TOWN OF RICO WASTEWATER TREATMENT & COLLECTION SYSTEM

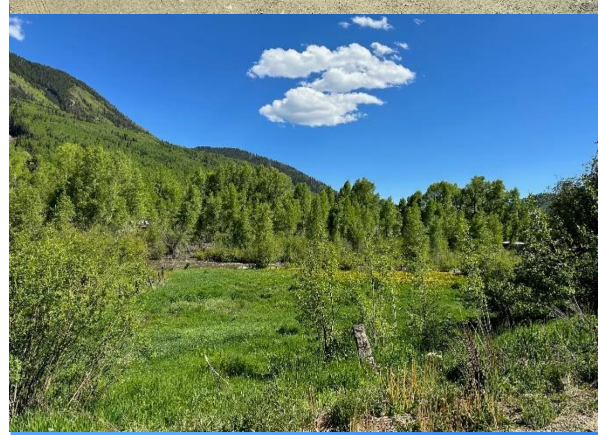
PRELIMINARY ENGINEERING REPORT UPDATE

DRAFT

DECEMBER 21, 2023

Prepared for:

Prepared by:



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PRELIMINARY ENGINEERING REPORT UPDATE

DECEMBER 21, 2023

Prepared for:

TOWN OF RICO
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LIST OF ACRONYMS

AC	Acres
ACS	American Community Survey
BHI	Bohannan Huston, Inc.
BOD	Biochemical Oxygen Demand
BMP	Best Management Practices
CDPHE	Colorado Department of Public Health & Environment
CFS	Cubic Feet Per Second
CMU	Concrete Masonry Unit
CO DOT	Colorado Department of Transportation
DWR	Division of Water Resources
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GPCD	Gallons per Capita per Day
GPD	Gallons per Day
HDPE	High Density Polyethylene
ISDS	Individual Sewer Disposal System
LF	Linear Feet
MBBR	Moving Bed Biofilm Reactor
MBR	Membrane Bioreactor
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
O&M	Operation and Maintenance
OWTS	Onsite Wastewater Treatment System
PEL	Primary Effluent Limitations
PER	Preliminary Engineering Report
RAS	Return Activated Sludge
RBC	Rotating Biological Contactor
ROW	Right-of-Way

RUS	Rural Utilities Service
SBR	Sequential Batch Reactor
TN	Total Nitrogen
Town	Town of Rico
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UV	Ultraviolet
WAS	Waste Activated Sludge
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The Town of Rico (Town) currently uses septic tanks to treat wastewater. However, the Town wishes to upgrade from individual sewage disposal systems (ISDSs) to a centralized wastewater treatment system in order to standardize wastewater treatment and improve the quality of wastewater effluent in an effort to protect the environment and people living in the Town of Rico. In order to have a centralized treatment facility, the Town will need to install a wastewater collection system to convey wastewater to the treatment facility.

This report evaluates WWTP and wastewater collection alternatives to serve the Town. Each of the WWTP alternatives evaluated within this report were selected based on their ability to meet wastewater effluent requirements as set by the Colorado Department of Public Health and Environment (CDPHE). Furthermore, each of the WWTP and collection system alternatives have the ability to treat and convey a calculated design average daily flow rate of 53,600 GPD, and a peak flow of 134,000 GPD. The evaluated WWTP alternatives include:

- Alternative 1 – No Action, illustrates current WWTP conditions.
- Alternative 2 – Conventional Activated Sludge, including flow metering, a new fine screen, activated sludge treatment basins, secondary clarification, chemical feed, tertiary filters, disinfection, solids handling equipment, and a building to contain treatment infrastructure.
- Alternative 3 – Membrane Bioreactor (MBR) including flow metering, a new fine screen, membrane treatment basins, chemical feed, disinfection, solids handling equipment, and a building to contain treatment infrastructure.
- Alternative 4 – Mixed Bed Biofilm Reactor (MBBR) including flow metering, a new fine screen, treatment tanks, secondary clarifiers, chemical feed, tertiary filters, disinfection equipment, solids handling equipment, and two small buildings for mechanical process equipment.

The evaluated collection system alternatives include:

- Alternative 1 – No Action, illustrates current wastewater collection conditions.
- Alternative 2 – Collection System including new 8-inch gravity and 2-inch force sewer mains (installed with a 4-inch pipe in trench for future), as well as two new lift stations. The collection system is separated into three construction phases.

The recommended project is the installation of an MBR Treatment Facility (WWTP, Alternative 2), and the installation of the first phase of the collection system (Collection System, Alternative 2 – P1).These projects, when combined, will convey sewage from the Town of Rico and treat it to the highest effluent quality, with the smallest overall footprint and without the requirement of tertiary filters. The total combined estimated cost for these recommended projects is $16,548,300.69. This project will improve the quality of wastewater effluent produced by the Town of Rico, comply with updated CDPHE regulations, and accommodate for future growth within the Town.

1 PROJECT OVERVIEW

1.1 PURPOSE AND SCOPE

This Preliminary Engineering Report (PER) was prepared by Bohannan Huston, Inc. (BHI) for the Town of Rico, located in Dolores County, Colorado. The purpose of this report is to evaluate wastewater treatment alternatives and wastewater collection system alternatives to serve the Town of Rico and to provide planning services.

The scope of this PER includes the following tasks:

- Define the project planning area boundary.
- Discuss project area, growth, and population trends.
- Define existing facilities, conditions, and wastewater facility needs.
- Evaluate wastewater treatment alternatives to serve the Town of Rico.
    - Alternatives developed in this PER include:
        - Alternative 1 – No Action, illustrates current WWTP conditions.
        - Alternative 2 – Conventional Activated Sludge, including flow metering, a new fine screen, activated sludge treatment basins, secondary clarification, chemical feed, tertiary filters, disinfection, and a building to contain treatment infrastructure.
        - Alternative 3 – Membrane Bioreactor (MBR) including flow metering, a new fine screen, membrane treatment basins, chemical feed, disinfection, and a building to contain treatment infrastructure.
        - Alternative 4 – Mixed Bed Biofilm Reactor (MBBR) including flow metering, a new fine screen, treatment tanks, secondary clarifiers, chemical feed, tertiary filters, disinfection equipment and two small buildings for mechanical process equipment.
- Evaluate wastewater collection systems alternatives to serve the Town of Rico.
    - Alternative 1 – No Action, illustrates current wastewater collection conditions.
    - Alternative 2 – Collection System including new 8-inch gravity and 2-inch force sewer mains (installed with a 4-inch pipe in trench for future), as well as two new pump stations.
- Review the recommended alternative for the Town of Rico.

1.2 BACKGROUND INFORMATION

The Town of Rico is located in the Eastern Region of Dolores County, Colorado. The Town is situated along the Dolores River and can be accessed by Colorado State Highway 145, and is located 28 miles Southwest of Telluride, CO, and 49 miles Northeast of Dolores, CO. The Town of Rico is about 400 acres and encompasses approximately 32 town blocks with roughly 5 blocks of commercial property. Existing development in the year 2021 consisted of 297 single family homes and roughly 30 commercial properties.

The Town is currently served primarily by private septic tanks. A centralized wastewater treatment system and facility does not yet exist in the Town or in any nearby region. With septic, it is challenging to regulate the effluent water quality in all tanks because some are new and designed by an engineer, while others are older and no longer meet regulation standards. All new construction and installation of individual sewage disposal systems (ISDSs) are required to be designed by a licensed engineer. The installation of new septic tanks, however, is usually prompted only by the failure of an existing ISDS or when a property is sold to a new owner.

For almost 30 years, the Town has been considering moving off septic and onto a centralized collection and wastewater treatment system. With Rico's proximity to Telluride, and the general appeal of mountain areas in Colorado, an increase in development and population is to be expected. While no evidence suggesting pollution of nearby water sources exists, moving to a centralized system will ensure that local water sources remain protected and that the effluent water quality meets Preliminary Effluent Limitations (PELs) defined by the Colorado Department of Public Health & Environment (CDPHE), especially as the Town grows. In recent years, Colorado Regulations 31 and 85, which pertain to surface water quality and nutrient regulations, have been amended to be more stringent. This recent update to regulations emphasizes the growing importance for the Town of Rico to move onto a centralized collection and wastewater treatment system in order to remain in compliance with current regulations.

1.3 PRIOR REPORTS

Throughout the last 30 years, the Town has had several evaluations and reports written in regard to a wastewater collection and treatment system. In preparing this PER, each of the Town's previous reports were closely analyzed in an effort build on work previously performed. The Town's previous reports are briefly summarized below.

1.3.1 WASTEWATER EVALUATION AND ANALYSIS (GOFF, 1995)

The 1995 report stated that the Town would be better off moving to a centralized collection and wastewater treatment system based on the various components of onsite sewage systems. The evaluation looked at three different alternatives: aerated ponds with advanced secondary treatment, a mechanical plant with advanced secondary treatment, and an advanced mechanical plant with advanced secondary treatment. A public meeting was held where the advantages and disadvantages of each option were discussed, and ultimately, the two options considered were a package treatment plant (oxidation ditch) and constructed wetlands. Both alternatives could remove the required amount of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) loadings after analysis. However, it appeared the constructed wetlands would not be able to meet the corresponding effluent limit for ammonia on a regular year-round basis. This report also stated that most of the Town could be served by conventional sewage collection lines but lift stations would be needed to serve some residences located below the potential gravity collection system. It concluded that an oxidation ditch would best serve the Town's needs if designed, constructed, and operated appropriately.

1.3.2 201 WASTEWATER FACILITIES PLAN (1999)

This study reviewed existing conditions of wastewater generation and treatment, along with the future need for the service area. Based on water quality standards and effluent limitations, several alternative wastewater collection systems and treatment options were presented. The evaluated alternatives included a wetland application, aerated lagoons, a rotating biological contactor (RBC), a sequential batch reactor (SBR), and an extended aeration activated sludge process. The aerated lagoon alternative was deemed undesirable for the Town due to the cold weather during winter months, which would create operational problems. In addition to operational problems, lagoons require more land area than mechanical plants. The recommended alternative was the RBC due to effective, reliable treatment with minimal process control problems and minimal land area usage. The components of this treatment method include primary settling or a flow equalization basin, RBC, secondary clarifier, effluent fine screen, ultraviolet (UV) disinfection, and an aerated sludge holding tank.

1.3.3 PRELIMINARY ENGINEERING REPORT (2003)

This analysis investigated potential issues with the Town continuing to rely on ISDSs and analyzed alternative solutions. The report primarily homed in on human health and safety concerns as the main reason for the Town to move onto a centralized wastewater treatment system. Due to course-grained soil conditions, the report stated that there likely was not sufficient depth to adequately treat septic tank effluents in many areas. The criteria evaluated to determine the best solution for the Town were location, environmental resources present, growth area, and population trends.

The evaluated criteria concluded that the best option would be moving from ISDS to a centralized wastewater treatment process to support the growth of the Town and preserve both human and environmental health. The alternative treatment processes included an aerated lagoon, constructed wetlands, extended aeration activated sludge, re-circulating sand filter, RBC, and SBR. All the treatment technologies considered would require some form of primary treatment (such as trash screening and grit removal) and some form of sludge wasting and handling. Constructed wetlands were eliminated as an alternative because they are used to polish the effluent from primary or secondary treatment and do not function well in cold climates. The aerated lagoon was also eliminated as an option because it would not provide adequate treatment during winter months and was less aesthetically pleasing. The re-circulating sand filter followed by disinfection via UV light was the most preferred alternative due to its relatively low capital and operation and maintenance (O&M) costs, simplicity of operation, effluent which is well-suited for UV disinfection, need for only a relatively small area of land, and excellent odor control.

1.3.4 CULTURAL RESOURCE SURVEY (2003)

This survey was a Class III intensive cultural resource survey for a portion of the proposed central wastewater collection and treatment facilities for the Town. The report contains a section on the cultural history of the Colorado River Basin, specifically in the Western San Juan Mountains. The objective was to identify any remaining cultural resources, determine their significance, and to make recommendations for the proposed installation of a wastewater treatment system. A site containing the structure of a former power plant and the neck of a prehistoric bottle were found in the area. Additionally, the railroad grade was recorded as a linear segment of the Rio Grande Southern Railroad, and a water tank from the Rio Grande Southern Railroad was noted in the survey. No artifacts or indications of prehistoric activity were observed. In the end, no further action was recommended regarding the known cultural resources in the Town.

1.3.5 RICO FLOOD HAZARD EVALUATION REPORT (2004)

This report identified areas in the Town that are more prone to flooding. One major flood hazard identified was the Dolores River, which is known to have caused costly railroad washouts in the past. It was estimated that a 100-year flood in the Dolores River would produce a flow of 2,800 cfs, while a 500-year flood would produce a flow of 6,000 cfs. Another hazard identified in the Town were tributary fans, which are known to transport large volumes of sediment during and following torrential rainstorms. Other potential bodies of water prone to flooding include Deadwood Gulch, Spruce Gulch, Sulphur Creek, and Burnette Creek. Based on these flooding patterns, three sites were identified as good spots to place a new WWTP: North Cemetery, Sundial, and softball fields. After analysis, it was determined that the best place to put the WWTP would be at the softball fields.

1.3.6 RICO WWTP AND COLLECTION SYSTEM FINAL DESIGN REPORT (2007)

In 2007, design plans were drawn up for a wastewater collection system for the Town. Within the design report, there was a geotechnical report, trench drawings and details, sewer line capacity calculations, phasing, and an engineer's cost estimate. The geotechnical report found that the underlying soil material was made primarily of clayey sand with various amounts of gravel, cobbles, and boulders in addition to limestone bedrock. Different sizes of multi-benched trenches were proposed for various bury depths. The collection system was laid out for the vast majority of the Town. The collection system was designed such that the trunk line terminated on the southern end of the Town along Street 3. This was done with the implied intent that wastewater would be conveyed from the Town to the WWTP at the North Cemetery site as laid out in the Rico Flood Hazard Evaluation Report done in 2004.

1.4 REPORT ORGANIZATION

This PER follows the U.S. Department of Agriculture's Rural Utilities Service Bulletin 1780-2, Preliminary Engineering Reports for the Water and Waste Disposal Program (USDA RUS 1780-2).

2 PROJECT PLANNING

2.1 LOCATION

The project planning area is the Town of Rico (Town), located in the Eastern Region of Dolores County, Colorado. The Town is situated along the Dolores River and was originally settled in 1879 for the purposes of serving as a silver-mining hub. The Town can be accessed by Colorado State Highway 145, and is located 28 miles Southwest of Telluride, CO, and 49 miles Northeast of Dolores, CO. Figure 1 shows the location of the Town in relation to key landmarks and neighboring towns.

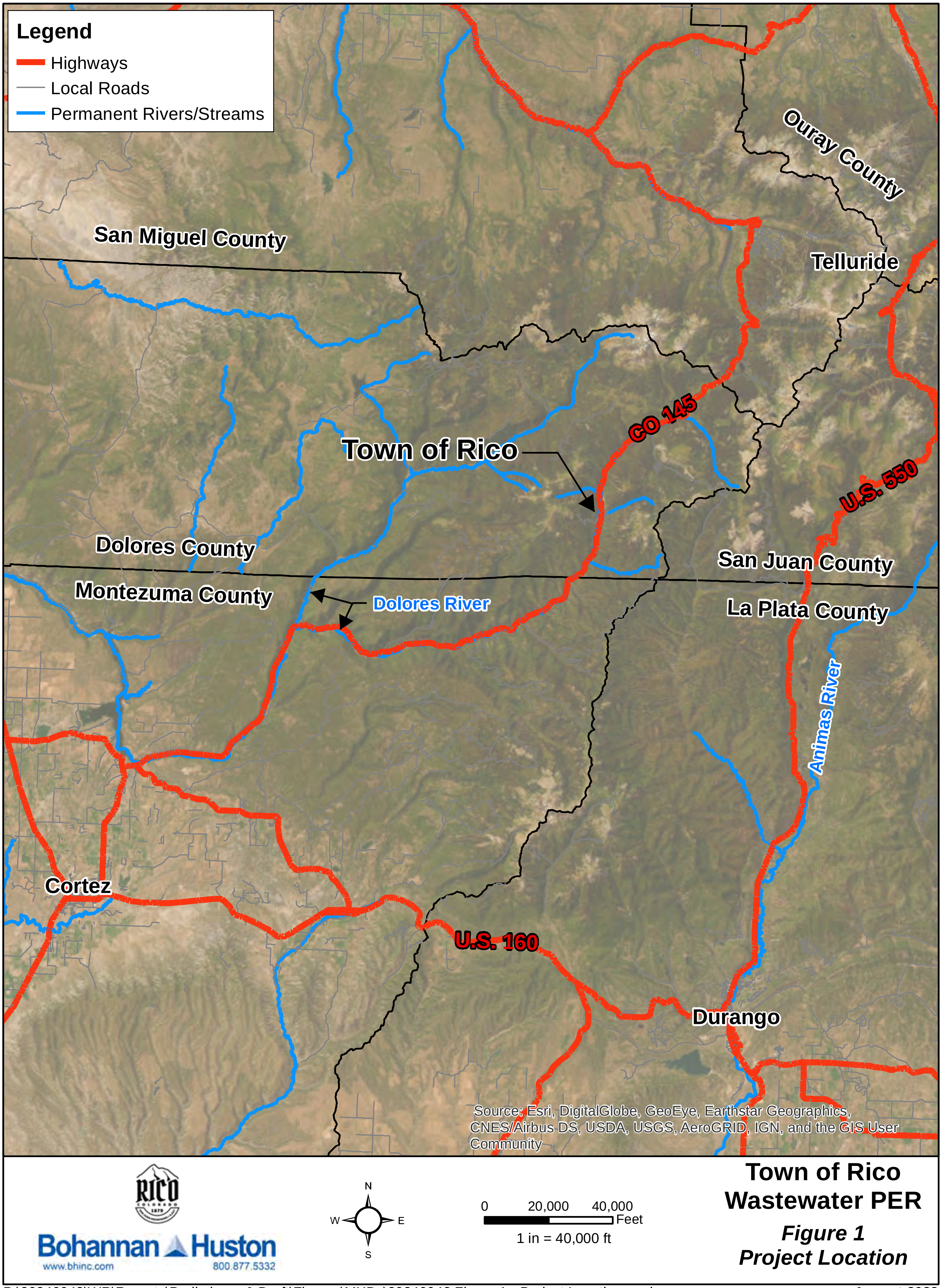
2.2 ENVIRONMENTAL RESOURCES PRESENT

2.2.1 LAND USE

2.2.1.1 *Land Cover*

Land Cover information was obtained from the USDA's Natural Resources Conservation Service (NRCS) Data Portal. An analysis was performed to determine the distribution of land cover within the Town of Rico and surrounding areas. The land cover distribution for the area can be observed in Table 1. Figure 2 shows the land cover distribution within the Town of Rico and the surrounding vicinity.

Current zoning information for the project planning area was downloaded from the Town's website. The largest land zones in the Town are Residential and Residential Planned Unit Development, followed by Mixed Used and then Commercial (including Historic and Planned Unit Development) and Open Space. The land zone for public facilities is among the smallest zoning category in the project planning area. Appendix A shows the Official Zoning Map for the Town of Rico.



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Town of Rico
Wastewater PER

Figure 1
Project Location

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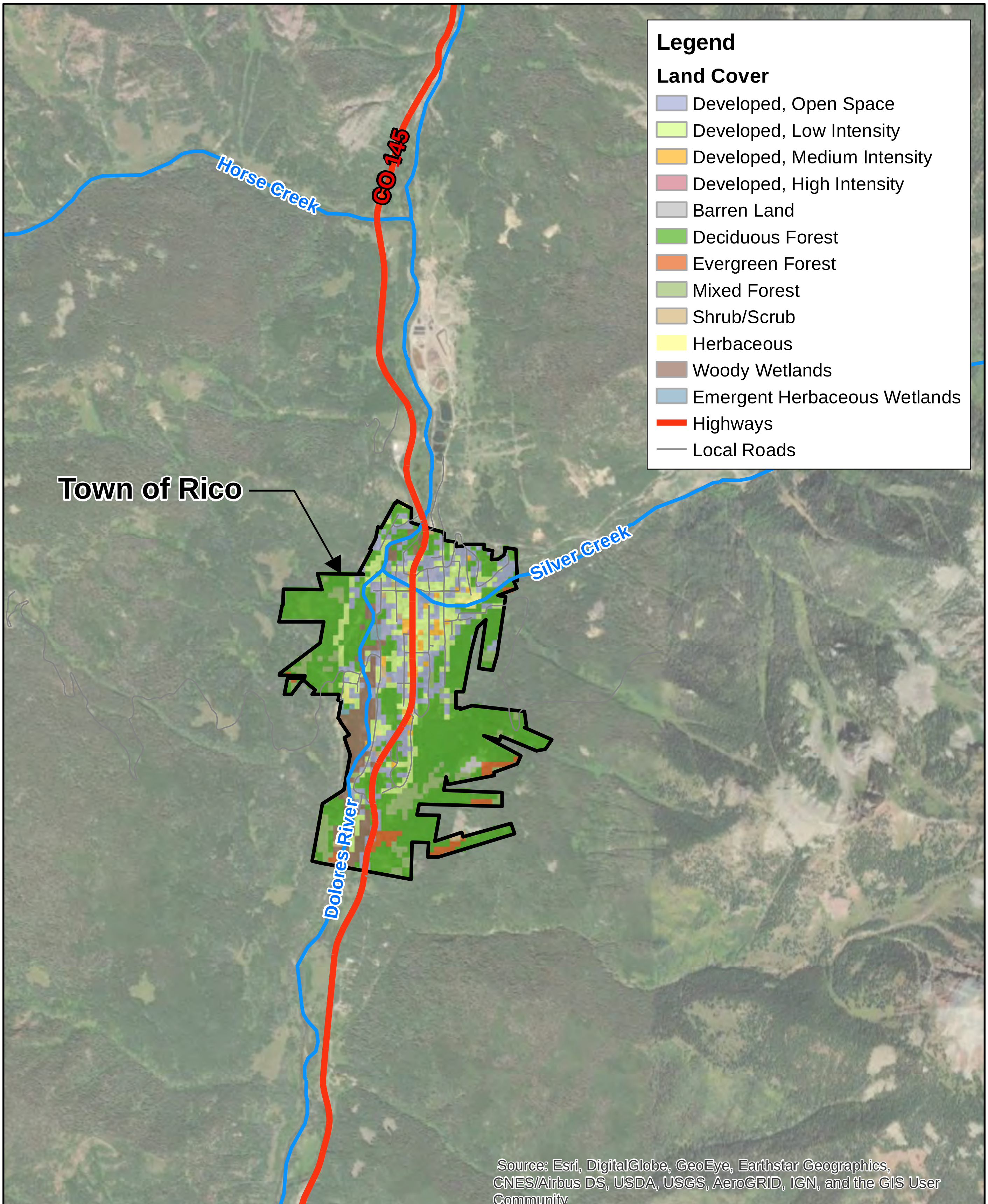
Author: cpepin

August 2023



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N W E S

0 1,250 2,500 Feet
1 in = 2,500 ft

Town of Rico
Wastewater PER

Figure 2
Land Cover

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Table 1 – Land Cover within the Town of Rico

Land Cover	Area (ac)	Percentage
Developed, Open Space	73.11	16.85%
Developed, Low Intensity	65.78	15.16%
Developed, Medium Intensity	8.67	2.00%
Developed, High Intensity	0.22	0.05%
Barren Land	1.33	0.31%
Deciduous Forest	202.00	46.54%
Evergreen Forest	10.00	2.30%
Mixed Forest	27.78	6.40%
Shrub/Scrub	3.33	0.77%
Herbaceous	3.56	0.82%
Woody Wetlands	35.78	8.24%
Emergent Herbaceous Wetlands	2.44	0.56%

2.2.1.2 *Important Farmland*

Prime and important farmland includes all land that is defined as prime, unique, and farmlands of statewide or local importance as designated by the NRCS. Likely given its mountainous terrain, the Town only contains land which is classified as “not prime farmland”, as demonstrated in Figure 3. The data used in Figure 3 was obtained from the NRCS along with a soil and farmland designation report for the Town of Rico and the greater surrounding area. The NRCS Soil Survey containing farmland designations can be observed in Appendix B.

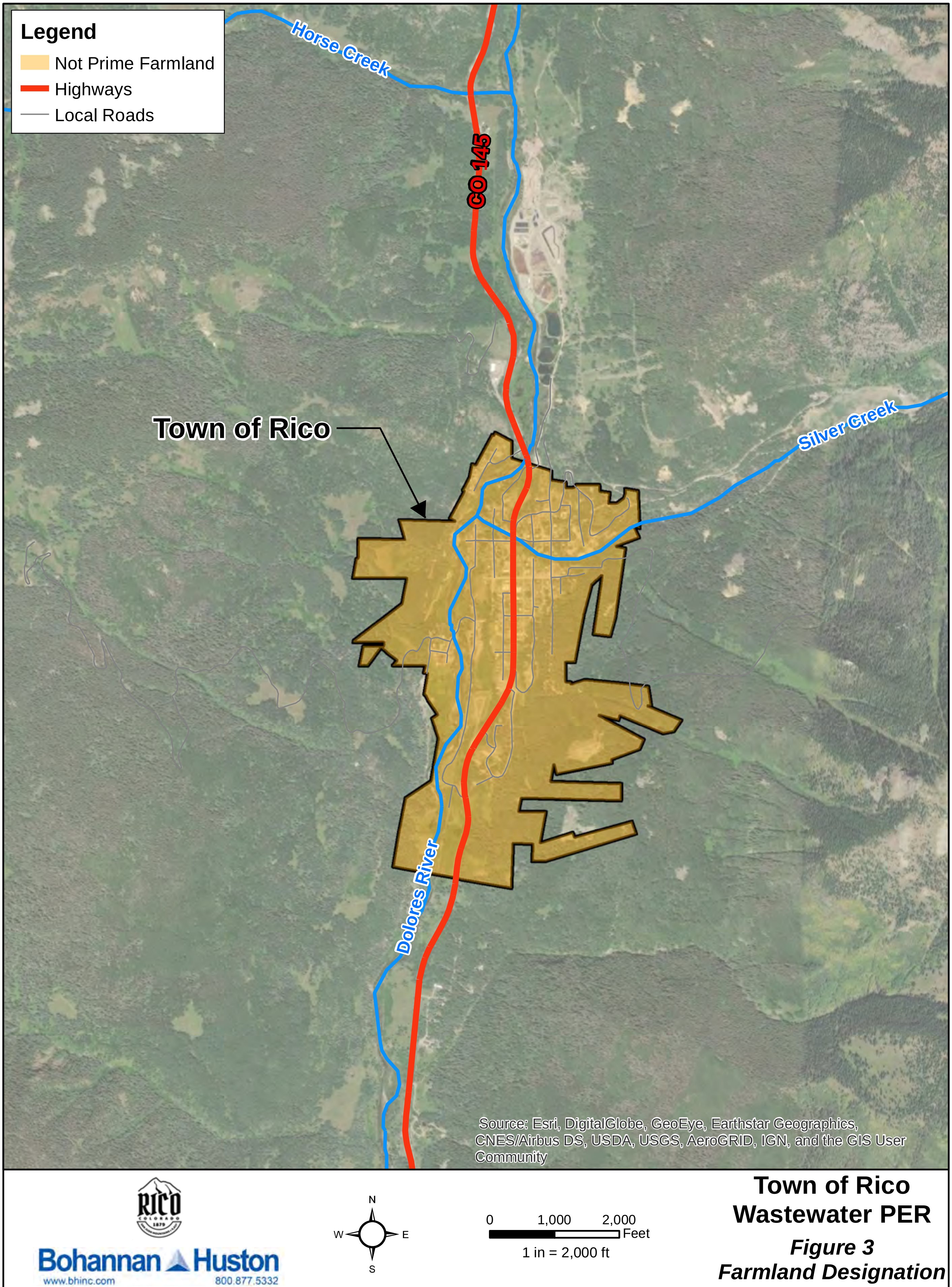

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Figure 3
Farmland Designation

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\\a-abq-fs2\ABQ-Projects\20240048\WR\Reports\Preliminary & Draft\Figures\MXDs\20240048 Figure 3 - Important Farmland.mxd **August 2023**
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2.2.2 SOILS

Soil data was obtained from the NRCS Web Soil Survey for the Town of Rico. Soil types within the Town Limits are listed by percent of total area in Table 2. Soil within the Town is primarily classified as Frisco-Horsethief complex (30 – 75 percent slopes), which is a well-drained soil originating from mountain slopes. The majority of soils in the Town originate from Mountain slopes with the exception of Quazar very cobbly loam, which originates directly from alluvial fans and Cryaquolls-Typic Cryaquents complex that lines the Dolores River and originates from floodplains and valley floors. Figure 4 shows the distribution of soils within the Town, and the NRCS Soil Survey can be found in Appendix B.

Table 2 – Town of Rico Soils

Soil Name	Area (ac)	Percent
Water	7.19	1.66%
Frisco-Horsethief complex, 10 – 30 percent slopes	11.99	2.76%
Frisco-Horsethief complex, 30 – 75 percent slopes	199.02	45.86%
Hourglass-Bucklon-Wander complex, 30 – 60 percent slopes	57.55	13.26%
Cryaquolls-Typic Cryaquents complex, 1 – 5 percent slopes	55.15	12.71%
Quazar very cobbly loam, 5 – 25 percent slopes	79.13	18.23%
Dressel-Jersey complex, 30 – 80 percent slopes	23.98	5.52%

2.2.3 GEOLOGY

Geological data for the State of Colorado, prepared by the Colorado Geological Survey, was obtained from the Colorado Information Marketplace. Figure 5 demonstrates the geology of the Town of Rico and the surrounding area. Within the Town, the geology is primarily sedimentary and unconsolidated, with a small proportion of metamorphic geology in the northern part of Town.

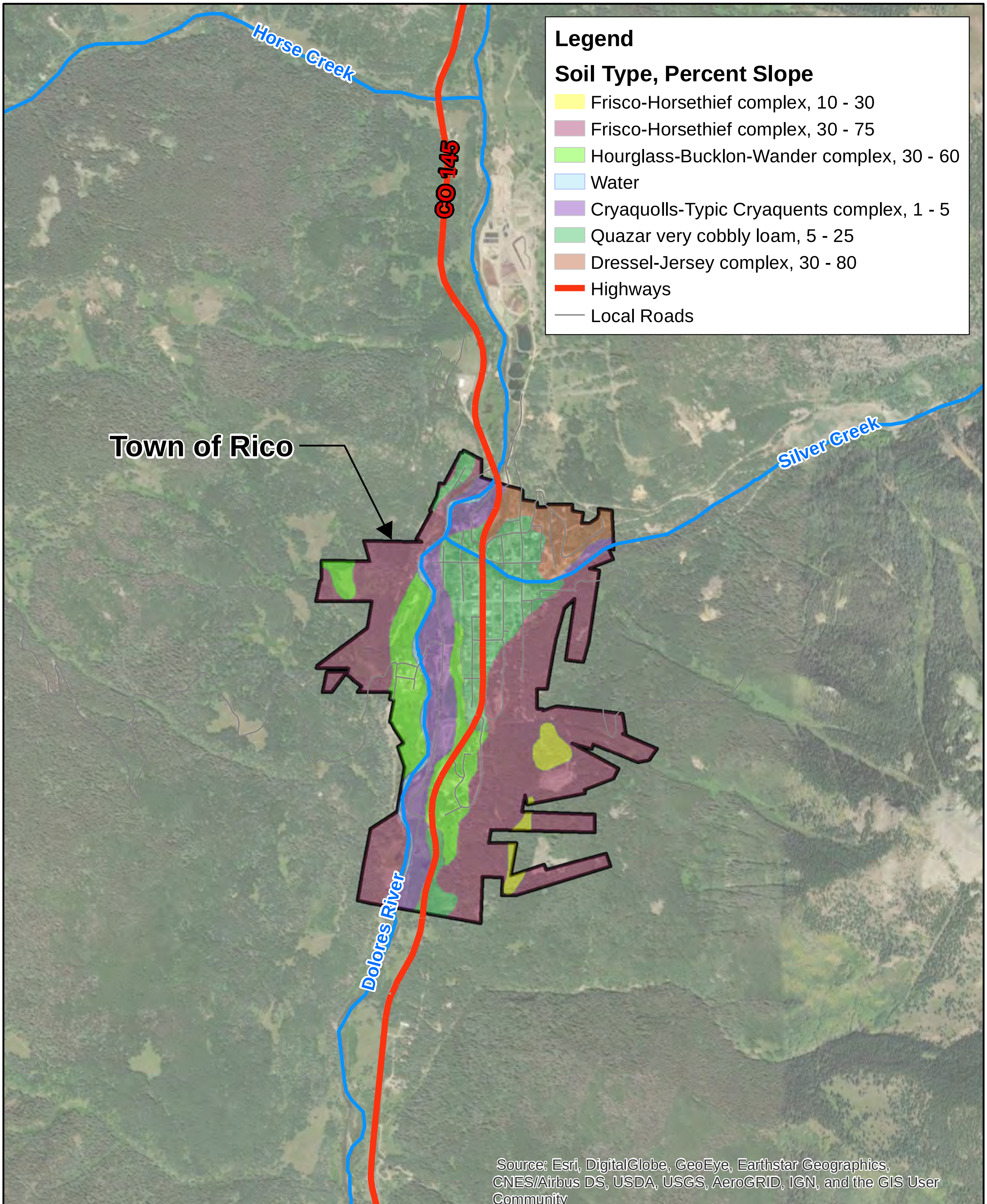

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Figure 4
Soil Types

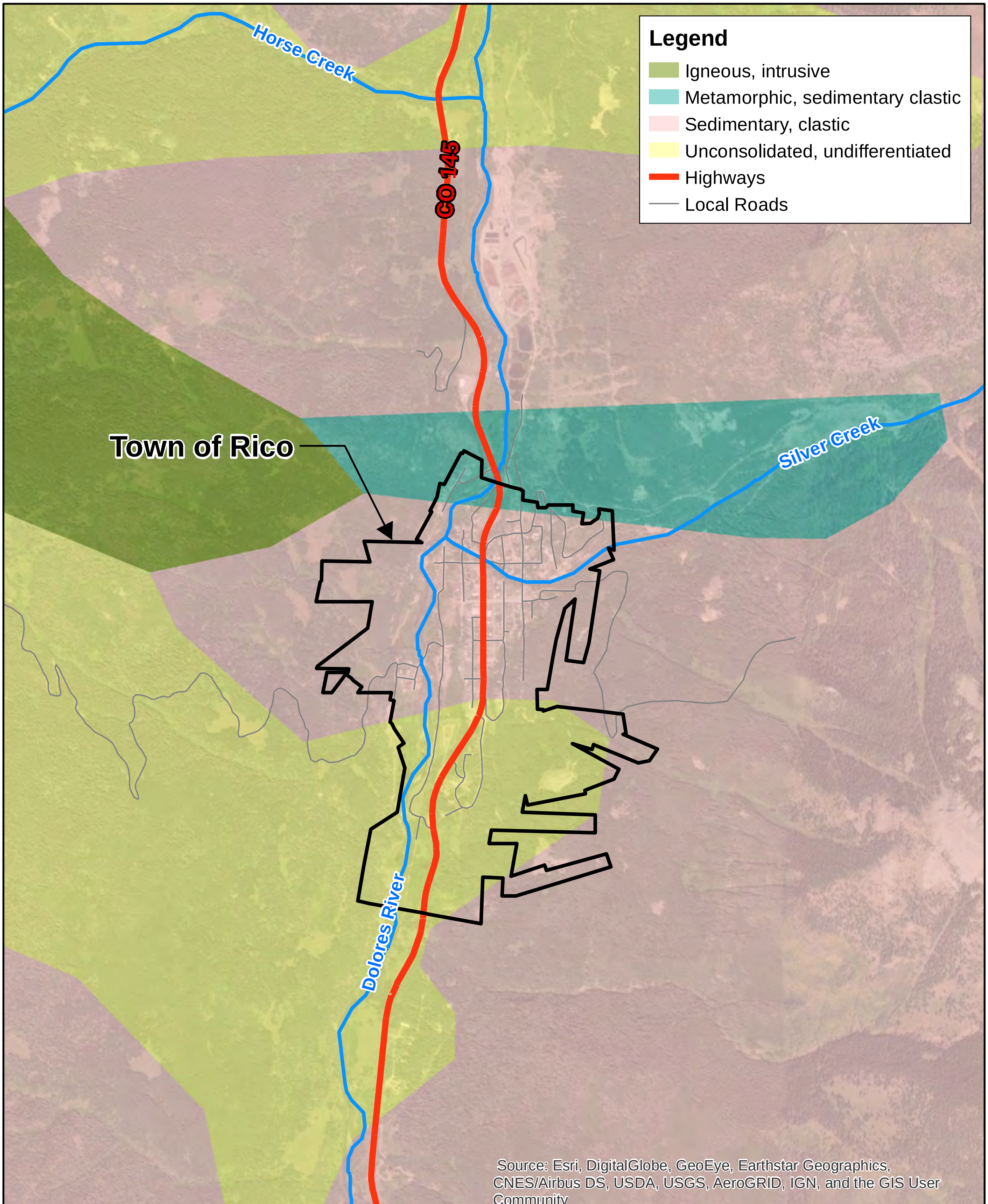

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Figure 5
Geology

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2.2.4 WATER RESOURCES

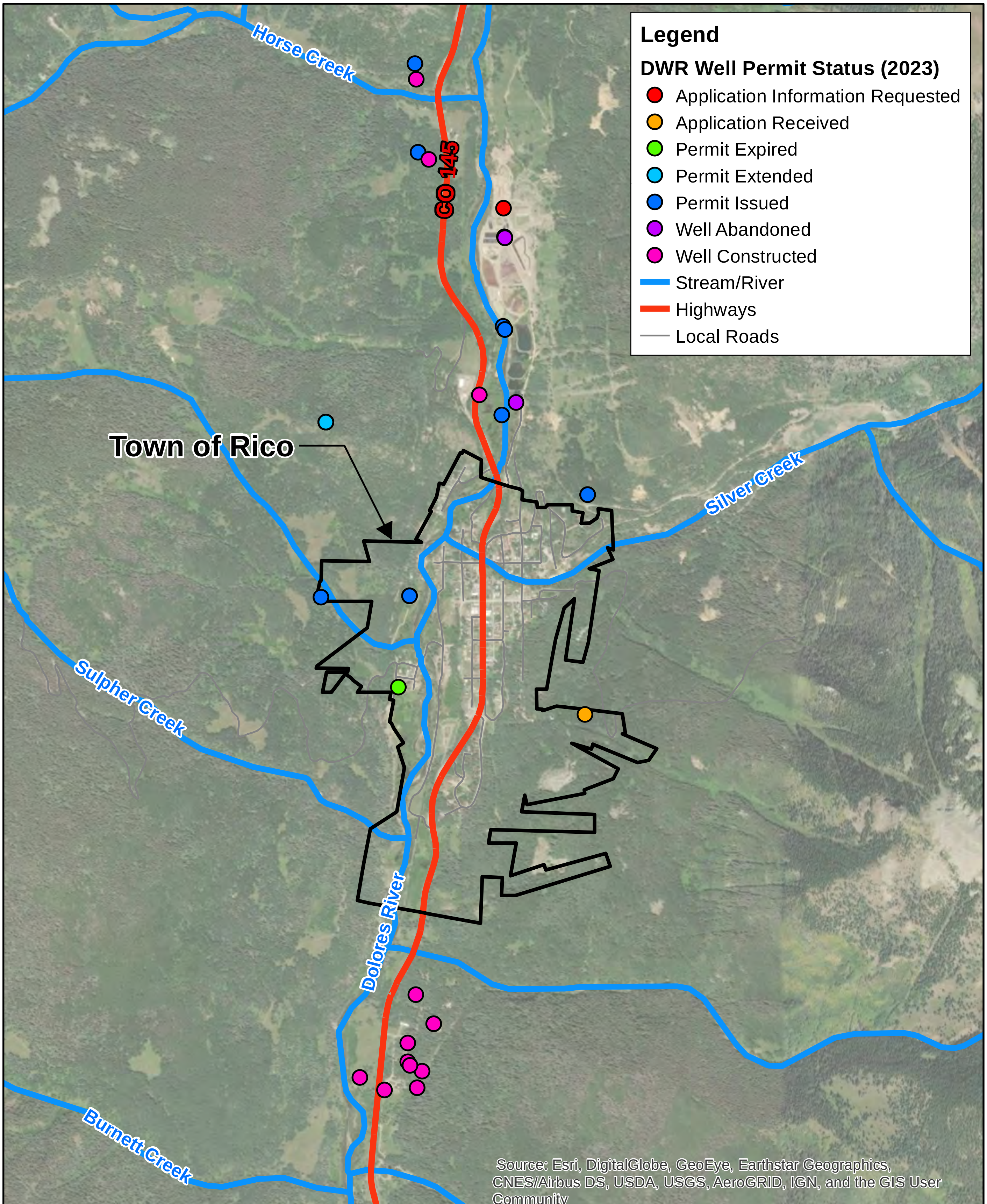
2.2.4.1 *Surface Water and Groundwater*

The Town is situated along the Dolores River within the San Juan Range of the Rocky Mountains. There are three known creeks that flow into the Dolores River within the Town limits, and there are no lakes within the Town. Generally, rainfall and snowmelt in the Town will either infiltrate to groundwater or flow into the Dolores River and the Dolores River's tributaries. Data for linear surface water features was downloaded from the United States Geological Survey (USGS) as part of the National Hydrography Dataset (NHD).

The Town is situated above the Paradox Groundwater Basin, and according to data from the Colorado Division of Water Resources (DWR), there are several groundwater wells nearby and within the Town in various stages of permitting and use. Figure 6 shows the surface water features and groundwater wells, including their DWR permit status, for the Town of Rico and surrounding areas.

Drinking water in the Town is sourced from both surface and groundwater. The groundwater drinking well is located north of the Town and Silver Creek, while surface drinking water is obtained from an infiltration gallery located along Silver Creek. According to the Town's most recent Drinking Water Quality Report published in 2021, the Town's water does not exceed any U.S. Environmental Protection Agency (EPA)-regulated primary drinking water quality standards. The 2021 Drinking Water Quality Report for the Town of Rico can be found in Appendix C.

There is significant geothermal activity surrounding the Town. A Geothermal report for the Town of Rico, published in 2018, noted that the Town had been identified by the Colorado Geological Survey as a particularly promising geothermal resource given that the area has the second-highest heat flow in the state and is surrounded by ample water resources. The purpose of the 2018 report was to perform a magnetotelluric survey in order to measure the depth, volume, and temperature of the Town's geothermal reservoir; information which may provide additional insight on the feasibility of a future geothermal project. The Rico Geothermal Report is included as Appendix D.



Town of Rico
Wastewater PER

Figure 6
Water Features

2.2.4.2 *Wetlands*

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development. The U.S. Fish and Wildlife Service (USFWS) provides information on the extent and status of the Nation's wetlands through the National Wetlands Inventory (NWI). The Wetlands Geodatabase was downloaded from the NWI.

The project planning area has several freshwater emergent wetlands and forested/shrub wetlands. Furthermore, there are a few freshwater ponds and a significant riverine corridor within the project planning area. The wetlands, ponds, and riverine corridor within the project planning area and surrounding vicinity can be observed in Figure 7.

2.2.5 FLOODPLAINS

The Federal Emergency Management Agency (FEMA) last published a flood insurance study of the Town of Rico in 1986, according to FEMA's map service center website. The FEMA flood insurance rate map (FIRM) can be observed in Appendix E. The FIRM identified 100-year flood areas and areas of minimal flooding; however, given that this FIRM is 37 years old at the time this report is being written, some areas identified in the FIRM may have shifted or changed in size. All 100-year flood areas identified in the FIRM are located along the banks of the Dolores River and Silver Creek and appear to be of minimal impact to the Town's infrastructure. The area assessed in the 1986 FIRM was limited and did not include the entire Town of Rico; no additional data for the remaining portion of the Town was available from FEMA.

2.2.6 HISTORIC PROPERTIES

The National Park Service's (NPS) National Register of Historic Places lists five sites for Dolores County and three sites for the Town of Rico. The first listed historic site is the Rico City Hall. The Rico City Hall was built in 1882 during the middle of the Town's gold boom. The City Hall served as the County Seat for Dolores County for 53 years until it was moved to Dove Creek in 1946 during the decline of the Town's gold boom. The City Hall was registered as a historic place in 1974.

The second listed historic site is the William Kauffman House. This historic site is a brick masonry house built in 1891. The William Kauffman House served as the Kauffman family home until 1915; this home was later acquired in the 1940s by the Rico Argentine Mining Company and was used for worker housing until the mine closed in 1971. The William Kauffman House was registered as a historic place in 1982.

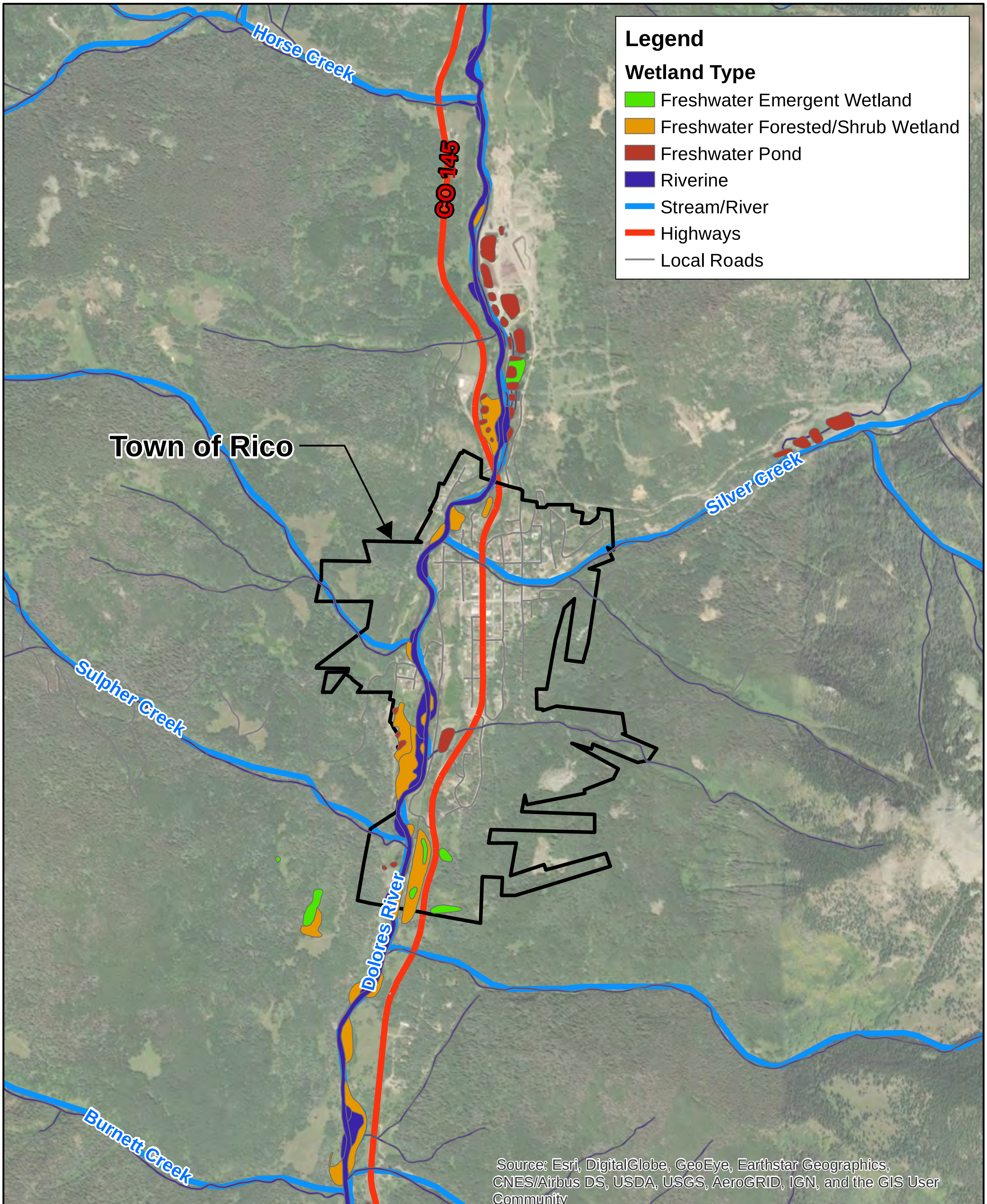


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Figure 7
Wetlands

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The third listed historic site is the Dey Building. The Dey Building, built in 1892, was constructed around the same time as the Rico City Hall. The Dey Building was constructed to house a Saloon on the ground floor and offices on the second floor. Throughout the building's lifespan, the Saloon has remained in almost-continuous operation and remains operational in present times as the Enterprise Bar and Grill. The Dey Building was registered as a historic place in 1999.

The addresses and listing details for Rico's three historical sites can be found on the National Park Services website in the National Register of Historic Places Database and are listed below in Table 3.

Table 3 – Registered Historic Sites

Name	Address
Rico City Hall	NE corner of Commercial and Mantz Streets
William Kauffman House	Silver Street
Dey Building	3 N. Glasgow Street

2.2.7 THREATENED OR ENDANGERED SPECIES

The USFWS is responsible for protecting the many plant and animal species that are threatened with extinction because of human activities. The USFWS Critical Habitat Portal was used to obtain information regarding threatened or endangered species and important wildlife habitats in or near the project planning area that might be disturbed by new wastewater collection infrastructure and a wastewater treatment facility. While no designated critical habitats are identified within the planning area, there is one critical habitat identified in the western region of Dolores County (Table 4).

Table 4 – Dolores County Critical Habitat

Group	Common Name	Scientific Name	Status
Birds	Gunnison Sage-Grouse	Centrocercus minimus	Threatened

2.2.8 SOCIOECONOMICS, ENVIRONMENTAL JUSTICE

Executive Order 12898 established the requirement to address environmental justice concerns within the context of agency operations. As part of the National Environmental Policy Act (NEPA) process, agencies are required to identify and address disproportionately high and adverse human health of environmental effects on minority or low-income communities (Council on Environmental Quality, 1997).

The American Community Survey (ACS) produces population, demographic, and housing unit estimates. The 2021 ACS 5-Year Estimate lists median household income and poverty status in the past 12 months for families by family type. Socioeconomic data was compiled for Colorado, Dolores County, and the Town of Rico, where the project is located, as shown in Table 5. The survey estimates that there are 238 households within the Town of Rico with a median household income of $57,500, and 6.3% of the Town is living in poverty. Furthermore, the median household income in the Town is substantially lower than the median household incomes of both Dolores County and the State of Colorado.

The project discussed herein is not expected to result in disproportionately high and adverse human health or environmental effects but would instead improve conditions for an area with a higher percentage of persons in poverty than both Dolores County and the State of Colorado.

Table 5 – Income and Poverty Estimates

2021 ACS 5-Year Estimates	Median Household Income	Total Households	Persons in Poverty
Colorado	$82,254 ± $791	2,313,042 ± 8,099	6.2% ± 0.4%
Dolores County	$65,061 ± $18,181	906 ± 118	5.2% ± 4.9%
Town of Rico	$57,500 ± $35,445	238 ± 63	6.3% ± 7.8%

2.3 POPULATION TRENDS

Population data was obtained from the U.S. Census Bureau for the years 2011 and 2021. The U.S Census Bureau-reported population of the Town of Rico was 332 at the time of the 2011 Census, and 406 in 2021. From 2011 to 2021, the Town's population increased by 74 people. This increase corresponds to an annual population increase of 2.03%.

The planning period for this project is 20 years and is projected to span through 2043. Given the significant population increase in the Town from 2011 to 2021, the population of the Town in 2043 was estimated using the 2.03% annual growth rate observed from 2011 to 2021.The population of Dolores County in 2043 was estimated using a calculated 1.14% annual growth rate, and the population of Colorado was estimated using a calculated 1.43% annual growth rate. Table 6 lists census data and future-projected populations for the State of Colorado, Dolores County, and the Town of Rico.

Table 6 – Census Data

Location	2011 Census	2021 Census	2023 Estimate*	2043 Estimate
Colorado	4,966,061	5,723,176	5,887,923	7,820,098
Dolores County	2,043	2,288	2,340	2,935
Town of Rico	332	406	432	632

*2023 Census data is not yet available and was therefore estimated.

2.4 COMMUNITY ENGAGEMENT

The Town is governed under a Home Rule Charter, which was adopted on May 2, 2000. The Home Rule Charter establishes autonomy for the Town of Rico within the framework of the Colorado Constitution, provides structure and guidelines for local governance, and documents methods for safeguarding overall community health. As defined in the Home Rule Charter, the Town is governed by a publicly elected board of seven non-partisan trustees, and one mayor.

A comprehensive list of the Town's current mayor and board of trustees can be found on the Town website along with the updated Board of Trustees meeting schedule. At the time this report is being written, the Board of Trustees meets the third Wednesday of every month to discuss and vote on local issues and ordinances. All Town ordinances and changes in Town guidelines, including water system changes and possible future sewer rate structures, must be approved by the Board of Trustees; however, public participation at each board meeting is strongly encouraged so that changes enacted by the Board can be assured to be representative of public interests and needs.

3 EXISTING FACILITIES

3.1 EXISTING SYSTEM

The Town currently relies upon privately owned septic tanks. They do not have a collection system or a uniform wastewater treatment facility to treat water and dispose of waste properly.

3.2 CONDITION OF EXISTING FACILITIES

The Town is currently dependent on septic tanks. Due to the private nature of septic tanks, there is no consistently reliable way to know the quality of effluent produced or the status of the septic tanks themselves. Furthermore, the structural integrity of private septic tanks could range anywhere from good to potentially damaged and defective, depending on original quality, age, operation, and many other variables. Existing septic tanks must follow the CDPHE Regulation 43. This regulation requires permitting prior to installing, altering, or repairing a septic system and became effective in June 2017. Septic tanks installed prior to this date may not have adhered to such uniform regulations. Around the same time, the Town also passed Town ordinance number 2017-01, which is "an ordinance amending the Rico land use code by the addition of onsite wastewater treatment system regulations". This regulation establishes minimum standards for onsite wastewater treatment systems (OWTSs) with a capacity of less than 2,000 GPD in regard to design, construction, performance, installation, alteration, and use of OWTSs. This regulation delves into the specific permitting requirements for the installation of a new OWTS.

3.3 FINANCIAL STATUS OF EXISTING FACILITIES

Due to the private nature of the infrastructure in the Town, there is currently no income generated by wastewater related utilities for management of wastewater infrastructure. This is entirely due to the fact that the Town does not have any wastewater collection or treatment infrastructure to maintain at this stage. In conversations with the Town, once infrastructure and a WWTP are installed, the Town will undergo a rate study in order to determine an appropriate service charge to be implemented for both residential and commercial users. Furthermore, the Town has stated that they also intend to instate a one-time connection fee for all new residential and commercial wastewater system users. Once the collection system and WWTP are installed, the Town intends to begin requiring that septic tanks are properly de-commissioned and connections to the collection system are made in order to comply with CDPHE regulations and maintain the pristine water quality of surrounding water bodies.

3.4 WATER/ENERGY/WASTE AUDITS

Specific information regarding past energy and waste audits conducted by the Town is not known. However, the Town is currently undergoing a water impact fee study to evaluate the appropriate water rates that should be applied to the Town's water distribution network. Previous reports regarding the water supply and distribution network in the Town have focused primarily on water supply resiliency and capacity. These reports will likely be considered in the current water impact fee study along with current water usage data.

4 NEED FOR PROJECT

The Town currently relies on private septic tanks to treat waste. Without proper maintenance, septic tanks will eventually fail over the course of time and may lead to contamination of local water resources. Furthermore, with tightening regulations from CDPHE, it is important that the Town address wastewater treatment so as to not be found out of compliance.

The Town's desire to move to a centralized sewer and wastewater treatment system can be summarized as follows:

- The current system relies on individual septic tanks for wastewater treatment which produces wastewater effluent of varying quality that may pose a risk of contamination to nearby water resources.
- Given the Town's current treatment system, the Town would like to proactively address wastewater treatment and improve wastewater quality to avoid potential effluent quality mandates that could be imposed on the Town by CDPHE.
- CDPHE has tightened discharge requirements for treatment facilities looking to discharge to surface water bodies. The amendments to Regulations 31 and 85 will not be enforced for approximately four years; however, the Town would like to proactively evaluate these amendments to ensure compliance with these regulations before they are enforced.
- The Town is expected to continue to grow. By installing a centralized sewer and wastewater treatment system, the Town will be able to grow without installing additional septic tanks that produce lower quality effluent than a mechanical wastewater treatment facility.
- The Town has been considering a centralized sewer and treatment system for almost 30 years and currently feels well positioned to transition off of septic tanks.

4.1 HEALTH, SANITATION AND SECURITY

The composition of wastewater discharged to the environment is not currently known since the septic tanks are privately owned and effluent flows are unmonitored. If a septic system is older or failing, wastewater will not be treated sufficiently enough to remove pathogens or nutrients, and therefore, insufficiently treated wastewater will be released into the environment. Untreated wastewater can contaminate ground and surface water with pathogens, chemicals, and nutrients. In some cases, the release of untreated wastewater to the environment can negatively impact drinking water and create unhealthy conditions for those using surface water for recreational uses. Additional nutrients brought into surface water from wastewater can also cause the formation of harmful algal blooms which produce dangerous toxins that can cause harm to people and animals and make water treatment difficult. Poorly maintained septic tanks can also become vulnerable to collapse and cave-ins over time. Failing tanks have the potential to release fumes, such as carbon dioxide, ammonia, and hydrogen sulfide, into the air.

Implementing a centralized wastewater treatment facility would ensure that the wastewater treatment performed is reliable and reduces or eliminates poor-quality effluent. With a mechanical system, a certified operator will ensure that the effluent quality meets the PEL standards and be onsite to operate and maintain the treatment facility. Although septic tanks require less resources than a mechanical system, there is no way to know how well a septic tank is working. Therefore, for health, sanitation, and security a centralized collection system and wastewater treatment facility would be the most effective option.

4.2 AGING INFRASTRUCTURE

Since there is not a current mechanical wastewater treatment plant in place, there is no aging infrastructure owned by the Town. The existing septic tanks have unknown ages and levels of structural integrity, but we assume that some of the existing tanks are near the end of their functional life.

4.3 REASONABLE GROWTH

The population of the Town has increased from 2011 to 2021, and it is expected to increase steadily through the project planning year of 2043. Increasing population would require septic tanks to be reviewed and approved by the Town, which would occupy Town resources. Without a centralized sewer and wastewater treatment system, the use of septic tanks as a means of wastewater treatment would continue to increase with population growth; this would likely lead to increase in soil and groundwater contamination. For this reason, it is more sustainable to install a wastewater collection and treatment system based on projected growth. In order to prepare and account for future increased wastewater flow, the Town is evaluating its current wastewater infrastructure needs and WWTP options through this PER.

5 WASTEWATER TREATMENT ALTERNATIVES

5.1 INTRODUCTION

To propose effective wastewater treatment alternatives, the Town's wastewater flow rate, characteristics, and effluent requirements have been considered. Given that the Town does not currently operate a WWTP, the wastewater flow rate and characteristics were calculated and estimated based on CDPHE wastewater design criteria policy, Code of Colorado Regulations, and Census Bureau Data.

These calculations and assumptions are detailed in the following sections along with an evaluation of three wastewater treatment alternatives and a no action alternative (Alternative 1). The no action alternative is included to illustrate the current status of wastewater treatment in the Town. Alternatives 2, 3, and 4 present viable wastewater treatment facility designs for treatment of wastewater in the Town.

5.2 PROJECT DESIGN BASIS

5.2.1 WASTEWATER FLOW RATE

A community's wastewater flow rate is an important parameter to consider in the evaluation of any wastewater treatment system as it allows for the appropriate development of the type and size of the treatment facility. Given that the Town of Rico does not have a wastewater treatment facility to provide flow metering data, the projected flowrate (or wastewater generation rate) for the Town of Rico was estimated using data from the U.S. Census Bureau and design manuals published by the State of Colorado.

Residential flow rates for the Town were determined based on the projected population for both 2023 and 2043. A per capita flowrate of 75 gpcd was applied to the population data for the Town since the CDPHE design manual suggests a range of 75-100 gpcd, and the Code of Colorado Regulations (Section 43.6.A.2.a) specifically recommends 75 gpcd. The peak hourly flow rate was determined using a peaking factor of 2.5, referenced from the CDPHE Wastewater Design Criteria Policy (Section 3.2.2.d). The commercial flow rates were determined based on the ratio of residential to commercial water usage from raw data provided by the Town.

The projected average daily wastewater flow rates are the sum of residential and commercial average daily flows. The daily average residential flow rates were calculated by multiplying the projected population for each year by 75 gpcd. Daily average commercial flowrates were found by dividing the daily average residential flow by the percent of residential flow and then multiplying that value by the percent of commercial flow. Similarly, the peak hour flow rate for each year is found by multiplying the total average daily wastewater flow rate by the peaking factor of 2.5. These flow values are found in Table 7, below.

Table 7 – Town of Rico Projected Average and Peak Wastewater Flow

Year	Projected Population	Projected Average Daily Wastewater Flow Rate (gpd)	Projected Peak Hour Wastewater Flow Rate (gpd)
2023	423	35,833.07	89,582.66
2043	632	53,587.05	133,967.63

Water consumption data provided by the Town was used to gauge the results of the above method to measured values. This is typically done to ensure wastewater generation rate is similar or lower than water usage rates, since the potable water used in commercial and residential settings is typically returned as wastewater at an average rate of 80%. The total calculated average daily wastewater flow exceeds the maximum total water consumption in 2022 by a little over 3,000 GPD. However, this provides a buffer, as the data received from the Town does not include 2023 consumption, and there may be residences not on Town water that will need to connect to the new sewer system, if installed. Furthermore, this buffer provides additional room for growth within the Town of Rico that may occur due to the Town's ability to provide sewer service to new developers. Based on the projected average and peak daily wastewater flow rates for 2043, the design flow for the new wastewater treatment facility to serve the Town should be 53,600 GPD, with a peak flow of 134,000 GPD.

5.2.2 INFLUENT WASTEWATER CHARACTERISTICS

In addition to wastewater flow rate, the characteristics of wastewater are important in the development of an appropriate recommendation for the type of WWTP. Since there is no centralized wastewater treatment system for the Town, wastewater samples could not be collected in order to definitively understand influent wastewater composition; therefore, the expected wastewater composition was estimated by evaluating the Town's property uses and applying known composition estimation resources. The types of commercial facilities that exist in the Town include restaurants, a gas station, government buildings, a museum, a church, a fire department, an inn, and a handful of other small businesses, including a bike shop and a web design company. The breakdown as a percentage is approximately 43% food/drink/gas, 28% government/educational/religious, 5% lodging, and 24% other small businesses. This distribution of residential and commercial properties in Rico most closely correlates to an average between typical medium and typical high strength domestic wastewater. The composition of typical medium-high strength domestic wastewater is shown in Table 8. The concentrations in Table 8 were derived by averaging medium and high strength typical domestic wastewater values from *Metcalf and Eddy's Wastewater Engineering Treatment and Resource Recovery Manual,* Fifth Edition (2013).

Table 8 – Rico Wastewater Composition, Typical Medium-High Strength Domestic

Constituent	Concentration
5-day Biochemical Oxygen Demand (BOD_5)	300 mg/L
Total Suspended Solids (TSS)	300 mg/L
Total Nitrogen (TN)	55 mg/L

5.2.3 TREATED WASTEWATER EFFLUENT

The Town of Rico does not currently hold a discharge permit due to the Town's individualized use of septic tanks. If a centralized mechanical wastewater treatment plant is implemented, the treatment facility will need to comply with PELs as defined by the CDPHE. The new facility would discharge into the Dolores River and a surface water discharge permit, with the PELs will need to be obtained from CDPHE.

Recently, Colorado Regulations 31 and 85 have been amended to reduce the permitted discharge concentration of nitrogen and phosphorus. The enforcement framework for these nutrients is still being developed by CDPHE, but the acceptable nutrient concentrations published in these regulations provide insight into permit requirements that the Town may need to adhere to. Regulation 31 sets water quality standards for specific water bodies in Colorado. Water quality standards describe the desired condition of a water body and the levels of constituents in the water required to achieve the water body's designated use. In Colorado, these standards are intended to protect pristine water bodies and are set to maintain very low phosphorus and nitrogen concentrations in surface water bodies. The water quality standards are based on surface water body type and whether the water body hosts cold or warm water biota. The Dolores River is classified to have cold water biota, and according to Regulation 31, the water quality standard for the Dolores River would be 1.25 mg/L for nitrogen and 0.11 mg/L for phosphorus. Regulation 85 pertains to the nutrient effluent limitations for point sources, such as wastewater treatment facilities. This regulation primarily focuses on parameter limitations for Total Phosphorus and Total Inorganic Nitrogen as N[3]. Regulation 62 contains point source effluent limitations for 5-day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and 5-day Carbonaceous Biological Oxygen Demand ($CBOD_5$).

The determination of a new wastewater treatment facility's discharge permit limitations is first done by requesting preliminary effluent limitations from CDPHE. Once requested, CDPHE uses the background concentration of the proposed discharge location (in this case the Dolores River), along with Regulations 31, 62, and 85 to determine the appropriate effluent limitations for the treatment facility. This process takes into account the blending of point sources with water quality standards for each water body to ensure that the point source does not produce an exceedance of the given water body's quality standard. Practically speaking, this means that point sources discharging to water bodies with little to no nutrient concentration are typically allowed to discharge slightly higher nutrient concentrations than point sources discharging to more contaminated water bodies; however, the size and flowrate of the water body can also significantly impact this process.

BHI has requested a PEL from CDPHE for the Town with the Dolores River as the proposed discharge location. The PEL is currently being evaluated and will be incorporated into this report once received; however, a summarization of parameter limitations from Regulations 62 and 85 are shown in Table 9. The parameter limitations in Table 9 were used as design criteria for the treatment facility alternatives evaluated herein, as they are expected to be close to the PEL given the pristine quality of the Dolores River.

Table 9 – Rico Wastewater Effluent Goals

Constituent	Concentration*
5-day Biochemical Oxygen Demand (BOD_5)	< 30 mg/L
Total Suspended Solids (TSS)	< 30 mg/L
Total Nitrogen (TKN)	7 mg/L
Phosphorous	0.7 mg/L

*Note that these values are estimates based on Colorado Regulations 62 and 85. Actual PEL values will replace the above table values once the PELs have been received.

It is important to note that the regulations mentioned above pertain only to surface water discharge. Although surface water discharge is the least complicated from an operational standpoint, if the constituent concentrations required by the PEL are found to be infeasible from a treatment technology perspective, the discharge type could be amended to another type such as a modified groundwater discharge permit or an effluent re-use permit.

5.3 ALTERNATIVE 1 – NO ACTION

5.3.1 DESCRIPTION

Alternative 1 is the No Action alternative and does not include any improvements to the Town's current methods of wastewater treatment. This alternative would have the Town remain on a decentralized network of septic tanks.

5.3.2 DESIGN CRITERIA

Alternative 1 does not include improvements and therefore, there is no design criteria for this alternative.

5.3.3 ENVIRONMENTAL IMPACTS

Alternative 1 does not include improvements and therefore, there are no environmental impacts due to construction. However, the environmental impact of taking no action to migrate off of septic systems is that low quality septic effluent will continue to infiltrate pristine nearby water resources.

5.3.4 LAND REQUIREMENTS

Alternative 1 does not include improvements and therefore, there are no additional land requirements.

5.3.5 POTENTIAL CONSTRUCTION PROBLEMS

Alternative 1 does not include improvements and therefore, there are no potential construction problems.

5.3.6 SUSTAINABILITY CONSIDERATIONS

Alternative 1 does not include improvements so it would remain at the current level of sustainability; however, without ongoing maintenance and improvements, the septic tanks used throughout the Town are expected to deteriorate over time. Furthermore, the lack of a centralized wastewater treatment and sewer system may impede future growth of the Town.

5.3.6.1 *Water and Energy Efficiency*

Alternative 1 does not include improvements and may not impact the water and energy efficiency in the short term; however, without ongoing maintenance and improvements, the tanks are expected to deteriorate.

5.3.6.2 *Green Infrastructure*

Alternative 1 does not include improvements and does not impact green infrastructure.

5.3.7 ADVANTAGES AND DISADVANTAGES

Alternative 1 is the least costly alternative from a capital cost perspective, though it does not resolve any deficiencies identified in this report.

5.3.8 COST ESTIMATE

No construction costs would occur with Alternative 1.

5.4 ALTERNATIVE 2 – CONVENTIONAL ACTIVATED SLUDGE

The improvements within this alternative include the construction of a conventional activated sludge facility, including fine screens, chemical addition, tertiary filtration, and solids handling.

5.4.1 DESCRIPTION

The type of treatment facility selected for Alternative 2 is a conventional activated sludge process. This process is a very well-developed treatment technology that uses biologically activated sludge to reduce BOD and nitrogen. Conventional activated sludge treatment processes usually include pre-treatment, where large solids are screened out of the waste stream before flowing into a series of treatment basins. The conventional activated sludge process will usually feature an anoxic zone where bacteria are readied for denitrification (nitrogen reduction), an aerobic treatment zone where microbes are given oxygen to enable enhanced removal of BOD, and a clarifier basin where treated water can be separated from sludge. From the clarifier, sludge is either returned to the anoxic basin, sent to a digestor or sludge holding tank, or pumped out for disposal. Treated water from the clarifier is disinfected and can be discharged.

In conventional activated sludge treatment facilities where phosphorus needs to be removed, chemicals such as aluminum sulfate can be added prior to the secondary clarifier, and a tertiary filter can be installed on the treated water side of the clarifier prior to disinfection in order to reduce phosphorus. Given the small size of this treatment facility, enhanced biological phosphorus removal, which requires precise cultivation of special phosphorus-fixing microbes, is not practical; therefore, chemical phosphorus removal was selected for this application.

This treatment technology was selected as an alternative for the Town, as it is a very well-known and reliable treatment process that can be installed as a relatively small, pre-packaged treatment facility. The conventional activated sludge facility evaluated for the Town would feature a mechanical fine screen installed prior to the treatment basins in the same building as the treatment facility. The mechanical fine screen would be independently procured from the pre-packaged activated sludge treatment facility and would be mounted on the facility’s floor, with a large dumpster provided under the fine screen to capture large debris not suitable for the pre-packaged facility. The pre-packaged facility would include two treatment trains for redundancy, each equipped with an anoxic basin, an aeration basin, a digester basin, a secondary clarifier, blowers to supply air to the aeration basin, mixers, airlift pumps, piping, and a chlorine contact chamber. Furthermore, the pre-packaged treatment facility would have modifications added for phosphorus removal; this would include a chemical feed system between the aeration basin and the secondary clarifier, and tertiary filters to be installed between the clarifier and the chlorine contact chamber. A pre-packaged lift station would be required at the front of this facility in order to ensure that wastewater can be positively conveyed throughout each treatment basin. Lastly, this treatment facility would be housed inside a concrete masonry unit (CMU) block type building to prevent freezing and unnecessary wear on process components. Information regarding the pre-packaged conventional activated sludge treatment facility can be found in Appendix F.

The location for this facility was chosen to be on the same land parcel as the future Town and Bridge facility. This site was selected for several reasons. First, this site is easily accessible from the Town during winter and because the Town and Bridge facility will also need to be accessed during the winter, this location reduces the need to plow a second location. Another benefit is the site’s proximity to the Town and Bridge facility, as operators can access the Town and Bridge Facility’s equipment and public restroom as deemed appropriate. Additionally, this site is a local low point for the Town and allows the collection system to maximize gravity flow where possible. Other treatment facility sites evaluated in previous PERs were considered in this process; however, each of the other sites were a much longer distance from the Town, which requires longer pipe lengths and more manholes, which was avoided due to the extra costs and maintenance demands.

Furthermore, access to the other treatment facility locations would be more complicated during snowy, winter months.

Operation of this treatment facility will require a level B operator's license issued by the State of Colorado. This requires 3 years of experience working at a wastewater treatment facility under a certified operator and the successful completion of a level B licensure test. Alternatively, a contract operator could be hired by the Town. The contract operator would need to be onsite to make process changes, but the servicing and maintaining of equipment could be performed at the direction of the contract operator, by an individual not holding an operator's license. These operational tasks could include applying lubrication to mechanical equipment, replacing bearings and nozzles on mechanical equipment, coordinating equipment servicing and calibrations, replacing mixers and pumps, replacing chemical and chemical feed hoses, replacing diffusers and impellers, performing solids handling, and monitoring the treatment facility for general health.

This treatment facility could be constructed simultaneously with the collection system. Given the long winters in Rico, CO, it would be imperative for the construction of the building and placement of the treatment tanks to be completed during warmer months. The construction of the building may require an expedited construction schedule from a contractor to complete. Installation of smaller mechanical equipment and integration of internal electrical and controls may be reserved for colder months if needed; however, this work would likely be more expeditious if also done during warmer months.

5.4.2 DESIGN CRITERIA

The design for Alternative 2 was based on the projected flow for the Town for the year 2043, as well as the Town's estimated wastewater characteristics. The footprint for this alternative was determined to require approximately 6,400 square feet and would include flow metering, a new fine screen, activated sludge treatment basins, secondary clarification, disinfection, solids handling equipment, and a building to contain treatment infrastructure.

5.4.3 EFFLUENT REQUIREMENTS

The current plan for effluent with Alternative 2 is to discharge to the Dolores River. Effluent produced by the Rico WWTP would be required to comply with a surface water discharge permit from the CDPHE. The discharge permit would also contain sampling requirements that must be adhered to by the Town.

With the enforcement framework for Regulations 31 and 85 still being developed by CDPHE, the discharge location could also be updated to groundwater discharge if the new regulations were later updated to be infeasible to meet with the selected treatment alternative.

5.4.4 SLUDGE MANAGEMENT

A conventional activated sludge process is likely to produce more sludge than an MBR and a similar volume to an MBBR; however, the extent of this is difficult to know before facility startup. With Alternative 2, the current sludge management plan would be to pump sludge from the treatment basin, as wasting is required. The sludge would then be sent through de-watering equipment, such as a belt or fan press, and placed in a large dumpster or dumpster trailer, which could be lidded and located outside to save building space, while excess water would be returned to the plant headworks. Once the dumpster became full, the de-watered solids would be trucked/hauled to a nearby biosolids facility, CDPHE-approved composting facility, or a CDPHE-approved solid/hazardous waste landfill. Depending on Town preference, the facility's de-watered solids would need to be tested and approved by CDPHE for disposal prior to sending the solids to any disposal site. The costs associated with each of these options are variable; however, for the purposes of this report, the operational cost of solids handling assumes the biosolids would be sent to a CDPHE-approved landfill. The nearest CDPHE-approved solid/hazardous waste landfills are the Montrose County Landfill and the Broad Canyon Landfill. Typically, the requirements for CDPHE approval of biosolids disposal at approved landfills are a paint filter test and the EPA method TCLIP & TNORM tests. At full build out, the solids produced at the conventional activated sludge treatment facility are expected to fill a 14 yd^3 dumpster an average of 1.6 times per week, or 83.5 times per year; however, these numbers are for full build out, and solids production at startup is expected to be lower until the full treatment capacity is achieved. While the solids production values can generally be scaled with the magnitude of influent flow, the true extent of solids production is difficult to know until the facility is constructed and operating at steady state.

De-watering sludge produced at the WWTP and disposing of biosolids is more cost effective than directly hauling sludge, as sludge requires more frequent disposal trips due to the large volume of water content in the sludge. However, if this method is preferred, the Town could opt to not install de-watering equipment and instead hire a septic hauling company to pump and dispose of sludge from the WWTP at a regular interval.

5.4.5 MAP

Figure 8 provides a layout of Alternative 2. The treatment facility would be placed within a zone currently classified as a 100-year flood zone by FEMA; however this placement can be done safely by ensuring the building finish floor is above the base flood elevation and applying to the Dolores County Floodplain Manager. This process requires a base flood elevation determination by a registered professional engineer to be submitted to the Dolores County Floodplain Manager.

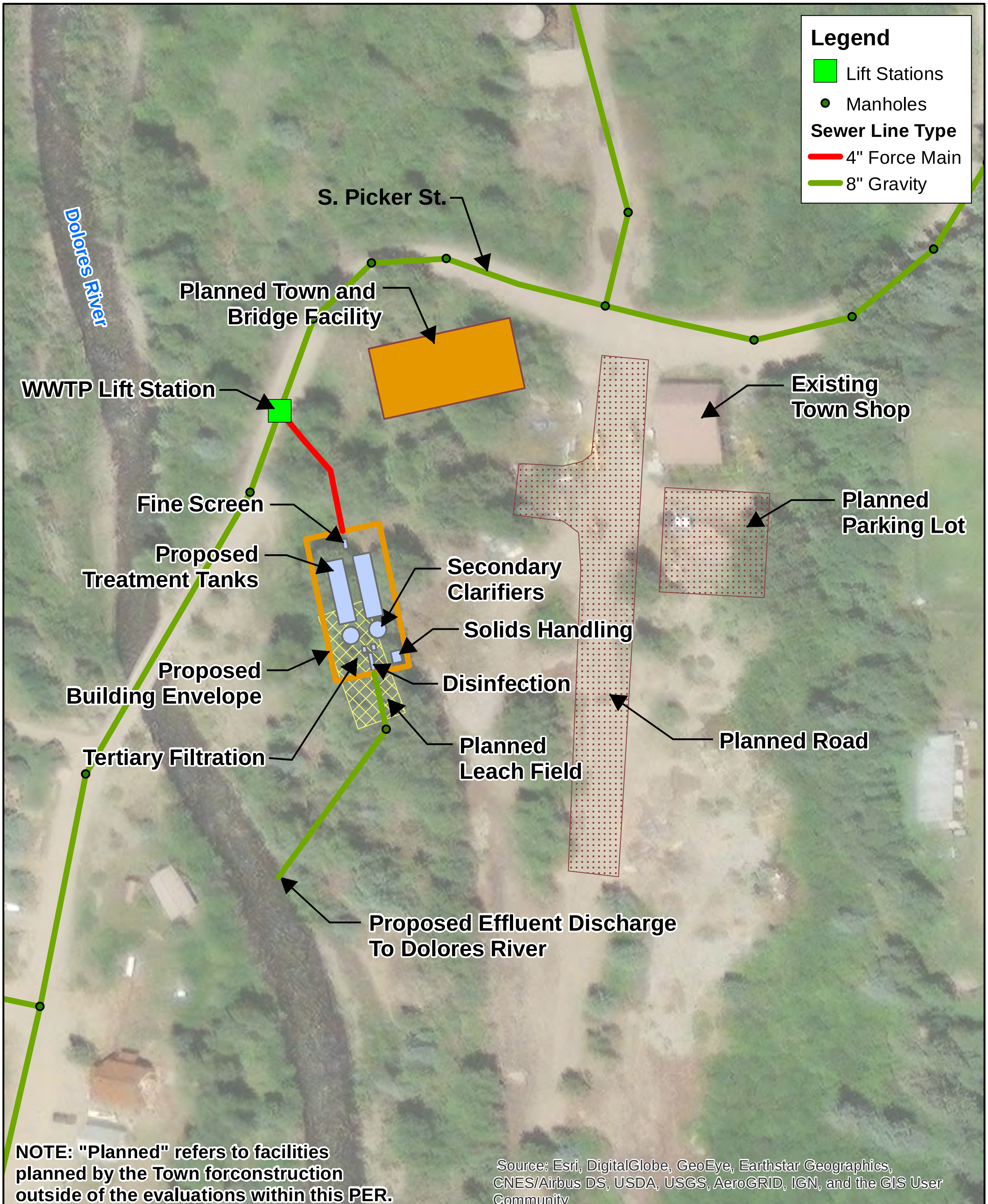
Furthermore, Figure 8 shows the treatment facility building overlapping with the planned leach field. Since the planned leach field will only receive wastewater from the Town and Bridge facility, this facility layout will require the Town and Bridge facility's restrooms to be shut down during construction and portable restrooms brought on site. While the wastewater treatment facility location shown in Figure 8 requires portable restrooms during construction, this layout ultimately uses the Town's land most effectively while allowing for maximum vehicle clearance and future development.

5.4.6 ENVIRONMENTAL IMPACTS

Alternative 2 will improve environmental stewardship in the Town by producing a higher quality effluent discharged into the Dolores River. In addition, methods such as prefabrication, using locally sourced materials, and the proper selection of a site that avoids areas such as farmlands, threatened animal habitats, and wetlands, are ways to reduce emissions and eliminate the unnecessary use of resources. The project does not go through any endangered animal habitats as there are no endangered or native species in the area. The proposed site for the WWTP does not directly interfere with any existing wetlands, however, according to the NWI, there is a 0.25 acre freshwater forested/shrub wetland area approximately 0.1 mile south of the proposed site. It is not anticipated that an Environmental Information Document will be required for this treatment facility as it does not interfere with this delineated wetland.

5.4.7 LAND REQUIREMENTS

The Town would not need any additional land for Alternative 2 as the Town owns the land where the treatment facility would be constructed.



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Town of Rico
Wastewater PER
Figure 8
Alternative 2 - Conventional Activated Sludge

P:\20240048\WR\Reports\Preliminary & Draft\Figures\MXDs\20240048 Figure 8 - Alternative 2 - Conventional Activated Sludge.mxd
Author: cpepin

December 2023

5.4.8 POTENTIAL CONSTRUCTION PROBLEMS

Potential construction problems for Alternative 2 are primarily due to the location of the Town. Rico, CO has a shallow ground surface and is situated above bedrock. The facility would be built above grade where possible to minimize the amount of excavation required. Rico is situated in the mountains of Colorado where there are below freezing temperatures in the winter, so the construction season is limited. The Town is also fairly remote, which may require additional coordination between suppliers and contractors in order to receive necessary material on the jobsite.

5.4.9 SUSTAINABILITY CONSIDERATIONS

Alternative 2 would produce a significantly higher quality of wastewater effluent than what is currently being produced by the Town's network of septic tanks. Septic tanks are an unsustainable option since the effluent quality is unknown, they must be replaced on an individual basis in the case of failure, and they must be maintained by individual owners to continue working properly. There is no way of knowing how well each tank is being maintained or is functioning. Poor quality effluent produced over the course of years has potentially harmful impacts on the environment, people, and wildlife.

5.4.9.1 *Water and Energy Efficiency*

As previously mentioned, Alternative 2 would improve the quality of the wastewater effluent. This improves water efficiency from an environmental perspective as it returns cleaner water to the environment, which can then be used for a wide array of purposes.

A conventional treatment process would consume more energy than the existing septic tanks, however, water stewardship would be boosted by this process due to the improved quality of water being discharged into the environment. The electric efficiency of the facility could be improved in the future by investing in renewable electricity generation sources such as solar and wind power.

5.4.9.2 *Green Infrastructure*

Modern construction techniques can be used to improve the green factor of Alternative 2. Alternative 2 requires a building to house the various process components. This structure could be built so that it is insulated sustainably, optimized for heat loss, and sourced from local materials. Prefabricating components related to Alternative 2 in a controlled environment off site could also boost the green factor of this alternative.

5.4.10 ADVANTAGES AND DISADVANTAGES

The advantage of using a conventional activated sludge system is that it is a very well-known and resilient treatment process. Conventional activated sludge processes have lower O&M requirements compared to MBRs. This treatment process is most resilient to changes and wastewater composition and has the lowest capital cost.

The primary disadvantage to a conventional activated sludge process is that they have a larger footprint than an MBR, but still need to be housed in a large building given Rico's climate. Furthermore, the conventional activated sludge process will require the addition of tertiary filters in order to remove phosphorus. Lastly, a conventional activated sludge process can tend to produce more sludge than an MBR.

5.4.11 COST ESTIMATE

Preliminary capital costs for Alternative 2 are shown in Table 10 below. It is important to note that the costs associated with decommissioning individual septic tanks are not included in this cost estimate. This is because the Town has conveyed to BHI that the costs associated with septic tank decommissioning will be the responsibility each individual septic tank owner. The estimated cost of installing a conventional activated sludge treatment system, including construction costs and the engineering total, would be $7,430,038.59.

Table 10 – Alternative 2 Conventional Activated Sludge Facility Cost Estimate

Item	Unit	Unit Price	Quantity	Cost
Construction Staking and Survey	%	$4,225,800.00	4.0%	$169,032.00
Construction Mobilization and Demobilization	%	$4,225,800.00	12.0%	$507,096.00
Site Clearing and Grubbing, compl.	AC	$6,000.00	1	$6,000.00
Trees, 8" to 30" circumference, Remove and Dispose, compl.	EA	$2,300.00	15	$34,500.00
Excavation, Backfill, and Compaction, removal of excess material offsite	CY	$120.00	550	$66,000.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip.	CY	$120.00	138	$16,500.00
Procurement of New Wastewater Treatment Facility, incl. submittals, purchase, shipping, offloading	LS	$1,073,446.00	1	$1,073,446.00

Procurement of New Fine Screen, incl. submittals, purchase, shipping, offloading	LS	$180,000.00	1	$180,000.00
Procurement of Headworks Lift Station	EA	$400,000.00	1	$400,000.00
Procurement of Tertiary Filters	EA	$62,000.00	2	$124,000.00
Solids Handling Equipment and Dumpster	LS	$220,000.00	1	$220,000.00
Mechanical installation of WWTP, fine screen, lift station, tertiary filters cip.	%	$1,935,446.00	30.00%	$580,633.80
Building to house facility	SF	$150.00	6,400	$960,000.00
Chemical Addition System and Components	LS	$50,000.00	1	$50,000.00
Site Work, incl grading, civil site improvements, cip.	LS	$64,000.00	1	$64,000.00
Piping, including outfall, other mechanical installation, valves, incl. all installation, trenching, placement, cip.	LS	$200,000.00	1	$200,000.00
Electrical Materials and Installation incl. all power distribution equipment, underground facilities and duct banks, conduit, wire, support systems, switches, and all associated electrical	LS	$188,016.90	1	$188,016.90
Instrumentation & Controls, incl. loop drawings, factory testing, installation of I&C systems, start-up and commissioning activities, cip.	LS	$62,672.30	1	$62,672.30
			Subtotal	**$4,901,897.00**
Construction Contingency			30%	$1,470,569.10
Utility Relocation Allowance			LS	$25,000.00
			Construction Cost Total	**$6,397,466.10**
*Engineering Design			7.5%	$369,517.28
*Construction Oversight and Administration			7.5%	$369,517.28
*Resident Project Representative (RPR) - $30,000 per mo. for 6 mos.				$180,000.00
*Permitting and Environmental			2%	$98,537.94
*Base Flood Elevation Determination			LS	$15,000.00
			Engineering Total	**$1,032,572.49**
			New Conventional Activated Sludge Facility Total	**$7,430,038.59**

*Not calculated on Construction Contingency.

The estimated O&M costs and the present value O&M cost were calculated for Alternative 2 and are shown in Table 11 below. Power was based on rates obtained from the San Miguel Power Association, and the maintenance items were determined by analyzing the facility's specific operational needs. The estimated daily power requirement for a conventional activated sludge facility is 430 kilowatt-hours. The solids handling was based on preliminary solids production and de-watering calculations for the facility. Labor and benefits were estimated based on approximate time needed for onsite duties and current WWTP operator rates in Dolores County. The present value O&M cost was based on the annuities equation and used an inflation rate of 3% and a duration of 20 years.

Table 11 – Summary of Estimated O&M Costs for Alternative 2

Item	Unit	Annual Cost
Power	LS	$23,610.00
Mechanical Treatment System	LS	$28,810.00
Solids Handling Costs	LS	$65,160.00
Labor and Benefits	LS	$32,234.00
	Total	**$149,814.00**
	Present Value of O&M Cost	**$4,025,547.82**

The O&M costs for Alternative 2 are most effected by the solids handling and trucking costs; however, these costs are significantly lower than the costs associated with pure sludge pumping and disposal. The O&M costs for a conventional activated sludge treatment facility for the Town are lower than those for an MBR facility, and only slightly lower than those for an MBBR facility. The cost of power is lowest for a conventional activated sludge facility when compared to an MBR or an MBBR. The overall O&M costs for the conventional activated sludge treatment facility is lower than an MBR and similar to an MBBR because the conventional activated sludge process has lower power requirements than the MBR and similar process requirements to the MBBR.

5.5 ALTERNATIVE 3 – MEMBRANE BIO-REACTOR (MBR)

5.5.1 DESCRIPTION

The type of treatment facility selected for Alternative 3 is an MBR treatment process. This process uses membranes to replace the secondary clarification stage of a typical wastewater treatment process. In an MBR facility, membranes are placed in the aerobic stage of the treatment process and a slight vacuum applied across the membrane pulls treated wastewater effluent through the membrane, where it can then be disinfected and discharged. MBRs are very effective in treating BOD, TSS, and TN; effluent from MBRs is often higher quality than typical wastewater treatment processes and can often be reused without the need for additional polishing processes.

A typical MBR facility begins with a headworks that features a fine screen and an (optional) grit chamber. Fine screens at MBR facilities require smaller screen openings (usually about 2mm - 3mm) than typical wastewater treatment processes since the membranes are more susceptible to damage from large debris. After the headworks, wastewater typically enters a series of basins where BOD reduction, nitrification, and denitrification are promoted. Typically, this includes an anoxic zone, a aeration/aerobic zone, and the membrane zone (also aerobic) with recycling capabilities for return activated sludge (RAS) and the option of additional denitrification. Once effluent is pulled through the membranes in the membrane zone, it is disinfected either by chlorination or UV radiation before it is discharged or sent to a storage or disposal site. In smaller plants, solids from the process can be pumped out and hauled to a nearby, larger treatment plant or to a septage handling facility at a regular interval or de-watered using small de-watering equipment.

In small MBR treatment facilities, where phosphorus needs to be removed, chemicals such as aluminum sulfate can be added prior to the membrane basin and the membranes can be used to remove phosphorus.

This treatment technology was selected as an alternative for the Town, as it is produces a very high quality effluent and can be housed in a small building. The MBR evaluated for the Town would be a pre-packaged treatment facility by the reputable MBR company, Kubota, or other. This pre-packaged MBR would feature an integrated fine screen, membrane treatment basins, membranes, blowers and pumps, level transmitters and controls. The pre-packaged treatment facility would be modified to include a chemical feed system to remove phosphorus, and a chlorine disinfection system prior to the outfall at the Dolores River. Given the small size of this treatment facility, enhanced biological phosphorus removal, which requires precise cultivation of special phosphorus-fixing microbes is not practical; therefore, chemical phosphorus removal was selected for this application. Furthermore, a pre-packaged lift station would be required at the front of this facility in order to ensure that wastewater can be positively conveyed throughout each treatment basin. Lastly, this treatment facility would be housed inside a CMU block type building to prevent freezing and unnecessary wear on process components. Information regarding the pre-packaged MBR facility can be found in Appendix G.

The location for this facility was chosen to be on the same land parcel as the future Town and Bridge facility. This site was selected for several reasons. First, this site is easily accessible from the Town during winter and because the Town and Bridge facility will also need to be accessed during the winter, this location reduces the need to plow a second location. This site also benefits from its proximity to the Town and Bridge facility, as operators can access the Town and Bridge facility's equipment and public restroom as deemed appropriate. Additionally, this site is a local low point for the Town and allows the collection system to maximize gravity flow where possible. Other treatment facility sites evaluated in previous PERs were considered in this process; however, each of the other sites were a much longer distance from the Town, requiring longer pipe lengths and more manholes, which was avoided due to extra costs and maintenance demands. Furthermore, access to the other treatment facility locations would be more complicated during snowy, winter months.

Operation of this treatment facility will require a level B operator's license issued by the State of Colorado. This requires 3 years of experience working at a wastewater treatment facility under a certified operator and the successful completion of a level B licensure test. Alternatively, a contract operator could be hired by the Town. The contract operator would need to be onsite to make process changes, but the servicing and maintaining of equipment could be performed at the direction of the contract operator, by an individual not holding an operator's license. These operational tasks could include applying lubrication to mechanical equipment, replacing bearings and nozzles on mechanical equipment, cleaning and replacing membranes, coordinating equipment servicing and calibrations, replacing mixers and pumps, replacing chemical and chemical feed hoses, replacing diffusers and impellers, coordinating sludge removal, and monitoring the treatment facility for general health.

This treatment facility could be constructed simultaneously with the collection system. Given the long winters in Rico, CO, it would be imperative for the construction of the building and placement of the treatment tanks to be completed during warmer months. The construction of the building may require an expedited construction schedule from a contractor to complete. Installation of smaller mechanical equipment and integration of internal electrical and controls may be reserved for colder months if needed; however, this work would likely be more expeditious if also done during warmer months.

5.5.2 DESIGN CRITERIA

The design for Alternative 3 was based on the projected flow for the Town in the year 2043, as well as the assumed wastewater characteristics of the Town. The MBR footprint was determined to require approximately 2,600 square feet and would consist of a headworks, process tanks, MBR treatment basins and equipment, chemical addition, disinfection, electrical components/integration, and site improvements.

5.5.3 EFFLUENT REQUIREMENTS

The current plan for effluent with Alternative 3 is to discharge to the Dolores River. Effluent produced by the Rico WWTP would be required to comply with a surface water discharge permit from the CDPHE. The discharge permit would also contain sampling requirements that must be adhered to by the Town.

With the enforcement framework for Regulations 31 and 85 still being developed by CDPHE, the discharge location could also be updated to groundwater discharge if the new regulations were later updated to be infeasible to meet with the selected treatment alternative.

5.5.4 SLUDGE MANAGEMENT

An MBR is likely to produce less sludge than a conventional activated sludge process or an MBBR; however, the extent of this is difficult to know before facility startup. With Alternative 3, the current sludge management plan would be to pump sludge from the treatment basin, as wasting is required. The sludge would then be sent through de-watering equipment, such as a belt or fan press, and placed in a large dumpster or dumpster trailer, which could be lidded and located outside to save building space, while excess water would be returned to the plant headworks. Once the dumpster became full, the de-watered solids would be trucked/hauled to a nearby biosolids facility, CDPHE-approved composting facility, or a CDPHE-approved solid/hazardous waste landfill. Depending on Town preference, the facility's de-watered solids would need to be tested and approved by CDPHE for disposal prior to sending the solids to any disposal site. The costs associated with each of these options are variable; however, for the purposes of this report, the operational cost of solids handling assumed the biosolids would be sent to a CDPHE-approved landfill. The nearest CDPHE-approved solid/hazardous waste landfills are the Montrose County Landfill and the Broad Canyon Landfill. Typically, the requirements for CDPHE approval of biosolids disposal at approved landfills are a paint filter test and the EPA method TCLIP & TNORM tests. At full build out, the solids produced at the MBR facility are expected to fill a 14 yd^3 dumpster an average of 1.3 times per week, or 69.5 times per year; however, these numbers are for full build out, and solids production at startup is expected to be lower until the full treatment capacity is achieved. While the solids production values can generally be scaled with the magnitude of influent flow, the true extent of solids production is difficult to know until the facility is constructed and operating at steady state.

De-watering sludge produced at the WWTP and disposing of biosolids is more cost effective than directly hauling sludge, as sludge requires more frequent disposal trips be made due to the large volume of water content in the sludge. However, if this method is preferred, the Town could opt to not install de-watering equipment and instead hire a septic hauling company to pump and dispose of sludge from the WWTP at a regular interval.

5.5.5 MAP

Figure 9 provides a site layout for Alternative 3. The treatment facility will be placed within a zone currently classified as a 100-year flood zone by FEMA; however, this placement can be done safely by ensuring the building finish floor is above the base flood elevation and applying to the Dolores County Floodplain Manager. This process requires a base flood elevation determination by a registered professional engineer to be submitted to the Dolores County Floodplain Manager.

Furthermore, Figure 9 shows the treatment facility building very near to the planned leach field. Since the planned leach field will only receive wastewater from the Town and Bridge facility, this facility layout will likely require the Town and Bridge facility's restrooms to be shut down during construction and portable restrooms brought onsite, unless the piping to the leach filed site does not interfere with the treatment facility building footprint. While this location, shown in Figure 9, will likely require portable restrooms during construction, this layout ultimately uses the Town's land most effectively while allowing for maximum vehicle clearance and future development.

5.5.6 ENVIRONMENTAL IMPACTS

Alternative 3 will improve environmental stewardship in the Town by producing a higher quality effluent discharged into the Dolores River. In addition, methods such as prefabrication, using locally sourced materials, and the proper selection of a site that avoids areas such as farmlands, threatened animal habitats, and wetlands, are ways to reduce emissions and eliminate the unnecessary use of resources. The project does not go through any endangered animal habitats as there are no endangered or native species in the area.

Town of Rico
Wastewater PER
Figure 9
Alternative 3 -
Membrane Bioreactor

The proposed site for the WWTP does not directly interfere with any existing wetlands, however, according to the NWI there is a 0.25 acre freshwater forested/shrub wetland area approximately 0.1 mile south of the proposed site. It is not anticipated that an Environmental Information Document will be required for this treatment facility, as it does not interfere with this delineated wetland.

5.5.7 LAND REQUIREMENTS

The Town would not need any additional land for Alternative 3 as the Town owns the land where the treatment facility would be constructed.

5.5.8 POTENTIAL CONSTRUCTION PROBLEMS

Potential construction problems for Alternative 3 are primarily due to the location. Rico, CO has a shallow ground surface and is situated above bedrock. The facility would be built above grade where possible to minimize the amount of excavation required. Rico is situated in the mountains of Colorado where there are below freezing temperatures in the winter, so the construction season is limited. The Town is also fairly remote, which may require additional coordination between suppliers and contractors in order to receive necessary material on the jobsite.

5.5.9 SUSTAINABILITY CONSIDERATIONS

Alternative 3 would produce a significantly higher quality of wastewater effluent than what is currently being produced by the Town’s network of septic tanks. Septic tanks are an unsustainable option since the effluent quality is unknown, they must be replaced on an individual basis in the case of failure, and they must be maintained by individual owners to continue working properly. There is no way of knowing how well each tank is being maintained or is functioning. Poor quality effluent produced over the course of years has potentially harmful impacts on the environment, people, and wildlife.

Furthermore, an MBR typically produces a superior effluent quality without the addition of tertiary filtration, which is required for the conventional activated sludge and MBBR options to produce an equivalent effluent quality.

5.5.9.1 *Water and Energy Efficiency*

As previously mentioned, Alternative 3 would improve the quality of the wastewater effluent. This improves water efficiency from an environmental perspective, as it returns cleaner water to the environment, which can then be used for a wide array of purposes.

An MBR process would consume more energy than the existing septic tanks, however, water stewardship would be boosted by this process due to the improved quality of water being discharged into the environment. The electric efficiency of the facility could be improved in the future by investing in renewable electricity generation sources such as solar and wind power.

5.5.9.2 *Green Infrastructure*

Modern construction techniques can be used to improve the green factor of Alternative 3. Alternative 3 requires a building to house the various process components. This structure could be built so that it is insulated sustainably, optimized for heat loss, and sourced from local materials. Prefabricating components related to Alternative 3 in a controlled environment off-site could also boost the green factor of this alternative.

5.5.10 ADVANTAGES AND DISADVANTAGES

The advantage of Alternative 3 is that it would reliably produce a higher quality effluent than what Alternatives 2 or 4 would produce without the need for tertiary filtration. Furthermore, low flows, intermittent flows, and wide variations in flows can be easily accommodated by an MBR. MBRs can be automated, and some functions can be operated remotely; however, the system requires an operator with an advanced knowledge of MBR facility operations. MBR facilities typically require a much smaller land footprint than other treatment technologies; this is because aerobic treatment and pressure-driven solids separation are performed in the same basin.

The main disadvantage of Alternative 3 is that MBRs typically have higher capital and operating costs than conventional activated sludge processes. Operationally, MBRs require more electricity than Alternatives 2 or 4. This is primarily due to the requirement to aerate the membrane basin in order to foster air scouring and cleaning of the membranes. Furthermore, membranes used in membrane bioreactors can be fragile, and if a membrane fails, mixed liquor is able to pass through the failed membrane and can potentially lead to effluent contamination. For this reason, special care must be taken by operational staff to ensure the membranes remain in good condition.

5.5.11 COST ESTIMATE

Preliminary capital costs for Alternative 3 are shown in Table 12 below. It is important to note that the costs associated with decommissioning individual septic tanks are not included in this cost estimate. This is because the Town has conveyed to BHI that the costs associated with septic tank decommissioning will be the responsibility each individual septic tank owner. The estimated cost of installing an MBR treatment system, including construction costs and the engineering total, would be $8,059,644.00.

Table 12 – Alternative 3 MBR Facility Cost Estimate

Item	Unit	Unit Price	Quantity	Cost
Construction Staking and Survey, compl.	%	$4,595,000.00	4.0%	$183,800.00
Construction Mobilization and Demobilization, compl.	%	$4,595,000.00	12.0%	$551,400.00
Site Clearing and Grubbing, compl.	AC	$6,000.00	1	$6,000.00
Trees, 8" to 30" circumference, Remove & Dispose, compl.	EA	$2,300.00	15	$34,500.00
Excavation, Backfill, and Compaction, removal of excess material offsite	CY	$120.00	200	$24,000.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip	CY	$120.00	50	$6,000.00
Procurement of New Wastewater Treatment Facility, incl. submittals, purchase, shipping, offloading	LS	$2,035,000.00	1	$2,035,000.00
Headworks Lift Station	EA	$400,000.00	1	$400,000.00
Solids Handling Equipment and Dumpster	LS	$220,000.00	1	$220,000.00
Mechanical installation of WWTP, cip.	%	$2,655,000.00	30.00%	$796,500.00
Building to house facility	SF	$150.00	2,600	$390,000.00
Chemical Addition System and Components	LS	$50,000.00	1	$50,000.00
Site Work, incl grading, civil site improvements, cip.	LS	$26,000.00	1	$26,000.00
Piping, including outfall, other mechanical installation, valves, incl. all installation, trenching, placement, cip.	LS	$200,000.00	1	$200,000.00

Electrical Materials and Installation incl. all power distribution equipment, underground facilities and duct banks, conduit, wire, support systems, switches, and all associated electrical hardware, all labor to install electrical equipment, conduit, wire, support systems as well as associated studies, testing and commissioning activities for the electrical system, cip.	LS	$305,250.00	1	$305,250.00
Instrumentation & Controls, incl. loop drawings, factory testing, installation of I&C systems, start-up and commissioning activities, cip.	LS	$101,750.00	1	$101,750.00
			Subtotal	**$5,330,200.00**
Construction Contingency			30%	$1,599,060.00
Utility Relocation Allowance			LS	$25,000.00
			Construction Cost Total	**$6,954,260.00**
*Engineering Design			7.5%	$401,640.00
*Construction Oversight and Administration			7.5%	$401,640.00
*Resident Project Representative (RPR) - $30,000 per mo. for 6 mos.				$180,000.00
*Permitting and Environmental			2%	$107,104.00
*Base Flood Elevation Determination			LS	$15,000.00
			Engineering Total	**$1,105,384.00**
			New MBR Facility Total	**$8,059,644.00**

*Not calculated on Construction Contingency.

The estimated O&M costs and the present value O&M cost were calculated for Alternative 3 and are shown in Table 13 below. Power was based on rates obtained from the San Miguel Power Association, and the maintenance items were determined by analyzing the facility’s specific operational needs. The estimated daily power requirement for an MBR facility is 657 kilowatt-hours. The solids handling was based on preliminary solids production and de-watering calculations for the facility. Labor and benefits were estimated based on approximate time needed for onsite duties and current WWTP operator rates in Dolores County. The present value O&M cost was based on the annuities equation and used an inflation rate of 3% and a duration of 20 years.

Table 13 – Summary of Estimated O&M Costs for Alternative 3

Item	Unit	Annual Cost
Power	LS	$36,050.00
Mechanical Treatment System	LS	$50,810.00
Solids Handling Costs	LS	$54,300.00
Labor and Benefits	LS	$32,234.00
Total		**$173,394.00**
Present Value of O&M Cost		**$4,659,151.25**

The O&M costs for Alternative 3 are most effected by the solids handling and trucking costs; however, these costs are significantly lower than the costs associated with pure sludge pumping and disposal. The O&M costs for an MBR facility for the Town are higher than both those for a conventional activated sludge facility and an MBBR facility. This is because the power requirement for an MBR is higher than that of a conventional activated sludge or MBBR process.

5.6 ALTERNATIVE 4 – MIXED BED BIOFILM REACTOR (MBBR)

5.6.1 DESCRIPTION

The type of treatment facility selected for Alternative 4 is a mixed bed biofilm reactor (MBBR). An MBBR features a biological treatment process that combines fixed-film and suspended bacteria to treat wastewater. It uses suspended plastic carriers to provide a surface for microorganisms to attach and grow. As wastewater passes over the plastic carriers, the attached microorganism consume and break down organic matter in the wastewater. This process is similar to the Rotating Biological Contactor (RBC) treatment process, evaluated in several of the Town's previous PERs, as it uses a media to promote microorganism growth; however, an MBBR does not require rotation of the media, which reduces mechanical components in the system and also incorporates activated sludge to improve the overall process. In an MBBR facility, there is typically a primary clarifier that removes settleable solids coming into the plant followed by mixed media reactors tanks. The mixed media reactor tanks are aerated and mixed in order to provide microorganisms with oxygen for organic matter consumption and greater contact with incoming wastewater. MBBRs are designed to reduce nitrogen and BOD. MBBRs also often include secondary settling. Chemicals, such as aluminum sulfate, can be added along with the installation of tertiary filters in order to reduce phosphorus. Lastly, MBBRs use disinfection equipment to sterilize effluent as required by a facilities discharge permit.

This treatment technology was selected as an alternative for the Town of Rico, as it is an effective way to treat wastewater, and the majority of treatment tanks can be buried underground. The MBBR evaluated for the Town would feature a mechanical fine screen, housed in a small building, prior to the buried treatment basins. The mechanical fine screen would be independently procured and would be mounted on the building's floor, with a large dumpster provided under the fine screen to capture large debris not suitable for the downstream processes. The pre-packaged treatment facility would feature a splitter manhole and two redundant treatment trains each featuring three treatment tanks, secondary clarifiers, pumps and blowers, mixed bed media, UV disinfection, and controls. All of the treatment tanks would be buried with heat tracing installed around them, and the clarifiers would have covers on them to prevent freezing. The pre-packaged treatment facility would also be modified to remove phosphorus by including a chemical feed system between the media treatment basin and the secondary clarifiers, and tertiary filters to be installed between the clarifier and the UV disinfection system. Given the small size of this treatment facility, enhanced biological phosphorus removal, which requires precise cultivation of special phosphorus-fixing microbes is not practical; therefore, chemical phosphorus removal was selected for this application. The tertiary filters, chemical feed system, extra chemicals, and blowers would all be housed in a small building to be located after the clarifiers. A pre-packaged lift station at the front of this facility is currently included in this alternative to ensure that wastewater can be positively conveyed throughout each treatment basin; however, there is a possibility that a design of this facility may be able to eliminate the lift station due to the treatment tanks being mostly buried. Information regarding the pre-packaged MBBR facility can be found in Appendix H.

The location for this facility was chosen to be on the same land parcel as future Town and Bridge facility. This site was selected for several reasons. First, this site is easily accessible from the Town during winter and because the Town and Bridge facility will need to be accessed during the winter also, this location reduces the need to plow a second location. This site also benefits from its proximity to the town and bridge facility, as operators can access the Town and Bridge Facility's equipment and public restroom, as deemed appropriate. Additionally, this site is a local low point for the Town and allows the collection system to maximize gravity flow where possible. Other treatment facility sites evaluated in previous PERs were considered in this process; however, each of the other sites were located a much longer distance from the Town, which requires longer pipe lengths, more manholes, which was avoided due to extra costs and maintenance demands. Furthermore, access to the other treatment facility locations would be more complicated during snowy, winter months.

Operation of this treatment facility will require a level B operator's license issued by the State of Colorado. This requires 3 years of experience working at a wastewater treatment facility under a certified operator and the successful completion of a level B licensure test. Alternatively, a contract operator could be hired by the Town of Rico. The contract operator would need to be onsite to make process changes, but the servicing and maintaining of equipment could be performed at the direction of the contract operator, by an individual not holding an operator's license. These operational tasks could include tasks such as applying lubrication to mechanical equipment, replacing bearings and nozzles on mechanical equipment, coordinating equipment servicing and calibrations, replacing mixers and pumps, replacing chemical and chemical feed hoses, replacing diffusers and impellers, coordinating sludge removal, and monitoring the treatment facility for general health.

This treatment facility could be constructed simultaneously with the collection system. Given the long winters in Rico, CO, it would be imperative for the construction of the building and placement of the treatment tanks to be completed during warmer months. The construction of the building may require an expedited construction schedule from a contractor to complete. Installation of smaller mechanical equipment and integration of internal electrical and controls may be reserved for colder months if needed; however, this work would likely be more expeditious if also done during warmer months.

5.6.2 DESIGN CRITERIA

The design for Alternative 4 was based on the projected flow for the Town in the year 2043, as well as the estimated wastewater characteristics of the Town. The two buildings required for the MBBR facility have been determined to require a combined approximate 1,250 square feet and would consist of the following: a dual flat weir flow splitter manhole, two 25,000 gallon primary settling tanks in series, each followed by a 25,000 gallon tank split between primary settling and flow equalization in parallel, two 25,000-gallon-5-stage MBBR tanks in parallel, a secondary clarifier, three chemical feed systems for alkalinity, carbon and coagulant, a separate chemical feed system for phosphorus removal, tertiary filters, four 1,000 watt UV units in parallel, and an integrated PLC control panel with remote monitoring capability.

5.6.3 EFFLUENT REQUIREMENTS

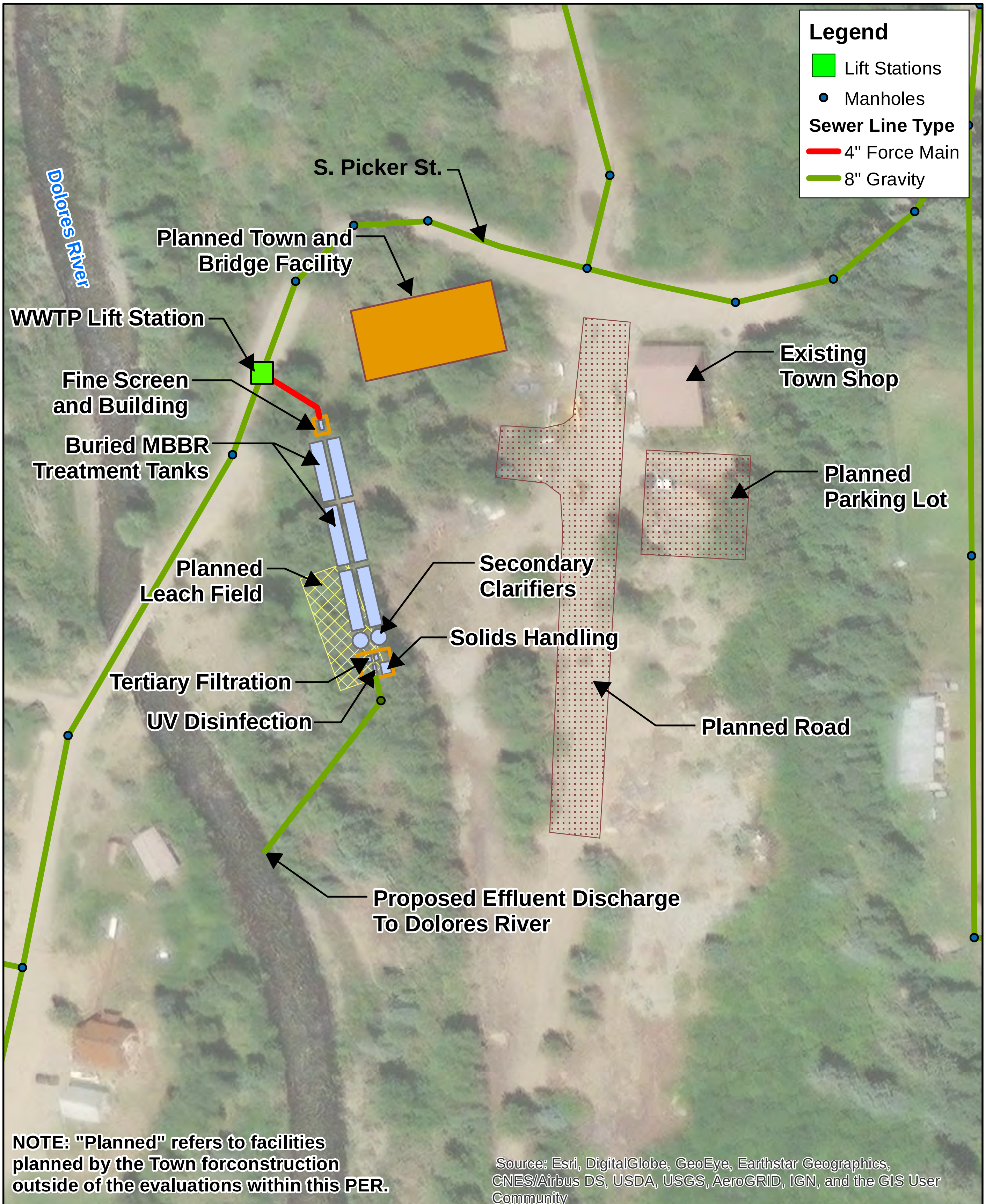
The current plan for effluent with Alternative 4 is to discharge to the Dolores River. Effluent produced by the Rico WWTP would be required to comply with a surface water discharge permit from the CDPHE. The discharge permit would also contain sampling requirements that must be adhered to by the Town.

With the enforcement framework for Regulations 31 and 85 still being developed by CDPHE, the discharge location could also be updated to groundwater discharge if the new regulations were later updated to be infeasible to meet with the selected treatment alternative.

5.6.4 MAP

Figure 10 provides a site layout for Alternative 4. The treatment facility and two buildings would be placed within a zone currently classified as a 100-year flood zone by FEMA; however, the placement of the two buildings can be done safely by ensuring the building finish floor is above the base flood elevation and applying to the Dolores County Floodplain Manager. This process requires a base flood elevation determination by a registered professional engineer to be submitted to the Dolores County Floodplain Manager. The buried tanks will not require any evaluation, as they do not have the same occupancy concerns, and will be protected from flooding by earthen cover.

Furthermore, Figure 10 shows the treatment facility overlapping the planned leach field. Since the planned leach field will only receive wastewater from the Town and Bridge facility, this facility layout will require the Town and Bridge facility's restrooms be shut down during construction and portable restrooms brought onsite. While this location ,shown in Figure 10, will require portable restrooms during construction, this layout ultimately uses the Town's land most effectively while allowing for maximum vehicle clearance and future development.



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Town of Rico
Wastewater PER
Figure 10
Alternative 4 - MBBR

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Author: cpepin

December 2023

5.6.5 SLUDGE MANAGEMENT

An MBBR is likely to produce more sludge than an MBR and a similar volume to a conventional activated sludge process; however, the extent of this is difficult to know before facility startup. With Alternative 4, the current sludge management plan would be to pump sludge from the treatment basin, as wasting is required. The sludge would then be sent through de-watering equipment, such as a belt or fan press, and placed in a large dumpster or dumpster trailer ,which could be lidded and located outside to save building space, while excess water would be returned to the plant headworks. Once the dumpster became full, the de-watered solids would be trucked/hauled to a nearby biosolids facility, CDPHE-approved composting facility, or a CDPHE-approved solid/hazardous waste landfill. Depending on Town preference, the facility's de-watered solids would need to be tested and approved by CDPHE for disposal prior to sending the solids to any disposal site. The costs associated with each of these options are variable; however, for the purposes of this report, the operational cost of solids handling assumed the biosolids would be sent to a CDPHE-approved landfill. The nearest CDPHE-approved solid/hazardous waste landfills are the Montrose County Landfill and the Broad Canyon Landfill. Typically, the requirements for CDPHE approval of biosolids disposal at approved landfills are a paint filter test and the EPA method TCLIP & TNORM tests. At full build out, the solids produced at the MBBR facility are expected to fill a 14 yd^3 dumpster an average of 1.6 times per week, or 83.5 times per year; however, these numbers are for full build out, and solids production at startup is expected to be lower until the full treatment capacity is achieved. While the solids production values can generally be scaled with the magnitude of influent flow, the true extent of solids production is difficult to know until the facility is constructed and operating at steady state.

De-watering sludge produced at the WWTP and disposing of biosolids is more cost effective than directly hauling sludge, as sludge requires more frequent disposal trips due to the large volume of water content in the sludge. However, if this method is preferred, the Town could opt to not install de-watering equipment and instead hire a septic hauling company to pump and dispose of sludge from the WWTP at a regular interval.

5.6.6 ENVIRONMENTAL IMPACTS

Alternative 4 will improve environmental stewardship in the Town by producing a higher quality effluent discharged into the Dolores River. In addition, methods such as prefabrication, using locally sourced materials, and the proper selection of a site that avoids areas such as farmlands, threatened animal habitats, and wetlands, are ways to reduce emissions and eliminate the unnecessary use of resources. The project does not go through any endangered animal habitats as there are no endangered or native species in the area. The proposed site for the WWTP does not directly interfere with any existing wetlands, however, according to the NWI there is a 0.25 acre freshwater forested/shrub wetland area approximately 0.1 mile south of the proposed site. It is not anticipated that an Environmental Information Document will be required for this treatment facility, as it does not interfere with this delineated wetland.

5.6.7 LAND REQUIREMENTS

The Town would not need any additional land for Alternative 4 as the Town owns the land where the treatment facility would be constructed.

5.6.8 POTENTIAL CONSTRUCTION PROBLEMS

Potential construction problems for Alternative 4 are primarily due to the location. Rico, CO has a shallow ground surface and is situated above bedrock. The facility would be built above grade where possible to minimize the amount of excavation required. Rico is situated in the mountains of Colorado where there are below freezing temperatures in the winter, so the construction season is limited. The Town is also fairly remote, which may require additional coordination between suppliers and contractors in order to receive necessary material on the jobsite.

5.6.9 SUSTAINABILITY CONSIDERATIONS

Alternative 4 would produce a significantly higher quality of wastewater effluent than what is currently being produced by the Town's network of septic tanks. Septic tanks are an unsustainable option since the effluent quality is unknown, they must be replaced on an individual basis in the case of failure, and they must be maintained by individual owners to continue working properly. There is no way of knowing how well each tank is being maintained or is functioning. Poor quality effluent produced over the course of years has potentially harmful impacts on the environment, people, and wildlife.

5.6.9.1 *Water and Energy Efficiency*

As previously mentioned, Alternative 4 would improve the quality of the wastewater effluent. This improves water efficiency from an environmental perspective, as it returns cleaner water to the environment, which can then be used for a wide array of purposes.

A conventional treatment process would consume more energy than the existing septic tanks, however, water stewardship would be boosted by this process due to the improved quality of water being discharged into the environment. The electric efficiency of the facility could be improved in the future by investing in renewable electricity generation sources such as solar and wind power.

5.6.9.2 *Green Infrastructure*

Modern construction techniques can be used to improve the green factor of Alternative 4. Alternative 4 requires a building to house the various process components. This structure could be built so that it is insulated sustainably, optimized for heat loss, and sourced from local materials. Prefabricating components related to Alternative 4 in a controlled environment off-site could also boost the green factor of this alternative.

5.6.10 ADVANTAGES AND DISADVANTAGES

The advantage of Alternative 4 is that MBBRs are very resilient to changes in wastewater composition, which makes them a good choice for remote areas without a dedicated wastewater treatment operator. MBBR treatment tanks can also be buried, which eliminates the need for a large building to house the entire treatment facility.

The disadvantage of an MBBR is that in order to remove phosphorus, tertiary filters are required. An MBBR, while not required to be housed in a building, requires more land area than an MBR or conventional activated sludge treatment process. Furthermore, excavation for burying of the tanks could be costly if rock is encountered, and access to the tanks will be limited once they are buried.

5.6.11 COST ESTIMATE

Preliminary capital costs for Alternative 4 are shown in Table 14 below. It is important to note that the costs associated with decommissioning individual septic tanks are not included in this cost estimate. This is because the Town has conveyed to BHI that the costs associated with septic tank decommissioning will be the responsibility each individual septic tank owner. The estimated cost of installing an MBBR treatment system, including construction costs and the engineering total, would be $8,162,788.90.

Table 14 – Alternative 4 MBBR Facility Cost Estimate

Item	Unit	Unit Price	Quantity	Cost
Construction Staking and Survey, compl.	%	$4,655,500.00	4.0%	$186,220.00
Construction Mobilization and Demobilization, compl.	%	$4,655,500.00	12.0%	$558,660.00
Site Clearing and Grubbing, compl.	AC	$6,000.00	1	$6,000.00
Trees, 8" to 30" circumference, Remove & Dispose, compl.	EA	$2,300.00	15	$34,500.00
Excavation, Backfill, and Compaction, removal of excess material offsite	CY	$120.00	2,000	$240,000.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip	CY	$120.00	500	$60,000.00
Tank ballasting. Incl. concrete deadmen with straps and turnbuckles for primary/eq & MBBR tanks	LS	$120,295.00	1	$120,295.00
Procurement of New Wastewater Treatment Facility, incl. submittals, purchase, shipping, offloading	LS	$1,589,394.40	1	$1,589,394.40
Procurement of New Fine Screen, incl. submittals, purchase, shipping, offloading	LS	$180,000.00	1	$180,000.00
Headworks Lift Station	EA	$400,000.00	1	$400,000.00
Procurement of Tertiary Filters	EA	$62,000.00	2	$124,000.00
Heat Trace for Tanks	LS	$40,000.00	1	$40,000.00
Solids Handling Equipment and Dumpster	LS	$220,000.00	1	$220,000.00
Mechanical installation of WWTP and fine screen, cip.	%	$2,491,394.40	30.0%	$747,418.32
Digester Covers	EA	$45,000.00	2	$90,000.00
Blower, chemical, tertiary filter, and storage building	SF	$150.00	1,250	$187,500.00
Chemical Addition System and Components	LS	$50,000.00	1	$50,000.00
Site Work, incl grading, civil site improvements, cip.	LS	$12,500.00	1	$12,500.00
Piping, including outfall, other mechanical installation, valves, incl. all installation, trenching, placement, cip.	LS	$200,000.00	1	$200,000.00

Electrical Materials and Installation incl. all power distribution equipment, underground facilities and duct banks, conduit, wire, support systems, switches, and all associated electrical hardware, all labor to install electrical equipment, conduit, wire, support systems as well as associated studies, testing and commissioning activities for the electrical system, cip.	LS	$265,409.16	1	$265,409.16
Instrumentation & Controls, incl. loop drawings, factory testing, installation of I&C systems, start-up and commissioning activities, cip.	LS	$88,469.72	1	$88,469.72
			Subtotal	**$5,400,366.60**
Construction Contingency			30%	$1,620,109.98
Utility Relocation Allowance			LS	$25,000.00
			Construction Cost Total	**$7,045,476.58**
*Engineering Design			7.5%	$406,902.50
*Construction Oversight and Administration			7.5%	$406,902.50
*Resident Project Representative (RPR) - $30,000 per mo. for 6 mos.				$180,000.00
*Permitting and Environmental			2%	$108,507.33
*Base Flood Elevation Determination			LS	$15,000.00
			Engineering Total	**$1,117,312.32**
			New MBBR Facility Total	**$8,162,788.90**

*Not calculated on Construction Contingency.

The estimated O&M costs and the present value O&M cost were calculated for Alternative 4 and are shown in Table 15 below. Power was based on rates obtained from the San Miguel Power Association, and the maintenance items were determined by analyzing the facility's specific operational needs. The estimated daily power requirement for an MBBR facility is 599 kilowatt-hours. The solid handling was based on preliminary solids production and de-watering calculations for the facility. Labor and benefits were estimated based on approximate time needed for onsite duties and current WWTP operator rates in Dolores County. The present value O&M cost was based on the annuities equation and used an inflation rate of 3% and a duration of 20 years.

Table 15 – Summary of Estimated O&M Costs for Alternative 4

Item	Unit	Annual Cost
Power	LS	$32,830.00
Mechanical Treatment System	LS	$21,410.00
Solids Handling Costs	LS	$65,160.00
Labor and Benefits	LS	$32,234.00
Total		**$151,634.00**
Present Value of O&M Cost		**$4,074,451.90**

The O&M costs for Alternative 4 are most effected by the solids handling and trucking costs; however, these costs are significantly lower than the costs associated with pure sludge pumping and disposal. The O&M costs for an MBBR facility for the Town are lower than those for an MBR facility, and only slightly higher than those for a conventional activated sludge facility. The power cost is lower for an MBBR when compared to an MBR, but higher when compared to a conventional activated sludge facility. The overall O&M costs for the MBBR is lower than an MBR and similar to a conventional activated sludge treatment facility because the MBBR process has lower power requirements than the MBR and has similar process requirements to the conventional activated sludge treatment facility.

6 WASTEWATER COLLECTION SYSTEM ALTERNATIVES

6.1 INTRODUCTION

The Town is interested in migrating from wastewater treatment by individual septic tanks to a town-operated mechanical wastewater treatment system. In order to do this, a centralized collection system to bring sewage from commercial and residential properties to the mechanical treatment system will need to be installed.

In the following sections the installation of a wastewater collection system is evaluated (Alternative 2), along with the no action alternative (Alternative 1). The no action alternative is included to illustrate the current status of wastewater collection in the Town. Alternative 2 presents a viable wastewater collection design for the transport of wastewater to a new WWTP in Rico.

6.2 PROJECT DESIGN BASIS

The project design basis for the Town's proposed collection system is summarized as follows:

- Flow Rate and Hydraulic Capacity – The individual flow rate for each segment of collection line was considered when selecting pipe sizes. Additionally, guidelines from the *CDPHE Wastewater Design Criteria Policy* were considered along with engineering assumptions applied to minimize the possibility of blockages in pipelines. The larger sewer mains were sized to be capable of conveying the total average and peak flow for 2043 developed in Section 5.2.1 herein.
- Town Topography – The collection system was laid out to maximize gravity sewer flow throughout the Town. Topographic low points were analyzed closely in order to eliminate any unnecessary lift stations. Necessary lift stations were placed in geographic low points to maximize potential for additional homes to be served by lift stations as population continues to grow.
- Existing Infrastructure and Features – Areas where difficult easements or rights of way would need to be procured were minimized, where known. For instance, known Colorado Department of Transportation (CO DOT) Rights-of-Way (ROWs) were avoided when laying the collection system out so that complicated and time-intensive coordination regarding the ROW could be reduced.

6.3 ALTERNATIVE 1 – NO ACTION

6.3.1 DESCRIPTION

Alternative 1 is the No-Action alternative and does not include any improvements to the Town's current methods of wastewater collection. This alternative would have the Town remain on a de-centralized network of septic tanks.

6.3.2 DESIGN CRITERIA

Alternative 1 does not include improvements and therefore, there is no design criteria for this alternative.

6.3.3 ENVIRONMENTAL IMPACTS

Alternative 1 does not include improvements and therefore, there are no environmental impacts due to construction.

6.3.4 LAND REQUIREMENTS

Alternative 1 does not include improvements and therefore, there are no additional land requirements.

6.3.5 POTENTIAL CONSTRUCTION PROBLEMS

Alternative 1 does not include improvements and therefore, there are no potential construction problems.

6.3.6 SUSTAINABILITY CONSIDERATIONS

Alternative 1 does not include improvements, thus it would maintain the current level of sustainability with respect to the environment.

6.3.6.1 *Water and Energy Efficiency*

Alternative 1 does not include improvements and may not impact the water and energy efficiency in the short term.

6.3.6.2 *Green Infrastructure*

Alternative 1 does not include improvements and does not impact green infrastructure.

6.3.7 ADVANTAGES AND DISADVANTAGES

Alternative 1 is the least costly alternative from a capital cost perspective, though it does not resolve any deficiencies identified in this report.

6.3.8 COST ESTIMATE

No construction costs would occur with Alternative 1.

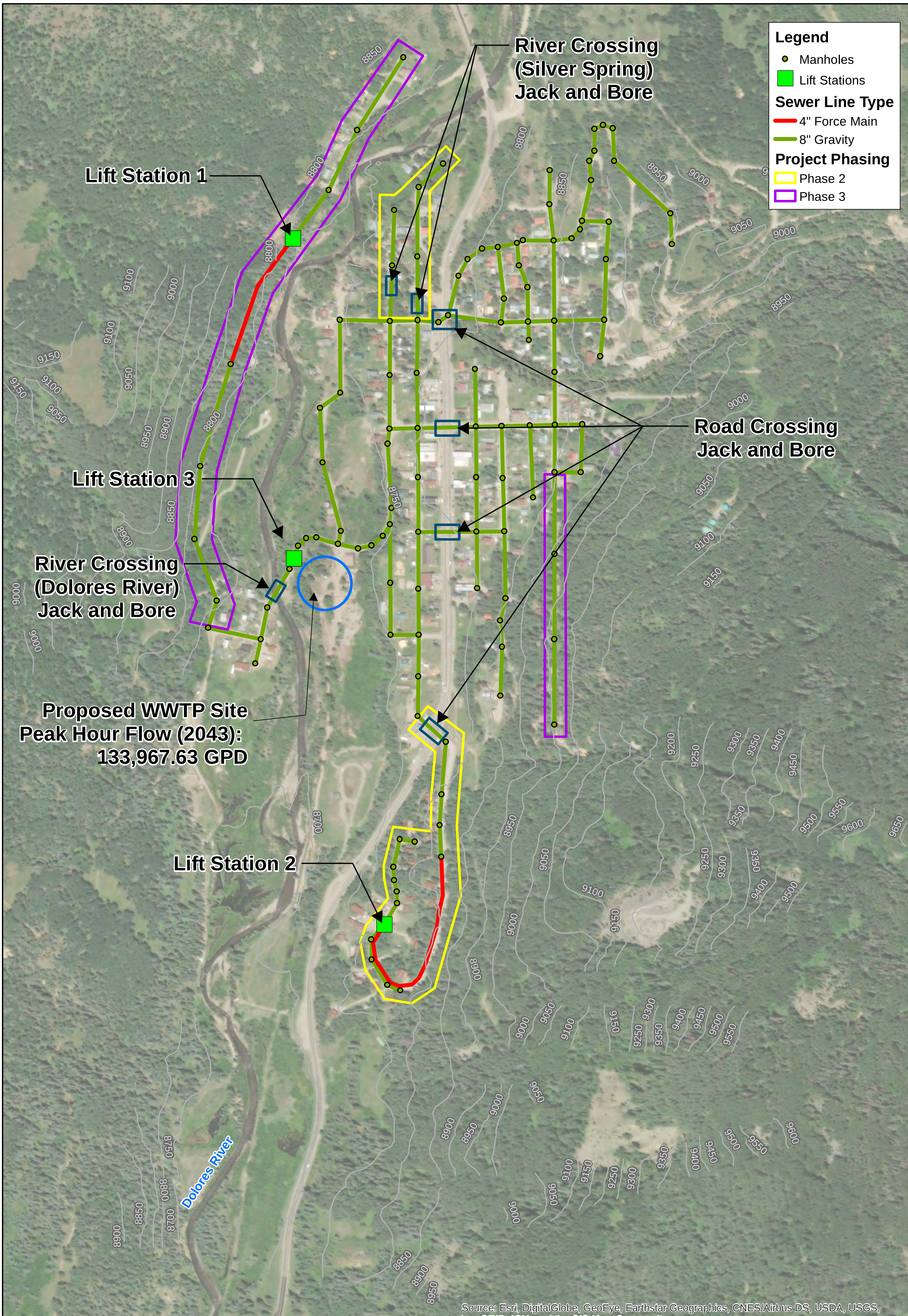
6.4 ALTERNATIVE 2 – COLLECTION SYSTEM

6.4.1 DESCRIPTION

A wastewater collection system is composed of a network of pipes, manholes, lift stations and various other components; however, its primary function is to convey sewage from various system users to a wastewater treatment facility so that the wastewater can be properly treated.

Given the Town's mountainous topography, the collection system can primarily rely on gravity flow for conveyance of sewage to the wastewater treatment facility, with the exception of two lift stations needed (excluding the lift station required at the WWTP) once the collection system is fully built out to serve the entire Town of Rico. The Town generally slopes downward from north to south, similar to the flow direction of the Dolores River, and the three largest topographical challenges to the collection system are the Dolores River, Silver Creek, and Glasgow Avenue.

The proposed collection system is shown in Figure 11, and construction of the complete system is proposed as three separate phases. The first phase encapsulates the majority of the collection system and is shown without a phasing boundary on Figure 11. The second phase is denoted on Figure 11 by the phase 2 boundary and includes two jack and bore pipelines under Silver Creek, one jack and bore pipeline under Glasgow Avenue, lift station 2, force main, gravity lines, and some manholes. Phase 2 would connect approximately 33 residences to the collection system; however due to topographical constraints, connection of these houses is more expensive and work intensive than the connections identified in the first phase of the system (the central portion of Rico). Therefore, these connections have been broken out as a second phase to allow additional flexibility in the construction of the collection system. The third phase is denoted on Figure 11 by a phase 3 boundary and includes lift station 1, force main, gravity lines, and some manholes. Phase 3 would connect approximately 16 residences to the collection system, and similarly to Phase 2, was broken out as a separate phase due to its more extensive topographical challenges.



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N W E S

0 750 1,500 Feet

1 in = 500 ft

Town of Rico
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Figure 11
Wastewater Collection System

P:\20240048\WR\Reports\Preliminary & Draft\Figures\MXDs\20240048_Figure 11 - Collection System.mxd
Author: cpepin

December 2023

At full build out, there would be approximately 27,400 linear feet (LF) of 8-inch gravity sewer and approximately 2,000 LF of 2-inch force main (with the same amount of 4-inch pipe installed in the same trench for future use). There would be approximately 115 manholes in the system, which would be placed approximately 500 LF apart and at horizontal pipe bend locations. There would be two lift stations required due to topographical constraints. There would be roughly 300 service connections. Of the 300 connections, it is estimated that roughly 30 would need to be pumped via lift station. The collection system would cross Glasgow Avenue four times, Silver Creek twice, and the Dolores River once; however, each of these crossings would utilize a trenchless construction method such a jack and bore. The crossing on Silver Creek on the East of Town is not expected to require a jack and bore crossing based on a preliminary evaluation of topographic data.

6.4.2 COLLECTION SYSTEM DESIGN

The Town's collection system was designed to optimize gravity flow and minimize the number of required lift stations and crossings of Glasgow Avenue, Silver Creek, and the Dolores River. As mentioned above, at full build out, the Town's collection system features approximately 27,400 LF of 8-inch gravity sewer, 2,000 LF of 2-inch force main, and 2 system lift stations (not including the WWTP lift station). The collection system crosses Glasgow Avenue in four locations, Silver Creek in two locations, and the Dolores River in one location; each of these crossings are planned to be installed using a trenchless construction method such as jack and bore, so as not to interfere with the CO DOT ROW or any active waterways.

In designing the complete collection system, each pipe segment was placed based on the Town's topography and proposed pipe slope. This process prioritized gravity flow and assessed each crossing of Glasgow Avenue, Silver Creek, and the Dolores River closely in order to ensure that each crossing was critical to maintain positive flow to the proposed WWTP. Lastly, in areas where gravity flow was identified as not possible, lift stations were strategically placed to convey sewage from geographically constrained regions to other higher areas of the system so that they may then flow by gravity to the WWTP. While construction of the entire collection system is proposed in three phases, the fully built out collection system was evaluated for capacity and ability to operate as either gravity or pressurized sewer in order to ensure that the system would function as intended when complete. In order to evaluate and verify the complete system layout and the location of the lift stations, five representative pipeline profiles throughout the proposed collection system were prepared. The alignments selected for each of the representative pipeline profiles can be observed in Figure 12.

Profile 1 (Alignment 1) can be observed in Figure 13 and was selected as it collects the largest amount of flow in the system and represents a large portion of the Town's topography from east to west. The pipeline shown in profile 1 is included in the first phase of construction for the collection system and would flow entirely by gravity and connect to eight other collection system pipelines. The manholes shown on profile 1 are placed at pipeline connections, horizontal bends, and every 500 feet as needed. The pipeline shown in profile 1 crosses Glasgow Avenue once, and a jack and bore trenchless construction method is called for in this location.

Profile 2 (Alignment 2) is shown in Figure 14. This profile was drawn, as it represents the topography and flows from the northeast portion of the Town. The pipeline shown in profile 2 is included in the first phase of construction for the collection system and would flow entirely by gravity before it connects into the pipeline shown in profile 1. The pipeline shown in profile 2 generally matches the topography and has a large range of both shallow and steeper slopes. This pipeline ties into eight other collection system pipelines, and has several manholes located at connection points, horizontal bends, and every 500 feet as needed. The pipeline shown in profile 2 also crosses Glasgow Avenue once, and a jack and bore trenchless construction method is called for in this location. It is important to note that due to the opposite slope direction on Van Winkle Road, all homes located along Van Winkle Road will need to be served by the collection line shown here or the above section in E. Mill Road in order for these homes to have a gravity connection.

Profile 3 (Alignment 3) can be seen in Figure 15. This profile represents a very flat section of the Town's collection system. The pipeline shown in profile 3 is included in the first phase of construction for the collection system and will have a small negative slope before it connects into the pipeline shown in profile 1. This small slope was optimized so that the bury depth at the connection point to profile 1 was maintained as shallow as possible while still maintaining over a 4-foot bury depth to prevent line freezing.

Profile 4 (Alignment 4) can be observed in Figure 16 and was selected as it represents flows from the most northern and western portions of the Town. The majority of the pipeline shown in profile 4 is included in the third phase of construction for the collection system, and the profile itself illustrates the requirement for the first lift station (Lift Station 1). The pipeline shown in profile 4 begins by collection sewage from the homes at the beginning of the pipeline by gravity. Flow from those homes then collect at a low point south of the homes,

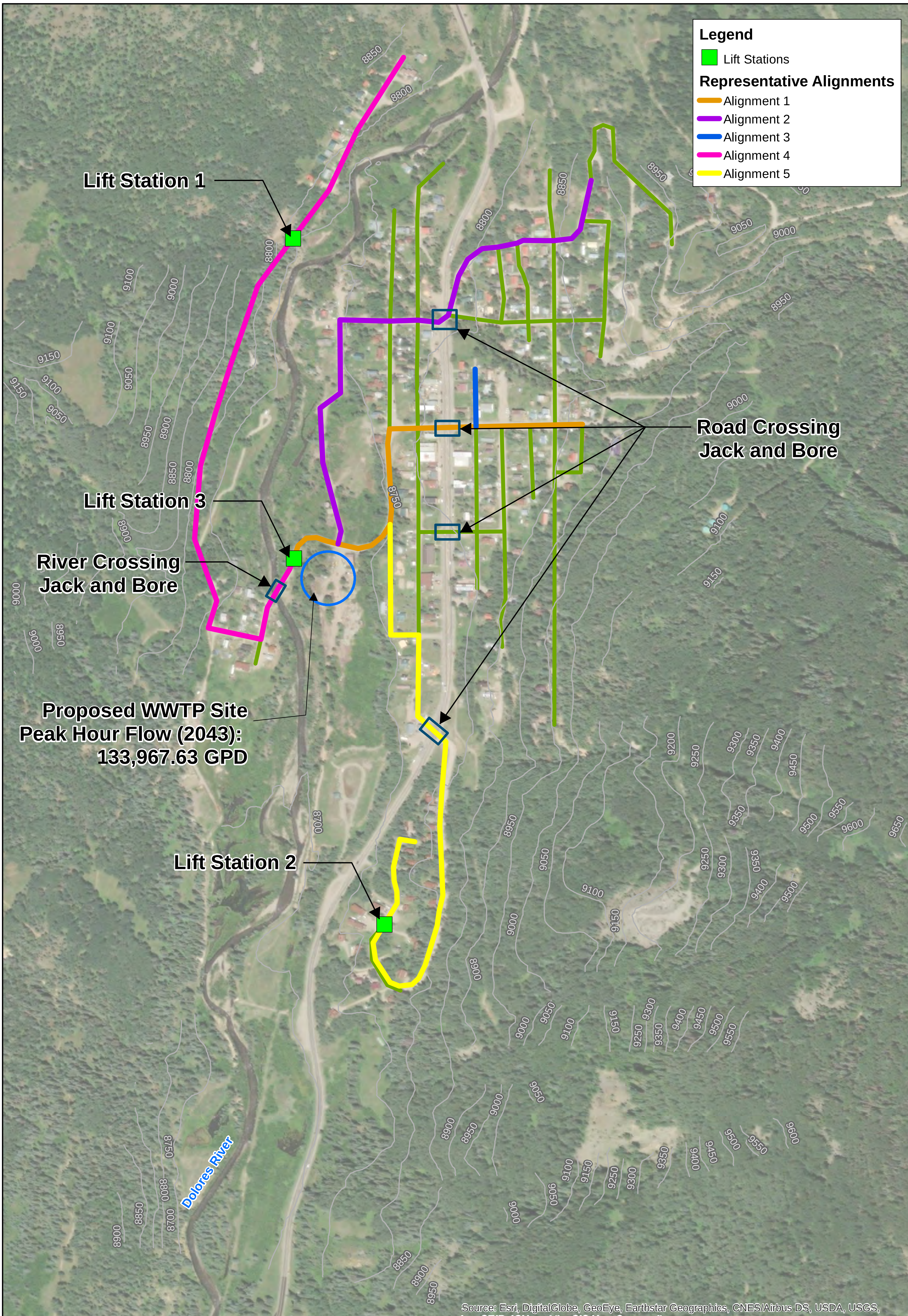

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Figure 12
Collection System Alignments

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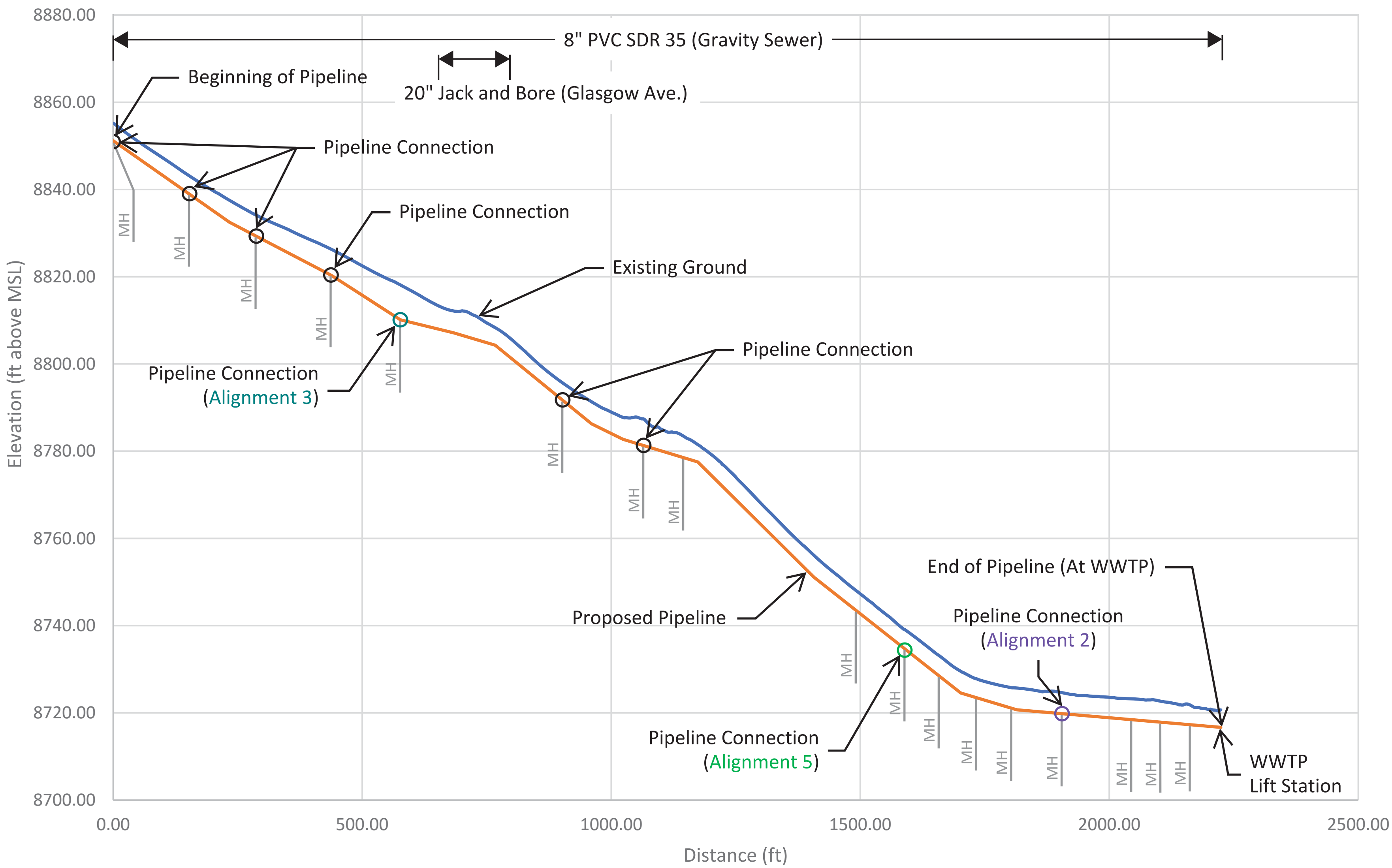

Figure 13 - Profile 1

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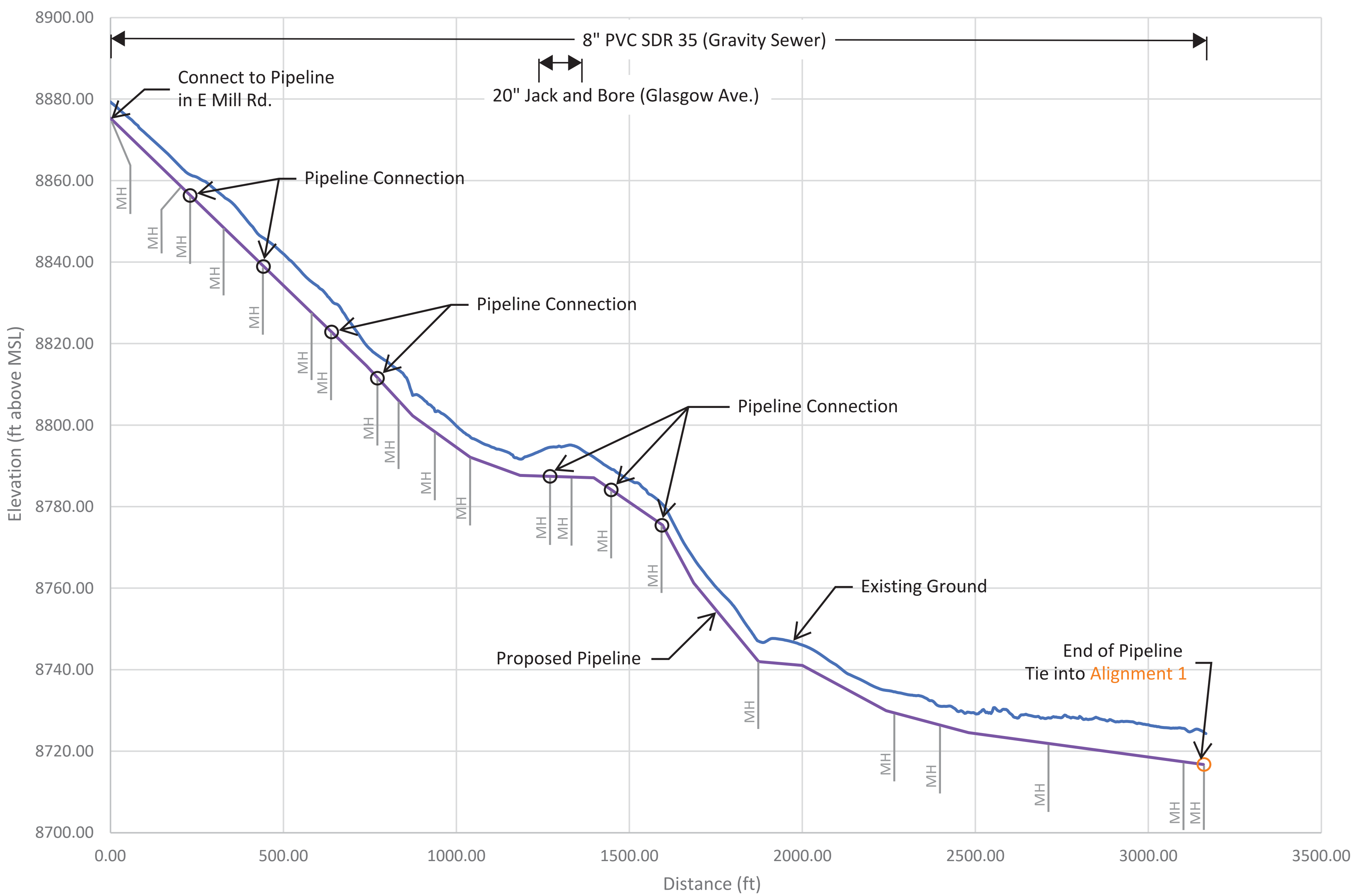

Figure 14 - Profile 2

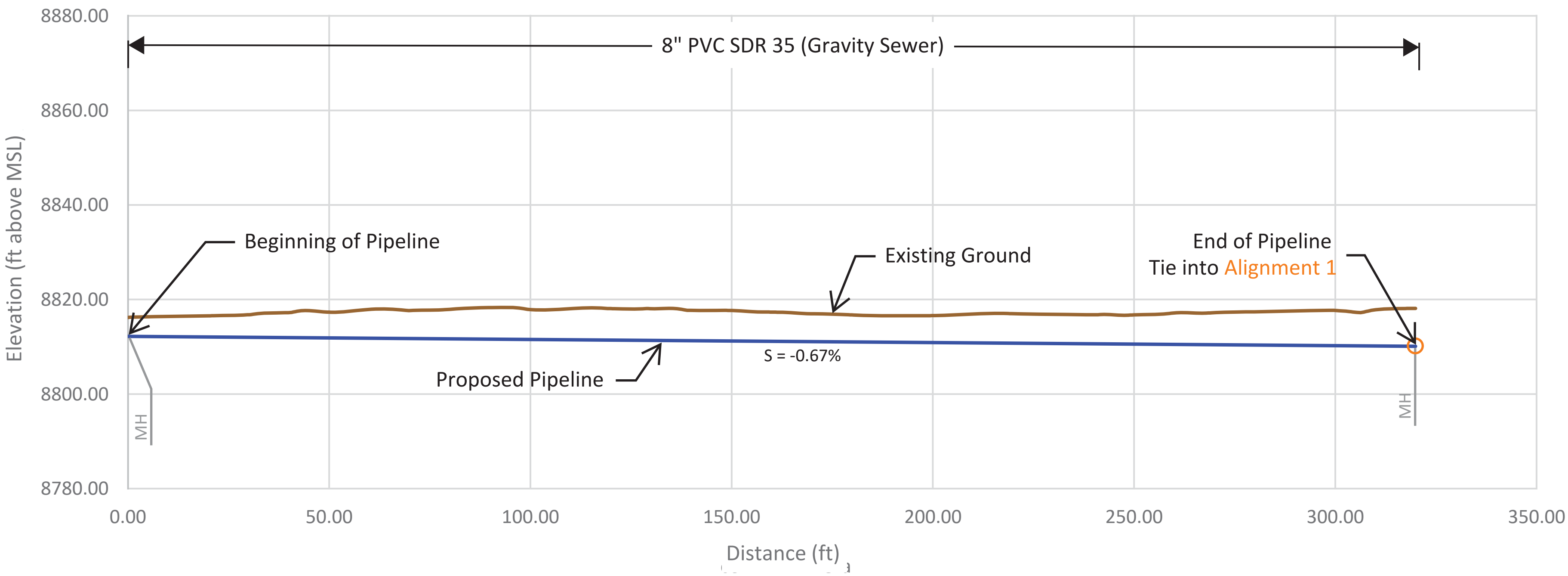

Figure 15 - Profile 3

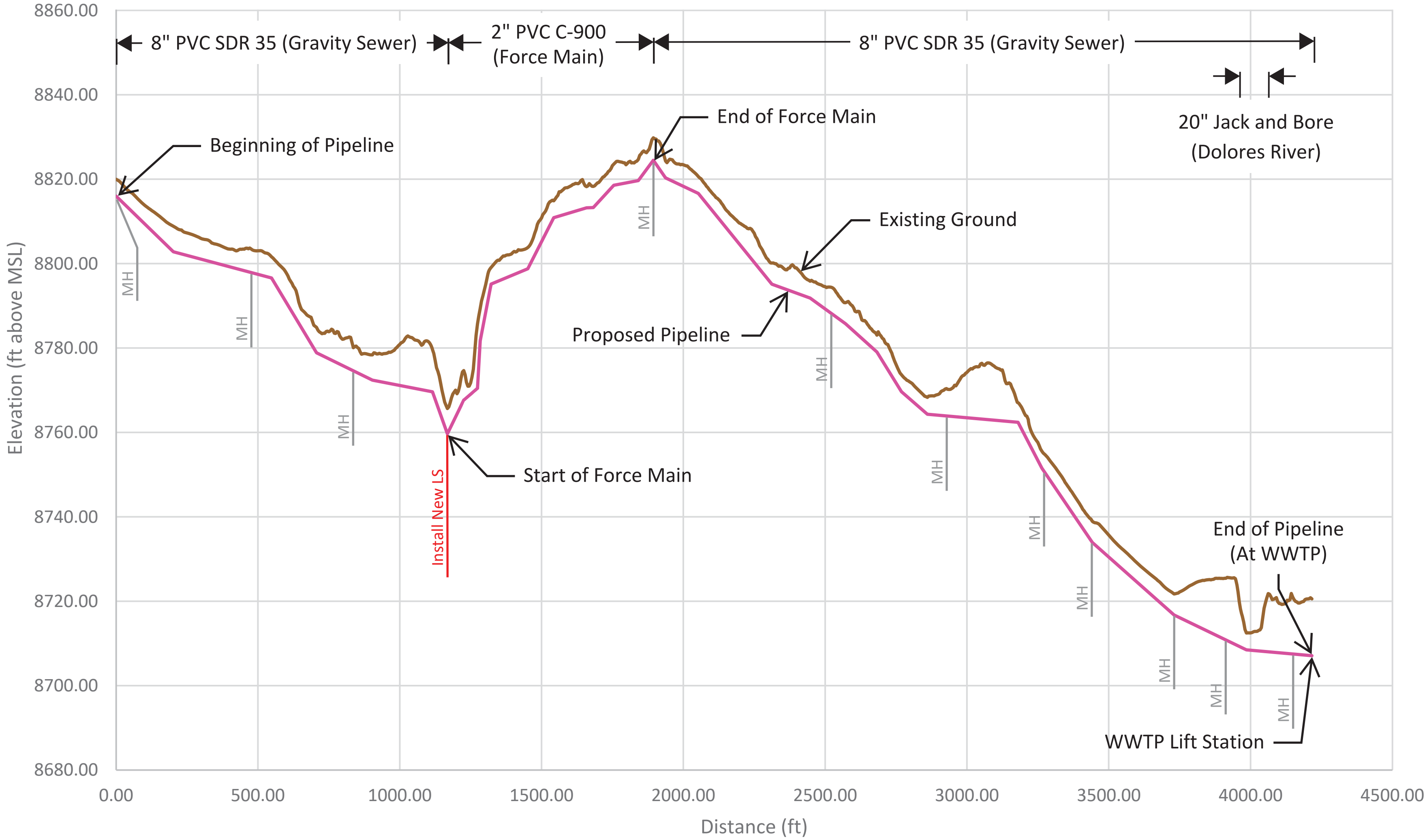

Figure 16 - Profile 4

and a lift station placed at the low point will pump sewage over a topographical high point, where it will flow by gravity to the lift station at the front of the new WWTP. This pipeline location was selected because installing a gravity sewer to the east would require a lengthy section of pipe be installed along Glasgow Ave in the CO DOT ROW, which could complicate permissions, construction timeline, and provide minimal access to the pipeline after installation. Furthermore, this pipeline will be installed underneath the Dolores River. Installation of this pipe section will require trenchless construction and will deepen the pipeline in this section and sections prior. After the river, sewage will continue to flow by gravity into a deep wet well at the WWTP lift station. The pipeline shown in profile 4 has one pipeline connection and manholes placed along the gravity line section at pipeline connections, horizontal bends, and every 500 feet as needed; there are no manholes required for the force main sections.

Profile 5 (Alignment 5), shown in Figure 17, is included in the second construction phase of the collection system and represents flows from the southernmost portion of the Town as well as the second required collection system lift station (Lift Station 2). The pipeline in profile 5 begins as gravity sewer, which collects sewage from the homes located along the pipeline in the south of Town. The gravity sewer flows to a regional low point, where a lift station will be installed to pump sewage over a large hill. After the hill, the pipeline becomes gravity sewer again, and sewage flows under a jack and bore-installed pipeline under Glasgow Avenue. Sewage will then flow by gravity in a pipeline installed in S. River Street before it meets the pipeline shown in Profile 1. The pipeline shown in profile 5 has one pipeline connection and manholes placed along the gravity line section at pipeline connections, horizontal bends, and every 500 feet as needed; there are no manholes required for the force main sections.

The five profiles prepared for the Town of Rico's collection system, presented above, represent areas of the system with the widest range of slope, flow, and pumping requirements. For this reason, an analysis was performed on these pipelines to verify the current, future, and full flow capacities through each of these pipes. For the purposes of this analysis and to maintain a conservative design, full flow is defined as 80% of maximum flow through each pipe. This approach ensures that maximum capacity is never exceeded, from a design standpoint, within the system. The current and future flows through each pipe were estimated based on a ratio of current users served by each pipeline segment to the overall peak current and future flows. The full pipe flow was calculated using Manning's formula, and system specific slopes, diameters, elevation, and manning's roughness coefficient for

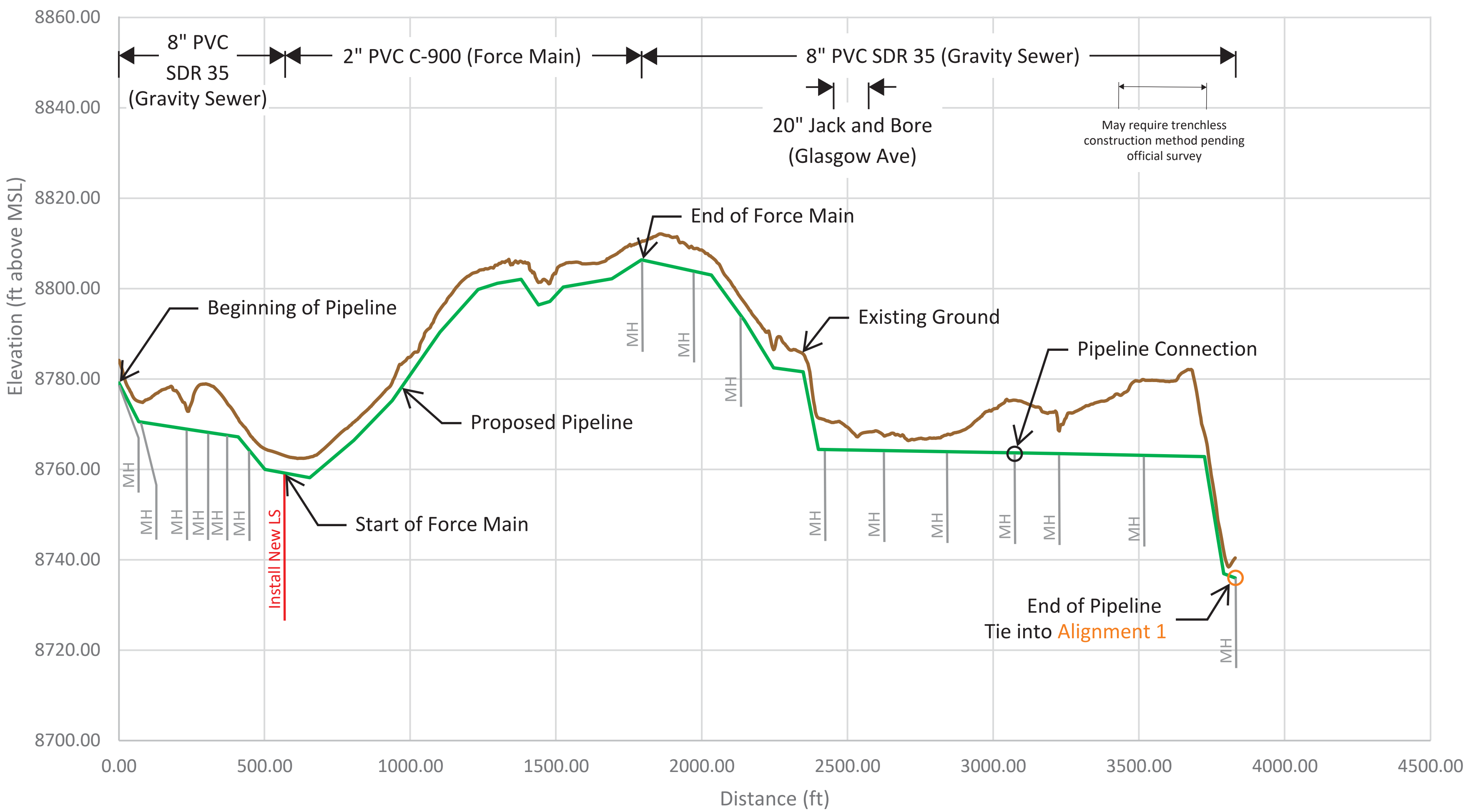

Figure 17 - Profile 5

PVC pipe. These calculated flows can be observed in Table 16.

Table 16 – Calculated Flow Rates

Pipe Section (Gravity Only)	2023 Flow Through Pipe (GPM)	2043 Flow Through Pipe (GPM)	Full Flow Through Pipe (GPM)	Pipe Slope Range
Profile 1	7.04	10.53	696.14	-0.98% to -11.31%
Profile 2	11.12	16.63	365.35	-0.27% to -15.75%
Profile 3	1.86	2.78	566.87	-0.67%
Profile 4 – before force main	0.89	1.33	802.06	-1.30% to 18.86%
Profile 4 – after force main	2.08	3.10	941.20	0.60% to 12.92%
Profile 5 – before force main	1.33	2.00	687.61	0.97% to 12.40%
Profile 5 – after force main	2.68	4.00	231.60	0.11% to 25.58%

As shown in Table 16, the collection system design provides the Town with the ability to well-exceed current and future-projected wastewater flows. This means that the system can accommodate large instantaneous surges of sewage flow through the system, as well as future growth beyond the 2043 projected population. While it may seem desirable to downsize a collection system with such a large flow capacity, this is not advised, as installing 8-inch sewer mains reduces the risk of costly sewage blockages. Furthermore, the *CDPHE Wastewater Design Criteria Policy* states that sewer mains must be a minimum of 8-inches in diameter.

In addition to the gravity sewer analysis, the two lift stations required in the collection system were also evaluated. First, the projected future flow through each lift station was calculated using the same user-based ratio method used for the gravity sewer analysis. Using profiles 4 and 5 (Figures 16 and 17, above), the static head and total design head were then determined. Typically, the minimum size for a force mains is 4-inches so that blockages can be minimized; however, given the current low flows at each of these lift stations, it is proposed that a 2-inch force main be installed for current use, with an additional 4-inch capped pipeline installed in the same trench so that it can be used in the future if flows increase beyond current and future calculations. Given the length of force main needed, it is expected that the force main will always remain full and that a portion of this sewage will go septic, but due to its small volume, it will not affect the ability of the WWTP to effectively treat the Town's sewage. Lastly, the expected head losses associated with general loss, system bends, and piping were estimated. These parameters were provided to a E/ONE grinder pump lift station supplier, and parameters for suitable pumps to meet the Town's requirements and specific duty point will be incorporated into the final PER. The lift station parameters can be observed in Table 17; the names of each lift station are as labeled in Figure 11.

Table 17 – Lift Station Parameters

Parameter	Lift Station 1 (North)	Lift Station 2 (South)
*Flow Rate (GPM)	5.32	7.98
Static Head (ft)	64.86	47.24
Combined Head Losses (ft)	15.0018	15.0032
Total Design Head (TDH)	79.86	62.24

*Based on a design peaking factor of 4.

6.4.3 PROJECT PHASING

In order to maximize funding flexibility, the installation of the collection system has been broken into three phases.

The first phase includes the majority of the Town and only gravity sewer lines. The first phase is estimated to take a total of 9 months to complete. As it is predicted that the Town may not have 9 consecutive construction months due to the climate, it is recommended that the project either be expedited or broken into a 2-year project. An expedited project would require that extra construction crews mobilize to Rico for this project but could complete the project during the warmer months in a single year and might eliminate the possibility of the project being charged double mobilization costs. Breaking the projects into two seasons could be done by separating the Town into sections and prioritizing installation based on need and geographic location; this method would likely incur mobilization costs for each section of the project.

The first phase of the collection system can be constructed simultaneously with the selected treatment facility. The treatment facility will need to be fully constructed and operational first before customers can be tied onto the collection system. Once the treatment system is operational and customers are tied into the sewer system, septic tank decommissioning can begin. It is expected that septic tank decommissioning will be the responsibility of the Owner; however, the Town may evaluate this further as the project progresses.

The second and third phases of the collection system are estimated to take 4 months each to complete. These projects could be bid together and awarded to the same contractor, or bid and awarded separately as budget availability allowed. If these projects were awarded together, cost savings may be associated with combining contractor mobilization, engineer construction inspection, and overall construction duration.

6.4.4 ENVIRONMENTAL IMPACTS

The project does not go through any endangered animal habitats as there are no endangered or native species in the Town. While lines are being installed, dust control measures and stormwater management best management practices (BMPs) can be applied to minimize the impacts of construction on the local ecosystem and wildlife habitats. After lines are installed, disturbed areas can be re-seeded to reduce the aerosolizing of dust and prevent erosion.

6.4.5 LAND REQUIREMENTS

For Alternative 2, and all construction phases proposed within, the collection system was laid out to primarily use Town-maintained roadways. Installing pipeline along Glasgow Avenue was avoided to eliminate the need to request the use of the CO DOT ROW. The four locations where the sewer line would cross Glasgow Avenue can be performed with a trenchless construction method such as a jack and bore. Furthermore, this same method can be used for installing force main line under the Dolores River. The phase 3 sewer line planned for the very west side of Town, as shown in Figure 11, may require that the Town negotiate easements through private land; discussions with the Town have indicated that the obtainment of these easements are likely feasible.

6.4.6 POTENTIAL CONSTRUCTION PROBLEMS

Potential construction problems for Alternative 2, and all construction phases proposed within, pertain to the location of the Town. Rico, CO has a shallow ground surface and is situated above bedrock. Rico is situated in the mountains of Colorado where there are below freezing temperatures in the winter and construction season is limited, so this must be taken into consideration. The collection lines will be designed to minimize bury depth, where possible. However, with Rico's cold climate, a minimum bury depth of 4 feet will need to be applied to all lines in order to prevent line freezing. The Town is also fairly remote and it could be complicated to get materials, such as concrete, onsite as materials will have to be brought in.

6.4.7 Sustainability Considerations

Alternative 2 would convey wastewater to a mechanical WWTP for removal of contaminants. The collection system is integral to the WWTP, which improves the water and environmental sustainability by helping to protect Colorado's pristine water bodies. Therefore, the collection system is intrinsically sustainable.

Without the collection system, the Town would not have the ability to mechanically treat wastewater and would continue to use septic tanks. As mentioned previously, septic tanks are an unsustainable option because the effluent quality is unknown, they must be replaced on an individual basis in the case of failure, and they must be maintained to continue working properly which there is no way of knowing how well each tank is being maintained.

6.4.7.1 *Water and Energy Efficiency*

Alternative 2 would improve the water efficiency of the Town since the installation of a collection system is integral to the treatment of wastewater at a mechanical treatment facility. The quality of effluent produced by a mechanical treatment facility will be much higher than that produced by septic tanks. Producing high quality wastewater effluent that can be released to the environment for other uses is water efficient; therefore, the installation of a sewer collection system intrinsically improves water efficiency.

The collection system has been laid out in such a way to maximize gravity flow and minimize the number of required lift stations. This boosts the energy efficiency of the collection system.

6.4.7.2 *Green Infrastructure*

Green infrastructure can be encouraged in the collection system by adding bioswales, permeable pavement and detention ponds where feasible and necessary.

6.4.8 Advantages and Disadvantages

The main advantage of Alternative 2 is that if a collection system is implemented in the Town, then wastewater can be brought to a facility where it is uniformly treated. A collection system will cost more than staying on septic, but in the long run, a uniform collection system will pay off for the Town in terms of environmental stewardship, updated CDPHE regulations, and human safety. Furthermore, breaking the collection system into phases allows additional funding flexibility to the Town so that they may begin collection system installation without necessarily having the full amount of funding required for the entire collection system.

6.4.9 COST ESTIMATES

Preliminary capital costs for Alternative 2 are broken out by each of the three construction phases. The cost for the first (base) phase is shown in Table 18 below. The estimated cost of the first phase of the wastewater collection system, including construction costs and the engineering total, would be $8,488,656.69. The estimated cost of phases 2& 3 of the collection system are summarized in Table 19, and the full cost breakdown can be found in Appendix I.

Table 18 – Alternative 2 Phase 1 Collection System Cost Estimate

Item	Unit	Unit Price	Quantity	Cost
Construction Staking and Survey, compl.	%	$4,626,000.00	4.0%	$185,040.00
Construction Mobilization and Demobilization, compl.	%	$4,626,000.00	12.0%	$555,120.00
Traffic Control, cip.	%	$4,626,000.00	4.0%	$185,040.00
Seeding, cip.	LS	$10,000.00	1	$10,000.00
8" sewer, all depths, including pipe, excavation and compaction, cip.	LF	$92.30	18,490	$1,706,627.20
20" Jack and Bore, including .375" thick steel casing, casing spacers, excavation and support of bore and receiving pits & end seals (excl. 8" carrier pipe), compl.	LF	$500.00	470	$235,000.00
New Manhole, 4' DIA	EA	$13,850.00	86	$1,191,100.00
Rock Excavation, Remove & Dispose , cip.	CY	$360.00	3,090	$1,112,400.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip.	CY	$120.00	3,090	$370,800.00
			Subtotal	**$5,551,127.00**
Construction Contingency			30%	$1,665,338.10
Utility Relocation Allowance			N/A	$50,000.00
			Construction Cost Total	**$7,266,465.10**
Engineering Design			7.5%	$420,084.53
Construction Oversight and Administration			7.5%	$420,084.53
Resident Project Representative (RPR) - $30,000 per mo. for 9 mos.				$270,000.00
Permitting and Environmental			2%	$112,022.54
			Engineering Total	**$1,222,191.59**
			Phase 1 Collection System Facility Total	**$8,488,656.69**

The estimated costs of phases 2 & 3 include both construction and engineering costs. Each of these phases can be constructed independently from the base collection system phase and are estimated to take approximately 4 months each for construction.

Table 19 – Alternative 2 Phase 2 & 3 Collection System Cost Estimate

Collection System Phase	Total
Phase 2	$3,534,097.87
Phase 3	$2,815,359.39

The estimated O&M costs and the present value O&M costs were calculated for each of the phases within Alternative 2 and are shown in Table 20 below. The full breakdown of these costs can be found in Appendix J. Power was based on rates obtained from the San Miguel Power Association, and the maintenance items were determined by analyzing the collection system's specific operational needs such as lift station maintenance and occasional hydro jetting of pipes. Labor and benefits were estimated based on approximate time needed for maintenance duties. The present value O&M costs were based on the annuities equation and used an inflation rate of 3% and a duration of 20 years.

Table 20 – Summary of Estimated O&M Costs for Alternative 2

Project Phase	Total Annual Cost	Present Value of O&M Cost
Phase 1	$12,300.00	$330,505.61
Phase 2	$18,340.00	$492,802.67
Phase 3	$18,340.00	$492,802.67
Total	**$48,980.00**	**$1,316,110.95**

7 SELECTION OF AN ALTERNATIVE

The selection of an alternative for the improvements to the Town of Rico Wastewater System was based on an evaluation of life cycle costs as well as other non-monetary factors. The life cycle cost analysis for the treatment facility and collection system alternatives are presented in the subsequent sections.

7.1 LIFE CYCLE COST ANALYSIS

A comparison of capital and life cycle costs for Wastewater Treatment Facility Alternatives 2, 3, and 4, are presented in Table 21. Alternative 1 for the wastewater treatment system was not considered in the life cycle cost analysis since this is a no action alternative and would not entail any improvements or costs.

Table 21 – WWTP Capital and Life Cycle Cost Comparison

Item	Estimated Capital Cost	Annual O&M Cost	Present Worth of Annual O&M Costs	Total Capital and Present Worth Annual O&M Costs
Alternative 2 – Conventional Activated Sludge	$7,430,038.59	$149,814.00	$4,025,547.82	$11,455,586.41
Alternative 3 – MBR	$8,059,644.00	$173,394.00	$4,659,151.25	$12,718,795.25
Alternative 4 – MBBR	$8,162,788.90	$151,634.00	$4,074,451.90	$12,237,240.81

The capital and life cycle costs for each phase of the collection system are shown in Table 22. The costs associated with the first phase of the collection system will be required regardless of the treatment facility selected since wastewater from the Town will need to be conveyed to the WWTP in order for it to be treated.

Table 22 – Collection System Capital and Life Cycle Cost Comparison

Item	Estimated Capital Cost	Annual O&M Cost	Present Worth of Annual O&M Costs	Total Capital and Present Worth Annual O&M Costs
Collection System – Phase 1	$8,488,656.69	$12,300.00	$330,505.61	$8,819,162.30
Collection System – Phase 2	$3,534,097.87	$18,340.00	$492,802.67	$4,026,900.54
Collection System – Phase 3	$2,815,359.39	$18,340.00	$492,802.67	$3,308,162.05
Total Collection System	**$14,838,113.95**	**$48,980.00**	**$1,316,110.94**	**$16,154,224.89**

The first phase of the collection system, as mentioned above, will be a necessary cost in order to convey wastewater to the WWTP. Given the required nature of the first phase, the first phase collection system costs were added to each wastewater treatment alternative, shown in Table 23.

Table 23 – Total Project Capital and Life Cycle Cost Comparison

Item	Estimated Capital Cost	Annual O&M Cost	Present Worth of Annual O&M Costs	Total Capital and Present Worth Annual O&M Costs
Conventional Activated Sludge w/ Collection System (P1)	$15,918,695.28	$162,113.61	$4,356,053.43	$20,274,748.71
MBR w/ Collection System (P1)	$16,548,300.69	$185,693.61	$4,989,656.86	$21,537,957.55
MBBR w/ Collection System (P1)	$16,651,445.59	$163,933.61	$4,404,957.51	$21,056,403.10

7.2 ALTERNATIVE EVALUATION

Each of the wastewater treatment alternatives will require the installation of the first phase of the collection system in order to provide benefit to the Town. Therefore, the first phase of the collection system is assumed to be included in each of the wastewater treatment alternatives.

In comparing the three treatment alternatives, the parameters described below were most strongly considered:

- Capital and Operational Costs – Alternative 2 has the lowest capital cost and present worth O&M cost. Alternative 4 has the highest capital cost, while Alternative 3 has the highest present worth O&M cost. Each of the facilities have a relatively similar lifespan and it is important to note that all of the alternatives a relatively similar in magnitude of cost.
- Operational Complexity And Requirements – Both Alternatives 2 and 4 require the addition of tertiary filtration to remove phosphorus, while Alternative 3 can use its included process membranes to remove phosphorus. Furthermore, Alternatives 2 and 4 are likely to slightly produce more sludge than Alternative 3, which may equate to additional solids handling and processing time. Alternative 2 is the least complex biological process, Alternative 4 is only slightly more complex, and Alternative 3 is the most complex. Despite varying complexities, all of these processes require the same level of operator's

license from the State of Colorado, and a contract operator could be hired to operate the facility with a utility employee onsite to assist with operations. Furthermore, the pre-packaged treatment facility associated with Alternative 3 features an integrated fine-screen designed with the specific MBR requirements, whereas Alternatives 2 and 4 require a fine screen to be added to their respective pre-packaged treatment options. All fine screens provided in each alternative will provide the screening necessary to maintain treatment standards; however, Alternative 3 would require fewer manufacturer-issued warranties. Alternative 3 would also require special care be paid to the maintenance of the process membranes; however much of this process can be automated, and a routine maintenance interval should be established to ensure smooth operations. However, generally, the overall amount of work required and time spent on-site for each facility is relatively similar.

- Treatment Efficiency and Adaptability – While all treatment alternatives will be designed to meet CDPHE PELs, Alternative 3 provides the highest quality of wastewater effluent with the least amount of additional equipment. Alternative 3 will require the addition of a chemical injection system to remove phosphorus; however, Alternatives 2 and 4 require both the chemical injection system and tertiary filters to remove phosphorus. While there may be slight differences between each alternative, all of the alternatives are resilient to changes in influent wastewater flows and composition.
- Facility Footprint – The facility that requires the largest amount of land is Alternative 4 due to the large size of the tanks that would be buried; however, Alternative 4 features the smallest combined building footprint. The facility with the largest building footprint is Alternative 2, and the entire facility is located in the building. The facility that requires the least amount of land is Alternative 3, and the entire treatment facility is also planned to be housed in a building.

8 PROPOSED PROJECT (RECOMMENDED ALTERNATIVE)

8.1 PRELIMINARY PROJECT DESIGN

The final project should be determined by the Town of Rico. Each of the treatment alternatives evaluated within this report were selected based on their ability treat wastewater to high effluent quality. Additionally, the collection system has been designed to optimize gravity flow and avoid geographical constraints. Therefore, each of the treatment alternatives feature the ability to meet the Town's treatment needs, while the collection system provides the Town with a viable means for conveying wastewater to a treatment facility.

While the final decision should be made by the Town, it is BHI's recommendation that treatment Alternative 3 be selected. This alternative is competitively priced, and only slightly higher than Alternative 2, which is the least expensive option. Alternative 3 provides the highest quality effluent with the least number of additional equipment and is likely to produce less sludge than Alternatives 2 and 4. Furthermore, Alternative 3 requires the smallest land area and can be housed entirely in a building to prevent freezing.

Once the Town of Rico has determined their preferred alternative, this section will be further populated in the final PER with details such as project schedule, permit requirements, environmental impacts, total project cost, and operating budgets.

9 REFERENCES

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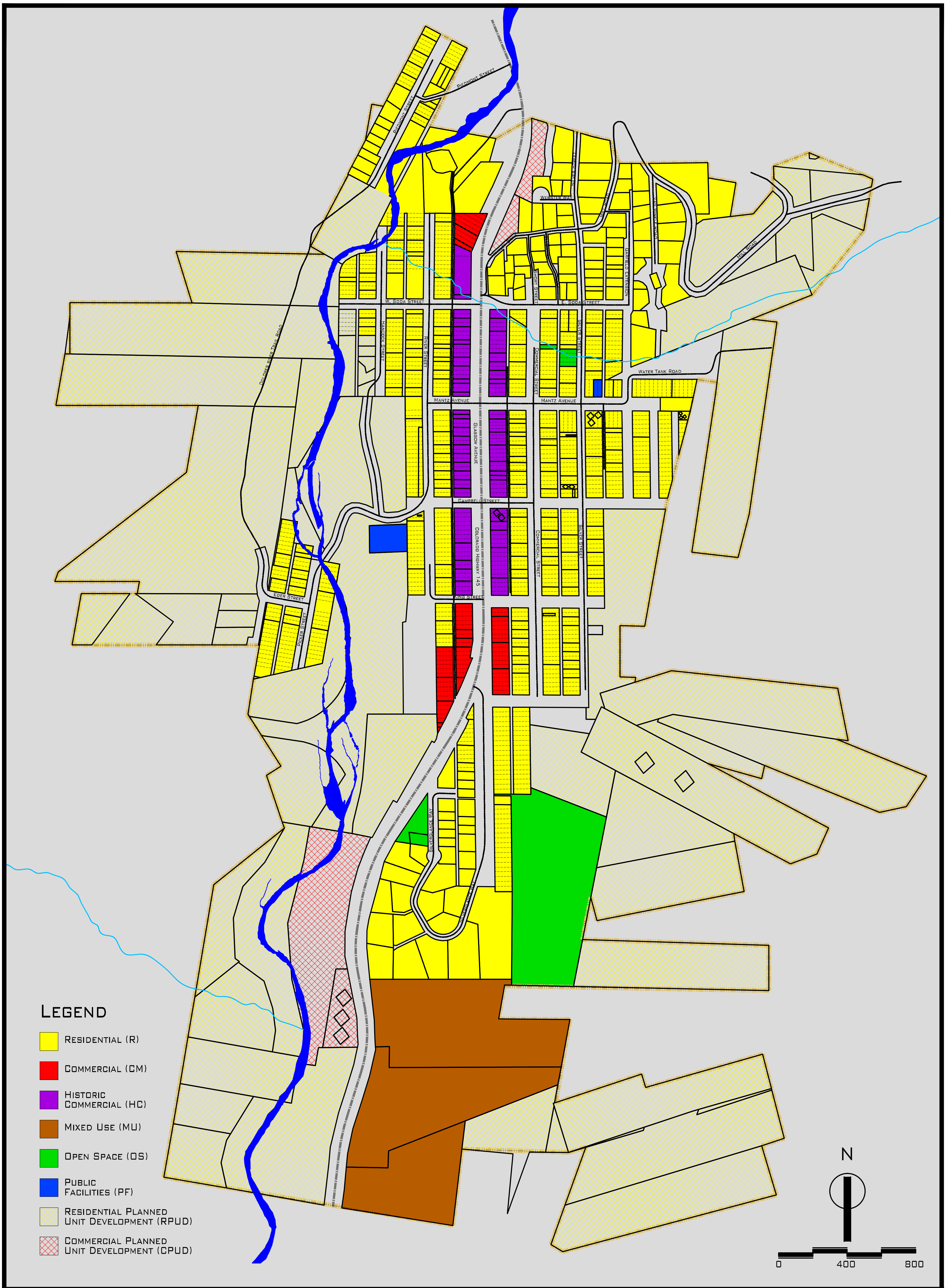
APPENDIX A – OFFICIAL ZONING MAP



Town of Rico Official Zoning Map

APPENDIX B – NRCS SOIL SURVEY

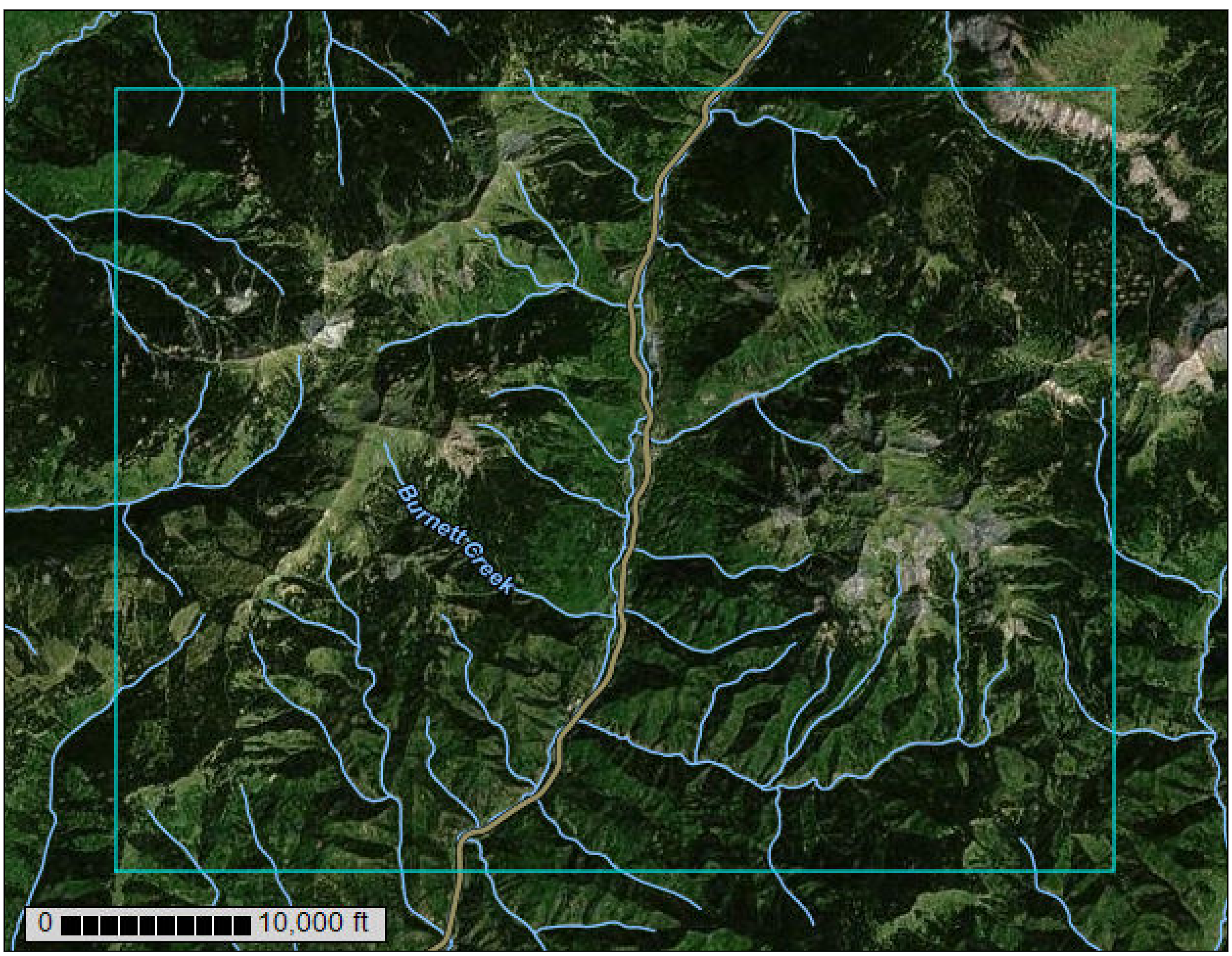
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties



August 14, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

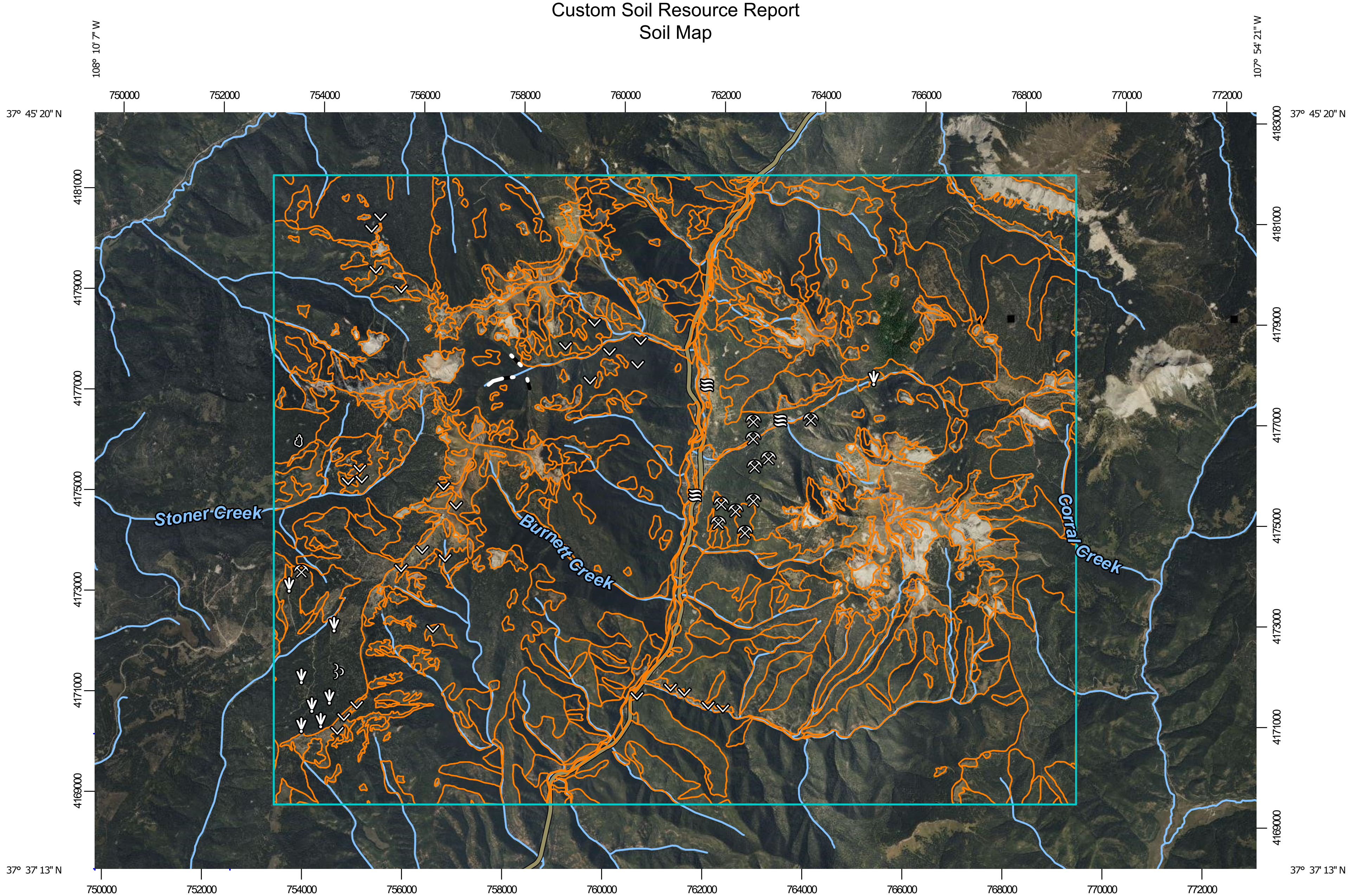
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:106,000 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 1500, 3000, 6000, 9000

Feet: 0, 5000, 10000, 20000, 30000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties
Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 26, 2010—Sep 17, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
14	Dalmatian-Apmay-Schrader complex, 0 to 5 percent slopes	58.2	0.1%
20	Mavreeso loam, 5 to 30 percent slopes	43.7	0.1%
53	Cryaquolls-Typic Cryaquents complex, 1 to 5 percent slopes	293.7	0.6%
54	Quazar very cobbly loam, 5 to 25 percent slopes	271.6	0.5%
56	Typic Cryaquents-Cryaquolls-Cryofibrists complex, 0 to 5 percent slopes	35.4	0.1%
152	Frisco loam, 25 to 45 percent slopes	126.0	0.3%
153	Frisco-Horsethief complex, 10 to 30 percent slopes	88.8	0.2%
154	Frisco-Horsethief complex, 30 to 75 percent slopes	7,509.9	15.1%
155	Tuckerville-Rock outcrop complex, 30 to 60 percent slopes	1,101.7	2.2%
158	Sponsor-Tuckerville complex, 30 to 60 percent slopes	188.9	0.4%
163	Clayburn-Hourglass complex, 15 to 30 percent slopes	3.1	0.0%
164	Hourglass-Bucklon-Wander complex, 30 to 60 percent slopes	195.2	0.4%
250	Snowdon-Rock outcrop complex, 30 to 65 percent slopes	15.2	0.0%
251	Rock outcrop-Snowdon complex, 45 to 75 percent slopes	142.7	0.3%
254	Cryorthents-Rubble land complex, 30 to 75 percent slopes	116.6	0.2%
334	Henson very gravelly loam, south aspect, 30 to 60 percent slopes	1,057.0	2.1%
335	Whitecross, very stony-Rock outcrop complex, 15 to 45 percent slopes	213.8	0.4%
336	Whitecross-Rock outcrop complex, south aspect, 30 to 75 percent slopes	834.1	1.7%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
337	Whitecross-Rock outcrop complex, 45 to 75 percent slopes	257.6	0.5%
338	Henson very gravelly loam, 10 to 30 percent slopes	49.9	0.1%
339	Henson very gravelly loam, 30 to 60 percent slopes	667.8	1.3%
345	Papaspila loam, 0 to 15 percent slopes	20.6	0.0%
374	Mavreeso-Valto-Rock outcrop complex, 30 to 80 percent slopes	431.1	0.9%
375	Needleton-Snowdon complex, 5 to 15 percent slopes	12.6	0.0%
376	Needleton loam, 15 to 30 percent slopes	54.1	0.1%
378	Needleton-Haviland complex, 30 to 60 percent slopes	7,664.9	15.4%
381	Needleton-Snowdon-Rock outcrop complex, 30 to 80 percent slopes	10,569.2	21.3%
382	Needleton-Snowdon complex, 15 to 30 percent slopes	1,142.1	2.3%
383	Haviland-Needleton complex, 10 to 30 percent slopes	521.0	1.0%
387	Frisco-Quazar complex, 30 to 60 percent slopes	306.2	0.6%
390	Clayburn-Heisspitz complex, 30 to 60 percent slopes	15.4	0.0%
392	Runlett-Needleton-Sessions complex, 15 to 45 percent slopes	72.4	0.1%
394	Clayburn-Heisspitz complex, 15 to 30 percent slopes	27.4	0.1%
450	Lostlake-Rock outcrop complex, 30 to 80 percent slopes	40.9	0.1%
495	Riverwash	1.5	0.0%
496	Rock outcrop	1,268.5	2.6%
497	Rubble land	1,659.4	3.3%
499	Water	61.6	0.1%
572	Sudduth loam, 0 to 15 percent slopes	4.6	0.0%
606	Snowdon-Needleton complex, 45 to 90 percent slopes	718.7	1.4%
607	Graysill-Scotch complex, south aspect, 30 to 60 percent slopes	2,933.8	5.9%
608	Scotch-Graysill complex, 30 to 60 percent slopes	1,518.3	3.1%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
609	Hourglass-Wander complex, 5 to 30 percent slopes	36.1	0.1%
610	Wander-Hotter-Hourglass complex, 30 to 60 percent slopes	2,228.0	4.5%
612	Haviland-Graysill complex, 5 to 30 percent slopes	235.7	0.5%
815	Behanco-Powderhorn family complex, 0 to 15 percent slopes	0.7	0.0%
816	Storm extremely flaggy loam, 15 to 30 percent slopes	2,679.8	5.4%
826	Ute-Frisco complex, 0 to 20 percent slopes	29.3	0.1%
830	Dressel-Jersey complex, 30 to 80 percent slopes	1,399.3	2.8%
832	Storm extremely flaggy loam, 0 to 15 percent slopes	341.5	0.7%
834	Haycamp-Jersey complex, 30 to 80 percent slopes	402.6	0.8%
891	Tamarron-Frisco complex, 15 to 30 percent slopes	37.0	0.1%
Totals for Area of Interest		**49,715.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties

14—Dalmatian-Apmay-Schrader complex, 0 to 5 percent slopes

Map Unit Setting

National map unit symbol: srm5
Elevation: 7,100 to 8,500 feet
Mean annual precipitation: 15 to 20 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 75 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Apmay and similar soils: 35 percent
Dalmatian and similar soils: 30 percent
Schrader and similar soils: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Apmay

Setting

Landform: Flood plains, valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

A - 0 to 4 inches: loam
AB - 4 to 10 inches: clay loam
Bw1 - 10 to 18 inches: clay loam
Bw2 - 18 to 22 inches: sandy loam
2C1 - 22 to 28 inches: extremely gravelly loamy sand
2C2 - 28 to 49 inches: extremely gravelly sandy loam
2C3 - 49 to 60 inches: extremely gravelly loamy sand

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: NoneRare
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.7 inches)

Interpretive groups

Land capability classification (irrigated): 4c
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C

Ecological site: R036XC013UT - Southwestern Plateau Riparian Complex Intermittent (Valley Type IV - F4/B4C Stream Type)
Hydric soil rating: No

Description of Dalmatian

Setting

Landform: Flood plains, valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

A - 0 to 2 inches: loam
AB - 2 to 13 inches: loam
Bw1 - 13 to 25 inches: loam
Bw2 - 25 to 39 inches: loam
Bw3 - 39 to 45 inches: sandy clay loam
Bg1 - 45 to 49 inches: sandy clay loam
Bg2 - 49 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: NoneRare
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 4c
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B
Ecological site: R036XC013UT - Southwestern Plateau Riparian Complex Intermittent (Valley Type IV - F4/B4C Stream Type)
Hydric soil rating: No

Description of Schrader

Setting

Landform: Flood plains, valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

Ap - 0 to 4 inches: loam
A - 4 to 13 inches: loam
AC1 - 13 to 17 inches: fine sandy loam
AC2 - 17 to 24 inches: sandy clay loam
C - 24 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Ecological site: R036XC013UT - Southwestern Plateau Riparian Complex Intermittent (Valley Type IV - F4/B4C Stream Type)
Hydric soil rating: Yes

Minor Components

Ustifluvents

Percent of map unit: 10 percent
Hydric soil rating: No

Riverwash

Percent of map unit: 5 percent
Landform: Flood plains
Hydric soil rating: Yes

20—Mavreeso loam, 5 to 30 percent slopes

Map Unit Setting

National map unit symbol: srmb
Elevation: 7,100 to 8,500 feet
Mean annual precipitation: 20 to 22 inches
Mean annual air temperature: 43 to 46 degrees F
Frost-free period: 75 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Mavreeso and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mavreeso

Setting

Landform: Fan remnants, mountain slopes
Landform position (three-dimensional): Lower third of mountainflank, base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium and slope alluvium derived from sandstone

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 10 inches: loam
Bw1 - 10 to 18 inches: loam
Bw2 - 18 to 28 inches: channery loam
Bk1 - 28 to 42 inches: loam
Bk2 - 42 to 50 inches: channery loam
Bk3 - 50 to 60 inches: loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F048AY925CO - Ponderosa Pine Forest
Other vegetative classification: Ponderosa pine/Gambel oak (PIPO/QUGA) (C1121)
Hydric soil rating: No

Minor Components

Pachic haplustolls

Percent of map unit: 15 percent
Hydric soil rating: No

Haplustolls, loamy-skeletal

Percent of map unit: 10 percent

53—Cryaquolls-Typic Cryaquents complex, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: srmf
Elevation: 8,500 to 10,000 feet
Mean annual precipitation: 20 to 40 inches
Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 50 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Cryaquolls and similar soils: 50 percent
Typic cryaquents and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cryaquolls

Setting

Landform: Flood plains, valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

A1 - 0 to 7 inches: loam
A2 - 7 to 12 inches: loam
C - 12 to 60 inches: stratified extremely gravelly loam to extremely gravelly sandy loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 6 to 20 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: R048AY241CO - Mountain Meadow
Hydric soil rating: Yes

Description of Typic Cryaquents

Setting

Landform: Flood plains, valley floors
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
A - 3 to 11 inches: loam
C - 11 to 63 inches: stratified very gravelly loamy sand to very gravelly sandy loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 6 to 20 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: R048AY241CO - Mountain Meadow
Hydric soil rating: Yes

Minor Components

Quazar

Percent of map unit: 10 percent
Hydric soil rating: No

Howardsville

Percent of map unit: 4 percent
Landform: Flood plains
Hydric soil rating: No

Riverwash

Percent of map unit: 1 percent
Landform: Flood plains
Hydric soil rating: Yes

54—Quazar very cobbly loam, 5 to 25 percent slopes

Map Unit Setting

National map unit symbol: srmg
Elevation: 9,000 to 10,700 feet
Mean annual precipitation: 26 to 40 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 65 days
Farmland classification: Not prime farmland

Map Unit Composition

Quazar and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quazar

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Mountainbase
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium derived from volcanic rock

Typical profile

A1 - 0 to 3 inches: very cobbly loam
A2 - 3 to 12 inches: very cobbly loam
Bt - 12 to 26 inches: extremely gravelly clay loam
C - 26 to 60 inches: extremely gravelly clay loam

Properties and qualities

Slope: 5 to 25 percent
Surface area covered with cobbles, stones or boulders: 5.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Ecological site: R048AY250CO - Subalpine Loam

Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

Clayburn

Percent of map unit: 3 percent
Hydric soil rating: No

Hourglass

Percent of map unit: 2 percent

56—Typic Cryaquents-Cryaquolls-Cryofibrists complex, 0 to 5 percent slopes

Map Unit Setting

National map unit symbol: srmh
Elevation: 9,100 to 13,000 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 28 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Typic cryaquents and similar soils: 35 percent
Cryaquolls and similar soils: 30 percent
Cryofibrists and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Typic Cryaquents

Setting

Landform: Depressions on mesas, flood plains, valley floors
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
A - 3 to 11 inches: loam
C - 11 to 63 inches: stratified very gravelly sandy loam to very gravelly loamy sand

Properties and qualities

Slope: 0 to 5 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 6 to 20 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.7 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: R048AY305CO - Alpine Meadow
Hydric soil rating: Yes

Description of Cryaquolls

Setting
Landform: Flood plains, depressions on mesas, valley floors
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from mixed sources

Typical profile
A1 - 0 to 7 inches: loam
A2 - 7 to 12 inches: loam
C - 12 to 60 inches: stratified extremely gravelly loam to extremely gravelly sandy loam

Properties and qualities
Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 6 to 20 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: R048AY305CO - Alpine Meadow
Hydric soil rating: Yes

Description of Cryofibrists

Setting
Landform: Flood plains, drainageways, depressions on mesas
Landform position (three-dimensional): Tread, dip

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Organic material

Typical profile

Oi1 - 0 to 10 inches: peat
Oi2 - 10 to 30 inches: peat
Oa - 30 to 60 inches: muck

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: About 0 to 36 inches
Frequency of flooding: NoneFrequent
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very high (about 14.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: R048AY305CO - Alpine Meadow
Hydric soil rating: Yes

Minor Components

Quazar

Percent of map unit: 5 percent
Hydric soil rating: No

Henson

Percent of map unit: 2 percent
Hydric soil rating: No

Whitecross

Percent of map unit: 2 percent
Hydric soil rating: No

Howardsville

Percent of map unit: 1 percent

152—Frisco loam, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: k0nt
Elevation: 8,800 to 11,000 feet

Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Frisco and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Frisco

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Outwash, till, and slope alluvium derived from granitic, volcanic, and sedimentary rocks

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 11 inches: loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Mollic haplocryalfs

Percent of map unit: 10 percent
Hydric soil rating: No

Haplocryalfs, fine-loamy

Percent of map unit: 6 percent

Haplocryalfs, deep

Percent of map unit: 4 percent

153—Frisco-Horsethief complex, 10 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0nv
Elevation: 9,000 to 11,000 feet
Mean annual precipitation: 25 to 45 inches
Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Frisco and similar soils: 50 percent
Horsethief and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Frisco

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Outwash and slope alluvium derived from granitic, volcanic, and sedimentary rocks

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 11 inches: loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Horsethief

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone, volcanic, and igneous rocks

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 16 inches: fine sandy loam
E2 - 16 to 24 inches: fine sandy loam
E/B - 24 to 32 inches: sandy clay loam
Bt - 32 to 49 inches: very stony clay loam
BC - 49 to 62 inches: very stony clay loam

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Quazar

Percent of map unit: 15 percent

Hydric soil rating: No

Snowdon

Percent of map unit: 5 percent
Hydric soil rating: No

154—Frisco-Horsethief complex, 30 to 75 percent slopes

Map Unit Setting

National map unit symbol: k0nw
Elevation: 8,400 to 11,500 feet
Mean annual precipitation: 25 to 45 inches
Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Frisco and similar soils: 60 percent
Horsethief and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Frisco

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Outwash, colluvium, and slope alluvium derived from granitic, volcanic, and sedimentary rocks

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 11 inches: loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 30 to 70 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Horsethief

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and slope alluvium derived from sandstone, volcanic and igneous rocks

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 16 inches: fine sandy loam
E2 - 16 to 24 inches: fine sandy loam
E/B - 24 to 32 inches: sandy clay loam
Bt - 32 to 49 inches: very stony clay loam
BC - 49 to 62 inches: very stony clay loam

Properties and qualities

Slope: 30 to 75 percent
Surface area covered with cobbles, stones or boulders: 2.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 10 percent

Quazar

Percent of map unit: 5 percent
Hydric soil rating: Unranked

155—Tuckerville-Rock outcrop complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0nx
Elevation: 8,800 to 10,000 feet
Mean annual precipitation: 25 to 32 inches
Mean annual air temperature: 36 to 42 degrees F
Frost-free period: 60 to 80 days
Farmland classification: Not prime farmland

Map Unit Composition

Tuckerville and similar soils: 70 percent
Rock outcrop: 20 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tuckerville

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium, colluvium, and outwash derived from granite and sandstone

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
A - 3 to 6 inches: stony loam
E - 6 to 21 inches: very stony sandy loam
E/B - 21 to 26 inches: very stony sandy clay loam
Bt - 26 to 47 inches: very stony sandy clay loam
C - 47 to 63 inches: extremely stony sandy loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/elk sedge (ABLA-PIEN/CAGE2) (C0307)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Free face
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandstone

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 50 to 75 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Scotch

Percent of map unit: 5 percent
Hydric soil rating: No

Haviland

Percent of map unit: 5 percent
Hydric soil rating: No

158—Sponsor-Tuckerville complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0p0
Elevation: 8,800 to 10,000 feet
Mean annual precipitation: 25 to 35 inches
Mean annual air temperature: 36 to 42 degrees F
Frost-free period: 60 to 80 days
Farmland classification: Not prime farmland

Map Unit Composition

Sponsor and similar soils: 60 percent
Tuckerville and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sponsor

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium, colluvium, and outwash derived from granite and sandstone

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A1 - 1 to 7 inches: loam
A2 - 7 to 12 inches: loam
Bt1 - 12 to 25 inches: cobbly clay loam
Bt2 - 25 to 43 inches: cobbly clay loam
Bt3 - 43 to 61 inches: very stony clay loam

Properties and qualities

Slope: 30 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Tuckerville

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium, colluvium, and outwash derived from granite and sandstone

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
A - 3 to 6 inches: loam
E - 6 to 21 inches: stony loam
E/B - 21 to 26 inches: very stony sandy clay loam
Bt - 26 to 47 inches: very stony sandy clay loam
C - 47 to 63 inches: extremely stony sandy loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY908CO - Mixed Conifer
Other vegetative classification: White fir - Rocky Mountain Douglas fir/mountain snowberry (ABCO-PSME/SYOR2) (C0114)
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 5 percent
Hydric soil rating: No

Wander

Percent of map unit: 5 percent

163—Clayburn-Hourglass complex, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0p6
Elevation: 8,000 to 10,000 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 32 to 36 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Clayburn and similar soils: 50 percent
Hourglass and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clayburn

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 13 inches: loam
Bt1 - 13 to 18 inches: clay loam
Bt2 - 18 to 36 inches: clay loam
Bt3 - 36 to 48 inches: sandy clay loam
C - 48 to 60 inches: sandy clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C

Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Hourglass

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from limestone, sandstone, and shale

Typical profile

A - 0 to 11 inches: loam
Bt1 - 11 to 18 inches: clay loam
Bt2 - 18 to 31 inches: gravelly clay loam
Bt3 - 31 to 46 inches: very stony clay loam
C - 46 to 60 inches: very stony clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Minor Components

Sessions

Percent of map unit: 10 percent
Hydric soil rating: No

Frisco

Percent of map unit: 5 percent

164—Hourglass-Bucklon-Wander complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0p7
Elevation: 8,000 to 10,600 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 36 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Hourglass and similar soils: 50 percent
Bucklon and similar soils: 25 percent
Wander and similar soils: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hourglass

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium derived from limestone, sandstone, and shale

Typical profile

A - 0 to 11 inches: loam
Bt1 - 11 to 18 inches: clay loam
Bt2 - 18 to 31 inches: gravelly clay loam
Bt3 - 31 to 46 inches: very stony clay loam
C - 46 to 60 inches: very stony clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C

Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Bucklon

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone and shale

Typical profile

A1 - 0 to 1 inches: loam
A2 - 1 to 12 inches: loam
Cr - 12 to 22 inches: weathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Wander

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 14 inches: very cobbly loam
Bt1 - 14 to 27 inches: very cobbly clay loam
Bt2 - 27 to 40 inches: very cobbly clay loam
C - 40 to 60 inches: very cobbly clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Minor Components

Clayburn

Percent of map unit: 5 percent
Hydric soil rating: No

Frisco

Percent of map unit: 4 percent

Tamarron

Percent of map unit: 1 percent

250—Snowdon-Rock outcrop complex, 30 to 65 percent slopes

Map Unit Setting

National map unit symbol: k0pm
Elevation: 8,300 to 11,500 feet
Mean annual precipitation: 25 to 40 inches
Mean annual air temperature: 30 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Snowdon and similar soils: 55 percent
Rock outcrop: 25 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snowdon

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum and slope alluvium derived from rhyolite, sandstone, and limestone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: very stony loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 24 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 65 percent
Surface area covered with cobbles, stones or boulders: 5.0 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/common juniper (ABLA-PIEN/JUCO6) (C0309)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Cliffs, mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic and sedimentary rock and/or granite

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 65 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Needleton

Percent of map unit: 10 percent
Hydric soil rating: No

Quazar

Percent of map unit: 5 percent
Hydric soil rating: No

Henson

Percent of map unit: 3 percent
Hydric soil rating: No

Rubble land

Percent of map unit: 2 percent
Hydric soil rating: No

251—Rock outcrop-Snowdon complex, 45 to 75 percent slopes

Map Unit Setting

National map unit symbol: k0pn
Elevation: 8,300 to 11,500 feet
Mean annual precipitation: 25 to 40 inches
Mean annual air temperature: 30 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Rock outcrop: 60 percent
Snowdon and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Setting

Landform: Cliffs, mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Volcanic and sedimentary rock and/or granite

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 45 to 75 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Description of Snowdon

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and residuum derived from rhyolite, sandstone and limestone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: very stony loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 24 inches: unweathered bedrock

Properties and qualities

Slope: 45 to 75 percent
Surface area covered with cobbles, stones or boulders: 5.0 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/common juniper (ABLA-PIEN/JUCO6) (C0309)
Hydric soil rating: No

Minor Components

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

Quazar

Percent of map unit: 5 percent
Hydric soil rating: No

Whitecross

Percent of map unit: 3 percent
Hydric soil rating: No

Rubble land

Percent of map unit: 2 percent
Hydric soil rating: No

254—Cryorthents-Rubble land complex, 30 to 75 percent slopes

Map Unit Setting

National map unit symbol: k0pp
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 20 to 35 inches
Mean annual air temperature: 30 to 40 degrees F
Frost-free period: 40 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Typic cryorthents and similar soils: 50 percent
Rubble land: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Typic Cryorthents

Setting

Landform: Mountain slopes, alluvial fans
Landform position (three-dimensional): Mountainflank, mountainbase
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Colluvium and slope alluvium derived from rhyolite

Typical profile

A - 0 to 5 inches: extremely stony loam
C - 5 to 60 inches: extremely stony loam

Properties and qualities

Slope: 30 to 75 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Rubble Land

Setting

Landform: Mountain slopes, alluvial fans
Landform position (three-dimensional): Mountainflank, mountainbase
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Volcanic and sedimentary rock

Typical profile

C - 0 to 60 inches: fragmental material

Properties and qualities

Slope: 30 to 75 percent
Depth to restrictive feature: 40 to 80 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Quazar

Percent of map unit: 10 percent
Hydric soil rating: No

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

Henson

Percent of map unit: 3 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 2 percent

334—Henson very gravelly loam, south aspect, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0q6
Elevation: 11,500 to 12,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 30 to 34 degrees F
Frost-free period: 30 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Henson, south aspect, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Henson, South Aspect

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Concave
Parent material: Colluvium and slope alluvium derived from rhyolite

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 5 inches: very gravelly loam
Bw1 - 5 to 13 inches: very cobbly loam
Bw2 - 13 to 25 inches: very stony sandy clay loam
C - 25 to 61 inches: extremely stony sandy loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R048AY309CO - Warm Alpine
Hydric soil rating: No

Minor Components

Whitecross

Percent of map unit: 10 percent
Hydric soil rating: No

Moran

Percent of map unit: 5 percent
Hydric soil rating: No

Telluride

Percent of map unit: 4 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 1 percent

335—Whitecross, very stony-Rock outcrop complex, 15 to 45 percent slopes

Map Unit Setting

National map unit symbol: 2w4zl
Elevation: 11,500 to 13,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 28 to 34 degrees F
Frost-free period: 20 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Whitecross, very stony, and similar soils: 55 percent
Rock outcrop: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Whitecross, Very Stony

Setting

Landform: Mountain slopes
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from volcanic rock

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: very stony sandy loam
Bw1 - 4 to 10 inches: very stony loam
Bw2 - 10 to 19 inches: extremely stony sandy loam
R - 19 to 59 inches: bedrock

Properties and qualities

Slope: 15 to 45 percent

Surface area covered with cobbles, stones or boulders: 1.0 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R048AY308CO - Shallow Alpine
Hydric soil rating: No

Description of Rock Outcrop

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: Unranked

Minor Components

Henson

Percent of map unit: 10 percent
Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R048AY304CO - Alpine Slopes
Hydric soil rating: No

Telluride

Percent of map unit: 5 percent
Landform: Mountain slopes
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R048AY308CO - Shallow Alpine
Hydric soil rating: No

336—Whitecross-Rock outcrop complex, south aspect, 30 to 75 percent slopes

Map Unit Setting

National map unit symbol: k0q8
Elevation: 11,500 to 12,500 feet

Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 30 to 34 degrees F
Frost-free period: 30 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Whitecross, south aspect, and similar soils: 50 percent
Rock outcrop: 25 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Whitecross, South Aspect

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium and colluvium derived from rhyolite, tuff, and similar volcanic rocks

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: very stony sandy loam
Bw1 - 4 to 10 inches: very gravelly loam
Bw2 - 10 to 19 inches: extremely gravelly sandy loam
R - 19 to 23 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 75 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY309CO - Warm Alpine
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Rhyolite

Properties and qualities

Slope: 30 to 75 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Henson

Percent of map unit: 10 percent
Hydric soil rating: No

Telluride

Percent of map unit: 5 percent
Hydric soil rating: No

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

Snowdon

Percent of map unit: 3 percent

Rubble land

Percent of map unit: 2 percent

337—Whitecross-Rock outcrop complex, 45 to 75 percent slopes

Map Unit Setting

National map unit symbol: k0q9
Elevation: 11,500 to 13,800 feet
Mean annual precipitation: 35 to 60 inches
Mean annual air temperature: 28 to 34 degrees F
Frost-free period: 20 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Whitecross and similar soils: 60 percent
Rock outcrop: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Whitecross

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank, mountaintop

Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium and colluvium derived from rhyolite and similar volcanic rocks and in some places from granitic rocks

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 4 inches: very stony sandy loam
Bw1 - 4 to 10 inches: very gravelly loam
Bw2 - 10 to 19 inches: extremely gravelly sandy loam
R - 19 to 23 inches: unweathered bedrock

Properties and qualities

Slope: 45 to 75 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: 7 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY308CO - Shallow Alpine
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Rhyolite

Properties and qualities

Slope: 45 to 75 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Henson

Percent of map unit: 10 percent
Hydric soil rating: No

Needleton

Percent of map unit: 2 percent

Cryaquents

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

Rubble land

Percent of map unit: 1 percent
Hydric soil rating: No

Cryofibrists

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

338—Henson very gravelly loam, 10 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0qb
Elevation: 11,500 to 13,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 28 to 34 degrees F
Frost-free period: 25 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Henson and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Henson

Setting

Landform: Mountain slopes, valleys
Landform position (three-dimensional): Mountainflank, mountainbase
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Colluvium and/or slope alluvium derived from rhyolite

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 5 inches: very gravelly loam
Bw1 - 5 to 13 inches: very cobbly loam
Bw2 - 13 to 25 inches: very stony sandy clay loam
C - 25 to 61 inches: extremely stony sandy loam

Properties and qualities

Slope: 10 to 30 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R048AY304CO - Alpine Slopes
Hydric soil rating: No

Minor Components

Whitecross

Percent of map unit: 5 percent
Hydric soil rating: No

Moran

Percent of map unit: 5 percent
Hydric soil rating: No

Telluride

Percent of map unit: 5 percent
Hydric soil rating: No

Cryaquents

Percent of map unit: 2 percent
Landform: Swales
Hydric soil rating: Yes

Rock outcrop

Percent of map unit: 2 percent
Hydric soil rating: No

Cryofibrists

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

339—Henson very gravelly loam, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0qc
Elevation: 11,500 to 13,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 28 to 34 degrees F

Frost-free period: 25 to 40 days
Farmland classification: Not prime farmland

Map Unit Composition

Henson and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Henson

Setting

Landform: Valleys, mountain slopes
Landform position (three-dimensional): Lower third of mountainflank, mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Colluvium and/or slope alluvium derived from rhyolite

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 5 inches: very gravelly loam
Bw1 - 5 to 13 inches: very cobbly loam
Bw2 - 13 to 25 inches: very stony sandy clay loam
C - 25 to 61 inches: extremely stony sandy loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R048AY304CO - Alpine Slopes
Hydric soil rating: No

Minor Components

Moran

Percent of map unit: 5 percent
Hydric soil rating: No

Telluride

Percent of map unit: 5 percent
Hydric soil rating: No

Whitecross

Percent of map unit: 5 percent
Hydric soil rating: No

Cryaquents

Percent of map unit: 2 percent
Landform: Swales
Hydric soil rating: Yes

Rock outcrop

Percent of map unit: 2 percent
Hydric soil rating: No

Cryofibrists

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

345—Papaspila loam, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: k0qj
Elevation: 8,500 to 10,000 feet
Mean annual precipitation: 25 to 35 inches
Mean annual air temperature: 34 to 40 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Papaspila and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Papaspila

Setting

Landform: Mesas, structural benches
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from diorite

Typical profile

A1 - 0 to 4 inches: loam
A2 - 4 to 18 inches: loam
A3 - 18 to 25 inches: gravelly loam
E1 - 25 to 33 inches: very cobbly silt loam
E2 - 33 to 39 inches: extremely stony clay loam
B/E - 39 to 54 inches: extremely stony clay loam
C - 54 to 60 inches: extremely stony clay loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Pachic haplocryolls, fine-loamy

Percent of map unit: 10 percent
Hydric soil rating: No

Typic haplocryolls

Percent of map unit: 5 percent

374—Mavreeso-Valto-Rock outcrop complex, 30 to 80 percent slopes

Map Unit Setting

National map unit symbol: k0qp
Elevation: 7,100 to 8,500 feet
Mean annual precipitation: 20 to 22 inches
Mean annual air temperature: 43 to 46 degrees F
Frost-free period: 75 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Mavreeso and similar soils: 35 percent
Valto and similar soils: 30 percent
Rock outcrop: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mavreeso

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium derived from sedimentary rock

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 10 inches: loam
Bw1 - 10 to 18 inches: loam
Bw2 - 18 to 28 inches: channery loam
Bk1 - 28 to 42 inches: loam
Bk2 - 42 to 50 inches: channery loam
Bk3 - 50 to 60 inches: loam

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R048AY255CO - Pine Grasslands
Other vegetative classification: Ponderosa pine/Gambel oak (PIPO/QUGA) (C1121)
Hydric soil rating: No

Description of Valto

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 4 inches: very stony fine sandy loam
Bw - 4 to 14 inches: very stony fine sandy loam
R - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: F048AY439UT - Mountain Shallow Loam (Ponderosa pine)
Other vegetative classification: Ponderosa pine/Gambel oak (PIPO/QUGA) (C1121)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandstone

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Haplustolls, loamy-skeletal

Percent of map unit: 15 percent
Hydric soil rating: No

375—Needleton-Snowdon complex, 5 to 15 percent slopes

Map Unit Setting

National map unit symbol: k0qq
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches

Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Needleton and similar soils: 55 percent
Snowdon and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: stony loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Snowdon

Setting

Landform: Structural benches, mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum and slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 22 inches: unweathered bedrock

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Haviland

Percent of map unit: 5 percent
Hydric soil rating: No

Quazar

Percent of map unit: 5 percent
Hydric soil rating: No

Hourglass

Percent of map unit: 5 percent

376—Needleton loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0qr
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days

Farmland classification: Not prime farmland

Map Unit Composition

Needleton and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Clayburn

Percent of map unit: 10 percent
Hydric soil rating: No

Haviland

Percent of map unit: 5 percent
Hydric soil rating: No

Argicryolls, fine textures

Percent of map unit: 3 percent
Hydric soil rating: No

Snowdon

Percent of map unit: 2 percent

378—Needleton-Haviland complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0qt
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Needleton and similar soils: 65 percent
Haviland and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium derived from redbed sandstome and shale, and rhyolite

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Haviland

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from sandstone and shale and/or slope alluvium derived from sandstone and shale

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
E1 - 1 to 6 inches: loam
E2 - 6 to 19 inches: loam
Bt1 - 19 to 33 inches: clay loam
Bt2 - 33 to 61 inches: gravelly clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 5 percent
Hydric soil rating: No

Mollic haplocryalfs

Percent of map unit: 3 percent

Typic palecryalfs

Percent of map unit: 2 percent
Hydric soil rating: No

381—Needleton-Snowdon-Rock outcrop complex, 30 to 80 percent slopes

Map Unit Setting

National map unit symbol: k0qx
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Needleton and similar soils: 45 percent
Snowdon and similar soils: 30 percent
Rock outcrop: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium and colluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: stony loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Snowdon

Setting

Landform: Mountain slopes, structural benches
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum and slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: very stony loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 24 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511), Subalpine fir - Engelmann spruce/elk sedge (ABLA-PIEN/CAGE2) (C0307), Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes, structural benches
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Limestone and sandstone and/or rhyolite

Typical profile
R - 0 to 60 inches: unweathered bedrock

Properties and qualities
Slope: 30 to 80 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Horsethief
Percent of map unit: 5 percent
Hydric soil rating: No

Haviland
Percent of map unit: 5 percent
Hydric soil rating: No

382—Needleton-Snowdon complex, 15 to 30 percent slopes

Map Unit Setting
National map unit symbol: k0qy
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition
Needleton and similar soils: 50 percent
Snowdon and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting
Landform: Mountain slopes

Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: stony loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Snowdon

Setting

Landform: Structural benches, mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum and slope alluvium derived from rhyolite, limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: very stony loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 24 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Haviland

Percent of map unit: 5 percent
Hydric soil rating: No

Wander

Percent of map unit: 5 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 5 percent

Scotch

Percent of map unit: 3 percent

Graysill

Percent of map unit: 2 percent
Hydric soil rating: No

383—Haviland-Needleton complex, 10 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0qz
Elevation: 8,500 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Haviland and similar soils: 50 percent
Needleton and similar soils: 35 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Haviland

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from redbed sandstone and shale

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
E1 - 1 to 6 inches: loam
E2 - 6 to 19 inches: loam
Bt1 - 19 to 33 inches: clay loam
Bt2 - 33 to 61 inches: gravelly clay loam

Properties and qualities

Slope: 10 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from redbed sandstone and shale, and rhyolite

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 10 to 30 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Graysill

Percent of map unit: 5 percent
Hydric soil rating: No

Snowdon

Percent of map unit: 5 percent
Hydric soil rating: No

Scotch

Percent of map unit: 3 percent
Hydric soil rating: No

Cryaquolls

Percent of map unit: 2 percent
Hydric soil rating: Yes

387—Frisco-Quazar complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0r3
Elevation: 9,000 to 11,000 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 65 days
Farmland classification: Not prime farmland

Map Unit Composition

Frisco and similar soils: 50 percent
Quazar and similar soils: 40 percent

Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Frisco

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium and colluvium derived from rhyolite and tuff

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: stony loam
E1 - 5 to 11 inches: stony loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Quazar

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium and colluvium derived from rhyolite and tuff

Typical profile

A - 0 to 12 inches: very cobbly loam
Bt - 12 to 26 inches: extremely gravelly clay loam
C - 26 to 60 inches: extremely gravelly clay loam

Properties and qualities

Slope: 30 to 60 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 5 percent
Hydric soil rating: No

Horsethief

Percent of map unit: 4 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 1 percent

390—Clayburn-Heisspitz complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0r6
Elevation: 9,500 to 11,000 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Clayburn and similar soils: 40 percent
Heisspitz and similar soils: 30 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clayburn

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 13 inches: loam
Bt1 - 13 to 18 inches: clay loam
Bt2 - 18 to 36 inches: clay loam
Bt3 - 36 to 48 inches: sandy clay loam
C - 48 to 60 inches: sandy clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Description of Heisspitz

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from limestone and sandstone

Typical profile

A1 - 0 to 9 inches: loam
A2 - 9 to 14 inches: loam
R - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Runlett

Percent of map unit: 15 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 10 percent
Hydric soil rating: No

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

392—Runlett-Needleton-Sessions complex, 15 to 45 percent slopes

Map Unit Setting

National map unit symbol: k0r8
Elevation: 10,000 to 11,000 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Needleton and similar soils: 35 percent
Runlett and similar soils: 30 percent
Sessions and similar soils: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and slope alluvium derived from limestone and sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Runlett

Setting

Landform: Mountain slopes, mesas
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium and residuum derived from limestone, sandstone, and shale

Typical profile

A1 - 0 to 14 inches: loam
A2 - 14 to 19 inches: loam
Bt1 - 19 to 22 inches: clay loam
Bt2 - 22 to 27 inches: clay
R - 27 to 31 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Description of Sessions

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from schist, limestone and sandstone

Typical profile

A1 - 0 to 3 inches: loam
A2 - 3 to 11 inches: loam
Bt1 - 11 to 19 inches: clay loam
Bt2 - 19 to 34 inches: clay
Bt3 - 34 to 48 inches: clay
BC - 48 to 60 inches: gravelly clay loam

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam

Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Heisspitz

Percent of map unit: 10 percent
Hydric soil rating: No

Tamarron

Percent of map unit: 5 percent

394—Clayburn-Heisspitz complex, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0rb
Elevation: 9,000 to 10,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Clayburn and similar soils: 55 percent
Heisspitz and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clayburn

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A1 - 0 to 5 inches: loam
A2 - 5 to 13 inches: loam
Bt1 - 13 to 18 inches: clay loam
Bt2 - 18 to 36 inches: clay loam
Bt3 - 36 to 48 inches: sandy clay loam
C - 48 to 60 inches: sandy clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Description of Heisspitz

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium derived from limestone and sandstone

Typical profile

A1 - 0 to 9 inches: loam
A2 - 9 to 14 inches: loam
R - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Hourglass

Percent of map unit: 10 percent

Hydric soil rating: No

Runlett

Percent of map unit: 4 percent
Hydric soil rating: No

Needleton

Percent of map unit: 1 percent
Hydric soil rating: No

450—Lostlake-Rock outcrop complex, 30 to 80 percent slopes

Map Unit Setting

National map unit symbol: k0rh
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Lostlake and similar soils: 45 percent
Rock outcrop: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lostlake

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum and/or slope alluvium derived from granite

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: loam
Bw - 6 to 15 inches: gravelly sandy clay loam
R - 15 to 19 inches: bedrock

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: 8 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/grouse whortleberry (ABLA-PIEN/VASC) (C0321)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Granite

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 15 percent
Ecological site: F048AY918CO - Spruce-Fir Woodland
Hydric soil rating: No

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

495—Riverwash

Map Unit Setting

National map unit symbol: srlx
Elevation: 8,300 to 10,500 feet
Mean annual precipitation: 18 to 30 inches
Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 45 to 110 days
Farmland classification: Not prime farmland

Map Unit Composition

Riverwash: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Riverwash

Setting

Landform: Valley floors, flood plains

Typical profile

C1 - 0 to 6 inches: gravelly sand
C2 - 6 to 60 inches: stratified extremely gravelly coarse sand to gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: Frequent
Available water supply, 0 to 60 inches: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: D
Hydric soil rating: Yes

Minor Components

Fluvaquents

Percent of map unit: 10 percent
Landform: Flood plains
Hydric soil rating: Yes

Cryaquolls

Percent of map unit: 5 percent
Hydric soil rating: Yes

496—Rock outcrop

Map Unit Setting

National map unit symbol: srln
Elevation: 8,300 to 14,240 feet
Mean annual precipitation: 25 to 60 inches
Mean annual air temperature: 26 to 38 degrees F
Frost-free period: 20 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Rock outcrop: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rock Outcrop

Setting

Landform: Hills, canyons, mountains
Landform position (three-dimensional): Mountaintop, mountainflank, side slope, crest, free face
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Volcanic and sedimentary rock and/or igneous rock

Typical profile

R - 0 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 99 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Rubble land

Percent of map unit: 20 percent

Lithic cryorthents

Percent of map unit: 10 percent

497—Rubble land

Map Unit Setting

National map unit symbol: srlw
Elevation: 8,300 to 14,000 feet
Mean annual precipitation: 25 to 60 inches
Mean annual air temperature: 26 to 38 degrees F
Frost-free period: 20 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Rubble land: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rubble Land

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank, mountainbase
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Volcanic and sedimentary rock

Typical profile

C - 0 to 60 inches: fragmental material

Properties and qualities

Slope: 15 to 99 percent
Depth to restrictive feature: 40 to 80 inches to lithic bedrock
Drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Available water supply, 0 to 60 inches: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Rock outcrop

Percent of map unit: 10 percent

Varden

Percent of map unit: 5 percent

Hensen

Percent of map unit: 5 percent

499—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

572—Sudduth loam, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: k0sc
Elevation: 8,500 to 10,000 feet
Mean annual precipitation: 25 to 30 inches
Mean annual air temperature: 34 to 40 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Sudduth and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sudduth

Setting

Landform: Drainageways, depressions on mesas
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sandstone and shale

Typical profile

A1 - 0 to 3 inches: loam
A2 - 3 to 7 inches: loam
Bt - 7 to 13 inches: clay loam
2Bt - 13 to 22 inches: clay
2C1 - 22 to 38 inches: gravelly clay loam
2C2 - 38 to 52 inches: clay
2C3 - 52 to 60 inches: clay

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 36 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203)
Hydric soil rating: No

Minor Components

Argicryolls, deep

Percent of map unit: 10 percent

Argicryolls, loamy-skeletal

Percent of map unit: 5 percent

606—Snowdon-Needleton complex, 45 to 90 percent slopes

Map Unit Setting

National map unit symbol: k0sl
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Snowdon and similar soils: 50 percent
Needleton and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snowdon

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank, mountaintop
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and slope alluvium derived from redbed sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 6 inches: stony loam
E - 6 to 13 inches: very stony sandy loam
Bt - 13 to 20 inches: extremely stony sandy clay loam
R - 20 to 24 inches: unweathered bedrock

Properties and qualities

Slope: 45 to 90 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Needleton

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium and colluvium derived from redbed sandstone

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 16 inches: stony loam
B/E - 16 to 26 inches: very cobbly sandy clay loam
Bt1 - 26 to 48 inches: very stony sandy clay loam
Bt2 - 48 to 62 inches: very cobbly clay loam

Properties and qualities

Slope: 45 to 90 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Rock outcrop

Percent of map unit: 5 percent

Scotch

Percent of map unit: 5 percent
Hydric soil rating: No

Graysill

Percent of map unit: 3 percent
Hydric soil rating: No

Haviland

Percent of map unit: 2 percent
Hydric soil rating: No

607—Graysill-Scotch complex, south aspect, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0sm
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 30 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Graysill and similar soils: 45 percent
Scotch and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Graysill

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Slope alluvium and residuum derived from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 14 inches: loam
EB - 14 to 22 inches: clay loam
Bt - 22 to 37 inches: clay loam
R - 37 to 41 inches: bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/elk sedge (POTR5/CAGE2) (D0501)
Hydric soil rating: No

Description of Scotch

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum and sloope alluvium weathered from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 7 inches: loam
Bt - 7 to 17 inches: clay loam
R - 17 to 21 inches: bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/elk sedge (POTR5/CAGE2) (D0501)
Hydric soil rating: No

Minor Components

Haviland

Percent of map unit: 10 percent

Hydric soil rating: No

Needleton

Percent of map unit: 10 percent
Hydric soil rating: No

608—Scotch-Graysill complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0sn
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 30 to 38 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Scotch and similar soils: 45 percent
Graysill and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Scotch

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum and slope alluvium weathered from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 7 inches: loam
Bt - 7 to 17 inches: clay loam
R - 17 to 21 inches: bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Graysill

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium and residuum derived from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 14 inches: loam
EB - 14 to 22 inches: clay loam
Bt - 22 to 37 inches: clay loam
R - 37 to 41 inches: bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Haviland

Percent of map unit: 10 percent
Hydric soil rating: No

Needleton

Percent of map unit: 10 percent
Hydric soil rating: No

609—Hourglass-Wander complex, 5 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0sp
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Hourglass and similar soils: 50 percent
Wander and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hourglass

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 11 inches: loam
Bt1 - 11 to 18 inches: clay loam
Bt2 - 18 to 31 inches: gravelly clay loam
Bt3 - 31 to 46 inches: very stony clay loam
C - 46 to 60 inches: very stony clay loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam

Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202), Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203)
Hydric soil rating: No

Description of Wander

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 14 inches: very cobbly loam
Bt1 - 14 to 27 inches: very cobbly clay loam
Bt2 - 27 to 40 inches: very cobbly clay loam
C - 40 to 60 inches: very cobbly clay loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203), Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Haviland

Percent of map unit: 10 percent
Hydric soil rating: No

Needleton

Percent of map unit: 4 percent
Hydric soil rating: No

Sig

Percent of map unit: 1 percent

610—Wander-Hotter-Hourglass complex, 30 to 60 percent slopes

Map Unit Setting

National map unit symbol: k0sq
Elevation: 8,500 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Wander and similar soils: 45 percent
Hotter and similar soils: 30 percent
Hourglass and similar soils: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wander

Setting

Landform: Mountain slopes, structural benches
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 14 inches: very cobbly loam
Bt1 - 14 to 27 inches: very cobbly clay loam
Bt2 - 27 to 40 inches: very cobbly clay loam
C - 40 to 60 inches: very cobbly clay loam

Properties and qualities

Slope: 30 to 60 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e

Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202), Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203)
Hydric soil rating: No

Description of Hotter

Setting

Landform: Mountain slopes, structural benches
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 4 inches: very stony sandy loam
Bw - 4 to 14 inches: very stony sandy loam
R - 14 to 18 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Surface area covered with cobbles, stones or boulders: 8.0 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203), Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Description of Hourglass

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium derived from limestone, sandstone, and shale

Typical profile

A - 0 to 11 inches: loam

Bt1 - 11 to 18 inches: clay loam
Bt2 - 18 to 31 inches: gravelly clay loam
Bt3 - 31 to 46 inches: very stony clay loam
C - 46 to 60 inches: very stony clay loam

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: R048AY250CO - Subalpine Loam
Other vegetative classification: Thurber's fescue/Arizona fescue (FETH/FEAR2) (G2203), Thurber's fescue/American vetch-aspen peavine (FETH/VIAM-LALE) (G2202)
Hydric soil rating: No

Minor Components

Needleton

Percent of map unit: 5 percent
Hydric soil rating: No

Haviland

Percent of map unit: 4 percent

Rock outcrop

Percent of map unit: 1 percent

612—Haviland-Graysill complex, 5 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0ss
Elevation: 9,000 to 11,500 feet
Mean annual precipitation: 35 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Haviland and similar soils: 50 percent
Graysill and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Haviland

Setting

Landform: Mountain slopes, mesas
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium derived from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 14 inches: loam
Bt1 - 14 to 24 inches: clay loam
Bt2 - 24 to 62 inches: gravelly clay loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.21 to 0.71 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Graysill

Setting

Landform: Mountain slopes, mesas
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum or slope alluvium weathered from redbed sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
E - 2 to 14 inches: loam
EB - 14 to 22 inches: clay loam

Bt - 22 to 37 inches: clay loam
R - 37 to 41 inches: bedrock

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Needleton

Percent of map unit: 10 percent
Hydric soil rating: No

Scotch

Percent of map unit: 3 percent
Hydric soil rating: No

Snowdon

Percent of map unit: 2 percent

815—Behanco-Powderhorn family complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: k0vg
Elevation: 8,500 to 10,000 feet
Mean annual precipitation: 25 to 30 inches
Mean annual air temperature: 34 to 40 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Behanco and similar soils: 45 percent
Powderhorn family and similar soils: 40 percent

Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Behanco

Setting

Landform: Mesas
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum and/or slope alluvium derived from sandstone

Typical profile

A1 - 0 to 2 inches: loam
A2 - 2 to 17 inches: very flaggy loam
E - 17 to 25 inches: very channery loam
Bt - 25 to 33 inches: very channery loam
2C1 - 33 to 45 inches: very channery sand
2C2 - 45 to 47 inches: clay
2Cr - 47 to 59 inches: weathered bedrock
2R - 59 to 63 inches: bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock; 40 to 60 inches to lithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: B
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Powderhorn Family

Setting

Landform: Mesas
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 4 inches: loam
AB - 4 to 12 inches: loam
B/A - 12 to 24 inches: loam
Bt1 - 24 to 32 inches: cobbly clay

Bt2 - 32 to 41 inches: clay
C - 41 to 60 inches: clay
R - 60 to 64 inches: unweathered bedrock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 40 to 80 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Minor Components

Sudduth

Percent of map unit: 5 percent

Storm

Percent of map unit: 5 percent
Hydric soil rating: No

Lithic haplocryolls

Percent of map unit: 3 percent

Haplocryolls, mod deep

Percent of map unit: 2 percent

816—Storm extremely flaggy loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0vh
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Storm and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Storm

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone

Typical profile

Oi - 0 to 2 inches: moderately decomposed plant material
A - 2 to 6 inches: extremely flaggy loam
E - 6 to 13 inches: extremely flaggy loam
Bw1 - 13 to 19 inches: extremely flaggy clay loam
Bw2 - 19 to 31 inches: very gravelly clay loam
Bw3 - 31 to 40 inches: extremely cobbly clay loam
BC - 40 to 48 inches: very gravelly loam
C1 - 48 to 56 inches: extremely gravelly loam
C2 - 56 to 62 inches: extremely gravelly clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Hydric soil rating: No

Minor Components

Pachic argicryolls

Percent of map unit: 8 percent
Hydric soil rating: No

Eutrocryepts, clayey-skeletal

Percent of map unit: 3 percent

Lithic eutrocryepts

Percent of map unit: 2 percent

Eutrocryepts, mod deep

Percent of map unit: 2 percent

826—Ute-Frisco complex, 0 to 20 percent slopes

Map Unit Setting

National map unit symbol: k0vk
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Ute and similar soils: 50 percent
Frisco and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ute

Setting

Landform: Drainageways, depressions on mesas
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sandstone and shale

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 7 inches: loam
BAt - 7 to 13 inches: clay loam
Btg - 13 to 28 inches: clay
BCg - 28 to 45 inches: clay loam
Cg - 45 to 62 inches: clay loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: C/D
Ecological site: R048AY241CO - Mountain Meadow
Hydric soil rating: Yes

Description of Frisco

Setting

Landform: Mesas
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from volcanic and sedimentary rock

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 11 inches: loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Clayburn

Percent of map unit: 5 percent
Landform: Depressions
Hydric soil rating: No

Cryofibrists

Percent of map unit: 3 percent
Landform: Depressions
Hydric soil rating: Yes

Cryaquolls, loamy-skeletal

Percent of map unit: 2 percent
Landform: Depressions
Hydric soil rating: Yes

830—Dressel-Jersey complex, 30 to 80 percent slopes

Map Unit Setting

National map unit symbol: k0vn
Elevation: 7,600 to 10,500 feet
Mean annual precipitation: 25 to 35 inches
Mean annual air temperature: 34 to 40 degrees F
Frost-free period: 50 to 70 days
Farmland classification: Not prime farmland

Map Unit Composition

Dressel and similar soils: 55 percent
Jersey and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Dressel

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A1 - 2 to 8 inches: gravelly loam
A2 - 8 to 19 inches: very stony loam
E - 19 to 23 inches: very cobbly sandy clay loam
Bw1 - 23 to 30 inches: very cobbly sandy clay loam
Bw2 - 30 to 36 inches: extremely cobbly loam
Bw3 - 36 to 45 inches: extremely cobbly loam
C1 - 45 to 53 inches: extremely cobbly loam
C2 - 53 to 62 inches: very cobbly loam

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Description of Jersey

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: very cobbly loam
AB - 8 to 13 inches: very cobbly clay loam
Bw1 - 13 to 18 inches: very cobbly clay loam
Bw2 - 18 to 26 inches: extremely stony clay loam
Bw3 - 26 to 37 inches: very cobbly clay loam
C1 - 37 to 47 inches: very cobbly clay
C2 - 47 to 61 inches: very cobbly clay

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Minor Components

Haplocryalfs

Percent of map unit: 5 percent
Hydric soil rating: No

Haplocryolls, fine-loamy

Percent of map unit: 5 percent

Haplocryolls, deep

Percent of map unit: 4 percent

Rock outcrop

Percent of map unit: 1 percent
Hydric soil rating: No

832—Storm extremely flaggy loam, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: k0vq
Elevation: 10,000 to 11,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Storm and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Storm

Setting

Landform: Mesas, hills
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone

Typical profile

Oi - 0 to 2 inches: moderately decomposed plant material
A - 2 to 6 inches: extremely flaggy loam
E - 6 to 13 inches: extremely flaggy loam
Bw1 - 13 to 19 inches: extremely flaggy clay loam
Bw2 - 19 to 31 inches: very gravelly clay loam
Bw3 - 31 to 40 inches: extremely cobbly clay loam
BC - 40 to 48 inches: very gravelly loam
C1 - 48 to 56 inches: extremely gravelly loam
C2 - 56 to 62 inches: extremely gravelly clay loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/grouse whortleberry (ABLA-PIEN/VASC) (C0321)
Hydric soil rating: No

Minor Components

Pachic argicryolls

Percent of map unit: 8 percent
Hydric soil rating: No

Eutrocryepts, clayey-skeletal

Percent of map unit: 3 percent

Lithic eutrocryepts

Percent of map unit: 2 percent

Eutrocryepts, mod deep

Percent of map unit: 2 percent

834—Haycamp-Jersey complex, 30 to 80 percent slopes

Map Unit Setting

National map unit symbol: k0vr
Elevation: 8,600 to 11,500 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 32 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Haycamp and similar soils: 60 percent
Jersey and similar soils: 25 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Haycamp

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oe - 0 to 1 inches: slightly decomposed plant material
A - 1 to 5 inches: cobbly clay loam
E - 5 to 13 inches: cobbly clay
Bw1 - 13 to 21 inches: cobbly clay
Bw2 - 21 to 30 inches: clay
Bw3 - 30 to 38 inches: clay
C1 - 38 to 56 inches: gravelly clay
C2 - 56 to 61 inches: very cobbly clay loam

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/grouse whortleberry (ABLA-PIEN/VASC) (C0321)
Hydric soil rating: No

Description of Jersey

Setting

Landform: Mountain slopes, canyons
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: very cobbly loam

AB - 8 to 13 inches: very cobbly clay loam
Bw1 - 13 to 18 inches: very cobbly clay loam
Bw2 - 18 to 26 inches: extremely stony clay loam
Bw3 - 26 to 37 inches: very cobbly clay loam
C1 - 37 to 47 inches: very cobbly clay
C2 - 47 to 61 inches: very cobbly clay

Properties and qualities

Slope: 30 to 80 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F048AY449CO - Aspen Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/grouse whortleberry (ABLA-PIEN/VASC) (C0321), Quaking aspen/mountain snowberry (POTR5/SYOR2) (D0511)
Hydric soil rating: No

Minor Components

Pachic haplocryolls

Percent of map unit: 5 percent
Hydric soil rating: No

Haplocryolls, fine-loamy

Percent of map unit: 5 percent

Haplocryolls, mod deep

Percent of map unit: 4 percent

Rock outcrop

Percent of map unit: 1 percent

891—Tamarron-Frisco complex, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: k0vy
Elevation: 8,000 to 10,600 feet
Mean annual precipitation: 30 to 45 inches

Mean annual air temperature: 34 to 38 degrees F
Frost-free period: 40 to 60 days
Farmland classification: Not prime farmland

Map Unit Composition

Tamarron and similar soils: 45 percent
Frisco and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tamarron

Setting

Landform: Mountain slopes, ridges
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oi - 0 to 3 inches: slightly decomposed plant material
E - 3 to 9 inches: loam
Bt1 - 9 to 20 inches: very channery clay loam
Bt2 - 20 to 30 inches: very flaggy loam
C - 30 to 39 inches: extremely flaggy loam
Cr - 39 to 49 inches: weathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Description of Frisco

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Colluvium and/or slope alluvium derived from sandstone and shale

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 5 inches: loam
E1 - 5 to 11 inches: loam
E2 - 11 to 19 inches: cobbly loam
Bt1 - 19 to 48 inches: extremely stony sandy clay loam
Bt2 - 48 to 62 inches: extremely stony loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F048AY918CO - Spruce-Fir Woodland
Other vegetative classification: Subalpine fir - Engelmann spruce/myrtle whortleberry (ABLA-PIEN/VAMY2) (C0320)
Hydric soil rating: No

Minor Components

Snowdon

Percent of map unit: 10 percent
Hydric soil rating: No

Bucklon

Percent of map unit: 3 percent

Haviland

Percent of map unit: 2 percent
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

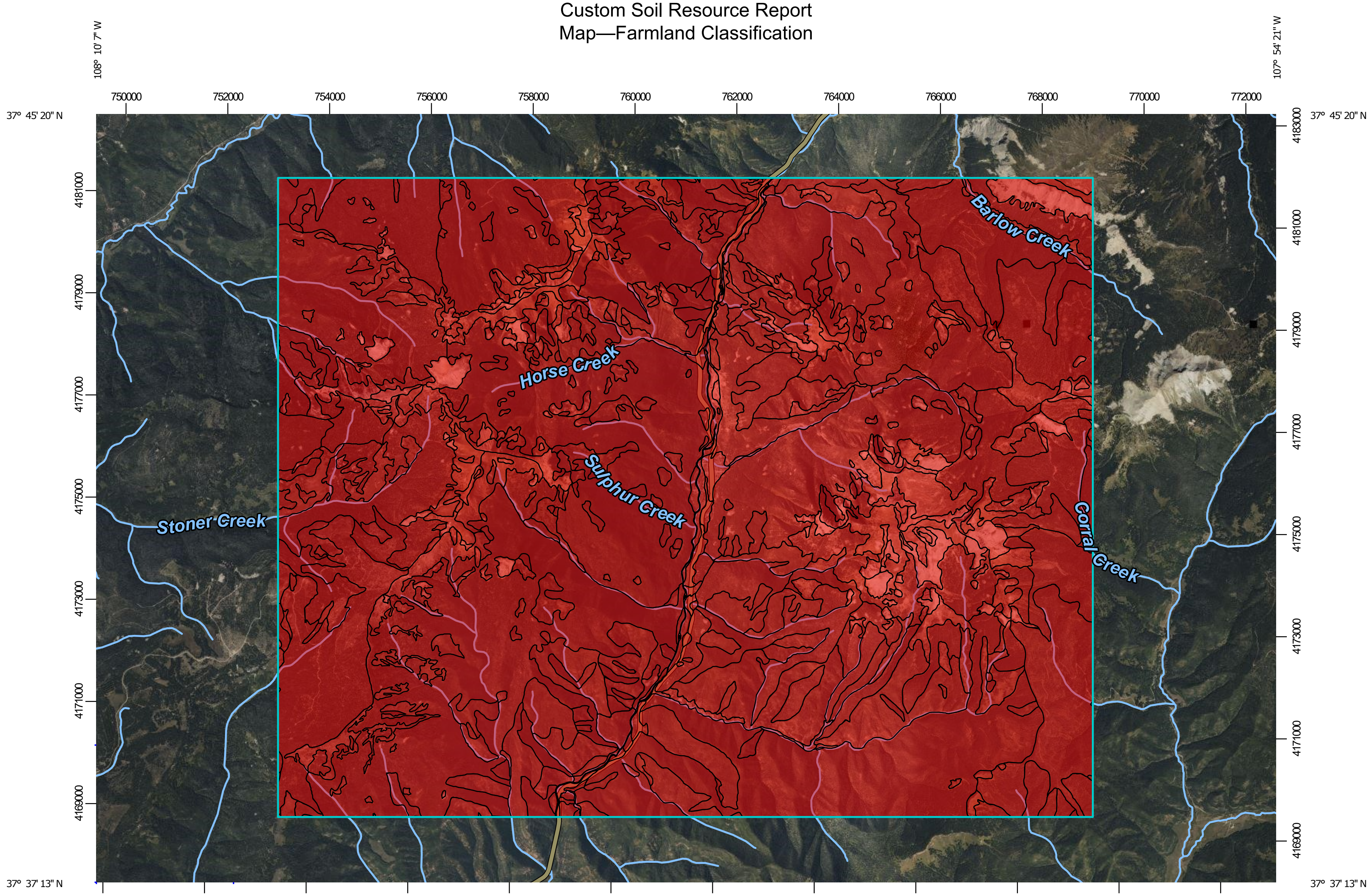
Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Map—Farmland Classification



Map Scale: 1:106,000 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 1500, 3000, 6000, 9000

Feet: 0, 5000, 10000, 20000, 30000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

Prime farmland if subsoiled, completely removing the root inhibiting soil layer

Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Prime farmland if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance

Farmland of statewide importance, if drained

Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated

Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated and drained

Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer

Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough

Farmland of statewide importance, if thawed

Farmland of local importance

Farmland of local importance, if irrigated

Farmland of unique importance

Not rated or not available

Soil Rating Points

Not prime farmland

All areas are prime farmland

Prime farmland if drained

Prime farmland if protected from flooding or not frequently flooded during the growing season

Prime farmland if irrigated

Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Prime farmland if irrigated and drained

Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

Prime farmland if subsoiled, completely removing the root inhibiting soil layer

Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Prime farmland if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance

Farmland of statewide importance, if drained

Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated

Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated and drained

Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer

Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough

Farmland of statewide importance, if thawed

Farmland of local importance

Farmland of local importance, if irrigated

Farmland of unique importance

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties
Survey Area Data: Version 17, Sep 6, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 26, 2010—Sep 17, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Farmland Classification

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
14	Dalmatian-Apmay-Schrader complex, 0 to 5 percent slopes	Not prime farmland	58.2	0.1%
20	Mavreeso loam, 5 to 30 percent slopes	Not prime farmland	43.7	0.1%
53	Cryaquolls-Typic Cryaquents complex, 1 to 5 percent slopes	Not prime farmland	293.7	0.6%
54	Quazar very cobbly loam, 5 to 25 percent slopes	Not prime farmland	271.6	0.5%
56	Typic Cryaquents-Cryaquolls-Cryofibrists complex, 0 to 5 percent slopes	Not prime farmland	35.4	0.1%
152	Frisco loam, 25 to 45 percent slopes	Not prime farmland	126.0	0.3%
153	Frisco-Horsethief complex, 10 to 30 percent slopes	Not prime farmland	88.8	0.2%
154	Frisco-Horsethief complex, 30 to 75 percent slopes	Not prime farmland	7,509.9	15.1%
155	Tuckerville-Rock outcrop complex, 30 to 60 percent slopes	Not prime farmland	1,101.7	2.2%
158	Sponsor-Tuckerville complex, 30 to 60 percent slopes	Not prime farmland	188.9	0.4%
163	Clayburn-Hourglass complex, 15 to 30 percent slopes	Not prime farmland	3.1	0.0%
164	Hourglass-Bucklon-Wander complex, 30 to 60 percent slopes	Not prime farmland	195.2	0.4%
250	Snowdon-Rock outcrop complex, 30 to 65 percent slopes	Not prime farmland	15.2	0.0%
251	Rock outcrop-Snowdon complex, 45 to 75 percent slopes	Not prime farmland	142.7	0.3%
254	Cryorthents-Rubble land complex, 30 to 75 percent slopes	Not prime farmland	116.6	0.2%
334	Henson very gravelly loam, south aspect, 30 to 60 percent slopes	Not prime farmland	1,057.0	2.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
335	Whitecross, very stony-Rock outcrop complex, 15 to 45 percent slopes	Not prime farmland	213.8	0.4%
336	Whitecross-Rock outcrop complex, south aspect, 30 to 75 percent slopes	Not prime farmland	834.1	1.7%
337	Whitecross-Rock outcrop complex, 45 to 75 percent slopes	Not prime farmland	257.6	0.5%
338	Henson very gravelly loam, 10 to 30 percent slopes	Not prime farmland	49.9	0.1%
339	Henson very gravelly loam, 30 to 60 percent slopes	Not prime farmland	667.8	1.3%
345	Papaspila loam, 0 to 15 percent slopes	Not prime farmland	20.6	0.0%
374	Mavreeso-Valto-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland	431.1	0.9%
375	Needleton-Snowdon complex, 5 to 15 percent slopes	Not prime farmland	12.6	0.0%
376	Needleton loam, 15 to 30 percent slopes	Not prime farmland	54.1	0.1%
378	Needleton-Haviland complex, 30 to 60 percent slopes	Not prime farmland	7,664.9	15.4%
381	Needleton-Snowdon-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland	10,569.2	21.3%
382	Needleton-Snowdon complex, 15 to 30 percent slopes	Not prime farmland	1,142.1	2.3%
383	Haviland-Needleton complex, 10 to 30 percent slopes	Not prime farmland	521.0	1.0%
387	Frisco-Quazar complex, 30 to 60 percent slopes	Not prime farmland	306.2	0.6%
390	Clayburn-Heisspitz complex, 30 to 60 percent slopes	Not prime farmland	15.4	0.0%
392	Runlett-Needleton-Sessions complex, 15 to 45 percent slopes	Not prime farmland	72.4	0.1%
394	Clayburn-Heisspitz complex, 15 to 30 percent slopes	Not prime farmland	27.4	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
450	Lostlake-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland	40.9	0.1%
495	Riverwash	Not prime farmland	1.5	0.0%
496	Rock outcrop	Not prime farmland	1,268.5	2.6%
497	Rubble land	Not prime farmland	1,659.4	3.3%
499	Water	Not prime farmland	61.6	0.1%
572	Sudduth loam, 0 to 15 percent slopes	Not prime farmland	4.6	0.0%
606	Snowdon-Needleton complex, 45 to 90 percent slopes	Not prime farmland	718.7	1.4%
607	Graysill-Scotch complex, south aspect, 30 to 60 percent slopes	Not prime farmland	2,933.8	5.9%
608	Scotch-Graysill complex, 30 to 60 percent slopes	Not prime farmland	1,518.3	3.1%
609	Hourglass-Wander complex, 5 to 30 percent slopes	Not prime farmland	36.1	0.1%
610	Wander-Hotter-Hourglass complex, 30 to 60 percent slopes	Not prime farmland	2,228.0	4.5%
612	Haviland-Graysill complex, 5 to 30 percent slopes	Not prime farmland	235.7	0.5%
815	Behanco-Powderhorn family complex, 0 to 15 percent slopes	Not prime farmland	0.7	0.0%
816	Storm extremely flaggy loam, 15 to 30 percent slopes	Not prime farmland	2,679.8	5.4%
826	Ute-Frisco complex, 0 to 20 percent slopes	Not prime farmland	29.3	0.1%
830	Dressel-Jersey complex, 30 to 80 percent slopes	Not prime farmland	1,399.3	2.8%
832	Storm extremely flaggy loam, 0 to 15 percent slopes	Not prime farmland	341.5	0.7%
834	Haycamp-Jersey complex, 30 to 80 percent slopes	Not prime farmland	402.6	0.8%
891	Tamarron-Frisco complex, 15 to 30 percent slopes	Not prime farmland	37.0	0.1%
Totals for Area of Interest			**49,715.7**	**100.0%**

Rating Options—Farmland Classification

Aggregation Method: No Aggregation Necessary

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The majority of soil attributes are associated with a component of a map unit, and such an attribute has to be aggregated to the map unit level before a thematic map can be rendered. Map units, however, also have their own attributes. An attribute of a map unit does not have to be aggregated in order to render a corresponding thematic map. Therefore, the "aggregation method" for any attribute of a map unit is referred to as "No Aggregation Necessary".

Tie-break Rule: Lower

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Prime and other Important Farmlands (Prime and Other Important Farmlands)

This table lists the map units in the survey area that are considered important farmlands. Important farmlands consist of prime farmland, unique farmland, and farmland of statewide or local importance. This list does not constitute a recommendation for a particular land use.

In an effort to identify the extent and location of important farmlands, the Natural Resources Conservation Service, in cooperation with other interested Federal, State, and local government organizations, has inventoried land that can be used for the production of the Nation's food supply.

Prime farmland is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil quality, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. The water supply is dependable and of adequate quality. Prime farmland is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

For some of the soils identified in the table as prime farmland, measures that overcome a hazard or limitation, such as flooding, wetness, and droughtiness, are needed. Onsite evaluation is needed to determine whether or not the hazard or limitation has been overcome by corrective measures.

A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables. It has the special combination of soil quality, growing season, moisture supply, temperature, humidity, air drainage, elevation, and aspect needed for the soil to economically produce sustainable high yields of these crops when properly managed. The water supply is dependable and of adequate quality. Nearness to markets is an additional consideration. Unique farmland is not based on national criteria. It commonly is in areas where there is a special microclimate, such as the wine country in California.

In some areas, land that does not meet the criteria for prime or unique farmland is considered to be *farmland of statewide importance* for the production of food, feed, fiber, forage, and oilseed crops. The criteria for defining and delineating farmland of statewide importance are determined by the appropriate State agencies. Generally, this land includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some areas may produce as high a yield as prime farmland if conditions are favorable. Farmland of statewide importance may include tracts of land that have been designated for agriculture by State law.

In some areas that are not identified as having national or statewide importance, land is considered to be *farmland of local importance* for the production of food, feed, fiber, forage, and oilseed crops. This farmland is identified by the appropriate local agencies. Farmland of local importance may include tracts of land that have been designated for agriculture by local ordinance.

Report—Prime and other Important Farmlands (Prime and Other Important Farmlands)

Prime and other Important Farmlands–Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties		
Map Symbol	**Map Unit Name**	**Farmland Classification**
14	Dalmatian-Apmay-Schrader complex, 0 to 5 percent slopes	Not prime farmland
20	Mavreeso loam, 5 to 30 percent slopes	Not prime farmland

Prime and other Important Farmlands–Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties		
Map Symbol	**Map Unit Name**	**Farmland Classification**
53	Cryaquolls-Typic Cryaquents complex, 1 to 5 percent slopes	Not prime farmland
54	Quazar very cobbly loam, 5 to 25 percent slopes	Not prime farmland
56	Typic Cryaquents-Cryaquolls-Cryofibrists complex, 0 to 5 percent slopes	Not prime farmland
152	Frisco loam, 25 to 45 percent slopes	Not prime farmland
153	Frisco-Horsethief complex, 10 to 30 percent slopes	Not prime farmland
154	Frisco-Horsethief complex, 30 to 75 percent slopes	Not prime farmland
155	Tuckerville-Rock outcrop complex, 30 to 60 percent slopes	Not prime farmland
158	Sponsor-Tuckerville complex, 30 to 60 percent slopes	Not prime farmland
163	Clayburn-Hourglass complex, 15 to 30 percent slopes	Not prime farmland
164	Hourglass-Bucklon-Wander complex, 30 to 60 percent slopes	Not prime farmland
250	Snowdon-Rock outcrop complex, 30 to 65 percent slopes	Not prime farmland
251	Rock outcrop-Snowdon complex, 45 to 75 percent slopes	Not prime farmland
254	Cryorthents-Rubble land complex, 30 to 75 percent slopes	Not prime farmland
334	Henson very gravelly loam, south aspect, 30 to 60 percent slopes	Not prime farmland
335	Whitecross, very stony-Rock outcrop complex, 15 to 45 percent slopes	Not prime farmland
336	Whitecross-Rock outcrop complex, south aspect, 30 to 75 percent slopes	Not prime farmland
337	Whitecross-Rock outcrop complex, 45 to 75 percent slopes	Not prime farmland
338	Henson very gravelly loam, 10 to 30 percent slopes	Not prime farmland
339	Henson very gravelly loam, 30 to 60 percent slopes	Not prime farmland
345	Papaspila loam, 0 to 15 percent slopes	Not prime farmland
374	Mavreeso-Valto-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland
375	Needleton-Snowdon complex, 5 to 15 percent slopes	Not prime farmland
376	Needleton loam, 15 to 30 percent slopes	Not prime farmland
378	Needleton-Haviland complex, 30 to 60 percent slopes	Not prime farmland
381	Needleton-Snowdon-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland
382	Needleton-Snowdon complex, 15 to 30 percent slopes	Not prime farmland
383	Haviland-Needleton complex, 10 to 30 percent slopes	Not prime farmland
387	Frisco-Quazar complex, 30 to 60 percent slopes	Not prime farmland
390	Clayburn-Heisspitz complex, 30 to 60 percent slopes	Not prime farmland
392	Runlett-Needleton-Sessions complex, 15 to 45 percent slopes	Not prime farmland
394	Clayburn-Heisspitz complex, 15 to 30 percent slopes	Not prime farmland
450	Lostlake-Rock outcrop complex, 30 to 80 percent slopes	Not prime farmland
495	Riverwash	Not prime farmland
496	Rock outcrop	Not prime farmland
497	Rubble land	Not prime farmland
499	Water	Not prime farmland

Prime and other Important Farmlands–Animas-Dolores Area, Colorado, Parts of Archuleta, Dolores, Hinsdale, La Plata, Montezuma, San Juan, and San Miguel Counties		
Map Symbol	**Map Unit Name**	**Farmland Classification**
572	Sudduth loam, 0 to 15 percent slopes	Not prime farmland
606	Snowdon-Needleton complex, 45 to 90 percent slopes	Not prime farmland
607	Graysill-Scotch complex, south aspect, 30 to 60 percent slopes	Not prime farmland
608	Scotch-Graysill complex, 30 to 60 percent slopes	Not prime farmland
609	Hourglass-Wander complex, 5 to 30 percent slopes	Not prime farmland
610	Wander-Hotter-Hourglass complex, 30 to 60 percent slopes	Not prime farmland
612	Haviland-Graysill complex, 5 to 30 percent slopes	Not prime farmland
815	Behanco-Powderhorn family complex, 0 to 15 percent slopes	Not prime farmland
816	Storm extremely flaggy loam, 15 to 30 percent slopes	Not prime farmland
826	Ute-Frisco complex, 0 to 20 percent slopes	Not prime farmland
830	Dressel-Jersey complex, 30 to 80 percent slopes	Not prime farmland
832	Storm extremely flaggy loam, 0 to 15 percent slopes	Not prime farmland
834	Haycamp-Jersey complex, 30 to 80 percent slopes	Not prime farmland
891	Tamarron-Frisco complex, 15 to 30 percent slopes	Not prime farmland

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APPENDIX C – 2021 DRINKING QUALITY REPORT

RICO TOWN OF 2021 Drinking Water Quality Report
Covering Data For Calendar Year 2020

Public Water System ID: CO0117700

Esta es información importante. Si no la pueden leer, necesitan que alguien se la traduzca.

We are pleased to present to you this year's water quality report. Our constant goal is to provide you with a safe and dependable supply of drinking water. Please contact KARI DISTEFANO at 970-901-3420 with any questions or for public participation opportunities that may affect water quality.

General Information

All drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline (1-800-426-4791) or by visiting epa.gov/ground-water-and-drinking-water.

Some people may be more vulnerable to contaminants in drinking water than the general population. Immunocompromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV-AIDS or other immune system disorders, some elderly, and infants can be particularly at risk of infections. These people should seek advice about drinking water from their health care providers. For more information about contaminants and potential health effects, or to receive a copy of the U.S. Environmental Protection Agency (EPA) and the U.S. Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and microbiological contaminants call the EPA Safe Drinking Water Hotline at (1-800-426-4791).

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity. Contaminants that may be present in source water include:

•**Microbial contaminants:** viruses and bacteria that may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.
•**Inorganic contaminants:** salts and metals, which can be naturally-occurring or result from urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming.
•**Pesticides and herbicides:** may come from a variety of sources, such as agriculture, urban storm water runoff, and residential uses.
•**Radioactive contaminants:** can be naturally occurring or be the result of oil and gas production and mining activities.
•**Organic chemical contaminants:** including synthetic and volatile organic chemicals, which are byproducts of industrial processes and petroleum production, and also may come from gas stations, urban storm water runoff, and septic systems.

In order to ensure that tap water is safe to drink, the Colorado Department of Public Health and Environment prescribes regulations limiting the amount of certain contaminants in water provided by public water systems. The Food and Drug Administration regulations establish limits for contaminants in bottled water that must provide the same protection for public health.

Lead in Drinking Water

If present, elevated levels of lead can cause serious health problems (especially for pregnant women and young children). It is possible that lead levels at your home may be higher than other homes in the community as a result of materials used in your home's plumbing. If you are concerned about lead in your water, you may wish to have your water tested. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. Additional information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline (1-800-426-4791) or at epa.gov/safewater/lead.

Source Water Assessment and Protection (SWAP)

The Colorado Department of Public Health and Environment may have provided us with a Source Water Assessment Report for our water supply. For general information or to obtain a copy of the report please visit wqcdcompliance.com/ccr. The report is located under "Guidance: Source Water Assessment Reports". Search the table using 117700, RICO TOWN OF, or by contacting KARI DISTEFANO at 970-901-3420. The Source Water Assessment Report provides a screening-level evaluation of potential contamination that ***could*** occur. It ***does not*** mean that the contamination ***has or will*** occur. We can use this information to evaluate the need to improve our current water treatment capabilities and prepare for future contamination threats. This can help us ensure that quality finished water is delivered to your homes. In addition, the source water assessment results provide a starting point for developing a source water protection plan. Potential sources of contamination in our source water area are listed on the next page.

Please contact us to learn more about what you can do to help protect your drinking water sources, any questions about the Drinking Water Quality Report, to learn more about our system, or to attend scheduled public meetings. We want you, our valued customers, to be informed about the services we provide and the quality water we deliver to you every day.

Our Water Sources

Sources (Water Type - Source Type)	Potential Source(s) of Contamination
WELL NO 1 (Groundwater-Well) INF GAL ON SILVER CREEK (Surface Water-Intake)	Deciduous Forest, Evergreen Forest, Mixed Forest, Road Miles

Terms and Abbreviations

- **Maximum Contaminant Level (MCL)** − The highest level of a contaminant allowed in drinking water.
- **Treatment Technique (TT)** − A required process intended to reduce the level of a contaminant in drinking water.
- **Health-Based** − A violation of either a MCL or TT.
- **Non-Health-Based** − A violation that is not a MCL or TT.
- **Action Level (AL)** − The concentration of a contaminant which, if exceeded, triggers treatment and other regulatory requirements.
- **Maximum Residual Disinfectant Level (MRDL)** − The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Maximum Contaminant Level Goal (MCLG)** − The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
- **Maximum Residual Disinfectant Level Goal (MRDLG)** − The level of a drinking water disinfectant, below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Violation (No Abbreviation)** − Failure to meet a Colorado Primary Drinking Water Regulation.
- **Formal Enforcement Action (No Abbreviation)** − Escalated action taken by the State (due to the risk to public health, or number or severity of violations) to bring a non-compliant water system back into compliance.
- **Variance and Exemptions (V/E)** − Department permission not to meet a MCL or treatment technique under certain conditions.
- **Gross Alpha (No Abbreviation)** − Gross alpha particle activity compliance value. It includes radium-226, but excludes radon 222, and uranium.
- **Picocuries per liter (pCi/L)** − Measure of the radioactivity in water.
- **Nephelometric Turbidity Unit (NTU)** − Measure of the clarity or cloudiness of water. Turbidity in excess of 5 NTU is just noticeable to the typical person.
- **Compliance Value (No Abbreviation)** – Single or calculated value used to determine if regulatory contaminant level (e.g. MCL) is met. Examples of calculated values are the 90^{th} Percentile, Running Annual Average (RAA) and Locational Running Annual Average (LRAA).
- **Average (x-bar)** − Typical value.
- **Range (R)** − Lowest value to the highest value.
- **Sample Size (n)** − Number or count of values (i.e. number of water samples collected).
- **Parts per million = Milligrams per liter (ppm = mg/L)** − One part per million corresponds to one minute in two years or a single penny in $10,000.
- **Parts per billion = Micrograms per liter (ppb = ug/L)** − One part per billion corresponds to one minute in 2,000 years, or a single penny in $10,000,000.
- **Not Applicable (N/A)** – Does not apply or not available.
- **Level 1 Assessment** – A study of the water system to identify potential problems and determine (if possible) why total coliform bacteria have been found in our water system.
- **Level 2 Assessment** – A very detailed study of the water system to identify potential problems and determine (if possible) why an E. coli MCL violation has occurred and/or why total coliform bacteria have been found in our water system on multiple occasions.

Detected Contaminants

RICO TOWN OF routinely monitors for contaminants in your drinking water according to Federal and State laws. The following table(s) show all detections found in the period of January 1 to December 31, 2020 unless otherwise noted. The State of Colorado requires us to monitor for certain contaminants less than once per year because the concentrations of these contaminants are not expected to vary significantly from year to year, or the system is not considered vulnerable to this type of contamination. Therefore, some of our data, though representative, may be more than one year old. Violations and Formal Enforcement Actions, if any, are reported in the next section of this report.

Note: Only detected contaminants sampled within the last 5 years appear in this report. If no tables appear in this section then no contaminants were detected in the last round of monitoring.

Disinfectants Sampled in the Distribution System

TT Requirement: At least 95% of samples per period (month or quarter) must be at least 0.2 ppm ***OR***
If sample size is less than 40 no more than 1 sample is below 0.2 ppm
Typical Sources: Water additive used to control microbes

Disinfectant Name	Time Period	Results	Number of Samples Below Level	Sample Size	TT Violation	MRDL
Chlorine	December, 2020	Lowest period percentage of samples meeting TT requirement: 100%	0	1	No	4.0 ppm

Lead and Copper Sampled in the Distribution System

Contaminant Name	Time Period	90th Percentile	Sample Size	Unit of Measure	90th Percentile AL	Sample Sites Above AL	90th Percentile AL Exceedance	Typical Sources
Copper	12/09/2020 to 12/28/2020	0.24	10	ppm	1.3	0	No	Corrosion of household plumbing systems; Erosion of natural deposits
Lead	05/14/2020 to 05/19/2020	2.7	10	ppb	15	0	No	Corrosion of household plumbing systems; Erosion of natural deposits
Copper	05/14/2020 to 05/19/2020	0.07	10	ppm	1.3	0	No	Corrosion of household plumbing systems; Erosion of natural deposits
Lead	12/09/2020 to 12/28/2020	5.6	10	ppb	15	0	No	Corrosion of household plumbing systems; Erosion of natural deposits

Disinfection Byproducts Sampled in the Distribution System

Name	Year	Average	Range Low – High	Sample Size	Unit of Measure	MCL	MCLG	MCL Violation	Typical Sources
Total Trihalomethanes (TTHM)	2020	2.37	2.37 to 2.37	1	ppb	80	N/A	No	Byproduct of drinking water disinfection

Inorganic Contaminants Sampled at the Entry Point to the Distribution System									
Contaminant Name	**Year**	**Average**	**Range Low – High**	**Sample Size**	**Unit of Measure**	**MCL**	**MCLG**	**MCL Violation**	**Typical Sources**
Barium	2020	0.03	0.03 to 0.03	1	ppm	2	2	No	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Fluoride	2020	0.13	0.13 to 0.13	1	ppm	4	4	No	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories
Nitrate	2020	0.05	0.05 to 0.05	1	ppm	10	10	No	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits

Secondary Contaminants**

**Secondary standards are non-enforceable guidelines for contaminants that may cause cosmetic effects (such as skin, or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

Contaminant Name	Year	Average	Range Low – High	Sample Size	Unit of Measure	Secondary Standard
Sodium	2020	6.93	6.93 to 6.93	1	ppm	N/A

Violations, Significant Deficiencies, and Formal Enforcement Actions

Non-Health-Based Violations These violations do not usually mean that there was a problem with the water quality. If there had been, we would have notified you immediately. We missed collecting a sample (water quality is unknown), we reported the sample result after the due date, or we did not complete a report/notice by the required date.		
Name	**Description**	**Time Period**
LEAD & COPPER RULE	FAILURE TO MONITOR AND/OR REPORT	01/01/2020 - 01/26/2021
Additional Violation Information		
Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.		
This violation has been addressed by updating the Lead and Copper materials survey of water services in the district to better reflect the higher risk levels at lead and copper sample sites. We resolved this issue in January of 2020 and have been taking samples at the higher risk sample sites since then.		

APPENDIX D – RICO GEOTHERMAL REPORT

Technical Report Rico 2018

Prepared by Lucila Dunnington

In cooperation with Masami Nakagawa & Meghan Helper

June 26, 2018

Rico Geologic and Geothermal Setting

The Rio Grande Rift cuts through Colorado southeast to northwest. It imparts on Colorado a thinner continental crust, steep faults, and graben fill features. These three aspects of a rift system together create ideal conditions for geothermal in certain areas of Colorado. The San Juan Rift, an adjacent rift system is the setting of Rico's geothermal. The geothermal manifests as hot spring wells that are apparent north of downtown and south of the settling ponds. Other wellbores, drilled at the service of mining companies, have discovered higher than usual geothermal gradients. Whereas the average geothermal gradient of the earth's crust is 25 degrees Celsius per kilometer of depth, Rico's northern area averages geothermal gradients of 101.2 degrees Celsius per kilometer (Figure 1).

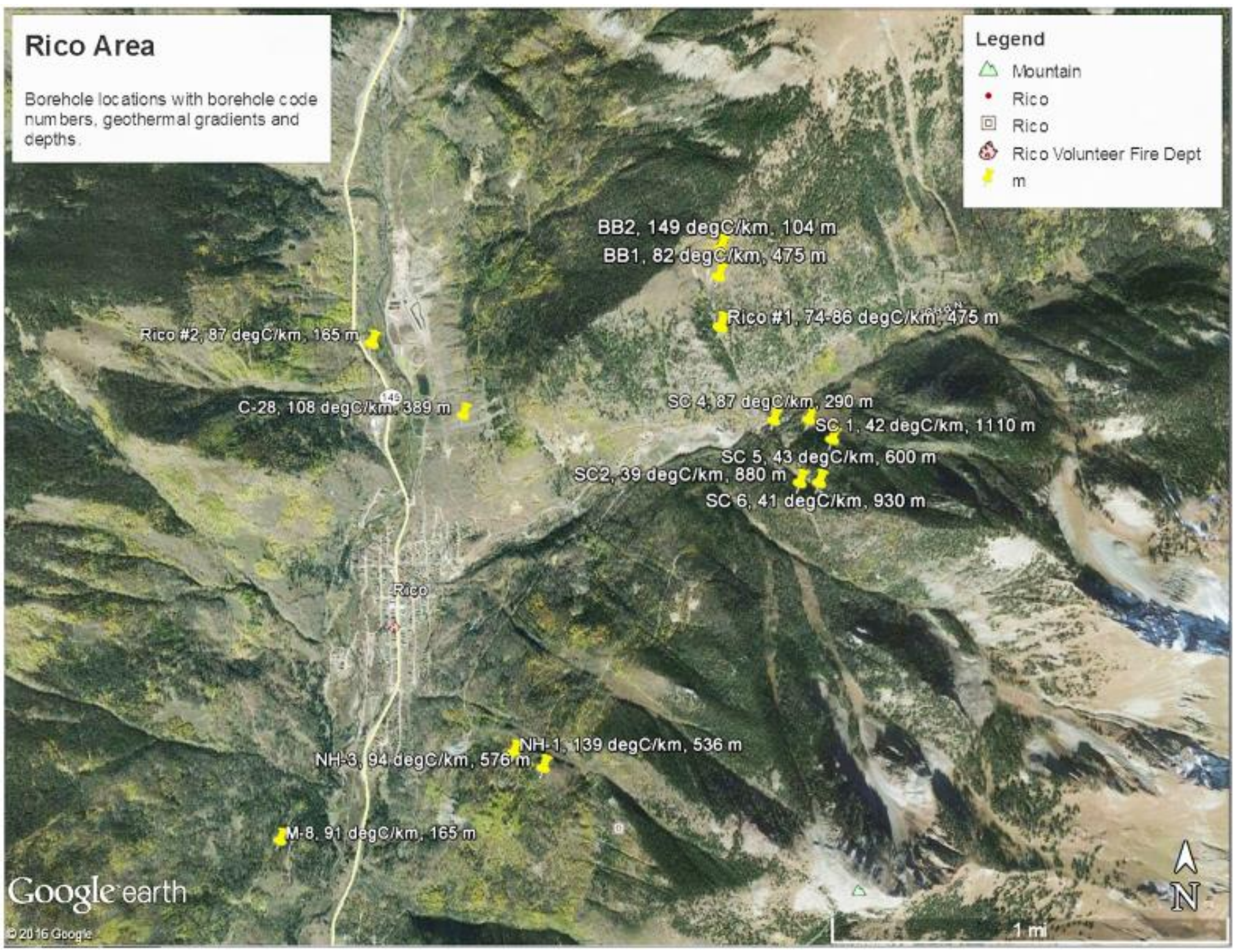

Figure 1 Wellbore data from mining exploration in Rico, CO with well identification numbers, depths and geothermal gradients

Another cluster of higher geothermal gradients (91-139 degC/km) south of Rico corresponds to old mine sites in the area: the Jones, Lexington, and Enterprise Mines. One mining company reported water from a well reaching temperatures of 114 degrees Celsius (Medlin, 1983).

The hydrothermal system that produced the enhanced geothermal gradient four million years ago likely followed older paths carved out by 65 million year old latite porphyries. These porphyries enrich the exposed geothermal water with iron, while the underlying Leadville Limestone gives the water its notable calcium carbonate signature.

Table 1 Metals and nonmetals in mg/L from Rico's three sampled hot springs (BDL indicates the measurement fell below detection limits).

Analyte	HS North	HS East	HS West
Boron	0.191363	0.132166	0.083106
Barium	0.025925	0.027909	0.034358
Beryllium	0.006216	0.005905	0.005445
Calcium	735.5724	699.691	648.9356
Cadmium	BDL	BDL	BDL
Cobalt	0.00073	0.000849	0.001148
Chromium	BDL	BDL	BDL
Copper	BDL	BDL	BDL
Iron	6.814743	5.375104	5.012546
Potassium	24.22891	24.3021	24.55809
Lithium	0.189954	0.187357	0.200981
Magnesium-279	78.91686	80.18077	80.73418
Magnesium-285	90.12084	89.65709	88.37058
Manganese	1.329997	1.112805	1.030429
Sodium	75.30716	71.81082	65.97644
Nickel	BDL	BDL	BDL
Phosphorus	0.020248	BDL	0.011906
Lead	BDL	BDL	BDL
Sulfur	264.4226	233.9239	226.4177
Selenium	0.031145	0.021302	0.026239
Silicon	49.09253	44.86067	46.78174
Strontium	10.17675	9.176513	7.956065
Thallium	BDL	BDL	BDL
Vanadium	BDL	BDL	BDL
Zinc	0.030006	0.047398	0.100093
Tin	BDL	BDL	BDL
Molybdenum	0.002769	0.003028	0.004633
Antimony	BDL	BDL	BDL
Titanium	BDL	BDL	BDL

Table 2 Anion report on Rico hot springs in mg/L

	Fluoride	Chloride	Sulfate
HS North	2.94	4.72	1009.29
HS West	1.68	3.67	1134.41
HS East	2.80	5.25	512.55

While many natural geothermal hot springs are radioactive, a 2016 result from accredited lab, ALS in Fort Collins, showed Rico water to be 11 ± 2.8 pCi/L, lower than Glenwood Springs (27 pCi/L) and Radium Hot Springs (17 pCi/L) in Colorado (Appendix A.3). The main elemental breakdown of the Rico Hot Spring water can be seen in Tables 1 and 2 (From 2015 sampling on Colorado School of Mines ICP-MS).

Previous researchers (and bathers at Rico's springs) have noted that Rico's geothermal resources are mixed with rain or surface water. In a dry season, the spring's temperature can elevate 1 or 2 degrees Celsius from its average of 42 degrees. Geophysics conducted in the early 2010's show that the Last Chance fault, located on the northern side of the Rico Dome (just south of the C-dot station, oriented east-west), is a major conduit introducing water to the deeper heat source. SP, resistivity, thermoluminescence, and geochemistry studies from 2015 to 2016 suggest that once the water enters the Last Chance Fault, it flows south to north in the subsurface.

2016 Geophysics

In 2016, team geologists found a site for a resistivity survey approximately two miles north of the Town of Rico, where a resistivity line of 720 meters could cross two of the three identified fault structures associated with the Blackhawk Fault. The southernmost and middle expression of the Blackhawk fault were identified in the resistivity data inversion (Appendix A.4; Figure A5).

A resistive mass was identified about 43 meters deep from the surface on the northern side of the Blackhawk Fault. This northern resistive mass could provide a northern boundary for the geothermal reservoir at Rico, forcing the warm waters upwards as the subsurface currents travel northward. If the resistive feature at the Blackhawk Fault is indeed the northern boundary for the Rico reservoir, then, assuming a continuous reservoir from the Rico Dome to the Blackhawk, Rico's reservoir's areal extent is about 1 square mile, double the previous estimate made by looking solely at surface expressions (Pearl, 1972).

Objectives of 2018

The task for the geophysics team from Colorado School of Mines during the 2018 expedition was to estimate the depth. With a depth estimate, prospective developers could plan drilling sites, estimate the volume of the reservoir and with the geothermal gradients from Figure 1, a reservoir temperature could be estimated.

Previous delineations of the reservoir suggest that the planar areal extent of Rico's reservoir was 2.5 km^2 or about 1 mi^2. The artesian pressure of Rico's springs yield 800 liters per minute on the fault of the Rico dome (Medlin, 1983). In order to sustainably manage the geothermal resource present in Rico, the amount withdrawn from the reservoir must be returned, either by a closed loop system, or by allowing adequate recharge from the surface waters. Vertical depth estimates are necessary for understanding the water budget of the geothermal system.

Similarly, reservoir temperature estimates are essential for project development. With an average geothermal gradient of 101 degC/km, if the reservoir is 400 m deep, the water will be around 40 degC, and if the reservoir is 800 m deep, the water will be 80 degC. 40 degree water can be developed into a spa like Dunton's or greenhouses like Pagosa's; while 80 degC water can be converted to electricity with the recently developed Organic Rankine Cycle binary geothermal technology.

Even though geothermal power has some of the lowest overall costs when compared to other power sources, uneven distribution of easily reached resources, high upfront costs, and uncertainty in the surface measurements have prevented it from being widely adopted (International Finance Corporation, 2013). A well-defined geophysics exploration program can help alleviate these issues. Even with the variability involved in geophysical data processing and inversion, the success rate of well drilling has been shown to increase by 30-40% when geophysical data is provided (Gray, 2011). Geophysical data inversion coupled with an understanding of the geologic setting of the geothermal reservoir helps with planning and executing successful wells. Since the cost of a typical well can be $143 per foot (increasing with depth), accounting for 30-60% of the capital investment in a geothermal power plant, proper drill planning can mitigate a major financial risk of reservoir development (Lukawski et al., 2014).

Methods

The geophysical method selected for this project based on budget and target depth was magnetotellurics (MT). Magnetotellurics can give deep resistivity estimates, to the 10 km range; the ground conditions, duration of a survey, and length of electrode cables all determine the depth the MT survey can reach at a particular site. Able to detect important features of a reservoir, including the more resistive "caprock," and less resistive faults and reservoir formation, MT has been widely used in geothermal reservoir delineations in the United States, Iceland, New Zealand, Hungary, China, Ethiopia, Peru, Australia, and India.

The MT setup generally requires a 100 m by 100 m flat expanse, set apart from electrical wires, busy roads, and other major sources of noise. At the center of the survey is a recording system (in our case an ADU-07e from Metronix), which reads the electric and magnetic fields and stores data from the long collection time (typically 6-14 hours). Four 50 m cables are reeled out from the recording system to the north, south, east and west directions. The extended ends attach to silver-silver chloride electrodes which must be buried 15-30 cm into the ground, depending on how rocky the soil is (deeper burial is required if the electrode does not have good contact with the shallow ground). Parallel and well-spaced from the electrode cables, magnetometers are placed in trenches in the ground (Figure 2).

The magnetometers collect the magnetic field from the earth's magnetosphere, and the electrodes collect the induced, associated electric field. Because the instrument has to be very sensitive to collect the magnetic field disturbances caused by solar winds and lightning, coiled wire, underground pipes, and more obvious electrical noise from cars and powerlines can produce substantial noise in the data.

The data must be pre-processed then processed in the case of noisy locations. The research group used the ProcMT program to pre-process and process the data, involving manual and programmed removal of unusual or abrupt variations in the natural curved signal. After preprocessing, the data can be "inverted," changing the frequency data into ground resistivity information (Zond 2D MT was used for inversion). The inversion of data varies modestly with the user, since programs will smooth and dampen the data based on the perceived quality of the collection. Most programs allow the inclusion of known geological structures or well logging data, which also influences the end result.

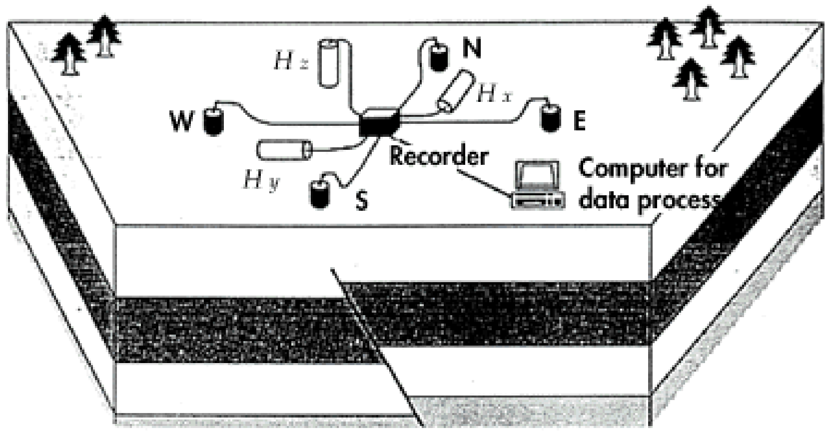

Figure 2 Top: basic schematic of MT survey layout (from seismo.geology.upatras.gr/MT.htm); Below: Actual image of equipment- long columns are magnetometers (smaller ones not used in Rico survey), orange case is recording system, short grey and yellow columns are electrodes

While eight areas were scouted as potential survey sites, only three sites were ultimately deemed suitable for the collection of MT data in Rico: the pavilion, the water tower, and the western hot spring (Figure 3). The other five locations were rejected mainly because of the noise level apparent in preliminary sampling. After a survey was set-up, a mini-survey was acquired to check that the readings had tolerable noise levels, and that good contact was made between the ground and the electrodes. If needed, deeper holes were dug for the electrodes, and sometimes a bentonite-water mixture was added to the hole to improve the contact conditions, then the mini-survey was rerun. While the recommended acquisition time for the target depth at Rico (500-1000m) is between 4 and 6 hours, the full pavilion survey acquired for 6 hours, the water tower survey acquired for 8 hours and the hot spring survey acquired for 8 hours to ensure quality depth measurements. The MT recording device registered frequencies between 0.0005 Hz and 1000 Hz, which invert to resistivities between 0.001 ohm-m and 10,000 ohm-m, an acceptable range for the expected resistivities in the subsurface of Rico.

After the data was collected, the raw data was analyzed as a time series plot to ensure it collected appropriate data throughout the survey, without egregious noise. The data was downloaded and taken back to Golden for processing. ProcMT was set to an auto-smooth setting in which data outside a coherency of 0.4 was rejected, and specific stand-alone peaks were removed. ProcMT provided the processed data as EDI files.

Then the three processed EDI files from each site were compiled on Zond 2D MT software and inverted together to produce a single 2D composite cross section, showing resistivity to a depth of 1.5 kilometers. The Marquardt inversion method was used, with 10 horizontal layers, and 20 vertical layers between sampling sites, in order to attain a fine mesh for processing. Medium depth smoothing and dampening values were used since the data had been processed and resistive boundaries were unknown. The inversion took 20 iterations to arrive at a result (for more about Marquardt inversion, see Appendix A.2).

Figure 3 MT survey sites for June 2018 Rico exploration overlaid on Google satellite image

Results

The image in Figure 4 is the composite cross section produced by the Zond 2D MT inversion. Warmer colors represent higher resistivities (lower water content) and cooler colors represent lower resistivities (higher water content). The depth represented in the inversion is 1.5 kilometers below the surface. The y-axis shows the level in kilometers above sea level. The x-axis marks the surveys and counts kilometers from the first survey point (the pavilion). The southern-most point is on the left and the northern-most point is on the right.

The top image is the original resistivity pseudo-section inferred by the square root of the period of signals received by the electrodes. The second image is the composite resistivity calculated by inversion equations, and the bottom image is the smoothed resistivity by depth image. The resistive Rico dome is the only information added to the MT data for the inversion image.

At the hot spring site (3-MT), a fault is visible, providing a less resistive conduit to a reservoir at depth. From 500 m deep to about 1000 m there is a less resistive zone that extends northward from the surveyed section. A similar pattern is observed south of the resistive feature under the pavilion. The resistivity of the subsurface appears to increase south of the pavilion site.

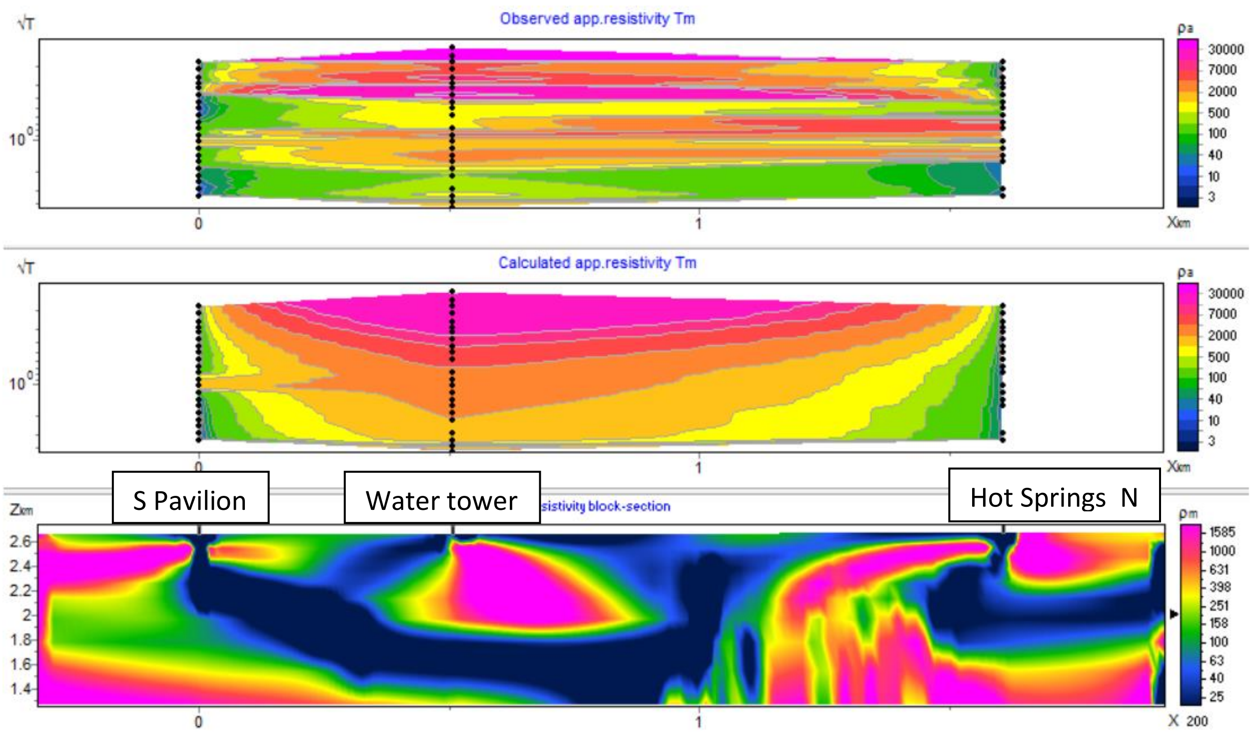

Figure 4 MT compilation and inversion of three survey sites from Zond 2D software, right is north, left is south, pink is high resistivity, blue is low resistivity, vertical axis is kilometers above sea level, horizontal axis is kilometers north of the pavilion

Several inversions were made at different smoothing factors, damping factors, and the Occam inversion method was also employed to test the sensitivity of this result. All variations show the appearance of a low resistivity zone between 500 and 1000 m directly below the hot spring survey site (see Appendix A.1).

Discussion

The depth and position of the less resistive zone north of the resistive Rico Dome correspond to the location of the Leadville Limestone, a formation which is typically bound at the top by a latite porphyry in the local geology (the orange stripe in Figure 5). The Leadville Limestone is offset by faulting all the way to the Blackhawk Fault (see light purple labeled "Ml" in cross section, Figure 5). Limestone dissolves when it comes in contact with acidic water, and thus serves as a accomodating reservoir. The high levels of calcium and bicarbonate in the hot spring water chemistry corroborate the limestone as a major storage formation. The Leadville Limestone also extends to the south where the MT shows another low resistivity zone, though less information is publicly available about the water resource potentially stored in the southern side of Rico (see well data Figure 1). The reservoir may also extend down to the Uncompahgre Quartzite (light brown "pCu" in Figure 5).

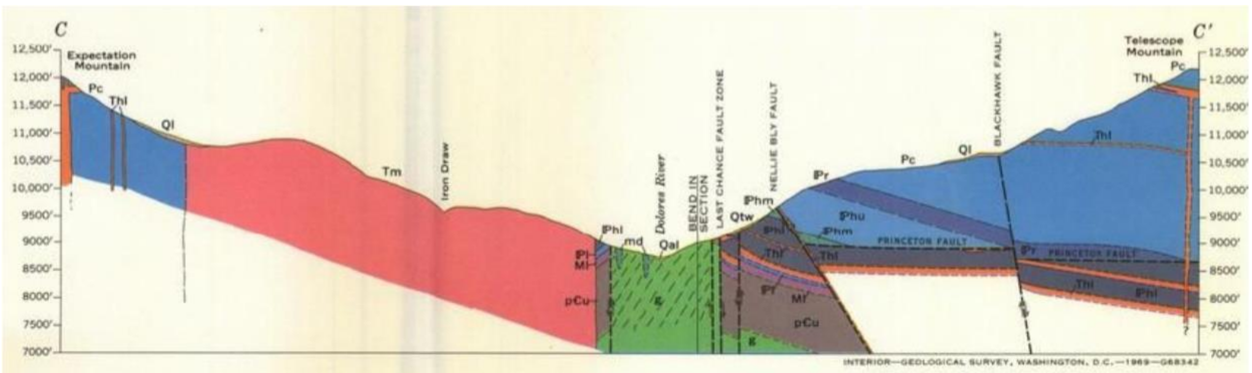

Figure 5 Geologic cross-section of Rico between Expectation Mountain and Telescope Mountain; left of the "bend in section," the cross section extends from Expectation Mountain to the east; right of the "bend in section," the section is oriented southwest to northeast (Telescope mountain is the northeastern-most feature) (Pratt et al., 1969)

Conclusion

The depth of a low resistivity zone detected by the MT survey corresponds to the location of the Leadville Limestone which is associated with a top confining layer: a low resistivity igneous sill. The permeable limestone, connected to the surface by a series of steep faults and capped by an impermeable rock, presents ideal conditions for a reservoir. If the Blackhawk and Last Chance faults are taken as the reservoir boundaries, and the Leadville Limestone is on average 30m thick, the water bearing reservoir is conservatively 75,000,000m^3. A 20% porosity limestone would yield 15,000,000m^3 of water. The lower depth of 800- 1000 m, using the average geothermal gradient measured at the wells, gives the north Rico water an estimated temperature of 81-101 degC, which agrees with reports from capped exploration wells of the area (Medlin, 1983).

The flowrate and temperatures potentially available at Rico are adequate for a greenhouse, spa, district heating (50-70 degC requirement), and even small scale power generation with the Organic Rankine cycle (70-100 degC requirement). A thorough economic analysis of these options is outside the scope of this report, though the corresponding non-technical report contains information on projects completed around the world, with similar resources.

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Appendix A

A.1 Inversion sensitivity study results

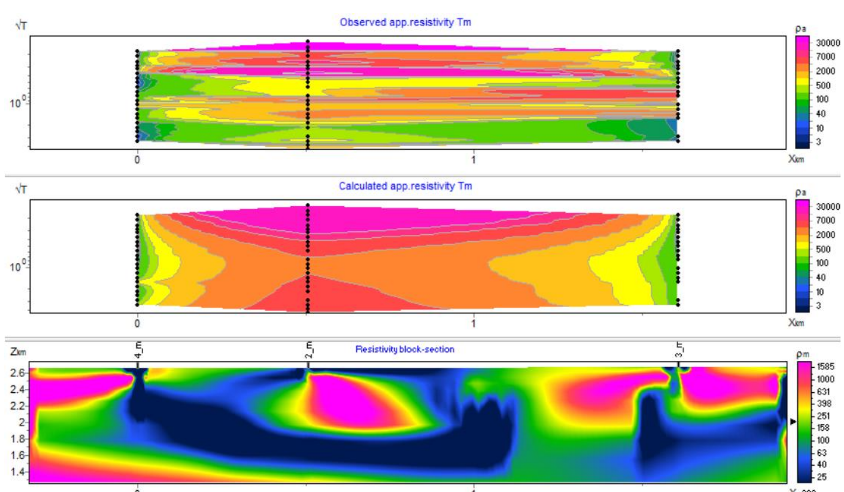

Figure A1 Processed data with dome feature added

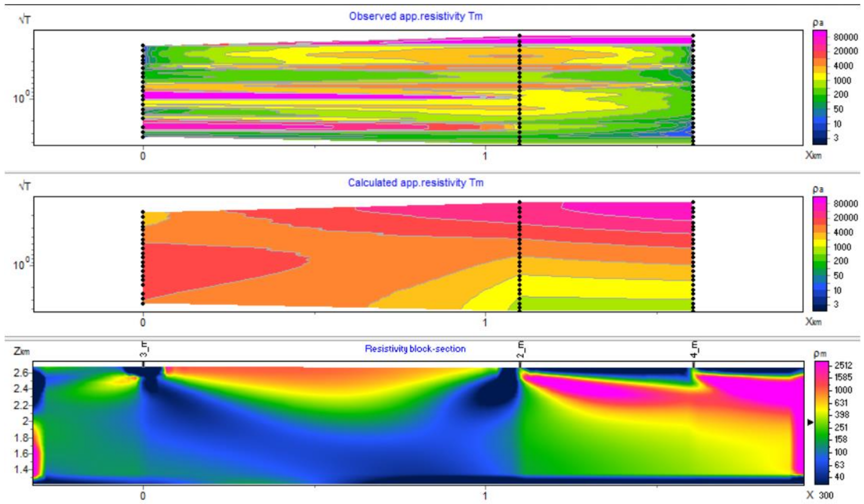

Figure A2 Unprocessed data with shadows from survey site, indicating more processing necessary

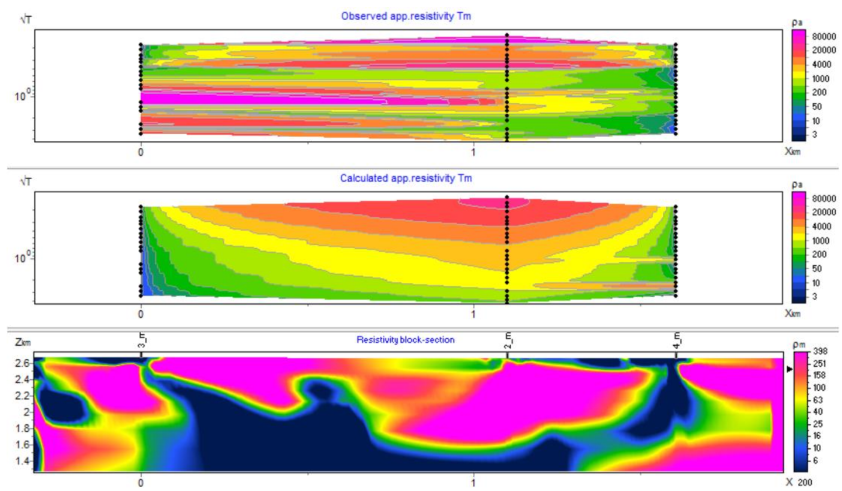

Figure A3 Processed data with no dome feature added, inverted with Occam method

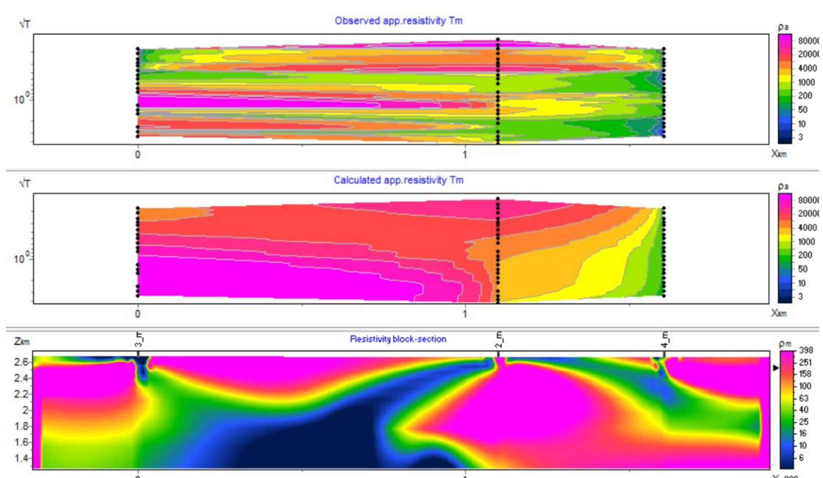

Figure A4 Semiprocessed data without Rico dome feature added, and Marquardt method used

A.2 Description of inversion methods

Occam Method

The Occam inversion method produces smooth models that fit the data of electromagnetic surveys. The smoothness depends of the number of rectangular elements manually added to the model mesh. Because smooth models are not always descriptive of the actual system, the Zond MT framework allows the user to add known sharp features. For more information on equations and methods, consult deGroot-Hedlin & Constable, 1990 (Occam's inversion to generate smooth, two-dimensional models from magnetotelluric data, http://marineemlab.ucsd.edu/resources/Pubs/OCCAM2D.pdf).

Marquardt Method

Algorithm that finds the least square fit for nonlinear solutions of data fitting for the model. Whereas Occam employs a smoothing constraint, the Marquardt uses a dampening factor to solve the non-unique data matrices. For more information, consult Widodo & Saputera, 2016 (Improving Levenberg-Marquardt Algorithm Inversion Result Using Singualr Value Decomposition, https://www.researchgate.net/publication/305800878_Improving_Levenberg-Marquardt_Algorithm_Inversion_Result_Using_Singular_Value_Decomposition).

A.3 ALS Radium test results

ALS -- Fort Collins **SAMPLE SUMMARY REPORT**

Client:	Colorado School of Mines	**Date:**	*16-Aug-16*
Project:	1 Rico Geothermal	**Work Order:**	1607368
Sample ID:	Rico HS 1W	**Lab ID:**	1607368-1
Legal Location:		**Matrix:**	WATER
Collection Date:	7/15/2016 14:00	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Radium-226 by Radon Emanation - Method 903.1		**PAI 783**		Prep Date: **8/9/2016**		PrepBy: **CDJ**
Ra-226	**11 (+/- 2.8)**		**0.2**	**pCi/l**	NA	8/16/2016 12:30
Carr: BARIUM	*95.5*		*40-110*	*%REC*	DL = NA	8/16/2016 12:30

A.4 Resistivity results from 2016

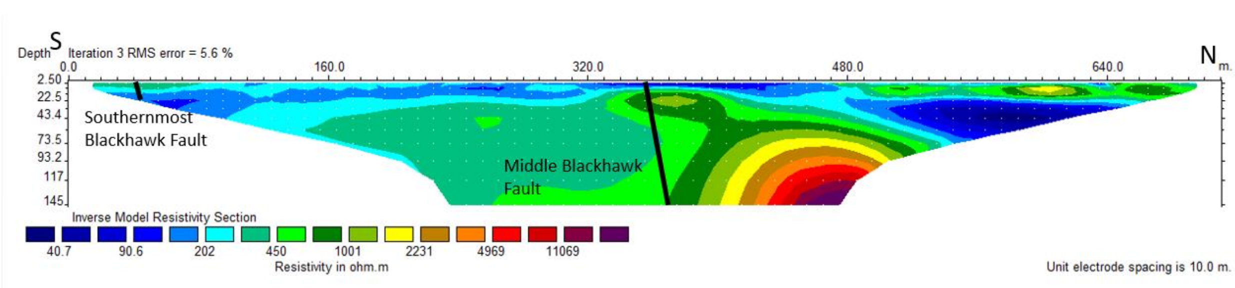

Figure A5 Resistivity results from Blackhawk Fault north of Rico along I-145

The suggested fault projections are presented as a result of in-field geologic observations as well as historic mapping in the region. To the north of the Middle Blackhawk Fault, the resistivity survey shows a highly resistive formation from about 43.3 m to the bottom of the survey's depth, represented by warmer colors on Figure A5. Between the two faults is large low resistivity region, represented by cool colors, which extends to the bottom of the survey.

Nontechnical Report Rico 2018

Prepared by Lucila Dunnington

In cooperation with Masami Nakagawa & Meghan Helper

June 26, 2018

Introduction

Rico has been identified by the Colorado Geological Survey for having a particularly promising geothermal resource, one of the few in Colorado. With the second highest heat flow in the state, and ample river resources feeding the reservoir, Rico is uniquely positioned to execute a successful geothermal project. Previous exploration trips have identified significant geologic faults in the region that potentially bound or feed the geothermal system below Rico: the Last Chance Fault just north of town diverts water down to the subsurface, and the Blackhawk fault near the National Forest information station provides a resistive boundary to the north.

A few crucial questions remained unanswered as of 2017; namely what is the depth of the reservoir, how much water does it contain, and what might the reservoir temperature be? These questions will never be fully known without a drilling program, but deep geophysical exploration can begin to answer these questions and better aim the exploration drill holes. Geophysics has been shown to improve the success rate of drilling by 30-40%. Since drilling can account for 30-60% of the entire cost of a geothermal project (about $150 per foot drilled, and increasing with depth), proper planning is critical.

Seismic and magnetotellurics (MT) are the two main deep geophysical methods used. MT has become dominant in the field of geothermal because it is inexpensive, portable in remote or rough terrain, and can distinguish well between water bearing rock and crystalline rock- which often serves as the heat source and cap rock in geothermal systems. MT operates by detecting natural electromagnetic signals of the Earth, making it a passive and very safe geophysical survey. However, because it relies on natural background signals, the survey is sensitive, and subject to common noise sources like traffic, powerlines, and even coiled metal wiring. It also requires a 100 m by 100 m flat expanse for setting out the cables, which is challenging in mountainous regions. Nevertheless, MT was selected as the deep geophysical exploration method for Rico.

Data Collection

The MT set-up centers on a recording system box at the survey site. At Rico, the recording system was connected to 4 electrode cables that extend in the north, south, east and west directions, and 2 magnetometer cables oriented parallel to the north-south and east-west cables. The electrodes at the ends of the cables were placed in deep enough holes in the ground to ensure adequate contact with the ground. Magnetometers also were placed in trenches that prevented them from moving in the wind.

While eight sites were scouted for potential MT surveys, only three could collect reliable and reasonably noise-free data. The three successful sites were near the pavilion, the water tower, and the western hot spring (Figure 1). While only a 4-6 hour collection time is required to explore the target depths at Rico (500-1000m), the collections times at the three sites were 6hr at the pavilion, 8hr at the water tower, and 6hr at the hot spring to acquire adequate data.

A short preliminary survey was taken before the full survey to check the ground contact and connectivity of the wires. If the survey pre-test failed, the cables were adjusted and/or the electrodes were dug deeper and sometimes coated with a bentonite-water mixture. Once the survey was collecting correctly, it was left alone to run for its programmed time.

Figure 1 Pink squares mark MT survey sites for 2018 Rico exploration

Results and Significance

Once the data was collected, it was processed to remove noisy and erroneous signals, then inverted so that frequency data was translated to resistivity at depth- the resistivity indicates the water content and type of rock present at depth. The data inversion can vary by user since different smoothing and dampening parameters are chosen based on the perceived quality of the data and prior knowledge of the subsurface (for instance from geological surveys). The data collected from Rico was tested with various inversion methods, dampening parameters and smoothing factors to ensure the consistency of the results.

The result given in Figure 2 included the added known Rico Dome, and results similar between all inversion trials. The cool dark colors are less resistive, water bearing zones, and the warm light colors are more resistive, water devoid zones, interpreted as crystalline rocks.

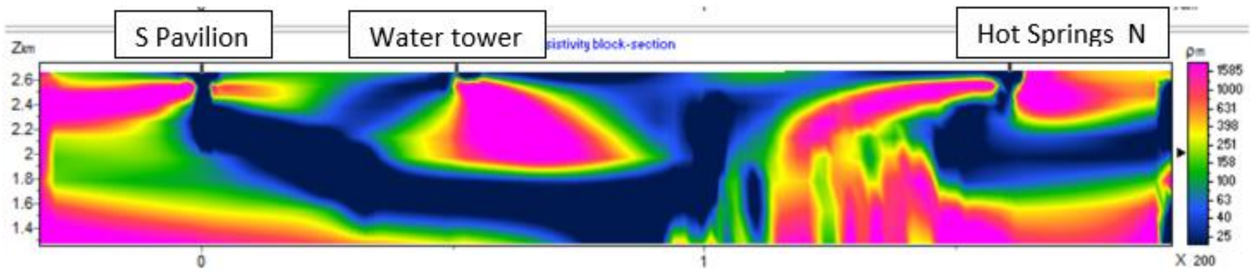

Figure 2 MT compilation and inversion of three survey sites, right is north, left is south, pink is high resistivity, blue is low resistivity, vertical axis is kilometers above sea level, horizontal axis is kilometers north of the pavilion

The result that persists through all trials of data inversion is the pond below the hot springs, from 500 to 1000m below the surface. This location is consistent with a permeable limestone layer known from the geologic record. If the Blackhawk and Last Chance faults are taken as the reservoir boundaries, and the water-bearing limestone layer is on average 30m thick, the geothermal reservoir is conservatively 75,000,000m^3. A 20% porosity limestone would yield 15,000,000m^3 of water. The lower part of the reservoir, 800- 1200 m deep, using the average geothermal gradient measured at the wells, should yield water of 81-121 degC, which agrees with reports from capped exploration wells of the area (Medlin, 1983).

Comparable systems in Colorado and World

While every geothermal system is hydrologically and geologically unique, as are the desires of the local people it might serve, established geothermal projects are presented in this section to illustrate the possibilities available from Rico's geothermal resource. With a million cubic meters of water, an observed artesian flowrate of 210 gallons per minute (gpm), and 100 degrees Celsius at less than a kilometer depth, Rico's resource is comparable to many in-use resources around the country and world.

Modoc County

In 2018, Modoc County became the sixth municipality in California to utilize geothermal energy for electricity production, and the first to use low temperature water. The breakthrough technology used, PwrCor™ is a modular scalable low-temperature power generator that can utilize water in the 80-100 degC range for energy production. It uses no fossil fuels or combustion, produces no emissions, and does not utilize flammable or harmful working fluids. Now in addition to having a rustic hot springs resort, it displays a new, sustainable way of producing electricity. Backed by a $2 million grant by the DOE, the plant's technology is "projected to produce 250 kW of electric power with 150 gallons per minute of water at 180 degrees F (82 degrees Celsius), enough power to service more than 150 homes" (Company release on Global Newswire). One module has a footprint of 5x10 feet according to a PwrCor spokesperson, and it utilizes a "closed loop" system, meaning the geothermal water is returned to the reservoir after heating the working fluid which transmits the heat energy to mechanical energy for electricity generation. The closed loop system does not deplete water in the reservoir, which is essential for water scarce regions. The community of Modoc County hopes to couple the electricity generation with cascading temperature usage schemes like a greenhouse or aquaculture to increase the value of their resource (Merrick, 2013).

Modoc County previously approved the use of 37 gpm well water at 87 degC to connect 34 buildings to a district heating project as well (MHA Environmental Consulting, Inc., 2003). The total project cost, which included retrofitting their old heating system, and constructing a laundry and food storage center, was $651,634. The school system that is connected to a geothermal district heating system is expected to save 70% on their annual $100,000 heating bill. The payback period for the project is an anticipated 7.5 years- high density towns, like Rico, can reduce the payback period for district heating to 4 years (EUDP, 2014).

Chena Hot Springs

The lowest temperature used for power generation from the Organic Rankine cycle to date is 73 degC in the Chena Hot Springs area in Alaska, which produces 400kW from two units (seen in Figure 3). Drawing 530 gallons per minute from their coastal reservoir, the technology called PureCycle-200 was designed with the aim to keep installation costs under $1300 per kW. The price of electricity generation per kilowatt-hour decreased from 30 cents to 5 cents for the rural Alaskan town (Chena Power, LLC.). The project cost a total of $2,007,770, funded in part by the Alaska Energy Authority, the AIDEA Power Project Loan Fund, and cash in kind contributions. The Chena Hot Springs power generation system won a Green Power Leadership Award from the EPA and DOE.

Figure 3 Two 225kW ORC Units at Chena Hot Springs, AK; Electricity from 73 degC warm water (from Holdmann, 2006)

The hot springs themselves have been used recreationally since 1905 by the miners in the area. Located 30 miles from the nearest power grid, Chena faces many problems shared by remote post-mining communities: arduous maintenance of power lines, sparse phone and internet reception, underdeveloped sewage treatment system, limited access to road maintenance equipment, and limited access to emergency services. The cost of these essential services is augmented by the town's relative inaccessibility, having only one paved road.

Even with these limitations Chena is thriving due to extensive and efficient usage of their geothermal resource. While their geothermal upflow zone is only 0.02mi^2 (compared to Rico's 0.5mi^2) in areal extent with a discharge temperature of only 74 degC, the town has managed to develop district heating of 44 buildings, two geothermal greenhouses (the only commercial scale, year-round greenhouse in northern Alaska), a hot springs resort, and they produce their own electricity (Erkan et al., 2007). The district heating alone saved the town $183,000 in one year, while the electricity generation is estimated to save them $550,000 annually (Chena Power Company, 2007).

Pagosa Springs

The Pagosa district heating system utilizes water at 63 degC with a capacity of 1000gpm, though in winter months the maximum flowrate is typically 450gpm. The town boasts their heating costs are 25% less than gas heating and 30% less than electrical heating (www.pagosasprings.co.gov). The heat is diverted for use in the local Riff Raff Brewery and Pagosa Bakery.

Figure 4 Education Geothermal Greenhouse at Pagosa Springs during balloon festival

Pagosa Springs has also successfully completed a geothermal greenhouse which has been used for adult learning workshops, hands-on elementary education, and producing flowers and produce for the community (Figure 4). The objective of the first dome is to educate the community on sustainable horticulture, and "local energy" (Peterson, 2017). The project has also helped revitalize a previously downtrodden area near Pagosa's downtown. The dome structure is 42 feet in diameter, with a pool for thermal storage, and solar powered fans (Geothermal Greenhouse Partnership, 2014). While the business model includes selling produce to local restaurants, the greenhouse project is intended to be a non-profit endeavor. Each dome, developed by Pagosa's Growing Spaces, costs about $100,000.

Olkaria, Kenya

Sitting atop another rift system, Kenya has thoroughly developed its geothermal resource in the last 15 years. Now with six operational geothermal power plants, the Olkaria geothermal field has the capacity to produce double the country's peak electricity demand. The benefits cited by supporters of geothermal energy usage in Kenya are its small footprint, stability in price and production, and its benefit to the local community as electricity, infrastructure, and job generation (Lagat, 2010).

An associated health spa and demonstration center have been developed to display and promote the potential of direct use (i.e. non-electricity generating) geothermal energy projects. The spa uses about 1,300 gpm diverted from the 30-35 degC water at the outlet of the geothermal power plant to supply three large recreational ponds (diameters of 30m, 40m, and 70m). The water is then supplied to a greenhouse for heating and cooling. Nutrients from the water, namely hydrogen sulfide and carbon dioxide, further enrich the soil to improve flower yield (Mangi, 2013).

Conclusion

Currently there are about 800 district heating systems, thousands of developed natural hot springs and 563 Organic Rankine Cycle power plants worldwide (orc-world-map.org). These can run on a variety of low temperature resources, utilizing water-conserving, closed loop systems. The USDOE and NREL have traditionally been available to partly finance the development of rural renewable projects, and as technology has become more tested and reliable, green investors have grown too. The cost and payback of a geothermal project depends on the desires of the community, and their interest in cascading usage. Many of the cascade projects in place began with a single direct use application such as a spa, then expanded to district heating, and then to electricity generation. Direct-use projects generally have minimal start-up time, quicker return on investment, and can employ conventional (or non-specialized) equipment (Boyd, 2009). The costs of drilling, excavation and construction are more quickly offset if the geothermal heat is optimally scavenged, by linking usages in series, as in a combined heat and power project. Geothermal projects generally require a proposal and business plan, an environmental assessment, a feasibility study, and the acquisition of land and water rights- the details of this process are outside the scope of this paper, and the requisites vary depending on the scale and type of project.

The potential of geothermal energy is largely untapped in the world. While applications like heating and electricity generation are established, other applications like desiccation, desalination, water treatment, and horticulture are still in the early stages of development, and still other usages are undiscovered. Energy sovereignty, a growing phenomenon at the local level, has been proven to revitalize the economies, tourism, and beauty of rural communities. Based on the geophysical surveys, accounts of well bores, and data from other geothermal projects, Rico has the capability to produce local energy with its geothermal resource.

Acknowledgements

This research is supported by Durfee Day and the Town of Rico through the Mining and Earth Systems Engineering Department at the Colorado School of Mines. Many members of the Rico community and Colorado School of Mines community have been instrumental in the execution and success of this research including Barbara Betts, Kari Distefano, Linda Yellowman, Matt Wisniewski, and Brian Passerella.

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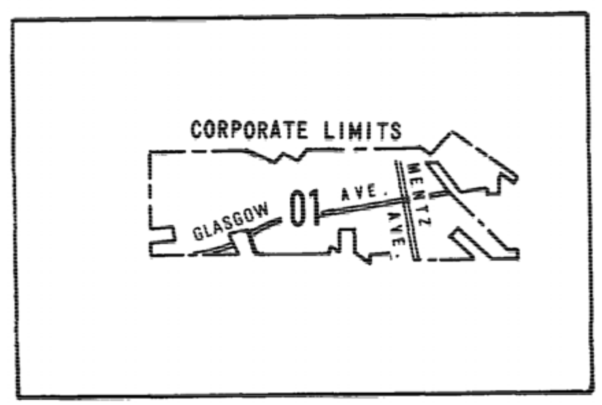
APPENDIX E – TOWN OF RICO FLOOD INSURANCE RATE MAP



KEY TO MAP

Zone Designations: ZONE C / ZONE A / ZONE C

Elevation Reference Mark — RM7x

Zone D Boundary

River Mile — •M1.5

EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood.
C	Areas of minimal flooding.
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.

NOTES TO USER

INITIAL IDENTIFICATION:
DECEMBER 20, 1974

FLOOD HAZARD BOUNDARY MAP REVISIONS:
NONE

FLOOD INSURANCE RATE MAP EFFECTIVE:
AUGUST 5, 1986

FLOOD INSURANCE RATE MAP REVISIONS:
NONE

To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program, at (800) 638-6620.

FEDERAL EMERGENCY MANAGEMENT AGENCY

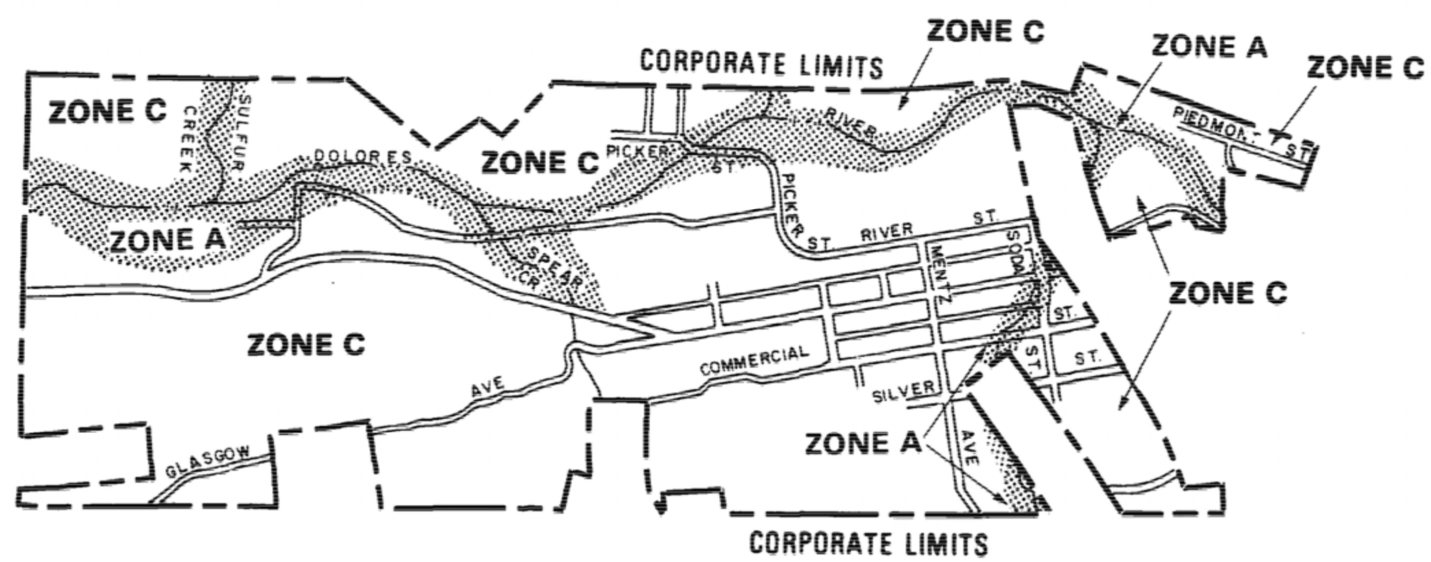
FLOOD INSURANCE RATE MAP

PANEL(S) 01

MAP INDEX

TOWN OF RICO, CO
(DOLORES CO.)

COMMUNITY NO. 080048 A



APPROXIMATE SCALE

500 0 1000 2000 3000 FEET

EFFECTIVE DATE:
AUGUST 5, 1986

FLOOD INSURANCE RATE MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY
TOWN OF RICO, CO
(DOLORES CO.)

01

APPENDIX F – CONVENTIONAL ACTIVATED SLUDGE QUOTE AND DETAILS

DESIGN BASIS 8/31/2023

Rico, Colorado

GIVEN:

FLOW	27,000	GPD
BOD	300	mg/l
PEAK Q	2.5	

REQ'D EFFLUENT	10	BOD
(SECONDARY)	15	TSS

ALL PARAMETERS BASED ON DESIGN PARAMETERS FOR COMPLETE MIX SECONDARY TREATMENT WITH NITRIFICATION REQUIRED

LBS BOD 67.6

AERATION VOLUME:

LOADING 15 LBS/1000 CU FT

VOLUME= LBD BOD / 15 4,504 CU FT

DIGESTER VOLUME:

VOLUME= LBS BOD X 15 1013 CU FT

CLARIFIER MINIMUMS BASED ON

1200.0	GPD@ PEAK
600.0	GPD@ ADF
1.5	HRS DETENTION @ PEAK
8.0	SWD

SURFACE @ PEAK= 56 SQ FT

SURFACE @ ADF= 45 SQ FT

CHECK VOLUME 450 CU FT OR 3,366 GALLONS

VOLUME REQUIRED 4,219 GALLONS CONTROL

SURFACE REQ'D= 71 SQ FT BASE ON VOLUME

CLARIFIER DIM

AREA ^0.5 9.47 FT **USE 12-0" MIN**

VOLUME= 564 CU FT 4,219 GALLONS

DETENTION @ADF 3.75 HOURS

CHLORINE TANK 20 MINUTE @ PEAK

VOLUME= 938 GALLONS 125 CU FT

AERATION AREA:

SWD= 10.5 WIDTH= 12 LENGTH= 35.7 **Use 12' section for anoxic zone.**

DIGESTER AREA:

SWD= 10.5	WIDTH	12	FT SQ	LENGTH	8.0	
CHLORINE						16
						23
LENGTH=	3	WIDTH=	12	SWD=	3.48 5'0"	3
						15

TOTAL LENGTH 43.8 USE 56' to include clarifier

57

BLOWERS REQUIRED:

AERATION AIR=3,200 X LBS BOD/1440=	150	CFM
DIGESTER AIR=30 X 1000 CU FT=	30	CFM
AIRLIFTS BASED ON 10 CFM EACH	40	CFM
TOTAL AIR REQUIRED=	**221**	**CFM**

Carolyn Pepin

From: Carolyn Pepin
Sent: Friday, September 15, 2023 10:06 AM
To: hhervol@gmail.com
Cc: 'Marshall Ray'
Subject: RE: Rico, Colorado -- Southwest Fluid Products - Budget Estimate

Thank you, Henry!

Carolyn Pepin, PE
Engineer Water & Wastewater Systems
Bohannan Huston
p. 505.823.1000 | **d.** 505.798.7887
bhinc.com

Great people supporting great communities. Want to be part of the team? Visit bhinc.com/careers

Upcoming Out of Office: Sept 7 & 8

From: hhervol@gmail.com <hhervol@gmail.com>
Sent: Friday, September 15, 2023 8:23 AM
To: Carolyn Pepin <cpepin@bhinc.com>
Cc: hhervol@gmail.com; 'Marshall Ray' <marshallwray@att.net>
Subject: Rico, Colorado -- Southwest Fluid Products - Budget Estimate
Importance: High

10% added for time to elapse between report publishing and actual procurement

Dear Carolyn,

Southwest Fluid Product's Budget Estimate is $ 975,860.00 (Exclusive of any taxes) for the two (2) each 26,000 gpd WWTP's delivered at the site.

Please let us know if you have any questions.

Best and kindest regards.
Sincerely,

Henry J. Hervol PE
President
Advanced Process Technologies
1188 Red Bud Lane
Round Rock, Texas 78664
Phone: 512-426-8483
FAX: 512-218-8891

Email: hhervol@gmail.com
OR: hhervol@advancedprocesstech.com

APPENDIX G – MBR QUOTE AND DETAILS

For Earth, For Life
Kubota

Budgetary Proposal for the

Rico, CO WWTP Project

MBR Package Treatment System

September 5, 2023

Prepared By:

KUBOTA Membrane USA
11807 North Creek Parkway S., Suite B-109
Bothell, WA 98011
425-898-2858

Local Representation By:

Kyle Winneker
Goble Sampson Associates
303.770.6418
kwinneker@goblesampson.com

For Earth, For Life
Kubota

Carolyn Pepin, PE
Bohannan Huston

We are pleased to present the attached material for your consideration regarding the proposed Kubota membrane bioreactor (MBR) package treatment system. Our approach to meet this goal includes utilizing the Kubota KSP6 MBR package plant.

Based on the influent loading and flow design parameters, we recommend using the KSP6, which is Kubota's largest package treatment system with a hydraulic daily design flow of 125,000 gpd. The Kubota KSP line of package treatment plants are designed around the core concept of simplicity: simple design, simple operation, and simple maintenance.

I'd like to highlight a few of the key benefits of the package treatment system.

- The design of the system is already complete which helps to minimize your client's design costs and expedite the project timeline.
- The system is largely assembled prior to delivery. After limited assembly and testing, the system is ready for seeding.
- The system uses the same Submerged Membrane Units (SMUs) that Kubota has used worldwide for over 30 years. We believe these package units offer a cost-effective solution allowing smaller installations to reliably produce high-quality effluent.

With the Kubota name comes a long history of excellence in MBR wastewater treatment. We are happy to put you in touch with operators and engineers who can share their experience with our product across the country. If you have any questions regarding the attached information, please feel free to contact us or our local representative, Kyle Winneker of Goble Sampson Associates at 303.770.6418 or kwinneker@goblesampson.com.

Regards,

Brian Codianne
Regional Manager | KUBOTA Membrane USA Corporation
Cell: 425-898-3888
Email: brian.codianne@kubota.com

1 Contents

Tables

Figures

1 Introduction

Kubota Membrane USA (KMU) would like to thank you for the opportunity to present the enclosed budgetary proposal to supply a membrane bioreactor (MBR) package treatment system for your project. Included below is an overview of the proposed treatment system along with a scope of supply and budgetary price.

2 Design Overview

The KSP6 package treatment plant was selected for this project based on the following influent flow data *(Tables 1 and 2)*.

2.1 Influent Design Flow

The following flow conditions were used for the preliminary design.

Table 1: Design Flow Conditions

Condition	Design Flow	Unit
Average Daily Flow	53,600	GPD
Peak Daily Flow	153,000	GPD

.

The wastewater characteristics used for the design are listed in the table below. Anticipated effluent concentrations are based on preliminary design calculations performed by KMU and on the performance of similar systems.

Table 2: Influent and Effluent Characteristics

Constituent	Influent Loading	Anticipated Effluent Concentration
BOD	300 mg/L	< 25 mg/L
TSS	292 mg/L	< 30 mg/L
TKN	52 mg/L	TN < 7 mg/L
TP	8 mg/L	0.7 mg/L

2.2 MBR Specifications

The KSP6 package treatment is based around the Kubota RM200 Submerged Membrane Unit (SMU). The RM series membrane was developed in 2008, and it improves upon previous Submerged Membrane Unit models while maintaining the reliable, simple operation that is characteristic of Kubota's membrane products. Kubota's philosophy of learning from our extensive experience in MBR systems worldwide is one of our greatest advantages, setting us apart from more newly developed membrane manufacturers.

A basic overview of the RM series of Submerged Membrane Unit and the Kubota 515-type membrane cartridge is included in the figure below.

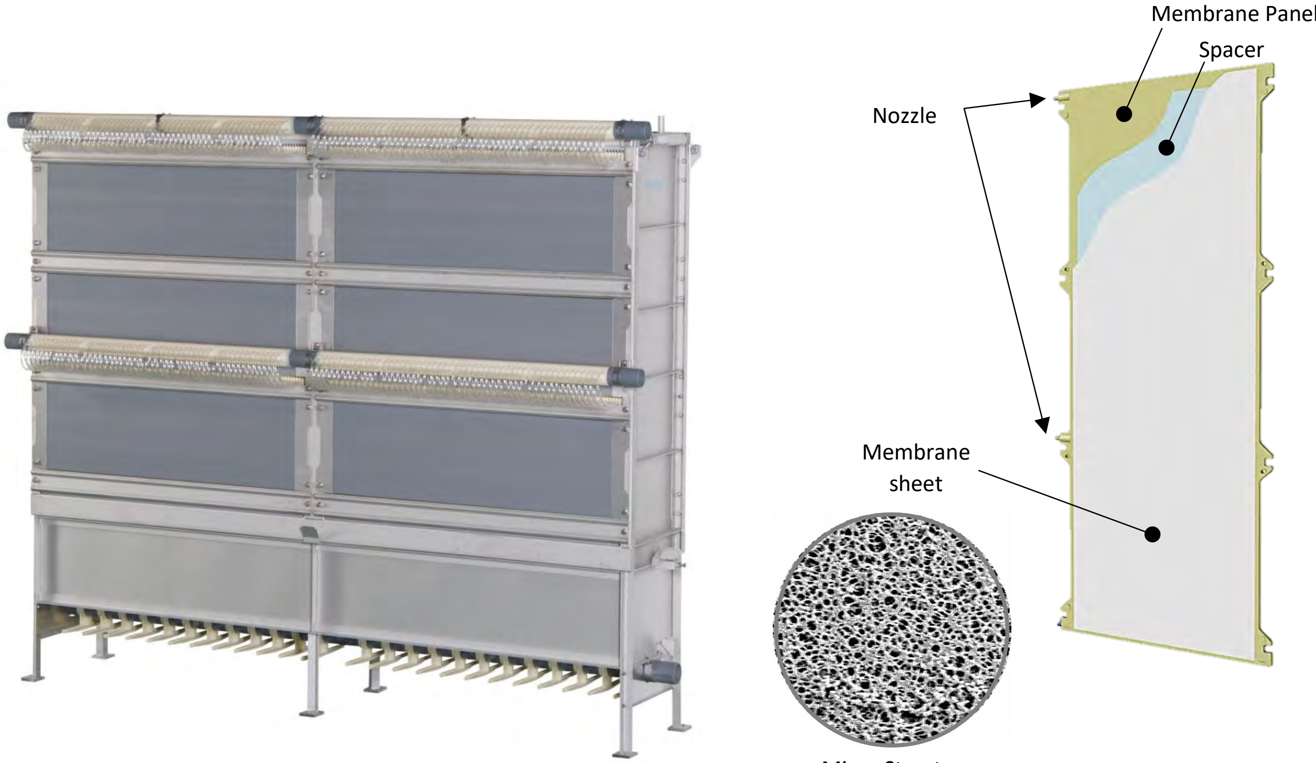


Figure 1: Kubota RM Series SMU (left) and Membrane Cartridge Structure (right)

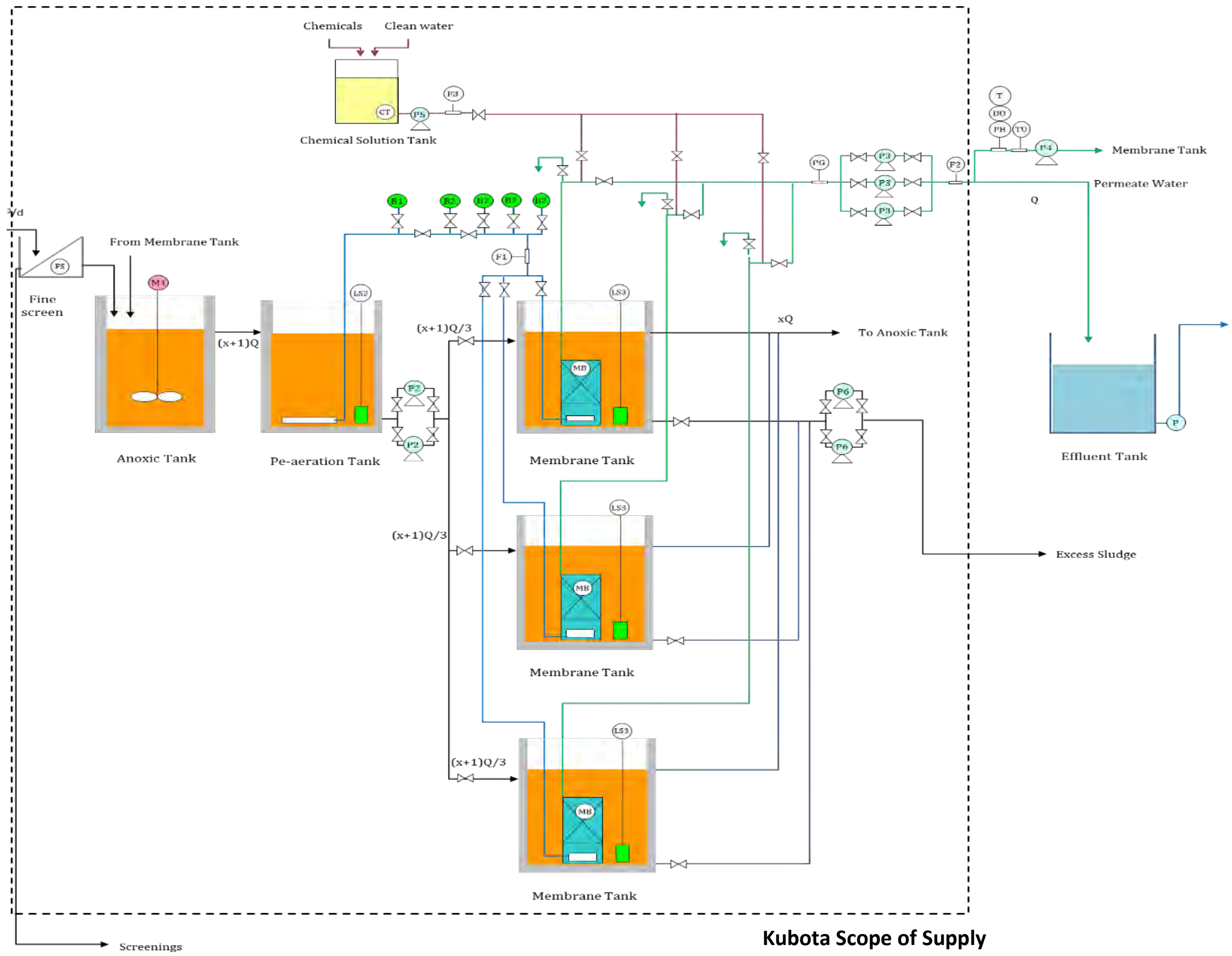
Details of the proposed membrane units are presented below.

Table 3: Membrane Equipment Specifications

Component	Specifications
Membrane Model	RM200
Membrane Type	Flat Plate
Membrane Surface Area per Unit	3,122 ft^2
Allowable MLSS at MBR	5,000 to 18,000 mg/L
Number of Treatment Trains	1 Train
Number of Membrane Tanks	3 Tanks
Total Number of Submerged Membrane Units	3 units (1 units per tank)
Assumed Minimum Wastewater Temperature	8°C

2.3 Process Flow

The process flow is shown in the figure below.



Symbol		Symbol	
FS	Fine Screen	P5	Chemical pump
M1	Mixer	P6	Sludge pump
MB	Membrane Unit	F1	Membrane flow meter
CT	Chemical Tank	F2	Permeate flow meter
B1	Pre-aeration blower	F3	Chemical flow meter
B2	Membrane blower	PG	Permeate pressure gauge
P2	Recirculation pump	LS1	Level sensor
P3	Permeate pump	LS2	Level sensor

Figure 2: Process Flow Diagram

2.4 KSP6 Layout

The KSP6 package treatment system is configured as a single biological treatment train. The system includes an anoxic tank, a pre-aeration tank, and three individual MBR tanks working in parallel. The tank layout is shown in plan view below.

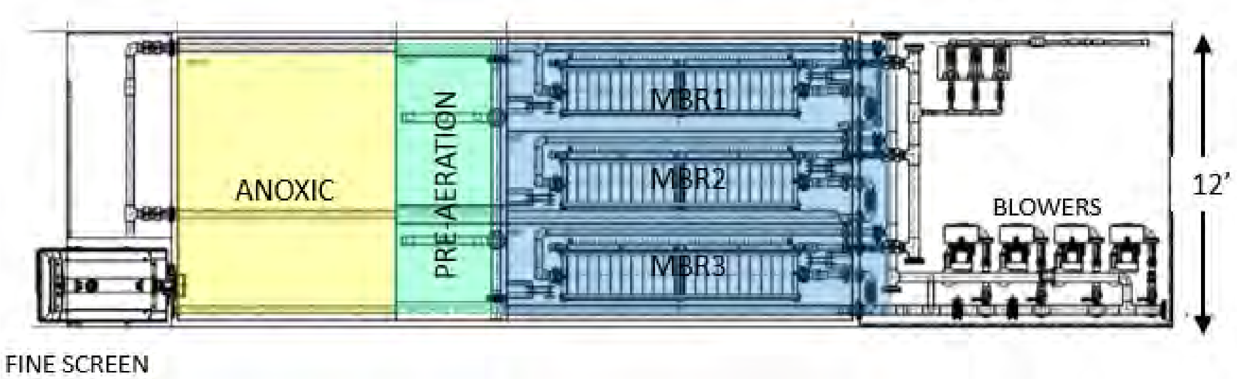


Figure 3: KSP6 Tank Layout (Plan View)

The entire KSP6 ships to the site mounted on a single skid which measures 45 feet long, 12 feet wide, and 12 feet high. All major equipment including blowers, pumps, and the control panel are mounted on the skid, and equipment stages are used to maximize the use of space. Some equipment, including the fine screen, is mounted in the field as it extends above the height of the skid. A profile view of the KSP6 is shown below.

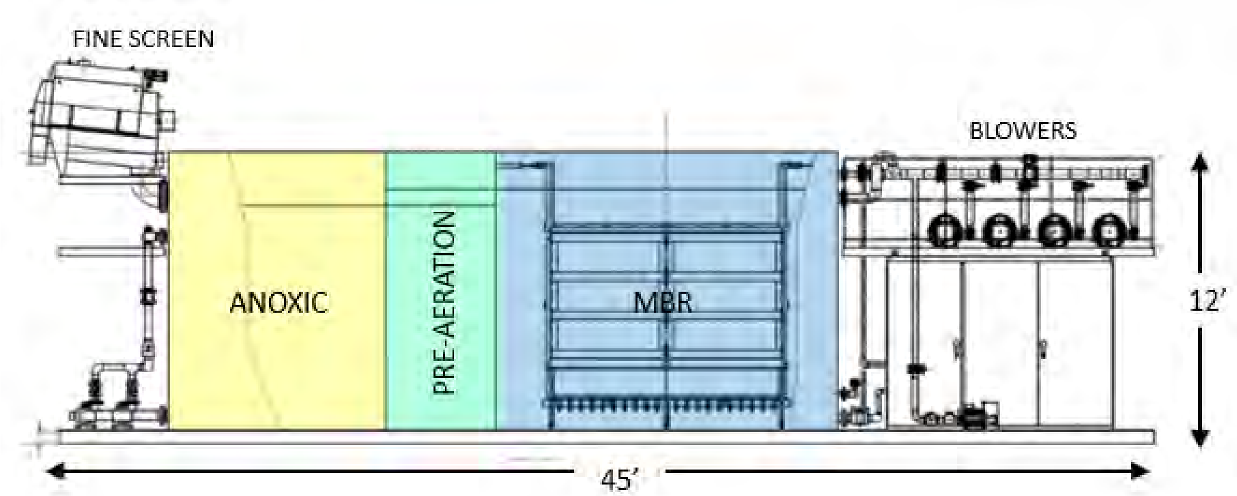


Figure 4: KSP6 Layout (Profile View)

Influent enters the treatment system through the fine screen which discharges into the anoxic tank. Flow travels from the anoxic tank to the pre-aeration tank by gravity. The recirculation pump (mounted below the fine screen) transfers flow forward to the MBR tanks. Permeate is withdrawn through the SMUs. Overflow outlets in the MBR tanks provide for a fixed depth in the MBR tanks, and return the remaining flow to the anoxic tank. The sludge pumps periodically remove activated sludge from the MBR tanks to maintain the desired MLSS concentration. This flow schematic is shown in the figure below.

3 Scope of Supply KSP6

KMU's scope of supply is limited to the equipment and services outlined in this proposal. The equipment will be supplied by Kubota Membrane USA and are included in the proposal price are listed in Section 8.

3.1 Major Equipment and Instrumentation

Table 4: Major Equipment and Instrumentation in KMU's Scope of Supply

Line	Name	Type	Size Capacity	Manufacturer	Model	HP	Power	Phase	VFD Motor Starter	Quantity
1	Pre-Fabricated Tanks and Skid	KUBOTA SMU Package	45'x12'x12'	KUBOTA	KSP6	-	-	-	-	1
Fine Screen Equipment										
2	Fine Screen	Internally Fed Drum	132 gpm	CleanTek	RS-22	0.75	460	3	Motor Starter	1 + spare parts
3	Screening Chute	Stainless	--	CleanTek	-	-	-	-	-	1
Anoxic Tank (AX) Equipment										
4	Mixer	Submersible	7,000 gal	Flygt	SR4610	1.2	460	3	Motor Starter	1
5	Mixer Hoist	Stainless	-	-	-	-	-	-	-	1
6	Level Transmitter	Hydrostatic	3-inch	EH	Cerabar M, PMP55	-	Loop	-	-	1
Pre-Aeration Tank Equipment										
7	Diffuser	Fine Bubble	-	Aquarius	Membrane Disc	-	-	-	-	1 set
8	Aeration Blower	Regenerative Blower	38 scfm 5.6 psig	Fuji	2VFB60-8.4-7W	8.45	460	3	VFD	1
9	Pre-Aeration Air Flow Meter	Thermal	2-inch	EH	T-Mass 65I	-	Loop	-	-	1
Recirculation Control Equipment										
10	Recirculation Pumps	Standard Centrifugal	230 gpm	Pioneer	SC425C75-CC.75	0.8	460	3	VFD	2

Line	Name	Type	Size Capacity	Manufacturer	Model	HP	Power	Phase	VFD Motor Starter	Quantity
11	Recirculation Flow Meter	Electromagnetic	3-inch	EH	MAG5100W	-	Loop	-	-	1
Membrane Bioreactor Tank (MBR) Equipment										
12	Kubota Submerged Membrane Unit	Flat Plate	-	KUBOTA	RM200	-	-	-	-	3
13	Guide and Stabilizer	Submerged Membrane Unit Guide and Stabilizer	-	KUBOTA	-	-	-	-	-	3 sets
14	Membrane Lifting Tool	Stainless	-	KUBOTA	-	-	-	-	-	1
15	Diffuser Cleaning Valve	Plug (manual)	3-inch	Various	Various	-	-	-	-	3
16	Level Transmitter	Hydrostatic	3-inch	EH	Cerabar M, PMP55	-	Loop	-	-	1
17	Waste Activated Sludge Pump	Self-Priming Centrifugal	16 gpm	AMT	12SP10C-3P	1	460	3	Motor Starter	2 (1 duty, 1 standby)
Permeate Control Equipment										
18	Permeate Pumps	Self-Priming Centrifugal	150 gpm	AMT	282M	3	460	3	VFD	3 (2 duty + 1 installed spare)
19	Permeate Flow Meter	Electromagnetic	2.5-inch	EH	MAG5100W	-	Loop	-	-	1
20	Permeate Pressure Gauge	Diaphragm	-	EH	Cerabar T, PMC 131	-	Loop	-	-	1
Blower Control Equipment										
21	Membrane Blowers	Regenerative Blower	76 scfm 5.2 psig	Fuji	2VFB60-8.4 -7W	8.45	460	3	VFD	4 (2 duty + 1 standby)
22	Membrane Air Flow Meter	Thermal	2-inch	EH	T-Mass 65I	-	Loop	-	-	1
Other										
23	Control System	PLC Panel, HMI, and SCADA	-	KUBOTA		-	-	-	-	1

Line	Name	Type	Size Capacity	Manufacturer	Model	HP	Power	Phase	VFD Motor Starter	Quantity
24	Clean in Place (CIP) System	Holding tank, pump, and instrumentation	-	Various		-	-	-	-	1

3.2 Direct Services Information

The following services are included in Kubota's scope of supply:

Design and Installation Support

- Design support including submittal drawings and P&IDs.
- Delivery coordination with the site contractor.
- 10 days of on-site support during system installation including final equipment placement, and dry/wet mechanical checks.

Commissioning and Operating Support

- Preparation and submittal of a system O&M manual for Kubota supplied systems and equipment.
- 10 days of on-site support during system start-up and commissioning including clean water testing and support during seeding.
- Additional days are available as needed at an additional cost.

Training

- 3 days of on-site, hands on operator training using a mix of classroom and field time. See Table 5 below for list of training topics.

Table 5: Training and Workshops included in KMU's Scope of Supply

Training/workshop	Brief summary
SCADA and HMI	1. Navigation of all HMI screens and menus. 2. Review of automatic operations and controls. 3. Changing process set points. 4. Overriding controls from the HMI. 5. Manual operation of the system in the event of a power failure.
CIP training	1. Navigation of CIP (Clean-In-Place), in-situ chemical cleaning (maintenance cleaning). 2. Control from HMI and operation of manual valve. 3. Adjust set points of chemical flow.
Troubleshooting	1. Case study of troubleshooting 2. Recovery from trouble 3. "Fish bone" approach
Daily testing	1. Filterability test 2. Viscosity measurement

Workshop/Additional Training Available (No Charge)

- In addition to our standard training at commissioning, Kubota Membrane USA will host an annual regional operator workshop in which operators meet to exchange ideas and learn about the latest developments in MBR technology.
- Customized individual training, such as membrane disassembling training, is also available upon request.

Remote Monitoring Available (No Charge for First Year)

- *Support by Remote Monitoring*

  The Kubota membrane system as proposed includes a SCADA system that can be remotely monitored and controlled, provided wireless connectivity is available. Technical support staff can monitor the status of your system to proactively address potential problems. Whenever a call is placed to our service staff, that person will be able to log in to the SCADA system and easily see what is happening at the plant.

3.3 Exclusions to KMU's Scope of Supply

The following items are not currently included in the KMU scope of supply:

- Site preparation including preparation of a suitable foundation for the package treatment system.
- Equipment unloading and installation at the site.
- Electrical site work and piping outside of the skid (i.e., connecting to main power, backup power, influent and effluent connections, etc), and piping/electrical work to interconnect multiple skids.
- Installation, piping, and wiring of items shipped loose including the fine screen.
- Coarse screening, grit removal, oil and grease removal (if needed).
- Building construction.
- Treated water holding tank.
- Sludge holding tank and sludge treatment (dewatering, etc).
- Effluent disinfection system (A separate power supply and control panel will be required).
- Alum/ferric chloride, carbon addition, and alkalinity addition systems (if needed).
- Heat tracing (A separate power supply will also be required).
- Covers on the package plant tanks or overhead walkways and stairs (available at an additional cost)
- Odor control.
- Seismic bracing for equipment, if needed.
- Any civil engineering (including seismic), permits, or inspection required.
- HVAC systems, fire protection, or other building systems.
- Cranes or overhead lifting equipment for the MBR basin.
- Any systems for operation in a classified area. All supplied systems will be "unclassified" in accordance NFPA Standard 820.

4 Warranty

Kubota's standard 2-year membrane warranty, and 1-year mechanical equipment warranty is included in the main budgetary price proposed (Table 6) and goes into effect at the commencement date of commissioning. The warranty included is a guarantee that the products supplied by Kubota are free from defect in material or workmanship.

5 Budgetary Price

The estimated budgetary price for the equipment and instrumentation described herein is shown below in Table 6. The pricing herein is for budgetary purposes only and does not constitute an offer of sale. Freight, taxes and duties are not included.

10% added for time to elapse between report publishing and actual procurement

Table 6: Budgetary Price for Proposed Kubota MBR Equipment

Budgetary Price – MBR Equipment, Instrumentation, and Services	
Budgetary Price – KSP6 Package Treatment Plant (Scope per Table 4)	$ 1,850,000

6 24/7 Technical Support

24/7 phone support is available in addition to support during regular business hours. 24-hour technical support calls are shared within the Kubota staff so that you can rest assured knowing that knowledgeable engineers and technicians are just a phone call away.

7 Additional Services (Optional)

The following service plans are optional and may be added to Kubota's scope of supply if desired for an additional cost.

Kubota Membrane Protection Plan

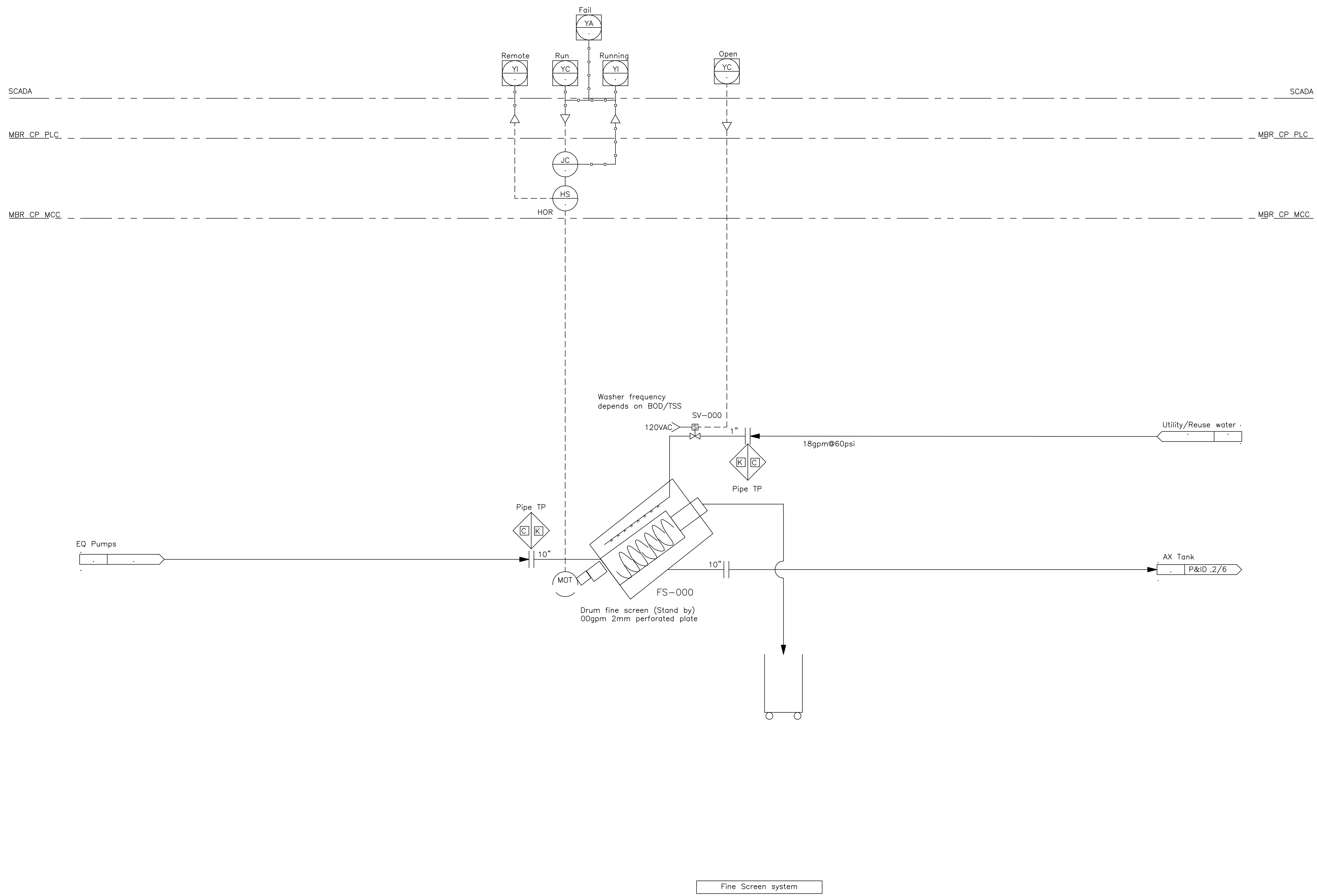
Under this plan, Kubota Membrane USA warrants against any membrane failure for 10 years when the system is operated in accordance with the O&M manual. This plan includes annual onsite membrane inspection with a membrane examination and inspection report, periodic replacement of parts and damaged membranes (if any), and phone support during the 10-year period. With this plan, Kubota will replace each cartridge at least once during the 10-year span, regardless of necessity.

Kubota Custom Membrane Support Plan

Kubota can customize your support/service package to meet your needs. The following table shows a variety of our available services:

Table 7: Kubota's Available Services

Service	Note
Periodical technical support	Monthly, Quarterly, Annually
24/7 phone support	
SCADA monitoring	Weekly, Monthly, Quarterly
Periodical site visit	Quarterly, Semi-annually, Annually
Membrane inspection	Annual, Semi-annual, 3x per year
Membrane protection (10-year contract)	Select annual or semi-annual inspections
Program (SCADA, etc.) update	Based on hydraulic changes, such as increases in flow or changes in operation.



C Supplied by Contractor

K Supplied by KUBOTA

General Notes

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Kubota

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No.	Revision/Issue	Date
2	Draft update	5.9 2017
1	Draft by SP175146	4.21 2017

Drawing Name

P&ID

Fine Screen System
(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

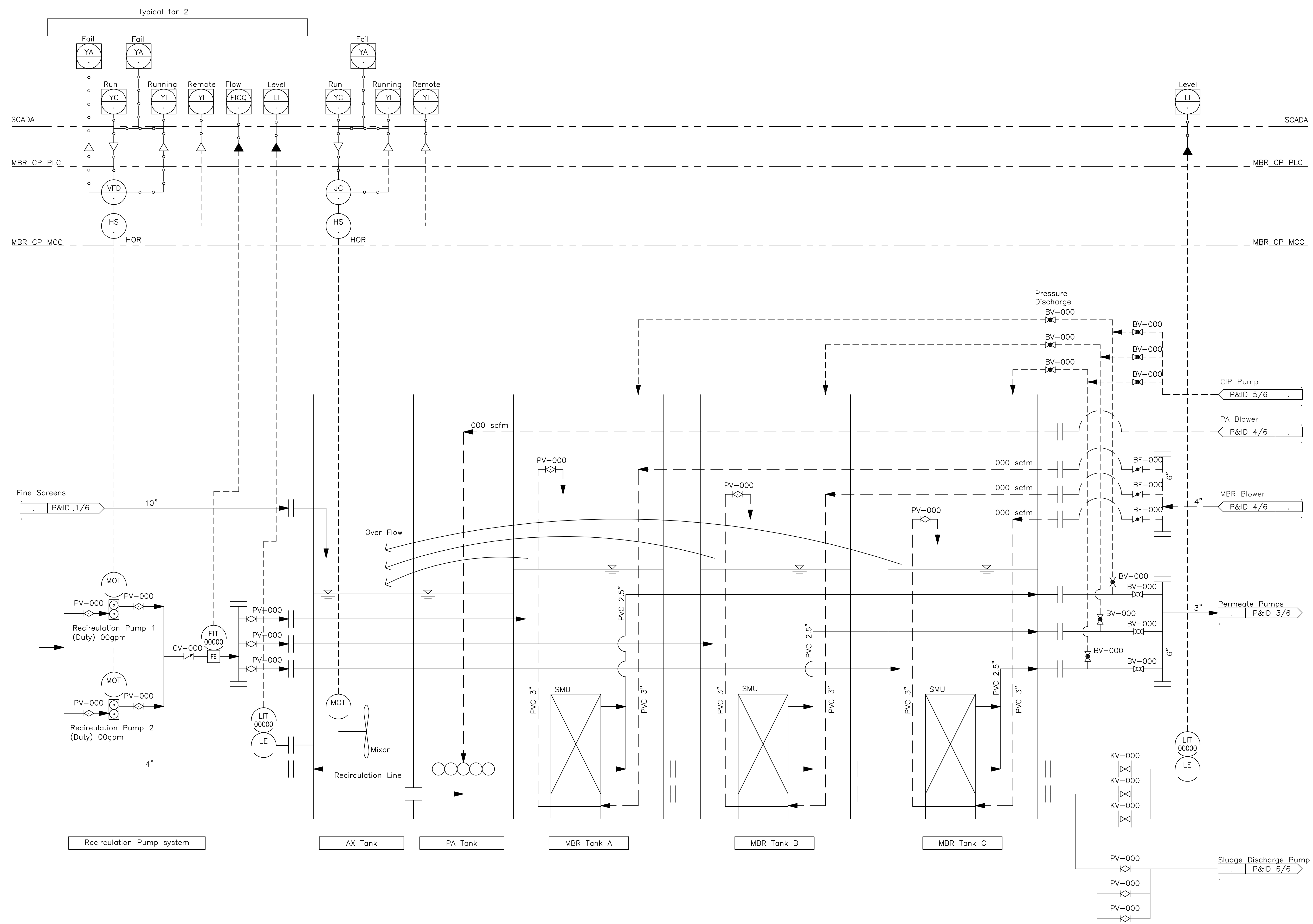
Stamp

Drawing Number

P&ID 1/6

Author

Kimihiro Ishikawa



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Drawing Name

P&ID
Re-circulation System
and
Process Tanks
(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

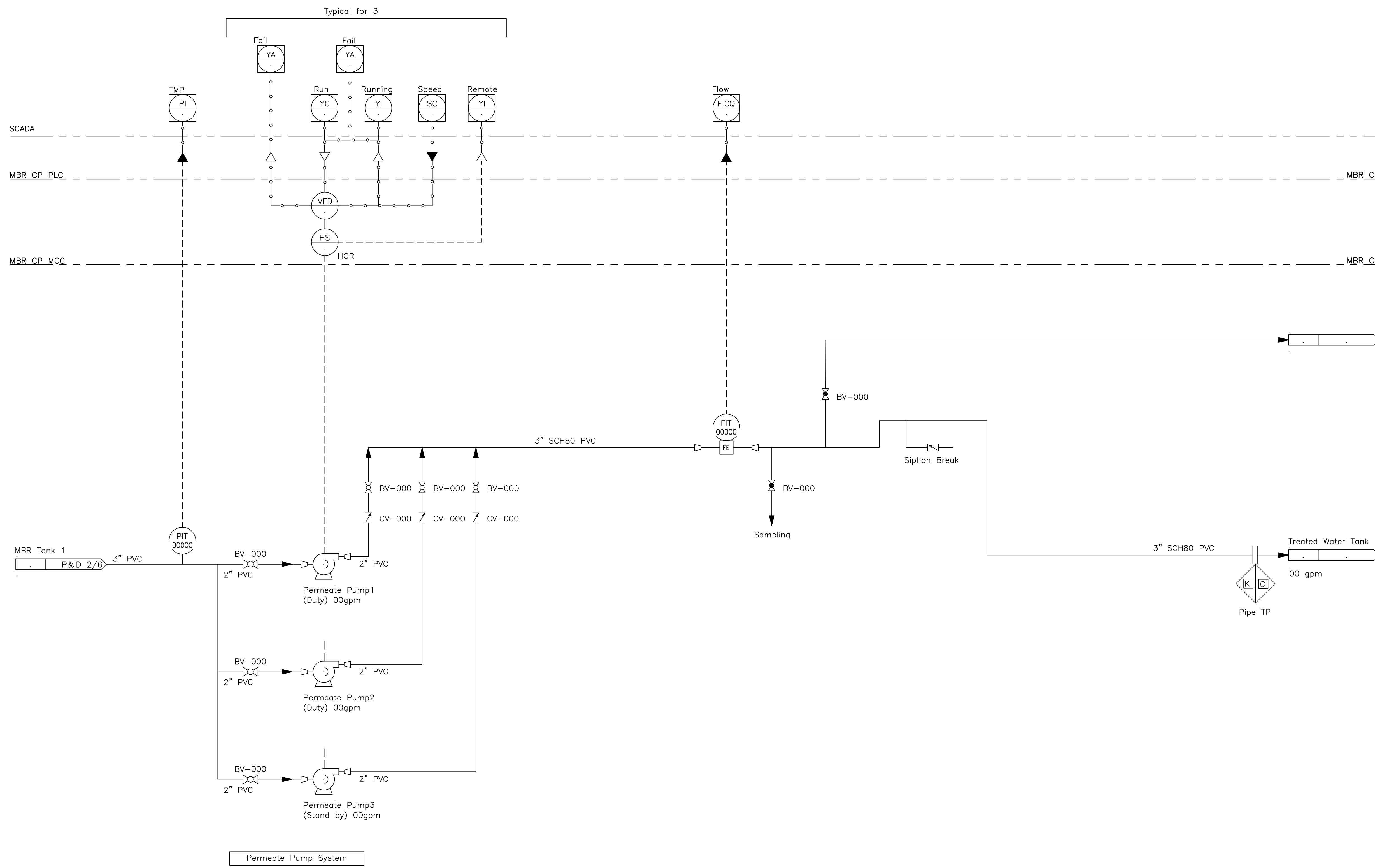
Stamp

Drawing Number

P&ID 2/6

Author

Kimihiro Ishikawa



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Drawing Name

P&ID

Permeate System
(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

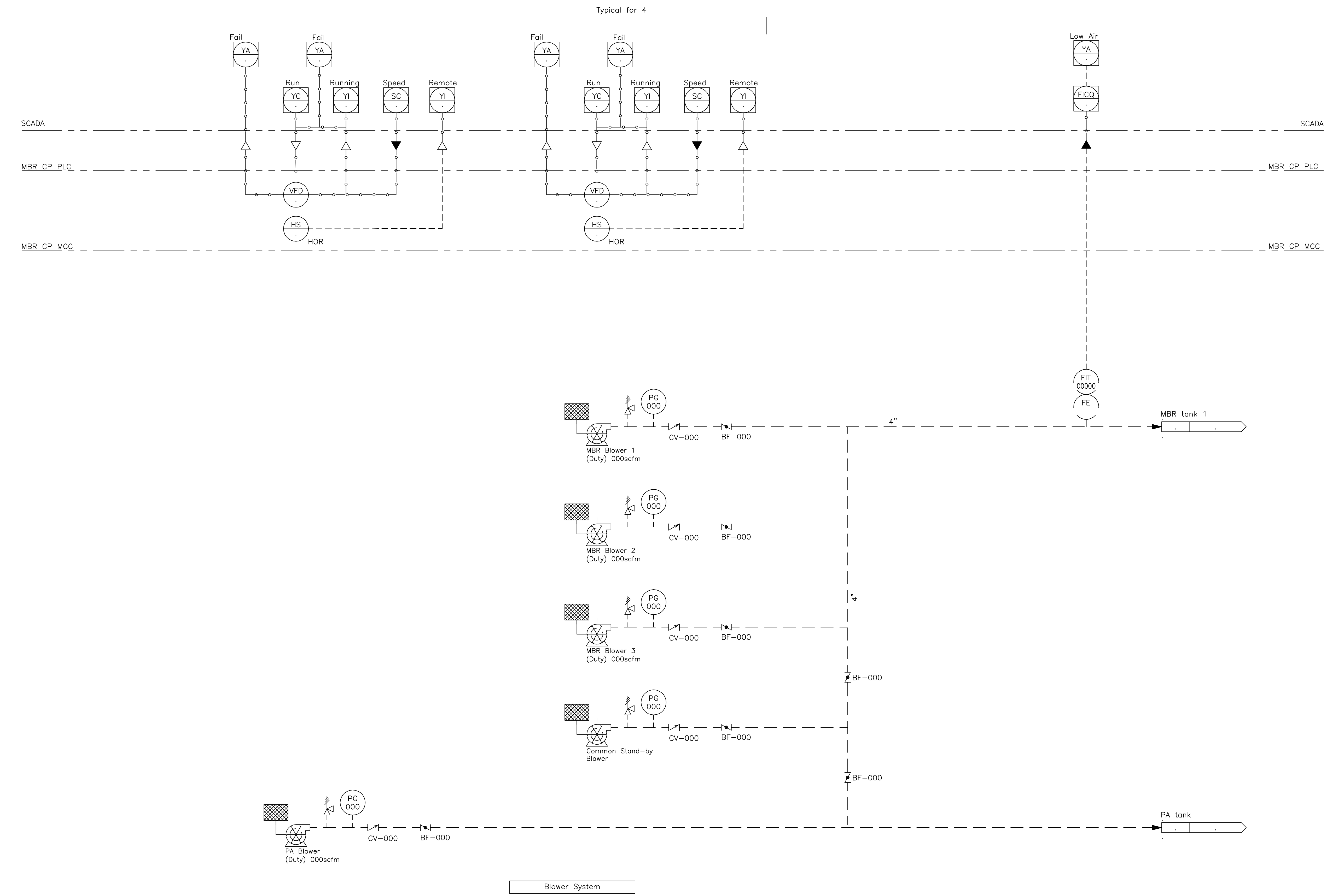
Stamp

Drawing Number

P&ID 3/6

Author

Kimihiro Ishikawa



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K Supplied by KUBOTA

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2	Draft update	5.9 2017
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Drawing Name

P&ID

Blower System
(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

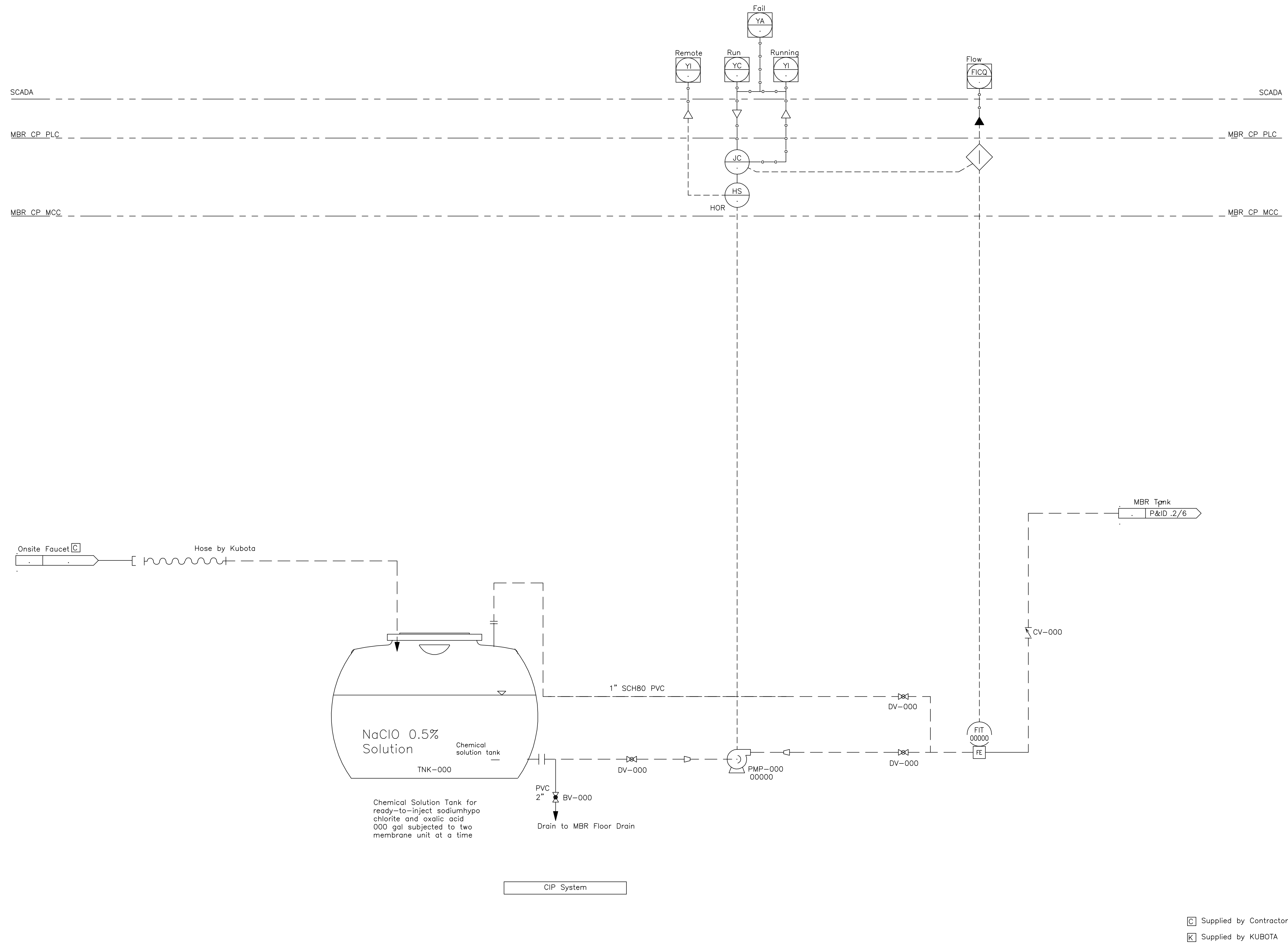
Stamp

Drawing Number

P&ID 4/6

Author

Kimihiro Ishikawa



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Drawing Name

P&ID

Permeate Line
(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

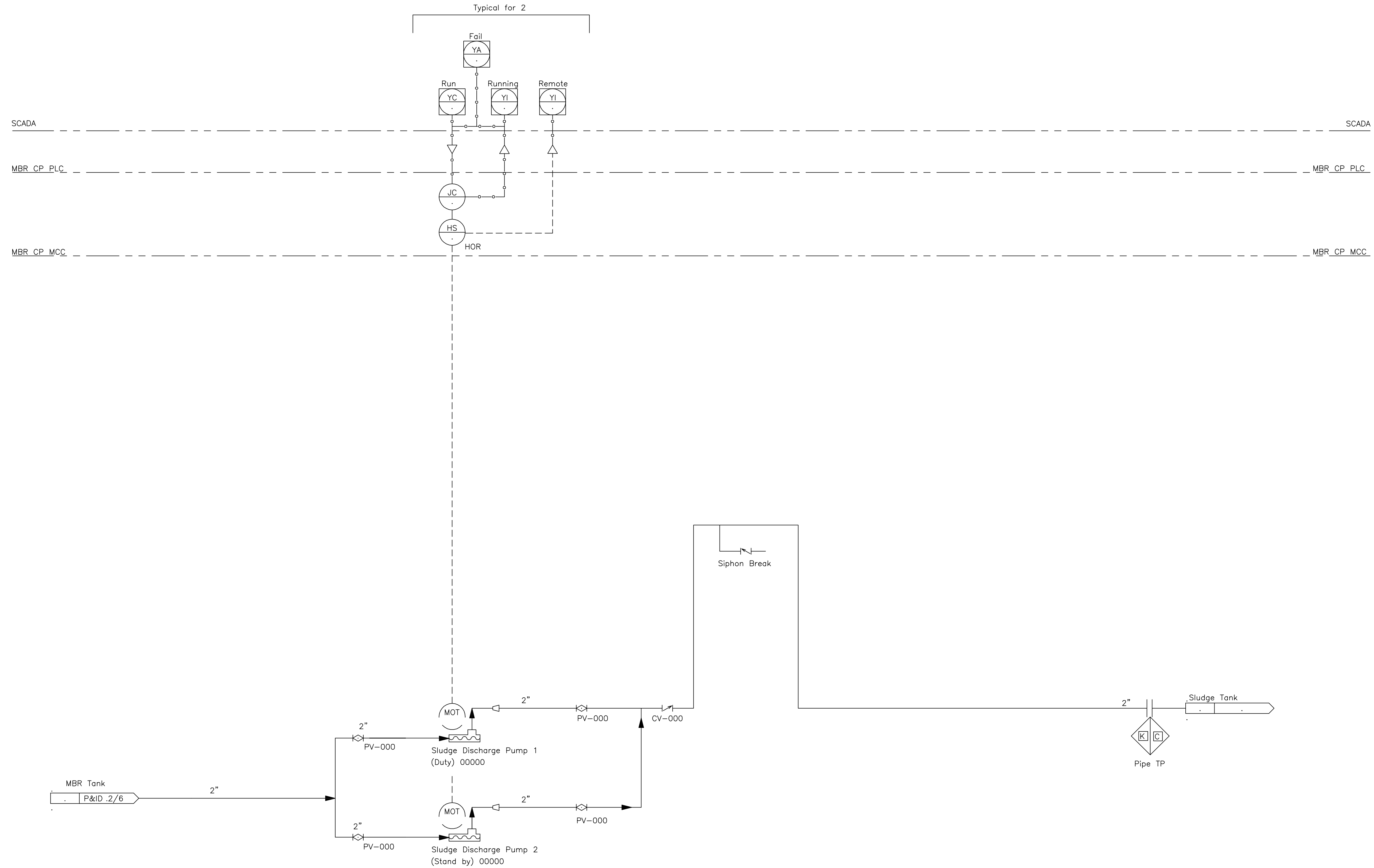
Stamp

Drawing Number

P&ID 5/6

Author

Kimihiro Ishikawa



Sludge Discharge Pump System

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Drawing Name

P&ID

WAS Pumps

(on MBR SKID)

Project Name and Address

KUBOTA
SMU Package
KSP6

Area

Stamp

Drawing Number

P&ID 6/6

Author

Kimihiro Ishikawa

J-1 IDENTIFICATION LETTERS

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER,COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	USER'S CHOICE			CONTROL	
D	DENSITY	DIFFERENTIAL			
E	VOLTAGE		SENSOR(PRIMARY ELEMENT)		
F	FLOW RATE	RATIO(FRACTION)			
G	USER'S CHOICE		GLASS,VIEWIG DEVIDE		
H	HAND				HIGH
I	CURRENT(ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME,TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	MOISTURE	MOMENTARY			MIDDLE,INTERMEDIATE
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE,RESTRICTION		
P	PRESSURE,VACUUM		POINT(TEST) CONNECTION		
Q	QUANTITY	INTEGRATE,TOTALIZE			
R	RADIATION		RECORD		
S	SPEED,FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION,MECANICAL ANALYSIS			VALVE,DAMPER,OR LOUVER	
W	WEIGHT,FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT,STATE,PRESENCE	Y AXIS		RELAY,COMPUTE,CONVERT	
Z	POSITION,DIMENSION	Z AXIS		DRIVER,ACTUATOR, UNCLASSIFIED,FINAL CONTROL ELEMENT	

GENERAL INSTRUMENT OR FUNCTION SYMBOLS	FIELD MOUNTED	PRIMARY LOCATION ACCESSIBLE TO OPERATOR	AUXILIARY LOCATION ACCESSIBLE TO OPERATOR	NORMALLY INACCESSIBLE OR BEHIND THE PANEL
DISCRETE INSTRUMENT				
SHARED DISPLAY SHARED CONTROL				
COMPUTER FUNCTION				
PROGRAMMABLE LOGIC CONTROL				
PLC INPUT/OUTPUT	ANALOG INPUT TAG	ANALOG OUTPUT TAG	DISCRETE INPUT TAG	DISCRETE OUTPUT TAG

INSTRUMENT SYMBOL IDENTIFIERS

J-1 J-2 J-3 J-4

J-1: IDENTIFICATION LETTERS (SEE TABLE ABOVE)
J-2: LOOP NUMBER
J-3: DEVICE SEQUENCE LETTER
J-4: INSTRUMENT MODIFIER

J-4 INSTRUMENT MODIFIER

1/2	SELECT 1 OR 2 POSITION
A/M	Remote-MANUAL SETTING
AMSS	Remote-MANUAL-START-STOP FUNCTION
DO	DISSOLVED OXYGEN
ESTOP	EMERGENCY STOP
FAIL	FAILURE CONDITION
HOR	HAND-OFF-REMOTE
I/I	CURRENT TO CURRENT CONVERTER
I/P	CURRENT TO PNEUMATIC CONVERTER
LEL	LOWER EXPLOSIVE LIMIT
LOR	LOCAL-OFF-REMOTE
LOS	LOCK-OUT-STOP
LR	LOCAL-REMOTE
OC	OPEN-CLOSE
OCR	OPEN-CLOSE-REMOTE
OIL	LUBRICATING OR COOLING OIL
ON	ON CONDITION
OPEN	OPEN CONDITION OR COMMAND
OSC	OPEN-STOP-CLOSE
RDY	READY CONDITION
RESET	RESET FAILURE
RUN	MAINTAINED RUN COMMAND
SP	SET POINT
SS	START-STOP
WND	MOTOR WINDING
BCN	BEACON
V/P	VOLTAGE TO PNEUMATIC CONVERTER
V/I	VOLTAGE TO CURRENT CONVERTER

LINES

	MAIN PROCESS FLOW (WITH TYPICAL DIRECTION OF SHOWN)
	MAIN (EXISTING)
	SECONDARY PROCESS FLOW
	SECONDARY (EXISTING)
	INSTRUMENT SUPPLY PROCESS TAPS,NON PROCESS FLOW
	PNEUMATIC SIGNAL
	ANALOG ELECTRIC SIGNAL
	DISCRETE ELECTRIC SIGNAL
	CAPILLARY TUBE OR FILLED SYSTEM
	ELECTROMAGNETIC OF SONIC SIGNAL (UNGUDED)
	SOFTWARE OR DATA LINK
	MECHANICAL
L L	HYDRAULIC
120V	POWER SUPPLY
SA	SERVICE AIR AUPPLY

FLOW PRIMARY ELEMENTS

	ORIFICE PLATE
	SINGLE PORT PITOT TUBE OR PITOT-VENTURI TUBE
	AVERAGING PITOT TUBE
T	THERMAL MASS FLOEMETER
M	MAGNETIC FLOWMETER
	TURBINE OR PROPELLER-TYPE PRIMARY ELEMENT
	ROTOMETER
	POSITIVE DISPLACEMENT TYPE FLOW TOTALIZING INDICATOR
	VORTEX SENSOR
	TARGET TYPE SENSOR
	VENTURI TUBE
	SONIC FLOWMETER
	DENDITY METER

VALVES

	GATE VALVES (2-WAY AND 3-WAY)
	GLOBAL VALVE (3-WAY AND 2-WAY)
	PLUG VALVE
	ECCENTRIC PLUG VALVE
	CHECK VALVE AND BALL CHECK VALVE
	DIAPHRAGM VALVE (PINCH VALVE)
	BUTTERFLY VALVE
	BALL VALVE (2-WAY AND 3-WAY)
	NEEDLE VALVE
	INSTERLOCK
	PRESSURE REDUCING REGULATING VALVE, SELF-CONTAINED
	BACK PRESSURE REGULATING VALVE, SELF-CONTAINED
S	SOLENOID VALVE
	PRESSURE SURGE DISCHARGE
	CONTROL VALVE
	TELESCOPING VALVE
NC	NORMALLY CLOSED
NUM	NORMALLY NUMBER

VALVE OPERATORS

	DIAPHRAGM
	DIAPHRAGM,PRESSURE BALANCED
	HAND
M	MOTOR
	CYLINDER OPERATOR
S	SOLENOID

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General Notes

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REFERENCE ONLY
FOR ENGINEERING
DESIGN WORK

No.	Revision/Issue	Date
2	Draft update	5.9 2017
1	Draft by SP175146	4.21 2017

Drawing Name
P&ID
Symbol

Project Name and Address
KUBOTA
SMU Package
KSP6

Area
Stamp
Drawing Number
Symbol 1/2
Author
Kimihiro Ishikawa

INSTRUMENT & MECHANICAL EQUIPMENT SYMBOLS & MISCELLANEOUS

CENTRIFUGAL BLOWER	INJECTOR	WELDED CAP
INTAKE SCREEN/FILTER	FILTER OR SEPARATOR	BLIND FLANGE
HVAC FAN	DRIP TRAP	PURGE
FLOW STRAIGHTENING VANE	CAP OR PLUG	DIAPHRAGM
FLEXIBLE COUPLING	HOSE CONNECTION	THERMOMETER WELL
INLET SILENCER/FILTER	RUPTURE DISK, PRESSURE	MOTOR
ROTARY LOBE PUMP	RUPTURE DISK,VACUUM	HEATING COIL
SUBMERSIBLE PUMP	ANNULAR SEAL	DRAIN
SUBMERSIBLE PUMP with GUIDE RAIL	CENTRIFICAL PUMP	DRAIN
INTERLOCK,RELAY, OR OTHER FUNCTION DESCRIBED IN DRAWINGS OR SPECIFICATIONS	METERING PUMP	SLUICE GATE
FLEXIBLE METAL HOSE	PROGRESSIVE CAVITY PUMP	FLAG GATE
HOSE	UNION	SLIDE GATE
INTERFACE MARKER NEW/EXISTIING	Y STRANER	FLANGE
MIXER	STATIC MIXER	REDUCER
ULTRASONIC TRANSMITTER	CENTRIFUGAL BLOWER	ROTARY BLOWER

ABBREVIATIONS

AFD	ADJUSTABLE FRECUENCY DRIVE
AS	AIR SUPPLY
CMPTR	COMPUTER
CS	CONSTANT SPEED
DWV	DRAIN,WASTE, & VENT
ES	ELECTRICAL SUPPLY
FC	FAIL CLOSED
FO	FAIL OPEN
FP	FIELD PANEL
GND	GROUND
HMI	HUMAN-MACHINE INTERFACE
I/O	INPUT/OUTPUT
LCP	LOCAL CONTROL PANEL
MCC	MOTOR CONTROL CENTER
MUX	TELEMETRY MULTIPLEXING
NaOH	SODIUM HYDROXIDE
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
OF	OVERFLOW
PLC	PROGRAMMABLE LOGIC CONTROLLER
PT	PRESSURE TAG
SP	SUMP PUMP
UNO	UNLESS NOTED OTHERWISE
UPS	UNINTERRUPTABLE POWER SUPPLY
V	VENT ABOVE ELEVATION
VS	VARIABLE SPEED
VSD	VARIABLE SPEED DRIVE(VFD)

FLOW STREAM DESIGNATION

XX" aaa

XX = LINE SIZE
aaa = FLOW STREAM ABBREVIATION AS DEFINED ON 00-G-04 GENERAL LEGEND

SHEET CONNECTION SYMBOLS

X | YY-a-ZZ — CONNECTION TO PROCESS WITH IN THIS CONTRACT

X = SEQUENCE
YY-a-ZZ = DWG. NO.

CONNECTION TO PROCESS NOT IN THIS CONTRACT

EQUIPMENT TAGS

aaa - xxxx

aaa = EQUIPMENT TAG PREFIX SEE 00-M-01 FOR DEFINTIONS

xxxx = TAG NO.

UNIT PROCESS

No	Unit Process
01	PUMP STATION AREA
02	HEAD WORKS AREA
03	EQUALIZATION AREA
04	DE-OX AREA
05	ANEAROBIC AREA
06	1ST ANOXIC AREA
07	SWING AREA
08	PRE-AERATION AREA
09	2ND ANOXIC AREA
10	SMU AREA
11	RAS AREA
12	IR AREA
13	PERMEATE SYSTEM
14	AIR SCOUR SYSTEM
15	PRE-AERATION SYSTEM
16	CIP SYSTEM
17	WAS SYSTEM
18	UV SYSTEM
19	-
20	OTHER
99	PLC/SCADA

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Drawing Name
P&ID Symbol

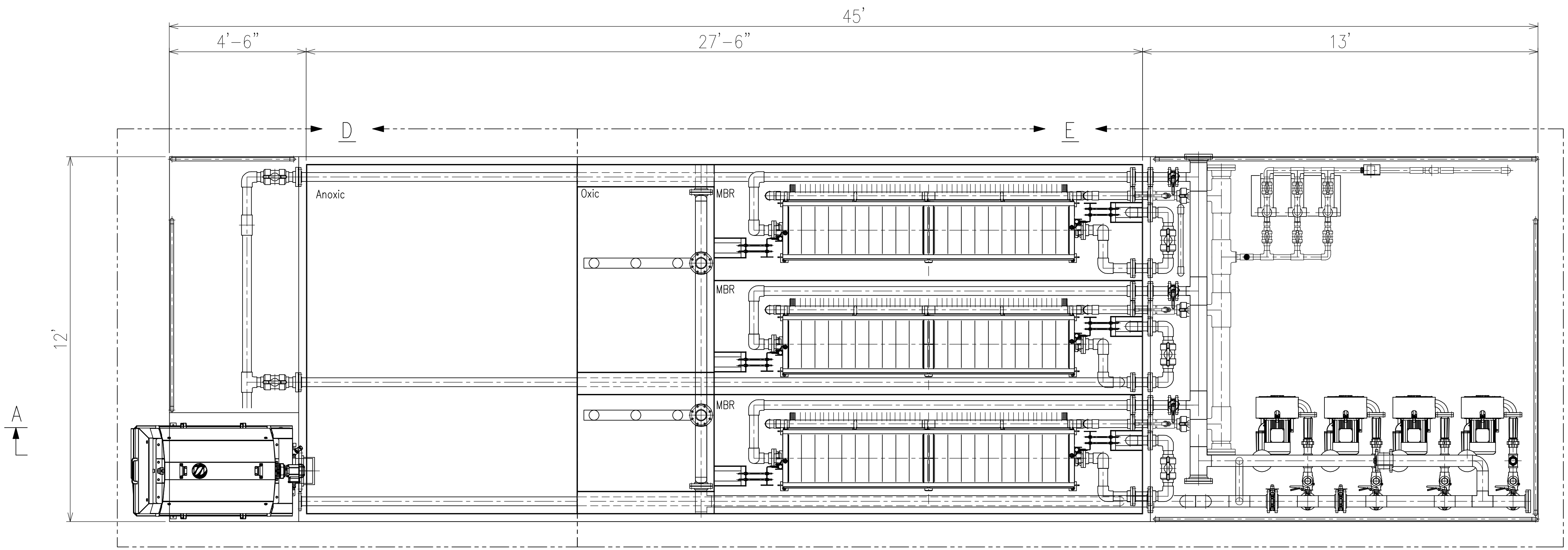
Project Name and Address
KUBOTA SMU Package KSP6

Area

Stamp

Drawing Number
Symbol 2/2

Author
Kimihiro Ishikawa

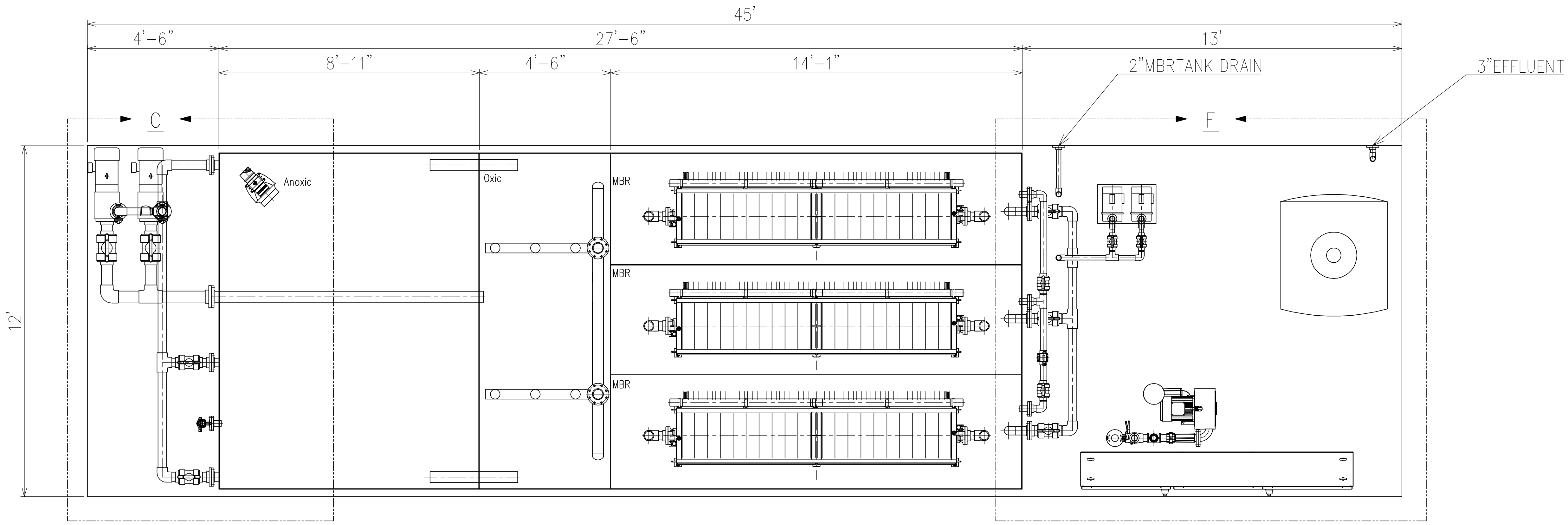


PLAN VIEW

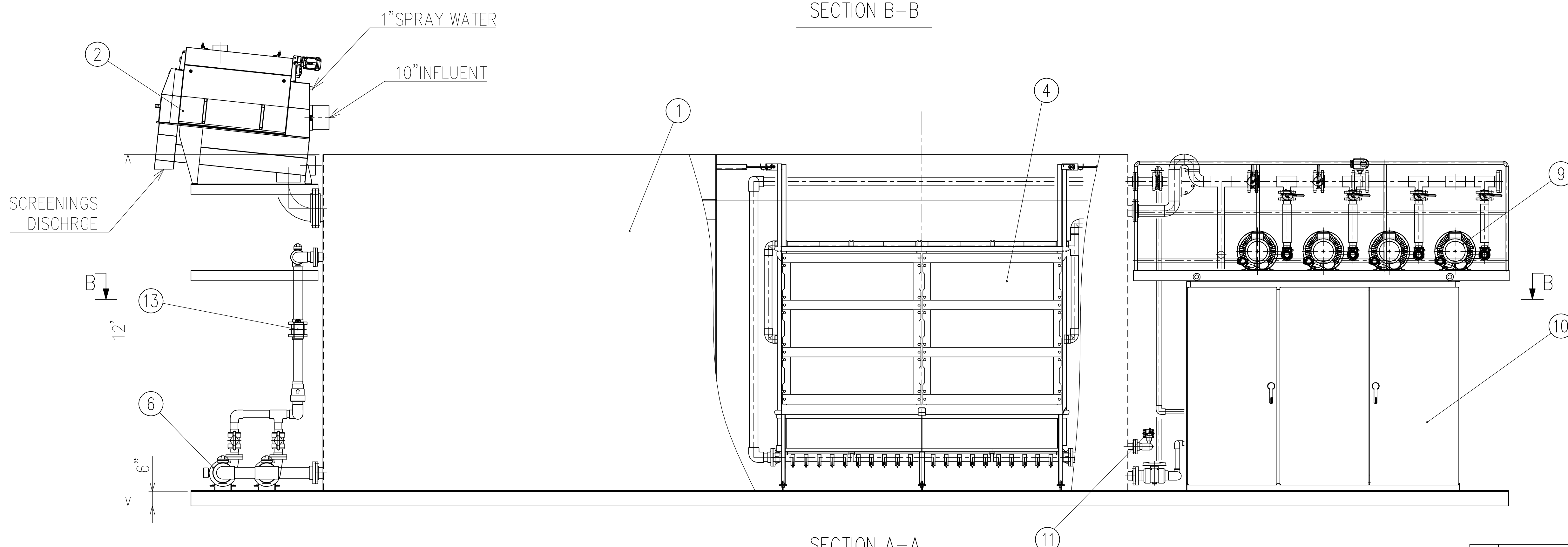
PARTS NO.	NAME OF PARTS	MATERIALS	NO.REQD.	lbs MASS	REMARKS
17	AERATION BLOWER		1	200	
16	FINE BUBBLE DIFFUSER		1		
15	PERMEATE FLOW GAUGE		1		
14	PERMEATE FLOW METER		1		
13	RECIRCULATION FLOW METER		1		
12	MEMBRANE AIR FLOW METER		1		
11	LEVEL TRANSMITTER		2		
10	CONTROL PANEL		1	1000	
9	MEMBRANE BLOWER		4	800	
8	SLUDGE DISCHARGE PUMP		2	140	
7	PERMEATE PUMP		3	210	
6	RECIRCULATION PUMP		2	1000	
5	CHEMICAL SOLUTION TANK		1		
4	MEMBRANE UNIT SS,etc.		3		
3	MIXER		1		
2	FINE SCREEN		1	815	
1	KSP6 TANK SS,etc.		1		

TYPE	KUBOTA SMU Package
CUSTOMER	
TITLE	KSP6 Layout Plan Section – View (1/5)
	Membrane Engineering
APPROVED BY	Y.O
CHECKED BY	T.S
DESIGNED BY	K.I
DRAWN BY	S.K
THIRD ANGLE	
DATE	9 May, 2017
SCALE	1/50
DWG NO.	SP-17-5026
ORDER NO.	
FILE NO.	

KUBOTA Corporation

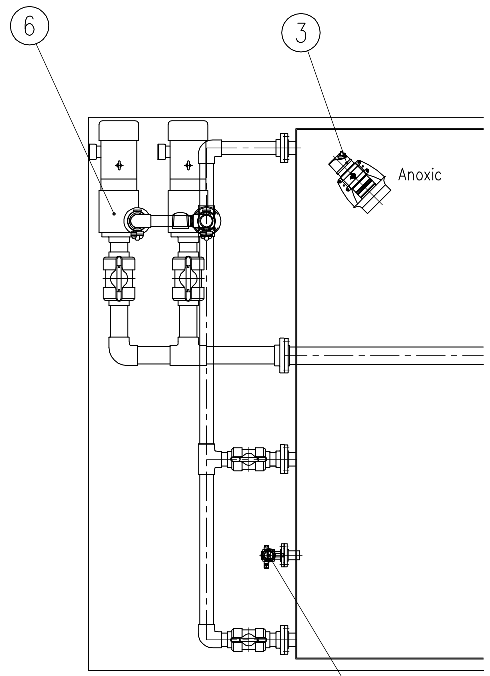


SECTION B-B

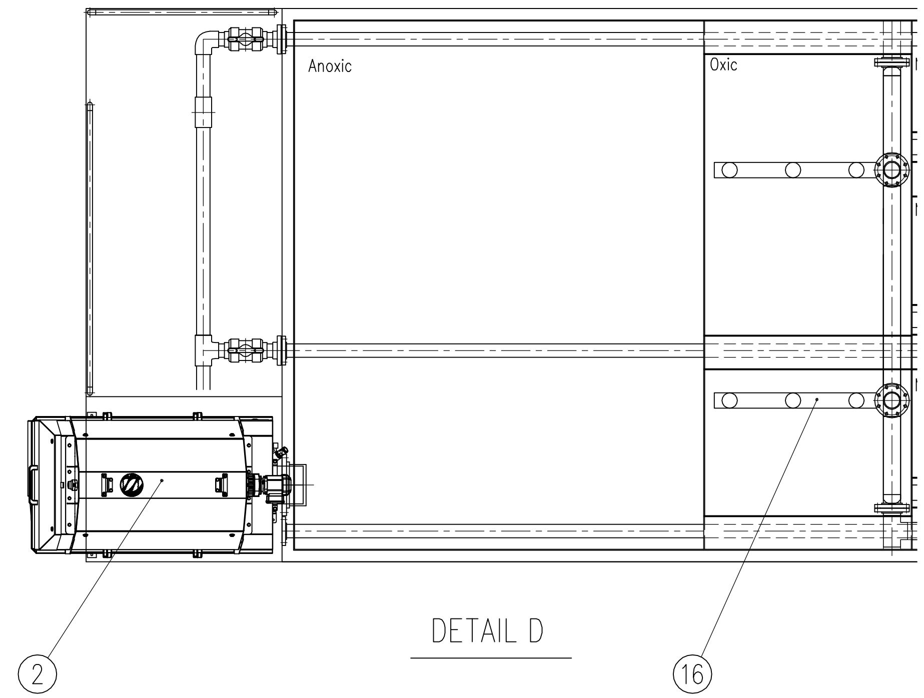


SECTION A-A

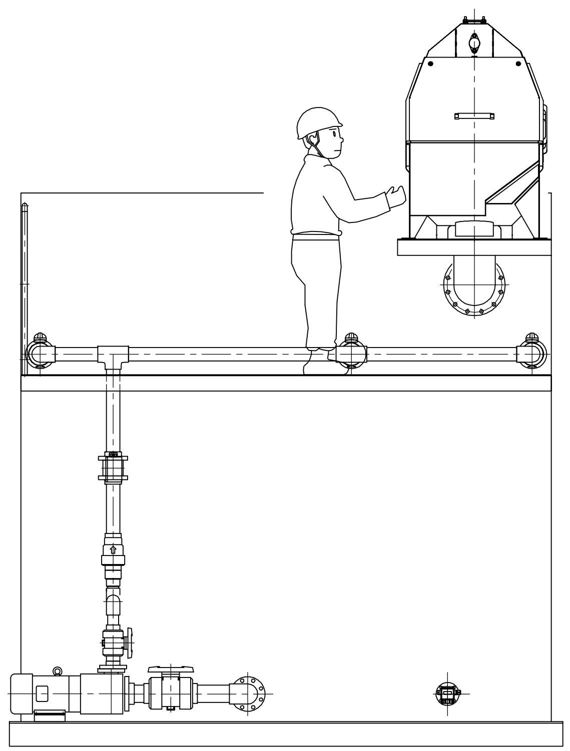
PARTS NO.	NAME OF PARTS	MATERIALS	NO.REQD.	lbs MASS	REMARKS
TYPE: KUBOTA SMU Package	CUSTOMER		TITLE: KSP6 Layout Plan Section – View (2/5)		
Membrane Engineering	APPROVED BY: Y.O	CHECKED BY: T.S	DESIGNED BY: K.I	DRAWN BY: S.K	THIRD ANGLE; DATE: 9 May, 2017; SCALE: 1/50; DWG NO.: SP-17-5026 d
KUBOTA Corporation			ORDER NO.		FILE NO.

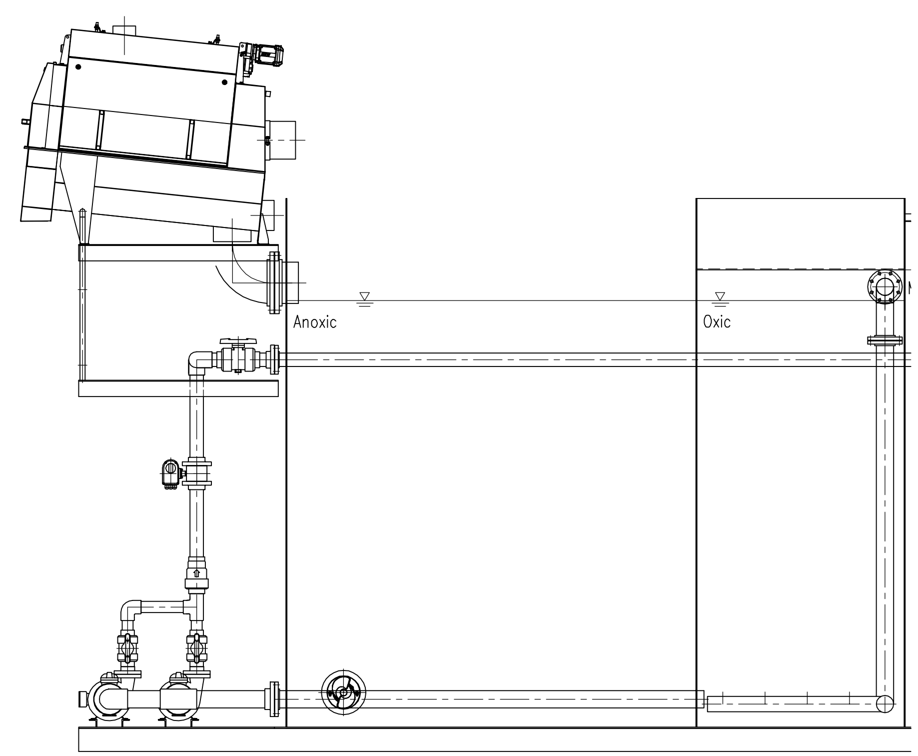


DETAIL C



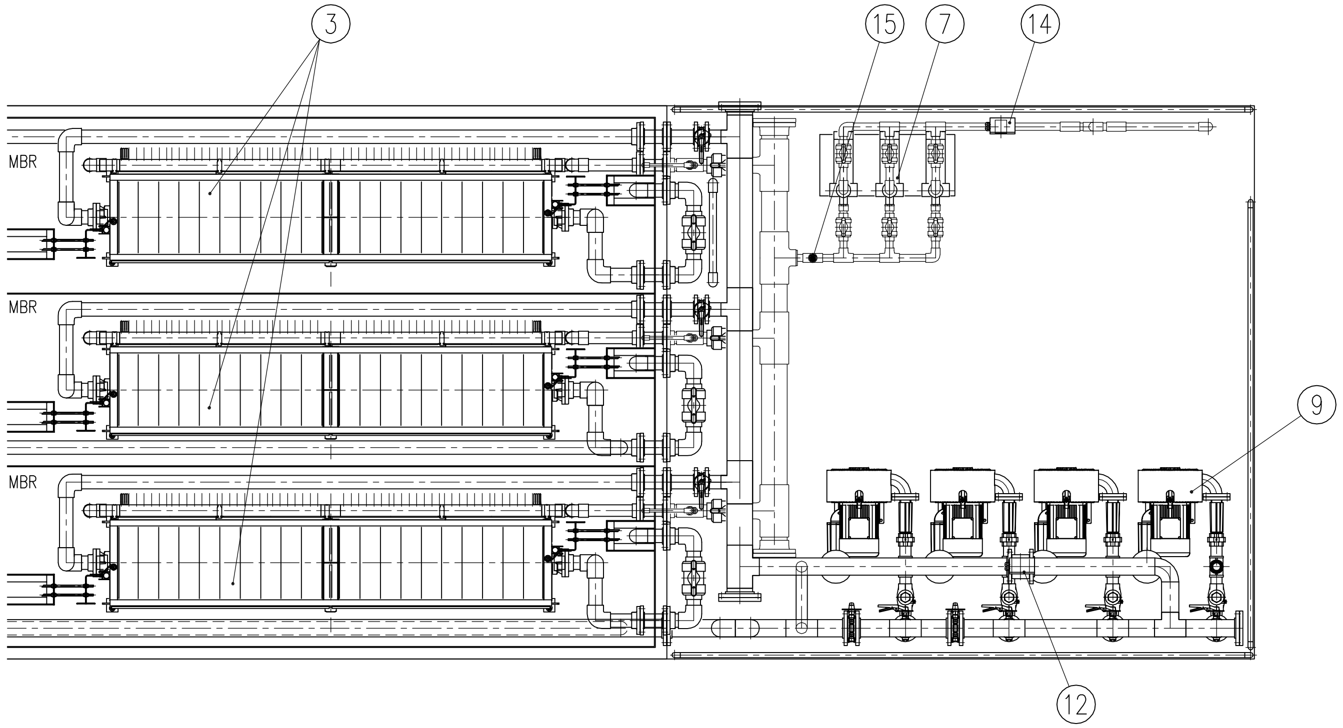
DETAIL D



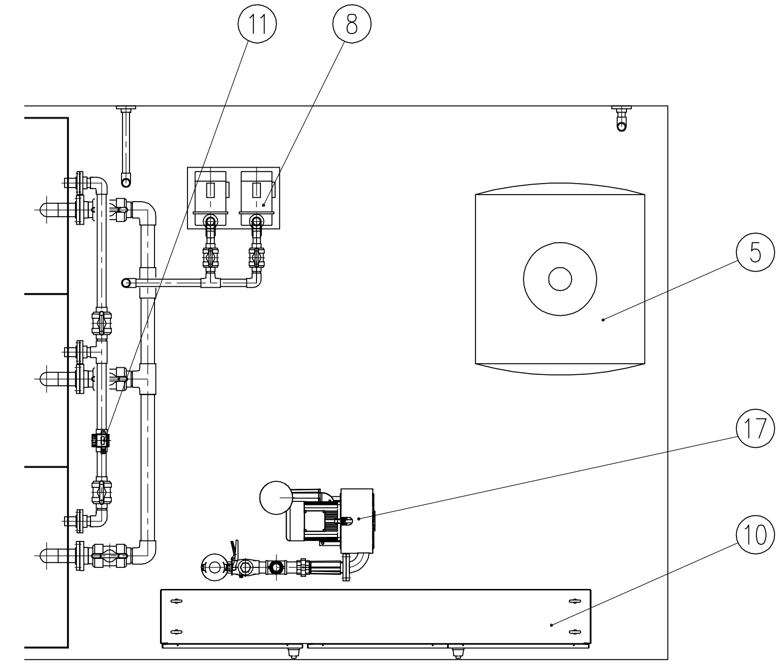


PARTS NO.	NAME OF PARTS	MATERIALS	NO.REQD.	lbs MASS	REMARKS

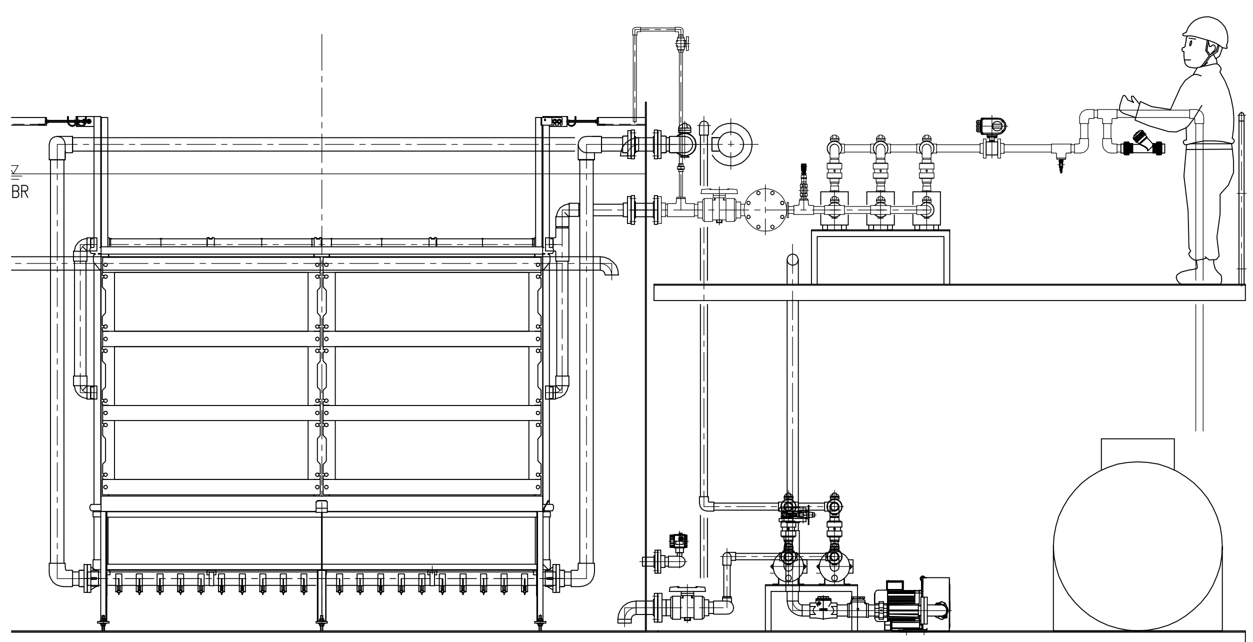
TYPE: KUBOTA SMU Package	CUSTOMER				TITLE: KSP6 Layout Plan Section – View (3/5)
Membrane Engineering	APPROVED BY: Y.O	CHECKED BY: T.S	DESIGNED BY: K.I	DRAWN BY: S.K	THIRD ANGLE · DATE: 9 May, 2017 · SCALE: 1/50 DWG NO. SP-17-5026 d
KUBOTA Corporation					ORDER NO. · FILE NO.

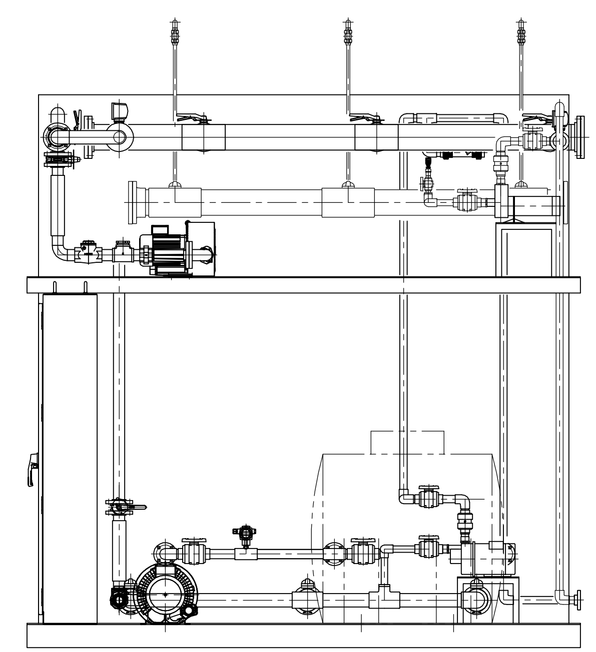


DETAIL E



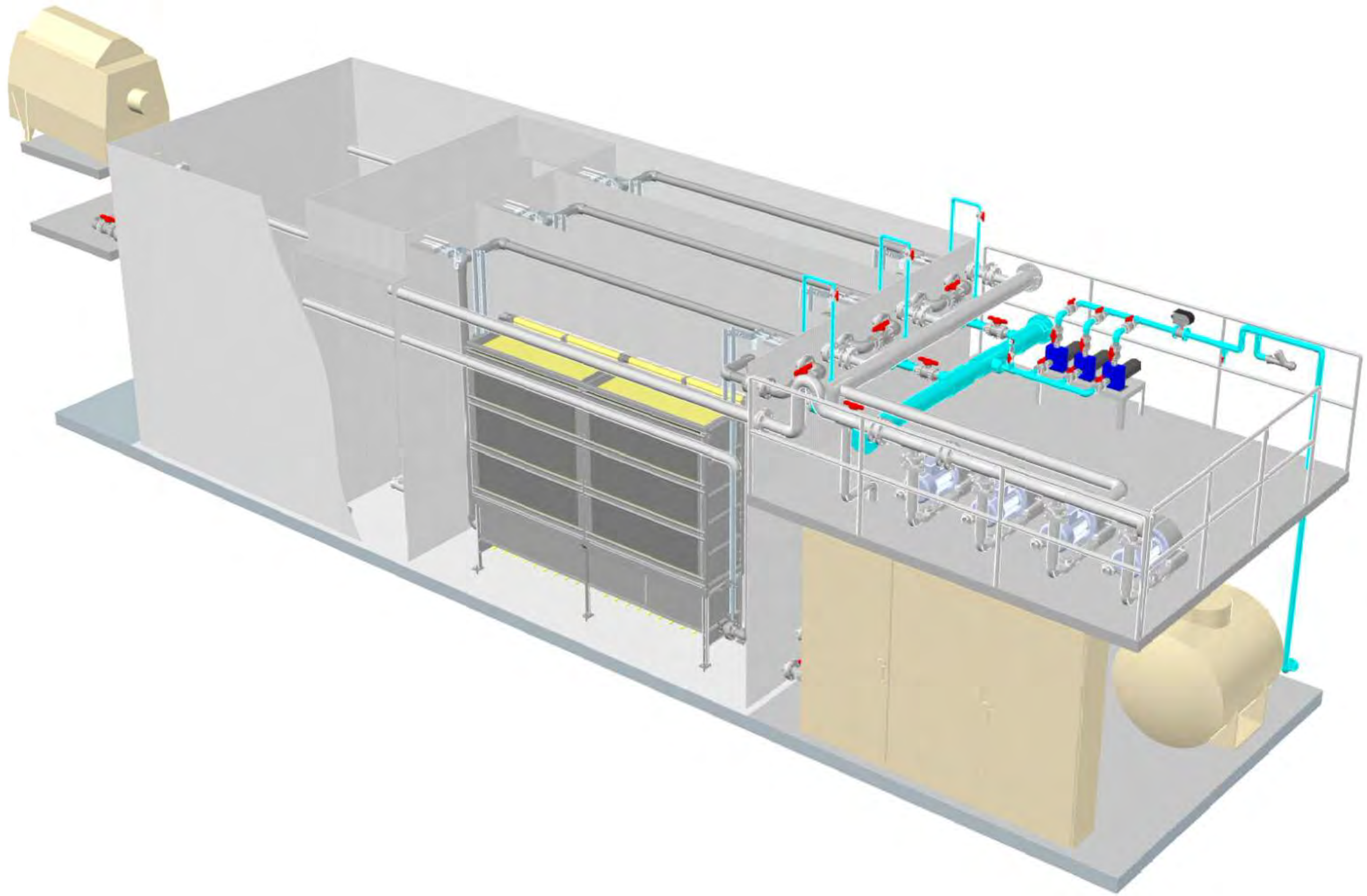
DETAIL F





PARTS NO.	NAME OF PARTS	MATERIALS	NO.REQD.	lbs MASS	REMARKS

TYPE: KUBOTA SMU Package	CUSTOMER		TITLE: KSP6 Layout Plan Section – View (4/5)	
Membrane Engineering	APPROVED BY: Y.O	CHECKED BY: T.S	DESIGNED BY: K.I	DRAWN BY: S.K
THIRD ANGLE	DATE: 9 May, 2017	SCALE: 1/50	DWG NO.: SP-17-5026	d
KUBOTA Corporation	ORDER NO.	FILE NO.		



PARTS NO.	NAME OF PARTS	MATERIALS	NO.REQD.	lbs MASS	REMARKS

TYPE: KUBOTA SMU Package			CUSTOMER:	TITLE: KSP6 Layout Plan Section – View (5/5)	
Membrane Engineering	APPROVED BY: Y.O	CHECKED BY: T.S	DESIGNED BY: K.I	DRAWN BY: S.K	THIRD ANGLE
				DATE: 9 May, 2017	SCALE: 1/50
				DWG NO.: SP–17–5026	d
KUBOTA Corporation				ORDER NO.:	FILE NO.:

APPENDIX H – MBBR QUOTE AND DETAILS

Carolyn Pepin

From: Jeremy Howard <JHoward@aquapoint.com>
Sent: Tuesday, September 5, 2023 7:24 AM
To: Carolyn Pepin
Subject: Pre-packaged IFAS/MBBR Treatment Facility in Rico, CO
Attachments: 1298-13_Primary_EQ_MBBR_Nitrate_Anoxic_Re-Aer_Clarifier.pdf; Pages from 3 Chmbr_6 Sparger_3.0_Drop_PVC_frp_tank_RevA_Jellystone - Carver MA.pdf; 1284-92_Two Stage Aerobic MBBR_Nitrate_Post Anoxic_Re-Aer.pdf; 1284-93_1st Stage Primary with Recycle Line.pdf; 1284-97_2nd Stage Primary_EQ.pdf; Catlett 12ft FRP Clarifier.pdf; Jellystone.jpeg; Cheatham.jpeg

Carolyn, please see below and attached for a budget & scope of supply for Rico, CO:

Design Criteria (see RFP below):
Design flow: 53,600 gpd
Elevation: 8,825 ft (has a large impact on air density so affects blower sizing)
Influent (mg/l): 300 BOD, 292 TSS, 52 TKN, 10 TP, 10 C
Effluent (mg/l): < 30 BOD, < 30 TSS, < 7 TIN, < 0.7 TP, < 1000 MPN/1000 ml Fecal

Scope of Supply:
- (1) Dual flat weir flow splitter manhole.
- (2) Parallel 50,000 gallon baffled FRP primary settling/flow equalization combo tanks (33K primary, 17K EQ). FYI this actually comes as (2) 25k tanks in series, first being all primary settling, and the 2nd being split between primary/flow eq. So this will be (4) total tanks.
  - (2) Duplex EQ pump and slide rail packages
- (2) Parallel 25,000 gallon five stage MBBR tanks each to include 2 stage aerobic, nitrate recycle, post anoxic, re-aeration.
  - Volumes approx. 7,000 Aer 1 / 7,000 Aer 2 / 2,000 Nitrate Recycle / 7,000 Anoxic / 2,000 Re-Aer (gal)
  - (56) m3 AquaCELL500 media (aerobic 1 & 2)
  - (10) m3 AquaCELL466 media (post anoxic)
  - (2) Inlet manifold with duckbill check valves
  - (8) 5.5" x 36" SS media retention screens (nominally 6")
  - (4) Schd 80 CPVC aeration grids
  - (3) 25 HP Kaeser blowers (two duty, one standby)
  - (2) Simplex pump nitrate recycle lift station with rails
  - (2) UET XCEL-5 anoxic mixer w/ SS pedestal
  - (2) Proximity sensor with weir box
  - (2) Schd 80 CPVC Re-Aeration grid
- (2) 12' Dia x 16' OAH FRP clarifier (includes air pump, controls and cover)
- (3) EC-65-2 chemical feed systems for alkalinity, carbon and coagulant
- (4) Hallett 1000W UV units in parallel
- (1) Integrated PLC control panel with remote monitoring capability

10% added to all costs for time to elapse between report publishing and actual procurement

Total estimated budget including 8 man days onsite for installation, startup and training = $\boxed{\$1,444,904}$
Freight estimate $\boxed{\$50,000-75,000.}$ Tying to be conservative here given the site location.
Lead time 16-18 weeks
If site conditions call for tank ballasting, concrete deadmen with straps and turnbuckles can be provided for primar/eq & mbbr tanks for an additional $\boxed{\$120,295.}$
Example drawing of one treatment train attached (1298-13).

The system will require a control building w/ heat and water supply to store/makeup chemicals, house controls and blowers, etc… Min size is probably 20' x 24'.
Attached a couple drone shots with similar looking installations weve done as well.

Lots of info to digest so please let me know of any questions
Jeremy

From: Jeremy Howard <JHoward@aquapoint.com>
Sent: Thursday, August 31, 2023 8:51 AM
To: Josh Lindell <JLindell@aquapoint.com>
Subject: FW: [EXTERNAL] Pre-packaged IFAS/MBBR Treatment Facility in Rico, CO
Importance: High

See below email inquiry…looks like we have what we need

From: Info <Info@aquapoint.com>
Sent: Wednesday, August 30, 2023 7:54 PM
To: Jeremy Howard <JHoward@aquapoint.com>
Subject: FW: [EXTERNAL] Pre-packaged IFAS/MBBR Treatment Facility in Rico, CO
Importance: High

From: Carolyn Pepin
Sent: Wednesday, August 30, 2023 7:53:50 PM (UTC-05:00) Eastern Time (US & Canada)
To: Info
Subject: [EXTERNAL] Pre-packaged IFAS/MBBR Treatment Facility in Rico, CO

Hello,

I'm working on a wastewater PER for the small mountain town of Rico, Colorado and wanted to see if you could provide me with a cost estimate for a pre-packaged IFAS or MBBR treatment facility. This project is well on its way to being funded and ready for design + construction, so anything you can do to help would be great!

Here is the information I currently have:

- **Influent (all medium-high strength assumption from Metcalf & Eddy):**
  - BOD: 300 mg/L
  - TSS: 292 mg/L
  - TKN: 52 mg/L
  - Chloride: 88.5 mg/L
  - TDS: 840.5 mg/L
  - Flow (Daily Avg.): 53,600 gpd (Peak: 134,000 gpd)

- **Effluent Requirements (New Facility – Estimated PELs based on Regs 62 & 85)**
  - BOD: <30 mg/L (CBOD: <25 mg/L)
  - TSS: < 30 mg/L
  - Total Nitrogen: 7 mg/L
  - Total Phosphorus: 0.7 mg/L
  - Fecal Coliforms: <1,000 cfu/ml

- **Site Conditions:**
  - Elevation: 8,825 ft above MSL

- Minimum Avg. Ambient Temperature: 1.9 F
- Maximum Avg. Ambient Temperature: 85.8 F

Please let me know if you have any other questions!

Carolyn Pepin, PE
Engineer Water & Wastewater Systems
Bohannan Huston
p. 505.823.1000 | **d.** 505.798.7887
bhinc.com

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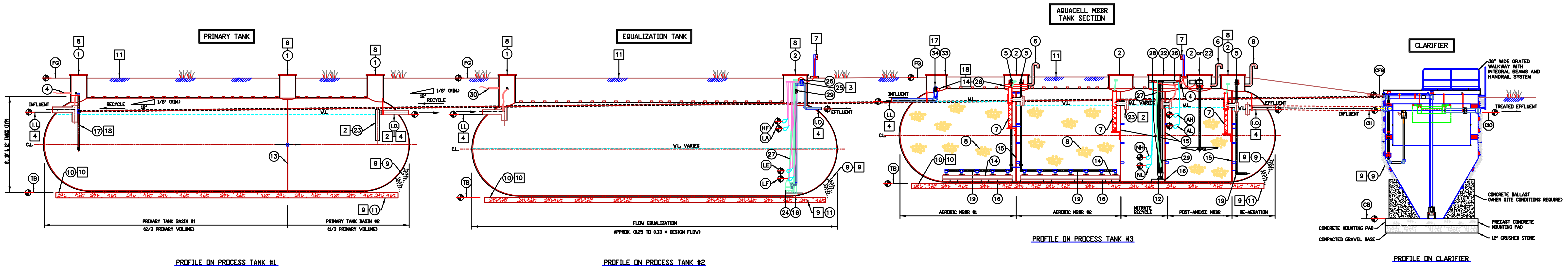
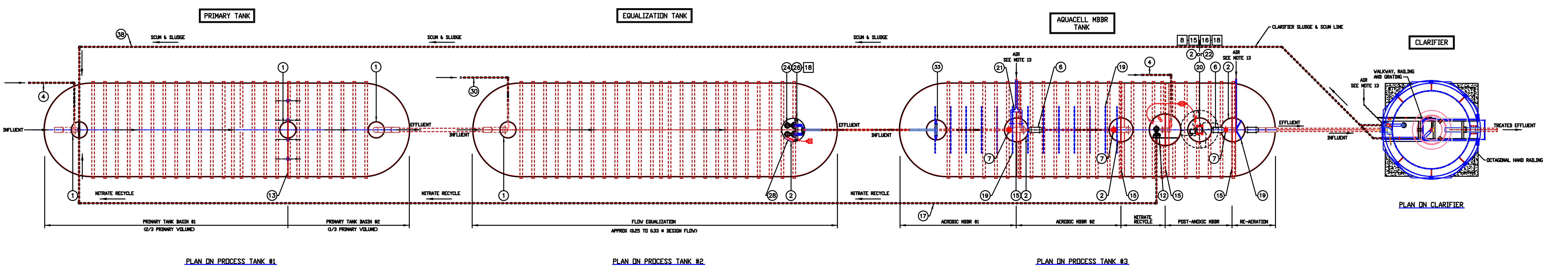
Upcoming Out of Office: Sept 7 & 8



GENERAL BAFFLED PRIMARY TANK, EQUALIZATION TANK, DUAL STAGE AEROBIC MBBR, NITRATE RECYCLE, POST-ANOXIC MBBR AND RE-AERATION TANK WITH A FRP CLARIFIER



DRAWING NOTES:

SEE UNIT PROCESS TANK DRAWINGS FOR:
- SYMBOL LEGENDS
- TANK NOTES AND DETAILS
- EQUIPMENT DETAILS

UNIT PROCESS TANK DRAWING SCHEDULE:

- PROCESS TANK #1 – DWG 1284-90
- PROCESS TANK #2 – DWG 1284-91
- PROCESS TANK #3 – DWG 1284-92
- FRP CLARIFIER

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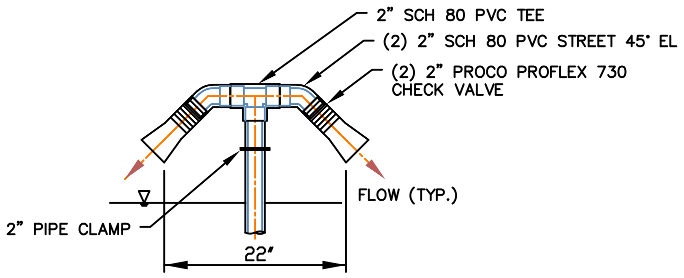
Performance Based Wastewater Treatment Systems
39 TARKILN PLACE
NEW BEDFORD, MA 02745
(508) 985-9050 FAX (508) 985-9072
WWW.AQUAPOINT.COM

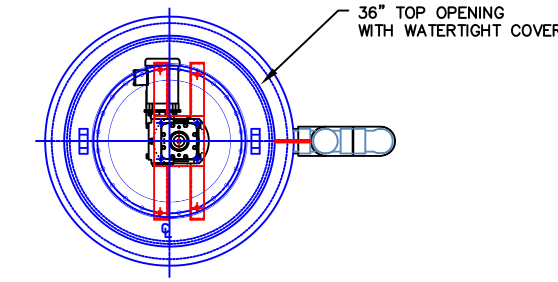
TITLE:	AQUACELL PROCESS – PRIMARY TANK, EQUALIZATION TANK, DUAL STAGE AEROBIC MBBR, NITRATE RECYCLE, POST-ANOXIC MBBR AND RE-AERATION TANK WITH A CLARIFIER
DRAWING NO.:	FRP-1298-13
REVISION:	A
DATE:	FEB. 2017
DWN BY:	KML
SCALE:	NTS — SIZE: B / A3
SHEET #:	SHEET 1 OF 1



VIEW ON "A"

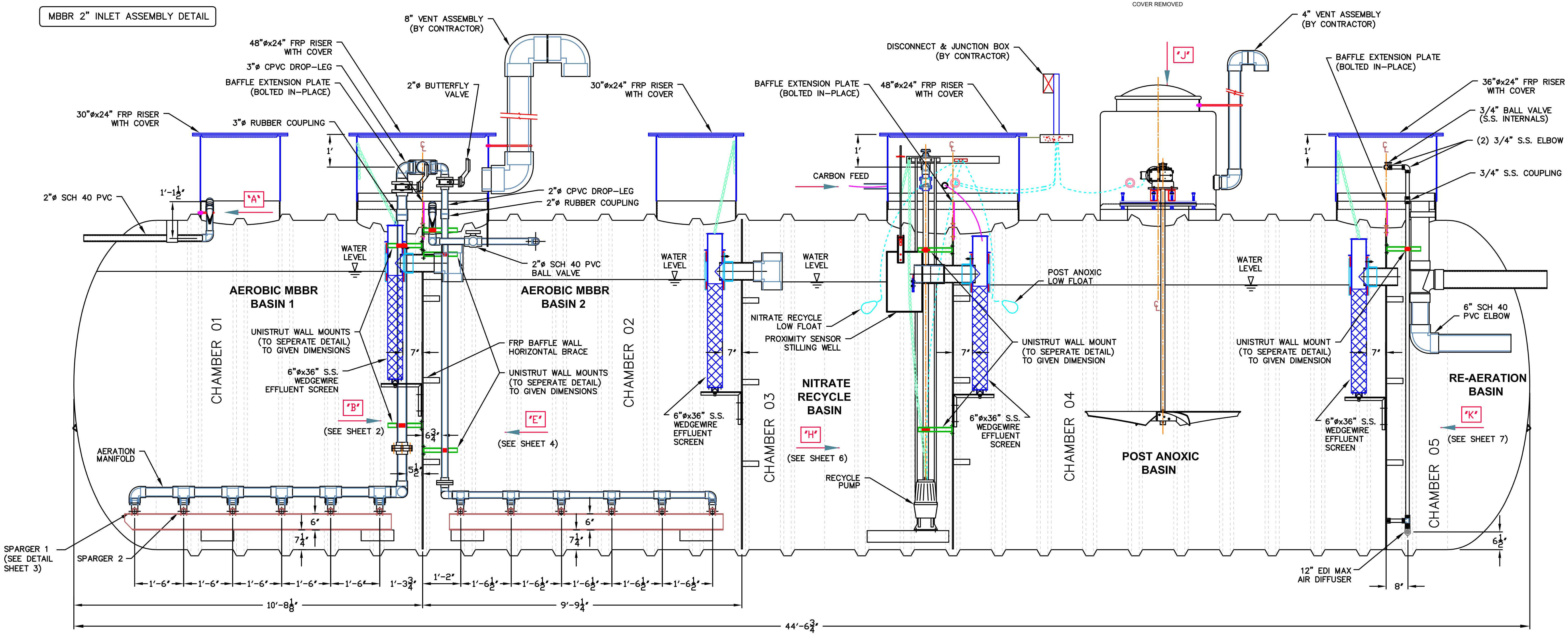
MBBR 2" INLET ASSEMBLY DETAIL

PROJECT:
JELLYSTONE CAMPGROUND
CARVER, MA



VIEW ON "J"

NOTE: VIEW SHOWN WITH RISER COVER REMOVED



ELEVATION VIEW

(OUTFITTED MBBR COMBO TANK)

GENERAL BILL OF MATERIALS:

- 6 FRP RISERS W/ LAMINATE KITS (INCLUDING ANOXIC MIXER SUMP RISER)
- 4 MEDIA RETENTION SCREENS, TEES W/SCH 80 PIPE STUBS, LOWER BRACKETS & S.S. CHAINS
- 2 MBBR DUCKBILL INLET ASSEMBLIES
- 2 AERATION GRIDS & 1 RE-AERATION GRID ASSEMBLY
- 3 RISER BAFFLE WALL FRP EXTENSION PLATES AND HARDWARE
- 2 FLOAT ASSEMBLIES
- NITRATE RECYCLE PUMP, PIPING, SLIDE RAILS, BRACKET & HARDWARE
- PROXIMITY SENSOR, BRACKET, STILLING WELL ASSEMBLY & HARDWARE
- ANOXIC MIXER, S.S. PEDESTAL AND FRP MANWAY COVER & HARDWARE
- CHEMICAL FEED TUBING

NOTES:
SEE THE FOLLOWING SUB ASSEMBLY DRAWINGS FOR MORE DETAILS.

- 6"ø x 36" MEDIA RETENTION SCREEN ASSEMBLY DETAILS – (DWG. 1243–21)
- 6"ø CUSTOM SCH 40 PVC TEE WITH SCH 80 PIPE STUBS
- PROXIMITY SENSOR FRP STILLING WELL WITH ADJUSTABLE WEIR AND 6" OUTLET – (DWG. 1290–15)
- MBBR ANOXIC FRP TANK WITH 1.5 HP UET MIXER @ GRADE DETAILS – (DWG. FRP–1290–3)

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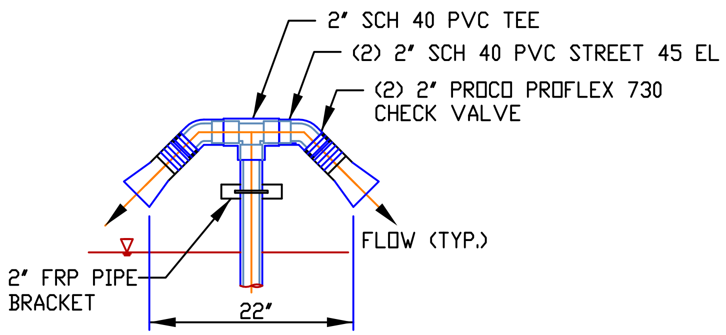
(508) 985–9050 FAX (508) 985–9072

TITLE: AQUACELL AEROBIC MBBR TANK PIPEWORK DETAILS FOR JELLYSTONE CAMPGROUND – CARVER, MA	
DRAWING #: JS–1002–1	
REVISION: A	
DATE: 02/24/22	
DWN BY: K._LEACH	
SCALE: NTS	SIZE: B
SHEET #: 1_OF_10	



MBBR 2" INLET ASSEMBLY DETAIL

GENERAL TWO STAGE AEROBIC AQUACELL, NITRATE RECYCLE, POST-ANOXIC MBBR & REAERATION TANK

AQUACELL MBBR TANK SECTION

PROCESS TANK ELEVATIONS

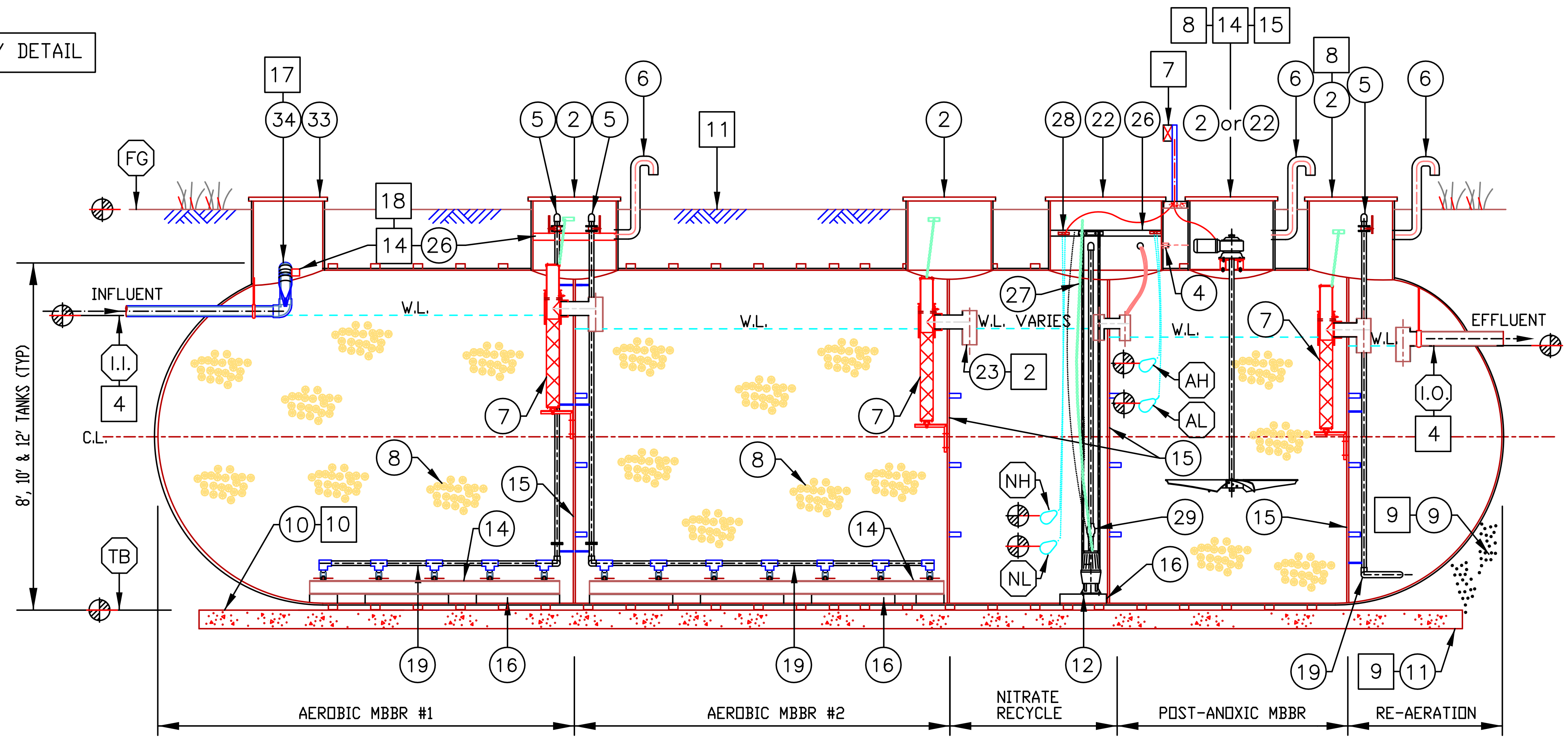
- FINISH GRADE (FG): ______
- TANK INVERT IN (I.I.): ______
- TANK INVERT OUT (I.O.): ______
- TANK BASE (TB): ______

ANOXIC MBBR FLOATS:

- HIGH FLOAT (AH): ______
- LOW FLOAT (AL): ______

NITRATE RECYCLE FLOATS:

- HIGH FLOAT (NH): ______
- LOW FLOAT (NL): ______



SECTION VIEW

SEE SHEET 2 FOR NOTES

SYMBOL LEGEND:

- □ = NOTES
- ○ = COMPONENTS USED
- ⊘ = COMPONENTS NOT USED
- ○ = FLOAT OR INVERTS
- ⊕ = ELEVATIONS

FRP PROCESS TANK COMPONENTS

ITEM NO.	ITEM DESCRIPTION	ITEM NO.	ITEM DESCRIPTION	ITEM NO.	ITEM DESCRIPTION
1	24" DIAMETER ACCESS RISER (TYP.)	16	FRP PUMP PLATFORM	31	SUBMERSIBLE ASPIRATOR
2	36" DIAMETER ACCESS RISER (TYP.)	17	NITRATE RECYCLE LINE (IF SPECIFIED)	32	ASPIRATOR INTAKE
3	24" OR 36" DIAMETER ACCESS RISER (TYP.)	18	ANOXIC SLUDGE PUMP & RAIL ASSEMBLY	33	30" DIAMETER ACCESS RISER (TYP.)
4	CARBON FEED CONDUIT (IF SPECIFIED)	19	AERATION MANIFOLD & SPARGER LATERALS	34	2" AEROBIC MBBR INLET ASSEMBLY
5	DROP LEG & VALVE ASSEMBLY (PNUEMATIC)	20	TOP MOUNTED MIXER ON PEDESTAL MOUNT	35	FRP BAFFLE WALL
6	4" PVC VENT	21	AERATION HEADER MANIFOLD	36	2" ANOXIC MBBR INLET ASSEMBLY
7	STAINLESS STEEL MEDIA RETENTION SCREEN	22	48" DIAMETER ACCESS RISER (TYP.)	37	FINAL PUMPS & RAIL ASSEMBLIES
8	NEUTRALLY BOUYANT HDPE BIOFILM CARRIER ELEMENTS (MEDIA)	23	EFFLUENT ASSEMBLY	38	SLUDGE RECYCLE LINE
9	BACKFILL	24	EQUALIZATION PUMPS & RAIL ASSEMBLIES	39	SUBMERSIBLE MIXER
10	CONCRETE DEADMEN (IF REQUIRED)	25	THROTTLING VALVE (HYDRAULIC)		
11	COMPACTED GRANULAR BASE	26	FRP SUPPORT BRACKET W/ HARDWARE		
12	NITRATE RECYCLE PUMP & RAIL ASSEMBLY	27	STAINLESS STEEL LIFTING CHAIN		
13	FRP BAFFLE WALL WITH 4 CENTER LINE 4" HOLDES (TYP.)	28	STAINLESS STEEL FLOAT BRACKET		
14	FRP AERATION GRID SUPPORT PLATFORM	29	CHECK VALVE (HYDRAULIC) (BY CONTRACTOR)		
15	FRP HYDROSTATIC BAFFLE WALLS	30	ALKALINITY FEED CONDUIT (IF SPECIFIED)		

PD BLOWER(S)
MANUFACTURER: ________
MODEL: ______

- ___ V 3 PHASE
- ___ HP
- ___ DIA. DISCHARGE

NITRATE RECYCLE PUMP
MANUFACTURER: BARNES
MODEL: ______

- ___ V __ PHASE
- ___ HP
- ___ DIA. DISCHARGE

ANOXIC MIXER
MANUFACTURER: ________
MODEL: ______

- ___ V 3 PHASE
- ___ HP
- ___ IMPELLER DIA.

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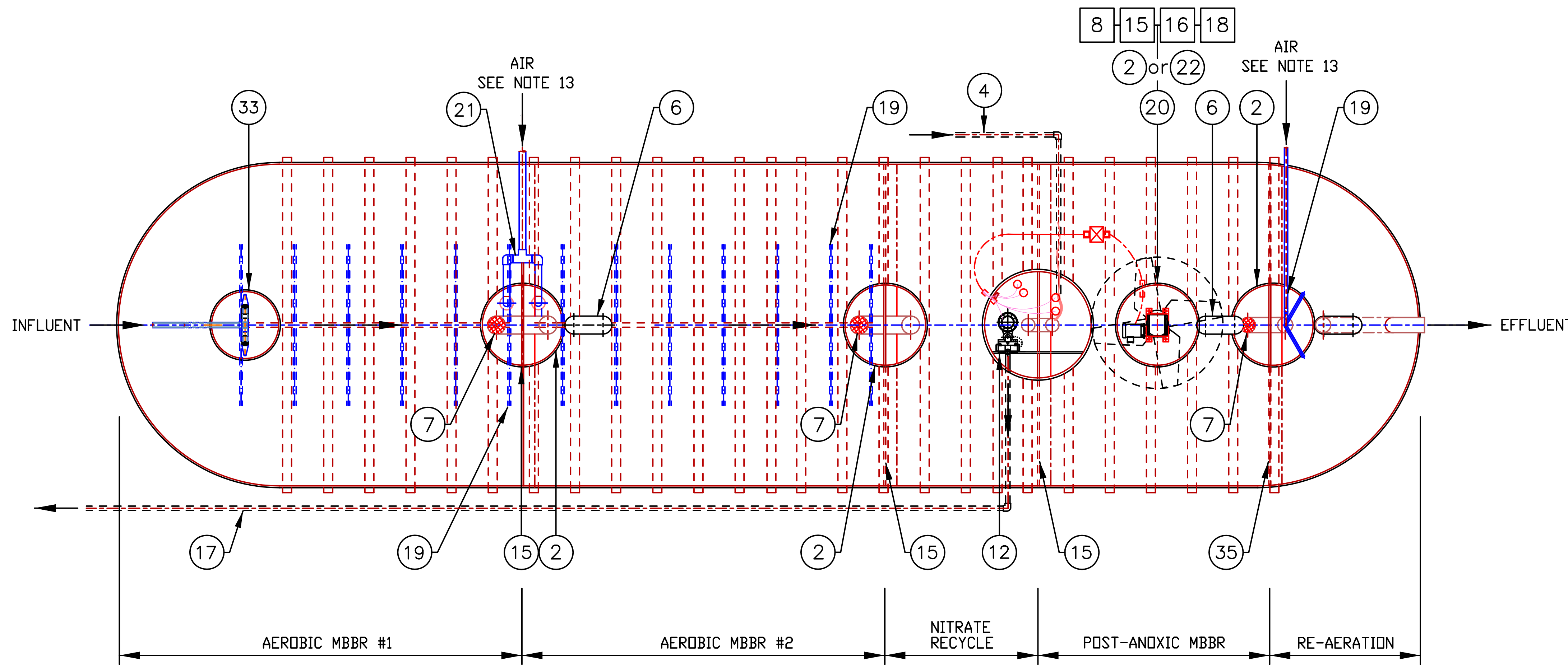
TITLE: TWO STAGE AEROBIC WITH NITRATE RECYCLE, POST-ANOXIC MBBR AND RE-AERATION ARRANGEMENT IN A HORIZONTAL FRP TANK

DRAWING NO.:	FRP-1284-92
REVISION:	D
DATE:	DECEMBER 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 1 OF 2

GENERAL TWO STAGE AEROBIC AQUACELL, NITRATE RECYCLE, POST-ANOXIC MBBR & REAERATION TANK

PLAN ON AQUACELL MBBR TANK



PLAN ON TANK

GENERAL NOTES:

1. TANK DEPICTED IS MEANT TO BE A GENERAL CONFIGURATION. ACTUAL TANK LENGTH, DIAMETER AND RISER LOCATIONS MAY VARY DEPENDING ON REQUIREMENTS.
2. EFFLUENT ASSEMBLY (FILTERS OR TEE) TO BE SIZED TO ACCOMODATE ALL FORWARD FLOWS AND RECYCLED FLOWS.
3. THROTTLING VALVE(S), LIFTING CHAINS AND PIPING UNIONS (IF APPLICABLE) TO BE LOCATED 16" (MAX) FROM TOP OF RISER.
4. SEE WWTP SYSTEM HYDRAULIC PROFILE FOR INVERT AND FLOAT ELEVATIONS.
5. CHEMICAL FEEDS SHOWN, ARE "IF SPECIFIED".
6. CONSULT AQUAPOINT TECHNICAL MANUAL FOR EQUIPMENT AND ELECTRICAL DETAILS.
7. CONSULT AQUAPOINT CONTROL PANEL'S FIELD WIRING DIAGRAM (SHIPPED IN PANEL) FOR REQUIREMENTS.
8. TANK RISER LENGHTS TO BE DETERMINED AND INSTALLED SEPERATELY. FOLLOW ALL FRP TANK INSTALLATION INSTRUCTIONS.
9. FOR INSTALLATION AND BACKFILLING INSTRUCTIONS CONSULT AND ADHERE TO THE FRP TANK MANUAL.
10. IF INSTALLED IN SEASONAL GROUNDWATER CONTACT ENGINEER TO SPECIFY ANCHORING & CONCRETE DEADMAN REQUIREMENTS.
11. MAXIMUM OVERBURDEN NOT TO EXCEED 6' WITHOUT WRITTEN AUTHORIZATION FROM THE MANUFACTURER.
12. AQUACELL PROCESS REACTOR(S) MUST BE PRECEDED BY PRIMARY SETTLING OR SCREENING AND FOLLOWED BY SECONDARY CLARIFICATION.
13. FIELD AIR PIPING SHALL BE SCHD 80 CPVC GALVANIZED OR STAINLESS STEEL, BY CONTRACTOR. (IF APPLICABLE)
14. FRP SLIDE RAIL SUPPORT, SHIPPED LOOSE WITH HARDWARE, INSTALLED BY CONTRACTOR. (IF APPLICABLE)
15. SIZE AND QUANTITY OF MIXERS WILL DEPEND ON TANK SIZE AND GEOMETRY. (IF APPLICABLE)
16. TANK RISER ABOVE MIXER MUST BE TALL ENOUGH FOR MIXER BASE, MIXER ASSEMBLY AND SUITABLE HEADSPACE. (IF APPLICABLE)
17. STANDARD PUMPED INLET ASSEMBLY CONFIGURATION SHOWN, SEE DETAIL. SEE TECHNICAL MANUAL FOR ANY JOB SPECIFIC REQUIREMENTS.
    IF FLOW BY GRAVITY, INFLUENT STRUCTURE TO BE A SUITABLE SIZED PIPE & INLET TEE, WITH INVERT 6" (MIN) ABOVE WATER LEVEL.
18. SEE SEPERATE DRAWING(S) FOR DETAILS.

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WWW.AQUAPOINT.COM

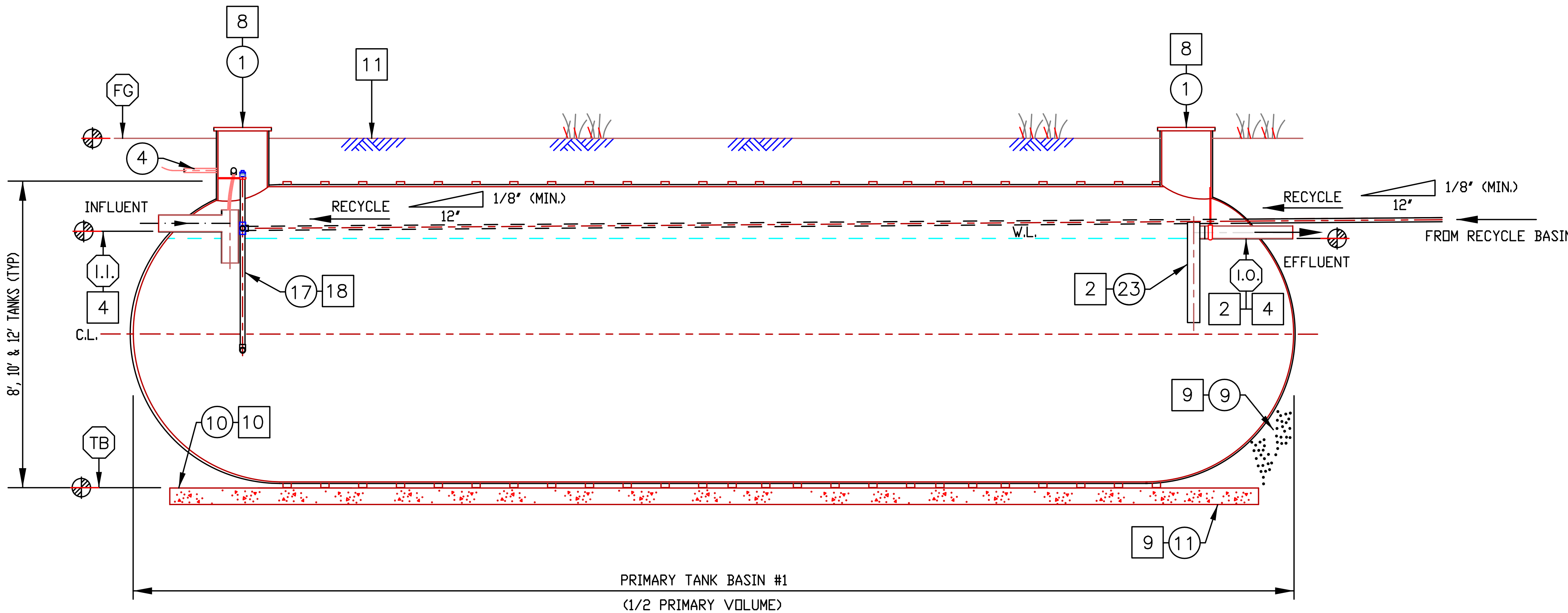
TITLE:	TWO STAGE AEROBIC WITH NITRATE RECYCLE, POST-ANOXIC MBBR AND RE-AERATION ARRANGEMENT IN A HORIZONTAL FRP TANK
DRAWING NO.:	FRP-1284-92
REVISION:	D
DATE:	DECEMBER 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 2 OF 2

PRIMARY TANK ELEVATIONS

- FINISH GRADE (FG): ______
- TANK INVERT IN (I.I.): ______
- TANK INVERT OUT (I.O.): ______
- TANK BASE (TB): ______

GENERAL ARRANGEMENT FRP PRIMARY TANK
NON-BAFFLED STAGE 1 OF 2

PRIMARY TANK SECTION



SECTION VIEW

SEE SHEET 2 FOR NOTES

SYMBOL LEGEND:

- ☐ = NOTES (SHEET 2)
- ○ = COMPONENTS USED
- ○ = COMPONENTS NOT USED
- ○ = FLOAT OR INVERTS
- = ELEVATIONS

FRP PROCESS TANK COMPONENTS

ITEM NO.	ITEM DESCRIPTION	ITEM NO.	ITEM DESCRIPTION	ITEM NO.	ITEM DESCRIPTION
1	24" DIAMETER ACCESS RISER (TYP.)	16	FRP PUMP PLATFORM	31	SUBMERSIBLE ASPIRATOR
2	36" DIAMETER ACCESS RISER (TYP.)	17	NITRATE RECYCLE LINE (IF SPECIFIED)	32	ASPIRATOR INTAKE
3	24" OR 36" DIAMETER ACCESS RISER (TYP.)	18	ANOXIC SLUDGE PUMP & RAIL ASSEMBLY	33	30" DIAMETER ACCESS RISER (TYP.)
4	CARBON FEED CONDUIT (IF SPECIFIED)	19	AERATION MANIFOLD & SPARGER LATERALS	34	2" AEROBIC MBBR INLET ASSEMBLY
5	DROP LEG & VALVE ASSEMBLY (PNUEMATIC)	20	TOP MOUNTED MIXER ON PEDESTAL MOUNT	35	FRP BAFFLE WALL
6	4" PVC VENT	21	AERATION HEADER MANIFOLD	36	2" ANOXIC MBBR INLET ASSEMBLY
7	STAINLESS STEEL MEDIA RETENTION SCREEN	22	48" DIAMETER ACCESS RISER (TYP.)	37	FINAL PUMPS & RAIL ASSEMBLIES
8	NEUTRALLY BOUYANT HDPE BIOFILM CARRIER ELEMENTS (MEDIA)	23	EFFLUENT ASSEMBLY	38	SLUDGE RECYCLE LINE
9	BACKFILL	24	EQUALIZATION PUMPS & RAIL ASSEMBLIES		
10	CONCRETE DEADMEN (IF REQUIRED)	25	THROTTLING VALVE (HYDRAULIC)		
11	COMPACTED GRANULAR BASE	26	FRP SLIDE RAIL SUPPORT BRACKET W/ HARDWARE		
12	NITRATE RECYCLE PUMP & RAIL ASSEMBLY	27	STAINLESS STEEL LIFTING CHAIN		
13	FRP BAFFLE WALL WITH 4 CENTER LINE 4" HOLDES (TYP.)	28	STAINLESS STEEL FLOAT BRACKET		
14	FRP AERATION GRID SUPPORT PLATFORM	29	CHECK VALVE (HYDRAULIC) (BY CONTRACTOR)		
15	FRP HYDROSTATIC BAFFLE WALLS	30	ALKALINITY FEED CONDUIT (IF SPECIFIED)		

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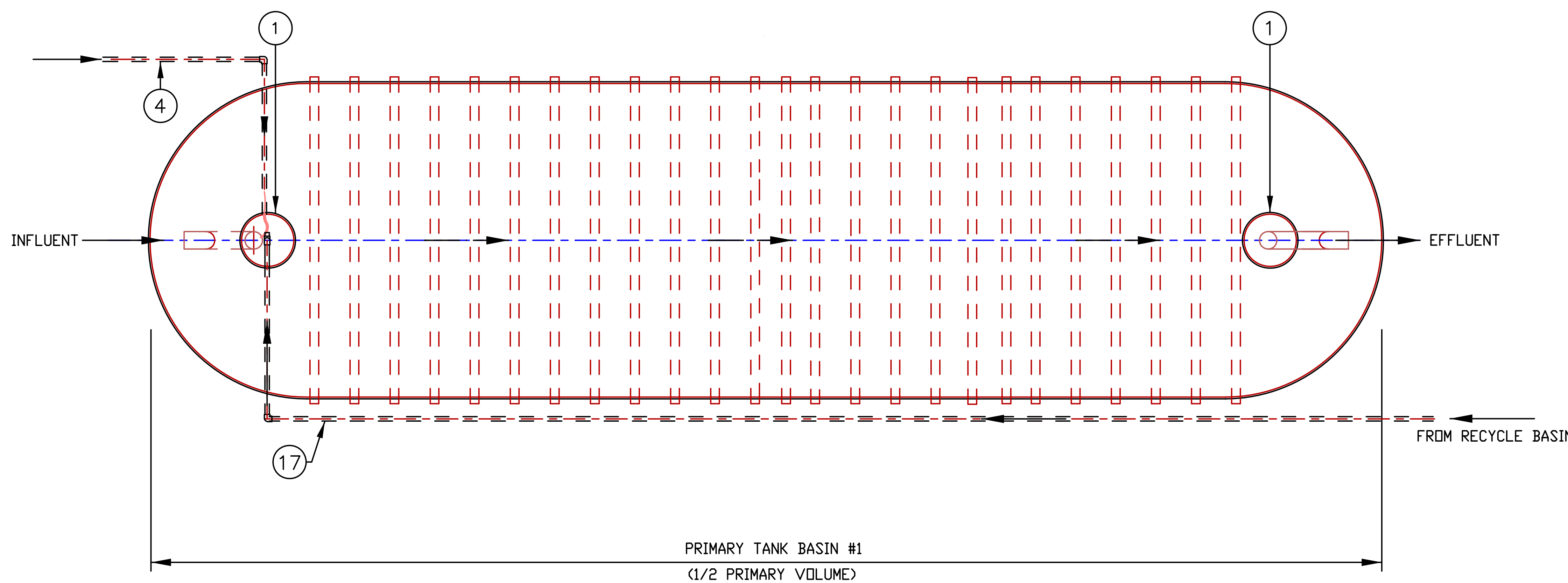
TITLE:	STAGE # 1 PRIMARY TANK ARRANGEMENT IN HORIZONTAL FRP TANK
DRAWING NO.:	1284-93
REVISION:	NONE
DATE:	AUGUST 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 1 OF 2

GENERAL ARRANGEMENT FRP PRIMARY TANK
NON-BAFFLED STAGE 1 OF 2

PRIMARY TANK SECTION



PLAN ON TANK

GENERAL NOTES:

1. TANK DEPICTED IS MEANT TO BE A GENERAL CONFIGURATION. ACTUAL TANK LENGTH, DIAMETER AND RISER LOCATIONS MAY VARY DEPENDING ON REQUIREMENTS.
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3. THROTTLING VALVE(S), LIFTING CHAINS AND PIPING UNIONS (IF APPLICABLE) TO BE LOCATED 16" (MAX) FROM TOP OF RISER.
4. SEE WWTP SYSTEM HYDRAULIC PROFILE FOR INVERT AND FLOAT ELEVATIONS.
5. CHEMICAL FEEDS SHOWN, ARE "IF SPECIFIED".
6. CONSULT AQUAPOINT TECHNICAL MANUAL FOR EQUIPMENT AND ELECTRICAL DETAILS.
7. CONSULT AQUAPOINT CONTROL PANEL'S FIELD WIRING DIAGRAM (SHIPPED IN PANEL) FOR REQUIREMENTS.
8. TANK RISER LENGHTS TO BE DETERMINED AND INSTALLED SEPERATELY. FOLLOW ALL FRP TANK INSTALLATION INSTRUCTIONS.
9. FOR INSTALLATION AND BACKFILLING INSTRUCTIONS CONSULT AND ADHERE TO THE FRP TANK MANUAL.
10. IF INSTALLED IN SEASONAL GROUNDWATER CONTACT ENGINEER TO SPECIFY ANCHORING & CONCRETE DEADMAN REQUIREMENTS.
11. MAXIMUM OVERBURDEN NOT TO EXCEED 6' WITHOUT WRITTEN AUTHORIZATION FROM THE MANUFACTURER.
12. AQUACELL PROCESS REACTOR(S) MUST BE PRECEDED BY PRIMARY SETTLING OR SCREENING AND FOLLOWED BY SECONDARY CLARIFICATION.
13. FIELD AIR PIPING SHALL BE SCHD 80 CPVC GALVANIZED OR STAINLESS STEEL, BY CONTRACTOR. (IF APPLICABLE)
14. FRP SLIDE RAIL SUPPORT, SHIPPED LOOSE WITH HARDWARE, INSTALLED BY CONTRACTOR. (IF APPLICABLE)
15. SIZE AND QUANTITY OF MIXERS WILL DEPEND ON TANK SIZE AND GEOMETRY. (IF APPLICABLE)
16. TANK RISER ABOVE MIXER MUST BE TALL ENOUGH FOR MIXER BASE, MIXER ASSEMBLY AND SUITABLE HEADSPACE. (IF APPLICABLE)
17. STANDARD PUMPED INLET ASSEMBLY CONFIGURATION SHOWN, SEE DETAIL. SEE TECHNICAL MANUAL FOR ANY JOB SPECIFIC REQUIREMENTS. IF FLOW BY GRAVITY, INFLUENT STRUCTURE TO BE A SUITABLE SIZED PIPE & INLET TEE, WITH INVERT 6" (MIN) ABOVE WATER LEVEL.
18. SEE SEPERATE DRAWING(S) FOR DETAILS.

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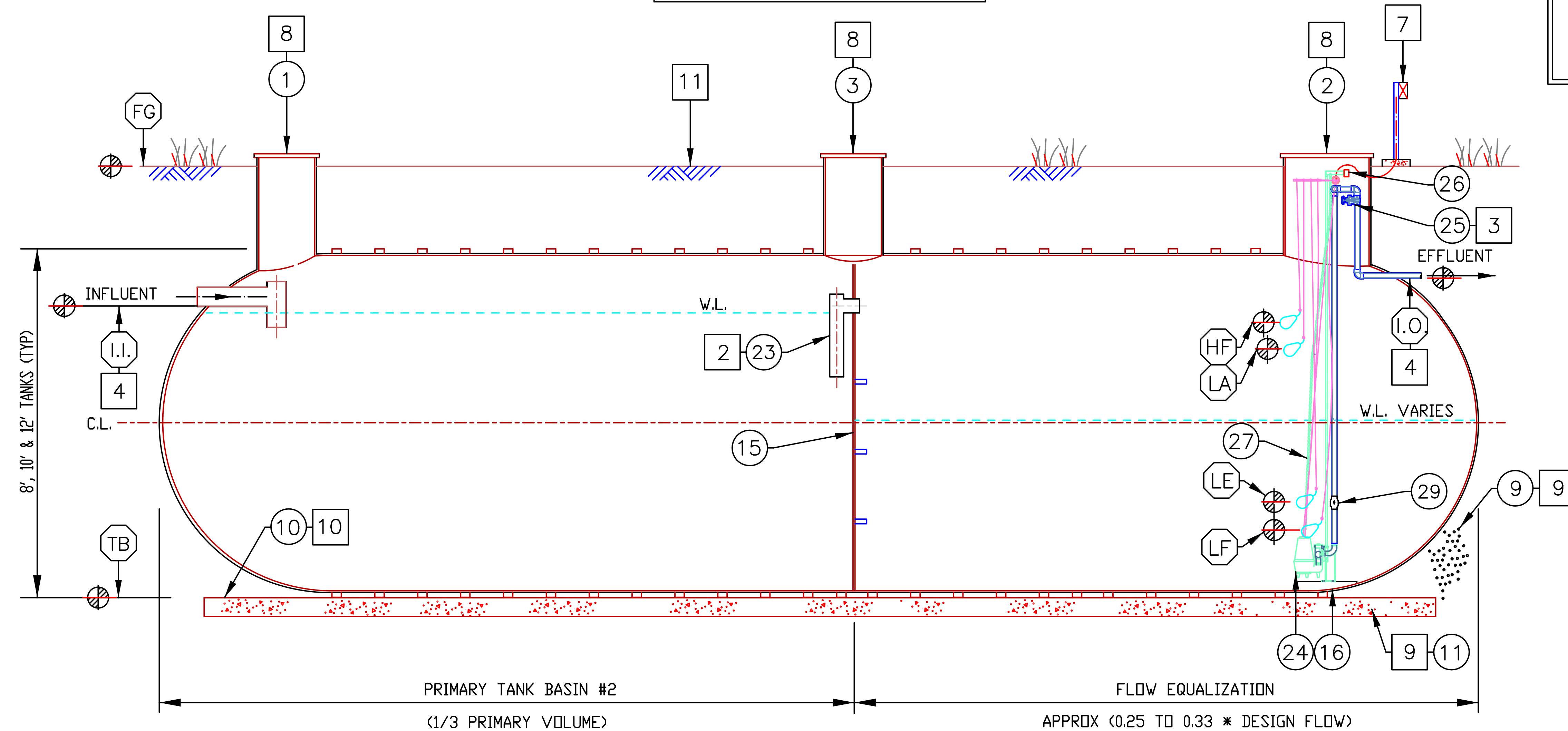
TITLE:	STAGE # 1 PRIMARY TANK ARRANGEMENT IN HORIZONTAL FRP TANK
DRAWING NO.:	1284-93
REVISION:	NONE
DATE:	AUGUST 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 2 OF 2

GENERAL PRIMARY TREATMENT STAGE 2 WITH EQUALIZATION

PRIMARY & EQUALIZATION TANK SECTIONS



SECTION VIEW

PROCESS TANK ELEVATIONS

- FINISH GRADE (FG): ______
- INVERT IN (I.I.): ______
- INVERT OUT (I.O.): ______
- TANK BASE (TB): ______

EQ FLOATS:
- HIGH FLOAT (HF): ______
- LAG FLOAT (LA): ______
- LEAD FLOAT (LE): ______
- LOW FLOAT (LF): ______

SEE SHEET 2 FOR NOTES

SYMBOL LEGEND:

- □ = NOTES
- ○ = COMPONENTS USED
- ⊘ = COMPONENTS NOT USED
- ○ = FLOAT OR INVERTS
- ⊕ = ELEVATIONS

FRP PROCESS TANK COMPONENTS

ITEM NO. ITEM DESCRIPTION	ITEM NO. ITEM DESCRIPTION	ITEM NO. ITEM DESCRIPTION
(1) - 24" DIAMETER ACCESS RISER (TYP.)	(16) - FRP PUMP PLATFORM	(31) - SUBMERSIBLE ASPIRATOR
(2) - 36" DIAMETER ACCESS RISER (TYP.)	(17) - NITRATE RECYCLE LINE (IF SPECIFIED)	(32) - ASPIRATOR INTAKE
(3) - 24" OR 36" DIAMETER ACCESS RISER (TYP.)	(18) - ANOXIC SLUDGE PUMP & RAIL ASSEMBLY	(33) - 30" DIAMETER ACCESS RISER (TYP.)
(4) - CARBON FEED CONDUIT (IF SPECIFIED)	(19) - AERATION MANIFOLD & SPARGER LATERALS	(34) - 2" AEROBIC MBBR INLET ASSEMBLY
(5) - DROP LEG & VALVE ASSEMBLY (PNUEMATIC)	(20) - TOP MOUNTED MIXER ON PEDESTAL MOUNT	(35) - FRP BAFFLE WALL
(6) - 4" PVC VENT	(21) - AERATION HEADER MANIFOLD	(36) - 2" ANOXIC MBBR INLET ASSEMBLY
(7) - STAINLESS STEEL MEDIA RETENTION SCREEN	(22) - 48" DIAMETER ACCESS RISER (TYP.)	(37) - FINAL PUMPS & RAIL ASSEMBLIES
(8) - NEUTRALLY BOUYANT HDPE BIOFILM CARRIER ELEMENTS (MEDIA)	(23) - EFFLUENT ASSEMBLY	(38) - SLUDGE RECYCLE LINE
(9) - BACKFILL	(24) - EQUALIZATION PUMPS & RAIL ASSEMBLIES	(39) - SUBMERSIBLE MIXER
(10) - CONCRETE DEADMEN (IF REQUIRED)	(25) - THROTTLING VALVE (HYDRAULIC)	
(11) - COMPACTED GRANULAR BASE	(26) - FRP SUPPORT BRACKET W/ HARDWARE	
(12) - NITRATE RECYCLE PUMP & RAIL ASSEMBLY	(27) - STAINLESS STEEL LIFTING CHAIN	
(13) - FRP BAFFLE WALL WITH 4 CENTER LINE 4" HOLDES (TYP.)	(28) - STAINLESS STEEL FLOAT BRACKET	
(14) - FRP AERATION GRID SUPPORT PLATFORM	(29) - CHECK VALVE (HYDRAULIC) (BY CONTRACTOR)	
(15) - FRP HYDROSTATIC BAFFLE WALLS	(30) - ALKALINITY FEED CONDUIT (IF SPECIFIED)	

EQUALIZATION PUMPS
MANUFACTURER: BARNES
MODEL: ______
- ___ V ___ PHASE
- ___ HP
- ___ DIA. DISCHARGE

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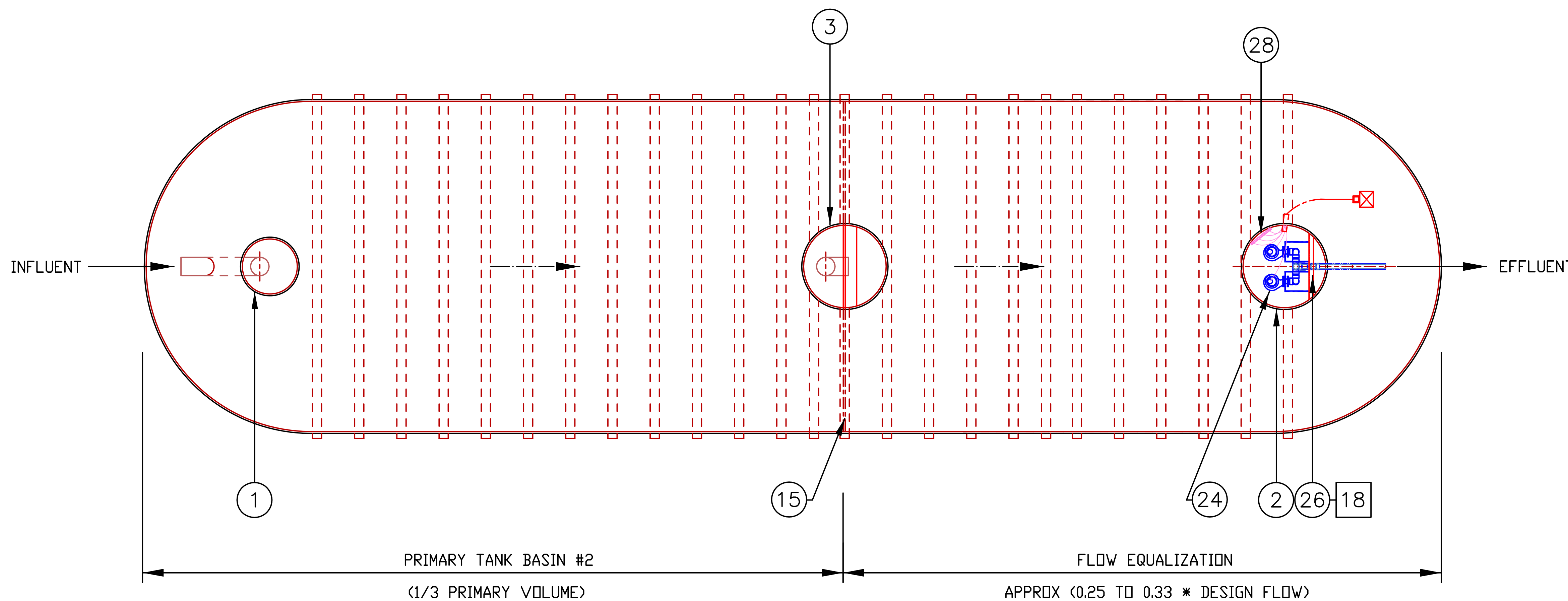
TITLE: STAGE 2 PRIMARY & EQUALIZATION TANK ARRANGEMENT IN HORIZONTAL FRP TANK

DRAWING NO.:	FRP-1284-97
REVISION:	NONE
DATE:	APRIL 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 1 OF 2

GENERAL PRIMARY TREATMENT STAGE 2 WITH EQUALIZATION

PLAN ON PRIMARY AND EQUALIZATION TANK SECTIONS



PLAN ON TANK

GENERAL NOTES:

1	TANK DEPICTED IS MEANT TO BE A GENERAL CONFIGURATION. ACTUAL TANK LENGTH, DIAMETER AND RISER LOCATIONS MAY VARY DEPENDING ON REQUIREMENTS.
2	EFFLUENT ASSEMBLY (FILTERS OR TEE) TO BE SIZED TO ACCOMODATE ALL FORWARD FLOWS AND RECYCLED FLOWS.
3	THROTTLING VALVE(S), LIFTING CHAINS AND PIPING UNIONS (IF APPLICABLE) TO BE LOCATED 16" (MAX) FROM TOP OF RISER.
4	SEE WWTP SYSTEM HYDRAULIC PROFILE FOR INVERT AND FLOAT ELEVATIONS.
5	CHEMICAL FEEDS SHOWN, ARE "IF SPECIFIED".
6	CONSULT AQUAPOINT TECHNICAL MANUAL FOR EQUIPMENT AND ELECTRICAL DETAILS.
7	CONSULT AQUAPOINT CONTROL PANEL'S FIELD WIRING DIAGRAM (SHIPPED IN PANEL) FOR REQUIREMENTS.
8	TANK RISER LENGHTS TO BE DETERMINED AND INSTALLED SEPERATELY. FOLLOW ALL FRP TANK INSTALLATION INSTRUCTIONS.
9	FOR INSTALLATION AND BACKFILLING INSTRUCTIONS CONSULT AND ADHERE TO THE FRP TANK MANUAL.
10	IF INSTALLED IN SEASONAL GROUNDWATER CONTACT ENGINEER TO SPECIFY ANCHORING & CONCRETE DEADMAN REQUIREMENTS.
11	MAXIMUM OVERBURDEN NOT TO EXCEED 6' WITHOUT WRITTEN AUTHORIZATION FROM THE MANUFACTURER.
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16	TANK RISER ABOVE MIXER MUST BE TALL ENOUGH FOR MIXER BASE, MIXER ASSEMBLY AND SUITABLE HEADSPACE. (IF APPLICABLE)
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18	SEE SEPERATE DRAWING(S) FOR DETAILS.

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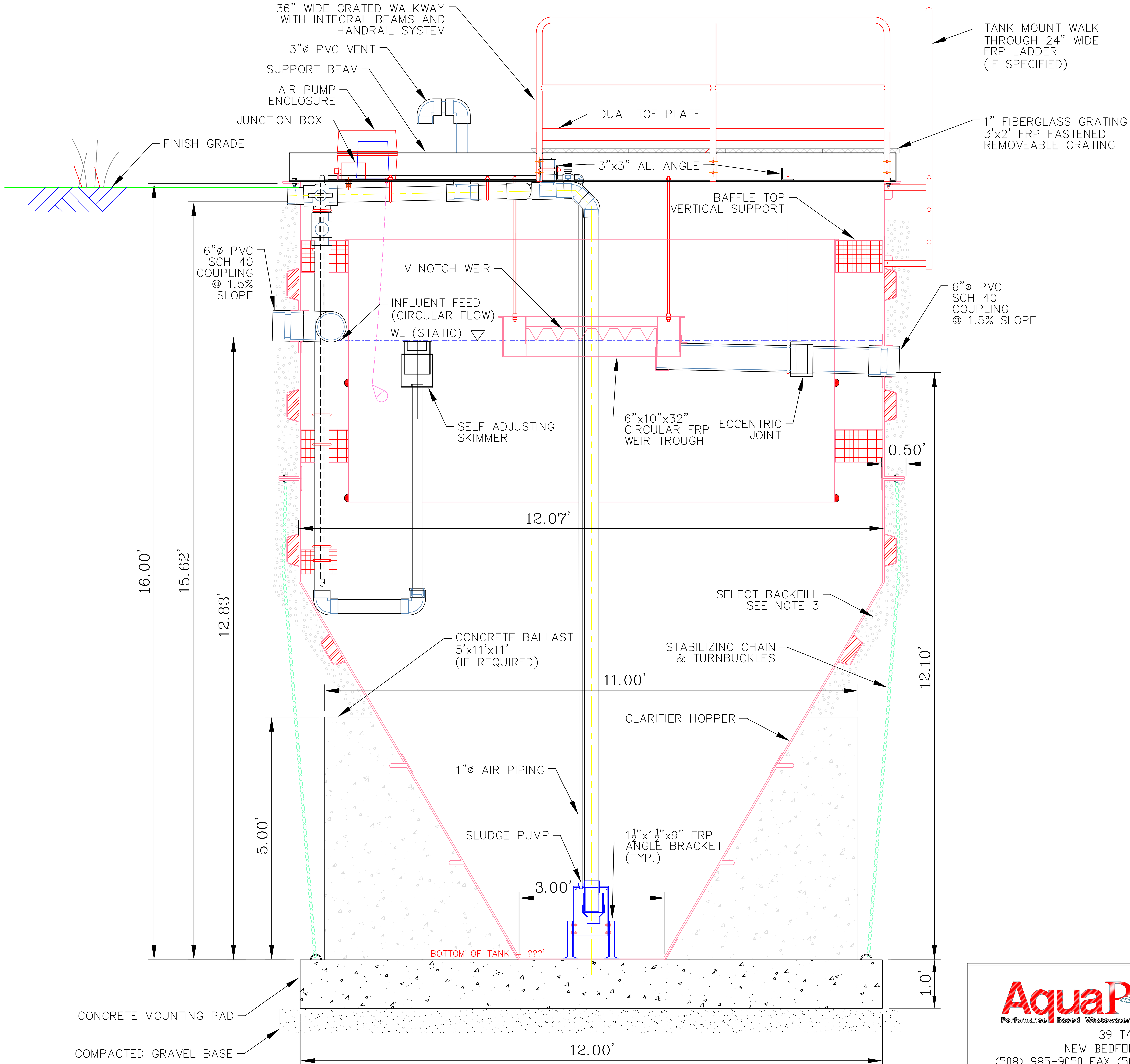
TITLE:	STAGE 2 PRIMARY & EQUALIZATION TANK ARRANGEMENT IN HORIZONTAL FRP TANK
DRAWING NO.:	FRP-1284-97
REVISION:	NONE
DATE:	APRIL 2016
DWN BY:	KML
SCALE:	NTS
SIZE:	B / A3
SHEET #:	SHEET 2 OF 2



ELEVATION VIEW

(OUTFITTED 12'ø CLARIFIER)

6,765 GALLONS

NOTES:

1. SCUM AND SLUDGE RETURN LINES TO HAVE A 1.5% SLOPE PITCHED TOWARDS THE RETURN/PRIMARY TANK.
2. FOR 12' FRP CLARIFIER MOUNTING PAD CONSTRUCTION DETAILS SEE DRAWING 1244-32.
3. FOR INSTALLATION AND BACKFILLING REQUIREMENTS CONSULT AND ADHERE TO THE FRP TANK MANUAL.

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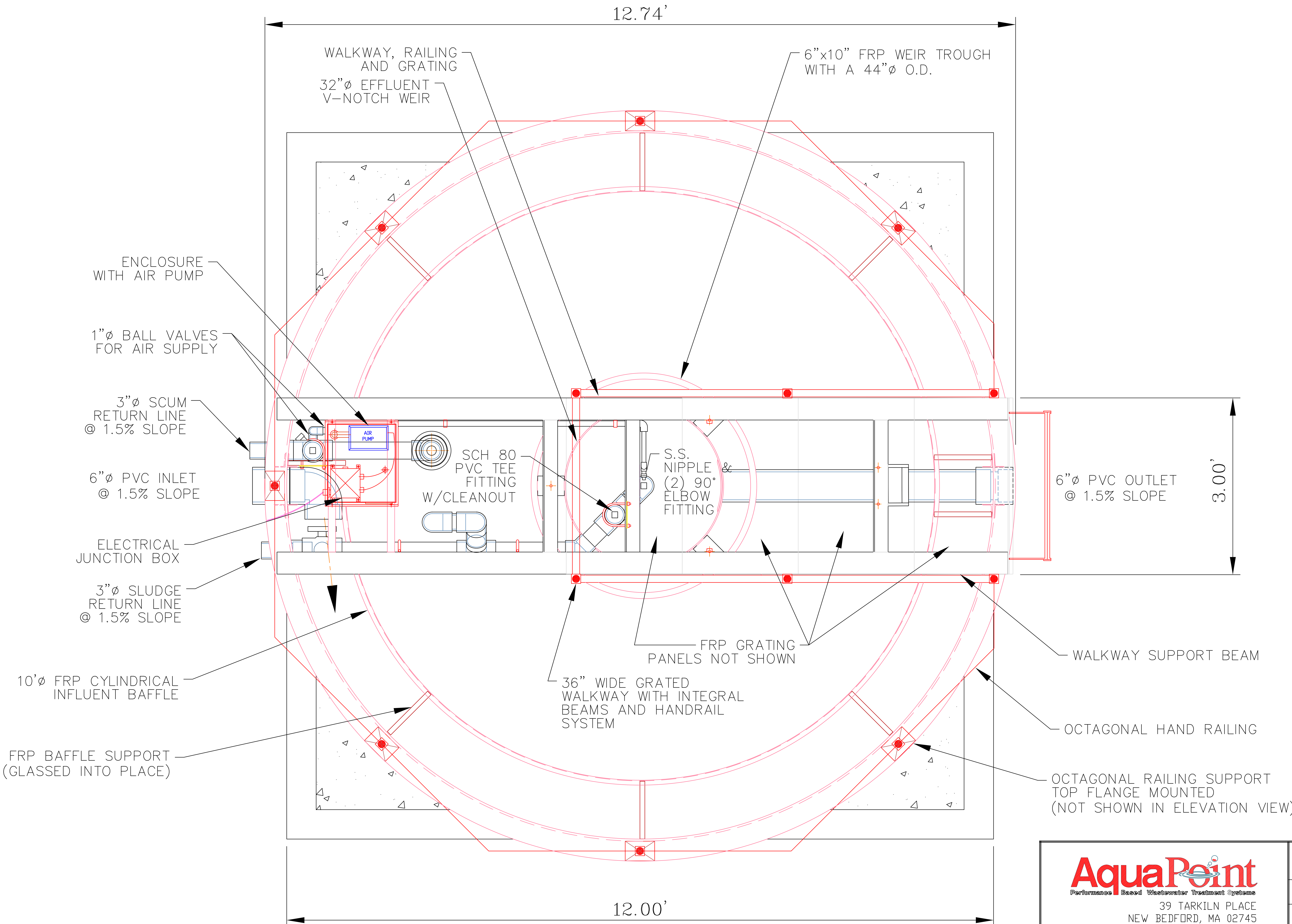
TITLE:	12' FRP HOPPER BOTTOM CLARIFIER
DRAWING NO.:	AWT 4064-CC
REVISION:	E
DATE:	JANUARY 29, 2019
DWN BY:	K. LEACH
SCALE:	NONE — SIZE: B / A3
SHEET:	1 OF 2



PLAN VIEW
(OUTFITTED 12'ø CLARIFIER)

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TITLE:	12' FRP HOPPER BOTTOM CLARIFIER		
DRAWING NO.:	AWT 4064-CC		
REVISION:	E		
DATE:	JANUARY 29, 2019		
DWN BY:	K. LEACH		
SCALE:	NONE	SIZE:	B / A3
SHEET:	2 OF 2		

APPENDIX I – COLLECTION SYSTEM COST ESTIMATE BREAKDOWN

Phase 1 Cost Estimate				
Item	**Unit**	**Unit Price**	**Quantity**	**Cost**
Construction Staking and Survey, compl.	%	$4,626,000.00	4.0%	$ 185,040.00
Construction Mobilization and Demobilization, compl.	%	$4,626,000.00	12.0%	$ 555,120.00
Traffic Control, cip.	%	$4,626,000.00	4.0%	$ 185,040.00
Seeding, cip.	LS	$10,000.00	1	$ 10,000.00
8" sewer, all depths, including pipe, excavation and compaction, cip.	LF	$92.30	18,490	$ 1,706,627.00
20" Jack and Bore, including .375" thick steel casing, casing spacers, excavation and support of bore and receiving pits & end seals (excl. 8" carrier pipe), compl.	LF	$500.00	470	$ 235,000.00
New Manhole, 4' DIA	EA	$13,850.00	86	$ 1,191,100.00
Rock Excavation, Remove & Dispose , cip.	CY	$360.00	3,090	$ 1,112,400.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip	CY	$120.00	3,090	$ 370,800.00
			SUBTOTAL	**$ 5,551,127.00**
Construction Contingency			30%	$ 1,665,338.10
Utility Relocation Allowance			N/A	$50,000
			Construction Cost Total	**$ 7,266,465.10**
Engineering Design (Not Calculated on Contingency)			7.50%	$ 420,084.53
Construction Oversight and Administration (Not Calculated on Contingency)			7.50%	$ 420,084.53
Resident Project Representative (RPR) - $30,000 per Month for 9 Months				$ 270,000.00
Permitting and Environmental (Not Calculated on Contingency)			2%	$ 112,022.54
			Engineering Total	**$ 1,222,191.59**
			Phase 1 Collection System Construction and Engineering Total	**$ 8,488,656.69**

Phase 2 Cost Estimate				
Item	**Unit**	**Unit Price**	**Quantity**	**Cost**
Construction Staking and Survey, compl.	%	$1,918,900.00	4.0%	$ 76,756.00
Construction Mobilization and Demobilization, compl.	%	$1,918,900.00	12.0%	$ 230,268.00
Traffic Control, cip.	%	$1,918,900.00	4.0%	$ 76,756.00
Seeding, cip.	LS	$5,000.00	1	$ 5,000.00
8" sewer, all depths, including pipe, excavation and compaction, cip.	LF	$92.30	3,992	$ 368,461.60
20" Jack and Bore, including .375" thick steel casing, casing spacers, excavation and support of bore and receiving pits & end seals (excl. 8" carrier pipe), compl.	LF	$500.00	350	$ 175,000.00
New Manhole, 4' DIA	EA	$13,850.00	19	$ 263,150.00
Lift Station Site Grading, including Fill, Borrow, Haul & Comp, Gravel Rock Cover & Install, cip	LS	$12,500.00	1	$ 12,500.00
Lift station and all associated infrastructure and appurtenances, including pumps, wet well, valves, valve vault, flow meter and vault, piping, dewatering, etc., cip.	EA	$400,000.00	1	$ 400,000.00
Lift Station Electrical, cip.	LS	$100,000.00	1	$ 100,000.00
Pressure Force Main Cleanouts, cip.	EA	$5,422.00	8	$ 43,376.00
2" sewer force main, cip.	LF	$40.00	1,221	$ 48,840.00
4" sewer force main, incl. line caps, cip.	LF	$70.00	1,221	$ 85,470.00
Rock Excavation, Remove & Dispose , cip.	CY	$360.00	869	$ 312,780.00
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip	CY	$120.00	869	$ 104,260.00
			SUBTOTAL	**$ 2,302,617.60**
Construction Contingency			30%	$ 690,785.28
Utility Relocation Allowance			N/A	$25,000
			Construction Cost Total	**$ 3,018,402.88**
Engineering Design (Not Calculated on Contingency)			7.50%	$ 174,571.32
Construction Oversight and Administration (Not Calculated on Contingency)			7.50%	$ 174,571.32
Resident Project Representative (RPR) - $30,000 per Month for 4 Months				$ 120,000.00
Permitting and Environmental (Not Calculated on Contingency)			2%	$ 46,552.35
			Engineering Total	**$ 515,694.99**
			Phase 2 Collection System Construction and Engineering Total	**$ 3,534,097.87**

Phase 3 Cost Estimate

Item	Unit	Unit Price	Quantity	Cost
Construction Staking and Survey, compl.	%	$1,511,400.00	4.0%	$ 60,456.00
Construction Mobilization and Demobilization, compl.	%	$1,511,400.00	12.0%	$ 181,368.00
Traffic Control, cip.	%	$1,511,400.00	4.0%	$ 60,456.00
Seeding, cip.	LS	$5,000.00	1	$ 5,000.00
8" sewer, all depths, including pipe, excavation and compaction, cip.	LF	$92.30	4,044	$ 373,247.36
New Manhole, 4' DIA	EA	$13,850.00	10	$ 138,500.00
Lift Station Site Grading, including Fill, Borrow, Haul & Comp, Gravel Rock Cover & Install, cip	LS	$12,500.00	1	$ 12,500.00
Lift station and all associated infrastructure and appurtenances, including pumps, wet well, valves, valve vault, flow meter and vault, piping, dewatering, etc., cip.	EA	$400,000.00	1	$ 400,000.00
Lift Station Electrical, cip.	LS	$100,000.00	1	$ 100,000.00
Pressure Force Main Cleanouts, cip.	EA	$5,422.00	2	$ 10,844.00
2" sewer force main, cip.	LF	$40.00	778	$ 31,120.00
4" sewer force main, incl. line caps, cip.	LF	$70.00	778	$ 54,450.90
Rock Excavation, Remove & Dispose , cip.	CY	$360.00	804	$ 289,303.20
Fill, construction, incl. excavation, placement & compaction of unclassified material, over 2 ft. deep, cip	CY	$120.00	804	$ 96,434.40
			SUBTOTAL	**$ 1,813,679.86**
Construction Contingency			30%	$ 544,103.96
Utility Relocation Allowance			N/A	$25,000
			Construction Cost Total	**$ 2,382,783.81**
Engineering Design (Not Calculated on Contingency)			7.50%	$ 137,900.99
Construction Oversight and Administration (Not Calculated on Contingency)			7.50%	$ 137,900.99
Resident Project Representative (RPR) - $30,000 per Month for 4 Months				$ 120,000.00
Permitting and Environmental (Not Calculated on Contingency)			2%	$ 36,773.60
			Engineering Total	**$ 432,575.58**
			Phase 3 Collection System Construction and Engineering Total	**$ 2,815,359.39**

APPENDIX J – COLLECTION SYSTEM O&M COST BREAKDOWNS

Appendix J - Collection System O&M Cost Breakdowns

Alternative 2, Phase 1 – Summary of Estimated O&M Costs

Item	Unit	Annual Cost
Power	LS	-
General Maintenance	LS	$5,000.00
Labor and Benefits	LS	$7,300.00
	Total	**$12,300.00**
	Present Value of O&M Cost	**$330,505.61**

Alternative 2, Phase 2 – Summary of Estimated O&M Costs

Item	Unit	Annual Cost
Power	LS	$2,120.00
General Maintenance	LS	$12,520.00
Labor and Benefits	LS	$3,700.00
	Total	**$18,340.00**
	Present Value of O&M Cost	**$492,802.67**

Alternative 2, Phase 3 – Summary of Estimated O&M Costs

Item	Unit	Annual Cost
Power	LS	$2,120.00
General Maintenance	LS	$12,520.00
Labor and Benefits	LS	$3,700.00
	Total	**$18,340.00**
	Present Value of O&M Cost	**$492,802.67**