Ridgway Town Council
Special Meeting Agenda
Monday, June 2, 2025

**Pursuant to the Town's Electronic Participation Policy,
the meeting will be conducted both in person and via a virtual meeting portal.
Members of the public may attend in person at the Community Center, located at
201 N. Railroad Street, Ridgway, Colorado 81432, or virtually using the meeting
information below.**

Join Zoom Meeting
https://us02web.zoom.us/j/86138044316?pwd=caRrefMmNZkLcO1OfuSyERL3a2dchr.1
Meeting ID: 861 3804 4316
Passcode: 271889
Dial by your location
+1 346 248 7799 US
+1 253 215 8782 US

5:30 p.m.

ROLL CALL Councilors Kevin Grambley, Polly Kroger, Michelle Montague, Terry Schuyler, Josey Scoville, Mayor Pro Tem Beth Lakin and Mayor John Clark

AGENDA ITEM

1. Review, Discussion and Direction on ***Existing Conditions & Alternatives Analysis for the Beaver Creek Diversion Restoration Project***

ADJOURNMENT

EXTERNAL MEMORANDUM

To: Preston Neill, MPA, ICMA-CM
Ridgway Town Manager
Town of Ridgway
201 N. Railroad St.
Ridgway, Colorado 81432

cc: Project Central File W0708.25001

From: Michelle Hopkins, PE
Project Manager
RESPEC
720 South Colorado Blvd., Suite 410 S
Denver, CO 80246

Date: May 30, 2025

Subject: Existing Conditions & Alternatives Analysis
Beaver Creek Diversion Restoration Project

This memorandum documents the existing conditions of the site as of May 7, 2025, as well as the design alternatives considered and evaluated and recommendations for the Town to consider.

EXECUTIVE SUMMARY

The August 2024 flood event wiped out the existing diversion structure and altered the channel geomorphology. RESPEC has evaluated a range of diversion options including restoring the existing diversion structure, constructing the diversion structure at a more stable location, and several different diversion designs. The final alternatives for selection are: Alternative 1 - Restore the Existing Diversion Structure and location, Alternative 2 – Rock Weir with Coanda Screen 200-feet upstream, and Alternative 2A – Rock Weir with Coanda Screen and Infiltration Gallery.

The table below summarizes RESPEC's ranking for three major decision categories (Table 1). There are other factors to consider that are not summarized in the table (i.e. adding the infiltration gallery will potentially increase the amount of water diverted in the winter months) which are described further in this Memorandum. RESPEC recommends the Town select Alternative 2 as more fully described in this Memorandum. Telemetry improvements would be an add-on as described in this Memorandum.

Table 1 – Alternatives ranked by category.

Categories	Alt 1: Restore Existing	Alt 2: Coanda Screen	Alt 2 + Add Alt A: Infiltration Gallery
Rank of Risk for future failure	Highest	Lowest	Middle
Rank for Maintenance	Highest	Lowest	Middle
Rank for Disturbance	Highest	Lowest	Middle
Price	$1.21M	$1.33M	$1.53M

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BACKGROUND

GEOLOGIC AND GEOMORPHIC CONTEXT AT THE BEAVER CREEK DIVERSION SITE

The Beaver Creek diversion site is situated within a narrow valley underlain by undivided glacial deposits and landslide debris. These unconsolidated materials are confined by prominent ridges of intrusive igneous rock, uplifted during the Oligocene caldera event approximately 20 million years ago. These ridges have played a critical role in shaping the valley's geomorphology by channeling glacial and fluvial processes into narrow corridors.

Approximately five million years ago, extensive glaciation covered the surrounding mountain peaks and the Uncompahgre Plateau with ice sheets up to 1,800 feet thick. As these glaciers advanced and retreated, they carved deep valleys and deposited thick sequences of alluvium and glacial outwash. Lateral moraines composed of large boulders now line the paleo-channels, providing both lateral confinement and intermittent grade control for the modern-day channel.

The current channel system is dynamic, characterized by alternating periods of aggradation and degradation. During degradation phases, the stream incises into the deep alluvial and landslide deposits, leaving behind large boulders as lag deposits that temporarily shape and stabilize the channel. In contrast, aggradation events often triggered by landslides and debris flows from steep, colluvium rich slopes and avalanche paths infuse the narrow valley floor with gravels, cobbles, and small boulders, effectively resetting the channel morphology.

The modern-day channel braids across the narrow valley floor, reworking glacial and modern-day alluvium and landslide sediments. The channel character is multiple shallow threads of flow weaving through coarse alluvium. The floodplain shows overflow pathways and linear deposits of 1= to 2-foot size boulders reflecting modern day hydrology. Glacial boulders of 6ft plus size are strewn along the edges, as well as in the channel bed. The channel is steep with an average slope of 8 percent, dropping about 420 feet per mile, as it braids and cuts through coarse boulder and cobble alluvium.

BEAVER CREEK DIVERSION STRUCTURE

A push-up dam, constructed from in-channel materials, was installed to divert flows into the diversion structure. The push-up dam routed Beaver Creek flows from the main channel into a side channel and through an intake structure made of concrete with a steel grate. The grated intake was a Tyrolean style structure set at channel grade. The intake structure was four feet wide by eight feet long with a grate opening of ½ inch. There is a timber headwall that runs parallel to flow to separate the side channel from the diversion ditch. Behind the timber headwall a steel sluice channel functioned as a sediment trap, where there were stop logs at the end that would be used to sluice sediments back to the main channel of Beaver Creek. The sluice channel is 3 feet wide by 2 feet deep and has a capacity of about 10cfs, flows greater than 10cfs were routed back to the main channel through the chute (Figure 1 Diversion Configuration).

MAINTENANCE OF EXISTING STRUCTURE

The open diversion structure required a regular maintenance schedule to sweep cobbles from the intake grate, as well as sluice sediments from the collection box. During spring runoff and monsoon season, the flume would need to be cleaned two to three times a week. During the off-season, a Ridgway employee would check and clean the diversion structure once a week while access was free from snow. The maintenance window spans from mid-May to late November for a typical year. In addition to the diversion structure needing maintenance, the Ridgway Ditch also has a maintenance schedule. The ditch requires periodic larger scale maintenance work for the first 5 miles from the Beaver Creek diversion location. Problematic areas are addressed on a rotating annual basis. In addition to sedimentation, high flows were known to cause erosion of the ditch banks that required periodic cleaning. The stop log setup had limited ability to control the amount of water entering the ditch. A backhoe was used to reconstruct the push-up dam in the stream bed several times a year.

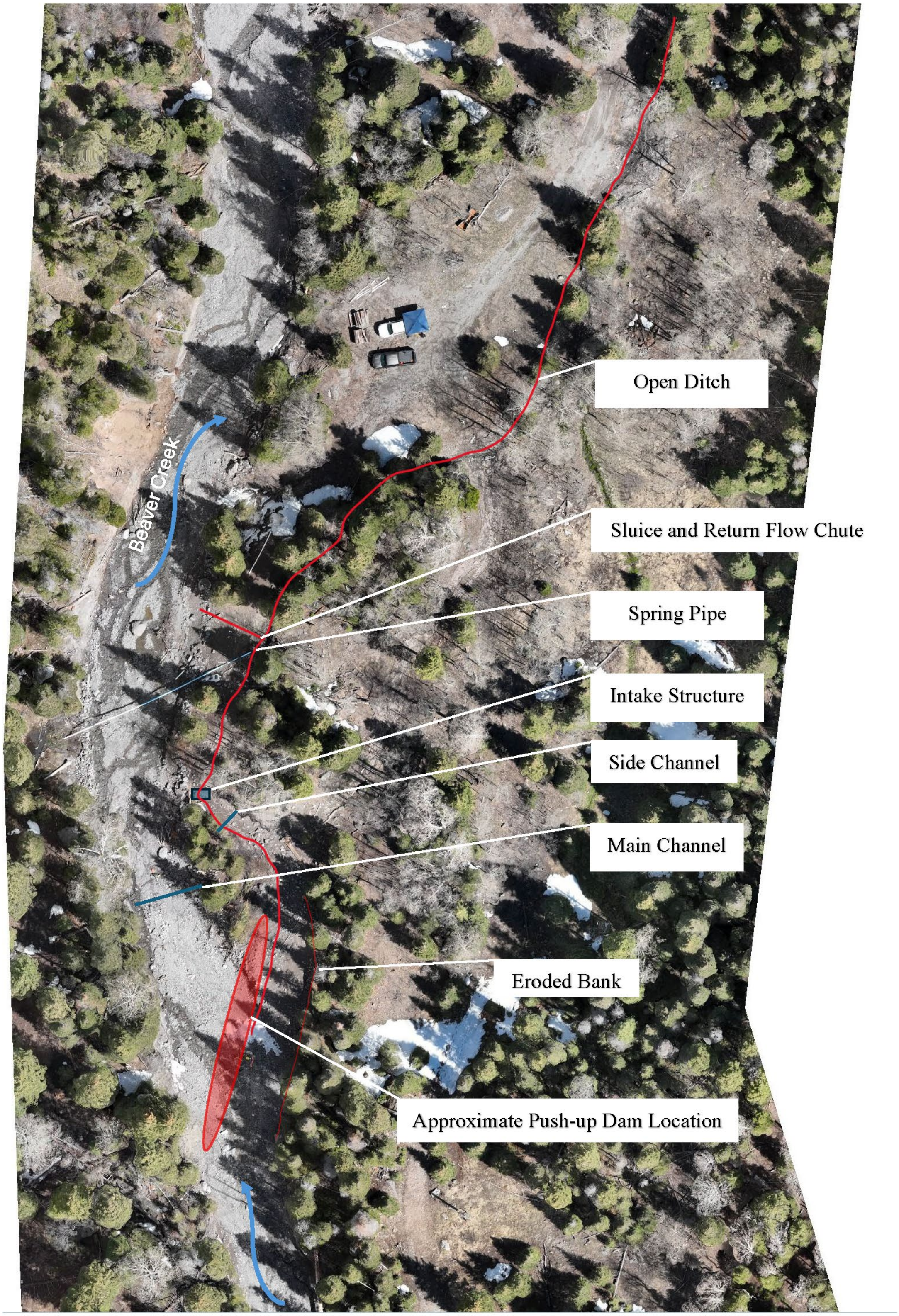


Figure 1 – Diversion Configuration

AUGUST 2024 EVENT

In August 2024, a high intensity thunderstorm of unknown magnitude covered the small watershed initiating a flood event. During the high-magnitude flood event, the incoming flow was heavily laden with debris, including large woody material and coarse sediments including large rocks. Debris was predominately alluvium and bulking of sediment from channel materials in the surging flood flow. The channel banks eroded and widened, providing ample materials. The push-up dam initially succeeded in routing both water and debris into the side channel. However, the increased hydraulic force and debris load initiated channel avulsion and rapidly eroded the adjacent right bank (Figure 2 and 3 Avulsion Path and Eroded Bank). This erosion was exacerbated by the high energy of the floodwaters and the unconsolidated nature of the channel and bank materials. Eventually, the push-up dam breached under the pressure of the floodwaters. Once breached, the full volume of the flood was released down the original main channel. The sudden surge transported a massive load of gravel and cobbles, which were deposited across the valley floor, effectively burying the main channel under a thick layer of coarse sediment (Figure 4 Aggradation from August 2024 Event).

As the flood receded the diversion structure and sluice channel were completely buried with small boulders and cobbles and a veneer of fine sediments (Figure 5 and 6 Existing Diversion Structure). These fines were likely sourced from the immediate eroded bank during the avulsion process. The redistribution of sediment types across the landscape was evident during field reconnaissance, coarse materials dominating the valley floor and finer particles settling in the floodplain. Fine particles completely filled the ditch (Figure 7 Sediments Cleaned from the Ditch). The event caused the diversion and ditch to be completely inoperable to divert flows.

Figure 2 – Photograph looking downstream showing the main channel and side channel where the temporary avulsion occurred.

Figure 3 – Photograph looking upstream at the main channel where the channel avulsed and eroded the right bank.

Figure 4 – Photograph showing aggradation of gravels and cobbles filling the channel.

Figure 5 – Photograph showing the existing diversion structure filled with sediments. Only the top of the 4ft tall timber wall is exposed to the surface.

Figure 6 – Photograph showing the steel sediment channel and spring pipe. Notice the boulders that were transported and deposited at the head of the sluice channel.

Figure 7 – Photograph showing the ditch cleaned of sand and gravel after the flood event. These materials may be reused to restore the bank as soil fill in coir wraps.

HYDROLOGICAL CONDITIONS

The Division of Water Resources (DWR) maintains a record of daily diversions from the Middle Fork of Beaver Creek through a 30" Parshall flume located in the ditch approximately 700 feet from the headgate. Historical records evaluated between 1999-2021concluded that water is diverted year-round; however, measurements are not taken in the winter and actual flows are likely impacted by ice (Water Supply Assessment, LRE, 2022). On an average year current operations divert between 0.67cfs to 1.46cfs. The maximum recorded diverted flow is 6.26cfs occurring in June, and the minimum recorded diverted flow is 0.58cfs in November (Water Supply Assessment, LRE, 2022).

Annual hydrographs for the Middle Fork of Beaver Creek at the diversion location were approximated by using the gage records located in the East Fork of Dallas Creek and applying the comparative drainage basin ratio (Figure 2.3.1, Applegate, 2011). The East Fork of Dallas Creek was considered the most representative watershed to determine flows based on basin characteristics. The annual hydrograph shows that flows are above 2cfs from May to September, with annual peak flows averaging 10cfs in June. It has been observed that the ditch diverts the entire flow of Beaver Creek during baseflow conditions (Applegate, 2011). Due to sedimentation and conveyance losses of the Ridgway ditch the town receives approximately 37% of their total available municipal raw water. Improvements to the diversion and headgate are recommended to be sized to convey 10cfs (Applegate, 2011).

The U.S. Geological Survey (USGS) StreamStats tool was utilized to delineate the watershed upstream of the diversion site and estimate peak flow events. The 2-year flow event is estimated to be 40 cfs, and the 100-year flow event is estimated to be 231 cfs (Table 2).

Table 2 – Design flows for Stream and Structure Stability

Source	Drainage Area (sqmi)	2yr flow (cfs)	5yr flow (cfs)	10yr flow (cfs)	50yr flow (cfs)	100yr flow (cfs)
StreamStats	1.57	40	74	104	154	231
(c)	USGS Regional Equations for Estimation of Natural Streamflow Statistics in Colorado.					

The magnitude and recurrence interval of the August 2025 flood event is still under investigation. Peak water surface elevations and cross-section data collected during the site visit May 12, 2025, are currently being modeled.

An existing conditions 2D hydraulic model has been developed based on 2016 LiDAR terrain. Preliminary results show that flow in the channel averages approximately 0.5ft deep during bankfull flow conditions, and about 1 foot deep during the 100-year flow event. Due to the naturally steep grade of the channel (8%), shear forces during the 2-year event show the channel is competent to mobilize a 6-inch cobble size, and a 3ft size boulder during the 100-year event. We note that these are average flow depths whereas actual maximum flow depths are likely deeper as the channel erodes and aggrades over time.

DIVERSION LOCATION ALTERNATIVES

Selecting a site that is the most stable will be critical to restoring the diversion and ditch operations. It is imperative for the design to function with the braided channel morphology and the natural aggradation and degradation processes. During the site visit the entire reach was walked to document post-event conditions. At the downstream end of the reach, approximately 2,000 feet downstream of the current diversion location, glacial outwash materials terminate. A significant head cut is propagating upstream (Figure 8 terminal end of glacial outwash deposits), reworking recently deposited material restoring the channel back to pre-flood conditions, where the channel has a natural 8% slope cascading through boulder and cobble materials. Figure 8 also provides a good picture of the subsurface boulders that could be encountered at the diversion structure locations. This location is where the valley drops significantly descending down the plateau and cutting through colluvial materials. Figure 9 is approximately 1,300 linear feet downstream of the existing diversion location, likely depicting the natural regrade of the channel near the diversion location. Figure 10 shows the head cut working its way up about 700 feet downstream of the diversion location. The channel is currently in the process of cutting through the recently deposited materials, establishing a new grade. This head cut is expected to continue moving upstream over time and, depending on the frequency and magnitude of future flood events, may ultimately reach the existing diversion structure location. However, without a significant amount of future flood events, this process of head cutting will take a substantial amount of time. In addition, large flood events that transport armoring materials may again fill the valley floor and the head cut will again be moved downstream and start the process over again.

Figure 8 – Photograph showing the terminal end of glacial outwash materials.

Figure 9 – Photograph showing the mid-point of the head cut approximately 1,300 feet downstream of the existing diversion location.

Figure 10 – Photograph showing the head cut moving up the valley approximately 700 feet downstream of the existing diversion location.

The USGS 2016 LiDAR terrain was used to evaluate the reach and determine where there are opportunities for natural confinement and stable channel locations. The geologic maps and profile did not reveal stable knickpoints that would provide natural vertical control for a diversion location. Based on the 2016 LiDAR terrain surface three locations were investigated to replace the diversion structure (Figure 11 Beaver Creek Terrain and Valley Width).

CURRENT LOCATION

The current location of the diversion structure lies in a geomorphic transition zone where the valley widens significantly. This broader valley floor, underlain by unconsolidated landslide and glacial outwash deposits, is inherently more susceptible to overbank flows, sediment deposition, and debris spreading during high-flow events. These conditions promote the development of side channels and ephemeral high-flow pathways, increasing the likelihood of avulsion processes.

Consistent with the geologic mapping our site visit confirmed that this zone is composed of loosely consolidated materials, which are easily eroded and reworked during flood events. The terrain and sedimentary evidence suggest that the historic channel has migrated across the valley floor over time, occupying multiple positions and leaving behind a mosaic of paleo-channels and floodplain deposits. This dynamic history reflects a natural tendency for avulsion and lateral channel migration in response to sediment loading and hydrologic variability.

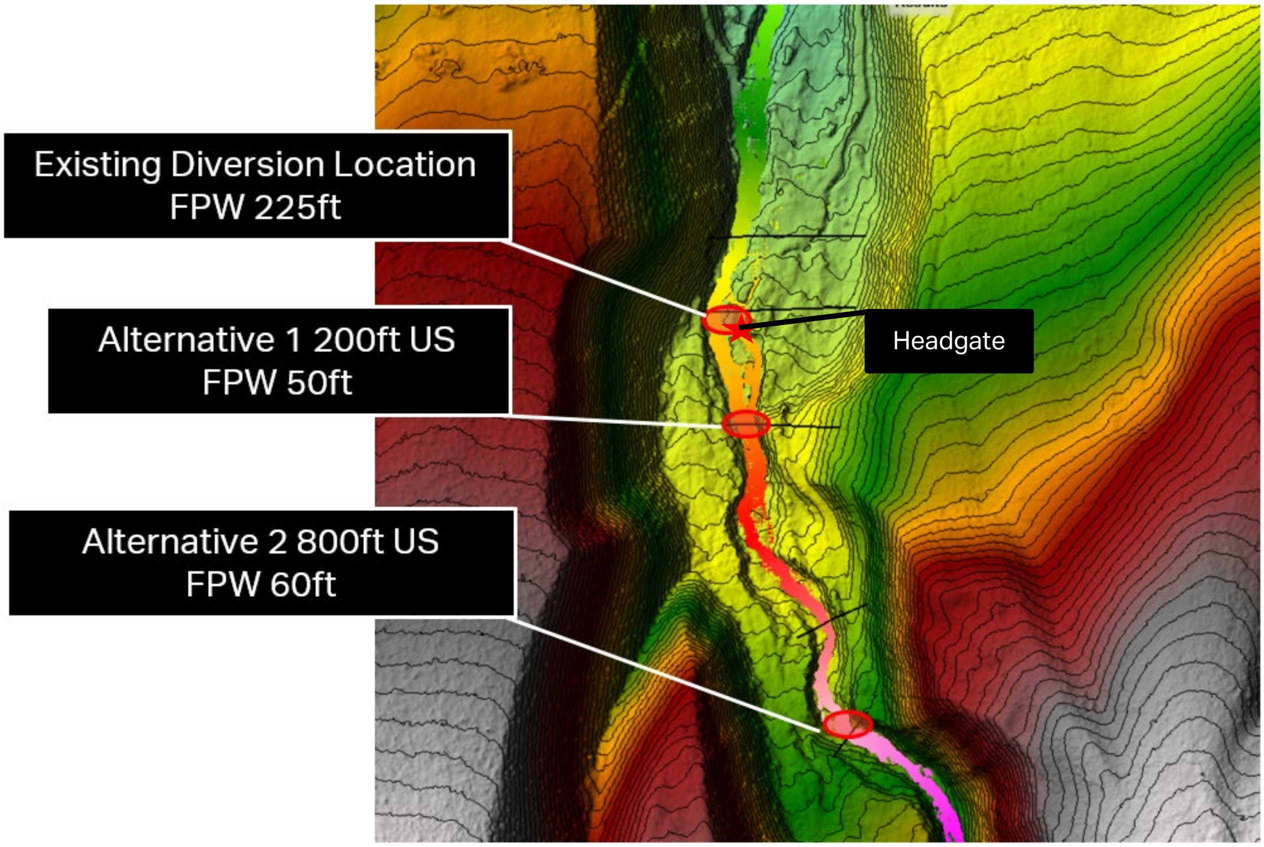


Figure 11 – Beaver Creek Terrain and Valley Width. The mounds in the topography are large glacial boulders.

In contrast, upstream sections of the valley are more narrowly confined by colluvial slopes. In these reaches, the channel is restricted to the valley bottom where the channel braids within the valley walls. These confined sections are less prone to avulsion but are still subject to rapid sediment transport and channel shifting during high-energy events.

The confined and unconfined valley segments creates a geomorphic setting where sediment and flow dynamics are highly variable. The location of the existing diversion structure within the unconfined reach makes it particularly vulnerable to avulsion, erosion, and sediment deposition during extreme events such as the one that led to the recent channel avulsion and eroded bank.

Replacing a diversion structure here would likely require significant stabilization of the main channel and side channel. Rather than a pushup dam, a more stable diversion constructed of native boulder materials is recommended that would route flows up to bankfull flow event into the side channel and intake structure but would bypass other flows during flood events into the main channel so that erosive forces are spread across the floodplain. The island separating the two channels and the eroded east bank would need to be stabilized. The side channel and the existing intake structure have filled 4 feet with sediments and excavation of the deposited sediments from the August 2025 flood event would be required to restore grade. The side channel and the main channel have a 4-foot elevation difference at the head of the island, and a 5-foot elevation difference at the return flow area, which would require placing boulders so that flows that spill out over the diversion back to the main channel would not cause erosion. Wood and channel training structures (such as boulder j-hooks) would be required to stabilize a side channel and main channel and route base flows into the diversion intake.

Replacing the existing diversion would be less stable than other locations because of the laterally active floodplain, as well as the side channel and main channel split flow configuration is more dynamic to route base flows to the intake structure. No change in point of diversion would be required for this location. In addition, environmental permitting should be minimal since the structure would be replaced at the same location as it currently exists.

200' UPSTREAM

Approximately 200 feet upstream of the current diversion, a string of glacial boulders exist confining the valley to the east (right bank). The west (left) bank is confined by a floodplain terrace approximately 5 feet high above the current channel. Two large 5-6′ keystone boulder are exposed, and the bank is stable with mature trees. Portions of these boulders were likely further exposed due to the down cutting of the stream during the August 2025 flood event but they prevented lateral movement of the stream. It is unlikely that future flood events would be able to disturb these boulders, but some stream training improvements may be desirable to minimize the risk of further erosion of the banks at these boulders. This location offers the most laterally stable location to construct a new diversion. A diversion structure could be keyed into both the left and right bank boulders (Figure 12 and 13 Potential Diversion Location 200ft Upstream). Per conversations with the Colorado Division 4 Water Engineer, moving the headgate to this location would not trigger a change in water rights. In addition, environmental permitting should be minimal given the close location to the existing diversion structure.

Figure 12 – Aerial view looking upstream at the potential diversion location.

800' UPSTREAM

Approximately 800 feet upstream of the existing diversion structure, the Beaver Creek valley becomes significantly narrower and more confined by steep colluvial slopes (Figure 14 Upstream Location). In this reach, the channel transitions into a steeper gradient, approximately 10%, and adopts a straighter, cascade-like planform with limited low-flow meandering. While this confined section may offer greater channel stability and reduced avulsion risk, a site visit revealed several critical limitations that make it unsuitable for a diversion structure.

Most notably, the area lies directly adjacent to an active avalanche path, posing a considerable risk of sudden debris loading and channel obstruction. Additionally, the overbank area, likely a remnant of a historic diversion alignment, exhibits exposed groundwater and wetland features. Installing a diversion pipe through this zone

Figure 13 – Photograph is looking upstream and at the east bank showing the string of boulders confining the valley.

would not only increase construction costs due to the need for longer and more durable piping, but also result in greater environmental impacts, particularly to sensitive wetland habitats. These factors, combined with the geomorphic instability associated with avalanche-prone terrain, render this upstream location less favorable for diversion infrastructure. In addition, moving the point of diversion 800 feet upstream would trigger the need for a change in water rights and environmental permitting could be more difficult as this site is significantly further away from the location of the existing diversion structure.

DIVERSION LOCATION RECOMMENDATION

The most stable location for a diversion structure is 200 feet upstream of the existing diversion location. The boulders confining the channel provide an opportunity to contain flows to the active channel. This location also has a natural meander planform that will make it easier to install flow training structures to route low-flow into the diversion structure. This location avoids a change in point of diversion requirement per the Division 4 water engineer and should have minimal environmental permitting restrictions and requirements.

Figure 14 – Photograph looking upstream at the channel approximately 800 feet upstream of the existing diversion location.

DIVERSION DESIGN ALTERNATIVES

PUSH-UP DAM, INTAKE GRATE, & SLUICE

One design alternative under consideration is to replicate the existing diversion structure using a similar configuration. The current system consists of an in-creek push-up dam that directs water into a side channel, where it is collected by a grated intake structure. The grated intake structure features a grated metal opening that allows surface water to pass through while blocking small-diameter cobbles. From the grate, water flows through a sluice channel designed to further remove small-diameter materials. The sluice channel includes a screened stainless-steel section to aid in solids removal and includes a side channel that returns water to the creek. The sluice channel includes an adjustable vane with an adjustable swing gate that can be turned to regulate the quantity of flow diverting to the Town versus the quantity of flow back to the channel.

Figure 15 – Photograph of the existing intake grate structure .

Figure 16 – Photograph of the existing sluice channel with adjustable vane.

Replacing the diversion structure would require similar operations and maintenance for the Town of Ridgway as occurred prior to the August 2025 flood event. The Town of Ridgway made two to three trips per week during runoff season, and weekly trips during the rest of the year to remove accumulated sand, silt, and fine materials from the intake grate and channel. The challenges the Town faced with the existing structure are unreliable year-round operation due to ice, regular sediment removal, and periodic restoration of the push-up dam. It is likely that replacing the structure may require more maintenance initially as Beaver Creek attempts to restore itself over time to a more stable configuration.

The approximate height of the push-up dam is unknown which makes it difficult to understand the actual magnitude of flows which were routed to the side channel. However, it is our understanding that all flows up to the bankfull flow was routed to the diversion structure. The push up dam constructed of channel materials failed during the flood and debris event, eventually breaching where flows went back into the main channel. The east bank substantially eroded creating a much larger side channel. Overall, the damage that took place in the channel requires significant and costly repairs to restabilize this diversion location to allow it to operate in a comparable manner as it did historically. Additionally, the existing channel side channel was filled with two to four feet of sediment which therefore must be excavated to again deliver channel flows to the intake grate structure location.

Figure 17 – Photograph is facing downstream toward the existing diversion channel on the right, showing the significant fill that must be cut to restore the channel.

BURIED INTAKE / INFILTRATION GALLERY

A buried intake, also known as an infiltration gallery, functions by capturing subsurface flows through screened pipes installed horizontally beneath the creek bed. These pipes are buried and backfilled with native riverbed material, which allows water to filter through the coarse substrate before entering the intake system.

The design of this alternative depends on several factors, including the depth of water within the river (hydraulic head), the hydraulic conductivity of the riverbed materials, and the desired diverted flow rate. Based on these parameters, the required length and depth of the intake pipes can be determined. To ensure the design will infiltrate 10 cfs, a geotechnical analysis would be necessary to accurately assess the hydraulic conductivity of the creek substrate.

This system offers several operational and environmental benefits. Buried intakes provide the ability to divert flow throughout the year as it can capture subsurface flows in the winter allowing for continuous water collection. The system is designed to be underground at a depth that would be protected from damage caused by large debris, cobbles, or landslide materials. A subsurface system also allows for some bed level adjustments. Water collected through this system undergoes natural filtration as it moves through the overlying riverbed material, resulting in higher water quality compared to direct surface water intakes.

The disadvantage for this alternative is the risk of clogging. Over time, fine materials will clog the screened pipes, reducing the system's intake capacity. Maintenance may include periodic backwashing using water and pressurized air to clear the intake screens. This process requires specialized equipment, such as a trailer-mounted generator capable of delivering the necessary air and water pressure. The frequency of required maintenance is difficult to predict, as it depends on the variability of debris and sediment flows within the creek. The filter pack material surrounding the screened pipes may need to be imported if suitable native material is unavailable, which could increase costs. Other risks include plugging of the filter pack over time, rendering the diversion facility useless without excavating and replacing the filter media.

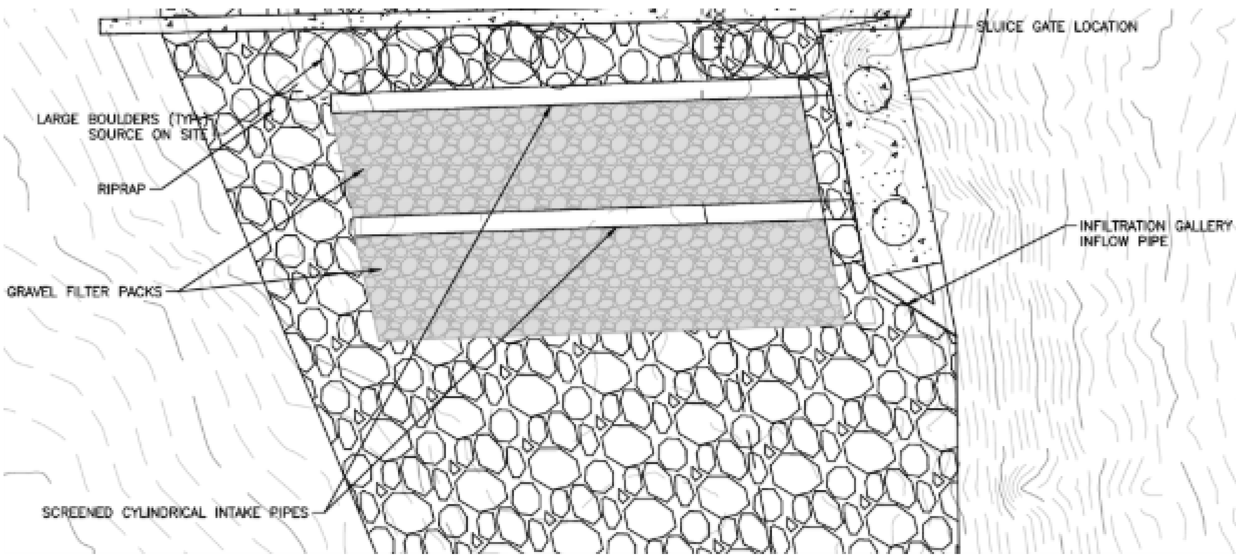


Figure 18 – Buried Intake Structure Option – Plan View

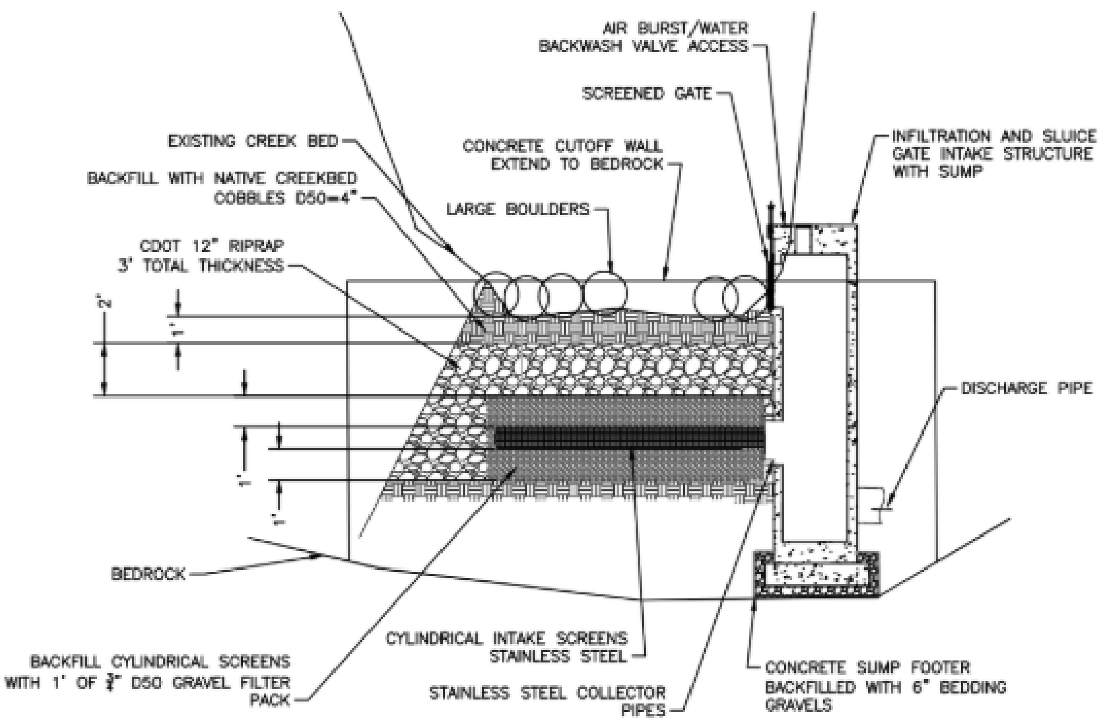


Figure 19 – Buried Intake Structure Option – Profile View

WEIR STRUCTURE WITH HEADGATE

Instead of a push-up dam to divert surface flows to the Town, several other dam options were considered including a rock weir, a concrete weir, and sheet piling. Each of these design options can be configured in manner that better controls channel flows in both low flow conditions as well as for larger storm events. Each of these structure options assumes the water will be diverted to a collection box structure with a headgate. These options are described below:

/ ROCK WEIR

A rock weir can be constructed across the width of the channel using native boulders. This structure creates a low dam, causing creek flows to back up slightly and allowing water to be directed toward a headgate structure. The headgate, placed adjacent to the weir, collects water for diversion into the conveyance system.

Figure 20 – Example Rock Weir with Headgate (Trout Unlimited)

Advantages of this design include utilizing native boulders that can likely be sourced directly from the project site, reducing material costs and transportation requirements. The rock weir facilitates fish and aquatic organism passage during flow periods in the creek. Although, the existing stream and stream bed conditions do not currently support fish species in the vicinity of the project.

The disadvantages of this alternative compared to other alternatives include less precise control over diverted flows due to the permeable nature of the rock structure which allows water to spill through the voids between the boulders and cobbles, whereas a weir constructed of concrete has a solid surface, providing the ability to capture more stream flow. Current hydraulic modeling indicates shallow flow depths in the creek. Some flow is expected to bypass the headgate by seeping through the rock weir, as the structure would not be sealed or tied into impermeable banks. However, this option can be modified to include grouting to minimize excess water seepage through the dam. This grouting will not be structurally sound and will be subject to cracking over time.

Another option to partially seal the dam consists of the contractor washing finer gravels and sands between the larger boulders and cobbles to help facilitate a more natural seal along the rock dam. Permitting may be required for using stream water for this purpose and diverting it back to the stream when finished.

All of the weir options would require regular maintenance to clean out a headgate intake. Other disadvantages include possible vulnerability to damage or displacement from landslides or high-flow events, potentially compromising its long-term functionality and requiring periodic maintenance or reconstruction. In particular, scour downstream of the weir is common and can cause the rocks to rotate or become displaced if not protected with larger rocks. The stream bed is also very gravelly and there is a risk that the channel flow could disappear underground periodically, and bypass the weir vertically, preventing the Town from taking a diversion.

/ CONCRETE WEIR

A concrete headwall, incorporating a weir and headgate, is another viable design alternative. The proposed headwall spans the entire width of the channel to dam creek flows, with a headgate installed at one end to control and divert water. For structural stability, the headwall will likely need to be anchored to bedrock. Bedrock was not observed at any location during our site visit. Typically, a geotechnical analysis is performed to assist with the structural design of a concrete structure. However, traditional geotechnical bores are not possible at this site due to the presence of large boulders and cobbles in the stream bed. If the drill rig hits refusal, we will have no way of knowing if they found bedrock or a boulder. If this design option becomes the most favorable, the contractor can perform some exploratory excavation to better understand the geotechnical conditions in the specific structure location. However, if a more natural design option is preferred, then disturbing the already compacted streambed will likely be counterproductive and could encourage the stream flow to travel underground through the gravely streambed materials.

Figure 21 – Example Concrete Weir

Unlike a rock weir or grate structure, this design concentrates all surface and subsurface flows at a single intake point, maximizing the flow of 10 cfs to be reliably captured and diverted through the headgate. Infiltration and grate systems do not focus surface and subsurface flows like the concrete weir design. By consolidating flows into one location, this system achieves the highest potential diversion efficiency among the evaluated alternatives. However, this funneling of flow also induces scour and the need for deeper structural stability, depending on the depth to bedrock.

Construction disadvantages include the site access for concrete deliveries. Delivering concrete to the site may be logistically difficult and expensive. Upgrades to the existing access road would likely be necessary to accommodate concrete trucks and construction equipment. The creek bed must be excavated to near bedrock to ensure the structure is properly anchored. The exact depth to bedrock is currently unknown, introducing design uncertainty and potential cost increases. With no bypass flow path, debris, including trees and large organic material, would accumulate in front of the structure, potentially requiring frequent maintenance and posing risks to structural integrity. A bypass could be built into the design but only for flows above the diversion capacity and thus would not mitigate the risks described above.

/ SHEET PILING

Sheet piling is another design option for creating a cutoff wall to assist with collecting stream flows that could seep underground and travel through the gravelly stream bed material in low flow conditions. The primary advantage of sheet piling is that it is typically driven into the ground, eliminating the need to excavate the stream bed. However, there is evidence that the stream contains significant sized boulders and cobbles, preventing the ability to drive sheet piling. Therefore, the most likely method of installation is to excavate the stream bed, place the sheet piling and backfill against it. This installation method is much less structurally sound than installing by driving the sheet piles. Much of the structural stability is achieved in the friction between the existing undisturbed ground and the sheet piling. Excavating a trench for the sheet piles also opens the risk of creating a water path along the face of the sheet allowing water to travel down and under the piling, further undermining the structural integrity of a sheet pile dam. Downstream protection (i.e. boulders, etc.) would also be required to prevent scouring of the downstream backfill.

COANDA SCREEN WITH COLLECTION BOX

An additional alternative involves the implementation of a Coanda screen (see Figure 22) in conjunction with a rock weir. The rock weir would create minor ponding in the creek, directing flow over the Coanda screen, which is designed to capture water as it passes across its surface. The approximate elevation drop over the screen evaluated for this discussion is approximately 51 inches which provides self-cleaning, allowing large sediment particles, leaves, and debris to slide over the screen. Coanda screens intake flow based on their length; following discussions with Elgin, the manufacturer of the Coanda screen, it was determined that a 5-foot-long Coanda screen would be sufficient to capture the full design flow of 10 cfs.

The Coanda screen would be installed near the existing channel grade along the trained flow path. As flow overtops the screen, it passes through a stainless steel screen, which filters the water and directs it into a collection trough located directly below. Water collected in the trough would then be conveyed via pipe to a collection box, and subsequently to either a new pipeline connection or the existing ditch infrastructure.

One of the main advantages of the Coanda screen is its ability to improve water quality. This type of screen provides a level of filtration by allowing detritus and other debris and larger materials to pass over it, while cleaner water is captured and directed into the conveyance system. Although it does not eliminate all fine sediments, it reduces the amount of material that enters downstream infrastructure.

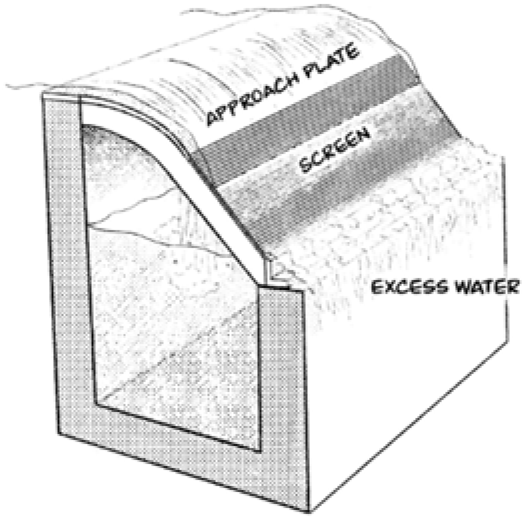


Figure 22 – Coanda Screen Design Concept

Another benefit is its minimal environmental impact. With a compact size of approximately five feet in length, the excavation for the Coanda screen is limited. The construction of the associated rock weir can be achieved using on-site boulders, which further reduces both environmental disruption and logistical demands. There are trade-offs between drop height and the length and capacity of the screen which would need to be further evaluated if this alternative is selected.

Figure 23 – Rock Weir with Coanda Screen

Additionally, the Coanda screen offers physical protection for the infrastructure. Surrounding it with boulders helps shield the screen from direct impact by large debris. Moreover, these screens can be manufactured with integrated debris racks that provide additional protection by minimizing damage to the screen from larger materials overtopping the screen structure. Elgin also provided design examples for installations in Canada which are operating successfully under similar stream and freezing conditions.

Figure 24 – Coanda Screen with Optional Protection Assembly

There are some disadvantages to the use of a Coanda screen such as the Coanda screen, and its associated trough, require routine maintenance. This includes manual power washing and scrubbing of the screen surface to remove clogging, as well as the periodic removal of accumulated silt and fine materials from the trough (which can be reduced with a sloping trough). Another drawback is the lack of fish passage. The design of the Coanda screen does not accommodate the movement of fish or aquatic organisms, which could be a concern in areas where ecological connectivity or regulatory compliance is important. Based on initial discussions with Colorado Fish and Wildlife, the proposed diversion location does not have any aquatic organisms that require passage.

OTHER CONSIDERATIONS

ENVIRONMENTAL AND REGULATORY

Environmental stewardship is central to the design and permitting process. We intend to prepare one pre-construction notification (PCN) under Regional General Permit (RGP) 96 for natural disaster mitigation and flood-related activities which permits up to 0.5 acre of wetland impacts and 1.0 acre of stream impacts, and RGP 37 for stream stabilization activities which allows up to 1,000 feet of in-channel work. This will enable strategic harvesting of boulder material and allow the contractor to work within the active Beaver Creek channel. Based on a recent wetland delineation on the project site, only a very small (<0.02 acre) wetland exists in the diversion project site. Additionally, no suitable habitat for federally-listed threatened and endangered species was identified in the project area. A survey for raptor nests potentially impacted by the project was conducted; no nests were observed. Conversations with Colorado Parks and Wildlife indicate the design of the diversion structure need not include a fish passage mechanism. Whichever alternative is selected, we will ensure it complies with all applicable environmental rules and regulations.

LANDOWNER IMPACTS

All of the design options require channel restoration and bank stabilization. To reduce construction costs, environmental impact, and landowner impact, we recommend maximizing the use of onsite materials. Native boulders can be used for grade control and bank stabilization, while downed or senescent trees can be used for floodplain sills, channel training, and bank stabilization structures. These structures typically need to be maintained approximately every 25-50 years. Bank restoration is also recommended to stabilize the east bank area where the avulsion occurred.

To minimize maintenance trips to the site, each design alternative can include a proposed measurement vault with upgraded measurement equipment and instrumentation to facilitate remote reading. Figure 25 provides an example of the suggested communications equipment. This equipment allows for real time monitoring of flows through the State of Colorado's satellite monitoring system. Routine visits to the site, such as once a week, would still be recommended to visually observe the diversion system for maintenance. Other telemetry for flood conditions could be added but the availability of reliable communications would need to be determined as the State of Colorado's satellite system is not intended for this purpose.

Figure 25 – Example of equipment required for remote flow measurement readings.

ACCESS ROAD

Access from County Road 5 to the intake structure has been through a locked gate at County Road 5 and along a two-track road (Ranch Road) from the gate approximately 4,100 total feet to the intake facilities for approximately 30 years. The first 1,050 feet of that road is through a forested area. Past the forest area, the road crosses the Ridgway Ditch and then proceeds approximately 1,650 feet through a meadow, crossing East Beaver Creek, then through another forested area at which point the road then becomes the berm of the Ridgway Ditch. The road then follows along the berm of the ditch for approximately 1,400 feet to the current intake facilities.

The initial design intent for access to rehabilitate the Town's diversion was to disturb the least amount of vegetation and use the Ranch Road as the access to get materials and equipment to the intake structure. The initial design was to place geotextile fabric over the road and then place 5" of road base over the fabric, which is the minimum for the fabric to be structurally beneficial. At completion of the project, the gravel would be removed and the fabric rolled up leaving the existing two track road with the least disturbance as possible. The Town discussed piping the 1,100 feet along the segment where the existing road is adjacent to the ditch. Material from the access road/berm could be used to bed the pipe and place approximately 12" of cover over the pipe while allowing for the access road in that segment to be widened to approximately 12'. The topographic survey was completed along the full Ranch Road access, and a preliminary design of the road improvements was completed by the Town. Since this alignment and related disturbance exists, no additional permits or environmental investigations should be necessary.

In a recent discussion with representatives of Wolf Land Company, they requested the Town evaluate piping another 2,050 feet of the existing ditch and build the access over the pipe/existing ditch from the point where the Ranch Road first crosses the Ridgway Ditch to the point where the access road is adjacent to the Ridgway Ditch. They noted that the Town already has a prescriptive easement along that portion of the ditch so the Town would not need a separate access easement if they instead use the existing ditch alignment. It should be noted that the Ridgway Ditch crosses the Ranch Road about 1,050 feet west of the Ranch Road gate and for the segment between the gate and where the Ranch Road crosses the Ridgway Ditch, the Town would still want an access easement on the Ranch Road granted from Wolf Land Company, which would be separate of the existing prescriptive ditch easement. This alternative access, as requested by Wolf Land Company, would require significant vegetation and tree removal in some sections along with earthwork and road improvements.

The request to evaluate access along the Ridgway Ditch occurred after the completion of the topographic survey so only field observations were performed to evaluate this request. The observed challenges associated with this alignment include the northerly approximately 200 feet where there is very little ditch bank with steeper side slope and necessitating trees and other vegetation be removed as well as some earthwork to develop sufficient access for construction. In addition, the alignment of the ditch at this location is also very tight, which would require an adjustment of the alignment for equipment movements. There are also some saturated soils on the ditch bank at the bend where the Ridgway Ditch crosses East Beaver Creek that would need to be stabilized. The alignment of the ditch at this bend is also very tight, which would require an adjustment of the alignment for equipment movements. This again would require vegetation removal and earthwork construction. The remainder of that alignment would require some vegetation trimming and brush removal to accommodate the equipment.

Representatives from the Natural Resources Conservation Service pointed out that the alignment where the Ranch Road is immediately adjacent to the Ridgway Ditch is already cleared for environmental and historic permitting compliance, but in the area where the access road would be moved to adjacent to the Ridgway Ditch, the Town would need additional environmental and historical clearances and likely some mitigation of the impacts. It would likely take several months to secure the clearances which would delay the construction of the diversion improvements until 2026.

ALTERNATIVES EVALUATION

Our evaluation of diversion location and design alternatives included evaluation of channel stability and suitability, construction impacts and feasibility, and water right and environmental permitting requirements. Based on this evaluation, we recommend that only the two following alternatives be considered.

ALTERNATIVE 1 – RESTORE THE EXISTING DIVERSION STRUCTURE AND LOCATION (SHEET 1 IN ATTACHMENT A)

For comparison purposes, a proposed design alternative was developed to determine the work and cost required to restore the existing diversion structure in the existing location. The sediment that was deposited during the August 2024 event must be excavated to restore diversion by gravity. Therefore, the existing diversion channel must be re-graded from the main channel to the grated intake location. The eastern bank must also be restabilized by harvesting and using onsite boulders and downed trees. Rather than a push-up dam that must be restored several times a year, we recommend a more formal design for the dam structure considering base flood elevations for larger storm events. The dam must be large enough to divert daily flows to the grated intake, but small enough to allow larger storm events to be routed down the main channel. This will help prevent additional bank erosion along the east bank.

Alternative 1 will impact the land more than Alternative 2 since it requires more earthwork and will likely require import materials from offsite which could lead to needing a further improved access road through private property.

Maintenance requirements for Alternative 1 are similar to the existing maintenance requirements. Operations staff must clean debris from the grated intake and sediment out of the sluice channel as frequently as 2 to 3 times per week during runoff and monsoon season. Outside of the runoff and monsoon season, the staff cleans the structures about once per week. A more formal dam structure will eliminate the required push-up dam maintenance of 2 to 3 times per year but would still require maintenance to address gravel and silt build-up. The boulders for the dam and stream stabilization must be maintained and reset approximately every 25 to 50 years.

The attached Exhibit 1 shows the conceptual Alternative 1. The approximate cost based on conceptual level engineering is $1.21M (see Note 1). This is not RESPEC's design recommendation since it does not provide the best 'bang for the buck', has a higher impact on the land, and has a higher risk of failure due to its less stable location.

ALTERNATIVE 2 – ROCK WEIR WITH COANDA SCREEN 200-FEET UPSTREAM (SHEET 2 IN ATTACHMENT A)

Alternative 2 consists of the recommended diversion design configuration and location. We recommend relocating the diversion structure approximately 200 feet upstream of its current location, where the valley narrows and the active channel is naturally confined by large glacial boulders. This setting offers improved hydraulic control and channel stability, reducing the risk of avulsion that compromised the existing structure.

The recommended diversion design consists of a rock weir with an optional infiltration gallery upstream of the weir, and a Coanda or similar type of screen system designed to capture 10 cfs. Sediment vaults with manholes at the Coanda and the junction location with the spring are recommended for periodic silt and sediment cleanout efforts. The Coanda screen will likely need quarterly or more frequent cleaning of both the screen surface and the intake trough but will require less maintenance than Alternative 1. Concrete structures are recommended to be precast off-site to eliminate the need for delivery of concrete to the project site. The Coanda screen will require replacement approximately every 20 to 30 years.

The attached Exhibit 2 shows the conceptual design of the recommended alternative. The alignment of the piping will be further evaluated if this alternative is selected. The approximate cost based on conceptual level engineering design is $1.33M (see Note 1).

ALTERNATIVE 2A – INFILTRATION GALLERY ADDED TO ALTERNATIVE 2

The combination of an infiltration gallery and the Coanda screen offers a degree of water filtration, improving the overall quality of diverted water by reducing silt, sand, and other fines in the raw water delivery system, and allows for wintertime diversions. As previously outlined, both the Coanda and an infiltration gallery will require routine maintenance to sustain performance. A passive infiltration gallery would require no maintenance but would be subject to siltation over time and ultimately, would require replacement of the infiltration material. An active infiltration gallery will require quarterly maintenance for backwashing the collector screens and filter media with the use of pressurized air and water. Maintenance staff will need a portable pressure washer and air compressor for both cleaning processes. It is estimated that the filter media for a passive infiltration gallery will require replacement approximately every 5-10 years with an active infiltration gallery requiring replacement of the filter media every 10-20 years.

The approximate cost based on conceptual level engineering design for an infiltration gallery add-on is estimated to cost an additional $200,000 to $300,000 (see Note 1).

ADD ALTERNATIVE B – TELEMETRY

The approximate cost based on conceptual level engineering design is an estimated additional $25,000 for installation of telemetry and transmission equipment for connection into the State of Colorado's satellite monitoring system (see Note 1).

DIVERSION DESIGN RECOMMENDATION

The recommended diversion design is Alternative 2 which includes a rock weir with a Coanda screen and an optional infiltration gallery upstream of the weir. The rock weir will help direct channel flow to the Coanda screen, and the larger rocks will help protect the screen from large debris and cobbles. The optional Coanda protection assembly is also recommended to further protect the screen.

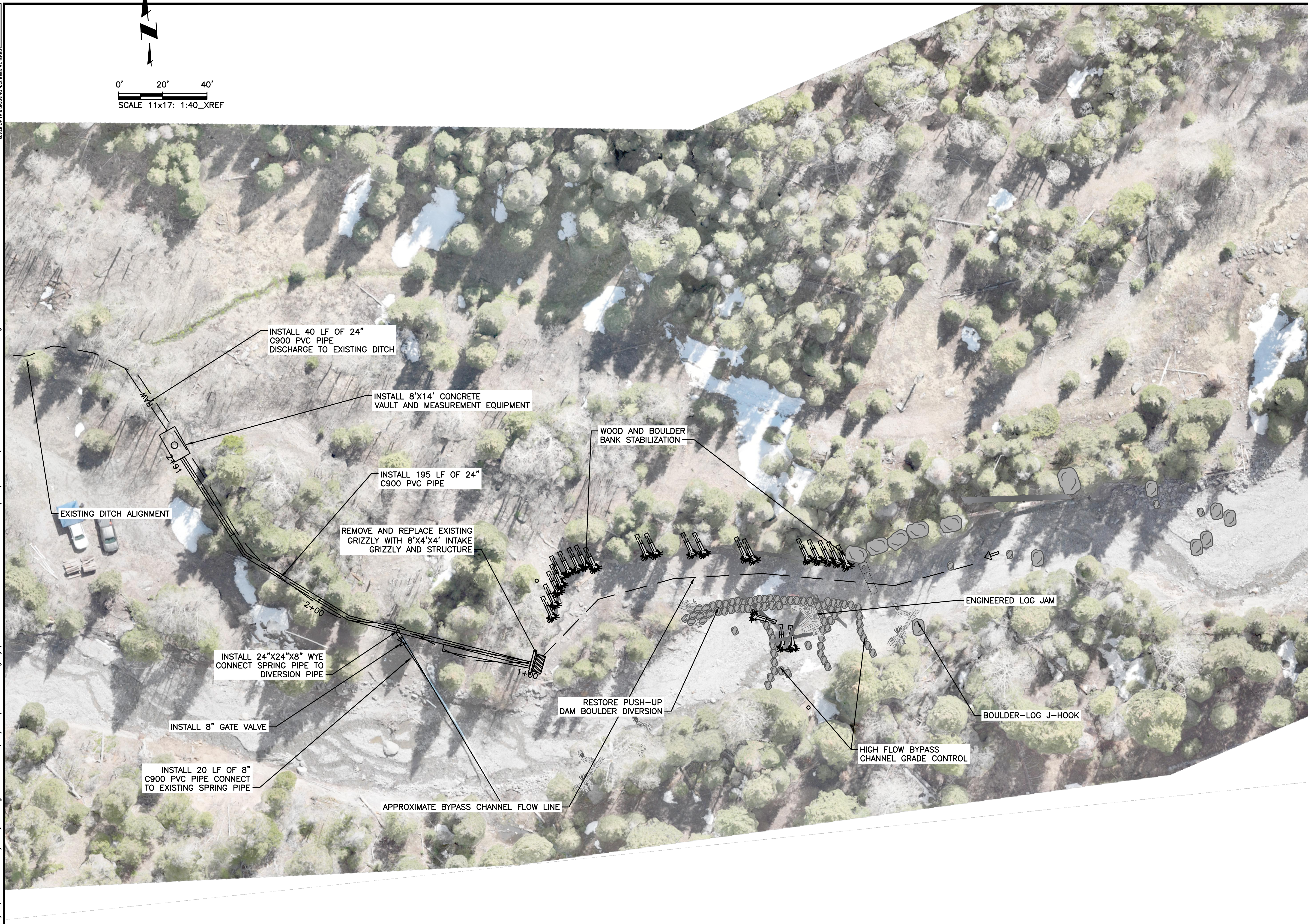
This design could offer an advantage of potentially diverting both surface and subsurface flows if the optional infiltration gallery (active or passive) is included. During the winter and other periods of low flow, the infiltration gallery would be designed in conjunction with the Coanda screen trough to capture creek flows that seep underground between the voids in the gravel channel bed or when the creek surface is frozen. Incorporating multiple diversion features within a single design also provides operational redundancy. In scenarios where one component is undergoing maintenance, the other can continue to function, ensuring consistent water diversion, although at potentially reduced flow rates.

However, the addition of an infiltration gallery comes with an increase in operation and maintenance costs due to the periodic need to remove and replace filter media as it becomes clogged or cleaning with an active system. Our field observations did not indicate that a significant amount of surface flows were being lost into the subsurface gravels. Thus, given the higher operation, maintenance, and replacement costs of an infiltration system and our field observations, we do not currently recommend inclusion of the infiltration galley unless it is imperative that the diversion system be operated in the winter or further investigations reveal a large porous alluvium at the diversion site.

In case site conditions during construction reveal a large amount of flow in the alluvium, it may be prudent to include the design of an infiltration system in the final design but as an add alternate such that it can be added if needed.

Note 1. The cost estimates provided are based upon conceptual designs for the purpose of a relative comparison of alternatives. The actual construction costs of these alternatives may vary from these estimates from -25% to +50% based upon a Class 4 level of engineering analysis per the Association for the Advancement of Cost Engineering (AACE) estimating standards. These costs will be further refined as the selected alternative concept is moved from concept to final design. As we move into the next design phases, we are prioritizing channel morphology and sediment transport dynamics, resilience to future debris flow events, and long-term structural stability and maintenance feasibility.

Attachment A – Conceptual Design Drawings



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RESPEC

TOWN OF RIDGWAY

BEAVER CREEK DIVERSION

DIVERSION ALTERNATIVE 1 EXHIBIT

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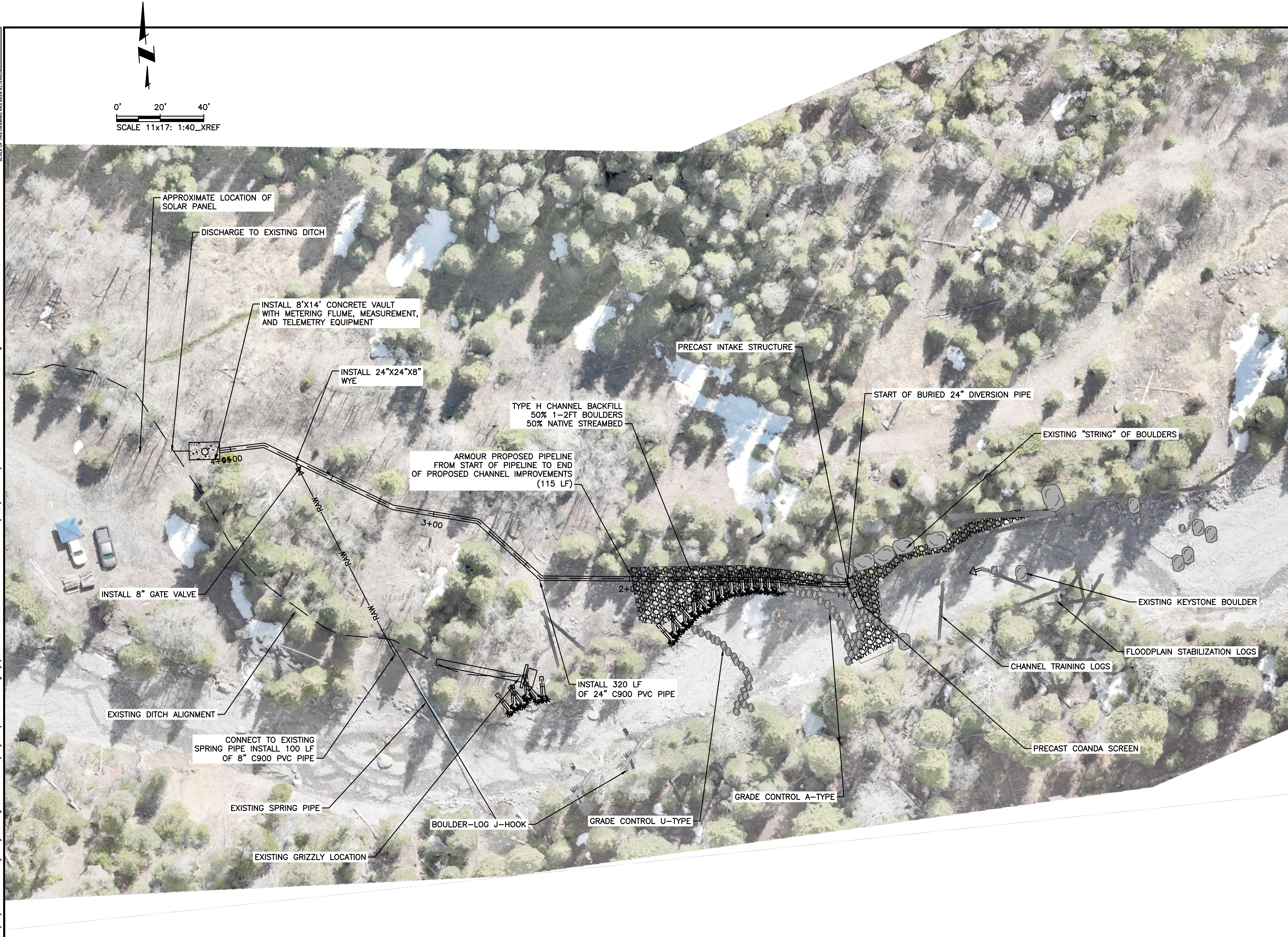

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RESPEC

TOWN OF RIDGWAY

BEAVER CREEK DIVERSION

DIVERSION ALTERNATIVE 2 EXHIBIT

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