Great West Engineering, Inc.

Water Resources Monitoring Plan
Central Montana Regional Water Authority

WESTERN GROUNDWATER SERVICES

WATER RESOURCES MONITORING PLAN
CENTRAL MONTANA REGIONAL
WATER AUTHORITY

ABSTRACT

The Central Montana Regional Water Authority (CMRWA) prepared this monitoring plan in relation to operations of their proposed wellfield in Judith Basin County. The wellfield is designated the U Bet Wellfield and will produce drinking water from the Madison Aquifer for rural users and communities located between approximately Hobson and Melstone. The monitoring plan preparation included a meeting of interested parties to obtain feedback on the plan outline and to incorporate comments into the final plan. There are nine activities included in the plan that pertain to monitoring and characterizing the water resources of Judith Basin. Several of the monitoring plan activities will continue indefinitely into the future and will be operated and maintained by the CMRWA as part of water system operations. The total budget estimate for the plan is $483,000 which includes three years of operations and maintenance. This total amount includes $292,000 in contractor fees, equipment purchases, and laboratory analyses. Engineering services to plan and oversee construction, set instrumentation, collect water quality samples, and complete data analysis and reporting has a budget of $156,000. The budget estimate also includes a contingency amount of $35,000. The annual operations and maintenance budget that would be required in the fourth year and thereafter is $13,800.

1. INTRODUCTION

The Central Montana Regional Water Authority (CMRWA) is in the process of planning the Musselshell-Judith Rural Water System (MJRWS). The MJRWS is a public water system intended to serve several communities and rural users approximately between Hobson and Melstone. The source of water supply is the Madison Aquifer diverted from a wellfield near Garneill and referred to as the U Bet Wellfield (Figure 1-1). A test well constructed at this location in 2012 identified a high capacity aquifer of potable water quality.

Construction of the wellfield at this location has generated interest from citizens in Judith Basin and Fergus Counties, and State government.[1] This interest generally reflects a concern of possible wellfield impacts to water resources in the area. There are numerous private wells throughout Judith Basin and also many water supplies sourced from springs. Among these is Big Spring, which is also a Madison Aquifer water resource, and the source of water to the City of Lewistown.

This water resource monitoring plan has been prepared to develop baseline information and to track trends of specific water resources of Judith Basin. The purpose for the monitoring system that will be developed through plan implementation is to provide factual data for water users, including the CMRWA and others. These data and associated analyses will further the understanding of the relations between various water resources components and how they may be changing in the future.

1 Judith Basin is a hydrologic basin that occurs in parts of Judith Basin County and also Fergus County.

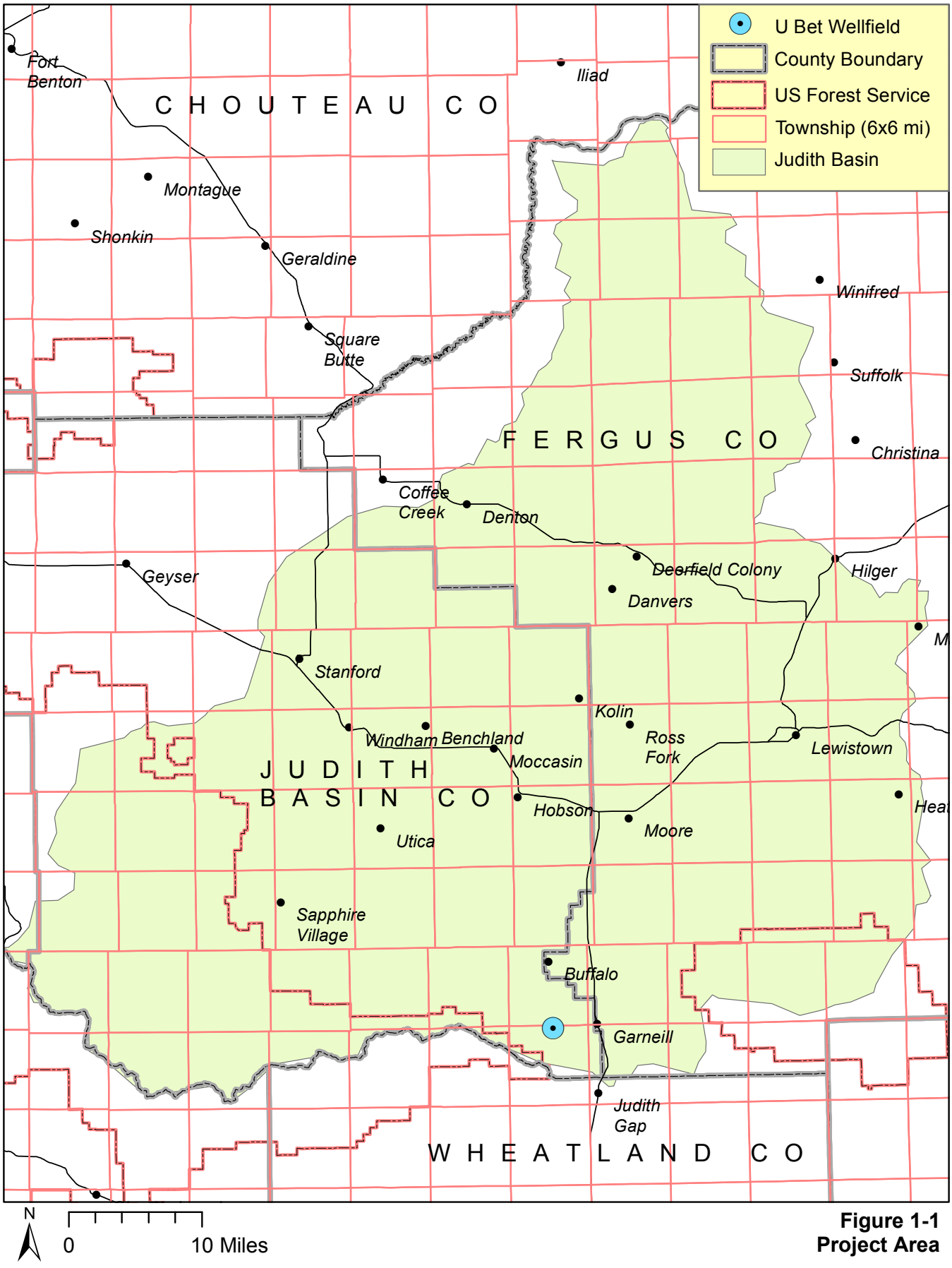


Figure 1-1
Project Area

The Montana Bureau of Mines and Geology (MBMG) recently completed a study of the Madison Aquifer between approximately Lewistown and Great Falls, which included Judith Basin.[2] They identified that this area is too large for a detailed study, and that it should be separated into sub-areas for more detailed investigations. This monitoring plan helps to achieve this recommendation by collecting data that facilitates detailed analyses of the Madison Aquifer in the Judith Basin portion of the larger region studied by MBMG.

Western Groundwater Services, LLC[3] completed this water resources monitoring plan while working as a subconsultant to Great West Engineering, Inc. Great West Engineering is the CMRWA's engineering consultant.

2. BACKGROUND

Aquifers and Geology

Water supply wells in Judith Basin are completed in the sandstone of the Kootenai Formation, also referred to as the Cat Creek Aquifer, and less defined aquifers that overlie the Kootenai. It appears that most of the private wells actually produce from these shallower less defined aquifers, as the Kootenai is too deep to access in the basin interior (+2000 ft). These formations consist of sandstone and shale, and also unconsolidated alluvium.

The Madison aquifer discharges at Big and Warm Springs, and also at a single well diversion referred to as the Hanover Well, located northwest of Lewistown. The U Bet Wellfield is the first Madison Aquifer diversion in Judith Basin using pumped wells.

Figure 2-1 illustrates the surface outcrop of the Kootenai and Madison Formations along the periphery of Judith Basin, and also shows the locations of existing Madison Aquifer diversions. Figure 2-2 is a profile view of the basin geology along transect line A-A' which is shown on the geology map. The cross section view is down the axis of the basin, toward the northeast. The Madison is very deep throughout Judith Basin, except where it outcrops along the basin margins. The Kootenai also occurs at the surface along the basin margin and then dips inward toward the basin center.

The primary groundwater recharge areas for the Madison Aquifer are the Little Belt and Big Snowy Ranges, however the Judith Mountains and North and South Moccasin Mountains also are important recharge areas. In these areas the Madison outcrops at the surface. Precipitation that infiltrates the soil and stream flow across the outcrop area results in aquifer recharge. Peak precipitation exceeds 50 inches per year in the Big Snowy Mountains and 35 inches per year in the Little Belt Mountains (Figure 2-3).

The Kootenai Aquifer is recharged along the basin periphery where it is exposed at the surface. Recharge occurs by the same processes as for the Madison, however the amount of precipitation at the lower elevation is less, ranging from 15 to 20 inches per year. Shallower aquifers are recharged in the basin where precipitation, surface water leakage, and irrigation canal leakage occurs. Precipitation is lower in the basin interior, ranging from 10 to 20 inches per year. In the drier parts of the basin, leakage from creeks and ditches could be a greater contributor than precipitation, which is largely lost through evapotranspiration.

2 MBMG (2014) Sustainable Water Supplies from the Madison Aquifer, Central Montana, Administrative Report, p. 14, RDGP Grant #RIT-10-8714.

3 Western Groundwater Services, LLC, Bozeman, MT (406) 585-5947.

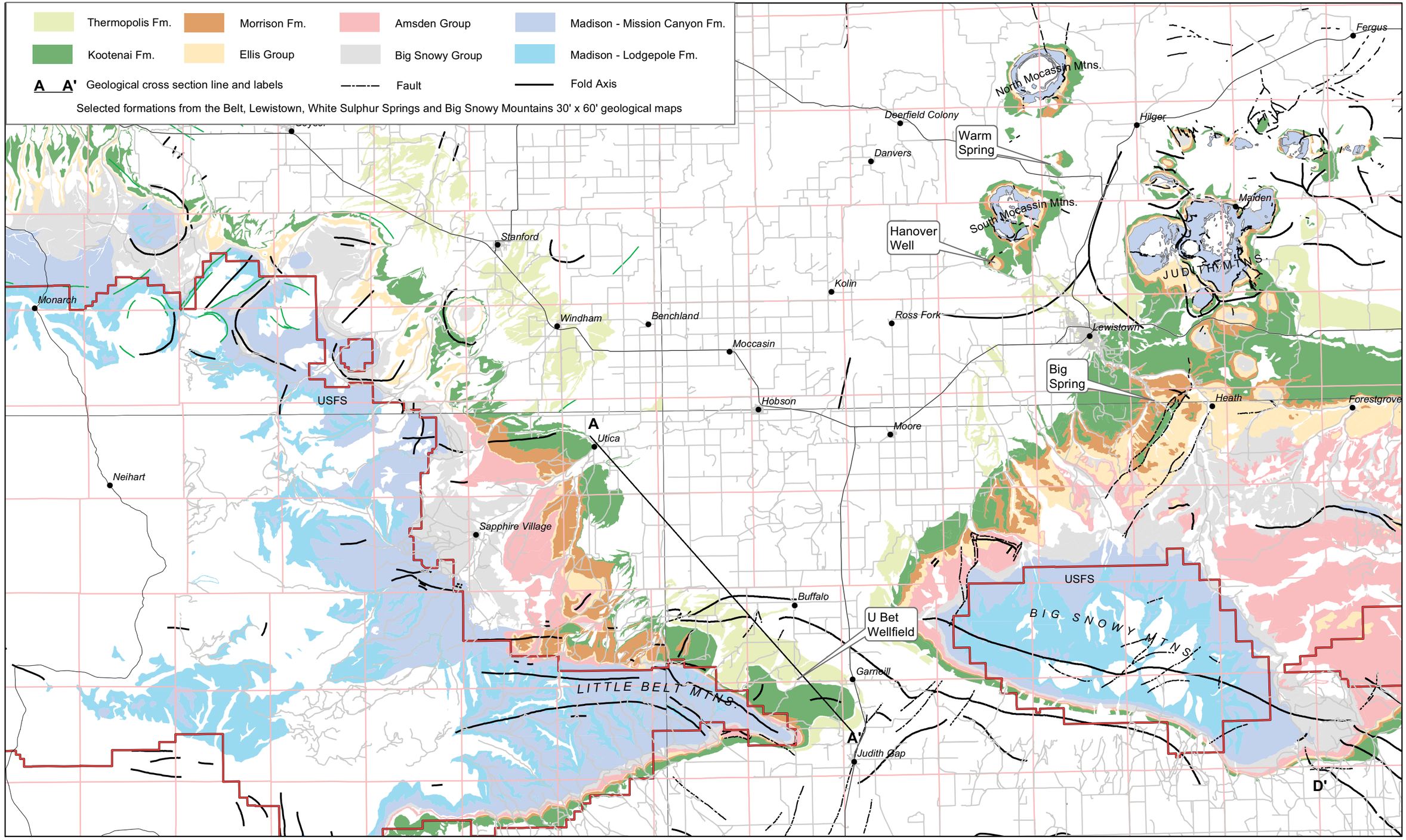
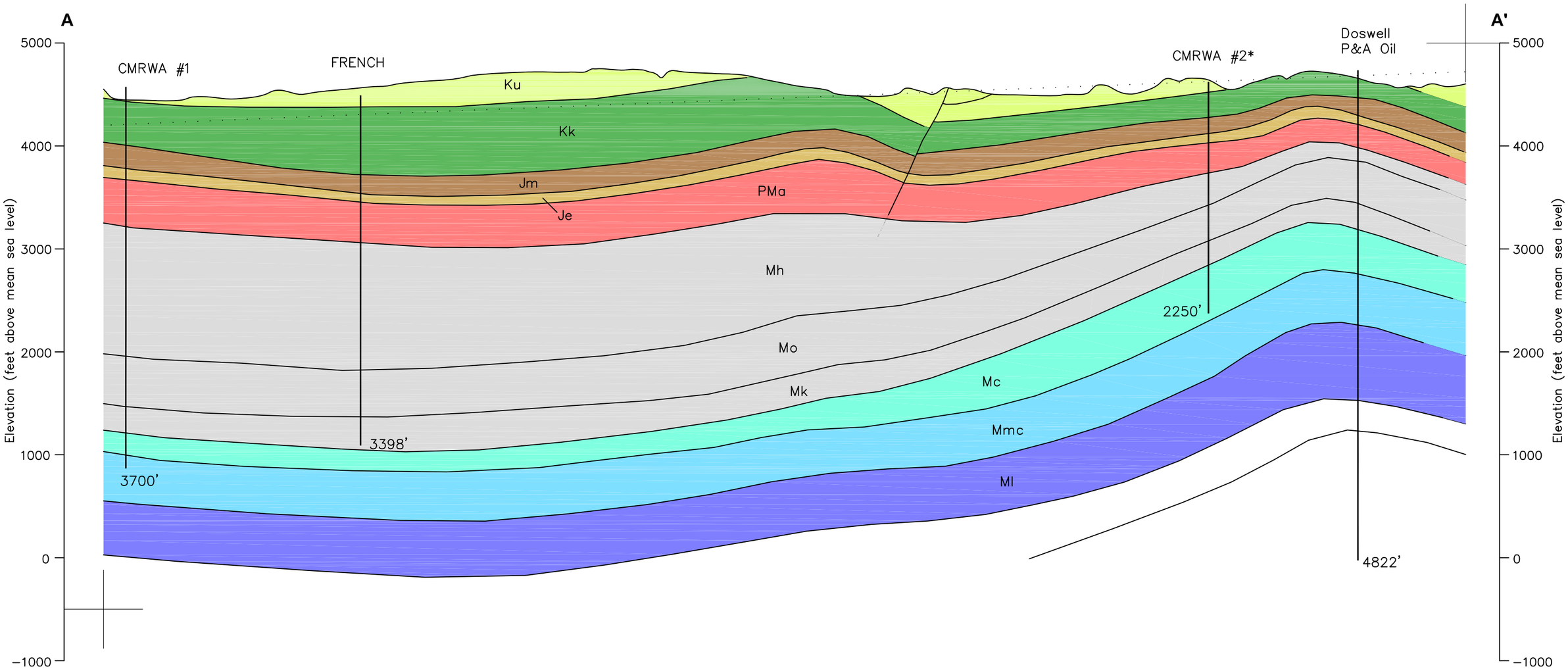


Figure 2-1
Surface Geology



Cross sections were drawn balanced at exaggerated scales.

Ku	Cretaceous rocks, undifferentiated, mostly marine shale	Je	Ellis Group, sandstone, limestone, shale	Mc	Madison Group, Charles fm., limestone, dolomite, shale, anhydrite	CMRWA #1 / 3700’	Borehole location, name and total depth
Kk	Kootenai fm., sandstone and shale	PMa	Amsden Group, limestone, shale, sandstone	Mmc	Madison Group, Mission Canyon fm., limestone, dolomite, target aquifer		Estimated piezometric surface
Jm	Morrison fm., shale	Mbs	Big Snowy Group, Mh (Heath), Mo (Otter), Mk (Kibbey), shale, sandstone, some limestone	Ml	Madison Group, Lodgepole fm., limestone/shale, thin bedded		

*This geologic section predates the construction of CMRWA #2. The geology is approximately as shown at the well location.

0 10,000 20,000 Feet
Horizontal Scale

Figure 2-2
Geological Cross Section A-A'

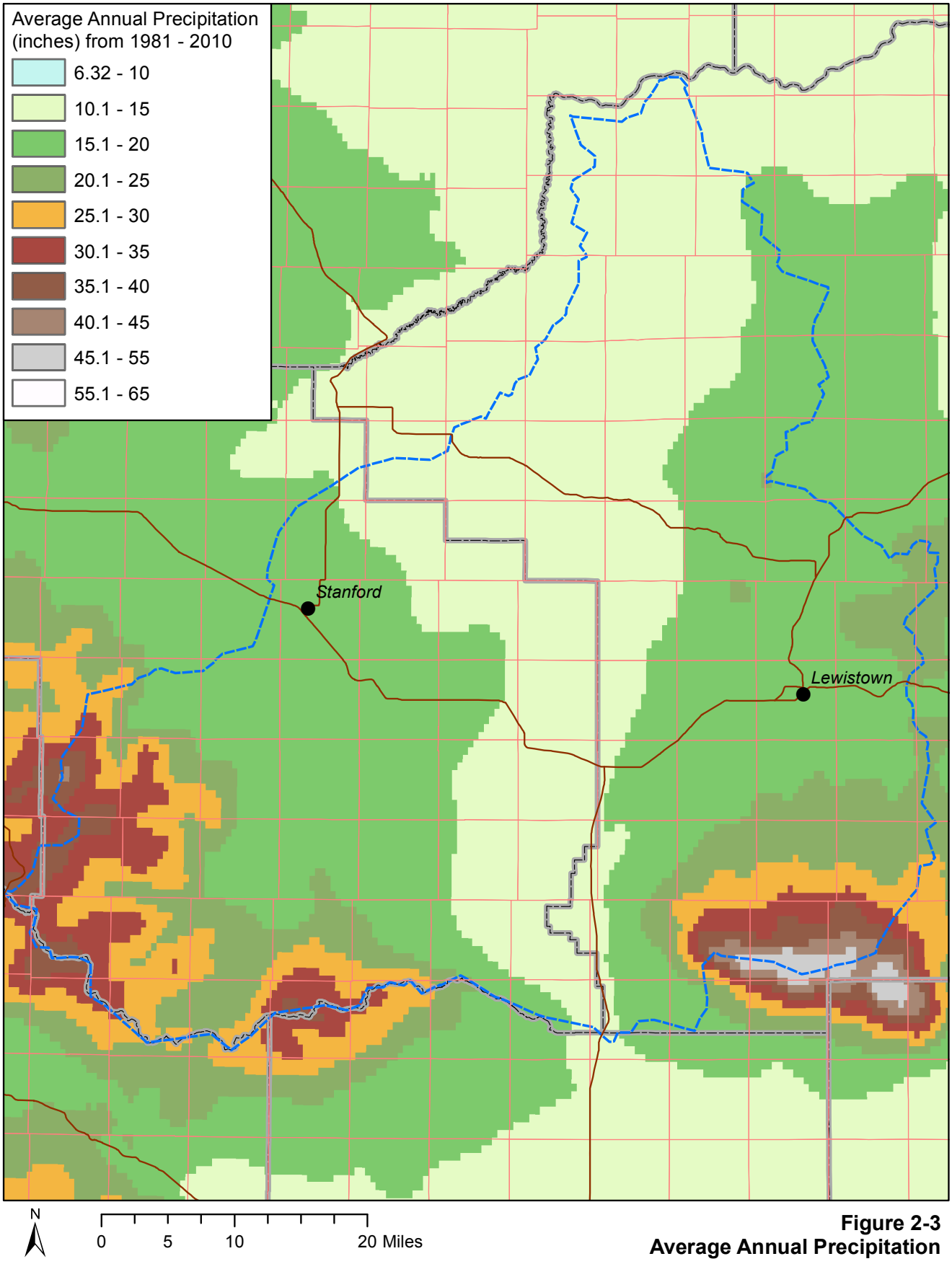


Figure 2-3
Average Annual Precipitation

Discharge of groundwater from the Madison occurs at the major springs, Hanover Well, and also by regional outflow. The regional outflow in the Madison, which ultimately discharges in Saskatchewan was estimated by the U.S. Geological Survey at 12,000 acre-feet per year.[4] The Kootenai Aquifer also is likely to convey groundwater out of the basin.

One of the concerns of the area is whether or not, or to what degree the Madison Aquifer is hydraulically connected to shallower aquifers. The relation of the Kootenai and Madison Aquifers is considered to provide an index for this hydraulic connection. If the Madison is not connected to the Kootenai, then it would be unlikely to have a hydraulic connection to shallower groundwater. Continued assessment of this hydraulic connection is being addressed in the monitoring plan.

Water Users

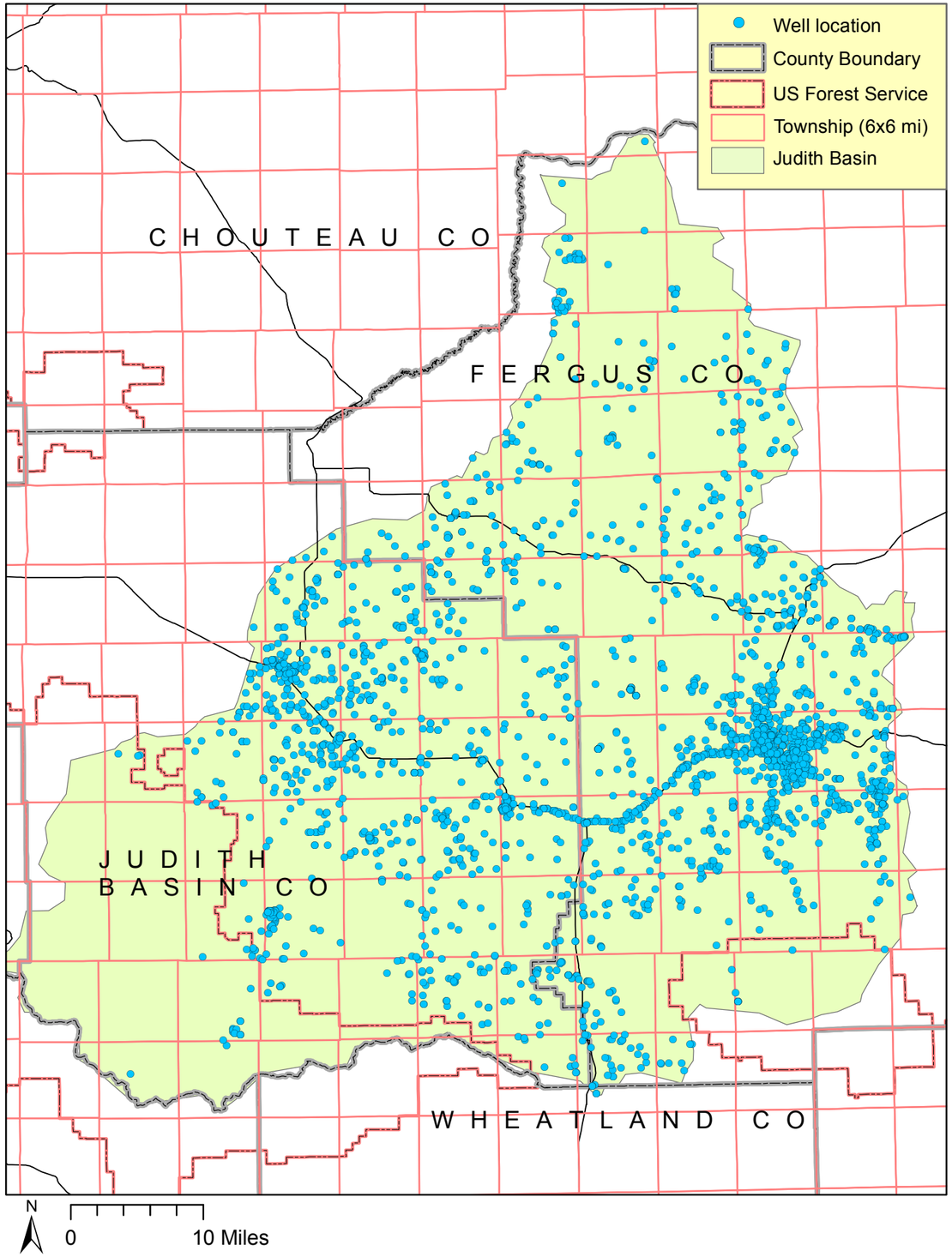
Judith Basin includes 3,006 water supply wells identified in the State's database (Figure 2-4). Approximately 80% of the wells are less than 250 feet in total depth and produce groundwater from shallow aquifers. The mean well depth of all wells is 217 feet. Most wells yield less than 100 gallons per minute (gpm) and are used for domestic and stock.

Big Spring discharges at a rate of approximately 100 cubic feet per second (cfs) and is used for municipal water supply in Lewistown, for the State fish hatchery, and by irrigators. It is also one of only 12 surface waters in Montana for which the 1969 Legislature authorized FWP to file for instream water rights to protect the fishery (Murphy Rights). Warm Spring discharges at a rate of approximately 150 cfs and is used primarily for irrigation. The Hanover Well when first constructed in 1921 produced 4,500 gpm of artesian flow. In the early 1970s the well was flowing at slightly more than 1,600 gpm.[5] This well had been used for power generation for about the last 30 years.

The U Bet Wellfield water production is planned according to the rates and volumes shown in Table 2-1. The average day demand for the water system will initially be slightly over 500 gpm, and based on a 1% estimated growth rate will increase to about 800 gpm in year 2065. The maximum annual volume planned for the wellfield is 1,310 acre-feet. Maximum day demand (MDD) ranges from near 1,800 to 2,840 gpm in year 2065. The wellfield capacity is designed to achieve the MDD rate, and will be developed in phases.

4 Downey, J. S. (1984) Geohydrology of the Madison and Associated Aquifers in Parts of Montana, North Dakota, South Dakota, and Wyoming, U.S. Geological Survey Professional Paper 1273-G.

5 Reported flows in this paragraph are from Feltis, R. D. (1973) Geology and Water Resources of Eastern Part of Judith Basin, Montana, Bulletin 87, Montana Bureau of Mines and Geology, Butte, MT.



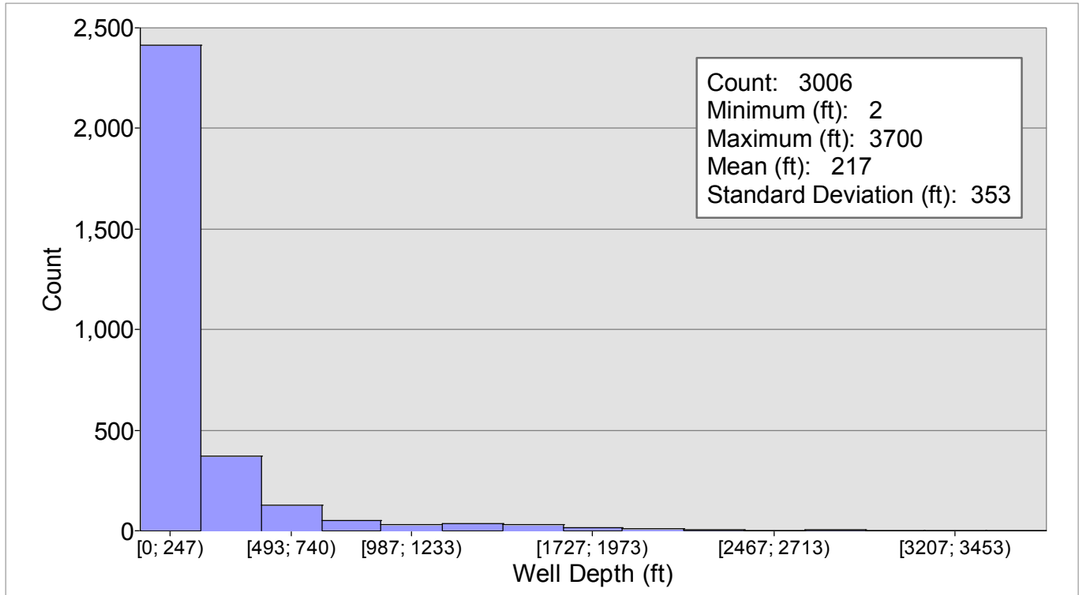


Figure 2-4
Groundwater Users

TABLE 2-1
U BET WELLFIELD WATER PRODUCTION ESTIMATES

Year	Estimated Population[A]	Average Rate (gpm)	Average Rate (cfs)	Annual Volume (af)	MDD (gpm)[B]
2015	4700	509	1.13	821	1,781
2025	5200	563	1.25	908	1,971
2035	5700	617	1.38	996	2,160
2045	6200	671	1.50	1083	2,350
2055	6800	736	1.64	1188	2,577
2065	7500	812	1.81	1310	2,840

[A] Based on 1% estimated growth rate.
[B] Estimated maximum day demand used for design of source capacity.

There are 3442 surface water rights listed in the State database for Judith Basin (designation 41S) (Figure 2-5). Slightly more than half of these rights are listed as “livestock direct from source”. As an individual water right can have multiple points of diversion, there are 5096 diversion locations identified. There are approximately 128,500 acres of land identified on water rights, with most of the irrigated areas being less than 500 acres. The highest frequency of irrigated area is between 50 and 100 acres. Median flow rate was 1.63 cfs, while the average flow rate was 7.3 cfs.[6] These are maximum diversion rates and do not necessarily reflect the actual diverted rate or the duration.

Petroleum Activity

Since year 2000 there have been 11 petroleum permits issued for wildcat well drilling in Judith Basin (Figure 2-6). Of these, one is a shut-in gas well located 23 miles north of Lewistown, four were dry holes, three of which were plugged and one of which was released as a water well. Six of the permits have not yet been completed, however two are underway 8 to 10 miles west of Lewistown. Recent permits list the Otter Formation as the target, which occurs in the Big Snowy Group overlying the Madison. There is currently no proof that viable oil and gas reserves exist in Judith Basin. Until such proof is established through a successful production well and estimation of reserve potential, it is unlikely that petroleum activity will intensify.

3. MONITORING PLAN PROCESS

The monitoring plan presented here was initially outlined and presented to local and state interests at a meeting in Lewistown on April 1, 2014. Participants of the meeting included members of the Lower Missouri River Basin Advisory Council, City of Lewistown, Fergus County Conservation District, Central Montana Resource Council, Montana Fish, Wildlife and Parks (FWP), and Montana Department of Natural Resources and Conservation (DNRC). MBMG and the U.S. Geological Survey were invited but could not attend. A two hour discussion was utilized to go over the plan outline and obtain feedback from the group. This feedback was subsequently incorporated into the plan. The meeting began with a discussion of the goals and objectives, which are listed below.

6 Some water rights, including all stock rights, do not list a flow rate on the water right.

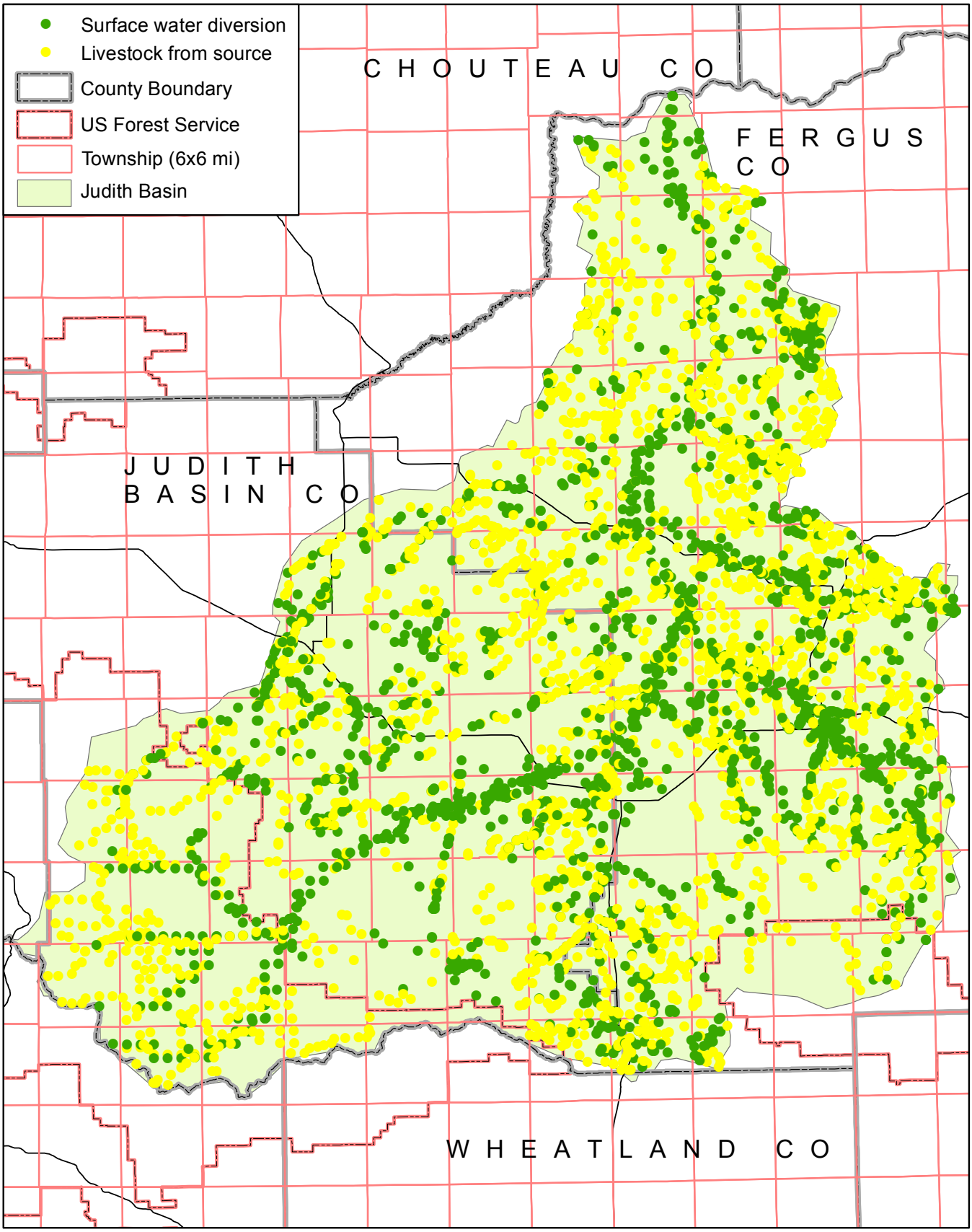


Figure 2-5
Surface Water Users

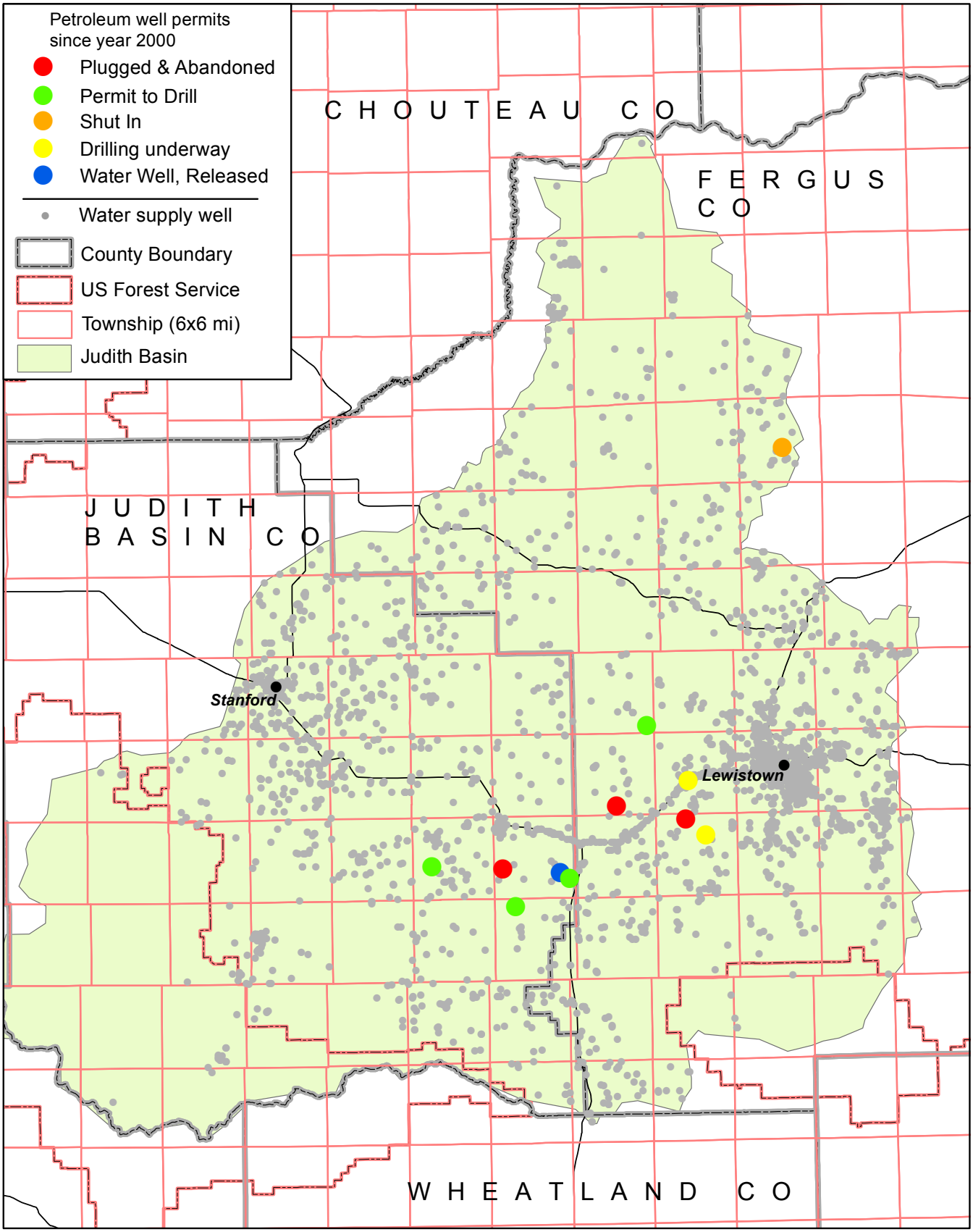


Figure 2-6
Petroleum Activity

GOALS:

- Utilize water resource monitoring to assist water users of Judith Basin.
- Share useful water resources data with the community.
- Improve the understanding of Judith Basin water resources.
- Provide information to assess impacts of climatic trends.

OBJECTIVES:

- Determine magnitudes and trends of water resources parameters.
- Develop and maintain an accessible data archive.
- Periodically analyze, report and hold meetings to share data and inform the public.
- Incorporate regional climate information into local forecasts.
- Establish aquifer parameters and boundaries for the Madison and Kootenai Aquifers.
- Identify source aquifers to area springs.
- Characterize the recharge and discharge of Big Spring.
- Establish baseline groundwater quality parameters ahead of petroleum development.
- Coordinate monitoring plan activities with work completed by the Montana Bureau of Mines and Geology (MBMG).
- Develop public/private partnerships to facilitate monitoring plan activities.

Because of budgetary constraints, not all of the objectives were addressed through a plan activity. For example, the study of recharge and discharge to Big Spring is not included, however, it is considered an important study and is included in the list for a possible future activity. This plan includes an activity to improve the flow metering system of Big Spring to achieve an instantaneous total flow measurement and data archive, as there is presently no functional flow metering system for the spring.

Establishing baseline groundwater quality in relation to petroleum development was not included for budgetary reasons, and because a baseline study was just completed for Fergus County.[7] Should petroleum development intensify due to proven reserves, this activity could then be completed for Judith Basin County.

There is also no element of the plan that has a significant public/private partnership component, except that many of the sampling points will be on private land, and two groundwater monitoring locations are planned to use private wells. Coordination with MBMG also was not included as a specific activity, however, this correspondence will be ongoing and the plan data will be shared.

7 Montana DNRC (2013) Montana Baseline Groundwater Sampling Pilot Study Results & Recommendations, report tot he Committee for Coal Bed Methan Protection Act, Fergus County Conservation District, Petroleum County Conservation District

4. PLAN COMPONENTS

Spring Inventory and Water Quality Characterization

The CMRWA and FWP have entered into a Memorandum of Understanding (MOU) concerning possible impacts of groundwater pumping from the Madison Aquifer on area springs. The MOU requires that CMRWA complete a spring inventory report prior to the onset of pumping to determine the hydrologic relationship between each spring and the Madison Aquifer (i.e., water levels, geology, water chemistry). The purpose of this activity is to fulfill the MOU requirements, which also provides important data towards understanding the relationship between the Madison Aquifer and shallow groundwater, and the baseline water quality of area springs. The activity includes detailed water quality chemistry analysis of up to 24 springs identified by FWP (Figure 4-1). A final screening and selection of springs will occur as part of a sampling and analysis plan prepared when the activity is completed.

Sampling is presently planned to consist of a single grab sample from each spring. A listing of water quality parameters is provided in Table 4-1. This list includes primarily inorganic parameters that characterize the water quality and may provide differentiation among the sources of groundwater contributing to the spring. The inclusion of tritium provides general age classification, as non-detect tritium indicates a groundwater that became isolated from the atmosphere at least 60 years ago. The presence of organic material will be measured based on total organic carbon (TOC) and total petroleum hydrocarbons (TPH). TPH analysis is planned to include both gas-range (GRO) and diesel-range (DRO) organic compounds.

Analysis of water chemistry data will follow standard geochemistry methods. These include for example, descriptive statistics, piper diagrams, stiff diagrams and geochemical modeling. Geochemical modeling will use the U.S. Geological Survey program PHREEQC. Modeling analyses provide the equilibrium dissolved ion speciation and also the saturation indices for solid phases, or minerals, in equilibrium with the pore water. This information furthers the ability to categorize differences observed in the water quality data.

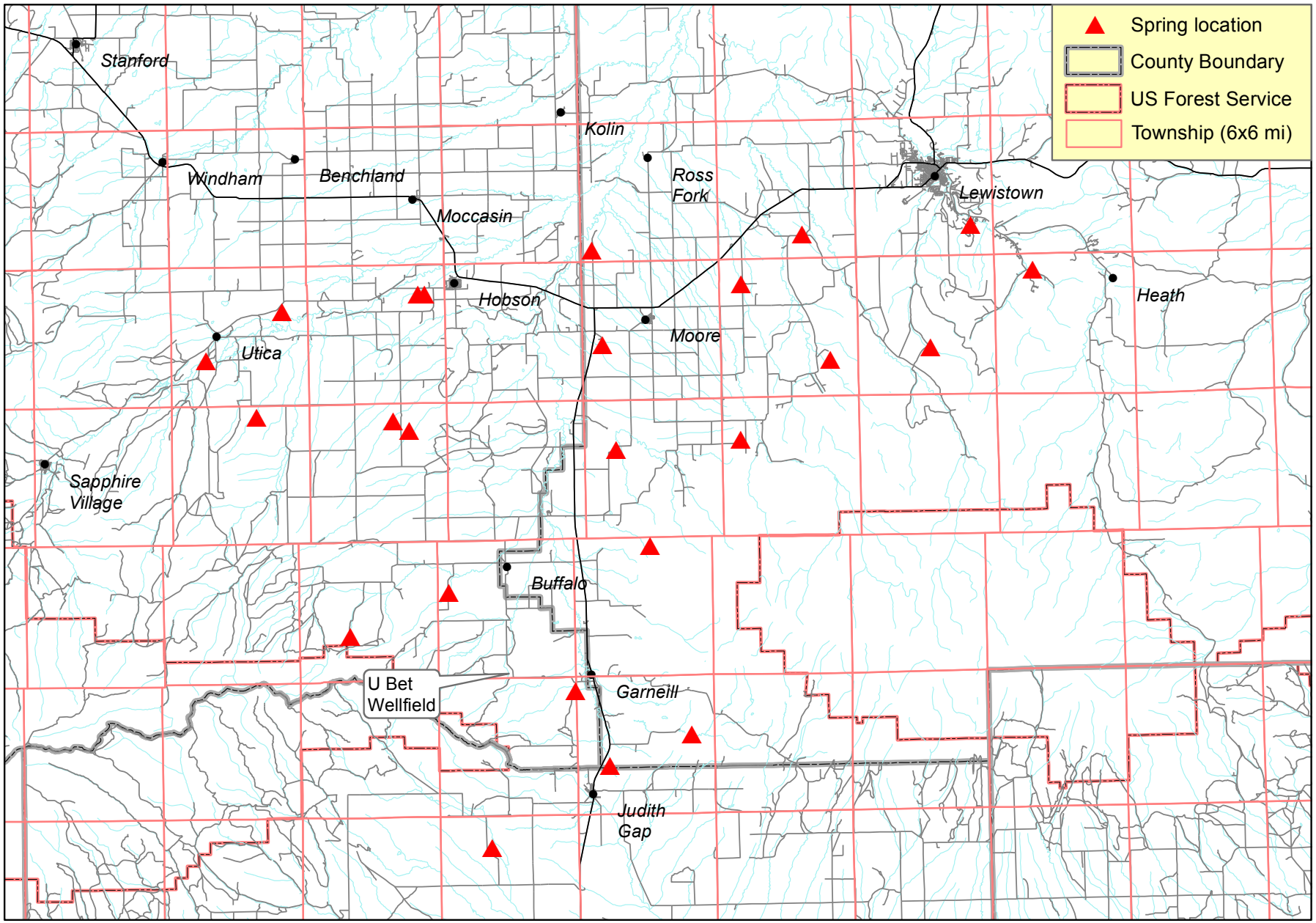


Figure 4-1
Spring Inventory Locations

TABLE 4-1
WATER QUALITY ANALYSIS PARAMETERS

Parameter	Method	Detection Limit	Units
GENERAL			
Total Dissolved Solids (Calculated)	SM 1030E	10	mg/L
Hardness (Calculated)	SM 2340B	1	mg/L
Specific Conductance	SM 2510B	5	uS/cm
Total Organic Carbon	SM 5310	1	mg/L
pH	SM 4500 H B	0.1	s.u.
CATIONS			
Calcium	EPA 200.7	1	mg/L
Magnesium	EPA 200.7	1	mg/L
Sodium	EPA 200.7	1	mg/L
Potassium	EPA 200.7	1	mg/L
Iron	EPA 200.7	0.05	mg/L
Manganese	EPA 200.7	0.02	mg/L
Aluminum	EPA 200.7	0.01	mg/L
Silica	EPA 200.7	0.1	mg/L
Strontium	EPA 200.7	0.02	mg/L
ANIONS			
Chloride	EPA 300.0	1	mg/L
Sulfate	EPA 300.0	1	mg/L
Hydrogen Sulfide	HACH 8131	0.01	mg/L
Alkalinity (carbonate, bicarbonate)	SM 2320B	5	mg/L
Nitrate	EPA 300.0	0.05	mg/L
Flouride	SM 4500 H B	0.1	mg/L
Orthophosphate	EPA 300.0	0.01	mg/L
ISOTOPES			
$\delta^{18}O$ / $\delta^{2}H$ (VSMOW) (Oxygen 18, Hydrogen 2)	Lab	0.03 / 0.9	‰
$\delta^{13}C$ (PDB) (Carbon 13)	Lab	0.3	‰
$\delta^{34}S$ (CDT) (Sulfur 34)	Lab	0.15	‰
^{3}H (Tritium)	Lab	0.6	T.U.
ORGANICS			
TPH-GRO/DRO	8015	20	ug/L

Parameter	Method	Detection Limit	Units
FIELD PARAMETERS			
Temperature	HI 991002	0.5	C
pH	HI 991003	0.02	s.u.
Specific Conductance	HI 99300	2	uS/cm
Oxidation-Reduction Pot.	HI 991003	2	mV
Dissolved Oxygen	HI 98106	0.01	Ppm
Turbidity	HI 93414	0.01	NTU

CMRWA #2 Extended Pumping Test

This activity conducts an extended pumping test in the U Bet Wellfield CMRWA #2 well. The purpose of this activity is to further assess hydraulic properties, boundary conditions, and hydraulic connection to other aquifers. This well was newly constructed in 2012 and pump tested for a three day period. This activity will test the well for a continuous 20-day pumping period.

The activity includes purchase and installation of a new test pump with a capacity of 700 gpm against a backpressure of 70 pounds per square inch gage (psig). Portable power will be used to run the pump for testing. Contractor services will be retained through a public bidding process for both the pumping system purchase and operation of the equipment during testing. Testing will be planned and directed by a CMRWA consultant.

Testing duration is planned for 20-days as this is the maximum duration that can be achieved with continuous pump operation. After 500 hours (20.1 days), the generator powering the pump must be shut down for servicing. The test is not being restarted primarily for budgetary reasons, however, such a restart also complicates the testing data and analysis.

Approximately two weeks prior to testing, water level data collection will begin. Testing will then consist of a step rate test (4 hours) followed a week later by a constant rate test. The constant rate test will include 20 days of continuous pumping followed by up to 20 days of recovery monitoring.

During testing, discharge from the well will be monitored using a flow meter, and pumping water level will be measured with a pressure transducer. Both instruments will be computer logging and collecting data at one minute intervals. The pressure transducer will be a new purchase and will remain in the well for recording long term changes in static water level. A Kootenai Aquifer monitoring well will also be monitored for water level during testing. This monitoring well is a monitoring plan activity described below.

During testing, water quality data will be collected by monitoring field parameters. On the last day of testing, a water sample will be collected and analyzed as per the parameter list of Table 4-1. This sample is intended to provide a baseline for the Madison Aquifer in proximity to the recharge area, and will be used in comparisons to analytical results obtained from spring sampling.

Analysis of the pumping tests will follow standard well hydraulics methods. Data will first be evaluated for trends in static water level that can be corrected if necessary. A modeling analysis will be used to estimate aquifer parameters and assess boundary conditions. Testing data will be formatted according to DNRC Form 633 and provided to the Montana Bureau of Mines and Geology Ground Water Information Center for incorporation into the website database. The new pumping system and test analysis will be documented in a project report.

Although this activity is expensive, the pump purchase (rather than rental) is approximately the same fee as would occur if a contractor were to provide a temporary pump. When CMRWA #2 was initially tested, the temporary pumping system was $52,100, but could only produce about 500 gpm to atmosphere. The new pump planned to produce 700 gpm against a backpressure of 70 psig has permanent use capability. The new pumping system also can be used for subsequent testing which may be considered pending the results of the extended pumping test. Such future testing could be completed by the CMRWA or possibly MBMG and is made much more affordable by implementing this activity as planned. Future testing may be for water quality and/or additional hydraulic analyses.

Kootenai Aquifer Monitoring Well

The Kootenai Aquifer extends throughout Judith Basin but is primarily accessible in the south and west regions, and near Lewistown where it is used for domestic and stock. In the central part of the basin and north, the formation dips to substantial depths exceeding 2000 feet. The Kootenai Aquifer is considered an index for assessment of hydraulic continuity between the Madison Aquifer and shallow groundwater. It is effectively the deepest of the shallow groundwater aquifers that can be developed in Judith Basin.

This activity establishes a Kootenai Aquifer monitoring well at the U Bet Wellfield. There are several purposes for this monitoring well. Firstly, it provides a non-pumping well for accurate water level measurement. The non-pumping aspect of the well is critical for tracking trends in water level which are needed to assess if pumping of U Bet Wellfield wells installed into the Madison are impacting the Kootenai. This location also provides an excellent opportunity to characterize Kootenai Aquifer water quality. Finally, as the well will be owned and maintained by the CMRWA, it will have longevity as a Kootenai monitoring well in Judith Basin.

Data obtained from this well will be useful for evaluation of the Madison - Kootenai hydraulic connection, and also for understanding changes to the Kootenai Aquifer apart from any effects due to Madison pumping. A meteorological station is planned for the same location, as detailed in a separate activity below. This combined data set will be effective for differentiating climatic and pumping effects into the future, which has direct value in water rights management in Judith Basin.

The well construction will undergo final design and then will be publicly bid. The well construction used for project planning includes an 8-inch diameter surface casing cemented to a depth of 40 feet (Figure 4-2). This casing is included in the design to meet well construction standards and to provide well control, should the Kootenai Aquifer be flowing artesian at this location. A preliminary estimate of static water level at the site was within 10-feet of ground surface, however, the estimation error is on the order of ±100 feet. The remainder of the well would be drilled at 6-inch diameter and completed

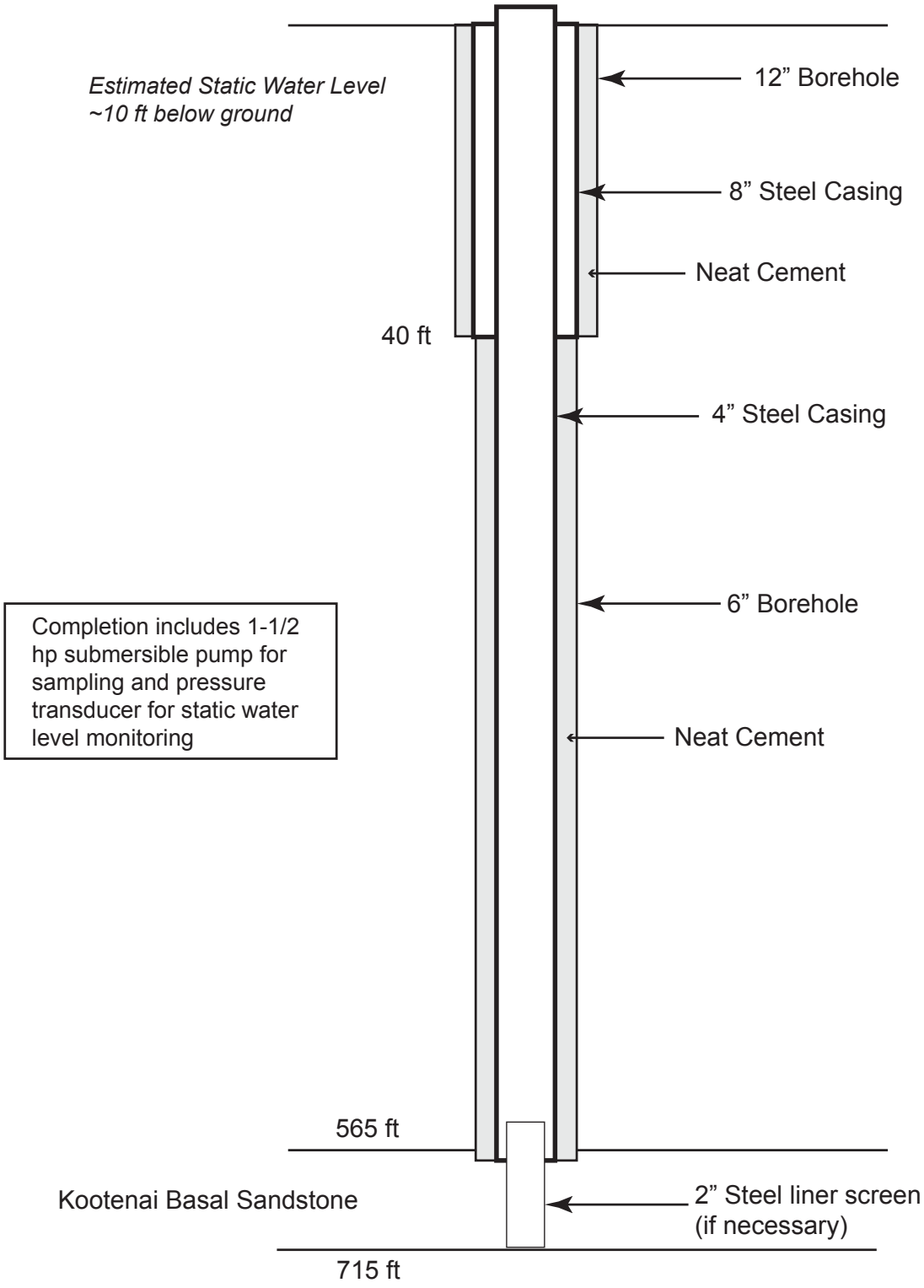


Figure 4-2
Kootenai Monitoring Well

with 4-inch steel casing set and cemented. The aquifer interval would be drilled at 3-7/8 inch diameter and left as an open hole. If the formation is unstable, a 2-inch diameter liner screen would be set over the lower borehole.

The monitoring well is planned to be completed with a 1-1/2 hp submersible pump to facilitate sampling. This pump will be run using auxiliary power at the time of sampling. A dedicated pressure transducer is included in the activity. This sensor will have the capability to be connected to the MJRWS SCADA system when the wellfield is put into operation.

It is intended that well construction will occur prior to the CMRWA #2 pumping test, and that monitoring of water level will be in place for the test. The Kootenai monitoring well will also be sampled for the parameter list presented in Table 4-1. The construction of the well and testing data will be presented in a monitoring well construction report.

Groundwater Level Monitoring Sensors

This activity deploys five computerized water level sensors at locations in Judith Basin (Figure 4-3). The purpose of this activity is to provide water level data for the Madison and Kootenai Aquifers for trend analysis and inter-aquifer comparison. Sensors are planned for deployment at three Madison Aquifer locations and four Kootenai Aquifer locations.[8] A final selection of sensor locations will be made when the activity is underway. Sensors are rated according to the anticipated pressures at the location, and provide an accuracy of 0.1% of scale, and resolution of 0.01 ft.

Well water level is one of the most critical data to be used for tracking trends in aquifer level and specifically identifying the response of groundwater to climate variables and user withdrawals. These data will be collected at high frequency of typically one reading per 15 minutes. Data will be analyzed for trends, and for correlations to pumping and climate data.

Database and Website

The purpose of this activity is to make data available to the public. Distribution of monitoring data will be through the CMRWA website and as appropriate the MBMG Ground Water Information Center (GWIC). It is intended that water level and water quality data will be available in electronic spreadsheet format. This information will appear on a dedicated website page that includes location maps and project reports. This activity consists of website programming and the development of a data archive and distribution procedure. This activity will occur during the initial phase of the monitoring plan implementation and will be in operation for posting of plan data.

Big Spring Flow Metering System

The purpose of this activity is to enable total discharge of Big Spring to be measured. Measuring total flow at Big Spring is challenged by the diffuse nature of the spring and the occurrence of multiple diversions, and one major inflow (Figure 4-4). The existing metering equipment installed at Big Spring does not enable total flow measurement of the discharge.

8 Sensors for CMRWA #2 and the U Bet Kootenai monitoring well are included in those activities.

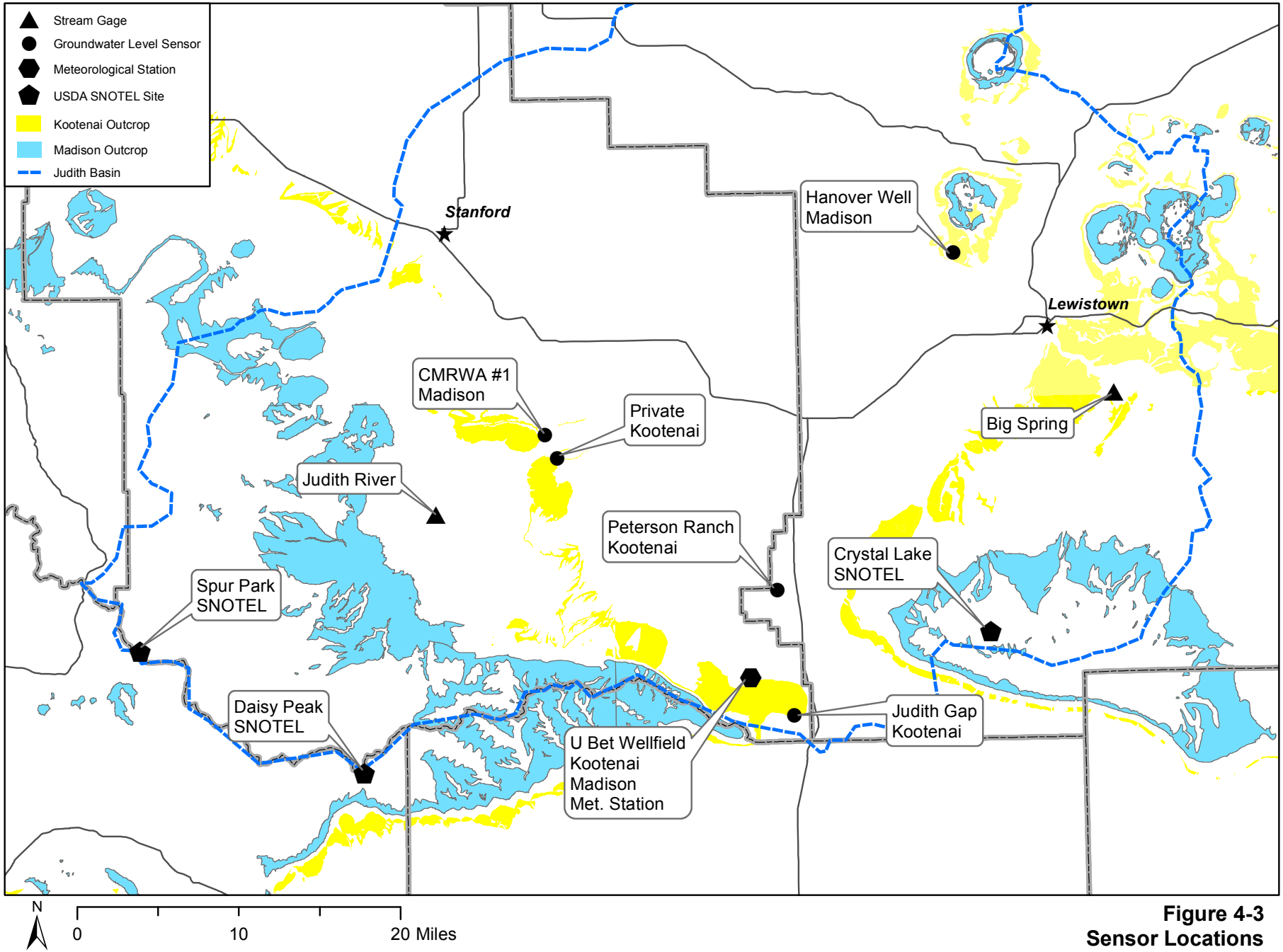
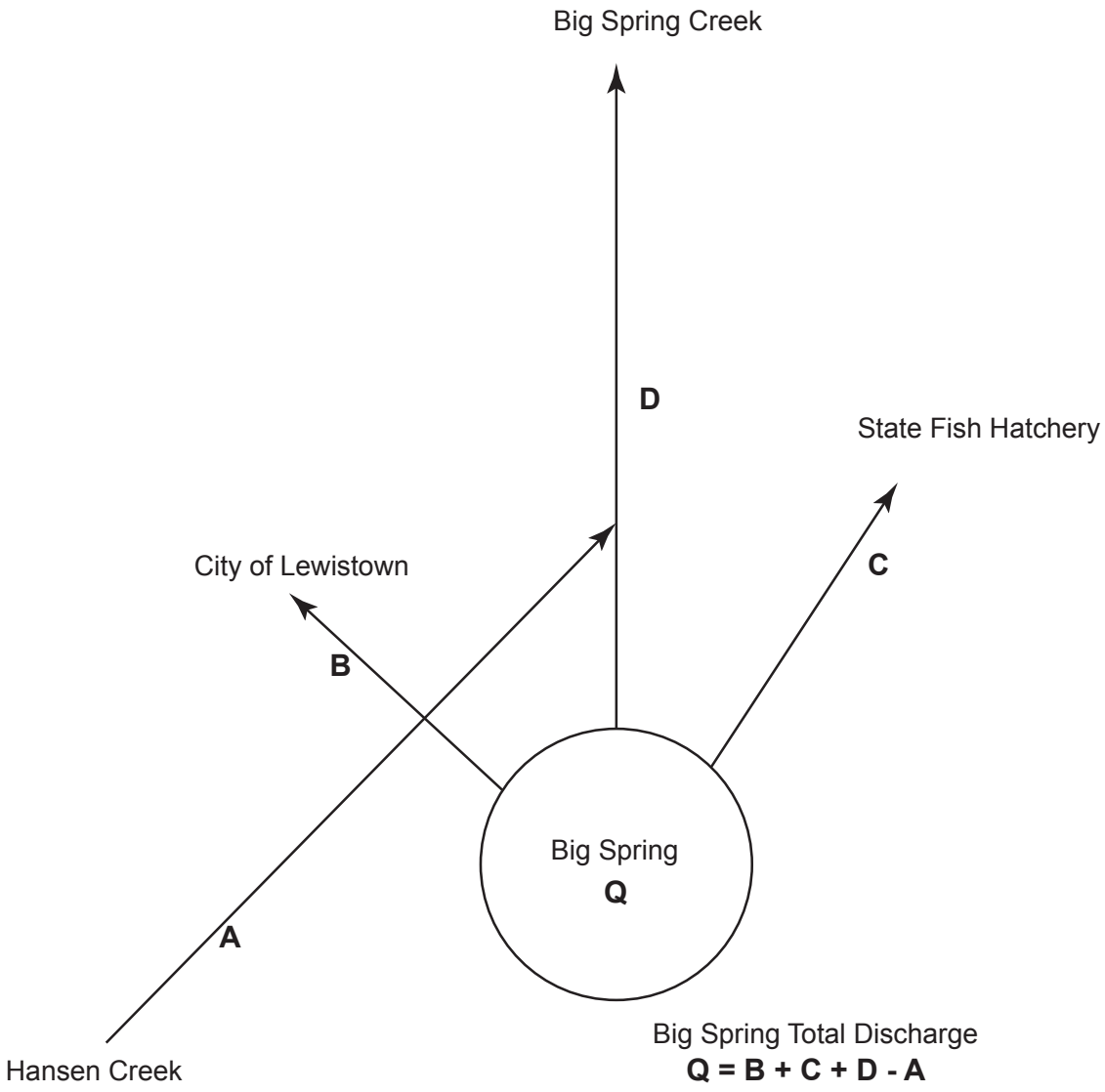


Figure 4-3
Sensor Locations



A. Operating meter present; not connected to SCADA.

B. Operating meters present; connected to SCADA.

C. Meter malfunction; not connected to SCADA.

D. Stream gaging station with poor sensor resolution; not connected to SCADA.

Figure 4-4
Big Spring Flow Measuring System

This activity begins with a review of existing metering facilities, and design of an operational system. The design will then be implemented, which includes hardware installations and also SCADA[9] programming. This activity will be managed by CMRWA and coordinated with the City of Lewistown and FWP.

It is intended that this work will result in SCADA recording of each flow component and a total flow measurement. The data will be recorded at a suitable frequency and provide at least a daily average for each meter and the total flow. The work required is generally understood as follows:

- Hansen Creek, which flows into Big Spring Creek, is presently metered where it passes through a rectangular concrete channel. The meter is considered accurate, but is not connected to the SCADA system. The activity provides for connection of the Hansen Creek meter to the SCADA system.
- The City of Lewistown obtains water supply through two pipelines, both of which are equipped with flow meters and connected to SCADA. There is software programming work that will incorporate these flows into the flow calculation, however, there is no hardware included in the activity for these measuring locations.
- FWP operates a large hatchery that also diverts flow from Big Spring. The hatchery flow meter is malfunctioning at high flows and requires repair or replacement. This activity includes work to identify the problem with the flow meter and fix the problem by repair, re-installation, and/or replacement. This location has SCADA equipment installed, but is not yet connected to the SCADA system. The activity provides for final connection of the metering location to the SCADA system.
- FWP also measures flow in Big Spring Creek immediately downstream from the spring discharge. This gaging station is impacted by changes in channel properties due to vegetation growth. It also needs a new pressure transducer with a lower rating and higher resolution to accurately record small changes in stage height. There is conduit and wire run from the SCADA center to the location of the sensor, but the sensor is not presently connected. The activity provides for sensor replacement, software programming to facilitate re-entry of flow conversion factors, and connection to the SCADA system. FWP will be responsible for collecting stage-discharge data for the gaging location.
- The final step of this activity is to provide customized programming of the City's SCADA system interface to record, archive and display the metered flow rate data.

Judith River Gage

The Judith River gage at Sapphire Village, officially designated as 'Judith River Near Utica', has been out of service since 1979. DNRC and the U.S. Geological Survey (USGS) are working to re-establish a gage at this location. This gage is considered critical for assessing the water resources of Judith Basin and is a high priority for DNRC and FWP. The gage data are directly used in estimation of the water balance for the Little Belt Mountains, which is considered a primary recharge area of the Madison Aquifer.

9 SCADA stands for supervisory control and data acquisition. It is a physical computing system used to assist operation of the municipal water system.

There is presently consideration that DNRC will re-establised this gage for operation starting October 2014 and continue operation into the future. Should this work be completed, the CMRWA can utilize these data for assessing Madison Aquifer recharge trends and for analysis of the Madison Aquifer water balance.

Given the current plans by DNRC, there is no funding allocated in the monitoring plan for this activity. However, if re-establishment of the gage is postponed, the CMRWA Board should actively pursue this matter, as it is considered vital to the water resources database for Judith Basin, and therefore has value to continued operation of the U Bet Wellfield. The data are considered critically important for addressing water rights issues that may arise in the future.

Meteorological Monitoring Station

Measurement of climate parameters is required to assess changes in recharge to groundwater and surface water. These data are also used in periodic computations of the area water balance. Judith Basin has three operating SNOTEL stations that measure climate data at high elevations (Figure 4-3). However, there are no meteorological stations located at similar elevation as the Kootenai Formation outcrop area.

The purpose of this activity is to install a meteorological station at the U Bet Wellfield to fill this data gap.[10] These data are critical for comparative analysis of long term climatic trends, long term aquifer declines due to pumping, and assessment of the Kootenai-Madison hydraulic connection.

The meteorological station includes a standard agricultural package of sensors and three soil moisture probes.[11] The sensors connect into a central data logging system, which can be connected to the MJRWS SCADA system when installed at the operating wellfield. The station includes solar power recharging of its batteries. Sensors will be deployed from a 10-ft tower mounted into a concrete pad. The entire unit will be enclosed in chain-link fencing, offset sufficiently to prevent interference with measurements. Specific sensors included in the plan are as follows:

- Solar radiation pyranometer
- Temperature, humidity, and barometric pressure
- Precipitation
- Soil temperature and moisture at three depths (e.g., 8”, 20”, and 40”)

Data from the station will be periodically downloaded and archived for analysis. Analysis of climate data will evaluate trends and periodicities that may be observed in the data, and compute statistical parameters for use in other hydrologic applications, such as water balance calculations.

10 There is a meteorological station at the Moccasin Experiment Station, however, this location is substantially away from the Kootenai outcrop area, at lower elevation, and in a drier climate zone.

11 Wind speed and direction is not being included to reduce maintenance labor and costs.

Operations and Maintenance

The purpose of this activity is to operate and maintain monitoring sensors for a three year period under the grant funded project.[12] This activity consists of visiting sensor field sites, downloading data and repairing sensors, as needed, twice per year. Each data download event will include addition of the data to the project database and a summary report. Both the data and summary report will be available from the CMRWA website.

Monitoring Plan Report and Meeting

This activity includes analysis and reporting of data collected from the monitoring stations for a three year period. These data will be used to illustrate the levels observed for a three year period, and to calculate a baseline water balance. Individual reports prepared for other activities will be included in this document as appendices, providing full documentation of the work completed under the monitoring plan. This activity also include a public meeting to present the overall monitoring plan implementation and findings.

5. BUDGET ESTIMATE AND SCHEDULE

Budget data were developed for completion of each activity described above. These data were obtained based on direct vendor quotations and engineering experience from similar project work. Table 5-1 provides a summary of the costs for each activity. Detailed cost data sheets for each activity are appended.

TABLE 5-1
MONITORING PLAN BUDGET ESTIMATE

Activity	Construction	Engineering	Contingency	Total
Spring Water Quality	$15,408	$31,980	$-	$47,388
CMRWA #2 Pumping Test	$117,485	$33,777	$17,623	$168,885
Kootenai Monitoring Well	$88,250	$20,298	$13,238	$121,785
Groundwater Level Monitoring	$20,930	$4,800	$3,860	$29,590
Website and Database	$-	$5,000	$-	$5,000
Big Spring Flow Metering Assist.	$23,000	$15,000	$-	$38,000
U Bet Weather Station	$17,919	$4,480	$-	$22,399
O&M, 3 yrs	$9,000	$27,000	$-	$36,000
Final Report and Public Meeting	$-	$13,800	$-	$13,800
TOTAL	$291,992	$156,134	$34,720	$482,846

The budget estimate is prepared for a three year grant funded period. At the end of the three year period, final reports would be submitted where included in the activities. Future operation of the monitoring network would be completed by the CMRWA. It is assumed that FWP and the USGS would be responsible for continued operation of the Judith River gage (after year one) and that the City of Lewistown and FWP would be responsible for operation of the metering system of Big Spring.[13]

12 The monitoring plan is being proposed as part of a grant application to DNRC.
13 The City and FWP will operate and maintain this system from inception.

Annual operation and maintenance (O&M) fees were budgeted at $13,800 per year, which includes a $3,000 budget item for repair and replacement of sensors. This O&M budget includes bi-annual data downloading from seven groundwater locations and the U Bet meteorological station. The groundwater locations include three Madison Aquifer locations and four Kootenai Aquifer locations. Database updating and reporting would also occur as described for the activity.

Implementation of the monitoring plan would begin in July 2015. Field components of each activity are planned for the period from August 1 to December 1, 2015. Initial reporting where included in an activity would be completed by July 1, 2016. These reports correspond to spring and well sampling, pump testing of the CMRWA #2 well, and installation of the Kootenai monitoring well. Data collection within the grant funded project would continue as planned through July 1, 2018. From July 1, 2018 to December 1, 2018, data collected from the Judith River gage, groundwater sensors, and the U Bet meteorological data would be analyzed, documented in a report and presented in a public meeting.

APPENDIX A

BUDGET DATA SHEETS

SPRING INVENTORY AND WATER QUALITY CHARACTERIZATION

Plan, collect, create database, and reporting				
Item	Qty	Units	Rate	Total
Spring Selection (labor + costs)	16	HR	$ 150	$ 2,400
Owner contact and access (labor + costs)	16	HR	$ 150	$ 2,400
Sample collection (labor + costs)	24	EA	$ 450	$ 10,800
Sample analysis	24	EA	$ 642	$ 15,408
Database	24	HR	$ 150	$ 3,600
Spring Quality Report	1	EA	$ 10,350	$ 10,350
Vehicle, fuel	9	DAYS	$ 120	$ 1,080
Per diem	9	DAYS	$ 150	$ 1,350
TOTAL				$ 47,388

CMRWA #2 EXTENDED PUMPING TEST

Item	Qty	Units	Rate	Total
Equipment				
Grundfos 625S1250-6AA pump w/check	1	EA	$ 12,100	$ 12,100
Grundfos 125 hp, 8" submersible motor	1	EA	$ 22,500	$ 22,500
125 hp control panel set on pole	1	EA	$ 4,700	$ 4,700
Wire, 4 x 0000 AWG (3-wire + gnd)	425	LF	$ 21	$ 8,925
6" x 0.280" galvanized steel column pipe w/ couplings	350	LF	$ 50	$ 17,500
Flomatic 6" 80DI check valve	1	EA	$ 1,000	$ 1,000
6" Std galvanized steel discharge pipe	20	LF	$ 50	$ 1,000
6" C509 gate valve w/hand wheel	1	EA	$ 1,000	$ 1,000
Misc. 6" galvanized fittings	2	EA	$ 500	$ 1,000
Pipe support and saddle	1	EA	$ 300	$ 300
Discharge hose, 6" lay flat	100	LF	$ 10	$ 1,000
Discharge hose, 6" min, disposable	500	LF	$ 2	$ 1,000
Support plate, 1" steel, 16x16"	1	EA	$ 250	$ 250
Mobilization	1	LS	$ 5,000	$ 5,000
Rig and labor	24	HR	$ 300	$ 7,200
SUBTOTAL				$ 84,475
Pumping Test	Qty	Units	Rate	Total
Generator system rental, 20 days w/mobe	1	EA	$ 12,500	$ 12,500
Fuel, 300 gal/day	6000	GAL	$ 4	$ 24,000
Contractor labor (4 hrs/day + 16 hrs mobe)	96	HR	$ 60	$ 5,760
SUBTOTAL				$ 29,760
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	375	LF	4.40	$ 1,650
Deployment labor	0	HR	150	$ -
SUBTOTAL				$ 3,250
TOTAL NEW CONSTRUCTION				$ 117,485
Contingency			15%	$ 17,623
SUBTOTAL w/Contingency				$ 135,108
Engineering/Administration			25%	$ 33,777
PROJECT TOTAL				$ 168,885

KOOTENAI AQUIFER MONITORING WELL

Kootenai Formation monitoring well at U Bet Wellfield				
Well Construction	Qty	Units	Rate	Total
Mobilization/Demobilization	1	LS	5000	$ 5,000
Drill for, set and cement surface casing, 8" dia.	40	LF	150	$ 6,000
Drill for, set and cement intermediate casing, 4" dia.	535	LF	90	$ 48,150
Open hole drilling and steel liner, 4" dia.	140	LF	90	$ 12,600
Development	12	HR	300	$ 3,600
SUBTOTAL				$ 75,350
Submersible Pump	Qty	Units	Rate	Total
Grundfos 10S15-21 with 1-1/2 HP motor, 2-wire	1	EA	2500	$ 2,500
1 in Sch 80 PVC column pipe w/couplings	300	LF	2	$ 600
Pump wire, 10 AWG	350	LF	2	$ 700
Pitless adapter installed	1	EA	250	$ 250
Instrument deployment tube, 1-1/4 in PVC	300	LF	2	$ 600
Well cap, sealing	1	EA	50	$ 50
Labor including mobe fee	12	HR	225	$ 2,700
SUBTOTAL				$ 7,400
Well site reclamation	Qty	Units	Rate	Total
Grading	6	HR	175	$ 1,050
Seeding and raking	4	HR	175	$ 700
Weed control	4	HR	175	$ 700
SUBTOTAL				$ 2,450
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	325	LF	4.46	$ 1,450
Deployment labor	0	HR	150	$ -
SUBTOTAL				$ 3,050
TOTAL NEW CONSTRUCTION				$ 88,250
Contingency			15%	$ 13,238
SUBTOTAL w/Contingency				$ 101,488
Engineering/Administration			20%	$ 20,298
PROJECT TOTAL				$ 121,785

GROUNDWATER LEVEL SENSORS

Peterson, J., Kootenai Well				
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	15	LF	14.00	$ 210
Deployment (labor + costs)	4	HR	150	$ 600
SUBTOTAL				$ 2,410
Judith Gap, Kootenai Well				
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	250	LF	4.60	$ 1,150
Deployment (labor + costs)	8	HR	150	$ 1,200
Contractor labor, equipment	1	EA	6000	$ 6,000
SUBTOTAL				$ 9,950
Utica Area, Kootenai Well (Artesian)				
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	15	LF	14.00	$ 210
Deployment (labor + costs)	8	HR	150	$ 1,200
Contractor labor, equipment	1	EA	2500	$ 2,500
SUBTOTAL				$ 5,510
Hanover Well, Madison (Artesian)				
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 100 psig ft	1	EA	1600	$ 1,600
Deployment cable	15	LF	14.00	$ 210
Deployment (labor + costs)	8	HR	150	$ 1,200
SUBTOTAL				$ 3,010
CMRWA #1, Madison				
Water Level/Temp Sensor	Qty	Units	Rate	Total
Level Troll 700, 300 psig	1	EA	1600	$ 1,600
Deployment cable	625	LF	4.24	$ 2,650
Deployment (labor + costs)	4	HR	150	$ 600
SUBTOTAL				$ 4,850
SUBTOTAL - All Sensors				$ 25,730
Contingency			15%	$ 3,860
TOTAL				$ 29,590

WEB SITE PROGRAMMING

Database coordination (MBMG-GWIC) and CMRWA data sharing				
Item	Qty	Units	Rate	Total
Web design/programming	1	EA	$ 5,000	$ 5,000
TOTAL				$ 5,000

BIG SPRING FLOW METERING ASSISTANCE

Big Spring Monitoring System Calibration/Programming				
Item	Qty	Units	Rate	Total
Metering System Evaluation	1	EA	$ 8,000	$ 8,000
Hansen Creek Connection	1	EA	$ 5,000	$ 5,000
Big Spring Creek Sensor & Connection	1	EA	$ 8,000	$ 8,000
State Hatchery Meter & Connection	1	EA	$ 10,000	$ 10,000
SCADA programming	1	EA	$ 7,000	$ 7,000
TOTAL				$ 38,000

U BET METEOROLOGICAL STATION

Meteorological monitoring station at U Bet Wellfield				
Item	Qty	Units	Rate	Total
Equipment				
Instrument Tower & Cross Arm	1	EA	$ 922	$ 922
Solar radiation pyranometer	1	EA	$ 1,327	$ 1,327
Temp, humidity, pressure	1	EA	$ 1,365	$ 1,365
Precipitation, rain gauge	1	EA	$ 610	$ 610
Soil temp and moisture	3	EA	$ 415	$ 1,245
Data logger & Software	1	EA	$ 3,350	$ 3,350
SUBTOTAL				$ 8,819
Construction	Qty	Units	Rate	Total
Concrete pad	1	EA	$ 1,500	$ 1,500
Chain link fence	80	LF	$ 15	$ 1,200
Gate	1	EA	$ 300	$ 300
Landscaping	1	EA	$ 1,500	$ 1,500
Installation Labor	24	HR	$ 150	$ 3,600
Freight	1	EA	$ 1,000	$ 1,000
SUBTOTAL				$ 9,100
TOTAL NEW CONSTRUCTION				$ 17,919
Engineering/Administration			25%	$ 4,480
PROJECT TOTAL				$ 22,399

OPERATIONS AND MAINTENANCE

CMRWA O&M Costs per year.				
Activity	Qty	Units	Rate	Total
Field Data Download (labor + costs)	28	HR	$ 150	$ 4,200
Database (labor + costs)	16	HR	$ 150	$ 2,400
Bi-annual Report	16	HR	$ 150	$ 2,400
Parts Replacement (labor + costs)	1	EA	$ 3,000	$ 3,000
TOTAL				$ 12,000
Three year Grant Period Total				$ 36,000

MONITORING PLAN FINAL REPORT PUBLIC MEETING

Item	Qty	Units	Rate	Total
Analysis (labor + costs)	40	HRS	$ 150	$ 6,000
Draft/Final Reports (labor + costs)	32	HRS	$ 150	$ 4,800
Prep & Meeting (labor + costs)	8	HRS	$ 150	$ 1,200
Other Direct Costs	1	EA	$ 1,800	$ 1,800
TOTAL				$ 13,800