FINAL

Pond Design Strategy Report

Pond Optimization Study 2

Submitted to:

Wastren Advantage, Inc.

1571 Shyville Road

Piketon, Ohio 45661

Submitted by:

Amec Foster Wheeler Environment & Infrastructure, Inc.

San Diego, California

February 2017

Amec Foster Wheeler Project No. 1655500023

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amec foster wheeler

February 2017

Dave Sablosky
Wastren Advantage, Inc.
1571 Shyville Road
Piketon, Ohio45661

Re: Final Design Strategy Report for Paradox Valley Unit Pond Optimization Study

Dear Dave:

The report included here satisfies the deliverable for the Paradox Valley Unit Evaporation Ponds Study 2: Final Pond Design Strategy Report. This is a final version that has been made 508-compliant.

If you have any questions or concerns regarding this report, please contact Carla Scheidlinger at 858-300-4311 or by email at carla.scheidlinger@amecfw.com.

Respectfully submitted,

Amec Foster Wheeler Environment & Infrastructure, Inc.

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EXECUTIVE SUMMARY

The Bureau of Reclamation (Reclamation) is currently evaluating alternatives for brine disposal for the Paradox Valley Unit (PVU). One of the long-term disposal alternatives under consideration is evaporation of brine in ponds and either sale or disposal of salt products. This report details conceptual designs associated with the evaporation pond alternative of brine disposal for three sites identified in the Paradox Valley region during the Pond Site Selection Strategy study. These sites are designated Paradox NW, BLM and Landfill. The conceptual designs were prepared for a 50-year life and include brine and freshwater delivery pipelines to each site, evaporation ponds and evaluation of disposal of salt in a salt storage facility or in the Broad Canyon landfill.

Topographic surveys were carried out at each site using unmanned aerial vehicle (UAV) and photogrammetry methods. The topographic surveys were used to develop the pond and salt storage facility layouts, grading and estimation of construction quantities for cost estimation. The designs take into consideration pond construction and operational aspects, site constraints such as topography and surface water management, and measures for wildlife protection.

The Paradox NW site was identified to be the most economically attractive site relative to the BLM and Landfill sites based on its proximity to Reclamation's brine extraction facility and freshwater source at the Dolores River, relatively gentle and uniform slopes, minimal topographic complexity, and lower estimated costs compared to the BLM and Landfill sites. Due to the distance to the Broad Canyon landfill, construction of an on-site salt storage facility would be the preferred method to dispose of salt at the Paradox NW and BLM sites.

Estimated capital costs for each site are summarized in Table 1.

Table 1. Summary of Capital Costs

Site	Estimated Capital Costs			
	Brine and Fresh Water Pipelines	Evaporation Ponds	Salt Storage Facility	Total Capital Cost
Paradox NW	$4,623,000	$42,238,000	$2,194,000	$49,055,000
BLM	$8,529,000	$43,534,000	$2,047,000	$54,110,000
Landfill	$28,465,000	$60,310,000	N/A	$88,775,000

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ACRONYMS AND ABBREVIATIONS

AMSL	Above mean sea level
AF	acre feet
Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure, Inc.
BLM	Bureau of Land Management
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CQA	Construction Quality Assurance
DR	dimension ratio
ft	feet
gpm	gallons per minute
H_2S	hydrogen sulfide
HDPE	high density polyethylene
HP	horsepower
IDF	Inflow Design Flood
LCRS	Leachate Collection and Removal system
lf	linear feet
MTO	Material Take Off
NPV	Net Present Value
PERA	Predictive Ecological Risk Analysis
PVC	polyvinyl chloride
PVU	Paradox Valley Unit
Reclamation	Bureau of Reclamation
Sch	Schedule
STF	Surface water Treatment Facility

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1.0 BACKGROUND AND INTRODUCTION

1.1 Statement of Problem

The Bureau of Reclamation's (Reclamation) Paradox Valley Unit (PVU) is a component of the Colorado River Basin Salinity Control Program, a multi-works program to control the salinity of Colorado River water delivered to users in the United States and Mexico. The PVU currently intercepts 200 gpm of 260,000 mg/l brine and diverts it to a 16,000' deep injection well for disposal. The injection rate has been curtailed during the 20 year life of the well due mainly to induced seismic activity associated with the injection process. At the current rate, Reclamation prevents approximately 100,000 tons of salt per year from entering the Colorado River system. The current collection well field is capable of producing 400 gpm. However salinity control benefits may decrease when pumping in excess of 300 gpm. Therefore, for purposes of this study, the goal is to control up to 170,000 tons per year, or 300 gpm. Due to current and future limitations of the injection well, and long term salinity control considerations at Paradox, Reclamation is currently evaluating alternative methods of brine disposal of this produced brine. One of the long-term strategies being considered for brine disposal is diverting the brine to an evaporation pond or series of ponds. The Pond Optimization Study, of which this Pond Design Strategy report is a part, evaluates the potential development of a series of evaporation ponds on three sites identified in the Paradox Valley region.

Amec Foster Wheeler is conducting studies for three other aspects of the evaporation ponds. These studies include the management of hydrogen sulfide (H_2S), the nature and disposal options for the salt byproducts produced in the ponds, and the ecological risk associated with the development and operation of the ponds. The results of these studies are integrated as appropriate with the pond optimization study.

This report presents the results of the pond design evaluation. For each of the three sites selected during the Pond Site Selection Strategy study, pond construction aspects and costs are considered, as well as the conceptual costs associated with the delivery of brine and of freshwater. This information allows for the selection of a preferred site based on costs and logistics.

1.2 Location

The PVU is located near Bedrock, Colorado in the Paradox Valley of Montrose County, about 10 miles east of the Colorado-Utah state line (Figure 100. This, and all design figures, are found at the end of the report, before the Appendices). The well sites are located adjacent to the Dolores River, which flows from south to north through the valley. The elevation of the well sites is about 5000 feet. Three sites have been evaluated for the evaporation ponds and salt storage facility: (i) NW Paradox site; (ii) BLM site, and (iii) Landfill site. The locations of these sites is presented on Figure 100. The Broad Canyon Landfill, which is discussed in the disposal sections, is located approximately 25 miles from the production well sites, adjacent to the Landfill site.

1.3 Organization of Report

The report begins with a summary of the findings of the Site Selection process, and the assumptions about pond sizes and configurations. It discusses the considerations that were used, as well as the methods, to determine how the ponds were sited on each property, making reference to other studies and reports that are part of this overall project. Considerations regarding environmental issues are summarized. Then, each site is discussed individually, with information presented regarding the rationale for the selection of each site for evaluation, followed by figures and tables that show infrastructure considerations for each site. Information and figures include access, earthwork, delivery of brine and freshwater to the site, methods for protection of the environment, and disposal of salt products at the site. There is a summary table for each site that shows complete conceptual construction costs for pond development.

2.0 PROCESS FOR DEVELOPMENT OF DESIGN STRATEGY

2.1 Site Selection

The selection of three sites in the Paradox Valley region was the product of an evaluation process that involved a map evaluation effort, a field trip, and extensive discussions with a team that included Reclamation personnel, on-site PVU management personnel, salt product and process experts, consulting engineers, environmental risk analysts, and project managers. This process is described in full in the Site Selection Strategy report (Amec Foster Wheeler 2016a). The process resulted in the selection of three sites in the Paradox Valley region, identified as Paradox Northwest (Paradox NW), BLM, and Landfill. It is these sites that are considered in detail in this design strategy report.

2.2 Evaporation Ponds and Salt Products

A key consideration in the design of the ponds is an understanding of the processes that will lead to the evaporation of the brine produced by the PVU wells, and of the products that will result from the evaporative processes. Issues considered regarding these processes are discussed in this section.

There are five different types of ponds that make up the evaporation pond sequence. These are the surge pond, the concentrator pond, four crystallizer ponds, and the bittern concentration pond plus a small bittern product storage pond. Additionally, there is a freshwater pond. The approximate size and surface area of the ponds is presented in Table 2.

Table 2. Volumes and Acres For Each Kind of Pond

Pond	Volume (acre-ft)	Surface Area (acres)
Surge Pond	190	27
Concentrator Pond	58	39
Crystallizer Ponds (4 ponds)	435 (total 4 ponds)	290 (total 4 ponds)
Bittern	150	24
Bittern Product	10	2
Freshwater	-	6

The method for determining the size of each pond is detailed in the Byproducts Disposal report (Amec Foster Wheeler 2016b). Briefly, a model was developed using the rate of flow anticipated by Reclamation, the initial chemistry of the brine, the characteristics of the brine as it evaporated under laboratory conditions, and an evaluation of the history of weather and climate in the region. The results of this model, when optimized for the production of a preferred solid salt product, showed the size of the ponds that will be required to produce that product under the conditions evaluated. The design strategy works with these pond types, using the same size determinations for each site. It should be noted that the hydrogen sulfide treatment process will result in precipitation of an estimated 60 tons per year of ferric hydroxide and elemental sulfur into the surge pond, which will result in a highly compacted mass that will also include precipitated salt and other solids. At closure, the solids would be disposed of in the salt storage facility and covered by a native soil cover and/or the final cover system. The solids shall be maintained moist to preclude formation of dust. The size of the surge pond was increased by approximately 10 acre-feet to accommodate these precipitates over the 50 year operational period. A general schematic showing the pond flow sequence and sizing is presented in Figure 110.

The evaporation ponds are not considered for permanent storage, but rather for evaporation until salt is harvested and transported to the salt storage facility or sold. The evaporation ponds and brine will be regulated by CDPHE as “environmental media” and not as impoundments. As such, only a single liner system equivalent with a hydraulic conductivity less than $1x10^{-6}$ cm/sec is required. This conceptual design of the ponds is based on installation of a 60 mil HDPE geomembrane for each pond.

If the ponds were to be unlined, a discharge permit would be required. A discharge permit application would require site specific evaluation of groundwater depth and flow, geology/lithology, surrounding land use, etc.

Conceptual design concepts for the evaporation ponds and the salt storage facility are presented in Section 4.1.

2.3 Topographic Data

The existing topographic data for the sites chosen was inadequate for the level of design and cost to which the project is committed. To provide sufficient topographic data to inform a responsible design, a topographic survey using photogrammetry methods was acquired by Juniper Unmanned of Golden, Colorado for the three sites to allow for conceptual grading plans and pumping strategies to be developed. It is this data that was used in the development of the pond configurations and construction quantities presented in this report.

2.4 Incorporation of Salt Storage Facility

The Byproducts Disposal report (Amec Foster Wheeler 2016b) presented a finding that even if some portion of the solid salt produced is marketable in some years, the requirement of the project to produce brine at a constant rate will make it necessary to anticipate storing some amount of solid salt product in at least some years. This is because the market is unpredictable as to the requirement for

road de-icing salt, which is the principal product the project anticipates producing. Therefore, the Paradox NW and BLM site design incorporates a salt storage facility that would be constructed and permitted for the exclusive use of the evaporation pond site. For the Landfill site, the harvested salt would be disposed of in the adjacent Broad Canyon Landfill. The details of the permitting requirements are in the Byproducts Disposal report (Amec Foster Wheeler 2016b).

2.5 Incorporation of a Freshwater Pond for Environmental Mitigation

The evaporation ponds present a specific risk to wildlife, even if a fence is constructed to exclude land mammals from the ponds. Birds that could be attracted to the ponds risk the encrusting of their feathers with salt, and ingesting saline water. The appropriate mitigation for this eventuality is to construct a freshwater pond adjacent to the evaporation ponds, as described in the Predictive Ecological Risk Analysis (PERA) report (Amec Foster Wheeler 2016c). Waterfowl or other birds that experience negative effects of contact with the saline water of any of the ponds could seek refuge on the freshwater pond that would allow them to clean their feathers and imbibe freshwater. The PERA determined that such a pond, if adjacent to the evaporation ponds, could be as small as 6 acres, and could be operated such that it could be reduced in volume during the summer months, refilling during the migration season to its full volume. A pond meeting the PERA requirements of 6 acres has been designed adjacent to the evaporation pond complex at all sites evaluated. To minimize water losses to infiltration, the freshwater pond will be lined with a single geomembrane. The geomembrane will be covered with a soil layer to protect the geomembrane and provide habitat. A portion of the freshwater pond will be aerated with a coarse bubble diffused air system to prevent complete surface freeze up.

3.0 CRITERIA FOR OPTIMAL POND DESIGN

3.1 Topography and Site Conditions

One of the criteria for the initial selection of pond sites was topography. Sites were selected that did not have any major drainages upslope of the presumed pond location, and which generally had an overall slope of less than 4% as determined from the topographic contours available on United States Geological Survey (USGS) topographic maps (Amec Foster Wheeler 2016a). Each site, however, has unique topographical challenges that the design team addressed in the development of the conceptual design approach for each site. The topographic survey data acquired for each site allowed for the understanding of micro-topographic features that were incorporated into the pond design, and which affected pond placement and construction cost. In addition, the pond design took into account the needs of operation (Amec Foster Wheeler 2016d), and provided for gravity feed from one pond to another to the extent allowed by the topography.

3.1.1 Paradox NW Site

The Paradox NW site is located at the foot of slopes of the northern flank of the Paradox Valley, approximately 3.5 miles north of the town of Bedrock and 3 miles east of the town of Paradox. The site is mapped as Quaternary alluvial/colluvial fan material (Withington, 1955). Topography at the Paradox NW site typically slopes at 1.5 to 4% down to the south, with localized slopes up to approximately 10%

(especially at the northern side of the site). Several small washes/arroyos cross the site in a dendritic pattern. While these washes do not present perennial flows, surface water diversion channels will likely be needed along the northern margin of the site to route stormwater away from and around the proposed site infrastructure.

Localized hills with 25 to 50 feet of relief are located at the southern portion of the site. Ponds located in this area would require significant excavation and may encounter bedrock. These hills constitute approximately 15% of the site area.

The conceptual design for the ponds at the Paradox NW site consists of:

- The surge pond is located at the topographic high point at the northwestern portion of the site. Brine from the surge pond will be transferred to the concentrator pond by gravity through a concrete lined channel at flow rates up to 500 gpm. A sluice gate at the channel entrance will be used as necessary to control flow rate. Channel dimensions are 2 feet bottom width with vertical side walls. Drop structures will used to control velocity.
- The concentrator pond has been designed to be long and narrow to provide a longer brine flowpath conducive to brine evaporation (i.e., avoid brine “short-circuiting” from the inlet to outlet).
- Discharge from the concentrator pond to the crystallizer ponds will be through a network of trapezoidal lined channels at flow rates up to 300 gpm. A sluice gate will control flow from the concentrator. Channel dimensions will be 1 foot bottom width with 2:1 side slopes and a minimum channel slope of 0.3%. Intra-channel sluice gates will direct flow to any of the four crystallizer ponds.
- When brine in the crystallizers reaches the bittern point, it will be pumped from crystallizer sumps to an open, lined channel network to transfer to the bittern pond, located at the southern end of the site. The system will be designed for a pumping rate of 4,800 gpm to 5,000 gpm to allow for pumping the volume of one crystallizer pond over a five day period. The pumps will be portable, diesel driven, variable speed, self-priming centrifugal pumps with 12 inch rubber hose suction lines and 12 inch rubber hose discharge lines. The open channel network will have channel dimensions of 2 foot bottom width and 2:1 side slopes.
- Prior to salt harvest, the liquid contents of a crystallizer pond will be pumped to another crystallizer pond. The portable diesel driven pump described above will be used for this service as well. Depending on the pond to pond transfer points, up to 2,200 feet of rubber discharge hose may be required. The pump will be sized for this duty, and operate at lower speeds for other transfers.
- Concentrated bittern will be pumped from the deep portion of the bittern pond to an adjacent bittern product pond. The bittern product pump will be sized at 125 gpm to allow typical daily bittern production to be pumped in a 6-hr period. The bittern product pump will also be used to pump from the bittern product pond to truck loading.
- Bittern solids will be removed by backhoe or dragline every few years to the salt storage facility.
- The freshwater pond is located near the concentrator pond at the north side of the site. Freshwater will be pumped/piped to the hydrogen sulfide treatment plant and to each brine/bittern transfer point to provide freshwater to channels, pumps and pipelines during

brine/bittern transfers. The capacity of the fresh water pumping system will be 50 gpm. A portion of the freshwater pond will be aerated with a coarse bubble diffused air system to prevent complete surface freeze up.

- The salt storage facility is located at the southeastern portion of the site. Salt harvested from the crystallizers will be hauled by truck to the salt storage facility.
- Access roads are provided to the hydrogen sulfide treatment plant, along the perimeter of all ponds and to the salt storage facility.

3.1.2 BLM Site

The BLM site is located in the Paradox Valley near the intersection of Highway 90 and BB16 Road and is bounded by Highway 90 on the south and East Paradox Creek on the north. The site is mapped as Quaternary alluvial, colluvial and eolian deposits (Cater et al., 1955). The ground surface at the site generally slopes 1.5 to 5% down to the north towards East Paradox Creek. Based on studies performed for the Piñon Ridge Uranium project, located south of the BLM site, depth to groundwater in the area is greater than 450 feet (Golder, 2008).

The western portion of the site is limited by “badlands-type” topography, characterized by steep, incised arroyos with high drainage density. Pond construction in this area should be avoided as it would be difficult and require significant earthworks. Less dense drainages tributary to East Paradox Creek cross the eastern portion of the site. Ponds will need to either be sited between these drainages or a diversion channel will need to be constructed to intercept surface water (i.e., stormwater) from these drainages and route it around the facilities.

The conceptual design for the ponds at the BLM site consists of:

- The surge pond is located at the topographic high point at the south central portion of the site. Brine from the surge pond will be transferred to the concentrator pond by gravity through a concrete lined channel at flow rates up to 500 gpm. A sluice gate at the channel entrance will be used as necessary to control flow rate. Channel dimensions are 2 feet bottom width with vertical side walls. Drop structures will used to control velocity.
- The concentrator pond has been designed to be long and narrow to provide a longer brine flowpath conducive to brine evaporation (i.e., avoid brine “short-circuiting” from the inlet to outlet).
- Discharge from the concentrator pond to the crystallizer ponds will be through a network of trapezoidal lined channels at flow rates up to 300 gpm. A sluice gate will control flow from the concentrator. Channel dimensions will be 1 foot bottom width with 2:1 side slopes and a minimum channel slope of 0.3%. Intra-channel sluice gates will direct flow to any of the four crystallizer ponds.
- When brine in the crystallizers reaches the bittern point, it will be pumped from the crystallizer sumps to an open, lined channel network to transfer to the bittern pond, located at the northern end of the site.
- The system will be designed for a pumping rate of 4,800 gpm to 5,000 gpm to allow for pumping the volume of one crystallizer pond over a five day period. The pumps will be portable, diesel

driven, variable speed, self-priming centrifugal pumps with 12 inch rubber hose suction lines and 12 inch rubber hose discharge lines. The open channel network will have channel dimensions of 2 foot bottom width and 2:1 side slopes.

- Prior to salt harvest, the liquid contents of a crystallizer pond will be pumped to another crystallizer pond. The portable diesel driven pump described above will be used for this service as well. Depending on the pond to pond transfer points, up to 2,200 feet of rubber discharge hose may be required. The pump will be sized for this duty, and operate at lower speeds for other transfers.
- Concentrated bittern will be pumped from the deep portion of the bittern pond to an adjacent bittern product pond. The bittern product pump will be sized at 125 gpm to allow typical daily bittern production to be pumped in a 6-hr period. The bittern product pump will also be used to pump from the bittern product pond to truck loading.
- Bittern solids will be removed by backhoe or dragline every few years to the salt storage facility.
- The freshwater pond is located near the bittern pond at the south side of the site. Freshwater will be pumped/piped to the hydrogen sulfide treatment plant and to each brine/bittern transfer point to provide freshwater to channels, pumps and pipelines during brine/bittern transfers. The capacity of the fresh water pumping system will be 50 gpm. A portion of the freshwater pond will be aerated with a coarse bubble diffused air system to prevent complete surface freeze up.
- Construction of a surface water diversion channel is likely to be necessary along the southern limits of the site to divert stormwater from the natural channel away from and around the east side of the proposed ponds.
- The salt storage facility is located at the western portion of the site. Salt harvested from the crystallizers will be hauled by truck to the salt storage facility.
- Access roads are provided to the hydrogen sulfide treatment plant, along the perimeter of all ponds and to the salt storage facility.

3.1.3 Landfill Site

The Landfill site is located approximately 5 miles south of the town of Naturita, adjacent to the Broad Canyon Landfill. The ground surface at the site generally slopes 2 to 4% down to the north, with steeper slopes (5 to 7%) at the southern portion of the site. A northeast-southwest trending ridge runs along the northwest side of the Broad Canyon Landfill. Construction of ponds on the ridge should be avoided due to the significant earthworks quantities that would be required.

The site is mapped as Cretaceous Dakota Sandston and Burro Canyon Formation (Williams, 1964). Based on discussions with the operator of the Broad Canyon Landfill, bedrock consisting of interbedded shale and sandstone have typically been encountered within 5 feet or so of the ground surface at the site. These ground conditions may provide justification for design of alternative liner systems based on low hydraulic conductivity of the lithology. However, blasting may be required for pond excavation, which would increase construction costs. Groundwater was reported at a depth of approximately 60 feet in a nearby well by the landfill operator.

Two north-south trending drainages tributary to Long Draw cross the site. These drainages are steeply incised at the southern and northern limits of the site, and would present challenges to pond design and construction in these areas. For the central portion of the site, pond construction should either avoid the drainages, if possible, or may be sited within the drainages with construction of surface water diversion channels to route stormwater around the ponds.

The conceptual design for the ponds at the Landfill site consists of:

- The surge pond is located at the topographic high point at the northwestern portion of the site. Brine from the surge pond will be transferred to the concentrator pond by gravity through a concrete lined channel at flow rates up to 500 gpm. A sluice gate at the channel entrance will be used as necessary to control flow rate. Channel dimensions are 2 feet bottom width with vertical side walls. Drop structures will used to control velocity.
- The concentrator pond has been designed to be long and narrow to provide a longer brine flowpath conducive to brine evaporation (i.e., avoid brine "short-circuiting" from the inlet to outlet). Discharge from the concentrator pond to the crystallizer ponds will be through a network of trapezoidal lined channels at flow rates up to 300 gpm. A sluice gate will control flow from the concentrator. Channel dimensions will be 1 foot bottom width with 2:1 side slopes and a minimum channel slope of 0.3. Intra-channel sluice gates will direct flow to any of the four crystallizer ponds.
- Brine transfers from the concentrator to the four crystallizer ponds will be via gravity flow through a lined channel. Figure 180 presents a typical section of the lined channel.
- When brine in the crystallizers reaches the bittern point, it will be pumped from the crystallizer sumps to an open, lined channels to transfer to the bittern pond, located at the southern end of the site.
- The system will be designed for a pumping rate of 4,800 gpm to 5,000 gpm to allow for pumping the volume of one crystallizer pond over a five day period. The pumps will be portable, diesel driven, variable speed, self-priming centrifugal pumps with 12 inch rubber hose suction lines and 12 inch rubber hose discharge lines. The open channel network will have channel dimensions of 2 foot bottom width and 2:1 side slopes.
- Prior to salt harvest, the liquid contents of the crystallizer pond will be pumped to another crystallizer pond. The portable diesel driven pump described above will be used for this service as well. Depending on the pond to pond transfer points, up to 2,200 feet of rubber discharge hose may be required. The pump will be sized for this duty, and operate at lower speeds for other transfers.
- Concentrated bittern will be pumped from the deep portion of the bittern pond to an adjacent bittern product pond. . The bittern product pump will be sized at 125 gpm to allow typical daily bittern production to be pumped in a 6-hr period. The bittern product pump will also be used to pump from the bittern product pond to truck loading.
- Bittern solids will be removed by backhoe or dragline every few years to the Broad Canyon Landfill.
- The freshwater pond is located in the central portion of the site, just north of the Broad Canyon Landfill. Freshwater will be pumped/piped to the hydrogen sulfide treatment plant and to each brine/bittern transfer point to provide freshwater to channels, pumps and pipelines during

brine/bittern transfers. The capacity of the fresh water pumping system will be 50 gpm. A portion of the freshwater pond will be aerated with a coarse bubble diffused air system to prevent complete surface freeze up.

- Construction of a surface water diversion channel is likely to be necessary along the southern limits of the site to divert stormwater from the natural channel away from and around the west side of the proposed ponds.
- Access roads are provided to the hydrogen sulfide treatment plant, along the perimeter of all ponds and to the Broad Canyon Landfill.
- Salt harvested from the crystallizers will be hauled by truck to the adjacent Broad Canyon Landfill.

3.2 Minimizing Construction Costs

The costs having the most significant impact on the difference of total costs of each site are the earthworks (cut and fill) quantities, and distance from the brine and freshwater sources. Once a brine disposal alternative is selected from among the three alternatives, costs can likely be reduced by optimization of the earthworks cut and fill quantities. Topography with minimal complexity and gentle slopes help to minimize earthworks quantities. Costs for land acquisition, permitting, and utility distribution are not considered in this analysis.

3.3 Optimizing for Operational Strategy

The pond design is guided by operational considerations that are detailed in the Operational Strategy report (Amec Foster Wheeler 2016d). The critical aspects of pond design that relate to operation are the relative location of the ponds to each other in the sequence. The treatment facility H_2S must be located adjacent to the delivery point where well water is piped to the project, as the water must be treated before it is discharged to any open pond. As shown in the operation schematic (Figure 110), the surge pond is at the top of the pond series; it is expected that it will receive the water from the treatment facility through a pipeline, and can feed by gravity to the concentrator pond that is the first of the salt production ponds. The surge pond design criterion was that it be able to contain up to 180 acre-feet (AF) of brine during the winter months. The delivery from the concentrator to the crystallizers can be done by either gravity feed through a pipeline or open (lined) channel, or using a pump. The method specified depends on the configuration of each individual site. Delivery from the crystallizers to the bittern evaporation pond will be by open channel, where possible, and piped as necessary. The bittern will be recovered from a sump in a crystallizer pond and pumped to the open channel or directly to the bittern concentrator pond. A pump will also be used to deliver the concentrated bittern from the bottom of the bittern concentrator to the bittern product storage, and from the bittern storage to a truck to convey it to a point of sale. The exact position and configuration of each of these ponds depends on the specifics of site characteristics.

In addition, the ponds are designed such that the salt products can be removed from the crystallizers for storage or market. There are four individual crystallizer ponds, so that one can be managed for harvesting each year, as the others are managed for continuing solid salt deposition (Amec Foster Wheeler 2016b). Each crystallizer pond has an access route designed such that salt harvesting

equipment can enter the pond to remove solid salt. The crystallizer pond design includes a 2-foot protective layer over the geomembrane. It is envisioned a portion, and possibly majority, of the protective layer could be formed of salt.

3.4 Minimizing Risk to Migratory Birds and Other Wildlife

The PERA (Amec Foster Wheeler 2016c) identified certain risks to migratory birds and other wildlife associated with the evaporation ponds. Because of the very high salinity of the water that will be retained in these ponds, they will present a potentially significant hazard to wildlife that may attempt to use them for drinking, feeding, or resting. These hazards include the toxic effects from ingestion of the salts and trace elements in the water; osmotic imbalances from consuming or resting on the water; and entrapment, waterlogging, and eventual mortality due to salt encrustation. The PERA identified protective measures could be implemented to assure that impacts to wildlife are minimized, and the pond design incorporates appropriate measures. These include both active and passive methods, including barriers (netting and wires), hazing of various types, and providing alternative habitat. It was determined the most feasible method is construction and operation of year-round freshwater habitat of approximately 6 acres located adjacent to the evaporation ponds to provide alternate wetland habitat. A portion of the freshwater pond will be aerated with a coarse bubble diffused air system to prevent complete surface freeze up. Netting for the bittern and bittern product ponds is an alternative that is also considered, and this alternative is included for the conceptual designs. Finally, the entire site, including all ponds, is to be fenced to prevent access by non-avian wildlife.

If birds or wildlife gain access to the ponds in spite of the protective measures described, the facilities in the H_2S treatment plant could be used to recover such wildlife. Staff training would be provided by an appropriate agency or organization.

4.0 PROPOSED CONCEPTUAL DESIGNS

4.1 Basis of Designs

The following sections summarize the design basis used to develop costs for the conceptual designs of the brine and freshwater pipelines to the sites, the evaporation ponds and the salt storage facility. The ponds and salt storage facility were designed for a 50-year design life. Figures 120 through 180 present the locations and details of the infrastructure described in the following sections. Again, costs for land acquisition, permitting, and utility distribution are not considered in this analysis.

4.1.1 Evaporation Ponds

The conceptual design and cost estimate for the evaporation ponds for each site were based on the following components:

- **Brine Pipeline** – Brine pumped from Reclamation's well field at the Dolores River will be pumped and piped via pipeline to the selected site. Capital and operating and maintenance costs for the brine pipeline have been estimated.

- **Freshwater Pipeline** – Freshwater is required at site for addition to pipelines and channels during brine transfers, for keeping pumps, pipes, and channels from salting up, and to supply the freshwater pond. The freshwater supply is assumed to come from the existing freshwater tanks at the PVU injection well site and will be pumped and piped to the selected site. Capital and operating and maintenance costs for the freshwater pipeline have been estimated.
- **Earthworks** – Earthworks for the ponds includes clearing and grubbing, topsoil removal and stockpile, excavation, placement of compacted fill, subgrade preparation for liner installation, geomembrane anchor trench excavation and backfill and stormwater management and sediment control during construction. The perimeter of all ponds includes a 12-foot wide road for light vehicle access. Heavy vehicles will be needed only for access to the ponds for harvest activities, and they will be able to use access routes that connect directly between the pond and the outside of the ponds, with no need to traverse the access road. Earthworks for construction of the hydrogen sulfide treatment plant were included in the earthworks for the adjacent surge pond. The ponds have been designed to accommodate maximum brine levels, 6 inches of precipitation (Amec Foster Wheeler 2016b) and 2 feet of freeboard.
- **Liner System** – For the evaporation ponds, a single geomembrane liner installed over prepared subgrade was adopted for the conceptual designs. As the brine will be considered "environmental media" by CHPHE, only a single liner with a hydraulic conductivity less than 1 x 10^{-6} cm/sec is required. A 60 mil HDPE geomembrane was selected for the liner as it meets the hydraulic conductivity requirement and has very good durability and protection against UV degradation. A compacted clay liner would also be acceptable, however, it may prove difficult to find a suitable source and quantity of clay for the ponds near the project sites. The HDPE geomembrane in the evaporation ponds has an estimated operational life of 25 years and therefore would need to be replaced one time over the 50 year project life.
- **Bird Netting** –Netting is considered in the conceptual designs to restrict avian access to the bittern ponds. Effective installation requires a design allowing for snow-loading and one that also prevents ground entry by small mammals and birds. According to a professional net installation contractor, a maximum mesh size of 1 1/2 inches will allow for snow-loading and will exclude most birds. Netting should be suspended a minimum of 4 to 5 feet from the surface of the pond to prevent the net from sagging into the oil-covered pond during heavy snow-loads. Three-inch steel tubing can be used for support posts and are set a maximum of 7 feet apart. These are buried a minimum of 7 feet in depth and set in concrete. Three-inch steel tubing is also used as a top rail to connect the posts. Cable is strung across this frame at 7-foot intervals along the y-axis and the x-axis to form a grid of 7-foot squares by the cable. The netting is draped over this cable grid. Netting should be wide enough to drape down the sides of the frame to prevent ground entry by wildlife. A bottom perimeter cable strung along the bottom of the posts at ground level is used to attach the bottom of the net. Cables are strung over the net at 7-foot intervals to prevent the wind from whipping the net back and forth. Proper maintenance should be performed to repair holes in the netting and to re-stretch sagging nets after heavy snow-loads. Sides are netted to prevent ground entry by birds and other wildlife. Netting to exclude migratory birds should also extend down the sides of the supporting frame to prevent ground entry by birds and other wildlife. Netting should be replaced every 10 years.
- **Access Roads** – Gravel surfaced access roads to the hydrogen sulfide plant and to the salt storage facility are included in the designs. As mentioned previously, all ponds include a

perimeter access road. The cost for the pond perimeter access roads is included in the earthworks line item.

- **Wildlife Fence** – The conceptual designs include an 8-foot high wildlife fence around the entire site.
- **Brine Transfers** – Transfers of brine and bittern between ponds will be by lined open channel where gravity flow is feasible. The channels will be lined with 60 mil HDPE geomembrane. A typical section of the lined channel is presented on Figure 180. Transfer from the storage pond to the concentrator pond and from the concentrator pond to the crystallizer ponds will be a 24/7 operation during the hottest summer months at a brine transfer rate of approximately 245 gpm. Transfer from a crystallizer pond to the bittern pond will be sized to drain one pond volume over five days at a rate of 5,000 gpm. A portable self-priming diesel driven pump will be used to pump from the crystallizers to the open channels. During harvest, the volume of one crystallizer pond will be pumped to another using the same portable diesel powered self-priming 5,000 gpm pumps. Bittern will be transferred over a daily 6 hour period from the bittern pond to the bittern product pond at a production 125 gpm flow rate; delivery will be through 6-inch DR 11 HDPE pipeline. These same pumps will be used to load trucks.
- **Surface Water Diversion Channel** – The BLM and Landfill sites have drainages that cross the sites that carry intermittent or ephemeral flows. Where ponds impact drainages in the conceptual designs, diversion channels have been included to route stormwater around the proposed site infrastructure. It may be possible to avoid disturbance of natural drainages by modification of pond designs to non-rectangular shapes, thereby eliminating the need for these surface water diversion channels.
- **Indirect Costs** – Indirect costs considered include engineering design, construction management and construction quality assurance.
- **Operating and Maintenance** – Operation and maintenance costs of the evaporation ponds include making field measurements with hand-held instruments for identifying brine concentrations, harvesting salt from the crystallizers, management of pumping and piping systems for brine and freshwater, general maintenance of access roads, bird netting and geomembrane. Although adaptive management activities for wildlife protection could be implemented if necessary, costs for such as-yet undefined measures have not been anticipated in this evaluation.
- **Closure Costs** – For closure, all of the project's pond liners and their contents will be removed and disposed of in the salt storage facility. Any accumulated materials in the ponds will not be allowed to dry out, thus eliminating the need for dust suppression. The underlying ground will be tested and demonstrated to be clean. The site topography will be regraded and vegetated.

4.1.2 Evaporation Pond Dam Hazard Classification

According to the Colorado Rules and Regulations for Dam Safety and Dam Construction (DWR, 2007), the dam hazard classification is derived from an evaluation of the probable incremental adverse consequences due to failure of the dam. Consequences to be evaluated include the potential for loss of human life and damage to public and private structures and facilities. Four dam hazard categories are specified including "High Hazard", "Significant Hazard", "Low Hazard" and "No Public Hazard". The dam hazard classification will define design criteria for the ponds such as the Inflow Design Flood (IDF),

seepage and drainage design and stability evaluations. Dam breach analyses and flood inundation mapping would be necessary to determine the hazard classification of the various proposed pond perimeters. Making such determinations at this time is beyond the scope of this project.

Due to the remote nature of the project locations, the loss of human life due to a failure of one of the evaporation ponds is unlikely. Possible exceptions include residences downstream of the Paradox NW site, travelers on Highway 90 along the BLM site, and employees or visitors of the Broad Canyon landfill for the Landfill site. Likewise damage to structures and facilities resulting from a failure of an evaporation pond would tend to be minor due to the remote nature of these sites. Environmental impacts due to brine flow into drainages are possible.

4.1.3 Salt Storage Facility

The conceptual configuration of the salt storage facility consists of the following:

- Cell excavation on the order of 15 feet, with 2.5H:1V (horizontal:vertical) side slopes;
- An ultimate vertical height of salt of 115 feet over the liner (i.e., 100 feet above the surrounding ground surface); and
- Salt stacking slope angle (above grade) of 3H:1V.

The Salt Storage Facility would be designed, constructed and operated in accordance with the Code of Colorado Regulations for Solid Waste Disposal Sites and Facilities (6 CCR 1007-2 Part 1). As such the conceptual design of the Salt Storage Facility includes the following components:

- **Earthworks** - Earthworks for the ponds includes clearing and grubbing, topsoil removal and stockpile, excavation, placement of compacted fill, subgrade preparation for liner installation, geomembrane anchor trench excavation and backfill, and stormwater management and sediment control during construction.
- **Liner System** – For this study, the salt storage facility is assumed to be regulated as a solid waste landfill and as such would require a composite liner system with leak detection system**.** Due to the uncertainty of locating a soil borrow source near the project site that will provide sufficient volume and hydraulic conductivity characteristics for a soil barrier layer, a double geomembrane system has been considered for the conceptual design to preclude the need for a soil barrier layer. The double geomembrane liner is proposed to consist of 60-mil HDPE primary geomembrane overlying a 60-mil HDPE Drain Liner® secondary geomembrane. The Drain Liner® geomembrane includes raised studs on the top side of the geomembrane which creates a fluid flow medium between the primary and secondary geomembrane for leak detection and recovery. Leachate collected by the leak detection system will be routed to a collection sump and pumped back into the landfill.
- **Leachate Collection and Removal System (LCRS)** - The LCRS is proposed to consist of a network of 4-inch diameter corrugated, perforated polyethylene pipes installed on top of the primary geomembrane that will be sloped to provide drainage to a collection sump, where the leachate will be pumped and returned to the evaporation pond system's crystallizers. The piping network will be covered with an approximate 2-foot thick layer of harvested salt to provide protection of the liner system and act as a drainage medium to the piping system.

- **Wildlife Fence** – The salt storage facility will include an 8-foot high perimeter wildlife fence. The cost for the wildlife fence is included in the evaporation pond cost estimate, as the fence will surround the entire project site.
- **Intermediate cover -** Intermediate soil cover placement of 6 inches of native material is proposed following annual salt placement in the landfill site. It is possible that the requirements for an intermediate cover may waived if can be demonstrated that fugitive dust emission from the exposed salt will not be an issue.
- **Indirect costs** – Indirect costs considered include engineering design, construction management and construction quality assurance.
- **Operating and Maintenance Costs** – Operating and maintenance costs for the salt storage area include hauling and placement of harvested salt from the ponds to the salt storage area, placement of intermediate soil cover over the salt stack each year, management of leachate, monitoring and general maintenance of roads and liner system.
- **Sustaining Capital Expenditures (Facility Expansions)** - As is typical for landfills, the salt storage facility is envisioned to be constructed in phases throughout its 50-year life. The phased construction defers capital expenditures to the future and limits the unnecessary exposure of liner. For the purposes of this conceptual study, a total of 6 cells constructed every 8 years or so has been assumed. Each cell footprint measures approximately 600 ft x 600 ft.
- **Closure** – Closure for the salt storage facility is anticipated to include construction of an engineered cover system, and grading the facility as needed to provide long-term physical stability and manage surface water runoff and erosion.
- **Post-Closure** – Post-closure activities will include inspections and monitoring, periodic maintenance, and leachate management. For the cost estimate, a 20-year post-closure period was included.

5.0 CONCEPTUAL DESIGN AND COST ESTIMATE

5.1 Basis for Cost Estimates

For each site, capital and operating cost estimates were developed for the conceptual design of the ponds, pipelines delivering freshwater and brine to the site, and the salt storage facility. In accordance with the conceptual study, the cost estimate has been developed to an accuracy of +/- 40%.

Material take-offs (MTOs) were estimated based on the conceptual design drawings presented in this report. Unit costs were estimated based on vendor quotes, RSMeans online cost estimating tool (The Gordian Group, 2016), Colorado Department of Transportation (CDOT) construction cost databases, and unit rates from other projects.

To compare alternatives, the net present value (NPV) for each site could be calculated based on a 50-year project life and the estimated capital, operating, closure and post-closure costs. Such a NPV analysis could include routine repair and replacement for certain relatively low cost items as part of annual operations and maintenance costs. Major future capital expenses such as cell expansion would be included as future costs in the anticipated year of construction and discounted to present value. Salvage value was ignored given the 50 year life-cycle analysis. Interest during construction, which accounts for financing charges incurred during construction, was calculated using the same discount

rate and the estimated construction duration. Inflation was not included in the cost estimate as it is not customary to consider inflation for alternative evaluation analyses.

Additional details and assumptions pertaining to the cost estimates are provided in the following sections.

5.1.1 Contingency and Unlisted Items

The cost estimates include allowances of 25% for contingencies and 10% for unlisted items.

5.1.2 Indirect Costs

The following indirect costs were considered for the cost estimates:

- Legal and Administrative (3% of the construction cost).
- Technical Services which include engineering, construction quality assurance (CQA) and construction management. Technical services were estimated to be between 10 and 15% of the construction costs for the various project components (i.e., ponds, salt storage facility and brine/freshwater pipelines).

5.1.3 Operations and Maintenance Costs

Operations and maintenance costs have been estimated for the freshwater and brine pipelines to site, evaporation ponds and the salt storage facility. Items included in the operations and maintenance costs are listed below. It is assumed that the facility developed for the H_2S treatment program (Amec Foster Wheeler 2016e) could be used as needed by the operation and maintenance staff for the salt ponds.

Freshwater and Brine Pipelines

- Routine repair and replacement of motors and pumps within the pond complex on an estimated 3 year interval

Evaporation Ponds

- Pond operator
- Salt harvesting
- Pump replacement (estimated every 3 years)
- Geomembrane repairs
- Geomembrane replacement (estimated every 25 years)
- Bird netting replacement (every 10 years)
- General maintenance

Salt Storage Facility

- Hauling and placement of salt
- Placement of intermediate cover (annually following salt disposal);
- Management of leachate
- Monitoring

- General maintenance

5.1.4 Closure and Post-Closure Costs

Closure of the evaporation ponds will consist of removal of pumping and piping systems, removal of geomembrane and site grading to restore the ground to a natural appearance. It is assumed that the geomembrane liners and the contents will be disposed of in the salt storage facility or the Broad Canyon Landfill (for the Landfill site). The soils below the liner system will be sampled and analytical testing will be conducted to confirm if the soil meets applicable quality standards. If the soils are demonstrated to meet standards, no post-closure activities will be required.

Closure of the salt storage facility will include construction of an earthen cover system, grading and establishment of surface water management structures to control erosion. Post-closure costs associated with the salt storage facility include general inspection and maintenance of the cover system and surface water management features, management of leachate, and monitoring and reporting. A 20-year post-closure period has been assumed for the cost estimate.

Brine and freshwater pipelines to the sites are assumed to be abandoned in place and capped at each end.

5.2 Paradox NW

5.2.1 Rationale for the Design at Paradox NW Site

Paradox NW has several advantages as an evaporation pond site. It is the site that is closest to the brine production facility and to a freshwater source, and has a relatively gentle slope and minimal topographic complexity. It is almost entirely owned by a single private individual. There is space for an on-site salt storage facility, which would be the favored option for storage.

Disadvantages include the fact that it is the farthest distance from the permitted Broad Canyon Landfill, which would incur large transport costs if an on-site storage facility proves to be infeasible. It is also likely the site with the shallowest groundwater and least amenable ground conditions for permitting alternative liner systems. There is one home in the immediate vicinity.

The conceptual evaporation pond layout for the Paradox NW site takes advantage of the broad, gentle slopes offered by the site. The southernmost crystallizer pond will require additional excavation due to the topographic relief in this portion of the site. Further optimization of the design may reduce the required earthworks. There is sufficient area of gently sloping ground for construction of the salt storage facility near the crystallizers.

5.2.2 Paradox NW Evaporation Ponds

The layout of the evaporation ponds and other infrastructure at the Paradox NW site is presented in Figure 120. Construction quantities were developed based on the site layout and topographic survey for cost estimation. The present cost estimate for the Paradox NW Evaporation is presented in Table 3.

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Table 3. Cost Estimate - Paradox NW Evaporation Ponds

	Description	Unit	Unit Rate	Quantity	Cost
CAPITAL COSTS					
1.0 Earthworks					
1.1	Contractor Mobilization (Earthworks)	LS	5%	$13,626,627	$681,331
1.2	Contractor Demobilization (Earthworks)	LS	2%	$13,626,627	$272,533
1.3	Clearing and Grubbing	AC	$500	459	$229,743
1.4	Strip Topsoil and Stockpile	CY	$3.50	370,654	$1,297,288
1.5	Cut to Fill (soil) - Excavate, haul, place and compact	CY	$3.50	3,037,226	$10,630,291
1.6	Excavation to Waste	CY	$1.50	0	$-
1.7	Excavation in Rock (Blasting)	CY	$4.00	0	$-
1.8	Subgrade preparation - grade, scarify and compact	SY	$0.50	2,214,951	$1,107,476
1.9	Geomembrane Anchor Trench Excavation and Backfill	LF	$4.75	47,771	$226,912
1.10	Stormwater management and sediment control	EST	1%	$13,491,710	$134,917
2.0 Geosynthetic Liner System					
2.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,386,693	$167,734
2.2	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	18,637,095	$8,386,693
3.0 Bird Netting					
3.1	Bird Netting (Bittern and Bittern Product Ponds Only)	AC	$10,500	33	$348,677
4.0 Access Roads					
4.1	Access Roads	LF	$10.00	3,001	$30,006
5.0 Wildlife Fence					
5.1	Wildlife Fence	LF	$20.00	23,527	$470,546
5.2	Wildlife Fence Gates	EA	$5,000	1	$5,000

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Table 3. Cost Estimate - Paradox NW Evaporation Ponds (Continued)

Description		Unit	Unit Rate	Quantity	Cost
6.0 Brine Transfer Channels and Pumping & Piping					
6.1	Portable Self-Priming Brine Pump 5,000 pgm, 300 HP diesel drive - supply and install	EA	$225,000	1	$225,000
6.2	Brine Transfer 12" Portable Rubber Hose	LF	$141	2,400	$338,400
6.3	Bittern Product Pump - 125 gpm	EA	$3,000	1	$3,000
6.4	Fresh Water Pump Station Compete - supply and install	EA	$130,000	1	$130,000
6.5	Freshwater HDPE Piping - supply and install	LF	$30	16,188	$485,640
6.6	Valves & Misc - Freshwater Pipeline	EST	10%	$485,640	$48,564
6.7	Crystallizer feed channels	LF	$22.00	6,593	$145,046
6.8	Bittern feed channels	LF	$22.00	6,200	$136,400
7.0 Surface Water Management					
7.1	Surface Water Diversion Channel	LF	$22.00	0	$-
8.0 Indirect Costs					
8.1	Engineering	EST	10%	$25,501,197	$2,550,120
8.2	Construction Management and QA/QC	EST	8%	$25,501,197	$2,040,096
8.3	Legal and Administrative	EST	3%	$25,501,197	$765,036
8.4	Interest During Construction	MONTHS	12	$25,501,197	$430,333
	SUBTOTAL CAPITAL COSTS				$31,287,000
	UNLISTED ITEMS	EST	10%	$31,287,000	$3,128,700
	CONTINGENCY	EST	25%	$31,287,000	$7,822,000
	TOTAL CAPITAL COSTS				$42,238,000
SUSTAINING CAPITAL COSTS					
9.0 Sustaining Capital (Liner Replacement at Year 26)					
9.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,386,693	$167,734
9.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	18,637,095	$5,591,129
9.3	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	18,637,095	$8,386,693
	SUBTOTAL SUSTAINING CAPITAL COSTS				$14,146,000

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Table 3. Cost Estimate - Paradox NW Evaporation Ponds (Continued)

	Description	Unit	Unit Rate	Quantity	Cost
ANNUAL OPERATING AND MAINTENANCE COSTS					
10.0 Annual Operating and Maintenance Costs					
10.1	Pond Operator	YR	$100,000	1	$100,000
10.2	Diesel fuel for bittern transfer pumping (100 AF/yr)	GAL	$3.00	1,640	$4,920
10.3	Diesel fuel for salt harvesting brine transfer pumping from one pond/yr (109 AF/yr)	GAL	$3.00	1,788	$5,363
10.4	Power for bittern product transfer and truck loading	$/kWh	$0.0800290	8,520	$682
10.5	Portable bittern transfer pump impeller/casting replacement (every third year)	EA	$25,000	0.33	$8,333
10.6	Bittern product pump replacement (every third year)	EA	$3,000	0.33	$1,000
10.7	Geomembrane repair	YR	$10,000	1	$10,000
10.8	Salt Harvesting	TON	$0.75	137,000	$102,750
10.9	Bird Netting replacement	YR	$0.10	348,677	$34,868
10.10	General Maintenance	YR	$30,000	1	$30,000
	TOTAL ANNUAL OPERATING COSTS				$298,000
CLOSURE COSTS					
11.0 Closure Costs					
11.1	Pump and Piping System Removal	LS	$50,000	1	$50,000
11.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	18,637,095	$5,591,129
11.3	Site grading and surface water management	AC	$5,000	468	$2,340,240
	SUBTOTAL CLOSURE COSTS				$7,981,000

5.2.3 Paradox NW Salt Storage Facility

The layout of the 56.7 acre salt storage facility at the Paradox NW site is presented on Figure 120 and typical sections of the facility are shown on Figure 180. Table 4 presents the cost estimate of the salt storage facility at Paradox NW.

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Table 4. Present Worth Analysis - Paradox NW Salt Storage Facility

	Description	Unit	Unit Rate	Quantity	Cost
CAPITAL COSTS (INITIAL LANDFILL CELL)					
1.0 Earthworks					
1.1	Contractor Mobilization (Earthworks)	LS	5%	442,675	$22,134
1.2	Contractor Demobilization (Earthworks)	LS	2%	442,675	$8,854
1.3	Clearing and Grubbing	AC	$500	11	$5,605
1.4	Strip Topsoil and Stockpile	CY	$3.50	9,043	$31,651
1.5	Cut to Fill (soil) - Excavate, haul, place and compact	CY	$3.50	98,925	$346,238
1.6	Excavation to Waste	CY	$1.50	0	$-
1.7	Excavation in Rock (Blasting)	CY	$4.00	0	$-
1.8	Subgrade preparation - grade, scarify and compact	SY	$0.50	54,870	$27,435
1.10	Geomembrane Anchor Trench Excavation and Backfill	LF	$4.75	2,544	$12,084
1.11	Access roads	LF	$10.00	1,746	$17,460
1.12	Stormwater management and sediment control	EST.	0.5%	440,473	$2,202
2.0 Geosynthetic Liner System					
2.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	SF	2%	520,348	$10,407
2.2	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	452,477	$203,614
2.3	Supply and Install 60 mil HDPE Drain Liner	SF	$0.70	452,477	$316,734
3.0 Leak Collection and Recovery System (LCRS)					
3.1	4-inch Dia. Perforated CPE Piping - Supply and Install	AC	$4,368	7	$30,888
3.2	LCRS Sump and Pumps	EA	$40,000	3	$120,000
3.3	Placement of Protection Layer (Harvested Salt)	CY	$5.30	30,470	$161,490
4.0 Indirect Costs					
4.1	Engineering	EST	10%	$1,316,796	$131,680
4.2	Construction Management and QA/QC	EST	10%	$1,316,796	$131,680
4.3	Legal and Administrative	EST	3%	$1,316,796	$39,504
4.4	Interest During Construction	MONTHS	3	$1,316,796	$5,555
	SUBTOTAL CAPITAL COSTS				$1,625,000

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Table 4. Present Worth Analysis - Paradox NW Salt Storage Facility (Continued)

Description		Unit	Unit Rate	Quantity	Cost
	UNLISTED ITEMS	EST	10%	$1,625,000	$162,500
	CONTINGENCY	EST	25%	$1,625,000	$406,250
	TOTAL CAPITAL COSTS				$2,194,000
SUSTAINING CAPITAL COSTS (CELL EXPANSIONS)					
5.0 Sustaining Capital (Cell Expansions - Estimated every 8 years)					
5.1	Salt Storage Facility Cell Expansion	EA	$2,194,000	5	$10,970,000
ANNUAL OPERATING AND MAINTENANCE COSTS					
6.0 Annual Operating and Maintenance Costs					
6.1	Intermediate Cover	CY	$3.50	3,200	$11,200
6.2	Leachate Management	YR	$100,000	1	$100,000
6.3	Monitoring	YR	$20,000	1	$20,000
6.4	General Maintenance	YR	$30,000	1	$30,000
6.5	Haul and place harvested salt at salt storage area	TON	$3.00	137,000	$411,000
	SUBTOTAL ANNUAL O&M COSTS				$572,000
CLOSURE COSTS					
7.0 Closure Costs					
7.1	Salt Storage Facility Capping	AC	$20,000	67	$1,345,254
7.2	Grading and Surface Water Drainage Improvements	AC	$10,000	67	$672,627
	SUBTOTAL CLOSURE COSTS				$2,018,000
POST-CLOSURE COSTS (ASSUMES 20 YEARS POST CLOSURE)					
8.0 Post-Closure Costs (Annual)					
8.1	Inspection and Maintenance	YR	$25,000	1	$25,000
8.2	Leachate Management	YR	$50,000	1	$50,000
8.3	Monitoring and Reporting	YR	$25,000	1	$25,000
	SUBTOTAL ANNUAL POST-CLOSURE COSTS				$100,000

5.2.4 Brine transfer to the Paradox NW site

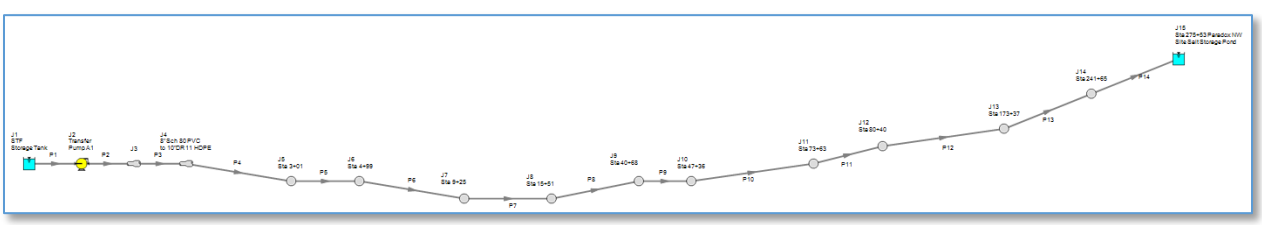
The NW Paradox site is the closest site to the existing brine withdrawal wells. Figure 150 shows the conceptual pipeline routing from the Surface Water Treatment Facility (STF) to the salt storage surge pond at the Paradox NW site. The brine pipeline would exit the STF site headed westward for 300 lf to the collection well access road, thence north 200 lf to a point on the right bank of the Dolores River above the floodplain. A 430 lf horizontal directional drilled bore under the Dolores River to the left bank past the floodplain would mitigate any environmental issues associated with the Dolores River crossing. From the left bank, the pipeline would head north for just over 600 ft to an existing fence line. The pipeline would turn westward for 2,500 lf to County Road X. The pipeline would follow the shoulder of County Road X for 13,400 to County Road 900. The pipeline would travel north along County Road 900 for 6,800 lf and then veer northeast for 3,400 lf to the salt storage surge pond inlet. The total pipeline length is approximately 27,560 lf. The elevation at the STF is 4,960 ft AMSL and the elevation at the terminus at the salt storage surge pond is 5,134 ft AMSL.

The proposed brine pipeline was modeled using Applied Flow Technology's Fathom 9® software package (Applied Flow Technology, 2015). The following assumptions were made regarding raw brine characteristics. The viscosity of brine is greatest at lower temperatures, lower pressures, and higher molarity. The temperature for a buried brine pipeline was taken as the annual average temperature for the Paradox Valley (US Climate Data, 2016). The dynamic viscosity was determined according to interpolation of published tables for brine viscosity (Kestin et al., 1981).

- Brine Design Flow Rate, gpm 300
- Brine Concentration, mg/l TDS: 260,000
- Brine Concentration, mol NaCl equivalent: 4.45
- Pressure Range (typical upper pump pressure), psi 320
- Pressure Range, MPa 2.21
- Brine Temperature, °C 10.4
- Brine Density, kg/m^3 1,164
- Dynamic Viscosity, Pa•s 0.002113

Figure 1 shows the Fathom 9® model schematic.

Figure 1 – Hydraulic Model Schematic for Brine Pipeline to Paradox NW Site



The brine transfer pipeline size was determined by the criteria of keeping the velocity less than 5 fps, and to keep the maximum pipeline pressure below 200 psi (the allowable working pressure for DR 11 4710 HDPE). The piping at the pump station would be Sch 80 PVC. Pipelines of 8 inch DR 11 4710 HDPE

and 10 inch DR 11 4710 HDPE were evaluated. The larger pipeline results in less operating pump brake horsepower (28.1 HP versus 35.8 HP) but costs significantly more. Lined steel pipelines were not considered since the pressure ranges were within the limits of DR 11 HDPE. Table 5 shows the present worth analysis based on an interest rate of 3.375%, 50 year project life, and based on San Miguel Power Association Rate Schedule. Itemized construction costs were developed using RSMeans online cost estimating tool (The Gordian Group, 2016) adjusted for 2nd Quarter 2016, standard union rates in Montrose, Colorado. The pump station cost was input into the RS Means program based on a separate cost analysis using the W/W Cost$model (Wesner, 2000) developed by George Wesner updated to 2016 ENR cost indices.

Table 5. Present Worth Analysis – Brine to Paradox NW Site

		8" Brine Pipeline	10" Brine Pipeline
Capital Cost			
Itemized Construction Cost		$2,276,439	$2,584,330
Contingency	25%	$569,110	$646,083
Unlisted Items	10%	$227,644	$258,433
Estimated Construction Cost		$3,073,192	$3,488,846
Technical Services	12%	$368,783	$418,662
Legal and Administrative	3%	$92,196	$104,665
Interest During Construction (months)	3	$12,965	$14,719
Total Capital Cost		$3,547,136	$4,026,891
Annual Operation and Maintenance Cost			
Routine Repair and Replacement	LS	$12,855	$9,641
Brake Horsepower	HP	35.8	28.1
Motor Efficiency	96%		
VFD Efficiency	98%		
Power Factor	0.85		
Power Input	kW	33.38	26.20
Annual Power Usage	kWh	292,439	229,540
Monthly Meter Charge		$105	$105
Monthly Demand Charge per kW	$14.00	$467	$367
Monthly Energy Charge per kWh	$0.080029	$1,950	$1,531
Total Monthly Charge		$2,523	$2,003
Annual Power Charge		$30,272	$24,032
Total Annual O&M Cost		$43,127	$33,673
Present Worth of Annual O&M		$1,034,785	$807,952
Total Present Worth		$4,582,000	$4,835,000

The present worth analysis shows that the 8 inch DR 11 4710 HDPE brine pipeline is most cost effective.

Figure 2 shows the hydraulic profile for the proposed 8 inch DR 11 4710 HDPE pipeline. Appendix A contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the brine transfer pipeline to the Paradox NW site.

Figure 2 – Hydraulic Profile for Brine Pipeline to Paradox NW Site

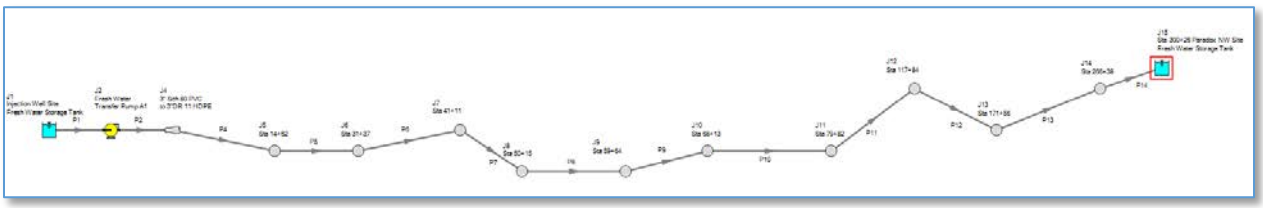
5.2.5 Freshwater Supply to the Paradox NW site

Freshwater is required at the evaporation pond site to accommodate pipeline dilution, brine pumping, and to provide makeup water to the freshwater wildlife pond. NOAA Technical Report 33, *Evaporation Atlas for the Contiguous 48 United States* (National Oceanic and Atmospheric Administration, 1982), indicates an annual free water surface evaporation rate of 45 inches for the Bedrock, CO area. To prevent freezing, the freshwater line will be drained from October 15th through April 15th. This provides for six months (180 days) with which to supply the 45 inches of evaporation makeup water. This is equal to 4.71 gpm per acre. For a six acre wildlife pond, the makeup water requirement is 28.3 gpm. Additionally, 10 gpm to 20 gpm is required for transfer pumping between process ponds. Therefore, a design target of 50 gpm was selected. This is conservative, but lesser pumping rates at high heads are difficult to achieve using normal vertical turbine pumps (would require an excessive number of stages).

The freshwater supply is assumed to come from the existing freshwater tanks at the injection well site. New can type vertical turbine pumps would be installed to supply freshwater to the Paradox NW Site. The pipeline would follow the injection well access road northward for approximately 6,200 lf to Colorado Highway 90. A directionally drilled 400 lf bore under the Dolores River would parallel the Hwy 90 Bridge to the west. The pipeline would follow Hwy 90 westward for another 5,180 lf through the community of

Bedrock to County Road 9.5. The pipeline would then follow County Road 9.5 northward, County Road X westward and County Road 900 for approximately 18,300 ft to a freshwater storage tank at the Paradox NW Site. The elevation at the injection well site is approximately 5,003 ft above mean sea level and 5,137 ft above mean sea level at the Paradox NW Site. Figure 3 shows the model schematic.

Figure 3 – Hydraulic Model Schematic for Freshwater Pipeline to Paradox NW Site



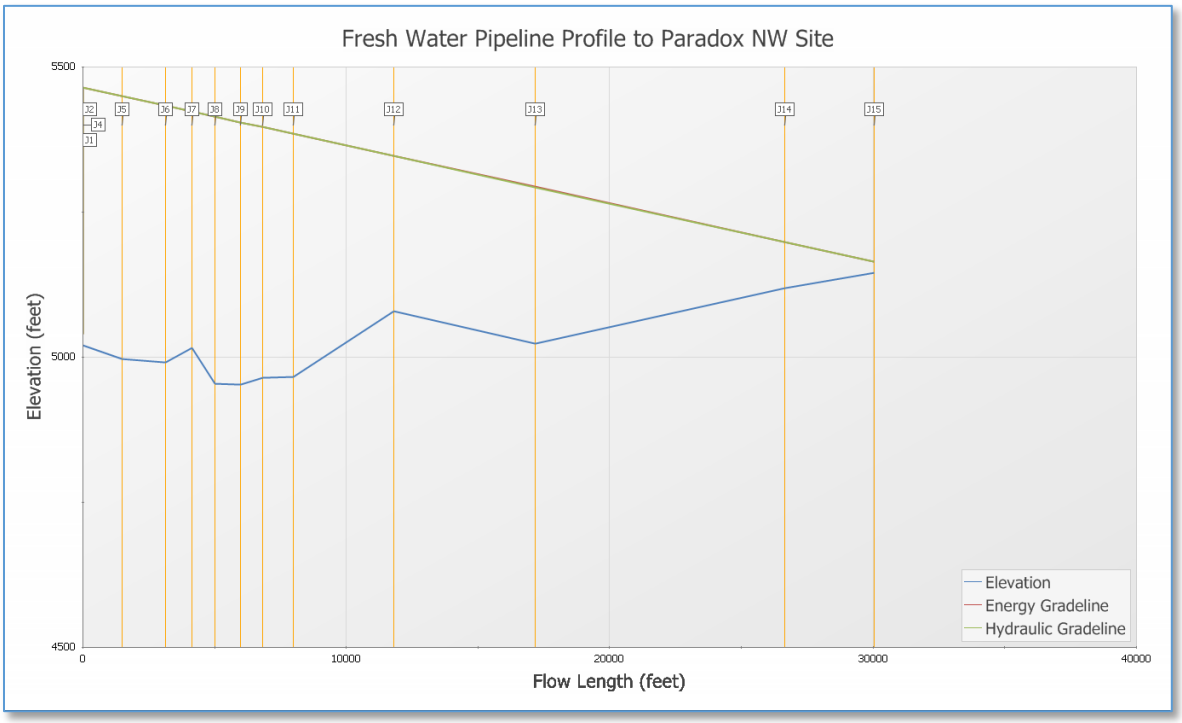
Pipelines of 4 inch DR 11 4710 HDPE and 3 inch DR 11 4710 HDPE were evaluated. Table 5 shows the present worth analysis using the same methodology as for the brine pipeline. The 3 inch DR 11 4710 HDPE Pipeline is the most cost effective.

Table 6. Present Worth Analysis – Freshwater to Paradox NW Site

		4" Fresh Water Pipeline	3" Fresh Water Pipeline
Capital Cost			
Itemized Construction Cost		$751,508	$690,418
Contingency	25%	$187,877	$172,604
Unlisted Items	10%	$75,151	$69,042
Estimated Construction Cost		$1,014,535	$932,064
Technical Services	12%	$121,744.23	$111,848
Legal and Administrative	3%	$30,436.06	$27,962
Interest During Construction (months)	3	$4,280	$3,932
Total Capital Cost		$1,170,996	$1,075,806
Annual Operation and Maintenance Cost			
Routine Repair and Replacement	LS	$3,117.00	$3,896
Brake Horsepower	HP	4.2	8.7
Motor Efficiency	96%		
VFD Efficiency	98%		
Power Factor	0.85		
Power Input, peak 50 gpm	kW	3.14	6.52
Power Input at 20 gpm	kW	1.02	1.41
Annual Power Usage (6 months)	kWh	4,413	6,088
Monthly Meter Charge		$105	$105
Monthly Demand Charge per kW	$14.00	$43.95	$91
Monthly Energy Charge per kWh	$0.080029	$29.43	$41
Total Monthly Charge		$178	$237
Annual Power Charge		$2,140.61	$2,842
Total Annual O&M Cost		$5,258	$6,738
Present Worth of Annual O&M		$126,151	$161,681
Total Present Worth		$1,297,000	$1,237,000

Figure 4 shows the hydraulic profile for the proposed 3 inch DR 11 4710 HDPE pipeline. Appendix B contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the freshwater pipeline to the Paradox NW site.

Figure 4 – Hydraulic Profile for Freshwater Pipeline to Paradox NW Site



5.3 BLM Site

5.3.1 Rationale for the design at BLM site

Advantages of the BLM site include the relatively flat topography, although it includes some topographic complexity. It is owned entirely by the Bureau of Land Management (BLM). The site is accessible by paved roads. It has the potential for on on-site salt disposal facility to be constructed. Groundwater has been reported at depths greater than 450 feet at the nearby Piñon Ridge project site (Golder, 2008), however East Paradox Creek is at the northern limits of the BLM site.

Disadvantages include its location at a middle distance from the brine production facility and from a potential source of freshwater, as well as from the permitted Broad Canyon Landfill. It does not therefore offer an advantage of proximity for either water delivery or salt storage in the event that an on-site storage facility is not constructed. There are no homes near the site, although it would be visible from Highway 90. There is some irregular “badlands-type” topography at the western portion of the site and need to construct a surface water diversion channel to route stormwater around the proposed ponds.

5.3.2 BLM Evaporation Ponds

The layout of the evaporation ponds and other infrastructure at the BLM site is presented in Figure 130. Construction quantities were developed based on the site layout and topographic survey for cost estimation. The cost estimate for the evaporation ponds at the BLM site is presented in Table 7.

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Table 7. Cost Estimate - BLM Evaporation Ponds

Description		Unit	Unit Rate	Quantity	Cost
CAPITAL COSTS					
1.0 Earthworks					
1.1	Contractor Mobilization (Earthworks)	LS	5%	14,319,648	$715,982
1.2	Contractor Demobilization (Earthworks)	LS	2%	14,319,648	$286,393
1.3	Clearing and Grubbing	AC	$500	451	$225,293
1.4	Strip Topsoil and Stockpile	CY	$3.50	363,474	$1,272,160
1.5	Cut to Fill (soil) - Excavate, haul, place and compact	CY	$3.50	3,249,032	$11,371,612
1.6	Excavation to Waste	CY	$1.50	0	$-
1.7	Excavation in Rock (Blasting)	CY	$4.00	0	$-
1.8	Subgrade preparation - grade, scarify and compact	SY	$0.50	2,161,666	$1,080,833
1.9	Geomembrane Anchor Trench Excavation and Backfill	LF	$4.75	47,994	$227,972
1.10	Stormwater management and sediment control	EST.	1%	14,177,869	$141,779
2.0 Geosynthetic Liner System					
2.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,611,727	$172,235
2.2	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	19,137,170	$8,611,727
3.0 Bird Netting					
3.1	Bird Netting (Bittern and Bittern Product Ponds Only)	AC	$10,500.00	33	$349,650
4.0 Access Roads					
4.1	Access Roads	LF	$8.00	1,337	$10,698
5.0 Wildlife Fence					
5.1	Wildlife Fence	LF	$20	22,937	$458,748
5.2	Wildlife Fence Gates	EA	$5,000	1	$5,000

Table 7. Cost Estimate - BLM Evaporation Ponds (Continued)

Description		Unit	Unit Rate	Quantity	Cost
6.0 Brine Transfer Channels and Pumping & Piping					
6.1	Portable Self-Priming Brine Pump 5,000 pgm, 300 HP diesel drive - supply and install	EA	$225,000	1	$225,000
6.2	Brine Transfer 12" Portable Rubber Hose	LF	$141	2,400	$338,400
6.3	Bittern Product Pump - 125 gpm	EA	$3,000	1	$3,000
6.4	Fresh Water Pump Station Compete - supply and install	EA	$130,000	1	$130,000
6.5	Freshwater HDPE Piping - supply and install	LF	$30	10,130	$303,903
6.6	Valves & Misc - Freshwater Pipeline	EST	10%	303,903	$30,390
6.7	Crystallizer feed channels	LF	$22.00	5,987	$131,714
6.8	Bittern feed channels	LF	$22.00	6,530	$143,660
7.0 Surface Water Management					
7.1	Surface Water Diversion Channel	LF	$22.00	2,155	$47,405
8.0 Indirect Costs					
8.1	Engineering	EST	10%	26,283,554	$2,628,355
8.2	Construction Management and QA/QC	EST	8%	26,283,554	$2,102,684
8.3	Legal and Administrative	EST	3%	26,283,554	$788,507
8.4	Interest During Construction	MONTHS	12	26,283,554	$443,535
	SUBTOTAL CAPITAL COSTS				$32,247,000
	UNLISTED ITEMS	EST	10%	32,247,000	$3,224,700
	CONTINGENCY	EST	25%	$32,247,000	$8,062,000
	TOTAL CAPITAL COSTS				$43,534,000
SUSTAINING CAPITAL COSTS					
9.0 Sustaining Capital (Liner Replacement at Year 26)					
9.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,611,727	$172,235
9.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	19,137,170	$5,741,151
9.3	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	19,137,170	$8,611,727
	SUBTOTAL SUSTAINING CAPITAL COSTS				$14,525,000

Table 7. Cost Estimate - BLM Evaporation Ponds (Continued)

	Description	Unit	Unit Rate	Quantity	Cost
ANNUAL OPERATING COSTS					
10.0 Annual Operating and Maintenance Costs					
10.1	Pond Operator	YR	$100,000.00	1	$100,000
10.2	Diesel fuel for bittern transfer pumping (100 AF/yr)	GAL	$3.00	1,640	$4,920
10.3	Diesel fuel for salt harvesting brine transfer pumping from one pond/yr (109 AF/yr)	GAL	$3.00	1,788	$5,363
10.4	Power for bittern product transfer and truck loading	$/kWh	$0.0800290	8,520	$682
10.5	Portable bittern transfer pump impeller/casting replacement (every third year)	EA	$25,000.00	0.33	$8,333
10.6	Bittern product pump replacement (every third year)	EA	$3,000.00	0.33	$1,000
10.7	Geomembrane repair	YR	$10,000.00	1	$10,000
10.8	Salt Harvesting - excavate, load, haul to on-site landfill	TON	$0.75	137,000	$102,750
10.9	Bird Netting Replacement	YR	$0.10	349,650	$34,965
10.10	General Maintenance	YR	$30,000.00	1	$30,000
	TOTAL ANNUAL OPERATING COSTS				$298,000
CLOSURE COSTS					
11.0 Closure Costs					
11.1	Pump and Piping System Removal	LS	$50,000.00	1	$50,000
11.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	19,137,170	$5,741,151
11.3	Site grading and surface water management	AC	$5,000.00	447	$2,233,117
	SUBTOTAL CLOSURE COSTS				$8,024,000

5.3.3 BLM Salt Storage Area

The layout of the 56.7 acre salt storage facility at the BLM site is presented on Figure 130 and typical sections of the facility are shown on Figure 180. Table 8 presents the cost estimate for the salt storage facility at the BLM site.

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Table 8. Cost Estimate - BLM Salt Storage Facility

	Description	Unit	Unit Rate	Quantity	Cost
CAPITAL COSTS (INITIAL LANDFILL CELL)					
1.0 Earthworks					
1.1	Contractor Mobilization (Earthworks)	LS	5%	327,710	$16,385
1.2	Contractor Demobilization (Earthworks)	LS	2%	327,710	$6,554
1.3	Clearing and Grubbing	AC	$500	11	$5,348
1.4	Strip Topsoil and Stockpile	CY	$3.50	8,628	$30,196
1.5	Cut to Fill (soil) - Excavate, haul, place and compact	CY	$3.50	64,903	$227,161
1.6	Excavation to Waste	CY	$1.50	0	$-
1.7	Excavation in Rock (Blasting)	CY	$4.00	0	$-
1.8	Subgrade preparation - grade, scarify and compact	SY	$0.50	51,188	$25,594
1.9	Geomembrane Anchor Trench Excavation and Backfill	LF	$4.75	6,010	$28,548
1.10	Access roads	LF	$8.00	1,154	$9,233
1.11	Stormwater management and sediment control	EST.	0.5%	326,079	$1,630
2.0 Geosynthetic Liner System					
2.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	SF	2%	520,348	$10,407
2.2	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	452,477	$203,614
2.3	Supply and Install 60 mil HDPE Drain Liner	SF	$0.70	452,477	$316,734
3.0 Leak Collection and Recovery System (LCRS)					
3.1	4-inch Dia. Perforated CPE Piping - Supply and Install	AC	$4,368	10.6	$46,197
3.2	LCRS Sump and Pumps	EA	$40,000	3	$120,000
3.3	Placement of Protection Layer (Harvested Salt)	CY	$5.30	34,125	$180,864
4.0 Indirect Costs					
4.1	Engineering	EST	10%	$1,228,466	$122,847
4.2	Construction Management and QA/QC	EST	10%	$1,228,466	$122,847
4.3	Legal and Administrative	EST	3%	$1,228,466	$36,854
4.4	Interest During Construction	MONTS	3	$1,228,466	$5,183
	SUBTOTAL CAPITAL COSTS				$1,516,000
	UNLISTED ITEMS	EST	10%	$1,516,000	$151,600
	CONTINGENCY	EST	25%	$1,516,000	$379,000
	TOTAL CAPITAL COSTS				$2,047,000

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Table 8. Cost Estimate - BLM Salt Storage Facility (Continued)

Description		Unit	Unit Rate	Quantity	Cost
SUSTAINING CAPITAL COSTS (CELL EXPANSIONS)					
5.0 Sustaining Capital (Cell Expansions)					
5.1	Salt Storage Facility Cell Expansion	EA	$2,047,000.00	5	$10,235,000
ANNUAL OPERATING AND MAINTENANCE COSTS					
6.0 Annual Operating and Maintenance Costs					
6.1	Intermediate Cover	CY	$3.50	3200	$11,200
6.2	Leachate Management	YR	$100,000	1	$100,000
6.3	Monitoring	YR	$20,000	1	$20,000
6.4	General Maintenance	YR	$30,000	1	$30,000
6.5	Haul and place harvested salt at salt storage area	TON	$3.00	137,000	$411,000
	SUBTOTAL ANNUAL O&M COSTS				$572,000
CLOSURE COSTS					
7.0 Closure Costs					
7.1	Salt Storage Facility Capping	AC	$20,000	63.5	$1,270,000
7.2	Grading and Surface Water Drainage Improvements	AC	$10,000	63.5	$635,000
	SUBTOTAL CLOSURE COSTS				$1,905,000
POST-CLOSURE COSTS (ASSUMES 20 YEARS POST CLOSURE)					
8.0 Post-Closure Costs (Annual)					
8.1	Inspection and Maintenance	YR	$25,000	1	$25,000
8.2	Leachate Management	YR	$50,000	1	$50,000
8.3	Monitoring and Reporting	YR	$25,000	1	$25,000
	SUBTOTAL ANNUAL POST-CLOSURE COSTS				$100,000

5.3.4 Brine Transfer to the BLM Site

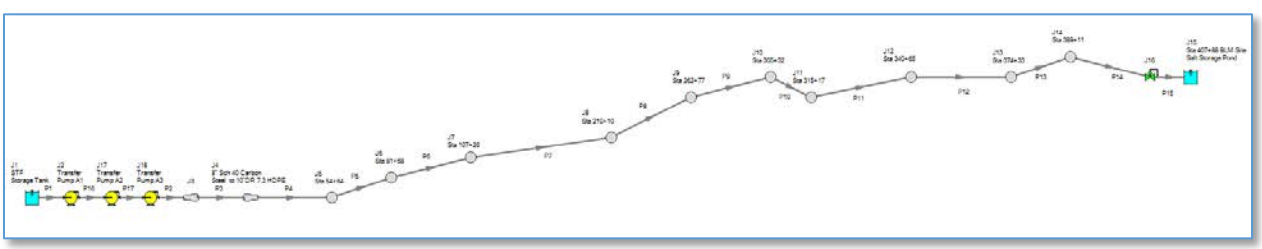
The BLM site is located to the east of the existing brine withdrawal wells. Figure 160 shows the conceptual pipeline routing from the Surface water Treatment Facility (STF) to the salt storage surge pond at the BLM site. The brine pipeline would exit the STF site headed eastward for 250 lf to County Road Y11, thence south 8,000 lf to Colorado Highway 90. The pipeline would turn eastward for 32,150 lf to a point just east of County Road BB16. The pipeline would then turn northward for 500 lf to the salt storage surge pond inlet. The total pipeline length is approximately 40,760 lf. The elevation at the STF is 4,960 ft AMSL and the elevation at the terminus at the salt storage surge pond is 5,414 ft AMSL.

As with the brine transfer pipeline to the Paradox NW site, the proposed brine pipeline was modeled using Applied Flow Technology's Fathom 9® software package (Applied Flow Technology, 2015). The following assumptions were made regarding raw brine characteristics. The viscosity of brine is greatest at lower temperatures, lower pressures, and higher molarity. The temperature for a buried brine pipeline was taken as the annual average temperature for the Paradox Valley (US Climate Data, 2016). The dynamic viscosity was determined according to interpolation of published tables for brine viscosity (Kestin et al., 1981).

- Brine Design Flow Rate, gpm 300
- Brine Concentration, mg/l TDS: 260,000
- Brine Concentration, mol NaCl equivalent: 4.45
- Pressure Range (typical upper pump pressure), psi 320
- Pressure Range, MPa 2.21
- Brine Temperature, °C 10.4
- Brine Density, kg/m^3 1,164
- Dynamic Viscosity, Pa•s 0.002113

Figure 5 shows the Fathom 9® model schematic. Note that three pump stages are required to overcome the additional static head and friction head associated with the greater distance to the BLM Site.

Figure 5 – Hydraulic Model Schematic for Brine Pipeline to BLM Site



Unlike, the brine pipeline to the Paradox NW site, only a 10 inch pipe diameter using DR 7.3 4710 HDPE can maintain acceptable pressures using plastic pipe. The use of polyurethane lined carbon steel pipe was considered as an alternative to the plastic pipe. The polyurethane liner was used to eliminate internal corrosion. The exterior of the polyurethane lined carbon steel pipe would be epoxy coated, wrapped in polyethylene film, and provided with sacrificial anodes for corrosion protection. The brine transfer pipeline size was determined by the criteria of keeping the velocity less than 5 fps, and to keep

the maximum pipeline pressure below 320 psi (the allowable working pressure for DR 7.3 4710 HDPE) or 2,038 psi (the allowable maximum pressure for urethane lined mild steel). Pipelines of 10 inch DR 7.3 HDPE and 8 inch and 6 inch polyurethane lined carbon steel were evaluated. 8 inch DR 7.3 HDPE was not evaluated as the pressures would have exceeded the pressure rating for the pipe. Table 9 shows the present worth analysis based on an interest rate of 3.375%, 50 year project life, and based on San Miguel Power Association Rate Schedule. Itemized construction costs were developed using RSMeans online cost estimating tool (The Gordian Group, 2016) adjusted for 2nd Qtr 2016, standard union rates in Montrose, Colorado. The pump station cost was input into the RS Means program based on a separate cost analysis using the W/W Cost$model (Wesner, 2000) developed by George Wesner updated to 2016 ENR cost indices.

Table 9. Present Worth Analysis – Brine to BLM Site

		10" Brine Pipeline	8" Brine Pipeline	6" Brine Pipeline
Capital Cost				
Itemized Construction Cost		$4,174,205	$8,591,877	$7,593,353
Contingency	25%	$1,043,551	$2,147,969	$1,898,338
Unlisted Items	10%	$417,420	$859,188	$759,335
Estimated Construction Cost		$5,635,177	$11,599,034	$10,251,026
Technical Services	12%	$676,221	$1,391,884	$1,230,123
Legal and Administrative	3%	$169,055	$347,971	$307,531
Interest During Construction (months)	6	$47,547	$97,867	$86,493
Total Capital Cost		$6,528,000	$13,436,755	$11,875,173
Annual Operation and Maintenance Cost				
Routine Repair and Replacement	LS	$38,565	$38,565	$57,848
Brake Horsepower	HP	70.0	68.4	96.2
Motor Efficiency	96%			
VFD Efficiency	98%			
Power Factor	0.85			
Power Input	kW	65.23	63.74	89.72
Annual Power Usage	kWh	571,399	558,329	785,991
Monthly Meter Charge		$105	$106	$105
Monthly Demand Charge per kW	$14.00	$913	$892	$1,256
Monthly Energy Charge per kWh	$0.080029	$3,811	$3,724	$5,242
Total Monthly Charge		$4,829	$4,722	$6,603
Annual Power Charge		$57,947	$56,662	$79,236
Total Annual O&M Cost		$96,512	$95,227	$137,083
Present Worth of Annual O&M		$2,315,696	$2,284,873	$3,289,164
Total Present Worth		$8,844,000	$15,722,000	$15,164,000

The present worth analysis shows that the 10 inch DR 7.3 4710 HDPE brine pipeline is the most cost effective.

Figure 6 shows the hydraulic profile for the proposed 8" DR 11 4710 HDPE pipeline. Appendix C contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the brine transfer pipeline to the BLM site.

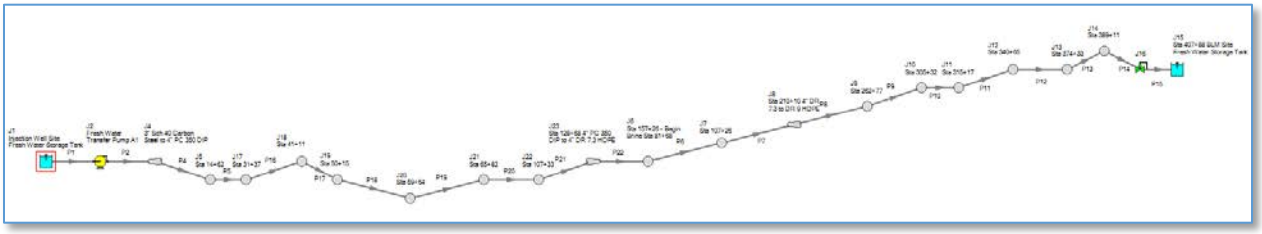
Figure 6 – Hydraulic Profile for Brine Pipeline to BLM Site

5.3.5 Freshwater Supply to the BLM Site

Freshwater requirements are the same as previously established for the Paradox NW site.

The freshwater supply is assumed to come from the existing freshwater tanks at the injection well site. New can type vertical turbine pumps would be installed to supply freshwater to the Paradox NW Site. The pipeline would follow the injection well access road northward for approximately 6,200 lf to Colorado Highway 90. The pipeline would turn eastward along Hwy 90 for 7,300 to meet up with the Brine Transfer pipeline at the intersection with County Road Y11. The pipeline would parallel the Brine Transfer pipeline for 34,850 lf to a freshwater storage tank at the evaporation pond complex. The elevation at the injection well site is approximately 5,003 ft above mean sea level and 5,414 ft above mean sea level at the BLM Site. Figure 7 shows the model schematic.

Figure 7 – Hydraulic Model Schematic for Freshwater Pipeline to BLM Site



Only a pipelines of 4 inch Ductile Iron Pipe with 4 inch DR 7.3 4710 HDPE and 4 inch DR 9 4710 HDPE was evaluated. Smaller diameter plastic lines would exceed pressure limits, and 3 inch Ductile Iron Pipe is generally more expensive than 4 inch Ductile Iron Pipe since it is rarely used. Therefore a Present Worth comparison of pipeline alternatives was unnecessary, but was provided for the combined material 4 inch line to provide information on capital cost and annual operation and maintenance costs. The results are show in Table 10.

Figure 8 shows the hydraulic profile for the proposed 4 inch pipeline. Appendix D contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the freshwater pipeline to the BLM site.

Figure 8 – Hydraulic Profile for Freshwater Pipeline to the BLM Site

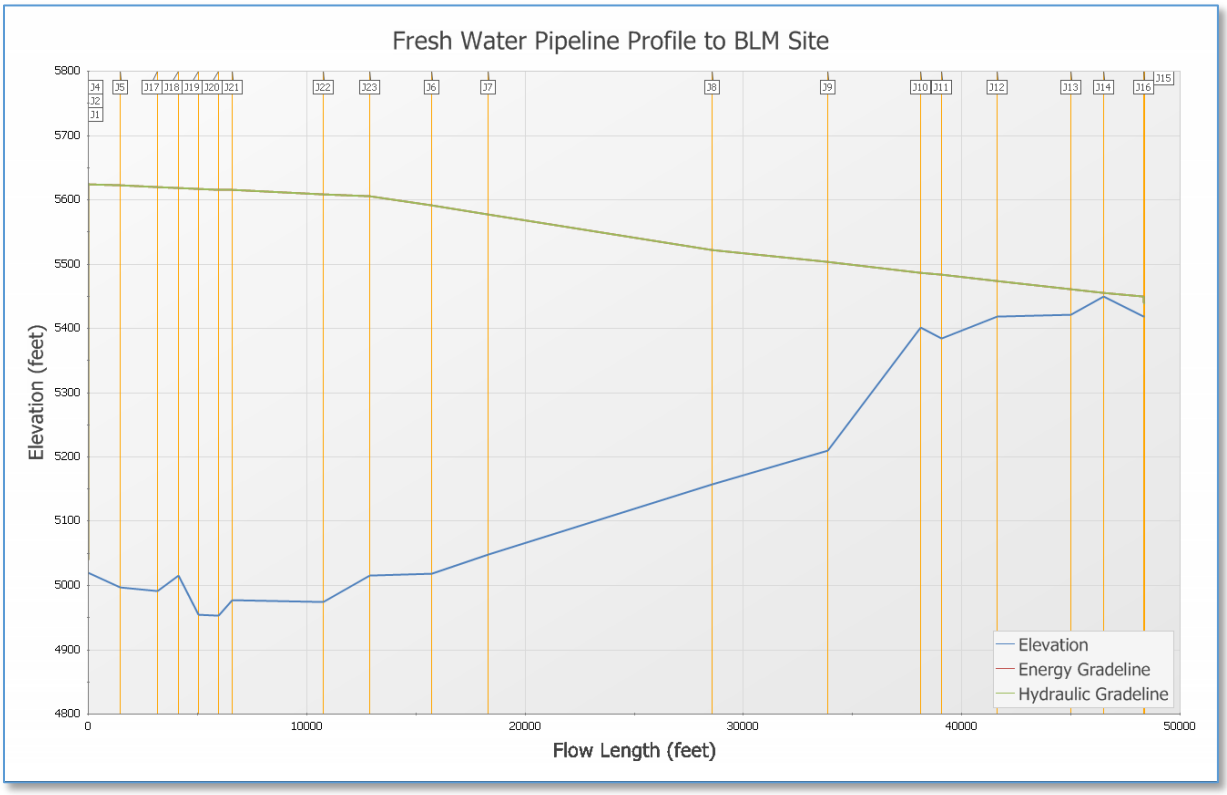


Table 10. Present Worth Analysis – Freshwater to BLM Site

		4" Fresh Water Pipeline
Capital Cost		
Itemized Construction Cost		$1,284,008
Contingency	25%	$321,002
Unlisted Items	10%	$128,401
Estimated Construction Cost		$1,733,411
Technical Services	12%	$208,009
Legal and Administrative	3%	$52,002
Interest During Construction (months)	3	$7,313
Total Capital Cost		$2,000,736
Annual Operation and Maintenance Cost		
Routine Repair and Replacement	LS	$3,117
Brake Horsepower	HP	13.3
Motor Efficiency	96%	
VFD Efficiency	98%	
Power Factor	0.85	
Power Input, peak 50 gpm	kW	9.91
Power Input at 20 gpm	kW	3.85
Annual Power Usage (6 months)	kWh	16,623
Monthly Meter Charge		$105
Monthly Demand Charge per kW	$14.00	$139
Monthly Energy Charge per kWh	$0.080029	$111
Total Monthly Charge		$355
Annual Power Charge		$4,255
Total Annual O&M Cost		$7,372
Present Worth of Annual O&M		$176,888
Total Present Worth		$2,178,000

5.4 Landfill Site

5.4.1 Rationale for the design at Landfill site

The principal advantage of the Landfill site is that it is located adjacent to a permitted storage facility, the Broad Canyon Landfill. There are no homes in the vicinity of this site, and it is accessible by paved and dirt roads. It is mostly gently sloping, although it has some complex drainage features both on-site and off-site and a ridge at the eastern portion of the site, adjacent to the Broad Canyon Landfill.

Disadvantages are that it is at the greatest distance from the brine production facility, as well as from a source of freshwater. The surface soil is expected to be thin, and underlain by bedrock and therefore likely will require blasting for some pond excavations. The Landfill site includes land held by three private owners, as well as a portion of BLM land.

The conceptual pond layout has avoided topographic constraints at the site to the extent possible, however the crystallizers are still impacted somewhat by the incised drainages at the northern portion of the site and by a ridge at the eastern side of the site. The surge pond and concentrator are located at the southern limits of the site to take advantage of the topographic high portion of the site. However, the concentrator is impacted by a deeper section of a drainage in this area. A surface water diversion channel will be required at the southern end of the site to divert stormwater around the evaporations ponds and site infrastructure.

If the Broad Canyon landfill is to be used for salt storage for this option, it will require significant expansion to be able to manage the projected volume of salt. Based on the conceptual layout of the evaporation ponds on the west side of the landfill, the landfill expansions would have to extend to the east.

5.4.2 Landfill Evaporation Ponds

The layout of the evaporation ponds and other infrastructure at the Landfill site is presented in Figure 140. Construction quantities were developed based on the site layout and topographic survey for cost estimation. The cost estimate for the evaporation ponds at the Landfill site is presented in Table 11.

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Table 11. Cost Estimate - Landfill Evaporation Ponds

	Description	Unit	Unit Rate	Quantity	Cost
CAPITAL COSTS					
1.0 Earthworks					
1.1	Contractor Mobilization (Earthworks)	LS	5%	23,427,886	$1,171,394
1.2	Contractor Demobilization (Earthworks)	LS	2%	23,427,886	$468,558
1.3	Clearing and Grubbing	AC	$500	508	$253,800
1.4	Strip Topsoil and Stockpile	CY	$3.50	409,465	$1,433,128
1.5	Cut to Fill - Excavate, haul, place and compact	CY	$3.50	5,745,305	$20,108,568
1.6	Excavation to waste	CY	$4.00	0	$-
1.7	Subgrade preparation - grade, scarify and compact	SY	$0.50	2,356,358	$1,178,179
1.8	Geomembrane Anchor Trench Excavation and Backfill	LF	$4.75	46,790	$222,253
1.9	Stormwater management and sediment control	EST	1%	23,195,927	$231,959
2.0 Geosynthetic Liner System					
2.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,609,290	$172,186
2.2	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	19,131,755	$8,609,290
3.0 Bird Netting					
3.1	Bird Netting (Bittern and Bittern Product Ponds Only)	AC	$10,500.00	32.6	$342,300
4.0 Access Roads					
4.1	Access Roads	LF	$8.00	5,065	$40,517
5.0 Wildlife Fence					
5.1	Wildlife Fence	LF	$20	27,055	$541,108
5.2	Wildlife Fence Gates	EA	$5,000	3	$15,000
6.0 Brine Transfer Channels and Pumping & Piping					
6.1	Portable Self-Priming Brine Pump 5,000 pgm, 300 HP diesel drive - supply and install	EA	$225,000	1	$225,000
6.2	Brine Transfer 12" Portable Rubber Hose	LF	$141	2,400	$338,400
6.3	Bittern Product Pump - 125 gpm	EA	$3,000	1	$3,000
6.4	Fresh Water Pump Station Compete - supply and install	EA	$130,000	1	$130,000
6.5	Freshwater HDPE Piping - supply and install	LF	$30	15,759	$472,782
6.6	Valves & Misc - Freshwater Pipeline	EST	10%	472,782	$47,278
6.7	Crystallizer feed channels	LF	$22.00	5,574	$122,628
6.8	Bittern feed channels	LF	$22.00	6,188	$136,136

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Table 11. Cost Estimate - Landfill Evaporation Ponds (Continued)

	Description	Unit	Unit Rate	Quantity	Cost
7.0 Surface Water Management					
7.1	Surface Water Diversion Channel	LF	$22.00	6,807	$149,747
8.0 Indirect Costs					
8.1	Engineering	EST	10%	36,413,210	$3,641,321
8.2	Construction Management and QA/QC	EST	8%	36,413,210	$2,913,057
8.3	Legal and Administrative	EST	3%	36,413,210	$1,092,396
8.4	Interest During Construction	MONTHS	12	36,413,210	$614,473
	SUBTOTAL CAPITAL COSTS				$44,674,000
	UNLISTED ITEMS	EST	10%	44,674,000	$4,467,400
	CONTINGENCY	EST	25%	44,674,000	$11,169,000
	TOTAL CAPITAL COSTS				$60,310,000
SUSTAINING CAPITAL COSTS					
9.0 Sustaining Capital (Liner Replacement at Year 26)					
9.1	Contractor Mobilization/Demobilization (Geosynthetics Installer)	LS	2%	8,609,290	$172,186
9.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	19,131,755	$5,739,527
9.3	Supply and Install 60 mil SST HDPE Geomembrane	SF	$0.45	19,131,755	$8,609,290
SUBTOTAL SUSTAINING CAPITAL COSTS					$14,521,000
ANNUAL OPERATING COSTS					
10.0 Annual Operating and Maintenance Costs					
10.1	Pond Operator	YR	$100,000	1	$100,000
10.2	Diesel fuel for bittern transfer pumping (100 AF/yr)	GAL	$3.00	1,640	$4,920
10.3	Diesel fuel for salt harvesting brine transfer pumping from one pond/yr (109 AF/yr)	GAL	$3.00	1,788	$5,363
10.4	Power for bittern product transfer and truck loading	$/kWh	$0.0800290	8,520	$682
10.5	Portable bittern transfer pump impeller/casting replacement (every third year)	EA	$25,000	0.33	$8,333
10.6	Bittern product pump replacement (every third year)	EA	$3,000	0.33	$1,000
10.7	Geomembrane repair	YR	$10,000	1	$10,000
10.8	Salt Harvesting	TON	$0.75	137,000	$102,750
10.9	Bird Netting Replacement	YR	$0.10	342,300	$34,230
10.10	General Maintenance	YR	$30,000	1	$30,000
	TOTAL ANNUAL OPERATING COSTS				$297,000

Table 11. Cost Estimate - Landfill Evaporation Ponds (Continued)

Description		Unit	Unit Rate	Quantity	Cost
CLOSURE COSTS					
11.0 Closure Costs					
11.1	Pump and Piping System Removal	LS	$50,000	1	$50,000
11.2	Geomembrane Removal and Disposal in Salt Landfill	SF	$0.30	19,131,755	$5,739,527
11.3	Site grading and surface water management	AC	$5,000	487	$2,434,245
	SUBTOTAL CLOSURE COSTS				$8,224,000

5.4.3 Broad Canyon Landfill

For this study, harvested salt from the crystallizers at the Landfill site are assumed to be disposed of in the adjacent Broad Canyon landfill. Costs associated with disposal of salt in the Broad Canyon landfill are presented by Amec Foster Wheeler (2016b) and reproduced in Section 6.0.

5.4.4 Brine Transfer to the Landfill Site

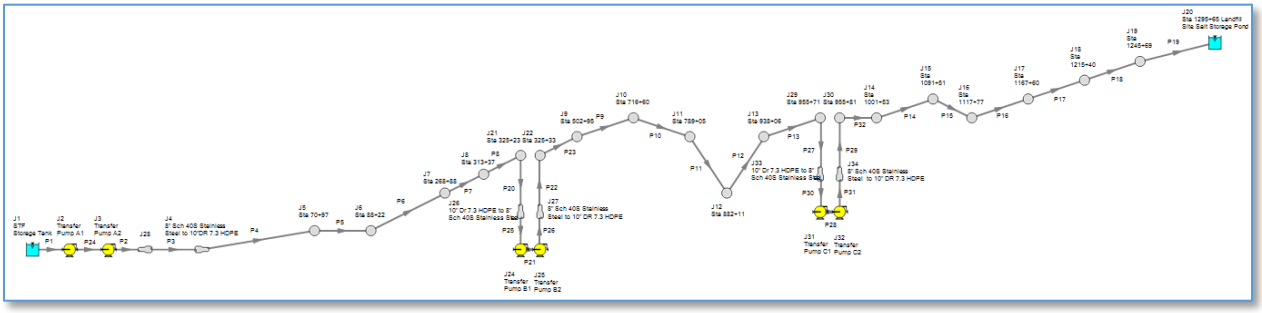
The Landfill site is located to the east of the existing brine withdrawal wells. Figure 170 shows the conceptual pipeline routing from the Surface water Treatment Facility (STF) to the salt storage surge pond at the BLM site. The brine pipeline would exit the STF site headed eastward for 250 lf to County Road Y11, thence south 8,000 lf to Colorado Highway 90. The pipeline would turn eastward for 29,200 lf to the intersection with County Road GG25. The pipeline would then eastward along unimproved County Road GG25 for 35,900 lf to a point just west of the intersection with County Road HH31. The pipeline would then continue an additional 6,070 lf past the proposed evaporation ponds to the salt storage surge pond inlet. The total pipeline length is approximately 129,360 lf. The elevation at the STF is 4,960 ft AMSL and the elevation at the terminus at the salt storage surge pond is 6,283 ft AMSL.

As with the brine transfer pipelines to the two previous sites, the proposed brine pipeline was modeled using Applied Flow Technology's Fathom 9® software package (Applied Flow Technology, 2015). The following assumptions were made regarding raw brine characteristics. The viscosity of brine is greatest at lower temperatures, lower pressures, and higher molarity. The temperature for a buried brine pipeline was taken as the annual average temperature for the Paradox Valley (US Climate Data, 2016). The dynamic viscosity was determined according to interpolation of published tables for brine viscosity (Kestin et al., 1981).

- Brine Design Flow Rate, gpm 300
- Brine Concentration, mg/l TDS: 260,000
- Brine Concentration, mol NaCl equivalent: 4.45
- Pressure Range (typical upper pump pressure), psi 320
- Pressure Range, MPa 2.21
- Brine Temperature, °C 10.4
- Brine Density, kg/m^3 1,164
- Dynamic Viscosity, Pa•s 0.002113

Two different scenarios were investigated for the brine transfer. Because of the long distance and elevation difference, a plastic pipeline would require intermediate booster pump stations. Figure 9 shows the Fathom 9® model schematic for an HDPE pipeline with two intermediate booster pump stations. The pumps would be end suction centrifugal pumps similar to the existing brine transfer pumps. Each pump station would have two pumps in series, for a total of six pumps operating to reach the Landfill site.

Figure 9 – Hydraulic Model Schematic for HDPE Brine Pipeline to Landfill Site



Alternatives without the intermediate pump stations were investigated considering the use of multi-stage vertical turbine pumps and polyurethane lined carbon steel pipelines. Figure 10 shows the model schematic for the single pump station alternative. Pipelines of 8 inch and 6 inch were evaluated.

Figure 10 – Hydraulic Model Schematic for Polyurethane Lined Carbon Steel Brine Pipeline to Landfill Site

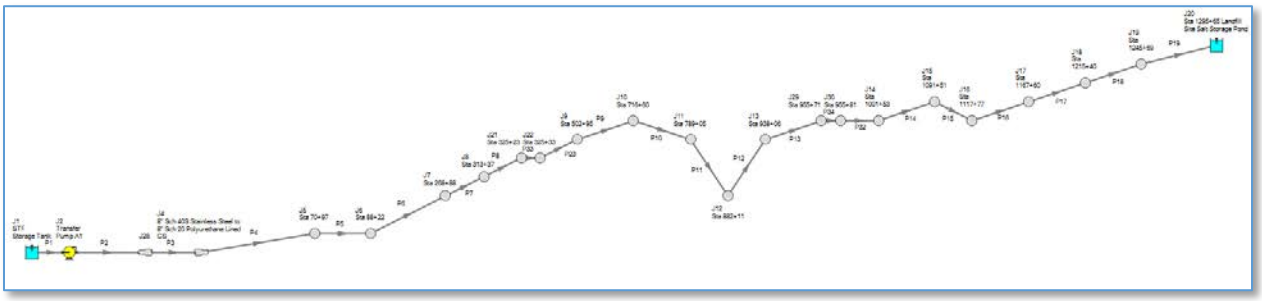


Table 12 shows the present worth analysis based on an interest rate of 3.375%, 50 year project life, and based on San Miguel Power Association Rate Schedule. Itemized construction costs were developed using RSMeans online cost estimating tool (The Gordian Group, 2016) adjusted for 2nd Qtr 2016, standard union rates in Montrose, Colorado. The pump station cost was input into the RS Means program based on a separate cost analysis using the W/W Cost$model (Wesner, 2000) developed by George Wesner updated to 2016 ENR cost indices.

Table 12. Present Worth Analysis – Brine to Landfill Site

		10" Brine Pipeline	8" Brine Pipeline	6" Brine Pipeline
Capital Cost				
Itemized Construction Cost		$12,921,777	$26,326,788	$22,199,398
Contingency	25%	$3,230,444	$6,581,697	$5,549,850
Unlisted Items	10%	$1,292,178	$2,632,679	$2,219,940
Estimated Construction Cost		$17,444,399	$35,541,164	$29,969,188
Technical Services	12%	$2,093,328	$4,264,940	$3,596,303
Legal and Administrative	3%	$523,332	$1,066,235	$899,076
Interest During Construction (months)	12	$294,374	$599,757	$505,730
Total Capital Cost		$20,355,434	$41,472,096	$34,970,296
Annual Operation and Maintenance Cost				
Routine Repair and Replacement	LS	$77,130	$96,413	$115,695
Brake Horsepower	HP	200.0	139.3	96.2
Motor Efficiency	96%			
VFD Efficiency	98%			
Power Factor	0.85			
Power Input	kW	186.51	129.90	89.72
Annual Power Usage	kWh	1,633,818	1,137,897	785,991
Monthly Meter Charge	3	$315	$105	$105
Monthly Demand Charge per kW	$14.00	$2,611	$1,819	$1,256
Monthly Energy Charge per kWh	$0.080029	$10,896	$7,589	$5,242
Total Monthly Charge		$13,822	$9,512	$6,603
Annual Power Charge		$165,866	$114,147	$79,236
Total Annual O&M Cost		$242,996	$210,560	$194,931
Present Worth of Annual O&M		$5,830,430	$5,052,155	$4,677,151
Total Present Worth		$26,186,000	$46,524,000	$39,647,000

The present worth analysis shows that the 10 inch DR 7.3 4710 HDPE brine pipeline with intermediate pump stations is the most cost effective.

Figure 11 shows the hydraulic profile for the proposed 10” DR 7.3 4710 HDPE pipeline. Appendix E contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the brine transfer pipeline to the Landfill site.

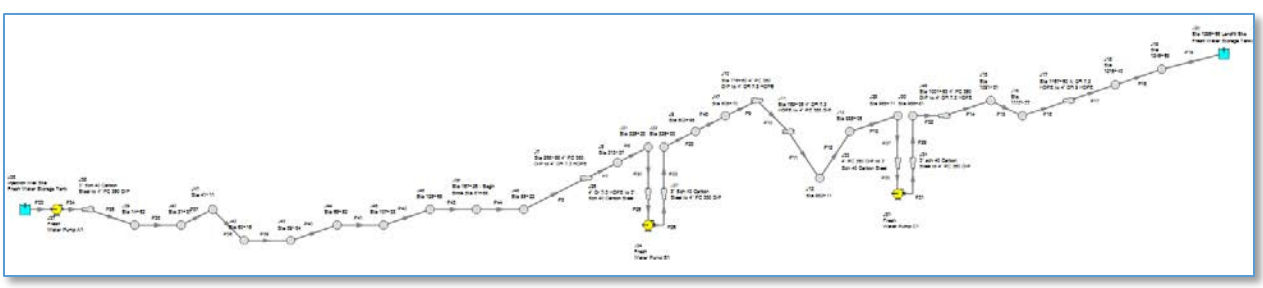
Figure 11 – Hydraulic Profile for Brine Pipeline to Landfill Site

5.4.5 Freshwater Supply to the Landfill Site

Freshwater requirements are the same as previously established for the Paradox NW and BLM site.

The freshwater supply is assumed to come from the existing freshwater tanks at the injection well site. New can type vertical turbine pumps would be installed to supply freshwater to the Paradox NW Site. The pipeline would follow the injection well access road northward for approximately 6,200 lf to Colorado Highway 90. The pipeline would turn eastward along Hwy 90 for 7,300 to meet up with the Brine Transfer pipeline at the intersection with County Road Y11. The pipeline would parallel the Brine Transfer pipeline for 123,700 lf to a freshwater storage tank at the evaporation pond complex. The elevation at the injection well site is approximately 5,003 ft above mean sea level and 6,283 ft above mean sea level at the Landfill Site. Intermediate freshwater booster pump stations would be constructed co-located with the two intermediate brine transfer pump stations. Figure 12 shows the model schematic.

Figure 12 – Hydraulic Model Schematic for Freshwater Pipeline to Landfill Site



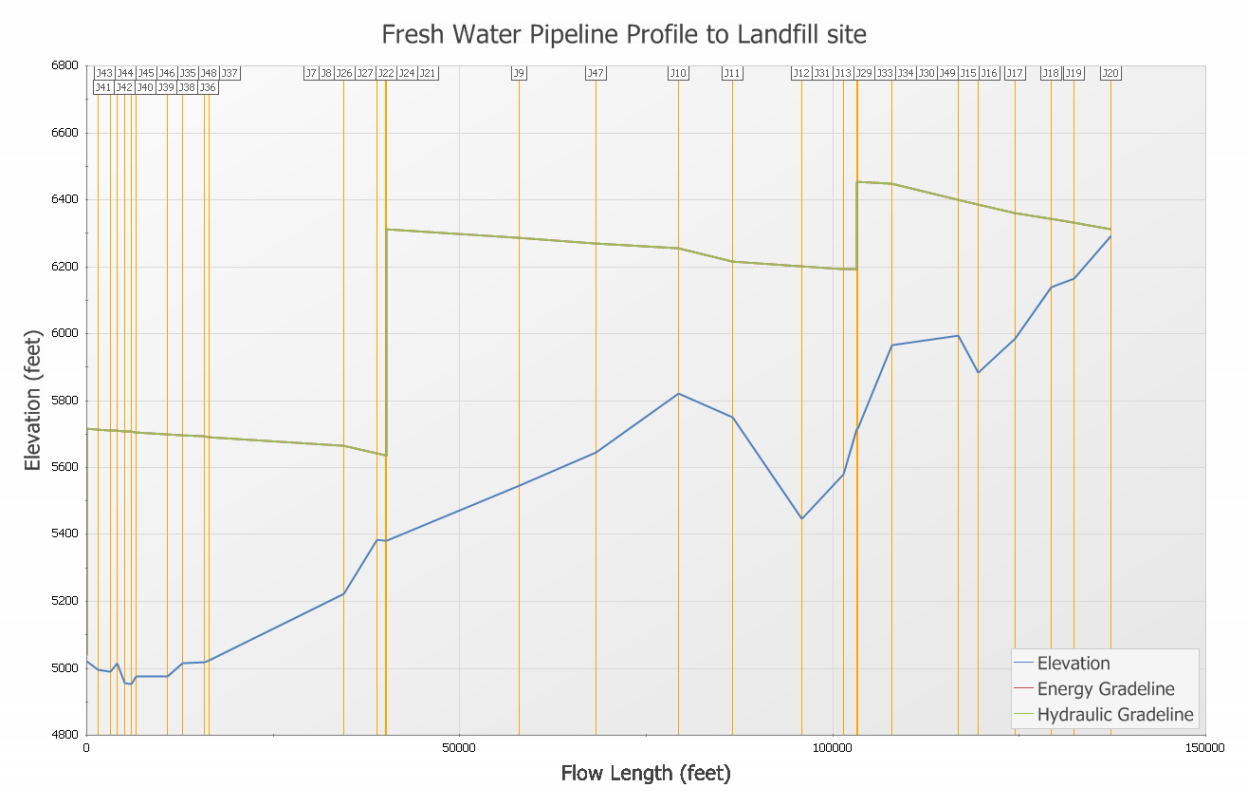
As with the freshwater pipeline to the BLM site, only a pipeline of 4 inch Ductile Iron Pipe with 4 inch DR 7.3 4710 HDPE and 4 inch DR 9 4710 HDPE was evaluated. Smaller diameter plastic lines would exceed pressure limits, and 3 inch Ductile Iron Pipe is generally more expensive than 4 inch Ductile Iron Pipe since it is rarely used. Therefore a present worth comparison of pipeline alternatives was unnecessary, but was provided for the combined material 4 inch line to provide information on capital cost and annual operation and maintenance costs. The results are show in Table 13.

Table 13. Present Worth Analysis – Freshwater to Landfill Site

		4" Fresh Water Pipeline
Capital Cost		
Itemized Construction Cost		$5,204,776
Contingency	25%	$1,301,194
Unlisted Items	10%	$520,478
Estimated Construction Cost		$7,026,447
Technical Services	12%	$843,174
Legal and Administrative	3%	$210,793
Interest During Construction (months)	3	$29,643
Total Capital Cost		$8,110,057
Annual Operation and Maintenance Cost		
Routine Repair and Replacement	LS	$9,351
Brake Horsepower	HP	37.1
Motor Efficiency	96%	
VFD Efficiency	98%	
Power Factor	0.85	
Power Input, peak 50 gpm	kW	27.64
Power Input at 20 gpm	kW	13.18
Annual Power Usage (6 months)	kWh	56,923
Monthly Meter Charge	3	$315
Monthly Demand Charge per kW	$14.00	$387
Monthly Energy Charge per kWh	$0.080029	$380
Total Monthly Charge		$1,082
Annual Power Charge		$12,978
Total Annual O&M Cost		$22,329
Present Worth of Annual O&M		$535,766
Total Present Worth		$8,646,000

Figure 13 shows the hydraulic profile for the proposed 4 inch pipeline. Appendix F contains the Fathom 9 model output, information on the proposed pump and the RSMeans cost estimates for the freshwater pipeline to the BLM site.

Figure 13 – Hydraulic Profile for Freshwater Pipeline to the Landfill Site



6.0 SUMMARY OF ESTIMATED COSTS

The intent of the conceptual design was to provide a sufficient level of detail to develop a cost estimate of reasonable accuracy for capital investment, sustaining capital expenditures (e.g., salt storage facility expansions), 50-year operations and maintenance, closure and post-closure for the evaporation ponds, salt storage facility and brine/freshwater delivery pipelines to each site. The life cycle costs are shown by year in present dollars based on a 50-year project life, 20 years of post-closure activities at the on-site salt storage facility (if constructed). Material quantities (e.g., earthworks, liner area, netting area) were developed from the conceptual designs and the topographic surveys of the sites.

Life cycle costs, including the freshwater and brine pipelines, evaporation ponds and salt storage facility, for the three sites are presented in Table 14. The cost analysis indicates that the Paradox NW site is the most economically favorable.

Table 14. Summary of Life Cycle Evaluation

Description	Year	Paradox NW	BLM	Landfill
BRINE AND FRESHWATER PIPELINES TO SITE				
Capital Costs Brine Pipeline to Site	0	$3,547,000	$6,528,000	$20,355,000
Annual Operating and Maintenance Costs - Brine Pipeline	1 - 50	$43,000	$97,000	$243,000
Capital Costs Freshwater Pipeline to Site	0	$1,076,000	$2,001,000	$8,110,000
Annual Operating and Maintenance Costs - Freshwater Pipeline	Annually	$7,000	$7,000	$22,000
EVAPORATION PONDS				
Total Capital Costs	0	$42,238,000	$43,534,000	$60,310,000
Annual Operating and Maintenance Costs	1 - 50	$263,000	$263,000	$263,000
Closure Costs	51	$7,981,000	$8,024,000	$8,224,000
SALT STORAGE AREA				
Total Capital Costs	0	$2,194,000	$2,047,000	N/A
Sustaining Capital Costs (Cell Expansions)	7	$10,970,000	$10,235,000	N/A
Sustaining Capital Costs (Cell Expansions)	15	$10,970,000	$10,235,000	N/A
Sustaining Capital Costs (Cell Expansions)	24	$10,970,000	$10,235,000	N/A
Sustaining Capital Costs (Cell Expansions)	32	$10,970,000	$10,235,000	N/A
Sustaining Capital Costs (Cell Expansions)	41	$10,970,000	$10,235,000	N/A
Operating and Maintenance Costs	1 - 50	$572,000	$572,000	N/A
Closure Costs	51	$2,018,000	$1,905,000	N/A
Annual Post Closure Costs	52 - 71	$100,000	$100,000	N/A

7.0 SUMMARY AND CONCLUSIONS

Conceptual designs were developed for evaporation ponds, brine and freshwater delivery pipelines and salt disposal (either on-site salt storage facility or disposal in the Broad Canyon landfill) for the Paradox NW, BLM and Landfill sites. The Paradox NW site appears to be the most favorable site of the three considered, due to its proximity to the brine and freshwater supply sources, favorable topography and lowest estimated costs.

The BLM site ranks second as far as the estimated costs. The BLM site is at a medium distance from the brine and freshwater sources, has some topographic limitations due to irregular topography in places, need for surface water diversion and limits posed by the adjacent East Paradox Creek.

The Landfill site is ranked third based on the highest cost. The higher cost is attributed to being the farthest distance from the brine and freshwater sources, shallow bedrock at the site, higher earthworks volumes due to steeper topography, and higher estimated disposal costs per ton of salt in the Broad Canyon landfill compared to on-site storage facilities at the Paradox NW and BLM sites.

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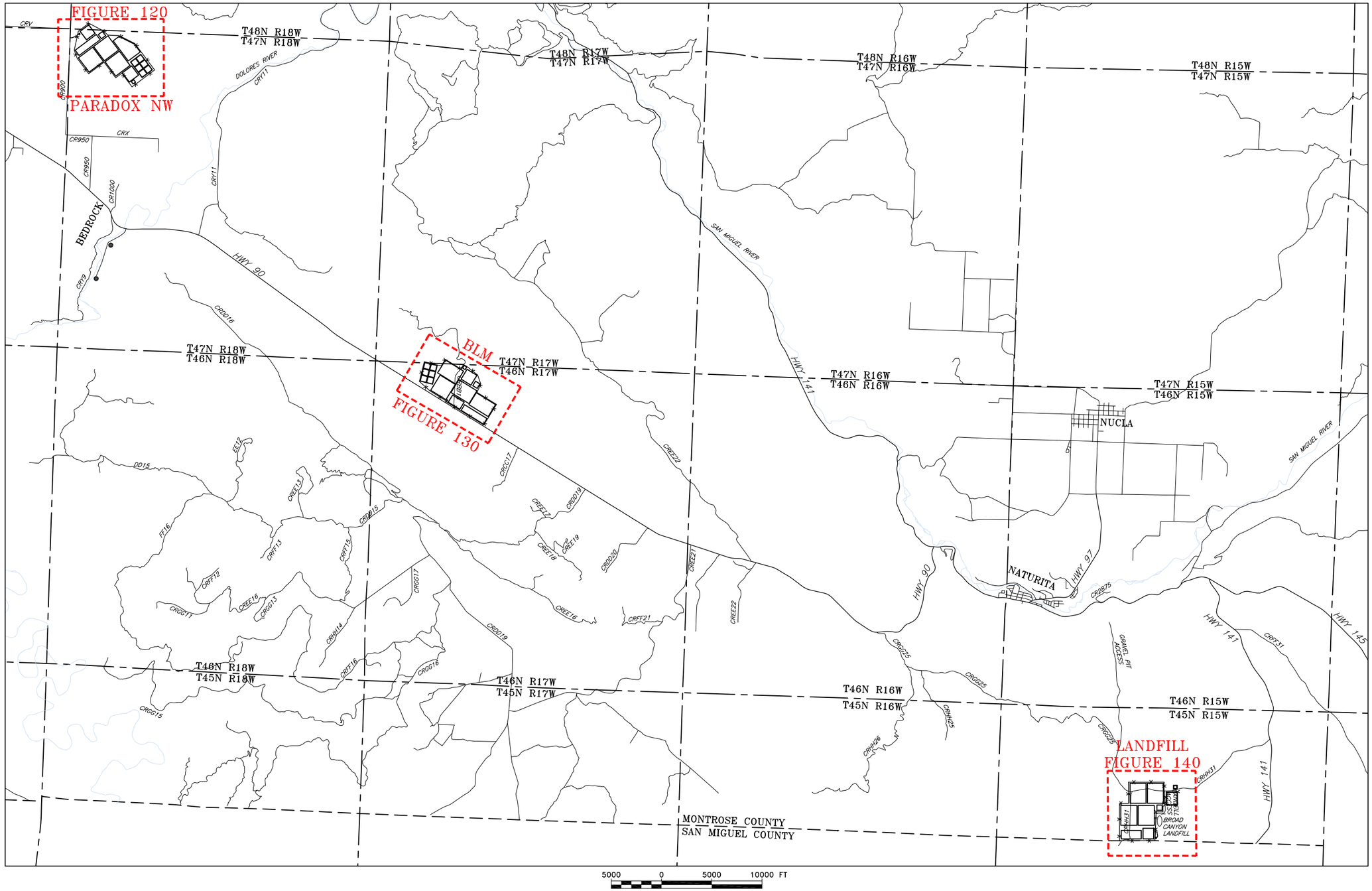

LEGEND:

- 100 — EXISTING GROUND SURFACE CONTOUR EL, FEET
- EXISTING HIGHWAYS
- EXISTING COUNTY ROADS
- PROPOSED PONDS

CLIENT: BUREAU OF RECLAMATION		ISSUED DATE: 02/02/2017
DRN BY: HJV	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: MGC	TITLE: SITE ALTERNATIVE LOCATION MAP	
CHK BY: BRB		FIGURE No.: 100
APR BY: CS		REV: B

amec foster wheeler

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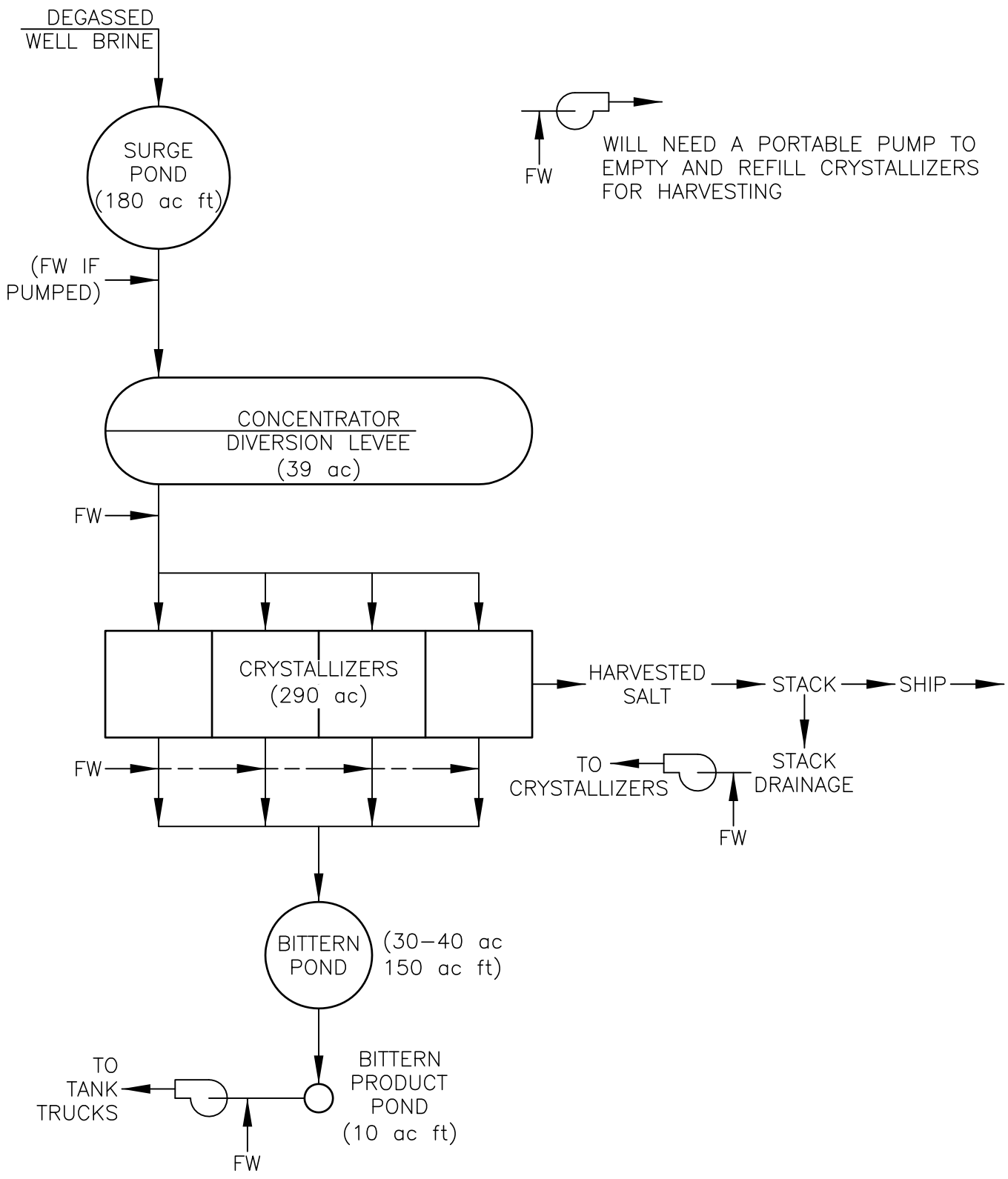

amec foster wheeler	CHK BY BRB	CLIENT BUREAU OF RECLAMATION	ISSUED DATE 02/02/2017
	APR BY CS	PROJECT PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No. 1655500023
	DRN BY MGC	TITLE POND SEQUENCE SCHEMATIC	FIGURE No. 110 / REV B
	DSN BY JP		

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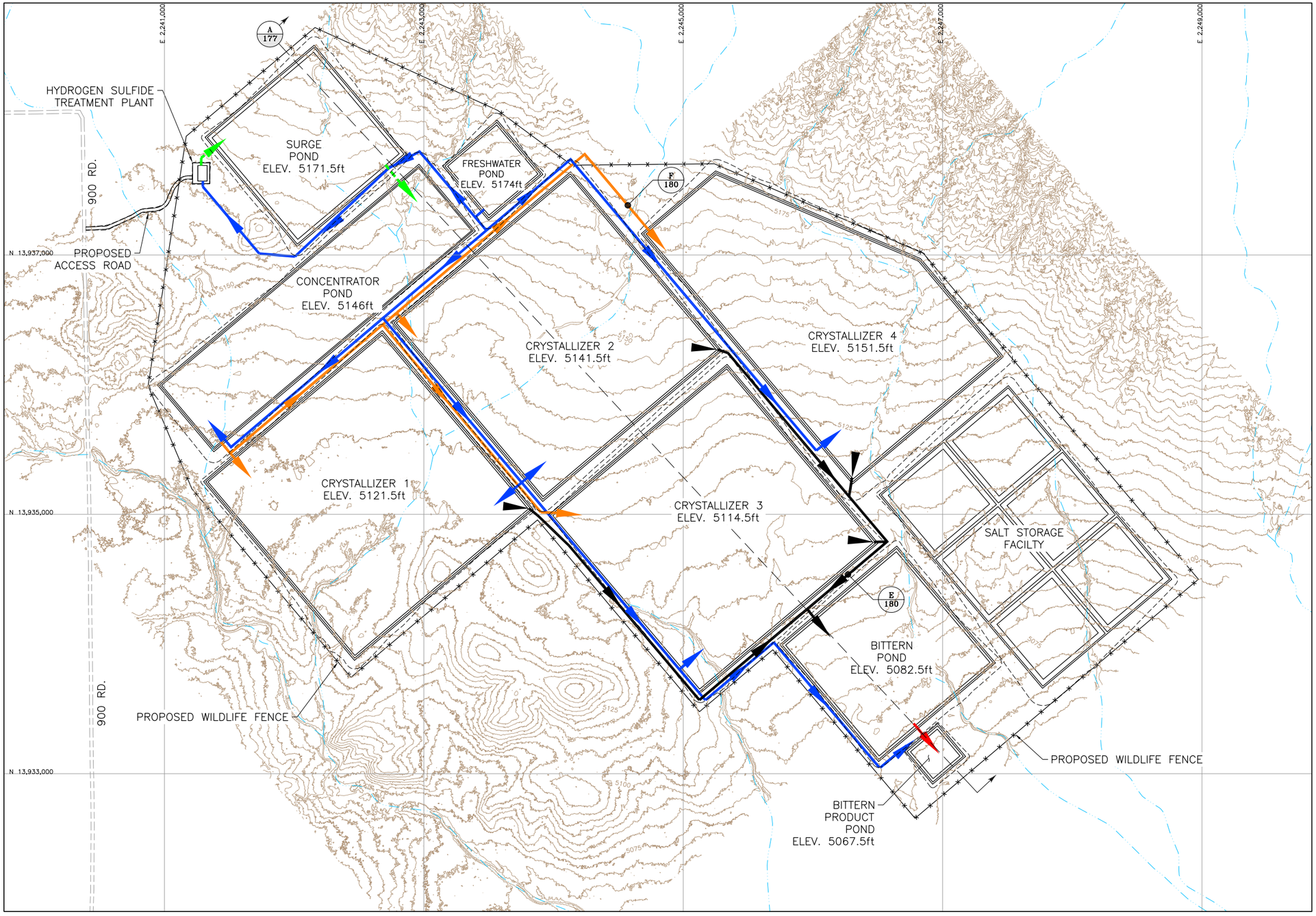

LEGEND:

- EXISTING GROUND SURFACE CONTOUR EL, FEET
- EXISTING ROADS
- PROPOSED ACCESS ROADS
- EXISTING DRAINAGES
- PROPOSED WILDLIFE FENCE
- AREA OF DISTURBANCE
- FRESHWATER PIPELINE (PUMPED)
- CRYSTALLIZER FEED CHANNEL
- BITTERN FEED CHANNEL
- BITTERN/BRINE PIPELINE (PUMPED)
- LINED CHANNEL BITTERN/BRINE TRANSFER

amec foster wheeler

CLIENT	BUREAU OF RECLAMATION	ISSUED DATE	02/02/2017
DRN BY HJV	PROJECT PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.	1655500023
DSN BY MGC	TITLE		
CHK BY BRB	PARADOX NW SITE	FIGURE No. 120	REV B
APR BY CS			

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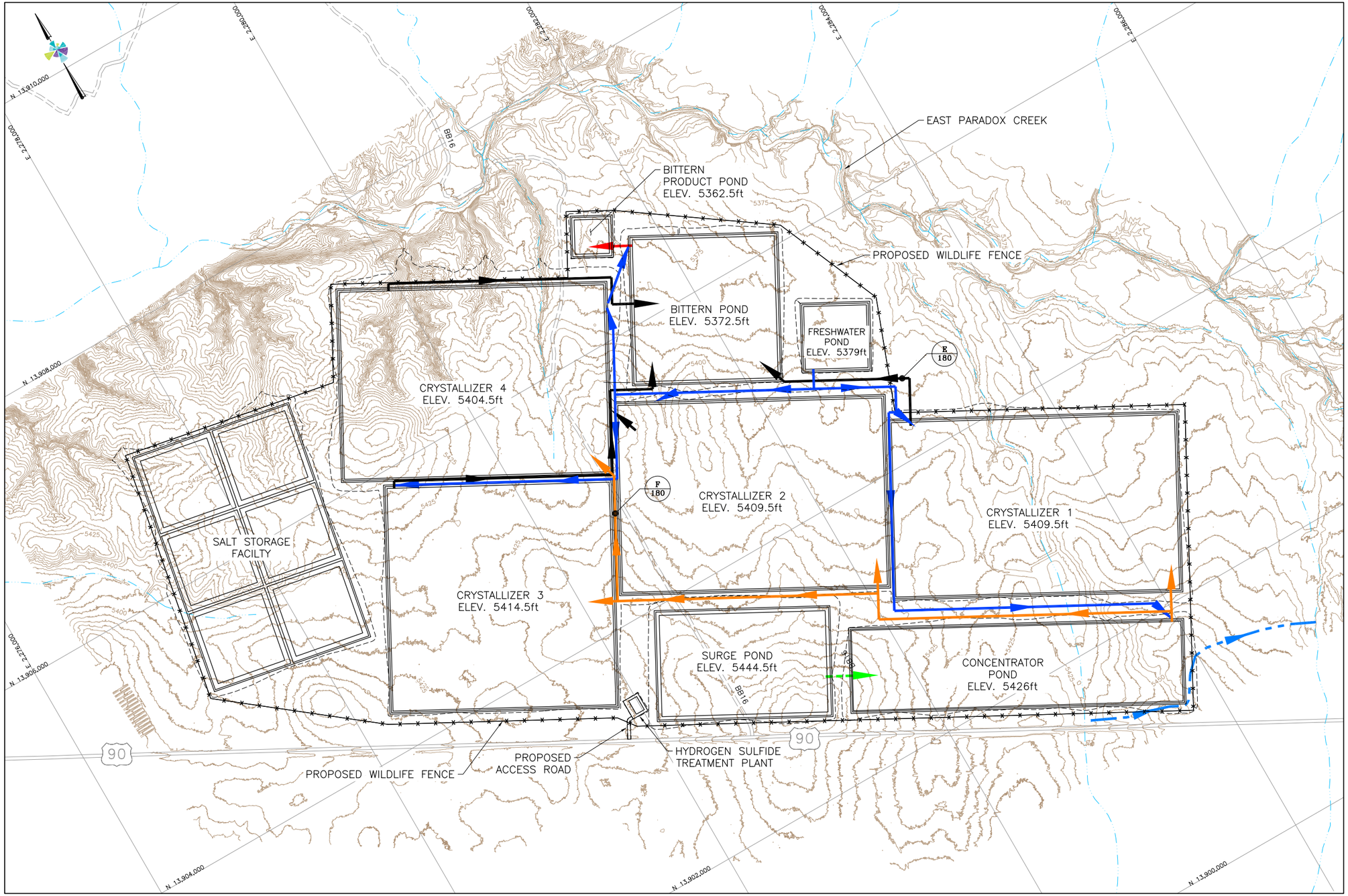

LEGEND:

- EXISTING GROUND SURFACE CONTOUR EL, FEET
- EXISTING ROADS
- EXISTING HIGHWAY
- PROPOSED ACCESS ROADS
- EXISTING DRAINAGES
- PROPOSED WILDLIFE FENCE
- AREA OF DISTURBANCE
- SURFACE WATER DIVERSION CHANNEL
- FRESHWATER PIPELINE (PUMPED)
- CRYSTALLIZER FEED CHANNEL
- BITTERN FEED CHANNEL
- BITTERN/BRINE PIPELINE (PUMPED)
- LINED CHANNEL BITTERN/BRINE TRANSFER

400 0 400 800 FT

amec foster wheeler

CLIENT	BUREAU OF RECLAMATION	ISSUED DATE	02/02/2017
DRN BY HJV	PROJECT PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.	1655500023
DSN BY MGC	TITLE BLM SITE		
CHK BY BRB		FIGURE No. 130	REV B
APR BY CS			

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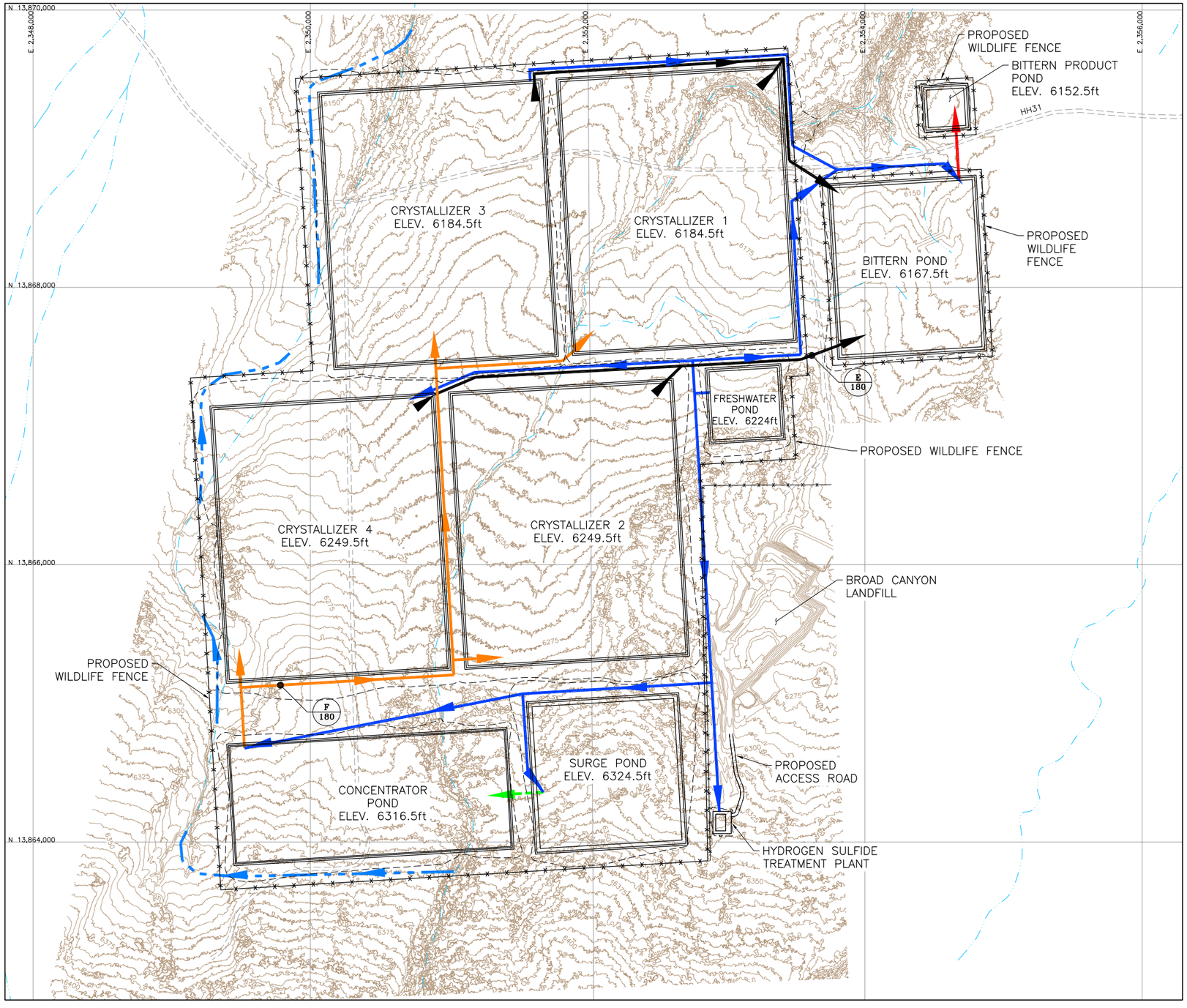

LEGEND:

- EXISTING GROUND SURFACE CONTOUR EL, FEET
- EXISTING ROADS
- PROPOSED ACCESS ROADS
- EXISTING DRAINAGES
- PROPOSED WILDLIFE FENCE
- AREA OF DISTURBANCE
- SURFACE WATER DIVERSION CHANNEL
- FRESHWATER PIPELINE (PUMPED)
- CRYSTALLIZER FEED CHANNEL
- BITTERN FEED CHANNEL
- BITTERN/BRINE PIPELINE (PUMPED)
- LINED CHANNEL BITTERN/BRINE TRANSFER

400 0 400 800 FT

amec foster wheeler

CLIENT: BUREAU OF RECLAMATION		ISSUED DATE: 02/02/2017
DRN BY: HJV	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: MGC	TITLE: LANDFILL SITE	
CHK BY: BRB		FIGURE No.: 140
APR BY: CS		REV: A

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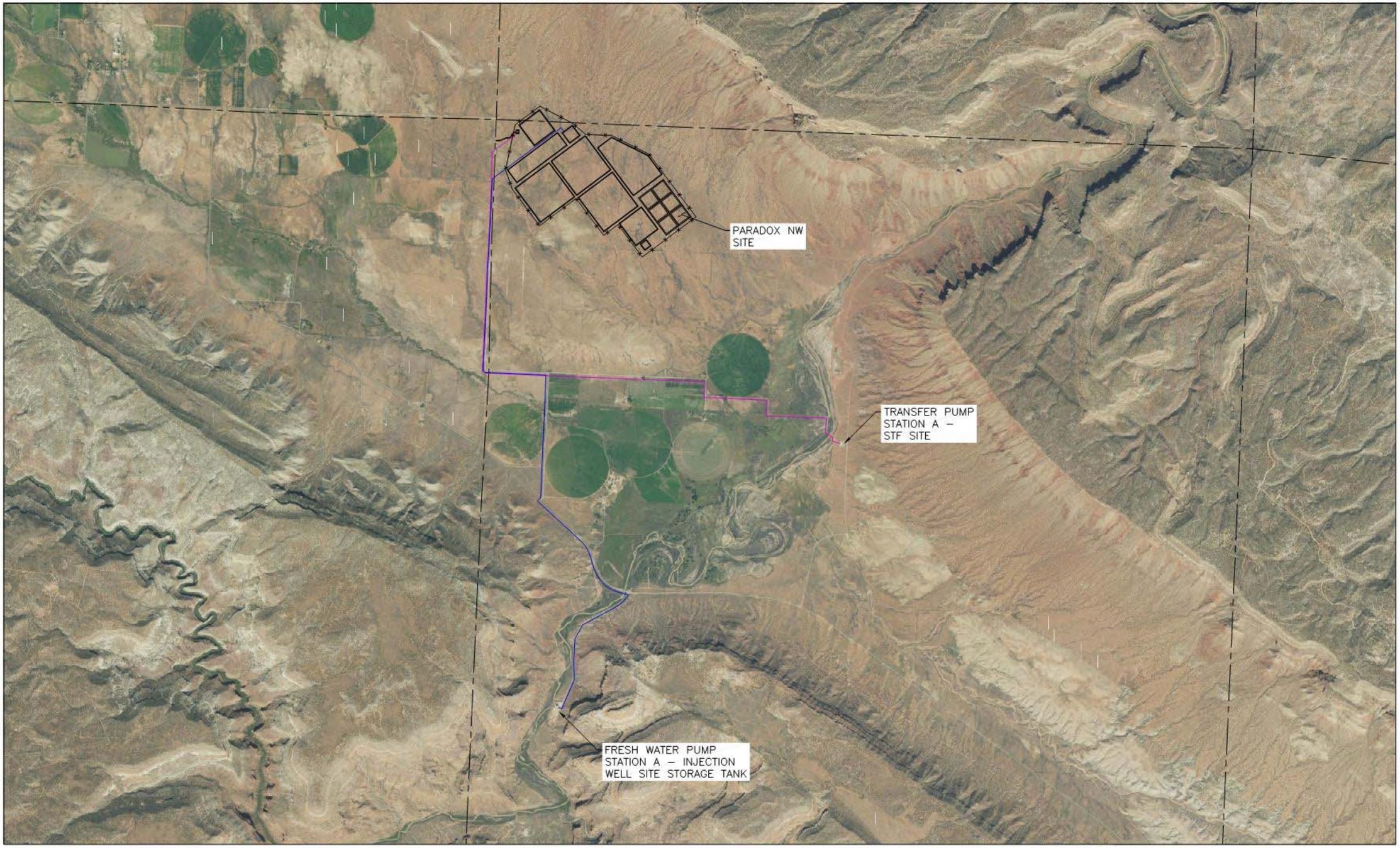

LEGEND:

BRINE SOLUTION PIPELINE
FRESH WATER PIPELINE

2000 0 2000 4000 FT

CLIENT: BUREAU OF RECLAMATION		ISSUED DATE: 02/02/2017
DRN BY: MGC	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: RDH	TITLE: PARADOX NW BRINE AND FRESHWATER SUPPLY PIPELINES	
CHK BY: BRB		FIGURE No.: 150
APR BY: CS		REV: B

amec foster wheeler

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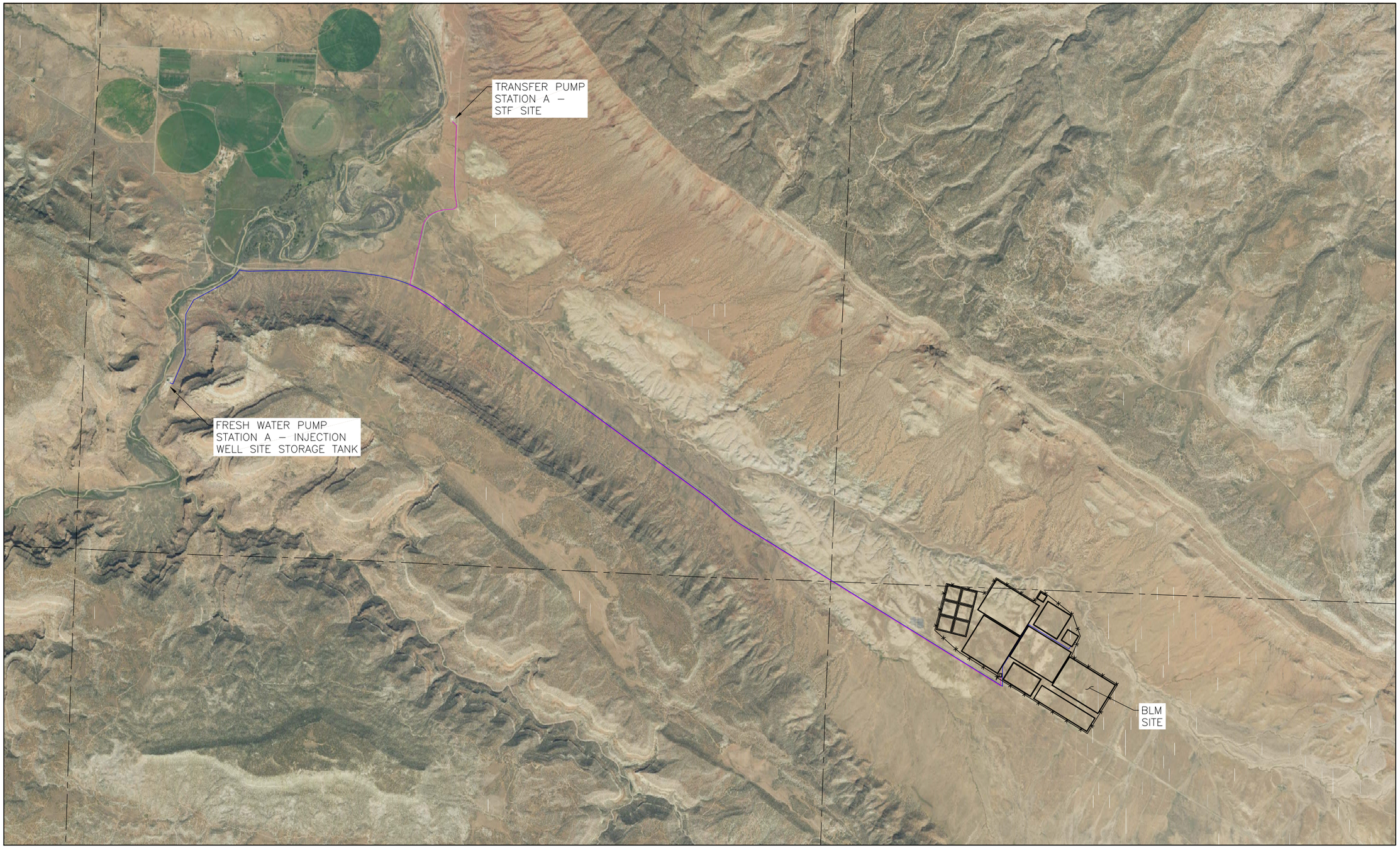

LEGEND:

BRINE SOLUTION PIPELINE

FRESH WATER PIPELINE

2000 0 2000 4000 FT

amec foster wheeler	CLIENT: BUREAU OF RECLAMATION	ISSUED DATE: 02/02/2017
DRN BY: MGC	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: RDH	TITLE: BLM BRINE AND FRESHWATER SUPPLY PIPELINES	
CHK BY: BRB		FIGURE No.: 160
APR BY: CS		REV: B

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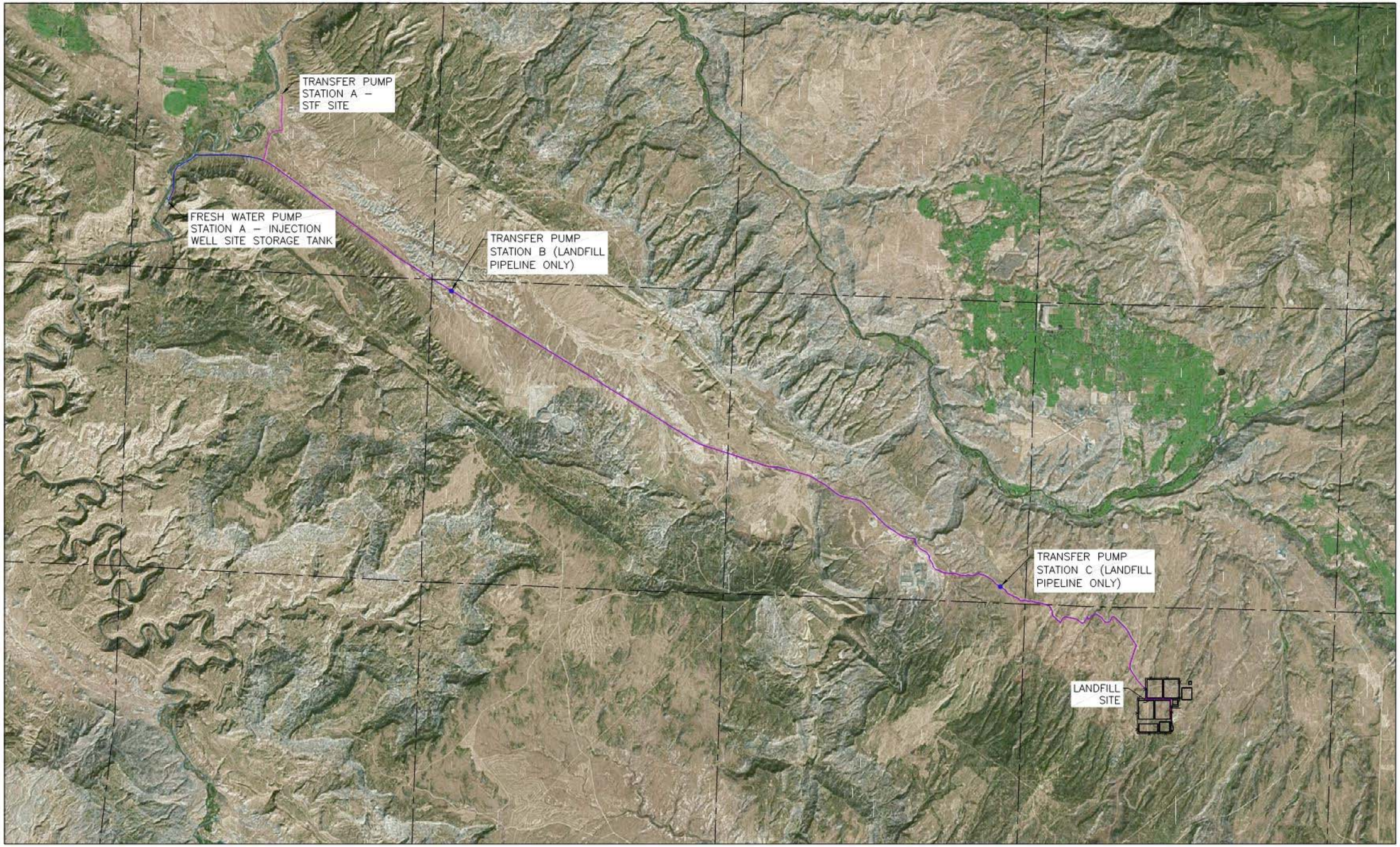

LEGEND:

BRINE SOLUTION PIPELINE

FRESH WATER PIPELINE

5000 0 5000 10000 FT

amec foster wheeler

CLIENT	BUREAU OF RECLAMATION
PROJECT	PARADOX VALLEY UNIT EVAPORATION PONDS
TITLE	LANDFILL BRINE AND FRESHWATER SUPPLY PIPELINES
DRN BY	MGC
DSN BY	RDH
CHK BY	BRB
APR BY	CS
ISSUED DATE	02/02/2017
PROJECT No.	1655500023
FIGURE No.	170
REV	B

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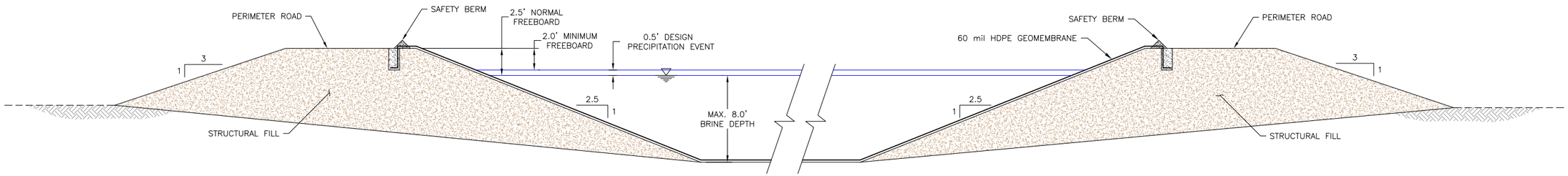
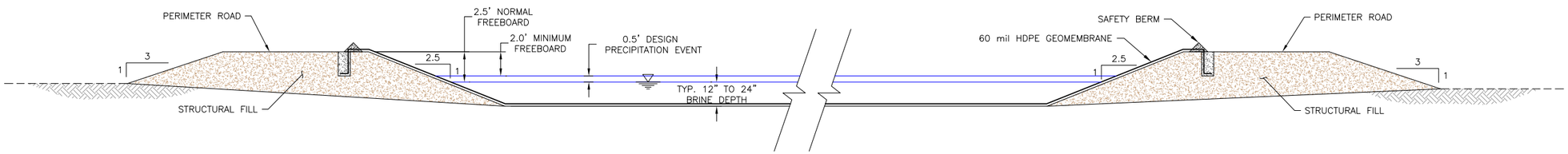
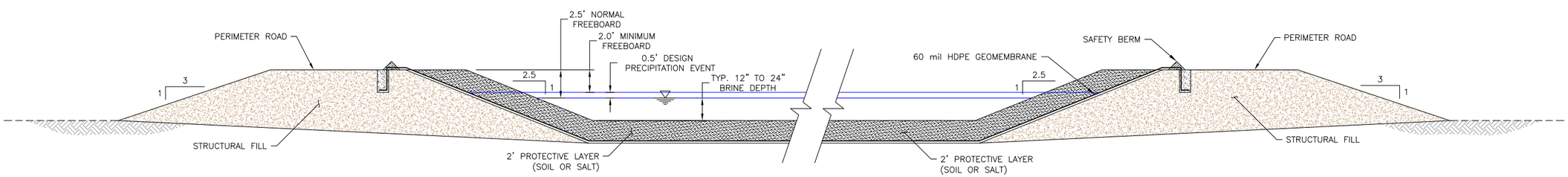


TYPICAL CROSS SECTION SURGE POND
N.T.S.



TYPICAL CROSS SECTION CONCENTRATOR POND
N.T.S.



TYPICAL CROSS SECTION CRYSTALLIZER PONDS
N.T.S.

amec foster wheeler	CLIENT: BUREAU OF RECLAMATION	ISSUED DATE: 02/02/2017
DRN BY: HJV	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: MGC	TITLE: SURGE, CONCENTRATOR, AND CRYSTALLIZER PONDS SECTIONS	
CHK BY: BRB		FIGURE No.: 175
APR BY: CS		REV: B

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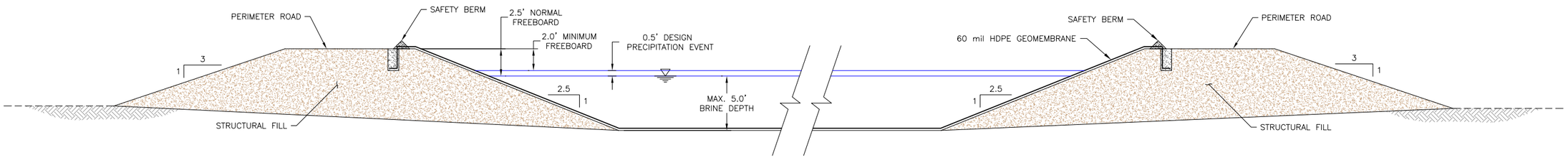
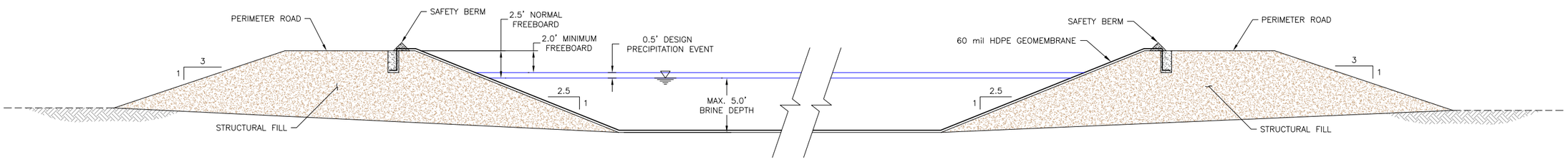
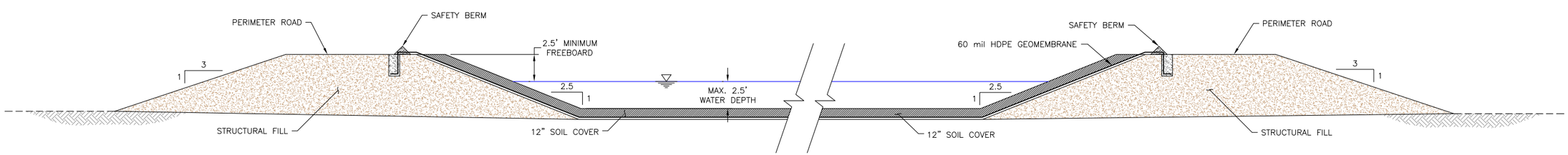


TYPICAL CROSS SECTION BITTERN POND
N.T.S.



TYPICAL CROSS SECTION BITTERN PRODUCT POND
N.T.S.



TYPICAL CROSS SECTION FRESHWATER POND
N.T.S.

amec foster wheeler	CLIENT: BUREAU OF RECLAMATION		ISSUED DATE: 02/02/2017
DRN BY: HJV	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS		PROJECT No.: 1655500023
DSN BY: MGC	TITLE: BITTERN, BITTERN PRODUCT, AND FRESHWATER PONDS SECTIONS		
CHK BY: BRB			FIGURE No.: 176
APR BY: CS			REV: B

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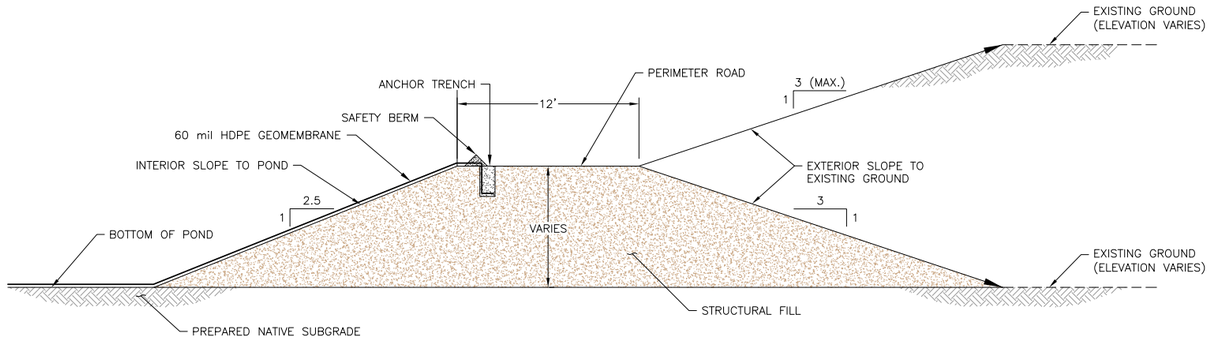

A TYPICAL EVAPORATION POND EMBANKMENT
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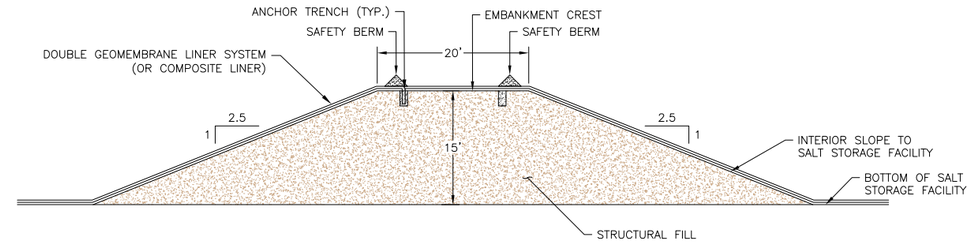
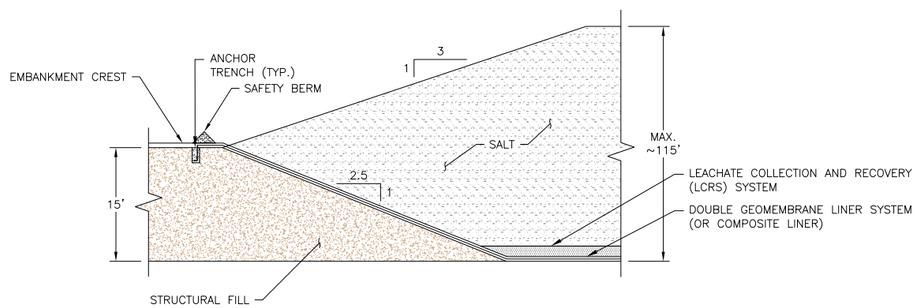
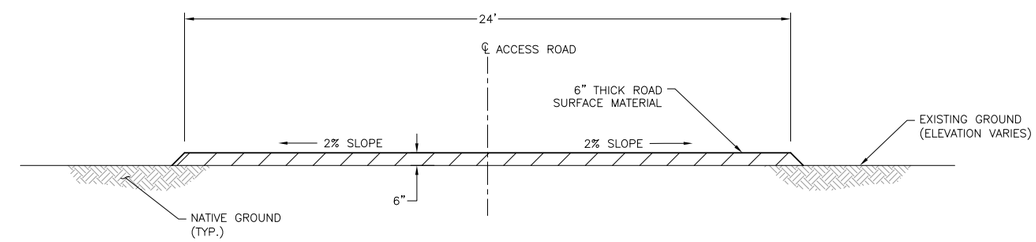


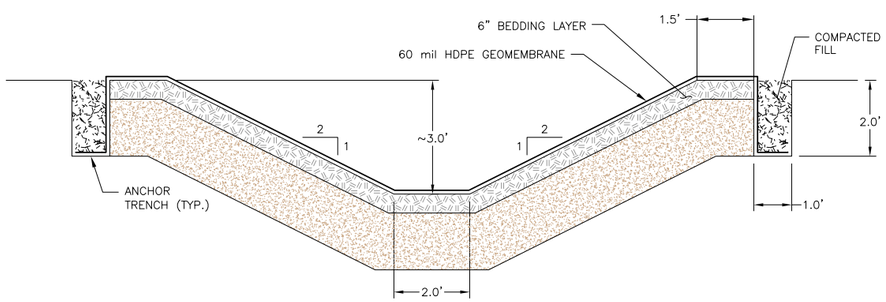
B TYPICAL SECTION FOR SALT STORAGE CELL INTERIOR EMBANKMENT
N.T.S.



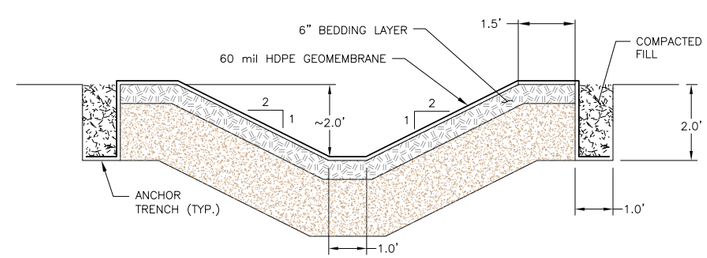
C TYPICAL SECTION FOR SALT STORAGE FACILITY PERIMETER EMBANKMENT
N.T.S.



D TYPICAL ACCESS ROAD SECTION
N.T.S.



E 180 E 180 E 180 TYPICAL BITTERN FEED CHANNEL
N.T.S.



F 180 F 180 F 180 TYPICAL CRYSTALLIZER FEED CHANNEL
N.T.S.

LEGEND:

- NATIVE GROUND OR PREPARED NATIVE SUBGRADE
- STRUCTURAL FILL
- ROAD SURFACE MATERIAL
- BEDDING LAYER
- SALT

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CLIENT: BUREAU OF RECLAMATION		ISSUED DATE: 02/02/2017
DRN BY: HJV	PROJECT: PARADOX VALLEY UNIT EVAPORATION PONDS	PROJECT No.: 1655500023
DSN BY: MGC	TITLE: DETAILS AND SECTIONS	
CHK BY: BRB		FIGURE No.: 180 / REV: B
APR BY: CS		

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APPENDIX A

Fathom 9 Model Output – Brine Pipeline to Paradox NW

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Model Reference Information

General

Title: Brine Transfer to Paradox NW Site 8 inch DR 11 4710 HDPE
Analysis run on: 7/22/2016 10:00:47 AM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Paradox NW Site\Brine Pipeline to Paradox NW Site.fth
Scenario: Base Scenario/Design at 300 gpm - 8 inch
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Paradox NW Site\Brine Pipeline to Paradox NW Site_3.out

Execution Time= 0.22 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 2
Total Number Of Temperature Iterations= 0
Number Of Pipes= 14
Number Of Junctions= 15
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1164 kg/m3
Viscosity= 0.002113 Pa-sec
Vapor Pressure= Unspecified
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 300.0 gal/min
Total Outflow= 300.0 gal/min
Maximum Static Pressure is 152.1 psig at Pipe 6 Outlet
Minimum Static Pressure is -5.163 psig at Pipe 1 Outlet

Warnings

No Warnings

Pump Summary

Brine Transfer to Paradox NW Site 8 inch
DR 11 4710 HDPE

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
2	Show	...	Transfer Pump A1	300.0	48.57	146.5	290.4	71.66	100.1	35.78	361.4	83.01

Jct	NPSHA (feet)	NPSHR (feet)
2	N/A	14.24

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
1	STF Storage Tank	Infinite	N/A	4,960	0	N/A	N/A	-300.0	-48.57
15	Sta 275+53 Paradox NW Site Salt Storage Pond	Infinite	N/A	5,145	0	N/A	N/A	300.0	48.57

Pipe Output Table

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
1	Pipe	4 inch	PVC - ASTM	schedule 80	12.000	300.0	8.372	4,955	4,958
2	Pipe	3 inch	PVC - ASTM	schedule 80	7.000	300.0	14.572	4,966	5,243
3	Pipe	8 inch	PVC - ASTM	schedule 80	8.000	300.0	2.108	4,964	5,238
4	Pipe	8 inch	HDPE - AFT Customary	SDR 11	301.000	300.0	2.528	4,960	5,237
5	Pipe	8 inch	HDPE - AFT Customary	SDR 11	198.000	300.0	2.528	4,941	5,236
6	Pipe	8 inch	HDPE - AFT Customary	SDR 11	426.000	300.0	2.528	4,940	5,236
7	Pipe	8 inch	HDPE - AFT Customary	SDR 11	626.000	300.0	2.528	4,933	5,234
8	Pipe	8 inch	HDPE - AFT Customary	SDR 11	2,517.000	300.0	2.528	4,935	5,232
9	Pipe	8 inch	HDPE - AFT Customary	SDR 11	668.000	300.0	2.528	4,942	5,224
10	Pipe	8 inch	HDPE - AFT Customary	SDR 11	2,627.000	300.0	2.528	4,992	5,222
11	Pipe	8 inch	HDPE - AFT Customary	SDR 11	677.000	300.0	2.528	4,969	5,213
12	Pipe	8 inch	HDPE - AFT Customary	SDR 11	9,297.000	300.0	2.528	4,980	5,211
13	Pipe	8 inch	HDPE - AFT Customary	SDR 11	6,828.000	300.0	2.528	5,046	5,181
14	Pipe	8 inch	HDPE - AFT Customary	SDR 11	3,388.000	300.0	2.528	5,119	5,158

Brine Transfer to Paradox NW Site 8 inch
DR 11 4710 HDPE

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	4,965	4,955	1.699	-5.163	6.8615	6.8615	5.0463	3.5973	1.699	-5.163	2.248	-4.61322
2	4,964	5,237	140.013	137.714	2.2989	2.2989	-0.7569	6.0556	140.013	137.714	141.678	139.37906
3	4,960	5,237	140.021	138.126	-1.8950	-1.8950	-2.0185	0.2448	138.126	140.021	138.161	140.05576
4	4,941	5,236	149.060	139.999	-9.0606	-9.0606	-9.5879	1.0450	139.999	149.060	140.049	149.10982
5	4,940	5,236	149.237	149.060	-0.1769	-0.1769	-0.5046	0.6494	149.060	149.237	149.110	149.28671
6	4,933	5,234	152.064	149.237	-2.8273	-2.8273	-3.5324	1.3973	149.237	152.064	149.287	152.11398
7	4,935	5,232	152.064	150.018	2.0454	2.0454	1.0093	2.0533	152.064	150.018	152.114	150.06857
8	4,942	5,224	150.018	142.320	7.6985	7.6985	3.5324	8.2559	150.018	142.320	150.069	142.37007
9	4,992	5,222	142.320	115.983	26.3370	26.3370	25.2313	2.1911	142.320	115.983	142.370	116.03310
10	4,969	5,213	123.241	115.983	-7.2582	-7.2582	-11.6064	8.6167	115.983	123.241	116.033	123.29129
11	4,980	5,211	123.241	116.570	6.6715	6.6715	5.5509	2.2206	123.241	116.570	123.291	116.61984
12	5,046	5,181	116.570	67.876	48.6937	48.6937	33.3053	30.4946	116.570	67.876	116.620	67.92618
13	5,119	5,158	67.876	19.737	48.1394	48.1394	36.8377	22.3961	67.876	19.737	67.926	19.78680
14	5,147	5,147	19.737	0.000	19.7367	19.7367	14.1295	11.1115	19.737	0.000	19.787	0.05011

All Junction Table

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
1	STF Storage Tank	4,960	4,960	0.000	2.523	0.000	2.523	300.0
2	Transfer Pump A1	4,965	4,955	-5.163	140.013	-4.613	141.678	300.0
3	Area Change	4,964	5,237	137.714	138.126	139.379	138.161	300.0
4	8" Sch 80 PVC to 8"DR 11 HDPE	4,960	5,237	140.021	139.999	140.056	140.049	300.0
5	Sta 3+01	4,941	5,236	149.060	149.060	149.110	149.110	300.0
6	Sta 4+99	4,940	5,236	149.237	149.237	149.287	149.287	300.0
7	Sta 9+25	4,933	5,234	152.064	152.064	152.114	152.114	300.0
8	Sta 15+51	4,935	5,232	150.018	150.018	150.069	150.069	300.0
9	Sta 40+68	4,942	5,224	142.320	142.320	142.370	142.370	300.0
10	Sta 47+36	4,992	5,222	115.983	115.983	116.033	116.033	300.0
11	Sta 73+63	4,969	5,213	123.241	123.241	123.291	123.291	300.0
12	Sta 80+40	4,980	5,211	116.570	116.570	116.620	116.620	300.0
13	Sta 173+37	5,046	5,181	67.876	67.876	67.926	67.926	300.0
14	Sta 241+65	5,119	5,158	19.737	19.737	19.787	19.787	300.0
15	Sta 275+53 Paradox NW Site Salt Storage Pond	5,145	5,145	0.000	0.000	0.000	0.000	300.0

Brine Transfer to Paradox NW Site 8 inch
DR 11 4710 HDPE

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	48.57	0.5000
2	48.57	0.0000
3	48.57	0.7316
4	48.57	0.1872
5	48.57	0.0000
6	48.57	0.0000
7	48.57	0.0000
8	48.57	0.0000
9	48.57	0.0000
10	48.57	0.0000
11	48.57	0.0000
12	48.57	0.0000
13	48.57	0.0000
14	48.57	0.0000
15	48.57	1.0000

Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User:		Issued by :			
Item/Equip.No. :	ITEM 001	Quotation No. :		Date :	07/22/2016
Service :	Brine Transfer to Paradox NW Site				
Order No. :				Rev. :	0

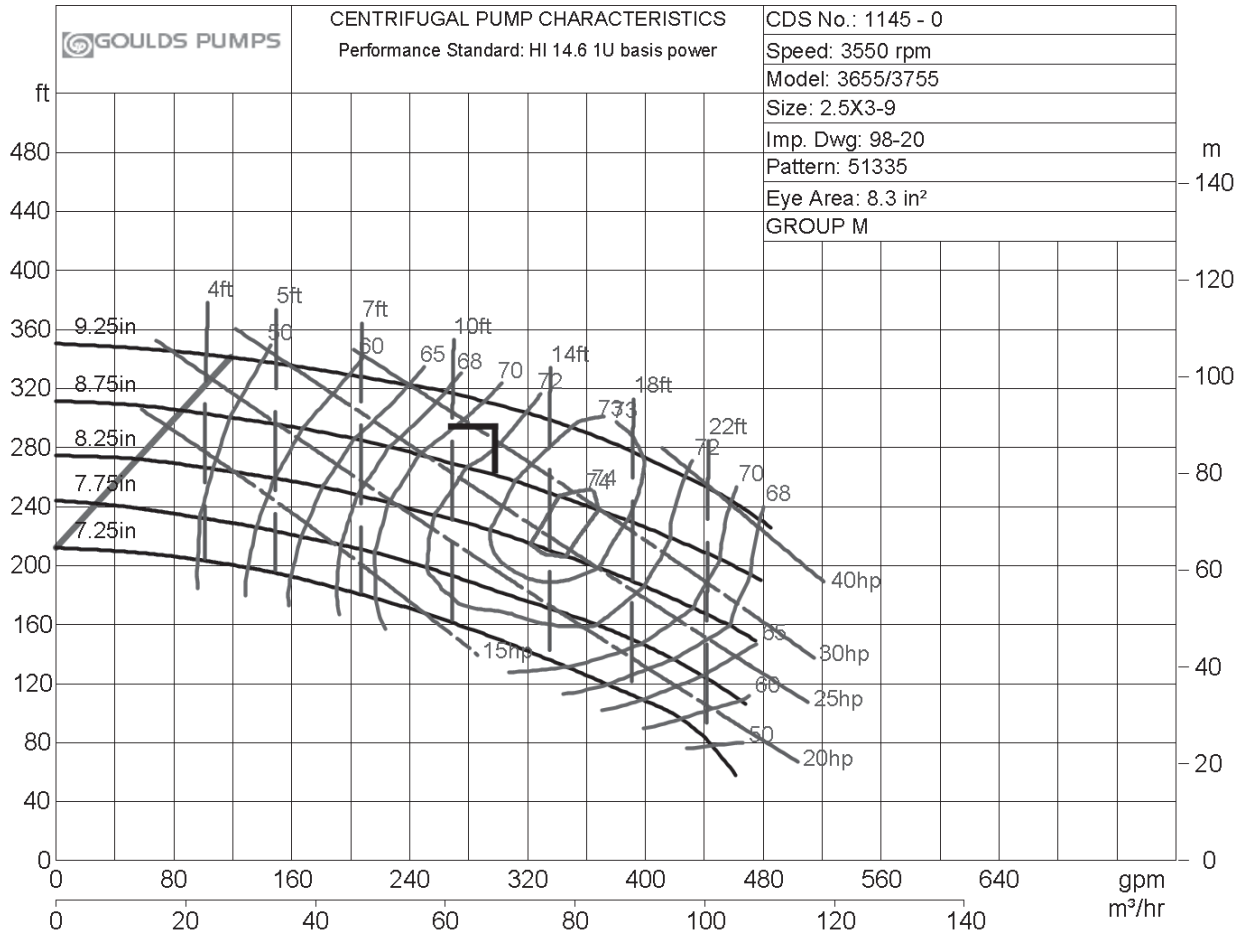
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.003 cp
Flow:	300.0 gpm
TDH:	290.4 ft
NPSHa:	28.9 ft
Solid size:	
% Susp. Solids (by wtg):	

Pump Performance

Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	45.9 hp		
Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHr:	11.8 ft		
Shut off Head:	340.6 ft		
Vapor Press:		Max. Solids Size:	0.3130 in

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



ITT

Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

Job/Inq.No. :
Purchaser : UNDEFINED
End User :
Item/Equip.No. : ITEM 001
Service : Brine Transfer to Paradox NW Site
Order No. :

Issued by :
Quotation No. :

Rev. : 0
Date : 07/22/2016

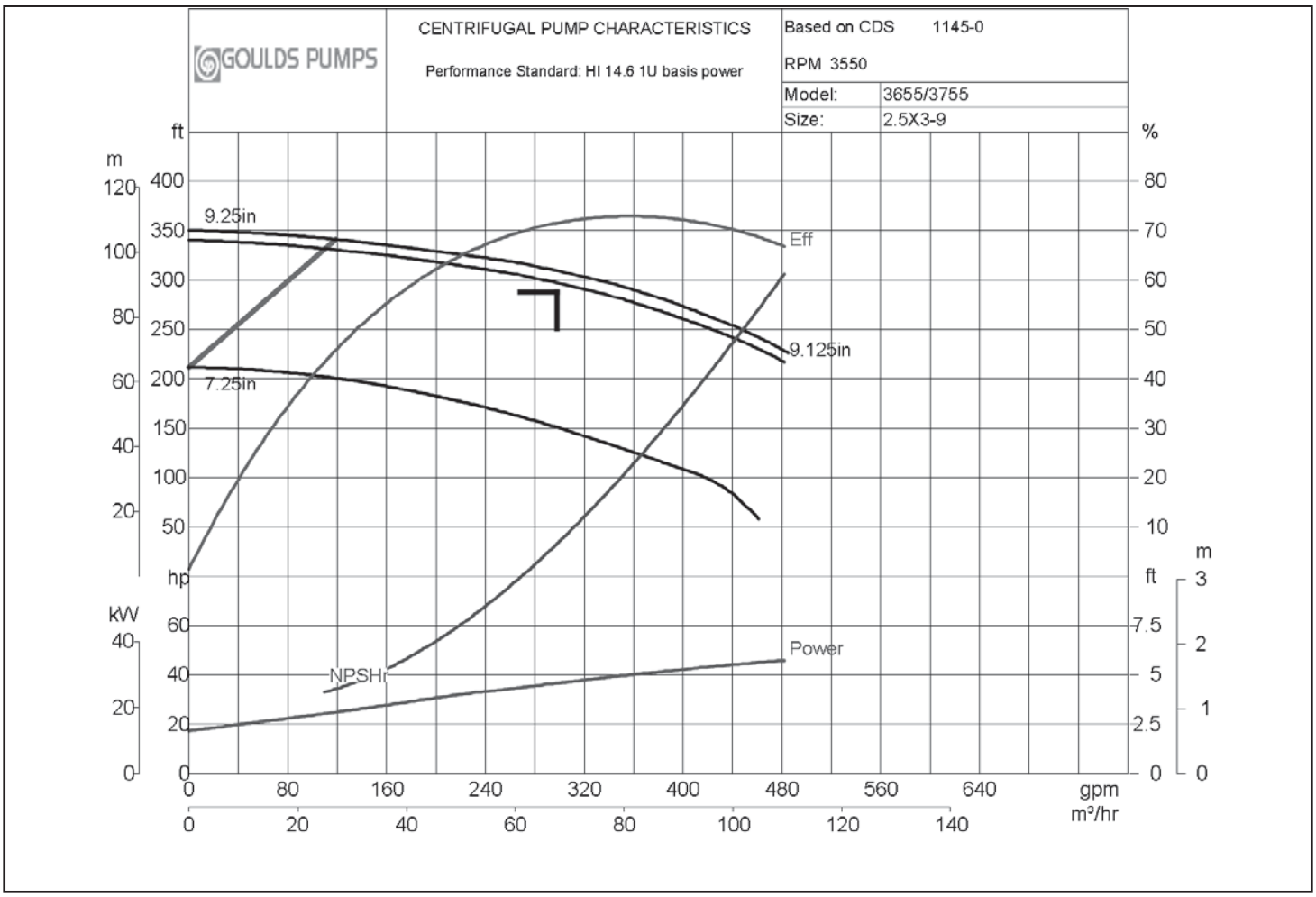
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.003 cp
Flow:	300.0 gpm
TDH:	290.4 ft
NPSHa:	28.9 ft
Solid size:	
Vapor Press:	

Pump Performance

Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	45.9 hp		
Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHr:	11.8 ft	Shut off Head:	340.6 ft
Max. Solids Size:	0.3130 in	% Susp. Solids (by wtg):	

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

ITT

Model: 3655	Size: 2.5X3-9	60Hz	RPM Variable	Stages: 1

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :			
Item/Equip.No. :	ITEM 001	Quotation No. :		Date :	07/22/2016
Service :	Brine Transfer to Paradox NW Site				
Order No. :				Rev. :	0

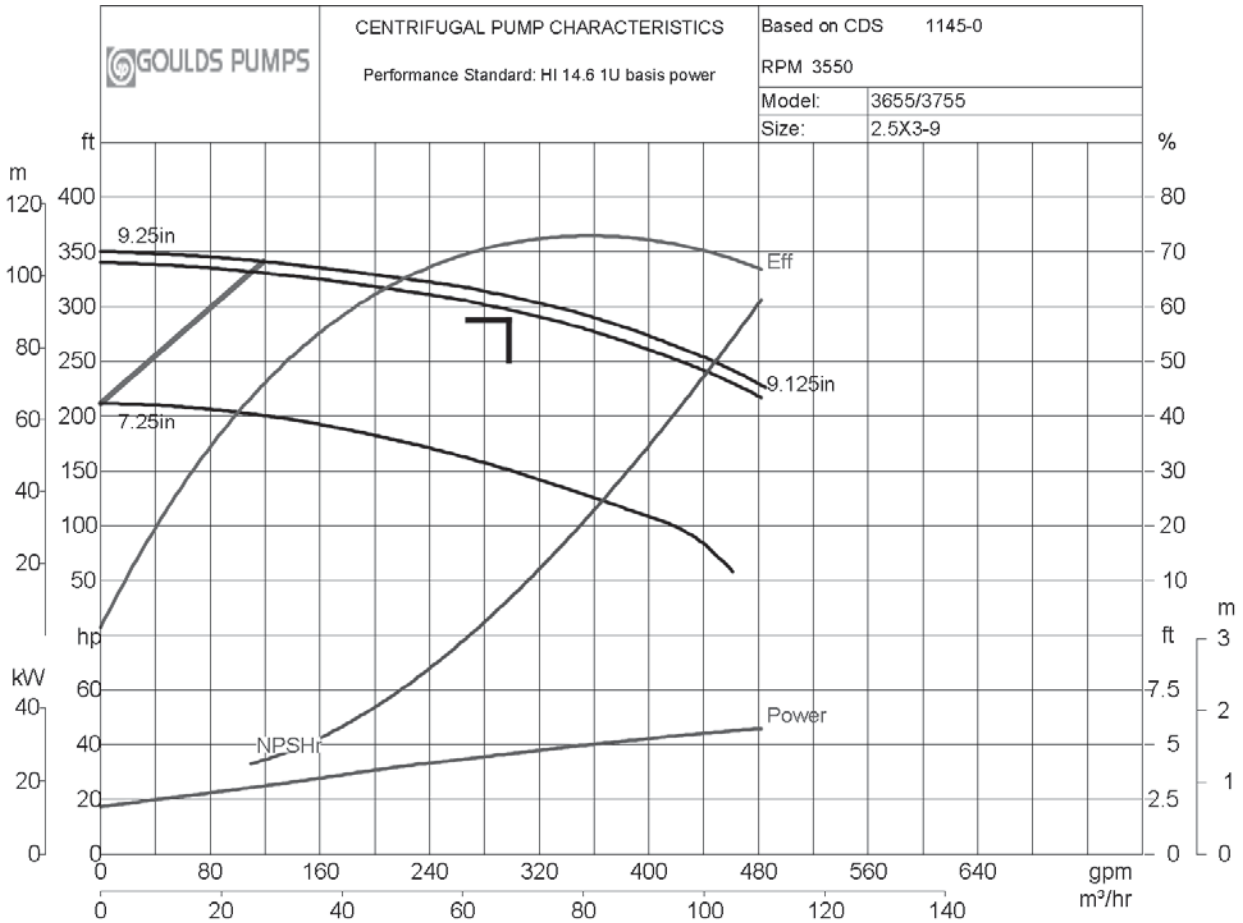
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.003 cp
Flow:	300.0 gpm
TDH:	290.4 ft
NPSHa:	28.9 ft
Solid size:	
% Susp. Solids (by wtg):	
Max. Solids Size:	0.3130 in

Pump Performance @ 3550 RPM

Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	45.9 hp		
Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHr:	11.8 ft		
Shut off Head:	340.6 ft		
Vapor Press:			

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/21/2016

Bedrock, Colorado

Paradox Valley - Brine to Paradox NW - 8 inch

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780090	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 8" diam., DR 11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment	27,560.00	L.F.	$13.46	370,957.60	0.00
221113789080	Welding, plastic, high density polyethylene (HDPE), dual wall contained pipe, labor per joint, pipe joint size is the outer pipe, cost based on the thickest walls, 8" pipe size, weld, excludes welding machine	689.00	Ea.	$62.99	43,400.11	0.00
221113789390	Welding, plastic, high density polyethylene (HDPE), dual wall, machine, rental per day based on diam. capacity, 6" thru 8" diameter	34.00	Ea.	$228.00	7,752.00	0.00
221123999	Cost for 300 gpm Brine Pump Station with Building	1.00	Ea.	$365,334.00	365,334.00	0.00
22 Plumbing Subtotal					**787,443.71**	**0.00**
26 Electrical						
2609999	Electrical, Instrumentation and Control for Pump Station	1.00	Ea.	$155,387.00	0.00	155,387.00
26 Electrical Subtotal					**0.00**	**155,387.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	11.20	Acre	$6,829.45	76,489.84	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	54,260.00	S.Y.	$0.55	29,843.00	0.00
312316140840	Excavating, chain trencher, utility trench, common earth, 12 H.P., 18" wide, 6' deep, fly wheel trencher, medium soil	5,360.00	B.C.Y.	$1.16	6,217.60	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	0.00	B.C.Y.	$2.32	0.00	0.00
312323132200	Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with vibrating roller	4,426.00	E.C.Y.	$3.73	16,508.98	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	1,470.00	L.C.Y.	$59.44	87,376.80	0.00
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	5,896.00	E.C.Y.	$4.97	29,303.12	0.00
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	1,470.00	L.C.Y.	$2.92	4,292.40	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	27,130.00	L.F.	$1.69	45,849.70	0.00
31 Earthwork Subtotal					**295,881.44**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	9,947.00	C.Y.	$5.71	0.00	56,797.37
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	54,260.00	S.Y.	$1.14	0.00	61,856.40
329219131100	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed with wood fiber mulch added	54,260.00	S.Y.	$3.84	0.00	208,358.40
32 Exterior Improvements Subtotal					**0.00**	**327,012.17**
33 Utilities						
330523220210	Directional drilling, mobilization or demobilization	2.00	Ea.	$4,690.75	0.00	9,381.50
330523220240	Directional drilling, hard clay, cobble, random boulders, mobilization w/ demobilization, per linear feet, 18" diameter	430.00	L.F.	$32.13	0.00	13,815.90
33 Utilities Subtotal					**0.00**	**23,197.40**

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
Subtotal					**1,083,325.15**	**505,596.57**
General Contractor's Markup on Subs				**12.00%**		**$60,671.59**
Subtotal					**$1,083,325.15**	**$566,268.16**
General Conditions				**20.00%**	**$216,665.03**	**$113,253.63**
Subtotal					**$1,299,990.18**	**$679,521.79**
General Contractor's Overhead and Profit				**15.00%**	**$194,998.53**	**$101,928.27**
Subtotal					**$1,494,988.71**	**$781,450.06**

Grand Total **$2,276,438.77**

APPENDIX B

Fathom 9 Model Output – Freshwater Pipeline to Paradox NW

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Model Reference Information

General

Title: Fresh Water to Paradox NW Site: 3: DR 11 4710 HDPE
Analysis run on: 7/26/2016 3:33:45 PM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Paradox NW Site\Fresh Water Pipeline to Paradox NW Site.fth
Scenario: Base Scenario/3" Pipeline/Design at 50 gpm
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Paradox NW Site\Fresh Water Pipeline to Paradox NW Site_6.out

Execution Time= 0.13 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 2
Total Number Of Temperature Iterations= 0
Number Of Pipes= 13
Number Of Junctions= 14
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 34 deg. F
Density= 999.9463 kg/m3
Viscosity= 0.00171 Pa-sec
Vapor Pressure= -14.591 psig
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 50.00 gal/min
Total Outflow= 50.00 gal/min
Maximum Static Pressure is 199.2 psig at Pipe 7 Outlet
Minimum Static Pressure is 8.518 psig at Pipe 1 Outlet

Warnings

No Warnings

Pump Summary

Fresh Water to Paradox NW Site: 3: DR 11 4710 HDPE

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)
2	Show	...	Fresh Water Transfer Pump A1	50.00	6.954	184.3	425.2	64.45	96.75	8.341	54.33

Jct	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
2	92.03	53.40	7.869

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
1	Injection Well Site Fresh Water Storage Tank	Infinite	N/A	5,040	0	N/A	N/A	-50.00	-6.954
15	Sta 300+26 Paradox NW Site Fresh Water Storage Tank	Infinite	N/A	5,165	0	N/A	N/A	50.00	6.954

Pipe Output Table

Pipe	Name	Pipe Material	Pipe Type-Schedule	Pipe Nominal Size	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
1	Pipe	PVC - ASTM	schedule 80	3 inch	6.000	50.00	2.429	5,020	5,040
2	Pipe	PVC - ASTM	schedule 80	3 inch	7.000	50.00	2.429	5,020	5,465
4	Pipe	HDPE - AFT Customary	SDR 11	3 inch	1,462.000	50.00	2.558	5,020	5,465
5	Pipe	HDPE - AFT Customary	SDR 11	3 inch	1,675.000	50.00	2.558	4,997	5,450
6	Pipe	HDPE - AFT Customary	SDR 11	3 inch	974.000	50.00	2.558	4,991	5,433
7	Pipe	HDPE - AFT Customary	SDR 11	3 inch	904.000	50.00	2.558	5,016	5,423
8	Pipe	HDPE - AFT Customary	SDR 11	3 inch	949.000	50.00	2.558	4,955	5,414
9	Pipe	HDPE - AFT Customary	SDR 11	3 inch	849.000	50.00	2.558	4,953	5,405
10	Pipe	HDPE - AFT Customary	SDR 11	3 inch	1,169.000	50.00	2.558	4,964	5,397
11	Pipe	HDPE - AFT Customary	SDR 11	3 inch	3,802.000	50.00	2.558	4,966	5,385
12	Pipe	HDPE - AFT Customary	SDR 11	3 inch	5,372.000	50.00	2.558	5,079	5,347
13	Pipe	HDPE - AFT Customary	SDR 11	3 inch	9,482.000	50.00	2.558	5,023	5,293
14	Pipe	HDPE - AFT Customary	SDR 11	3 inch	3,388.000	50.00	2.558	5,119	5,199

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	5,020	5,040	8.610	8.518	0.09220	0.09220	0.0000	0.2127	8.610	8.518	8.650	8.558
2	5,020	5,465	192.862	192.713	0.14904	0.14904	0.0000	0.3438	192.862	192.713	192.902	192.753
4	4,997	5,450	196.324	192.706	-3.61789	-3.61789	-9.9706	14.6543	192.706	196.324	192.750	196.368
5	4,991	5,433	196.324	191.683	4.64083	4.64083	-2.6010	16.7054	196.324	191.683	196.368	191.727
6	5,016	5,423	191.683	176.635	15.04869	15.04869	10.8376	9.7141	191.683	176.635	191.727	176.679
7	4,955	5,414	199.170	176.635	-22.53532	-22.53532	-26.4438	9.0159	176.635	199.170	176.679	199.214
8	4,953	5,405	199.170	195.934	3.23599	3.23599	-0.8670	9.4647	199.170	195.934	199.214	195.978
9	4,964	5,397	195.934	187.495	8.43920	8.43920	4.7685	8.4674	195.934	187.495	195.978	187.539
10	4,966	5,385	187.495	181.574	5.92118	5.92118	0.8670	11.6589	187.495	181.574	187.539	181.618
11	5,079	5,347	181.574	116.150	65.42392	65.42392	48.9860	37.9188	181.574	116.150	181.618	116.194
12	5,023	5,293	117.200	116.150	-1.05041	-1.05041	-24.2762	53.5769	116.150	117.200	116.194	117.244
13	5,119	5,199	117.200	34.588	82.61181	82.61181	41.6164	94.5675	117.200	34.588	117.244	34.632
14	5,145	5,165	34.588	8.670	25.91821	25.91821	11.2711	33.7877	34.588	8.670	34.632	8.714

All Junction Table

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	Injection Well Site Fresh Water Storage Tank	5,040	5,040	0.000	8.670	0.000	8.670
2	Fresh Water Transfer Pump A1	5,020	5,040	8.518	192.862	8.558	192.902
4	3" Sch 80 PVC to 3"DR 11 HDPE	5,020	5,465	192.713	192.706	192.753	192.750
5	Sta 14+62	4,997	5,450	196.324	196.324	196.368	196.368
6	Sta 31+37	4,991	5,433	191.683	191.683	191.727	191.727
7	Sta 41+11	5,016	5,423	176.635	176.635	176.679	176.679
8	Sta 50+15	4,955	5,414	199.170	199.170	199.214	199.214
9	Sta 59+64	4,953	5,405	195.934	195.934	195.978	195.978
10	Sta 68+13	4,964	5,397	187.495	187.495	187.539	187.539
11	Sta 79+82	4,966	5,385	181.574	181.574	181.618	181.618
12	Sta 117+84	5,079	5,347	116.150	116.150	116.194	116.194
13	Sta 171+56	5,023	5,293	117.200	117.200	117.244	117.244
14	Sta 266+38	5,119	5,199	34.588	34.588	34.632	34.632
15	Sta 300+26 Paradox NW Site Fresh Water Storage Tank	5,165	5,165	0.000	8.670	0.000	8.670

Fresh Water to Paradox NW Site: 3: DR
11 4710 HDPE

Jct	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	50.00	6.954	0.50000
2	50.00	6.954	0.00000
4	50.00	6.954	0.05933
5	50.00	6.954	0.00000
6	50.00	6.954	0.00000
7	50.00	6.954	0.00000
8	50.00	6.954	0.00000
9	50.00	6.954	0.00000
10	50.00	6.954	0.00000
11	50.00	6.954	0.00000
12	50.00	6.954	0.00000
13	50.00	6.954	0.00000
14	50.00	6.954	0.00000
15	50.00	6.954	1.00000

Model: VIT	Size: 6ALC	60Hz	RPM: 3550	Stages: 8

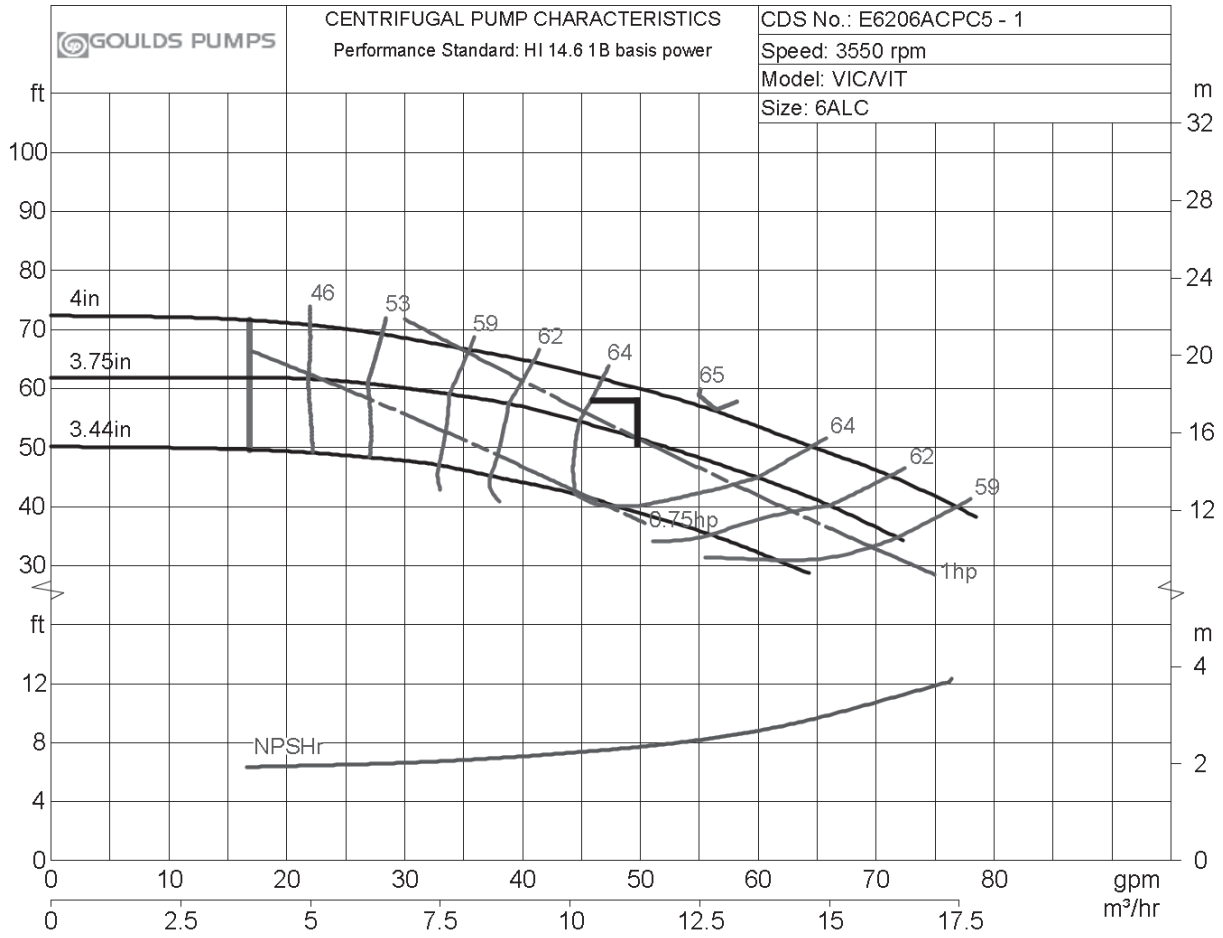
Job/Inq.No. :
Purchaser : UNDEFINED
End User: Issued by :
Item/Equip.No. : ITEM 001 Quotation No. : Date : 07/26/2016
Service : Fresh Water to Paradox NW Site
Order No. : Rev. : 0

Operating Conditions

Liquid:	Water	Published Efficiency:	64.6 %	Specific Speed:	1,300 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	64.6 %	Min. Hydraulic Flow:	16.9 gpm
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	9.1 hp	Min. Thermal Flow:	N/A
Flow:	50.0 gpm	Non-Overloading Power:	10.2 hp		
TDH:	468.0 ft	Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHa:		NPSHr:	7.7 ft		
Solid size:		Shut off Head:	564.0 ft		
% Susp. Solids (by wtg):		Vapor Press:		Max. Solids Size:	0.1500 in

Pump Performance

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Model: VIT	Size: 6ALC	60Hz	RPM: 3550	Stages: 8

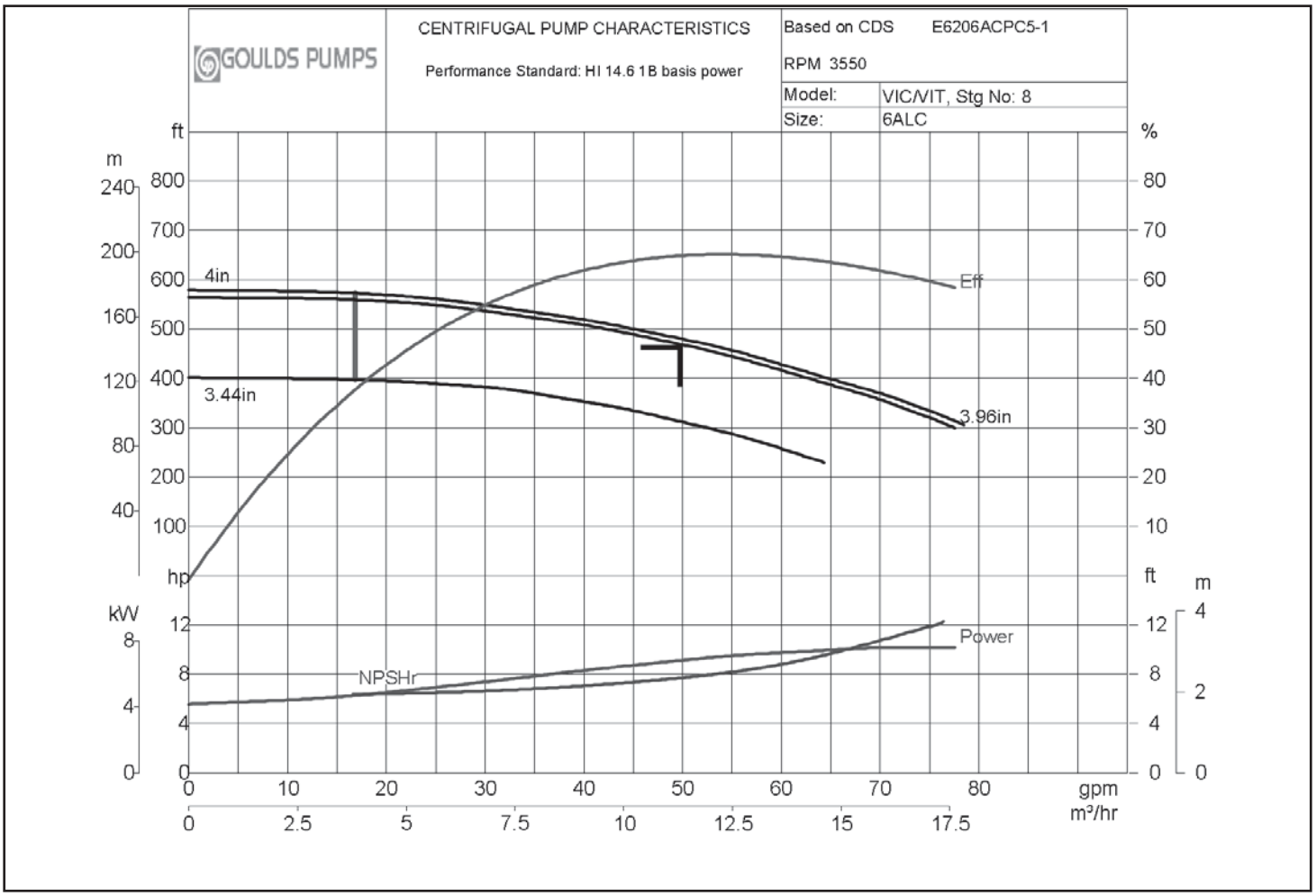
Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :		Rev. :	0
Item/Equip.No. :	ITEM 001	Quotation No. :		Date :	07/26/2016
Service :	Fresh Water to Paradox NW Site				
Order No. :					

Operating Conditions **Pump Performance**

Liquid:	Water	Published Efficiency:	64.6 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	64.6 %	Specific Speed Adl stg:	1,300 gpm(US) ft
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	9.1 hp	Min. Hydraulic Flow:	16.9 gpm
Flow:	50.0 gpm	Non-Overloading Power:	10.2 hp		
TDH:	468.0 ft	Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHa:		NPSHr:	7.7 ft	Shut off Head:	564.0 ft
Solid size:		Max. Solids Size:	0.1500 in	% Susp. Solids (by wtg):	

Vapor Press:

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

ITT

Model: VIT	Size: 6ALC	60Hz	RPM Variable	Stages: 8

Job/Inq.No. :
Purchaser : UNDEFINED
End User :
Issued by :
Item/Equip.No. : ITEM 001
Quotation No. :
Date : 07/26/2016
Service : Fresh Water to Paradox NW Site
Order No. :
Rev. : 0

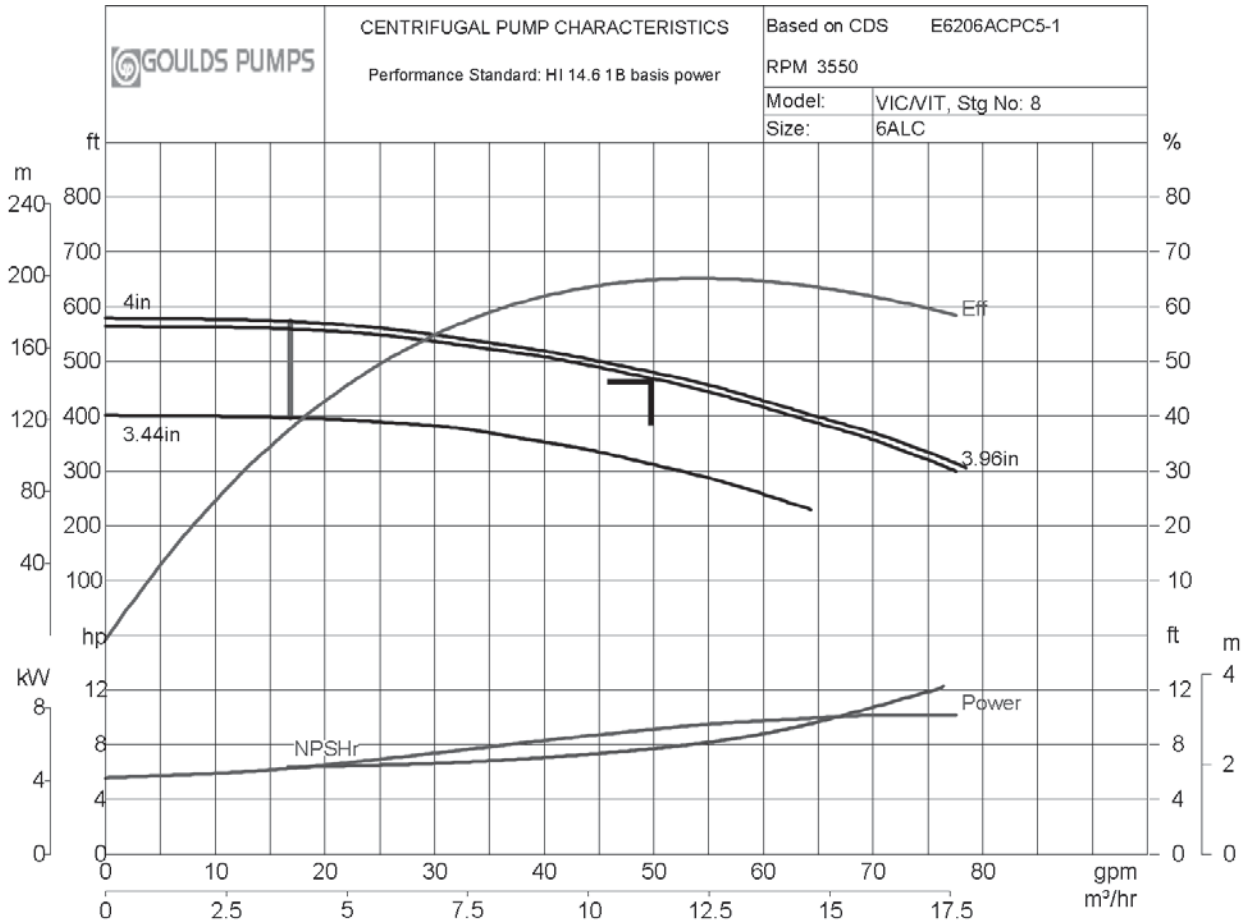
Operating Conditions

Liquid:	Water
Temp.:	70.0 deg F
S.G./Visc.:	1.000/1.000 cp
Flow:	50.0 gpm
TDH:	468.0 ft
NPSHa:	
Solid size:	
% Susp. Solids (by wtg):	
Max. Solids Size:	0.1500 in

Pump Performance @ 3550 RPM

Published Efficiency:	64.6 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Rated Pump Efficiency:	64.6 %	Specific Speed Adl stg:	1,300 gpm(US) ft
Rated Total Power:	9.1 hp	Min. Hydraulic Flow:	16.9 gpm
Non-Overloading Power:	10.2 hp		
Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHr:	7.7 ft		
Shut off Head:	564.0 ft		
Vapor Press:			

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/25/2016

Bedrock, Colorado

Paradox Valley - Fresh Water to Paradox NW - 3 inch HDPE

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780066	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 3" diam., DR 11, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting or digging equipment	30,043.00	L.F.	$1.94	58,283.42	0.00
221113784060	Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 3" pipe size, weld, excludes welding machine	751.00	Ea.	$20.04	15,050.04	0.00
221113784360	Welding, plastic, high density polyethylene (HDPE), single wall, machine, rental per day based on diam. capacity, 3" thru 4" diameter, weld	19.00	Ea.	$50.50	959.50	0.00
221123999	Cost for 50 gpm Fresh Water Pump Station with Building	1.00	Ea.	$163,994.00	163,994.00	0.00
22 Plumbing Subtotal					**238,286.96**	**0.00**
26 Electrical						
2609999	Electrical, Instrumentation and Control for Pump Station	1.00	Ea.	$10,112.00	0.00	10,112.00
26 Electrical Subtotal					**0.00**	**10,112.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	7.09	Acre	$6,829.45	48,420.80	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	5,720.00	S.Y.	$0.55	3,146.00	0.00
312316142600	Excavating, chain trencher, utility trench, common earth, 40 H.P., 8" wide, 48" deep, operator riding, includes backfill	30,043.00	L.F.	$1.35	40,558.05	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	0.00	B.C.Y.	$2.32	0.00	0.00
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	494.00	L.C.Y.	$59.44	29,363.36	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	494.00	E.C.Y.	$4.97	2,455.18	0.00
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	544.00	L.C.Y.	$2.92	1,588.48	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	17,160.00	L.F.	$1.69	29,000.40	0.00
31 Earthwork Subtotal					**154,532.27**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	5,720.00	C.Y.	$5.71	0.00	32,661.20
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	34,320.00	S.Y.	$1.14	0.00	39,124.80
32 Exterior Improvements Subtotal					**0.00**	**71,786.00**
33 Utilities						
330523220210	Directional drilling, mobilization or demobilization	2.00	Ea.	$4,690.75	0.00	9,381.50
330523220220	Directional drilling, hard clay, cobble, random boulders, mobilization w/ demobilization, per linear feet, 6" diameter	400.00	L.F.	$11.72	0.00	4,688.00
33 Utilities Subtotal					**0.00**	**14,069.50**
Subtotal					**392,819.23**	**95,967.50**
General Contractor's Markup on Subs				**12.00%**		**$11,516.10**
Subtotal					**$392,819.23**	**$107,483.60**
General Conditions				**20.00%**	**$78,563.85**	**$21,496.72**
Subtotal					**$471,383.08**	**$128,980.32**
General Contractor's Overhead and Profit				**15.00%**	**$70,707.46**	**$19,347.05**
Subtotal					**$542,090.54**	**$148,327.37**
Grand Total						**$690,417.91**

APPENDIX C

Fathom 9 Model Output – Brine Pipeline to BLM Site

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Model Reference Information

General

Title: Brine Transfer to BLM Site: 10 inch DR 7.3 4710 HDPE
Analysis run on: 7/22/2016 11:02:15 AM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\BLM site\Brine Pipeline to BLM Site.fth
Scenario: Base Scenario/10" HDPE Design at 300 gpm
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\BLM site\Brine Pipeline to BLM Site_3.out

Execution Time= 0.21 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 2
Total Number Of Temperature Iterations= 0
Number Of Pipes= 17
Number Of Junctions= 18
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1164 kg/m3
Viscosity= 0.001632 Pa-sec
Vapor Pressure= Unspecified
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 300.0 gal/min
Total Outflow= 300.0 gal/min
Maximum Static Pressure is 285.9 psig at Pipe 3 Outlet
Minimum Static Pressure is -5.146 psig at Pipe 1 Outlet

Warnings

No Warnings

Pump Summary

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
2	Show	...	Transfer Pump A1	300.0	48.57	107.26	212.5	73.14	100.00	25.66	323.0	92.89

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
17	Show	...	Transfer Pump A2	300.0	48.57	107.26	212.5	73.14	100.00	25.66	323.0	92.89
18	Show	...	Transfer Pump A3	300.0	48.57	77.97	154.5	73.24	88.11	18.63	284.6	105.42

Jct	NPSHA (feet)	NPSHR (feet)
	N/A	13.36

Jct	NPSHA (feet)	NPSHR (feet)
17	N/A	13.36
	N/A	15.70

Valve Summary

Jct	Name	Valve Type	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP Stag. (psid)	dH (feet)	P Static In (psig)	Cv	K	Valve State
16	Control Valve	PDCV	300.0	48.57	13.00	25.76	13.01	89.81	373.7	Open

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
	STF Storage Tank	Infinite	N/A	4,960	0	N/A	N/A	-300.0	-48.57
	Sta 407+88 BLM Site Salt Storage Pond	Infinite	N/A	5,419	0	N/A	N/A	300.0	48.57

Pipe Output Table

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
1	Pipe	4 inch	PVC - ASTM	schedule 80	12.000	300.0	8.372	4,955	4,958
2	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	7.000	300.0	13.020	4,966	5,531
3	Pipe	8 inch	Steel - ANSI	STD (schedule 40)	8.000	300.0	1.924	4,964	5,527
4	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	5,464.000	300.0	2.106	4,960	5,527
5	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	2,704.000	300.0	2.106	4,962	5,516
6	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	2,558.000	300.0	2.106	5,018	5,510
7	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	10,284.000	300.0	2.106	5,048	5,505
8	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	5,267.000	300.0	2.106	5,158	5,484
9	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,255.000	300.0	2.106	5,210	5,474
10	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	985.000	300.0	2.106	5,402	5,465
11	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	2,548.000	300.0	2.106	5,384	5,463

Fathom 9 (Output) 7/27/2016 Page 3 ray.hamilton	Brine Transfer to BLM Site: 10 inch DR 7.3 4710 HDPE	

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
12	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	3,368.000	300.0	2.106	5,419	5,458
13	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	1,478.000	300.0	2.106	5,421	5,451
14	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	1,866.000	300.0	2.106	5,449	5,449
15	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	10.000	300.0	2.106	5,419	5,419
16	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	5.000	300.0	13.020	4,966	5,166
17	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	5.000	300.0	13.020	4,966	5,377

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)
1	4,965	4,955	1.698675	-5.1456	6.844256	6.844256	5.0463	3.56303	1.698675	-5.1456
2	4,964	5,526	285.321838	283.6539	1.667895	1.667895	-0.7569	4.80521	285.321838	283.6539
3	4,960	5,527	285.936218	283.9888	-1.947439	-1.947439	-2.0185	0.14083	283.988770	285.9362
4	4,962	5,516	285.927673	279.3680	6.559711	6.559711	1.0093	10.99915	285.927673	279.3680
5	5,018	5,510	279.367950	248.3719	30.996077	30.996077	28.2591	5.42386	279.367950	248.3719
6	5,048	5,505	248.371887	230.6439	17.728017	17.728017	15.1388	5.13100	248.371887	230.6439
7	5,158	5,484	230.643875	164.7254	65.918441	65.918441	55.5089	20.62830	230.643875	164.7254
8	5,210	5,474	164.725433	133.1536	31.571869	31.571869	26.2406	10.56488	164.725433	133.1536
9	5,402	5,465	133.153564	31.9584	101.195157	101.195157	96.8882	8.53495	133.153564	31.9584
10	5,384	5,463	40.044651	31.9584	-8.086241	-8.086241	-9.0833	1.97578	31.958408	40.0447
11	5,419	5,458	40.044651	19.8036	20.241025	20.241025	17.6619	5.11094	40.044651	19.8036

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)
12	5,421	5,451	19.803623	15.3852	4.418379	4.418379	1.0093	6.75575	19.803623	15.3852
13	5,449	5,449	15.385248	-0.2403	15.625577	15.625577	14.1295	2.96467	15.385248	-0.2403
14	5,419	5,445	13.009666	-0.2403	-13.249995	-13.249995	-15.1388	3.74294	-0.240330	13.0097
15	5,419	5,419	0.009665	0.0000	0.009665	0.009665	0.0000	0.01915	0.009665	0.0000
16	4,965	5,165	101.079468	100.8385	0.240996	0.240996	-0.2523	0.97757	101.079468	100.8385
17	4,965	5,376	207.843216	207.6022	0.241001	0.241001	-0.2523	0.97758	207.843216	207.6022

Pipe	P Stag. In (psig)	P Stag. Out (psig)
1	2.24831	-4.59595
2	286.65118	284.98328
3	284.01779	285.96524
4	285.96246	279.40274
5	279.40274	248.40668
6	248.40668	230.67867
7	230.67867	164.76022
8	164.76022	133.18835
9	133.18835	31.99319
10	31.99319	40.07944
11	40.07944	19.83841

Pipe	P Stag. In (psig)	P Stag. Out (psig)
12	19.83841	15.42003
13	15.42003	-0.20554
14	-0.20554	13.04445
15	0.04445	0.03479
16	102.40880	102.16780
17	209.17255	208.93155

All Junction Table

Jct	Name	Elevation Inlet (feet)	EGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	STF Storage Tank	4,960	4,960	0.0000	2.523130	0.0000	2.52313
2	Transfer Pump A1	4,965	4,956	-5.1456	101.079468	-4.5959	102.40880
3	Area Change	4,964	5,529	283.6539	283.988770	284.9833	284.01779
4	8" Sch 40 Carbon Steel to 10"DR 7.3 HDPE	4,960	5,527	285.9362	285.927673	285.9652	285.96246
5	Sta 54+64	4,962	5,516	279.3680	279.367950	279.4027	279.40274
6	Sta 81+68	5,018	5,510	248.3719	248.371887	248.4067	248.40668
7	Sta 107+26	5,048	5,505	230.6439	230.643875	230.6787	230.67867
8	Sta 210+10	5,158	5,484	164.7254	164.725433	164.7602	164.76022
9	Sta 262+77	5,210	5,474	133.1536	133.153564	133.1884	133.18835
10	Sta 305+32	5,402	5,465	31.9584	31.958408	31.9932	31.99319
11	Sta 315+17	5,384	5,463	40.0447	40.044651	40.0794	40.07944
12	Sta 340+65	5,419	5,458	19.8036	19.803623	19.8384	19.83841
13	Sta 374+33	5,421	5,452	15.3852	15.385248	15.4200	15.42003
14	Sta 389+11	5,449	5,449	-0.2403	-0.240330	-0.2055	-0.20554
15	Sta 407+88 BLM Site Salt Storage Pond	5,419	5,419	0.0000	0.000000	0.0000	0.00000
16	Control Valve	5,419	5,445	13.0097	0.009665	13.0445	0.04445
17	Transfer Pump A2	4,965	5,167	100.8385	207.843216	102.1678	209.17255
18	Transfer Pump A3	4,965	5,379	207.6022	285.321838	208.9315	286.65118

Brine Transfer to BLM Site: 10 inch DR
7.3 4710 HDPE

Jct	Vol. Flow Rate Thru Jct (gal/min)	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	300.0	48.57	0.50000
2	300.0	48.57	0.00000
3	300.0	48.57	0.72629
4	300.0	48.57	0.09555
5	300.0	48.57	0.00000
6	300.0	48.57	0.00000
7	300.0	48.57	0.00000
8	300.0	48.57	0.00000
9	300.0	48.57	0.00000
10	300.0	48.57	0.00000
11	300.0	48.57	0.00000
12	300.0	48.57	0.00000
13	300.0	48.57	0.00000
14	300.0	48.57	0.00000
15	300.0	48.57	1.00000
16	300.0	48.57	373.72195
17	300.0	48.57	0.00000
18	300.0	48.57	0.00000

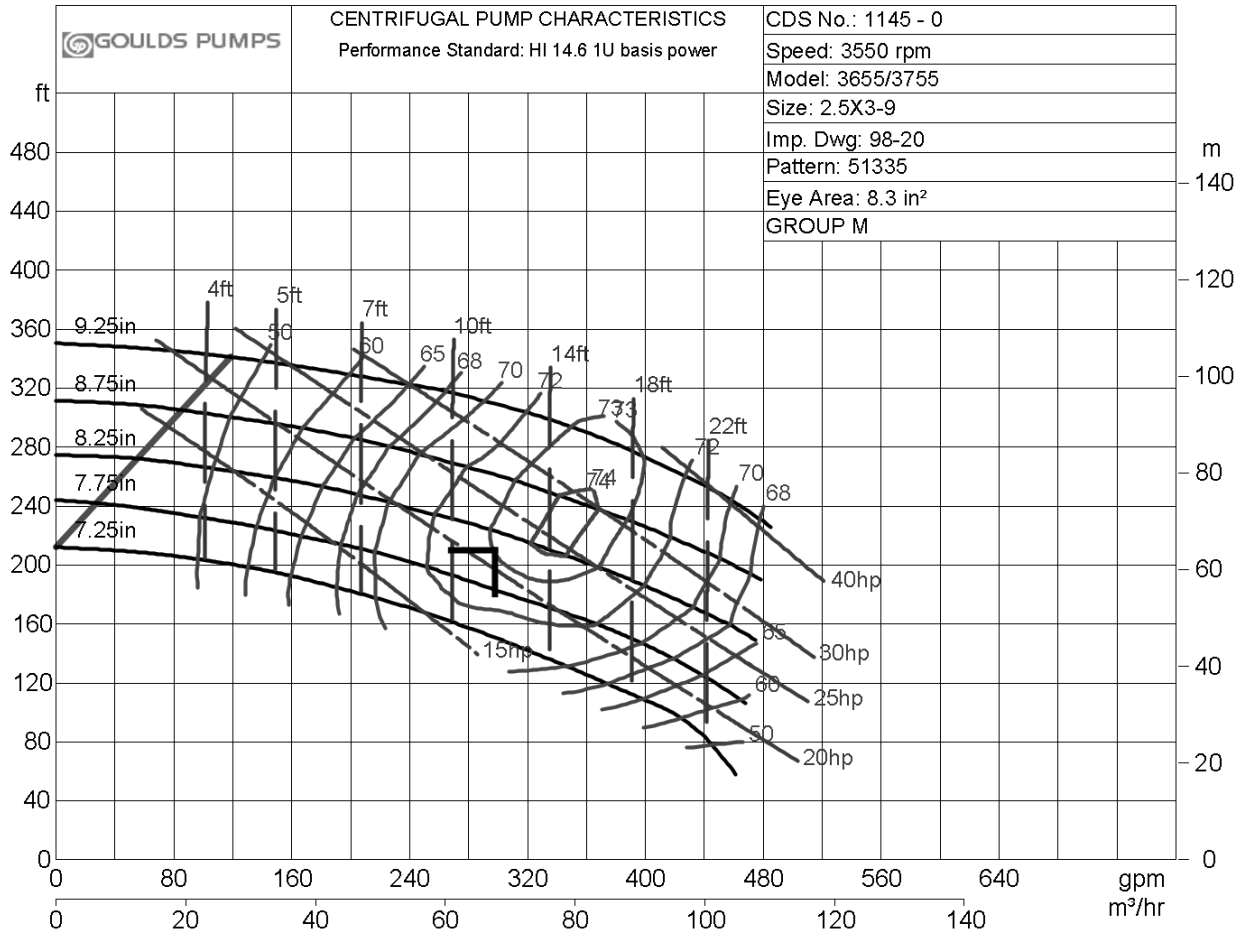
Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User:		Issued by :			
Item/Equip.No. :	ITEM 002	Quotation No. :		Date :	07/15/2016
Service :	Brine Transfer to BLM Site				
Order No. :				Rev. :	0

Operating Conditions **Pump Performance**

Liquid:	Brine	Published Efficiency:	73.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	73.0 %	Min. Hydraulic Flow:	52.1 gpm
S.G./Visc.:	1.170/1.320 cp	Rated Total Power:	25.7 hp	Min. Thermal Flow:	N/A
Flow:	300.0 gpm	Non-Overloading Power:	30.3 hp		
TDH:	211.9 ft	Imp. Dia. First 1 Stg(s):	8.1250 in		
NPSHa:	28.9 ft	NPSHr:	11.8 ft		
Solid size:		Shut off Head:	267.0 ft		
% Susp. Solids (by wtg):		Vapor Press:		Max. Solids Size:	0.3130 in

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



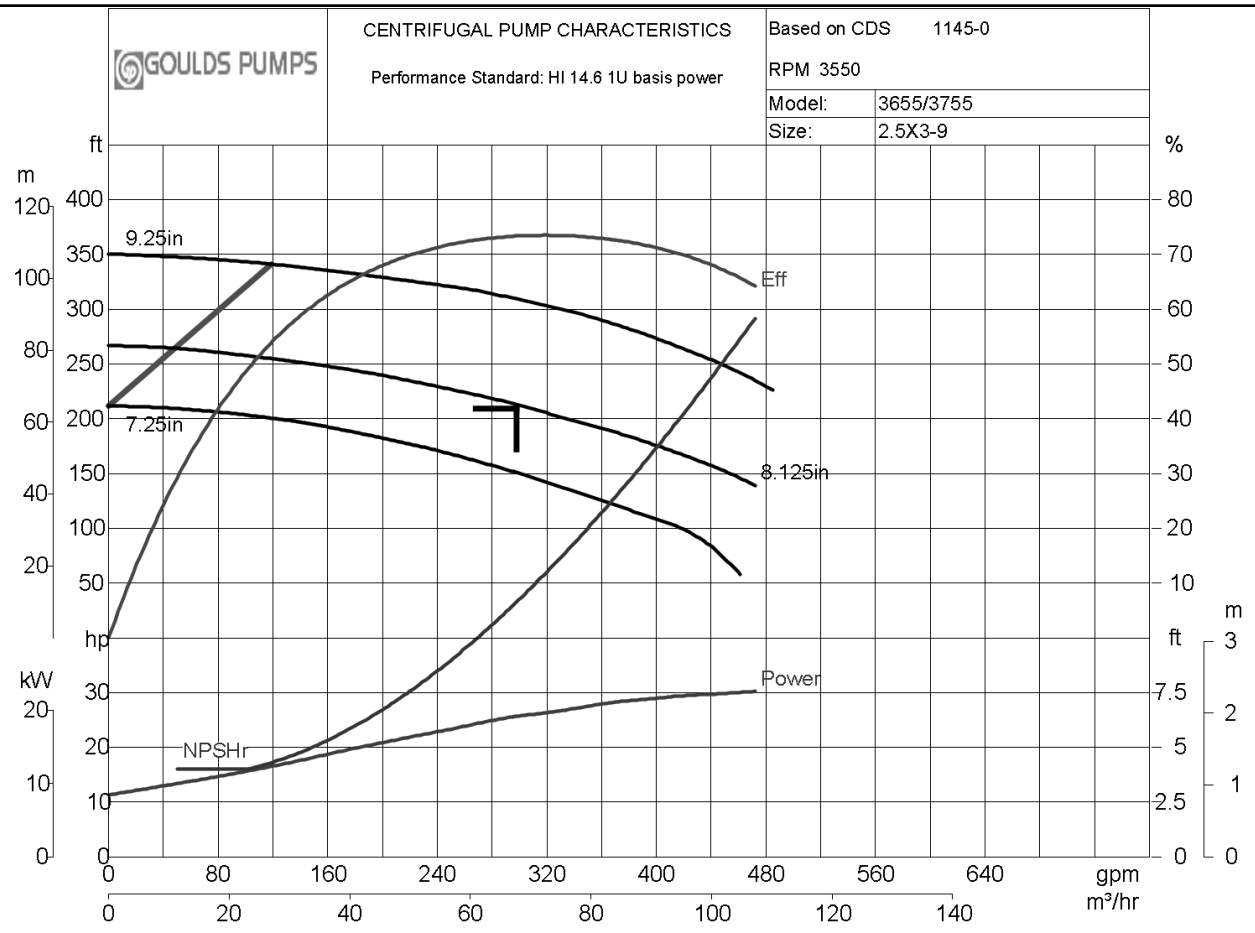
Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :		Rev. :	0
Item/Equip.No. :	ITEM 002	Quotation No. :		Date :	07/15/2016
Service :	Brine Transfer to BLM Site				
Order No. :					

Operating Conditions **Pump Performance**

Liquid:	Brine	Published Efficiency:	73.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	73.0 %	Min. Hydraulic Flow:	52.1 gpm
S.G./Visc.:	1.170/1.320 cp	Rated Total Power:	25.7 hp	Min. Thermal Flow:	N/A
Flow:	300.0 gpm	Non-Overloading Power:	30.3 hp		
TDH:	211.9 ft	Imp. Dia. First 1 Stg(s):	8.1250 in		
NPSHa:	28.9 ft	NPSHr:	11.8 ft	Shut off Head:	267.0 ft
Solid size:		Max. Solids Size:	0.3130 in	% Susp. Solids (by wtg):	
Vapor Press:					

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

ITT

Model: 3655	Size: 2.5X3-9	60Hz	RPM Variable	Stages: 1

Job/Inq.No. :
Purchaser : UNDEFINED
End User :
Issued by :
Item/Equip.No. : ITEM 002
Quotation No. :
Date : 07/15/2016
Service : Brine Transfer to BLM Site
Order No. :
Rev. : 0

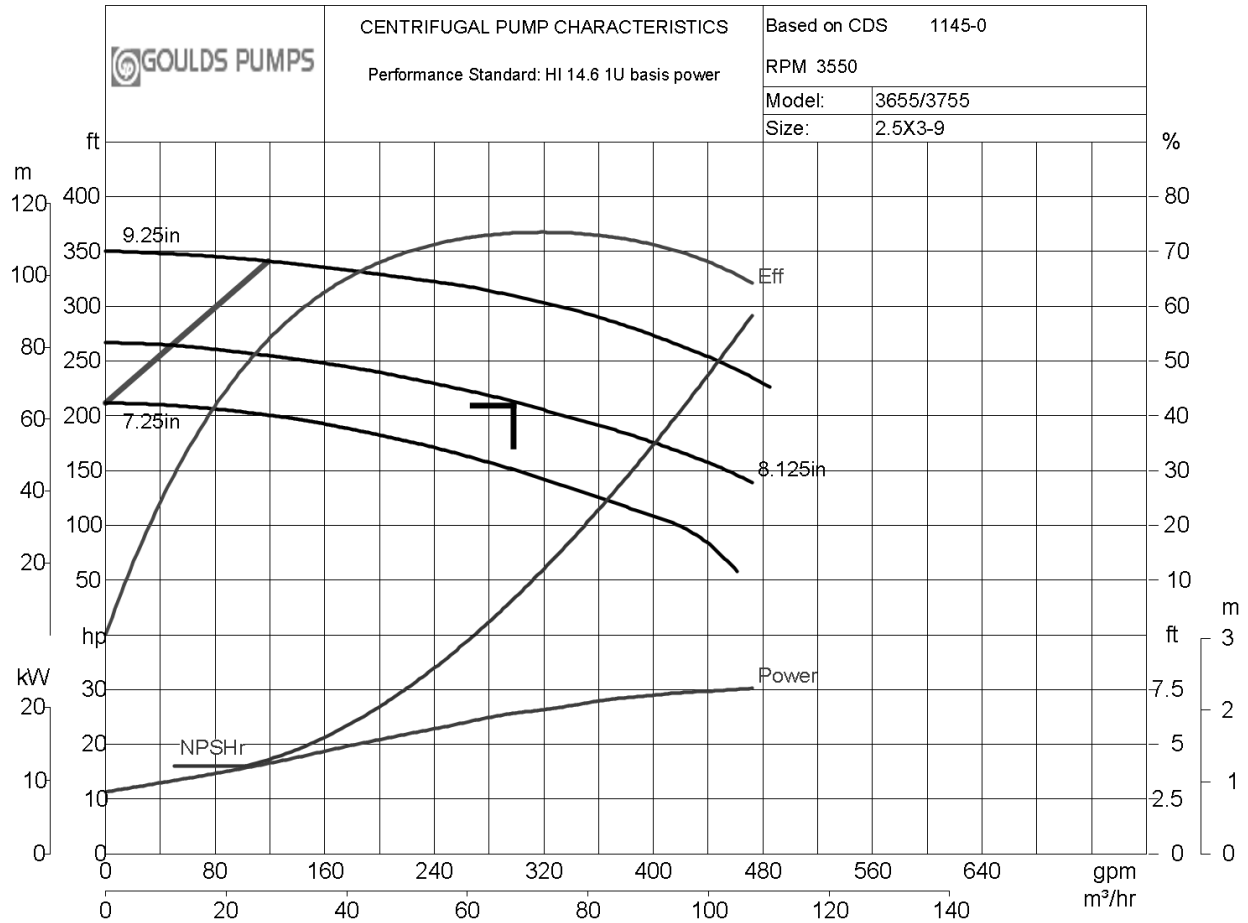
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.320 cp
Flow:	300.0 gpm
TDH:	211.9 ft
NPSHa:	28.9 ft
Solid size:	
% Susp. Solids (by wtg):	
Max. Solids Size:	0.3130 in

Pump Performance @ 3550 RPM

Published Efficiency:	73.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	73.0 %	Min. Hydraulic Flow:	52.1 gpm
Rated Total Power:	25.7 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	30.3 hp		
Imp. Dia. First 1 Stg(s):	8.1250 in		
NPSHr:	11.8 ft		
Shut off Head:	267.0 ft		
Vapor Press:			

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



ITT

Model: 3655	Size: 2.5X3-9	60Hz	RPM Variable	Stages: 1

Job/Inq.No. :
Purchaser : UNDEFINED
End User : Issued by :
Item/Equip.No. : ITEM 002 Quotation No. : Date : 07/15/2016
Service : Brine Transfer to BLM Site
Order No. : Rev. : 0

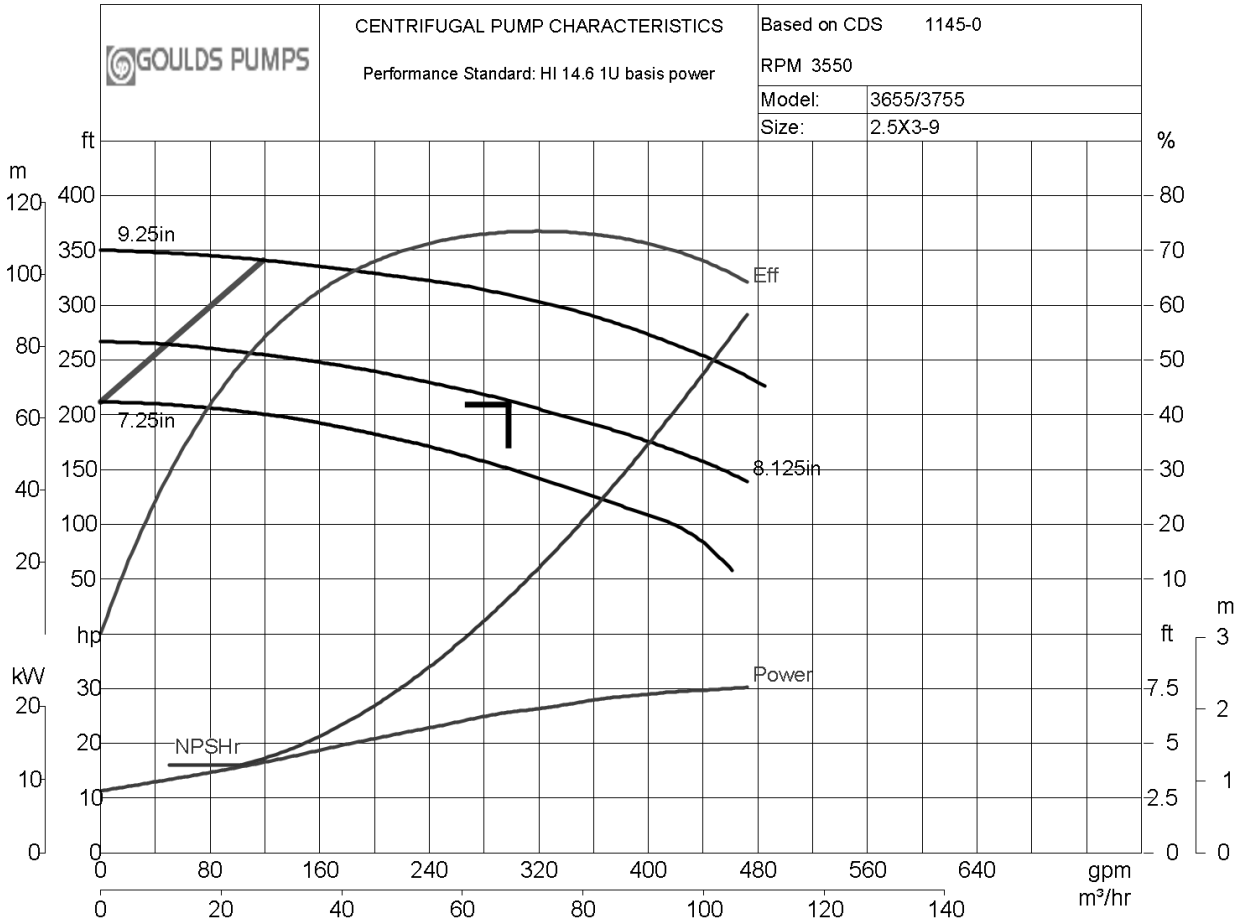
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.320 cp
Flow:	300.0 gpm
TDH:	211.9 ft
NPSHa:	28.9 ft
Solid size:	
% Susp. Solids (by wtg):	
Max. Solids Size:	0.3130 in

Pump Performance @ 3550 RPM

Published Efficiency:	73.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	73.0 %	Min. Hydraulic Flow:	52.1 gpm
Rated Total Power:	25.7 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	30.3 hp		
Imp. Dia. First 1 Stg(s):	8.1250 in		
NPSHr:	11.8 ft		
Shut off Head:	267.0 ft		
Vapor Press:			

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/22/2016

Paradox Valley - Brine to BLM - 10 inch HDPE

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780099	pipe, plastic, high density polyurethane (HDPE), single wall, straight, welded, based on 40' length, 10" diam, DR 7.3, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment	40,760.00	L.F.	$30.10	1,226,876.00	0.00
221113784100	Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 10" pipe size, weld, excludes welding machine	1,019.00	Ea.	$62.99	64,186.81	0.00
221113784380	Welding, plastic, high density polyethylene (HDPE), single wall, machine, rental per day based on diam. capacity, 10" thru 12" diameter, weld	51.00	Ea.	$196.00	9,996.00	0.00
221123999	Cost for 300 gpm Brine Pump Station with Building 30 HP motors	1.00	Ea.	$440,922.00	440,922.00	0.00
22 Plumbing Subtotal					**1,741,980.81**	**0.00**
26 Electrical						
2609999	Electrical, Instrumentation and Control for Pump Station adjusted for three pumps	1.00	Ea.	$233,082.00	0.00	233,082.00
26 Electrical Subtotal					**0.00**	**233,082.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	16.82	Acre	$6,829.45	114,871.35	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	81,520.00	S.Y.	$0.55	44,836.00	0.00
312316140840	Excavating, chain trencher, utility trench, common earth, 12 H.P., 18" wide, 6' deep, fly wheel trencher, medium soil	9,059.00	B.C.Y.	$1.16	10,508.44	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	0.00	B.C.Y.	$2.32	0.00	0.00
312323132200	Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with vibrating roller	7,480.00	E.C.Y.	$3.73	27,900.40	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	2,485.00	L.C.Y.	$59.44	147,708.40	0.00
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	9,965.00	E.C.Y.	$4.97	49,526.05	0.00
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	2,485.00	L.C.Y.	$2.92	7,256.20	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	40,760.00	L.F.	$1.69	68,884.40	0.00
31 Earthwork Subtotal					**471,491.24**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	14,945.00	C.Y.	$5.71	0.00	85,335.95
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	81,520.00	S.Y.	$1.14	0.00	92,932.80
329219131100	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed with wood fiber mulch added	81,520.00	S.Y.	$3.84	0.00	313,036.80
32 Exterior Improvements Subtotal					**0.00**	**491,305.55**
Subtotal					**2,213,472.05**	**724,387.55**
General Contractor's Markup on Subs				**12.00%**		**$86,926.51**
Subtotal					**$2,213,472.05**	**$811,314.06**
General Conditions				**20.00%**	**$442,694.41**	**$162,262.81**
Subtotal					**$2,656,166.46**	**$973,576.87**
General Contractor's Overhead and Profit				**15.00%**	**$398,424.97**	**$146,036.53**
Subtotal					**$3,054,591.43**	**$1,119,613.40**
Grand Total						**$4,174,204.83**

APPENDIX D

Fathom 9 Model Output – Freshwater Pipeline to BLM Site

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Model Reference Information

General

Title: Fresh Water Supply to BLM Site: 4 inch PC 350 DIP, 4 inch DR 7.3 4710 HPDE and 4 inch DR 9 4710 HDPE
Analysis run on: 7/26/2016 4:22:23 PM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\BLM site\Fresh Water Pipeline to BLM Site.fth
Scenario: Base Scenario/4" DIP and 4" HDPE/Design at 50 gpm
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\BLM site\Fresh Water Pipeline to BLM Site_1.out

Execution Time= 0.18 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 2
Total Number Of Temperature Iterations= 0
Number Of Pipes= 21
Number Of Junctions= 22
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1164 kg/m3
Viscosity= 0.001632 Pa-sec
Vapor Pressure= Unspecified
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 50.00 gal/min
Total Outflow= 50.00 gal/min
Maximum Static Pressure is 334.6 psig at Pipe 18 Outlet
Minimum Static Pressure is 3.480 psig at Pipe 13 Outlet

Warnings

No Warnings

Pump Summary

Fresh Water Supply to BLM Site: 4 inch PC 350 DIP, 4 inch DR 7.3 4710 HPDE and 4 inch DR 9 4710 HDPE

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)
2	Show	...	Fresh Water Transfer Pump A1	50.00	8.095	295.4	585.3	64.81	96.43	13.29	50.19

Jct	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
2	99.63	N/A	7.841

Valve Summary

Jct	Name	Valve Type	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP Stag. (psid)	dH (feet)	P Static In (psig)	Cv	K	Valve State
16	Control Valve	PDCV	50.00	8.095	5.000	9.908	15.11	24.13	214.0	Open

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
1	Injection Well Site Fresh Water Storage Tank	Infinite	N/A	5,040	0	N/A	N/A	-50.00	-8.095
15	Sta 407+88 BLM Site Fresh Water Storage Tank	Infinite	N/A	5,439	0	N/A	N/A	50.00	8.095

Pipe Output Table

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
1	Pipe	3 inch	PVC - ASTM	schedule 80	6.000	50.00	2.429	5,020	5,040
2	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	7.000	50.00	2.170	5,020	5,625
4	Pipe	4 inch	Ductile Iron - ANSI	class 51	1,462.000	50.00	1.115	5,020	5,625
5	Pipe	4 inch	Ductile Iron - ANSI	class 51	1,675.000	50.00	1.115	4,997	5,623
6	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	2,558.000	50.00	2.003	5,018	5,591
7	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	10,284.000	50.00	2.003	5,048	5,577
8	Pipe	4 inch	HDPE - AFT Customary	SDR 9	5,267.000	50.00	1.726	5,158	5,523
9	Pipe	4 inch	HDPE - AFT Customary	SDR 9	4,255.000	50.00	1.726	5,210	5,503
10	Pipe	4 inch	HDPE - AFT Customary	SDR 9	985.000	50.00	1.726	5,402	5,487
11	Pipe	4 inch	HDPE - AFT Customary	SDR 9	2,548.000	50.00	1.726	5,384	5,483
12	Pipe	4 inch	HDPE - AFT Customary	SDR 9	3,368.000	50.00	1.726	5,419	5,474
13	Pipe	4 inch	HDPE - AFT Customary	SDR 9	1,478.000	50.00	1.726	5,421	5,461
14	Pipe	4 inch	HDPE - AFT Customary	SDR 9	1,866.000	50.00	1.726	5,449	5,456
15	Pipe	4 inch	HDPE - AFT Customary	SDR 9	10.000	50.00	1.726	5,419	5,439
16	Pipe	4 inch	Ductile Iron - ANSI	class 51	974.000	50.00	1.115	4,991	5,620
17	Pipe	4 inch	Ductile Iron - ANSI	class 51	904.000	50.00	1.115	5,016	5,619

Fathom 9 (Output) 7/27/2016 Page 3 ray.hamilton	Fresh Water Supply to BLM Site: 4 inch PC 350 DIP, 4 inch DR 7.3 4710 HPDE and 4 inch DR 9 4710 HDPE	

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
18	Pipe	4 inch	Ductile Iron - ANSI	class 51	949.000	50.00	1.115	4,955	5,617
19	Pipe	4 inch	Ductile Iron - ANSI	class 51	618.000	50.00	1.115	4,953	5,616
20	Pipe	4 inch	Ductile Iron - ANSI	class 51	4,151.000	50.00	1.115	4,977	5,615
21	Pipe	4 inch	Ductile Iron - ANSI	class 51	2,135.000	50.00	1.115	4,975	5,609

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	5,020	5,040	10.02	9.917	0.10614	0.10614	0.000	0.21033	10.023	9.917	10.069	9.963
2	5,020	5,625	305.30	305.159	0.13757	0.13757	0.000	0.27261	305.296	305.159	305.333	305.196
4	4,997	5,623	315.71	305.177	-10.52803	-10.52803	-11.606	2.13697	305.177	315.705	305.187	315.715
5	4,991	5,620	317.51	315.705	-1.79975	-1.79975	-3.028	2.43350	315.705	317.505	315.715	317.515
6	5,048	5,577	289.05	267.053	21.99846	21.99846	15.139	13.59359	289.051	267.053	289.083	267.084
7	5,158	5,523	267.05	183.966	83.08704	83.08704	55.509	54.65071	267.053	183.966	267.084	183.997
8	5,210	5,503	183.97	147.833	36.14069	36.14069	26.241	19.61876	183.973	147.833	183.997	147.856
9	5,402	5,487	147.83	42.947	104.88612	104.88612	96.888	15.84921	147.833	42.947	147.856	42.970
10	5,384	5,483	50.18	42.947	-7.23181	-7.23181	-9.083	3.66897	42.947	50.178	42.970	50.202
11	5,419	5,474	50.18	27.727	22.45127	22.45127	17.662	9.49090	50.178	27.727	50.202	27.751
12	5,421	5,461	27.73	20.387	7.33993	7.33993	1.009	12.54528	27.727	20.387	27.751	20.411
13	5,449	5,456	20.39	3.480	16.90766	16.90766	14.130	5.50532	20.387	3.480	20.411	3.503
14	5,419	5,449	15.11	3.480	-11.63135	-11.63135	-15.139	6.95056	3.480	15.111	3.503	15.134
15	5,419	5,439	10.11	10.093	0.01846	0.01846	0.000	0.03658	10.111	10.093	10.134	10.116
16	5,016	5,619	317.51	304.175	13.32973	13.32973	12.616	1.41506	317.505	304.175	317.515	304.185
17	4,955	5,617	334.29	304.175	-30.11943	-30.11943	-30.782	1.31336	304.175	334.295	304.185	334.304
Pipe												
18	4,953	5,616	334.61	334.295	-0.31350	-0.31350	-1.009	1.37874	334.295	334.608	334.304	334.618
19	4,977	5,615	334.61	322.044	12.56411	12.56411	12.111	0.89785	334.608	322.044	334.618	322.054
20	4,975	5,609	322.04	320.010	2.03401	2.03401	-1.009	6.03073	322.044	320.010	322.054	320.020
21	5,015	5,606	320.01	298.260	21.75029	21.75029	20.185	3.10181	320.010	298.260	320.020	298.270
22	5,018	5,591	298.23	289.051	9.17806	9.17806	1.514	15.18784	298.230	289.051	298.261	289.083

All Junction Table

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
1	Injection Well Site Fresh Water Storage Tank	5,040	5,040	0.000	10.093	0.000	10.093	50.00
2	Fresh Water Transfer Pump A1	5,020	5,040	9.917	305.296	9.963	305.333	50.00
4	3" Sch 40 Carbon Steel to 4" PC 350 DIP	5,020	5,625	305.159	305.177	305.196	305.187	50.00
5	Sta 14+62	4,997	5,623	315.705	315.705	315.715	315.715	50.00
6	Sta 157+26 - Begin Brine Sta 81+68	5,018	5,591	289.051	289.051	289.083	289.083	50.00

Fresh Water Supply to BLM Site: 4 inch PC 350 DIP, 4 inch DR 7.3 4710 HPDE and 4 inch DR 9 4710 HDPE

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
7	Sta 107+26	5,048	5,577	267.053	267.053	267.084	267.084	50.00
8	Sta 210+10 4" DR 7.3 to DR 9 HDPE	5,158	5,523	183.966	183.973	183.997	183.997	50.00
9	Sta 262+77	5,210	5,503	147.833	147.833	147.856	147.856	50.00
10	Sta 305+32	5,402	5,487	42.947	42.947	42.970	42.970	50.00
11	Sta 315+17	5,384	5,483	50.178	50.178	50.202	50.202	50.00
12	Sta 340+65	5,419	5,474	27.727	27.727	27.751	27.751	50.00
13	Sta 374+33	5,421	5,461	20.387	20.387	20.411	20.411	50.00
14	Sta 389+11	5,449	5,456	3.480	3.480	3.503	3.503	50.00
15	Sta 407+88 BLM Site Fresh Water Storage Tank	5,439	5,439	0.000	10.093	0.000	10.093	50.00
16	Control Valve	5,419	5,449	15.111	10.111	15.134	10.134	50.00
17	Sta 31+37	4,991	5,620	317.505	317.505	317.515	317.515	50.00
18	Sta 41+11	5,016	5,619	304.175	304.175	304.185	304.185	50.00
19	Sta 50+15	4,955	5,617	334.295	334.295	334.304	334.304	50.00
20	Sta 59+64	4,953	5,616	334.608	334.608	334.618	334.618	50.00
21	Sta 65+82	4,977	5,615	322.044	322.044	322.054	322.054	50.00
22	Sta 107+33	4,975	5,609	320.010	320.010	320.020	320.020	50.00
23	Sta 128+68 4" PC 350 DIP to 4" DR 7.3 HDPE	5,015	5,606	298.260	298.230	298.270	298.261	50.00

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	8.095	0.50000
2	8.095	0.00000
4	8.095	0.23636
5	8.095	0.00000
6	8.095	0.00000

Fresh Water Supply to BLM Site: 4 inch PC 350 DIP, 4 inch DR 7.3 4710 HPDE and 4 inch DR 9 4710 HDPE

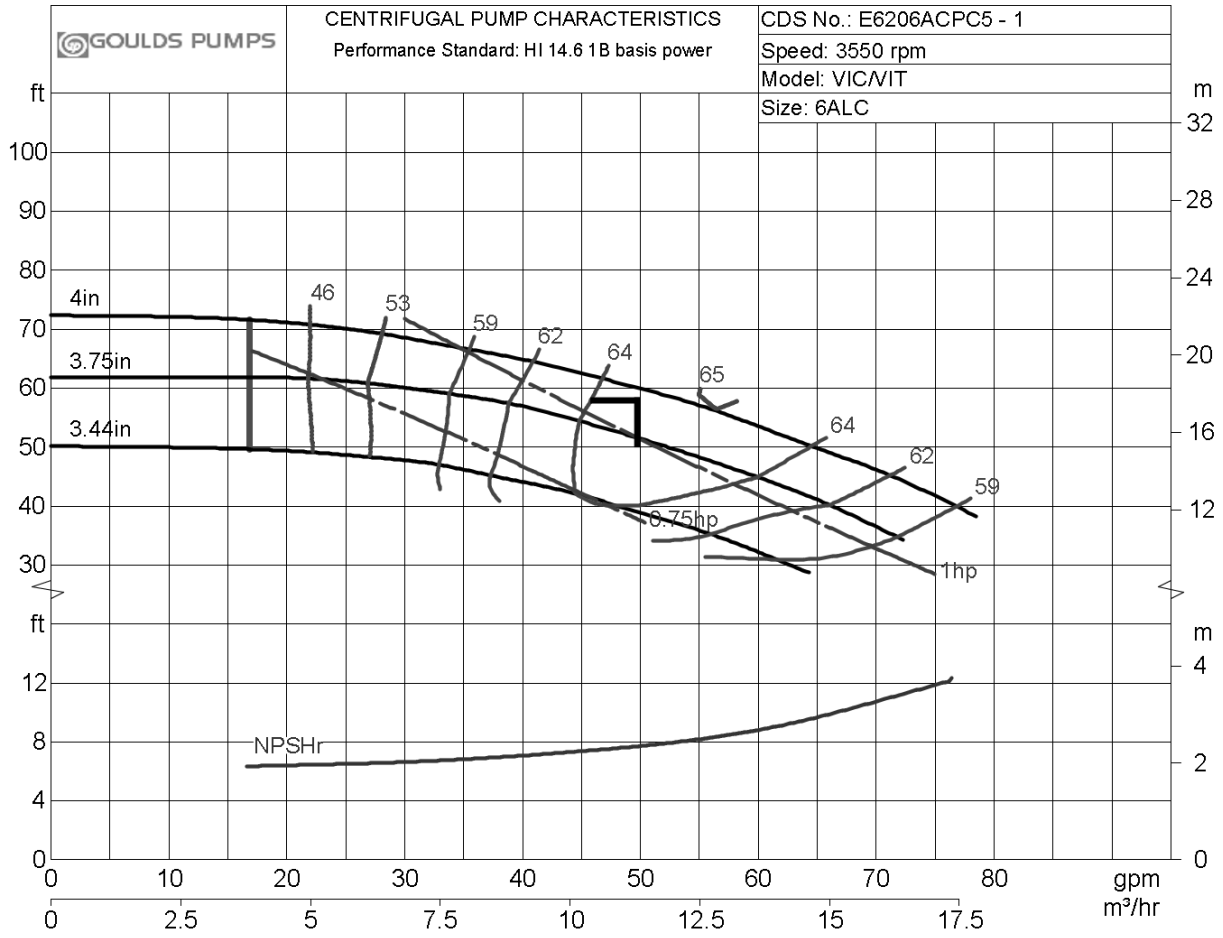
Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
7	8.095	0.00000
8	8.095	0.01915
9	8.095	0.00000
10	8.095	0.00000
11	8.095	0.00000
12	8.095	0.00000
13	8.095	0.00000
14	8.095	0.00000
15	8.095	1.00000
16	8.095	214.01791
17	8.095	0.00000
18	8.095	0.00000
19	8.095	0.00000
20	8.095	0.00000
21	8.095	0.00000
22	8.095	0.00000
23	8.095	0.87691

Model: VIC	Size: 6ALC	60Hz	RPM: 3550	Stages: 11

Job/Inq.No. :
Purchaser : UNDEFINED
End User: Issued by :
Item/Equip.No. : ITEM 005 Quotation No. : Date : 07/15/2016
Service : Fresh Water To BLM Site
Order No. : Rev. : 0

Operating Conditions		**Pump Performance**			
Liquid:	Water	Published Efficiency:	64.6 %	Specific Speed:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.6 %	Min. Hydraulic Flow:	16.9 gpm
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	12.6 hp	Min. Thermal Flow:	N/A
Flow:	50.0 gpm	Non-Overloading Power:	14.0 hp		
TDH:	643.0 ft	Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHa:		NPSHr:	7.7 ft		
Solid size:		Shut off Head:	774.9 ft		
% Susp. Solids (by wtg):		Vapor Press:		Max. Solids Size:	0.1500 in

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



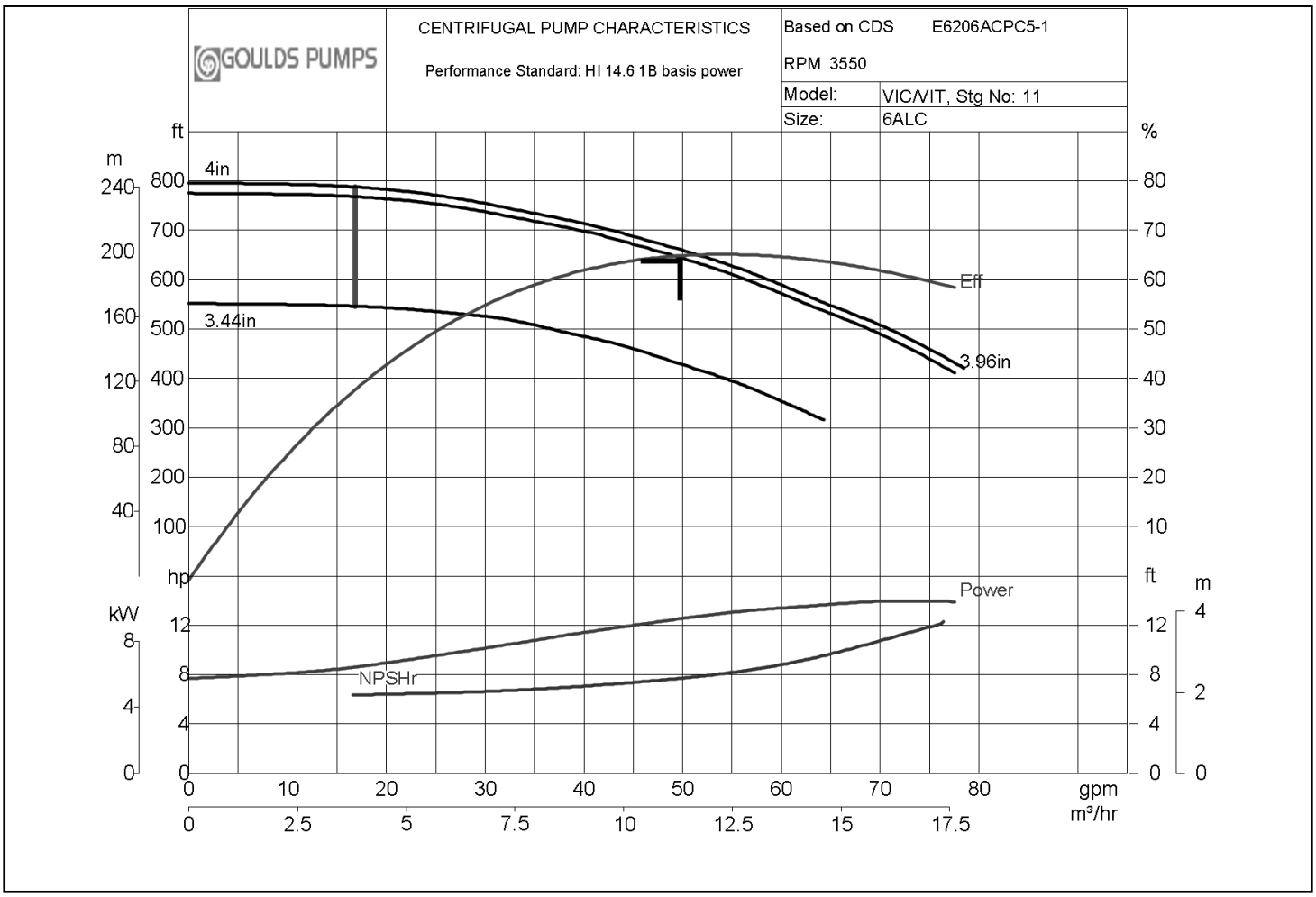
Model: VIC	Size: 6ALC	60Hz	RPM: 3550	Stages: 11

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :		Rev. :	0
Item/Equip.No. :	ITEM 005	Quotation No. :		Date :	07/15/2016
Service :	Fresh Water To BLM Site				
Order No. :					

Operating Conditions		Pump Performance			
Liquid:	Water	Published Efficiency:	64.6 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.6 %	Specific Speed Adl stg:	1,300 gpm(US) ft
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	12.6 hp	Min. Hydraulic Flow:	16.9 gpm
Flow:	50.0 gpm	Non-Overloading Power:	14.0 hp		
TDH:	643.0 ft	Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHa:		NPSHr:	7.7 ft	Shut off Head:	774.9 ft
Solid size:		Max. Solids Size:	0.1500 in	% Susp. Solids (by wtg):	

Vapor Press:

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

ITT

Model: VIC	Size: 6ALC	60Hz	RPM Variable	Stages: 11

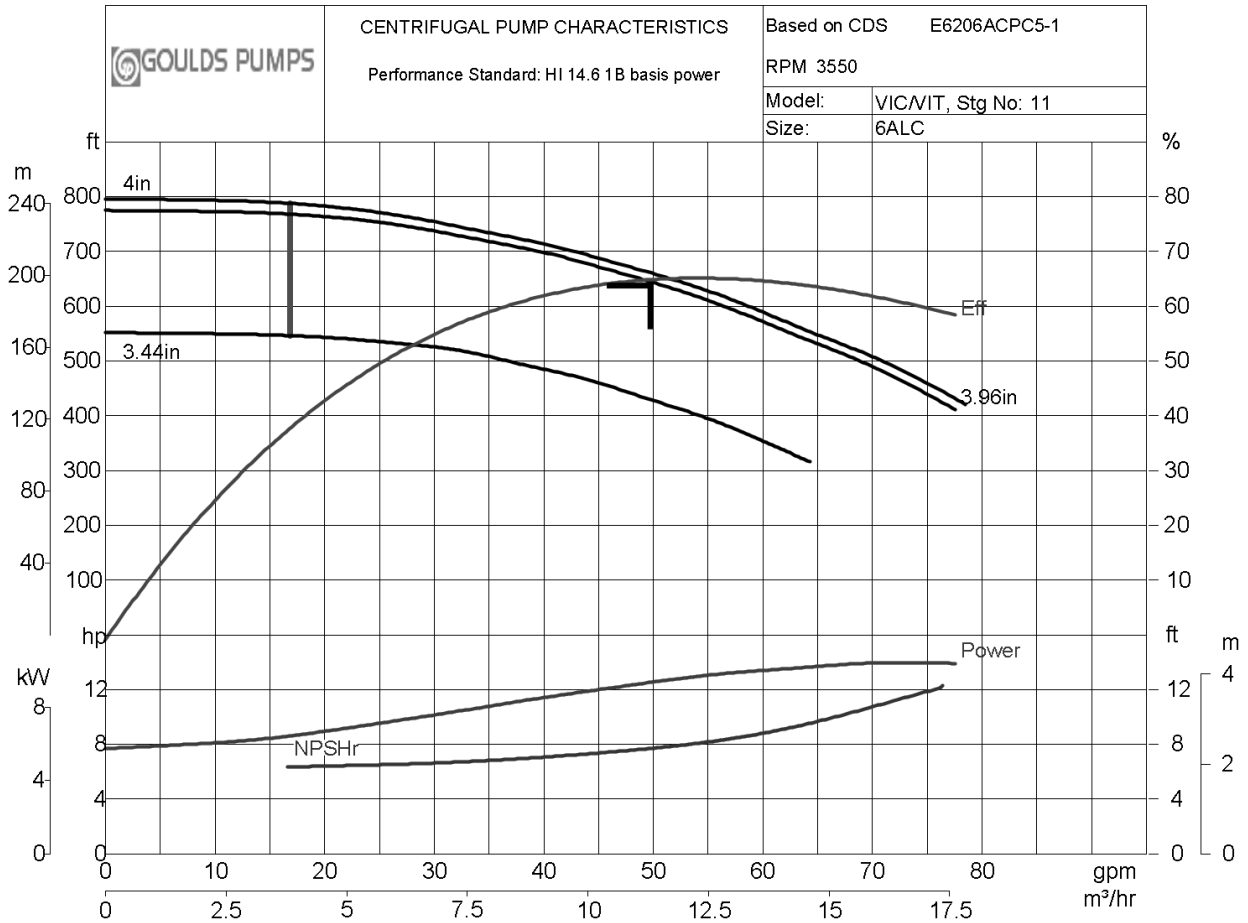
Job/Inq.No. :
Purchaser : UNDEFINED
End User : Issued by :
Item/Equip.No. : ITEM 005 Quotation No. : Date : 07/15/2016
Service : Fresh Water To BLM Site
Order No. : Rev. : 0

Operating Conditions

Liquid:	Water	Published Efficiency:	64.6 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.6 %	Specific Speed Adl stg:	1,300 gpm(US) ft
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	12.6 hp	Min. Hydraulic Flow:	16.9 gpm
Flow:	50.0 gpm	Non-Overloading Power:	14.0 hp		
TDH:	643.0 ft	Imp. Dia. First 1 Stg(s):	3.96 in	Imp. Dia. Adl Stg(s):	3.96 in
NPSHa:		NPSHr:	7.7 ft		
Solid size:		Shut off Head:	774.9 ft		
% Susp. Solids (by wtg):		Vapor Press:			
Max. Solids Size:	0.1500 in				

Pump Performance @ 3550 RPM

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/26/2016

Bedrock, Colorado

Paradox Valley - Fresh Water to BLM - 4 inch DIP and HDPE

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780075	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 4" diam., DR 9, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment	19,777.00	L.F.	$3.89	76,932.53	0.00
221113780076	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 4" diam., DR 7.3, add 1 weld per joint, excludes hanges, trenching, backfill, hoisting or digging equipment.	15,700.00	L.F.	$4.65	73,005.00	0.00
221113784070	Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 4" pipe size, weld, excludes welding machine	887.00	Ea.	$26.18	23,221.66	0.00
221113784360	Welding, plastic, high density polyethylene (HDPE), single wall, machine, rental per day based on diam. capacity, 3" thru 4" diameter, weld	23.00	Ea.	$50.50	1,161.50	0.00
221123999	Cost for 50 gpm Fresh Water Pump Station with Building	1.00	Ea.	$163,994.00	163,994.00	0.00
22 Plumbing Subtotal					**338,314.69**	**0.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	5.58	Acre	$6,829.45	38,108.33	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	4,505.00	S.Y.	$0.55	2,477.75	0.00
312316142600	Excavating, chain trencher, utility trench, common earth, 40 H.P., 8" wide, 48" deep, operator riding, includes backfill	48,345.00	L.F.	$1.35	65,265.75	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	0.00	B.C.Y.	$2.32	0.00	0.00
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	796.00	L.C.Y.	$59.44	47,314.24	0.00
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	796.00	E.C.Y.	$4.97	3,956.12	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	875.00	L.C.Y.	$2.92	2,555.00	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	13,517.00	L.F.	$1.69	22,843.73	0.00
31 Earthwork Subtotal					**182,520.92**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	4,505.00	C.Y.	$5.71	0.00	25,723.55
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	27,034.00	S.Y.	$1.14	0.00	30,818.76
32 Exterior Improvements Subtotal					**0.00**	**56,542.31**
33 Utilities						
330110101180	Corrosion resistance, coating, polyethylene H.D. extruded, .035" thick, 4" diameter, add	12,868.00	L.F.	$1.28	16,471.04	0.00
331113153000	Water supply distribution piping, ductile iron, cement lined, push-on joint, no fittings, 18' lengths, 4" diameter, class 50, excludes excavation or backfill	12,868.00	L.F.	$25.63	329,806.84	0.00
33 Utilities Subtotal					**346,277.88**	**0.00**
Subtotal					**867,113.49**	**56,542.31**
General Contractor's Markup on Subs				**12.00%**		**$6,785.08**
Subtotal					**$867,113.49**	**$63,327.39**
General Conditions				**20.00%**	**$173,422.70**	**$12,665.48**
Subtotal					**$1,040,536.19**	**$75,992.87**
General Contractor's Overhead and Profit				**15.00%**	**$156,080.43**	**$11,398.93**
Subtotal					**$1,196,616.62**	**$87,391.80**
Grand Total						**$1,284,008.42**

APPENDIX E

Fathom 9 Model Output – Brine Pipeline to Landfill Site

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Model Reference Information

General

Title: Brine Transfer to Landfill Site: 10 inch DR 7.3 4710 HDPE
Analysis run on: 7/25/2016 8:23:57 AM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Landfill Site\Brine Pipeline to Landfill Site.fth
Scenario: Base Scenario/10" HDPE Design at 300 gpm
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Landfill Site\Brine Pipeline to Landfill Site_1.out

Execution Time= 0.55 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 18
Total Number Of Temperature Iterations= 0
Number Of Pipes= 32
Number Of Junctions= 33
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1164 kg/m3
Viscosity= 0.002113 Pa-sec
Vapor Pressure= Unspecified
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 298.7 gal/min
Total Outflow= 298.7 gal/min
Maximum Static Pressure is 327.4 psig at Pipe 31 Inlet
Minimum Static Pressure is -5.141 psig at Pipe 1 Outlet

Warnings

No Warnings

Pump Summary

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
2	Show	...	Transfer Pump A1	298.7	48.36	135.8	269.0	71.56	96.10	33.06	345.8	86.38

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)	% of BEP (Percent)
3	Show	...	Transfer Pump A2	298.7	48.36	135.8	269.0	71.56	96.10	33.06	345.8	86.38
24	Show	...	Transfer Pump B1	298.7	48.36	138.8	275.0	71.43	97.00	33.84	349.1	85.57
25	Show	...	Transfer Pump B2	298.7	48.36	138.8	275.0	71.43	97.00	33.84	349.1	85.57
31	Show	...	Transfer Pump C1	298.7	48.36	135.8	269.0	71.56	96.10	33.06	345.8	86.38
32	Show	...	Transfer Pump C2	298.7	48.36	135.8	269.0	71.56	96.10	33.06	345.8	86.38

Jct	NPSHA (feet)	NPSHR (feet)
2	N/A	11.71

Jct	NPSHA (feet)	NPSHR (feet)
3	N/A	11.71
24	N/A	11.54
25	N/A	11.54
31	N/A	11.71
32	N/A	11.71

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
1	STF Storage Tank	Infinite	N/A	4,960	0	N/A	N/A	-298.7	-48.36
20	Sta 1295+65 Landfill Site Salt Storage Pond	Infinite	N/A	6,292	0	N/A	N/A	298.7	48.36

Pipe Output Table

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
1	Pipe	4 inch	PVC - ASTM	schedule 80	12.000	298.7	8.336	4,955	4,958
2	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	7.000	298.7	12.964	4,966	5,490
3	Pipe	8 inch	Stainless Steel - ANSI	schedule 40S	8.000	298.7	1.916	4,964	5,483
4	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	7,079.000	298.7	2.097	4,960	5,483
5	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	1,725.000	298.7	2.097	5,025	5,468
6	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	18,066.000	298.7	2.097	5,025	5,465
7	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,449.000	298.7	2.097	5,224	5,427
8	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	1,186.000	298.7	2.097	5,385	5,417

Brine Transfer to Landfill Site: 10 inch DR 7.3 4710 HDPE

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
9	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	21,365.000	298.7	2.097	5,546	5,925
10	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	7,245.000	298.7	2.097	5,820	5,880
11	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	9,306.000	298.7	2.097	5,749	5,865
12	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	5,595.000	298.7	2.097	5,446	5,845
13	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	1,765.000	298.7	2.097	5,581	5,834
14	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	8,998.000	298.7	2.097	5,966	6,356
15	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	2,626.000	298.7	2.097	5,994	6,337
16	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,983.000	298.7	2.097	5,885	6,332
17	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,780.000	298.7	2.097	5,987	6,321
18	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	3,029.000	298.7	2.097	6,139	6,311
19	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,996.000	298.7	2.097	6,164	6,305
20	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	30.000	298.7	2.097	5,381	5,415
21	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	5.000	298.7	12.964	5,382	5,687
22	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	30.000	298.7	2.097	5,381	5,963
23	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	17,762.000	298.7	2.097	5,381	5,962
24	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	5.000	298.7	12.964	4,966	5,222
25	Pipe	8 inch	Stainless Steel - ANSI	schedule 40S	10.000	298.7	1.916	5,381	5,415
26	Pipe	8 inch	Stainless Steel - ANSI	schedule 40S	10.000	298.7	1.916	5,382	5,963
27	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	30.000	298.7	2.097	5,717	5,830
28	Pipe	3 inch	Stainless Steel - ANSI	schedule 40S	5.000	298.7	12.964	5,718	6,096
29	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	30.000	298.7	2.097	5,717	6,366
30	Pipe	8 inch	Stainless Steel - ANSI	schedule 40S	10.000	298.7	1.916	5,717	5,830
31	Pipe	8 inch	Stainless Steel - ANSI	schedule 40S	10.000	298.7	1.916	5,718	6,366
32	Pipe	10 inch	HDPE - AFT Customary	SDR 7.3	4,572.000	298.7	2.097	5,717	6,366

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
1	4,965	4,955	1.706	-5.141	6.84643	6.84643	5.0463	3.5673	1.706	-5.141	2.251	-4.59579
2	4,964	5,483	264.861	261.742	3.11970	3.11970	-0.7569	7.6822	264.861	261.742	266.179	263.05972
3	4,960	5,483	264.023	262.074	-1.94907	-1.94907	-2.0185	0.1376	262.074	264.023	262.102	264.05148
4	5,025	5,468	264.014	223.682	40.33206	40.33206	32.8007	14.9247	264.014	223.682	264.049	223.71667
5	5,025	5,465	223.682	221.852	1.83046	1.83046	0.0000	3.6274	223.682	221.852	223.717	221.88622
6	5,224	5,427	221.852	102.261	119.59110	119.59110	100.4206	37.9896	221.852	102.261	221.886	102.29510
7	5,385	5,417	102.261	16.295	85.96580	85.96580	81.2448	9.3554	102.261	16.295	102.295	16.32931
8	5,381	5,415	17.055	16.295	-0.75999	-0.75999	-2.0185	2.4939	16.295	17.055	16.329	17.08931

Brine Transfer to Landfill Site: 10 inch DR 7.3 4710 HDPE

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
9	5,820	5,880	191.285	30.347	160.93875	160.93875	138.2675	44.9268	191.285	30.347	191.320	30.38119
10	5,749	5,865	58.487	30.347	-28.14050	-28.14050	-35.8284	15.2349	30.347	58.487	30.381	58.52169
11	5,446	5,845	201.514	58.487	-143.02674	-143.02674	-152.9017	19.5689	58.487	201.514	58.522	201.54842
12	5,581	5,834	201.514	127.452	74.06158	74.06158	68.1245	11.7653	201.514	127.452	201.548	127.48685
13	5,717	5,830	127.452	56.950	70.50205	70.50205	68.6291	3.7115	127.452	56.950	127.487	56.98479
14	5,994	6,337	196.805	173.128	23.67765	23.67765	14.1295	18.9212	196.805	173.128	196.840	173.16199
15	5,885	6,332	225.345	173.128	-52.21769	-52.21769	-55.0042	5.5220	173.128	225.345	173.162	225.37967
16	5,987	6,321	225.345	168.586	56.75951	56.75951	51.4719	10.4784	225.345	168.586	225.380	168.62016
17	6,139	6,311	168.586	86.810	81.77540	81.77540	76.7032	10.0515	168.586	86.810	168.620	86.84477
18	6,164	6,305	86.810	70.980	15.82984	15.82984	12.6157	6.3694	86.810	70.980	86.845	71.01494
19	6,294	6,294	70.980	0.000	70.98044	70.98044	65.6014	10.6595	70.980	0.000	71.015	0.03449
20	5,381	5,415	17.055	17.003	0.05141	0.05141	0.0000	0.1019	17.055	17.003	17.089	17.03790
21	5,381	5,686	153.974	153.721	0.25288	0.25288	-0.2523	1.0011	153.974	153.721	155.292	155.03943
22	5,381	5,962	293.448	293.397	0.05141	0.05141	0.0000	0.1019	293.448	293.397	293.483	293.43115
23	5,546	5,925	293.397	191.285	102.11123	102.11123	83.2633	37.3503	293.397	191.285	293.431	191.31993
24	4,965	5,221	129.600	129.347	0.25288	0.25288	-0.2523	1.0011	129.600	129.347	130.918	130.66537
25	5,381	5,414	17.009	16.758	0.25119	0.25119	0.0000	0.4978	17.009	16.758	17.038	16.78646
26	5,381	5,963	293.517	293.457	0.05995	0.05995	-0.2523	0.6188	293.517	293.457	293.545	293.48532
27	5,717	5,830	56.950	56.899	0.05141	0.05141	0.0000	0.1019	56.950	56.899	56.985	56.93339
28	5,717	6,095	190.878	190.625	0.25288	0.25288	-0.2523	1.0011	190.878	190.625	192.196	191.94310
29	5,717	6,366	327.360	327.309	0.05141	0.05141	0.0000	0.1019	327.360	327.309	327.394	327.34305
30	5,717	5,829	56.904	56.653	0.25119	0.25119	0.0000	0.4978	56.904	56.653	56.933	56.68194
31	5,717	6,366	327.428	327.368	0.05995	0.05995	-0.2523	0.6188	327.428	327.368	327.457	327.39719
32	5,966	6,356	327.309	196.805	130.50341	130.50341	125.6519	9.6141	327.309	196.805	327.343	196.83963

All Junction Table

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
1	STF Storage Tank	4,960	4,960	0.000	2.523	0.000	2.523	298.7
2	Transfer Pump A1	4,965	4,955	-5.141	129.600	-4.596	130.918	298.7
3	Transfer Pump A2	4,965	5,221	129.347	264.861	130.665	266.179	298.7
4	8" Sch 40S Stainless Steel to 10"DR 7.3 HDPE	4,960	5,483	264.023	264.014	264.051	264.049	298.7
5	Sta 70+97	5,025	5,468	223.682	223.682	223.717	223.717	298.7
6	Sta 88+22	5,025	5,465	221.852	221.852	221.886	221.886	298.7
7	Sta 268+88	5,224	5,427	102.261	102.261	102.295	102.295	298.7
8	Sta 313+37	5,385	5,417	16.295	16.295	16.329	16.329	298.7
9	Sta 502+95	5,546	5,925	191.285	191.285	191.320	191.320	298.7
10	Sta 716+60	5,820	5,880	30.347	30.347	30.381	30.381	298.7
11	Sta 789+05	5,749	5,865	58.487	58.487	58.522	58.522	298.7

Brine Transfer to Landfill Site: 10 inch DR 7.3 4710 HDPE

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
12	Sta 882+11	5,446	5,845	201.514	201.514	201.548	201.548	298.7
13	Sta 938+06	5,581	5,834	127.452	127.452	127.487	127.487	298.7
14	Sta 1001+53	5,966	6,356	196.805	196.805	196.840	196.840	298.7
15	Sta 1091+51	5,994	6,337	173.128	173.128	173.162	173.162	298.7
16	Sta 1117+77	5,885	6,332	225.345	225.345	225.380	225.380	298.7
17	Sta 1167+60	5,987	6,321	168.586	168.586	168.620	168.620	298.7
18	Sta 1215+40	6,139	6,311	86.810	86.810	86.845	86.845	298.7
19	Sta 1245+69	6,164	6,305	70.980	70.980	71.015	71.015	298.7
20	Sta 1295+65 Landfill Site Salt Storage Pond	6,292	6,292	0.000	0.000	0.000	0.000	298.7
21	Sta 325+23	5,381	5,415	17.055	17.055	17.089	17.089	298.7
22	Sta 325+33	5,381	5,962	293.397	293.397	293.431	293.431	298.7
24	Transfer Pump B1	5,381	5,414	16.758	153.974	16.786	155.292	298.7
25	Transfer Pump B2	5,381	5,686	153.721	293.517	155.039	293.545	298.7
26	10" Dr 7.3 HDPE to 8" Sch 40S Stainless Steel	5,381	5,415	17.003	17.009	17.038	17.038	298.7
27	8" Sch 40S Stainless Steel to 10" DR 7.3 HDPE	5,381	5,963	293.457	293.448	293.485	293.483	298.7
28	Area Change	4,964	5,483	261.742	262.074	263.060	262.102	298.7
29	Sta 955+71	5,717	5,830	56.950	56.950	56.985	56.985	298.7
30	Sta 955+81	5,717	6,366	327.309	327.309	327.343	327.343	298.7
31	Transfer Pump C1	5,717	5,829	56.653	190.878	56.682	192.196	298.7
32	Transfer Pump C2	5,717	6,095	190.625	327.428	191.943	327.457	298.7
33	10" Dr 7.3 HDPE to 8" Sch 40S Stainless Steel	5,717	5,830	56.899	56.904	56.933	56.933	298.7

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
1	48.36	0.500000
2	48.36	0.000000
3	48.36	0.000000
4	48.36	0.095552
5	48.36	0.000000
6	48.36	0.000000
7	48.36	0.000000
8	48.36	0.000000
9	48.36	0.000000
10	48.36	0.000000
11	48.36	0.000000

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
12	48.36	0.000000
13	48.36	0.000000
14	48.36	0.000000
15	48.36	0.000000
16	48.36	0.000000
17	48.36	0.000000
18	48.36	0.000000
19	48.36	0.000000
20	48.36	1.000000
21	48.36	0.000000
22	48.36	0.000000
24	48.36	0.000000
25	48.36	0.000000
26	48.36	0.007480
27	48.36	0.095552
28	48.36	0.726290
29	48.36	0.000000
30	48.36	0.000000
31	48.36	0.000000
32	48.36	0.000000
33	48.36	0.007480
34	48.36	0.095552

Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

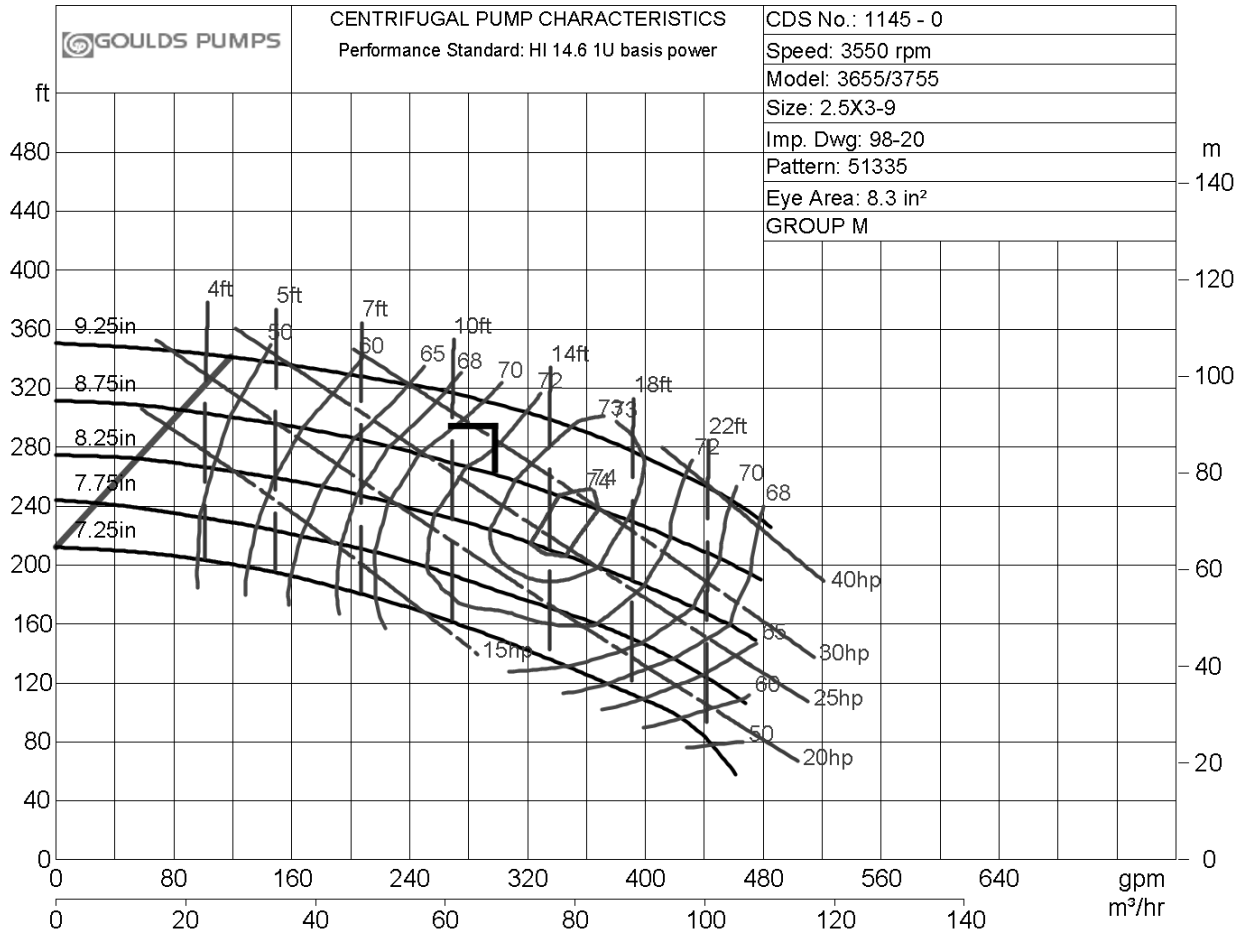
Job/Inq.No. :
Purchaser : UNDEFINED
End User: Issued by :
Item/Equip.No. : ITEM 003 Quotation No. : Date : 07/15/2016
Service : Brine Transfer to Landfill Site
Order No. : Rev. : 0

Operating Conditions

Liquid:	Brine	Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
S.G./Visc.:	1.170/1.320 cp	Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Flow:	300.0 gpm	Non-Overloading Power:	45.9 hp		
TDH:	296.0 ft	Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHa:	28.9 ft	NPSHr:	11.8 ft		
Solid size:		Shut off Head:	340.6 ft		
% Susp. Solids (by wtg):		Vapor Press:		Max. Solids Size:	0.3130 in

Pump Performance

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Model: 3655	Size: 2.5X3-9	60Hz	RPM: 3550	Stages: 1

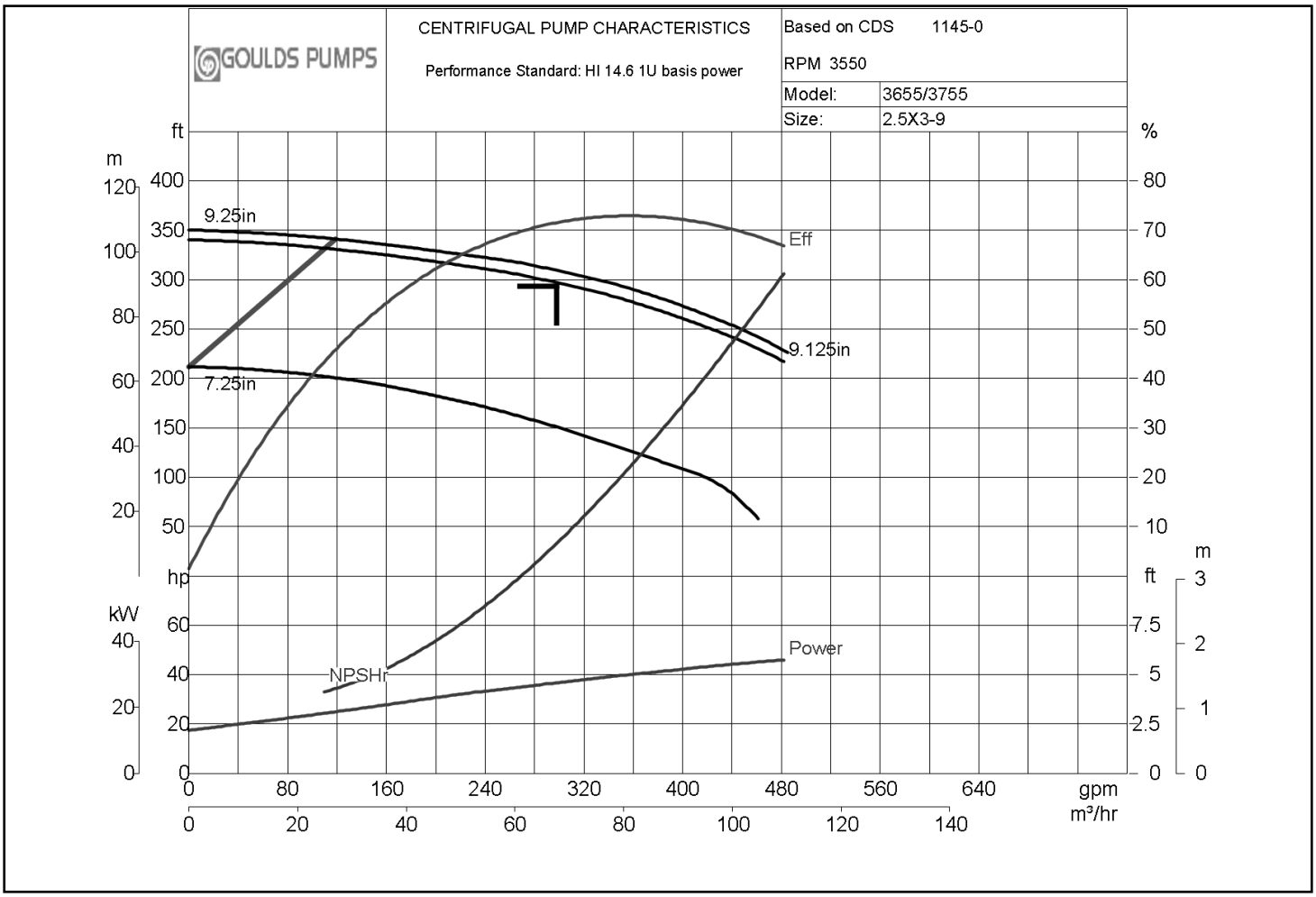
Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :		Rev. :	0
Item/Equip.No. :	ITEM 003	Quotation No. :		Date :	07/15/2016
Service :	Brine Transfer to Landfill Site				
Order No. :					

Operating Conditions **Pump Performance**

Liquid:	Brine	Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
S.G./Visc.:	1.170/1.320 cp	Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Flow:	300.0 gpm	Non-Overloading Power:	45.9 hp		
TDH:	296.0 ft	Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHa:	28.9 ft	NPSHr:	11.8 ft	Shut off Head:	340.6 ft
Solid size:		Max. Solids Size:	0.3130 in	% Susp. Solids (by wtg):	

Vapor Press:

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

ITT

Model: 3655	Size: 2.5X3-9	60Hz	RPM Variable	Stages: 1

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :			
Item/Equip.No. :	ITEM 003	Quotation No. :		Date :	07/15/2016
Service :	Brine Transfer to Landfill Site				
Order No. :				Rev. :	0

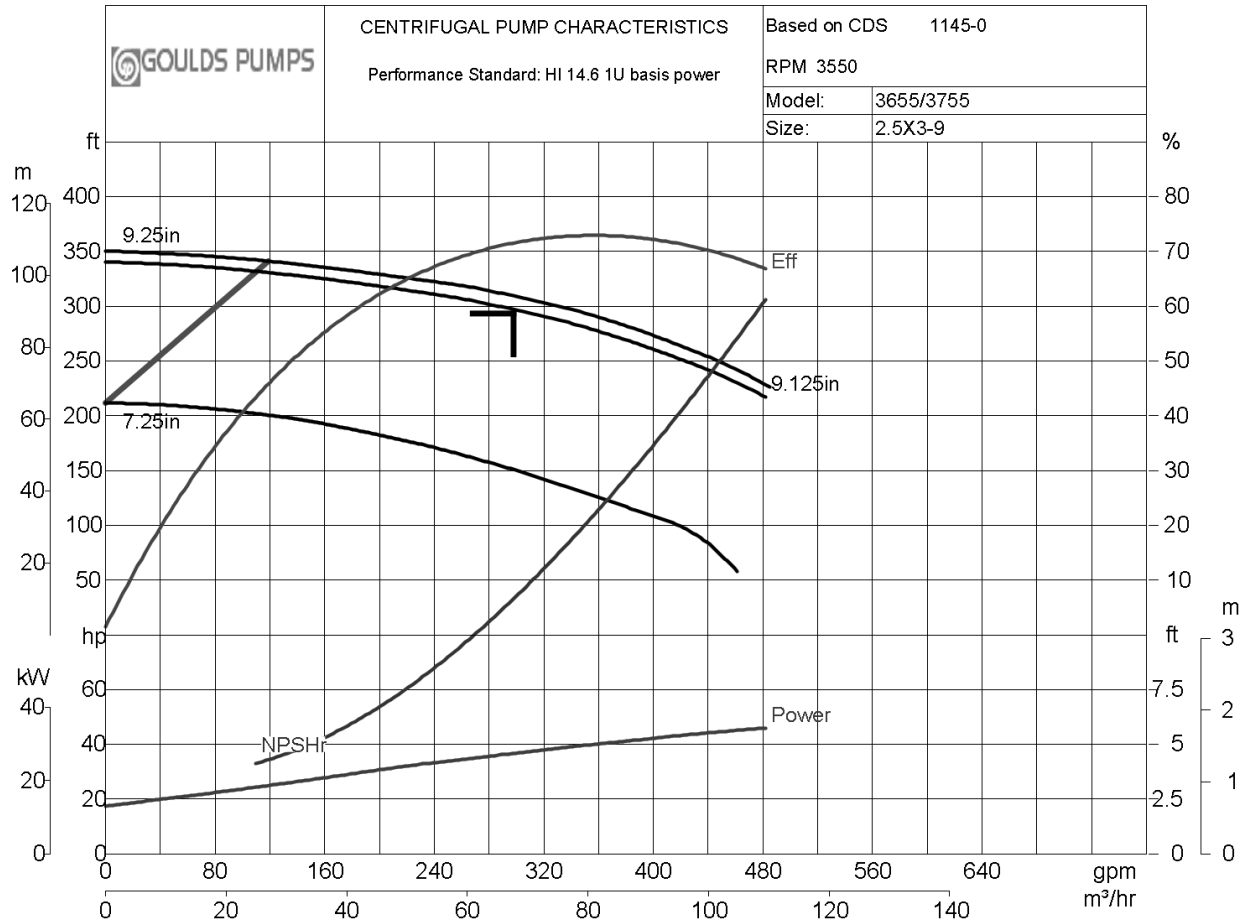
Operating Conditions

Liquid:	Brine
Temp.:	70.0 deg F
S.G./Visc.:	1.170/1.320 cp
Flow:	300.0 gpm
TDH:	296.0 ft
NPSHa:	28.9 ft
Solid size:	
% Susp. Solids (by wtg):	
Max. Solids Size:	0.3130 in

Pump Performance @ 3550 RPM

Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Non-Overloading Power:	45.9 hp		
Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHr:	11.8 ft		
Shut off Head:	340.6 ft		
Vapor Press:			

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Model: 3655	Size: 2.5X3-9	60Hz	RPM Variable	Stages: 1

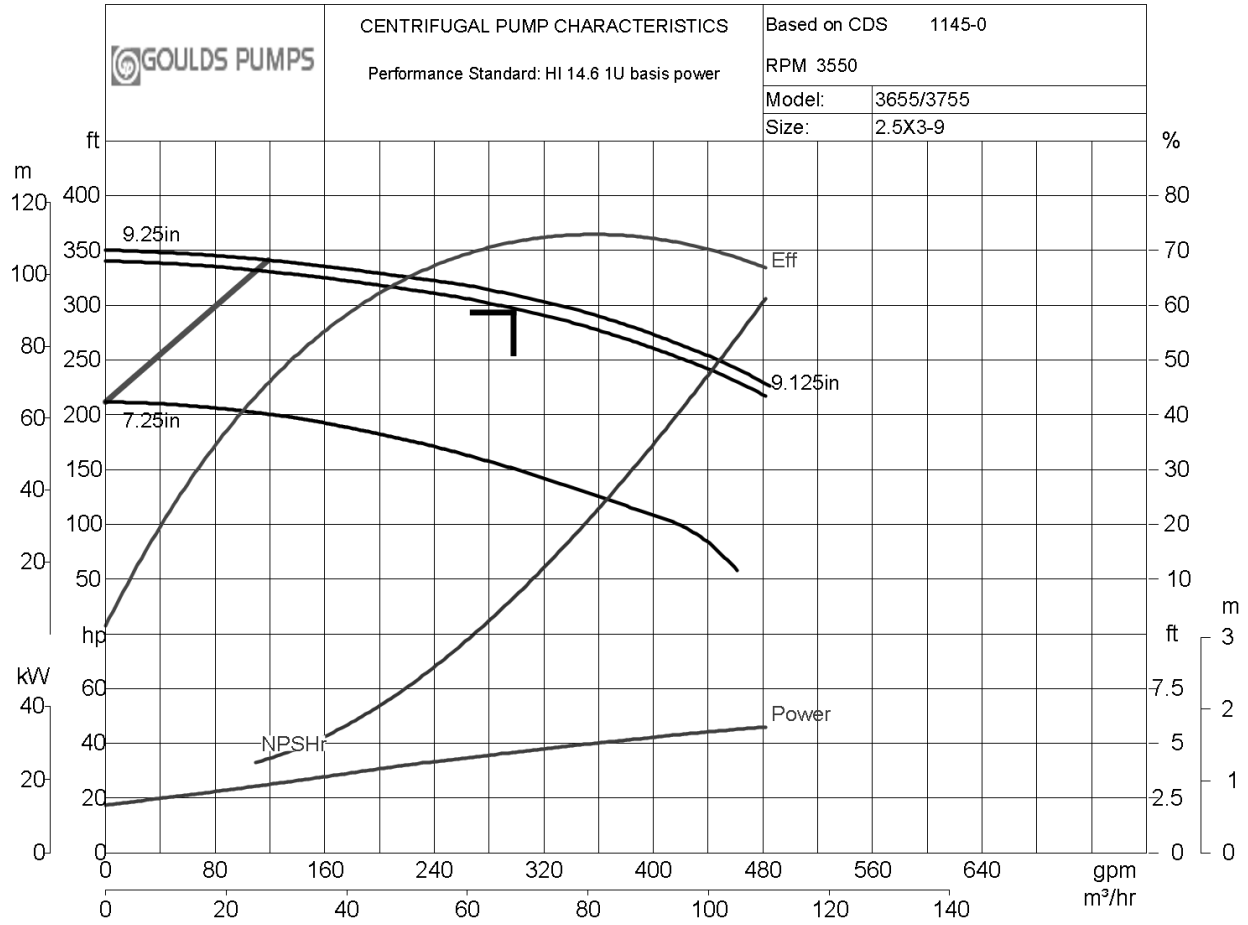
Job/Inq.No. :
Purchaser : UNDEFINED
End User : Issued by :
Item/Equip.No. : ITEM 003 Quotation No. : Date : 07/15/2016
Service : Brine Transfer to Landfill Site
Order No. : Rev. : 0

Operating Conditions

Liquid:	Brine	Published Efficiency:	71.0 %	Suction Specific Speed:	8,445 gpm(US) ft
Temp.:	70.0 deg F	Rated Pump Efficiency:	71.0 %	Min. Hydraulic Flow:	111.6 gpm
S.G./Visc.:	1.170/1.320 cp	Rated Total Power:	36.8 hp	Min. Thermal Flow:	N/A
Flow:	300.0 gpm	Non-Overloading Power:	45.9 hp		
TDH:	296.0 ft	Imp. Dia. First 1 Stg(s):	9.1250 in		
NPSHa:	28.9 ft	NPSHr:	11.8 ft		
Solid size:		Shut off Head:	340.6 ft		
% Susp. Solids (by wtg):		Vapor Press:			
Max. Solids Size:	0.3130 in				

Pump Performance @ 3550 RPM

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/25/2016

Paradox Valley - Brine to Landfill - 10 inch HDPE

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780099	pipe, plastic, high density polyurethane (HDPE), single wall, straight, welded, based on 40' length, 10" diam, DR 7.3, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment	129,360.00	L.F.	$30.10	3,893,736.00	0.00
221113784100	Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 10" pipe size, weld, excludes welding machine	3,234.00	Ea.	$62.99	203,709.66	0.00
221113784380	Welding, plastic, high density polyethylene (HDPE), single wall, machine, rental per day based on diam. capacity, 10" thru 12" diameter, weld	162.00	Ea.	$196.00	31,752.00	0.00
221123999	Cost for 300 gpm Brine Pump Station with Building 30 HP motors	3.00	Ea.	$397,829.00	1,193,487.00	0.00
22 Plumbing Subtotal					**5,322,684.66**	**0.00**
26 Electrical						
2609999	Electrical, Instrumentation and Control for Pump Station adjusted for three pumps	3.00	Ea.	$233,082.00	0.00	699,246.00
26 Electrical Subtotal					**0.00**	**699,246.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	53.38	Acre	$6,829.45	364,556.04	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	258,720.00	S.Y.	$0.55	142,296.00	0.00
312316140840	Excavating, chain trencher, utility trench, common earth, 12 H.P., 18" wide, 6' deep, fly wheel trencher, medium soil	28,751.00	B.C.Y.	$1.16	33,351.16	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	4,635.00	B.C.Y.	$2.32	10,753.20	0.00
312323132200	Backfill, trench, 6" to 12" lifts, dozer backfilling, compaction with vibrating roller	24,882.00	E.C.Y.	$3.73	92,809.86	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	7,887.00	L.C.Y.	$59.44	468,803.28	0.00
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	31,626.00	E.C.Y.	$4.97	157,181.22	0.00
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	7,887.00	L.C.Y.	$2.92	23,030.04	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	129,360.00	L.F.	$1.69	218,618.40	0.00
31 Earthwork Subtotal					**1,511,399.20**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	47,431.00	C.Y.	$5.71	0.00	270,831.01
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	258,720.00	S.Y.	$1.14	0.00	294,940.80
329219131100	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed with wood fiber mulch added	258,720.00	S.Y.	$3.84	0.00	993,484.80
32 Exterior Improvements Subtotal					**0.00**	**1,559,256.61**
Subtotal					**6,834,083.86**	**2,258,502.61**
General Contractor's Markup on Subs				**12.00%**		**$271,020.31**
Subtotal					**$6,834,083.86**	**$2,529,522.92**
General Conditions				**20.00%**	**$1,366,816.77**	**$505,904.58**
Subtotal					**$8,200,900.63**	**$3,035,427.50**
General Contractor's Overhead and Profit				**15.00%**	**$1,230,135.09**	**$455,314.13**
Subtotal					**$9,431,035.72**	**$3,490,741.63**

Grand Total **$12,921,777.35**

APPENDIX F

Fathom 9 Model Output – Freshwater Pipeline to Landfill Site

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Model Reference Information

General

Title: Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE
Analysis run on: 7/27/2016 10:28:07 AM
Application version: AFT Fathom Version 9 (2015.07.22)
Input File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Landfill Site\FW Pipeline to Landfill Site.fth
Scenario: Base Scenario/Design at 50 gpm
Output File: S:\Projects\1655500023-Paradox Valley Unit\8.0 Project Design\8.8 Civil\Landfill Site\FW Pipeline to Landfill Site_1.out

Execution Time= 0.23 seconds
Total Number Of Head/Pressure Iterations= 0
Total Number Of Flow Iterations= 2
Total Number Of Temperature Iterations= 0
Number Of Pipes= 37
Number Of Junctions= 38
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: User Specified
Fluid= User Specified
Density= 1164 kg/m3
Viscosity= 0.001632 Pa-sec
Vapor Pressure= Unspecified
Viscosity Model= Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polynomials
Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant)= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 50.00 gal/min
Total Outflow= 50.00 gal/min
Maximum Static Pressure is 469.6 psig at Pipe 26 Inlet
Minimum Static Pressure is 9.917 psig at Pipe 33 Outlet

Warnings

For an explanation of Warnings, click an item in this list and press F1 or search for 'Warnings' in the Help system.

CAUTION Pump Junction 31 (Fresh Water Pump C1) speed is below 80%

Pump Summary

Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)
24	Show	...	Fresh Water Pump B1	50.00	8.095	341.3	676.3	64.83	100.00	15.352	54.40

Jct	Results Diagram		Name	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP (psid)	dH (feet)	Overall Efficiency (Percent)	Speed (Percent)	Overall Power (hp)	BEP (gal/min)
31	Show	...	Fresh Water Pump C1	50.00	8.095	133.1	263.8	61.04	72.27	6.358	39.31
37	Show	...	Fresh Water Pump A1	50.00	8.095	341.3	676.3	64.83	100.00	15.352	54.40

Jct	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
24	91.91	N/A	7.689

Jct	% of BEP (Percent)	NPSHA (feet)	NPSHR (feet)
31	127.18	N/A	5.017
	91.91	N/A	7.689

Reservoir Summary

Jct	Name	Type	Liq. Height (feet)	Liq. Elevation (feet)	Surface Pressure (psig)	Liquid Volume (feet3)	Liquid Mass (lbm)	Net Vol. Flow (gal/min)	Net Mass Flow (lbm/sec)
20	Sta 1295+65 Landfill Site Fresh Water Storage Tank	Infinite	N/A	6,312	0	N/A	N/A	50.00	8.095
36	Injection Well Site Fresh Water Storage Tank	Infinite	N/A	5,040	0	N/A	N/A	-50.00	-8.095

Pipe Output Table

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
6	Pipe	4 inch	Ductile Iron - ANSI	class 51	18,066.000	50.00	1.115	5,025	5,692
7	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	4,449.000	50.00	2.003	5,224	5,666
8	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	1,186.000	50.00	2.003	5,385	5,642
9	Pipe	4 inch	Ductile Iron - ANSI	class 51	11,090.000	50.00	1.115	5,646	6,270
10	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	7,245.000	50.00	2.003	5,820	6,254
11	Pipe	4 inch	Ductile Iron - ANSI	class 51	9,306.000	50.00	1.115	5,749	6,216
12	Pipe	4 inch	Ductile Iron - ANSI	class 51	5,595.000	50.00	1.115	5,446	6,202
13	Pipe	4 inch	Ductile Iron - ANSI	class 51	1,765.000	50.00	1.115	5,581	6,194
14	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	8,998.000	50.00	2.003	5,966	6,448
15	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	2,626.000	50.00	2.003	5,994	6,400
16	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	4,983.000	50.00	2.003	5,885	6,386
17	Pipe	4 inch	HDPE - AFT Customary	SDR 9	4,780.000	50.00	1.726	5,987	6,360
18	Pipe	4 inch	HDPE - AFT Customary	SDR 9	3,029.000	50.00	1.726	6,139	6,342
19	Pipe	4 inch	HDPE - AFT Customary	SDR 9	4,996.000	50.00	1.726	6,164	6,331

Fathom 9 (Output) 7/27/2016 Page 3 ray.hamilton	Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE	

Pipe	Name	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	Elevation Inlet (feet)	HGL Inlet (feet)
20	Pipe	4 inch	HDPE - AFT Customary	SDR 7.3	30.000	50.00	2.003	5,381	5,636
22	Pipe	4 inch	Ductile Iron - ANSI	class 51	30.000	50.00	1.115	5,381	6,311
23	Pipe	4 inch	Ductile Iron - ANSI	class 51	17,762.000	50.00	1.115	5,381	6,311
25	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	10.000	50.00	2.170	5,381	5,635
26	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	10.000	50.00	2.170	5,381	6,312
27	Pipe	4 inch	Ductile Iron - ANSI	class 51	30.000	50.00	1.115	5,717	6,192
29	Pipe	4 inch	Ductile Iron - ANSI	class 51	30.000	50.00	1.115	5,717	6,455
30	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	10.000	50.00	2.170	5,717	6,191
31	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	10.000	50.00	2.170	5,717	6,455
32	Pipe	4 inch	Ductile Iron - ANSI	class 51	4,572.000	50.00	1.115	5,717	6,455
33	Pipe	3 inch	PVC - ASTM	schedule 80	6.000	50.00	2.429	5,020	5,040
34	Pipe	3 inch	Steel - ANSI	STD (schedule 40)	7.000	50.00	2.170	5,020	5,716
35	Pipe	4 inch	Ductile Iron - ANSI	class 51	1,462.000	50.00	1.115	5,020	5,716
36	Pipe	4 inch	Ductile Iron - ANSI	class 51	1,675.000	50.00	1.115	4,997	5,714
37	Pipe	4 inch	Ductile Iron - ANSI	class 51	974.000	50.00	1.115	4,991	5,711
38	Pipe	4 inch	Ductile Iron - ANSI	class 51	904.000	50.00	1.115	5,016	5,710
39	Pipe	4 inch	Ductile Iron - ANSI	class 51	949.000	50.00	1.115	4,955	5,708
40	Pipe	4 inch	Ductile Iron - ANSI	class 51	618.000	50.00	1.115	4,953	5,707
41	Pipe	4 inch	Ductile Iron - ANSI	class 51	4,151.000	50.00	1.115	4,977	5,706
42	Pipe	4 inch	Ductile Iron - ANSI	class 51	2,135.000	50.00	1.115	4,975	5,700
43	Pipe	4 inch	Ductile Iron - ANSI	class 51	2,858.000	50.00	1.115	5,015	5,697
44	Pipe	4 inch	Ductile Iron - ANSI	class 51	654.000	50.00	1.115	5,018	5,693
45	Pipe	4 inch	Ductile Iron - ANSI	class 51	10,275.000	50.00	1.115	5,546	6,285

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
6	5,224	5,666	336.57	222.904	113.66548	113.66548	100.421	26.24696	336.57	222.904	336.58	222.914
7	5,385	5,642	222.87	129.698	93.17549	93.17549	81.245	23.64265	222.87	129.698	222.91	129.730
8	5,381	5,636	129.70	128.536	1.16194	1.16194	-2.019	6.30258	129.70	128.536	129.73	128.568
9	5,820	6,254	315.13	219.197	95.93545	95.93545	87.805	16.11197	315.13	219.197	315.14	219.206
10	5,749	6,216	235.57	219.166	-16.39983	-16.39983	-35.828	38.50101	219.17	235.566	219.20	235.598
11	5,446	6,202	381.66	235.582	-146.07909	-146.07909	-152.902	13.52011	235.58	381.661	235.59	381.671
12	5,581	6,194	381.66	309.435	72.22643	72.22643	68.125	8.12863	381.66	309.435	381.67	309.444
13	5,717	6,192	309.43	239.511	69.92313	69.92313	68.629	2.56426	309.43	239.511	309.44	239.521
14	5,994	6,400	243.20	204.937	38.25909	38.25909	14.130	47.81672	243.20	204.937	243.23	204.968
15	5,885	6,386	252.90	204.937	-47.96220	-47.96220	-55.004	13.95496	204.94	252.899	204.97	252.931
16	5,987	6,360	252.90	188.065	64.83456	64.83456	51.472	26.48041	252.90	188.065	252.93	188.096
17	6,139	6,342	188.07	102.384	85.68790	85.68790	76.703	17.80476	188.07	102.384	188.10	102.408
18	6,164	6,331	102.38	84.075	18.30912	18.30912	12.616	11.28255	102.38	84.075	102.41	84.098
19	6,292	6,312	84.08	10.093	73.98258	73.98258	64.592	18.60874	84.08	10.093	84.10	10.116

Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE

Pipe	Elevation Outlet (feet)	HGL Outlet (feet)	P Static Max (psig)	P Static Min (psig)	dP Stag. Total (psid)	dP Static Total (psid)	dP Gravity (psid)	dH (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)
20	5,381	5,636	128.54	128.434	0.10286	0.10286	0.000	0.20384	128.54	128.434	128.57	128.465
22	5,381	6,311	469.44	469.413	0.02851	0.02851	0.000	0.05651	469.44	469.413	469.45	469.423
23	5,546	6,285	469.41	373.128	96.28532	96.28532	83.263	25.80530	469.41	373.128	469.42	373.138
25	5,381	5,635	128.43	128.300	0.12505	0.12505	0.000	0.24781	128.43	128.300	128.46	128.337
26	5,381	6,311	469.60	469.423	0.17802	0.17802	0.000	0.35278	469.60	469.423	469.64	469.460
27	5,717	6,192	239.51	239.483	0.02851	0.02851	0.000	0.05651	239.51	239.483	239.52	239.493
29	5,717	6,455	372.26	372.230	0.02851	0.02851	0.000	0.05651	372.26	372.230	372.27	372.240
30	5,717	6,191	239.44	239.320	0.12479	0.12479	0.000	0.24729	239.44	239.320	239.48	239.357
31	5,717	6,455	372.42	372.240	0.17802	0.17802	0.000	0.35278	372.42	372.240	372.46	372.277
32	5,966	6,448	372.23	243.226	129.00380	129.00380	125.652	6.64237	372.23	243.226	372.24	243.236
33	5,020	5,040	10.02	9.917	0.10614	0.10614	0.000	0.21033	10.02	9.917	10.07	9.963
34	5,020	5,716	351.23	351.090	0.13757	0.13757	0.000	0.27261	351.23	351.090	351.26	351.127
35	4,997	5,714	361.64	351.108	-10.52803	-10.52803	-11.606	2.13697	351.11	361.636	351.12	361.646
36	4,991	5,711	363.44	361.636	-1.79975	-1.79975	-3.028	2.43350	361.64	363.436	361.65	363.446
37	5,016	5,710	363.44	350.106	13.32973	13.32973	12.616	1.41506	363.44	350.106	363.45	350.116
38	4,955	5,708	380.23	350.106	-30.11943	-30.11943	-30.782	1.31336	350.11	380.226	350.12	380.235
39	4,953	5,707	380.54	380.226	-0.31350	-0.31350	-1.009	1.37874	380.23	380.539	380.24	380.549
40	4,977	5,706	380.54	367.975	12.56411	12.56411	12.111	0.89785	380.54	367.975	380.55	367.985
41	4,975	5,700	367.97	365.941	2.03401	2.03401	-1.009	6.03073	367.97	365.941	367.98	365.951
42	5,015	5,697	365.94	344.191	21.75029	21.75029	20.185	3.10181	365.94	344.191	365.95	344.200
43	5,018	5,693	344.19	340.581	3.60919	3.60919	1.514	4.15221	344.19	340.581	344.20	340.591
44	5,025	5,692	340.58	336.570	4.01186	4.01186	3.532	0.95016	340.58	336.570	340.59	336.579
45	5,646	6,270	373.13	315.132	57.99561	57.99561	50.463	14.92790	373.13	315.132	373.14	315.142

All Junction Table

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
7	Sta 268+88 4" PC 350 DIP to 4" DR 7.3 HDPE	5,224	5,666	222.904	222.87	222.914	222.91	50.00
8	Sta 313+37	5,385	5,642	129.698	129.70	129.730	129.73	50.00
9	Sta 502+95	5,546	6,285	373.128	373.13	373.138	373.14	50.00
10	Sta 716+60 4" PC 350 DIP to 4" DR 7.3 HDPE	5,820	6,254	219.197	219.17	219.206	219.20	50.00
11	Sta 789+05 4" DR 7.3 HDPE to 4" PC 350 DIP	5,749	6,216	235.566	235.58	235.598	235.59	50.00
12	Sta 882+11	5,446	6,202	381.661	381.66	381.671	381.67	50.00
13	Sta 938+06	5,581	6,194	309.435	309.43	309.444	309.44	50.00
15	Sta 1091+51	5,994	6,400	204.937	204.94	204.968	204.97	50.00
16	Sta 1117+77	5,885	6,386	252.899	252.90	252.931	252.93	50.00
17	Sta 1167+60 4; DR 7.3 HDPE to 4" DR 9 HDPE	5,987	6,360	188.065	188.07	188.096	188.10	50.00
18	Sta 1215+40	6,139	6,342	102.384	102.38	102.408	102.41	50.00
19	Sta 1245+69	6,164	6,331	84.075	84.08	84.098	84.10	50.00

Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE

Jct	Name	Elevation Inlet (feet)	HGL Inlet (feet)	P Static In (psig)	P Static Out (psig)	P Stag. In (psig)	P Stag. Out (psig)	Vol. Flow Rate Thru Jct (gal/min)
20	Sta 1295+65 Landfill Site Fresh Water Storage Tank	6,312	6,312	0.000	10.09	0.000	10.09	50.00
21	Sta 325+23	5,381	5,636	128.536	128.54	128.568	128.57	50.00
22	Sta 325+33	5,381	6,311	469.413	469.41	469.423	469.42	50.00
24	Fresh Water Pump B1	5,381	5,635	128.300	469.60	128.337	469.64	50.00
26	4" Dr 7.3 HDPE to 3" Sch 40 Carbon Steel	5,381	5,636	128.434	128.43	128.465	128.46	50.00
27	3" Sch 40 Carbon Steel to 4" PC 350 DIP	5,381	6,311	469.423	469.44	469.460	469.45	50.00
29	Sta 955+71	5,717	6,192	239.511	239.51	239.521	239.52	50.00
30	Sta 955+81	5,717	6,455	372.230	372.23	372.240	372.24	50.00
31	Fresh Water Pump C1	5,717	6,191	239.320	372.42	239.357	372.46	50.00
33	4" PC 350 DIP to 3" Sch 40 Carbon Steel	5,717	6,192	239.483	239.44	239.493	239.48	50.00
34	3" sch 40 Carbon Steel to 4" PC 350 DIP	5,717	6,455	372.240	372.26	372.277	372.27	50.00
35	Sta 157+26 - Begin Brine Sta 81+68	5,018	5,693	340.581	340.58	340.591	340.59	50.00
36	Injection Well Site Fresh Water Storage Tank	5,040	5,040	0.000	10.09	0.000	10.09	50.00
37	Fresh Water Pump A1	5,020	5,040	9.917	351.23	9.963	351.26	50.00
38	3" Sch 40 Carbon Steel to 4" PC 350 DIP	5,020	5,716	351.090	351.11	351.127	351.12	50.00
39	Sta 14+62	4,997	5,714	361.636	361.64	361.646	361.65	50.00
40	Sta 31+37	4,991	5,711	363.436	363.44	363.446	363.45	50.00
41	Sta 41+11	5,016	5,710	350.106	350.11	350.116	350.12	50.00
42	Sta 50+15	4,955	5,708	380.226	380.23	380.235	380.24	50.00
43	Sta 59+64	4,953	5,707	380.539	380.54	380.549	380.55	50.00
44	Sta 65+82	4,977	5,706	367.975	367.97	367.985	367.98	50.00
45	Sta 107+33	4,975	5,700	365.941	365.94	365.951	365.95	50.00
46	Sta 128+68	5,015	5,697	344.191	344.19	344.200	344.20	50.00
47	Sta 605+70	5,646	6,270	315.132	315.13	315.142	315.14	50.00
48	Sta 88+22	5,025	5,692	336.570	336.57	336.579	336.58	50.00
49	Sta 1001+53 4" PC 350 DIP to 4" DR 7.3 HDPE	5,966	6,448	243.226	243.20	243.236	243.23	50.00

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
7	8.095	0.87691
8	8.095	0.00000
9	8.095	0.00000
10	8.095	0.87691
11	8.095	0.19659
12	8.095	0.00000
13	8.095	0.00000
15	8.095	0.00000
16	8.095	0.00000
17	8.095	0.01915
18	8.095	0.00000
19	8.095	0.00000

Fresh Water Supply to Landfill Site: 4 inch DIP and 4 inch HDPE

Jct	Mass Flow Rate Thru Jct (lbm/sec)	Loss Factor (K)
20	8.095	1.00000
21	8.095	0.00000
22	8.095	0.00000
24	8.095	0.00000
26	8.095	0.08564
27	8.095	0.23636
29	8.095	0.00000
30	8.095	0.00000
31	8.095	0.00000
33	8.095	1.10258
34	8.095	0.23636
35	8.095	0.00000
36	8.095	0.50000
37	8.095	0.00000
38	8.095	0.23636
39	8.095	0.00000
40	8.095	0.00000
41	8.095	0.00000
42	8.095	0.00000
43	8.095	0.00000
44	8.095	0.00000
45	8.095	0.00000
46	8.095	0.00000
47	8.095	0.00000
48	8.095	0.00000
49	8.095	0.87691

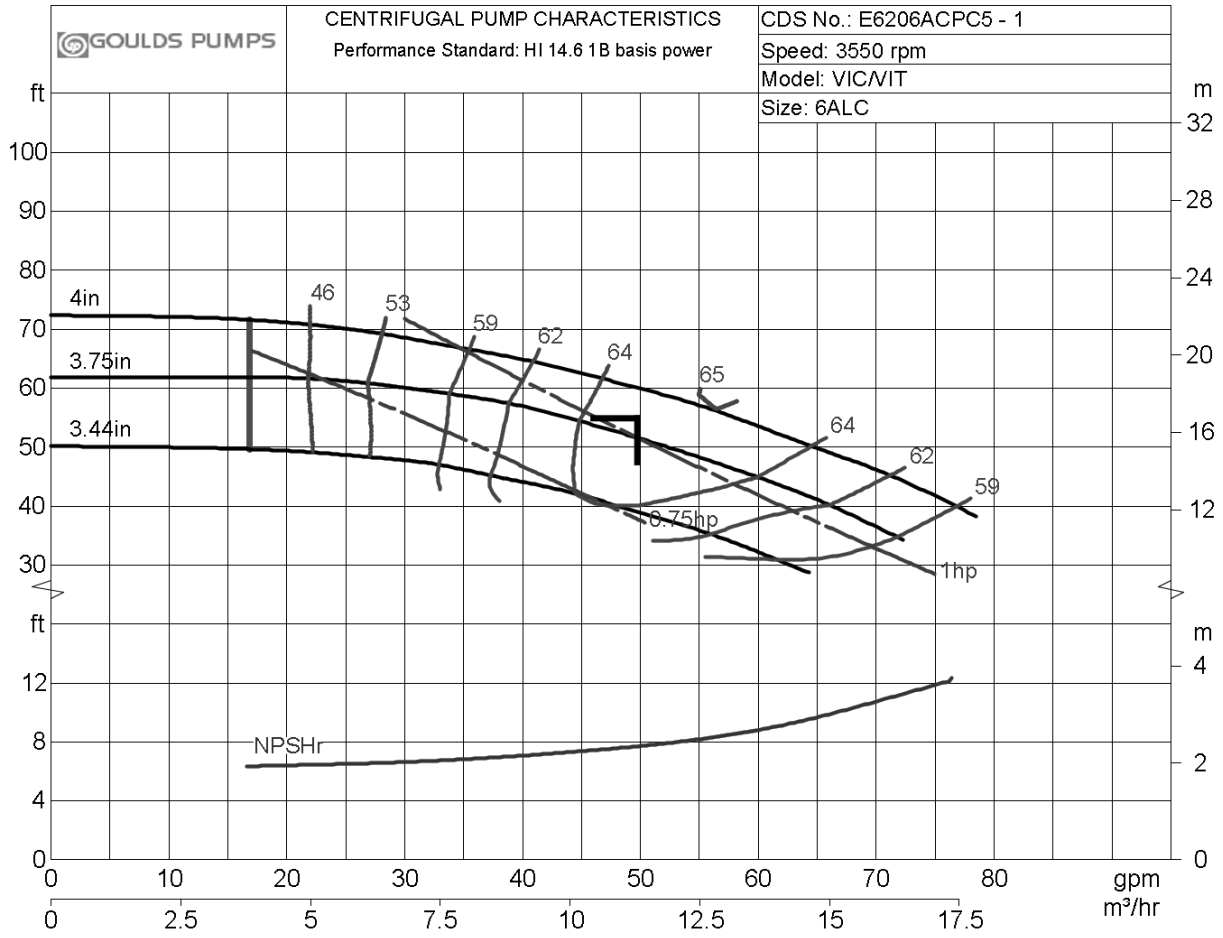
Model: VIC	Size: 6ALC	60Hz	RPM: 3550	Stages: 12

Job/Inq.No. :
Purchaser : UNDEFINED
End User: Issued by :
Item/Equip.No. : ITEM 006 Quotation No. : Date : 07/18/2016
Service : Fresh Water To Landfill Site
Order No. : Rev. : 0

Operating Conditions **Pump Performance**

Liquid:	Water	Published Efficiency:	64.7 %	Specific Speed:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.7 %	Min. Hydraulic Flow:	16.9 gpm
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	13.0 hp	Min. Thermal Flow:	N/A
Flow:	50.0 gpm	Non-Overloading Power:	14.2 hp		
TDH:	665.0 ft	Imp. Dia. First 1 Stg(s):	3.87 in	Imp. Dia. Adl Stg(s):	3.87 in
NPSHa:		NPSHr:	7.7 ft		
Solid size:		Shut off Head:	799.3 ft		
% Susp. Solids (by wtg):		Vapor Press:		Max. Solids Size:	0.1500 in

Notes: 1.The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



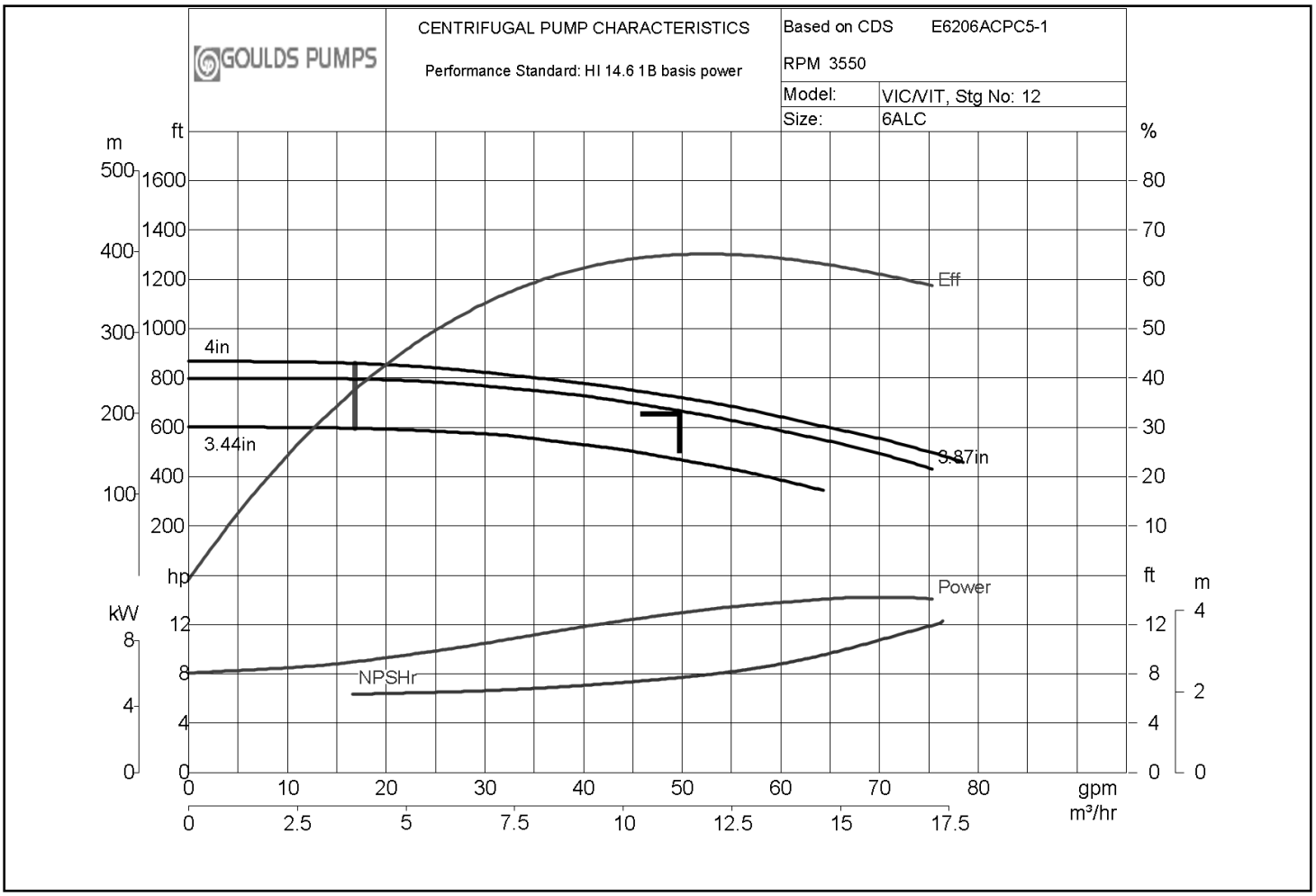
Model: VIC	Size: 6ALC	60Hz	RPM: 3550	Stages: 12

Job/Inq.No. :					
Purchaser :	UNDEFINED				
End User :		Issued by :		Rev. :	0
Item/Equip.No. :	ITEM 006	Quotation No. :		Date :	07/18/2016
Service :	Fresh Water To Landfill Site				
Order No. :					

Operating Conditions		Pump Performance			
Liquid:	Water	Published Efficiency:	64.7 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.7 %	Specific Speed Adl stg:	1,300 gpm(US) ft
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	13.0 hp	Min. Hydraulic Flow:	16.9 gpm
Flow:	50.0 gpm	Non-Overloading Power:	14.2 hp		
TDH:	665.0 ft	Imp. Dia. First 1 Stg(s):	3.87 in	Imp. Dia. Adl Stg(s):	3.87 in
NPSHa:		NPSHr:	7.7 ft	Shut off Head:	799.3 ft
Solid size:		Max. Solids Size:	0.1500 in	% Susp. Solids (by wtg):	

Vapor Press:

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Viscosity corrections have been performed in accordance with HI 9.6.7-2015

Model: VIC	Size: 6ALC	60Hz	RPM Variable	Stages: 12

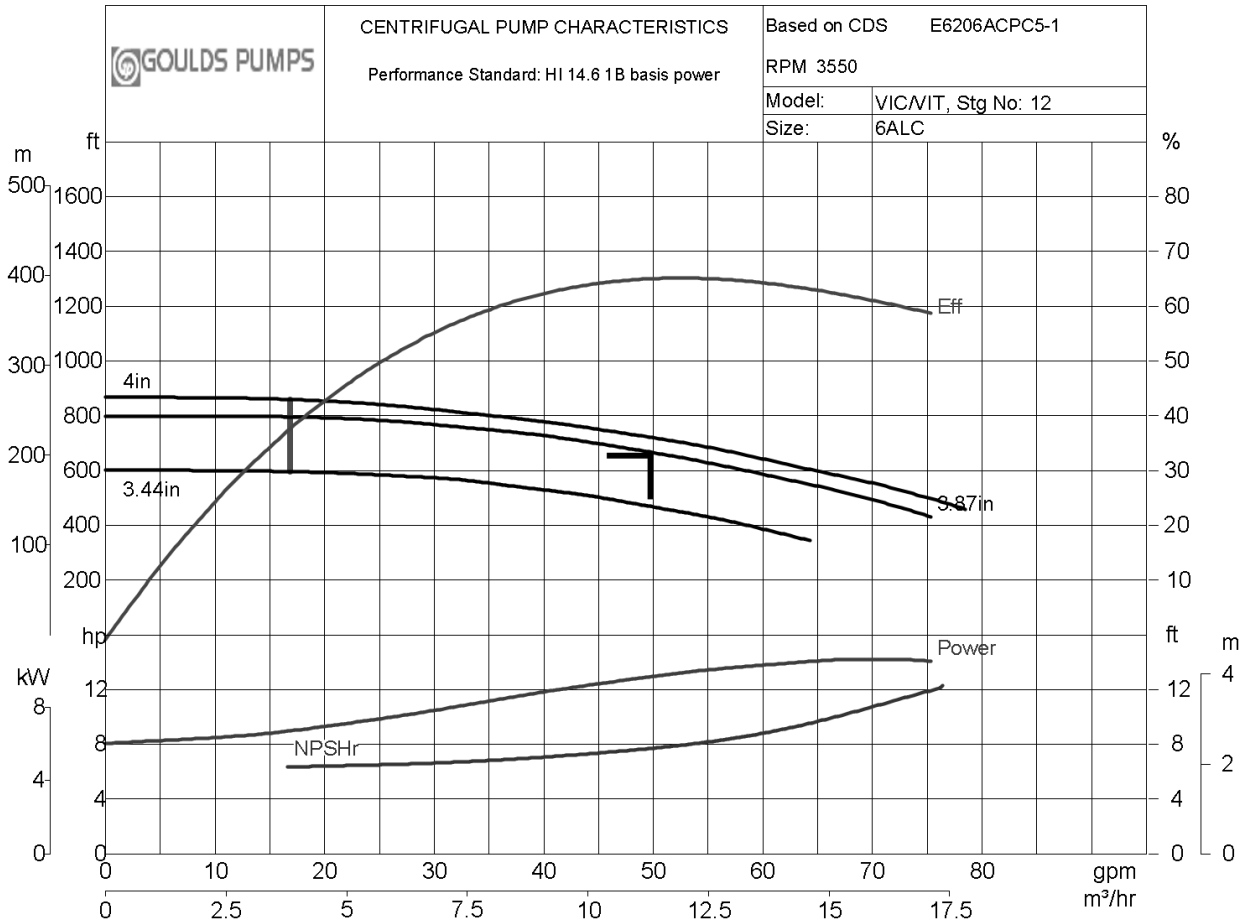
Job/Inq.No. :
Purchaser : UNDEFINED
End User : Issued by :
Item/Equip.No. : ITEM 006 Quotation No. : Date : 07/18/2016
Service : Fresh Water To Landfill Site
Order No. : Rev. : 0

Operating Conditions

Liquid:	Water	Published Efficiency:	64.7 %	Specific Speed 1st stg:	1,300 gpm(US) ft
Temp.:	34.0 deg F	Rated Pump Efficiency:	64.7 %	Specific Speed Adl stg:	1,300 gpm(US) ft
S.G./Visc.:	1.000/1.000 cp	Rated Total Power:	13.0 hp	Min. Hydraulic Flow:	16.9 gpm
Flow:	50.0 gpm	Non-Overloading Power:	14.2 hp		
TDH:	665.0 ft	Imp. Dia. First 1 Stg(s):	3.87 in	Imp. Dia. Adl Stg(s):	3.87 in
NPSHa:		NPSHr:	7.7 ft		
Solid size:		Shut off Head:	799.3 ft		
% Susp. Solids (by wtg):		Vapor Press:			
Max. Solids Size:	0.1500 in				

Pump Performance @ 3550 RPM

Notes: 1. The Mechanical seal increased drag effect on power and efficiency is not included, unless the correction is shown in the appropriate field above. 2. Magnetic drive eddy current and viscous effect on power and efficiency is not included. 3. Elevated temperature effects on performance are not included. 4. Non Overloading power does not reflect v-belt/gear losses.



Cost Estimate Report

Date: 07/26/2016

Paradox Valley - Fresh Water to Landfill - 4 inch DIP and HDPE

Year 2016 Quarter 2

Unit Detail Report with Subcontracted Lines

Prepared By: Raymond Hamilton AMEC Environment and Infrastructure

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
22 Plumbing						
221113780075	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 4" diam., DR 9, add 1 weld per joint, excludes hangers, trenching, backfill, hoisting, or digging equipment	12,805.00	L.F.	$3.89	49,811.45	0.00
221113780076	Pipe, plastic, high density polyethylene (HDPE), single wall, straight, welded, based on 40' length, 4" diam., DR 7.3, add 1 weld per joint, excludes hanges, trenching, backfill, hoisting or digging equipment.	29,517.00	L.F.	$4.65	137,254.05	0.00
221113784070	Welding, plastic, high density polyethylene (HDPE), single wall, labor per joint, cost based on the thickest wall for each diameter, 4" pipe size, weld, excludes welding machine	1,058.00	Ea.	$26.18	27,698.44	0.00
221113784360	Welding, plastic, high density polyethylene (HDPE), single wall, machine, rental per day based on diam. capacity, 3" thru 4" diameter, weld	28.00	Ea.	$50.50	1,414.00	0.00
221123999	Cost for 50 gpm Fresh Water Pump Station with Building	3.00	Ea.	$163,994.00	491,982.00	0.00
22 Plumbing Subtotal					**708,159.94**	**0.00**
26 Electrical						
2600999	Pump Station Electrical, Instrumentation and Controls - 50 gpm	3.00	Ea.	$10,112.00	0.00	30,336.00
26 Electrical Subtotal					**0.00**	**30,336.00**
31 Earthwork						
311110100160	Clearing & grubbing, brush, including stumps	5.58	Acre	$6,829.45	38,108.33	0.00
311413231550	Topsoil stripping and stockpiling, loam or topsoil, remove and stockpile on site, by dozer,1101-4000 S.Y., 6" deep, 200' haul	4,505.00	S.Y.	$0.55	2,477.75	0.00
312316142600	Excavating, chain trencher, utility trench, common earth, 40 H.P., 8" wide, 48" deep, operator riding, includes backfill	137,223.00	L.F.	$1.35	185,251.05	0.00
312316322400	Ripping shale, medium hard, ideal conditions, 300 H.P., dozer with single shank ripper	4,693.00	B.C.Y.	$2.32	10,887.76	0.00

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
312323160100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	2,259.00	L.C.Y.	$59.44	134,274.96	0.00
312323160500	Fill by borrow and utility bedding, for pipe and conduit, compacting bedding in trench	2,259.00	E.C.Y.	$4.97	11,227.23	0.00
312323204050	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 20 C.Y. truck, cycle 4 miles, 30 MPH, excludes loading equipment	2,485.00	L.C.Y.	$2.92	7,256.20	0.00
312514161000	Synthetic erosion control, silt fence, install and maintain, remove, 3' high	13,517.00	L.F.	$1.69	22,843.73	0.00
31 Earthwork Subtotal					**412,327.01**	**0.00**
32 Exterior Improvements						
329119130400	Topsoil placement and grading, loam or topsoil, F.E. loader, 1-1/2 C.Y., remove and stockpile on site, spread from pile to rough finish grade	4,505.00	C.Y.	$5.71	0.00	25,723.55
329219131000	Seeding, mechanical seeding hydro or air seeding for large areas, includes lime, fertilizer and seed	27,034.00	S.Y.	$1.14	0.00	30,818.76
32 Exterior Improvements Subtotal					**0.00**	**56,542.31**
33 Utilities						
330110101180	Corrosion resistance, coating, polyethylene H.D. extruded, .035" thick, 4" diameter, add	94,901.00	L.F.	$1.28	121,473.28	0.00
331113153000	Water supply distribution piping, ductile iron, cement lined, push-on joint, no fittings, 18' lengths, 4" diameter, class 50, excludes excavation or backfill	94,901.00	L.F.	$25.63	2,432,312.63	0.00
33 Utilities Subtotal					**2,553,785.91**	**0.00**

Line Number	Description	Quantity	Unit	Total Incl.O&P	Ext. Total Incl .O&P	Ext. Total Incl. O&P (Sub-Contracted)
Subtotal					**3,674,272.86**	**86,878.31**
General Contractor's Markup on Subs				**12.00%**		**$10,425.40**
Subtotal					**$3,674,272.86**	**$97,303.71**
General Conditions				**20.00%**	**$734,854.57**	**$19,460.74**
Subtotal					**$4,409,127.43**	**$116,764.45**
General Contractor's Overhead and Profit				**15.00%**	**$661,369.11**	**$17,514.67**
Subtotal					**$5,070,496.54**	**$134,279.12**

Grand Total **$5,204,775.66**