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SPONSORING ORGANIZATION: Illinois State Water Survey

PROJECT TITLE: Continued Development and Maintenance of the Illinois Water-Level Database for the National Ground-Water Monitoring Network

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MAJOR GOALS: The main goals of this project were expanding ISWS well coverage in the NGWMN and establishing data services from the ISWS database to the NGWMN Portal.

PROJECT SUMMARY: The ISWS expanded the initial 15 Illinois wells present in the NGWMN pilot to a total of 54 wells across Illinois. Site information was populated and entered in the NGWMN well registry and data collection and quality assurance procedures were documented. During the last quarter of the project data services were established from the ISWS SQL Server database, providing continuous data to the NGWMN Portal.

Overview of Work

The Illinois State Water Survey (ISWS) received funding to begin providing data to the National Ground-Water Monitoring Network (NGWMN). The ISWS was part of the original pilot project for the NGWMN; as an existing data provider, in this round of work the ISWS was tasked with expanding the monitoring network to include additional wells with water level data. As the ISWS has several existing monitoring networks throughout the state, this task consisted of updating and maintaining the list of network sites, populating data elements for new sites in the well registry, and establishing data services for the NGWMN sites. The ISWS successfully completed these tasks in fall of 2016; including the original 15 pilot sites, a total of 54 water level sites have been added to the NGWMN Portal, providing a framework to add additional sites to the NGWMN as monitoring networks in Illinois continue to expand.

Existing Network

The ISWS maintains several monitoring networks throughout Illinois; the pilot project for the NGWMN focused on incorporating monitoring wells within the Mahomet Aquifer in Central Illinois and Eastern Indiana. This is a major sand and gravel aquifer system that is confined for most of its extent and serves many communities and irrigators (Roadcap et al., 2011). The aquifer has a long history of data collection, with over 170 wells monitored by the ISWS, some dating back to the 1950s. From this network a total 28 sand and gravel wells were selected for the NGWMN pilot. Currently the 13 Indiana wells are not part of the active network and their status is unknown.

At this time the ISWS does not have a regular water quality sampling program implemented, at least not with the sampling frequency desired as part of the minimum data standards (Section 4.5.2, Subcommittee on Ground Water, 2013), so no existing sites are suitable for the water quality portion of the NGWMN. The pilot program included some sites sampled by the Illinois Environmental Protection Agency (IEPA), but these sites are no longer actively maintained in the network. Future water quality monitoring will likely need to work in coordination with the IEPA.

Site Selection

Almost all monitoring wells within Illinois' local monitoring networks fall within one of the major aquifers outlined in the national aquifer map (USGS, 2003). New monitoring sites were selected primarily based on the current or planned availability of high-frequency water level data collection, mostly among existing networks for which there is funding available for continued monitoring. Availability of complete lithological and well construction data was also an important consideration, though a handful of locations were chosen for length of historical data record in spite of missing some of the data elements.

Since bedrock monitoring sites were not included in the NGWMN pilot project, focus was given to adding these sites in the Portal. Bedrock monitoring sites are more common in northern Illinois. The Cambrian-Ordovician Aquifer system, particularly the confined St. Peter and Ironton-Galesville Sandstones, has been the subject of many synoptic measurements by the ISWS since 1959, but there are relatively few sites appropriate for the NGWMN as most sandstone monitoring historically has been done at active production wells (Abrams et al., 2015); sites were only considered if cooperative agreements providing access to abandoned wells were

established, or the wells are otherwise maintained as dedicated monitoring wells by the ISWS, most of these are being outfitted with transducers and telemetry. In total, 14 sandstone monitoring wells were added to the registry (Figure 1). Several of these sites have additional historical data in the form of Stevens Recorder charts, so the length and frequency of historical data will improve as it is entered into the database. Additional bedrock monitoring sites can also be seen in Figure 1, though most of these are not part of a regional network at this time.

The monitoring network was also expanded in the major sand and gravel aquifers. In the Mahomet Aquifer, additional sites were selected to fill data gaps that were present from the initial pilot study for the NGWMN (Figure 1). The Sankoty Aquifer in northwestern Illinois is another irrigated sand and gravel aquifer system that has been monitored by the Survey since 1991 (Burch, 2004); no sites were currently part of the NGWMN, so all four sites with transducers (seven wells) were added to the network (Figure 1). Wells within the Water and Atmospheric Resources Monitoring (WARM) network, which is a statewide Illinois monitoring network focused on real-time climate data and water table conditions, were another addition to shallow monitoring in the NGWMN. WARM wells were considered for inclusion in the NGWMN if they were part of a major aquifer system, including two in sand and gravel aquifers in northeast Illinois, and one in the sand and gravel aquifers near St. Louis (Figure 1).

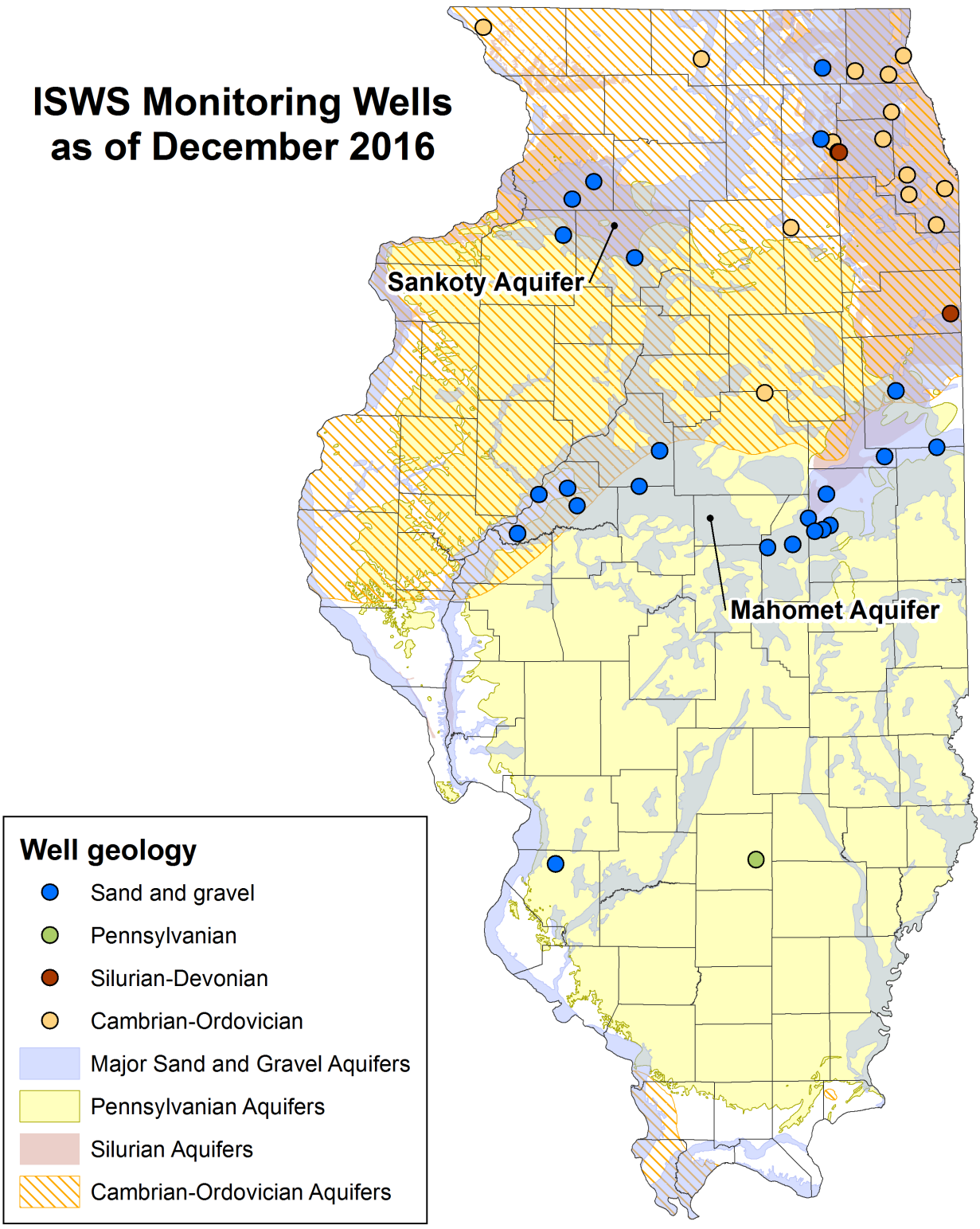

Figure 1. Location of ISWS monitoring wells included in the NGWMN. Note the southern extent of the Cambrian-Ordovician Aquifers represents a saline boundary of approximately 2500 mg/L TDS in the St. Peter Sandstone.

Assigning Subnetworks and Monitoring Categories

Most monitoring networks in Illinois are comprised of multiple water-bearing units, so in addition to being classified regionally they are also grouped by local aquifer. The Mahomet Network in central Illinois includes the Glasford Aquifer overlying the Mahomet Aquifer. At the western edge of its extent the Mahomet becomes unconfined and is sometimes referred to as the Mason Aquifer. The Sankoty Network in northwestern Illinois is comprised of the upper Tampico Aquifer and the basal Sankoty Aquifer; dedicated monitoring wells are present in both units (Figure 1). As discussed previously, though WARM network wells are a statewide network this is not an aquifer-specific monitoring network.

For bedrock monitoring, most wells in the Cambrian-Ordovician aquifer system are open to multiple aquifers, however two recently drilled Cambrian-Ordovician monitoring wells are single-aquifer wells open to the St. Peter Sandstone and Ironton-Galesville Sandstone, respectively, along with one Galena-Platteville Dolomite well in northwest Illinois that is part of the WARM network. Other wells are not part of active regional networks at this time, including a monitoring well in the Pennsylvanian sandstone of southern Illinois and two Silurian Dolomite wells in northeast Illinois (Figure 1), though part of the Silurian monitoring network has been the subject of a recent synoptic measurement and may be reactivated with new interest in the region.

The ISWS wells currently part of the NGWMN are a mix of Trend and Surveillance wells. Most wells currently in the network will be outfitted with telemetry and transducers in the coming years, so wells that are classified as Surveillance will change to Trend. Shallow monitoring wells, both in the Sand and Gravel and shallow bedrock units, are classified as a mix of "background" and "known changes," mainly dependent on the proximity to irrigation. In contrast

the vast majority of the Cambrian-Ordovician wells are classified as “known changes” as the system continues to be heavily stressed by municipal and industrial withdrawals, especially near the Chicago suburbs in northeast Illinois.

Field Techniques for Water Level Measurements

Water level measurement protocols are documented in ISWS Standard Operating Procedures, which are currently undergoing revision to add a section for transducer measurements and update language. Practices follow those outlined in Appendix 5 of the Framework Document (Subcommittee on Ground Water, 2013). Additional documentation for ISWS procedures for water level measurement and groundwater sampling can be found in Barcelona et al. (1985).

Minimum Data Elements

Per the guidelines in Appendix 5 of the Framework Document (Subcommittee on Ground Water, 2013), the ISWS populated well information required as part of the minimum data elements for the Well Registry and web services for the NGWMN Portal. Most data elements came from the ISWS wells table in SQL Server, which contains pertinent information for over 400,000 domestic, industrial, irrigation, and public supply wells in Illinois, particularly since well construction reporting became required in 1967. Wells in the ISWS database are identified with a unique “P” number, typically six digits, along with a local Site Name. Basic geologic and well information, including National Aquifer, Local Aquifer Name, well depth, open interval, and whether the aquifer is confined were garnered from the lithological and well construction data. Although the ISWS database contains information about well construction, establishing a lithology and well construction table for inclusion in the NGWMN data services required

supplementing ISWS data with lithological and well construction data from the Illinois State Geological Survey (ISGS) database, who traditionally maintains these records. As both Surveys are part of the Prairie Research Institute (PRI), long term the ISGS lithology and well construction data is expected to be linked directly to the ISWS database as the two Surveys work through procedures to combine workflows and link relevant records (Figure 2).

The ISWS referenced Site Location and Site Location Accuracy is dependent on the method for locating the well; many of the existing observation wells have been inherited from other owners, and few of the wells have been surveyed, so most wells have been verified with aerial imagery and ArcGIS. Accuracy will improve with site visits and locating wells using handheld GPS units. Generally elevation will have some degree of inaccuracy as land surface for many wells has historically been extrapolated from topographic maps. Once the location is verified the elevations will be extracted from LIDAR, if available. Additionally, the ISWS has an existing water level table in SQL Server, though for this project the ISWS modified the data structure to a uniform format in order to consolidate historical water level project data for inclusion in the water level table, as well as accommodate provisional data as the ISWS prepares to serve real-time data on the web (Figure 2).

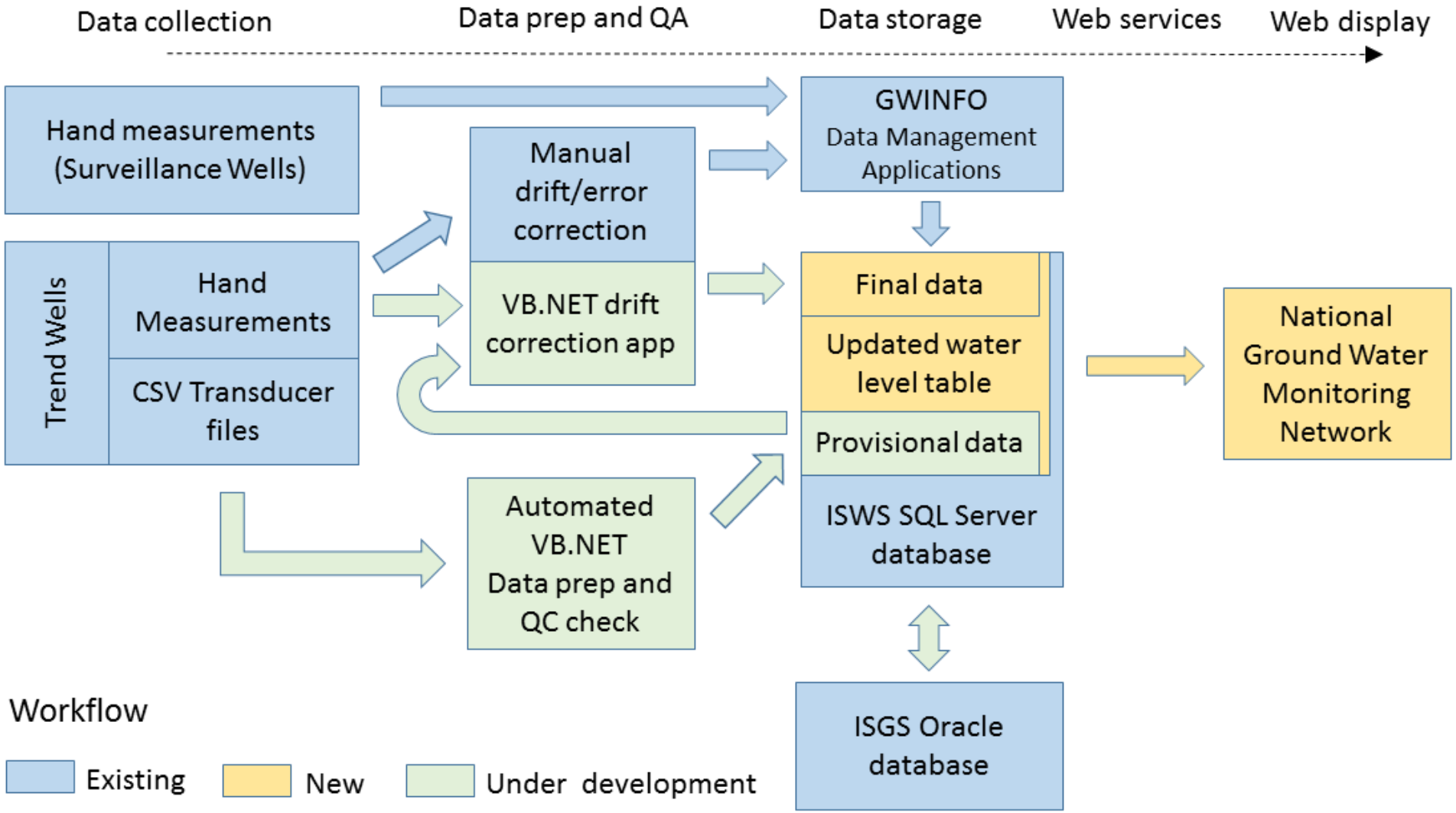

Figure 2. Workflow for managing and serving water level data to the NGWMN Portal. Most data is currently imported through GWINFO, the ISWS Groundwater portal for accessing the SQL Server database, while ISWS staff develop procedures for managing real-time data.

Missing Data Elements

Currently some of the existing wells in the monitoring network are missing site information such as the casing elevation. Often this information is included in field visit handbooks and supplemental data sheets, and in most cases this data has historically been corrected such that the measuring point elevation is adjusted to land surface. ISWS staff are working to verify site data in future visits and populate missing site information in the database to ensure consistency among measurements. Additionally, several sites are missing detailed geologic and well construction data. In some cases these data may be available in paper records and needs inclusion in the data services; however certain wells are old enough to predate detailed record keeping. In these cases geologic logs for nearby wells will likely be used if appropriate. Some wells are part of the registry but are not yet live on the Network as the ISWS develops a mechanism to manage real-time data collection for trend wells with transducers (Figure 2).

Web Services

As part of this project the ISWS established web services for the NGWMN, as no existing framework was present for serving data to the Portal. The workflow developed for this phase of the project and proposed internal enhancements for managing water level data are shown in Figure 2. All Illinois State Water Survey data provided to the NGWMN is hosted internally behind a firewall protected MS SQL Server database while the web services delivering data to the NGWMN portal are deployed on a public facing ISWS data server. The web services provide water level, lithology and well construction data from the selected observation well network(s) into a common data format consistent with NGWMN data requirements as follows.

Water Levels

- Measurement date and time
- Measuring point elevation
- Depth to water and measurement method
- Measurement precision, measurement quality remarks

Lithology

- Layer tops and bottoms
- Unit descriptions
- Method of observation

Well Construction

- Surface elevation and measurement method
- Well depth
- Casing depth, diameter, and material
- Screen length, diameter, and material

The initial focus on this phase of the project required mapping fields from ISWS native format schemas to those required for NGWMN portal usage. Future versions of the services will accommodate wells containing multiple open intervals and will pull this data directly from the Illinois State Geological Survey database. Currently, ISGS related data is hosted on a firewall protected Oracle database server which will be migrated to a SQL server database environment. The ISWS plans to replace the current ASMX web services with .NET based Web API RESTful

services and to ultimately develop open standard data services such as those based on the Open Geospatial Consortium (OGC) protocols. This will enable ISWS observation well network data to be more readily integrated and shared with the broader water data community.

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