Proposal

HYDROGEOLOGIC STUDY OF THE BRYCE CANYON CITY AREA AND EMERY VALLEY, GARFIELD COUNTY, UTAH

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INTRODUCTION

The Utah Geological Survey (UGS) has been asked by the Division of Water Rights to submit a proposal for a hydrogeologic study of southwestern Johns Valley, Garfield County, Utah, with emphasis on the area of Bryce Canyon City and the topographic bench and valley (Emery Valley) to the north (figure 1). The primary goals of the study are: (1) characterize the hydrogeology of the southwestern Johns Valley drainage basin as it pertains to the occurrence and flow of groundwater, with emphasis on delineating the basin-fill aquifer thickness and lithology and determining the bedrock hydrostratigraphy of the study area, and (2) characterize groundwater levels, chemistry, flow paths, and connection to surface water. We enumerate the products and tasks required to achieve these goals below. Based on the scope and geographic extent of the proposed work, we expect this project will require two years and three months of research, data collection, data analysis, and report preparation. This proposal provides background information for the study area, the proposed scope of work, and budget.

BACKGROUND INFORMATION

Location and Geography

Southwestern Johns Valley is in eastern Garfield County, central Utah, between Latitudes 37° 35′ and 37° 48′ North and Longitudes 112° 3′ and 112° 20′ West. The main focus of the study (figure 1) will be Bryce Canyon City and the gently rolling, forested slope to the northwest and north; the East Fork of the Sevier River below Tropic Reservoir and associated side drainages, particularly East Creek; and Johnson Bench and Emery Valley, which comprise the southwestern end of Johns Valley. Bryce Canyon City is about 20 miles southeast of the community of Panguitch. The northwest rim of Bryce Canyon itself forms the southeastern study area boundary. Emery Valley is an intermontane basin that is bounded by the Sevier Plateau on the north and east, and the Paunsagunt Plateau on the southwest, and opens to Johns Valley to the northeast. The East Fork Sevier River flows through Emery Valley from southwest to northeast and continues northeast through Johns Valley. The hand-dug Tropic Ditch taps into the East Fork of the Sevier River and transports water east through Water Canyon toward Tropic Valley (Davis and Pollock, 2010).

Geologic Setting

Johns Valley is in the Colorado Plateau physiographic province between the Markagunt and Paunsagunt plateaus. Bryce Canyon National Park is a major geologic feature to the southeast. Johns Valley is a topographic depression in which valley-fill sediment has accumulated from the East Fork Sevier River and alluvial fans and side drainages emanating from the surrounding hills. The valley fill forms the principal aquifer of southwestern Johns Valley.

Geologic units in the study area are Quaternary unconsolidated deposits, Tertiary volcanic and sedimentary rocks, and Cretaceous sedimentary rocks. The predominant geologic units are Quaternary valley fill, the Tertiary Mt Dutton, Brian Head, and Claron Formations, and the Cretaceous Straight Cliffs and Wahweap Formations. Unit descriptions below are from Biek and others (2015).

The Quaternary unconsolidated deposits include gravel, sand, and clay derived from adjacent hills and mountains and deposited in alluvial fan, stream, and mass-movement environments. Study of driller's logs as part of this project will better delineate the Quaternary deposits.

The Miocene Mount Dutton Formation is moderately resistant to nonresistant volcanic mudflow breccia consisting of angular to subrounded, matrix-supported, pebble- to boulder-sized clasts of dacitic to andesitic volcanic rock in a muddy to sandy matrix (Mackin and Rowley, 1976; Maldonado and Williams, 1993a,b; Rowley and others, 1994). The mudflow breccia is interbedded with volcaniclastic conglomerate and tuffaceous sandstone.

The informally named Oligocene Brian Head Formation is poorly resistant and is mapped separately from the upper-most part of the Claron Formation of Anderson and Rowley (1975) due to the abundance of volcaniclastic material (Maldonado and Moore, 1993). The unit consists dominantly of yellowish-gray and light-gray, cross-bedded, tuffaceous sandstone with interbedded pebble- to boulder-size conglomerate, sandstone, and minor limestone and mudflow breccia (Maldonado and Moore, 1995).

The early Tertiary Claron Formation, thought to be of Paleocene age (Hintze, 1988), rests on an angular unconformity above the Cretaceous-age rocks (Averitt and Threet, 1973). The cliff-forming Claron Formation consists mainly of thin- to thick-bedded sandstone, shale, and limestone with some pebble conglomerate; the upper part of the formation includes volcanic detritus (Rowley and Threet, 1976). The Claron Formation was mostly deposited in lakes (Doelling and Graham, 1972), but also in streams (Rowley and Threet, 1976).

The Late Cretaceous Wahweap Sandstone overlies the Straight Cliffs Formation in the eastern part of the Cedar City Valley drainage basin; these two units are very similar, especially near their contact, and are commonly lumped together as an undivided map unit. In the Cedar City area, the slope-forming Wahweap Sandstone consists of shale, siltstone, and a few thin beds of sandstone (Averitt and Threet, 1973). Sandstone is more abundant in the lower part of the formation (Averitt, 1962). The Wahweap Sandstone was deposited in nearshore marine and stream channel and floodplain deposits (Doelling and Graham, 1972).

The Late Cretaceous Straight Cliffs Formation overlies the Dakota-Tropic Formation in the eastern part of the Cedar City Valley drainage basin and consists of a lower cliff-forming, fine-grained massive sandstone and subordinate siltstone and an upper slope-forming fine-grained, thin-bedded sandstone and siltstone (Averitt and Threet, 1973). The Straight Cliffs Formation contains shale and marl at is base, four or five layers of up to six-feet-thick oyster beds distributed throughout the formation, and thin, discontinuous coal beds in the upper part of the formation (Averitt, 1962). The Straight Cliffs Formation was deposited in primarily nearshore marine environments (Doelling and Graham, 1972).

The principal structural elements of Johns Valley (Biek and others, 2015) include

1. the Paunsagunt Fault Zone, a northwest-side-down Quaternary normal fault that strikes northeast through Johns Valley along the eastern margin of the study area,

2. the Pine Hills and Rubys Inn thrust faults, which strike east-west and bound the northern and southern boundaries, respectively, of Emery Valley, and
3. the Johns Valley thrust fault northwest of Flake Mountain, which strikes northeast through the central part of Johns Valley in the northern part of the study area.

Hydrogeology

Groundwater is present in the shallow valley fill aquifer. Pre-Quaternary sedimentary deposits and Tertiary and Cretaceous rocks may also yield water to some wells, but the number of wells screened in and water production from these units is presently unknown. The limestone in the Claron Formation forms a karst aquifer on the Markagunt Plateau and may form an aquifer in the Emery Valley area. The East Fork Sevier River is sourced in the Paunsagunt Plateau, enters the study area from the south, and flows northeast through the study area in Emery Valley and Johns Valley.

Well Data

The U.S. Geological Survey has water-level records for 36 wells in the study area, determined from a search of their National Water Information System (NWIS) database. Most wells are used for domestic supply. Irrigation wells provide water to crops, though most irrigation water is diverted surface water from the East Fork Sevier River and its tributaries and associated canals.

Based on a preliminary review of well logs from the Utah Division of Water Rights database, the valley fill ranges in thickness from tens of feet near the basin margins to more than 100 feet below the valley floor, and up to 200 feet on Johnson Bench. Most valley-fill deposits are Quaternary stream alluvium (map unit Qaly of Biek and others, 2015), which consists of stream alluvium and stream-terrace alluvium and likely has high transmissivity.

Current groundwater levels and flow directions in the study area are unknown and will be the object of a significant part of this study. The groundwater level at the Bryce Airport averaged 29 feet below land surface over the past 5 years (U.S. Geological Survey NWIS data). Most additional groundwater-level data are about 20 to 30 years old. Based on regional topography and hydrology, the direction of groundwater flow is likely generally northeast toward Otter Creek Reservoir.

Groundwater Chemistry

Water quality and the potential for water-quality degradation are critical elements determining the extent and nature of future development in Johns Valley. Most development is on unconsolidated basin-fill deposits, the primary source of groundwater. Unlike other Utah communities, the population of Bryce Canyon City decreased from 2010 to 2016, from 198 to 182 residents (Town Charts, 2018; http://www.towncharts.com/Utah/Demographics/Bryce-Canyon-City-town-UT-Demographics-data.html). This, however, is an area of active tourism and, therefore, potential future growth. Increased demand on drinking water would warrant careful land-use planning and resource management to preserve Johns Valley's surface and groundwater resources.

A preliminary search of water-quality data for the study area yielded only one sample from the Utah Department of Agriculture and Food. A sample from a well in the northeast corner of the study area taken in 2003 had a total dissolved solids content of 218 ppm, a pH of 8.5, and no constituents that exceeded secondary drinking-water or agricultural standards.

PROPOSED SCOPE OF WORK

Tasks

- Compile a geologic map of study area; refine, as necessary, with new mapping; and construct two cross sections. Delineate the hydrostratigraphy of unconsolidated and fractured-rock units.
- Assemble pre-existing gravity data.
- Construct up to 4 cross sections through the valley fill using driller's logs. Construct an isopach map of the valley fill using driller's logs and gravity data. As appropriate, construct isopach and structure-contour maps of select fractured-rock aquifers.
- Assemble existing well data and specific-capacity and aquifer-test results.
- Measure water levels in selected wells and construct a potentiometric-surface map for the principal valley-fill aquifer and, where possible, the shallow unconfined and/or selected fractured-rock aquifers.
- Conduct seepage runs for streams at strategic points and times to evaluate groundwater-surface water relations.
- Collect groundwater and surface water samples and analyze for major-solute chemistry and environmental isotopes and tracers, including total dissolved solids and dissolved metals in order to characterize water quality.
- From the results outlined in the previous steps, produce a simplified conceptual model of groundwater flow in the study area, including recharge-to-discharge paths and groundwater-surface water interactions.

- Write a report outlining the results of the study.

Tasks are outlined in more detail below.

Geologic mapping, stratigraphy, and cross sections. From GIS mapping of the Panguitch 30’ by 60’ quadrangle, clip out a coverage for Johns Valley drainage basin. Construct stratigraphic and hydrogeologic columns for the study area. Refine from cross sections of Biek and others (2015), more localized cross section(s) at locations chosen to improve conceptual understanding of groundwater flow. Refine the GIS coverage and produce plates that include the geologic map, correlations and unit descriptions, and cross sections. Where sufficient data are available, construct structure contour maps for fractured-rock aquifers in upland areas.

Valley-fill lithology and isopach map. Enter data from driller’s logs into a well management program, construct profiles through the valley fill, and identify any laterally continuous lithologic units. These sections will assist interpreting water levels, flow paths, groundwater-surface water interactions, and constructing the conceptual flow model. Combine data from wells that penetrate through the unconsolidated valley fill into bedrock with gravity data to construct 2D model profiles using GM-SYS. Use these sections to construct an isopach map of the valley fill.

Hydrologic data assembly. Assemble existing hydrologic data from literature, online databases, and consultant’s reports. Compile data into spreadsheets or databases. Data of interest include water levels in wells, stream- and spring-flow records, and specific capacity/aquifer tests. Assess aquifer characteristics (transmissivity and storativity) based on existing aquifer tests and specific-capacity data from driller's logs of water wells for both basin-fill and fractured-rock aquifers.

Potentiometric surface mapping. During spring 2019, prior to irrigation season, measure water levels in selected wells in valley-fill and fractured-rock aquifers. Construct a potentiometric surface map for the principal valley-fill aquifer. Where sufficient data exists, construct potentiometric surface maps for portions of the shallow unconfined aquifer and fractured-rock aquifers. Document seasonal and historic changes in wells and the potentiometric surface where possible.

Groundwater—surface-water interactions. Use hydrogeologic, seepage, and environmental tracer data to delineate areas of groundwater—surface-water interaction. Delineations will range from areas where groundwater is disconnected from surface water to areas where groundwater and surface water are closely connected. Delineations may also include important areas of gaining or losing surface water, and sources and degree of connection with the local groundwater system. Delineations will cover both bedrock and basin-fill areas.

Collect and analyze groundwater samples. Collect samples from wells, springs, surface water, and precipitation. During the spring through fall of 2018, sample collection will focus on characterizing the valley-wide major solute chemistry and stable-isotope composition of water from wells, springs, and streams, as well as limited sampling of radiogenic-isotopes and possible seasonal variations in stable isotopes. During 2019, sample collection will focus on addressing specific issues and questions that will arise from the first season of sampling, such as groundwater sources to springs or streams, or regional to local flow paths, using general chemistry, stable and/or radiogenic isotopes, and other tracers as appropriate. All water-quality data will be entered into spreadsheets, and analyzed using standard water-quality maps and diagrams as well as simple numerical modeling as appropriate.

Conceptual model of groundwater flow. Determine and describe the nature of local, intermediate, and regional groundwater flow systems in the study area including valley-fill and bedrock aquifers, and of groundwater-surface water interactions.

Write final report. Produce a draft final report, including GIS maps, figures, evaluations of environmental tracer data to delineate recharge and discharge systematic, conceptual model of groundwater flow, and water budget.

Products.

- Report, including background information, descriptions of data collection and results, and interpretations including a simplified conceptual model of groundwater flow.
- Data tables in numerical electronic form.
- Hydrostratigraphic map at 1:100,000 scale in GIS format.
- Structural and valley-fill lithologic cross sections.
- Isopach map showing thickness of basin-fill deposits in GIS format.
- Structure contour maps for basin-fill aquifer and, if appropriate, aquitard layers and select fractured-rock aquifers in GIS format.

- Transmissivity maps from specific-capacity and aquifer-test data for basin-fill aquifer and selected fractured rock aquifers, if appropriate, in GIS format.
- Potentiometric surface map in GIS format.

TIME FRAME AND BUDGET

The study will begin April 1, 2018 and will be completed by June 30, 2020. See attached proposed budget and work plan. During April 2018 to February 2019, work will focus on data collection, field reconnaissance, geologic analysis, and preliminary water levels, surface flows, and sampling. During March to October 2019, work will focus on a groundwater-level campaign, seepage runs, and sample collection including radiogenic isotopes and other tracers. During November 2019 to June 2020, work will focus on collection of final data, data analysis, and report writing.

The total cost of the project will be approximately $239,300: $21,200 in FY18, $110,300 in FY19, and $107,800 in FY20 (see budget proposal sheets for precise amounts). Each year, the Utah Geological Survey will provide a 50% in-kind match. Requested outside funding is approximately $10,600 in FY18, $55,200 in FY19, and $54,000 in FY20.

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