in Database
Carthage	371036094171301	Previously in Database
Caruthersville	361145089394101	Previously in Database
Cassville	364059093520001	Previously in Database
Centralia	391149092072901	Previously in Database
Clarksville	392147090541901	Previously in Database
Coffey	400458093582001	Previously in Database
Cole Camp	382726093121601	Previously in Database
Columbia	385718092234201	Previously in Database
Columbia Bottoms	384849090092001	Previously in Database
Cooper Creek	363728093150401	Previously in Database
Crane	365415093342301	Previously in Database
Cuivre River State Park	390150090542801	Added to Database

Daniel Boone Home	383906090511401	Added to Database
Dawn	394013093400201	Previously in Database
De Soto	380501090335501	Added to Database
Deer Ridge Wildlife Area	401057091494501	Previously in Database
Delta	371125089445301	Previously in Database
Drake	382745091275701	Previously in Database
Dresden R-12 School	384455093201001	Previously in Database
Duck Creek	370248090042601	Previously in Database
Eagle Bluffs	385156092263202	Eliminated
East Prairie	364643089212301	Previously in Database
Eureka	383031090384101	Previously in Database
Fairview	371800092094801	Previously in Database
Farmington #10	374649090242601	Previously in Database
Festus	381405090260301	Previously in Database
Forest City #7	395355095051601	Previously in Database
Fountain Grove Wldlf Area	394201093181101	Previously in Database
Four Rivers Conservation Area	375930094222001	Eliminated
Fredericktown	373210090180601	Previously in Database
Fulton	384917091594401	Previously in Database
Gideon	362718089552301	Previously in Database
Golden City	372338094052801	Previously in Database
Graham Cave State Park	385432091343201	Previously in Database
Ha Ha Tonka State Park	375920092463001	Eliminated
Halfway	373701093151601	Previously in Database
Hallsville	390651092125101	Previously in Database
Hannibal	395043091262601	Previously in Database
Hermann #4	384258091243001	Previously in Database
Hopkins	403301094492301	Previously in Database
Independence	390945094234001	Previously in Database
Indian Hills	401920092130301	Previously in Database
Jackson	372521089362401	Previously in Database
Jameson	400105093591601	Previously in Database
Jefferson City	383550092094201	Previously in Database
Jefferson City East	383226092054001	Previously in Database
Joplin	370224094320201	Previously in Database
Knob Noster	384545093331601	Previously in Database
Koshkonong	363539091384501	Eliminated
Lake of the Ozarks State Park	380717092395401	Previously in Database
Lamar	372958094161001	Previously in Database
Lebanon	373906092385201	Previously in Database
Lesterville	372715090510701	Added to Database

Lewis and Clark State Park	393218095032601	Eliminated
Lincoln University Carver Farm	383151092081601	Eliminated
Linn	382836091502301	Previously in Database
Little Bean Marsh Conservation Area	392954095013101	Eliminated
Longview	364313094121101	Previously in Database
Lost Valley Hatchery	381641093214601	Eliminated
Malden	362955089581801	Previously in Database
Marion Bottoms	384258092231401	Eliminated
Marshall	391222093185501	Previously in Database
Marshfield	372022092542201	Eliminated
Mendon	393544093075601	Previously in Database
Mexico	390945091494001	Previously in Database
Middle Grove	392321092153901	Added to Database
Monett #10	365451093555501	Previously in Database
Monett #16	365634093542701	Eliminated
Mountain View	365949091421401	Previously in Database
Mt. Leonard	390750093233401	Previously in Database
Mt. Vernon - Ozark Aquifer	370539093494001	Previously in Database
Mt. Vernon - Springfield Plateau Aquifer	370539093494002	Previously in Database
National Lead	373559090082901	Added to Database
Naylor	363442090364301	Previously in Database
Neosho - Ozark Aquifer	364818094185302	Previously in Database
Neosho - Springfield Plateau Aquifer	364818094185301	Previously in Database
New Florence	385428091265001	Previously in Database
New Haven	383644091124901	Previously in Database
Nixa	370236093174401	Previously in Database
Noble Lake	365559092030001	Previously in Database
Noel	363236094290301	Previously in Database
North Hawker Point	373620093470301	Previously in Database
Norwood	370624092244701	Previously in Database
Onondaga State Park	380322091142601	Previously in Database
Oronogo	371220094302401	Eliminated
Osceola	380229093464701	Added to Database
Ozark	370005093122401	Previously in Database
Ozark Fisheries	375429092300701	Previously in Database
Pershing State Park	394508093132101	Eliminated
Pierce City	365644094001301	Previously in Database
Pineville	363550094232601	Previously in Database
Platte City	392228094473101	Eliminated
Pomme de Terre State Park	375259093181401	Previously in Database
Potosi	375617090465401	Previously in Database

Qulin	363551090152801	Previously in Database
Reform	384713091474301	Previously in Database
Rich Hill	380545094213501	Added to Database
Rogersville	370655093035301	Previously in Database
Rolla - Dept of Conservation	375749091475001	Previously in Database
Rolla - Industrial Park	375907091432201	Previously in Database
Rolla- Ramada Inn	375625091480401	Previously in Database
Rosendale	400251094485901	Previously in Database
Sedalia	384832093192501	Added to Database
Sedalia East	384147093101901	Added to Database
Shelbina	394156092030201	Previously in Database
Sheridan	403055094364701	Previously in Database
Sikeston	365319089331001	Previously in Database
Silver Dollar City	364006093200301	Previously in Database
South Jefferson County	380435090281301	Added to Database
Spickard	401444093442001	Previously in Database
Springfield	371435093134701	Added to Database
Springfield - McDaniel Lake	371558093181901	Eliminated
Springfield - Valley Park	370907093144101	Added to Database
Springfield - Valley Water Mills Ozark Aquifer	371548093144702	Added to Database
Springfield - Valley Water Mills Springfield Plateau Aquifer	371548093144701	Added to Database
St. Clair	382100090592801	Added to Database
St. Joseph	374254094524501	Added to Database
St. Peters	384737090372001	Added to Database
Steele	360425089485001	Added to Database
Sullivan	381217091104501	Added to Database
Tarkio Alluvial	402627095220601	Added to Database
Tarkio Glacial Drift	402618095222701	Added to Database
Theodosia	363436092391001	Previously in Database
Tipton	383929092464901	Previously in Database
Troy - deep	385837090594701	Previously in Database
Troy - shallow	385845090583801	Previously in Database
Urich	382748093595101	Previously in Database
Van Meter State Park	391622093161001	Eliminated
Vandalia	391825091285101	Previously in Database
Vandike Farms	403452092292901	Previously in Database
Viburnum Trend #2	373905091071001	Eliminated
Viburnum Trend #5	373056091063801	Eliminated
Viburnum Trend #6	372853091061801	Previously in Database
Vienna	381045091564801	Previously in Database
Warrensburg	384534093431101	Previously in Database

Warsaw	381652093215501	Previously in Database
Watkins Woolen Mill State Park	392310094154301	Eliminated
Webb City #6	370828094274101	Previously in Database
Weingarten	375306090125301	Previously in Database
Wentzville	384846090510301	Previously in Database
West Plains	364324091515001	Previously in Database
Weston	392336094550403	Previously in Database
Wildwood	383302090420201	Previously in Database
Willard	371801093260401	Previously in Database
Winona	370003091205301	Eliminated
Wofford Farm	373653091330101	Added to Database