Project Description and Work Plan
Big Sky Area
Gallatin County, Montana

July, 2013
Montana Bureau of Mines and Geology
Ground Water Investigation Program

DRAFT

Background and Purpose

The Big Sky Area is located mainly in the West Fork Gallatin River drainage basin, about 40 miles south of Bozeman (fig. 1). It is a recreational and residential area nestled in the Madison Range, just south of the Spanish Peaks. The area has experienced relatively heavy development pressure since the inception of the Big Sky Ski Resort in the early 1970's. Developments include resort facilities, housing developments, and a golf course. Moonlight Basin, a ski resort at the west end of the Big Sky Area is situated in the upper reaches of Jack Creek, which is a tributary of the Madison River to the west. Groundwater is the principal water source used throughout the area. The aquifers include structurally complex bedrock formations and overlying unconsolidated gravels and sands associated with stream alluvium and glacial deposits. The development of groundwater resources in the area has led to problems and difficulties such as declining groundwater water levels, water right questions and issues regarding aquifer configuration and extents, and uncertainties about their capabilities to sustain current and potential futures uses.

The Big Sky project area includes a public water supply system operated by Big Sky Water and Sewer District No. 363, which provides water to many of the residences in Big Sky Meadow Village and surrounding area near and between the Big Sky Mountain Resort and Highway 191 along the West Fork Gallatin River. The most productive wells in this system are located in a meadow adjacent to the West Fork Gallatin River, near Big Sky Meadow Village. There are currently five production wells in the meadow area, and the capability of this groundwater system to support additional wells is unknown.

In some areas within the water-system boundary, and in the adjacent areas, individual wells derive water from a variety of aquifers; predominately bedrock aquifers. Severe water-level declines have reportedly occurred in parts of this area, causing residents to deepen or replace their wells. The structurally complex underlying bedrock geology makes it difficult to understand groundwater conditions in some areas, or to develop a conceptual model of the overall groundwater flow system, including the locations of groundwater divides.

There is interest in determining sources for future groundwater supplies, both for individual wells and for potential expansion of the Big Sky Water and Sewer District. The DNRC is specifically interested in obtaining information about the development potential of the Madison Aquifer and whether the aquifer is connected to the Yellowstone hydrothermal system. DNRC notes that water sources connected to the Madison River watershed may have significant advantages due to legalities of surface water availability in the Gallatin and Madison Rivers.

The purposes of this project are to characterize the local groundwater systems, improve the groundwater-monitoring network in and near the Big Sky Meadows Village alluvial aquifer and public water supply well field, and develop a numerical groundwater flow model for the Big Sky Meadows

Village alluvial aquifer. This study will attempt identify the portions of the groundwater system that form cohesive, identifiable aquifer units and to describe the stresses and conditions within such units. It will include a focus on determining how pumping from the identified local aquifers affects groundwater levels, aquifer storage reserves, and the hydrogeologic system as a whole. The Madison Aquifer will be investigated to the extent possible. The proposed groundwater model can potentially be used to evaluate the capacity of the Big Sky Meadows Village well field, the potential for expansion of the well field and increased groundwater withdrawals, and how the well field and aquifer will respond to various pumping scenarios.

Project Location

The project study area will include most of the West Fork Gallatin River drainage basin, and portions of the Jack Creek drainage, which is located across the watershed divide, west of the Big Sky Resort. Water well logs and data are generally more abundantly available in the more populated portions of the drainage basins, including the Big Sky Water and Sewer District service areas and adjacent locations with individual wells and water systems. This more populated and developed area extends from the Moonlight Basin area, east through the Big Sky Mountain Village, and Big Sky Meadow Village to the Gallatin River along the Middle and North Forks of the West Fork Gallatin River. It also extends upstream to the southwest along the South Fork of the West Fork of the Gallatin River. These more developed areas offer the most data for detailed well log evaluations and well inventory efforts. A focused effort will be undertaken at the alluvial aquifer in the vicinity of Big Sky Meadow Village.

Cooperating Agencies

This study is being conducted with the cooperation of the following agencies and individuals:

- Big Sky Water and Sewer District #363
- Blue Water Task Force
- Gallatin Local Water Quality District
- Water Resource Division, Montana Dept. of Natural Resources and Conservation
- Bozeman Water Resources Regional Office, Montana Dept. of Natural Resources and Conservation
- Dr. Steve Custer, MSU Associate Professor of Geology (retired)

Project Work Plan

- Previous Studies
    - Assemble and evaluate existing geologic, hydrologic, and hydrogeologic data and interpretations from previous investigations. These will include published or otherwise publically available maps and reports, and any materials private entities are willing to provide to us. The Big Sky Water and Sewer District No. 363 has an extensive library of relevant reports that we will be reviewing.
- Collect and evaluate groundwater use data from high-capacity wells and water systems in the Big Sky area.
    - A well production summary has been provided by Big Sky Water and Sewer District for the years 2004 through 2012. Additional details and information will be sought.

- This project will attempt to obtain similar water-use information from any other entities in the area that use high-production wells and are willing to provide such data.

- Determine what data is available concerning the quantification of sewage effluent from the Big Sky Water and Sewer District and any other local entities which may operate sewer systems.
- A detailed analysis of geologic data, well logs, reported and inventoried groundwater levels combined with the possible installation of exploratory wells and bedrock monitoring wells in key locations to evaluate the hydrogeologic framework of the bedrock aquifers.
  - Existing reports and evaluations of groundwater conditions in the greater Big Sky area will be sought and considered in our hydrogeologic interpretations.
  - Existing well log data will be analyzed. Project investigators will verify that well logs are properly located and can be tied to a specific parcel. Well logs for which locations can be reasonably verified will be assigned map elevations, or elevations from LIDAR where available. Once complete, the lithologic descriptions can be coded to the appropriate lithology groups then imported into Groundwater Modeling System software where they can be evaluated in 3D space.
  - The well-log lithologic data will be compared with the current understanding of geologic conditions at the surface and in the subsurface.
  - Some exploration drilling is possible. Detailed locations or depths will be determined based on interpretations of existing geologic maps, cross sections, well log data, and the location of existing accessible wells; and considering recommendations and desires of the project stakeholders. The purposes of such drilling will vary, however they may include determining subsurface geology, determining groundwater levels, or determining the productivity of specific aquifers at specific locations.
- The Ground Water Characterization Program inventoried area wells and established a groundwater monitoring network as part of the Gallatin-Madison Ground Water Assessment Area. Their monitoring well network will be assessed, and permissions sought to re-instate monitoring during this study. Groundwater-level measurements will be made approximately once every four to six weeks, depending on access and other considerations.
  - Groundwater-level data will be categorized by the depth of the screened intervals, the geologic units, and the aquifer they are completed in.
  - Potentiometric surfaces will be analyzed where water-level data, geology, and water-quality data indicate cohesive aquifer units exist.
  - Additional groundwater monitoring wells will be considered to bolster the existing data set. Such wells will be inventoried in a similar manner as during the Characterization Program, recording the basic response of pumping water-levels and basic field parameters of water quality, (specific conductance, temperature, and pH).
- Surface water gauging locations and staff gauges, if present, will be evaluated and considered for use during the project duration. The Blue Water Task Force and Gallatin Local Water Quality District will be contacted to optimize the placement of stream monitoring sites. Staff gauges and water level and temperature recording devices will potentially be installed at selected locations.
- Groundwater-quality data collected by the Ground Water Characterization Program, and any interpretative studies they completed, will be compared with the distribution of geologic materials at the completed depth interval.

- Based on the assessment of available groundwater-quality data, a groundwater-quality sampling plan will be developed to infill areas with data gaps or those areas needing a more detailed data set. The sampling will likely include full-suite chemical analyses of groundwater and surface-water samples from throughout the project area, including major-ion chemistry, minor constituents, certain metals, and augmented with some selected isotope analyses at various sites.
- Big Sky Meadow Village alluvial aquifer.
    - The existing groundwater-level monitoring network will be evaluated in consultation with the Big Sky Water and Sewer District No. 363. If it is deemed that additional groundwater monitoring wells would be useful and permissions can be obtained, such wells will be installed. Work activities and site access will be coordinated with the water and sewer district and local landowners.
    - Aquifer tests previously conducted in the area will be reviewed and evaluated to the extent possible.
    - Opportunities will be sought to conduct aquifer tests on existing wells, potentially with additional or new observation wells in cases where we believe such wells would improve the analyses of aquifer properties. For example, opportunities to develop distance-drawdown data or multi-directional data will be sought.
    - Sources of recharge to, and discharge from, the Big Sky Meadow Village alluvial aquifer will be evaluated. Investigators will seek opportunities to quantify gains and losses in the West Fork Gallatin River in the vicinity of the alluvial aquifer, if practical. Available data regarding irrigation and groundwater pumping will be used to determine the level of groundwater use and to develop a groundwater budget for the aquifer. Efforts will likely include some evaluation of recharge sourced from streams, adjacent bedrock aquifers, and rain and snowmelt events.
    - A numerical groundwater flow model is planned for the Big Sky Meadow alluvial well field
- Planned products of the study will include:
    - An interpretive report describing the results of the study.
    - A groundwater model and groundwater model report.
    - An Educational pamphlet about water resources in the Big Sky area.
        - The objectives and content of an educational pamphlet will be proposed and discussed with the other agencies involved.
        - The pamphlet can potentially be published as a Montana Bureau of Mines and Geology Information Pamphlet.

Project Duration: July 2013-June 2016