Partial Alluvial Valley Floor Determination
For Mizpah Creek and 15 tributaries in South East Montana

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Regulatory Framework

The Montana Strip and Underground Mining Reclamation Act (MSUMRA) § 82-4-201 through 82-4-254, MCA, and its implementing rules, Administrative Rules of Montana (ARM) 17.24.301 through 17.24.1309, specifically § 82-4-227(3)(b)(i)-(ii) MCA, and ARM 17.24.301 and 17.24.325 set forth the process for identifying an alluvial valley floor (AVF) located in the arid and semi-arid lands of Montana. The “significance” of an AVF is determined based on the criteria set forth in ARM 17.24.325 and 17.24.805. Any mine proposal or mine related disturbance within a valley holding a stream, or adjacent to and connected to a valley holding a stream, must have an AVF determination. MSUMRA requires protection of identified AVFs from impacts of coal mining that are averse to agricultural activities or farming.

An AVF determination consists of three separate evaluations. The first evaluation determines the presence and extent or absence of AVFs based on criteria defined in ARM 17.24.325(2). The second evaluation determines the significance of the AVF for adversely affected agricultural or farming operations, ARM 17.24.805. Included in this significance determination, DEQ consults with the affected landowner(s) or ranch operator(s). The third evaluation determines the essential hydrologic functions of each AVF, ARM 17.24.325 (3)(c)(i)(ii) and (e). If the first evaluation determines that no AVF is present, then further evaluation is not warranted. If an AVF is identified, then significance of the AVF must be determined, and the essential hydrologic functionality of that AVF must also be determined.

As explained in detail below, both geologic and hydrologic criteria must be met to designate an AVF. The key to the existence of an AVF is the presence of both geomorphic characteristics and water availability for agricultural activities or farming.

I. Presence or Absence

Analysis of Presence or Absence

Section 82-4-203(3)(a), MCA, defines an AVF as: “the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities.” Section 82-4-203(3)(b), MCA, distinguishes “upland areas that are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion and deposits by un-concentrated runoff or slope wash, together with talus, other mass movement accumulation, and windblown deposits” from AVFs. Uplands is further defined in ARM 17.24.301 (136) as “with respect to alluvial valley floors, those geomorphic features located outside the floodplain and terrace complex, such as isolated higher terraces, alluvial fans, pediment surfaces, landslide deposits, and surfaces covered with residuum, mud flows or debris flows, as well as highland areas underlain by bedrock and covered by residual weathered material or material deposited by sheetwash, rillwash, or wind.”

Alluvium and colluvium are deposits of materials resulting from erosion and deposition. Alluvium is a general term for materials deposited by water, including gravel, sand, silt, clay, and all the variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated (Brady and Weil, 2010).
Colluvium is a deposit of rock fragments and soil material accumulated at the base of steep slopes as a result of gravitational action (Brady and Weil, 2010). Both transport processes result in unconsolidated material on the earth’s surface.

According to the Dictionary of Geologic Terms, “colluvial” is defined as “consisting of alluvium in part and also containing angular fragments of the original rocks.” Colluvium may be mixed with alluvium. Various processes may account for this. For example, alluvial stream channel deposits may slide down terrace banks resulting in new colluvial deposition.

The definition of AVF is further clarified as “unconsolidated streamlaid deposits holding streams” as “all flood plains and terraces located in the lower portions of valleys which contain perennial or other streams with channels.” ARM 17.24.301(132). This definition of unconsolidated deposits allows for colluvium as defined above to be contained in a terrace or floodplain of an AVF. Therefore, the presence of surface colluvium does not exclude a stream from AVF status. The underlying geology rather than surface deposition dictates a determination of alluvial or colluvial character in a valley floor.

ARM 17.24.325(2)(b) sets forth the procedure for determining the presence or absence of an AVF:

Based on the investigations conducted under [ARM 17.24.325(2)] (a), the department shall make a written determination of the extent of any alluvial valley floors within the study area and whether any stream in the study area may be excluded from further consideration as lying within an alluvial valley floor. The department shall determine that an alluvial valley floor exists if it finds that:

(i) unconsolidated streamlaid deposits holding streams are present; and
(ii) there is sufficient water to support agricultural activities as evidenced by:
(A) the existence of current flood irrigation in the area in question;
(B) the capability of the area to be flood irrigated, based on typical regional agricultural practices, historical flood irrigation, stream-flow, water yield, soils, water quality, and topography; or
(C) subirrigation of the lands in question, derived from the ground water system of the valley floor; and
(iii) the valley does not meet the definition of upland areas in ARM 17.24.301.

(c) If the department determines in writing that an alluvial valley does not exist pursuant to (b), no further consideration of this rule is necessary;

Finally stream valleys “adjacent” to proposed mining operations must be evaluated for the presence or absence of AVFs. “Adjacent” is also a defined term under MSUMRA and means in pertinent part, “the area outside the permit area where a resource or resources, determined in the context in which the term is used, are or could reasonably be expected to be adversely affected by proposed mining operations.” § 82-4-203(2), MCA.

Introduction
Mizpah Creek is a perennial tributary of the Powder River in the semi-arid to arid region of southeast Montana. The confluence with the Powder River is near the town of Mizpah, Montana, approximately 50 straight line miles downstream from the point Mizpah Creek leaves the study area and 40 miles from the north extent of the study area. Mizpah Creek’s drainage basin is approximately 800 square miles.
Mizpah Creek and its tributaries are perennial, intermittent, and ephemeral streams that occupy valleys within and adjacent to Great Northern Properties Limited Partnership (GNP) coal mineral holdings.

The area identified by GNP in its request for an AVF determination (study area) lies northwest of Broadus, MT in the southwestern portion of the Mizpah Creek drainage basin. The study area covers over 60 square miles. It is 15 miles long from north to south, 2 miles wide at the north extent and 6 miles wide at the south extent (Map 1, Study Area Overview). GNP coal holdings are in the “checkerboard” pattern created by railroad land grants of the late 1800s. GNP requested AVF presence or absence determination for the study area and submitted data in October of 2016 (Application N2013013).

Fifteen named drainages flow east, through the study area, into Mizpah Creek or one of its tributaries; Lost Soldier Creek, Double Corral Creek, Johnson Creek, Lake Creek, Ash Creek (North Fork Ash Creek and South Fork Ash Creek converge in the study area to form Ash Creek), Y T Creek, Second Creek, Middle Creek, Leslie Creek, Third Creek, Road Creek, Wiser Creek, and Two Tree Creek. There are many unnamed tributaries within the study area not in consideration for AVF determination. These tributaries fit the upland stream designation, tend to be ephemeral, and do not contain unconsolidated stream laid deposits.

1. Unconsolidated Streamlaid Deposits
The presence of unconsolidated streamlaid deposits in Mizpah Creek and its tributaries may be ascertained by use of maps, field geology, and monitoring well and piezometer drill logs. The monitoring well logs are presented in Appendix A and soil survey data is presented in Appendix E of Application N2013013. Monitoring well, piezometer, and surface water monitoring locations are marked on Map 2A and Map 2B. Specific well logs and soil transect data were examined to demonstrate the distribution of alluvial materials throughout the Mizpah Creek AVF study area. For the purposes of this presence or absence determination, the area depicted in Map 1, Study Area Overview was considered. This determination evaluates information on alluvial deposits mapped by United States Geological Survey (USGS), Montana Bureau of Mines and Geology (MBMG) and the Natural Resources Conservation Service (NRCS). Data indicating the presence of unconsolidated stream laid deposits and the presence of sub-irrigation or flood irrigation in individual drainages are discussed, below.

Geology and Soils
As explained above, the first step in determining the presence or absence of an alluvial valley floor is to identify valleys with streams holding unconsolidated streamlaid deposits. Unconsolidated stream laid deposits are alluvium.

In the Mizpah Creek drainage, the subject of this evaluation, the parent (source) materials for alluvium are derived from the Tongue River Member and the Lebo Member of the Fort Union formation. The source materials for these alluvial deposits are sandstone and clinker capped buttes that are underlain by softer strata (USDA 1980). Through time, the source materials have been eroded and deposited in the drainages and lowlands as alluvium. The alluvium is sorted into finer silts and clays on floodplains that lie over coarser clinker gravels, fine sands, or bedrock. Drill logs may refer to these materials in descriptions of alluvium.
Lithology descriptions, from drill logs completed in and adjacent to tributaries of Mizpah Creek, indicate that drainages in the Mizpah Creek watershed are composed of finer textured materials. These materials consist primarily of silty to clayey loam soils found in the surface horizons (soil layers) with coarser loams and sands mixed or layered with gravels deeper in the soil profiles (Application N2013013). These surface horizons rest on unconsolidated deposits composed of sand, silt, and clay over gravels occurring at the greatest depths in the geologic column. This is a typical layering of deposits. When water transports earthen materials the largest particles, gravels and then sands, settle out first. As flow decreases, smaller and lighter particles settle out. The smallest and lightest particles, silty then clayey particles, settle out last generally to be found in the surface horizons.

Soil types of these geologic units have similar characteristics. Most of the soils in the Mizpah Creek study area fall in the fine loamy, fine silty and fine clay soil textural classes. With coarse loamy and sandy soil textures encountered occasionally. Coarse fragments when present are mostly found below the soil horizons.

**Prime Farmland soil and Farmland of statewide importance**

Soils designated as prime farmlands or farmlands of statewide importance indicate soils with enhanced ability to cultivate the land surface. As part of this investigation the presence of prime farmlands and farmlands of statewide importance were determined. The Natural Resources Conservation Service (NRCS) cooperative soil survey was evaluated for these soil types. An AVF determination is not dependent on prime farmlands. However, prime farmland soils do indicate areas favorable for cultivation.

Prime farmlands when irrigated and farmlands of state wide importance were identified in the study area. These farmlands cover 12,958 acres of the entire study area of 38,574 acres. This is roughly a third of the study area. Broken down into land uses the NRCS mapped Prime Farmlands if Irrigated or Farmlands of Statewide importance are utilized as follows: Rangeland (5,859.3 acres, 45.2%), Croplands (4,692.9 acres, 36.2%), Pasturelands (2,185.5 acres, 16.9%), and Residential (220.3 acres, 1.7%) (Application N2013013).

**Unconsolidated Material Data Utilization**

There were a few data sets included in the Mizpah Application N2013013 indicating the extent of unconsolidated deposits. Two geologic maps one from Montana Bureau of Mines and Geology and one from United States Geologic Survey were submitted along with four drill data sets (Map 3A, 3B, and 3C). During analysis and verification of the data inconsistencies were realized. When an inconsistency was noted efforts were made to validate the data; however, this was not always possible.

To identify unconsolidated deposits drill logs were used. The drilled data sets included four types of drill hole or water well information. These types are ground water wells, resource drill holes, water monitoring wells, and piezometers. Actual drill logs were only included for water monitoring wells and piezometers. Data sets from ground water wells and resource drill holes were submitted and marked as, “with alluvial lithology, or with no alluvial lithology.” These last two drill hole sets did not have accompanying drill logs.
Resource drill holes and water wells adjacent to each other, approximately 11 feet apart, were identified with conflicting outcomes for alluvial lithology. Because the actual drill logs were not available the data sets for water wells and resource drill holes are given less weight than the piezometers and water monitoring well drill logs. The data sets lacking drill logs are noted in discussion of the drainages below; however, they are not used to determine extents. Without the water well and resource drill logs the extent of unconsolidated materials is mainly determined with the available drill logs and maps from geologic surveys.

Hydrology
The geomorphology of Mizpah Creek and its tributaries falls into two general categories. The first category includes the main-stem channel of Mizpah Creek and the lower reaches of the 15 tributaries in the study area characterized by meanders within a lower gradient valley consisting of alluvium. A second category includes erosional channels represented by unnamed upland tributaries and the upper reaches, above AVF conditions, of the 15 tributaries in the study area where the channel is characterized by an incision formed on a steeper gradient slope and lacks major depositional zones and meanders. The low gradient valleys support agricultural production adjacent to the active stream channels. In contrast, erosional channels flow through rangeland, where runoff is directed to flood irrigation on the lower gradient valleys, used in stock watering ponds, or not captured for use.

2. Sufficient Water to Support Agricultural Activities:
The presence of irrigation sufficient to support agricultural activities or farming must be determined. See Section 82-4-203(3)(a), MCA; ARM 17.24.325(2)(b). The three criteria to determine if there is sufficient water to support agricultural activities or farming are discussed in ARM 17.24.325(2)(b)(ii)(A)-(C).

a. The Existence of Current or Historic Flood Irrigation
Flood irrigation is defined as “supplying water to plants by natural overflow or the diversion of flows, so that the irrigated surface is largely covered by a sheet of water,” ARM 17.24.301(44). Surface water management structures such as dams or spreader and containment dikes indicate the existence of current or historic flood irrigation. Of these water management structures, dams, containment dikes and spreader dikes can be found in the study area. The area with evidence of current or historic flood irrigation was delineated using Montana Department of Natural Resources and Conservation (DNRC) water right information and aerial photographs. Active water rights in the study area are listed in Table G.1, Attachment G, Appendix B of the Application for AVF Determination (Application N2013013). The existence and extent of current or historic flood irrigation is variable across the study area. As this study area encompasses fifteen drainages, they will be discussed separately.

b. Capability of the Area to be Flood Irrigated
An area has the capacity to be flood irrigated if there is enough available water to support flood irrigation and there is an appropriate location on the landscape to irrigate with that water. Areas with active water rights and gentle slopes over soils classified as prime farmland if irrigated or farmland of statewide importance, by the Natural Resources Conservation Service (NRCS), were considered capable of being flood irrigated. As this study area encompasses fifteen drainages, they will be discussed separately.
c. The Existence of Subirrigation

Areas with unconsolidated streamlaid deposits that are subirrigated are AVF’s. Subirrigation occurs when groundwater is close enough to the surface to support agricultural activities or farming. This happens when water reaches the root zone of the plants being grown. According to ARM 17.24.301(118) “Subirrigation” means, with respect to alluvial valley floors, the supplying of water to plants from a subsurface zone where water is available and suitable for use by vegetation. Subirrigation may be identified by:

(a) diurnal fluctuation of the water table, due to the differences in nighttime and daytime evapotranspiration rates;

(b) increasing soil moisture from a portion of the root zone down to the saturated zone, due to capillary action;

(c) mottling of the soils in the root zone;

(d) existence of an important part of the root zone in the capillary fringe or water table of an alluvial aquifer; or

(e) an increase in streamflow or a rise in ground water levels, shortly after the first killing frost on the valley floor.

The portion of the study area that is subirrigated was defined using evidence of the phenomena described above. This effort was limited by the available data. The area identified as subirrigated within the study area is an approximation and could be further refined by collection of additional data. The following analysis of subirrigation will focus on ARM 17.24.301(118)(a), (d), and (e) because those phenomena can be evaluated using available evidence.

Groundwater elevation data from shallow alluvial wells, equipped with pressure transducers, were evaluated for the presence of daily fluctuations indicating the effects of evapotranspiration (ET). Evapotranspiration is the sum of water lost to the atmosphere through evaporation and transpiration by plants where roots are interacting with groundwater. These daily fluctuations, referred to as diurnal fluctuations, are indicative of ET lowering shallow groundwater levels and have been used to estimate ET rates in numerous studies (summarized in Gribovszki et al. 2010). During daylight hours, when ET is actively occurring, groundwater levels continually decline as water is lost to the atmosphere. During night hours, after ET has ceased, groundwater levels recover as recharge from adjacent areas occurs. Diurnal fluctuations were observed in all shallow alluvial wells equipped with pressure transducers that intersected the water table in the study area.

When evaluating the depth to useful groundwater, the rooting depth and thickness of the capillary fringe needs to be considered. According to Tables 5 and 8 in Appendix E of the Application for AVF Determination (Application N2013013), 469 observations of rooting depth were recorded from the study area but only 5 soil test pits were completed below 72 inches below ground surface (bgs). The maximum rooting depth observed in the Broadus study area was 144 inches but the average rooting depth was 57.7
inches (rounded to 60 inches). The vast majority of test pits were only completed to 60 inches bgs. Of the 469 recorded observations of rooting depth in the study area, 376 locations had roots extending to at least 60 inches bgs. Average rooting depth in the study area may exceed 60 inches; however, data that supports an average rooting depth greater than 60 inches was not included in the Application. The average rooting depth is considered to be 60 inches (5 feet) in this evaluation because this is what the existing data supports. This five-foot depth will be considered the depth to which roots can utilize water in this area.

Capillary fringe refers to the ability of water to rise in the soil column above the water table due to capillary action. Pore sizes of the material above the water table determine the thickness of the capillary fringe. Based on the soils data collected as part of the AVF investigation, a site-specific capillary fringe was established. This process took into consideration the depth of each soil textural class and their proportional grain size to determine the capillary rise possible for these alluvial soils.

<table>
<thead>
<tr>
<th>TABLE 2.3</th>
<th>Typical Height of Capillary Fringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Grain Size (mm)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>...</td>
</tr>
<tr>
<td>Fine</td>
<td>2-5</td>
</tr>
<tr>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>Very coarse</td>
<td>1-2</td>
</tr>
<tr>
<td>Coarse</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Medium</td>
<td>0.2-0.5</td>
</tr>
<tr>
<td>Fine</td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>Silt</td>
<td>0.05-0.1</td>
</tr>
<tr>
<td></td>
<td>0.02-0.05</td>
</tr>
<tr>
<td>Clay</td>
<td>...</td>
</tr>
</tbody>
</table>

Source: [5, 6].

Note: Calculation for capillary rise initiates in metric units from Table 2.3. Final results are in United States customary units (inches and feet) for consistency.

Capillary rise was determined based on soil texture and Table 2.3 above (Kuo 2014). Soil samples, collected at select transect locations in the AVF study area, were analyzed for their soil textural class. Each soil textural class is comprised of percentages of sand, silt, and clay, equaling 100 percent. Each of the textural components has a capillary rise associated with it as evidenced in the table above.

Loam is a type of soil that can generally be defined as having 42% sand, 42% silt, and 16% clay. Using the table, medium sand has a capillary rise of 24.6 centimeters (cm), silt a rise of 150 cm, and clay a rise of 300 cm. The weighted average capillary rise for loam is calculated as the sum of 42% times 24.6 cm
(equal to 10.3 cm or 4 inches), 42% times 150 cm (equal to 63 cm or 24.8 inches), and 16% times 300 cm (equal to 48 cm or 18.9 inches) resulting in approximately 121 cm (47.8 inches).

The weighted average capillary rise for each soil texture class was used to estimate the capillary rise for the entire soil profile in each sample location. Table 6 in Appendix E of the Application for AVF Determination (Application N2013013) presents data on soil texture by location for over 200 locations in the study area. For example, location 3B, in the Lost Soldier Creek drainage, has a 60-inch soil profile of which 50% (30 inches) is loam, 40% (24 inches) is sandy loam and 10% (6 inches) is silty loam. Using these soil textures, a capillary rise is calculated using 50% times 47.8 inches (the weighted average capillary rise calculated for loam in the previous paragraph), 40% times 32.1 inches (the weighted average capillary rise for sandy loam), and 10% times 58 inches (the weighted average capillary rise for silty loam). The three are then added together to give a weighted average capillary rise of 42.5 inches. This process was repeated in each drainage with data from three to eight individual soil profiles. Soil profiles from upland locations were not included. The results of this analysis indicated a minimum average capillary rise of 51 inches, a maximum average of 72.7 inches, and an overall average of 60.9 inches of rise. This was rounded to a 5-foot capillary rise.

By applying this average, DEQ expects subirrigation will occur when the water level is approximately 10 feet below ground surface or shallower (approximately 5-foot rooting depth and approximately 5-foot capillary fringe). This may be an underestimate of the true depth at which subirrigation occurs in the study area because maximum rooting depth may be deeper than 60 inches. Rooting depths that exceed 60 inches are not uncommon for some plant species. An area where water is less than 14 feet below the surface is considered within the zone of subirrigation for alfalfa (Dollhopf, et al., 1982). Alfalfa is present in the study area although it is not dominant in most areas, according to Appendix F of the Application for AVF Determination (Application N2013013). Alfalfa is present near piezometer LESC-1-2. Diurnal fluctuations were observed in LESC-1-2 when groundwater was over 11 feet below ground surface. Diurnal fluctuations were also observed in NFAC-1-3 when groundwater was almost 13 feet bgs. The NFAC-1 transect wells are located near a group of large trees which tend to have much deeper roots than grasses and may be responsible for the diurnal fluctuation observed in those wells.

Map A.A-7, included in Appendix A of the Application for AVF Determination (Application N2013013), identifies areas within the study area that have alluvial groundwater within approximately 10 feet of the ground surface. This map was created using groundwater elevation contours developed by GNP. It is important to note that an error in the groundwater elevation data, used to generate this map, is present in the North Fork Ash Creek drainage. The erroneous groundwater elevation does not appear to impact estimates of depth to groundwater outside of the North Fork Ash Creek drainage. The groundwater gradient was apparently inferred from a limited number of data points in each drainage included in the study area. A groundwater elevation model created from so few data points should be interpreted cautiously as it only represents a rough approximation of groundwater elevation. This approximate groundwater elevation model along with other evidence of subirrigation, listed in ARM 17.24.301(118), was used to establish the existence of subirrigation in the study area.
Groundwater elevation data from shallow alluvial wells, equipped with pressure transducers, was evaluated for the presence of an increase in groundwater levels in the fall. Starting in early fall, ET rates start to decline due to shorter days, cooler temperatures, and vegetation senescence (hibernation or frost kill). Thus, groundwater levels start to recover in the fall as ET markedly declines. Hydrographs depicting groundwater elevation in shallow alluvial wells, equipped with pressure transducers, can be found in Appendix A, Attachment C of Application N2013013. An increase in groundwater level in the fall was observed in select shallow alluvial wells. As this study area encompasses fifteen drainages, subirrigation will be discussed separately for each.

The characteristics, relevant to AVF determination, of study area drainages will be detailed in the following discussion. The drainages are discussed separately and in the order of their geographical position from north to south across the study area.

**Lost Soldier Creek**

**Evidence of Unconsolidated Deposits**
Lost Soldier Creek demonstrates unconsolidated deposits in drill logs for 3 monitoring well logs drilled in T2S R50E Sections 5 and 9 (Map 3A). These drill logs show unconsolidated deposits that include sorted sand, mixed with very fine clays, silt, sands and gravels up to 35 feet below ground surface. Additionally, five water wells or resource holes, without drill logs, are reported in these sections to have unconsolidated materials. These additional holes support possible unconsolidated deposits 1,000 ft. wide. The pilot hole data shows that unconsolidated materials may extend most of the way across the study area from east to west. Geologic conditions for AVF designation exist in Lost Soldier Creek.

**Hydrology**
The Lost Soldier Creek watershed covers 14.5 mi² and includes 4.1 mi² within the Study Area. The Lost Soldier watershed has a mean slope of 10.1% and a channel slope of 0.43%, with a moderate sinuosity ratio of 1.62. The watershed contains 11.8 mi of channels within the Study Area.

There were two surface water monitoring sites on Lost Soldier Creek, LSC-1 and LSC-4 (Map 2B). Water was present in June 2013 and in March 2014 at both locations. Measured flow on June 4, 2013, was 0.016 cubic feet per second (cfs) at LSC-1 and 0.035 cfs at LSC-4. Measured flow on March 9, 2014, was 0.039 cfs at LSC-1 and 0.050 cfs at LSC-4.

Two existing and one abandoned groundwater monitoring wells (2S50E05SW, 2S50E09SE2, and 2S50E09SE respectively) are located adjacent to Lost Soldier Creek. The upstream well, 2S50E05SW, had a depth to water ranging from 17.94 ft. bgs in March 2014 to 18.90 ft. bgs in December 2014. Depth to water in the downstream well, 2S50E09SE2, ranged from 10.77 ft. bgs in March 2014 to 12.30 ft. bgs in September 2013.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of water rights on Lost Soldier Creek, performed by GNP, revealed evidence of flood irrigation. Lost Soldier Creek has 1 diversion dam permitted for irrigation with the potential to impound 45.4 ac-ft of water and irrigate 50 acres within the study area.
**Capability to be Flood Irrigated**
Lost Soldier Creek is an intermittent to ephemeral stream. There are few locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**
The existence of subirrigation along Lost Solider Creek is difficult to determine because of the lack of data. No continuous water level loggers were installed near Lost Soldier Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation it is likely that subirrigation does not occur in the upper reaches of Lost Soldier Creek, near 2S50E05SW; however, subirrigation may occur near well 2S50E09SE2 where groundwater is closer to the land surface.

**Double Corral Creek**

**Evidence of Unconsolidated Deposits**
Double Corral Creek demonstrates unconsolidated deposits in a drill log for 1 monitoring well drill log drilled in T2S R50E Section 17 (Map 3A). The well log shows unconsolidated materials that include clayey silt, clayey sand, sandy clay, silt and rounded gravel to 20 feet below ground surface. Eight water wells or resource holes, without drill logs, are reported in sections 17 and 21 to have unconsolidated materials. The additional wells support possible deposits approximately 2,700 feet up one of the southern tributaries to Double Corral Creek. However, the data for most of the drainage indicate that unconsolidated materials are mainly concentrated around the mainstem stream channel. The east to west extent of the drill logs suggest unconsolidated deposits reach most of the way across the study area. Geologic conditions for AVF designation exist in Double Corral Creek.

**Hydrology**
The Double Corral Creek watershed covers 15.5 mi² and includes 3.8 mi² within the Study Area. The Double Corral watershed has a mean watershed slope of 8.5% and a channel slope of 0.44%, with a moderate sinuosity ratio of 1.50. The watershed contains 11.2 mi of channels within the Study Area.

There were three surface water monitoring sites on Double Corral Creek, DCC-1, DCC-3, and DCC-4 (Map 2B). Water was present in early June 2013 and in March 2014 at DCC-1. Water was present during all site visits in 2013 and 2014 at DCC-3, with water present at DCC-4 in March 2014.

Groundwater monitoring well, 2S50E17SE, was installed along Double Corral Creek near the center of the study area. The depth to water in 2S50E17SE ranged from 12.11 ft. in March 2014 to 13.18 ft. bgs in September 2013.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of Double Corral Creek water rights, performed by GNP, revealed evidence of current or historic flood irrigation. Double Corral Creek and its tributaries have 10 dams permitted to impound
135.3 ac-ft. of water. One diversion dam permitted to irrigate 71 acres, and 3 dikes permitted to irrigate 46 acres are located within the Study Area boundary. Water management structures are visible on 2016 aerial imagery along Double Corral Creek.

**Capability to be Flood Irrigated**

Double Corral Creek is an intermittent to perennial stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**

The existence of subirrigation along Double Corral Creek is difficult to determine due to the lack of data. No continuous water level loggers were installed near Double Corral Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in well 2S50E17SE, it is possible that subirrigation occurs along Double Corral Creek within the study area.

**Johnson Creek**

**Evidence of Unconsolidated Deposits**

Johnson Creek starts in T2S R50E Section 20 and flows southeast through section 29 where 5.5 feet of sandy overburden was reported in a resource drill hole, BR20 (Map 3A). This point is approximately 800 feet south of the stream near the watershed boundary; however, the drill log was not available for verification. Another resource drill hole BR 19 in section 21 indicates 3.5 feet of sand. This point is approximately 1,500 feet north of the stream near the watershed boundary in section 21 and did not have a drill log available. The stream turns south in section 28, following the section line between sections 33 and 34 emptying into Lake Creek in section 34. Groundwater wells noted in section 28 do not indicate any unconsolidated materials and do not include drill logs. Finally, in section 33 a drill log for a monitoring well drill log indicates 15 feet of sand. Data closer to the stream channel in sections 28 and 29 would be required to support AVF geology in Johnson Creek. The data available indicates Johnson Creek contains limited geologic conditions supporting an AVF determination.

**Hydrology**

Johnson Creek is a small tributary of Lake Creek. The Johnson Creek watershed covers 1.8 mi² and is almost entirely within the Study Area. The Johnson Creek watershed has a mean watershed slope of 7.5% and a channel slope of 0.93%, with a low sinuosity ratio of 1.06. The watershed contains 4.1 mi of channels within the Study Area.

There were two surface water monitoring sites on Johnson Creek, JC-1-RES and JC-4. Water was consistently present during all site visits in 2013 and 2014 at JC-1-RES. Water was present at JC-4 in March 2014.
Groundwater was not encountered within the first 43 ft. bgs at 2S50E33NE, which is the closest boring to Johnson Creek, during drilling to investigate unconsolidated deposits. No monitoring wells were installed adjacent to Johnson Creek.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of water rights on Johnson Creek, performed by GNP, revealed evidence of flood irrigation east of the study area boundary. Johnson Creek has seven permitted dams, with the potential to impound 43.4 ac-ft. of water and irrigate 20.6 acres. Five of the dams are permitted for stock, and two of the dams are permitted for irrigation. Only stock water rights are in the study area while irrigation water rights and water management structures are located adjacent to the study area.

**Capability to be Flood Irrigated**
Johnson Creek is an intermittent to ephemeral stream. There are limited locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. No active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance within the study area. The aspects described above indicate that the Johnson Creek watershed, within the study area, has very limited capability to be flood irrigated.

**The Existence of Subirrigation**
The existence of subirrigation along Johnson Creek is difficult to determine because of the lack of data. No continuous water level loggers were installed near Johnson Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and lack of water in 2S50E33NE it is likely that subirrigation does not occur along Johnson Creek within the study area.

**Lake Creek**

**Evidence of Unconsolidated Deposits**
Lake Creek demonstrates unconsolidated deposits in drilling logs for 3 monitoring well drill logs in T2S R49E section 25 and T2S R50E section 33 (Map 3A). The drill logs show layers of sorted silt, silty gravel, sand and gravel up to 40 feet below ground surface extending across the entire study area east to west. Water well or resource holes, without drill logs, indicate unconsolidated materials could be wide spread and are generally 15 to 20 feet below ground surface.

There are two piezometer batteries with three drill logs each in the Lake Creek drainage. Piezometer battery LC 1-3 is in T2S R50E section 30 and battery LC2 1-3 is in T2S R50E section 32. These drill logs indicate unconsolidated sandy clays, silts with occasional gravels. Unconsolidated material depths in the piezometers generally range between 10 and 15 feet below ground surface. Geologic conditions for AVF designation exist in Lake Creek.
Hydrology
The Lake Creek watershed covers 16.2 mi² of which 7.3 mi² are within the Study Area. The Lake Creek watershed has a mean watershed slope of 7.4% and a channel slope of 0.38%, with a moderate sinuosity ratio of 1.49. The watershed contains 22.6 mi of channels within the Study Area.

There were six surface water monitoring sites on Lake Creek; LKC-1 and adjacent LKC-1-RES, LKC-2-RES, LKC-3, LKC-3.5, and LKC-4. Water was present in March 2014 at LKC-1 and LKC-4. Water was present during all 14 site visits in 2013 through 2016 at LKC-1-RES. LKC-2-RES had water present during 11 of the 14 site visits in 2013 through 2016, with water present at LKC-3 during 12 of the 14 site visits. LKC-3 had a flow of 0.0072 cfs on May 4, 2013, and on March 19, 2015, a flow of 0.035 cfs was observed. Flow appeared to be perennial in locations below springs, but largely intermittent throughout the drainage.

Groundwater monitoring wells were installed at two locations along Lake Creek. Six piezometers were also installed along Lake Creek. Groundwater in the upstream monitoring well location, 2S49E25NW, was observed at depths ranging from 11.56 ft. bgs in June 2013 to 16.43 ft. bgs in June 2016. The downstream well, 2S50E33NW, had depths to water ranging from 5.87 ft. in June 2014 to 9.45 ft. in October 2015.

The Existence of Current or Historic Flood Irrigation
An evaluation of water rights along Lake Creek, performed by GNP, revealed evidence of flood irrigation. Water right filings on Lake Creek and its tributaries, within the Study Area, include 14 dams, 1 stock pond, 5 diversion dams, 4 dikes, and 3 springs. Eleven of the dams are permitted for stock watering, 1 is permitted for irrigation, and 2 are permitted for both stock and irrigation. There is the potential to impound 443.55 ac-ft. of water, and there are 308.5 acres of permitted irrigation areas. Water management structures are visible on 2016 aerial imagery along Lake Creek.

Capability to be Flood Irrigated
Lake Creek is an intermittent stream with limited perennial flow in areas below springs. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
Six piezometers (LC-1-1, LC-1-2, LC-1-3, LC-2-1, LC-2-2, and LC-2-3) were installed, in groups of three wells, at two locations along Lake Creek. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. Hydrographs depicting continuous water level data are presented in Attachment C, Appendix A of the GNP Application for AVF Determination (Application N2013013).

Hydrographs from the LC-1 piezometer cluster of wells exhibit no increase in groundwater levels in the fall of 2015. Diurnal fluctuations occurred in July and August of 2015.
Figure 1. Diurnal fluctuations in LC-1-1 during July of 2015.

Hydrographs from the LC-2 piezometer cluster of wells exhibit a seasonal pattern of increasing groundwater levels in the fall of 2015. Diurnal fluctuations were recorded in July, and August of 2015, in the LC-2 cluster of piezometers.

Figure 2. Diurnal fluctuations in LC-2-1 during July of 2015.
Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 2S49E25NW and 2S50E33NW, diurnal fluctuation of the water table and rise in ground water levels in the fall it is likely that subirrigation occurs along a portion of Lake Creek within the study area.

**North Fork Ash Creek**

**Evidence of Unconsolidated Deposits**

North Fork Ash Creek demonstrates unconsolidated deposits in drilling logs for 3 monitoring well drill logs in T3S R49E section 1 and T3S R50E section 9 at the confluence of the north and south fork (Map 3B). The monitoring well drill logs indicate well sorted silt and gravel 24 feet below ground surface in section 1, and well sorted silt, silty sands, and gravels up to 48 feet below ground surface at the confluence with South Fork Ash Creek. Water well or resource holes, without drill logs, indicate unconsolidated materials are not present in T3S R50E section 6, the middle section of the drainage area. This indicates a possible break in unconsolidated properties. The unconsolidated deposits are present across the study area east to west other than section 6.

There are two piezometer batteries with three drill logs each in the North Fork Ash Creek drainage. Piezometer battery NFAC 1-3 is in T3S R49E section 1 and battery NFAC2 1-3 is in T3S R50E section 8. The NFAC1 1-3 battery drill logs indicate sandy clay, silty clay and gravelly clay 6-16 feet below ground surface. The NFAC2 1-3 battery indicates unconsolidated silty clay with gravel lenses 14 feet below ground surface. There are geologic conditions present to support AVF determination in portions of North Fork Ash Creek.

**Hydrology**

The North Fork Ash Creek watershed covers 6 mi\(^2\) with 4.2 mi\(^2\) located within the Study Area. The North Fork Ash Creek watershed has a mean watershed slope of 8.6% and a channel slope of 0.73%, with a low sinuosity ratio of 1.20. The watershed contains 13.1 mi of channels within the Study Area.

There were four surface water monitoring sites on North Fork Ash Creek; NFASH-1-RES, the adjacent NFASH-1, NFASH-3, and NFASH-4. Water was present in June 2013, April 2014, and March 2015 at NFASH-1. Water was present during 9 of the 14 site visits at NFASH-1-RES, with dry conditions encountered August 2015 through June 2016. Water was present at NFASH-3 and NFASH-4 in March 2014.

One groundwater monitoring well, 3S49E01NW, and six piezometers were installed in the Study Area along the North Fork of Ash Creek. Well 3S49E01NW had depths to water ranging from 8.32 ft. in June 2014 to 15.51 ft. in April 2016.

**The Existence of Current or Historic Flood Irrigation**

An evaluation of North Fork Ash Creek water rights, performed by GNP, revealed evidence of current or historic flood irrigation. North Fork Ash Creek and its tributaries within the Study Area include 3 diversion dams with the potential to irrigate 88.5 acres. Water management structures are visible on 2016 aerial imagery along North Fork Ash Creek.
Capability to be Flood Irrigated
North Fork Ash Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
Six piezometers (NFAC-1-1, NFAC-1-2, NFAC-1-3, NFAC-2-1, NFAC-2-2, and NFAC-2-3) were installed, in groups of three wells, at two locations along North Fork Ash Creek. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. Hydrographs depicting continuous water level data are presented in Attachment C, Appendix A of the GNP Application for AVF Determination (Application N2013013).

Hydrographs from the NFAC-1 piezometer cluster of wells did not exhibit an increase in groundwater levels in the fall of 2015, although the rate of groundwater level decrease slowed considerably in the NFAC-1 cluster during October 2015. Diurnal fluctuations were present during July and August of 2015.

![Piezometer NFAC-1-1](image)

**Figure 3.** Diurnal fluctuations in NFAC-1-1 during July of 2015.

Hydrographs from the NFAC-2-2 and NFAC-2-3 wells exhibited a slight increase groundwater levels in the fall. Diurnal fluctuations were present during July and August of 2015 in the NFAC-2 well cluster. A confounding factor in the analysis of hydrographs from the NFAC-2 cluster of wells was a large increase in groundwater levels during a short period of time in mid-August. Groundwater level in NFAC-2-1
increased over 12 ft. in less than one hour during August of 2015. NFAC-2-2 and NFAC-2-3 also exhibited an increase in groundwater level during the same period, although it was not as drastic.

Figure 4. Diurnal fluctuations in NFAC-2-1 during July of 2015.

Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 3S49E01NW, diurnal fluctuation of the water table and rise in ground water levels in the fall it is likely that subirrigation occurs along a portion of North Fork Ash Creek within the study area.

South Fork Ash Creek

Evidence of Unconsolidated Deposits
South Fork Ash Creek demonstrates unconsolidated deposits in drilling logs for 3 monitoring well drill logs in T3S R50E sections 7 and 9 at the confluence of the north and south fork (Map 3B). The monitoring well drill logs indicate clay with sandstone fragments and gravel down to 24 feet below ground surface in section 7. With well sorted silt, silty sands, and gravels up to 48 feet below ground surface at the confluence with North Fork Ash Creek. Water well or resource holes, without drill logs, indicate South Fork Ash Creek has unconsolidated deposits throughout the southern reach east to west across most of the study area.

There are two piezometer batteries with three drill logs each in the South Fork Ash Creek drainage. Piezometer battery SFAC 1-3 is in T3S R49E section 11 and battery SFAC2 1-3 located in T3S R50E section 7. Both the SFAC1 1-3 and SFAC2 1-3 drill logs indicate sandy clays, silty clay and gravelly clay down to 16 feet below ground surface. There are geologic conditions present to support AVF determination in South Fork Ash Creek.
Hydrology
The South Fork Ash Creek watershed covers 8 mi² with 6.1 mi² located within the Study Area. The South Fork Ash Creek watershed has a mean watershed slope of 9.1% and a channel slope of 0.59%, with a moderate sinuosity ratio of 1.35. The watershed contains 23.9 mi of channels within the Study Area.

There were four surface water monitoring sites on South Fork Ash Creek; SFASH-1, SFASH-2, SFASH-3, and SFASH-4. Water was present during all 14 sampling events in 2013 through 2016 at SFASH-1 and SFASH-3. Water was present in April 2014 at SFASH-2 and in March 2014 at SFASH-4, with both locations dry during the other 13 site visits.

One groundwater monitoring well, 3S50E07SW, and six piezometers were installed along the South Fork of Ash Creek. Measured depth to water in well 3S50E07SW ranged from 8.36 ft. in June 2014 to 11.45 ft. bgs in September 2013.

The Existence of Current or Historic Flood Irrigation
An evaluation of South Fork Ash Creek water rights, performed by GNP, revealed evidence of current and historic flood irrigation. Flood irrigation is permitted for 75 acres within the watershed, according to active water rights. Water management structures are visible on 2016 aerial imagery along South Fork Ash Creek.

Capability to be Flood Irrigated
South Fork Ash Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
Six piezometers (SFAC-1-1, SFAC-1-2, SFAC-1-3, SFAC-2-1, SFAC-2-2, and SFAC-2-3) were installed, in two groups of three wells, at locations along South Fork Ash Creek. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. Hydrographs depicting continuous water level data are presented in Attachment C, Appendix A of the GNP Application for AVF Determination (Application N2013013).

Hydrographs from the SFAC-1 piezometer cluster of wells exhibited a slight increase in groundwater levels in the fall of 2015. Diurnal fluctuations were present during July and August of 2015.
No hydrographs were available for the SFAC-2 wells because they were reported as dry.

It is likely that subirrigation occurs along a portion of South Fork Ash Creek based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 3S49E01NW, diurnal fluctuation of the water table and rise in ground water levels in the fall.

**Ash Creek**

**Evidence of Unconsolidated Deposits**

Ash Creek from the confluence of its north and south forks demonstrates unconsolidated deposits in drilling logs for 4 monitoring well drill logs in T3S R50E section 9 (Map 3B). The monitoring well drill logs indicate presence of sorted silt, silty sands, and gravels up to 48 feet below ground surface at the north and south fork confluence. Pilot holes in tributaries downstream of the confluence indicate well sorted silt, very fine sands, and gravels at least 25 feet below ground surface.

There is one additional piezometer battery with three drill logs in Main Fork Ash Creek drainage. Piezometer battery AC 1-3 is in T3S R50E section 15. Battery AC1 1-3 drill logs indicate silty clays, silty sand and gravelly clay down to 16 feet below ground surface. Ash creek from its confluence of the north and south forks to Mizpah Creek contains geologic conditions to support AVF determination.

**Hydrology**

Ash Creek is formed below the confluence of North Fork Ash Creek and South Fork Ash Creek. The Ash Creek watershed covers 19.7 mi² with 12.5 mi² located within the Study Area. The Ash Creek watershed
has a mean watershed slope of 9.1% and a channel slope of 0.39%, with a moderate sinuosity ratio of 1.52. The watershed contains 43.8 mi of channels within the Study Area.

There is one surface water monitoring site on Ash Creek, ASH-4. Water was present at ASH-4 in March 2014. The location was dry during the other site visits.

Two groundwater monitoring wells, 3S50E09SW and 3S50E09SW2, and 3 piezometers were installed along Ash Creek below the confluence of the North Fork and South Fork. Depth to groundwater is similar in 3S50E09SW and 3S50E09SW2 ranging from 25.60 ft. in June 2013 to 28.67 ft. in June 2016.

Two borings were completed along tributaries to Ash Creek, at 3S50E09NW and 3S50E09SE. Groundwater was not encountered above the bedrock at 3S50E09NW. At 3S50E09SE, groundwater was encountered at 68 ft. in unconsolidated material, and a well was installed. The measured depth to water was more than 65 ft. in all subsequent sampling events.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of Ash Creek water rights, performed by GNP, revealed evidence of current or historic flood irrigation. Below the confluence of North Fork Ash Creek and South Fork Ash Creek, there are 2 dikes and 1 diversion dam within the Study Area with permitted irrigation on 110 acres. Water management structures are visible on 2016 aerial imagery along Ash Creek.

**Capability to be Flood Irrigated**
Ash Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**
Three piezometers (AC-1-1, AC-1-2, and AC-1-3) were installed, in a group of three wells, along Ash Creek near the eastern study area boundary. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. No hydrographs were available for the Ash Creek piezometer wells because they were reported as dry.

Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 3S50E09SW and 3S50E09SW2, it is likely that subirrigation does not occur along Ash Creek within the study area.

**Y T Creek**

**Evidence of Unconsolidated Deposits**
Y T Creek demonstrates unconsolidated deposits in a drill log for 1 monitoring well drill log in T3S R50E sections 19 (Map 3B). This monitoring well drill log’s materials are silt mixed with very fine gravel, above gravel and sand followed by a clay layer down to 65 feet below ground surface. There are 16 water wells or resource holes, without drill logs, indicating unconsolidated materials. In these wells unconsolidated
materials are reported up to 55 feet below ground surface near the stream channel. These 16 additional holes show unconsolidated materials might be approximately 2,300 feet outside the main channel with a depth of 20 feet below ground surface. The deposits are mapped three quarters of the way across the study area east to west.

There is one piezometer battery with three drill logs in the Y T Creek drainage. Piezometer battery YT1-1-3 is in T3S R50E section 19. The YT1 1-3 battery of drill logs indicate silty loam, silty clay, silty sand and some fine gravel at least 14 feet below ground surface. There are geologic conditions present to support AVF determination in Y T Creek.

**Hydrology**

The Y T Creek watershed covers 6.9 mi² with 5.0 mi² located within the Study Area. The Y T Creek watershed has a mean watershed slope of 8.8% and a channel slope of 0.80%, with a moderate sinuosity ratio of 1.30. The watershed contains 17.6 mi of channels within the Study Area.

There are three surface water monitoring sites on Y T Creek; YTC-1, YTC-2, and YTC-4. Water was present in October 2013 and in April 2014 at YTC-1. Water was present during all site visits in 2013 and 2014 at YTC-2, with water present at YTC-4 in April 2014. No site visits were conducted at YTC-1, YTC-2, or YTC-4 in 2015 or 2016.

One groundwater monitoring well, 3S50E19SE, and three piezometers were installed on Y T Creek. Measured depth to water in 3S50E19SE ranged from 17.22 ft. in June 2013 to 20.14 ft. in September 2013.

**The Existence of Current or Historic Flood Irrigation**

An evaluation of Y T Creek water rights, performed by GNP, revealed evidence of flood irrigation. Y T Creek and its tributaries have three permitted dams, one ditch, and three spreader dikes, with the potential to impound 183.15 ac-ft of water and irrigate 104.6 acres within the Study Area. Stock use is designated for two of the three dams, with the third dam permitted for stock and irrigation. The ditch and three dikes are permitted for irrigation. Water management structures are visible on 2016 aerial imagery along Y T Creek.

**Capability to be Flood Irrigated**

Y T Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**

Three piezometers (YTC-1-1, YTC-1-2, and YTC-1-3) were installed, in a group of three wells, along Y T Creek near the eastern study area boundary. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be
evaluated. No hydrographs were available for the Y T Creek piezometer wells because they were reported as dry.

Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 3S50E19SE, it is likely that subirrigation does not occur along Y T Creek within the study area.

Second Creek

Evidence of Unconsolidated Deposits
Second Creek demonstrates unconsolidated deposits in 2 monitoring well drill logs in T3S R49E section 23 and T3S R50E section 29 (Map 3B). The monitoring well drill log in T3S R49E section 23 shows silt, sand and clay layering to 28 feet below ground surface and the drill log in T3S R50E section 29 has silt and clay layers over alternating gravel and clay to 30 feet below ground surface. There are 14 water wells or resource holes, without drill logs, showing unconsolidated deposits. The deposits are in the clayey and silty categories near the surface with fine sands and gravel strata present deeper in profiles extending east to west across the study area.

There is one piezometer battery with three drill logs in the Second Creek drainage. Piezometer battery SC1 1-3 is in T3S R50E section 30. The SC1 1-3 battery of drill logs indicate silty loam, clay, mixed gravelly clay and gravel up to 16 feet below ground surface. There are geologic conditions present to support AVF determination in Second Creek.

Hydrology
The Second Creek watershed covers 8.6 mi² with 5.5 mi² located within the Study Area. The Second Creek watershed has a mean watershed slope of 7.2% and a channel slope of 0.41%, with a moderate sinuosity ratio of 1.49. The watershed contains 17.6 mi of channels within the Study Area.

There are four surface water monitoring sites on Second Creek; SEC-1, SEC-2-RES, SEC-3, and SEC-4. Water was present in early March 2014 at SEC-1, SEC-3, and SEC-4. Water was present during all site visits in 2013 and 2014 at SEC-2-RES. No site visits were conducted at SEC-1 or SEC-2-RES in 2015 or 2016.

Two groundwater monitoring wells were installed along Second Creek. The upstream well, 3S49E23NW, was completed with the screen near the base of the alluvium, at 40 to 50 ft. Depth to water ranged from 27.74 ft. in March 2014 to 35.77 ft. in September 2013. Depth to groundwater in the downstream well, 3S50E29SW, ranged from 9.60 ft. in March 2014 to 14.94 ft. in March 2015. Three piezometers were installed above 3S50E29SW along Second Creek.

The Existence of Current or Historic Flood Irrigation
An evaluation of Second Creek water rights, performed by GNP, revealed evidence of current or historic flood irrigation. Second Creek watershed has 16 dams, 1 diversion dam, 1 pit, and 1 spring. Permitted water rights have the potential to impound 241.1 ac-ft of water. Water right documents identify 196.3 acres of permitted irrigated lands. Seven dams are designated as supporting stock watering. Water management structures are visible on 2016 aerial imagery along Second Creek.
**Capability to be Flood Irrigated**

Second Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**

Three piezometers (SC-1-1, SC-1-2, and SC-1-3) were installed, in a group of three wells, along Second Creek above well 3S50E29SW. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. Hydrographs depicting continuous water level data are presented in Attachment C, Appendix A of the GNP Application for AVF Determination (Application N2013013).

Hydrographs from the SC-1 piezometer cluster of wells exhibited a slight increase in groundwater levels in the fall of 2015. Diurnal fluctuations were present during July and August of 2015.

![Piezometer SC-1-1](image.png)

**Figure 6.** Diurnal fluctuations in SC-1-1 during July of 2015.

Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 3S49E23NW and 3S50E29SW, diurnal fluctuation of the water table and rise in ground water levels in the fall it is likely that subirrigation occurs along a portion of Second Creek within the study area.
Middle Creek

Evidence of Unconsolidated Deposits
Middle Creek contains one monitoring well drill log in T4S R49E Section 1 indicating well sorted fine silt and sands from 3 to 17 feet (Map 3B). This layer overlays a mixed layer of silty gravel with fine clays and rock fragments. There are 3 other water well or resource holes, without drill logs, that do not have alluvial lithology. Two of these sites are adjacent the monitoring well drill log in section 1. Middle Creek geologic data is not conclusive; however, available data supports limited AVF determination in its lower reach.

Hydrology
The Middle Creek watershed covers 2.5 mi² with 2.4 mi² located within the Study Area. The Middle Creek watershed has a mean watershed slope of 5.2% and a channel slope of 1.01%, with a low sinuosity ratio of 1.14. The watershed contains 7.8 mi of channels within the Study Area.

There are two surface water monitoring sites on Middle Creek; MID-4-RES and MID-4. Water was present during 8 of the 14 site visits at MID-4, and during every site visit except the October 2015 site visit at MID-4-RES.

One groundwater well, 4S49E01NE, was installed along Middle Creek. Depth to groundwater ranged from 6.76 ft. in June 2014 to 10.38 ft. bgs in December 2013.

The Existence of Current or Historic Flood Irrigation
An evaluation of Middle Creek water rights, performed by GNP, revealed evidence of flood irrigation. Middle Creek has 4 dams with the potential to impound 69.8 ac-ft of water and irrigate 79 acres.

Capability to be Flood Irrigated
Middle Creek is an ephemeral to intermittent stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
The existence of subirrigation along Middle Creek is difficult to determine because of the lack of data. No continuous water level loggers were installed near Middle Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in 4S49E01NE it is likely that subirrigation occurs along Middle Creek within the study area.

Leslie Creek

Evidence of Unconsolidated Deposits
Leslie Creek demonstrates unconsolidated deposits in one monitoring well drill log in T4S R49E section 1 with well sorted silt to 30 feet below ground surface (Map 3C). There are 5 water wells or resource
holes, without drill logs, indicating unconsolidated deposits. Deposits only extend about halfway to the west from Mizpah Creek across the study area. Two adjacent drill logs in T3S R49E Section 35 show different results. One indicates alluvial deposits the other indicates alluvial deposits are not present. The drill logs for these borings are not available to determine what is present.

There is one piezometer battery with three drill logs in the Leslie Creek drainage. Piezometer battery LEC1 1-3 is in T4S R49E section 1. The LE1 1-3 battery of drill logs indicate silty clay, clayey loam, sandy clay, and sand 14 feet below ground surface. There are geologic conditions present to support AVF determination in the eastern portion of Leslie Creek.

**Hydrology**

The Leslie Creek watershed covers 4.9 mi² with 3.4 mi² located within the Study Area. The Leslie Creek watershed has a mean watershed slope of 5.9% and a channel slope of 0.56%, with a moderate sinuosity ratio of 1.33. The watershed contains 15.7 mi of channels within the Study Area.

There are two surface water monitoring sites on Leslie Creek; LES-1 and LES-4. Water was never observed during site visits at LES-1. Water was present during all 14 site visits at LES-4.

One groundwater monitoring well, 4S49E01NW, was installed along Leslie Creek. Depth to water ranged from 9.23ft in March 2014 to 11.17ft bgs in June 2016. Three Piezometers were also installed along Leslie Creek downstream of 4S49E01NW.

**The Existence of Current or Historic Flood Irrigation**

An evaluation of Leslie Creek water rights, performed by GNP, revealed evidence of flood irrigation. Leslie Creek and its tributaries include two dams, one diversion dam, and eight dikes, with the potential to impound 235.85 ac-ft. of water and irrigate 226.9 acres. Water management structures are visible on 2016 aerial imagery along Leslie Creek.

**Capability to be Flood Irrigated**

Leslie Creek is an intermittent to ephemeral stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**

Three piezometers (LESC-1-1, LESC-1-2, and LESC-1-3) were installed along Leslie Creek below well 4S49E01NW. The piezometers were fitted with continuous water level loggers so diurnal fluctuation of the water table and rise in ground water levels in the fall could be evaluated. Hydrographs depicting continuous water level data are presented in Attachment C, Appendix A of the GNP Application for AVF Determination (Application N2013013).

Hydrographs from the LESC-1 piezometer cluster of wells exhibited a slight increase in groundwater levels in the fall of 2015. Diurnal fluctuations were present during July and August of 2015.
Figure 7. Diurnal fluctuations in LESC-1-1 during July of 2015.

Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, depth to water in 4S49E01NW, diurnal fluctuation of the water table and rise in ground water levels in the fall it is likely that subirrigation occurs along a portion of Leslie Creek within the Study Area.

Third Creek

Evidence of Unconsolidated Deposits
Third Creek demonstrates unconsolidated deposits in two monitoring well drill logs in T4S R49E section 3 with silt, sand, silty clay, and gravel to 20 feet below ground surface (Map 3C). There are 4 water wells or resource holes, without drill logs, indicating unconsolidated deposits. The deposits were reported up to 38 feet below ground surface consisting of silt, sand, and gravels. Drill logs from the pilot holes only indicate the eastern half of Third Creek containing unconsolidated deposits. There are geologic data supporting AVF determination in the eastern portion of Third Creek.

Hydrology
The Third Creek watershed covers 4.2 mi² with 3.3 mi² located within the Study Area. The Third Creek watershed has a mean watershed slope of 6.3% and a channel slope of 0.73%, with a moderate sinuosity ratio of 1.31. The watershed contains 16.8 mi of channels within the Study Area.

There are five surface water monitoring sites on Third Creek; THRD-1-RES, THRD-1, THRD-2, THRD-3, and THRD-4. Water was present during all site visits in 2013 and 2014 at THRD-1-RES and THRD-2. No site visits were conducted at any of the five surface water monitoring sites on Third Creek in 2015 or 2016.
Two borings were completed along Third Creek for the purpose of installing a monitoring well. The first, 4S49E03NE, was dry. The second boring, 4S49E03NE2, was completed 30 ft. closer to Third Creek and water was encountered. Measured depth to water in well 4S49E03NE2 ranged from 15.54 ft. in June 2014 to 20.14 ft. in June 2013.

The Existence of Current or Historic Flood Irrigation
An evaluation of Third Creek water rights, performed by GNP, did not reveal evidence of current or historic flood irrigation. Third Creek and a tributary have 8 stock dams capable of impounding 42.4 ac-ft. of water.

Capability to be Flood Irrigated
Third Creek is an ephemeral to intermittent stream. There are limited locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. No active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The aspects described above indicate that the Third Creek watershed, within the study area, does not have capability to be flood irrigated.

The Existence of Subirrigation
The existence of subirrigation along Third Creek is difficult to determine due to the lack of data. No continuous water level loggers were installed near Third Creek, so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in well 4S49E03NE2, subirrigation is not expected to occur along Third Creek within the Study Area.

Road Creek

Evidence of Unconsolidated Deposits
Road Creek demonstrates unconsolidated deposits in one monitoring well drill log in T4S R49E section 11 with well sorted silt to 22 feet below ground surface (Map 3C). There are two water wells or resource holes, without drill logs, situated near the stream channel that indicate unconsolidated materials. These well drill logs could extend unconsolidated deposits east to west across the study area in a narrow band. Geologic data in Road Creek supports AVF determination.

Hydrology
The Road Creek watershed covers 4.1 mi² with 2.5 mi² located within the Study Area. The Road Creek watershed has a mean watershed slope of 4.9% and a channel slope of 0.47%, with a moderate sinuosity ratio of 1.47. The watershed contains 9.8 mi of channels within the Study Area.

There are three surface water monitoring sites on Road Creek; RDC-1, RDC-3 (UTRDC-4), and RDC-4. RDC-1 was dry during all site visits in 2013 and 2014. No site visits were conducted at RDC-1 in 2015 or 2016. Water was present in March 2014 at RDC-3 (UTRDC-4), with the location dry during the other 13 site visits from 2013 through 2016. Flow at RDC-3 (UTRDC-4) in March 2014 was 0.348 cfs.
Groundwater monitoring well 4S49E11SW is located in the Road Creek valley. Depth to water in the well ranged from 5.98 ft. in March 2014 to 7.92 ft. in September 2013.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of Road Creek water rights, performed by GNP, revealed evidence of flood irrigation. Road Creek and its tributaries include seven dams and two dikes with the potential of impounding 60.0 ac-ft. and irrigating 66.1 permitted acres. Six dams are permitted for stock watering. Water management structures are visible on 2016 aerial imagery along Road Creek.

**Capability to be Flood Irrigated**
Road Creek is an ephemeral to intermittent stream. There are several locations, within the Study Area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**
The existence of subirrigation along Road Creek is difficult to determine due to the lack of data. No continuous water level loggers were installed near Road Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in well 4S49E11SW it is likely that subirrigation occurs along a portion of Road Creek within the Study Area.

**Wiser Creek**

**Evidence of Unconsolidated Deposits**
Wiser Creek demonstrates unconsolidated deposits in one monitoring well drill log in T4S R49E section 9 with well sorted silt to 15 feet below ground surface (Map 3C). There are 8 water well or resource holes, without drill logs, identifying unconsolidated materials. The data is situated around the stream channel throughout the study area. Geologic data is present to support a narrow AVF determination in Wiser Creek.

**Hydrology**
The Wiser Creek watershed covers 2.6 mi² with 1.9 mi² located within the Study Area. The Wiser Creek watershed has a mean watershed slope of 6.7% and a channel slope of 1.05%, with a low sinuosity ratio of 1.21. The watershed contains 10.9 mi of channels within the Study Area.

There is one surface water monitoring site on Wiser Creek; WC-1. There was water at WC-1 during the June 2013, July 2013, and March 2014 site visits. No site visits were conducted at this location in 2015 or 2016.

One groundwater monitoring well, 4S49E09SE, was installed along Wiser Creek west of the confluence with Two Tree Creek. Depth to water in the well ranged from 21.85 ft. in March 2014 to 26.26 ft. in December 2013.
The Existence of Current or Historic Flood Irrigation
An evaluation of Wiser Creek water rights, performed by GNP, revealed evidence of flood irrigation. Wiser Creek and a tributary have 4 dams and 1 dike, with the potential for impounding 42.96 ac-ft. of water and irrigating 6.5 acres.

Capability to be Flood Irrigated
Wiser Creek is an ephemeral to intermittent stream. Some locations, within the study area, are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
The existence of subirrigation along Wiser Creek is difficult to determine due to the lack of data. No continuous water level loggers were installed near Wiser Creek so diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in well 4S49E09SE it is likely that subirrigation does not occur along Wiser Creek within the study area.

Two Tree Creek

Evidence of Unconsolidated Deposits
Two Tree Creek has two water wells or resource holes, without drill logs, indicating unconsolidated materials (Map 3C). Materials are reported as clay, sandy clay, sand and gravels up to 27 feet below ground surface. Geologic materials support limited AVF determination for Two Tree Creek.

Hydrology
The Two Tree Creek watershed covers 27.6 mi² with 7.1 mi² located within the Study Area. The Two Tree Creek watershed has a mean watershed slope of 5.2% and a channel slope of 0.44%, with a moderate sinuosity ratio of 1.57. The watershed contains 36.1 mi of channels within the Study Area.

There are two monitoring sites on Two Tree Creek; TWTRC-4 (WC-4) and TWTRC-4-RES. Water was present twice at TWTRC-4 (WC-4), once in May 2013 and again in March 2014. Water was observed during every visit in 2013 and 2014 at TWTRC-4-RES. No site visits were conducted at either location on Two Tree Creek in 2015 or 2016.

No groundwater monitoring wells were installed along Two Tree Creek.

The Existence of Current or Historic Flood Irrigation
An evaluation of water rights on Two Tree Creek, performed by GNP, revealed evidence of flood irrigation. Two Tree Creek has 1 dam and 7 dikes, with the capability to impound 186.5 ac-ft. of water within the Study Area. Irrigation is permitted on 152.2 acres. Water management structures are visible on 2016 aerial imagery along Two Tree Creek.
**Capability to be Flood Irrigated**
Two Tree Creek is an ephemeral to intermittent stream. There are locations, within the study area, that are relatively flat and close to the channel elevation. There may be limited water available as flow is low and not consistent along the length of the stream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

**The Existence of Subirrigation**
Due to the absence of groundwater data in the Two Tree Creek drainage, a robust evaluation of subirrigation along Two Tree Creek could not be completed.

**Mizpah Creek**

**Evidence of Unconsolidated Deposits**
Mizpah Creek is the receiving watershed for the drainages mentioned above. There is only one water well, without a drill log, indicating 40 feet of clay, sand, and gravel for the extent of Mizpah Creek in the study area in T4S R50E Section 12 (Map 3C). The extent of Mizpah Creek crossing the study area is small compared to its overall drainage basin. However, as the receiving stream for all the above drainages there should be extensive unconsolidated deposits. Mizpah creek being the major drainage for this drainage basin is on the receiving end of water and sediment from all other drainages in the study area. Through its geographic position, geologic conditions in Mizpah Creek would be an anomaly if unconsolidated deposits were not present to support AVF status.

**Hydrology**
Mizpah Creek is a perennial to intermittent stream with a watershed area of 803 mi². Only a small section of Mizpah Creek, approximately six stream miles, flows through the southeast corner of the study area. All drainages within the study area lie in the Mizpah Creek watershed.

No regular flow data was collected on Mizpah Creek by GNP. The USGS performed monthly stream flow measurements on Mizpah Creek, near Olive MT, from late 1975 to mid-1979. While some flow was measured during each month of the year throughout the monitoring period, the creek consistently flowed from late winter through mid-summer. Based on USGS stream flow measurement from late 1975 to mid-1979, the upper portion of Mizpah Creek may be characterized as flowing intermittently. Three surface water sampling locations, MIZ-1, MIZ-2, and MIZ-3 were located along the creek. Surface water data indicate the peak flow, observed at MIZ-1 during March of 2014, was 5.9 cfs.

Groundwater monitoring wells were not installed adjacent to Mizpah Creek as part of GNP’s AVF study.

**The Existence of Current or Historic Flood Irrigation**
An evaluation of water rights on Mizpah Creek, performed by GNP, revealed evidence flood irrigation. Water rights for 4 dams, 2 diversion dams, and 5 dikes permitted at a volume of 248.75 ac-ft. of water with the ability to irrigate 284.5 acres were located in the study area. Water management structures are visible on 2016 aerial imagery along Mizpah Creek.
Capability to be Flood Irrigated
Mizpah Creek is an intermittent to perennial stream. There are several locations, within the study area, that are relatively flat and close to the channel elevation. This is typical throughout much of the length of Mizpah Creek which is evidenced by irrigation structures and flood irrigation downstream of the study area. There may be limited water available as flow is not consistent and water rights exist upstream. However, active water rights exist over soils classified as prime farmland if irrigated or farmland of statewide importance. The capability of this area to be flood irrigated is limited to those areas.

The Existence of Subirrigation
The existence of subirrigation along Mizpah Creek is difficult to determine due to the lack of data. No groundwater wells were installed near Mizpah Creek in the study area so depth to water, diurnal fluctuation of the water table and rise in ground water levels in the fall could not be evaluated. Based on ground surface elevation, estimates of capillary fringe thickness, rooting depth, and groundwater elevation in the nearest well, 4S49E11SW located adjacent to Road Creek, it is likely that subirrigation occurs in the vicinity of Mizpah Creek.

Unnamed Tributaries
There are many unnamed drainages located within the study area. These drainages can be identified as narrow branched valleys on Maps 1 and 4. In all cases they meet criteria for upland tributaries in that they are highland erosional channels outside the terrace structure of the AVF streams they flow to and do not contain streamlaid deposits. Another distinction of these drainages is the lack of agricultural activity or farming. These drainages are all considered Upland.

Presence or Absence Conclusion
An AVF is defined by having unconsolidated streamlaid deposits which are either flood irrigated or subirrigated. As described above, there is evidence within the study area of the presence of AVFs. Unconsolidated deposits are present in and found adjacent to active channels of the creeks discussed. The unconsolidated deposits depict one half of the AVF potential, while the flood irrigation or subirrigation depicts the other half. Each creek has varying aspects of this flood irrigation and subirrigation.

The information above confirms that AVF’s are present in the Study Area. Lost Soldier Creek, Double Corral Creek, Johnson Creek, Lake Creek, North Fork Ash Creek, South Fork Ash Creek, Ash Creek, Y T Creek, Second Creek, Middle Creek, Leslie Creek, Third Creek, Road Creek, Wiser Creek, Two Tree Creek, and Mizpah Creek have unconsolidated deposits and either flood irrigation or subirrigation. The presence and extent of AVFs in the study area is depicted on Map 4, AVF Extent.

The following table depicts which valleys have the indicators of an Alluvial Valley Floor and the approximate location of the AVF.
<table>
<thead>
<tr>
<th>Drainage</th>
<th>Unconsolidated Deposits</th>
<th>Flood Irrigated or Capability to be Flood Irrigated</th>
<th>Subirrigated</th>
<th>Alluvial Valley Floor</th>
<th>Approximate Location of AVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost Soldier Creek</td>
<td>X</td>
<td>X</td>
<td>X*</td>
<td>Yes</td>
<td>T2SR50E S8, S9, and S10.</td>
</tr>
<tr>
<td>Double Corral Creek</td>
<td>X</td>
<td>X</td>
<td>X*</td>
<td>Yes</td>
<td>T2SR50E S16, S17, and S21.</td>
</tr>
<tr>
<td>Johnson Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Lake Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T52R49E S25; T2SR50E S30, S29, S32, and S33; T3550E S4.</td>
</tr>
<tr>
<td>North Fork Ash Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T3SR49E S1; T3SR50E S6 and S8.</td>
</tr>
<tr>
<td>South Fork Ash Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T3SR49E S11 and S12; T3SR50E S7, S16, and S17.</td>
</tr>
<tr>
<td>Ash Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T3SR50E S16.</td>
</tr>
<tr>
<td>Y T Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T3SR50E S29.</td>
</tr>
<tr>
<td>Second Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T3SR49E S24 and S25; T3SR50E S30 and S32.</td>
</tr>
<tr>
<td>Middle Creek</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>Yes</td>
<td>T3SR49E S36; T4SR49E S1; T4SR50E S6.</td>
</tr>
<tr>
<td>Leslie Creek</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>Yes</td>
<td>T3SR49E S35; T4R49E S1, S2, and S12.</td>
</tr>
<tr>
<td>Third Creek</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>Yes</td>
<td>T4R49E S12.</td>
</tr>
<tr>
<td>Road Creek</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>Yes</td>
<td>T4SR49E S4, S10, and S11.</td>
</tr>
<tr>
<td>Wiser Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T4SR49E S9, S10, S11, and S15.</td>
</tr>
<tr>
<td>Two Tree Creek</td>
<td>X</td>
<td></td>
<td></td>
<td>Yes</td>
<td>T4SR49E S15.</td>
</tr>
<tr>
<td>Mizpah Creek</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>Yes</td>
<td>T4SR49E S12; T4SR50E S5 and S7.</td>
</tr>
</tbody>
</table>

* Indicates that subirrigation is likely but definitive evidence is not available.

Table 1. Summary of AVF characteristics by drainage.
II. Statutory Exclusions and Significance

If statutory exclusions apply, an AVF is deemed insignificant, and the operator is not required to provide information explaining whether the operation will avoid interrupting, discontinuing, or precluding farming on the AVF and whether the operation will cause material damage to the quality and quantity of water supplying the AVF.

ARM 17.24.325(3)(a)(ii)(A–C) define the statutory exclusions for significance. They are included below:

(A) the premining land type is undeveloped rangeland that is not significant to farming;
(B) any farming on the alluvial valley floor that would be affected by the coal mining operation is of such small acreage as to be of negligible impact on the farm's agricultural production. Negligible impact of the proposed operation on farming is based on the relative importance of the affected vegetation and water of the developed grazed or hayed alluvial valley floor area to the farm's production over the life of the mine; or
(C) the circumstances set forth in ARM 17.24.802(3) exist (pertaining to AVF’s contained in a reclamation plan approved prior to August 3, 1977).

Landowner/Ranch operator Interviews

Rule 17.24.805 states, “In making the determination of “significance”, the department shall consult with the affected Landowner(s).” Ranch operator interviews were conducted in September and October of 2018 to satisfy this rule’s requirement. During the interviews, DEQ explained the AVF delineation process, and then discussed how the potential AVF fit in with each rancher’s operation. Appendix A includes a synopsis of each interview completed with each ranch operator. The interviews do not have decisions addressing AVF status; however, the ranch operator is asked about their use of subirrigated acres and if they are critical to operations. The responses are summarized in Table 2 below.

Significance Conclusion

Pursuant to ARM 17.24.325(3)(a)(ii)(A–C), DEQ utilized existing scientific data and surface operator information to determine whether any statutory exclusions were applicable to the significance determination for the study area. Under exclusion (A), if the premining land type is undeveloped rangeland that is not significant to farming, the AVF is considered insignificant. Under exclusion (B), if agricultural acreage is impacted but the acreage is negligible to the farm or ranch operation, the AVF is considered insignificant.
<table>
<thead>
<tr>
<th>Drainage</th>
<th>Significant AVF</th>
<th>Rationale from Ranch Operator</th>
<th>Approximate Location of AVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost Soldier Creek</td>
<td>No</td>
<td>Not significant based on information provided by the ranch operator (R. Leatherberry).</td>
<td>T2SR50E S8, S9, and S10.</td>
</tr>
<tr>
<td>Double Corral Creek</td>
<td>Yes/No</td>
<td>Not significant in section 17 based on information provided by the ranch operator (R. Leatherberry). Significant in Sections 16 and 21 based on information provided by the ranch operator (B. Emmons).</td>
<td>T2SR50E S16, S17, and S21.</td>
</tr>
<tr>
<td>Lake Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (B. Williams and T. Smith).</td>
<td>T52R49E S25; T2SR50E S30, S29, S32, and S33; T3SR50E S4.</td>
</tr>
<tr>
<td>North Fork Ash Creek</td>
<td>Yes</td>
<td>May be significant, depending on yearly precipitation, based on information provided by the ranch operator (E. Gotfredson)</td>
<td>T3SR49E S1; T3SR50E S6 and S8.</td>
</tr>
<tr>
<td>South Fork Ash Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (J. and R. Gnerer).</td>
<td>T3SR49E S11 and S12; T3SR50E S7, S16, and S17.</td>
</tr>
<tr>
<td>Ash Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (J. and R. Gnerer).</td>
<td>T3SR50E S16.</td>
</tr>
<tr>
<td>Y T Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (T. Smith).</td>
<td>T3SR50E S29.</td>
</tr>
<tr>
<td>Second Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (R. Jesse).</td>
<td>T3SR49E S24 and S25; T3SR50E S30 and S32.</td>
</tr>
<tr>
<td>Middle Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (G. Archer).</td>
<td>T3SR49E S36; T4SR49E S1; T4SR50E S6.</td>
</tr>
<tr>
<td>Leslie Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (G. Archer, A. Mader, and E. Mader).</td>
<td>T3SR49E S35; T4SR49E S1, S2, and S12.</td>
</tr>
<tr>
<td>Third Creek</td>
<td>No</td>
<td>Not significant based on information provided by the ranch operator (B. Aye).</td>
<td>T4SR49E S12.</td>
</tr>
<tr>
<td>Road Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (A. Mader, and E. Mader).</td>
<td>T4SR49E S4, S10, and S11.</td>
</tr>
<tr>
<td>Wiser Creek</td>
<td>Yes</td>
<td>Significant based on information provided by the ranch operator (A. Mader, and E. Mader).</td>
<td>T4SR49E S9, S10, S11, and S15.</td>
</tr>
<tr>
<td>Two Tree Creek</td>
<td>No</td>
<td>Not significant based on information provided by the ranch operator (B. Aye and D. Gali).</td>
<td>T4SR49E S15.</td>
</tr>
<tr>
<td>Mizpah Creek</td>
<td>Yes</td>
<td>Significant based on information provided by ranch operators.</td>
<td>T4SR49E S12; T4SR50E S5 and S7.</td>
</tr>
</tbody>
</table>

Table 2. Summary of AVF significance to individual ranch operations by drainage.
III. **Summary**

In the study area, Lost Soldier Creek, Double Corral Creek, Johnson Creek, Lake Creek, North Fork Ash Creek, South Fork Ash Creek, Ash Creek, Y T Creek, Second Creek, Middle Creek, Leslie Creek, Third Creek, Road Creek, Wiser Creek, Two Tree Creek, and Mizpah Creek, have been evaluated for the presence of an AVF. Drainages demonstrating AVF characteristics are depicted on Map 4 and summarized in Table 1. Significance of areas identified as AVF to ranching operations is summarized in Table 2. Drainages demonstrating AVF characteristics, where statutory exclusions do not apply, require additional analysis to evaluate hydrologic function prior to any planned disturbance.

Pursuant to ARM 17.24.325(3)(a)(ii) (A–C), DEQ utilized existing scientific data and surface operator information to determine whether any statutory exclusions were applicable to the significance determination for each of these creeks. Under exclusion (A), an area cannot be deemed significant if the area is undeveloped rangeland. Under exclusion (B), if agricultural acreage is impacted but the acreage is negligible to the farm or ranch operation, the AVF is considered insignificant. If statutory exclusions exist, the applicant is not obligated to “submit the information required in ARM 17.24.325(3)(c)(ii)(B) and (C), and the department is not required to make the findings of ARM 17.24.325(3)(f)(ii)(A) and (B)” as stated in ARM 17.24.325(3)(a)(ii). Areas identified in Table 2 as not significant AVFs fall under exclusion B.

An AVF determination consists of three separate evaluations. The first evaluation determines the presence and extent or absence of AVFs based on criteria defined in ARM 17.24.325(2). The second evaluation determines the significance of the AVF for adversely affected agricultural or farming operations, ARM 17.24.805. The third evaluation determines the essential hydrologic functions of each AVF, ARM 17.24.325 (3)(c)(i)(ii) and (e). Determination of presence and extent or absence and significance of AVFs based on criteria defined in ARM 17.24.325(2), has been completed. A mine plan and application for a surface mining permit would initiate a hydrologic function evaluation for creeks affected by the mine plan.
Appendix A

Landowner/Ranch operator Interviews

ARM 17.24.805 states, “[i]n making the determination of “significance”, the department shall consult with the affected landowner(s).” In September of 2018, DEQ conducted in person Interviews with each of the ranch owners or operators with property containing an identified AVF within the study area. If ranch owners or operators were not available for an in person interview they were contacted by phone. The ranch owner or operator interviews were designed to determine the utility of the AVF and its “significance” to their operation. The statements made by the operator are to inform the AVF decision process. Therefore, the synopsis of interviews in this Appendix A may not contain conclusive statements about an AVF. Conclusion to the ranch operator interviews are included in table 2 of the AVF document.

The creeks with AVF extents include: Lost Soldier Creek, Double Corral Creek, Lake Creek, North Fork Ash Creek, South Fork Ash Creek, Ash Creek, Y T Creek, Second Creek, Middle Creek, Leslie Creek, Third Creek, Road Creek, Wiser Creek, Two Tree Creek, and Mizpah Creek. There were unconsolidated deposits and either flood or subirrigation identified on all 15 of these drainages. The presence and extent of AVFs is depicted on Map 4, AVF Extent.

Michael and Marjorie Riley (Lost Soldier Creek)
Michael and Marjorie Riley own 20 acres with approximately 2.5 acres along the Lost Soldier Creek AVF extent. Mr. Riley indicated that they do not farm, ranch, or lease these acres. Michael was contacted via phone and indicated these acres were not critical.

Raymond and Robin Leatherberry (Lost Soldier Creek, Double Corral Creek)
Mr. Leatherberry indicated he conducts farming and ranching on approximately 4,500 acres. The entire 4,500 acres are stocked with 120 head of cattle. Of the 4,500 acres, 3,700 acres are uplands (grazing only) and 800 acres are utilized for wheat and alfalfa hay production. Wheat and alfalfa are rotated using a long duration rotation schedule utilizing dryland farming methods. Mr. Leatherberry indicated that even though there may be AVF extents on the property, water is used opportunistically for flood irrigation and subirrigation water is saline and not useful. He does not consider the AVF critical to his operation due to insufficient precipitation and marginal groundwater quality.

Emmons Ranch: Barry and Marilyn Emmons (Double Corral Creek)
The Emmons Ranch consists of approximately 10,000 acres. There are 3,000 to 4,000 acres used for crops depending on the year. These acres are rotated between barley and triticale utilizing passive flood irrigation. There are approximately 400 acres with subirrigation. The yield on these acres is approximately 50 percent greater than non-subirrigated acres. In the study area one half section (sec 21) is located on Double Corral Creek. The data shows that there are about 85 acres of AVF in this half section. This is 20 percent of the ranch subirrigated area sustaining a 50 percent higher yield. All 10,000 acres are grazed with approximately 600 head of cattle or around 17 acres per cow. Mr. Emmons says these acres are very critical to operations.
Lake Creek Ranch: Raymond (Bud) Williams (Lake Creek)
Lake Creek Ranch, owned and operated by Bud Williams, utilizes 5 sections or approximately 3,200 acres. Three hundred acres produce hay with wheat rotated on about 150 of these acres. Flood irrigation is only passively used and about 500 of the total acres are subirrigated. The entire ranch is utilized for grazing with 2,700 of the total 3,200 acres upland rangeland. The subirrigation is critical to the operation.

Robert and Gaylene Jauch (Lake Creek)
These two landowners own one-half section along Lake Creek. The AVF acres owned by Mr. and Mrs. Jauch are leased to and utilized by the Lake Creek ranch discussed above.

Jerauld L. and Karen Woodring (Lake Creek)
These two landowners own approximately 280 acres south of Lake Creek. The land is used as a hobby farm and approximately 100 acres are used to produce hay. Approximately 20-35 horses are kept on the property. Historic flood irrigation dykes are present on the northern portion of the property in the hay field. Production on subirrigated acres are used for winter pasture and would be critical if the operator were dependent on the production. However, this ranch is a hobby and the operator is not concerned about the viability of the subirrigated acres.

Smith Cattle Co.: Eugene and Diane Smith, Terri and Kebi Smith (Lake Creek, Y T Creek)
The Smith Cattle Co. operates on, approximately, 25,000 acres. In the study area, section 25 on Lake Creek contains around 124 acres of AVF extent and the north half of section 29 on Y T Creek contains around 76 acres of AVF extent. Eugene Smith indicated that the entire ranch is grazed with various intensities. The AVF acres in the study area are generally utilized for alfalfa and grass hay with a lower grazing intensity. Mr. Smith indicated that there are fewer than 1,000 acres subirrigated over the 25,000 acres. With 153 acres of AVF in the study area, using 1,000 acres as total ranch acres subirrigated, approximately 15 percent of the ranches subirrigated acres are on Lake and Y T Creeks. These 25,000 acres sustain approximately 1,940 head of cattle. Mr. Smith indicated that the hay production on these AVF acres are fairly critical; however, the additional groundwater resources these creeks provide, especially Lake Creek, are very critical for operations.

Gotfredson Ranch Inc.: Ed Gotfredson (North Fork Ash Creek)
Gotfredson Ranch Inc. consists of approximately 5,500 acres. The land is used for summer grazing and hay production. Mr. Gotfredson raises alfalfa and tame grass on the ranch. Mr. Gotfredson estimated there was 75-80 acres flood irrigated. Flood irrigation is only a passive practice with spreader dikes slowing the flow of surface water when precipitation is heavy enough. During the summer grazing season, there may be 350-500 head of cattle on the ranch. Mr. Gotfredson indicated the flood irrigation and subirrigation is good for extra hay but may not be critical to sustaining the ranch’s operation.

Archer Ranch Inc.: Joe and Rene Gnerer (Ash Creek, South Fork Ash Creek)
The Archer Ranch consists of 6,000 acres of which 600 are utilized for barley, wheat, and occasionally millet production. Wheat is rotated through these acres depending on the water resource. Flood irrigation is a passive practice with subirrigation matching approximately the AVF boundary. Production on the AVF is around a ton to a ton and a half of hay or approximately 30 bushels of wheat per acre. All
the ranches acres are grazed. There are 300-320 head of cattle grazed on the land. The subirrigated area is about 5 percent of the ranch and is critical to the operation.

**Richard Jesse (Second Creek, Y T Creek)**
Mr. Jesse’s ranching operation consists of approximately 3,600 acres. Nearly all of the land is grazed. Approximately 600 acres are used for hay production. Passive flood irrigation, using spreader dykes, occurs on a portion of the ranch. Mr. Jesse reported that subirrigation occurs and seems to increase production where it occurs. The land is grazed by 120-125 cattle year-round. Mr. Jesse stated that the floodplain acres are fairly critical; however, he treats it all as dryland cropping.

**Green Acre Ranch Inc.: Gordon Archer (Middle Creek, Leslie Creek, Mizpah Creek)**
The Green Acre Ranch consists of approximately 4,500 acres. No flood irrigation is used. Subirrigation is present along creeks on land used for hay production and grazing. Approximately 300 cows and 400 sheep are kept on the ranch year-round. Mr. Archer indicated that the subirrigated acres are critical to the ranch operation.

**Ezekiel and Raquel Mader, Arnold Mader (Road Creek, Wiser Creek, Two Tree Creek)**
The landowners ranching operations are managed together and consist of approximately 3,000 acres. There is potential for flood irrigation but it has not been attempted in the past few years. Approximately 745 acres are in hay production, mostly in creek bottoms. The operators run one cow per 20-28 acres. Production from subirrigated areas is noticeably better than in upland areas. Hay production is critical for the ranching operation rendering this area very critical to ranching operations.

**Betty and Earl Aye (Road Creek, Wiser Creek, Two Tree Creek, Mizpah Creek)**
The landowners ranching operation consists of approximately 10,000 acres. Hay is produced mainly from alfalfa and crested wheatgrass. Most of the acres are in upland areas. Passive flood irrigation is used on approximately 200 acres when there is enough surface water. The land is grazed by approximately 200 cattle. Mrs. Aye indicated that there is not a substantial difference in yield between upland and lowland areas reducing the lowlands to non-critical acres for sustaining ranch operations.

**Gali Ranch Inc.: Dan Gali (Two Tree Creek)**
The Gali Ranch consists of approximately 19,200 acres, which includes leased State Land and BLM Land. Flood irrigation is not used on Two Tree Creek. The ranch is grazed by approximately 700 to 800 cows. The floodplain of Two Tree Creek is not critical to the ranching operation.
References


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Sando, Roy, Sando, Steven K., McCarthy, Peter M., and Dutton, DeAnn M. 2016; Methods for Estimating Peak-Flow Frequencies at Ungaged Sites in Montana Based on Data through Water Year 2011; Chapter F of Montana StreamStats; U.S. Geological Survey, Reston, Virginia: 2016; Prepared in cooperation with the Montana Department of Natural Resources and Conservation.

Map 2A - Study Area Detail
Partial AVF Determination
Powder River County, Montana

Legend
- Streams
- Piezometers
- Sampled Monitoring Well
- Sampled Stock Well
- Abandoned Monitoring Well
- AVF Study Area
Map 3A - Study Area Detail
Partial AVF Determination
Powder River County, Montana

Legend
- MBMG Alluvium
- USGS Alluvium
- Monitoring Well
- Piezometer

GW Wells
- GW Wells with no Alluvial Lithology
- GW Wells with Alluvial Lithology

Drilled Resource Locations
- Resource Drill Holes with no Alluvial Lithology
- Resource Drill Holes with Alluvial Lithology
Map 3C - Study Area Detail
Partial AVF Determination
Powder River County, Montana

Legend
- MBMG Alluvium
- USGS Alluvium
- Monitoring Well
- Piezometer

GW Wells
- GW Wells with no Alluvial Lithology
- GW Wells with Alluvial Lithology

Drilled Resource Locations
- Resource Drill Holes with no Alluvial Lithology
- Resource Drill Holes with Alluvial Lithology
Map 4 - AVF Extent
Partial AVF Determination
Powder River County, Montana

Legend
- AVF Study Area
- Streams
- AVF Extent