PIONEER
TECHNICAL SERVICES, INC.

September 2, 2015

Scott M. Helm
Geotechnical Operations Manager
Montana Department of Transportation
2710 Prospect
PO Box 201001
Helena, Montana 59620-1001

Subject: Stone Creek-North, Geotechnical/Hydrogeological Site Evaluation Phase I Summary Report

Dear Mr. Helm:

Please find enclosed the three bound copies and one electronic copy of the final Stone Creek-North, Geotechnical/Hydrogeological Site Evaluation Phase 1 Summary Report. The report documents the work performed at the Stone Creek North/Beaverhead Rock site located northeast of Dillon, Montana, in June and July 2015. The work included two separate site visits to identify and survey important hydrogeologic features and meet with landowners, ditch maintenance personnel, and Montana Department of Transportation (MDT) staff to obtain an understanding of the site. Comments received from MDT after reviewing the draft Phase I Report have been incorporated into the final document. If you have any questions or concerns about the Phase I Summary Report, please call me at 406-497-8040.

Sincerely,

Kenneth R. Manchester PG
Pioneer Technical Services

RESTORING OUR ENVIRONMENT • DESIGNING OUR FUTURE

Stone Creek – North Geotechnical/Hydrogeological Site Evaluation

Highway 41 in the Vicinity of Beaverhead Rock
Twin Bridges, Montana 59754

Prepared for:

Montana Department of Transportation
2701 Prospect Avenue
Helena, Montana 59620-1001

Prepared by:

Pioneer Technical Services, Inc.
P. O. Box 3445
Butte, Montana 59702

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1 INTRODUCTION

This Phase I Summary Report (Summary Report) describes the geotechnical and hydrogeological site evaluation conducted by Pioneer Technical Services, Inc. (Pioneer) at the thermal spring complex in the vicinity of Beaverhead Rock (Figure 1). The site evaluation and yet-to-be-performed site exploration and monitoring are part of the Montana Department of Transportation (MDT) efforts to provide geometric improvements to the existing roadway (e.g., shoulder widening, structure replacements, etc.) while ensuring the integrity of the thermal spring complex (i.e., flow, temperature, and water quality) is not inadvertently compromised.

This Summary Report was compiled to establish a qualitative and quantitative site condition baseline (designated as Phase I), and a provision for conceptual mitigation strategies for the selected highway alignment and continued quantifiable monitoring of the thermal spring complex (designated as Phase II). For continuity with previous and future reports, this report uses the specific nomenclature below (Poehls and Smith, 2009):

1. Springs – A groundwater discharge, either ephemeral or continuous, at the ground surface. The observation of flowing water usually differentiates a spring from a seep, which may simply be a moist area.

2. Hot Spring – Natural flow of groundwater whose temperature is greater than normal human-body temperature (generally greater than 45-50 degrees Celsius [^{o}C] or 110-120 degrees Fahrenheit [^{o}F]).

3. Thermal Spring – Also known as a hot spring or warm spring. Groundwater that naturally flows above the ground and whose temperature is higher than the mean local atmospheric temperature.

There are several different types of springs (e.g., fault spring, contact spring, joint spring, fracture spring, etc.); however, the scope of this Summary Report was not to identify or differentiate between the type of springs encountered but rather center on the thermal spring complex. And while field personnel did notice seeps during field visits, the primary focus of the site evaluation was on the springs (i.e., groundwater discharging as flowing water). During the site evaluation, measured spring water temperatures ranged between 24.0 and 28.6 ^{o}C (75.2 and 83.5 ^{o}F). As such, the springs will be referred to as thermal springs and not hot springs.

2 PROJECT INFORMATION

The MDT project is located on Highway 41 (N-49) and begins near the Stone Creek Bridge crossing in Beaverhead County and ends in Madison County, approximately 2 miles north of the Beaverhead River Bridge crossing. The section of interest for this investigation begins at the north end of the bridge crossing the Beaverhead River (Station 754+/-) and extends approximately 3,600 feet north (Station 790) (Figure 2a and Figure 2b). The owner of Point of Rocks Ranch (PRR) has identified areas, both to the east and west, within this 3,600-foot stretch of Highway 41 where thermal springs flow.

3 SITE CONDITIONS

Pioneer personnel completed the evaluation of the site conditions based on existing published data and two site reconnaissance visits (June 29 and July 10, 2015). The published data included documents from the Montana Bureau of Mines and Geology (MBMG) and the U.S. Geological Survey (USGS).

3.1 Existing Site Data

Because of site-specific features (e.g., water resources, prominent rock outcropping, thermal springs) and historical significance (i.e., Lewis and Clark Expedition), there are many publications detailing the area that discuss topics such as physiography, hydrology and hydrogeology, geology, and geothermal waters. The sections below described the relevant topic areas.

3.1.1 Physiography

The Beaverhead River drainage basin encompasses an area of about 2,895 square miles below the Clark Canyon Reservoir, located 23 miles southwest of Dillon, Montana (MBMG, 2013). Sixteen miles northeast of Dillon is Beaverhead Rock and within that 39-mile stretch are numerous tributaries that contribute to the Beaverhead River. The valley floodplain northeast of Dillon is approximately 3 miles wide; however, at Beaverhead Rock the floodplain is less than a quarter mile wide and is constricted by bedrock. Faulting in the vicinity of Beaverhead Rock has brought Madison Limestone to the surface, therefore constricting the valley and forcing groundwater to the surface (MBMG, 2013).

3.1.2 Hydrology and Hydrogeology

Surface water (i.e., rivers, creeks, canals, ditches, and springs) and groundwater (i.e., alluvial, Tertiary sediment, and volcanic rock aquifers) resources are seen and used extensively for agricultural and recreational purposes in the lower Beaverhead River drainage basin. Some agricultural use includes high-capacity irrigation aquifer pumping, which could adversely impact groundwater resources and cause stream depletion. Due to this potential impact, the MBMG Ground Water Investigation Program (GWIP) performed a hydrogeologic investigation of this drainage basin. Results from this investigation were presented as MBMG Open-File Report 637 (MBMG, 2013).

The GWIP Beaverhead River project area is approximately 100 square miles and includes 172 monitoring sites (155 wells and piezometers and 17 surface water and irrigation canal sites) (MBMG, 2013). Conversely, this Summary Report is focused on a significantly smaller project area within the vicinity of Beaverhead Rock and includes 3 surface water bodies (Beaverhead River, Co-op Ditch, and Warm Springs Ditch), an unidentified number of thermal springs, and groundwater (Figure 2a and Figure 2b). Anticipated Phase II work includes an effort to determine the connectivity, if any, of the spring complex to itself (i.e., a single thermal vent versus multiple thermal vents that heat the groundwater before it is expressed as springs) and to non-thermal surface and/or groundwater.

3.1.3 Geology

Both the USGS and the MBMG have produced quadrangle geologic maps that include Beaverhead Rock and the vicinity (Geologic Map of the Dillon 1^{o} x 2^{o} Quadrangle, Idaho and Montana [USGS, 1993] and Geologic Map of Montana [MBMG, 2009], respectively). Because of the unique geologic features of the area, specifically fault zones and thermal springs, both maps were used for the investigation. Each agency geologic description and map unit of the area is listed below.

USGS		MBMG	
Geologic Description	**Map Unit**	**Geologic Description**	**Map Unit**
Snowcrest Range Group and Madison Group, undivided	ℙMu	Madison Group	Mm
Permian to Mississippian rocks	PMu	Phosphoria and Quadrant Formations	PℙPpq
Triassic rocks, undivided	₸u	Not recognized	
Alluvial and pediment gravels (Quaternary and Tertiary)	QTg	Gravel	Qgr
Bozeman Group and related valley-fill deposits, undivided	Tbz	Sediment or sedimentary rock	Ts
Alluvium	Qa	Alluvium	Qal

Fault zones near Beaverhead Rock brought the Madison Limestone to the surface constricting the floodplain and possibly encouraging the expression of groundwater as thermal springs, albeit the thermal source is still undetermined. A northwest to southeast cross section from McCartney Mountain to the Gravelly Range, bisecting Beaverhead Rock, is presented on Figure 3 (Alt and Hyndman, 2009).

3.1.4 Geothermal Waters

The impetus behind this Summary Report was the thermal upwelling of groundwater (Ground Water Information Center [GWIC] ID 260069) that is the sole source for supplying Warm Springs Ditch. The MBMG first sampled this water in 1966 and again in 2012. While MBMG Hydrogeologic Map 4 (MBMG, 1981) and Open-File Report 415 (MBMG, 2000) only refer to the 1966 sampling event, information for both sampling events can be accessed through the MBMG GWIC. While the MBMG refers to this upwelling groundwater as both Beaverhead Rock Spring and Beaverhead Rock Springs, it is currently unknown if the source is a single thermal spring that branches out the closer it gets to the surface or multiple thermal springs (complex). Notwithstanding the recently found proliferation of thermal springs, this Summary Report uses Beaverhead Rock Spring (BRS) when discussing the source of water that supplies the Warm Springs Ditch and assigned GWIC ID 260069.

A second thermal spring, approximately 4,600 feet southwest from the BRS and located between the Beaverhead River and Co-op ditch headgate (Photo 1 and Figure 1) and the 10-foot Parshall flume Photo 2 and Figure 1), was sampled by GWIP personnel (GWIC ID 242227) as part of their investigation. While the MBMG uses spring and seep interchangeably for this site, the spring was both flowing and had an elevated temperature; thus, established nomenclature indicates that this would be considered a thermal spring. Results from the GWIP's three site visits, presented in open-file report 637 (MBMG, 2013), are used in this Summary Report.

Photo 1. Co-op Ditch headgate (looking northeast)

Photo 2. Parshall flume used to measure Co-op Ditch flow

3.2 Phase I Field Reconnaissance

3.2.1 June 29, 2015, Site Visit

Pioneer personnel first visited the study area on June 29, 2015. Per discussions with MDT and using existing MBMG data, the intent was to investigate the two known thermal springs filed with GWIC ID 260069 and ID 242227 (Section 3.1.4). Also, Pioneer personnel were to determine if other thermal springs were in the vicinity, survey applicable points, and engineer a way to quantify/qualify the extent of groundwater discharging as thermal springs using the groundwater's elevated temperature to delineate it.

Because so little was known about the site, Pioneer personnel arrived at 05:00, anticipating steam rising from discharging thermal springs once exposed to the atmosphere, to get a better idea of possible thermal spring locations. Incidentally, the region had experienced above average temperatures prior to the site visit. When coupled with the site's average thermal spring temperature (as opposed to a much higher hot spring temperature), there was no evidence of steam rising.

Following the initial drive around the site and in preparation for survey work, a global positioning system (GPS) base station was setup using an established MDT control point (horizontal North American Datum [NAD]: NAD83 [Montana State Plane]; North American Vertical Data [NAVD]: NAVD88) off of Beaverhead Rock Road. Starting on the southwest side of Beaverhead Rock, Pioneer personnel started hiking northeast along the base of Beaverhead

Rock. Personnel first discovered thermal springs northwest of Beaverhead Rock Road and west of Highway 41 after noticing the presence of tropical fish (black mollys, mosquitofish, and variable platyfish) (Confluence, 2013) (Photo 3) where the thermal springs were discharging into the Co-op Ditch (Photo 4 and Figure 2a). Eleven more thermal springs were identified and surveyed between the first one and the end of Beaverhead Rock, with all of them discharging into the Co-op Ditch from the west bank and each with their own school of fish (Figure 2a).

Photo 3. Tropical fish at thermal spring discharge

Photo 4. Thermal spring discharge into Co-op Ditch

The temperatures of the 12 springs were verified as thermal by measuring their temperatures using a forward looking infrared (FLIR) camera and then cross checked with a cased thermometer and non-contact infrared thermometer. As the day progressed and the atmospheric temperature increased, while low there was still a considerable thermal contrast of approximately 5.0 to 9.0 ^{o}C (9.0 to 16.0 ^{o}F) to differentiate between the thermal springs and irrigation water from the Co-op Ditch. Because of the relatively low flow of each spring (approximately 0.50 to 2.0 gallons per minute [gpm]) it was difficult to take a picture with the FLIR camera to show the contrast between the two waters; consequently, no photographs were taken. For reference, the Beaverhead River and Co-op Ditch waters were measured multiple times and averaged approximately 18.0 ^{o}C (64.4 ^{o}F) and 20.5 ^{o}C (68.9 ^{o}F), respectively. It is speculated that the higher Co-op Ditch water temperature is influenced by the discharge of and mixing with thermal springs.

After surveying and flagging the 12 thermal springs west of Highway 41, Pioneer personnel crossed over the highway to explore BRS and ascertain its characteristics, specifically size, flow, and temperature. Roughly half of BRS is fairly accessible (east and north sides) with the remaining half requiring brush clearing tools to make it through because of the dense and expansive vegetation (Photo 5). Due to this expansive vegetation, it was difficult to identify the start of BRS; however, a few points were surveyed that were likely in the vicinity of the southern boundary of BRS (Photo 6 and Figure 2a).

Photo 5. Dense vegetation south of the likely start of BRS

Photo 6. Likely start (southern extent) of BRS, looking north

Additionally, personnel noticed numerous thermal springs along the western bank of BRS, accessed by wading through the water, as well as bubbling up from the bottom of BRS (Figure 2a). Walking along the bank it became apparent the large number of thermal springs discharging to BRS. After verifying that the discharges were thermal springs by measuring the water temperature, personnel surveyed a few of them to use as reference points. It could not be verified whether thermal springs were discharging from the eastern bank of BRS. The BRS is channelized at its northern boundary as it transitions to the Warm Springs Ditch (Photo 7 and Figure 2a). Field observations suggest that channel construction was strategically completed beyond the last observed thermal spring discharge. The warmest measured temperature from a thermal spring in the entire project area was along the west bank of BRS (28.6 ^{o}C [83.5 ^{o}F]). One final BRS observation was the prolific amount of empty mollusk shells on the thermal spring bottom. The shells belong to the gastropod class, are approximately two inches long, slender, high spired, and appear to be non-native to Montana. Biologists are currently trying to identify them.

Photo 7. Likely end (northern extent) of BRS, looking south

Leaving BRS, Pioneer personnel hiked south to investigate points on an MDT-provided map where PRR had indicated additional thermal springs. Located approximately 500 feet east of Highway 41 and straight east from where the Co-op Ditch crosses under Beaverhead Rock Road, they are not visible from the highway (Figure 2a). These springs are of importance not only to get an idea of the area the thermal spring complex encompasses but because they are in the direct path of the proposed new alignment. While there was no flowing water in the area, it was evident that water had recently been flowing in an easterly direction towards a Beaverhead River oxbow but had since dried up Photo 8 and Figure 2a). This could be indicative of a seasonality relationship that could include a lack of resources (i.e., less groundwater recharge from precipitation, lower snowpack, less surface water seepage due to declining surface water levels, etc.). Alongside the dried up remnants of water was an area of isolated dense vegetation similar to the vegetation encountered near BRS, an additional spring indicator (Photo 9 and Figure 2a). Evidence that conclusively proves these springs are thermal is only circumstantial at this point as there was no flowing water to measure the temperature. As such, water from this area will only be referred to as springs and the thermal designation will be left off until a temperature can be taken and the water classified accordingly.

Photo 8. Looking SE from thermal spring depression at an oxbow

Photo 9. Dense vegetation indicative of a thermal spring

3.2.2 July 10, 2015 Site Visit

A follow-up site visit was deemed necessary and predicated on the initial field reconnaissance visit results. The presence of more thermal springs than anticipated required Pioneer to develop a new strategy, part of which included meeting MDT personnel on the site and visiting with PRR.

Shortly after arriving at 08:00 and while setting up the GPS base station, Pioneer personnel met the ditch rider responsible for the Co-op Ditch, Mr. Ray Fournier (ditch rider). The ditch rider is in charge of the headgate that diverts water from the Beaverhead River to the Co-op Ditch and then to the water rights holders for irrigation. Many factors can influence the amount of water that needs to be diverted and the ditch rider may have to visit the headgate daily to increase or decrease the amount of water taken from the Beaverhead River. During events where one or more water rights holders have not received adequate water, the ditch rider coordinates releasing more water from the Clark Canyon Dam to meet these demands. Water released from Clark Canyon Dam takes three days to reach the Co-op Ditch diversion, ensuring that the increased irrigation demand does not impact Beaverhead River flow volumes.

The ditch rider offered to walk Pioneer personnel along the Co-op Ditch to point out thermal springs that were possibly overlooked. During this time, the ditch rider shared his knowledge of the Co-op Ditch and the thermal springs in the area, including the fact that the Co-op Ditch is shut off from the Beaverhead River in early October every year, followed by the closing of a headgate that splits the Co-op Ditch during the non-irrigation period (Figure 1). Thermal springs discharge a consistent 560 to 670 gpm annually to the upstream portion (denoted by the yellow dashed line on Figure 2b) of the Co-op Ditch separated by the headgate. The downstream portion (denoted by the pink dashed line on Figure 2b) of the Co-op Ditch receives approximately 1,680 to 2,240 gpm annually from thermal springs discharging into it. The isolated upstream flow is routed to the Beaverhead River while the isolated downstream flow continues north/northeast to be used by livestock throughout the non-irrigation period, especially winter. Excess water is diverted east under Highway 41, north of the Point of Rocks Cemetery, to the Warm Springs Ditch and ultimately to the Beaverhead River (Photo 10).

A relationship between the area faults and thermal springs was confirmed following the July 26, 2005, earthquake located about 8 miles north of Dillon, Montana. Shortly after the seismic event, the flow volume from thermal springs discharging into the Co-op Ditch increased to approximately 3,370 gpm. This increase in flow lasted roughly 1.5 years before returning to the pre-earthquake flow of approximately 1,680 to 2,240 gpm, where it has remained since.

Photo 10. Convergence of Co-op Ditch with Warm Springs Ditch, flowing east

Adding to the complexity of understanding the area thermal springs is that the 2005 seismic activity did not appear to impact thermal spring flow from BRS. Records indicate that flow from BRS has been and continues to be measured at a consistent 740 gpm. While earlier record keeping does not indicate how these measurements were made, flow is currently measured by a metal weir installed downstream of any thermal spring discharge in the re-routed anthropogenic Warm Springs Ditch. There are currently three water rights assigned to BRS, with the original water right filed in 1866 for 560 gpm. These details were provided by PRR, whose property includes BRS, and who also corroborated the Co-op Ditch information that the ditch rider provided.

During the walk with the ditch rider, he pointed out innumerable thermal springs that discharge into the Co-op Ditch. Of significant importance was the area bordered by Beaverhead Rock Road to the south, Co-op Ditch to the west, and Highway 41 to the east (approximately 3.3 acres). Based on the thick vegetation coverage and the witnessed discharge volume from the thermal springs emptying into the Co-op Ditch, it appears this whole area is underlain by thermal springs. Taking this into consideration, it was confirmed that the Co-op Ditch receives thermal spring water from both the west and east as well as from directly below the channel bottom (Figure 2b).

The walk with the ditch rider was followed by a meeting with PRR, and it proved just as revealing. In addition to what the ditch rider had already shared, area history and other thermal spring locations were shared, including the rationale behind placement of the fence that surrounds BRS. Prior to fence construction, PRR cattle would gather near the thermal springs during the winter and if they stayed too long in the sultry environment while the ambient temperature was below freezing, they would develop pneumonia and die. The fence was constructed to prevent repeat incidents but required special consideration during layout (i.e., non-saturated, stable soil to support the fence posts). While Pioneer personnel had a difficult time delineating the extent of BRS, it is essentially the area that is enclosed by the fence. Based on conversations with PRR and the contrast of the vegetation on either side of the fence, soil within the fence perimeter appears to be compromised by excess groundwater and would not provide adequate support for a fence (Photo 11 and Figure 2b). However, other than the visual observation (Photo 11), Pioneer personnel were unable to confirm the soil integrity and this will be a data gap until it can be investigated further. In the interim, the PRR fence will be treated as the northern and eastern extent of BRS and the northern and eastern boundaries of the final study area.

Additional areas of interest were provided by PRR. These areas were all east of Highway 41 and along the study area's 3,600-foot stretch. Wetlands, low-flow streams, pools, and dried up remnants of water were all encountered (Photo 12 and Figure 2b). Many of these features were surveyed and photographed; however, it was difficult to assess if any of the encountered water was truly thermal spring related because of access and the elevated ambient temperature. Sources contributing to the flowing water could rarely be located or accessed, thus accurate temperature measurements could not be taken.

Photo 11. Northeast corner of BRS fence, looking south

Photo 12. Area with wetlands, low-flow streams, and pools

Aerial imagery indicates that many of these areas could be "wet" from Beaverhead River oxbows and/or the shallow groundwater table caused by the constricted floodplain (Section 3.1.1). In either case, seasonality could be a major factor in how much water is in the area at any given time and must be considered when accessing the area. Another line of evidence was the inclusion of a culvert between two oxbows (Photo 13, Photo 14, and Figure 2b) east of the hay bales. While the culvert was dry during this field visit, the need for the culvert to facilitate drainage to gain field access during wet period was apparent.

Photo 13. Standing on field culvert separating two oxbows, looking south

Photo 14. Standing on field culvert separating two oxbows, looking west

In addition to the aforementioned culvert, Pioneer personnel surveyed four other culverts that were found within the project area. All four are beneath Highway 41 with the two in the middle sloping west towards the Co-op Ditch and Beaverhead Rock Road. The northern and southern Highway 41 culverts, along with the culvert east of the hay bale storage area, all slope to the east. All five culverts appeared dry; though evidence suggested that there had been water flowing somewhat recently. Case in point was the southernmost culvert where surface water flow (Beaverhead River oxbow groundwater being expressed as surface water and/or thermal springs) could not be verified in the area west of Highway 41 but the vegetation was lush and the channel it drained into was muddy (Photo 15). On the opposite side of the culvert, east of Highway 41, the vegetation was just as lush and dense suggesting a wetland that is fed by its own source (Beaverhead River oxbow groundwater being expressed as surface water and/or thermal springs) as well as getting additional water from the culvert (Photo 16).

Photo 15. Southernmost culvert channel of recently dried up thermal spring/oxbow draining to the east under Highway 41

Photo 16. Southern most culvert draining to the east under Highway 41 to wetlands

4 PHASE II GEOTECHNICAL/HYDROGEOLOGIC EVALUATION

The future Phase II investigation work will likely include conceptual mitigation strategies for the selected highway alignment and an ongoing monitoring regimen to insure the "health" and productivity of the thermal spring complex so that it maintains established baseline conditions during and following MDT's construction activities. Initially, a Phase II Work Plan (Work Plan) was to be developed using Phase I results. Once complete, the Work Plan was to be submitted, along with the Phase I Summary Report, as part of Phase I deliverables. However, due to the complexity of the thermal springs' area and the fact that a final highway alignment has not been decided, the Work Plan development has been delayed until the new highway alignment is finalized.

4.1 Phase II Work Plan

The original intent of the Work Plan was to detail recommendations for Phase II exploration and monitoring using the Pioneer-developed working map of the area that established final study area bounds. However, per discussions with MDT, and based on the detailed findings from the two field reconnaissance visits by Pioneer presented in this Summary Report, Phase II has been temporarily postponed. Due to this postponement, the Work Plan deliverable date has been pushed back until MDT performs additional work along a newly proposed alternate alignment. Among the additional work to be completed, MDT Environmental will revisit the area to perform an environmental site assessment to help establish which alignment will be pursued and set the final area bounds. Once the area bounds are set, Pioneer will develop the Work Plan proposal and submit it to MDT.

4.1.1 Probable Phase II Tasks

While substantial information was collected during Phase I, until an alignment is chosen and area bounds are set, the following list of Phase II tasks and anticipated time frames can only be considered probable. Also included, and new to the original scope of work, are site visits during the fall.

1. Fall field visits at the end of irrigation season and the Co-op ditch shutting down to both quantify and qualify the extent of the thermal spring complex. Baseline conditions can be established once there is no longer an influence from groundwater diluted by irrigation water and/or the Beaverhead River. Conducting field visits in the fall will allow the following benefits:
    a. Better thermal contrast between groundwater being expressed as surface water and the ambient temperature (i.e., FLIR images will have better resolution).
    b. Without dilution taking place, collected thermal spring water samples can be "fingerprinted" more accurately. Sampling 5 to 10 strategic locations is suggested to determine if different water types can be classed (e.g., are the thermal springs separate or are they part of one large complex), with a minimum of 2 sampling events (late fall and early spring) at each location.
    c. By continuously measuring water levels in the Co-op ditch and the BRS/Warm Springs ditch, evaluators can establish if there are non-irrigation seasonal

fluctuations in thermal spring discharge volumes. This could be completed by installing up to five stilling wells, each with its own datalogger. Each datalogger would record at regular intervals, therefore eliminating the need for frequent site visits. Possible locations include the upstream portion of the Co-op Ditch (denoted by the yellow dashed line on Figure 2b), the downstream portion of the Co-op Ditch (denoted by the pink dashed line on Figure 2b), BRS (possibly upstream and downstream where discharge has been verified), and in areas where there is surface water but the source has not been identified.

2. 2016 spring and summer field visits prior to winter thaw and subsequent runoff and the start of construction. The field visits will likely continue during MDT work and after irrigation has resumed for the season (i.e., opening of the Co-op Ditch headgate). Tasks include the following:
    a. Continue thermal imaging of the thermal springs' discharges using a FLIR camera to verify the temperature and note any changes.
    b. Continue to measure water levels using dataloggers. Stilling wells and dataloggers in the Co-op Ditch will likely be removed prior to the opening of the Co-op Ditch headgate due to irrigation needs and associated flow variability.
    c. Collect at least a second set of thermal springs water samples to compare and use with samples collected during the fall.
    d. Establish if it would be beneficial to install a borehole in the Beaverhead Rock limestone.
    e. Depending on the chosen alignment, install piezometers in areas where there is little to no groundwater or spring information, which would be critical to the design of a new section of highway.

5 Discussion

The MDT retained Pioneer to perform a geotechnical and hydrogeological site evaluation as part of their larger effort to provide geometric improvements to the existing roadway while ensuring that the integrity of the thermal spring complex was not inadvertently compromised. The project area is located on Highway 41 (N-49) and begins at the north end of the bridge crossing the Beaverhead River (Station 754+/-) and extends approximately 3,600 feet north (Station 790) (Figure 2a and Figure 2b).

Pioneer's Phase I site evaluation included compiling existing data, multiple phone conversations and meetings with MDT, and two field reconnaissance visits on June 29 and July 10, 2015. Garnered information for this site evaluation can be summed up in one sentence: there is a lot of water in the area, both thermal and non-thermal, and the source has not been determined.

Thermal springs in the area of BRS are likely outflows from the Beaverhead Rock limestone formation. Water from the limestone is older water (water that recharged the groundwater system prior to the early 1950s) as opposed to newer alluvial groundwater (within the last few years) being expressed as surface water by bedrock due to the narrowing of the floodplain/alluvial material system.

The source of the "thermal" in thermal springs is pure conjecture at this point and will likely not be determined for this effort. While establishing the source would better help understand the site, it is not something that will keep the MDT project from moving forward.

While the Phase II investigation will focus on the north end of the project near BRS, regardless of the chosen alignment, the south areas are different enough that knowing what highway alignment will be used throughout the study area will play a big factor when scoping the Phase II work to be completed. The wet area on the south end of the project boundary, immediately north of the Beaverhead River crossing, can be attributed to the Beaverhead River complex and does not appear to be impacted by thermal springs. As such, Pioneer does not anticipate this area requiring further investigation unless otherwise directed by MDT.

A new highway alignment east of the current highway alignment would not adversely impact the Co-op Ditch area, or associated thermal springs, as the new roadway would be located further east. However, the new alignment passes directly through a "Spring Depression Area" that could disrupt a portion of the thermal spring complex. The springs appear to be intermittent, which could be indicative of a seasonality relationship. This seasonality relationship demonstrates that this "Spring Depression Area" is currently not an important component of the surface water system, likely due to a lack of resources (i.e., less groundwater recharge from precipitation, lower snowpack, less surface water seepage due to declining surface water levels, etc.). With that in mind, PRR spoke of the area as if it was flowing and MDT should be prepared if there are a string of "wet" years that recharge the underlying basin causing the springs to perpetually discharge.

Lastly, the other potential problem area of the new alignment is the area adjacent to the BRS and associated Warm Springs Ditch. This is a problem area due to the lack of information. A better understanding of the groundwater and springs (thermal and non-thermal) in the area would be critical to the design of the new section of highway.

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Figures

LEGEND

- FENCE
- CULVERT
- PROPOSED ALTERNATE ALIGNMENT
- FLOW DIRECTION

N

DISPLAYED AS:
COORD SYS/ZONE:
DATUM:
UNITS:
SOURCE:

SCALE IN FEET
0 250 500

FIGURE 1

PIONEER
TECHNICAL SERVICES, INC.
BUTTE, MT 59701
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BEAVERHEAD ROCK THERMAL SPRING COMPLEX SITE MAP

DATE: 8/7/15

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LEGEND

- THERMAL SPRING
- SEASONALITY INFLUENCED SPRINGS
- SOUTHERN AND NORTHERN EXTENT OF BEAVERHEAD ROCK SPRING
- FENCE
- PROPOSED ALTERNATE ALIGNMENT
- FLOW DIRECTION

DISPLAYED AS:	
COORD SYS/ZONE:	MSP
DATUM:	NAD83
UNITS:	IF
SOURCE:	PIONEER/BING MAPS

SCALE IN FEET
0 125 250

FIGURE 2a

STONE CREEK-NORTH THERMAL SPRINGS INVESTIGATION, JUNE 29, 2015 SITE EVALUATION

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DATE: 8/11/15

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LEGEND

- THERMAL SPRING
- SOUTHERN AND NORTHERN EXTENT OF BEAVERHEAD ROCK SPRING
- WETLAND, LOW-FLOW STREAM, POOL, ETC.
- FENCE
- PROPOSED ALTERNATE ALIGNMENT
- FLOW DIRECTION
- UPSTREAM PORTION OF THE CO-OP DITCH
- DOWNSTREAM PORTION OF THE CO-OP DITCH

DISPLAYED AS:
COORD SYS/ZONE: MSP
DATUM: NAD83
UNITS: IF
SOURCE: PIONEER/BING MAPS

SCALE IN FEET
0 125 250

FIGURE 2b

STONE CREEK-NORTH THERMAL SPRINGS INVESTIGATION, JULY 10, 2015 SITE EVALUATION

PIONEER TECHNICAL SERVICES, INC.
1101 SOUTH MONTANA
BUTTE, MONTANA 59701
(406) 782-5177

DATE: 8/11/15

8/12/2015 8:02:39 AM P:\MDT\STONECREEKAREAINVESTIGATION\OFFICEWORK\FIGURES\CAD\MDT-ST-CK INVENTORY-4.DWG

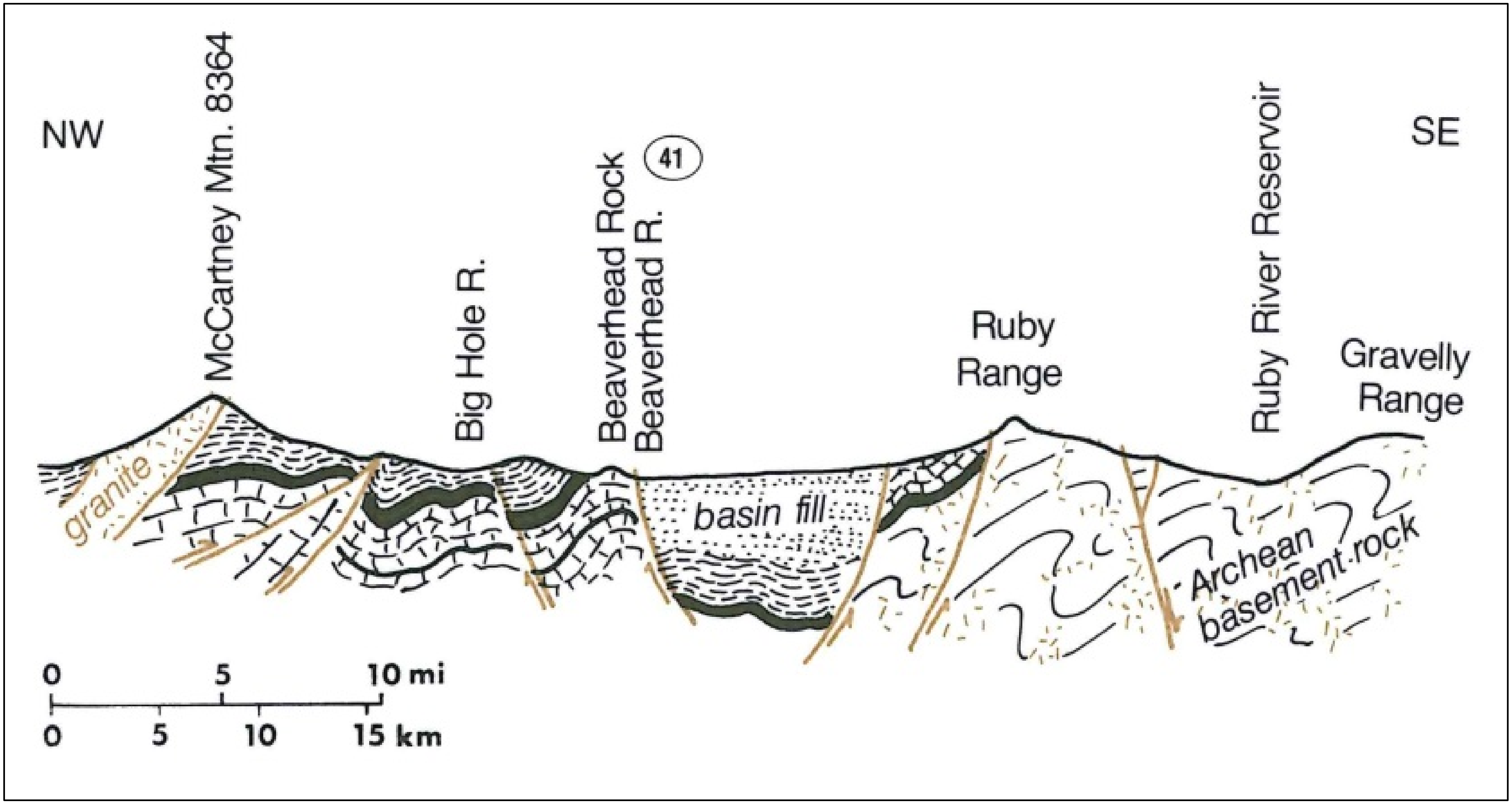

Figure 3. Cross Section Across Montana 41 About Midway Between Dillon and Twin Bridges (Roadside Geology of Montana, 2009)