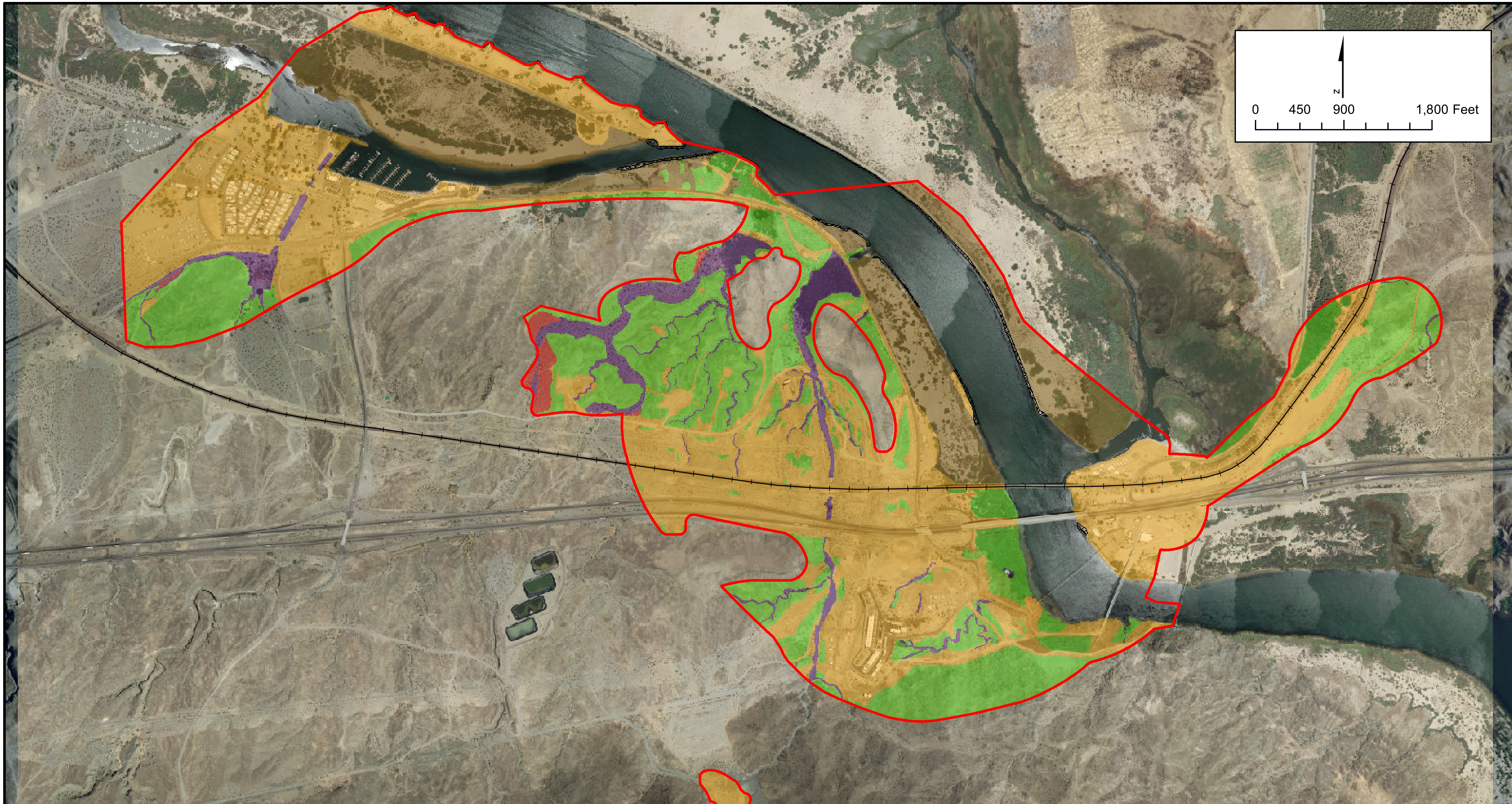
Appendix A1
Analytical Data (on CD-ROM)

Appendix A2
Aerial Map of Disturbed Areas
(November 2011)

The Draft Aerial Map was prepared in compliance with EIR Mitigation Measure CUL-1a-9.



LEGEND

Railroad

EIR Project Area

Surface Condition

Disturbed

Rip Rap

Mechanical Soil Surface Damage

Dredged Sand

Active Wash Channel

Inactive Wash Channel

Undistrubed

Undisturbed and Archaeological/Historical Sites

Notes:
1. Mapping results are shown only within the EIR Project Area.
2. Per "EIR CUL-1a9" disturbed areas are defined as those areas outside documented archaeological site boundaries that have experienced ground disturbance within the last 50 years. Note that it may not be possible to distinguish between disturbance before and after the 50 year time frame, so for the purpose of this mapping, unless it was known that disturbance was limited to that older than 50 years, it has been included as a disturbed area.

Aerial Source:
Toponex Inc. aerial flyover, conducted August 2011

AERIAL MAP OF DISTURBED AREAS
NOVEMBER 2011
(EIR MITIGATION MEASURE CUL-1A-9 REQUIREMENT)

Groundwater Remedy Basis of Design Report
Preliminary (30%) Design
PG&E Topock Compressor Station,
Needles, California

CH2MHILL

D:\Projects\Topock\MapFiles\2011\CMS\BOD\Disturbance

Appendix A3
Technical Memoranda on Methodologies for Mature Plant Survey, Floristic Survey, and the Identification/Mapping of OHWM

Prepared for Pacific Gas and Electric Company

Prepared by CH2M HILL and Garcia and Associates (GANDA)

Technical Memorandum

Date: October 31, 2011

To: Melanie Day and Curt Russell, PG&E

From: Kim Steiner and Jay Piper

cc: Morgan King, Gary Santolo, Marjorie Eisert, Christina Hong

Re: Topock Compressor Station Groundwater Remediation Project, Mature Plants Survey Methodology

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Introduction

The purpose of this technical memorandum (memo) is to describe the methodology used for surveying, mapping, and documenting the Mature Plants that occur in the PG&E Topock Compressor Station Groundwater Remediation Project (project) area. A Mature Plants survey was conducted to comply with the January 2011 Final Environmental Impact Report (EIR) requirements as set forth in Mitigation Measures AES-1a and AES-2b. These Mitigation Measures are from the Aesthetics (AES) portion of the mitigation plan presented in the EIR and are intended to ensure the protection of views from specific vantage points, as discussed in greater detail below.

On August 18, 2011 the methodology described in this memo was presented by PG&E and CH2M HILL at a plant survey kickoff meeting to stakeholder representatives from the Colorado River Indian Tribes, Fort Mojave Indian Tribe, Hualapai Tribe, and the PG&E cultural/archeological resources contractor, Applied Earthworks. During the kickoff meeting, the Tribes requested that the entire Project Area, as defined by the EIR, be the subject of the Mature Plants survey, instead of only the eastern portion of the site on and near the Colorado River Floodplain as is identified in the EIR Mitigation Measures AES-1a and AES-2b. The stated purpose of this request was to ensure the protection of other vantage points of cultural significance that may be present within the Project Area. The Tribes also requested a written copy of the survey methodology, and this technical memo was prepared to meet this request and as part of a Mature Plants survey report that will be prepared to document the survey effort.

At the request of PG&E, Garcia and Associates (GANDA) Senior Botanist Kim Steiner and assisting CH2M HILL Biologist Morgan King conducted botanical field surveys on August 18-26, 2011 in the Project Area. The surveys included data collection in preparation for the following four deliverables:

1) A Mature Plants Map and Species List for the Project Area. Mature Plants were defined as living: trees, large or prominent shrubs, and tall predominantly herbaceous plants (a more detailed description of Mature Plants is included in the Methodology section below). A list of Mature Plant species will accompany the Mature Plants Map in addition to a report documenting the survey effort.

2) An updated Vegetation Communities Map. The 2007 Programmatic Biological Assessment (PBA) for the project included a Vegetation Communities Map for the Area of Potential Effect, prepared from 2004-2005 field mapping. The Project Area largely, though not completely, overlaps with the Area of Potential Effect previously mapped under the PBA. Figure 1 depicts the extent of the Project Area. To facilitate survey logistics and track daily survey progress, the Project Area was divided into twelve segments which are labeled A through L.

3) A map of the ethnobotanically significant plants, which are identified in the EIR Appendix PLA: Ethnobotany Plant List. This survey is also being conducted to facilitate compliance with the EIR requirements described in Mitigation Measure CUL-1a-5, which requires the protection of culturally significant plants. Similarly to the Mature Plants survey described above, the extent of this survey area was increased at stakeholder request to include the Project Area. Future floristic surveys, for purposes other than Mature Plant mapping (as described in item 4 below) will collect additional data about ethnobotanically significant plants in the Project Area.

4) A preliminary species checklist in support of upcoming comprehensive floristic surveys. This checklist was developed using the Mature Plants survey as an opportunity to perform reconnaissance for upcoming fall, winter and/or spring Floristic and Rare Plant surveys. The checklist will serve as the starting point for these future surveys and will be updated and augmented with each upcoming survey. The checklist and botanical surveying and mapping efforts will ultimately result in a master plant list that can be sorted into subset lists including rare species or culturally significant species. This master plant list will be an important tool that will support plant protection during construction and design planning for the project.

Survey Area Description

The survey area encompasses the Project Area, totals approximately 780 acres, and varies in elevation from approximately 400 to 700 feet above sea level.[1] The survey team arbitrarily divided the Project Area into twelve sections (A—L) as described above. Nine of the sections (A, B, C, D, E, H, I, K, and L) are located in San Bernardino County, California. The remaining three sections (F, J, and G) are located in Mohave County, Arizona. Sections of the survey area within California are primarily on land managed by the Bureau of Land Management (BLM) or U.S. Fish and Wildlife Service (USFWS); with the exception of a portion of sections C and D, which is owned by the Fort Mojave Indian Tribe; and a portion of section H, which is owned by PG&E. On the Arizona side of the Colorado River, sections F and most of G are also part of the

[1] The Burlington Northern Santa Fe railroad and Interstate 40 rights-of-way are within the boundaries of the Project Area; however, they were not included in the Floristic Survey because the project is not anticipated to impact these areas.

USFWS Havasu National Wildlife Refuge, and land in section J and a portion of section G is privately owned.

The most common and widespread plant community in the Project Area is Creosote Bush Scrub. As the name implies, this plant community is dominated by creosote bush (*Larrea tridentata*) and is one of the most extensive plant communities found within the California Deserts (Sawyer et al. 2009). Creosote Bush Scrub is present in all upland areas of the Project Area. In the valleys and dry washes that dissect the upland areas, the most common plant community is the Palo Verde/Ironwood alliance that is dominated by blue palo verde (*Parkinsonia florida*) and various associates including catclaw acacia (*Acacia greggii*) (Sawyer et al. 2009). This alliance takes many forms and in the Project Area it is form that lacks ironwood (*Olneya tesota*). Along the floodplain of the Colorado River, the primary vegetation type is salt cedar (*Tamarix* ssp. semi-natural shrubland) which often forms impenetrable thickets (e.g. under the railroad and Interstate I-40 bridges) of single species, *Tamarix ramosissima*, or mixtures with other species; for example honey mesquite (*Prosopis glandulosa* var. *torreyana*) (Sawyer et al. 2009). Salt cedar often interdigitates with arrow weed (*Pluchea sericea*) thickets and Mesquite Bosque on the flood plain as well. Scattered throughout the project area on the flood plain or in broad washes near the flood plain are smaller patches of shadscale and all scale scrub (*Atriplex* spp.) which grow on alkaline or saline soils (Sawyer et al. 2009). Along the Colorado River and its inlets are patches of wetlands with various marsh plants forming associations in the water such as cattail (*Typha latifolia*) and California bulrush (*Scirpus californicus*) marshes, whereas on the adjacent shores and flood plain common reed (*Phragmites australis*) marshes and occasionally great reed (*Arundo donax*) breaks are present.

Methodology

Field Survey Preparation

Pursuant to Mitigation Measure AES-1a and AES-2b,

> *"The identification of plant specimens that are determined to be mature and retained shall occur as part of the design phase and mapped/identified by a qualified plant ecologist or biologist and integrated into the final design and project implementation."*

In order to identify potential Mature Plants that occur in the Project Area, Botanist Steiner, Biologist King, and PG&E Biologist Melanie Day reviewed existing documentation of vegetation types that occur in the Project Area; for example: the EIR, previous biological surveys in preparation for the PBA, incidental species lists from Protocol Desert Tortoise and Southwest Willow Flycatcher surveys, and the PBA Vegetation Communities Map. In addition, a brief pre-survey reconnaissance of the Project Area was conducted by Botanist Steiner, Biologist King, and Biologist Day on August 18, 2011. A Mature Plant was defined as a living:

- tree,
- large or prominent shrub, or
- tall predominately herbaceous plant

that could add to the aesthetic value of the Project Area from Key Views 5 and 11, and other potential culturally significant views in the Project Area.

A “Key View”, according to the EIR, is a vantage point offering a view of some or all of the Project Area from one of eleven specified points. Each Key View vantage point is located and described in Section 4, volume II, of the EIR. Two of the Key Views specified in the EIR are incorporated in the Aesthetic Mitigation Measures related to botanical surveys. Based on interpreting the PBA Plant Communities Map, these two Key Views 5 and 11 are described as follows: The “view corridor” from Key View 11 looking west from boats on the Colorado River consists of several overlapping areas of plant growth including: wetlands along the river, riparian vegetation on the banks and floodplain, and upland shrubs and trees on the slopes up to the next plateau and beyond (i.e. the edge of National Trails Highway and farther west). Key View 5 looks in the opposite direction (i.e. eastward) from a higher vantage point at the eastern edge of Maze Locus B outwards over the vegetated flood plain of the Colorado River.

Also included as Mature Plants were those used for landscaping around Park Moabi and the Topock Compressor Station; for example: eucalyptus (*Eucalyptus* sp.), fan palm (*Washingtonia* sp.), athel tamarisk (*Tamarix aphylla*), Fremont’s cottonwood (*Populus fremontii*), and oleander (*Nerium oleander*.). Shrubs were included if they occurred in a large or prominent form; for example, the widespread creosote bush was included where it was observed in a large or prominent form; however, it was not included where it more typically occurred as a small shrub.

Twenty-one species were considered appropriate to categorize and map as Mature Plants (Table 1). More than half of these (N=12) are trees, with the remainder split between shrubs (N= 5) and herbaceous perennials (N= 4).

Current high-resolution aerial photographs of the Project Area were prepared as base maps for Global Positioning System (GPS) and field notation to be used during the surveys. Although the aerial photographs are of sufficient quality and resolution that some Mature Plants can be identified, it is not feasible to identify all Mature Plants through the use of the photographs alone. The aerial photographs have been incorporated into project Geographic Information System data files and may also be used as a base map for the deliverables described in the *Introduction* section of this memo.

Field Survey

The field survey was conducted on August 18-26, 2011 in clear, calm, and hot summer weather. The list of Mature Plants described in Table 1, aerial photographs, and the Vegetation Communities Map were used as reference documents. Though surveyors were prepared to identify and record all observed species that may be considered to be a Mature Plant, and not just those listed is Table 1, no other species that would meet these criteria were observed. The field mapping was conducted using GPS data collection and surveyor notations were recorded on the aforementioned aerial photographs.

The protocol for the survey was developed expressly for Mitigation Measures AES-1a and AES-2b and designed to ensure that all Mature Plants were identified and recorded. The protocol was a mix of focused and transect-based surveys for Mature Plants based on terrain and the inherent visibility of Mature Plants. Surveyors were able to walk or scan the entire Project Area at a distance that guaranteed complete coverage for Mature Plants; therefore, surveyors were able to identify all of the Mature Plants in the Project Area. Trees and shrubs of interest were not distributed evenly across the Project Area; therefore, survey efforts were concentrated in dry riverbeds and washes in the upland areas, and along river banks and floodplains in the lower areas on both sides of the Colorado River. To ensure that surveyors did not overlook any Mature Plants in the Project Area, hilltops and ridges were used as vantage points to locate all Mature Plants in the washes and ravines below.

Vegetative sampling of individual plants was minimized during the survey in response to a request from the Tribes and because it was not necessary for accurate identification of the majority of the Mature Plants. In some cases, identifications were facilitated by taking photographs in the field.

GPS data was collected for each Mature Plant encountered during the survey using a Trimble GeoXH 6000 with decimeter accuracy. In areas where individual plants were numerous and closely clustered together, it was not feasible to GPS each plant individually (e.g. salt cedar and mesquite in sections C and D near National Trails Highway, see Fig. 1). This was especially true along the Colorado River floodplain where salt cedar often formed impenetrable thickets with other shrubs and trees (e.g. honey mesquite and arrow weed). In such situations, the clusters of mature plants were represented as polygon centroids.

For each Mature Plant or cluster of Mature Plants, surveyors recorded the height and health of the plant with the GPS device. Four height categories were used as follows:

- short (< 6 feet),
- medium (≥ 6 and < 12 feet),
- tall (≥ 12 and < 20 feet), or
- very tall (≥ 20 feet).

Plant health was also assessed using three categories as follows:

- good (plants with no dead or damaged branches or other signs of branch senescence),
- fair (plants with a few dead or senescent branches), or
- poor (plants with more than half of the branches dead or damaged).

All of the Mature Plants recorded and mapped on the flood plain of the Colorado River, with the exception of eucalyptus, fan palms, and athel tamarisk, were assumed to have established themselves naturally (i.e. not planted); however, not all naturally established plants were indigenous. For example, salt cedar and giant reed are native to eastern Asia and Europe, respectively; and the common reed, at least under the railroad bridge, is the invasive form from the eastern U.S. and not the native form from California (J. Andre, personal communication). Salt cedar and giant reed are also considered highly invasive in many parts of the arid Southwest, including California and Arizona (California Invasive Plant Council, 2011). In some landscaped areas, plants had clearly been planted; however, these occasionally impacted the view corridor of the Colorado River and were therefore included.

Deliverables

The primary deliverable resulting from the Mature Plant survey will be a detailed Mature Plants Map that depicts the location and distribution of all Mature Plants that occur within the Project Area. This map will also provide information on the height and general health of each Mature Plant (or cluster). These data will also be presented in a tabular/list form that will enable any user to find, for example, the largest concentration of honey mesquite trees, the tallest blue palo verde trees, the largest desert smoke tree, all clusters of arrow weed, or the only known locations for Goodding's willow and Fremont's cottonwood in the Project Area. A report summarizing the survey effort, including the methodology described herein, will also be prepared. The target completion date of these deliverables is December 30, 2011.

Table 1. List of Mature Plants in the Project Area

Species	Common name	Plant habit
TREES		
Athel tamarisk	*Tamarix aphylla*	Tall to very tall tree
Blue palo verde	*Parkinsonia florida*	Shrub to tree
California fan palm	*Washingtonia filifera*	Medium to tall tree
Catclaw acacia	*Acacia greggii*	Shrub to small tree
Desert smoke tree	*Psorothamnus spinosus*	Medium to tall tree
Eucalyptus[1]	*Eucalyptus* sp.	Tall tree
Fremont's cottonwood	*Populus fremontii*	Tall tree
Goodding's willow	*Salix gooddingii*	Medium to tall tree
Honey mesquite	*Prosopis glandulosa* var. *torreyana*	Medium to tall tree
Narrow-leaved willow	*Salix exigua*	Medium tree
Salt cedar	*Tamarix ramosissima*	Shrub to large tree
Screwbean mesquite	*Prosopis pubescens*	Medium to tall tree
SHRUBS		
Arrow weed	*Pluchea sericea*	Medium to tall shrub
Creosote bush	*Larrea tridentata*	Shrub
Ocotillo	*Fouquieria splendens*	Tall shrub
Oleander[2]	*Nerium oleander*	Medium to tall shrub
Shadscale saltbush	*Atriplex confertifolia*	Shrub
HERBACEOUS PLANTS		
Broad-leaved cattail	*Typha latifolia*	Tall herb
California bulrush	*Scirpus californicus*	Tall sedge
Common reed	*Phragmites australis*	Tall perennial grass
Giant reed	*Arundo donax*	Tall perennial grass

[1]Cultivated trees used in landscaping in Moabi Park
[2]Cultivated horticultural plants around the Compressor Station

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LEGEND

Survey Segments

N

0 500 1,000 2,000 Feet

FIGURE 1
EIR PROJECT AREA WITH VEGETATION SURVEY SEGMENTS

PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

D:\Projects\Topock\MapFiles\2011\CMS\BioSurveySegements

Pacific Gas and Electric Company®

Prepared for Pacific Gas and Electric Company

Prepared by CH2M HILL and Garcia and Associates (GANDA)

Technical Memorandum

Date: October 31, 2011

To: Melanie Day and Curt Russell, PG&E

From: Kim Steiner and Jay Piper

cc: Morgan King, Gary Santolo, Marjorie Eisert, Christina Hong

Re: Topock Compressor Station Groundwater Remediation Project, Floristic Survey Methodology

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Introduction

The purpose of this technical memorandum (memo) is to describe the methodology that will be used for surveying, mapping, and documenting the plant species that occur in the PG&E Topock Compressor Station Groundwater Remediation Project (project) area. A Floristic survey will be conducted to establish a comprehensive inventory of plant species that occur in the Project Area, identify any plants species that are considered to be sensitive as defined in the *Methodology* section below, and to comply with the requirements of the January 2011 Final Environmental Impact Report (EIR) Mitigation Measure CUL-1a-5, which requires PG&E to avoid, protect, and encourage the regeneration of ethnobotanically significant plants listed in Appendix PLA of the EIR. The Project Area is defined in the EIR and depicted in Figure 1.

On August 18, 2011 the methodology for plant surveys in the Project Area was presented by PG&E and CH2M HILL at a plant survey kickoff meeting to stakeholder representatives from the Colorado River Indian Tribes, Fort Mojave Indian Tribe, Hualapai Tribe, and the PG&E cultural/archeological resources contractor, Applied Earthworks. During the kickoff meeting, The Tribes requested a written copy of the survey methodology for the Mature Plants survey and the Floristic survey, and this technical memo was prepared to meet this request and as part of a Floristic survey report that will be prepared to document the survey effort. The Mature Plants survey methodology was separately prepared.

At the request of PG&E, Garcia and Associates (GANDA) Senior Botanist Kim Steiner and assisting CH2M HILL Biologist Morgan King conducted botanical field surveys on August 18-26, 2011 in the Project Area. The primary purpose of the survey was the identification and mapping of Mature Plants, as required by EIR Mitigation Measures AES-1a and AES-2b. The Mature Plants survey was extended to cover the entire Project Area at the request of the Tribes during plant survey kickoff meeting. This survey also included incidental data collection in support of the Floristic survey as follows:

1) A preliminary plant species checklist was developed using the Mature Plants survey as an opportunity to perform reconnaissance for fall, winter and/or spring Floristic surveys. The checklist will serve as the starting point for the Floristic surveys and will be updated and augmented with each seasonal survey. The checklist and botanical surveying and mapping efforts will ultimately result in a comprehensive inventory of plant species (or master plant list) that can be sorted into subset lists including rare species or ethnobotanically significant species. This master plant list will be an important tool that will support plant protection during construction and design planning for the project.

2) Information to prepare a map and list of the ethnobotanically significant plants was collected. The Floristic survey will collect additional data about ethnobotanically significant plants in the Project Area.

In addition, information to prepare an updated Vegetation Communities Map was collected. The 2007 Programmatic Biological Assessment (PBA) for the project included a Vegetation Communities Map for the Area of Potential Effect, prepared from 2004-2005 field mapping. The Project Area largely, though not completely, overlaps with the Area of Potential Effect previously mapped under the PBA. To facilitate botanical survey logistics and track daily survey progress, the Project Area was divided into twelve sections which are labeled A through L (Figure 1).

Survey Area Description

The survey area encompasses the Project Area, totals approximately 780 acres, and varies in elevation from approximately 400 to 700 feet above sea level.[1] The survey team arbitrarily divided the Project Area into twelve sections (A—L) as described above. Nine of the sections (A, B, C, D, E, H, I, K, and L) are located in San Bernardino County, California. The remaining three sections (F, J, and G) are located in Mohave County, Arizona. Sections of the survey area within California are primarily on land managed by the Bureau of Land Management (BLM) or U.S. Fish and Wildlife Service (USFWS); with the exception of a portion of sections C and D, which is owned by the Fort Mojave Indian Tribe; and a portion of section H, which is owned by PG&E. On the Arizona side of the Colorado River, sections F and most of G are also part of the USFWS Havasu National Wildlife Refuge, and land in section J and a portion of section G is privately owned.

The most common and widespread plant community in the Project Area is Creosote Bush Scrub. As the name implies, this plant community is dominated by creosote bush (*Larrea tridentata*) and is one of the most extensive plant communities found within the California Deserts (Sawyer et al. 2009). Creosote Bush Scrub is present in all upland areas of the Project Area. In the valleys and dry washes that dissect the upland areas, the most common plant community is the Palo Verde/Ironwood alliance that is dominated by blue palo verde (*Parkinsonia florida*) and

[1] The Burlington Northern Santa Fe railroad and Interstate 40 rights-of-way are within the boundaries of the Project Area; however, they were not included in the Floristic Survey because the project is not anticipated to impact these areas.

various associates including catclaw acacia (*Acacia greggii*) (Sawyer et al. 2009). This alliance takes many forms and in the Project Area it is form that lacks ironwood (*Olneya tesota*). Along the floodplain of the Colorado River, the primary vegetation type is salt cedar (*Tamarix* ssp. semi-natural shrubland) which often forms impenetrable thickets (e.g. under the railroad and Interstate I-40 bridges) of single species, *Tamarix ramosissima*, or mixtures with other species; for example honey mesquite (*Prosopis glandulosa* var. *torreyana*) (Sawyer et al. 2009). Salt cedar often interdigitates with arrow weed (*Pluchea sericea*) thickets and Mesquite Bosque on the flood plain as well. Scattered throughout the project area on the flood plain or in broad washes near the flood plain are smaller patches of shadscale and all scale scrub (*Atriplex* spp.) which grow on alkaline or saline soils (Sawyer et al. 2009). Along the Colorado River and its inlets are patches of wetlands with various marsh plants forming associations in the water such as cattail (*Typha latifolia*) and California bulrush (*Scirpus californicus*) marshes, whereas on the adjacent shores and flood plain common reed (*Phragmites australis*) marshes and occasionally great reed (*Arundo donax*) breaks are present. The common reed is likely a non-indigenous and invasive species (this will be verified during the Floristic survey).

Methodology

Research and Literature Review

Pursuant to Mitigation Measure CUL-1a-5,

> *"Should any indigenous plants of traditional cultural significance and listed in Appendix PLA of this FEIR be identified within the project area, PG&E shall avoid, protect, and encourage the natural regeneration of the identified plants when developing the remediation design, final restoration plan, and IM-3 decommission plan…."*

The purpose of the Floristic survey is to comply with Mitigation Measure CUL-1a-5, obtain a comprehensive inventory of plant species that occur in the Topock Project survey area, and to ensure that sensitive plants (i.e. special-status and ethnobotanically significant plant species as described below) are detected and mapped or recorded. Therefore, prior to conducting the survey, research was conducted to: 1) determine the appropriate times to conduct surveys to maximize the potential for identifying plants that occur in the East Mojave Desert, and 2) identify special-status and ethnobotanically significant plant species with a potential to occur in the survey area.

Research included consideration of rain patterns in the East Mojave Desert, and specifically, timing of a fall survey to ensure fall blooming species are identified. Rainfall in the East Mojave Desert exhibits a bimodal pattern, with most rainfall occurring in the winter and a significant proportion of annual rainfall occurring in the late-summer (Brooks et al. 2001). Rains in September and October 2011 produced a fall bloom in wash floors, where runoff concentrates, and may have triggered a bloom in upland and floodplain areas. Therefore, an early November survey is currently planned that will allow for identification of plants emerging from late-summer rains. To further refine survey plans, a regional botanical expert and curator of the University of California Riverside, Granite Mountains Research Center, Jim Andre, Ph.D., was contracted to review survey planning to optimize timing, check target plant lists, and join the field survey team for a pre-survey reconnaissance and orientation towards locally occurring sensitive plants. Dr. Andre related that surveys from mid-November to mid-January are typically non-productive. The timing for a spring survey might advance if winter weather is wetter and milder than normal; however, the typically most productive timing for a spring survey is mid- to late- March. A follow-up survey may occur in late spring 2012 in wetlands or other areas as needed. Unusual weather might trigger surveys at other times of the year; for example, in late winter. Accordingly, the survey timing will maximize the number of plants detected and identified.

Sensitive Plants

Sensitive plants are defined as special-status plants and ethnobotanically significant plants. A plant species was considered to be special-status if it met one or more of the following criteria:

- Listed, proposed, or candidate for listing, as rare, threatened or endangered under the Federal or State Endangered Species Acts or California Native Plant Protection Act (USFWS 1996b, 2006, 2011; CNDDB 2011a)
- Special Plant as defined by the California Natural Diversity Database (CNDDB 2011b)
- California Rare Plant Ranked (CRPR) 1, 2, 3, or 4 by the California Native Plant Society (CNPS) in its Online Inventory of Rare and Endangered Plants of California (CNPS 2011)
- Listed by the BLM as a Special Status Plant (BLM 2011)
- Listed by the Arizona Rare Plant Committee (2001)
- Listed under the California Desert Native Plants Act (CDNPA)

A preliminary list of potentially occurring special-status plants (target list) was derived from several sources. Quadrangle-based searches of the CNPS Inventory and the CNDDB RareFind3 database (2011a) were conducted to identify potentially occurring special-status plants. The 7.5-minute United States Geological Survey (USGS) quadrangles containing the Project Area (i.e. Whale Mountain and Topock Quadrangles) and 11 surrounding USGS 7.5-minute quadrangles (i.e. Needles NW, Needles SW, Needles, Monumental Pass, Snaggle Tooth, Chemehuevi Peak, Castle Rock, Savahia Peak NW, Savahia Peak NE, Havasu Lake, and Lake Havasu City South) were included in the CNPS and CNDDB RareFine3 database searches. The CNDDB Quickviewer online database (CNDDB 2011c) was searched to identify potentially occurring plant species (CRPR 3 or 4) that are not recorded on a quadrangle basis in other databases. Since part of the project area occurs in Arizona and special-status plants in that state are not available in a database that can be queried by USGS quadrangle, each rare plant species listed for Mohave County (Arizona Rare Plant Committee 2001) was individually checked against data in the Southwest Environmental Information Network (SEI Net) to determine the likelihood of any of these plants occurring in the survey area. Special status plants not found in any of the aforementioned sources; however, known to have the potential to occur in the Project Area based on a list produced by Dr. Andre, were also included in the target list.

If a species distribution, habitat, or elevation range precluded its possible occurrence in the Project Area or vicinity, it was not considered further. A species was determined to have potential to occur within the Project Area if its known or expected geographic range included the Project Area or vicinity, and if its known or expected habitat was found within or adjacent to the Project Area during the August 2011 botanical survey.

Based on the pre-survey research and literature review, 50 special-status plants have the potential to our in the Project Area. Thirty-four CRPR (CNPS) plants occur or were determined to have the potential to occur in the survey area, and these species, along with data on flowering period, conservation status, habitat preferences, geographic distribution, and known locations in the vicinity of the survey area, are presented in Table 1. Also included in this table are 20 special-status plants that are protected under the CNDPA.

Table 1. Target list of special-status plant species with the potential to occur in the Project Area

Common Name	Scientific Name	Status[1] Fed/State/CRPR/ CDNPA	Flowering Period	Habitat	Potential to Occur[2]
TREES					
Blue palo verde	*Parkinsonia florida*	--/--/--/CDNPA	Apr–May	Creosote Bush Scrub; washes and floodplains.	**Present.** This tree is the most abundant native tree in the Project Area.
California fan palm	*Washingtonia filifera*	--/--/--/CDNPA	Feb–Jun	Creosote Bush Scrub; Moist places, seeps, springs, streamsides.	**Present.** This tree does not appear to be native to the Project Area; however, it is planted in the landscaped areas.
Catclaw acacia	*Acacia greggii*	--/--/--/CDNPA	Apr–Jun	Creosote Bush Scrub; Pinyon-Juniper Woodland, uncommon on dry slopes, chapparal, washes, flats, disturbed areas.	**Present.** This shrub to small tree is common in the Project Area, particularly in the upland washes
Desert ironwood	*Olneya tesota*	--/--/--/CDNPA	Apr–May	Creosote Bush Scrub; desert washes.	**Unlikely.** Suitable habitat for this tree occurs in the Project Area; however, it was not detected during the Mature Plants Survey in August 2011 and therefore is not anticipated to occur in the Project Area.
Desert smoke tree	*Psorothamnus spinosus*	--/--/--/CDNPA	Mar–May	Creosote Bush Scrub; desert washes.	**Present.** This shrub to small tree is locally common in several parts of the Project Area, but is not common overall.
Honey mesquite	*Prosopis glandulosa* var. *torreyana*	--/--/--/CDNPA	Apr–Aug	Creosote Bush Scrub and Alkali Sink Scrub; grasslands, alkali flats, washes, sandy alluvial flats, mesas.	**Present.** This medium to large tree is common in the Project Area especially on the flood plain and nearby areas.

Little-leaved palo verde	*Parkinsonia microphylla*	--/--/4.3/CDNPA	Apr–May	Creosote Bush Scrub; rocky or gravelly areas	**Unlikely**. This woody shrub or small tree is not known from the project area, but suitable habitat occurs there. It is known from 25 miles SW of the project area in the Whipple Mts. near Copper Basin and Lake Havasu; however, it was not detected during the Mature Plants Survey in August 2011 and therefore is not anticipated to occur in the Project Area.
Screwbean mesquite	*Prosopis pubescens*	--/--/--/CDNPA	Apr–Sep	Creosote Bush Scrub; creek, river bottoms, sandy or gravelly washes, ravines.	**Present.** This medium to large tree is common under the highway and RR bridges that cross the Colorado River, and on the Arizona side of the river opposite the Topock Marina.
Velvet mesquite	*Prosopis velutina*	--/--/--/CDNPA	Apr–Jun	Mojavean Desert Scrub; sandy, rocky soils in canyons, washes; only naturalized in CA, not native.	**Unlikely**. A single occurrence of this tree is known from the Topock Marsh; however, it was not detected during the Mature Plants Survey in August 2011 and therefore is not anticipated to occur in the Project Area.
SHRUBS					
Beaver tail	*Opuntia basilaris* ssp. *basilaris*	--/--/--/CDNPA	Mar–Jun.	Mojavean Desert Scrubto Pinyon-Juniper Woodland.	**Present.** This succulent shrub is scattered throughout the upland portion of the Project Area.
Buckhorn cholla	*Cylindropuntia acanthocarpa* var. *coloradensis*	--/--/--/CDNPA	May–Jun	Creosote Bush Scrub and Joshua Tree Woodland; gravelly or rocky places.	**Present.** This succulent shrub is scattered throughout the upland portion of the Project Area.
California Barrel Cactus	*Ferocactus cylindraceus* var. *cylindraceus*	--/--/--/CDNPA	Apr–May	Creosote Bush Scrub and Joshua Tree Woodland; gravelly or rocky places.	**Present.** This succulent shrub is locally scattered in the southern portion of the Project Area near the Colorado River.

Crucifixtion thorn	*Castela emoryi*	--/--/2.3/CDNPA	Apr, Jun–Jul*	Mojavean or Sonoran desert scrub; gravelly soils, sometimes in alkali playas or washes.	**Possible.** Suitable habitat is present, for this shrub; however, there are no occurrence records in the immediate vicinity of the Project Area. It has been collected near Chemehuevi Wash 19 miles southeast of Topock.
Corkseed mammillaria	*Mammillaria tetrancistra*	--/--/--/CDNPA	Apr	Creosote Bush Scrub; sandy hills.	**Present**. This small succulent shrub is uncommon on rocky slopes in upland parts of the Project Area.
Graham's fishhook cactus	*Mammillaria grahamii* var. *grahamii*	--/--/2.2/CDNPA	Apr–Jun	Creosote Bush Scrub; gravelly alluvial fans and rocky slopes.	**Unlikely**. Small succulent shrub with nearest known occurrences in the Whipple Mtns. 25 miles south of the Project Area; however typically occurs above 900 feet elevation.
Hall's tetracoccus	*Tetracoccus hallii*	--/--/4.3/--	Jan–May	Creosote Bush Scrub; rocky slopes and washes.	**Possible**. This woody shrub is not known from the Project Area. The closest known population is 14 miles southwest of Project Area.
Howe's hedgehog cactus	*Echinocereus engelmannii* var. *howei*	--/--/1B.1/CDNPA	May–Jun	Creosote Bush Scrub; hills and flats on well-drained rocky ledges and steep gravelly slopes.	**Unlikely**. Suitable habitat for this stem succulent cactus occurs in the project area; however, there are no occurrence records there. It is known to occur 35 miles northwest of the Project Area on rocky ledges.
Kofa Mountain barberry	*Berberis harrisoniana*	--/--/1B.2/--	Jan–Mar	Mojavean Desert Scrub, usually north-facing talus slopes, sometimes volcanic.	**Possible.** Known to occur near Colorado River in Whipple Mtns.
Mojave yucca	*Yucca schidigera*	--/--/--/CDNPA	Apr–May	Creosote Bush Scrub.	**Possible**. Shrub or tree-like; occurrence known from 10 miles south of Needles.

Narrow-leaved dalea)	*Psorothamnus fremontii* var. *attenuatus*	--/--/2.2/--	Mar–May	Desert Scrub; granitic or volcanic rocky slopes and canyons.	**Possible**. Known only from the Whipple Mtns approx. 30 miles south of project area.
Ocotillo	*Fouquieria splendens*	--/--/--/CDNPA	Mar–Jul	Creosote Bush Scrub; dry, generally rocky soils.	**Present.** This large shrub is known to occur as a few individuals on slopes above the National Trails Hwy
Pencil cholla	*Cylindropuntia ramosissima*	--/--/--/CDNPA	Apr–Aug	Creosote Bush Scrub and other Mojavean Desert Scrub.	**Present.** This small succulent shrub is uncommon on rocky slopes in the Project Area.
Silver cholla	*Cylindropuntia echinocarpa*	--/--/--/CDNPA	May–Jun	Mojavean Desert Scrub.	**Present.** This succulent shrub is common on rocky slopes in upland parts of the Project Area.
Utah cynanchum	*Cynanchum (*syn. *Funastrum) utahense*	--/--/4.2/--	Apr–Jun, Sep	Mojavean desert scrub; dry, sandy or gravelly areas	**Likely**. This perennial shrub is not known from the Project Area; however, suitable habitat is present and it occurs 12 miles northwest of the Project Area.
HERBACEOUS PLANTS					
Abram’s spurge	*Chamaesyce abramsiana*	--/--/2.2/--	Aug–Nov	Creosote Bush Scrub; open or vegetated sandy flats.	**Possible**. Annual herb known sporadically from Imperial to eastern Riverside and San Bernardino Counties. Nearest known occurrences are 35 miles west of the Project Area.
Arizona pholistoma	*Pholistoma auritum* var. *arizonicum*	--/--/2.3/--	Feb–Apr	Creosote Bush Scrub; rocky canyons, north-facing slopes.	**Possible**. Annual herb with nearest known occurrence from Dead Mtns. 15 miles northwest of Project Area (Andre # 18324).

Bare-stem larkspur	*Delphinium scaposum*	--/--/2.3/--	Mar–May	Creosote Bush Scrub; rocky granitic slopes and canyons.	**Unlikely**. Project Area is under species elevation range of 886 to 3,641 feet. Nearest occurrence in Whipple Mtns. 30 miles to the south of the Project Area.
Bitter hymenoxys	*Hymenoxys odorata*	--/--/2.2/--	Apr–Jun, Sep–Oct	Seasonally moist silty soils, sandy flats near the Colorado River.	**Possible**. Annual herb rediscovered in 2009 in CA 40 miles south of the Project Area along the flood plain of Colorado River (Andre #10531).
Borrego milkvetch	*Astragalus lentiginosus* var. *borreganus*	--/--/4.3/--	Feb–May, Sep	Creosote Bush Scrub; widely scattered in sand dunes, or semi-stabilized sandy areas in valleys.	**Possible**. Annual herb that is known from the Colorado River 45 miles south of the Project Area.
Cooper's rush	*Juncus cooperi*	--/--/4.3/--	Apr–May	Alkali Sink Scrub; meadows and seeps; often alkaline or saline.	**Possible**. This perennial herb is not known from the Project Area; however, suitable habitat is present and it is known from the Chemehuevi Mountains10 miles SW of the Project Area.
Cove's cassia	*Senna covesii*	--/--/2.2/--	Mar–Jun, Sep	Creosote Bush Scrub; washes, alluvial slopes, and sandy disturbed areas.	**Possible**. Perennial herb with nearest occurrences from the Whipple Mtns. to the south of the Project Area, and recently discovered in the Piute Range to the NW (Andre #12410).
Darlington's blazing star	*Mentzelia puberula*	--/--/2.2/--	April–May, Sept–Oct	Rocky slopes and canyons; sandy washes.	**Possible**. Perennial herb with nearest known occurrences 10 miles SE of the Project Area in the Needles area, AZ.
Desert germander	*Teucrium glandulosum*	--/--/2.3/--	Mar–May	Desert Scrub; dry rocky slopes.	**Possible**. Stoloniferous herb with closest occurrences from Whipple Mtns. to the south of the Project Area.

Desert portulaca	*Portulaca halimoides*	--/--/4.2/--	Aug–Oct	Desert Scrub; sandy washes, alluvial fans and flats. Emerges after summer rains.	**Possible.** Annual herb that is known from Little San Bernardino Mtns. to eastern San Bernardino County Mtns. Occurs in Piute Valley.
Desert unicorn-plant	*Proboscidea althaeifolia*	--/--/4.3/--	May–Oct	Creosote Bush Scrub; sandy soil.	**Possible**. The closest known site for this annual species is Chemehuevi Wash 19 miles southeast of the Project Area.
Glandular ditaxis	*Ditaxis claryana*	--/--/2.2/--	Oct–Mar	Mojavean and Sonoran Desert Scrub; dry washes and on rocky hillsides, sandy soils.	**Likely.** This annual herb has been collected in the vicinity of the Topock Compressor Station near the Colorado River.
Harwood's woolystar	*Eriastrum harwoodii*	--/--/1B.2/--	Apr–May	Know only from sandy areas (dunes and wind-blown ramps) of the Eastern San Bernardino and Riverside Counties.	**Possible**. Perennial herb with nearest known occurrence 40 miles southwest of the Project Area.
Lobed ground-cherry	*Physalis lobata*	--/--/2.3/--	Apr–Jun	Mojavean Desert Scrub; seasonally moist depressions, dry lake margins, and washes, and is active following summer rains.	**Possible.** Perennial herb known to occur along the Colorado River near Las Vegas, occurs in Piute Valley 13 miles from Needles.
Playa milkvetch	*Astragalus allochrous* var. *playanus*	--/--/2.2/--	March–May	Creosote Bush Scrub; sandy saline flats.	**Possible.** Known in CA only from Goffs area, 30 miles west of the Project Area. Occurs around playas near Buckeye, Arizona.
Pointed dodder	*Cuscuta californica* var. *apiculata*	--/--/3/--	Feb–Aug	Mojavean Desert Scrub; sandy soils.	**Possible.** Suitable habitat is present and it is known to occur near Parker Dam road, 38 miles southwest of Project Area.

Reveal's buckwheat	*Eriogonum contiguum*	--/--/2.3/--	May–Jul, Sept–Oct	Creosote Bush Scrub; sandy, clay or gypsum soils.	**Possible.** Annual herb with nearest known occurrence along Needles Hwy., 12 miles north of Needles (Andre #17823)
Ribbed cryptantha	*Cryptantha costata*	--/--/4.3/--	Feb–May	Mojavean and Sonoran Desert Scrub; sandy soil, dunes.	**Likely**. This small annual herb normally occurs in desert sand dunes. Nearest known occurrence is along the Colorado River just north of Topock. It has also been collected 30 miles northwest of the Project Area.
Sand evening primrose	*Camissonia arenaria*	--/--/2.2/--	Jan–May	Mojavean Desert Scrub; rocky slopes and canyon walls, may also be found in washes.	**Possible**. Annual or perennial herb with nearest known occurrence in the Needles area in Arizona 10 miles southeast of the Project Area.
Slender cottonheads	*Nemacaulis denudata* var. *gracilis*	--/--/2.2/--	Mar–May	Creosote Bush Scrub; sandy soils on stabilized dunes and sand ramps.	**Possible**. Annual herb with nearest known occurrence along the Colorado River in Arizona 15 miles south of Project Area.
Small-flowered androstephium	*Androstephium breviflorum*	--/--/2.2/--	Mar–Apr	Mojavean Desert Scrub; widely scattered in stabilized to semi-stabilized sandy areas in valleys.	**Possible.** Perennial herb (bulb) with nearest occurrence from sandy banks of Colorado River (Arizona) just north of Topock.
Spearleaf	*Matelea parvifolia*	--/--/2.3/--	Mar–May	Mojavean Desert Scrub; dry rocky areas, especially granitic rock.	**Possible.** Perennial herb with scattered populations to the south and west, nearest occurrence 15 miles west of the Project Area in the S. Sacramento Mtns. (Andre #14219).
Spiny-hair blazing star	*Mentzelia tricuspis*	--/--/2.1/--	Apr–Jun, Sept–Oct	Mojavean Desert Scrub; sandy or gravelly slopes and washes.	**Likely**. This annual species is not known from the project area, but suitable habitat is present and it has been recorded from 4 miles southeast of the Project Area.

Three-awned gramma	*Bouteloua trifida*	--/--/2.3/--	Apr–Nov	Creosote Bush Scrub; Rocky slopes, usually on limestone.	**Possible**. Perennial herb with nearest occurrence in Whipple Mtns. 30 miles to the south of the Project Area.
Wand-like fleabane daisy	*Erigeron oxyphyllus*	--/--/2.3/--	Apr–Jun	Desert Scrub, rocky slopes and canyons.	**Possible**. Perennial herb with nearest occurrence in Whipple Mtns. 30 miles to the south of the Project Area.
Winged cryptantha	*Cryptantha holoptera*	--/--/4.3/--	Mar–Apr	Mojavean Desert Scrub; sandy to rocky soils.	**Possible**. Suitable habitat is present and occurs 33 miles southwest of project area.

Sources:
California Native Plant Society 2011; California Natural Diversity Database 2011; Consortium of California Herbaria 2011; Jepson Online Interchange 2011

[1] **Conservation status abbreviations:**

U.S. Fish and Wildlife Service designations:
- FE Endangered: Any species in danger of extinction throughout all or a significant portion of its range.
- FT Threatened: Any species likely to become endangered within the foreseeable future.

California Department of Fish and Game designations:
- SE Endangered: Any species in danger of extinction throughout all or a significant portion of its range.
- ST Threatened: Any species likely to become endangered within the foreseeable future.
- SR Rare: Any species not currently threatened with extinction; however, in such small numbers that it may become endangered.

Department of Food and Agriculture designations:
- CDNPA Plants that are protected by the California Desert Native Plants At

BLM designations:
The California State Director has also conferred sensitive status on California State Endangered, Threatened, and Rare species, or species on List 1B (plants rare and endangered in California and elsewhere) of the CNPS' Inventory of Rare and Endangered Plants of California

California Rare Plant Ranks (formerly CNPS Lists)
- 1B Plants rare, threatened or endangered in California and elsewhere.
- 2 Plants rare, threatened or endangered in California, more common elsewhere.
- 3 Plants for which more information is needed – a review list.
- 4 Plants of limited distribution – a watch list.

California Rare Plant Ranks
- .1 Seriously endangered in California.
- .2 Fairly endangered in California.
- .3 Not very endangered in California.

[2] **Potential to occur definitions:**

- Present: Species observed on the site.
- Likely: Species not observed on the site, however reasonably certain to occur on the site.
- Possible: Species not observed on the site, however conditions suitable for occurrence.
- Unlikely: Species not observed on the site, conditions marginal for occurrence.

A separate target list derived from the ethnobotanically significant plants from the Colorado River Culture Ethnobotany document (Appendix PLA in the EIR) is presented in Table 2.

As with special-status plants, if an ethnobotanically significant plant distribution, habitat, or elevation range precluded its possible occurrence in the Project Area or vicinity, it was not considered further. A species was determined to have potential to occur within the Project Area if its known or expected geographic range included the Project Area or vicinity, and if its known or expected habitat was found within or adjacent to the Project Area during the August 2011 botanical survey.

Each species in this list was cross checked against special-status plant species listed in the CNPS CRPR Inventory, the CNDDB RareFind3 database, the list of protected desert plants in the CDNPA, the Arizona rare plant field guide (Arizona Rare Plant Committee 2001), the BLM special status plant list (BLM 2011), and the Federal list of endangered plants (USFWS 2011), in order to identify ethnobotanically significant plants that are also special-status species. Additionally, each plant species was searched in the Jepson Online Interchange (2011), the database of the Consortium of California Herbaria (CCH 2011), and in the SEI Net to determine its distribution, habitat, and potential to occur in the Project Area.

Of the 49 ethnobotanically significant plants listed in Appendix PLA, 30 occur or have the potential to occur in the Project Area. Ten are known to occur in the Project Area and the occurrence of an additional seven species is likely or possible. Seven plants (highlighted in bold type-face in Table 2) are special-status species and; therefore, also listed in Table 1 (i.e. they are listed in the CDNPA).

Table 2. Target list of ethnobotanically significant plant species with the potential to occur in the Project Area

Common Name	Scientific Name	Status[1] Fed/State/CRPR/ CDNPA	Flowering Period	Habitat	Potential to Occur[2]
TREES					
Blue palo verde	***Parkinsonia florida***	**--/--/--/CDNPA**	**Apr–May**	**Creosote Bush Scrub; washes and floodplains.**	**Present. This tree is the most abundant tree in the Project Area.**
Desert ironwood	***Olneya tesota***	**--/--/--/CDNPA**	**Apr–May**	**Creosote Bush Scrub; desert washes.**	**Unlikely. Suitable habitat for this tree occurs in the Project Area; however, it was not detected during the Mature Plants Survey in August 2011 and therefore is not anticipated to occur in the Project Area.**
Honey mesquite	***Prosopis glandulosa* var. *torreyana***	**--/--/--/CDNPA**	**Apr–Aug**	**Creosote Bush Scrub and Alkali Sink Scrub; grasslands, alkali flats, washes, sandy alluvial flats, mesas.**	**Present. This medium to large tree is common in the Project Area especially on the flood plain and nearby areas.**
Goodding's willow	*Salix gooddingii*	--/--/--/--	Mar–Apr	Desert Scrub; streamsides, marshes, seepage areas, washes, meadows.	**Present.** Uncommon large tree in the Project Area, section B.
Mojave yucca	***Yucca schidigera***	**--/--/--/CDNPA**	**Apr–May**	**Creosote Bush Scrub**	**Possible. Shrub or tree-like, occurrence known from 10 miles south of Needles.**
Screwbean mesquite	***Prosopis pubescens***	**--/--/--/CDNPA**	**Apr–Sep**	**Creosote Bush Scrub; creek, river bottoms, sandy or gravelly washes, ravines.**	**Present. This medium to large tree is common under the highway and RR bridges that cross the Colorado River, and on the Arizona side of the river opposite the Topock Marina.**

Velvet mesquite	***Prosopis velutina***	**--/--/--/CDNPA**	**Apr–Jun**	**Mojavean Desert Scrub; sandy, rocky soils in canyons, washes; only naturalized in CA, not native.**	**Unlikely. A single occurrence of this tree is known from the Topock Marsh; however, it was not detected during the Mature Plants Survey in August 2011 and therefore is not anticipated to occur in the Project Area.**
SHRUBS					
American agave	*Agave americana*	--/--/--/--	Jun–Aug	Original habitat unknown; grows wild in Mexico on cultivated lands and pine woodlands.	**Unlikely**. Leaf succulent shrub, long cultivated by indigenous tribes, commonly occurs on agricultural lands. Not native to California or Arizona.
Cattle saltbush	*Atriplex polycarpa*	--/--/--/--	Jul–Oct	Creosote Bush Scrub, Shadscale Scrub, Sagebrush Scrub, and Alkali Sink Scrub; dry lakes.	**Present**. Locally common in flood plain of Colorado River, sections A and J of the Project Area.
Desert tobacco	*Nicotiana obtusifolia* var. *obtusifolia*	--/--/--/--	Mar–Jun	Creosote Bush Scrub and Joshua Tree Woodland; gravelly or rocky washes, slopes	**Present.** Known to occur in Sections I and L of the Project Area.
Jojoba	*Simmondsia chinensis*	--/--/--/--	Mar–May	Creosote Bush Scrub, Joshua Tree Woodland, Chaparral.	**Unlikely**. Suitable habitat; however, no occurrences within 75 miles of the Project Area.
Iodine bush	*Allenrolfea occidentalis*	--/--/--/--	Jun–Aug	Alkali Sink Scrub; saline soils, flats, bluffs.	**Possible**. Suitable habitat; however, not known from Project Area, known from Earp 40 miles south of Topock.
Mule's fat	*Baccharis salicifolia*	--/--/--/--	All year	Coastal Sage Scrub, Foothill Woodland, Valley Grassland; moist streamsides, canyon bottoms, irrigation ditches.	**Likely.** Occurrence known from Topock Marsh.

Spiny chloracantha	*Chloracantha spinosa*	--/--/--/--	Jun–Dec	Creosote Bush Scrub and Alkali Sink Scrub; seeps, moist streamsides, ditches, sometimes saline or drier areas.	**Possible.** Habitat suitable**,** could occur in Topock marsh
Staghorn (or bukhorn) cholla	***Opuntia echinocarpa* (or *Cylindropuntia acanthocarpa* var. *coloradensi*)**	**--/--/--/CDNPA**	**May–Jun**	**Creosote Bush Scrub; gravelly or rocky places.**	**Present. This succulent shrub is scattered throughout the upland portion of the Project Area.**
HERBACEOUS PLANTS					
Awned cupgrass	*Eriochloa aristata*	--/--/--/--	Jun–Nov	Wetlands; seasonal streams, riverbanks.	**Unlikely**. Annual grass, suitable habitat; however, no known occurrence within 100 miles of the Project Area.
Broadleaf arrowhead	*Sagittaria latifolia*	--/--/--/--	Jul–Aug	Freshwater Wetlands; ponds, slow streams, ditches.	**Unlikely.** Perennial herb; however, no occurrences known for Western Riverside or San Bernardino Counties.
Broadleaf cattail	*Typha latifolia*	--/--/--/--	Jun–Jul	Freshwater Wetlands and Marshes.	**Present.** Perennial herb, known to occur in sections A, C, E, and I of the Project Area.
Careless weed	*Amaranthus palmeri*	--/--/--/--	Aug–Nov	Creosote Bush Scrub; roadside ditches, fields, arroyos.	**Unlikely.** Short-lived perennial; however, no known occurrences within 90 miles of the Project Area.
Chia	*Salvia columbariae*	--/--/--/--	Mar–Jun	Creosote Bush Scrub Chaparral, Coastal Sage Scrub; dry, disturbed sites.	**Present.** Annual herb that is common in the Project Area in washes and lower slopes; for example, Bat Cave Wash.
Common sunflower	*Helianthus annuus*	--/--/--/--	Jul–Oct	Disturbed areas in Shrublands and many habitats.	**Possible**. Annual herb, known occurrences from Parker Dam Road 18 miles south of the Project Area.

Datura (or Jimson) weed	*Datura wrightii*	--/--/--/--	Apr–Oct	Creosote Bush Scrub, Coastal Sage Scrub, Valley Grassland, Joshua Tree Woodland, Pinyon-Juniper Woodland; sandy or gravelly open areas.	**Likely.** Annual weed, suitable habitat present, known occurrence 13.3 miles northwest of Needles.
Desert lily	*Hesperocallis undulata*	--/--/--/--	Mar–May	Desert Shrublands; sandy flats and washes.	**Present.** Bulbous perennial, known to occur in sandy areas in the Project Area.
Field pumpkin	*Cucurbita pepo*	--/--/--/--	June–Aug	Cultivated lands.	**Unlikely**. Annual herb, known only from cultivated lands; however, no known occurrences in the Project Area.
Fragrant flatsedge	*Cyperus odoratus*	--/--/--/--	Jul–Oct	Wetlands; disturbed soils.	**Possible**. Annual sedge, occurrence known from Needles.
Indian woodoats	*Chasmanthium latifolium*	--/--/--/--	Jun–Aug	Woodlands; moist, fertile soils along creek and river banks.	**Unlikely**. Perennial grass, no known occurrences in California or Mojave County, Arizona.
Mexican lovegrass	*Eragrostis mexicana* ssp. *mexicana*	--/--/--/--	Jul–Oct	Disturbed Areas; generally open sites.	**Unlikely**. Annual grass, suitable habitat present; however, no known occurrences from near Topock.
Mexican panicgrass	*Panicum hirticaule*	--/--/--/--	Jul–Oct	Creosote Bush Scrub; sandy soils, open sites.	**Unlikely**. Annual grass, suitable habitat present; however, no known occurrences near Topock.
Purple ammannia	*Ammannia coccinea*	--/--/--/--	Jun–Aug	Many plant communities; wet places, drying ponds, lake and creek margins.	**Unlikely**. Annual weed; however, no occurrences known within 100 miles of the Project Area.
Sauwi	*Panicum sonorum* (syn. *hirticaule*) ssp. *hirticaule*	--/--/--/--	Jun–Aug	Domesticated, river flood plains.	**Unlikely**. Annual grass, cultivar of *P. hirticaule*; however, no known occurrences near the Project Area.

[1, 2] **See below Table 1 for Sources, Conservation status abbreviations, and Occurrence potential definitions.**

Field Surveys

Transect-based protocol-level Floristic surveys that conform to the guidelines of the California Department of Fish and Game (CDFG 2009), the USFWS (2000), and the CNPS (2001) will commence in November 2011 and continue at the end of March or beginning of April 2012. Other seasonal surveys may occur depending on weather patterns. Note that the November 2011 will be conducted because late-summer rainfall was sufficient to trigger germination and flowering of late-blooming species (J. Andre, personal communication). This late-season 2011 survey will be targeted to areas that exhibit germination and flowering. The appropriate survey areas will be decided, in consultation with Dr. Andre, after an initial reconnaissance at the beginning of the late-season survey. The goal of the floristic surveys is to generate a comprehensive and complete list of all plant species that occur in the survey area and to census, map, photograph, and record habitat data for special-status species listed in Table 1 and ethnobotanically significant species listed in Table 2. Some of these plants are widespread across the Project Area, and in these cases specific location information may not be collected for each plant. It is possible that a special-status plant not known to occur in the Project area or vicinity; and therefore not on the target list, is detected during the Floristic survey, especially given the relatively few survey records in the Needles and Topock area. The surveys will be floristic and comprehensive in nature, meaning that all plants found in identifiable condition will be identified, with the aid of a field guide with plant identification key, to the level necessary to determine their sensitivity (i.e. special-status or ethnobotanically significant).[2]

Trimble GeoXT or GeoXH global positioning systems (GPS) with sub-meter accuracy will be used to collect data on sensitive plant species. The GPS units will be equipped with data files for navigation and with data dictionaries for data collection. Transect lines, spaced at 50 feet, will be programmed into the GPS units and walked by surveyors. Surveyors will walk meandering routes along each transect to ensure coverage of the entire Project Area, unless vegetation density precludes surveyors from accessing certain areas (i.e. dense tamarisk/mesquite forest patches in the flood plain or saturated wetlands). To ensure that inaccessible areas are surveyed to the extent feasible, surveyors will identify species by making observations from the vegetation patch margins or vantage points, and through the use of the high resolution aerial photographs. In such areas, it is unlikely that understory vegetation would be present due to lack of sunlight and high soil salinity. Data dictionaries will be used to record locality information, the actual or estimated number of individuals observed, and habitat information. Point data collected in the field will be later digitized using Geographic Information System software to create map polygons that depict the total extent of each sensitive plant occurrence, where practicable.

A list of all plant species observed will be compiled for the Project Area during the surveys (see preliminary list in Appendix A). Nomenclature for scientific names will follow *The Jepson Online Interchange* (http://ucjeps.berkeley.edu/interchange.html) or Hickman (1993), except where noted. Representative habitat photographs will be taken as will photos of the sensitive plant species observed in the Project Area.

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[2] The primary field guide will be the Jepson Manual: Higher Plants of California (Hickman 1993)

The ability of surveyors to detect and identify plants efficiently and accurately in the field will be enhanced by a field review of the common plant species at the Project Area prior to beginning the surveys. Surveyors will also be provided with a photo guide of several targeted sensitive plants that are less familiar to the Senior Botanist (examples are in Appendix B) and preliminary species lists compiled prior to the Floristic surveys. These materials will supplement the field guide with plant identification key, which will be the primary resource used to identify plants. The services of Dr. Andre, expert on the East Mojave/Sonoran Desert flora, will be consulted regarding the target plant list, timing, and level of intensity of the seasonal (e.g. fall and spring) surveys and overall survey methodology.

Reference Site Visits

Before the Floristic surveys begin, searches of nearby reference populations will be made for spiny-hair blazing star (*Mentzelia tricuspis*), glandular ditaxis, Crucifixion thorn (*Castela emoryi*), Utah cynanchum *(Cynanchum utahense)*, Cooper's rush (*Juncus cooperi*), and Hall's tetracoccus (*Tetracoccus hallii*) based on locality data in the database of the Consortium of California Herbaria (CCH). These represent the special-status species that are closest to the Project Area and are most likely to occur there.

Deliverables

The primary deliverables resulting from the Floristic survey will be a detailed map that depicts the location and distribution of sensitive plants that occur within the Project Area (point or polygon data may not be included if species is widespread) and a master plant list that includes all plant species that occur in the Project Area. Sensitive plant location information data will also be presented in a tabular/list form that will enable any user to find the locations of sensitive plants that occur in the Project Area. A report summarizing the survey effort, including the methodology described herein, will also be prepared. The target completion date of these deliverables is June 1, 2012.

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LEGEND

Survey Segments

N

0 500 1,000 2,000 Feet

FIGURE 1
EIR PROJECT AREA WITH VEGETATION SURVEY SEGMENTS

PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

D:\Projects\Topock\MapFiles\2011\CMS\BioSurveySegements

Appendix A
Vascular Plant Species Observed

GYMNOSPERMS			**Survey Segment Location**
	EPHEDRACEAE	**ephedra family**	
	Ephedra sp.	joint fir	I
DICOTS			
	AIZOACEAE	**ice plant family**	
	Trianthema portulacastrum	horse-purslane	G
	AMARANTHACEAE	**amaranth family**	
	Tidestromia oblongifolia	honeysweet	A, G, K
	APIACEAE	**carrot family**	
	Hydrocotyle verticillata	marsh pennywort	A
	ASCLEPIADACEAE	**milkweed family**	
	Asclepias subulata	rush milkweed	H, C
	Sarcostemma cynanchoides ssp. *hartwegii*	climbing milkweed	A, C, D
	ASTERACEAE	**sunflower family**	
	Ambrosia dumosa	bursage	A, B, C, E
	Baccharis sarathroides	broom bacharis	B, E
	Bebbia juncea	sweetbush	D, H
	Encelia farinosa	brittlebush	B, C, E
	Hymenoclea salsola	cheesebush	B, I
	Palafoxia arida	Spanish needle	B, E, F
	Pectis papposa var. *papposa*	chinch-weed	G
	Peucephyllum schottii	pygmy-cedar	H, I
	Pluchea odorata	marsh fleabane	B
	Pluchea sericea	arrow weed	A, B, E, F, J, I
	Pulicaria paludosa	Spanish false-fleabane	B
	Sonchus asper	prickly sow-thistle	I
	Stephanomeria pauciflora	skeletonweed	I
	BORAGINACEAE	**borage family**	
	Amsinckia tessellata	devil's lettuce	C, D
	Tiquilia plicata	fanleaf crinklemat	B, E, F, B, J

		Survey Segment Location
BRASSICACEAE	**mustard family**	
Brassica tournefortii	African mustard	C, D
Guillenia lasiophylla	California mustard	
Lepidium lasiocarpum	pepperweed	C
CACTACEAE	**cactus family**	
Cylindropuntia acanthocarpa	buckhorn cholla	I
Cylindropuntia echinocarpa	silver cholla	A, C, D, H
Cylindropuntia ramosissima	pencil cholla	D
Ferocactus cylindraceus var cylindraceus	California barrel cactus	I
Opuntia basilaris var basilaris	beavertail	C, D, H
Mammillaria tetrancistra	foxtail cactus	C, D
CHENOPODIACEAE	**goosefoot family**	
Atriplex confertifolia	shadscale	A, J
Atriplex fruticulosa	ball saltbush	A
Atriplex polycarpa	cattle saltbush	A, B, C, J, G
Salsola tragus	Russian thistle	B, E, F
Suaeda moquinii	bush seepweed	A
CUCURBITACEAE	**gourd family**	
Cucurbita palmata	coyote gourd	G
EUPHORBIACEAE	**spurge family**	
Chamaesyce micromera	desert spurge	H, D, C, E, B, A
FABACEAE	**legume family**	
Acacia greggii	catclaw acacia	A, C, C, H, I
Parkinsonia florida	blue palo verde	A, C, D, E, G, H, I, J
Prosopis glandulosa var. *torreyana*	honey mesquite	A, E
Prosopis pubescens	screwbean mesquite	E, F
Psorothamnus spinosus	smoketree	A, D
FOUQUIERIACEAE	**ocotillo family**	
Fouquieria splendens ssp splendens	ocotillo	E
GENTIANACEAE		
Eustoma exaltatum	catchfly gentian	B
GERANIACEAE	**geranium family**	
Erodium cicutarium	redstem filaree	C, D, I

		Survey Segment Location
KRAMERIACEAE	**rhatany family**	
Krameria grayi	white ratany	I, H
LAMIACEAE	**mint family**	
Hyptis emoryi	desert-lavender	A, H
Salvia columbariae	chia	H
MALVACEAE	**mallow family**	
Sphaeralcea ambigua var. *ambigua*	apricot mallow	L
Myrtaceae	**myrtle family**	
Eucalyptus sp.	eucalyptus	A, B
NYCTAGINACEAE	**four-o-clock family**	
Boerhavia coccinea	spiderling	B
PLANTAGINACEAE	**plantain family**	
Plantago ovata	desert indianwheat	C, D, H, I
POLYGONACEAE	**buckwheat family**	
Chorizanthe rigida	spiney rigid herb	K, H
Eriogonum deflexum var deflexum	flatcrown buckwheat	H
Eriogonum inflatum var inflatum	desert trumpet	H
Eriogonum palmerianum	Palmer's buckwheat	H
Eriogonum trichopes	little desert buckwheat	H
SALICACEAE	**willow family**	
Salix exigua	sand-bar willow	E
Salix goodingii	Goodding's willow	B
Populus fremontii	Fremont cottonwood	B
SOLANACEAE	**nightshade family**	
Nicotiana obtusifolia	desert tobacco	I
Nicotiana quadrivalvis	indian tobacco I	
Physalis crassifolia	thick-leaf ground cherry	L
TAMARICACEAE	**tamarisk family**	
Tamarix ramosissima	salt cedar	A, B, C, C, E, F, G, I, J
Tamarix aphylla	athel	B, G,
VISCACEAE	**mistletoe family**	
Phoradendron californicum	desert mistletoe	A, B, E

				Survey Segment Location
	ZYGOPHYLLACEAE		**caltrop family**	
	Larrea tridentata		creosote bush	A-- L
	Kallstroemia californica		California kallstroemia	G
MONOCOTS				
	ARECACEAE		**palm family**	
	Washingtonia filifera		California fan palm	B
	CYPERACEAE		**sedge family**	
	Eleocharis thermalis		beakrush	A, B, E
	Schoenoplectus californicus		common reed	A, I
	JUNCACEAE		**rush family**	
	Juncus xiphioides		iris-leaved rush	A
	POACEAE		**grass family**	
	Arundo donax		giant reed	A, E, I, J
	Bromus madritensis ssp rubens		red brome	C, D
	Cynodon dactylon		Bermuda grass	G
	Distichlis spicata		saltgrass	E
	Paspalum dilatatum		dallis grass	E, B
	Pennisetum villosum		feathertop	A, I
	Phragmites australis		common reed	A, I
	Schismus arabicus		Arabian schismus	C, D
	Setaria gracilis		knotroot bristlegrass	B
	Triticum aestivum		wheat	G
	Vulpia myuros		foxtail fescue	C, D
	Vulpia octoflora		six weeks fescue	C, D
	TYPHACEAE		**cattail family**	
	Typha latifolia		broad-leaved cattail	A, G, I, J

Appendix B
CNPS List 2 species likely to occur at Topock

Mentzelia tricuspis CNPS 2B.1


©2005 James M. Andre © 2010 Neal Kramer

Ditaxis claryana CNPS 2B.2

Castela emoryi CNPS 2.3

Manzanita Project, © California Academy of Sciences

Pacific Gas and Electric Company®

Prepared for Pacific Gas and Electric Company

Prepared by CH2M HILL

Technical Memorandum

Date:	November 18, 2011
To:	Curt Russell, PG&E
From:	Barry Collom and Robert Hernandez
cc:	Christina Hong, Jay Piper
Re:	Topock Compressor Station Groundwater Remediation Project, Ordinary High Water Mark (OHWM) Identification/Mapping Methodology

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Introduction

The purpose of this technical memorandum (memo) is to describe the methodology used for identifying, surveying, and documenting the Ordinary High Water Mark (OHWM) in the PG&E Topock Compressor Station Groundwater Remediation Project (project) area. The identification of the OHWM (marking the United States Army Corps of Engineers (USACE) Jurisdictional limits of the California side of the Colorado River) was conducted to comply with the January 2011 Final Environmental Impact Report (EIR) (AECOM 2011) requirements as set forth in Mitigation Measure AES-2a. This Mitigation Measure is from the Aesthetics (AES) portion of the mitigation plan presented in the EIR and is intended to ensure the protection of views from specific vantage points, as discussed in greater detail below.

During the October 19, 2011 Consultative Work Group (CWG) meeting, the Fort Mojave Indian Tribe requested a written copy of the methodology used when performing the identification/ mapping required by the EIR. This technical memo was prepared in response to this request and to document the OHWM identification/mapping effort.

At the request of PG&E, CH2M HILL conducted a field survey to delineate the OHWM along the riverbank in March 2011. The survey included:

- Reviewing available aerial photography and photographs of the area;
- Examining the bank of the Colorado River by foot and by boat to identify the OHWM based on available indicators including vegetation, soil, and hydrology;
- Collecting data points with a Global Positioning System (GPS) device;
- Taking photographs at locations accessible from land; and

- Generating a map showing the OHWM.

The OHWM identification map is provided on Figure 1 and a series of photographs collected of the survey area documenting the OHWM identification is provided in Attachment 1. Figure 1 shows the individual GPS data points collected to define the OHWM and the locations where the photographs were taken. The photographs in Attachment 1 show the identified high water marks at each photographed location.

Survey Area Description

The survey area included the California side of the Colorado River bank, between the mouth of Bat Cave Wash and the BNSF railroad bridge (Figure 1) located within the Project Area. The survey area is located in San Bernardino County, California. The land along the Colorado River where the survey took place is managed by the Bureau of Land Management (BLM).

Methodology

Field Survey Preparation

Pursuant to Mitigation Measure AES-2a,

> *"A minimum setback requirement of 20 feet from the water (ordinary high water mark) shall be enforced, except with regard to any required river intake facilities, to prevent substantial vegetation removal along the riverbank."*

The requirement for the 20-foot setback from the OHWM is relevant to the aesthetic value of the Project Area from Key View 11. A "Key View", according to the EIR, is a vantage point offering a view of some or all of the Project Area from one of eleven specified points. Each Key View vantage point is located and described in Section 4, volume II, of the EIR. Key View 11 is from the Colorado River and looks southwest toward the floodplain, IM-3 Facility, and compressor station (see below).

Key View 11—View west toward the floodplain, IM-3, and compressor station.
(Photograph taken by AECOM in 2009)

The extent of waters of the United States (USACE jurisdictional limits) is generally identified as the limits of the OHWM of a stream or drainage as extended by any adjacent wetlands. To identify the OHWM for the purpose of determining the 20-foot setback requirements, CH2M

HILL reviewed and followed guidelines outlined in both the *Corps of Engineers Wetlands Delineation Manual* (USACE 1987) and *A Field Guide to the Identification of the Ordinary High Water Mark (OHWM) in the Arid West Region of the Western United States* (USACE 2008). As their names imply, the 1987 USACE document focuses primarily on the delineation of USACE jurisdictional wetlands, and the 2008 USACE document is a guide to delineating OHWMs typically associated with ephemeral/intermittent channel forms that dominate the Arid West landscape (where OHWM delineations can be quite complex). It is important to note that for the most part, the Colorado River in the area of Key View 11 has very definitive incised-cut banks (described in more detail below and on the photographs in Attachment 1), making the OHWM identification relatively straight forward. Aerial photos and photographs of the survey area were used during the field survey and for conducting a preliminary OHWM identification prior to the field survey.

Field Survey

The field survey was conducted in March 2011. The protocol for the survey was developed by Robert Hernandez (CH2M HILL) and the field surveyor was Barry Collom (CH2M HILL). The OHWM identification process (as specified in the USACE guidance documents) involves the visual identification of features associated with high water. Typical items that are checked along a stream or river bank include vegetation and soil types, erosion features, drainage patterns, presence of drift lines (e.g., debris or branches), sediment deposition, watermarks, cut banks, scour lines, etc. (Part IV, Section D, USACE 1987; Section 2.1, USACE 2008) The established protocols were in conformance with the appropriate guidelines (USACE 1987, 2008) and included a preliminary identification based on aerial photo followed by a field investigation using typical OHWM indicators to identify the OHWM. The field work was then re-verified using the aerial photograph.

Significant flexibility is incorporated into the guidance documents because of the variety of different information sources and methods of investigation that may prove helpful to a given OHWM identification. As specified in the guidance, the surveyor is not required to obtain information from all identified sources and indicators (USACE, 1987). Varying degrees of investigations are considered acceptable depending on the complexity of the identification and the quantity and quality of available information.

In dry-land fluvial systems typical of the Arid West (where the Project Area is located), a clear natural scour line impressed on the bank, recent bank erosion, destruction of native terrestrial vegetation, and the presence of litter and debris are the most commonly used physical characteristics to indicate the OHWM (Section 2.1 USACE 2008). Table 5 of the USACE 2008 document summarizes potential common geomorphic OHWM indicators below, at, and above ordinary high water. Several of the indicators from Table 5 in the USACE 2008 document noted in the field survey of the Project Area include: break in bank slope, upper limit of sand sized particles, change in particle size distribution, litter (organic debris, small twigs and leaves), and drift (organic debris, larger than twigs). These were the primary indicators used in the identification of the OHWM. Several of these indicators are visible on the photographs included in Attachment 1.

With two exceptions, most of the survey area has thick vegetative cover that made approach on land impossible. In those areas, the surveyor was able to access land by nosing a boat close enough to shore that he could get out on foot. The two exceptions are the area near the mouth of Bat Cave Wash to the north and the area near MW-27 to the south of the survey area (see Figure 1). Those two areas were accessed from land. The OHWM was identified and tracked during the survey using GPS data collected with a Trimble Geo-XT with sub-meter accuracy. Figure 1 shows the identification of the OHWM based on the aerial photography review and the field survey.

Deliverables

The primary deliverables resulting from the OHWM survey is the OHWM Map (Figure 1) that depicts the location of the OHWM identified and photographs taken of the field survey area (Attachment 1). The locations where the photographs were taken are shown on Figure 1.

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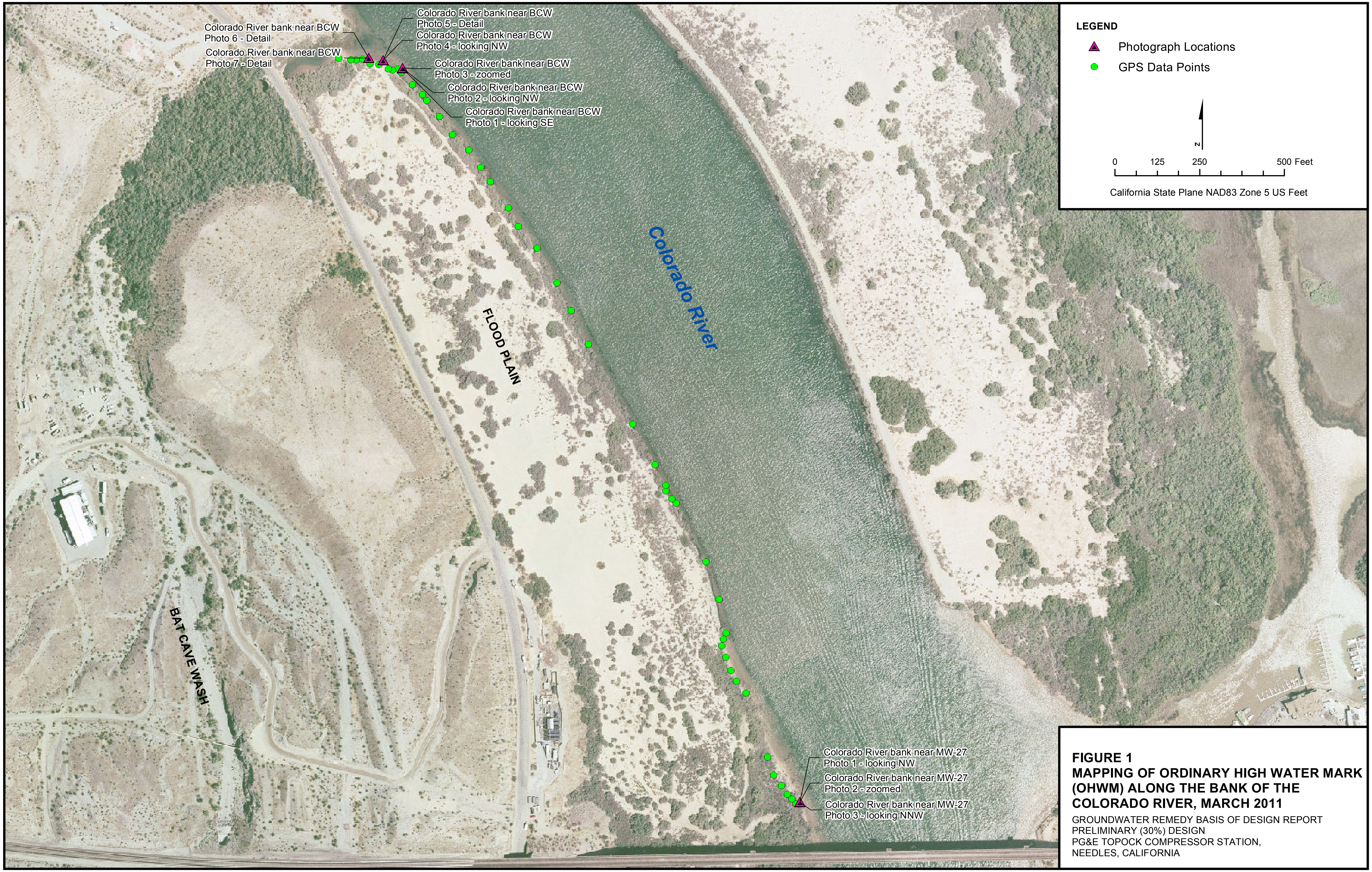
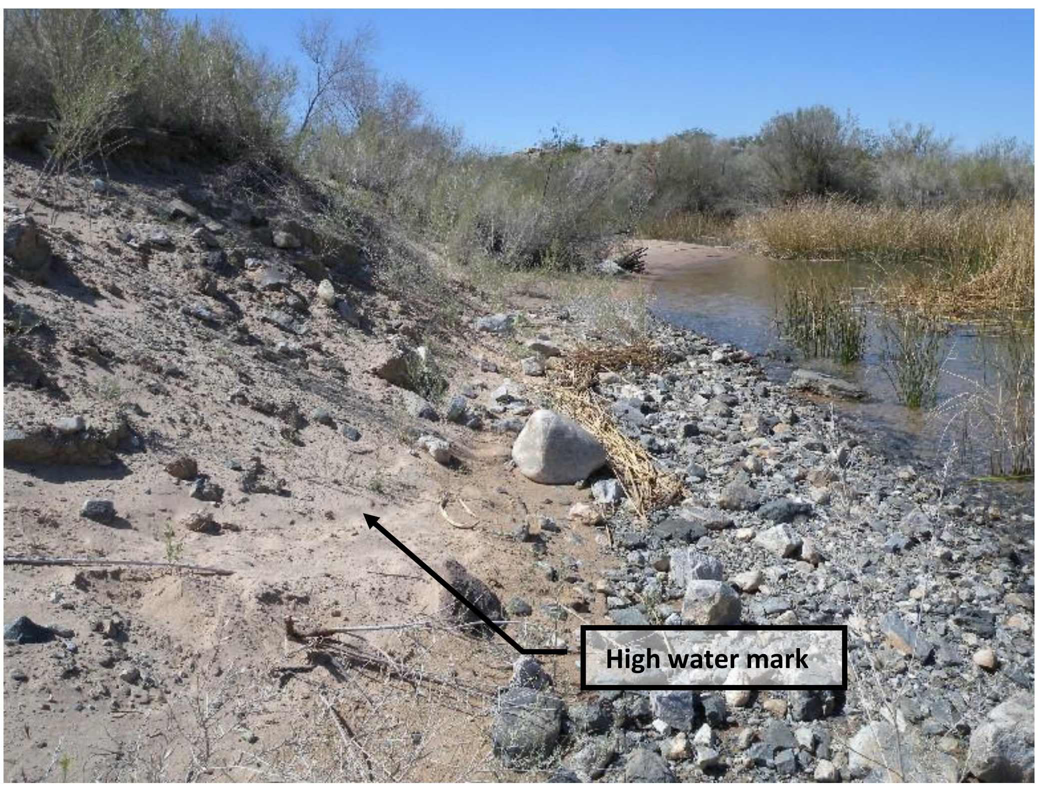


FIGURE 1
MAPPING OF ORDINARY HIGH WATER MARK (OHWM) ALONG THE BANK OF THE COLORADO RIVER, MARCH 2011

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
PRELIMINARY (30%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

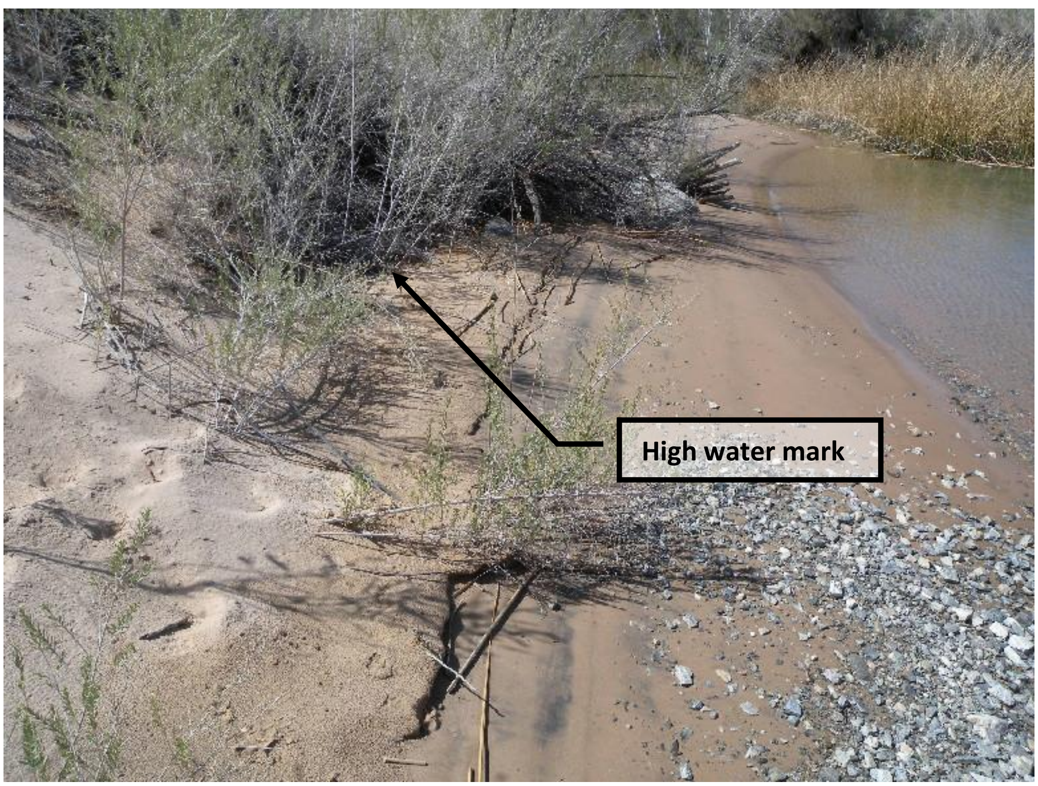
D:\Projects\Topock\MapFiles\2011\CMS\HighwaterLine_Photo

Colorado River Bank near BCW. Photo 1 (looking SE)

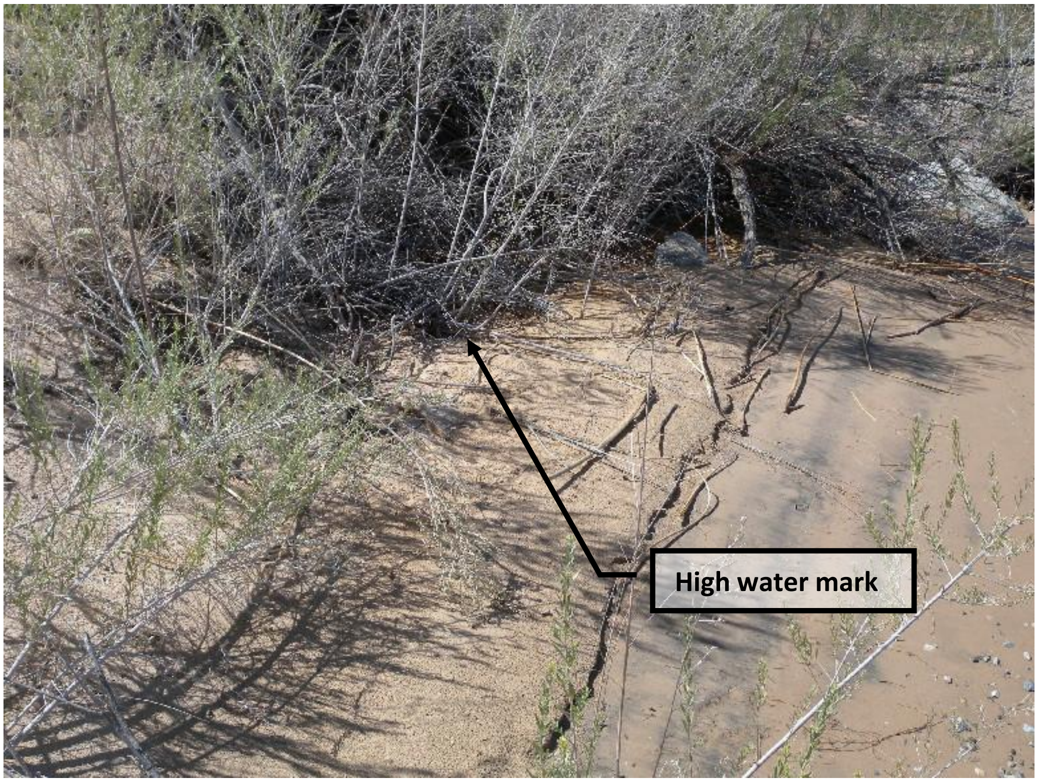


Colorado River Bank near BCW. Photo 2 (looking NW)

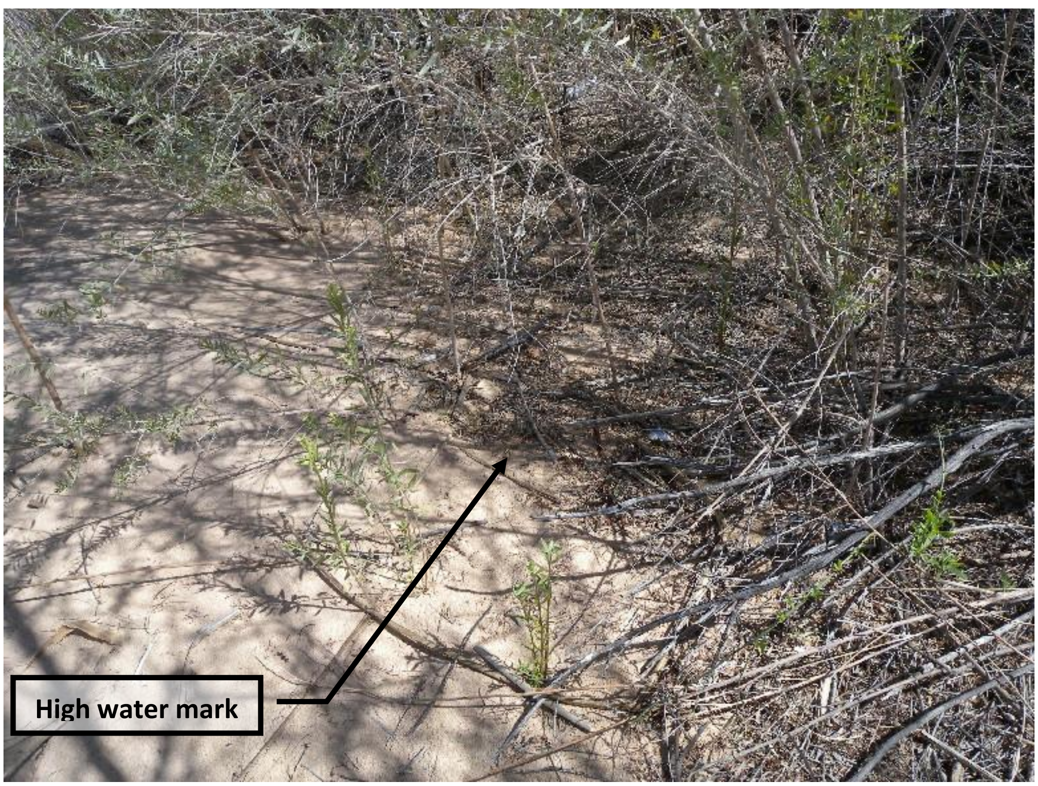
Colorado River Bank near BCW. Photo 3 (zoomed)



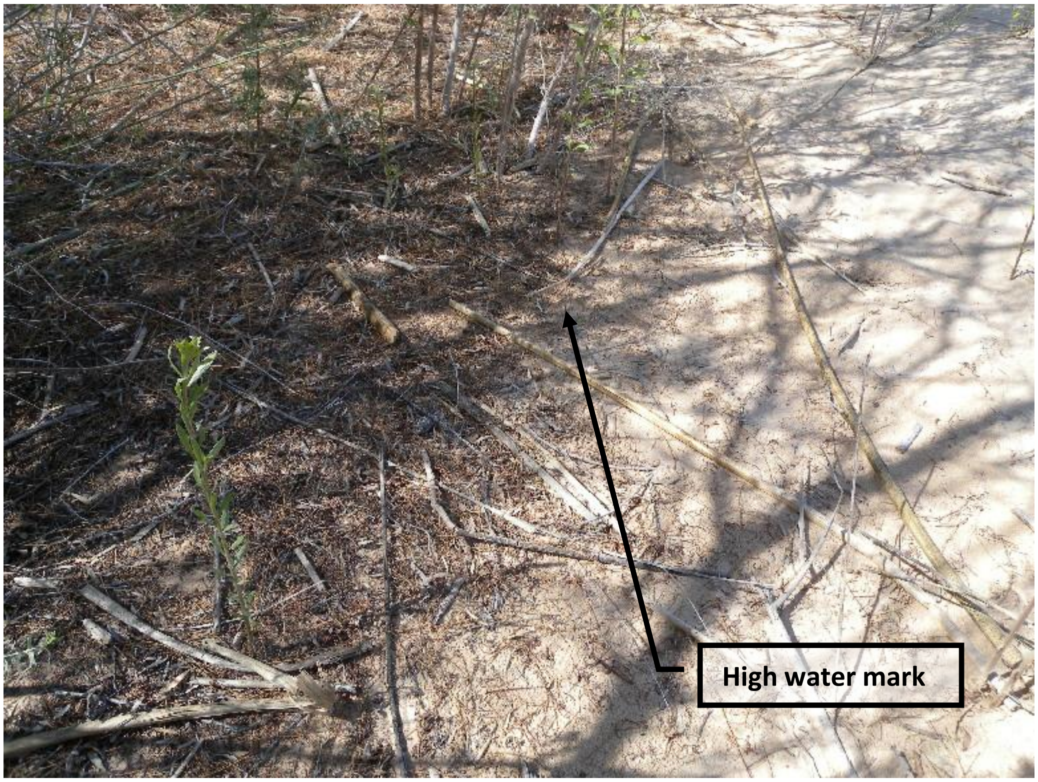
Colorado River Bank near BCW. Photo 4 (looking NW)



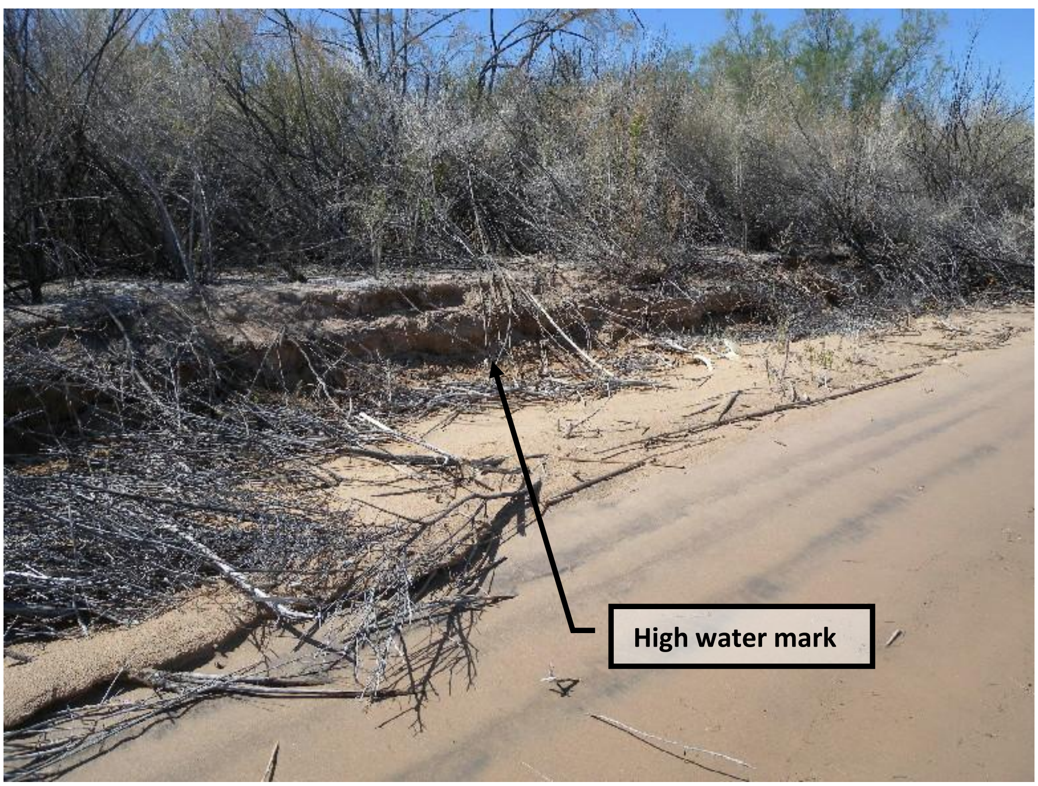
Colorado River Bank near BCW. Photo 5 (detail)



Colorado River Bank near BCW. Photo 6 (detail)



Colorado River Bank near BCW. Photo 7 (detail)



Colorado River Bank near MW-27. Photo 1 (looking NW)

Colorado River Bank near MW-27. Photo 2 (zoomed)

Colorado River Bank near MW-27. Photo 3 (looking NNW)

Appendix C
Design Criteria

APPENDIX C

Design Criteria

In conformance with requirements from the 1996 Corrective Action Consent Agreement (CACA) (California Department of Toxic Substances Control 1996) and the 2009 CERCLA Model Remedial Action/Remedial Design (RD/RA) Model Consent Decree (U.S. Environmental Protection Agency 2009), this appendix describes the design criteria for the groundwater remedy at the Topock Compressor Station (TCS). The design criteria are the technical parameters upon which the design is based, and are based on the translation of the identified applicable or relevant and appropriate requirements (ARARs) and the Environmental Impact Report (EIR; AECOM 2011) mitigation measures (where applicable), into site-specific engineering parameters.

The design criteria are grouped into engineering disciplines (Civil, Structural, Geotechnical, Mechanical, Electrical, Instrumentation and Control, and Architectural). In addition, this appendix describes PG&E Personnel Requirements and design criteria for Health and Safety, Noise, and Construction Requirements.

A detailed description of in situ remediation design basis including carbon substrate selection and discussion of chemical reactions is included as Attachment A at the end of this Appendix.

Calculations are provided in PDF format on a CD-ROM in Attachment B in the following order:

- Remedy-produced water filter feed pump sizing
- Remedy-produced water caustic usage
- Freshwater injection/remedy-produced water collection/conditioned remedy water distribution and disposal hydraulic network modeling calculations from EPANET software[1]
- Hydraulic calculations for National Trails Highway In-situ Remediation Zone (NTH IRZ), Inner Recirculation Loop, and TCS Recirculation Loop wells

C.1 Civil

C.1.1 Earthwork

This section describes the design criteria for the movement of soil and rock into forms and structures needed for the project. In conformance with the EIR mitigation measures and the Programmatic Agreement (U.S. Bureau of Land Management 2010), all project earthwork will be completed in accordance with cultural requirements including such things as archaeological monitoring and pre-construction surveys.

- Grading, Paving and Access Roads

  Cut and fill grading will take place at the Compressor Station to install the new facilities. Access roads may be required. Access roads will be designed to the following standards (barring terrain or cultural, biological or natural resource constraints):

  - Maximum grade ≤ 10%
  - One way traffic width = 14 feet
  - Two way traffic width = 20 feet
  - Cut slopes ≤ 1.5:1
  - Fill slopes ≤ 2:1 (H:V)
  - Out slope road (1/4 inch per foot) so that drainage flows perpendicular to road centerline
  - Roadside ditches (V shaped or trapezoidal) with a minimum top width of 2 feet

[1] Developed by the U.S. Environmental Protection Agency for hydraulic network modeling and drinking water quality analysis. For details, see http://www.epa.gov/nrmrl/wswrd/dw/epanet.html

Pavement replacement will be in accordance with the California Department of Transportation's (Caltrans') *Flexible Pavement Structural Section Design Guide for California Cities and Counties* (latest edition).

- Utility trenches will be excavated to a minimum 3 feet deep and 3 feet wide. Utility trenches may include pipes (freshwater, extracted groundwater, carbon-amended water, remedy-produced water, clean in place (CIP), or spare pipes), as well as electrical and instrumentation conduits. Trench cutoff walls with drain systems may be installed at locations where pipe slopes exceed 8%-10% for long runs (300 to 500 feet) to help divert any potential water flow that may undermine the trench section. These will be added in the intermediate design submittal if needed. In areas where utility crossings exist there will be a minimum of 2 feet separation between utilities unless mandated by the utility owner. GPS-based locations of utilities will be recorded as part of the as-built submittals as well as size, material, and horizontal and vertical separation distance from utilities. Construction GPS mapping and surveys of other pipelines will be required as appropriate.
- Pipe and conduit bedding material will be free of rock(s), rubbish, debris, and other objectionable material, and minimum compaction will be 90% to 95% relative density, per American Society for Testing and Materials (ASTM) D-1557 in areas sensitive to settlement. The minimum pipe bedding thickness will be 6 inches and the minimum pipe/conduit backfill zone thickness will be 3 inches. Bedding will be without voids, placed and consolidated to the proper depth in 8-inch maximum lifts. The backfill will be placed to final grade to conform to the elevation of the adjoining surface elevation. Detailed criteria for backfill and surface restoration will be provided in the intermediate design submittal.
- A survey of aboveground and underground utilities will be conducted within all work areas prior to beginning intrusive site work and construction activities. This survey will include, but will not be limited to, the following activities:
  - Notify Underground Service Alert (USA) or "Dig Alert"
  - Geophysical survey to identify underground features
  - Hand-digging and potholing prior to intrusive site work and construction activities and as determined necessary. Non-mechanical excavating methods within TCS are mandatory and requirements will be described in more detail in the intermediate design submittal.
- Trenchless construction will be used underneath existing infrastructure such as the I-40 highway and Burlington Northern Santa Fe (BNSF) railway bridges. In such locations, these will be installed using trenchless methods such as auger boring or horizontal directional drilling. The methods will be designed such that they comply with relevant guidelines prepared by Caltrans, the Arizona Department of Transportation (ADOT), and BNSF listed below.
  - Caltrans Encroachment Permits - Guidelines and Specifications for Trenchless Technology Projects, July 2008
  - Caltrans Manual for Encroachment Permits on California State Highways, Seventh Edition, January 2002, Section 518, and Table 5.24 - Permit Code TN
  - ADOT Policy for Accommodating Utilities on Highway Rights-of-Way, December 2009
  - BNSF Utility Accommodation Policy, May 2007

  Pipes and conduit will be installed in steel casings when required by Caltrans, BNSF, or ADOT. Casings will extend beyond the length of the crossing a minimum of 10 feet. The need for cathodic protection will be evaluated on a case-by-case basis using site conditions and utility requirements. All voids between the inside of the casing and the pipes will be completely backfilled by blowing sand or pumping grout (pressure grouting) between the casing and the pipes. Exhibit C-1 lists minimum depth of cover for trenchless crossings. In some cases, concerns for pavement or railroad settlement or potential for drill fluid "frac-out" may require a thicker cover. Geotechnical borings may be required by Caltrans, ADOT, or BNSF (see Section C.3). If drilling fluids are used, continuous monitoring for frac-out conditions will be performed to prevent harm to human health and the environment caused by the release of such fluids.

EXHIBIT C-1
Depth of Cover Design Criteria
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Casing Diameter	Minimum Depth Of Cover
2 -6 inches	4 feet
8-14 inches	6 feet
15-24 inches	10 feet
25-48 inches	15 feet

- Any earthwork near or within streambeds or washes may be subject to requirements specified by different regulations and agencies as listed under mitigation measure BIO-1 (see the Mitigation Monitoring and Reporting Program in the EIR [AECOM 2011]).

C.1.2 Storm Drainage

Stormwater will be managed to protect new structures and facilities built as part of the remedy. This section describes the design criteria associated with stormwater drainage.

Impervious surfaces will be sloped to drain. Culverts will be used to drain roadside ditches and protect stream crossings. Roof drainage from buildings will be collected in gutters and drain towards drainage systems. Stormwater captured within secondary containment will be managed at the remedy-produced water conditioning system.

- Rainfall intensity based on period equal to time of concentration for the basin being considered and 25-year recurrence interval.
- Minimum velocity for culverts is 2.0 feet per second. Maximum velocity for culverts is 10.0 feet per second.

C.1.3 Site Security

Facilities essential to the functioning of the remediation system will have security to protect against unwanted intrusions; security elements will include, but not be limited to, the following:

- Barriers, such as fencing will be chain link type in accordance with Chain Link Wind Load WLG 2445 by the Chain Link Manufacturers Institute
- Intrusion detection system and alarms
- Closed circuit television
- Training programs
- Backup power systems
- Patrols and inspections

C.1.4 Concrete Vaults

Concrete vaults will be installed to house mechanical and electrical equipment. Vaults will be precast concrete sections conforming to PG&E Standard K-35. The vaults will vary in depth depending upon use and location, but to the extent possible they will be designed to be shallow enough that entry would not require a confined space entry procedure. Each vault will be equipped with a steel ladder conforming to California Division of Occupational Safety and Health (Cal/OSHA) and PG&E standards. Well vaults will be designed for an H-20 loading in traffic areas and the lid may be supplied with spring assist lids for safe opening. For non-traffic areas, standard lids will be supplied. All vault lids will be equipped with security locks or other security devices (e.g., embedded locks or 5-point bolts).

C.2 Structural

This section describes design criteria for physical structures made of concrete and steel.

C.2.1 Concrete

Minimum requirements are listed below for structural concrete:

- Strength of poured-in-place concrete will be a minimum of 3,000 pounds per square inch (psi) at 28 days.
- Cement will be clean, fresh, Type II, low alkali, Portland cement conforming to ASTM C150.
- Aggregate will be non-reactive.
- Cement content will be a minimum of 4-1/2 sacks per cubic yard of concrete.
- Slump of concrete will be as low as practicable to produce a dense, well consolidated concrete and not exceed 4” unless otherwise authorized by PG&E Project Engineer.
- Finish of formed surfaces will be smooth and free of fins, honeycomb, and segregation.
- When the surfaces have become sufficiently hardened, they will be kept continually moist for a period of not less than seven days. Curing compound conforming to ASTM C309 may be used in-lieu of wetting surfaces.
- In conformance with the EIR mitigation measures AES-1d and AES-2e, integral color concrete will be used in place of standard gray concrete.

C.2.2 Reinforcing Steel (Minimum Requirements)

Minimum requirements for reinforcing steel are as follows:

- Reinforcing steel will be deformed, grade 60, conforming to ASTM A615, and be free from coating which will reduce the bond.
- Reinforcing steel will be sized in accordance with the ultimate strength method.
- Reinforcing steel splices will be 40 bar diameters.

C.2.3 Dead Loads

Dead loads will consist of gravity loads induced by all structural elements, equipment, piping, and contained liquids. The structural integrity of the I-3 bridge superstructure and substructure to carry the design dead loads will be verified during the design.

C.2.4 Live Loads

Live loads for different structural elements are listed below:

- Roof live loads will be designed for a minimum live load of 20 pounds per square foot (psf).
- Stairs, walkways, and platforms will be designed for a minimum live load of 100 psf.
- Floor loads in equipment rooms, shop areas, and platforms used for equipment removal will conform to the latest addition (2010) of the California Building Code (CBC), but will be a minimum live load of 250 psf.
- Pedestrian live load on the walkway area of the arch (I-3) bridge is 85 psf.

C.2.5 Seismic Loads

The design will meet CBC (2010) and as amended by San Bernardino County and/or American Society of Civil Engineers (ASCE) 7-10 “Minimum Design Loads for Buildings and Other Structures.”

C.2.6 Wind Loads

The design will meet CBC (2010) and as amended by San Bernardino County and/or ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures".

Detailed structural design criteria are shown in Exhibit C-2. The arch bridge design criteria will be provided in the intermediate design submittal.

EXHIBIT C-2
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
General	
Governing Code	Most recent edition of CBC (2010)
Concrete: CODE and SPECIFICATION	ACI 318-99, Building Code Requirements for Reinforced Concrete ACI 301-99, Specifications for Structural Concrete for Buildings ACI 350R-01, Environmental Engineering Concrete Structures
Concrete Masonry Units: SPECIFICATIONS	National Concrete Masonry Association (NCMA) Specifications for the Design and Construction of Load Bearing Concrete Masonry, Publication No. TR75-B
Structural Steel: SPECIFICATIONS	AISC Allowable Stress Design Specification for Structural Steel Buildings, Current Edition
Aluminum: SPECIFICATIONS	Specifications for Aluminum Structures, Published by Aluminum Association, Current Edition
Concrete	
Strength	F'c = 3000 psi and 2000 psi for concrete fill pipe/conduit encasement
Reinforcing	ASTM A615, Grade 60
Prestressing Strand	ASTM A416
Welded Steel Wire Fabric	ASTM A185
Design	Strength Design or Alternate Method
Detailing	ACI SP-66(00) Manual of Standard Practice for Detailing Concrete Structures
Color	Integral color concrete in place of standard gray color concrete (EIR mitigation measures AES-1d and AES-2e)
Reinforced Masonry	
Concrete Masonry Units	ASTM C90, Grade N, Type I (Unit Compressive Strength f'm = 1500 psi
Mortar for Unit Masonry	ASTM C270, Type M or S
Reinforcing	ASTM A615, Grade 60
Cold-Drawn Steel Wire	ASTM A82
Mortar and Grout	ASTM C476
Structural Steel	
Structural "W" Shapes	ASTM A992
Structural channels. plates, angles, etc.	ASTM A36
Structural Tubing	ASTM A500
Steel Pipes	ASTM A53, Grade B
Welding	AWS E70 Electrodes
High Strength Bolts	ASTM A325F, Min 3/4" Diameter

EXHIBIT C-2
Structural Design Criteria
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Category	Criteria
Other Bolts	ASTM A307, Grade A
Anchor Bolts	ASTM A36
Timber	
TBD	Latest version of the CBC
TBD	National Design Specification for Wood Construction

C.3 Geotechnical

The geotechnical design criteria presented in Exhibit C-3 are based on existing site-specific geologic information and geotechnical data, to support foundation and trenching designs, as well as trenchless crossings (I-40 and BNSF crossings). To date, two geotechnical investigations have been conducted by PG&E at the site:

- A geotechnical investigation study was conducted in 2004 (CH2M HILL 2004) to support the design of the IM-3 groundwater treatment facility. Two borings were drilled in the treatment plant area. Note that the largest tank at the IM-3 facility was a 25,000-gallon (nominal) fiberglass tank. Other large loads included several vertical tanks and a sunshade structure.
- In 2008, a geotechnical investigation was also conducted to evaluate slope stability and to assist with identifying applicable debris and fill removal method (CH2M HILL 2009). A total of four borings were installed to a maximum depth of 56 feet, along the top of the primary fill slope in the area of the debris ravine.

EXHIBIT C-3
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Parameter	Criteria
Moist soil unit weight	120 pounds per cubic foot (lbs/cu ft.)
Shear strength parameters	<u>Cohesionless Soils</u> Friction angle: from 32 to 35 degrees for compacted fill Friction angle: from 28 to 30 degrees for native soils <u>Cohesive Soils</u> Undrained shear strength: from 800 to 1,000 lbs/sq.ft
Controlling earthquake magnitudes	Mean earthquake magnitude is 6.6 Modal earthquake magnitude is 7.9
Peak ground acceleration	For structure design is 0.10 g (design value for Site Class D) For liquefaction assessment is 0.15 g (for Site Class D)
Allowable bearing capacity	2,000 lbs/sq. ft
Allowable long-term settlement	1 inch
Sliding coefficient of friction	0.45
Lateral soil pressure equivalent fluid unit weight	Active pressure: 45 pcf Passive resistance = 175 pcf
Temporary cut and fill slopes	2 Horizontal:1Vertical
Frost depth	8-10 inches

EXHIBIT C-3
Geotechnical Design Criteria
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Additional Geotechnical Criteria
• Soil is corrosive to concrete structures and steel (resistivity > 1,000 ohm-centimeters, sulfate > 2,000 parts per million (ppm) and chloride > 500 ppm). • Soil profile is classified as Site Class D (stiff soil site), as defined in the CBC (2010). • Shallow foundations for buildings with support extending a minimum of 2 feet below lowest adjacent grade. Slabs and footings set on a minimum of 6" layer of granular base leveling course. • Pipe design based on depth of fill, weight of fill, compaction of fill and modulus of soil reaction (E' = 1,000 psi). • Native onsite materials may be considered for backfill if they have an expansion index (EI) less than 50 and contain less than 8 percent fines, as determined by ASTM D4829 and D422.

It should be noted that, for the I-40 and BNSF trenchless crossings, additional geotechnical investigations may be required by Caltrans, ADOT, or BNSF. At this time, further discussions with Caltrans, ADOT, and BNSF on this topic are anticipated to occur between the preliminary (30%) and intermediate (60%) design.

C.4 Mechanical

This section describes the design criteria associated with key mechanical elements of the project. Mechanical design will follow the California Mechanical Code (2010) unless noted, and fire requirements per the California Fire Code (2010).

C.4.1 Piping

Based on experience with operation and maintenance of the IM facilities, the groundwater in the floodplain has high levels of total dissolved solids, chlorides, sulfate, and other minerals that have caused significant corrosion to iron-based piping material from mild carbon steel to Type 316 stainless steel. Therefore, piping will be designed and installed in accordance with best practices and past site experience for operation and maintenance, including used of flanged or union joints for serviceability and isolation valves for systems requiring routine maintenance.

In general, piping materials will be compatible with the characteristic of the conveying fluids and will be single-walled unless the pipe is used to convey: (1) groundwater or remedy-produced water that is California Hazardous waste; or (2) concentrated carbon substrate. In these cases, double-walled piping will be used.

Corrosion Control

For corrosion control, above ground pipe will be coated as described in PG&E Gas Standard E-30. Any steel pipe near the point where it emerges from the ground will be coated as described in the air-to-soil transition table in PG&E Gas Standard E-30. Air-to-soil transition piping is any steel piping located 18" below ground or 6" above ground. Cathodic protection equipment will be applied as follows: 1) steel piping and structures will be cathodically protected underground; 2) plastic pipe (e.g., HDPE or CPVC or PVC) will be preferentially used when appropriate for corrosion resistance; and 3) steel pipe will be concrete lined to prevent internal corrosion.

In compliance with the EIR mitigation measures AES-1d and AES-2e, the external coatings used for wells, pipelines, storage tanks, structures, and utilities will consist of muted, earth tone colors that are consistent with the surrounding natural color palette, and matte finishes. Coating materials will be corrosion-resistant to protect the underlying surfaces.

Pressure Loss

For the freshwater and the remedy-produced water piping network, a hydraulic model built using the EPANET water supply program was used to simulate and optimize the piping design. Attachment B of this Appendix contains more details about the hydraulic modeling.

For the design of the in-situ remediation piping system, to ensure adequate distribution, the pressure loss in the branch distribution piping to each of the injection wells (including frictional losses and wellhead pressures from drop pipe frictional losses and pressure drop across the foot valve) will be designed to be 10 times higher than the pressure drop in the distribution header. The CIP loop conveyance piping will be designed to operate at a velocity of 3 to 5 feet per second (fps) and will have cleanouts every 400 feet.

C.4.2 Process Equipment

Primary process equipment (substrate dosing pumps, compliance related sensors, safety switches, etc.) will be designed for parallel operation or provide stand-by equipment to provide sufficient redundant capacity.

To the extent practical, all valving, instrumentation, manways, and access ladders for tanks will be located on the northern face of the remedial facilities to allow O&M personnel to work on the shady side during O&M activities.

C.4.3 Valves

Valves installed for throttling and flow control will include; globe, needle, and diaphragm valves. Isolation valves will include; gate, ball, and butterfly valves. Other valves expected to be included in the remedy system include spring and swing check valves, pressure relief, air relief, variable orifice, foot, and vacuum relief valves. Carbon substrate storage tanks may include additional safety valves, including emergency ventilation and combination pressure/vacuum relief valves in accordance with applicable standards. Valves will meet PG&E and industry standards appropriate to the application and process conditions.

Exhibit C-4 lists potential valve types associated with the major equipment. Valves will meet PG&E and industry standards appropriate to the application and process conditions. More details will be provided in the Intermediate design submittal.

EXHIBIT C-4
Potential Valve Type with Associated Device
Groundwater Remedy Basis of Design Report/Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Equipment	Potential Valve Type
Fresh Water Injection Pumps	Pressure reducing, ball, gate, swing check
Floodplain Extraction Pumps	Gate, ball, swing check
Embayment Extraction Pumps	Gate, ball, swing check
IRZ Pumps	Pressure reducing, ball, gate, swing or spring check, solenoid, pressure relief
East Ravine Pumps	Gate, ball, swing check
IRZ Backflush Pumps	Gate, ball, swing or spring check, solenoid, pressure relief
Freshwater Backflush Pumps	Ball, swing or spring check, solenoid, or globe
Carbon Amendment Pumps	Butterfly, ball, swing or spring check, pressure relief
Pipelines	Combination air release, ball, butterfly, gate
Well Maintenance Reagent Pumps	Butterfly, ball, swing check
Ethanol Storage and Transfer	Pressure/vacuum relief, emergency vent, ball, or gate
Miscellaneous Pumps	To be determined

C.4.4 Water Storage Tanks

Fixed steel tanks used for storing conditioned or un-conditioned remedy-produced water will be designed in accordance with American Water Works Association Standard D-100. Foundations will be designed in accordance with the structural criteria described in Section C.2 above. Corrosion prevention measures will be applied, including internal coatings and cathodic protection, if required.

C.4.5 Secondary Containment

Where required, secondary containment systems will be sized and designed in conformance with applicable codes and standards. Secondary containment for outdoor tank systems under a roof with no side walls or partial roof (e.g., the liquid/solid separator area) will be sized to accommodate spillage from the largest single tank at a minimum plus a 24-hr rainfall, as determined by a 25-yr storm. To comply with the Fire Code, secondary containment for indoor tank systems (e.g., the remedy-produced water conditioning building) will be sized to accommodate spillage of the largest single tank plus discharge of the fire extinguishing system for a period of 20 minutes. The secondary containment system will also be designed to meet the drainage and monitoring requirements.

Detailed design of the secondary containment systems will be included in the intermediate (60%) design.

C.4.5 Septic and Plumbing System

The new remedial facilities on the Compressor Station will tie a new bathroom and wash facilities into the existing septic facilities. The work will follow PG&E standards and County codes (adopted California Plumbing Code 2010).

The facility plumbing system will include rain water downspouts with spill out fittings to outside splash blocks for surface runoff, potable water emergency eyewash and shower stations, and plant water piping with wash-down hose bibs and connections for flushing of the chemical feed systems. The emergency eyewash and shower stations will be located near the chemical storage/feed areas, unless existing stations are nearby, and will be provided with drains.

C.4.6 Fire Protection Equipment

The remedy-produced water and operations buildings are unclassified, as described by National Fire Protection Association (NFPA) 820; hence, only fire hydrants for fire protection are required. No fire and explosion hazard, materials of construction and ventilation requirements are listed in NFPA 820 for these facilities.

Portable fire extinguishers will be mounted in buildings in accordance with PG&E requirements and County Fire codes. Portable fire extinguishers will be ABC multipurpose dry chemical type UL-rated 20A:120B:C.

All electrical equipment will have Underwriters Laboratory approval where applicable. Areas of the electrical installation will be classified in accordance by Class, Division, and Group. Specifically, for the IRZ facilities at the MW-20 and the Transwestern Metering Station Bench, the following will apply:

- Class I, Division I within a 5-ft radius of the carbon storage tank vents.
- Class I, Division II within a 10-ft radius of the carbon storage tank vents (from vent elevation to ground).
- Class I, Division II from ground surface to 18-inches above grade within a 10-ft radius of the tank footprint.
- Class I, Division II within the carbon amendment building where there are pipes with >10% ethanol.

C.4.7 Air Pollution Control

Temporary and permanent mobile and fixed equipment emissions will comply with Clean Air Act - USC §§ 7401, et seq. (National Emission Standards for Hazardous Air Pollutants (NESHAP)); 40 Code of Federal Register (CFR) 61; 40 CFR 63 and local air district requirements (e.g., Mohave County).

C.4.8 Hazardous Materials Storage

Chemicals that will be used in the remedy and stored on site will be listed in the intermediate design submittal with location and estimated quantities. Storage of these chemicals will comply with California and San Bernardino County Fire Department (Certified Unified Program Agencies [CUPA]) requirements. Changes to hazardous materials storage will be updated in the TCS Hazardous Materials Business Plan and this will be communicated to the CUPA in interim form within 30 days of the chemicals or materials arrival on site.

C.5 Electrical

In this section, the electrical design criteria and activities are described. Electrical systems and equipment will be designed to meet PG&E standards and the California Electrical Code (2010) unless specifically noted.

C.5.1 Power System

The electrical supply system will be designed as follows:

- Power will be supplied by a new natural gas fired generator with gas supplied by the Compressor Station. The unit will be connected to the existing Compressor Station power system.
- A medium voltage loop will be connected to supply up to 7 distribution locations where the voltage will be transformed to 480 volts in alternating current (VAC), 3 phase power.
- An existing backup diesel generator equipped with automatic switchover equipment will supply power in case of an outage.

C.5.2 Energy Efficiency and Lighting

Energy efficiency will be a factor in equipment selection. Motors will be specified to be Premium Efficient per latest NEMA MG 1 standard where possible. Lighting equipment and facilities for safe operations will be designed to be energy efficient and comply with California Title 24 and county lighting ordinances.

In compliance with EIR mitigation measure CUL-1a-7, to minimize construction and operations-related lighting impacts, the lighting for the remedy will include the following features: (1) shrouding/shielding for portable lights during construction and operational activities; (2) installation of portable lights at the lowest allowable height and in the smallest number feasible to maintain adequate night lighting for safety; and (3) shielding and orientation of lights such that off-site visibility of light sources, glare, and light from construction activities are minimized to the extent feasible. In addition, no additional permanent poles will be installed for lighting. Since CUL-1a-7 is not meant to replace or subsume any actions required by the County or state or federal entities with regard to lighting required for minimum security and safety purposes, the following specifications will also be met:

- San Bernardino County Code Title 8 Section § 83.07.040 Glare and Outdoor Lighting - Mountain and Desert Regions
- Mohave County Outdoor Light Control Ordinance 87-1
- Specific requirements from land owners, if feasible and is not in conflicting with the mitigation measures and county codes

C.5.3 Receptacles

Convenience receptacles supplying 120 VAC power will be provided in all areas required. All exterior receptacles will be weather proof, with ground fault interrupting type circuit breakers.

C.5.4 Communications

Fiber optic cable or conventional copper wire will be used for sending signals via cable. Wireless communications devices like radio, satellite, or cellular, may be used as appropriate..

C.5.5 Existing Utilities

All existing utilities will be potholed for actual depth prior to construction following Compressor Station or utility owner methods and requirements, including a minimum 25-foot right-of-way will be maintained for the L300 gas pipelines located near occupied buildings. Existing engineering drawings will be reviewed to identify areas of potential conflict, but are for planning purposes only, not solely relied upon. A utility survey is planned in early 2012 to support the remedy design. See also Section C.1.1, Earthwork.

C.6 Instrumentation and Control

A Supervisory Control and Data Acquisition (SCADA) system, located in the remedy system control room, will be installed to initiate operation of all pumps, monitor all system status and alarm data, change control set points, and perform all remote control functions.

In general, emergency shutdown of equipment due to alarm conditions (low discharge flow, high discharge pressure, motor overload, pump seal water failure, high level vault alarms, etc.) will be hardwired and will occur remotely or be executed locally. These alarm conditions will require manual reset at the SCADA or the local digital controller. In conformance with the EIR mitigation measure CUL-1a-6, all additional phone calls and alarms associated with remediation activities or facilities will not be routed through PG&E's existing alarm system utilized at the Compressor Station. The notification system for remediation-related alerts and/or phone calls will not introduce additional noise to the project area, to the maximum extent feasible, provided there is ongoing compliance with applicable safety regulations or standards of the Federal Energy Regulatory Commission, Occupational Safety and Health Administration, and other agencies.

C.7 Architectural

Building and all infrastructure components will conform to the following:

- In conformance with the EIR mitigation measure AES-1d and AES-2e, the color of the wells, pipelines, reagent storage tanks, control structures, and utilities shall consist of muted, earth-tone colors that are consistent with the surrounding natural color palette. Matte finishes shall be used to prevent reflectivity along the view corridor. Integral color concrete should be used in place of standard gray concrete.
- Floors: Floors, including foundations, will be reinforced cast-in-place concrete.
- Doors and Frames: All insulated pedestrian doors will be constructed of heavy-gauge hollow metal or aluminum clad solid core slabs. The doors will have insulated tempered glass window openings (with internal wire mesh for security) to admit natural light. All-stainless-steel hardware is recommended for longevity considerations.
- Overhead Sectional Doors: A heavy-gauge insulated steel overhead sectional door. The doors will have insulated window openings to admit natural light.
- Wall Assemblies: The perimeter and interior walls will be metal wall panels or concrete masonry.
- Windows: Aluminum framed windows with a clear anodized finish. Energy efficient insulated tempered glass with a low-E coating.
- Louvers: Aluminum drainable louver with a clear anodized finish.
- Fire Extinguisher: Fire extinguishers will be strategically located to meet the requirements of the codes and NFPA 10 for size and locations.
- Finishes: All interior surfaces will receive a high-quality finish for appearance and longevity of materials. The following finishes will be provided:
  - Floors: Finished with a clear surface sealer to increase the durability of the concrete surface and to maintain a clean, dust-free environment.
  - Framing: Finished with an epoxy primer and polyurethane finish coating.
  - Interior Walls and Ceilings: Factory finished metal panels or epoxy coatings.
  - Pedestrian and overhead sectional doors: Field finished with a polyurethane and epoxy finish coating.

If alternate building materials are used such as straw bales, the following codes will be used; International Green Building Code and California Health and Safety Code, Section 18944. Building code analysis including hazardous chemical storage analysis will be performed for the intermediate (60%) design submittal.

C.8 PG&E Personnel Requirements

PG&E personnel will perform the following activities during construction:

- Monitor for compliance with PG&E safety standards and requirements and contract specifications, terms, and conditions.
- PG&E personnel, or their designee, will lead TCS-specific safety and biological and cultural sensitivity training.
- Serve as liaison and primary contact for any agency, tribal, or other third party personnel inspecting and/or monitoring construction activities.
- Attend stand-up tailboard (safety) meetings before the start of work each day to review safety policies and specific hazards likely to be encountered in the day's activities.
- Sign waste manifest forms

Additional criteria may be added for the intermediate (60%) design submittal.

C.9 Health and Safety

The project falls under federal Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) requirements (29 CFR 1910.120) so these procedures must be followed in addition to California and Arizona state requirements. These requirements will be embodied in health and safety work plans prepared by construction, drilling and other service contractors. In addition, non-PG&E personnel will work under existing health and safety plans that may be amended to suit new project requirements. PG&E personnel similarly work under their own health and safety plans. These plans will describe such things as training, site control, medical surveillance, safety personnel roles and responsibilities, personnel protective equipment, exposure monitoring and air sampling programs, heat and cold stress, and site work rules and procedures. Additional details will be provided in the Intermediate Design stage.

C.10 Noise

Under normal operating conditions, the noise design criteria will be as follows:

- For permanent and stationary remedy facilities located outside of the Compressor Station the upper limits for aggregate sound levels measured at the facility boundary will be as shown below. If necessary, appropriate sound control measures will be used to dampen sound below these levels.
  - California facilities, per San Bernardino County requirements, 70 decibels (dB)
  - Arizona facilities, per Mohave County requirements, 70 db daytime and 63 dB nighttime
- For remedy facilities located on the Compressor Station, the noise design criteria will be consistent with the noise environment at the Station.
- During construction, the noise criteria will conform to San Bernardino and Mojave County standards, as well as the EIR mitigation measures NOISE-1, 2, and 3, to lessen noise impacts.

C.11 Construction Requirements

Construction activities will be completed under approved health and safety plan. The activities described in the plans will comply with Cal/OSHA, Arizona Division of Occupational Safety and Health, and OSHA regulations, and PG&E safety requirements. The construction sequence will be described in the intermediate (60%) design submittal. The three main elements of the project, wells (injection, extraction, IRZ), pipelines, and conduits (freshwater, carbon-amended water, remedy-produced water, conditioned produced water, electrical, and instrumentation) may be constructed concurrently or sequentially with the buildings/structures (remedy-produced water conditioning plant, operations building, electrical control building, carbon amendment) as long as those elements do not affect Compressor Station operations.

Construction and field methods will comply with both the contract documents and Compressor Station procedures. Compressor Station procedures include such things as utility protection by hand digging within the Compressor Station, cultural and historical resource protection, restrictions on construction in the floodplain due to biological resource protection, and other biological resource protection outside the floodplain.

Excavation near existing utilities will be performed under the guidelines provided by the affected utility (BNSF, PG&E, Transwestern, etc). The appropriate excavation method will be selected in consultation with the owner of the feature (as appropriate) and may be dependent upon the type of feature being investigated.

A construction water source will be established onsite to provide adequate water resources for use in construction storm water best management practices (e.g., dust control), equipment decontamination, and other activities. A temporary storage system will be established such that the existing Topock Compressor Station water supply can be used for construction activities without interfering with Compressor Station operations. Clean, temporary fresh water storage tanks (estimated capacity of up to 21,000 gallons each) will be staged within the construction areas where accessible and where a connection to the existing water system can be made. A water truck (with associated fill tank) may also be used to convey water to the work areas or along vehicle traffic routes as necessary to suppress dust.

C.11.1 Staging and Storage

Staging and storage areas are located as follows:

- Area 1: I-40 Pull off at Park Moabi Road Exit (Transport Staging and Inspection)
- Area 2: New Ponds (Clean Bin and Fill Staging Area)
- Area 3: IM-3 and Adjacent Pull Off (Clean Fill Staging)
- Area 4: Compressor Station Main Station Area (Construction Equipment, Construction Materials, and Waste/Hazardous Material Storage)
- Area 5: Transwestern Meter Station and Route 66 Sign Areas (Transfer Location and Vehicle Turn-around)
- Area 6: MW-20 Bench (Crew Parking and Equipment/Material Staging)
- Hazardous Material and Waste Storage Areas: If a bulk waste or hazardous material storage area is required, the concrete storage pad near the Transwestern Meter Station will be used or the smaller hazardous material storage areas within Compressor Station and at IM-3. Any waste or hazardous material storage will be conducted in accordance with the Compressor Station Hazardous Materials Business Plan.

C.11.2 General Traffic Routes

Construction site access will be by way of existing, established roadways wherever possible. Any new access roads will be constructed to meet the criteria listed under Section C.1.1 above and will avoid, to the extent feasible, previously undisturbed areas.. Temporary signage and demarcation barriers/signs will be used to ensure that the traffic patterns and allowable travel areas are clear.

C.11.3 Equipment/Material Delivery Coordination, Routing, and Piloting

Requirements for equipment and material delivery are listed below:

- Material deliveries will typically be made by semi-trailer delivery to the designated laydown and material storage areas.
- Due to the limited space within TCS, transport and delivery vehicles may need to be queued temporarily off-site for safety, congestion, and other logistical concerns.
- Large vehicles and heavy construction equipment will be piloted through the TCS and along public roads by a pilot vehicle and an appropriate number of spotters. Pilot vehicle flashers will be used to warn pedestrians and motorists of coming large vehicles and equipment.

C.11.4 Load Limits, Size Restrictions, and Utility Protection

Load limits and utility protection requirements are as follows:

- Load limits for existing roadways will be adhered to. Transporting heavy equipment and vehicle loads over existing utilities will be performed under the guidelines provided by the affected utility (BNSF, PG&E, Transwestern, etc).
- Concrete K-Rail Traffic Barriers or similar barriers will be used to protect high value above-grade facilities and where necessary limit traffic to specific travel paths. Traffic plates or aggregate/asphalt cover will likely be used to protect high value below-grade facilities. The appropriate method of utility protection will be selected in consultation with the owner of the feature (as appropriate) and may be dependent upon the type of feature.

C.12 References

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U.S. Bureau of Land Management (BLM). 2010. Programmatic Agreement among the Bureau of Land Management, Arizona Historic Preservation Officer, California State Historic Preservation Officer, and the Advisory Council on Historic Preservation for the Topock Remediation Project in San Bernardino County, California and Mohave County, Arizona. October.

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Attachment A
Carbon Substrate Selection and Degradation Pathways Design Bulletin

1. Purpose

The objective of this Design Bulletin is to detail the basis of design for the selection and usage of carbon substrates and their degradation pathways for the In-Situ Reactive Zone (IRZ) at the Pacific Gas & Electric (PG&E) Topock site. There is a wide spectrum of organic carbon substrates available for anaerobic in-situ reactive zone (IRZ) applications including fermentable soluble substrates such as molasses, lactate, and whey; alcohols such as ethanol and methanol; semi-soluble substrates such as emulsified vegetable oil; and solids such as chitin and bark mulch.

The selection of the appropriate substrate will depend on the balance between the mode of delivery, the substrate properties, and the rate of carbon utilization. The likely substrates for the Topock Compressor Station final remedy will be discussed in this appendix, as well as general degradation pathways. Some information on carbon substrate dosing design is also provided in this appendix to supplement the thorough treatment of the dosing design in the groundwater modeling Appendix B.

2. References

ARCADIS 2007. *Floodplain Reductive Zone In Situ Pilot Test, Final Completion Report.* Pacific Gas and Electric Company Topock Compressor Station, Needles, California. March 5.

ARCADIS 2009. *Upland In-Situ Pilot Test, Final Completion Report.* Pacific Gas and Electric Company Topock Compressor Station, Needles, California. March 3.

ARCADIS 2010. *Central Area In-Situ Remediation Pilot Study Second Quarter 2010 Monitoring Report.* Pacific Gas and Electric Company Hinkley Compressor Station. Hinkley, California. July 29.

California Department of Toxic Substance Control (DTSC) 2011. *Final Environmental Impact Report for the Topock Compressor Station Groundwater Remediation Project.* January.

Lengeler, J.W, Drews, G., & Schlegel, H.G. (1999). Biology of the Prokaryotes. Georg Thieme Verlag, Stuttgarg, Germany.

Schink, B., Kremer, D.R, and T. A. Hansen. 1987. *Pathway of propionate formation from ethanol in* Pelobacter propionicus. Arch Microbiol. 147: 321 – 327.

Schnobrich, M., McCaughney, M., Mowder, C. and C. Divine. 2011. *Emulsified Vegetable Oil (EVO): Distribution as the Design Consideration.* RemTech Summit 2011. May 16-19, 2011. Chicago, Illinois.

Solutions IES (IES) 2006. *Protocol for Enhanced In Situ Bioremediation Using Emulsified Edible Oil.* Environmental Security Technology Certification Program (ESTCP). May.

3. Definitions

C-1	Single carbon compounds
CH_4	Methane
$C_2H_3O_2^-$	Acetate
C_2H_6O	Ethanol
$C_3H_5O_3^-$	Lactate
$C_3H_5O_2^-$	Propionate

$C_{12}H_{22}O_{11}$	Lactose
CO_2	Carbon dioxide
$Cr(III)$	Trivalent chromium
$Cr(VI)$	Hexavalent chromium
$Cr(OH)_3$	Chromium hydroxide
e^-	Electrons
$Fe(II)$	Ferrous iron
$Fe(III)$	Ferric Iron
$Fe(OH)_3$	Ferrihydrite
H^+	Hydronium ion
H_2	Hydrogen
H_2O	Water
H_2S	Hydrogen sulfide
HS^-	Bisulfide ion
$Mn(IV)$	Tetravalent manganese
$Mn(II)$	Divalent manganese
MnO_2	Manganese dioxide
NO_3^-	Nitrate
NO_2^-	Nitrite
N_2	Nitrogen
O_2	Oxygen
SO_4^{2-}	Sulfate

4. Carbon Substrate Selection

Based on the results of the preliminary evaluation, the carbon substrates that will be carried forward into remedy design include ethanol (used in the Uplands In-Situ Pilot Test [ARCADIS 2009]), sodium lactate (used in the Floodplains In-Situ Pilot Test [ARCADIS, 2007]), emulsified vegetable oil, and liquid whey. Each of these carbon substrates were evaluated in the Final Environmental Impact Report (FEIR, DTSC, 2011). The selection of the appropriate substrate will depend on the balance between the mode of delivery, the substrate properties, and the rate of carbon utilization.

It is anticipated that for most of the final remedy operational period, substrates that are soluble with short biodegradation half lives (i.e., 5 to 20 days), like lactate and ethanol, will be used to facilitate effective distribution and establishment of reducing conditions across the IRZ, with the highest degree of distribution control, given the utilization of the carbon substrates and by-products (discussed below) to completion (i.e. to complete degradation to carbon dioxide and methane).

Whey could be used if infrequent dosing of carbon substrate with a longer biodegradation half life (i.e., greater than 25 days) is needed. Whey is not an ideal carbon substrate for continuous usage because it is perishable (e.g., has a limited shelf life), and will develop septic odors relatively quickly. Emulsified vegetable oil may be used during future operational stages of the remedy if a low dosage, slow release reservoir of carbon would be advantageous.

5. Organic Carbon Degradation Pathways

Within an active IRZ, periodic injection activities support the development of a diverse microbial community that utilizes the augmented organic carbon supply via a complex network of degradation pathways. In general, there are two types of processes by which organic carbon substrates are consumed: respiratory processes and fermentation processes. Regardless of the carbon substrate selected and the complex network of degradation pathways stimulated, the resultant end products of degradation will include carbon dioxide, methane, and biomass. Eventually, biomass will also decay into carbon dioxide and methane. The following provides an overview of the various degradation pathways that will be stimulated within the IRZs, identifies the typical intermediates that may form, and includes several balanced oxidation-reduction reactions. This list may not be inclusive, considering the complex microbial ecology that will develop within the IRZ, but is intended to provide a basic framework for understanding the carbon degradation pathways.

In respiratory processes, organic carbon substrates are oxidized to carbon dioxide, releasing electrons that in turn reduce terminal electron acceptors (oxygen, nitrate, hexavalent chromium, iron, manganese, and sulfate). In fermentation processes, the organic carbon substrates are both oxidized and reduced via the metabolic pathways. The general pathways and intermediates for organic carbon degradation are shown on Figure 1. As shown on the figure, in the respiratory pathways coupled to reduction of oxygen, nitrate, chromium, iron, manganese and sulfate, the carbon substrate is completely oxidized to carbon dioxide. Consequently, total organic carbon concentrations return to ambient concentrations following IRZ injections.

Fermentation reactions produce additional intermediates such as fatty acids, alcohols, lactate, succinate, and hydrogen from primary fermentation of more complex organic carbon substrates, and acetate and single carbon (C-1) compounds, like formate, from less complex substrates or the intermediates of primary fermentation.

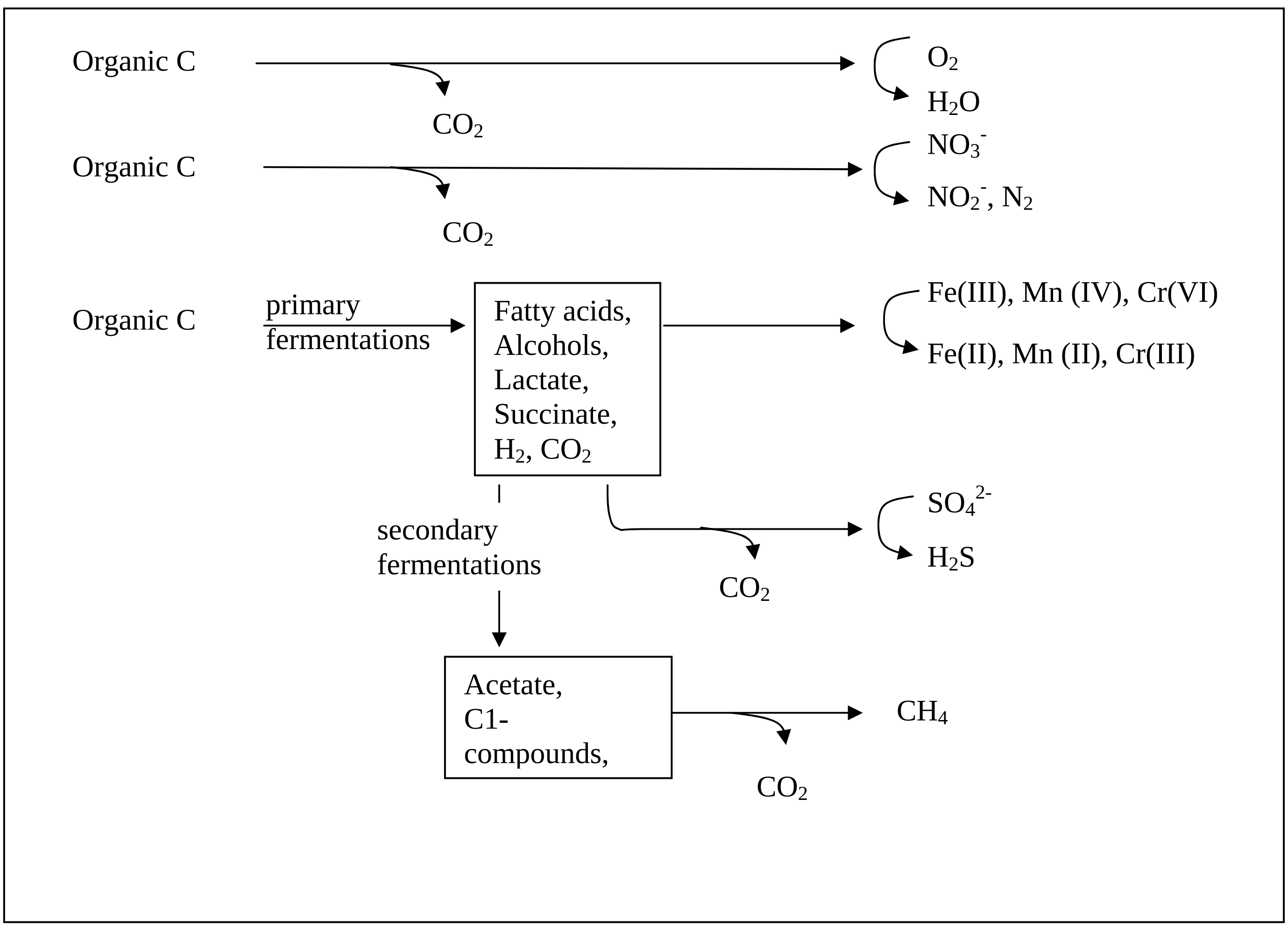


Figure 1: General Degradation Pathways for Organic Carbon Substrates (adapted from Lengeler et al., 1999)

For the IRZs that are part of the final groundwater remedy at the Topock Compressor Station, several organic carbon substrates are being considered. For the purposes of this discussion, however, only the four most likely substrates will be considered, ethanol, lactate, liquid whey, and emulsified vegetable oil (EVO). For reference, liquid whey is composed primarily of the disaccharide lactose, and EVO is a triglyceride.

EVO is a slightly different substrate than the others being considered, because it is delivered as a separate phase oil that will sorb to aquifer soils. The triglycerides are first hydrolyzed, releasing glycerol and long chain fatty acids (IES, 2006). As the long chain fatty acids are degraded by beta-oxidation, smaller molecules are generated which more easily dissolve into groundwater, such as butyric acid, and acetate (IES, 2006), as shown on Figure 2.

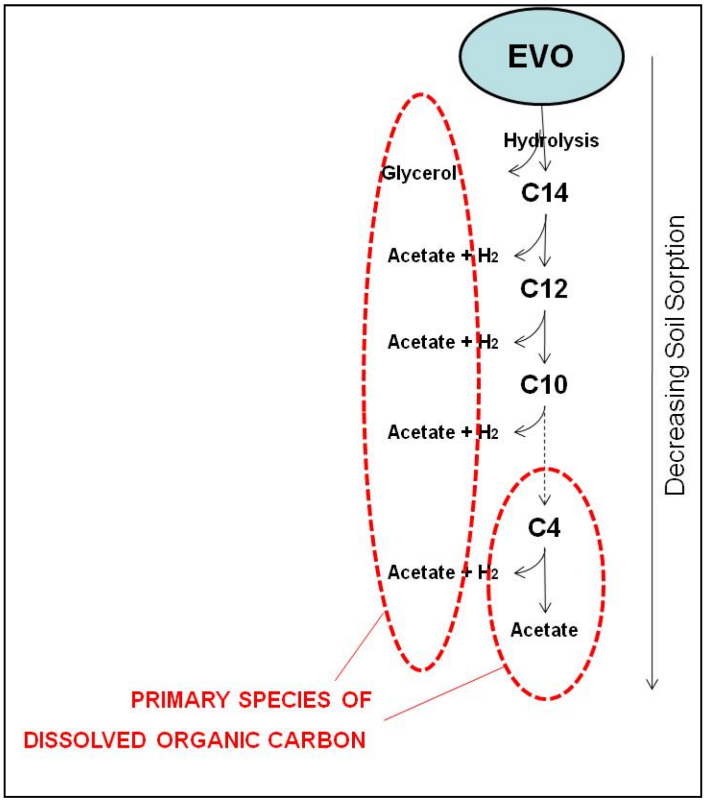


Figure 2. Degradation and Dissolution of EVO.

In the next few sections, the general breakdown pathways and balanced reactions for the respiration and fermentation of the various organic carbon substrates are presented. For the purpose of EVO, acetate will be discussed as an example of a dissolved organic compound.

a. Respiratory Processes

In respiratory processes, the oxidation of organic carbon substrates to carbon dioxide is coupled to the reduction of a terminal electron acceptor. Respiratory processes stimulated within an IRZ include aerobic respiration, denitrification, chromium reduction, iron reduction, manganese reduction, and sulfate reduction. The following discussion will provide an overview of the reactions for these respiratory processes.

The following are balanced oxidation half-reactions that release electrons for ethanol, lactate, lactose (from whey), and acetate (a degradation intermediate and one of the primary dissolved constituents released from EVO).

Ethanol	$1/12\ C_2H_6O + 1/4\ H_2O \rightarrow 1/6\ CO_2 + H^+ + e^-$	(1)
Lactate	$1/12\ C_3H_5O_3^- + 1/4\ H_2O \rightarrow 1/4\ CO_2 + 11/12\ H^+ + e^-$	(2)
Lactose	$1/48\ C_{12}H_{22}O_{11} + 13/48\ H_2O \rightarrow 1/4\ CO_2 + H^+ + e^-$	(3)
Acetate	$1/8\ C_2H_3O_2^- + 1/4\ H_2O \rightarrow 1/4\ CO_2 + 7/8\ H^+ + e^-$	(4)

The release of electrons from the oxidation of each substrate is coupled to the reduction of the various terminal electron acceptors. Below are the reduction half reactions for the various terminal electron acceptors. Note, for iron and manganese reduction (Reaction 8 and 9), various mineral phase reactants are possible and one example of each is shown. Similarly for chromium (Reaction 7), several mineral phase products are possible and one example is shown, chromium hydroxide.

Oxygen	$1/4\ O_2 + H^+ + e^- \rightarrow 1/2\ H_2O$	(5)
Nitrate	$1/5\ NO_3^- + 6/5\ H^+ + e- \rightarrow 1/10\ N_2 + 3/5\ H_2O$	(6)
Chromium	$1/3\ Cr^{6+} + H_2O + e^- \rightarrow 1/3\ Cr(OH)_3 + H^+$	(7)
Iron	$Fe(OH)_3 + 3H^+ + e^- \rightarrow Fe^{2+} + 3H_2O$	(8)
Manganese	$1/2\ MnO_2 + 2H^+ + e^- \rightarrow 1/2\ Mn^{2+} + H_2O$	(9)
Sulfate	$1/8\ SO_4^{2-} + 9/8\ H^+ + e^- \rightarrow 1/8\ HS- + 1/2\ H_2O$	(10)

For each substrate being considered, bacteria within the IRZ would couple the oxidation of the organic carbon substrate with the reduction of various electron acceptors. For example, balanced reactions for the coupling of ethanol oxidation with oxygen, iron and sulfate reduction (Reactions 11, 12 and 13, respectively) are as follows:

Ethanol/Oxygen	$1/12\ C_2H_6O + 1/4\ O_2 \rightarrow 1/6\ CO_2 + 1/4\ H_2O$	(11)
Ethanol/Iron	$1/12\ C_2H_6O + Fe(OH)_3 + 2H^+ \rightarrow Fe^{2+} + 2\ 3/4\ H_2O + 1/6\ CO_2$	(12)
Ethanol/Sulfate	$1/12\ C_2H_6O + 1/8\ SO_4^{2-} + 1/8\ H^+ \rightarrow 1/8\ HS- + 1/4\ H_2O + 1/6\ CO_2$	(13)

b. Fermentative Processes

Fermentative conditions will also develop within the IRZ, as indicated by increased methane concentrations in groundwater in IRZs at the PG&E Hinkley Site (ARCADIS 2010). As shown in Figure 1, various organic intermediates and hydrogen can be produced from the fermentation of the organic carbon substrates, but the ultimate end products of reaction are carbon dioxide and methane.

For example, fatty acids have been monitored during IRZ implementation at Hinkley. The most prominent fatty acids detected in IRZ groundwater during both lactate and ethanol applications have been acetate and propionate (ARCADIS 2010). The production of acetate and propionate from lactate and ethanol are well documented fermentation processes.

Propionibacteria produce acetate and propionate from the fermentation of lactate (Lengeler et al., 1999) as follows:

$$3\ C_3H_5O_3^- \rightarrow C_2H_3O_2^- + CO_2 + 2\ C_3H_5O_2^- + H_2O \qquad (14)$$

Ethanol ferments to produce acetate and propionate as follows (Schink et al., 1987):

$$3\ C_2H_6O + 2\ HCO_3^- \rightarrow C_2H_3O_2^- + 2\ C_3H_5O_2^- + H^+ + 3\ H_2O \qquad (15)$$

Finally, the products of fermentation will be used by methanogens to make methane. Acetoclastic methanogens will produce methane from acetate (Lengeler et al., 1999):

$$C_2H_3O_2^- + H^+ \rightarrow CH_4 + CO_2 \qquad (16)$$

Hydrogenotrophic methanogens will produce methane from carbon dioxide and hydrogen (Lengeler et al., 1999):

$$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O \qquad (17)$$

6. Dosing Design

The primary design consideration for carbon substrate dosing is the distribution of the substrate in the subsurface. As such, the hydraulic, fate and transport and geochemical models, as well as pilot test data, are being primarily used to guide reagent dosing design, as discussed in Appendix B.

The semi-soluble substrate, EVO is a special case and is discussed further in this section. As EVO is injected, significant portions of the oil will be retained on the soil. The amount of oil that will be retained per unit volume of aquifer varies with soil type as documented in the Protocol for Enhanced In Situ Bioremediation (IES, 2006) and is a lower bound on the amount of oil that will be required to achieve distribution within a given target volume. However, the amount of EVO required to achieve sufficient distribution can be up to an order of magnitude greater than the amount of oil retention reported in the literature, based on field implementation at a number of sites (Schnobrich et al., 2011). In practice, the required EVO loading must be evaluated on a case-by-case basis to confirm the site-specific degree of droplet retention and to ensure sufficient organic carbon distribution for treatment within the targeted area.

Attachment B
Calculations (On CD-ROM)

- Remedy-produced water conditioning process - Filter Feed Pump Sizing
- Remedy-produced water conditioning process - Caustic Usage
- Freshwater injection/remedy-produced water collection/conditioned remedy water distribution and disposal hydraulic network modeling calculations from EPANET software
- Hydraulic Calculations for NTH IRZ, Inner Recirculation Loop, and TCS Recirculation Loop Wells

Remedy-produced Water Conditioning Process - Filter Feed Pump Sizing

CH2MHILL

JOB NO.: 415087.01.05.02

SHEET NO.: 1

DATE: 10 05 2011

JOB NAME: TOPOCK GROUNDWATER CONDITIONING

COMPUTED BY CHRIS ABDULJABBAR

SUBJECT: Pump Calculation

CHECKED BY: JOHN PORCELLA

REVISION HISTORY:

Rev. No.	Date	By	Approved	Notes
1	10/05/11	C. Abduljabbar	John Porcella	Prelim. sizing for determining elec. load.

OWNER:

CH2M HILL Energy and Chemicals **Discipline:** Process

PUMP CALCULATION SHEET

Pump2K Version 1.2

PROJECT NO. :		BY:		DATE:	
CLIENT:		CHECKED:		DATE:	
EQUIPMENT NO(S):		REVISION NO.:		DATE:	BY:
SERVICE:		FLUID:		PFD #:	
LOCATION:		NO. PUMPS REQ'D:		P&ID #:	

DESIGN DATA			NORMAL OPERATING DATA	
DGN FLOW, GPM	35	PUMPS FROM:	NORMAL FLOW,GPM	20
SG, DESIGN TEMP	1		SG, NORMAL TEMP	1
DEN @ D T, LB/FT3	62.4		DEN @ N T, LB/FT3	62.4
VISC. @ D T, CP	0.9	PUMPS TO:	VISC. @ N T, CP	0.9
VAP P @ D T, PSIA	0.5069		VAP P @ N T, PSIA	0.5069
DGN TEMP, DEG F	80		NORM. TEMP, DEG I	80

PUMP SUCTION CONDITIONS

MINIMUM SYSTEM INITIAL PRES., PSIA		14.7
STATIC HEAD (+) OR LIFT (-), FT		2
STATIC HEAD (+) OR LIFT (-), PSI		0.9
LINE FRICTION LOSS, PSI		0.4
EQUIPMENT LOSS, PSI		
MISC LOSS, PSI		
DESIGN SUCTION PRES., PSIA		15.2

INPUT:	SUCTION PIPING DATA			DISCHARGE PIPING DATA		
NOMINAL SIZE, IN.	2.00	<-enter piping		2.00	<-enter piping	
SCHEDULE	40	& fitting data		40	& fitting data	
ACTUAL I.D., IN.	2.067			2.067		
FITTINGS	NO.	K *	DP, PSI	NO.	K *	DP, PSI
ELBOWS, 90 LR	1	0.31	0.02	6	0.31	0.14
ELBOWS, 45 LR		0.23	0.00		0.23	0.00
TEES, THRU	2	0.74	0.11	4	0.74	0.22
TEES, BRANCH	1	1.20	0.09		1.20	0.00
BALL VALVES	1	0.23	0.02	1	0.23	0.02
BUTTERFLY VALVES		0.38	0.00	1	0.38	0.03
GATE VALVES		0.15	0.00	0	0.15	0.00
GLOBE VALVES		5.96	0.00	1	5.96	0.45
CHECK VALVES		2.25	0.00	1	2.25	0.17
PLUG VALVES		0.39	0.00	0	0.39	0.00
PIPE ENTRANCE		0.50	0.00			
PIPE EXIT					1.00	0.00
OTHER			0.00			0.00
LIN. FT OF PIPE	10		0.10	600		6.09
OTHER, EQ FT			0.00			0.00
CONTINGENCY, %	30%			30%		
CONTINGENCY, FT	3.0		0.03	180		1.83
TOTAL EQ FT	37			881		
DP TOTAL, PSI			0.37			8.95

PUMP DISCHARGE CONDITIONS

MAX. SYSTEM TERMINAL PRES., PSIA		14.7
STATIC HEAD DIFFERENCE, FT		112
STATIC HEAD DIFFERENCE, PSI		48.5
TOTAL FIXED LOSSES, PSIA		63.2
LINE FRICTION LOSS, PSI		8.9
EQUIPMENT LOSS, PSI	GAC Vessels	2.0
EQUIPMENT LOSS, PSI	Cartridge Filters	2.5
MISCELLANEOUS LOSS, PSI		2.0
MISCELLANEOUS LOSS, PSI		0.0
TOTAL VARIABLE LOSS, PSI		15.4
TOTAL FIXED AND VARIABLE LOSS, PSIA		78.6
ALLOWED CONTROL VALVE PRES. DROP , PSI		
DISCHARGE PRESSURE, PSIA		78.6
CORRECTED DISCHARGE PRESSURE, PSIA		**80.9**

DIFFERENTIAL HEAD AND POWER CALCULATION

DESIGN SUCTION PRESSURE, PSIA	15.2
TOTAL DIFFERENTIAL PRESSURE, PSI	63.4
TOTAL DIFFERENTIAL HEAD, FT	147
OVERALL LOSS SAFETY FACTOR, % (e.g., 10 %)	15%
CORRECTED DIFFERENTIAL HEAD, FT	**152**
CORRECTED DIFFERENTIAL PRESS, PSI	**65.7**
HYDRAULIC HORSEPOWER, HP	1.3
PUMP EFFICIENCY, % (e.g., 50%)	50%
BRAKE HORSEPOWER, BHP (water only)	2.7
MIN. PUMP CASING DESIGN PRESSURE, PSIG	79.7

	CALCULATED SUCTION DATA	CALCULATED DISCHARGE DATA
PIPE I.D., IN	2.067	2.067
X-SECT AREA,FT2	0.0233	0.0233
DGN FLOW, LB/HR	17,500	17,500
VELOCITY, FT/SEC	3.34	3.34
REYNOLDS NUM	59,360	59,360
DARCY FRI FACT	0.02325	0.02325
FRICT DP, PSI/100'	1.02	1.02

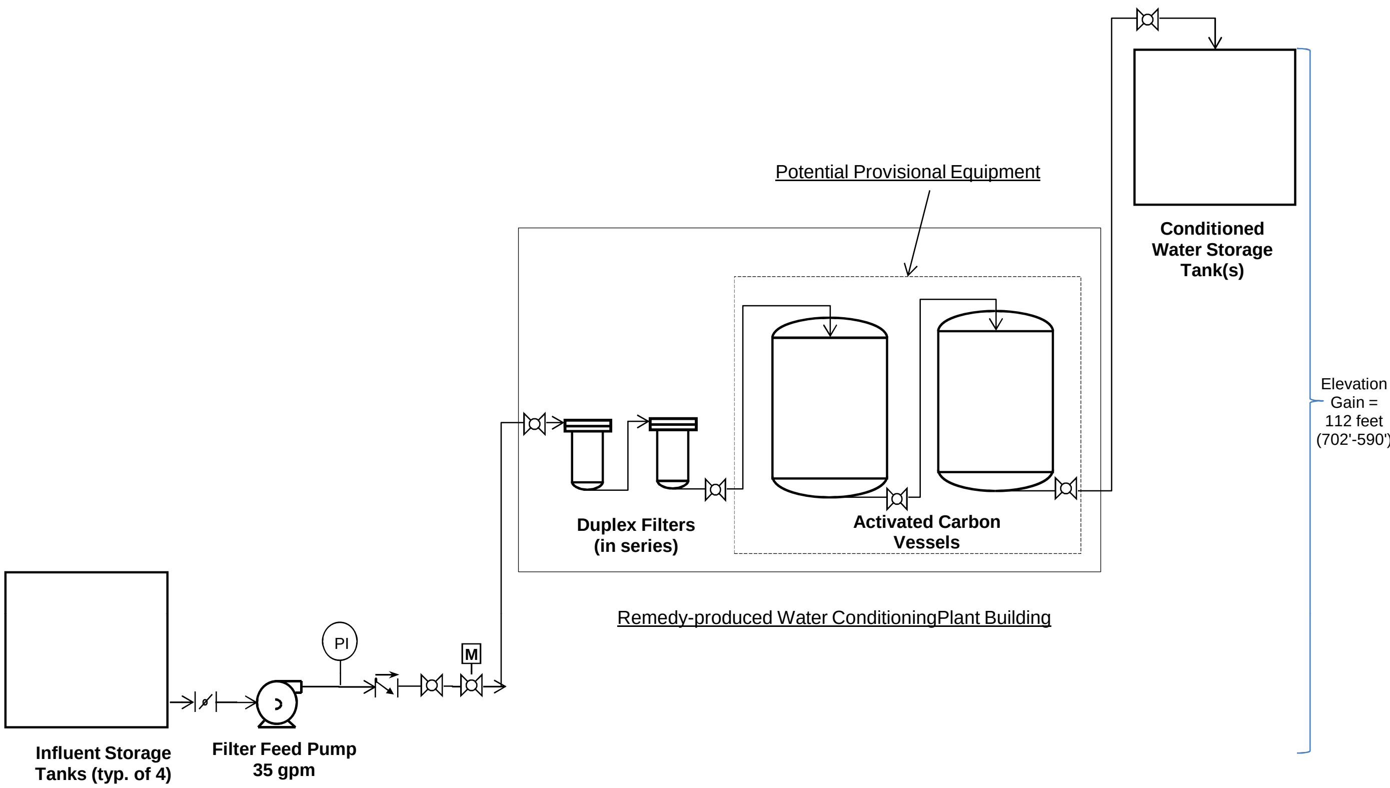
NET POSITIVE SUCTION HEAD CALCULATION (NPSHa)

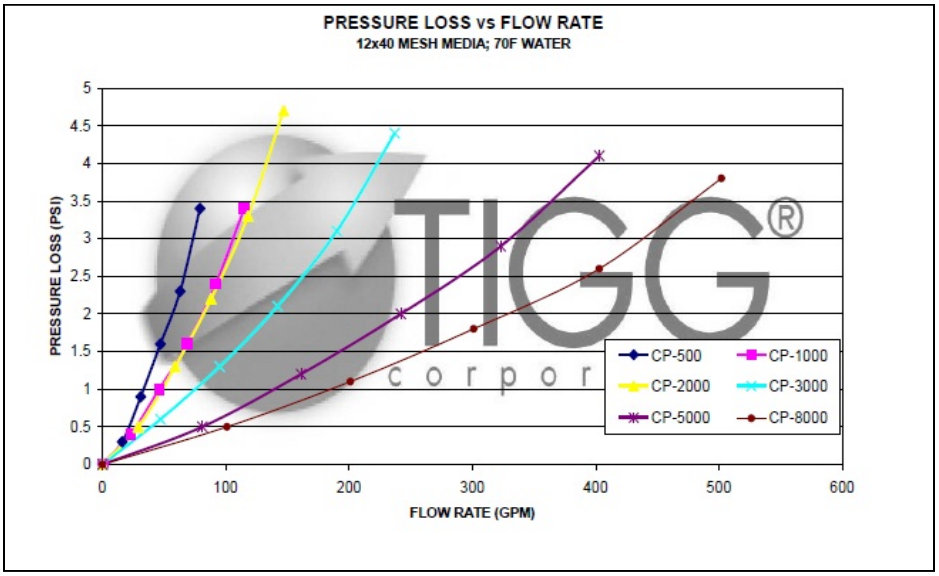
MINIMUM SYSTEM INITIAL PRESSURE, PSIA	14.7
MINIMUM STATIC HEAD, PSI	0.9
LINE FRICTION LOSS AT DESIGN FLOW, PSI	0.4
OTHER LOSSES, NET, PSI	0.0
LIQUID VAPOR PRESSURE, PSIA	0.5
NET POSITIVE SUCTION HEAD AVAILABLE, PSIA	14.7
NET POSITIVE SUCTION HEAD AVAILABLE, FT.	34
NPSHa SAFETY FACTOR, FT.	3
CORRECTED NPSHa, FT.	**30.9**

* CALCULATION OF K FACTOR BASED ON 2-K METHOD.

NOTES:

See "Key assumptions" worksheet.


Potential Provisional Equipment
Conditioned Water Storage Tank(s)
Elevation Gain = 112 feet (702'-590')
Duplex Filters (in series)
Activated Carbon Vessels
Remedy-produced Water ConditioningPlant Building
PI
M
Influent Storage Tanks (typ. of 4)
Filter Feed Pump 35 gpm



2

Figure -1-CARBON VESSEL PRESSURE DROP CURVE

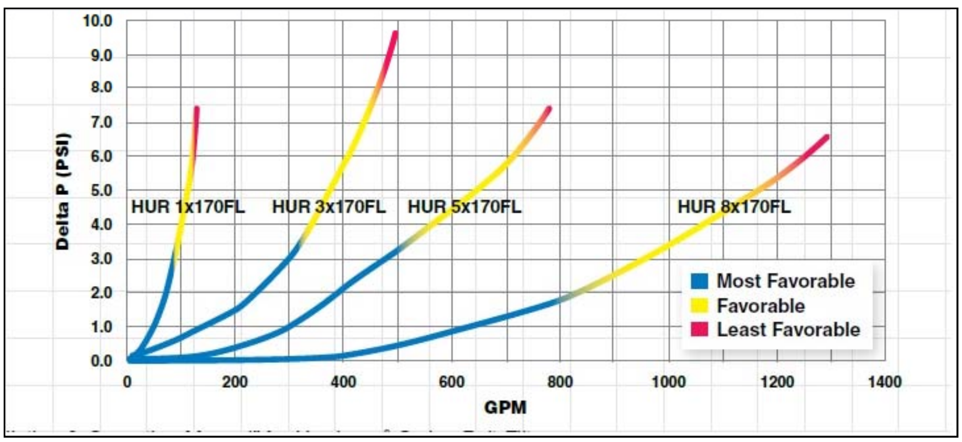


Figure -2-CARTRIDGE FILTER PRESSURE DROP CURVE

CH2MHILL	**Job Name:** TOPOCK GROUNDWATER CONDITIONING	**Sheet No.:** 4	
	Subject: Pump Calculation	**Date:** 10 05 2011	
	Job No.: 415087.01.05.02	**Computed By:** CHRIS ABDULJABBAR	
		Checked By: JOHN PORCELLA	

Assumptions:

1. Process piping will be Schedule 80 CPVC. Schedule 40 steel assumed for calculation.
2. Pump location will be 600 feet from building with filters. This will be in the TCS Lower Yard.
3. Lower Yard is 112 feet below the elevation of the filter building (Remedy Wastewater Treatment Buildiing).
4. The number of pipe fittings and valves is approximate and will be revised in subsequent submittals. This is because tank and equipment locations are not finalized.
5. Filter pressure drop based on Harmsco HUR 1x170 curves (see separate sheet) with a combined value of 2.5 psi.
6. Activated carbon vessel are assumed to be conditionally needed. Vessel pressure drop based on TIGG pressure drop curves for CP-500 vessels (2 in series) with a combined value of 2 psi.

Results: 80 psi x 2.31 '/psi = 185 feet tdh.
BHP = 2.7 hp
Assume 5 hp pump is required.

Remedy-produced Water Conditioning Process - Caustic Usage

Calculation Cover Sheet

ES-P04-03-F03 Calculation Sign Off Form

CH2MHILL

Project Name/Title:	PG&E Topock Final Groundwater Remedy Design	Project Number:	415087.01.05.02
Document Name:	Preliminary Design - Basis of Design Report - Appendix C	Preparer Name:	John Porcella
Project Manager:	Christina Hong	Design Manager:	John Porcella

Calculation Title:	Remedy WW Treatment Plant - Caustic Feed Usage					
Calculation Identifier:						
Date Prepared	Rev. No.	Preparer Signature/Date		Checker Signature/Date		*For Professional Seal When Required*
26-Oct	1	John Porcella	26-Oct-11	Ken Martins	10-Nov-11	
STC/SME Signature/Date						
LTR Signature/Date (if required)						
Comments:						
Information Requiring Confirmation:						

Problem Statement
Calculate caustic usage to neutralize first flush well rehabilitation water to 1) calculate caustic usage

Given/Assumptions
1. 700,000 gallons per year of first flush water (Table F-1)
2. First flush water is pH 2.1 and final pH is 7.0
3. Hydrochloric acid (32%) is used for acidifying well water from ambient conditions to dissolve precipitated minerals
4. Ambient concentrations based on IW-3 backwash water chemical analysis of samples collected 10/5/11 ("Raw Data")

Method
Use Stream Analyzer by OLI Systems to perform pH adjustment (http://www.olisystems.com/new-streamanalyzer.shtml)
Uses electrolyte thermodynamic equations to calculate equilibrium concentrations.
Results shown on "Stream Analyzer Modeling" worksheet
Screenshot 1 - Starting conditions
Screenshots 2/3 - acidifying process in two different pH ranges (pH on y-axis; ratio of acid volume (L) to million liters of water)
Screenshots 4/5 - neutralizing process in two different pH ranges (pH on y-axis; ratio of NaOH volume (L) to million liters of water)

Caustic Usage

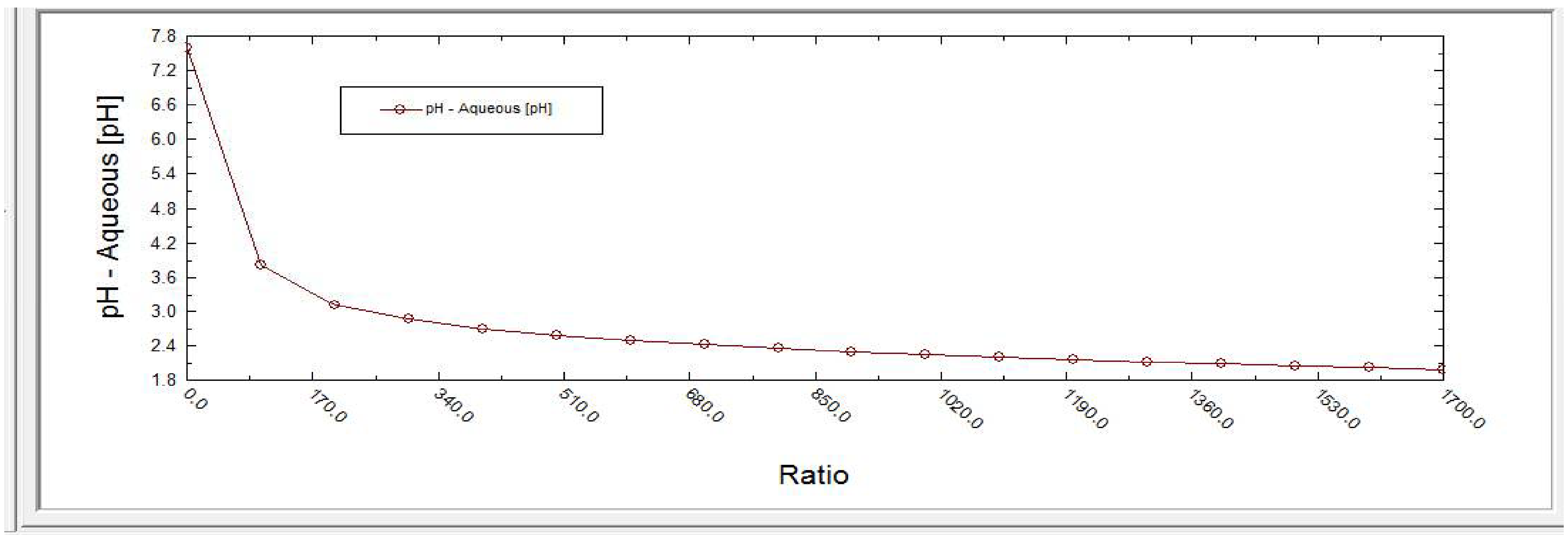
1850 L	25% caustic
to	
1e6 L	well water
700,000	gallons/year first flush water
3.7854	L/gal
2,649,788	Liters/year first flush water
4,902	Liters/year of 25% caustic
$\boxed{1,295}$	$\boxed{\text{gal/year of 25\% caustic}}$
1.15	specific gravity 25% caustic
8.34	lbs/gal
12,420	lbs/year caustic

SCREEN SHOT #1

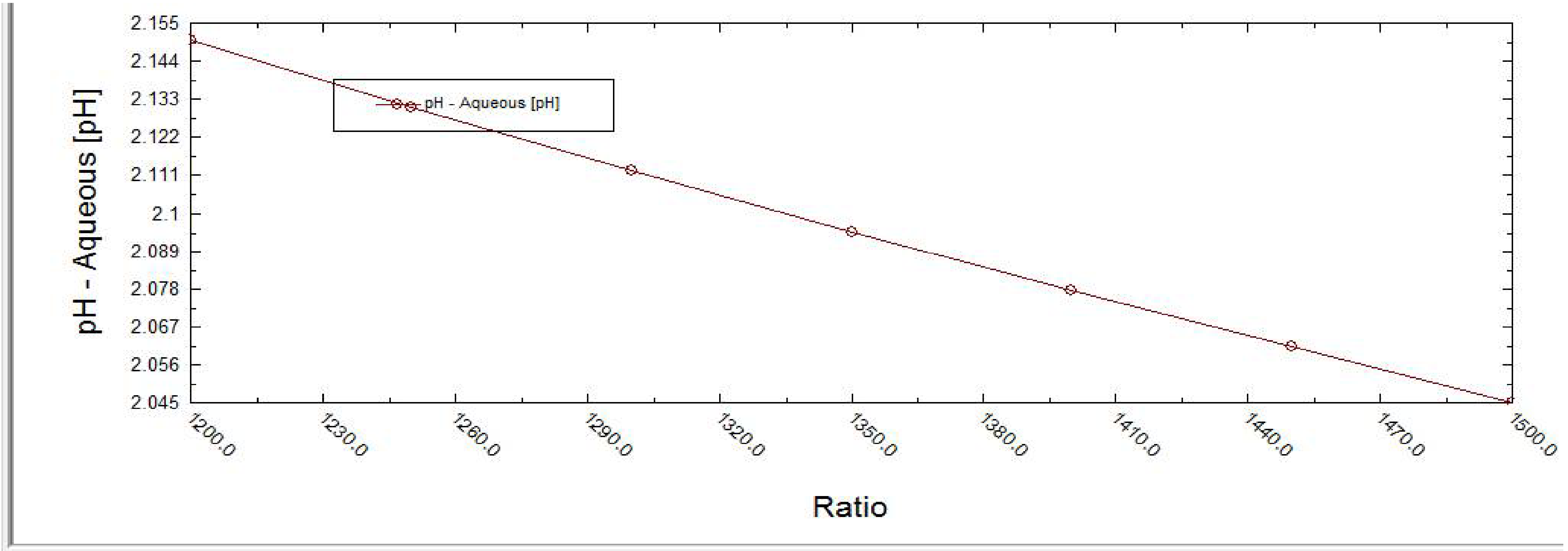
Description | Reconciliation | Molecular Basis | Report

Variable	Unit	Value
Known: pH - Aqueous	pH	7.60000
pH Acid Titrant: Carbon dioxide		
pH Base Titrant: Sodium hydroxide		
Neutrals		
Water		
Carbon dioxide	mg/L	0.0
Sodium hydroxide	mg/L	0.0
Cations		
Calcium ion(+2)	mg/L	95.0000
Magnesium ion(+2)	mg/L	22.0000
Sodium ion(+1)	mg/L	940.000
Strontium ion(+2)	mg/L	3.20000
Potassium ion(+1)	mg/L	10.0000
Anions		
Chloride ion(-1)	mg/L	2200.00
Nitrate ion(-1)	mg/L	2.60000
Sulfate ion(-2)	mg/L	490.000
Bicarbonate ion(-1)	mg/L	40.0000

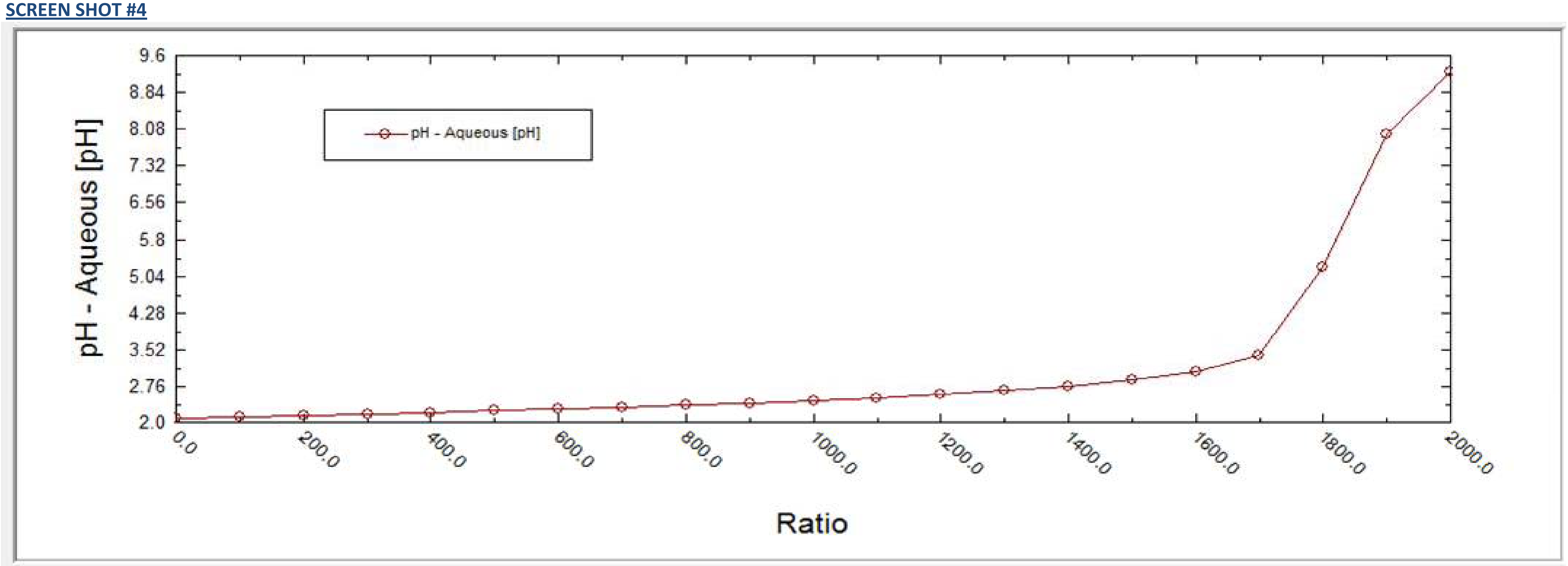
SCREEN SHOT #2



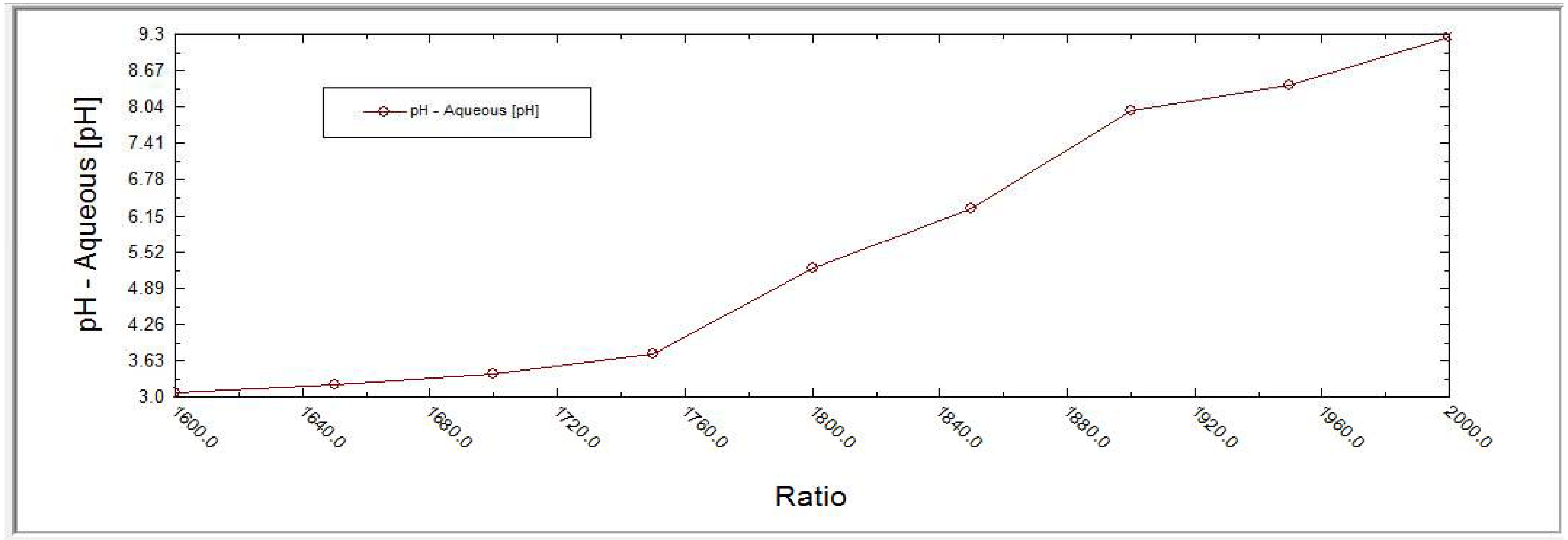
SCREEN SHOT #3



SCREEN SHOT #4



SCREEN SHOT #5



Method	Analyte	Final Result	Final Validation Flag	Reporting Limit	Units
E120.1	EC	7200		0.1	µmhos/cm
E180.1	Turbidity	0.1		0.1	NTU
E218.6	Hexavalent Chromium	1	U	1	ug/L
E300.0	Chloride	2200		250	mg/L
E300.0	Fluoride	5	U	5	mg/L
E300.0	Nitrate as N	2.6		1	mg/L
E300.0	Nitrogen, Nitrite	25	U	25	mg/L
E300.0	Sulfate	490		50	mg/L
E365.3	Phosphorus, Total (As P)	0.02	U	0.02	mg/L
SM2320B	Alkalinity	40		5	mg/L
SM2320B	Alkalinity, Bicarbonate (As CaCO3)	40		5	mg/L
SM2320B	Alkalinity, Carbonate (As CaCO3)	5	UJ	5	mg/L
SM2320B	Alkalinity, Hydroxide (As CaCO3)	5	U	5	mg/L
SM2540C	Total Dissolved Solids	3700		50	mg/L
SM2540D	Suspended Solids (Residue, Non-Filterable)	10	U	10	mg/L
SM4500-HB	pH	7.6	H=	0.1	pH Units
SM4500NH3C	Nitrogen, Ammonia (As N)	0.1	U	0.1	mg/L
SM5310C	Total Organic Carbon	1	U	1	mg/L
SW6010B	Aluminum	50	U	50	ug/L
SW6010B	Antimony	10	U	10	ug/L
SW6010B	Barium	7.6		3	ug/L
SW6010B	Beryllium	1	U	1	ug/L
SW6010B	Boron	740		100	ug/L
SW6010B	Cadmium	3	U	3	ug/L
SW6010B	Calcium	95000		500	ug/L
SW6010B	Chromium	1	U	1	ug/L
SW6010B	Cobalt	3	U	3	ug/L
SW6010B	Copper	5	U	5	ug/L
SW6010B	Iron	20	U	20	ug/L
SW6010B	Iron, dissolved	20	U	20	ug/L
SW6010B	Lead	10	U	10	ug/L
SW6010B	Magnesium	22000		100	ug/L
SW6010B	Manganese	10	U	10	ug/L
SW6010B	Manganese, dissolved	10	U	10	ug/L
SW6010B	Molybdenum	9.2		5	ug/L
SW6010B	Nickel	5	U	5	ug/L
SW6010B	Potassium	10000		5000	ug/L
SW6010B	Silver	3	U	3	ug/L
SW6010B	Sodium	940000		50000	ug/L
SW6010B	Strontium	3200		2500	ug/L
SW6010B	Vanadium	3	U	3	ug/L
SW6010B	Zinc	10	U	10	ug/L
SW6020A	Arsenic	0.12		0.1	ug/L
SW6020A	Selenium	2.8		0.5	ug/L
SW6020A	Thallium	0.5	U	0.5	ug/L
SW7470A	Mercury	0.2	U	0.2	ug/L

Freshwater Injection/ Remedy-Produced Water Collection/ Conditioned Remedy Water Distribution and Disposal Hydraulic Network Modeling Calculations from EPANET Software

Calculation Cover Sheet

ES-P04-03-F03 Calculation Sign Off Form

Project Name/Title:	Topock Remediation	Project Number:	415087
Document Name:	Freshwater System Hydraulic network Calculations	Preparer Name:	Paul Tjogas, E2 Consulting Engineers
Project Manager:	Christina Hong	Design Manager:	John Porcella

Calculation Title:	Hydraulic Analysis of Freshwater Injection					
Calculation Identifier:						
Date Prepared	Rev. No.	Preparer Signature/Date		Checker Signature/Date		*For Professional Seal When Required*
11-Oct-11	0	Paul Tjogas	11-Oct-11	Sarah Isbell	17-Oct-11	
STC/SME Signature/Date						
LTR Signature/Date (if required)						
Comments:						

Information Requiring Confirmation:

Topock Remediation Design

Hydraulic analysis of Freshwater Injection System

The piping for the freshwater injection system on the Topock Remediation project was sized from simulations of a hydraulic network model of the system. The hydraulic network model of the freshwater injection system proposed for Topock remediation was constructed using EPANET. EPANET is software that models water distribution piping systems. EPANET tracks the flow of water at each pipe, the pressure at each node, pumping heads and levels of water in tanks and reservoirs. Chemical species can be tracked, although that was not needed for the freshwater system at Topock.

Pipe junctions, reservoirs and tanks are represented as nodes. A listing of nodes is contained on the following pages. Pipes, pumps and valves are represented as links. A listing of links is contained on the pages following the node listing. A map showing the location of all nodes and links is shown on the sheet following the links listing.

The piping routes and corridors have been approved by the client, Pacific Gas & Electric; however, they are subject to change pending stakeholder and regulatory review. The following summary describes the development of the hydraulic model:

Junction nodes, tanks and wells (modeled as pumps attached to an underground reservoir) have been located by coordinates from an aerial survey conducted by Toponex, a subcontractor to PG & E. Some liberties were taken with underground reservoir (well) locations to make the node and link map more legible, however, this did not affect the accuracy of the analysis as exact coordinates were used in model simulations. A summary of the model development is as follows:

Ground elevations for pipe junctions, reservoirs, wells and tanks are taken from the Toponex aerial survey.

Pipe lengths have been taken off from plan and profile drawings.

Probable maximum flows are used for demands. The following demands are used:

- Freshwater Injection Well no. 1 (node FW-INJ-1) = 200 gpm
- Freshwater Injection Well no. 2 (node FW-INJ-2) = 200 gpm
- Freshwater Injection Well no. 4 (node FW-INJ-3) = 200 gpm (Note, FW-INJ-3 was eliminated)
- Upgradient injection Well no. 1 (node UPGRAD-INJ-1, carbon amendment well) = 0 gpm during the maximum condition
- Upgradient injection Well no. 2 (node UPGRAD-INJ-2, carbon amendment well) =200 gpm during the maximum condition
- Upgradient injection Well no. 3 (node UPGRAD-INJ-3) = 200 gpm during the maximum condition
- Upgradient injection Well no. 4 (node UPGRAD-INJ-4) = 200 gpm during the maximum condition
- Topock Compressor Station (node TCS) = 110 gpm

- Transwestern bench service (node 30) = 0 gpm – flows are too trivial and sporadic to consider as part of the maximum case
- MW-20 bench service (node 5) = 0 gpm – flows are too trivial and sporadic to consider as part of the maximum case
- Compressor Station Injection Well no. 1 (node COMP-INJ-1, carbon amendment well) = 37.5 gpm
- Compressor Station Injection Well no. 2 (node COMP-INJ-2, carbon amendment well) = 37.5 gpm
- Topock residential customers (node 23) = 5 gpm

Upgradient injection wells no 3 and 4 and Compressor Station injection wells no. 1 and 2 are normally fed with carbon amended water from the floodplain extracted wells, but will be designed to accept freshwater as a backup measure.

Injection wells will be fed from a pressure reducing valve (PRV). Minimum pressure upstream of the PRV is to be 8 psi.

There are three sources of supply. All are existing wells located in Arizona (where water quality is more suitable for freshwater injection). Two of the wells currently discharge to PG & E's water system.

- Havasu National Wildlife Refuge well (node HNWR-1 and pump 201) currently supplies a revegetation project in Topock marsh. A new 12 inch diameter transmission main is proposed to connect this well to the existing PG & E freshwater tanks. A manufacturer's pump curve was used to model this pump. The pumping well level has been observed to be about 410 feet (above sea level) and this was used for the analysis.
- Topock 2 and 3 currently supply PG & E's Topock Compressor Station with a 6 inch diameter pipe to the existing freshwater tanks. A manufacturer's pump curve was used to model this pump. The pumping well levels are not known for these wells. A level of 400 feet was assumed based on observations from similar wells.

There are two existing fresh water tanks located above TCS at a base elevation of 672 feet (above sea level). Each tank is 30 feet high and contains 210,000 gallons. A minimum tank level of 2 feet and maximum tank level of 28 feet was assumed for this analysis.

Hazen-Williams C value of 130 was assumed for all pipes.

Pipe sizing is an iterative process. After the initial simulation, pipe diameters for various segments of pipes are increased or decreased for subsequent simulations until an optimum size is selected for each segment. The criterion used for determining optimum size was based on unit head loss. In general, unit head losses of between 1 to 10 feet per 1,000 foot of pipe length yield the optimal combination of pipe capital cost and pumping energy costs. This was the criteria used to size most of the pipes. The only exceptions to this were for 1) short segments of pipes, such as pumping manifolds and 2) dead end pipes connected to injection wells. In the latter case, there was excess pressure which would have been dissipated in the pressure reducing valve. A larger pipe size does not serve any purpose in this case.

The freshwater system was modeled as a looped configuration without the extracted water system attached, unlooped configuration and as a looped configuration with the extracted water system attached. Low water levels (in the existing freshwater storage tanks) and high water levels were simulated for each of the three configurations. The results from these simulations were compared. The looped configuration without the extracted water system governs freshwater system design. Input data, output simulation results and system map schematic for all three configurations are contained in the following sections.

The combined pumping capacity of the existing well pumps at HNWR-1, Topock 2 and 3 were not sufficient to meet probable maximum system demands. During subsequent simulations, it was determined that the well pumping capacity at HNWR-1 well would need to be increased to approximately 950 gpm to accommodate probable maximum system demands.

Freshwater Injection System (Looped) - Junction, Reservoir and Tank Data

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM
Junc 6	493	0
Junc 20	551	0
Junc 11	555	0
Junc 28	572	0
Junc 10	530	0
Junc 2	510	0
Junc 1	478	0
Junc 3	509	0
Junc 9	488	0
Junc 17	555	0
Junc 19	595	0
Junc 27	620	0
Junc 4	508	0
Junc 5	496	0
Junc 7	481	0
Junc 8	469	0
Junc 13	588	0
Junc 14	620	0
Junc 15	501	0

Freshwater Injection System (Looped) - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc 16	554	0
Junc 18	571	0
Junc 12	572	0
Junc 29	672	0
Junc 30	536	0
Junc 21	519.7	0
Junc 25	502	0
Junc 22	506	0
Junc 23	502	5
Junc 24	502	0
Junc 26	628	0
Junc TCS	620	110
Junc FW-INJ-1	488	200
Junc UPGRAD-INJ-1	501	0
Junc UPGRAD-INJ-2	554	200
Junc FW-INJ-2	551	200
Junc UPGRAD-INJ-3	571	200
Junc UPGRAD-INJ-4	595	200
Junc FW-INJ-4	572	200
Junc COMP-INJ-1	620	37.5

Freshwater Injection System (Looped) - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc COMP-INJ-2	588	37.5
Resvr Topock2&3	410	#N/A
Resvr HNWR-1	400	#N/A
Tank 104	672	#N/A
Tank 103	672	#N/A

Freshwater Injection System (Looped) - Pipe, Pump and Valve Data

Network Table - Links

Link ID	Length ft	Diameter in	Roughness
Pipe 9	1756	6	130
Pipe 12	941	8	130
Pipe 19	580	4	130
Pipe 1	5068	12	130
Pipe 2	728	6	130
Pipe 3	416	6	130
Pipe 16	224	6	130
Pipe 22	1820	6	130
Pipe 8	308	4	130
Pipe 7	439	4	130
Pipe 6	1019	4	130
Pipe 5	743	6	130
Pipe 4	1328	6	130
Pipe 18	1016	6	130
Pipe 15	399	8	130
Pipe 14	330	8	130
Pipe 13	783	8	130
Pipe 17	312	6	130
Pipe 10	2013	8	130

Freshwater Injection System (Looped) - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Pipe 11	280	8	130
Pipe 20	249	3	130
Pipe 21	196	2	130
Pipe 23	510	2	130
Pipe 24	2842	6	130
Pipe 25	17	8	130
Pipe 26	229	8	130
Pipe 27	284	4	130
Pipe 28	3458	6	130
Pipe 29	112	12	130
Pipe 30	92	6	130
Pipe 31	20	6	130
Pipe 32	20	6	130
Pipe 33	900	4	130
Pump 201	#N/A	#N/A	#N/A
Pump 202	#N/A	#N/A	#N/A
Pump 203	#N/A	#N/A	#N/A
Valve 301	#N/A	4	#N/A
Valve 302	#N/A	4	#N/A
Valve 303	#N/A	4	#N/A

Freshwater Injection System (Looped) - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Valve 304	#N/A	4	#N/A
Valve 305	#N/A	4	#N/A
Valve 306	#N/A	4	#N/A
Valve 307	#N/A	4	#N/A
Valve 308	#N/A	2	#N/A
Valve 309	#N/A	2	#N/A

Freshwater Injection System
Link Tabulation

Link	Type	Start Node	End Node
1	Pipe	2	1
2	Pipe	3	2
3	Pipe	3	4
4	Pipe	4	5
5	Pipe	5	6
6	Pipe	6	7
7	Pipe	7	8
8	Pipe	9	8
9	Pipe	6	10
10	Pipe	11	10
11	Pipe	12	11
12	Pipe	27	12
13	Pipe	10	15
14	Pipe	15	16
15	Pipe	16	17
16	Pipe	17	18
17	Pipe	18	19
18	Pipe	17	20
19	Pipe	11	28
20	Pipe	12	13
21	Pipe	13	14
22	Pipe	27	2
23	Pipe	3	30
24	Pipe	21	22
25	Pipe	22	23
26	Pipe	23	24
27	Pipe	24	25
28	Pipe	25	26
29	Pipe	27	29
30	Pipe	26	29
31	Pipe	29	103
32	Pipe	29	104
33	Pipe	26	TCS
201	Pump	HNWR-1	1
202	Pump	Topock2&3	21
203	Pump	Topock2&3	21
301	Valve	9	FW-INJ-1
302	Valve	15	UPGRAD-INJ-1
303	Valve	16	UPGRAD-INJ-2
304	Valve	20	FW-INJ-2
305	Valve	18	UPGRAD-INJ-3
306	Valve	19	UPGRAD-INJ-4
307	Valve	28	FW-INJ-4
308	Valve	14	COMP-INJ-1
309	Valve	13	COMP-INJ-2

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	650.74	68.35
Junc 20	0.00	623.45	31.39
Junc 11	0.00	657.43	44.38
Junc 28	0.00	641.69	30.20
Junc 10	0.00	643.55	49.20
Junc 2	0.00	696.30	80.73
Junc 1	0.00	704.57	98.17
Junc 3	0.00	685.99	76.69
Junc 9	0.00	602.82	49.75
Junc 17	0.00	627.28	31.32
Junc 19	0.00	623.06	12.16
Junc 27	0.00	673.90	23.36
Junc 4	0.00	680.09	74.57
Junc 5	0.00	661.27	71.61
Junc 7	0.00	623.09	61.57
Junc 8	0.00	611.18	61.61
Junc 13	0.00	656.28	29.59

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 14	0.00	649.27	12.68
Junc 15	0.00	634.09	57.67
Junc 16	0.00	630.11	32.98
Junc 18	0.00	624.23	23.07
Junc 12	0.00	660.74	38.45
Junc 29	0.00	673.98	0.86
Junc 30	0.00	685.99	64.99
Junc 21	0.00	809.51	125.57
Junc 25	0.00	729.83	98.72
Junc 22	0.00	763.34	111.51
Junc 23	5.00	763.28	113.21
Junc 24	0.00	762.38	112.82
Junc 26	0.00	674.83	20.29
Junc TCS	110.00	666.76	20.26
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-440.43	410.00	0.00
Resvr HNWR-1	-788.31	400.00	0.00
Tank 104	-80.63	674.00	0.87
Tank 103	-80.63	674.00	0.87

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	209.17	2.37	4.09	0.023	Open
Pipe 12	865.83	5.53	13.99	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-788.31	2.24	1.63	0.021	Open
Pipe 2	-409.17	4.64	14.17	0.021	Open
Pipe 3	409.17	4.64	14.17	0.021	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-379.14	4.30	12.31	0.021	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	409.17	4.64	14.17	0.021	Open
Pipe 4	409.17	4.64	14.17	0.021	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	590.83	3.77	6.89	0.021	Open
Pipe 11	790.83	5.05	11.83	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	440.43	5.00	16.24	0.021	Open
Pipe 25	440.43	2.81	4.00	0.022	Open
Pipe 26	435.43	2.78	3.92	0.022	Open
Pipe 27	435.43	11.12	114.61	0.020	Open
Pipe 28	435.43	4.94	15.90	0.021	Open
Pipe 29	-486.69	1.38	0.67	0.023	Open
Pipe 30	325.43	3.69	9.27	0.022	Open
Pipe 31	-80.63	0.91	1.03	0.039	Open
Pipe 32	-80.63	0.91	1.03	0.039	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	788.31	0.00	-304.57	0.000	Open
Pump 202	220.21	0.00	-399.51	0.000	Open

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump 203	220.21	0.00	-399.51	0.000	Open
Valve 301	200.00	5.11	96.36	0.000	Active
Valve 302	0.00	0.00	114.63	0.000	Active
Valve 303	200.00	5.11	57.64	0.000	Active
Valve 304	200.00	5.11	53.99	0.000	Active
Valve 305	200.00	5.11	34.77	0.000	Active
Valve 306	200.00	5.11	9.59	0.000	Active
Valve 307	200.00	5.11	51.23	0.000	Active
Valve 308	37.50	3.83	10.81	0.000	Active
Valve 309	37.50	3.83	49.82	0.000	Active

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Network Table - Nodes

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc 6	493	0.00	656.82	70.98
Junc 20	551	0.00	626.70	32.80
Junc 11	555	0.00	658.94	45.04
Junc 28	572	0.00	643.20	30.85
Junc 10	530	0.00	646.80	50.61
Junc 2	510	0.00	711.25	87.20
Junc 1	478	0.00	722.92	106.12
Junc 3	509	0.00	698.93	82.29
Junc 9	488	0.00	608.91	52.39
Junc 17	555	0.00	630.52	32.72
Junc 19	595	0.00	626.30	13.56
Junc 27	620	0.00	673.96	23.38
Junc 4	508	0.00	691.88	79.68
Junc 5	496	0.00	669.40	75.13
Junc 7	481	0.00	629.18	64.20
Junc 8	469	0.00	617.27	64.24
Junc 13	588	0.00	657.48	30.10
Junc 14	620	0.00	650.47	13.20
Junc 15	501	0.00	637.34	59.08

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc 16	554	0.00	633.35	34.38
Junc 18	571	0.00	627.48	24.47
Junc 12	572	0.00	661.94	38.97
Junc 29	672	0.00	674.00	0.87
Junc 30	536	0.00	698.93	70.60
Junc 21	519.7	0.00	809.52	125.58
Junc 25	502	0.00	729.84	98.73
Junc 22	506	0.00	763.36	111.51
Junc 23	502	5.00	763.29	113.22
Junc 24	502	0.00	762.39	112.83
Junc 26	628	0.00	674.85	20.30
Junc TCS	620	110.00	666.78	20.27
Junc FW-INJ-1	488	200.00	506.46	8.00
Junc UPGRAD-INJ-1	501	0.00	519.46	8.00
Junc UPGRAD-INJ-2	554	200.00	572.46	8.00
Junc FW-INJ-2	551	200.00	569.46	8.00
Junc UPGRAD-INJ-3	571	200.00	589.46	8.00
Junc UPGRAD-INJ-4	595	200.00	613.46	8.00
Junc FW-INJ-4	572	200.00	590.46	8.00
Junc COMP-INJ-1	620	37.50	638.46	8.00

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	588	37.50	606.46	8.00
Resvr Topock2&3	410	-440.41	410.00	0.00
Resvr HNWR-1	400	-949.59	400.00	0.00
Tank 104	672	0.00	674.00	0.87
Tank 103	672	0.00	674.00	0.87

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	250.37	2.84	5.71	0.023	Open
Pipe 12	824.63	5.26	12.78	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-949.59	2.69	2.30	0.020	Open
Pipe 2	-450.37	5.11	16.93	0.021	Open
Pipe 3	450.37	5.11	16.93	0.021	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-499.22	5.66	20.49	0.021	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	450.37	5.11	16.93	0.021	Open
Pipe 4	450.37	5.11	16.93	0.021	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	549.63	3.51	6.03	0.021	Open

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	749.63	4.78	10.71	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	440.41	5.00	16.24	0.021	Open
Pipe 25	440.41	2.81	4.00	0.022	Open
Pipe 26	435.41	2.78	3.92	0.022	Open
Pipe 27	435.41	11.12	114.61	0.020	Open
Pipe 28	435.41	4.94	15.90	0.021	Open
Pipe 29	-325.41	0.92	0.32	0.024	Open
Pipe 30	325.41	3.69	9.27	0.022	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	949.59	0.00	-322.92	0.000	Open
Pump 202	220.21	0.00	-399.52	0.000	Open
Pump 203	220.21	0.00	-399.52	0.000	Open
Valve 301	200.00	5.11	102.45	0.000	Active
Valve 302	0.00	0.00	117.88	0.000	Active
Valve 303	200.00	5.11	60.89	0.000	Active

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, Low Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 304	200.00	5.11	57.24	0.000	Active
Valve 305	200.00	5.11	38.02	0.000	Active
Valve 306	200.00	5.11	12.84	0.000	Active
Valve 307	200.00	5.11	52.74	0.000	Active
Valve 308	37.50	3.83	12.01	0.000	Active
Valve 309	37.50	3.83	51.01	0.000	Active

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	635.54	61.76
Junc 20	0.00	611.13	26.05
Junc 11	0.00	651.68	41.89
Junc 28	0.00	635.95	27.71
Junc 10	0.00	617.21	37.79
Junc 2	0.00	700.20	82.41
Junc 1	0.00	708.15	99.72
Junc 3	0.00	695.85	80.96
Junc 9	0.00	628.89	61.05
Junc 17	0.00	614.95	25.98
Junc 19	0.00	613.91	8.20
Junc 27	0.00	699.90	34.62
Junc 4	0.00	685.76	77.02
Junc 5	0.00	653.55	68.27
Junc 7	0.00	631.70	65.30
Junc 8	0.00	630.05	69.78
Junc 13	0.00	656.66	29.75

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 14	0.00	649.65	12.85
Junc 15	0.00	615.90	49.79
Junc 16	0.00	615.34	26.58
Junc 18	0.00	614.20	18.72
Junc 12	0.00	661.12	38.62
Junc 29	0.00	699.98	12.13
Junc 30	0.00	695.85	69.26
Junc 21	0.00	854.95	145.26
Junc 25	0.00	763.90	113.48
Junc 22	0.00	802.23	128.36
Junc 23	5.00	802.15	130.06
Junc 24	0.00	801.13	129.61
Junc 26	0.00	701.00	31.63
Junc TCS	110.00	692.93	31.60
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-473.17	410.00	0.00
Resvr HNWR-1	-772.04	400.00	0.00
Tank 104	-72.39	700.00	12.13
Tank 103	-72.39	700.00	12.13

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	346.83	3.94	10.44	0.022	Open
Pipe 12	728.17	8.26	41.22	0.019	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-772.04	2.19	1.57	0.021	Open
Pipe 2	-546.83	3.49	5.97	0.021	Open
Pipe 3	546.83	6.20	24.25	0.020	Open
Pipe 16	400.00	2.55	3.35	0.022	Open
Pipe 22	-225.21	0.64	0.16	0.025	Open
Pipe 8	-200.00	2.27	3.76	0.024	Open
Pipe 7	200.00	2.27	3.76	0.024	Open
Pipe 6	200.00	2.27	3.76	0.024	Open
Pipe 5	546.83	6.20	24.25	0.020	Open
Pipe 4	546.83	6.20	24.25	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	1.70	0.98	0.022	Open
Pipe 14	800.00	2.27	1.68	0.021	Open
Pipe 13	800.00	2.27	1.68	0.021	Open

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 17	200.00	1.28	0.93	0.024	Open
Pipe 10	453.17	5.14	17.12	0.021	Open
Pipe 11	653.17	7.41	33.70	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	473.17	5.37	18.55	0.021	Open
Pipe 25	473.17	3.02	4.57	0.022	Open
Pipe 26	468.17	2.99	4.48	0.022	Open
Pipe 27	468.17	11.95	131.08	0.020	Open
Pipe 28	468.17	5.31	18.19	0.021	Open
Pipe 29	-502.96	1.43	0.71	0.022	Open
Pipe 30	358.17	4.06	11.08	0.022	Open
Pipe 31	-72.39	0.82	0.84	0.040	Open
Pipe 32	-72.39	0.82	0.84	0.040	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	772.04	0.00	-308.15	0.000	Open
Pump 202	328.96	0.00	-444.95	0.000	Open

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump 203	144.21	0.00	-444.95	0.000	Open
Valve 301	200.00	5.11	122.42	0.000	Active
Valve 302	0.00	0.00	96.44	0.000	Active
Valve 303	200.00	5.11	42.88	0.000	Active
Valve 304	200.00	5.11	41.66	0.000	Active
Valve 305	200.00	5.11	24.74	0.000	Active
Valve 306	200.00	5.11	0.45	0.000	Active
Valve 307	200.00	5.11	45.48	0.000	Active
Valve 308	37.50	3.83	11.19	0.000	Active
Valve 309	37.50	3.83	50.20	0.000	Active

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	635.86	61.90
Junc 20	0.00	611.38	26.16
Junc 11	0.00	651.83	41.96
Junc 28	0.00	636.09	27.77
Junc 10	0.00	617.46	37.90
Junc 2	0.00	700.69	82.62
Junc 1	0.00	711.62	101.23
Junc 3	0.00	696.33	81.17
Junc 9	0.00	629.21	61.19
Junc 17	0.00	615.21	26.09
Junc 19	0.00	614.17	8.30
Junc 27	0.00	699.96	34.65
Junc 4	0.00	686.21	77.22
Junc 5	0.00	653.93	68.43
Junc 7	0.00	632.03	65.44
Junc 8	0.00	630.37	69.92
Junc 13	0.00	656.79	29.81

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 14	0.00	649.78	12.90
Junc 15	0.00	616.15	49.90
Junc 16	0.00	615.60	26.69
Junc 18	0.00	614.46	18.83
Junc 12	0.00	661.25	38.67
Junc 29	0.00	700.00	12.13
Junc 30	0.00	696.33	69.47
Junc 21	0.00	854.96	145.27
Junc 25	0.00	763.91	113.49
Junc 22	0.00	802.24	128.36
Junc 23	5.00	802.17	130.06
Junc 24	0.00	801.14	129.62
Junc 26	0.00	701.02	31.64
Junc TCS	110.00	692.95	31.61
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-473.16	410.00	0.00
Resvr HNWR-1	-916.84	400.00	0.00
Tank 104	0.00	700.00	12.13
Tank 103	0.00	700.00	12.13

HNWR-1, Topock 2 and 3 wells are all operational

Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	347.58	3.94	10.48	0.022	Open
Pipe 12	727.42	8.25	41.14	0.019	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-916.84	2.60	2.16	0.021	Open
Pipe 2	-547.58	3.50	5.99	0.021	Open
Pipe 3	547.58	6.21	24.31	0.020	Open
Pipe 16	400.00	2.55	3.35	0.022	Open
Pipe 22	-369.26	1.05	0.40	0.024	Open
Pipe 8	-200.00	2.27	3.76	0.024	Open
Pipe 7	200.00	2.27	3.76	0.024	Open
Pipe 6	200.00	2.27	3.76	0.024	Open
Pipe 5	547.58	6.21	24.31	0.020	Open
Pipe 4	547.58	6.21	24.31	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	1.70	0.98	0.022	Open
Pipe 14	800.00	2.27	1.68	0.021	Open
Pipe 13	800.00	2.27	1.68	0.021	Open

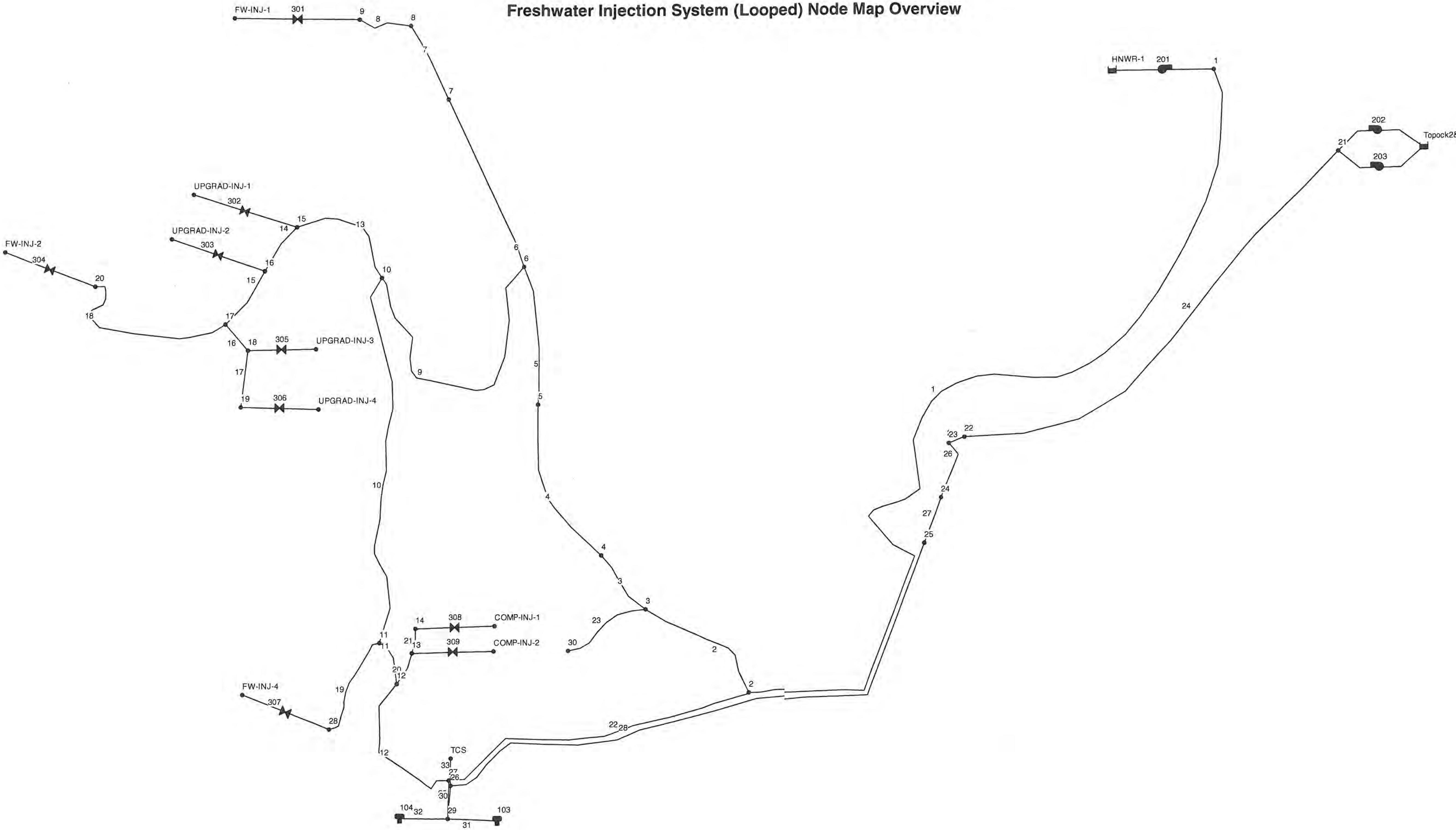
Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 17	200.00	1.28	0.93	0.024	Open
Pipe 10	452.42	5.13	17.07	0.021	Open
Pipe 11	652.42	7.40	33.63	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	473.16	5.37	18.55	0.021	Open
Pipe 25	473.16	3.02	4.57	0.022	Open
Pipe 26	468.16	2.99	4.48	0.022	Open
Pipe 27	468.16	11.95	131.08	0.020	Open
Pipe 28	468.16	5.31	18.19	0.021	Open
Pipe 29	-358.16	1.02	0.38	0.024	Open
Pipe 30	358.16	4.06	11.08	0.022	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	916.84	0.00	-311.62	0.000	Open
Pump 202	328.95	0.00	-444.96	0.000	Open

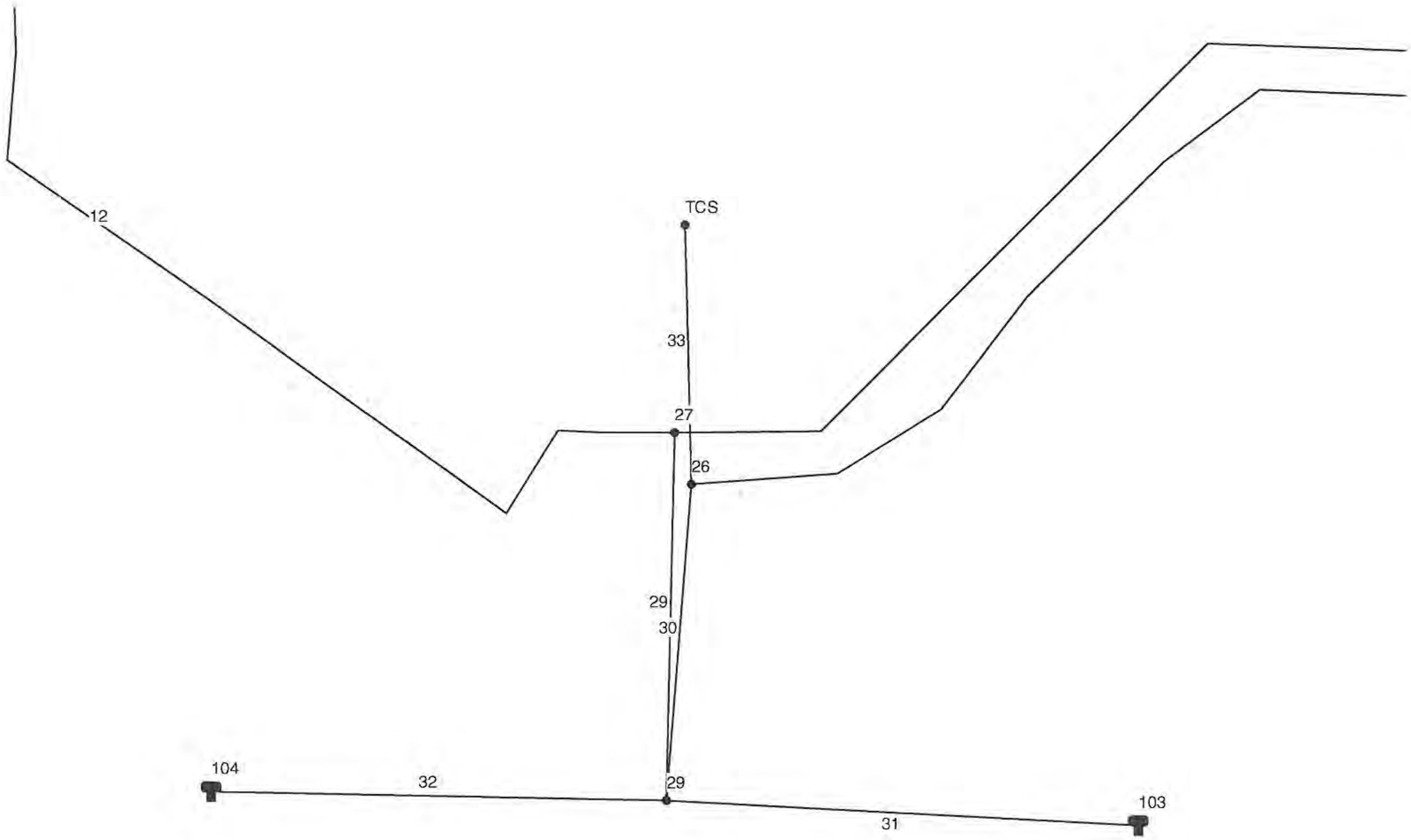
Freshwater Injection System (Looped) - Maximum Demands, High Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump 203	144.21	0.00	-444.96	0.000	Open
Valve 301	200.00	5.11	122.75	0.000	Active
Valve 302	0.00	0.00	96.69	0.000	Active
Valve 303	200.00	5.11	43.14	0.000	Active
Valve 304	200.00	5.11	41.92	0.000	Active
Valve 305	200.00	5.11	24.99	0.000	Active
Valve 306	200.00	5.11	0.70	0.000	Active
Valve 307	200.00	5.11	45.63	0.000	Active
Valve 308	37.50	3.83	11.31	0.000	Active
Valve 309	37.50	3.83	50.32	0.000	Active

Freshwater Injection System (Looped) Node Map Overview



Freshwater Injection System Node Map (zoom in of TCS area)



Topock Freshwater Injection System (Unlooped) - Junction, Reservoir and Tank Data

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM
Junc 6	493	0
Junc 20	551	0
Junc 11	555	0
Junc 28	572	0
Junc 10	530	0
Junc 2	510	0
Junc 1	478	0
Junc 3	509	0
Junc 9	488	0
Junc 17	555	0
Junc 19	595	0
Junc 27	620	0
Junc 4	508	0
Junc 5	496	0
Junc 7	481	0
Junc 8	469	0
Junc 13	588	0
Junc 14	620	0
Junc 15	501	0

Topock Freshwater Injection System (Unlooped) - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc 16	554	0
Junc 18	571	0
Junc 12	572	0
Junc 29	672	0
Junc 30	536	0
Junc 21	519.7	0
Junc 25	502	0
Junc 22	506	0
Junc 23	502	5
Junc 24	502	0
Junc 26	628	0
Junc TCS	620	110
Junc FW-INJ-1	488	200
Junc UPGRAD-INJ-1	501	0
Junc UPGRAD-INJ-2	554	200
Junc FW-INJ-2	551	200
Junc UPGRAD-INJ-3	571	200
Junc UPGRAD-INJ-4	595	200
Junc FW-INJ-4	572	200
Junc COMP-INJ-1	620	37.5

Topock Freshwater Injection System (Unlooped) - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc COMP-INJ-2	588	37.5
Resvr Topock2&3	410	#N/A
Resvr HNWR-1	400	#N/A
Tank 104	672	#N/A
Tank 103	672	#N/A

Topock Freshwater Injection System (Unlooped) - Pipe, Pump and Vallve Data

Network Table - Links

Link ID	Length ft	Diameter in	Roughness
Pipe 9	1756	10	130
Pipe 12	941	6	130
Pipe 19	580	4	130
Pipe 1	5068	12	130
Pipe 2	728	10	130
Pipe 3	416	10	130
Pipe 16	224	6	130
Pipe 22	1820	6	130
Pipe 8	308	4	130
Pipe 7	439	4	130
Pipe 6	1019	4	130
Pipe 5	743	10	130
Pipe 4	1328	10	130
Pipe 18	1016	6	130
Pipe 15	399	8	130
Pipe 14	330	8	130
Pipe 13	783	8	130
Pipe 17	312	6	130
Pipe 11	280	4	130

Topock Freshwater Injection System (Unlooped) - Pipe, Pump and Vallve Data

Link ID	Length ft	Diameter in	Roughness
Pipe 20	249	2	130
Pipe 21	196	2	130
Pipe 23	510	2	130
Pipe 24	2842	6	130
Pipe 25	17	8	130
Pipe 26	229	8	130
Pipe 27	284	4	130
Pipe 28	3458	6	130
Pipe 29	112	12	130
Pipe 30	92	6	130
Pipe 31	20	6	130
Pipe 32	20	6	130
Pipe 33	900	4	130
Pump 201	#N/A	#N/A	#N/A
Pump 202	#N/A	#N/A	#N/A
Pump 203	#N/A	#N/A	#N/A
Valve 301	#N/A	4	#N/A
Valve 302	#N/A	4	#N/A
Valve 303	#N/A	4	#N/A
Valve 304	#N/A	4	#N/A

Topock Freshwater Injection System (Unlooped) - Pipe, Pump and Vallve Data

Link ID	Length ft	Diameter in	Roughness
Valve 305	#N/A	4	#N/A
Valve 306	#N/A	4	#N/A
Valve 307	#N/A	4	#N/A
Valve 308	#N/A	2	#N/A
Valve 309	#N/A	2	#N/A

Freshwater Injection System (Unlooped)
Link Tabulation

Link	Type	Start Node	End Node
1	Pipe	2	1
2	Pipe	3	2
3	Pipe	3	4
4	Pipe	4	5
5	Pipe	5	6
6	Pipe	6	7
7	Pipe	7	8
8	Pipe	9	8
9	Pipe	6	10
11	Pipe	12	11
12	Pipe	27	12
13	Pipe	10	15
14	Pipe	15	16
15	Pipe	16	17
16	Pipe	17	18
17	Pipe	18	19
18	Pipe	17	20
19	Pipe	11	28
20	Pipe	12	13
21	Pipe	13	14
22	Pipe	27	2
23	Pipe	3	30
24	Pipe	21	22
25	Pipe	22	23
26	Pipe	23	24
27	Pipe	24	25
28	Pipe	25	26
29	Pipe	27	29
30	Pipe	26	29
31	Pipe	29	103
32	Pipe	29	104
33	Pipe	26	TCS
201	Pump	HNWR-1	1
202	Pump	Topock2&3	21
203	Pump	Topock2&3	21
301	Valve	9	FW-INJ-1
302	Valve	15	UPGRAD-INJ-1
303	Valve	16	UPGRAD-INJ-2
304	Valve	20	FW-INJ-2
305	Valve	18	UPGRAD-INJ-3
306	Valve	19	UPGRAD-INJ-4
307	Valve	28	FW-INJ-4
308	Valve	14	COMP-INJ-1
309	Valve	13	COMP-INJ-2

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	651.67	68.75
Junc 20	0.00	624.41	31.81
Junc 11	0.00	659.96	45.48
Junc 28	0.00	644.22	31.29
Junc 10	0.00	644.51	49.62
Junc 2	0.00	671.47	69.97
Junc 1	0.00	681.71	88.27
Junc 3	0.00	666.99	68.46
Junc 9	0.00	603.75	50.16
Junc 17	0.00	628.23	31.73
Junc 19	0.00	624.01	12.57
Junc 27	0.00	673.95	23.38
Junc 4	0.00	664.42	67.78
Junc 5	0.00	656.24	69.43
Junc 7	0.00	624.02	61.97
Junc 8	0.00	612.11	62.01
Junc 13	0.00	663.10	32.54
Junc 14	0.00	656.09	15.64
Junc 15	0.00	635.05	58.08

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	631.06	33.39
Junc 18	0.00	625.19	23.48
Junc 12	0.00	667.56	41.40
Junc 29	0.00	674.00	0.87
Junc 30	0.00	666.99	56.76
Junc 21	0.00	809.52	125.58
Junc 25	0.00	729.84	98.72
Junc 22	0.00	763.36	111.51
Junc 23	5.00	763.29	113.22
Junc 24	0.00	762.39	112.83
Junc 26	0.00	674.85	20.30
Junc TCS	110.00	666.78	20.27
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-440.42	410.00	0.00
Resvr HNWR-1	-884.56	400.00	0.00
Tank 104	-32.51	674.00	0.87
Tank 103	-32.51	674.00	0.87

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	800.00	3.27	4.07	0.020	Open
Pipe 12	275.00	3.12	6.79	0.022	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-884.56	2.51	2.02	0.021	Open
Pipe 2	-1000.00	4.08	6.16	0.020	Open
Pipe 3	1000.00	4.08	6.16	0.020	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	115.44	1.31	1.36	0.026	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	1000.00	4.08	6.16	0.020	Open
Pipe 4	1000.00	4.08	6.16	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 11	200.00	5.11	27.13	0.022	Open

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	440.42	5.00	16.24	0.021	Open
Pipe 25	440.42	2.81	4.00	0.022	Open
Pipe 26	435.42	2.78	3.92	0.022	Open
Pipe 27	435.42	11.12	114.61	0.020	Open
Pipe 28	435.42	4.94	15.90	0.021	Open
Pipe 29	-390.44	1.11	0.44	0.023	Open
Pipe 30	325.42	3.69	9.27	0.022	Open
Pipe 31	-32.51	0.37	0.18	0.043	Open
Pipe 32	-32.51	0.37	0.18	0.043	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	884.56	0.00	-281.71	0.000	Open
Pump 202	220.21	0.00	-399.52	0.000	Open
Pump 203	220.21	0.00	-399.52	0.000	Open
Valve 301	200.00	5.11	97.29	0.000	Active
Valve 302	0.00	0.00	115.59	0.000	Active
Valve 303	200.00	5.11	58.60	0.000	Active
Valve 304	200.00	5.11	54.94	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 305	200.00	5.11	35.72	0.000	Active
Valve 306	200.00	5.11	10.55	0.000	Active
Valve 307	200.00	5.11	53.76	0.000	Active
Valve 308	37.50	3.83	17.63	0.000	Active
Valve 309	37.50	3.83	56.63	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	653.63	69.60
Junc 20	0.00	626.37	32.66
Junc 11	0.00	659.98	45.49
Junc 28	0.00	644.24	31.30
Junc 10	0.00	646.47	50.47
Junc 2	0.00	673.43	70.81
Junc 1	0.00	685.10	89.74
Junc 3	0.00	668.95	69.30
Junc 9	0.00	605.71	51.00
Junc 17	0.00	630.19	32.58
Junc 19	0.00	625.97	13.42
Junc 27	0.00	673.96	23.38
Junc 4	0.00	666.38	68.63
Junc 5	0.00	658.20	70.28
Junc 7	0.00	625.98	62.82
Junc 8	0.00	614.07	62.86
Junc 13	0.00	663.11	32.55
Junc 14	0.00	656.11	15.64
Junc 15	0.00	637.01	58.93

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	633.02	34.24
Junc 18	0.00	627.15	24.33
Junc 12	0.00	667.58	41.41
Junc 29	0.00	674.00	0.87
Junc 30	0.00	668.95	57.61
Junc 21	0.00	809.52	125.58
Junc 25	0.00	729.84	98.73
Junc 22	0.00	763.36	111.51
Junc 23	5.00	763.29	113.22
Junc 24	0.00	762.39	112.83
Junc 26	0.00	674.85	20.30
Junc TCS	110.00	666.78	20.27
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-440.41	410.00	0.00
Resvr HNWR-1	-949.58	400.00	0.00
Tank 104	0.00	674.00	0.87
Tank 103	0.00	674.00	0.87

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	800.00	3.27	4.07	0.020	Open
Pipe 12	275.00	3.12	6.79	0.022	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-949.58	2.69	2.30	0.020	Open
Pipe 2	-1000.00	4.08	6.16	0.020	Open
Pipe 3	1000.00	4.08	6.16	0.020	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	50.42	0.57	0.29	0.029	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	1000.00	4.08	6.16	0.020	Open
Pipe 4	1000.00	4.08	6.16	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 11	200.00	5.11	27.13	0.022	Open

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	440.41	5.00	16.24	0.021	Open
Pipe 25	440.41	2.81	4.00	0.022	Open
Pipe 26	435.41	2.78	3.92	0.022	Open
Pipe 27	435.41	11.12	114.61	0.020	Open
Pipe 28	435.41	4.94	15.90	0.021	Open
Pipe 29	-325.42	0.92	0.32	0.024	Open
Pipe 30	325.41	3.69	9.27	0.022	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	949.58	0.00	-285.10	0.000	Open
Pump 202	220.21	0.00	-399.52	0.000	Open
Pump 203	220.21	0.00	-399.52	0.000	Open
Valve 301	200.00	5.11	99.25	0.000	Active
Valve 302	0.00	0.00	117.55	0.000	Active
Valve 303	200.00	5.11	60.56	0.000	Active
Valve 304	200.00	5.11	56.90	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, Low Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 305	200.00	5.11	37.68	0.000	Active
Valve 306	200.00	5.11	12.51	0.000	Active
Valve 307	200.00	5.11	53.78	0.000	Active
Valve 308	37.50	3.83	17.64	0.000	Active
Valve 309	37.50	3.83	56.65	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	673.34	78.14
Junc 20	0.00	646.08	41.20
Junc 11	0.00	685.92	56.73
Junc 28	0.00	670.18	42.54
Junc 10	0.00	666.18	59.01
Junc 2	0.00	693.14	79.36
Junc 1	0.00	701.67	96.91
Junc 3	0.00	688.66	77.85
Junc 9	0.00	625.42	59.55
Junc 17	0.00	649.90	41.12
Junc 19	0.00	645.68	21.96
Junc 27	0.00	699.91	34.62
Junc 4	0.00	686.10	77.17
Junc 5	0.00	677.91	78.82
Junc 7	0.00	645.69	71.36
Junc 8	0.00	633.78	71.40
Junc 13	0.00	689.06	43.79
Junc 14	0.00	682.05	26.89
Junc 15	0.00	656.72	67.47

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	652.73	42.78
Junc 18	0.00	646.86	32.87
Junc 12	0.00	693.52	52.65
Junc 29	0.00	699.98	12.12
Junc 30	0.00	688.66	66.15
Junc 21	0.00	823.72	131.73
Junc 25	0.00	750.94	107.86
Junc 22	0.00	781.53	119.39
Junc 23	5.00	781.47	121.10
Junc 24	0.00	780.65	120.74
Junc 26	0.00	700.73	31.51
Junc TCS	110.00	692.66	31.48
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-419.53	410.00	0.00
Resvr HNWR-1	-801.39	400.00	0.00
Tank 104	-84.54	700.00	12.13
Tank 103	-84.54	700.00	12.13

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	800.00	3.27	4.07	0.020	Open
Pipe 12	275.00	3.12	6.79	0.022	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-801.39	2.27	1.68	0.021	Open
Pipe 2	-1000.00	4.08	6.16	0.020	Open
Pipe 3	1000.00	4.08	6.16	0.020	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	198.61	2.25	3.72	0.024	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	1000.00	4.08	6.16	0.020	Open
Pipe 4	1000.00	4.08	6.16	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 11	200.00	5.11	27.13	0.022	Open

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	419.53	4.76	14.84	0.021	Open
Pipe 25	419.53	2.68	3.66	0.022	Open
Pipe 26	414.53	2.65	3.58	0.022	Open
Pipe 27	414.53	10.58	104.63	0.020	Open
Pipe 28	414.53	4.70	14.52	0.021	Open
Pipe 29	-473.61	1.34	0.64	0.023	Open
Pipe 30	304.53	3.46	8.20	0.022	Open
Pipe 31	-84.54	0.96	1.12	0.039	Open
Pipe 32	-84.54	0.96	1.12	0.039	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	801.39	0.00	-301.67	0.000	Open
Pump 202	209.76	0.00	-413.72	0.000	Open
Pump 203	209.76	0.00	-413.72	0.000	Open
Valve 301	200.00	5.11	118.96	0.000	Active
Valve 302	0.00	0.00	137.26	0.000	Active
Valve 303	200.00	5.11	80.27	0.000	Active
Valve 304	200.00	5.11	76.62	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 305	200.00	5.11	57.40	0.000	Active
Valve 306	200.00	5.11	32.22	0.000	Active
Valve 307	200.00	5.11	79.72	0.000	Active
Valve 308	37.50	3.83	43.59	0.000	Active
Valve 309	37.50	3.83	82.59	0.000	Active

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	679.97	81.01
Junc 20	0.00	652.71	44.07
Junc 11	0.00	685.98	56.75
Junc 28	0.00	670.25	42.57
Junc 10	0.00	672.81	61.88
Junc 2	0.00	699.77	82.23
Junc 1	0.00	711.92	101.36
Junc 3	0.00	695.29	80.72
Junc 9	0.00	632.05	62.42
Junc 17	0.00	656.53	43.99
Junc 19	0.00	652.31	24.83
Junc 27	0.00	699.97	34.65
Junc 4	0.00	692.72	80.04
Junc 5	0.00	684.54	81.70
Junc 7	0.00	652.32	74.23
Junc 8	0.00	640.41	74.27
Junc 13	0.00	689.12	43.81
Junc 14	0.00	682.11	26.91
Junc 15	0.00	663.35	70.35

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	659.36	45.65
Junc 18	0.00	653.49	35.74
Junc 12	0.00	693.58	52.68
Junc 29	0.00	700.00	12.13
Junc 30	0.00	695.29	69.02
Junc 21	0.00	823.74	131.74
Junc 25	0.00	750.96	107.87
Junc 22	0.00	781.55	119.40
Junc 23	5.00	781.49	121.10
Junc 24	0.00	780.67	120.75
Junc 26	0.00	700.75	31.52
Junc TCS	110.00	692.68	31.49
Junc FW-INJ-1	200.00	506.46	8.00
Junc UPGRAD-INJ-1	0.00	519.46	8.00
Junc UPGRAD-INJ-2	200.00	572.46	8.00
Junc FW-INJ-2	200.00	569.46	8.00
Junc UPGRAD-INJ-3	200.00	589.46	8.00
Junc UPGRAD-INJ-4	200.00	613.46	8.00
Junc FW-INJ-4	200.00	590.46	8.00
Junc COMP-INJ-1	37.50	638.46	8.00

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	606.46	8.00
Resvr Topock2&3	-419.51	410.00	0.00
Resvr HNWR-1	-970.49	400.00	0.00
Tank 104	0.00	700.00	12.13
Tank 103	0.00	700.00	12.13

Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	800.00	3.27	4.07	0.020	Open
Pipe 12	275.00	3.12	6.79	0.022	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-970.49	2.75	2.40	0.020	Open
Pipe 2	-1000.00	4.08	6.16	0.020	Open
Pipe 3	1000.00	4.08	6.16	0.020	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	29.51	0.33	0.11	0.031	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	1000.00	4.08	6.16	0.020	Open
Pipe 4	1000.00	4.08	6.16	0.020	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	800.00	5.11	12.08	0.020	Open
Pipe 13	800.00	5.11	12.08	0.020	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 11	200.00	5.11	27.13	0.022	Open

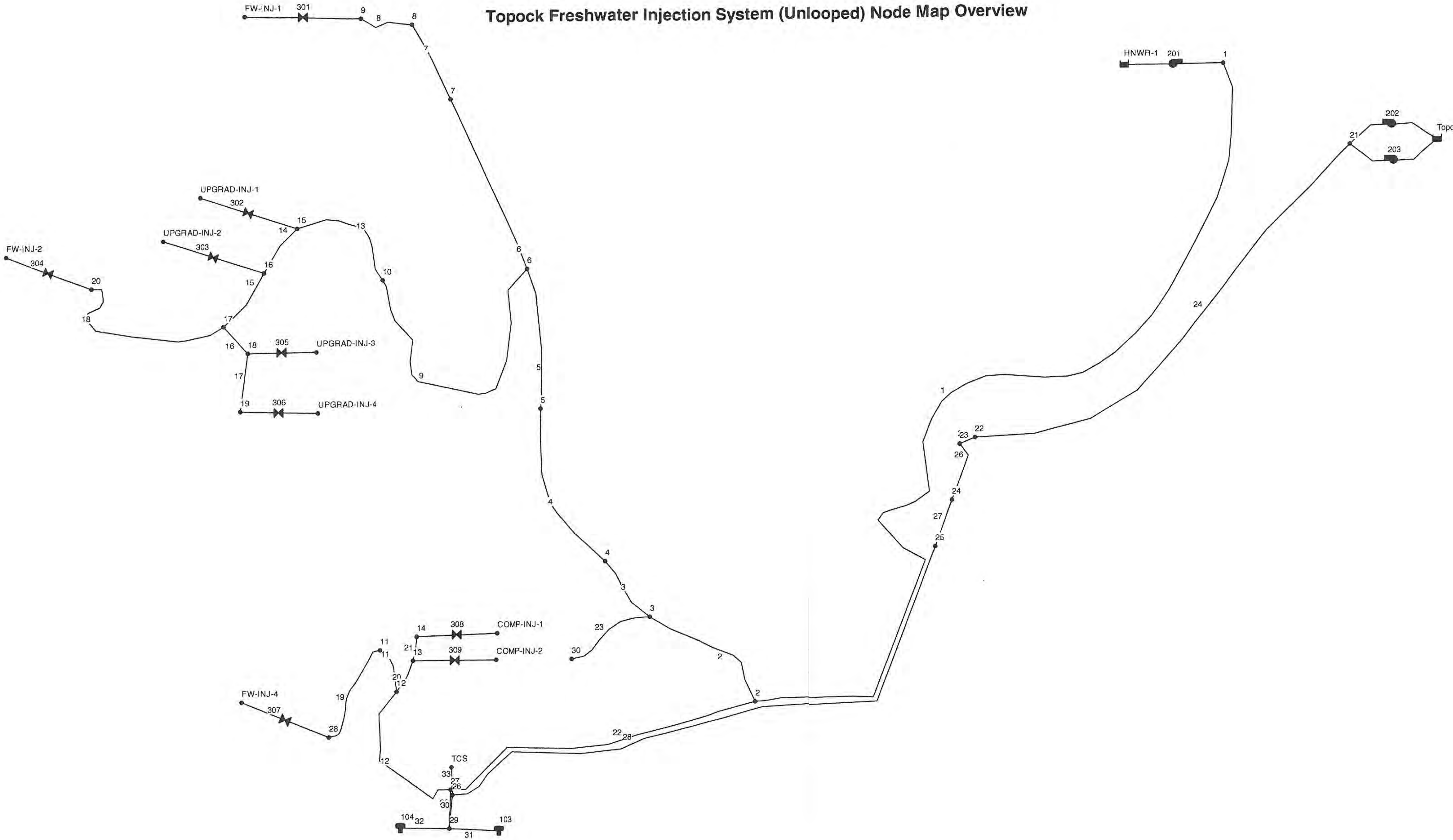
Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	419.51	4.76	14.84	0.021	Open
Pipe 25	419.51	2.68	3.65	0.022	Open
Pipe 26	414.51	2.65	3.58	0.022	Open
Pipe 27	414.51	10.58	104.62	0.020	Open
Pipe 28	414.51	4.70	14.52	0.021	Open
Pipe 29	-304.51	0.86	0.28	0.024	Open
Pipe 30	304.51	3.46	8.20	0.022	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pump 201	970.49	0.00	-311.92	0.000	Open
Pump 202	209.75	0.00	-413.74	0.000	Open
Pump 203	209.75	0.00	-413.74	0.000	Open
Valve 301	200.00	5.11	125.59	0.000	Active
Valve 302	0.00	0.00	143.89	0.000	Active
Valve 303	200.00	5.11	86.90	0.000	Active
Valve 304	200.00	5.11	83.24	0.000	Active

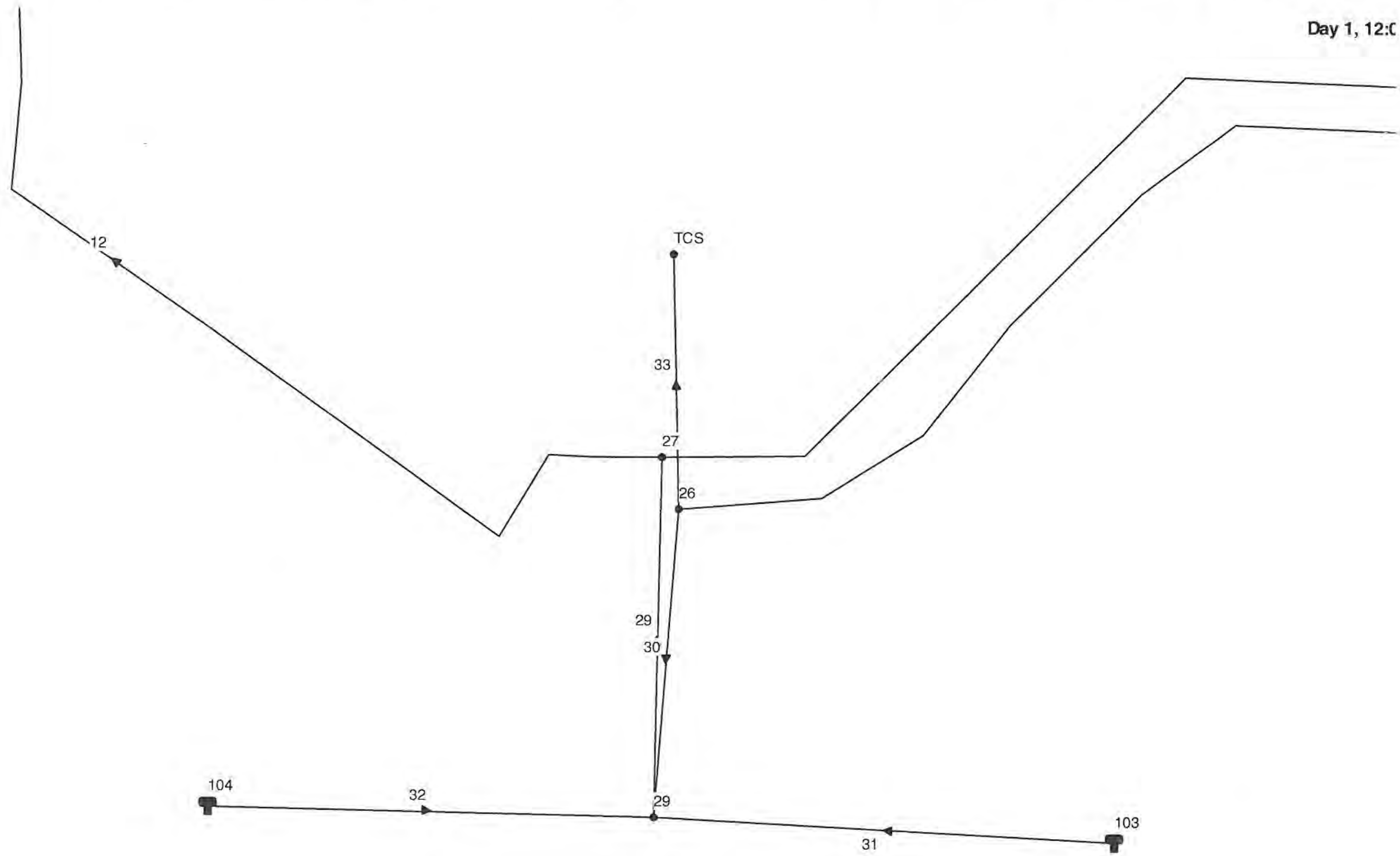
Freshwater Injection System (Unlooped) - Maximum Demands, High Tank Levels with new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 305	200.00	5.11	64.02	0.000	Active
Valve 306	200.00	5.11	38.85	0.000	Active
Valve 307	200.00	5.11	79.78	0.000	Active
Valve 308	37.50	3.83	43.65	0.000	Active
Valve 309	37.50	3.83	82.66	0.000	Active

Topock Freshwater Injection System (Unlooped) Node Map Overview



Topock Freshwater Injection System (Unlooped) Node Map (Zoom in of TCS area)



Freshwater Injection System (Looped), Extracted Water System - Junction, Reservoir and Tank Data

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM
Junc 6	493	0
Junc 20	551	0
Junc 11	555	0
Junc 28	572	0
Junc 10	530	0
Junc 2	510	0
Junc 1	478	0
Junc 3	509	0
Junc 9	488	0
Junc 17	555	0
Junc 19	595	0
Junc 27	620	0
Junc 4	508	0
Junc 5	496	0
Junc 7	481	0
Junc 8	469	0
Junc 13	588	0
Junc 14	620	0
Junc 15	501	0

Freshwater Injection System (Looped), Extracted Water System - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc 16	554	0
Junc 18	571	0
Junc 12	572	0
Junc 29	672	0
Junc 30	536	0
Junc 21	519.7	0
Junc 25	502	0
Junc 22	506	0
Junc 23	502	5
Junc 24	502	0
Junc 26	628	0
Junc TCS	620	110
Junc FW-INJ-1	488	200
Junc UPGRAD-INJ-1	501	0
Junc UPGRAD-INJ-2	554	200
Junc FW-INJ-2	551	200
Junc UPGRAD-INJ-3	571	200
Junc UPGRAD-INJ-4	595	200
Junc FW-INJ-4	572	200
Junc COMP-INJ-1	620	37.5

Freshwater Injection System (Looped), Extracted Water System - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc COMP-INJ-2	588	37.5
Junc 50	464	0
Junc 51	464	0
Junc 52	464	0
Junc 53	464	0
Junc 54	464	0
Junc 5A	496	0
Junc 6A	493	0
Junc 10A	530	0
Junc 15A	501	0
Junc 16A	554	0
Junc 55	470	0
Junc 56	470	0
Junc 57	467	0
Junc 58	466	0
Resvr Topock2&3	410	#N/A
Resvr HNWR-1	400	#N/A
Resvr 150	415	#N/A
Resvr 151	415	#N/A
Resvr 152	415	#N/A

Freshwater Injection System (Looped), Extracted Water System - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Resvr 153	415	#N/A
Resvr 154	415	#N/A
Tank 104	672	#N/A
Tank 103	672	#N/A

Freshwater Injection System (Looped), Extracted Water System - Pipe, Pump and Valve Data

Network Table - Links

Link ID	Length ft	Diameter in	Roughness
Pipe 9	1756	6	130
Pipe 12	941	8	130
Pipe 19	580	4	130
Pipe 1	5068	12	130
Pipe 2	728	6	130
Pipe 3	416	6	130
Pipe 16	224	6	130
Pipe 22	1820	6	130
Pipe 8	308	4	130
Pipe 7	439	4	130
Pipe 6	1019	4	130
Pipe 5	743	6	130
Pipe 4	1328	6	130
Pipe 18	1016	6	130
Pipe 15	399	8	130
Pipe 14	330	8	130
Pipe 13	783	8	130
Pipe 17	312	6	130
Pipe 10	2013	8	130

Freshwater Injection System (Looped), Extracted Water System - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Pipe 11	280	8	130
Pipe 20	249	3	130
Pipe 21	196	2	130
Pipe 23	510	2	130
Pipe 24	2842	6	130
Pipe 25	17	8	130
Pipe 26	229	8	130
Pipe 27	284	4	130
Pipe 28	3458	6	130
Pipe 29	112	12	130
Pipe 30	92	6	130
Pipe 31	20	6	130
Pipe 32	20	6	130
Pipe 33	900	4	130
Pipe 56	368	4	130
Pipe 57	1756	4	130
Pipe 58	783	4	130
Pipe 59	330	4	130
Pipe 60	20	4	130
Pipe 61	20	4	130

Freshwater Injection System (Looped), Extracted Water System - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Pipe 34	670	4	130
Pipe 35	1000	4	130
Pipe 36	308	4	130
Pipe 37	709	4	130
Pipe 38	231	4	130
Pipe 39	66	4	130
Pipe 40	423	4	130
Pipe 41	209	4	130
Pipe 42	489	4	130
Pump 201	#N/A	#N/A	#N/A
Pump 202	#N/A	#N/A	#N/A
Pump 203	#N/A	#N/A	#N/A
Pump P-401	#N/A	#N/A	#N/A
Pump P-402	#N/A	#N/A	#N/A
Pump P403	#N/A	#N/A	#N/A
Pump P404	#N/A	#N/A	#N/A
Pump P405	#N/A	#N/A	#N/A
Valve 301	#N/A	4	#N/A
Valve 302	#N/A	4	#N/A
Valve 303	#N/A	4	#N/A

Freshwater Injection System (Looped), Extracted Water System - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Valve 304	#N/A	4	#N/A
Valve 305	#N/A	4	#N/A
Valve 306	#N/A	4	#N/A
Valve 307	#N/A	4	#N/A
Valve 308	#N/A	2	#N/A
Valve 309	#N/A	2	#N/A

Freshwater Injection System with Extracted Water System
Link Tabulation

Link	Type	Start Node	End Node
1	Pipe	2	1
2	Pipe	3	2
3	Pipe	3	4
4	Pipe	4	5
5	Pipe	5	6
6	Pipe	6	7
7	Pipe	7	8
8	Pipe	9	8
9	Pipe	6	10
10	Pipe	11	10
11	Pipe	12	11
12	Pipe	27	12
13	Pipe	10	15
14	Pipe	15	16
15	Pipe	16	17
16	Pipe	17	18
17	Pipe	18	19
18	Pipe	17	20
19	Pipe	11	28
20	Pipe	12	13
21	Pipe	13	14
22	Pipe	27	2
23	Pipe	3	30
24	Pipe	21	22
25	Pipe	22	23
26	Pipe	23	24
27	Pipe	24	25
28	Pipe	25	26
29	Pipe	27	29
30	Pipe	26	29
31	Pipe	29	103
32	Pipe	29	104
33	Pipe	26	TCS
34	Pipe	50	55
35	Pipe	55	56
36	Pipe	51	56
37	Pipe	56	57
38	Pipe	52	57
39	Pipe	57	53
40	Pipe	53	58
41	Pipe	54	58
42	Pipe	58	5A
56	Pipe	5A	6A
57	Pipe	6A	10A

Freshwater Injection System with Extracted Water System
Link Tabulation

Link	Type	Start Node	End Node
58	Pipe	10A	15A
59	Pipe	15A	16A
60	Pipe	15A	15
61	Pipe	16A	16
201	Pump	HNWR-1	1
202	Pump	Topock2&3	21
203	Pump	Topock2&3	21
P401	Pump	150	50
P402	Pump	151	51
P403	Pump	152	52
P404	Pump	153	53
P405	Pump	154	54
301	Valve	9	FW-INJ-1
302	Valve	15	UPGRAD-INJ-1
303	Valve	16	UPGRAD-INJ-2
304	Valve	20	FW-INJ-2
305	Valve	18	UPGRAD-INJ-3
306	Valve	19	UPGRAD-INJ-4
307	Valve	28	FW-INJ-4
308	Valve	14	COMP-INJ-1
309	Valve	13	COMP-INJ-2

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	658.20	71.58
Junc 20	0.00	636.50	37.05
Junc 11	0.00	661.63	46.20
Junc 28	0.00	645.90	32.02
Junc 10	0.00	652.63	53.14
Junc 2	0.00	698.39	81.63
Junc 1	0.00	706.49	99.00
Junc 3	0.00	689.29	78.12
Junc 9	0.00	610.29	52.99
Junc 17	0.00	640.32	36.97
Junc 19	0.00	636.10	17.81
Junc 27	0.00	673.96	23.38
Junc 4	0.00	684.09	76.30
Junc 5	0.00	667.49	74.31
Junc 7	0.00	630.56	64.80
Junc 8	0.00	618.65	64.84
Junc 13	0.00	659.59	31.02
Junc 14	0.00	652.58	14.12
Junc 15	0.00	646.19	62.91

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	643.15	38.63
Junc 18	0.00	637.28	28.72
Junc 12	0.00	664.05	39.89
Junc 29	0.00	674.00	0.87
Junc 30	0.00	689.29	66.42
Junc 21	0.00	839.53	138.58
Junc 25	0.00	742.30	104.12
Junc 22	0.00	783.25	120.13
Junc 23	5.00	783.17	121.83
Junc 24	0.00	782.07	121.35
Junc 26	0.00	675.11	20.41
Junc TCS	110.00	667.04	20.38
Junc FW-INJ-1	200.00	511.08	10.00
Junc UPGRAD-INJ-1	0.00	524.08	10.00
Junc UPGRAD-INJ-2	200.00	577.08	10.00
Junc FW-INJ-2	200.00	574.08	10.00
Junc UPGRAD-INJ-3	200.00	594.08	10.00
Junc UPGRAD-INJ-4	200.00	618.08	10.00
Junc FW-INJ-4	200.00	595.08	10.00
Junc COMP-INJ-1	37.50	643.08	10.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	611.08	10.00
Junc 50	0.00	707.46	105.49
Junc 51	0.00	705.42	104.61
Junc 52	0.00	704.83	104.35
Junc 53	0.00	704.26	104.10
Junc 54	0.00	700.56	102.50
Junc 5A	0.00	692.52	85.15
Junc 6A	0.00	686.66	83.91
Junc 10A	0.00	658.69	55.76
Junc 15A	0.00	646.22	62.92
Junc 16A	0.00	643.33	38.71
Junc 55	0.00	706.64	102.54
Junc 56	0.00	705.42	102.01
Junc 57	0.00	704.55	102.93
Junc 58	0.00	700.31	101.52
Resvr Topock2&3	-490.16	410.00	0.00
Resvr HNWR-1	-779.61	400.00	0.00
Resvr 150	-37.50	415.00	0.00
Resvr 151	0.00	415.00	0.00
Resvr 152	-37.50	415.00	0.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 153	-37.50	415.00	0.00
Resvr 154	-37.50	415.00	0.00
Tank 104	14.89	674.00	0.87
Tank 103	14.89	674.00	0.87

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	182.32	2.07	3.17	0.024	Open
Pipe 12	742.68	4.74	10.53	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-779.61	2.21	1.60	0.021	Open
Pipe 2	-382.32	4.34	12.50	0.021	Open
Pipe 3	382.32	4.34	12.50	0.021	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-397.29	4.51	13.42	0.021	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	382.32	4.34	12.50	0.021	Open
Pipe 4	382.32	4.34	12.50	0.021	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	691.27	4.41	9.22	0.020	Open
Pipe 13	650.00	4.15	8.23	0.021	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	467.68	2.99	4.47	0.022	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	667.68	4.26	8.64	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	490.16	5.56	19.80	0.021	Open
Pipe 25	490.16	3.13	4.88	0.021	Open
Pipe 26	485.16	3.10	4.79	0.021	Open
Pipe 27	485.16	12.39	140.03	0.020	Open
Pipe 28	485.16	5.51	19.43	0.021	Open
Pipe 29	-345.39	0.98	0.35	0.024	Open
Pipe 30	375.16	4.26	12.07	0.021	Open
Pipe 31	14.89	0.17	0.04	0.048	Open
Pipe 32	14.89	0.17	0.04	0.048	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pipe 56	150.00	3.83	15.93	0.023	Open
Pipe 57	150.00	3.83	15.93	0.023	Open
Pipe 58	150.00	3.83	15.93	0.023	Open
Pipe 59	108.73	2.78	8.78	0.024	Open
Pipe 60	41.28	1.05	1.46	0.028	Open
Pipe 61	108.73	2.78	8.78	0.024	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 34	37.50	0.96	1.22	0.029	Open
Pipe 35	37.50	0.96	1.22	0.029	Open
Pipe 36	0.00	0.00	0.00	0.000	Open
Pipe 37	37.50	0.96	1.22	0.029	Open
Pipe 38	37.50	0.96	1.22	0.029	Open
Pipe 39	75.00	1.91	4.41	0.026	Open
Pipe 40	112.50	2.87	9.35	0.024	Open
Pipe 41	37.50	0.96	1.22	0.029	Open
Pipe 42	150.00	3.83	15.93	0.023	Open
Pump 201	779.61	0.00	-306.49	0.000	Open
Pump 202	340.77	0.00	-429.53	0.000	Open
Pump 203	149.39	0.00	-429.53	0.000	Open
Pump P-401	37.50	0.00	-292.46	0.000	Open
Pump P-402	0.00	0.00	0.00	0.000	Closed
Pump P403	37.50	0.00	-289.83	0.000	Open
Pump P404	37.50	0.00	-289.26	0.000	Open
Pump P405	37.50	0.00	-285.56	0.000	Open
Valve 301	200.00	5.11	99.21	0.000	Active
Valve 302	0.00	0.00	122.11	0.000	Active
Valve 303	200.00	5.11	66.07	0.000	Active

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 304	200.00	5.11	62.42	0.000	Active
Valve 305	200.00	5.11	43.20	0.000	Active
Valve 306	200.00	5.11	18.02	0.000	Active
Valve 307	200.00	5.11	50.82	0.000	Active
Valve 308	37.50	3.83	9.51	0.000	Active
Valve 309	37.50	3.83	48.51	0.000	Active

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	657.24	71.17
Junc 20	0.00	635.97	36.82
Junc 11	0.00	661.38	46.09
Junc 28	0.00	645.65	31.91
Junc 10	0.00	652.10	52.91
Junc 2	0.00	695.93	80.56
Junc 1	0.00	703.47	97.70
Junc 3	0.00	687.17	77.20
Junc 9	0.00	609.33	52.57
Junc 17	0.00	639.79	36.74
Junc 19	0.00	635.57	17.58
Junc 27	0.00	673.95	23.38
Junc 4	0.00	682.16	75.47
Junc 5	0.00	666.18	73.74
Junc 7	0.00	629.60	64.39
Junc 8	0.00	617.68	64.43
Junc 13	0.00	659.39	30.93
Junc 14	0.00	652.39	14.03
Junc 15	0.00	645.66	62.68

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	642.62	38.40
Junc 18	0.00	636.75	28.49
Junc 12	0.00	663.85	39.80
Junc 29	0.00	674.00	0.87
Junc 30	0.00	687.17	65.50
Junc 21	0.00	839.53	138.58
Junc 25	0.00	742.30	104.12
Junc 22	0.00	783.25	120.13
Junc 23	5.00	783.17	121.83
Junc 24	0.00	782.07	121.35
Junc 26	0.00	675.11	20.41
Junc TCS	110.00	667.04	20.38
Junc FW-INJ-1	200.00	511.08	10.00
Junc UPGRAD-INJ-1	0.00	524.08	10.00
Junc UPGRAD-INJ-2	200.00	577.08	10.00
Junc FW-INJ-2	200.00	574.08	10.00
Junc UPGRAD-INJ-3	200.00	594.08	10.00
Junc UPGRAD-INJ-4	200.00	618.08	10.00
Junc FW-INJ-4	200.00	595.08	10.00
Junc COMP-INJ-1	37.50	643.08	10.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	611.08	10.00
Junc 50	0.00	706.92	105.26
Junc 51	0.00	704.88	104.37
Junc 52	0.00	704.30	104.12
Junc 53	0.00	703.72	103.87
Junc 54	0.00	700.03	102.27
Junc 5A	0.00	691.98	84.92
Junc 6A	0.00	686.12	83.68
Junc 10A	0.00	658.16	55.53
Junc 15A	0.00	645.69	62.69
Junc 16A	0.00	642.80	38.48
Junc 55	0.00	706.10	102.30
Junc 56	0.00	704.88	101.77
Junc 57	0.00	704.01	102.70
Junc 58	0.00	699.77	101.29
Resvr Topock2&3	-490.16	410.00	0.00
Resvr HNWR-1	-749.84	400.00	0.00
Resvr 150	-37.50	415.00	0.00
Resvr 151	0.00	415.00	0.00
Resvr 152	-37.50	415.00	0.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 153	-37.50	415.00	0.00
Resvr 154	-37.50	415.00	0.00
Tank 104	0.00	674.00	0.87
Tank 103	0.00	674.00	0.87

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	174.57	1.98	2.93	0.024	Open
Pipe 12	750.43	4.79	10.73	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-749.84	2.13	1.49	0.021	Open
Pipe 2	-374.57	4.25	12.03	0.021	Open
Pipe 3	374.57	4.25	12.03	0.021	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-375.27	4.26	12.08	0.021	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	374.57	4.25	12.03	0.021	Open
Pipe 4	374.57	4.25	12.03	0.021	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	691.27	4.41	9.22	0.020	Open
Pipe 13	650.01	4.15	8.23	0.021	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	475.43	3.03	4.61	0.021	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	675.43	4.31	8.83	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	490.16	5.56	19.80	0.021	Open
Pipe 25	490.16	3.13	4.88	0.021	Open
Pipe 26	485.16	3.10	4.79	0.021	Open
Pipe 27	485.16	12.39	140.03	0.020	Open
Pipe 28	485.16	5.51	19.43	0.021	Open
Pipe 29	-375.16	1.06	0.41	0.023	Open
Pipe 30	375.16	4.26	12.07	0.021	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pipe 56	149.99	3.83	15.92	0.023	Open
Pipe 57	149.99	3.83	15.92	0.023	Open
Pipe 58	149.99	3.83	15.92	0.023	Open
Pipe 59	108.73	2.78	8.78	0.024	Open
Pipe 60	41.27	1.05	1.46	0.028	Open
Pipe 61	108.73	2.78	8.77	0.024	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 34	37.50	0.96	1.22	0.029	Open
Pipe 35	37.50	0.96	1.22	0.029	Open
Pipe 36	0.00	0.00	0.00	0.000	Open
Pipe 37	37.50	0.96	1.22	0.029	Open
Pipe 38	37.50	0.96	1.22	0.029	Open
Pipe 39	74.99	1.91	4.41	0.026	Open
Pipe 40	112.49	2.87	9.35	0.024	Open
Pipe 41	37.50	0.96	1.22	0.029	Open
Pipe 42	149.99	3.83	15.92	0.023	Open
Pump 201	749.84	0.00	-303.47	0.000	Open
Pump 202	340.77	0.00	-429.53	0.000	Open
Pump 203	149.39	0.00	-429.53	0.000	Open
Pump P-401	37.50	0.00	-291.92	0.000	Open
Pump P-402	0.00	0.00	0.00	0.000	Closed
Pump P403	37.50	0.00	-289.30	0.000	Open
Pump P404	37.50	0.00	-288.72	0.000	Open
Pump P405	37.50	0.00	-285.03	0.000	Open
Valve 301	200.00	5.11	98.25	0.000	Active
Valve 302	0.00	0.00	121.58	0.000	Active
Valve 303	200.00	5.11	65.54	0.000	Active

Freshwater Inj System (Looped), Extr Water System - Max Demands, Low Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 304	200.00	5.11	61.89	0.000	Active
Valve 305	200.00	5.11	42.67	0.000	Active
Valve 306	200.00	5.11	17.49	0.000	Active
Valve 307	200.00	5.11	50.57	0.000	Active
Valve 308	37.50	3.83	9.31	0.000	Active
Valve 309	37.50	3.83	48.32	0.000	Active

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	681.64	81.74
Junc 20	0.00	661.06	47.69
Junc 11	0.00	686.95	57.17
Junc 28	0.00	671.21	42.99
Junc 10	0.00	677.19	63.78
Junc 2	0.00	717.88	90.07
Junc 1	0.00	724.47	106.80
Junc 3	0.00	709.67	86.95
Junc 9	0.00	633.73	63.15
Junc 17	0.00	664.88	47.61
Junc 19	0.00	660.66	28.45
Junc 27	0.00	699.94	34.64
Junc 4	0.00	704.98	85.35
Junc 5	0.00	690.02	84.07
Junc 7	0.00	654.00	74.96
Junc 8	0.00	642.09	75.00
Junc 13	0.00	685.05	42.05
Junc 14	0.00	678.04	25.15
Junc 15	0.00	670.75	73.55

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	667.71	49.27
Junc 18	0.00	661.84	39.36
Junc 12	0.00	689.51	50.92
Junc 29	0.00	700.00	12.13
Junc 30	0.00	709.67	75.25
Junc 21	0.00	854.96	145.27
Junc 25	0.00	763.91	113.49
Junc 22	0.00	802.24	128.36
Junc 23	5.00	802.16	130.06
Junc 24	0.00	801.14	129.62
Junc 26	0.00	701.01	31.64
Junc TCS	110.00	692.95	31.61
Junc FW-INJ-1	200.00	511.08	10.00
Junc UPGRAD-INJ-1	0.00	524.08	10.00
Junc UPGRAD-INJ-2	200.00	577.08	10.00
Junc FW-INJ-2	200.00	574.08	10.00
Junc UPGRAD-INJ-3	200.00	594.08	10.00
Junc UPGRAD-INJ-4	200.00	618.08	10.00
Junc FW-INJ-4	200.00	595.08	10.00
Junc COMP-INJ-1	37.50	643.08	10.00

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	611.08	10.00
Junc 50	0.00	732.01	116.13
Junc 51	0.00	729.97	115.25
Junc 52	0.00	729.39	114.99
Junc 53	0.00	728.82	114.75
Junc 54	0.00	725.12	113.14
Junc 5A	0.00	717.08	95.79
Junc 6A	0.00	711.22	94.55
Junc 10A	0.00	683.25	66.40
Junc 15A	0.00	670.78	73.57
Junc 16A	0.00	667.89	49.35
Junc 55	0.00	731.20	113.18
Junc 56	0.00	729.97	112.65
Junc 57	0.00	729.11	113.57
Junc 58	0.00	724.86	112.17
Resvr Topock2&3	-473.16	410.00	0.00
Resvr HNWR-1	-697.84	400.00	0.00
Resvr 150	-37.50	415.00	0.00
Resvr 151	0.00	415.00	0.00
Resvr 152	-37.50	415.00	0.00

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 153	-37.50	415.00	0.00
Resvr 154	-37.50	415.00	0.00
Tank 104	-34.50	700.00	12.13
Tank 103	-34.50	700.00	12.13

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	161.53	1.83	2.53	0.024	Open
Pipe 12	763.47	4.87	11.08	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-697.84	1.98	1.30	0.021	Open
Pipe 2	-361.53	4.10	11.27	0.022	Open
Pipe 3	361.53	4.10	11.27	0.022	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-336.31	3.82	9.86	0.022	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	361.53	4.10	11.27	0.022	Open
Pipe 4	361.53	4.10	11.27	0.022	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	691.27	4.41	9.22	0.020	Open
Pipe 13	650.00	4.15	8.23	0.021	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	488.47	3.12	4.85	0.021	Open

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	688.47	4.39	9.15	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	473.16	5.37	18.55	0.021	Open
Pipe 25	473.16	3.02	4.57	0.021	Open
Pipe 26	468.16	2.99	4.48	0.022	Open
Pipe 27	468.16	11.95	131.08	0.020	Open
Pipe 28	468.16	5.31	18.19	0.021	Open
Pipe 29	-427.16	1.21	0.52	0.023	Open
Pipe 30	358.16	4.06	11.08	0.022	Open
Pipe 31	-34.50	0.39	0.20	0.043	Open
Pipe 32	-34.50	0.39	0.20	0.043	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pipe 56	150.00	3.83	15.92	0.023	Open
Pipe 57	150.00	3.83	15.92	0.023	Open
Pipe 58	150.00	3.83	15.92	0.023	Open
Pipe 59	108.73	2.78	8.78	0.024	Open
Pipe 60	41.27	1.05	1.46	0.028	Open
Pipe 61	108.73	2.78	8.78	0.024	Open

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 34	37.50	0.96	1.22	0.029	Open
Pipe 35	37.50	0.96	1.22	0.029	Open
Pipe 36	0.00	0.00	0.00	0.000	Open
Pipe 37	37.50	0.96	1.22	0.029	Open
Pipe 38	37.50	0.96	1.22	0.029	Open
Pipe 39	74.99	1.91	4.41	0.026	Open
Pipe 40	112.50	2.87	9.35	0.024	Open
Pipe 41	37.50	0.96	1.22	0.029	Open
Pipe 42	150.00	3.83	15.92	0.023	Open
Pump 201	697.84	0.00	-324.47	0.000	Open
Pump 202	328.96	0.00	-444.96	0.000	Open
Pump 203	144.21	0.00	-444.96	0.000	Open
Pump P-401	37.50	0.00	-317.01	0.000	Open
Pump P-402	0.00	0.00	0.00	0.000	Closed
Pump P403	37.50	0.00	-314.39	0.000	Open
Pump P404	37.50	0.00	-313.82	0.000	Open
Pump P405	37.50	0.00	-310.12	0.000	Open
Valve 301	200.00	5.11	122.65	0.000	Active
Valve 302	0.00	0.00	146.67	0.000	Active
Valve 303	200.00	5.11	90.63	0.000	Active

Freshwater Inj System (Looped), Extr Water System, Max Demands, High Tank Levels, existing HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 304	200.00	5.11	86.98	0.000	Active
Valve 305	200.00	5.11	67.76	0.000	Active
Valve 306	200.00	5.11	42.58	0.000	Active
Valve 307	200.00	5.11	76.13	0.000	Active
Valve 308	37.50	3.83	34.96	0.000	Active
Valve 309	37.50	3.83	73.97	0.000	Active

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	683.79	82.67
Junc 20	0.00	662.27	48.21
Junc 11	0.00	687.52	57.42
Junc 28	0.00	671.79	43.24
Junc 10	0.00	678.41	64.30
Junc 2	0.00	723.32	92.43
Junc 1	0.00	731.18	109.70
Junc 3	0.00	714.37	88.99
Junc 9	0.00	635.87	64.07
Junc 17	0.00	666.09	48.14
Junc 19	0.00	661.87	28.98
Junc 27	0.00	699.96	34.65
Junc 4	0.00	709.25	87.20
Junc 5	0.00	692.92	85.33
Junc 7	0.00	656.14	75.89
Junc 8	0.00	644.23	75.93
Junc 13	0.00	685.51	42.25
Junc 14	0.00	678.50	25.35
Junc 15	0.00	671.96	74.08

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc 16	0.00	668.92	49.80
Junc 18	0.00	663.05	39.88
Junc 12	0.00	689.97	51.12
Junc 29	0.00	700.00	12.13
Junc 30	0.00	714.37	77.29
Junc 21	0.00	854.96	145.27
Junc 25	0.00	763.91	113.49
Junc 22	0.00	802.24	128.36
Junc 23	5.00	802.17	130.06
Junc 24	0.00	801.14	129.62
Junc 26	0.00	701.02	31.64
Junc TCS	110.00	692.95	31.61
Junc FW-INJ-1	200.00	511.08	10.00
Junc UPGRAD-INJ-1	0.00	524.08	10.00
Junc UPGRAD-INJ-2	200.00	577.08	10.00
Junc FW-INJ-2	200.00	574.08	10.00
Junc UPGRAD-INJ-3	200.00	594.08	10.00
Junc UPGRAD-INJ-4	200.00	618.08	10.00
Junc FW-INJ-4	200.00	595.08	10.00
Junc COMP-INJ-1	37.50	643.08	10.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Junc COMP-INJ-2	37.50	611.08	10.00
Junc 50	0.00	733.24	116.66
Junc 51	0.00	731.19	115.78
Junc 52	0.00	730.61	115.52
Junc 53	0.00	730.04	115.27
Junc 54	0.00	726.34	113.67
Junc 5A	0.00	718.29	96.32
Junc 6A	0.00	712.43	95.08
Junc 10A	0.00	684.47	66.93
Junc 15A	0.00	671.99	74.09
Junc 16A	0.00	669.10	49.87
Junc 55	0.00	732.42	113.71
Junc 56	0.00	731.19	113.18
Junc 57	0.00	730.33	114.10
Junc 58	0.00	726.08	112.69
Resvr Topock2&3	-473.16	410.00	0.00
Resvr HNWR-1	-766.84	400.00	0.00
Resvr 150	-37.50	415.00	0.00
Resvr 151	0.00	415.00	0.00
Resvr 152	-37.50	415.00	0.00

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 153	-37.50	415.00	0.00
Resvr 154	-37.50	415.00	0.00
Tank 104	0.00	700.00	12.13
Tank 103	0.00	700.00	12.13

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 9	178.97	2.03	3.06	0.024	Open
Pipe 12	746.02	4.76	10.62	0.020	Open
Pipe 19	200.00	5.11	27.13	0.022	Open
Pipe 1	-766.84	2.18	1.55	0.021	Open
Pipe 2	-378.97	4.30	12.30	0.021	Open
Pipe 3	378.97	4.30	12.30	0.021	Open
Pipe 16	400.00	4.54	13.59	0.021	Open
Pipe 22	-387.87	4.40	12.84	0.021	Open
Pipe 8	-200.00	5.11	27.13	0.022	Open
Pipe 7	200.00	5.11	27.13	0.022	Open
Pipe 6	200.00	5.11	27.13	0.022	Open
Pipe 5	378.97	4.30	12.30	0.021	Open
Pipe 4	378.97	4.30	12.30	0.021	Open
Pipe 18	200.00	2.27	3.76	0.024	Open
Pipe 15	600.00	3.83	7.09	0.021	Open
Pipe 14	691.27	4.41	9.22	0.020	Open
Pipe 13	649.99	4.15	8.23	0.021	Open
Pipe 17	200.00	2.27	3.76	0.024	Open
Pipe 10	471.02	3.01	4.53	0.022	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	671.02	4.28	8.72	0.020	Open
Pipe 20	75.00	3.40	17.91	0.025	Open
Pipe 21	37.50	3.83	35.76	0.026	Open
Pipe 23	0.00	0.00	0.00	0.000	Open
Pipe 24	473.16	5.37	18.55	0.021	Open
Pipe 25	473.16	3.02	4.57	0.021	Open
Pipe 26	468.16	2.99	4.48	0.022	Open
Pipe 27	468.16	11.95	131.08	0.020	Open
Pipe 28	468.16	5.31	18.19	0.021	Open
Pipe 29	-358.15	1.02	0.38	0.024	Open
Pipe 30	358.16	4.06	11.08	0.022	Open
Pipe 31	0.00	0.00	0.00	0.000	Open
Pipe 32	0.00	0.00	0.00	0.000	Open
Pipe 33	110.00	2.81	8.97	0.024	Open
Pipe 56	150.01	3.83	15.93	0.023	Open
Pipe 57	150.01	3.83	15.93	0.023	Open
Pipe 58	150.01	3.83	15.93	0.023	Open
Pipe 59	108.73	2.78	8.78	0.024	Open
Pipe 60	41.28	1.05	1.46	0.028	Open
Pipe 61	108.73	2.78	8.77	0.024	Open

Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 34	37.50	0.96	1.22	0.029	Open
Pipe 35	37.50	0.96	1.22	0.029	Open
Pipe 36	0.00	0.00	0.00	0.000	Open
Pipe 37	37.50	0.96	1.22	0.029	Open
Pipe 38	37.50	0.96	1.22	0.029	Open
Pipe 39	75.00	1.91	4.41	0.026	Open
Pipe 40	112.51	2.87	9.35	0.024	Open
Pipe 41	37.50	0.96	1.22	0.029	Open
Pipe 42	150.01	3.83	15.93	0.023	Open
Pump 201	766.84	0.00	-331.18	0.000	Open
Pump 202	328.95	0.00	-444.96	0.000	Open
Pump 203	144.21	0.00	-444.96	0.000	Open
Pump P-401	37.50	0.00	-318.24	0.000	Open
Pump P-402	0.00	0.00	0.00	0.000	Closed
Pump P403	37.50	0.00	-315.61	0.000	Open
Pump P404	37.50	0.00	-315.04	0.000	Open
Pump P405	37.50	0.00	-311.34	0.000	Open
Valve 301	200.00	5.11	124.79	0.000	Active
Valve 302	0.00	0.00	147.89	0.000	Active
Valve 303	200.00	5.11	91.84	0.000	Active

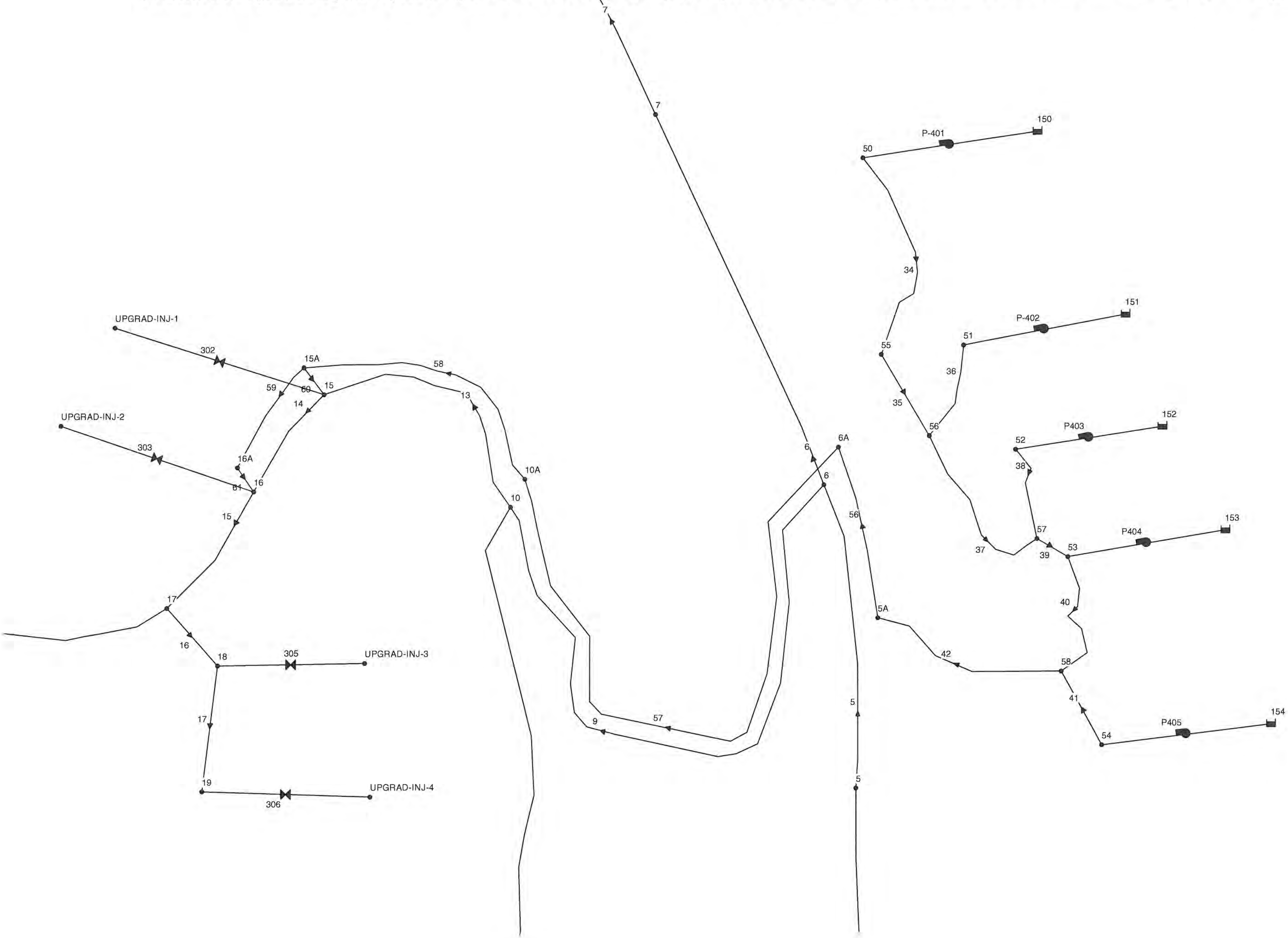
Freshwater Inj System (Looped), Extr Water System - Max Demands, High Tank Levels, new HNWR pump

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Valve 304	200.00	5.11	88.19	0.000	Active
Valve 305	200.00	5.11	68.97	0.000	Active
Valve 306	200.00	5.11	43.80	0.000	Active
Valve 307	200.00	5.11	76.71	0.000	Active
Valve 308	37.50	3.83	35.42	0.000	Active
Valve 309	37.50	3.83	74.43	0.000	Active

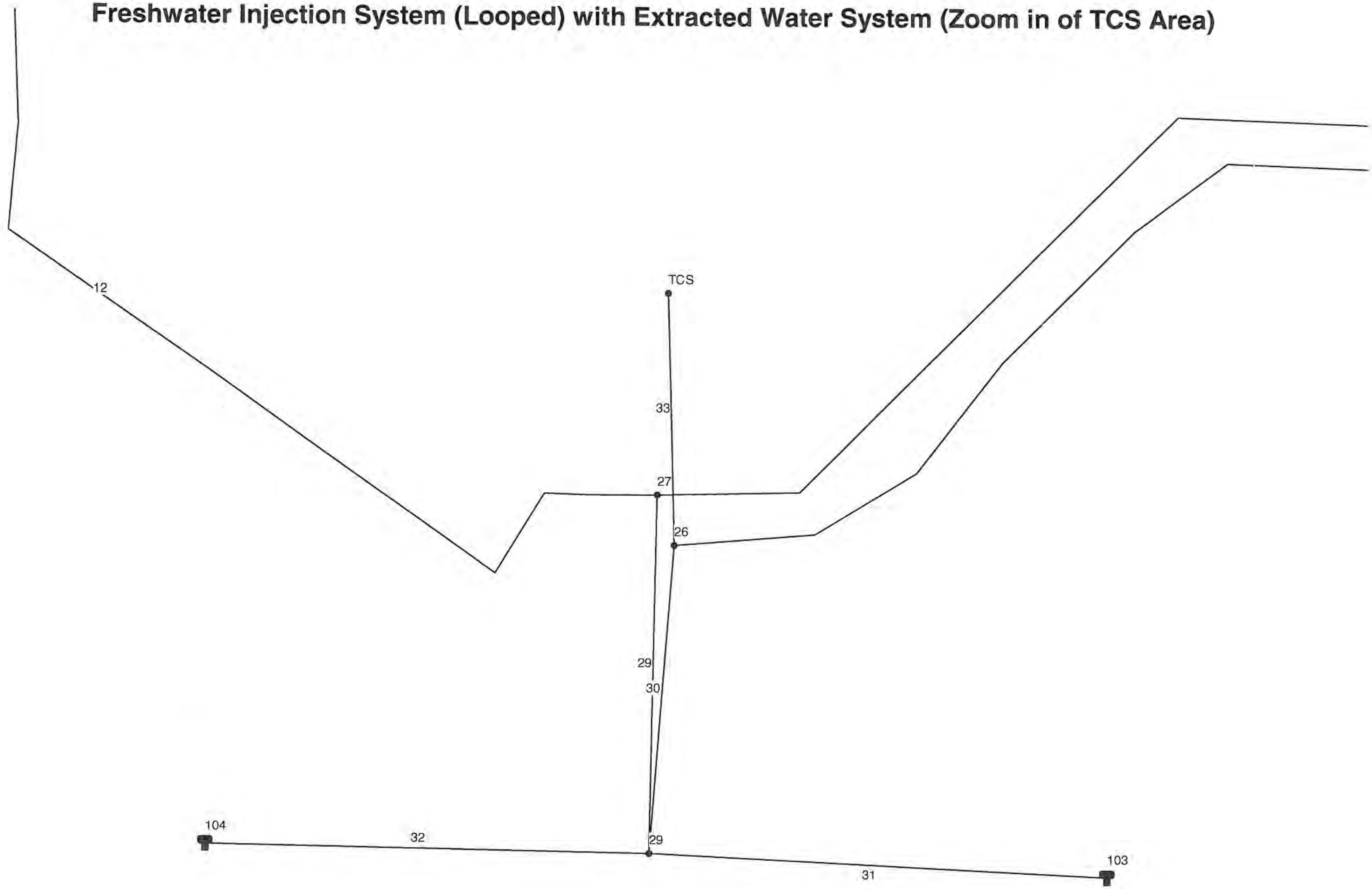
Freshwater Injection System (Looped) with Extracted Water System Node Map Overview

Freshwater Injection System (Looped) with Extracted Water System (Zoom in of Extracted Water and Carbon Amended Piping)

Day 1, 12:00 AM



Freshwater Injection System (Looped) with Extracted Water System (Zoom in of TCS Area)



Calculation Cover Sheet

CH2MHILL

ES-P04-03-F03 Calculation Sign Off Form

Project Name/Title:	Topock Remediation	Project Number:	415087
Document Name:	Conditioned Water System Hydraulic network Calculations	Preparer Name:	Paul Tjogas, E2 Consulting Engineers
Project Manager:	Christina Hong	Design Manager:	John Porcella

Calculation Title:	Hydraulic Analysis of Treated Water System					
Calculation Identifier:						
Date Prepared	Rev. No.	Preparer Signature/Date		Checker Signature/Date		*For Professional Seal When Required*
20-Oct-11	0	Paul Tjogas	20-Oct-11	Sarah Isbell	25-Oct-11	
STC/SME Signature/Date						
LTR Signature/Date (if required)						

Comments:

Information Requiring Confirmation:

Topock Remediation Design

Hydraulic analysis of Conditioned Water System

The piping for the conditioned (aka "treated") water system on the Topock Remediation project was sized from simulations of a hydraulic network model of the system. The hydraulic network model of the conditioned water system proposed for Topock remediation was constructed using EPANET. EPANET is software that models water distribution piping systems. EPANET tracks the flow of water at each pipe, the pressure at each node, pumping heads and levels of water in tanks and reservoirs. Chemical species can be tracked, although that was not needed for the conditioned system at Topock.

Pipe junctions, reservoirs and tanks are represented as nodes. A listing of nodes is contained on the following pages. Pipes, pumps and valves are represented as links. A listing of links is contained on the pages following the node listing. A map showing the location of all nodes and links is shown on the sheet following the links listing.

The piping routes and corridors have been approved by the client, Pacific Gas & Electric; however, they are subject to change pending stakeholder and regulatory review. The following summary describes the development of the hydraulic model:

Junction nodes and tanks have been located by coordinates from an aerial survey conducted by Toponex, a subcontractor to PG & E. A summary of the model development is as follows:

Ground elevations for pipe junctions and tanks are taken from the Toponex aerial survey.

Pipe lengths have been taken off from plan and profile drawings.

There are five potential options for conditioned water disposal. Each option was analyzed separately. The discharge requirements for each option are as follows:

- Case 1 – Future discharge to Park Moabi wastewater ponds = 20 gpm to high water level of ponds, which is estimated to be 505 feet above sea level
- Case 2 – Discharge to truck loading station located next to maintenance shop at Topock Compressor Station = 150 gpm
- Case 3 – Future discharge to infiltration gallery in Bat Cave Wash = 20 gpm with 10 psi residual pressure
- Case 4 – Discharge to truck loading station at MW-20 bench = 150 gpm
- Case 5 – Discharge to either cooling tower blow down tank (CTB) or cooling tank makeup line (CTA) at Topock Compressor Station = 20 gpm with 5 psi residual. CTB is farther away and governs

The bottom elevation of the conditioned water storage tank is 672 feet above sea level. A minimum water level of 2 feet is assumed for each case in the analysis.

An optimization process was not needed for sizing piping. All disposal options can be served by gravity, so there are no pumping costs. Since there is excess pressure available at each disposal point, pipe sizes could be minimized as excessive pressure could be used to overcome friction losses in smaller pipe. Hence, the minimum size pipe was selected which could serve each disposal option with minimally acceptable pressure.

Hazen-Williams C value of 130 was assumed for all pipes.

Treated Water System - Pipe data

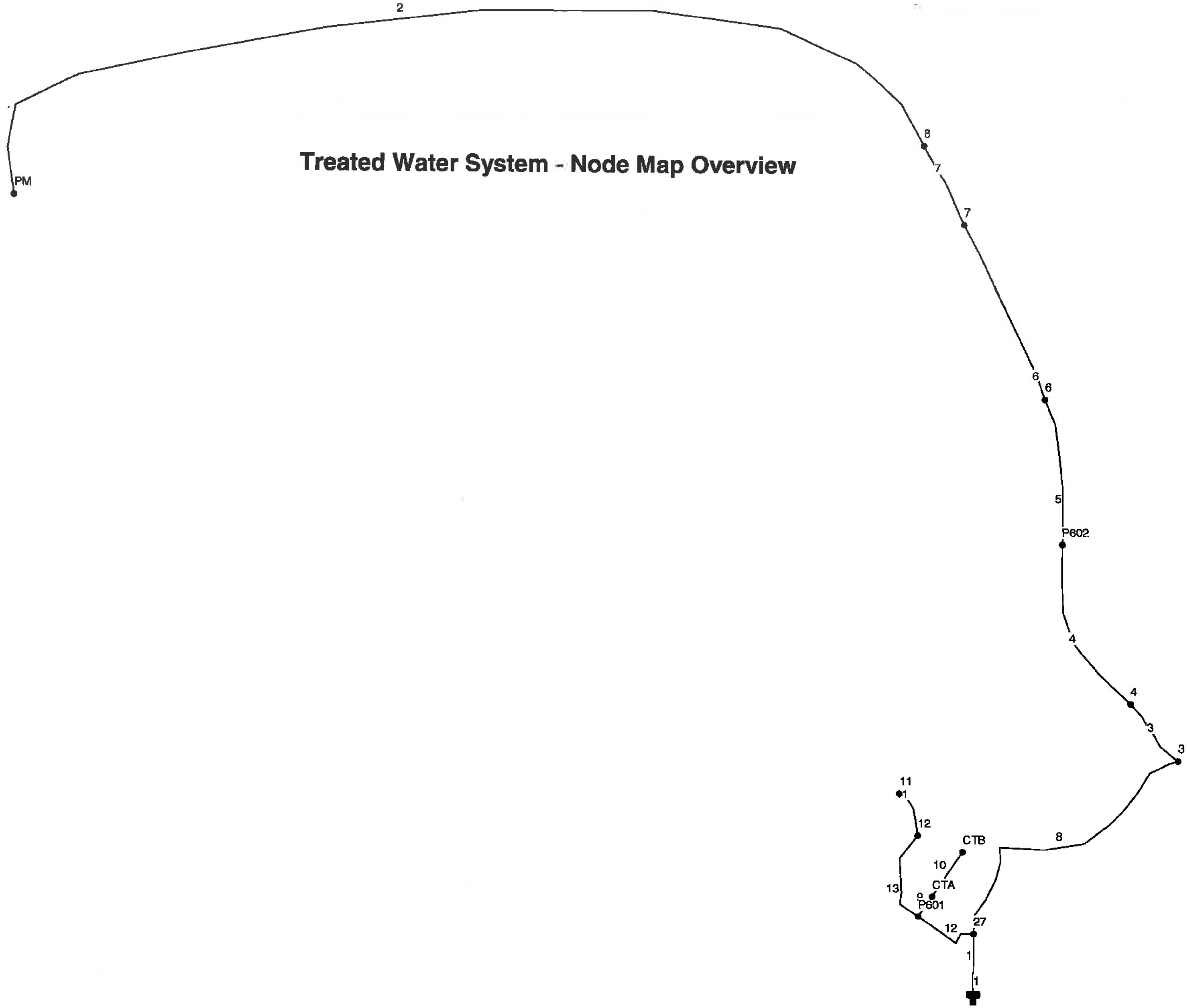
Network Table - Links

Link ID	Length ft	Diameter in	Roughness
Pipe 12	360	3	130
Pipe 3	416	4	130
Pipe 7	439	2	130
Pipe 6	1019	2	130
Pipe 5	743	2	130
Pipe 4	1328	4	130
Pipe 11	280	2	130
Pipe 1	112	4	130
Pipe 8	1624	4	130
Pipe 2	7173	2	130
Pipe 9	150	2	130
Pipe 10	750	2	130
Pipe 13	581	2	130

Treated Water System
Link Tabulation

Link	Type	Start Node	End Node
1	Pipe	1	27
2	Pipe	8	PM
3	Pipe	3	4
4	Pipe	4	P602
5	Pipe	P602	6
6	Pipe	6	7
7	Pipe	7	8
8	Pipe	27	3
9	Pipe	P601	CTA
10	Pipe	CTA	CTB
11	Pipe	12	11
12	Pipe	27	P601
13	Pipe	P601	12

Treated Water System - Node Map Overview



Case 1 - 20 gpm discharge to wastewater ponds at Park Moabi (node PM)

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	626.86	58.00
Junc 11	0.00	601.97	20.35
Junc 3	0.00	654.62	63.10
Junc 27	0.00	672.75	22.86
Junc 4	0.00	649.98	61.52
Junc P602	0.00	635.15	60.29
Junc 7	0.00	615.48	58.27
Junc 8	0.00	610.58	61.35
Junc 12	0.00	601.97	12.98
Junc P601	0.00	601.97	-7.81
Junc CTA	0.00	601.97	-7.81
Junc CTB	0.00	601.97	-7.81
Junc PM	20.00	530.51	11.05
Tank 1	-20.00	674.00	0.87

2 inch line from Treated Water Storage Tank to Park Moabi wastewater ponds is sufficient

Case 1 - 20 gpm discharge to wastewater ponds at Park Moabi (node PM)

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	0.00	0.00	0.00	0.000	Closed
Pipe 3	20.00	2.04	11.16	0.029	Open
Pipe 7	20.00	2.04	11.16	0.029	Open
Pipe 6	20.00	2.04	11.16	0.029	Open
Pipe 5	20.00	2.04	11.16	0.029	Open
Pipe 4	20.00	2.04	11.16	0.029	Open
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 1	20.00	2.04	11.16	0.029	Open
Pipe 8	20.00	2.04	11.16	0.029	Open
Pipe 2	20.00	2.04	11.16	0.029	Open
Pipe 9	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open

2 inch line from Treated Water Storage Tank to Park Moabi wastewater ponds is sufficient

Case 2 - 20 gpm discharge to truck loading station at TCS (node P601)

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	596.60	44.89
Junc 11	0.00	643.48	38.34
Junc 3	0.00	596.60	37.96
Junc 27	0.00	666.76	20.26
Junc 4	0.00	596.60	38.39
Junc P602	0.00	596.60	43.59
Junc 7	0.00	596.60	50.09
Junc 8	0.00	596.60	55.29
Junc 12	0.00	643.48	30.97
Junc P601	150.00	643.48	10.17
Junc CTA	0.00	643.48	10.17
Junc CTB	0.00	643.48	10.17
Junc PM	0.00	596.60	39.69
Tank 1	-150.00	674.00	0.87

3 inch line from Treated Water Storage Tank to Truck Loading Station is sufficient

Case 2 - 20 gpm discharge to truck loading station at TCS (node P601)

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	150.00	6.81	64.66	0.022	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 1	150.00	6.81	64.67	0.022	Open
Pipe 8	0.00	0.00	0.00	0.000	Closed
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 9	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open

3 inch line from Treated Water Storage Tank to Truck Loading Station is sufficient

Case 3 - 20 gpm discharge to future infiltration gallery in Bat Cave Wash (node 11)

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	601.97	47.22
Junc 11	20.00	659.12	45.11
Junc 3	0.00	601.97	40.28
Junc 27	0.00	672.75	22.86
Junc 4	0.00	601.97	40.72
Junc P602	0.00	601.97	45.92
Junc 7	0.00	601.97	52.41
Junc 8	0.00	601.97	57.61
Junc 12	0.00	662.24	39.10
Junc P601	0.00	668.73	21.12
Junc CTA	0.00	668.73	21.12
Junc CTB	0.00	668.73	21.12
Junc PM	0.00	601.97	42.02
Tank 1	-20.00	674.00	0.87

2 inch line from Treated Water Storage Tank to future infiltration gallery in Bat Cave Wash is sufficient

Case 3 - 20 gpm discharge to future infiltration gallery in Bat Cave Wash (node 11)

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	20.00	2.04	11.16	0.029	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 11	20.00	2.04	11.16	0.029	Open
Pipe 1	20.00	2.04	11.16	0.029	Open
Pipe 8	0.00	0.00	0.00	0.000	Closed
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 9	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open
Pipe 13	20.00	2.04	11.16	0.029	Open

2 inch line from Treated Water Storage Tank to future infiltration gallery in Bat Cave Wash is sufficient

Case 4 - 150 gpm discharge to truck loading station at MW-20 bench (node P602)

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	618.58	54.41
Junc 11	0.00	601.49	20.14
Junc 3	0.00	646.35	59.52
Junc 27	0.00	672.22	22.63
Junc 4	0.00	639.73	57.08
Junc P602	150.00	618.58	53.11
Junc 7	0.00	618.58	59.61
Junc 8	0.00	618.58	64.81
Junc 12	0.00	601.49	12.78
Junc P601	0.00	601.49	-8.02
Junc CTA	0.00	601.49	-8.02
Junc CTB	0.00	601.49	-8.02
Junc PM	0.00	618.58	49.21
Tank 1	-150.00	674.00	0.87

4 inch line from Treated Water Storage Tank to truck loading station at MW-20 bench is sufficient

Case 4 - 150 gpm discharge to truck loading station at MW-20 bench (node P602)

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	0.00	0.00	0.00	0.000	Closed
Pipe 3	150.00	3.83	15.93	0.023	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	150.00	3.83	15.93	0.023	Open
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 1	150.00	3.83	15.93	0.023	Open
Pipe 8	150.00	3.83	15.93	0.023	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 9	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open

4 inch line from Treated Water Storage Tank to truck loading station at MW-20 bench is sufficient

Case 5 - 20 gpm discharge to cooling tower blow down line (node CTB)

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	601.97	47.22
Junc 11	0.00	668.73	49.28
Junc 3	0.00	601.97	40.28
Junc 27	0.00	672.75	22.86
Junc 4	0.00	601.97	40.72
Junc P602	0.00	601.97	45.92
Junc 7	0.00	601.97	52.41
Junc 8	0.00	601.97	57.61
Junc 12	0.00	668.73	41.91
Junc P601	0.00	668.73	21.12
Junc CTA	0.00	667.06	20.39
Junc CTB	20.00	658.68	16.76
Junc PM	0.00	601.97	42.02
Tank 1	-20.00	674.00	0.87

2 inch line from Treated Water Storage Tank to cooling tower blow down line is sufficient

Case 5 - 20 gpm discharge to cooling tower blow down line (node CTB)

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	20.00	2.04	11.16	0.029	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 1	20.00	2.04	11.16	0.029	Open
Pipe 8	0.00	0.00	0.00	0.000	Closed
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 9	20.00	2.04	11.16	0.029	Open
Pipe 10	20.00	2.04	11.16	0.029	Open
Pipe 13	0.00	0.00	0.00	0.000	Open

2 inch line from Treated Water Storage Tank to cooling tower blow down line is sufficient

Calculation Cover Sheet

ES-P04-03-F03 Calculation Sign Off Form

CH2MHILL

Project Name/Title:	Topock Remediation	Project Number:	415087
Document Name:	Remedy-produced Water Conditioning System Hydraulic network Calculations	Preparer Name:	Paul Tjogas, E2 Consulting Engineers
Project Manager:	Christina Hong	Design Manager:	John Porcella

Calculation Title:		Hydraulic Analysis of Remedy Wastewater System				
Calculation Identifier:						
Date Prepared	Rev. No.	Preparer Signature/Date		Checker Signature/Date		*For Professional Seal When Required*
20-Oct-11	0	Paul Tjogas	20-Oct-11	Sarah Isbell	25-Oct-11	
STC/SME Signature/Date						
LTR Signature/Date (if required)						

Comments:

Information Requiring Confirmation:

Topock Remediation Design

Hydraulic analysis of Remedy-produced Water Conditioning System

The piping for the remedy-produced water conditioning (aka "wastewater") system on the Topock Remediation project was sized from simulations of a hydraulic network model of the system. The hydraulic network model of the remedy-produced water conditioning system proposed for Topock remediation was constructed using EPANET. EPANET is software that models water distribution piping systems. EPANET tracks the flow of water at each pipe, the pressure at each node, pumping heads and levels of water in tanks and reservoirs. Chemical species can be tracked, although that was not needed for the remedy-produced water conditioning system at Topock.

Pipe junctions, reservoirs and tanks are represented as nodes. A listing of nodes is contained on the following pages. Pipes, pumps and valves are represented as links. A listing of links is contained on the pages following the node listing. A map showing the location of all nodes and links is shown on the sheet following the links listing.

The piping routes and corridors have been approved by the client, Pacific Gas & Electric; however, they are subject to change pending stakeholder and regulatory review. The following summary describes the development of the hydraulic model:

Junction nodes, tanks and wells (modeled as pumps attached to an underground reservoir) have been located by coordinates from an aerial survey conducted by Toponex, a subcontractor to PG & E. Some liberties were taken with influent storage tank locations to make the node and link map more legible, however, this did not affect the accuracy of the analysis as exact coordinates were used in model simulations. A summary of the model development is as follows:

Ground elevations for pipe junctions, reservoirs, wells and tanks are taken from the Toponex aerial survey.

Pipe lengths have been taken off from plan and profile drawings.

Maximum remedy-produced water flows are generated during rehabilitation of injection wells. It is estimated that rehabilitation flows will be twice the amount of injection flows. It is assumed that only one well will be rehabilitated at a time. The following flow rates are used:

- Freshwater Injection Well no. 1 (Pump P901) = 400 gpm
- Freshwater Injection Well no. 2 (Pump P902) = 400 gpm
- Freshwater Injection Well no. 4 (Pump P903) = 400 gpm (Note, FW-INJ-3 was eliminated)
- Upgradient injection Well no. 1 (Pump P501) =400 gpm
- Upgradient injection Well no. 2 (Pump P502) =400 gpm
- Upgradient injection Well no. 3 (Pump P503) = 400 gpm
- Upgradient injection Well no. 4 (Pump P504) = 400 gpm

- Compressor Station Injection Well no. 1 (Pump P801) = 75 gpm
- Compressor Station Injection Well no. 2 (Pump P802) = 75 gpm
- MW-20 bench pump (Pump P1028) = 400 gpm

A pumping level elevation of 415 feet above sea level is assumed for all wells.

Remedy-produced water will be pumped to influent storage tanks for the proposed remedy-produced water conditioning plant at Topock Compressor Station. Influent storage tanks are designed to move between five different locations. The elevation of the tanks at the highest elevation (620 feet above sea level) was assumed for this analysis.

Hazen-Williams C value of 130 was assumed for all pipes.

Pipe sizing is an iterative process. After the initial simulation, pipe diameters for various segments of pipes are increased or decreased for subsequent simulations until an optimum size is selected for each segment. The criteria used for determining optimum size were unit head losses and minimum velocities. Usually, unit head losses of between 1 to 10 feet per 1,000 foot of pipe length yield the optimal combination of pipe capital cost and pumping energy costs. However, minimum velocities preclude the lower end of this range. It is desired to have at least two feet per second minimum velocity to flush sediments through the pipe. At 2 feet per second, unit head losses are approximately 6-7' per 1,000 feet of pipe, so the lower portion of the optimal range is not attainable. These criteria were used to size most of the pipes. The only exceptions to this were for short segments of pipes, such as pumping manifolds and for lower flow scenarios where minimum flow velocities are not achieved. Model simulations were run separately for each individual pump since only one well will be rehabilitated at a time. For a certain sections of pipe, the flow velocities are more than adequate to flush sediment for most of the well pumps discharging to that section of pipe. However, minimum velocities might not be achieved for smaller well rehabilitation pumps. This was deemed acceptable because the larger well rehabilitation flows would be able to flush out sediments deposited by lower well rehabilitation flows.

Pump sizing is also an iterative process in conjunction with pipe sizing. A horsepower is selected for each simulation. The horsepower is increased or decreased until the optimum pipe size and desired flow rate are achieved.

Remedy Wastewater System - Junction, Reservoir and Tank Data

Network Table - Nodes

Node ID	Elevation ft	Base Demand GPM
Junc 6	493	0
Junc 20	551	0
Junc 11	555	0
Junc 28	572	0
Junc 10	530	0
Junc 2	510	0
Junc 3	509	0
Junc 9	488	0
Junc 17	555	0
Junc 19	595	0
Junc 27	620	0
Junc 4	508	0
Junc 5	496	0
Junc 7	481	0
Junc 8	469	0
Junc 13	588	0
Junc 14	620	0

Remedy Wastewater System - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Junc 15	501	0
Junc 16	554	0
Junc 18	571	0
Junc 12	572	0
Junc 1	0	0
Junc 21	620	0
Junc 23	620	0
Junc 24	620	0
Junc 22	620	0
Resvr 101	415	#N/A
Resvr 102	415	#N/A
Resvr 103	415	#N/A
Resvr 104	415	#N/A
Resvr 105	415	#N/A
Resvr 106	415	#N/A
Resvr 107	415	#N/A
Resvr 108	415	#N/A
Resvr 109	415	#N/A

Remedy Wastewater System - Junction, Reservoir and Tank Data

Node ID	Elevation ft	Base Demand GPM
Resvr 110	415	#N/A
Tank T411	620	#N/A
Tank T412	620	#N/A
Tank T413	620	#N/A
Tank T414	620	#N/A

Remedy Wastewater System - Pipe, Pump and Valve Data

Network Table - Links

Link ID	Length ft	Diameter in	Roughness
Pipe 12	941	6	130
Pipe 19	580	4	130
Pipe 2	728	6	130
Pipe 3	416	6	130
Pipe 16	224	6	130
Pipe 22	1820	6	130
Pipe 8	308	6	130
Pipe 7	439	6	130
Pipe 6	1019	6	130
Pipe 5	743	6	130
Pipe 4	1328	6	130
Pipe 18	1016	6	130
Pipe 15	399	6	130
Pipe 14	330	6	130
Pipe 13	783	6	130
Pipe 17	312	6	130
Pipe 10	2013	6	130

Remedy Wastewater System - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Pipe 11	280	6	130
Pipe 20	249	2	130
Pipe 21	196	2	130
Pipe 1	400	6	130
Pipe 9	20	4	130
Pipe 23	20	4	130
Pipe 24	20	4	130
Pipe 25	20	4	130
Pipe 26	10	3	130
Pipe 27	10	3	130
Pipe 28	10	3	130
Pipe 29	10	3	130
Pump P901	#N/A	#N/A	#N/A
Pump P902	#N/A	#N/A	#N/A
Pump P501	#N/A	#N/A	#N/A
Pump P502	#N/A	#N/A	#N/A
Pump P503	#N/A	#N/A	#N/A
Pump P504	#N/A	#N/A	#N/A

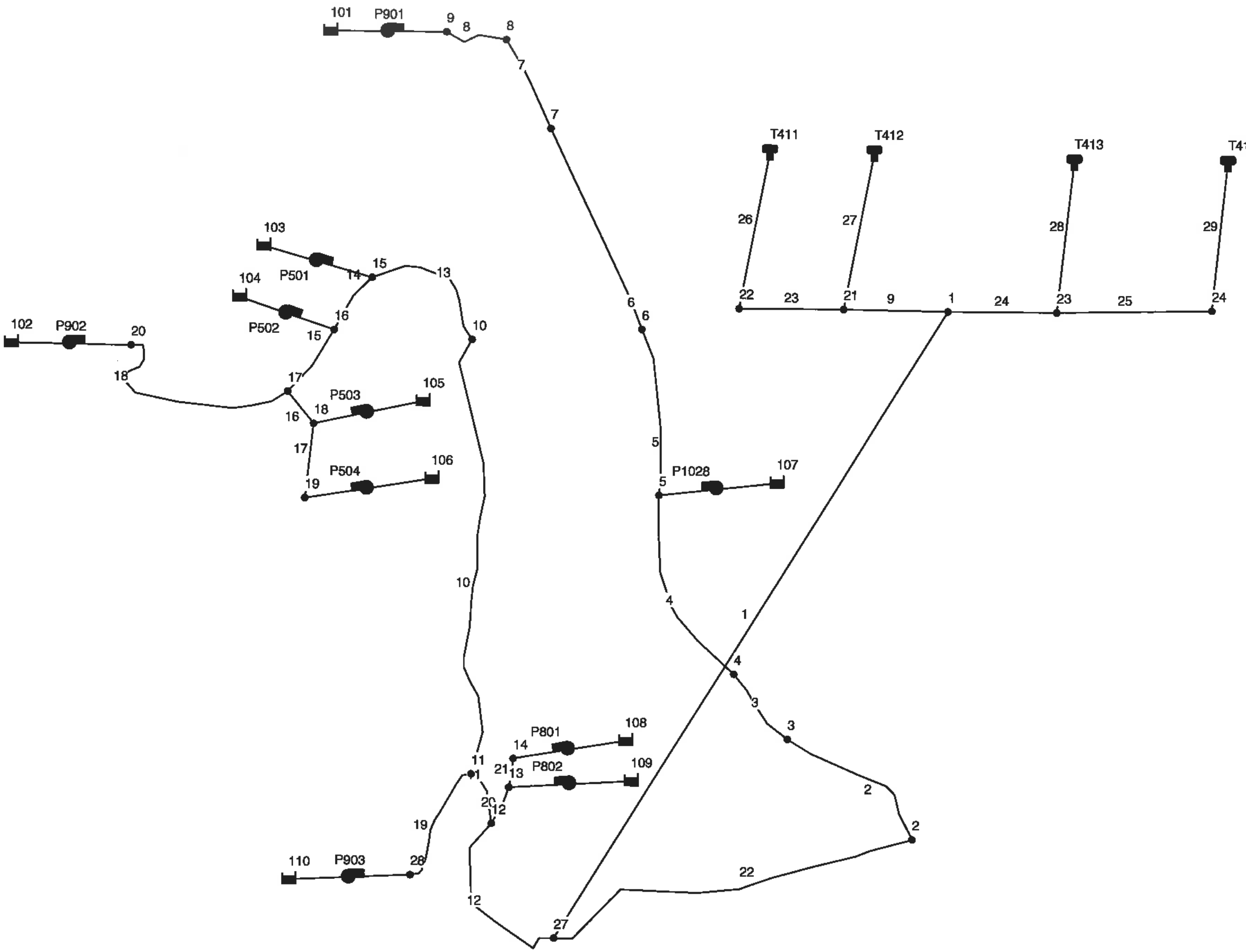
Remedy Wastewater System - Pipe, Pump and Valve Data

Link ID	Length ft	Diameter in	Roughness
Pump P1028	#N/A	#N/A	#N/A
Pump P801	#N/A	#N/A	#N/A
Pump P802	#N/A	#N/A	#N/A
Pump P903	#N/A	#N/A	#N/A

Remedy Wastewater System
Link Tabulation

Link	Type	Start Node	End Node
1	Pipe	27	1
2	Pipe	3	2
3	Pipe	3	4
4	Pipe	4	5
5	Pipe	5	6
6	Pipe	6	7
7	Pipe	7	8
8	Pipe	9	8
9	Pipe	1	21
10	Pipe	11	10
11	Pipe	12	11
12	Pipe	27	12
13	Pipe	10	15
14	Pipe	15	16
15	Pipe	16	17
16	Pipe	17	18
17	Pipe	18	19
18	Pipe	17	20
19	Pipe	11	28
20	Pipe	12	13
21	Pipe	13	14
22	Pipe	27	2
23	Pipe	21	22
24	Pipe	1	23
25	Pipe	23	24
26	Pipe	22	T411
27	Pipe	21	T412
28	Pipe	23	T413
29	Pipe	24	T414
P901	Pump	101	9
P902	Pump	102	20
P501	Pump	103	15
P502	Pump	104	16
P503	Pump	105	18
P504	Pump	106	19
P1028	Pump	107	5
P801	Pump	108	14
P802	Pump	109	13
P903	Pump	110	28

Remedy Wastewater System



Note - Nodes and links are in approximate geographical location, except for Influent tanks (T-411 through T414) which are relocated for clarity

Remedy Wastewater System - Pump P901 at FW-INJ-1

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	703.79	91.33
Junc 20	0.00	439.43	-48.34
Junc 11	0.00	439.43	-50.08
Junc 28	0.00	439.43	-57.44
Junc 10	0.00	439.43	-39.24
Junc 2	0.00	660.09	65.03
Junc 3	0.00	669.98	69.75
Junc 9	0.00	727.79	103.90
Junc 17	0.00	439.43	-50.08
Junc 19	0.00	439.43	-67.41
Junc 27	0.00	635.35	6.65
Junc 4	0.00	675.64	72.64
Junc 5	0.00	693.69	85.66
Junc 7	0.00	717.64	102.54
Junc 8	0.00	723.61	110.32
Junc 13	0.00	439.43	-64.38
Junc 14	0.00	439.43	-78.24

Remedy Wastewater System - Pump P901 at FW-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	439.43	-26.68
Junc 16	0.00	439.43	-49.64
Junc 18	0.00	439.43	-57.01
Junc 12	0.00	439.43	-57.44
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	-400.04	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P901 at FW-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.24	629.00	3.90
Tank T412	110.78	629.00	3.90
Tank T413	110.78	629.00	3.90
Tank T414	89.24	629.00	3.90

Remedy Wastewater System - Pump P901 at FW-INJ-1

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	0.00	0.00	0.00	0.000	Closed
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	400.03	4.54	13.59	0.021	Open
Pipe 3	-400.03	4.54	13.59	0.021	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	-400.03	4.54	13.59	0.021	Open
Pipe 8	400.04	4.54	13.59	0.021	Open
Pipe 7	-400.04	4.54	13.59	0.021	Open
Pipe 6	-400.04	4.54	13.59	0.021	Open
Pipe 5	-400.04	4.54	13.59	0.021	Open
Pipe 4	-400.03	4.54	13.59	0.021	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open

Remedy Wastewater System - Pump P901 at FW-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.03	4.54	13.59	0.021	Open
Pipe 9	200.02	5.11	27.13	0.022	Open
Pipe 23	89.24	2.28	6.09	0.025	Open
Pipe 24	200.02	5.11	27.13	0.022	Open
Pipe 25	89.24	2.28	6.09	0.025	Open
Pipe 26	89.24	4.05	24.71	0.024	Open
Pipe 27	110.78	5.03	36.89	0.023	Open
Pipe 28	110.78	5.03	36.89	0.023	Open
Pipe 29	89.24	4.05	24.71	0.024	Open
Pump P901	400.04	0.00	-312.79	0.000	Open
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P901 at FW-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P902 at FW-INJ-2

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.53	-1.94
Junc 20	0.00	713.66	70.48
Junc 11	0.00	651.94	42.01
Junc 28	0.00	651.94	34.64
Junc 10	0.00	679.30	64.69
Junc 2	0.00	488.53	-9.30
Junc 3	0.00	488.53	-8.87
Junc 9	0.00	488.53	0.23
Junc 17	0.00	699.85	62.76
Junc 19	0.00	699.85	45.43
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.53	-8.44
Junc 5	0.00	488.53	-3.24
Junc 7	0.00	488.53	3.26
Junc 8	0.00	488.53	8.46
Junc 13	0.00	648.14	26.06
Junc 14	0.00	648.14	12.19

Remedy Wastewater System - Pump P902 at FW-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	689.94	81.87
Junc 16	0.00	694.43	60.85
Junc 18	0.00	699.85	55.83
Junc 12	0.00	648.14	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	-400.02	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P902 at FW-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.77	629.00	3.90
Tank T413	110.77	629.00	3.90
Tank T414	89.23	629.00	3.90

Remedy Wastewater System - Pump P902 at FW-INJ-2

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-400.01	4.54	13.59	0.021	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	-400.02	4.54	13.59	0.021	Open
Pipe 15	-400.02	4.54	13.59	0.021	Open
Pipe 14	-400.02	4.54	13.59	0.021	Open
Pipe 13	-400.02	4.54	13.59	0.021	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	-400.02	4.54	13.59	0.021	Open

Remedy Wastewater System - Pump P902 at FW-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-400.01	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.01	4.54	13.59	0.021	Open
Pipe 9	200.01	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.01	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.77	5.03	36.88	0.023	Open
Pipe 28	110.77	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	400.02	0.00	-298.66	0.000	Open
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P902 at FW-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.44	-1.98
Junc 20	0.00	689.94	60.20
Junc 11	0.00	651.94	42.00
Junc 28	0.00	651.94	34.64
Junc 10	0.00	679.30	64.69
Junc 2	0.00	488.44	-9.34
Junc 3	0.00	488.44	-8.91
Junc 9	0.00	488.44	0.19
Junc 17	0.00	689.94	58.47
Junc 19	0.00	689.94	41.14
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.44	-8.48
Junc 5	0.00	488.44	-3.28
Junc 7	0.00	488.44	3.22
Junc 8	0.00	488.44	8.42
Junc 13	0.00	648.14	26.06
Junc 14	0.00	648.14	12.19

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	689.94	81.87
Junc 16	0.00	689.94	58.90
Junc 18	0.00	689.94	51.54
Junc 12	0.00	648.14	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	-400.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.77	629.00	3.90
Tank T413	110.77	629.00	3.90
Tank T414	89.23	629.00	3.90

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-399.99	4.54	13.59	0.021	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	-400.00	4.54	13.59	0.021	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	-400.00	4.54	13.59	0.021	Open

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-400.00	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	399.99	4.54	13.59	0.021	Open
Pipe 9	200.00	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.00	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.77	5.03	36.88	0.023	Open
Pipe 28	110.77	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	400.00	0.00	-274.94	0.000	Open
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P501 at UPGRAD-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.50	-1.95
Junc 20	0.00	694.41	62.14
Junc 11	0.00	651.94	42.00
Junc 28	0.00	651.94	34.64
Junc 10	0.00	679.29	64.69
Junc 2	0.00	488.50	-9.32
Junc 3	0.00	488.50	-8.88
Junc 9	0.00	488.50	0.22
Junc 17	0.00	694.41	60.41
Junc 19	0.00	694.41	43.08
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.50	-8.45
Junc 5	0.00	488.50	-3.25
Junc 7	0.00	488.50	3.25
Junc 8	0.00	488.50	8.45
Junc 13	0.00	648.13	26.06
Junc 14	0.00	648.13	12.19

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	689.93	81.86
Junc 16	0.00	694.41	60.84
Junc 18	0.00	694.41	53.48
Junc 12	0.00	648.13	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	-399.97	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.22	629.00	3.90
Tank T412	110.76	629.00	3.90
Tank T413	110.76	629.00	3.90
Tank T414	89.22	629.00	3.90

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-399.96	4.54	13.59	0.021	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	-399.96	4.54	13.59	0.021	Open
Pipe 13	-399.96	4.54	13.59	0.021	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	-399.96	4.54	13.59	0.021	Open

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-399.96	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	399.96	4.54	13.59	0.021	Open
Pipe 9	199.98	5.11	27.12	0.022	Open
Pipe 23	89.22	2.28	6.09	0.025	Open
Pipe 24	199.98	5.11	27.12	0.022	Open
Pipe 25	89.22	2.28	6.09	0.025	Open
Pipe 26	89.22	4.05	24.71	0.024	Open
Pipe 27	110.76	5.03	36.88	0.023	Open
Pipe 28	110.76	5.03	36.88	0.023	Open
Pipe 29	89.22	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	399.97	0.00	-279.41	0.000	Open
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P502 at UPGRAD-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.56	-1.92
Junc 20	0.00	699.85	64.50
Junc 11	0.00	651.94	42.00
Junc 28	0.00	651.94	34.64
Junc 10	0.00	679.30	64.69
Junc 2	0.00	488.56	-9.29
Junc 3	0.00	488.56	-8.86
Junc 9	0.00	488.56	0.24
Junc 17	0.00	699.85	62.76
Junc 19	0.00	702.89	46.75
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.56	-8.42
Junc 5	0.00	488.56	-3.22
Junc 7	0.00	488.56	3.27
Junc 8	0.00	488.56	8.47
Junc 13	0.00	648.14	26.06
Junc 14	0.00	648.14	12.19

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	689.94	81.87
Junc 16	0.00	694.43	60.85
Junc 18	0.00	702.89	57.15
Junc 12	0.00	648.14	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	-400.01	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.77	629.00	3.90
Tank T413	110.77	629.00	3.90
Tank T414	89.23	629.00	3.90

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-400.00	4.54	13.59	0.021	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	-400.01	4.54	13.59	0.021	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	-400.00	4.54	13.59	0.021	Open
Pipe 14	-400.00	4.54	13.59	0.021	Open
Pipe 13	-400.00	4.54	13.59	0.021	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	-400.00	4.54	13.59	0.021	Open

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-400.00	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.00	4.54	13.59	0.021	Open
Pipe 9	200.00	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.00	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.77	5.03	36.88	0.023	Open
Pipe 28	110.77	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	400.01	0.00	-287.89	0.000	Open
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P503 at UPGRAD-INJ-3

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.44	-1.98
Junc 20	0.00	699.85	64.50
Junc 11	0.00	651.94	42.01
Junc 28	0.00	651.94	34.64
Junc 10	0.00	679.30	64.69
Junc 2	0.00	488.44	-9.34
Junc 3	0.00	488.44	-8.91
Junc 9	0.00	488.44	0.19
Junc 17	0.00	699.85	62.76
Junc 19	0.00	707.14	48.59
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.44	-8.48
Junc 5	0.00	488.44	-3.28
Junc 7	0.00	488.44	3.22
Junc 8	0.00	488.44	8.42
Junc 13	0.00	648.14	26.06
Junc 14	0.00	648.14	12.19

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	689.94	81.87
Junc 16	0.00	694.43	60.85
Junc 18	0.00	702.90	57.15
Junc 12	0.00	648.14	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	-400.02	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.77	629.00	3.90
Tank T413	110.77	629.00	3.90
Tank T414	89.23	629.00	3.90

Influent Storage tanks at elevation 620' with 9 feet of water

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-400.01	4.54	13.59	0.021	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	-400.02	4.54	13.59	0.021	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	-400.02	4.54	13.59	0.021	Open
Pipe 14	-400.01	4.54	13.59	0.021	Open
Pipe 13	-400.01	4.54	13.59	0.021	Open
Pipe 17	-400.02	4.54	13.59	0.021	Open
Pipe 10	-400.01	4.54	13.59	0.021	Open

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-400.01	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.01	4.54	13.59	0.021	Open
Pipe 9	200.00	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.00	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.77	5.03	36.88	0.023	Open
Pipe 28	110.77	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	400.02	0.00	-292.14	0.000	Open

Remedy Wastewater System - Pump P504 at UPGRAD-INJ-4

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	693.68	86.96
Junc 20	0.00	439.53	-48.30
Junc 11	0.00	439.53	-50.03
Junc 28	0.00	439.53	-57.40
Junc 10	0.00	439.53	-39.20
Junc 2	0.00	660.09	65.03
Junc 3	0.00	669.98	69.75
Junc 9	0.00	693.68	89.12
Junc 17	0.00	439.53	-50.03
Junc 19	0.00	439.53	-67.37
Junc 27	0.00	635.35	6.65
Junc 4	0.00	675.63	72.64
Junc 5	0.00	693.68	85.66
Junc 7	0.00	693.68	92.16
Junc 8	0.00	693.68	97.36
Junc 13	0.00	439.53	-64.33
Junc 14	0.00	439.53	-78.20

Influent Storage tanks at elevation 620' with 9 feet of water

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	439.53	-26.64
Junc 16	0.00	439.53	-49.60
Junc 18	0.00	439.53	-56.97
Junc 12	0.00	439.53	-57.40
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	-400.02	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.78	629.00	3.90
Tank T413	110.78	629.00	3.90
Tank T414	89.23	629.00	3.90

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	0.00	0.00	0.00	0.000	Closed
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	400.02	4.54	13.59	0.021	Open
Pipe 3	-400.02	4.54	13.59	0.021	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	-400.02	4.54	13.59	0.021	Open
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	-400.02	4.54	13.59	0.021	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open

Influent Storage tanks at elevation 620' with 9 feet of water

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	0.00	0.00	0.00	0.000	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.02	4.54	13.59	0.021	Open
Pipe 9	200.01	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.01	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.78	5.03	36.88	0.023	Open
Pipe 28	110.78	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P1028 at MW-20 Maintenance Building

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	400.02	0.00	-278.68	0.000	Open
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	486.39	-2.86
Junc 20	0.00	629.86	34.17
Junc 11	0.00	629.86	32.44
Junc 28	0.00	629.86	25.07
Junc 10	0.00	629.86	43.27
Junc 2	0.00	486.39	-10.23
Junc 3	0.00	486.39	-9.80
Junc 9	0.00	486.39	-0.70
Junc 17	0.00	629.86	32.44
Junc 19	0.00	629.86	15.11
Junc 27	0.00	629.29	4.02
Junc 4	0.00	486.39	-9.36
Junc 5	0.00	486.39	-4.16
Junc 7	0.00	486.39	2.34
Junc 8	0.00	486.39	7.53
Junc 13	0.00	662.01	32.07
Junc 14	0.00	687.31	29.17

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	629.86	55.84
Junc 16	0.00	629.86	32.87
Junc 18	0.00	629.86	25.50
Junc 12	0.00	629.86	25.07
Junc 1	0.00	629.04	272.56
Junc 21	0.00	629.02	3.91
Junc 23	0.00	629.02	3.91
Junc 24	0.00	629.01	3.90
Junc 22	0.00	629.01	3.90
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	-75.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	16.73	629.00	3.90
Tank T412	20.77	629.00	3.90
Tank T413	20.77	629.00	3.90
Tank T414	16.73	629.00	3.90

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-75.00	0.85	0.61	0.027	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open

Influent Storage tanks at elevation 620' with 9 feet of water

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	0.01	0.00	0.00	0.000	Open
Pipe 20	-75.00	7.66	129.10	0.024	Open
Pipe 21	-75.00	7.66	129.11	0.024	Open
Pipe 1	75.00	0.85	0.61	0.027	Open
Pipe 9	37.50	0.96	1.22	0.029	Open
Pipe 23	16.73	0.43	0.27	0.032	Open
Pipe 24	37.50	0.96	1.22	0.029	Open
Pipe 25	16.73	0.43	0.27	0.032	Open
Pipe 26	16.73	0.76	1.11	0.031	Open
Pipe 27	20.77	0.94	1.66	0.030	Open
Pipe 28	20.77	0.94	1.66	0.030	Open
Pipe 29	16.73	0.76	1.11	0.031	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P801 at COMP-INJ-1

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	75.00	0.00	-272.31	0.000	Open
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	486.36	-2.88
Junc 20	0.00	629.86	34.17
Junc 11	0.00	629.86	32.44
Junc 28	0.00	629.86	25.07
Junc 10	0.00	629.86	43.27
Junc 2	0.00	486.36	-10.24
Junc 3	0.00	486.36	-9.81
Junc 9	0.00	486.36	-0.71
Junc 17	0.00	629.86	32.44
Junc 19	0.00	629.86	15.11
Junc 27	0.00	629.29	4.02
Junc 4	0.00	486.36	-9.38
Junc 5	0.00	486.36	-4.18
Junc 7	0.00	486.36	2.32
Junc 8	0.00	486.36	7.52
Junc 13	0.00	662.01	32.07
Junc 14	0.00	662.01	18.20

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	629.86	55.84
Junc 16	0.00	629.86	32.87
Junc 18	0.00	629.86	25.50
Junc 12	0.00	629.86	25.07
Junc 1	0.00	629.04	272.56
Junc 21	0.00	629.02	3.91
Junc 23	0.00	629.02	3.91
Junc 24	0.00	629.01	3.90
Junc 22	0.00	629.01	3.90
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	-75.00	415.00	0.00

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	0.00	415.00	0.00
Tank T411	16.73	629.00	3.90
Tank T412	20.77	629.00	3.90
Tank T413	20.77	629.00	3.90
Tank T414	16.73	629.00	3.90

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-75.00	0.85	0.61	0.027	Open
Pipe 19	0.00	0.00	0.00	0.000	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	0.00	0.00	0.00	0.000	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	0.00	0.00	0.00	0.000	Open

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	0.01	0.00	0.00	0.000	Open
Pipe 20	-75.00	7.66	129.09	0.024	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	74.99	0.85	0.61	0.027	Open
Pipe 9	37.50	0.96	1.22	0.029	Open
Pipe 23	16.73	0.43	0.27	0.032	Open
Pipe 24	37.50	0.96	1.22	0.029	Open
Pipe 25	16.73	0.43	0.27	0.032	Open
Pipe 26	16.73	0.76	1.11	0.031	Open
Pipe 27	20.77	0.94	1.66	0.030	Open
Pipe 28	20.77	0.94	1.66	0.030	Open
Pipe 29	16.73	0.76	1.11	0.031	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P802 at COMP-INJ-2

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	75.00	0.00	-247.01	0.000	Open
Pump P903	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P903 at FW-INJ-4

Network Table - Nodes

Node ID	Demand GPM	Head ft	Pressure psi
Junc 6	0.00	488.44	-1.98
Junc 20	0.00	651.94	43.74
Junc 11	0.00	651.94	42.00
Junc 28	0.00	708.75	59.25
Junc 10	0.00	651.94	52.84
Junc 2	0.00	488.44	-9.34
Junc 3	0.00	488.44	-8.91
Junc 9	0.00	488.44	0.19
Junc 17	0.00	651.94	42.00
Junc 19	0.00	651.94	24.67
Junc 27	0.00	635.35	6.65
Junc 4	0.00	488.44	-8.48
Junc 5	0.00	488.44	-3.28
Junc 7	0.00	488.44	3.22
Junc 8	0.00	488.44	8.42
Junc 13	0.00	648.14	26.06
Junc 14	0.00	648.14	12.19

Influent Storage tanks at elevation 620' with 9 feet of water

Remedy Wastewater System - Pump P903 at FW-INJ-4

Node ID	Demand GPM	Head ft	Pressure psi
Junc 15	0.00	651.94	65.40
Junc 16	0.00	651.94	42.44
Junc 18	0.00	651.94	35.07
Junc 12	0.00	648.14	32.99
Junc 1	0.00	629.91	272.94
Junc 21	0.00	629.37	4.06
Junc 23	0.00	629.37	4.06
Junc 24	0.00	629.25	4.01
Junc 22	0.00	629.25	4.01
Resvr 101	0.00	415.00	0.00
Resvr 102	0.00	415.00	0.00
Resvr 103	0.00	415.00	0.00
Resvr 104	0.00	415.00	0.00
Resvr 105	0.00	415.00	0.00
Resvr 106	0.00	415.00	0.00
Resvr 107	0.00	415.00	0.00
Resvr 108	0.00	415.00	0.00
Resvr 109	0.00	415.00	0.00

Remedy Wastewater System - Pump P903 at FW-INJ-4

Node ID	Demand GPM	Head ft	Pressure psi
Resvr 110	-400.00	415.00	0.00
Tank T411	89.23	629.00	3.90
Tank T412	110.77	629.00	3.90
Tank T413	110.77	629.00	3.90
Tank T414	89.23	629.00	3.90

Remedy Wastewater System - Pump P903 at FW-INJ-4

Network Table - Links

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 12	-400.00	4.54	13.59	0.021	Open
Pipe 19	-400.00	10.21	97.95	0.020	Open
Pipe 2	0.00	0.00	0.00	0.000	Open
Pipe 3	0.00	0.00	0.00	0.000	Open
Pipe 16	0.00	0.00	0.00	0.000	Open
Pipe 22	0.00	0.00	0.00	0.000	Closed
Pipe 8	0.00	0.00	0.00	0.000	Open
Pipe 7	0.00	0.00	0.00	0.000	Open
Pipe 6	0.00	0.00	0.00	0.000	Open
Pipe 5	0.00	0.00	0.00	0.000	Open
Pipe 4	0.00	0.00	0.00	0.000	Open
Pipe 18	0.00	0.00	0.00	0.000	Open
Pipe 15	0.00	0.00	0.00	0.000	Open
Pipe 14	0.00	0.00	0.00	0.000	Open
Pipe 13	0.01	0.00	0.00	0.000	Open
Pipe 17	0.00	0.00	0.00	0.000	Open
Pipe 10	0.01	0.00	0.00	0.000	Open

Remedy Wastewater System - Pump P903 at FW-INJ-4

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pipe 11	-400.00	4.54	13.59	0.021	Open
Pipe 20	0.00	0.00	0.00	0.000	Open
Pipe 21	0.00	0.00	0.00	0.000	Open
Pipe 1	400.00	4.54	13.59	0.021	Open
Pipe 9	200.00	5.11	27.13	0.022	Open
Pipe 23	89.23	2.28	6.09	0.025	Open
Pipe 24	200.00	5.11	27.13	0.022	Open
Pipe 25	89.23	2.28	6.09	0.025	Open
Pipe 26	89.23	4.05	24.71	0.024	Open
Pipe 27	110.77	5.03	36.88	0.023	Open
Pipe 28	110.77	5.03	36.88	0.023	Open
Pipe 29	89.23	4.05	24.71	0.024	Open
Pump P901	0.00	0.00	0.00	0.000	Closed
Pump P902	0.00	0.00	0.00	0.000	Closed
Pump P501	0.00	0.00	0.00	0.000	Closed
Pump P502	0.00	0.00	0.00	0.000	Closed
Pump P503	0.00	0.00	0.00	0.000	Closed
Pump P504	0.00	0.00	0.00	0.000	Closed

Remedy Wastewater System - Pump P903 at FW-INJ-4

Link ID	Flow GPM	Velocity fps	Unit Headloss ft/Kft	Friction Factor	Status
Pump P1028	0.00	0.00	0.00	0.000	Closed
Pump P801	0.00	0.00	0.00	0.000	Closed
Pump P802	0.00	0.00	0.00	0.000	Closed
Pump P903	400.00	0.00	-293.75	0.000	Open

Hydraulic Calculations for NTH IRZ, Inner Recirculation Loop, and TCS Recirculation Loop Wells

Attachment B

- NTH IRZ Extraction and Injection Wells
- Inner Recirculation Loop Extraction and Injection Wells
- TCS Recirculation Loop Extraction and Injection Wells

NTH IRZ Extraction and Injection Wells

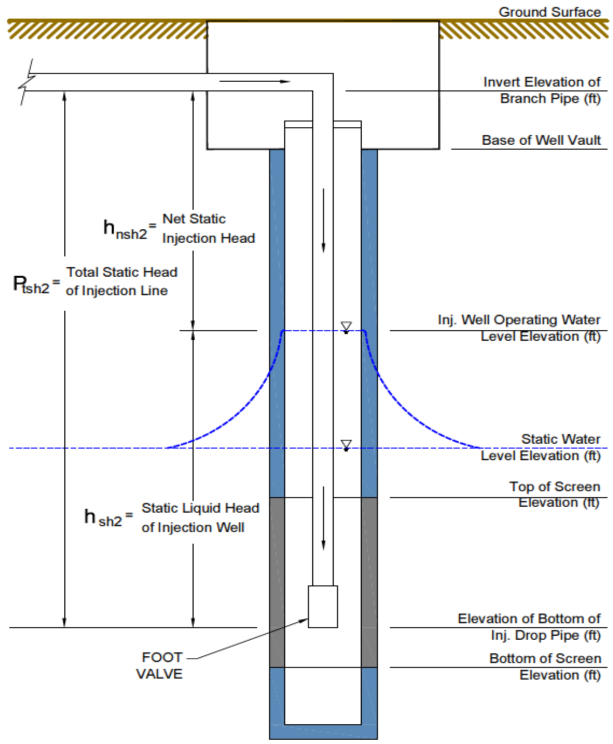
Injection Well Hydraulic Worksheet (IRZ-11, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-11, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	9.75
Design Injection Flowrate For All Layers in Well (gpm):	39
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	475.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	432.2
Top of Screen Elevation (ft):	430.2
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	50.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	43.3
Net Static Head of Injection Line, h_{nsh2} (ft):	7.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	50.8
Pipe Friction Factor, *f*:	0.0253
Flowrate (gpm):	9.75
Velocity, *v* (ft/s):	3.62
Reynolds Number, Re:	2.24E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 54.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0589

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **3.20**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0211
Flowrate (gpm):	39
Velocity, *v* (ft/s):	4.34
Reynolds Number, Re:	4.91E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 38.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 143.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0386

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 5.52

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**8.71**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.20**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**76.34**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	

Design Injection Head Required (ft):	**30.80**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**38.68**	*Safety factor of 5%*

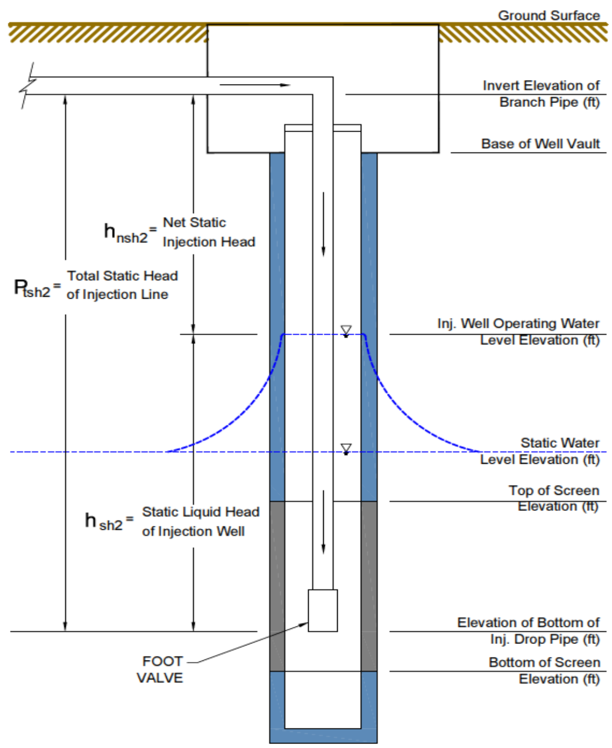
Injection Well Hydraulic Worksheet (IRZ-11, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-11, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	9.75
Design Injection Flowrate For All Layers in Well (gpm):	39
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	475.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	370.5
Top of Screen Elevation (ft):	368.5
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	112.5
Static Liquid Head of Injection Well, h_{sh2} (ft):	105
Net Static Head of Injection Line, h_{nsh2} (ft):	7.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	112.5
Pipe Friction Factor, f:	0.0253
Flowrate (gpm):	9.75
Velocity, v (ft/s):	3.62
Reynolds Number, Re:	2.24E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 116.0

Head Loss Across Drop Pipe Hp (ft/ft pipe): 0.0589

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **6.83**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0214
Flowrate (gpm):	39
Velocity, *v* (ft/s):	3.73
Reynolds Number, Re:	4.56E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 40.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 145.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0269

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 3.91

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 2)

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**10.74**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.20**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**78.37**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	
Design Injection Head Required (ft):	**32.93**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**40.81**	*Safety factor of 5%*

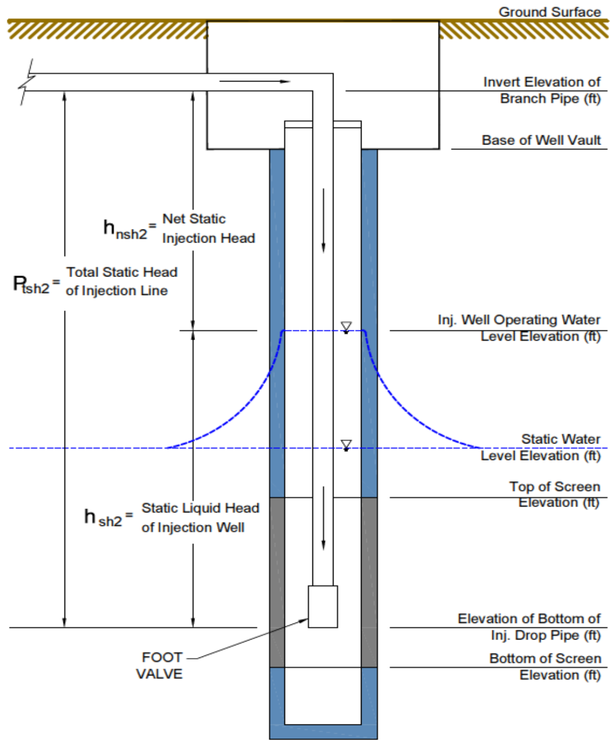
Injection Well Hydraulic Worksheet (IRZ-11, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-11, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	9.75
Design Injection Flowrate For All Layers in Well (gpm):	39
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	475.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	304
Top of Screen Elevation (ft):	302
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	179
Static Liquid Head of Injection Well, h_{sh2} (ft):	171.5
Net Static Head of Injection Line, h_{nsh2} (ft):	7.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	179
Pipe Friction Factor, *f*:	0.0253
Flowrate (gpm):	9.75
Velocity, *v* (ft/s):	3.62
Reynolds Number, Re:	2.24E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 182.5

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0589

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **10.75**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0211
Flowrate (gpm):	39
Velocity, *v* (ft/s):	4.34
Reynolds Number, Re:	4.91E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 38.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 143.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0386

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **5.52**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft): **16.27**

$$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.20**

Assumed equal to one velocity head, Hv.

$$\boxed{Hv = \frac{v^2}{2 \times 32.174}}$$

Total In-Line Equipment Head, *He* (ft): **1.00**

Foot Valve Fully Open Pressure, *Hf* $_2$ (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$\boxed{Hf_2 = Hf \times 2}$$

Total Injection Head Required at Branch Line, *Hd* (ft): **83.89**

$$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **47**

Design Injection Head Required (ft): **38.74**

Safety factor of 5%

Worst Case Injection Head Required (ft): **46.61**

Safety factor of 5%

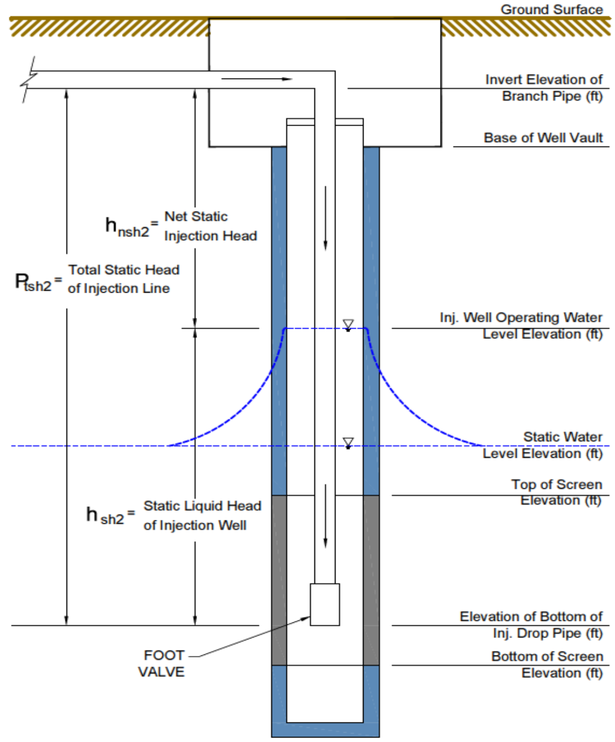
Injection Well Hydraulic Worksheet (IRZ-11, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-11, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	9.75
Design Injection Flowrate For All Layers in Well (gpm):	39
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	475.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	253
Top of Screen Elevation (ft):	251
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	230
Static Liquid Head of Injection Well, h_{sh2} (ft):	222.5
Net Static Head of Injection Line, h_{nsh2} (ft):	7.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	230
Pipe Friction Factor, f:	0.0253
Flowrate (gpm):	9.75
Velocity, v (ft/s):	3.62
Reynolds Number, Re:	2.24E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 233.5

Head Loss Across Drop Pipe Hp (ft/ft pipe): 0.0589

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **13.76**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0211
Flowrate (gpm):	39
Velocity, *v* (ft/s):	4.34
Reynolds Number, Re:	4.91E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 38.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 143.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0386

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **5.52**

Injection Well Hydraulic Worksheet (IRZ-11, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft): 19.27

$$Hp_{Injection} = Hp_{drop} + Hp_{branch}$$

Exit Loss at Liquid Discharge, *Hv* (ft): 0.20

Assumed equal to one velocity head, Hv.

$$Hv = \frac{v^2}{2 \times 32.174}$$

Total In-Line Equipment Head, *He* (ft): 1.00

Foot Valve Fully Open Pressure, Hf_2 (ft): 73.92

Assumed two times cracking pressure (Hf) to fully open.

$$Hf_2 = Hf \times 2$$

Total Injection Head Required at Branch Line, *Hd* (ft): 86.90

$$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$$

Maximum Static Elevation of Injection Well Network (ft): 530

Maximum Static Head from Branch Connection (ft): 47

Design Injection Head Required (ft): 41.89

Safety factor of 5%

Worst Case Injection Head Required (ft): 49.77

Safety factor of 5%

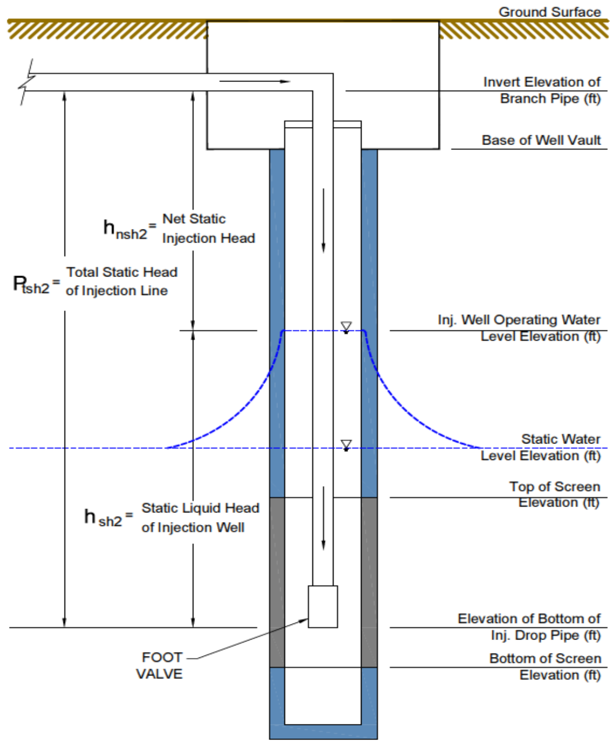
Injection Well Hydraulic Worksheet (IRZ-13, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-13, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	34
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	473
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	445.2
Top of Screen Elevation (ft):	443.2
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	37.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	27.8
Net Static Head of Injection Line, h_{nsh2} (ft):	10
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	37.8
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	8.5
Velocity, *v* (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 41.1

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 1.90

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0217
Flowrate (gpm):	34
Velocity, *v* (ft/s):	3.78
Reynolds Number, Re:	4.28E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 142.0

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0302

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **4.29**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft): **6.19**

$$Hp_{Injection} = Hp_{drop} + Hp_{branch}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.15**

Assumed equal to one velocity head, Hv.

$$Hv = \frac{v^2}{2 \times 32.174}$$

Total In-Line Equipment Head, *He* (ft): **1.00**

Foot Valve Fully Open Pressure, *Hf* $_2$ (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$Hf_2 = Hf \times 2$$

Total Injection Head Required at Branch Line, *Hd* (ft): **71.27**

$$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **47**

Design Injection Head Required (ft): **25.48**

Safety factor of 5%

Worst Case Injection Head Required (ft): **35.98**

Safety factor of 5%

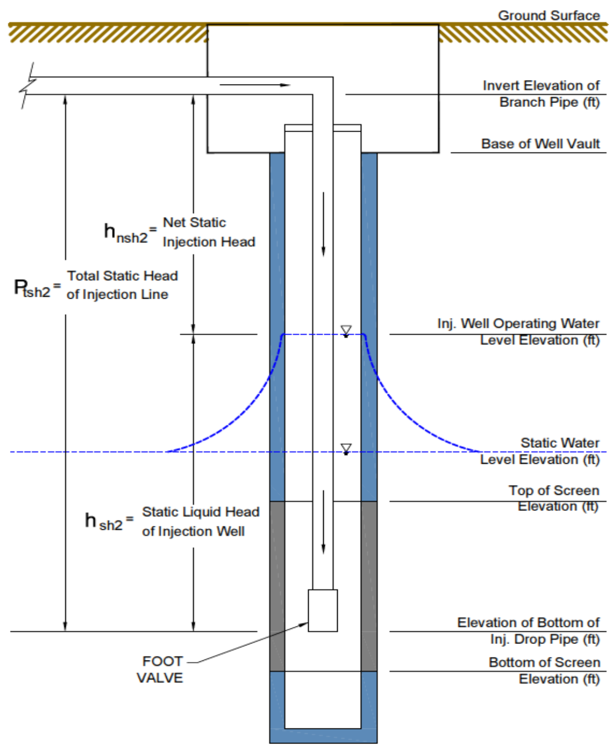
Injection Well Hydraulic Worksheet (IRZ-13, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-13, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	34
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	473
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	394.1
Top of Screen Elevation (ft):	392.1
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	88.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	78.9
Net Static Head of Injection Line, h_{nsh2} (ft):	10
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	88.9
Pipe Friction Factor, f:	0.0261
Flowrate (gpm):	8.5
Velocity, v (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 92.2

Head Loss Across Drop Pipe Hp (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **4.27**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0221
Flowrate (gpm):	34
Velocity, *v* (ft/s):	3.25
Reynolds Number, Re:	3.97E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 39.2

$$\boxed{Length = \frac{k \times \frac{ID}{12}}{f}}$$

Equivalent Length of Injection Branch Piping (ft): 144.2

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0211

$$\boxed{Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **3.04**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 2)

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**7.31**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.15**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**72.38**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	
Design Injection Head Required (ft):	**26.65**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**37.15**	*Safety factor of 5%*

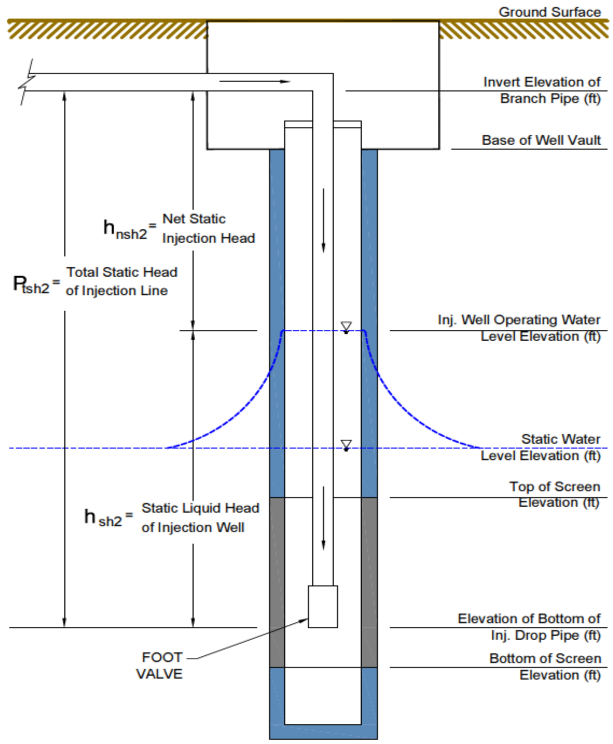
Injection Well Hydraulic Worksheet (IRZ-13, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-13, LAYER 3

Fluid:	(◉) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	34
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	473
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	337.1
Top of Screen Elevation (ft):	335.1
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	145.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	135.9
Net Static Head of Injection Line, h_{nsh2} (ft):	10
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	145.9
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	8.5
Velocity, *v* (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 149.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **6.91**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0217
Flowrate (gpm):	34
Velocity, *v* (ft/s):	3.78
Reynolds Number, Re:	4.28E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valve/Fitting Tag	K	# Units	Valves and Fitting Losses (K values) Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.0

$$\boxed{Length = \frac{k \times \frac{ID}{12}}{f}}$$

Equivalent Length of Injection Branch Piping (ft): 142.0

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0302

$$\boxed{Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **4.29**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

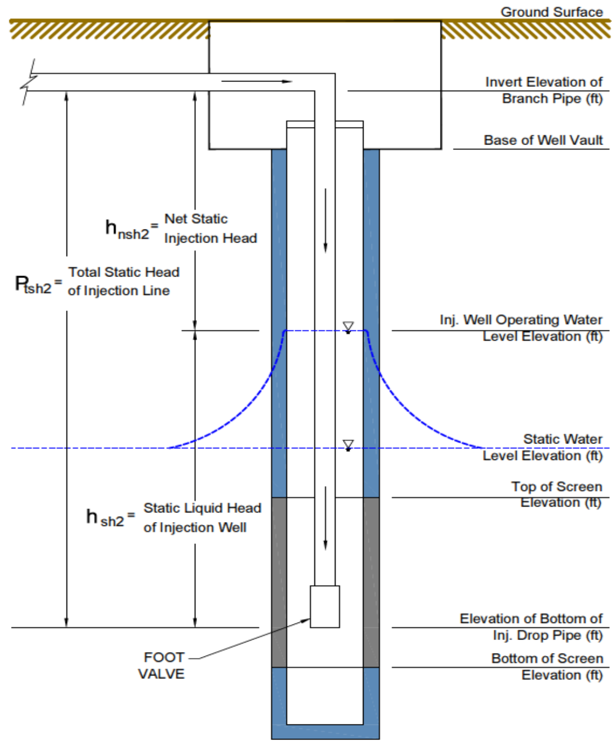
Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**11.20**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.15**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**76.27**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	
Design Injection Head Required (ft):	**30.73**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**41.23**	*Safety factor of 5%*

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID:	IRZ-13, LAYER 4
Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	34
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	473
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	284.6
Top of Screen Elevation (ft):	282.6
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	198.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	188.4
Net Static Head of Injection Line, h_{nsh2} (ft):	10
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	198.4
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	8.5
Velocity, *v* (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 201.7

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 9.34

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0217
Flowrate (gpm):	34
Velocity, *v* (ft/s):	3.78
Reynolds Number, Re:	4.28E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 142.0

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0302

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **4.29**

Injection Well Hydraulic Worksheet (IRZ-13, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**13.63**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.15**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**78.70**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\ 2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	
Design Injection Head Required (ft):	**33.29**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**43.79**	*Safety factor of 5%*

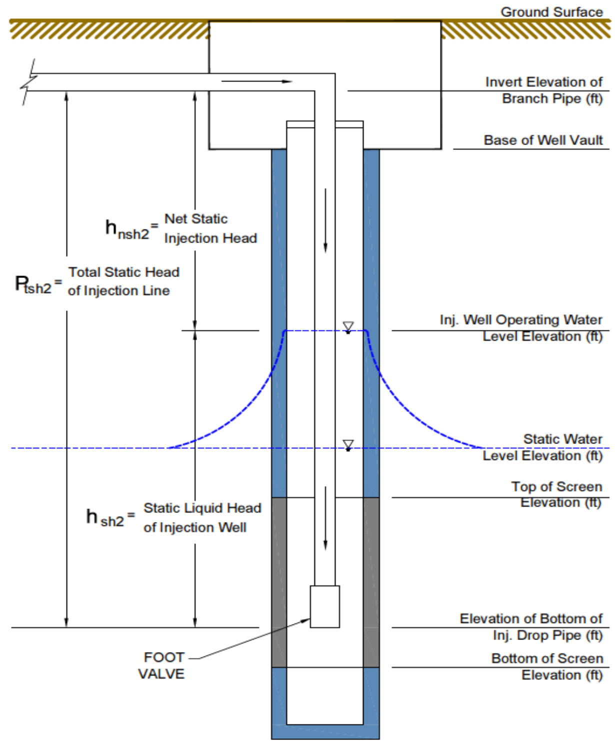
Injection Well Hydraulic Worksheet (IRZ-15, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-15, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7.5
Design Injection Flowrate For All Layers in Well (gpm):	30
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	471
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	449.8
Top of Screen Elevation (ft):	447.8
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	33.2
Static Liquid Head of Injection Well, h_{sh2} (ft):	21.2
Net Static Head of Injection Line, h_{nsh2} (ft):	12
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	33.2
Pipe Friction Factor, *f*:	0.0270
Flowrate (gpm):	7.5
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	1.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valve/Fitting Tag	K	# Units	Valves and Fitting Losses (K values) Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 36.4

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0372

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **1.35**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0224
Flowrate (gpm):	30
Velocity, *v* (ft/s):	3.33
Reynolds Number, Re:	3.78E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valve/Fitting Tag	K	# Units	Valves and Fitting Losses (K values) Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0242

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **3.41**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**4.76**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, Hv (ft):	**0.12**	*Assumed equal to one velocity head, Hv.* $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, He (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	*Assumed two times cracking pressure (Hf) to fully open.* $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, Hd (ft):	**67.80**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	
Design Injection Head Required (ft):	**21.84**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**34.44**	*Safety factor of 5%*

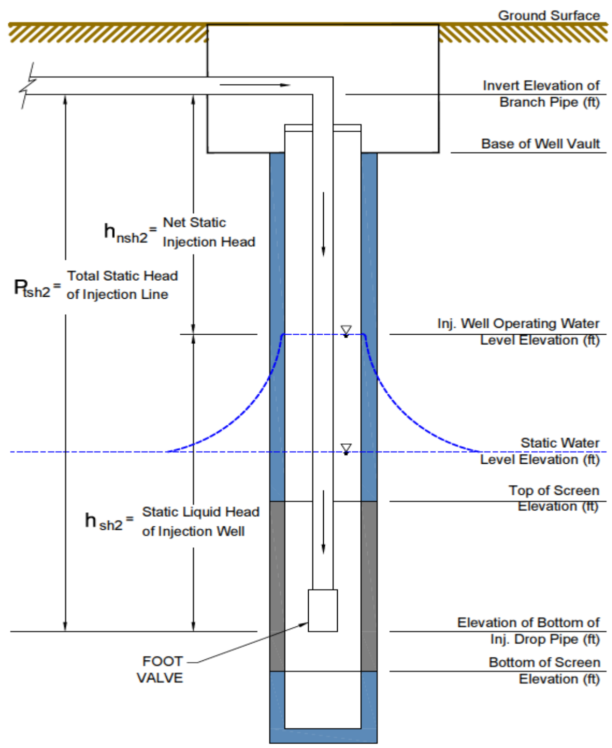
Injection Well Hydraulic Worksheet (IRZ-15, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-15, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7.5
Design Injection Flowrate For All Layers in Well (gpm):	30
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	471
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	402.6
Top of Screen Elevation (ft):	400.6
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	80.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	68.4
Net Static Head of Injection Line, h_{nsh2} (ft):	12
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	80.4
Pipe Friction Factor, *f*:	0.0270
Flowrate (gpm):	7.5
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	1.73E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 83.6

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0372

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 3.11

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0227
Flowrate (gpm):	30
Velocity, *v* (ft/s):	2.87
Reynolds Number, Re:	3.50E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 38.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 143.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0169

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 2.42

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 2)

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**5.52**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.12**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**68.56**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	

Design Injection Head Required (ft):	**22.64**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**35.24**	*Safety factor of 5%*

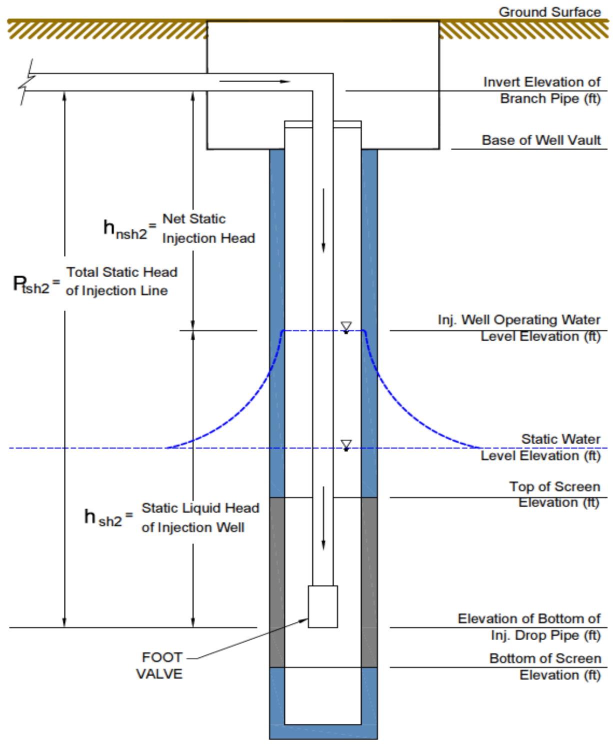
Injection Well Hydraulic Worksheet (IRZ-15, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-15, LAYER 3

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7.5
Design Injection Flowrate For All Layers in Well (gpm):	30
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	471
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	354
Top of Screen Elevation (ft):	352
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	129
Static Liquid Head of Injection Well, h_{sh2} (ft):	117
Net Static Head of Injection Line, h_{nsh2} (ft):	12
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	129
Pipe Friction Factor, *f*:	0.0270
Flowrate (gpm):	7.5
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	1.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 132.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0372

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **4.91**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0224
Flowrate (gpm):	30
Velocity, *v* (ft/s):	3.33
Reynolds Number, Re:	3.78E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0242

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 3.41

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft): **8.32**

$$Hp_{Injection} = Hp_{drop} + Hp_{branch}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.12**

Assumed equal to one velocity head, Hv.

$$Hv = \frac{v^2}{2 \times 32.174}$$

Total In-Line Equipment Head, *He* (ft): **1.00**

Foot Valve Fully Open Pressure, *Hf* $_2$ (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$Hf_2 = Hf \times 2$$

Total Injection Head Required at Branch Line, *Hd* (ft): **71.36**

$$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **47**

Design Injection Head Required (ft): **25.58**

Safety factor of 5%

Worst Case Injection Head Required (ft): **38.18**

Safety factor of 5%

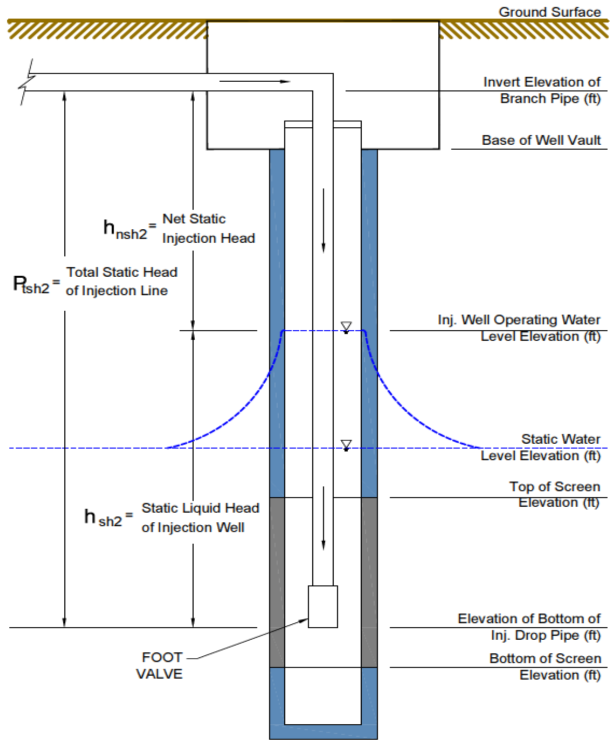
Injection Well Hydraulic Worksheet (IRZ-15, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-15, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7.5
Design Injection Flowrate For All Layers in Well (gpm):	30
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	483
Inj. Well Operating Water Elevation (ft):	471
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	310.2
Top of Screen Elevation (ft):	308.2
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	172.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	160.8
Net Static Head of Injection Line, h_{nsh2} (ft):	12
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	172.8
Pipe Friction Factor, *f*:	0.0270
Flowrate (gpm):	7.5
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	1.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 176.0

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0372

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **6.54**

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0224
Flowrate (gpm):	30
Velocity, *v* (ft/s):	3.33
Reynolds Number, Re:	3.78E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0242

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 3.41

Injection Well Hydraulic Worksheet (IRZ-15, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**9.95**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.12**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**72.99**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**47**	

Design Injection Head Required (ft):	**27.29**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**39.89**	*Safety factor of 5%*

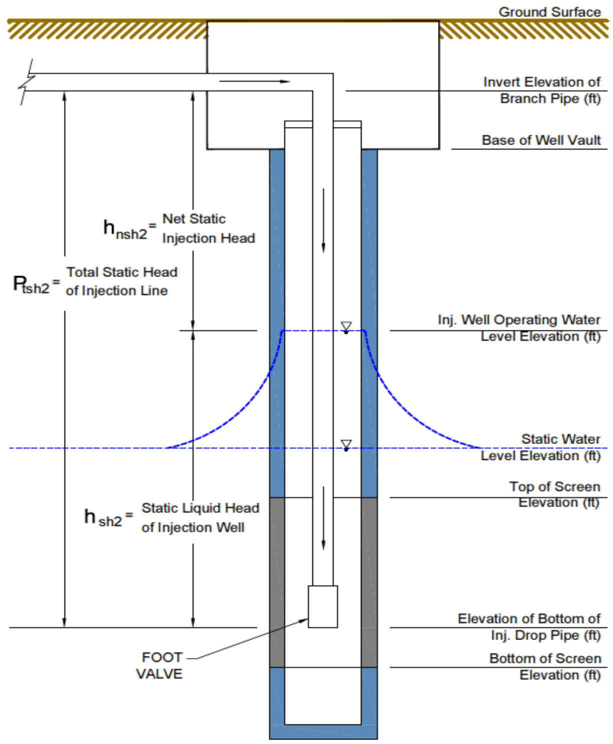
Injection Well Hydraulic Worksheet (IRZ-16, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-16, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	28
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	485
Inj. Well Operating Water Elevation (ft):	470
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	443.7
Top of Screen Elevation (ft):	441.7
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	41.3
Static Liquid Head of Injection Well, h_{sh2} (ft):	26.3
Net Static Head of Injection Line, h_{nsh2} (ft):	15
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	41.3
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 44.5

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 1.46

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0227
Flowrate (gpm):	28
Velocity, *v* (ft/s):	3.11
Reynolds Number, Re:	3.53E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0214

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 3.00

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**4.47**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, Hv (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, He (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, Hd (ft):	**64.49**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**45**	

Design Injection Head Required (ft):	**20.47**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**36.22**	*Safety factor of 5%*

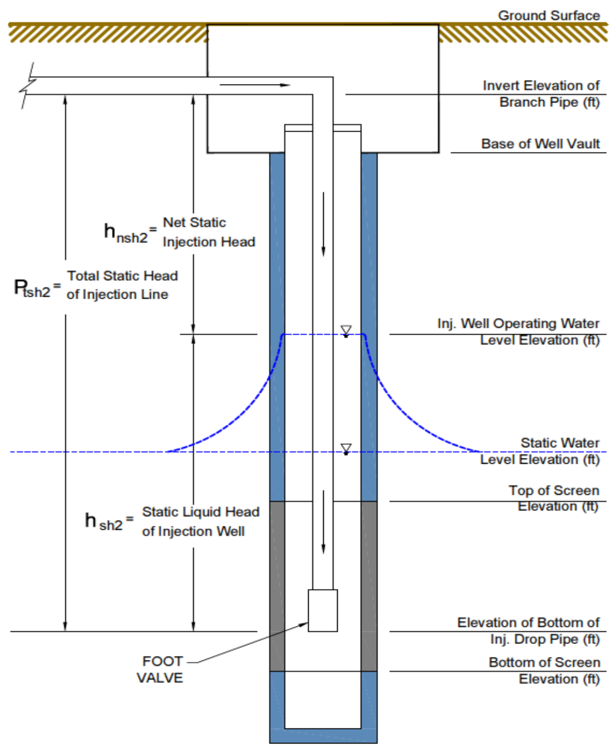
Injection Well Hydraulic Worksheet (IRZ-16, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-16, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	28
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	485
Inj. Well Operating Water Elevation (ft):	470
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	391
Top of Screen Elevation (ft):	389
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	94
Static Liquid Head of Injection Well, h_{sh2} (ft):	79
Net Static Head of Injection Line, h_{nsh2} (ft):	15
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		

Cumulative Pressure Drop (ft w.c.): 1

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	94
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)					
Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 97.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 3.20

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0231
Flowrate (gpm):	28
Velocity, *v* (ft/s):	2.68
Reynolds Number, Re:	3.27E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 142.5

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0149

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **2.13**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 2)

Total Injection Piping System Head Loss, *Hp*$_{injection}$ (ft):	**5.33**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf*$_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**65.35**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**45**	
Design Injection Head Required (ft):	**21.37**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**37.12**	*Safety factor of 5%*

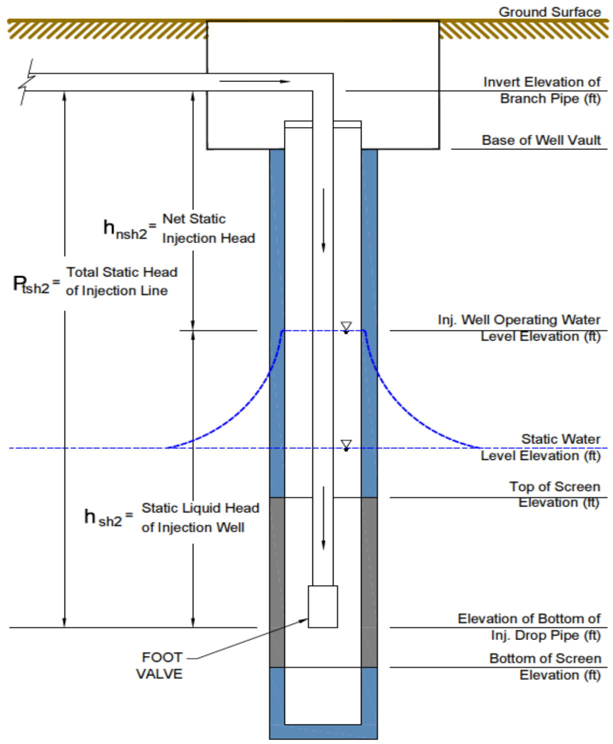
Injection Well Hydraulic Worksheet (IRZ-16, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-16, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	28
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	485
Inj. Well Operating Water Elevation (ft):	470
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	346.2
Top of Screen Elevation (ft):	344.2
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	138.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	123.8
Net Static Head of Injection Line, h_{nsh2} (ft):	15
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	138.8
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 142.0

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 4.67

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0227
Flowrate (gpm):	28
Velocity, *v* (ft/s):	3.11
Reynolds Number, Re:	3.53E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valve/Fitting Tag	K	# Units	Valves and Fitting Losses (K values) Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0214

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **3.00**

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**7.68**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**67.70**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**45**	
Design Injection Head Required (ft):	**23.84**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**39.59**	*Safety factor of 5%*

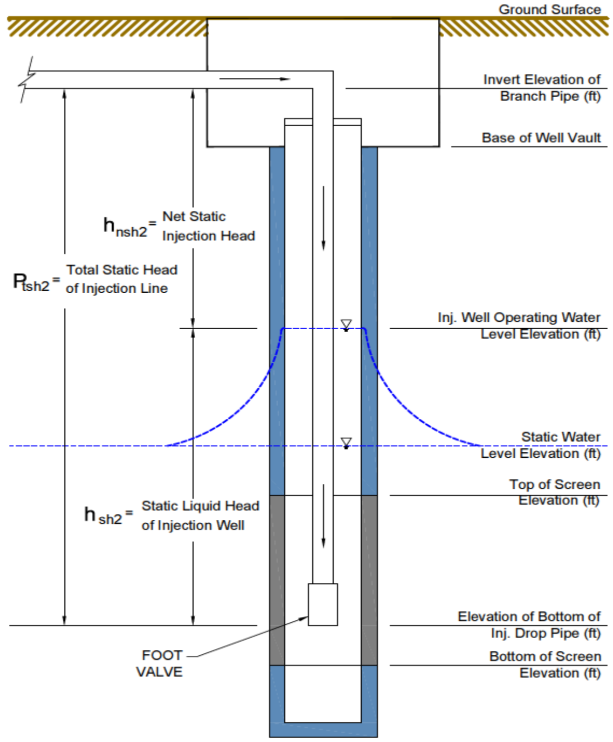
Injection Well Hydraulic Worksheet (IRZ-16, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-16, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	28
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	485
Inj. Well Operating Water Elevation (ft):	470
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	308.4
Top of Screen Elevation (ft):	306.4
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	176.6
Static Liquid Head of Injection Well, h_{sh2} (ft):	161.6
Net Static Head of Injection Line, h_{nsh2} (ft):	15
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	176.6
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 179.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **5.92**

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0227
Flowrate (gpm):	28
Velocity, *v* (ft/s):	3.11
Reynolds Number, Re:	3.53E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0214

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, *Hp* $_{branch}$ (ft): **3.00**

Injection Well Hydraulic Worksheet (IRZ-16, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**8.92**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**68.95**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**45**	
Design Injection Head Required (ft):	**25.15**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**40.90**	*Safety factor of 5%*

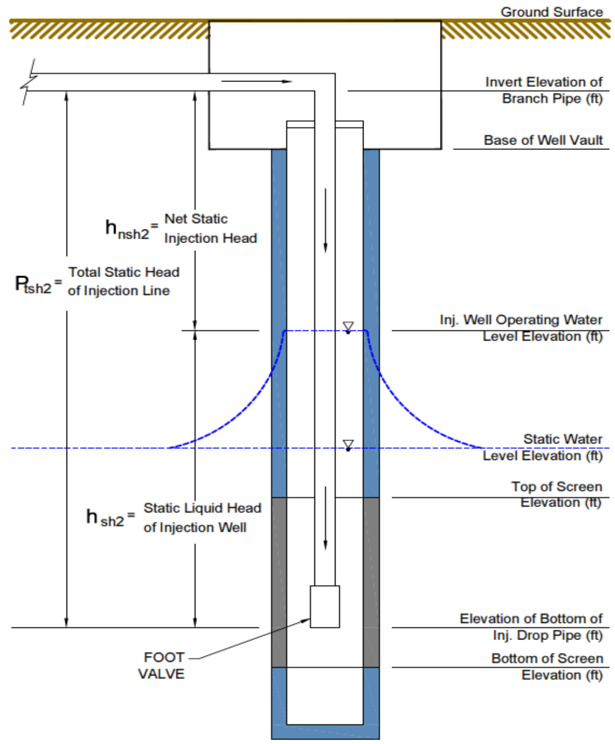
Injection Well Hydraulic Worksheet (IRZ-17, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-17, LAYER 1

Fluid:	(•) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	6.75
Design Injection Flowrate For All Layers in Well (gpm):	27
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	486
Inj. Well Operating Water Elevation (ft):	469.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	446.4
Top of Screen Elevation (ft):	444.4
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	39.6
Static Liquid Head of Injection Well, h_{sh2} (ft):	23.1
Net Static Head of Injection Line, h_{nsh2} (ft):	16.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	39.6
Pipe Friction Factor, *f*:	0.0277
Flowrate (gpm):	6.75
Velocity, *v* (ft/s):	2.51
Reynolds Number, Re:	1.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 42.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0309

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **1.32**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0229
Flowrate (gpm):	27
Velocity, *v* (ft/s):	3.00
Reynolds Number, Re:	3.40E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0201

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **2.81**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**4.13**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**62.65**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**44**	
Design Injection Head Required (ft):	**19.58**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**36.91**	*Safety factor of 5%*

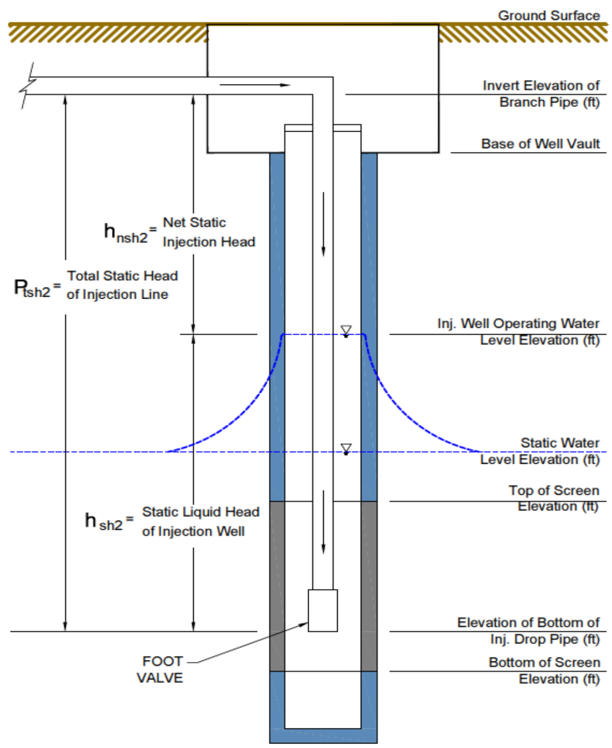
Injection Well Hydraulic Worksheet (IRZ-17, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-17, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	6.75
Design Injection Flowrate For All Layers in Well (gpm):	27
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	486
Inj. Well Operating Water Elevation (ft):	469.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	392.9
Top of Screen Elevation (ft):	390.9
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	93.1
Static Liquid Head of Injection Well, h_{sh2} (ft):	76.6
Net Static Head of Injection Line, h_{nsh2} (ft):	16.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	93.1
Pipe Friction Factor, *f*:	0.0277
Flowrate (gpm):	6.75
Velocity, *v* (ft/s):	2.51
Reynolds Number, Re:	1.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 96.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0309

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **2.97**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0233
Flowrate (gpm):	27
Velocity, *v* (ft/s):	2.58
Reynolds Number, Re:	3.15E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 142.2

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0140

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.99**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 2)

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**4.96**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**63.48**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**44**	
Design Injection Head Required (ft):	**20.46**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**37.78**	*Safety factor of 5%*

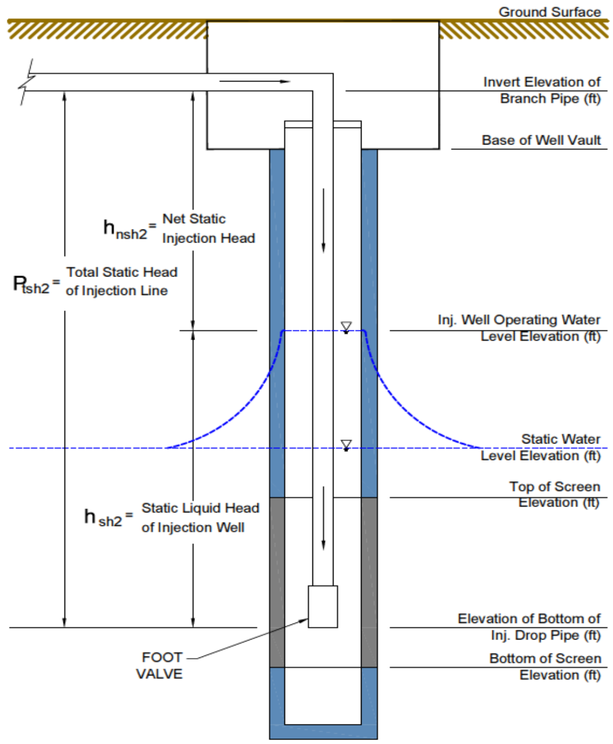
Injection Well Hydraulic Worksheet (IRZ-17, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-17, LAYER 3

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	6.75
Design Injection Flowrate For All Layers in Well (gpm):	27
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	486
Inj. Well Operating Water Elevation (ft):	469.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	345.6
Top of Screen Elevation (ft):	343.6
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	140.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	123.9
Net Static Head of Injection Line, h_{nsh2} (ft):	16.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	140.4
Pipe Friction Factor, *f*:	0.0277
Flowrate (gpm):	6.75
Velocity, *v* (ft/s):	2.51
Reynolds Number, Re:	1.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 143.6

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0309

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **4.43**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0229
Flowrate (gpm):	27
Velocity, *v* (ft/s):	3.00
Reynolds Number, Re:	3.40E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0201

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **2.81**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**7.25**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**65.76**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**44**	
Design Injection Head Required (ft):	**22.85**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**40.18**	*Safety factor of 5%*

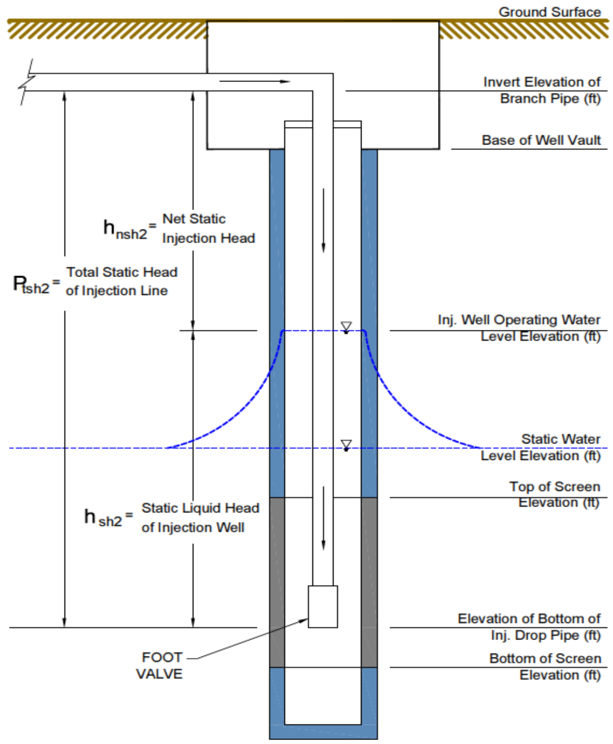
Injection Well Hydraulic Worksheet (IRZ-17, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-17, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	6.75
Design Injection Flowrate For All Layers in Well (gpm):	27
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	486
Inj. Well Operating Water Elevation (ft):	469.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	309.6
Top of Screen Elevation (ft):	307.6
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	176.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	159.9
Net Static Head of Injection Line, h_{nsh2} (ft):	16.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	176.4
Pipe Friction Factor, *f*:	0.0277
Flowrate (gpm):	6.75
Velocity, *v* (ft/s):	2.51
Reynolds Number, Re:	1.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 179.6

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0309

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **5.55**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0229
Flowrate (gpm):	27
Velocity, *v* (ft/s):	3.00
Reynolds Number, Re:	3.40E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.1

$$\boxed{Length = \frac{k \times \frac{ID}{12}}{f}}$$

Equivalent Length of Injection Branch Piping (ft): 140.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0201

$$\boxed{Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}}$$

Injection Branch Piping Head Loss, *Hp* $_{branch}$ (ft): **2.81**

Injection Well Hydraulic Worksheet (IRZ-17, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**8.36**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**66.87**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**44**	

Design Injection Head Required (ft):	**24.02**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**41.34**	*Safety factor of 5%*

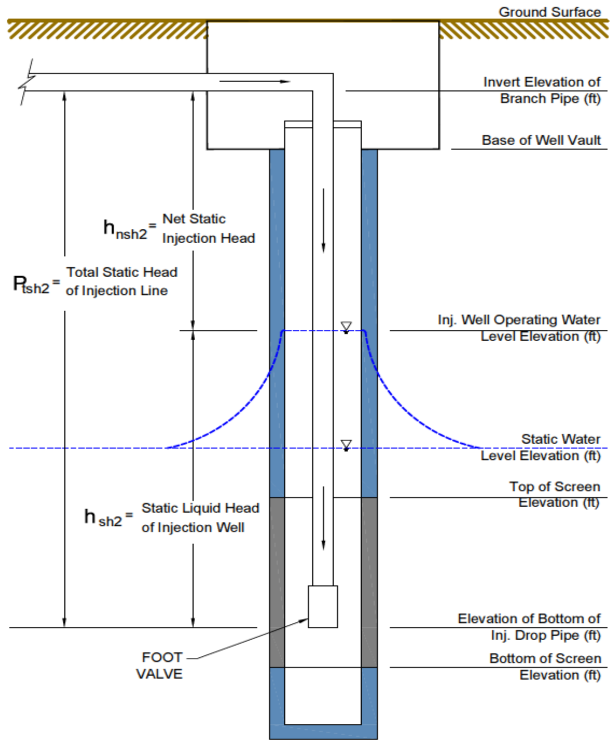
Injection Well Hydraulic Worksheet (IRZ-19, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-19, LAYER 1

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.75
Design Injection Flowrate For All Layers in Well (gpm):	23
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	490
Inj. Well Operating Water Elevation (ft):	467.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	446.2
Top of Screen Elevation (ft):	444.2
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	43.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	21.3
Net Static Head of Injection Line, h_{nsh2} (ft):	22.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	43.8
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	5.75
Velocity, *v* (ft/s):	2.13
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 46.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0233

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **1.09**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0238
Flowrate (gpm):	23
Velocity, *v* (ft/s):	2.56
Reynolds Number, Re:	2.90E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0151

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **2.10**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**3.19**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.07**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**55.68**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**40**	
Design Injection Head Required (ft):	**16.47**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**40.09**	*Safety factor of 5%*

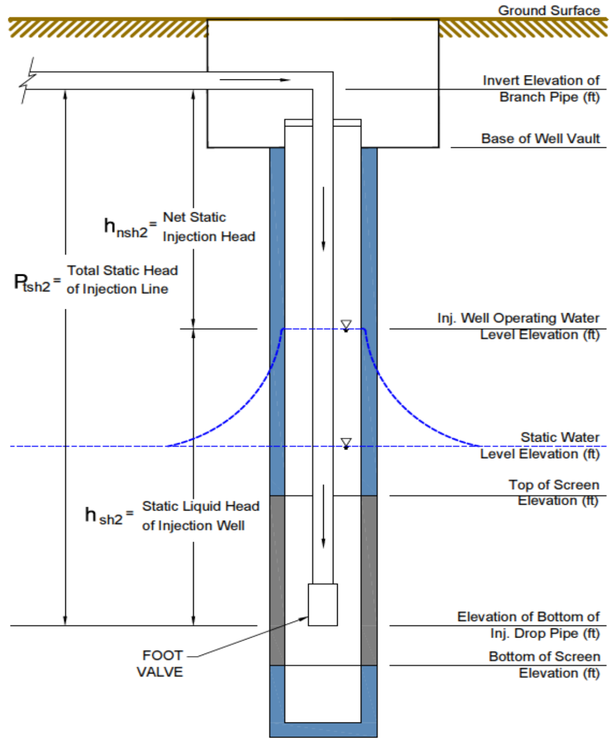
Injection Well Hydraulic Worksheet (IRZ-19, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-19, LAYER 2

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.75
Design Injection Flowrate For All Layers in Well (gpm):	23
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	490
Inj. Well Operating Water Elevation (ft):	467.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	395.3
Top of Screen Elevation (ft):	393.3
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	94.7
Static Liquid Head of Injection Well, h_{sh2} (ft):	72.2
Net Static Head of Injection Line, h_{nsh2} (ft):	22.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	94.7
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	5.75
Velocity, *v* (ft/s):	2.13
Reynolds Number, Re:	1.32E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 97.7

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0233

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **2.28**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0242
Flowrate (gpm):	23
Velocity, *v* (ft/s):	2.20
Reynolds Number, Re:	2.69E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0105

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 1.49

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 2)

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**3.77**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.07**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**56.26**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**40**	

Design Injection Head Required (ft):	**17.07**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**40.70**	*Safety factor of 5%*

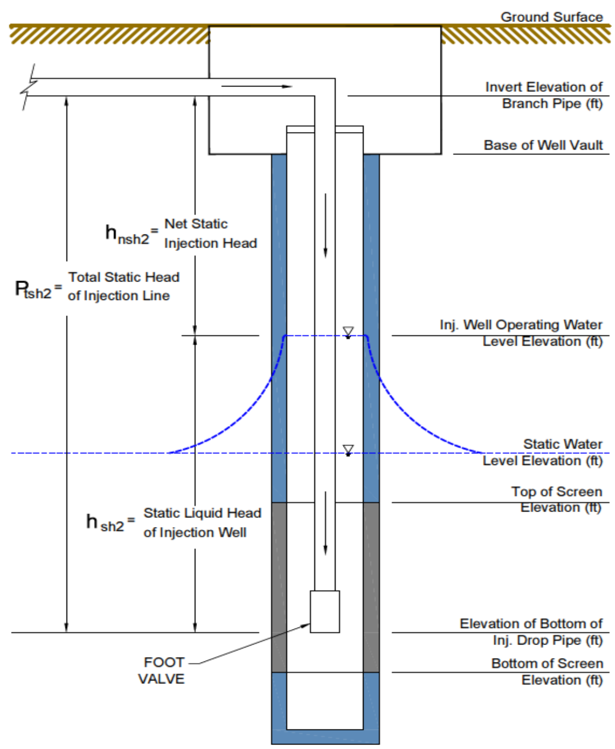
Injection Well Hydraulic Worksheet (IRZ-19, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-19, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.75
Design Injection Flowrate For All Layers in Well (gpm):	23
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	490
Inj. Well Operating Water Elevation (ft):	467.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	345.8
Top of Screen Elevation (ft):	343.8
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	144.2
Static Liquid Head of Injection Well, h_{sh2} (ft):	121.7
Net Static Head of Injection Line, h_{nsh2} (ft):	22.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	144.2
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	5.75
Velocity, *v* (ft/s):	2.13
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 147.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0233

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **3.44**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0238
Flowrate (gpm):	23
Velocity, *v* (ft/s):	2.56
Reynolds Number, Re:	2.90E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0151

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **2.10**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**5.53**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.07**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* *2* (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**58.02**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**40**	

Design Injection Head Required (ft):	**18.93**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**42.55**	*Safety factor of 5%*

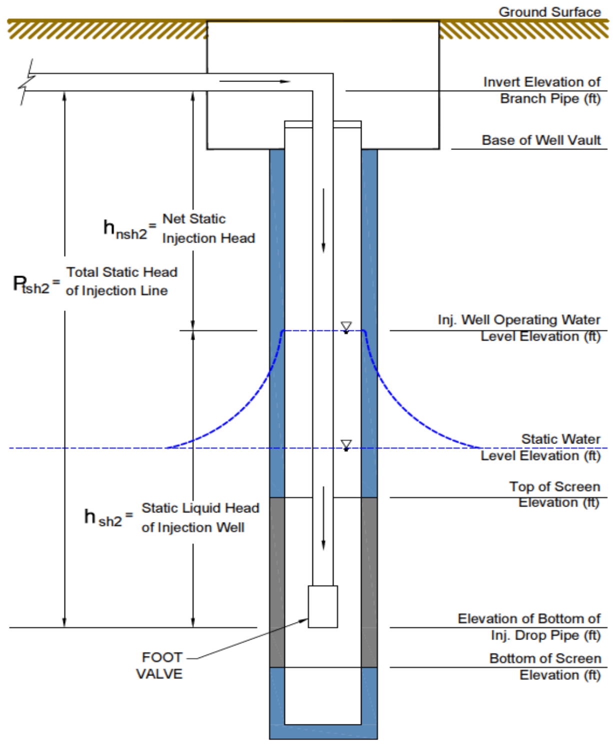
Injection Well Hydraulic Worksheet (IRZ-19, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-19, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.75
Design Injection Flowrate For All Layers in Well (gpm):	23
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	490
Inj. Well Operating Water Elevation (ft):	467.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	325.3
Top of Screen Elevation (ft):	323.3
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	164.7
Static Liquid Head of Injection Well, h_{sh2} (ft):	142.2
Net Static Head of Injection Line, h_{nsh2} (ft):	22.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	164.7
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	5.75
Velocity, *v* (ft/s):	2.13
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 167.7

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0233

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **3.91**

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0238
Flowrate (gpm):	23
Velocity, *v* (ft/s):	2.56
Reynolds Number, Re:	2.90E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0151

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 2.10

Injection Well Hydraulic Worksheet (IRZ-19, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**6.01**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.07**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**58.50**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**40**	
Design Injection Head Required (ft):	**19.43**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**43.05**	*Safety factor of 5%*

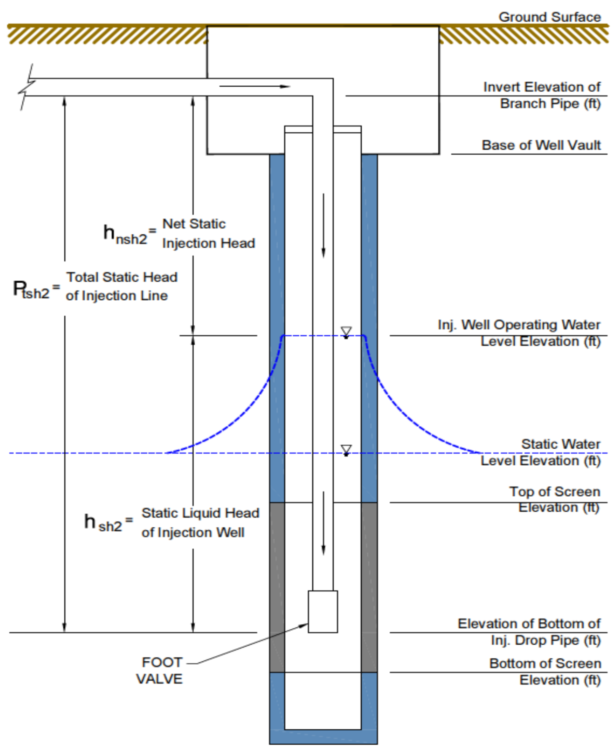
Injection Well Hydraulic Worksheet (IRZ-20, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-20, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	21
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	466.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	447
Top of Screen Elevation (ft):	445
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	49
Static Liquid Head of Injection Well, h_{sh2} (ft):	19.5
Net Static Head of Injection Line, h_{nsh2} (ft):	29.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	49
Pipe Friction Factor, *f*:	0.0295
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	1.95
Reynolds Number, Re:	1.21E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 52.0

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0199

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **1.03**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0243
Flowrate (gpm):	21
Velocity, *v* (ft/s):	2.33
Reynolds Number, Re:	2.64E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0129

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 1.78

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**2.81**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**48.29**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\ 2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**15.01**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**45.98**	*Safety factor of 5%*

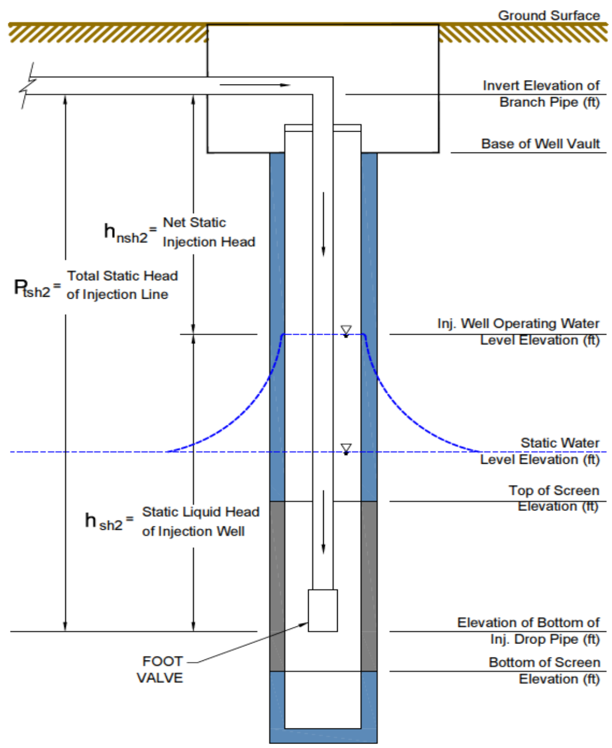
Injection Well Hydraulic Worksheet (IRZ-20, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-20, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	21
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	466.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	397.7
Top of Screen Elevation (ft):	395.7
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	98.3
Static Liquid Head of Injection Well, h_{sh2} (ft):	68.8
Net Static Head of Injection Line, h_{nsh2} (ft):	29.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		

Cumulative Pressure Drop (ft w.c.):	1

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	98.3
Pipe Friction Factor, *f*:	0.0295
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	1.95
Reynolds Number, Re:	1.21E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)					
Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 101.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0199

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **2.02**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0247
Flowrate (gpm):	21
Velocity, *v* (ft/s):	2.01
Reynolds Number, Re:	2.45E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 35.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 140.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0090

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.26**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 2)

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**3.27**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**48.75**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**15.49**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**46.47**	*Safety factor of 5%*

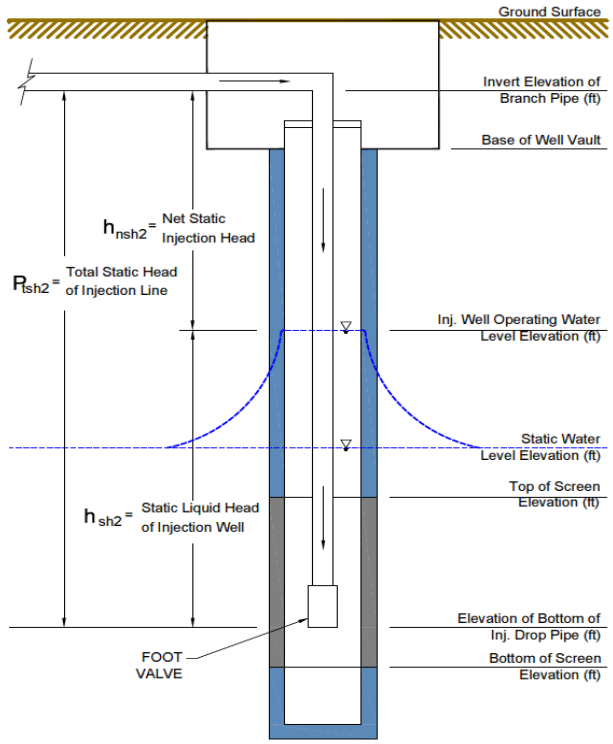
Injection Well Hydraulic Worksheet (IRZ-20, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-20, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	21
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	466.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	362.6
Top of Screen Elevation (ft):	360.6
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	133.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	103.9
Net Static Head of Injection Line, h_{nsh2} (ft):	29.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	133.4
Pipe Friction Factor, *f*:	0.0295
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	1.95
Reynolds Number, Re:	1.21E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

Valves and Fitting Losses (K values)

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 136.4

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0199

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **2.72**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0243
Flowrate (gpm):	21
Velocity, *v* (ft/s):	2.33
Reynolds Number, Re:	2.64E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0129

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.78**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**4.49**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**49.97**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**16.77**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**47.74**	*Safety factor of 5%*

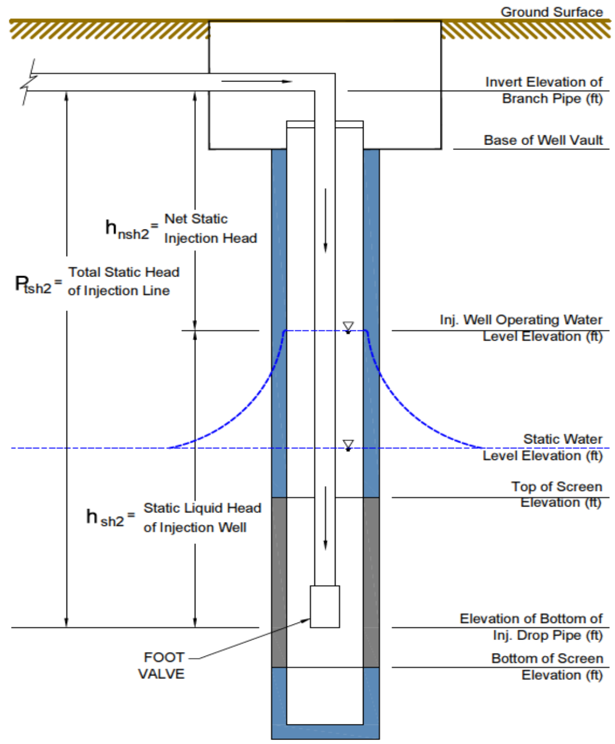
Injection Well Hydraulic Worksheet (IRZ-20, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-20, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	21
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	466.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	339.7
Top of Screen Elevation (ft):	337.7
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	156.3
Static Liquid Head of Injection Well, h_{sh2} (ft):	126.8
Net Static Head of Injection Line, h_{nsh2} (ft):	29.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	156.3
Pipe Friction Factor, *f*:	0.0295
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	1.95
Reynolds Number, Re:	1.21E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 159.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0199

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **3.17**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0243
Flowrate (gpm):	21
Velocity, *v* (ft/s):	2.33
Reynolds Number, Re:	2.64E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0129

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.78**

Injection Well Hydraulic Worksheet (IRZ-20, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**4.95**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**50.43**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	

Design Injection Head Required (ft):	**17.25**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**48.22**	*Safety factor of 5%*

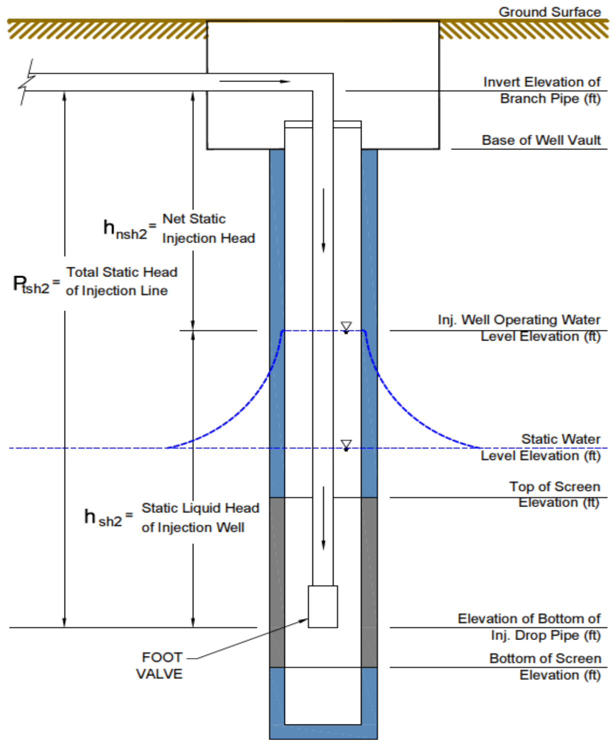
Injection Well Hydraulic Worksheet (IRZ-21, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-21, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	4.75
Design Injection Flowrate For All Layers in Well (gpm):	19
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	465.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	444.5
Top of Screen Elevation (ft):	442.5
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	51.5
Static Liquid Head of Injection Well, h_{sh2} (ft):	21
Net Static Head of Injection Line, h_{nsh2} (ft):	30.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	51.5
Pipe Friction Factor, *f*:	0.0303
Flowrate (gpm):	4.75
Velocity, *v* (ft/s):	1.76
Reynolds Number, Re:	1.09E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 54.4

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0167

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **0.91**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0249
Flowrate (gpm):	19
Velocity, *v* (ft/s):	2.11
Reynolds Number, Re:	2.39E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 32.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 137.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0108

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.48**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft): **2.39**

$$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$$

Exit Loss at Liquid Discharge, Hv (ft): **0.05**

Assumed equal to one velocity head, Hv.

$$\boxed{Hv = \frac{v^2}{2 \times 32.174}}$$

Total In-Line Equipment Head, He (ft): **1.00**

Foot Valve Fully Open Pressure, Hf_2 (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$\boxed{Hf_2 = Hf \times 2}$$

Total Injection Head Required at Branch Line, Hd (ft): **46.86**

$$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **34**

Design Injection Head Required (ft): **13.50** *Safety factor of 5%*

Worst Case Injection Head Required (ft): **45.53** *Safety factor of 5%*

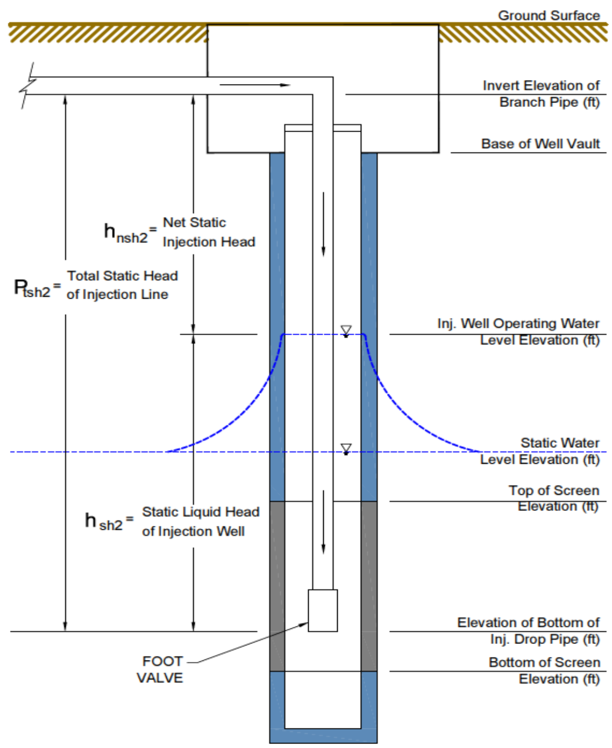
Injection Well Hydraulic Worksheet (IRZ-21, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-21, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	4.75
Design Injection Flowrate For All Layers in Well (gpm):	19
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	465.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	405.8
Top of Screen Elevation (ft):	403.8
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	90.2
Static Liquid Head of Injection Well, h_{sh2} (ft):	59.7
Net Static Head of Injection Line, h_{nsh2} (ft):	30.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 2)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	90.2
Pipe Friction Factor, *f*:	0.0303
Flowrate (gpm):	4.75
Velocity, *v* (ft/s):	1.76
Reynolds Number, Re:	1.09E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 93.1

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0167

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **1.56**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 2)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0253
Flowrate (gpm):	19
Velocity, *v* (ft/s):	1.82
Reynolds Number, Re:	2.22E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 34.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 139.2

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0075

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 1.05

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 2)

Total Injection Piping System Head Loss, *Hp* *injection* (ft):	**2.61**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.05**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* 2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**47.07**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	

Design Injection Head Required (ft):	**13.73**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**45.75**	*Safety factor of 5%*

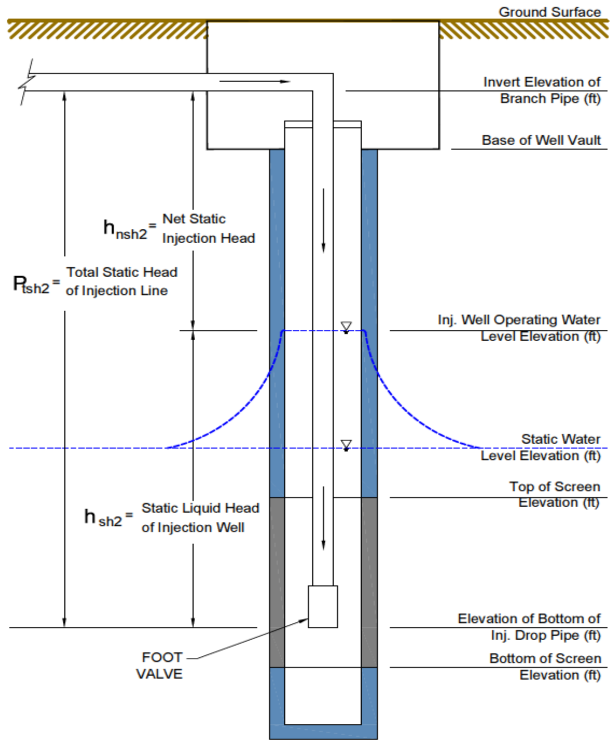
Injection Well Hydraulic Worksheet (IRZ-21, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-21, LAYER 3

Fluid:	(•) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	4.75
Design Injection Flowrate For All Layers in Well (gpm):	19
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	465.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	374
Top of Screen Elevation (ft):	372
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	122
Static Liquid Head of Injection Well, h_{sh2} (ft):	91.5
Net Static Head of Injection Line, h_{nsh2} (ft):	30.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	122
Pipe Friction Factor, *f*:	0.0303
Flowrate (gpm):	4.75
Velocity, *v* (ft/s):	1.76
Reynolds Number, Re:	1.09E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 124.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0167

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **2.09**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0249
Flowrate (gpm):	19
Velocity, *v* (ft/s):	2.11
Reynolds Number, Re:	2.39E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 32.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 137.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0108

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

<u>Injection Branch Piping Head Loss, *Hp* $_{branch}$ (ft):</u> **<u>1.48</u>**

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**3.57**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.05**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2\times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**48.04**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**14.74**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**46.77**	*Safety factor of 5%*

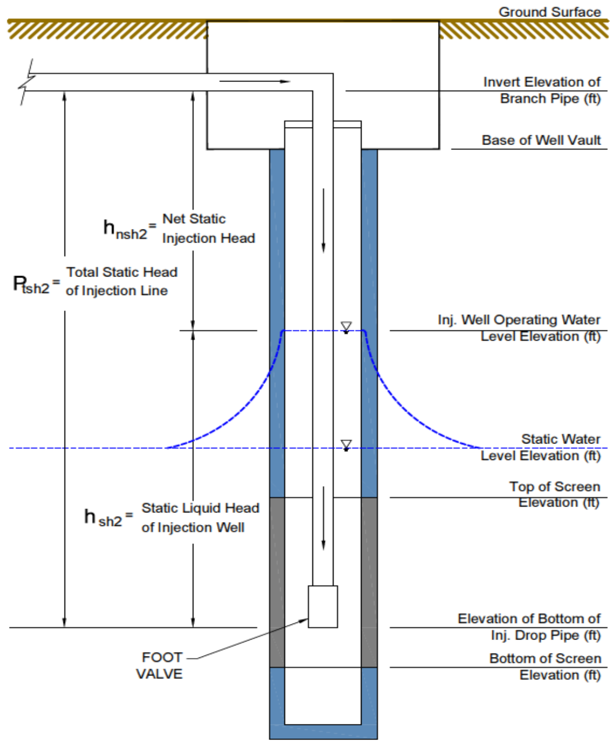
Injection Well Hydraulic Worksheet (IRZ-21, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-21, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	4.75
Design Injection Flowrate For All Layers in Well (gpm):	19
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	465.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	352.5
Top of Screen Elevation (ft):	350.5
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	143.5
Static Liquid Head of Injection Well, h_{sh2} (ft):	113
Net Static Head of Injection Line, h_{nsh2} (ft):	30.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	143.5
Pipe Friction Factor, *f*:	0.0303
Flowrate (gpm):	4.75
Velocity, *v* (ft/s):	1.76
Reynolds Number, Re:	1.09E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 146.4

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0167

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 2.45

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0249
Flowrate (gpm):	19
Velocity, *v* (ft/s):	2.11
Reynolds Number, Re:	2.39E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 32.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 137.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0108

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 1.48

Injection Well Hydraulic Worksheet (IRZ-21, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**3.93**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.05**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**48.40**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**15.12**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**47.14**	*Safety factor of 5%*

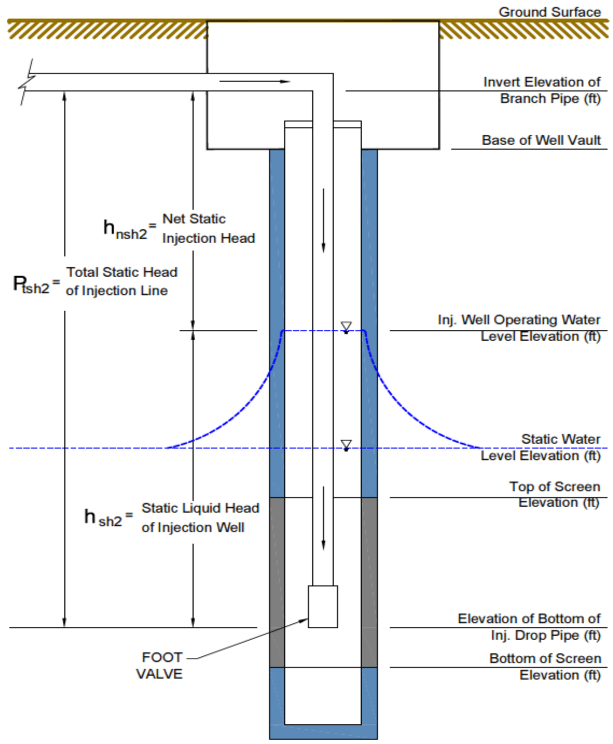
Injection Well Hydraulic Worksheet (IRZ-25, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-25, LAYER 1-2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	17
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	464.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	442.1
Top of Screen Elevation (ft):	440.1
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	53.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	22.4
Net Static Head of Injection Line, h_{nsh2} (ft):	31.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	53.9
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	8.5
Velocity, *v* (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 57.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 2.65

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0255
Flowrate (gpm):	17
Velocity, *v* (ft/s):	1.89
Reynolds Number, Re:	2.14E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 31.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 136.5

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0089

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **1.21**

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp*$_{injection}$ (ft):	**3.86**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.15**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf*$_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**47.43**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	

Design Injection Head Required (ft):	**14.11**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**47.18**	*Safety factor of 5%*

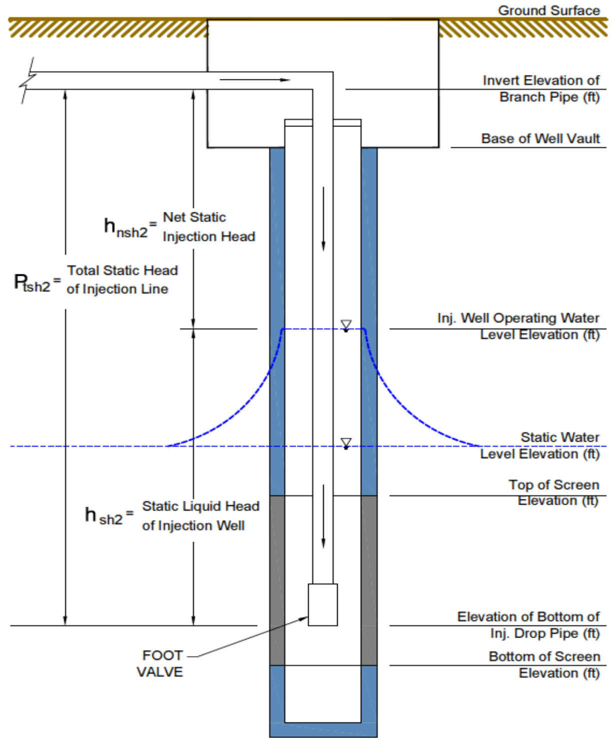
Injection Well Hydraulic Worksheet (IRZ-25, LAYER 3-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-25, LAYER 3-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8.5
Design Injection Flowrate For All Layers in Well (gpm):	17
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	496
Inj. Well Operating Water Elevation (ft):	464.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	393.1
Top of Screen Elevation (ft):	391.1
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	102.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	71.4
Net Static Head of Injection Line, h_{nsh2} (ft):	31.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 3-4)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	102.9
Pipe Friction Factor, f:	0.0261
Flowrate (gpm):	8.5
Velocity, v (ft/s):	3.16
Reynolds Number, Re:	1.96E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 106.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0463

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **4.92**

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 3-4)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0260
Flowrate (gpm):	17
Velocity, *v* (ft/s):	1.63
Reynolds Number, Re:	1.99E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 138.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0062

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.86

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-25, LAYER 3-4)

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**5.77**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.15**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**49.35**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**34**	
Design Injection Head Required (ft):	**16.12**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**49.19**	*Safety factor of 5%*

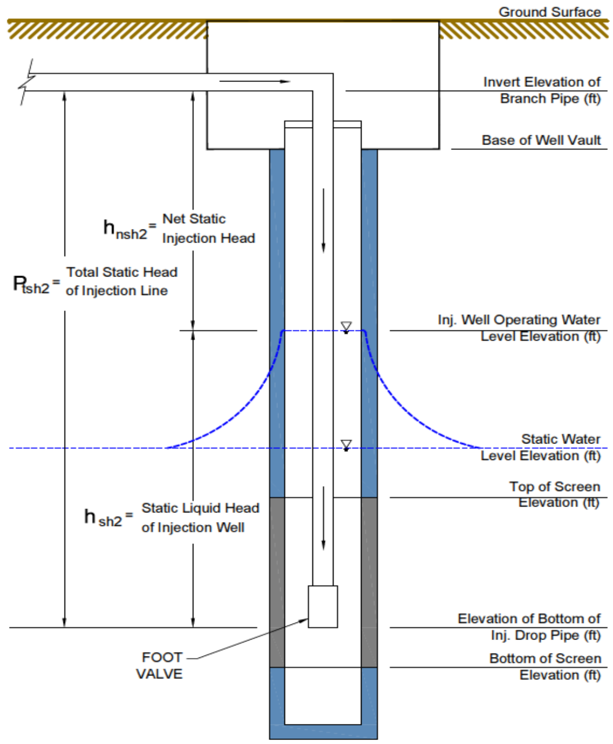
Injection Well Hydraulic Worksheet (IRZ-27, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-27, LAYER 1-2

Fluid:	◉ WATER ◯ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8
Design Injection Flowrate For All Layers in Well (gpm):	16
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	514
Inj. Well Operating Water Elevation (ft):	464
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	442.1
Top of Screen Elevation (ft):	440.1
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	71.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	21.9
Net Static Head of Injection Line, h_{nsh2} (ft):	50
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	71.9
Pipe Friction Factor, *f*:	0.0265
Flowrate (gpm):	8
Velocity, *v* (ft/s):	2.97
Reynolds Number, Re:	1.84E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 75.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0416

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **3.13**

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0259
Flowrate (gpm):	16
Velocity, *v* (ft/s):	1.78
Reynolds Number, Re:	2.01E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 31.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 136.0

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0080

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 1.08

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**4.21**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, Hv (ft):	**0.14**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, He (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, Hd (ft):	**29.27**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**16**	

Design Injection Head Required (ft):	**13.93**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**66.43**	*Safety factor of 5%*

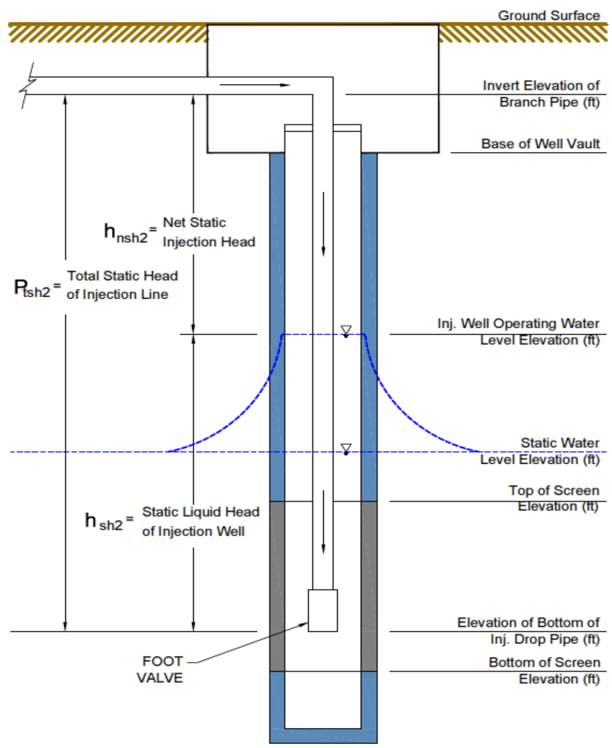
Injection Well Hydraulic Worksheet (IRZ-27, LAYER 3-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-27, LAYER 3-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	8
Design Injection Flowrate For All Layers in Well (gpm):	16
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	514
Inj. Well Operating Water Elevation (ft):	464
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	398
Top of Screen Elevation (ft):	396
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	116
Static Liquid Head of Injection Well, h_{sh2} (ft):	66
Net Static Head of Injection Line, h_{nsh2} (ft):	50
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 3-4)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	116
Pipe Friction Factor, *f*:	0.0265
Flowrate (gpm):	8
Velocity, *v* (ft/s):	2.97
Reynolds Number, Re:	1.84E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 119.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0416

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **4.96**

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 3-4)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0264
Flowrate (gpm):	16
Velocity, *v* (ft/s):	1.53
Reynolds Number, Re:	1.87E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 32.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 137.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0056

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.77**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-27, LAYER 3-4)

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**5.73**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.14**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**30.79**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**16**	

Design Injection Head Required (ft):	**15.53**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**68.03**	*Safety factor of 5%*

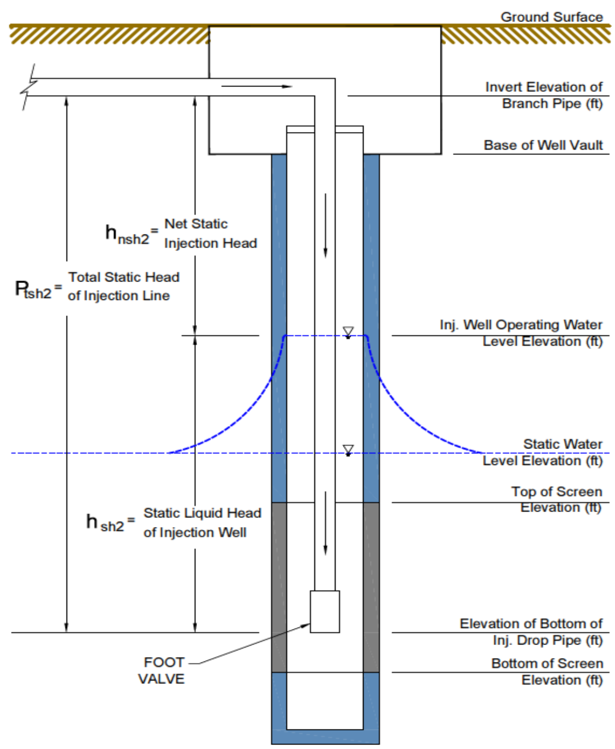
Injection Well Hydraulic Worksheet (IRZ-29, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-29, LAYER 1-2

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	14
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	516
Inj. Well Operating Water Elevation (ft):	463
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	451.1
Top of Screen Elevation (ft):	449.1
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	64.9
Static Liquid Head of Injection Well, h_{sh2} (ft):	11.9
Net Static Head of Injection Line, h_{nsh2} (ft):	53
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	64.9
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 68.1

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **2.24**

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0268
Flowrate (gpm):	14
Velocity, *v* (ft/s):	1.56
Reynolds Number, Re:	1.76E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 30.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 135.0

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0063

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.85**

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**3.09**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**25.12**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**14**	
Design Injection Head Required (ft):	**11.67**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**67.32**	*Safety factor of 5%*

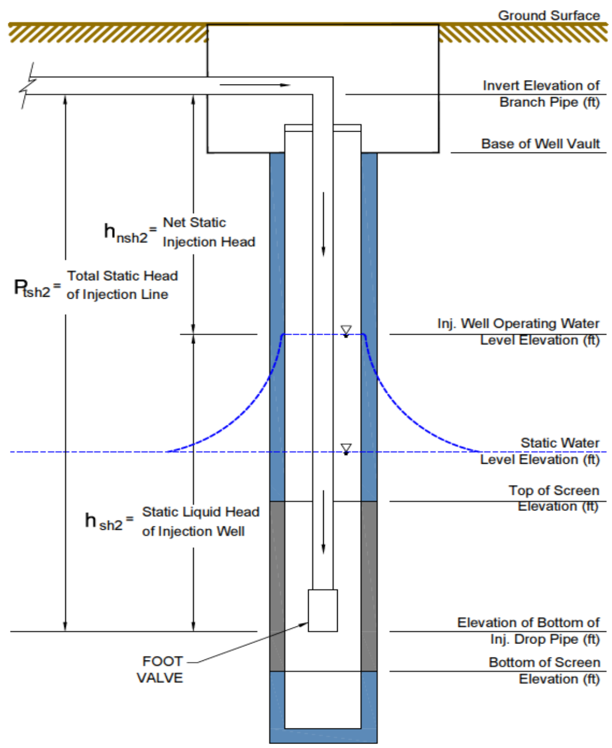
Injection Well Hydraulic Worksheet (IRZ-29, LAYER 3-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-29, LAYER 3-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	14
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	516
Inj. Well Operating Water Elevation (ft):	463
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	442.4
Top of Screen Elevation (ft):	440.4
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	73.6
Static Liquid Head of Injection Well, h_{sh2} (ft):	20.6
Net Static Head of Injection Line, h_{nsh2} (ft):	53
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 3-4)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	73.6
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 76.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **2.53**

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 3-4)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0273
Flowrate (gpm):	14
Velocity, *v* (ft/s):	1.34
Reynolds Number, Re:	1.64E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 31.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 136.8

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0044

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.60

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-29, LAYER 3-4)

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**3.13**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**25.16**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**14**	

Design Injection Head Required (ft):	**11.71**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**67.36**	*Safety factor of 5%*

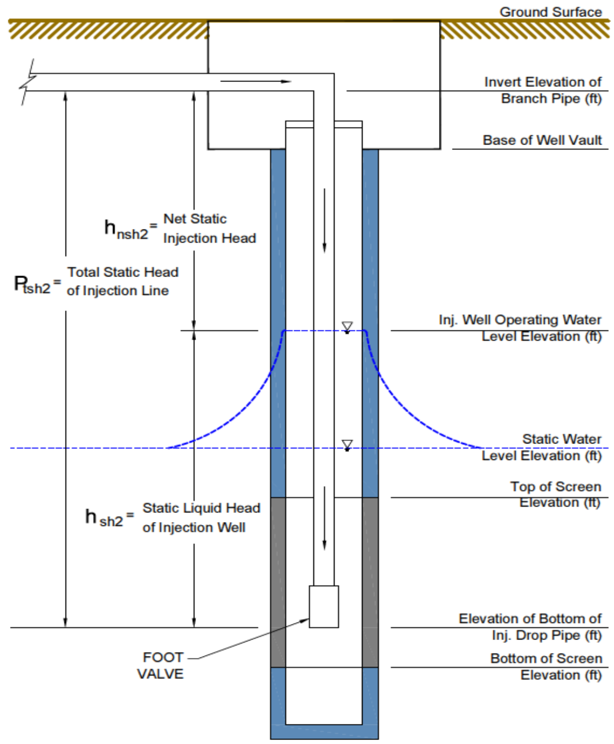
Injection Well Hydraulic Worksheet (IRZ-31, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: **IRZ-31, LAYER 1-2**

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.5
Design Injection Flowrate For All Layers in Well (gpm):	11
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	504
Inj. Well Operating Water Elevation (ft):	461.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	447.8
Top of Screen Elevation (ft):	445.8
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	56.2
Static Liquid Head of Injection Well, h_{sh2} (ft):	13.7
Net Static Head of Injection Line, h_{nsh2} (ft):	42.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		

Cumulative Pressure Drop (ft w.c.):	1

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	56.2
Pipe Friction Factor, *f*:	0.0291
Flowrate (gpm):	5.5
Velocity, *v* (ft/s):	2.04
Reynolds Number, Re:	1.27E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 59.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0216

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **1.28**

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0284
Flowrate (gpm):	11
Velocity, *v* (ft/s):	1.22
Reynolds Number, Re:	1.39E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 28.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 133.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0041

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.55**

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**1.83**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**34.31**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**26**	
Design Injection Head Required (ft):	**8.73**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**53.35**	*Safety factor of 5%*

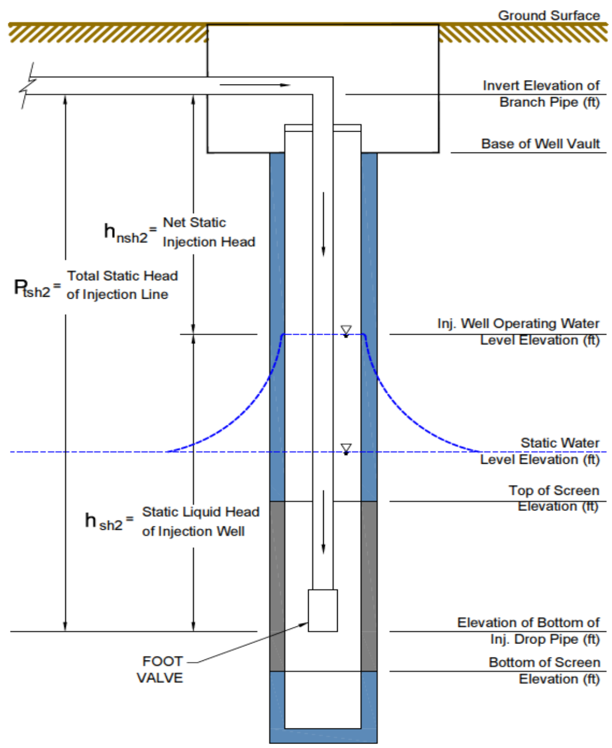
Injection Well Hydraulic Worksheet (IRZ-31, LAYER 3-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-31, LAYER 3-4

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.5
Design Injection Flowrate For All Layers in Well (gpm):	11
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	504
Inj. Well Operating Water Elevation (ft):	461.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	408.2
Top of Screen Elevation (ft):	406.2
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	95.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	53.3
Net Static Head of Injection Line, h_{nsh2} (ft):	42.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 3-4)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	95.8
Pipe Friction Factor, *f*:	0.0291
Flowrate (gpm):	5.5
Velocity, *v* (ft/s):	2.04
Reynolds Number, Re:	1.27E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

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Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 98.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0216

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 2.13

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 3-4)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0290
Flowrate (gpm):	11
Velocity, *v* (ft/s):	1.05
Reynolds Number, Re:	1.28E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 29.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 134.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0029

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.39

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-31, LAYER 3-4)

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**2.52**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.06**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**35.01**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**26**	
Design Injection Head Required (ft):	**9.46**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**54.08**	*Safety factor of 5%*

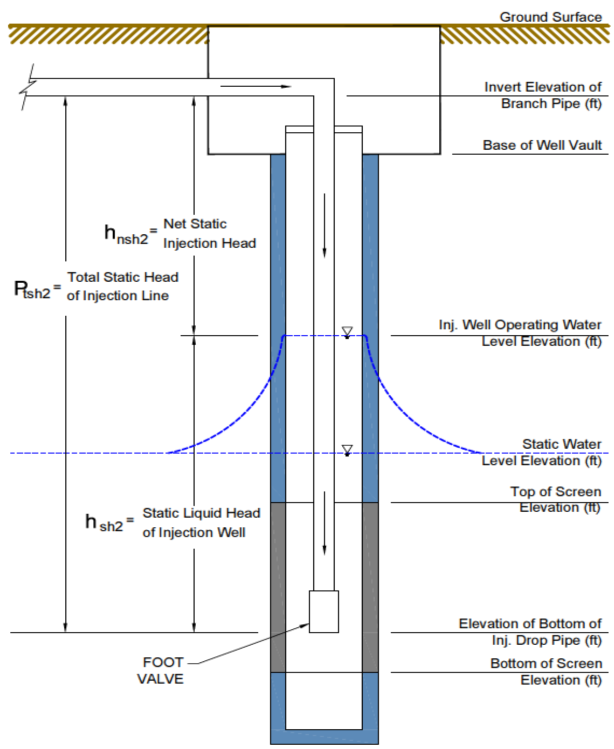
Injection Well Hydraulic Worksheet (IRZ-33, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-33, LAYER 1-2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5
Design Injection Flowrate For All Layers in Well (gpm):	10
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	513
Inj. Well Operating Water Elevation (ft):	461
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	448.3
Top of Screen Elevation (ft):	446.3
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	64.7
Static Liquid Head of Injection Well, h_{sh2} (ft):	12.7
Net Static Head of Injection Line, h_{nsh2} (ft):	52
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): 1.00

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	64.7
Pipe Friction Factor, *f*:	0.0299
Flowrate (gpm):	5
Velocity, *v* (ft/s):	1.86
Reynolds Number, Re:	1.15E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 67.6

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0183

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

<u>Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft):</u> **<u>1.24</u>**

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0291
Flowrate (gpm):	10
Velocity, *v* (ft/s):	1.11
Reynolds Number, Re:	1.26E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 27.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 132.6

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0035

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.46**

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft): **1.70**

$$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.05**

Assumed equal to one velocity head, Hv.

$$\boxed{Hv = \frac{v^2}{2 \times 32.174}}$$

Total In-Line Equipment Head, *He* (ft): **1.00**

Foot Valve Fully Open Pressure, *Hf* $_2$ (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$\boxed{Hf_2 = Hf \times 2}$$

Total Injection Head Required at Branch Line, *Hd* (ft): **24.67**

$$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **17**

Design Injection Head Required (ft): **8.06**

Safety factor of 5%

Worst Case Injection Head Required (ft): **62.66**

Safety factor of 5%

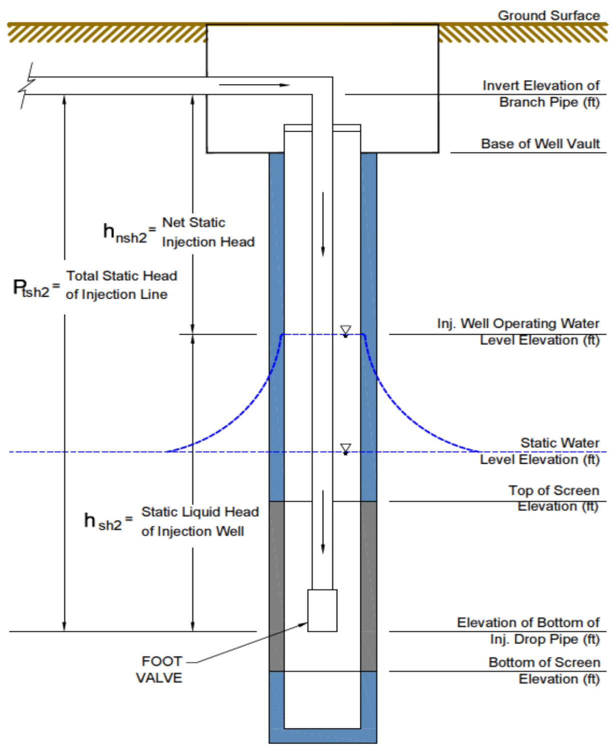
Injection Well Hydraulic Worksheet (IRZ-33, LAYER 3-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-33, LAYER 3-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5
Design Injection Flowrate For All Layers in Well (gpm):	10
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	513
Inj. Well Operating Water Elevation (ft):	461
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	411.9
Top of Screen Elevation (ft):	409.9
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	101.1
Static Liquid Head of Injection Well, h_{sh2} (ft):	49.1
Net Static Head of Injection Line, h_{nsh2} (ft):	52
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 3-4)

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	101.1
Pipe Friction Factor, *f*:	0.0299
Flowrate (gpm):	5
Velocity, *v* (ft/s):	1.86
Reynolds Number, Re:	1.15E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**

e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 104.0

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0183

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **1.90**

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 3-4)

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe length (ft):	105
Pipe Friction Factor, f:	0.0297
Flowrate (gpm):	10
Velocity, v (ft/s):	0.96
Reynolds Number, Re:	1.17E+04

Pipe Material:

Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 29.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 134.2

Head Loss Across Injection Branch Piping, Hp (ft/ft pipe): 0.0024

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.33**

Design Injection Head for Well

Injection Well Hydraulic Worksheet (IRZ-33, LAYER 3-4)

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**2.23**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.05**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**25.20**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**17**	

Design Injection Head Required (ft):	**8.61**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**63.21**	*Safety factor of 5%*

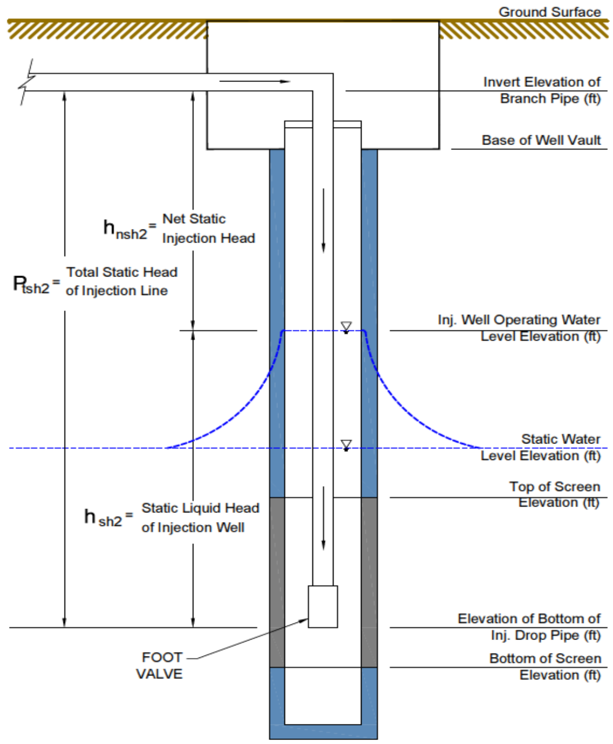
Injection Well Hydraulic Worksheet (IRZ-35)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-35

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	7
Design Injection Flowrate For All Layers in Well (gpm):	7
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	513
Inj. Well Operating Water Elevation (ft):	459.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	455.9
Top of Screen Elevation (ft):	453.9
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	57.1
Static Liquid Head of Injection Well, h_{sh2} (ft):	3.6
Net Static Head of Injection Line, h_{nsh2} (ft):	53.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-35)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	57.1
Pipe Friction Factor, *f*:	0.0274
Flowrate (gpm):	7
Velocity, *v* (ft/s):	2.60
Reynolds Number, Re:	1.61E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 60.3

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0329

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.98

Injection Well Hydraulic Worksheet (IRZ-35)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0320
Flowrate (gpm):	7
Velocity, *v* (ft/s):	0.78
Reynolds Number, Re:	8.82E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			
K (total):	5.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 25.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 130.1

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0019

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.25

Injection Well Hydraulic Worksheet (IRZ-35)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**2.23**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.10**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**23.75**	$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**17**	

Design Injection Head Required (ft):	**7.09**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**63.27**	*Safety factor of 5%*

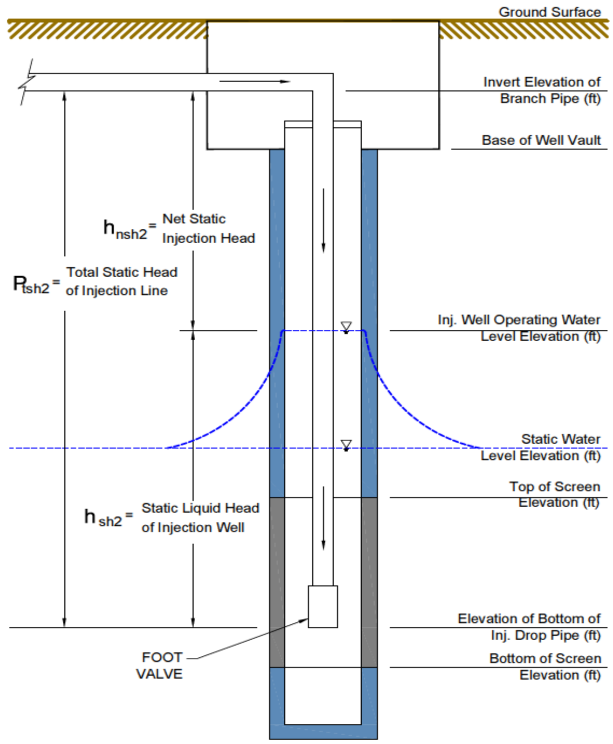
Injection Well Hydraulic Worksheet (IRZ-37)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-37

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	4
Design Injection Flowrate For All Layers in Well (gpm):	4
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	505
Inj. Well Operating Water Elevation (ft):	458
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	434.6
Top of Screen Elevation (ft):	432.6
Footvalve Cracking Pressure, Hf (psi):	16
Footvalve Cracking Pressure, Hf (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	70.4
Static Liquid Head of Injection Well, h_{sh2} (ft):	23.4
Net Static Head of Injection Line, h_{nsh2} (ft):	47
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-37)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	70.4
Pipe Friction Factor, *f*:	0.0317
Flowrate (gpm):	4
Velocity, *v* (ft/s):	1.48
Reynolds Number, Re:	9.21E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 2.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 73.2

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0124

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **0.91**

Injection Well Hydraulic Worksheet (IRZ-37)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0373
Flowrate (gpm):	4
Velocity, *v* (ft/s):	0.44
Reynolds Number, Re:	5.04E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 21.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 126.5

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0007

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.09

Injection Well Hydraulic Worksheet (IRZ-37)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* *injection* (ft): **1.00**

$$Hp_{Injection} = Hp_{drop} + Hp_{branch}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.03**

Assumed equal to one velocity head, Hv.

$$Hv = \frac{v^2}{2 \times 32.174}$$

Total In-Line Equipment Head, *He* (ft): **1.00**

Foot Valve Fully Open Pressure, *Hf* 2 (ft): **73.92**

Assumed two times cracking pressure (Hf) to fully open.

$$Hf_2 = Hf \times 2$$

Total Injection Head Required at Branch Line, *Hd* (ft): **28.95**

$$Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}$$

Maximum Static Elevation of Injection Well Network (ft): **530**

Maximum Static Head from Branch Connection (ft): **25**

Design Injection Head Required (ft): **4.15**

Safety factor of 5%

Worst Case Injection Head Required (ft): **53.50**

Safety factor of 5%

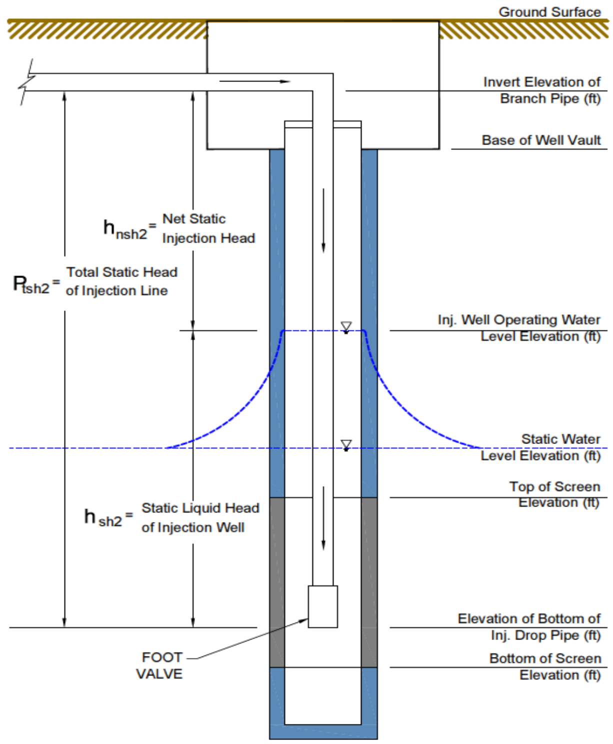
Injection Well Hydraulic Worksheet (IRZ-39)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Well ID: IRZ-39

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	1
Design Injection Flowrate For All Layers in Well (gpm):	1
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	500
Inj. Well Operating Water Elevation (ft):	456.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	458.2
Top of Screen Elevation (ft):	456.2
Footvalve Cracking Pressure, *Hf* (psi):	16
Footvalve Cracking Pressure, *Hf* (ft w.c.):	37
Total Static Head of Injection Line, P_{tsh2} (ft):	41.8
Static Liquid Head of Injection Well, h_{sh2} (ft):	-1.7
Net Static Head of Injection Line, h_{nsh2} (ft):	43.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	1		
Cumulative Pressure Drop (ft w.c.):	1		

Total In-Line Equipment Head, *He* (ft): **1.00**

Injection Well Hydraulic Worksheet (IRZ-39)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1
Pipe ID (in):	1.049
Pipe length (ft):	41.8
Pipe Friction Factor, *f*:	0.0473
Flowrate (gpm):	1
Velocity, *v* (ft/s):	0.37
Reynolds Number, Re:	2.30E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00006**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 1.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 43.6

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0012

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **0.05**

Injection Well Hydraulic Worksheet (IRZ-39)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe length (ft):	105
Pipe Friction Factor, *f*:	0.0577
Flowrate (gpm):	1
Velocity, *v* (ft/s):	0.11
Reynolds Number, Re:	1.26E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

9

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
			Valves and Fitting Losses (K values)		
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Tee, thru flow	0.38	2			

K (total): 5.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 13.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 118.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0001

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.01**

Injection Well Hydraulic Worksheet (IRZ-39)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, *Hp* $_{injection}$ (ft):	**0.06**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.00**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**1.00**	
Foot Valve Fully Open Pressure, *Hf* $_2$ (ft):	**73.92**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**31.48**	$\boxed{Hd = Hp_{system} + Hv + He + Hf + Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**30**	
Design Injection Head Required (ft):	**1.56**	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	**47.23**	*Safety factor of 5%*

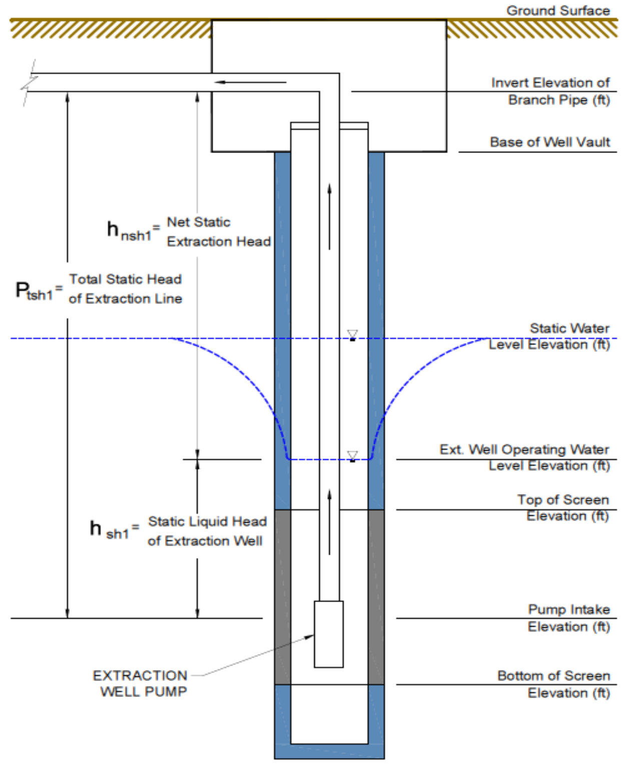
Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: **IRZ-1, LAYER 1**

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	473
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	412
Top of Screen Elevation:	410
Total Static Head of Extraction Line , P_{tsh1} (ft):	61
Static Liquid Head of Extraction Well, h_{slh1} (ft):	27.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	33.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	61
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 61.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 0.37

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

9

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp extraction* (ft):	**2.76**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**38.55**	$Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**57**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**107.84**	*Safety factor of 5%*

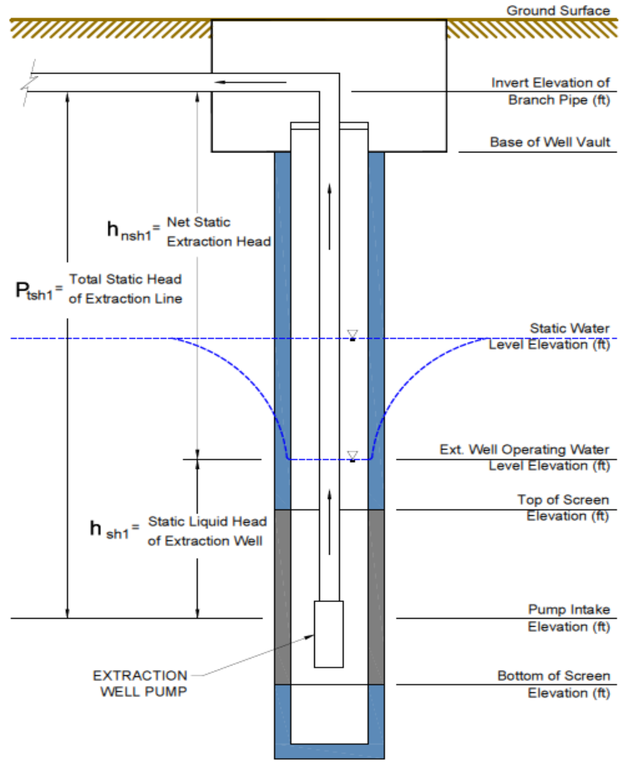
Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-1, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	473
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	317
Top of Screen Elevation:	315
Total Static Head of Extraction Line , P_{tsh1} (ft):	156
Static Liquid Head of Extraction Well, h_{slh1} (ft):	122.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	33.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	156
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

Valves and Fitting Losses (K values)

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 156.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **0.94**

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**3.34**	$\boxed{\mathrm{Hp}_{\mathrm{extraction}} = \mathrm{Hp}_{\mathrm{drop}} + \mathrm{Hp}_{\mathrm{branch}}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**39.13**	$\boxed{\mathrm{Hd} = \mathrm{Hp}_{\mathrm{extraction}} + \mathrm{Hv} + \mathrm{He} + \mathrm{h}_{\mathrm{nshl}} + \mathrm{P}_{\mathrm{sys}}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**57**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**108.44**	*Safety factor of 5%*

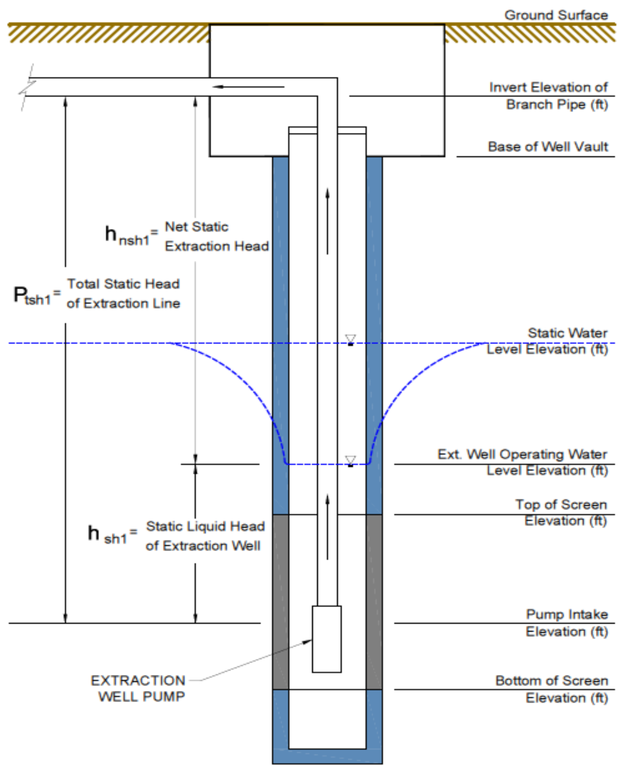
Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-1, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	473
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	192
Top of Screen Elevation:	190
Total Static Head of Extraction Line , P_{tsh1} (ft):	281
Static Liquid Head of Extraction Well, h_{slh1} (ft):	247.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	33.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	281
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				
K (total):	0				

Valves and Fitting Losses (K values)

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 281.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.70

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, *Hp* $_{branch}$ (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**4.09**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**39.88**	$Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**57**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**109.23**	*Safety factor of 5%*

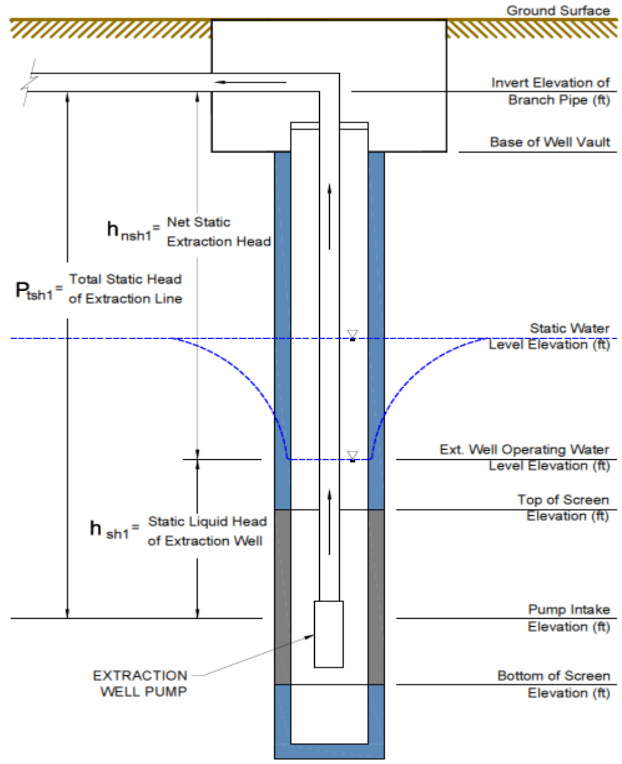
Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-1, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	473
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	117
Top of Screen Elevation:	115
Total Static Head of Extraction Line , P_{tsh1} (ft):	356
Static Liquid Head of Extraction Well, h_{slh1} (ft):	322.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	33.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	356
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 356.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 2.15

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-1, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**4.55**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**40.33**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**57**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**109.71**	*Safety factor of 5%*

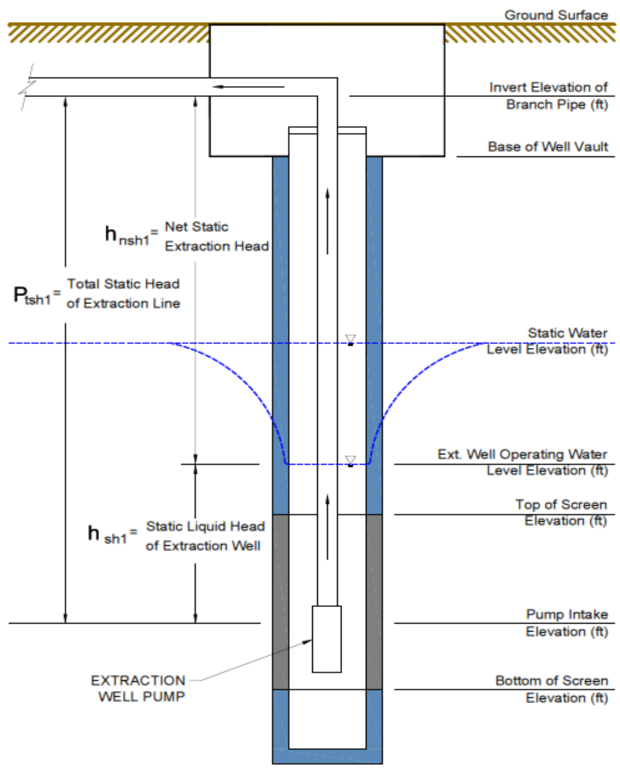
Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-5, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	472
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	382
Top of Screen Elevation:	380
Total Static Head of Extraction Line , P_{tsh1} (ft):	90
Static Liquid Head of Extraction Well, h_{slh1} (ft):	57.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	32.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	90
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 90.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): **0.54**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): **2.40**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* *extraction* (ft):	**2.94**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**37.73**	$Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**58**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**108.02**	*Safety factor of 5%*

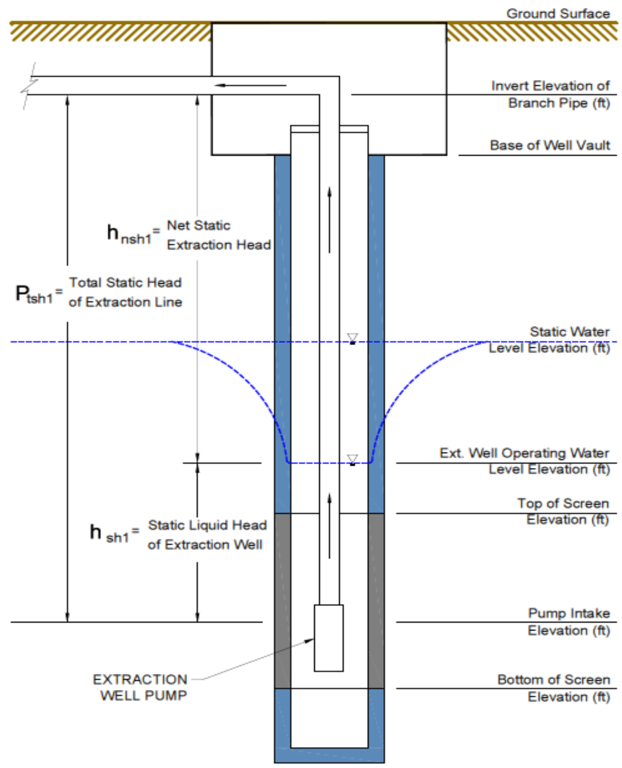
Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-5, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	472
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	297
Top of Screen Elevation:	295
Total Static Head of Extraction Line , P_{tsh1} (ft):	175
Static Liquid Head of Extraction Well, h_{slh1} (ft):	142.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	32.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	175
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an(

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 175.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 1.06

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**3.45**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**38.24**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**58**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**108.56**	*Safety factor of 5%*

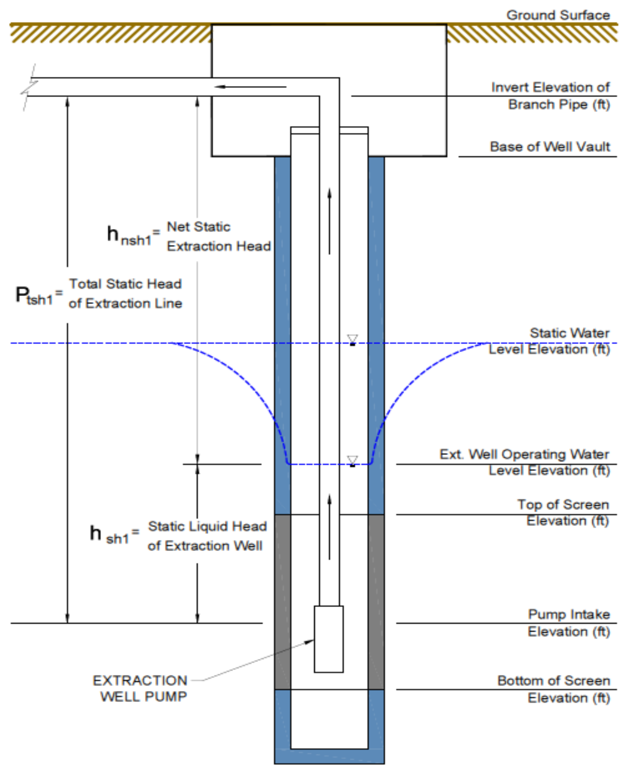
Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-5, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	472
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	187
Top of Screen Elevation:	185
Total Static Head of Extraction Line , P_{tsh1} (ft):	285
Static Liquid Head of Extraction Well, h_{slh1} (ft):	252.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	32.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	285
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 285.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.72

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**4.12**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**38.91**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**58**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**109.26**	*Safety factor of 5%*

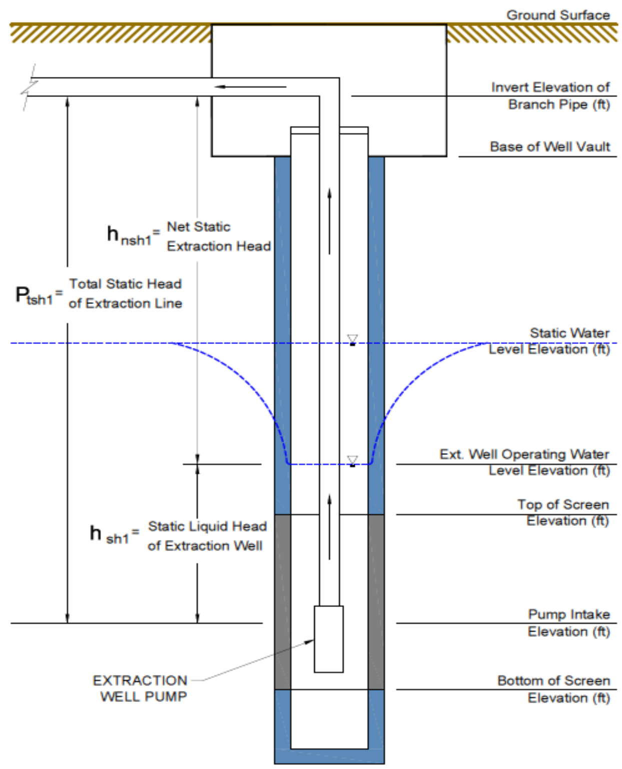
Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-5, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	472
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	132
Top of Screen Elevation:	130
Total Static Head of Extraction Line , P_{tsh1} (ft):	340
Static Liquid Head of Extraction Well, h_{slh1} (ft):	307.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	32.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	340
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 340.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 2.05

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

<u>Extraction Branch Piping Head Loss, *Hp* $_{branch}$ (ft):</u> **<u>2.40</u>**

Extraction Well Hydraulic Worksheet (IRZ-5, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* *extraction* (ft):	**4.45**	$\mathrm{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**39.24**	$\mathrm{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**58**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**109.61**	*Safety factor of 5%*

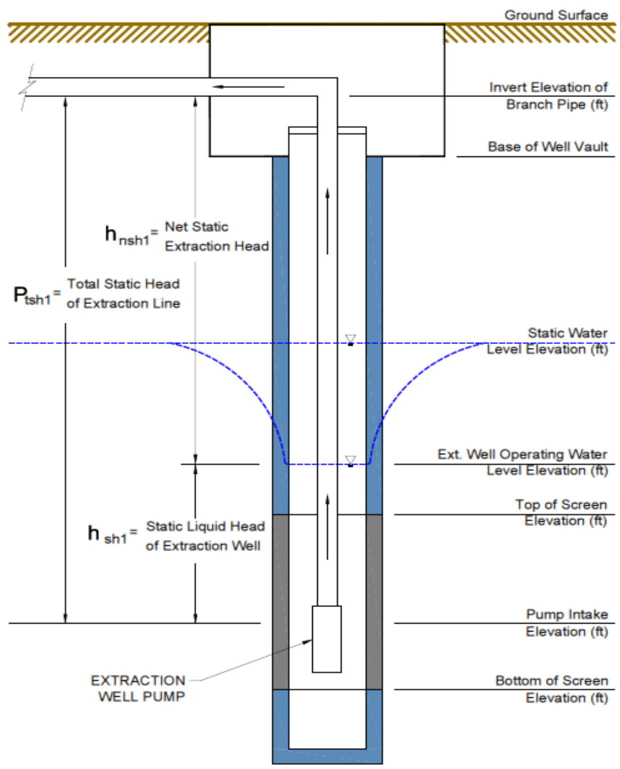
Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-9, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	475
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	407
Top of Screen Elevation:	405
Total Static Head of Extraction Line , P_{tsh1} (ft):	68
Static Liquid Head of Extraction Well, h_{slh1} (ft):	32.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	35.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	68
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

0

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 68.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 0.41

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp extraction* (ft):	**2.81**	$\boxed{\mathrm{Hp_{extraction}} = \mathrm{Hp_{drop}} + \mathrm{Hp_{branch}}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**40.60**	$\boxed{\mathrm{Hd} = \mathrm{Hp_{extraction}} + \mathrm{Hv} + \mathrm{He} + \mathrm{h_{nshl}} + \mathrm{P_{sys}}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**55**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**107.88**	*Safety factor of 5%*

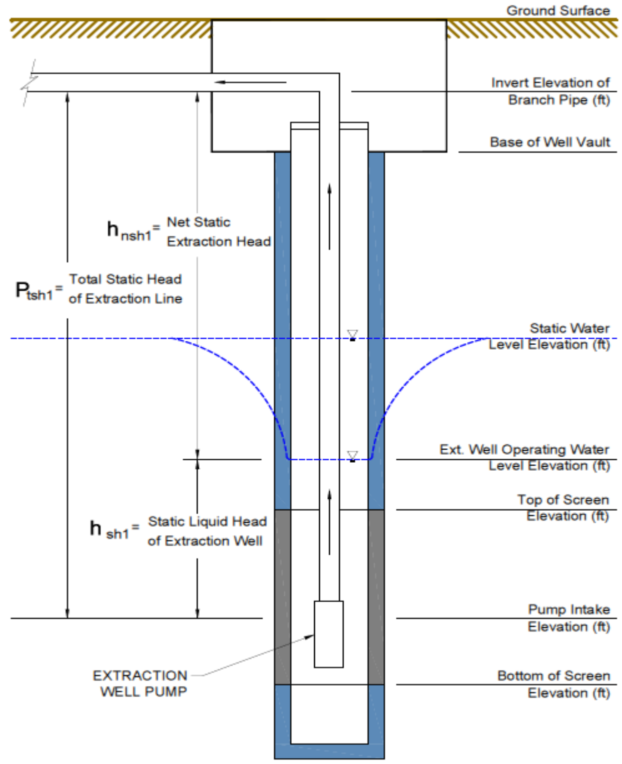
Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-9, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	475
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	327
Top of Screen Elevation:	325
Total Static Head of Extraction Line , P_{tsh1} (ft):	148
Static Liquid Head of Extraction Well, h_{slh1} (ft):	112.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	35.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	148
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 148.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 0.89

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**3.29**	$\boxed{\mathrm{Hp_{extraction}} = \mathrm{Hp_{drop}} + \mathrm{Hp_{branch}}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**41.08**	$\boxed{\mathrm{Hd} = \mathrm{Hp_{extraction}} + \mathrm{Hv} + \mathrm{He} + \mathrm{h_{nshl}} + \mathrm{P_{sys}}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**55**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**108.39**	*Safety factor of 5%*

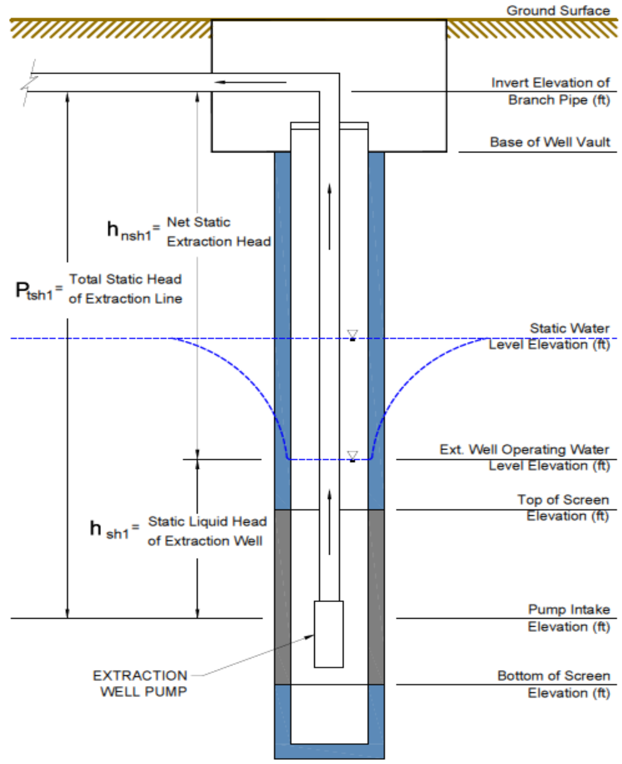
Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-9, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	475
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	242
Top of Screen Elevation:	240
Total Static Head of Extraction Line , P_{tsh1} (ft):	233
Static Liquid Head of Extraction Well, h_{slh1} (ft):	197.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	35.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	233
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 233.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.41

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* *extraction* (ft):	**3.80**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**41.59**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**55**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**108.93**	*Safety factor of 5%*

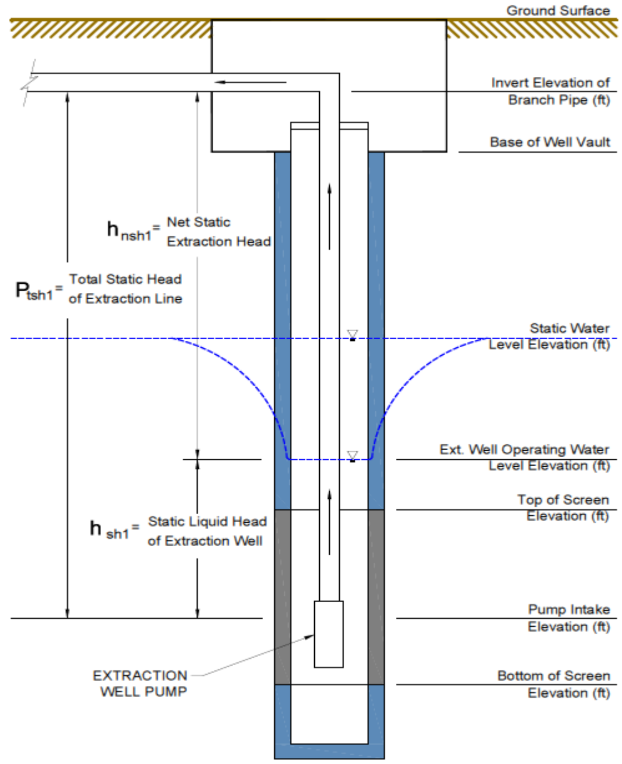
Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-9, LAYER 4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	16.75
Design Extraction Flowrate For All Layers in Well (gpm):	67
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	475
Ext. Well Operating Water Elevation (ft):	439.25
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	192
Top of Screen Elevation:	190
Total Static Head of Extraction Line , P_{tsh1} (ft):	283
Static Liquid Head of Extraction Well, h_{slh1} (ft):	247.25
Net Static Head of Extraction Line, h_{nsh1} (ft):	35.75
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	283
Pipe Friction Factor, *f*:	0.0261
Flowrate (gpm):	16.75
Velocity, *v* (ft/s):	1.60
Reynolds Number, Re:	1.96E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 283.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0060

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp*$_{drop}$ (ft): **1.71**

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0204
Flowrate (gpm):	67
Velocity, *v* (ft/s):	3.43
Reynolds Number, Re:	5.73E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 46.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 151.6

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0158

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 2.40

Extraction Well Hydraulic Worksheet (IRZ-9, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**4.10**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.04**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**41.89**	$Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**55**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**109.24**	*Safety factor of 5%*

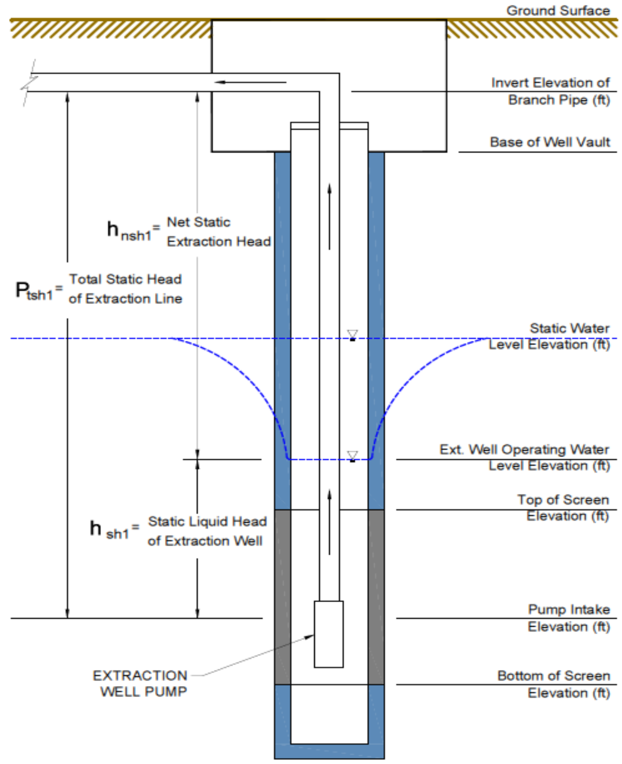
Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-23, LAYER 1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	100
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	498
Ext. Well Operating Water Elevation (ft):	431
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	432
Top of Screen Elevation:	430
Total Static Head of Extraction Line , P_{tsh1} (ft):	66
Static Liquid Head of Extraction Well, h_{slh1} (ft):	-1
Net Static Head of Extraction Line, h_{nsh1} (ft):	67
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): 2.00

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	66
Pipe Friction Factor, *f*:	0.0237
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.39
Reynolds Number, Re:	2.92E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 66.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0122

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 0.81

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0187
Flowrate (gpm):	100
Velocity, *v* (ft/s):	5.12
Reynolds Number, Re:	8.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			

K (total): 4.03

Valves/Fittings Equivalent Length of Straight Pipe (ft): 50.7

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 155.7

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0323

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): **5.04**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* *extraction* (ft):	**5.84**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.09**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**74.93**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**32**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**119.78**	*Safety factor of 5%*

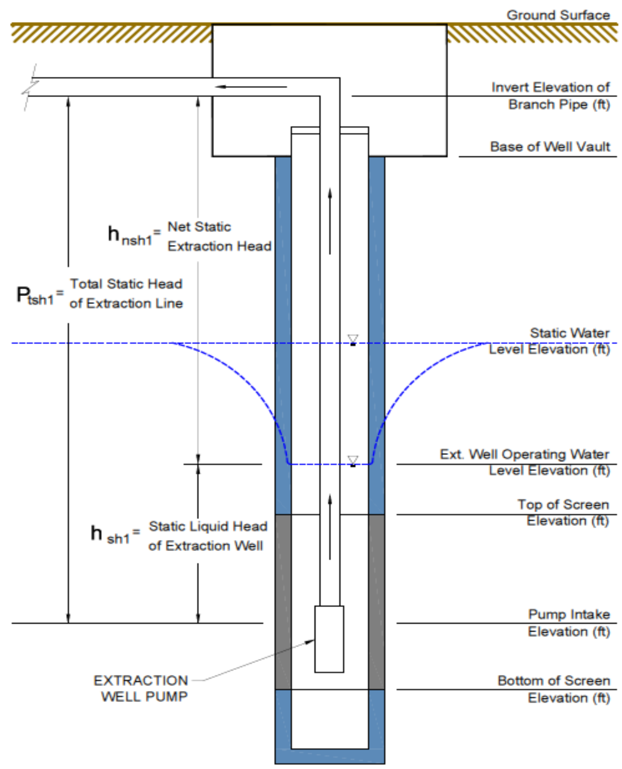
Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-23, LAYER 2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	100
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	498
Ext. Well Operating Water Elevation (ft):	431
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	412
Top of Screen Elevation:	410
Total Static Head of Extraction Line , P_{tsh1} (ft):	86
Static Liquid Head of Extraction Well, h_{slh1} (ft):	19
Net Static Head of Extraction Line, h_{nsh1} (ft):	67
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	86
Pipe Friction Factor, *f*:	0.0237
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.39
Reynolds Number, Re:	2.92E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 86.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0122

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.05

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0187
Flowrate (gpm):	100
Velocity, *v* (ft/s):	5.12
Reynolds Number, Re:	8.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 50.7

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 155.7

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0323

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 5.04

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**6.09**	$\boxed{\mathrm{Hp_{extraction}} = \mathrm{Hp_{drop}} + \mathrm{Hp_{branch}}}$
Exit Loss at Liquid Discharge (ft):	**0.09**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**75.18**	$\boxed{\mathrm{Hd} = \mathrm{Hp_{extraction}} + \mathrm{Hv} + \mathrm{He} + \mathrm{h_{nshl}} + \mathrm{P_{sys}}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**32**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**120.04**	*Safety factor of 5%*

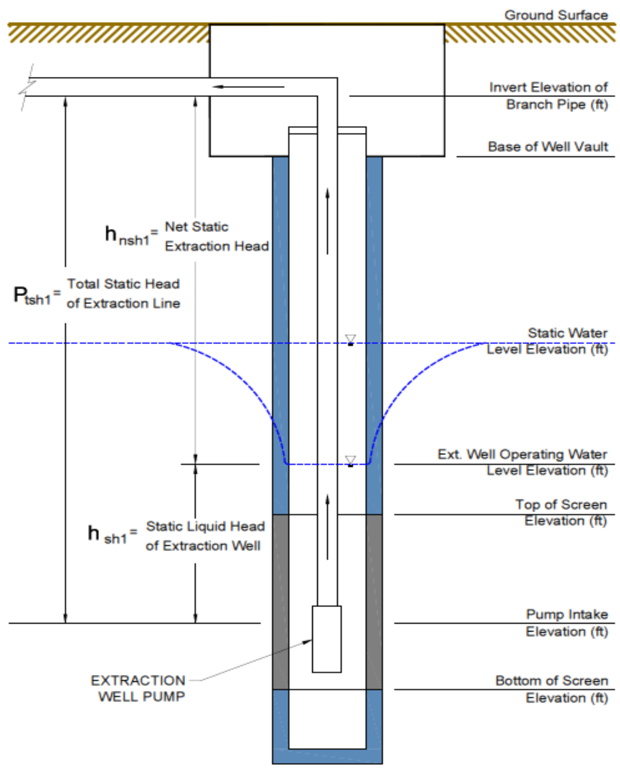
Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-23, LAYER 3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	100
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	498
Ext. Well Operating Water Elevation (ft):	431
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	377
Top of Screen Elevation:	375
Total Static Head of Extraction Line , P_{tsh1} (ft):	121
Static Liquid Head of Extraction Well, h_{slh1} (ft):	54
Net Static Head of Extraction Line, h_{nsh1} (ft):	67
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	121
Pipe Friction Factor, *f*:	0.0237
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.39
Reynolds Number, Re:	2.92E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 121.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0122

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 1.48

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0187
Flowrate (gpm):	100
Velocity, *v* (ft/s):	5.12
Reynolds Number, Re:	8.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 50.7

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 155.7

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0323

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 5.04

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**6.52**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.09**	*Assumed equal to one velocity head, Hv.* $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**75.60**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**32**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**120.49**	*Safety factor of 5%*

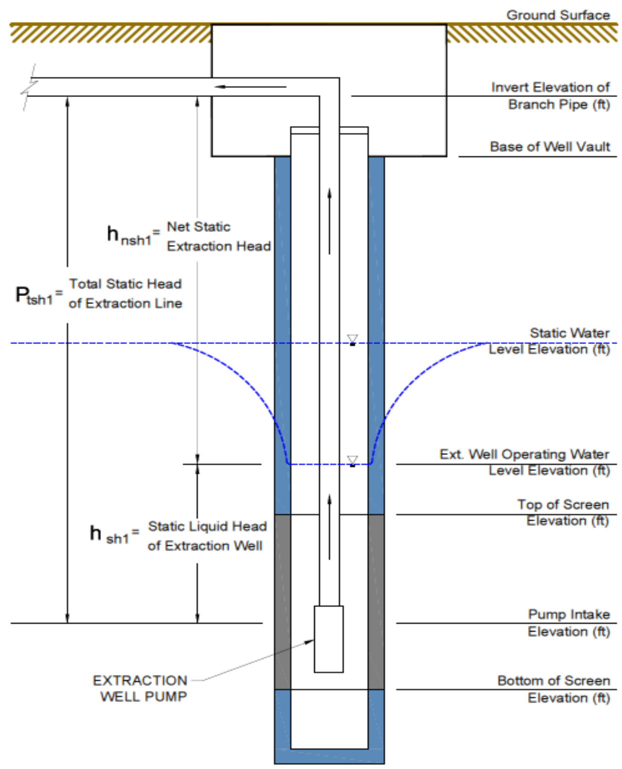
Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Well / Pump ID: IRZ-23, LAYER 4

Fluid:	(◉) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Pump Design Flowrate (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	100
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	498
Ext. Well Operating Water Elevation (ft):	431
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	352
Top of Screen Elevation:	350
Total Static Head of Extraction Line , P_{tsh1} (ft):	146
Static Liquid Head of Extraction Well, h_{slh1} (ft):	79
Net Static Head of Extraction Line, h_{nsh1} (ft):	67
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	2		
Cumulative Pressure Drop (ft w.c.):	2		

Total In-Line Equipment Head, *He* (ft): **2.00**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	2.067
Pipe Lenth (ft):	146
Pipe Friction Factor, *f*:	0.0237
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.39
Reynolds Number, Re:	2.92E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 40 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1				

K (total): 0

Valves/Fittings Equivalent Length of Straight Pipe (ft): 0.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 146.0

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0122

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **1.78**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Lenth (ft):	105
Pipe Friction Factor, *f*:	0.0187
Flowrate (gpm):	100
Velocity, *v* (ft/s):	5.12
Reynolds Number, Re:	8.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

1

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
K (total):	4.03				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 50.7

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 155.7

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0323

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): **5.04**

Extraction Well Hydraulic Worksheet (IRZ-23, LAYER 4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: CL
Revision No. 0
Revision Date: 10/24/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**6.82**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.09**	*Assumed equal to one velocity head, Hv.* $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**2.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**75.91**	$Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**530**	
Maximum Static Head from Branch Connection (ft):	**32**	
Conveyance Forcemain Pressure Drop (ft):	**7.15**	
Design Discharge Head Req. to Branch Line (ft):	**120.81**	*Safety factor of 5%*

Inner Recirculation Loop
Extraction and Injection Wells

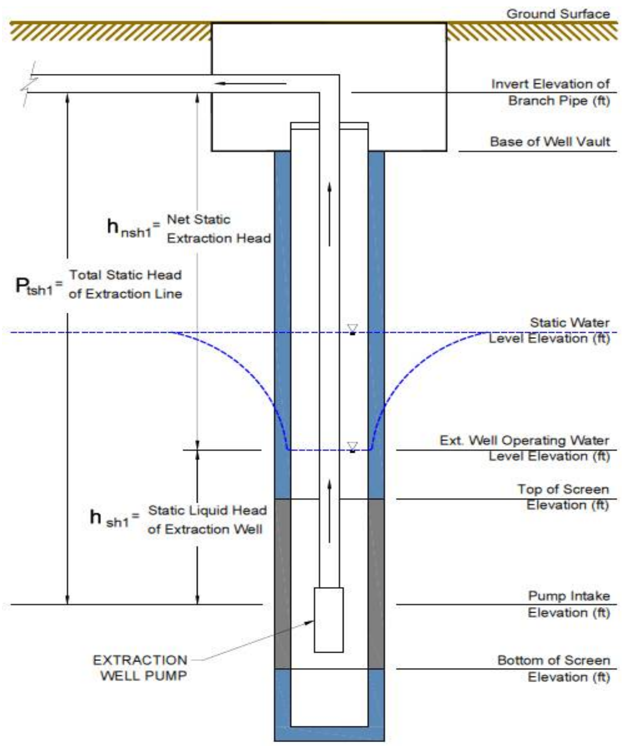
Extraction Well Hydraulic Worksheet (FP-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Well / Pump ID: FP-EX-1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	25
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	464
Ext. Well Operating Water Elevation (ft):	449.8
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	124
Top of Screen Elevation:	122
Total Static Head of Extraction Line , P_{tsh1} (ft):	340
Static Liquid Head of Extraction Well, h_{slh1} (ft):	325.8
Net Static Head of Extraction Line, h_{nsh1} (ft):	14.3
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (FP-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.939
Pipe Length (ft):	340
Pipe Friction Factor, *f*:	0.0234
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.72
Reynolds Number, Re:	3.11E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	7.5	1			

K (total): 7.5

Valves/Fittings Equivalent Length of Straight Pipe (ft): 51.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 391.9

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0166

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **6.50**

Extraction Well Hydraulic Worksheet (FP-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0233
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	3.15E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			

K (total): 5.41

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 67.1

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0175

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 1.17

Extraction Well Hydraulic Worksheet (FP-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *$Hp_{extraction}$* (ft):	**7.67**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.11**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**26.04**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**116**	
Conveyance Forcemain Pressure Drop (ft):	**2.11**	
Design Discharge Head Req. to Branch Line (ft):	**151.36**	*Safety factor of 5%*

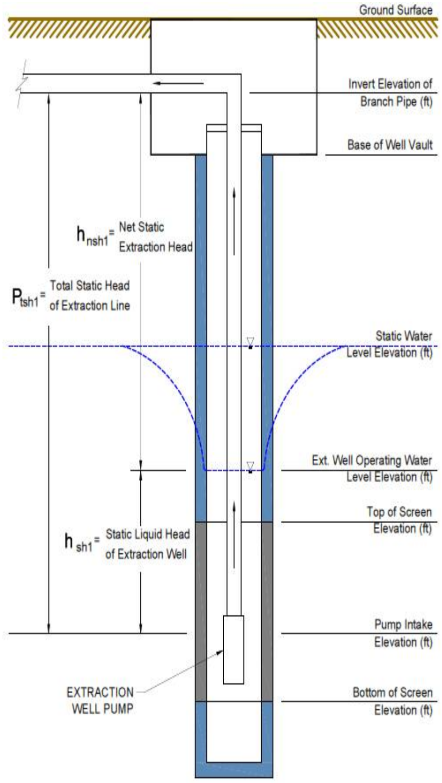
Extraction Well Hydraulic Worksheet (FP-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Well / Pump ID: FP-EX-3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	50
Design Extraction Flowrate For All Layers in Well (gpm):	50
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	464
Ext. Well Operating Water Elevation (ft):	443.5
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	277
Top of Screen Elevation:	275
Total Static Head of Extraction Line , P_{tsh1} (ft):	187
Static Liquid Head of Extraction Well, h_{slh1} (ft):	166.5
Net Static Head of Extraction Line, h_{nsh1} (ft):	20.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (FP-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.939
Pipe Length (ft):	187
Pipe Friction Factor, *f*:	0.0200
Flowrate (gpm):	50
Velocity, *v* (ft/s):	5.43
Reynolds Number, Re:	6.23E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	7.5	1			
K (total):	7.5				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 60.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 247.5

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0569

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): **14.07**

Extraction Well Hydraulic Worksheet (FP-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, f:	0.0200
Flowrate (gpm):	50
Velocity, v (ft/s):	5.56
Reynolds Number, Re:	6.30E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 43.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 73.2

Head Loss Across Extraction Branch Piping, Hp (ft/ft pipe): 0.0601

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 4.40

Extraction Well Hydraulic Worksheet (FP-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**18.47**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.46**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**43.43**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**116**	
Conveyance Forcemain Pressure Drop (ft):	**2.11**	
Design Discharge Head Req. to Branch Line (ft):	**169.62**	*Safety factor of 5%*

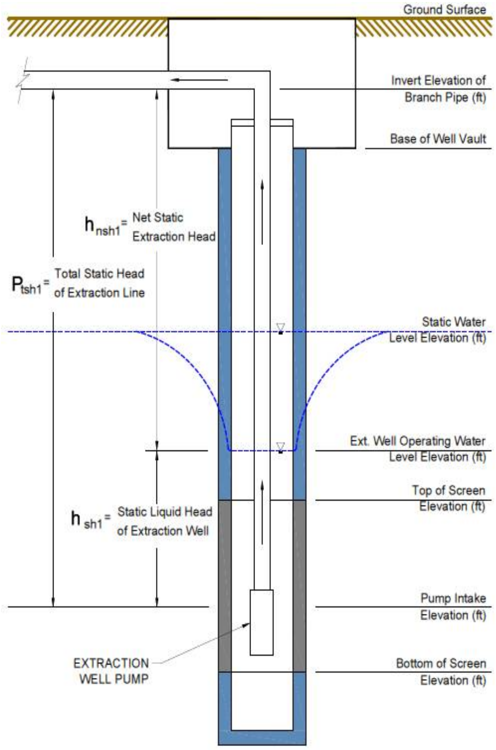
Extraction Well Hydraulic Worksheet (FP-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Well / Pump ID: FP-EX-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	50
Design Extraction Flowrate For All Layers in Well (gpm):	50
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	464
Ext. Well Operating Water Elevation (ft):	443.5
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	300
Top of Screen Elevation:	298
Total Static Head of Extraction Line , P_{tsh1} (ft):	164
Static Liquid Head of Extraction Well, h_{slh1} (ft):	143.5
Net Static Head of Extraction Line, h_{nsh1} (ft):	20.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (FP-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.939
Pipe Length (ft):	164
Pipe Friction Factor, *f*:	0.0200
Flowrate (gpm):	50
Velocity, *v* (ft/s):	5.43
Reynolds Number, Re:	6.23E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	7.5	1			

K (total): 7.5

Valves/Fittings Equivalent Length of Straight Pipe (ft): 60.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 224.5

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0569

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): **12.76**

Extraction Well Hydraulic Worksheet (FP-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0200
Flowrate (gpm):	50
Velocity, *v* (ft/s):	5.56
Reynolds Number, Re:	6.30E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 43.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 73.2

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0601

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): **4.40**

Extraction Well Hydraulic Worksheet (FP-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**17.16**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.46**	*Assumed equal to one velocity head, Hv.* $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**42.12**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**116**	
Conveyance Forcemain Pressure Drop (ft):	**2.11**	
Design Discharge Head Req. to Branch Line (ft):	**168.25**	*Safety factor of 5%*

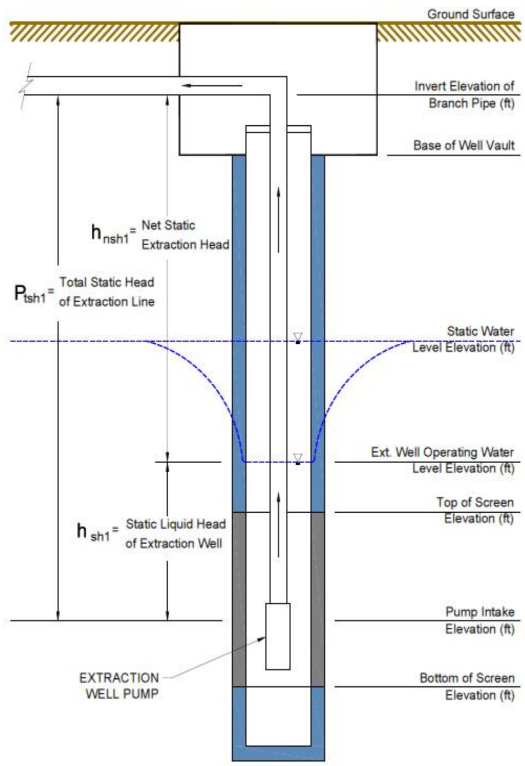
Extraction Well Hydraulic Worksheet (FP-EX-5)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Well / Pump ID: FP-EX-5

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	25
Design Extraction Flowrate For All Layers in Well (gpm):	25
Extraction Well Specific Capacity (gpm/ft):	4
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	464
Ext. Well Operating Water Elevation (ft):	449.8
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	379
Top of Screen Elevation:	377
Total Static Head of Extraction Line , P_{tsh1} (ft):	85
Static Liquid Head of Extraction Well, h_{slh1} (ft):	70.8
Net Static Head of Extraction Line, h_{nsh1} (ft):	14.3
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (FP-EX-5)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.939
Pipe Length (ft):	85
Pipe Friction Factor, *f*:	0.0234
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.72
Reynolds Number, Re:	3.11E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00003**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	7.5	1			

K (total): 7.5

Valves/Fittings Equivalent Length of Straight Pipe (ft): 51.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 136.9

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0166

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): **2.27**

Extraction Well Hydraulic Worksheet (FP-EX-5)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0233
Flowrate (gpm):	25
Velocity, *v* (ft/s):	2.78
Reynolds Number, Re:	3.15E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 37.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 67.1

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0175

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 1.17

Extraction Well Hydraulic Worksheet (FP-EX-5)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/15/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**3.44**	$\boxed{Hp_{extraction} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge (ft):	**0.11**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**21.81**	$\boxed{Hd = Hp_{extraction} + Hv + He + h_{nshl} + P_{sys}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**116**	
Conveyance Forcemain Pressure Drop (ft):	**2.11**	
Design Discharge Head Req. to Branch Line (ft):	**146.92**	*Safety factor of 5%*

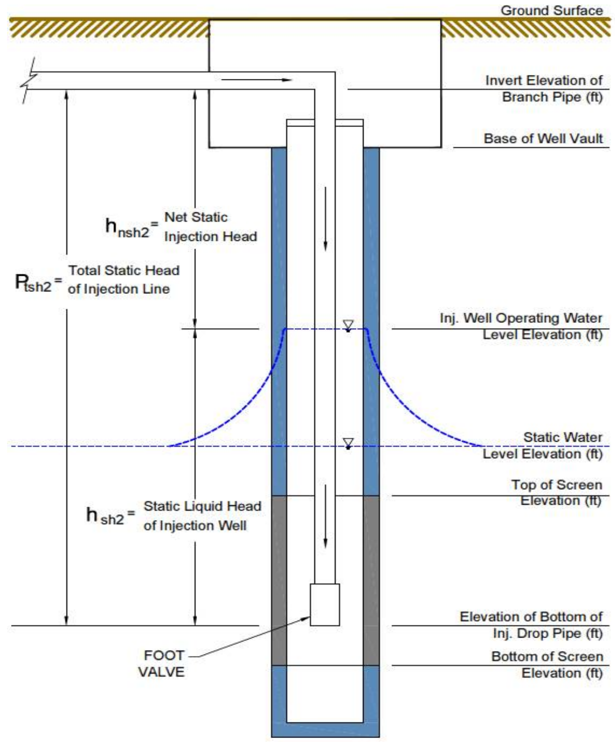
Injection Well Hydraulic Worksheet (UPGRAD-INJ-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Well ID: UPGRAD-INJ-1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	75
Design Injection Flowrate For All Layers in Well (gpm):	75
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	505
Inj. Well Operating Water Elevation (ft):	493.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	439
Top of Screen Elevation (ft):	437
Footvalve Cracking Pressure, *Hf* (psi):	27
Footvalve Cracking Pressure, *Hf* (ft w.c.):	62
Total Static Head of Injection Line, P_{tsh2} (ft):	66
Static Liquid Head of Injection Well, h_{sh2} (ft):	54.5
Net Static Head of Injection Line, h_{nsh2} (ft):	11.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): 4.00

Injection Well Hydraulic Worksheet (UPGRAD-INJ-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.9
Pipe Length (ft):	66
Pipe Friction Factor, *f*:	0.0200
Flowrate (gpm):	75
Velocity, *v* (ft/s):	3.64
Reynolds Number, Re:	6.24E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00002**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 12.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 78.1

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0170

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **1.33**

Injection Well Hydraulic Worksheet (UPGRAD-INJ-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0199
Flowrate (gpm):	75
Velocity, *v* (ft/s):	3.84
Reynolds Number, Re:	6.41E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
Standard Elbow, 90°	0.54	4			

K (total): 6.19

Valves/Fittings Equivalent Length of Straight Pipe (ft): 73.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 103.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0193

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 2.00

Injection Well Hydraulic Worksheet (UPGRAD-INJ-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**3.33**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.21**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**124.74**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**120.78**	$\boxed{Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**75**	

Design Inj. Head Required at Branch Line (ft):	**48.06**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**60.14**	*Safety factor of 5%*

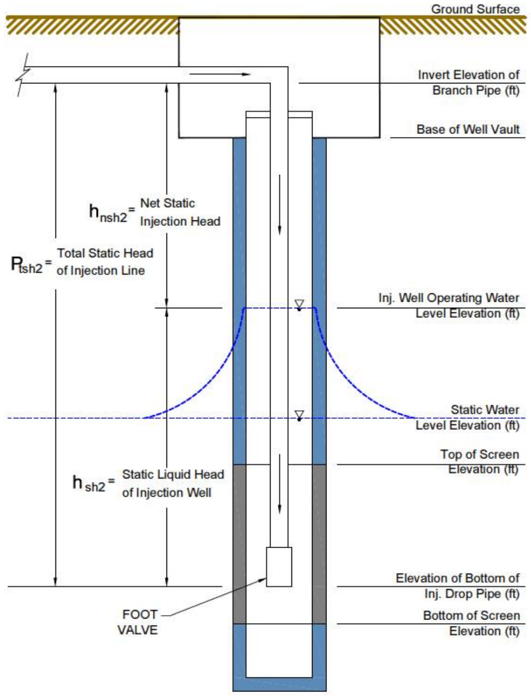
Injection Well Hydraulic Worksheet (UPGRAD-INJ-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Well ID: UPGRAD-INJ-2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	75
Design Injection Flowrate For All Layers in Well (gpm):	75
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	535
Inj. Well Operating Water Elevation (ft):	493.5
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	429
Top of Screen Elevation (ft):	427
Footvalve Cracking Pressure, Hf (psi):	27
Footvalve Cracking Pressure, Hf (ft w.c.):	62
Total Static Head of Injection Line, P_{tsh2} (ft):	106
Static Liquid Head of Injection Well, h_{sh2} (ft):	64.5
Net Static Head of Injection Line, h_{nsh2} (ft):	41.5
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (UPGRAD-INJ-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.9
Pipe Length (ft):	106
Pipe Friction Factor, *f*:	0.0200
Flowrate (gpm):	75
Velocity, *v* (ft/s):	3.64
Reynolds Number, Re:	6.24E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00002**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 12.1

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 118.1

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0170

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 2.01

Injection Well Hydraulic Worksheet (UPGRAD-INJ-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0199
Flowrate (gpm):	75
Velocity, *v* (ft/s):	3.84
Reynolds Number, Re:	6.41E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
Standard Elbow, 90°	0.54	4			

K (total): 6.19

Valves/Fittings Equivalent Length of Straight Pipe (ft): 73.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 103.3

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0193

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 2.00

Injection Well Hydraulic Worksheet (UPGRAD-INJ-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**4.01**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.21**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**124.74**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**91.46**	$\boxed{Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**45**	

Design Inj. Head Required at Branch Line (ft):	**48.78**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**92.36**	*Safety factor of 5%*

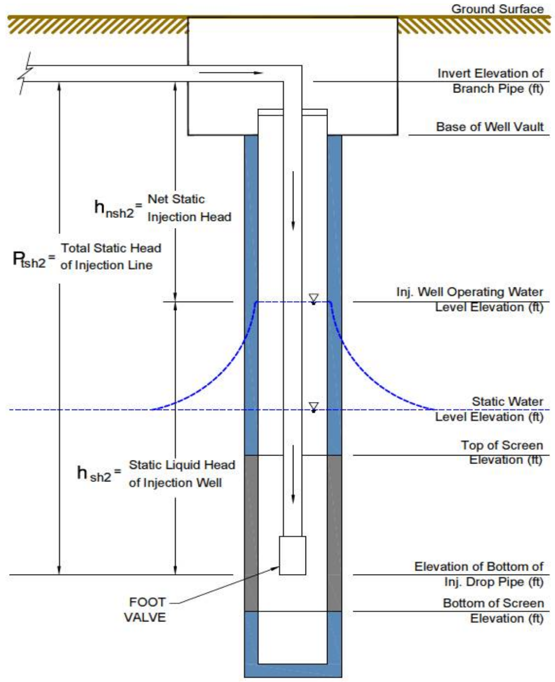
Injection Well Hydraulic Worksheet (UPGRAD-INJ-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Well ID: UPGRAD-INJ-3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	100
Design Injection Flowrate For All Layers in Well (gpm):	100
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	567
Inj. Well Operating Water Elevation (ft):	506.0
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	450
Top of Screen Elevation (ft):	448
Footvalve Cracking Pressure, Hf (psi):	27
Footvalve Cracking Pressure, Hf (ft w.c.):	62
Total Static Head of Injection Line, P_{tsh2} (ft):	117
Static Liquid Head of Injection Well, h_{sh2} (ft):	56.0
Net Static Head of Injection Line, h_{nsh2} (ft):	61.0
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (UPGRAD-INJ-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.9
Pipe Length (ft):	117
Pipe Friction Factor, *f*:	0.0188
Flowrate (gpm):	100
Velocity, *v* (ft/s):	4.86
Reynolds Number, Re:	8.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00002**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 12.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 129.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0285

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): 3.70

Injection Well Hydraulic Worksheet (UPGRAD-INJ-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Length (ft):	30
Pipe Friction Factor, f:	0.0187
Flowrate (gpm):	100
Velocity, v (ft/s):	5.12
Reynolds Number, Re:	8.55E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
Standard Elbow, 90°	0.54	4			
K (total):	6.19				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 77.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 107.9

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0323

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 3.49

Injection Well Hydraulic Worksheet (UPGRAD-INJ-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**7.19**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.37**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2\times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**124.74**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**75.30**	$\boxed{Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**13**	

Design Inj. Head Required at Branch Line (ft):	**65.42**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**129.47**	*Safety factor of 5%*

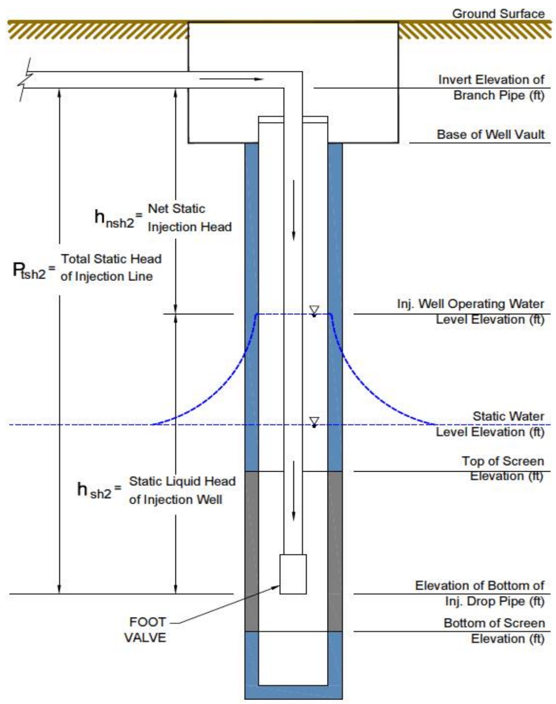
Injection Well Hydraulic Worksheet (UPGRAD-INJ-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Well ID: UPGRAD-INJ-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	200
Design Injection Flowrate For All Layers in Well (gpm):	200
Injection Well Specific Capacity (ft/gpm):	0.5
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	574
Inj. Well Operating Water Elevation (ft):	556.0
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	455
Top of Screen Elevation (ft):	453
Footvalve Cracking Pressure, *Hf* (psi):	27
Footvalve Cracking Pressure, *Hf* (ft w.c.):	62
Total Static Head of Injection Line, P_{tsh2} (ft):	119
Static Liquid Head of Injection Well, h_{sh2} (ft):	101.0
Net Static Head of Injection Line, h_{nsh2} (ft):	18.0
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (UPGRAD-INJ-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.9
Pipe Length (ft):	119
Pipe Friction Factor, *f*:	0.0164
Flowrate (gpm):	200
Velocity, *v* (ft/s):	9.71
Reynolds Number, Re:	1.66E+05

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00002**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 14.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 133.8

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0993

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): **13.29**

Injection Well Hydraulic Worksheet (UPGRAD-INJ-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	3
Pipe ID (in):	2.825
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0163
Flowrate (gpm):	200
Velocity, *v* (ft/s):	10.24
Reynolds Number, Re:	1.71E+05

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00002**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	0.9	1			
Standard Tee, thru branch	1.08	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.05	1			
Gate Valve	0.14	1			
Standard Elbow, 90°	0.54	4			
K (total):	6.19				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 89.5

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 119.5

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.1127

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 13.46

Injection Well Hydraulic Worksheet (UPGRAD-INJ-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/8/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**26.75**	$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**1.47**	***Assumed equal to one velocity head, Hv.*** $\boxed{Hv = \frac{v^2}{2 \times 32.174}}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**124.74**	***Assumed two times cracking pressure (Hf) to fully open.*** $\boxed{Hf_2 = Hf \times 2}$
Total Injection Head Required at Branch Line, *Hd* (ft):	**138.95**	$\boxed{Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}}$
Maximum Static Elevation of Injection Well Network (ft):	**580**	
Maximum Static Head from Branch Connection (ft):	**6**	

Design Inj. Head Required at Branch Line (ft):	**139.60**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**158.50**	*Safety factor of 5%*

TCS Recirculation Loop Extraction and Injection Wells

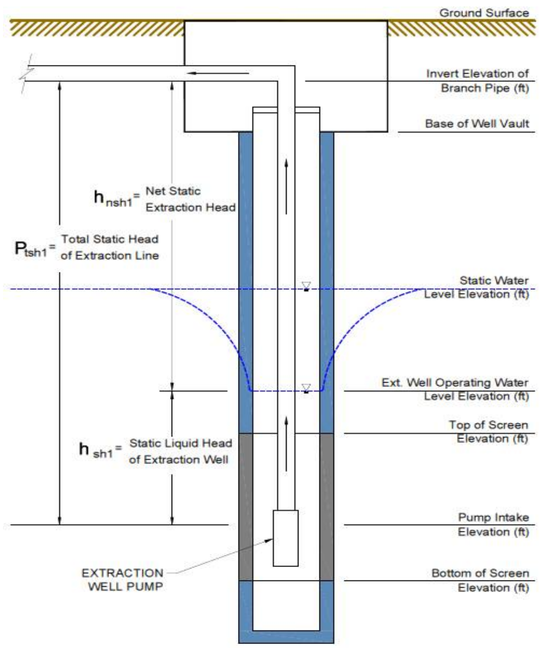
Extraction Well Hydraulic Worksheet (MID-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Well / Pump ID: MID-EX-1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	8
Design Extraction Flowrate For All Layers in Well (gpm):	8
Extraction Well Specific Capacity (gpm/ft):	0.6
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	516
Ext. Well Operating Water Elevation (ft):	442.7
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	412
Top of Screen Elevation:	410
Total Static Head of Extraction Line , P_{tsh1} (ft):	104
Static Liquid Head of Extraction Well, h_{slh1} (ft):	30.7
Net Static Head of Extraction Line, h_{nsh1} (ft):	73.3
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (MID-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	104
Pipe Friction Factor, *f*:	0.0290
Flowrate (gpm):	8
Velocity, *v* (ft/s):	1.45
Reynolds Number, Re:	1.29E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00004**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	8.4	1			

K (total): 8.4

Valves/Fittings Equivalent Length of Straight Pipe (ft): 36.2

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 140.2

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0076

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, *Hp*$_{drop}$ (ft): 1.07

Extraction Well Hydraulic Worksheet (MID-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, f:	0.0309
Flowrate (gpm):	8
Velocity, v (ft/s):	0.89
Reynolds Number, Re:	1.01E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00003**

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 28.0

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 58.0

Head Loss Across Extraction Branch Piping, Hp (ft/ft pipe): 0.0024

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 0.14

Extraction Well Hydraulic Worksheet (MID-EX-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**1.20**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.03**	*Assumed equal to one velocity head, Hv.* $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**78.57**	$Hd = Hp_{extraction} + Hv + He + h_{nsh1} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**618**	
Maximum Static Head from Branch Connection (ft):	**102**	
Conveyance Forcemain Pressure Drop (ft):	**8.25**	
Design Discharge Head Req. to Branch Line (ft):	**198.26**	*Safety factor of 5%*

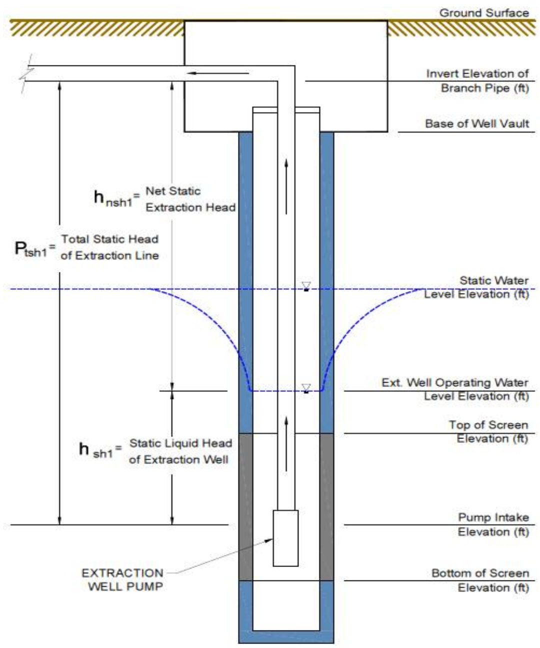
Extraction Well Hydraulic Worksheet (MID-EX-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Well / Pump ID: MID-EX-2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	6
Design Extraction Flowrate For All Layers in Well (gpm):	6
Extraction Well Specific Capacity (gpm/ft):	0.6
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	516
Ext. Well Operating Water Elevation (ft):	446.0
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	421
Top of Screen Elevation:	419
Total Static Head of Extraction Line , P_{tsh1} (ft):	95
Static Liquid Head of Extraction Well, h_{slh1} (ft):	25.0
Net Static Head of Extraction Line, h_{nsh1} (ft):	70.0
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (MID-EX-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	95
Pipe Friction Factor, *f*:	0.0312
Flowrate (gpm):	6
Velocity, *v* (ft/s):	1.09
Reynolds Number, Re:	9.66E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00004**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	8.4	1			
K (total):	8.4				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 33.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 128.6

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0046

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 0.59

Extraction Well Hydraulic Worksheet (MID-EX-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0333
Flowrate (gpm):	6
Velocity, *v* (ft/s):	0.67
Reynolds Number, Re:	7.56E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			

K (total): 5.41

Valves/Fittings Equivalent Length of Straight Pipe (ft): 25.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 55.9

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0014

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 0.08

Extraction Well Hydraulic Worksheet (MID-EX-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* extraction (ft): 0.67

$$Hp_{extraction} = Hp_{drop} + Hp_{branch}$$

Exit Loss at Liquid Discharge (ft): 0.02

Assumed equal to one velocity head, Hv.

$$Hv = \frac{v^2}{2 \times 32.174}$$

Total In-Line Equipment Head, *He* (ft): 4.00

Total Discharge Head Required to Branch Connection, *Hd* (ft): 74.69

$$Hd = Hp_{extraction} + Hv + He + h_{nsh\,1} + P_{sys}$$

Maximum Static Elevation of Injection Well Network (ft): 618

Maximum Static Head from Branch Connection (ft): 102

Conveyance Forcemain Pressure Drop (ft): 8.25

Design Discharge Head Req. to Branch Line (ft): 194.19

Safety factor of 5%

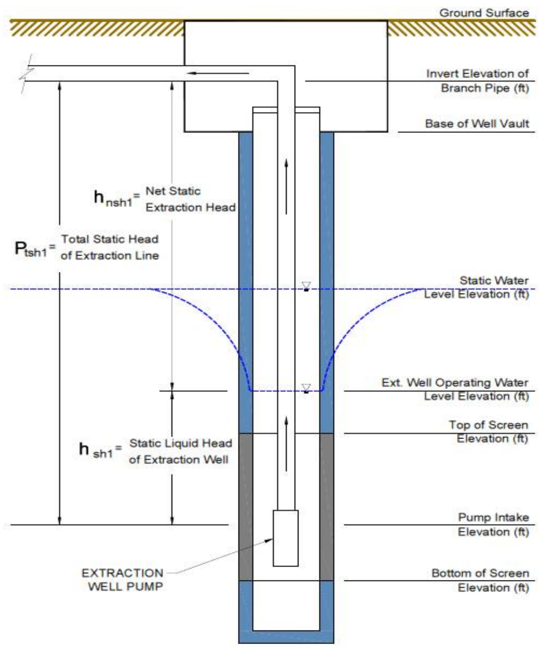
Extraction Well Hydraulic Worksheet (MID-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Well / Pump ID: MID-EX-3

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	3
Design Extraction Flowrate For All Layers in Well (gpm):	3
Extraction Well Specific Capacity (gpm/ft):	0.6
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	560
Ext. Well Operating Water Elevation (ft):	451.0
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	422
Top of Screen Elevation:	420
Total Static Head of Extraction Line , P_{tsh1} (ft):	138
Static Liquid Head of Extraction Well, h_{slh1} (ft):	29.0
Net Static Head of Extraction Line, h_{nsh1} (ft):	109.0
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses

Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (MID-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	138
Pipe Friction Factor, *f*:	0.0378
Flowrate (gpm):	3
Velocity, *v* (ft/s):	0.54
Reynolds Number, Re:	4.83E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00004**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	8.4	1			

K (total): 8.4

Valves/Fittings Equivalent Length of Straight Pipe (ft): 27.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 165.8

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0014

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): 0.23

Extraction Well Hydraulic Worksheet (MID-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0406
Flowrate (gpm):	3
Velocity, *v* (ft/s):	0.33
Reynolds Number, Re:	3.78E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 21.3

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 51.3

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0004

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 0.02

Extraction Well Hydraulic Worksheet (MID-EX-3)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 11/11/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, $Hp_{extraction}$ (ft):	**0.25**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.00**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**113.26**	$Hd = Hp_{extraction} + Hv + He + h_{nsh1} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**618**	
Maximum Static Head from Branch Connection (ft):	**58**	
Conveyance Forcemain Pressure Drop (ft):	**8.25**	
Design Discharge Head Req. to Branch Line (ft):	**188.49**	*Safety factor of 5%*

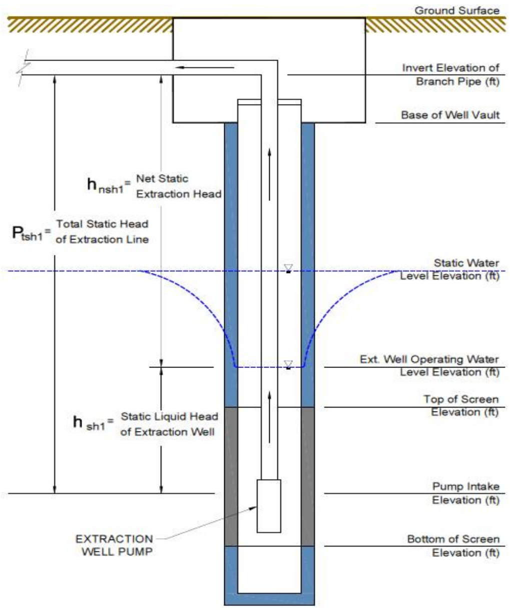
Extraction Well Hydraulic Worksheet (MID-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Extraction Well / Pump ID: MID-EX-4

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Extraction Flowrate For Layer (gpm):	2
Design Extraction Flowrate For All Layers in Well (gpm):	2
Extraction Well Specific Capacity (gpm/ft):	0.6
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Extraction Well Discharge Pipe (ft):	549
Ext. Well Operating Water Elevation (ft):	452.7
Extraction Well Static Water Level Elevation (ft):	456
Pump Intake (Impeller) Elevation (ft):	448
Top of Screen Elevation:	446
Total Static Head of Extraction Line , P_{tsh1} (ft):	101
Static Liquid Head of Extraction Well, h_{slh1} (ft):	4.7
Net Static Head of Extraction Line, h_{nsh1} (ft):	96.3
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Extraction Well Hydraulic Worksheet (MID-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Extraction Pump Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	101
Pipe Friction Factor, *f*:	0.0426
Flowrate (gpm):	2
Velocity, *v* (ft/s):	0.36
Reynolds Number, Re:	3.22E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00004**

30

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Stop Check Valve, flow thru	8.4	1			
K (total):	8.4				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 24.6

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 125.6

Head Loss Across Drop Pipe, *Hp* (ft/ft pipe): 0.0007

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Well Drop Piping Head Loss, Hp_{drop} (ft): **0.09**

Extraction Well Hydraulic Worksheet (MID-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Extraction Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Lenth (ft):	30
Pipe Friction Factor, *f*:	0.0460
Flowrate (gpm):	2
Velocity, *v* (ft/s):	0.22
Reynolds Number, Re:	2.52E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass and

Pipe Type:

Roughness, e (ft): **0.00001**
e / D: **0.00003**

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	1			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	5.41				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 18.8

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Extraction Branch Piping (ft): 48.8

Head Loss Across Extraction Branch Piping, *Hp* (ft/ft pipe): 0.0002

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Extraction Branch Piping Head Loss, Hp_{branch} (ft): 0.01

Extraction Well Hydraulic Worksheet (MID-EX-4)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Design Extraction Well Head

Total Extraction Piping System Head Loss, *Hp* *extraction* (ft):	**0.10**	$Hp_{extraction} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge (ft):	**0.00**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Total Discharge Head Required to Branch Connection, *Hd* (ft):	**100.43**	$Hd = Hp_{extraction} + Hv + He + h_{nsh1} + P_{sys}$
Maximum Static Elevation of Injection Well Network (ft):	**618**	
Maximum Static Head from Branch Connection (ft):	**69**	
Conveyance Forcemain Pressure Drop (ft):	**8.25**	
Design Discharge Head Req. to Branch Line (ft):	**186.57**	*Safety factor of 5%*

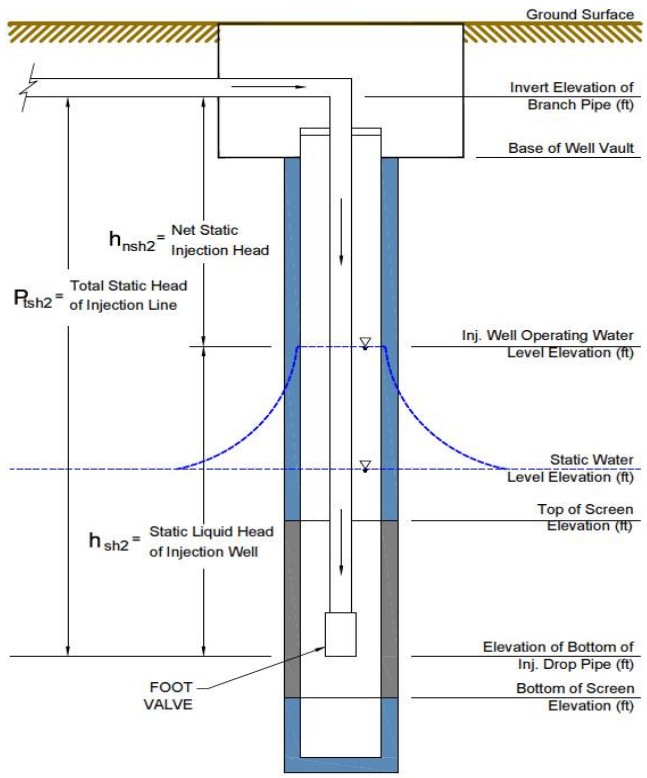
Injection Well Hydraulic Worksheet (COMP-INJ-1-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Well ID: COMP-INJ-1-1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	10.5
Injection Well Specific Capacity (ft/gpm):	3.3
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	618
Inj. Well Operating Water Elevation (ft):	490.65
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	447
Top of Screen Elevation (ft):	445
Footvalve Cracking Pressure, *Hf* (psi):	35
Footvalve Cracking Pressure, *Hf* (ft w.c.):	81
Total Static Head of Injection Line, P_{tsh2} (ft):	171
Static Liquid Head of Injection Well, h_{sh2} (ft):	43.65
Net Static Head of Injection Line, h_{nsh2} (ft):	127.35
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (COMP-INJ-1-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	171
Pipe Friction Factor, *f*:	0.0324
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	0.95
Reynolds Number, Re:	8.45E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00004**

45

Valves and Fitting Losses (K values)					
Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 174.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0037

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **0.64**

Injection Well Hydraulic Worksheet (COMP-INJ-1-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: **YS**
Revision No. **0**
Revision Date: **10/14/2011**

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	10.5
Velocity, *v* (ft/s):	1.17
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			

K (total): 6.55

Valves/Fittings Equivalent Length of Straight Pipe (ft): 36.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 66.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0038

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): **0.25**

Injection Well Hydraulic Worksheet (COMP-INJ-1-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	0.89	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, Hv (ft):	0.01	*Assumed equal to one velocity head, Hv.* $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, He (ft):	4.00	
Foot Valve Fully Open Pressure, Hf_2 (ft):	161.70	*Assumed two times cracking pressure (Hf) to fully open.* $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, Hd (ft):	39.26	$Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	618	
Maximum Static Head from Branch Connection (ft):	0	
Design Inj. Head Required at Branch Line (ft):	41.22	*Safety factor of 5%*
Worst Case Injection Head Required (ft):	174.94	*Safety factor of 5%*

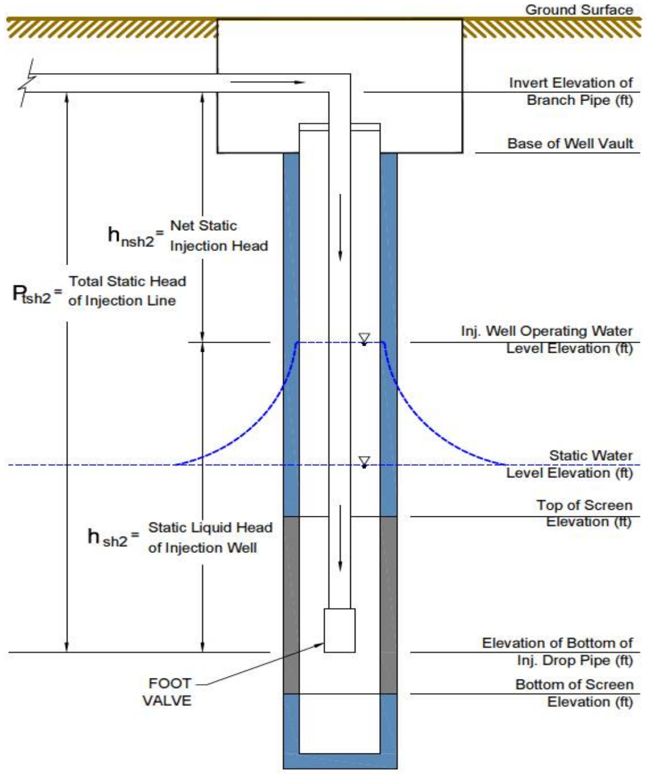
Injection Well Hydraulic Worksheet (COMP-INJ-1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Well ID: COMP-INJ-1-2

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	10.5
Injection Well Specific Capacity (ft/gpm):	3.3
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	618
Inj. Well Operating Water Elevation (ft):	490.65
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	396
Top of Screen Elevation (ft):	394
Footvalve Cracking Pressure, Hf (psi):	35
Footvalve Cracking Pressure, Hf (ft w.c.):	81
Total Static Head of Injection Line, P_{tsh2} (ft):	222
Static Liquid Head of Injection Well, h_{sh2} (ft):	94.65
Net Static Head of Injection Line, h_{nsh2} (ft):	127.35
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (COMP-INJ-1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	222
Pipe Friction Factor, *f*:	0.0324
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	0.95
Reynolds Number, Re:	8.45E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00004**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 225.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0037

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **0.83**

Injection Well Hydraulic Worksheet (COMP-INJ-1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	10.5
Velocity, *v* (ft/s):	1.17
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	6.55				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 36.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 66.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0038

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.25

Injection Well Hydraulic Worksheet (COMP-INJ-1-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft): **1.08**

$$\boxed{Hp_{Injection} = Hp_{drop} + Hp_{branch}}$$

Exit Loss at Liquid Discharge, *Hv* (ft): **0.01**

Assumed equal to one velocity head, Hv.

$$\boxed{Hv = \frac{v^2}{2 \times 32.174}}$$

Total In-Line Equipment Head, *He* (ft): **4.00**

Foot Valve Fully Open Pressure, Hf_2 (ft): **161.70**

Assumed two times cracking pressure (Hf) to fully open.

$$\boxed{Hf_2 = Hf \times 2}$$

Total Injection Head Required at Branch Line, *Hd* (ft): **39.44**

$$\boxed{Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}}$$

Maximum Static Elevation of Injection Well Network (ft): **618**

Maximum Static Head from Branch Connection (ft): **0**

Design Inj. Head Required at Branch Line (ft): **41.41** *Safety factor of 5%*

Worst Case Injection Head Required (ft): **175.13** *Safety factor of 5%*

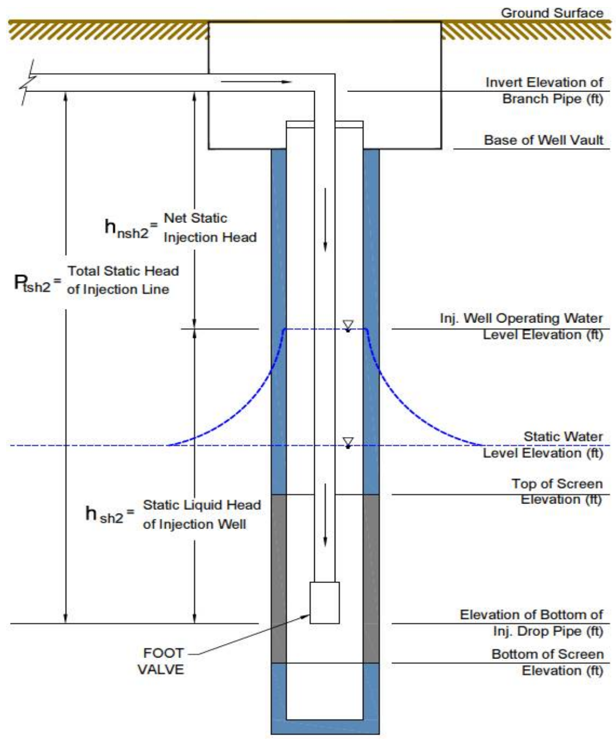
Injection Well Hydraulic Worksheet (COMP-INJ-2-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Well ID: COMP-INJ-2-1

Fluid:	◉ WATER ○ OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	10.5
Injection Well Specific Capacity (ft/gpm):	3.3
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	590
Inj. Well Operating Water Elevation (ft):	490.65
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	437
Top of Screen Elevation (ft):	435
Footvalve Cracking Pressure, *Hf* (psi):	35
Footvalve Cracking Pressure, *Hf* (ft w.c.):	81
Total Static Head of Injection Line, P_{tsh2} (ft):	153
Static Liquid Head of Injection Well, h_{sh2} (ft):	53.65
Net Static Head of Injection Line, h_{nsh2} (ft):	99.35
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (COMP-INJ-2-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	153
Pipe Friction Factor, *f*:	0.0324
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	0.95
Reynolds Number, Re:	8.45E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00004**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			
K (total):	1				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 156.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0037

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, *Hp* $_{drop}$ (ft): 0.57

Injection Well Hydraulic Worksheet (COMP-INJ-2-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	10.5
Velocity, *v* (ft/s):	1.17
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass a

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	6.55				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 36.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 66.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0038

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.25

Injection Well Hydraulic Worksheet (COMP-INJ-2-1)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**0.83**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.01**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**161.70**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**67.19**	$Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**618**	
Maximum Static Head from Branch Connection (ft):	**28**	

Design Inj. Head Required at Branch Line (ft):	**41.15**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**145.47**	*Safety factor of 5%*

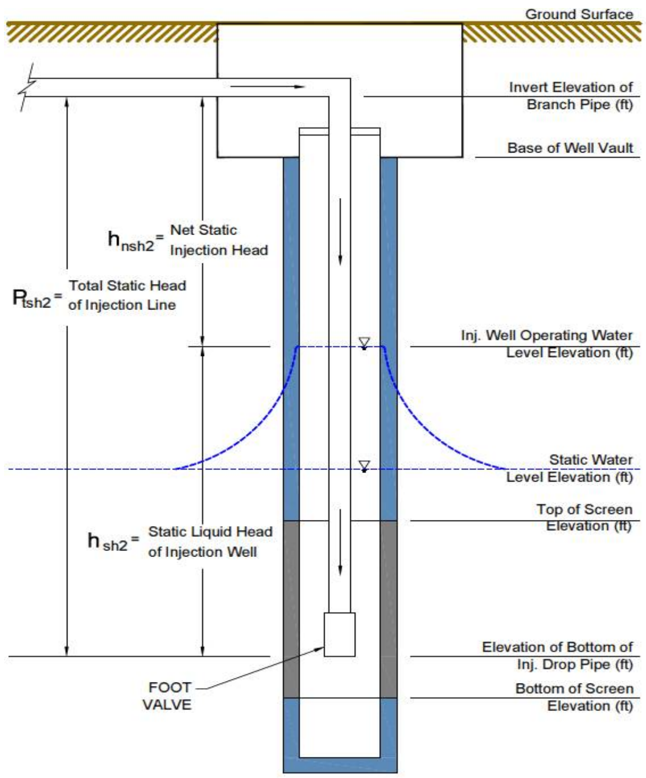
Injection Well Hydraulic Worksheet (COMP-INJ-2-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Well ID: COMP-INJ-2-2

Fluid:	(●) WATER ( ) OTHER
Fluid Description:	Groundwater
Enter Fluid Density if Other than Water (lb/ft^3):	62.4
Enter Fluid Viscosity if Other than Water (cp):	
Enter Vapor Pressure if Other than Water (psi):	
Design Injection Flowrate For Layer (gpm):	5.25
Design Injection Flowrate For All Layers in Well (gpm):	10.5
Injection Well Specific Capacity (ft/gpm):	3.3
Pressure of System to be Pumped, P_{sys} (psia):	14.7
Fluid Temperature (°F):	50
Invert Elevation of Branch Pipe (ft):	590
Inj. Well Operating Water Elevation (ft):	490.65
Injection Well Static Water Level Elevation (ft):	456
Elevation of Bottom of Inj. Drop Pipe (Injection Point) (ft):	396
Top of Screen Elevation (ft):	394
Footvalve Cracking Pressure, Hf (psi):	35
Footvalve Cracking Pressure, Hf (ft w.c.):	81
Total Static Head of Injection Line, P_{tsh2} (ft):	194
Static Liquid Head of Injection Well, h_{sh2} (ft):	94.65
Net Static Head of Injection Line, h_{nsh2} (ft):	99.35
Safety Factor:	5%
Fluid Kinematic Viscosity, h (ft^2/s):	1.41E-05



In-Line Equipment Head Losses

In-Line Equipment Head Losses			
Equipment Tag	Pressure Drop (ft w.c.)	Equipment Tag	Pressure Drop (ft w.c.)
Flow Meter	4		
Cumulative Pressure Drop (ft w.c.):	4		

Total In-Line Equipment Head, *He* (ft): **4.00**

Injection Well Hydraulic Worksheet (COMP-INJ-2-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Drop Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	1 1/2
Pipe ID (in):	1.5
Pipe Length (ft):	194
Pipe Friction Factor, *f*:	0.0324
Flowrate (gpm):	5.25
Velocity, *v* (ft/s):	0.95
Reynolds Number, Re:	8.45E+03

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SCH 80 - PVC/CPVC

Roughness, e (ft): **0.00001**
e / D: **0.00004**

45

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Pipe Exit (rounded)	1	1			

K (total): 1

Valves/Fittings Equivalent Length of Straight Pipe (ft): 3.9

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Drop Pipe (ft): 197.9

Head Loss Across Drop Pipe *Hp* (ft/ft pipe): 0.0037

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Drop Piping Head Loss, Hp_{drop} (ft): **0.72**

Injection Well Hydraulic Worksheet (COMP-INJ-2-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Injection Branch Piping Pressure Drop Calculations

Nominal Pipe Diameter (in):	2
Pipe ID (in):	1.917
Pipe Length (ft):	30
Pipe Friction Factor, *f*:	0.0288
Flowrate (gpm):	10.5
Velocity, *v* (ft/s):	1.17
Reynolds Number, Re:	1.32E+04

Pipe Material:
Smooth Pipes (PE and other thermoplastics/Brass/Glass an

Pipe Type:
SDR 11 - HDPE

Roughness, e (ft): **0.00001**
e / D: **0.00003**

5

Valves and Fitting Losses (K values)

Valve/Fitting Tag	K	# Units	Valve/Fitting Tag	K	# Units
Swing Check Valve (tee style)	1	1			
Standard Tee, thru branch	1.14	2			
Pipe Entrance (inward projecting)	0.78	1			
Ball Valve	0.06	1			
Gate Valve	0.15	1			
Standard Elbow, 90°	0.57	4			
K (total):	6.55				

Valves/Fittings Equivalent Length of Straight Pipe (ft): 36.4

$$Length = \frac{k \times \frac{ID}{12}}{f}$$

Equivalent Length of Injection Branch Piping (ft): 66.4

Head Loss Across Injection Branch Piping, *Hp* (ft/ft pipe): 0.0038

$$Hp = \frac{f \times v^2}{2 \times 32.174 \times \frac{ID}{12}}$$

Injection Branch Piping Head Loss, Hp_{branch} (ft): 0.25

Injection Well Hydraulic Worksheet (COMP-INJ-2-2)

Site: Pacific Gas & Electric Topock Compressor Station
Location: Topock, California

Created By: YS
Revision No. 0
Revision Date: 10/14/2011

Design Injection Head for Well

Total Injection Piping System Head Loss, $Hp_{injection}$ (ft):	**0.98**	$Hp_{Injection} = Hp_{drop} + Hp_{branch}$
Exit Loss at Liquid Discharge, *Hv* (ft):	**0.01**	***Assumed equal to one velocity head, Hv.*** $Hv = \frac{v^2}{2 \times 32.174}$
Total In-Line Equipment Head, *He* (ft):	**4.00**	
Foot Valve Fully Open Pressure, Hf_2 (ft):	**161.70**	***Assumed two times cracking pressure (Hf) to fully open.*** $Hf_2 = Hf \times 2$
Total Injection Head Required at Branch Line, *Hd* (ft):	**67.34**	$Hd = Hp_{injection} + Hv + He + Hf - Psys - h_{nsh\,2}$
Maximum Static Elevation of Injection Well Network (ft):	**618**	
Maximum Static Head from Branch Connection (ft):	**28**	

Design Inj. Head Required at Branch Line (ft):	**41.31**	*Safety factor of 5%*

Worst Case Injection Head Required (ft):	**145.62**	*Safety factor of 5%*

Appendix E
List of Specifications and Sample Specification Format

List of Technical Specifications

Final Groundwater Remedy
Topock Compressor Station
Topock, California

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SAMPLE SPECIFICATION FORMAT

SECTION 44 42 56.10

HORIZONTAL END SUCTION CENTRIFUGAL PUMPS

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Bearing Manufacturers' Association (ABMA).
   2. Hydraulic Institute Standards.
   3. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
   4. Occupational Safety and Health Administration (OSHA).

1.2 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.3 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Make, model, weight, and horsepower of each equipment assembly.
      b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
      c. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.
      d. Detailed [structural,] [mechanical,] [and] [electrical] drawings showing equipment dimensions, size, and locations of connections and weights of associated equipment.
      e. Power and control wiring diagrams, including terminals and numbers.
      f. Complete motor nameplate data, as defined by NEMA, motor manufacturer.
      g. Factory finish system data sheets.
      h. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Seismic Anchorage and Bracing.

B. Informational Submittals:
   1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Seismic Anchorage and Bracing.
   2. [Factory Functional Test Reports.]
   3. [Manufacturer's Certification of Compliance that factory finish system is identical to the requirements specified herein.]

4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer's printed installation instructions.
6. Suggested spare parts list to maintain the equipment in service for a period of [1 year] [and] [5 years]. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.4 EXTRA MATERIALS

A. Furnish for [each pump:] [this set of pumps:]
   1. [Complete set packing.]
   2. [Complete set bearings.]
   3. [Complete set gaskets and O-ring seals.]
   4. [Complete set of shaft sleeves.]
   5. [Complete set keys, dowels, pins, etc.]
   6. [Complete mechanical seal.]
   7. [Impeller.]
   8. [Impeller shaft.]
   9. [Impeller wear ring.]
   10. [Head shaft.]
   11. [One complete set of special tools required to dismantle pump.]

PART 2 PRODUCTS

2.1 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

2.2 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

B. [No "or-equal" or substitute products will be considered.]

2.3 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. OSHA-approved coupling guard for direct coupled or belt driven pumps.

D. Anchor Bolts: [Galvanized,] [Type 316 stainless steel,] [sized by equipment manufacturer,] [1/2-inch minimum diameter,] and as specified in Section 05 50 00, Metal Fabrications. [Coat in accordance with Section 09 90 00, Painting and Coating.]

2.4 FACTORY FINISHING

A. [Prepare, [and] prime, [and finish] coat in accordance with Section 09 90 00, Painting and Coating.]

B. [Manufacturer's standard [baked] enamel finish.]

2.5 SOURCE QUALITY CONTROL

A. [Factory Inspections:] Inspect [control panels] [________] for required construction, electrical connection, and intended function.

B. [Factory Tests and Adjustments:] Test [one] [________] [all] [equipment] [________] [and] [control panels [actually] [identical to that] furnished.

C. Factory Test Report: Include [test data sheets] [, curve test results] [, certified correct by a registered professional engineer].

D. Functional Test: Perform [manufacturer's standard,] [________] [motor] test on [equipment.] [________] [Include vibration test, as follows:
   1. Dynamically balance rotating parts of each [pump] [blower] [________] and its driving unit before final assembly.
   2. Limits:
      a. Driving Unit Alone: Less than [80] [________] percent of NEMA MG 1 limits.
      b. Complete Rotating Assembly Including [Coupling,] [Drive Unit,] [________,] [and Motor:] Less than [90] [________] [percent] [mils] [of limits established in the Hydraulic Institute Standards.] [________]]

E. Performance Test:
   1. In accordance with [Hydraulic Institute Standards] [________].
   2. Adjust, realign, or modify units and retest [in accordance with [Hydraulic Institute Standards] [________]] if necessary.

F. Motor Test: See Section [26 20 00, Low-Voltage AC Induction Motors] [26 19 00, Medium-Voltage AC Induction Motors].

G. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that the driving units are properly aligned, plumb, and level with the driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout the space between the bottom of the baseplate and the concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.2 FIELD FINISHING

A. Finish equipment as specified in Section 09 90 00, Painting and Coating.

3.3 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.
   1. Alignment: Test complete assemblies for [correct rotation,] proper alignment and connection, and quiet operation.
   2. Vibration Test:
      a. Test with unit installed and in normal operation, and discharging to the connected piping systems at rates [between low discharge head and high discharge head conditions specified,] [________] [and with actual building structures and foundations provided] shall not develop vibration exceeding [80 percent] [________] of the limits specified in HIS 9.6.4.
      b. If units exhibit vibration in excess of the limits [specified] [adjust] [or modify] as necessary. [Units which cannot be adjusted or modified to conform as specified shall be replaced.]
   3. [Flow Output: Measured by plant instrumentation and storage volumes.]

B. [Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.]

C. Performance Test:
1. Conduct on each pump.
2. Perform under simulated operating conditions.
3. Test for a continuous [3-hour] [________] period without malfunction.
4. Test Log: Record the following:
a. [Total head.]
b. [Capacity.]
c. [Horsepower requirements.]
d. [Flow measured by factory instrumentation and storage volumes.]
e. [Average distance from suction well water surface to pump discharge centerline for duration of test.]
f. [Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.]
g. [Calculated velocity head at the discharge flange.]
h. [Field head.]
i. [Driving motor voltage and amperage measured for each phase.]

3.4 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by [Owner,] [________,] for minimum person-days listed below, travel time excluded:
1. [________] person-days for [installation assistance] [and] [inspection].
2. [________] person-days for [functional] [and] [performance] testing and completion of Manufacturer's Certificate of Proper Installation.
3. [________] person-days for prestartup classroom or Site training.
4. [________] person-days for facility startup.
a. [________] person-days for post-startup training [of Owner's personnel]. [Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [Owner] [Engineer] [________].]

B. See [Section 01 43 33, Manufacturers' Field Services] [and] [Section 01 91 14, Equipment Testing and Facility Startup.]

3.5 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.
1. Pump Data Sheet.

END OF SECTION

HORIZONTAL END SUCTION CENTRIFUGAL PUMP DATA SHEET, 44 42 56.10-________

Tag Numbers: ____

Pump Name: ____

Manufacturer and Model Number: (1) ____

(2) ____

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): _________________________________

Pumping Temperature (Fahrenheit): Normal: _____________ Max _________ Min ____________

Specific Gravity at 60 Degrees F: ___________________ Viscosity Range: __________________

[Vapor Pressure at 60 Degrees F: ___________________] pH: ___________________________

Abrasive (Y/N) ___________________________ Possible Scale Buildup (Y/N): ______________

[Total suspended solids (mg/L) ____

[Largest diameter solid pump can pass (inches) ______________________________

Min. NPSH Available (Ft. Absolute): ____

[Suction Pressure (Ft): Max ________________________ Rated ____________________________

PERFORMANCE REQUIREMENTS AT PRIMARY DESIGN POINT

Capacity (US gpm): Rated:

Total Dynamic Head (Ft): Rated:

Min. Hydraulic Efficiency (%):

Maximum Shutoff Pressure (Ft):

Max. Pump Speed at Design Point (rpm):

Constant (Y/N): ___________________________ Adjustable (Y/N): _________________________

PERFORMANCE REQUIREMENTS AT SECONDARY DESIGN POINTS

Capacity (US gpm): ________________________ Capacity (US gpm): ________________________

Total Dynamic Head (Ft): __________________ Total Dynamic Head (Ft): __________________

Min. Hydraulic Efficiency (%): ______________ Min. Hydraulic Efficiency (%): _____________

PERFORMANCE REQUIREMENTS AT 50 PERCENT RATED SPEED

Capacity (US gpm): ________________________ Capacity (US gpm): ________________________

Total Dynamic Head (Ft): __________________ Total Dynamic Head (Ft): __________________

DESIGN AND MATERIALS

ANSI (Y/N) ______ Standard (Y/N) _______ Design: Frame-mounted (Y/N) _________________

Close-Coupled Casing (Y/N) _____ Back Pullout (Y/N) _______________

Discharge Orientation: _______________ Rotation (view from end coupling): _________________

Casing Materials: ____

Case Wear Ring (Y/N) _________________________ Material: ______________________________

Impeller: Type: ________________________________ Material: ______________________________

Impeller Wear Ring (Y/N): _____________________ Material: ______________________________

HORIZONTAL END SUCTION CENTRIFUGAL PUMP DATA SHEET, 44 42 56.10-________
(PAGE 2)

Shaft Material: ________________________________ Shaft Sleeve Material: _________________

Shaft Seal: ________________ Packing (Y/N) ________________ Material: _________________

Mechanical (Y/N) _____________________________ Type: _________________________________

Lubrication: ____

ABMA L-10 Bearing Life (Hrs): ________________ Lubrication: __________________________

Coupling: _________________ Falk (Y/N) ___________________ Fast (Y/N) ________________

Spring-Grid (Y/N) ___________

Gear Type (Y/N) ____ Spacer (Y/N) _________________ Manufacturer ______________

Standard (Y/N) _________

Baseplate: Design: _________________________ Material: _______________________________

Drive Type: Direct-Coupled: ___________ Belt ___________ Adjustable Speed _______________

Other: ____

[Adjustable Speed Drive Range: ____ min to ____ max, See Section 26 29 23, Low Voltage Adjustable Frequency Drive System.]

DRIVE MOTOR (See Section [26 20 00, Low-Voltage AC Induction Motors] [26 19 00, Medium-Voltage AC Induction Motors].)

Horsepower: ______Voltage: ________ Phase: ______ Synchronous Speed (rpm): ___________

Service Factor: ____________________ Inverter Duty (Y/N) ______________________________

Motor nameplate horsepower shall not be exceeded at any head-capacity point on the pump curve.

Enclosure: DIP ____ EXP ____ ODP ____ TEFC ____ CISD-TEFC ____ TENV ____
WPI ____ WPII ____ SUBM ____

Mounting Type: Horizontal ______________ Nonreverse Ratchet (Y/N) _____________________

REMARKS ____

____

____

____

Appendix F
Remedy-produced Water Management Technical Memorandum and Response to Comments

Management of Water Produced from Operation and Maintenance of Groundwater Remedy, PG&E Topock Compressor Station, Needles, California

TO: Pacific Gas and Electric Company

FROM: CH2M HILL

DATE: August 15, 2011 (Draft); November 18, 2011 (Rev. 0)

This technical memorandum summarizes the plan for managing water produced during the operation and maintenance (O&M) of the Topock groundwater remedy at the Pacific Gas and Electric Company (PG&E) Topock Compressor Station (TCS) in Needles, California. This water primarily consists of water pumped from remediation wells during well maintenance activities such as backwashing and rehabilitation. Other types of remedy-produced water (smaller volume) will also need to be managed such as monitoring well sampling purge water, equipment decontamination wastewater, and rainfall that collects in secondary containment areas of remedy facilities. The remedy is reliant on the dozens of wells used for the in-situ reactive zone (IRZ), freshwater and carbon-amended injection, and groundwater extraction. For all wells, especially for the injection and IRZ wells, regular maintenance is vital to keep efficient and effective operations during the 30-year projected life of the remedy. Well maintenance will also prevent or reduce the need for drilling new replacement wells. The management strategy must be sensible and flexible to meet the needs of the system and the regulatory requirements, be cost-effective, and must not constrain remedy operations.

This memorandum discusses the evaluation of remedy-produced water management options, the preferred management plan, and preliminary design basis/design criteria. The design basis covers three parts of the management system: transport, conditioning, and reuse/disposal. The approach described herein is for the operation phase of the final remedy. It is assumed that water produced during remedy construction will be managed at the Interim Measure Number 3 (IM-3) treatment system or by trucking off-site, or by the remedy-produced water management system (if it is available). This assumption will be revisited throughout the design and construction process.

The information presented here has been developed from PG&E's experience maintaining the IM-3 injection wells and operation of the IRZ system at the Hinkley site. This experience includes both routine well cleaning and backwashing and rehabilitation work. The information gained from these operations has been incorporated into this preliminary design and will be updated as additional operational data become available.

This memorandum was originally transmitted to DTSC and DOI on August 15, 2011. DTSC and DOI comments on the memorandum have been incorporated, and this memorandum has been updated accordingly. Responses to DTSC and DOI comments are attached to this memorandum.

Transport

Within the project area, water generated from well maintenance activities can be either trucked or conveyed via pipelines, or both. The preferred approach is to use both methods. Conveyance piping will be constructed to remediation wells requiring frequent maintenance such as the IRZ, carbon amendment, and freshwater injection wells. For wells requiring less frequent maintenance such as extraction and monitoring wells, trucking is the preferred option for conveying the remedy-produced water. Trucking is also the preferred option for wells where installing pipelines would be difficult.

The advantages of piping over trucking are that piping has a lower visual impact, lower safety risk during operation, lower risk of spills, lower carbon dioxide emissions, and will require less cleared space at the wellhead for maintenance activities. Using piping to convey remedy-produced water also allows automation of the backwashing for the injection and IRZ wells. This would entail installing dedicated backwashing pumps, valves, and controls, to enable the backwashing to occur on a regular schedule (all equipment can be installed in the well vault to reduce visual impacts). The backwashing sequencing would be planned such that one (or more) well is being backwashed at a time to optimize the system hydraulics. Automated backwashing could be done on a cyclic basis with 3 on-off cycles of 10 minutes on and 5 minutes off for a total of 30 minutes of pumping time. The duration and number of on-off cycles will be further evaluated during the design and refined during operation. Automated backwashing offers several benefits, including reducing the number of vehicles and crews traveling across the site and minimizing disturbance as well as the visual impacts from operations.

The piping for remedy-produced water may also serve as a backup for the main pipes carrying water to or from the wells. For example, if a pipe carrying freshwater to a freshwater injection well became unusable, the remedy-produced water pipe (after appropriate flushing) can be used to carry freshwater while the primary pipe is repaired. Having this backup minimizes such unplanned downtime.

Figure F-1 shows a layout of the remedy-produced water conveyance piping network. Piping will primarily be installed underground, but may also be installed aboveground in certain locations. To minimize disturbance from construction, all piping will be installed in common trenches, to the extent practicable, with other pipes and utilities serving the wells. Pipe sizes will range from 1 to 8 inches in diameter with trunk (main) line sizes from 4 to 6 inches. The design basis and criteria for remedy-produced water piping are described in Section 3.4 (Remedy-produced Water Management) and Appendix C (Design Criteria) of the Basis of Design Report.

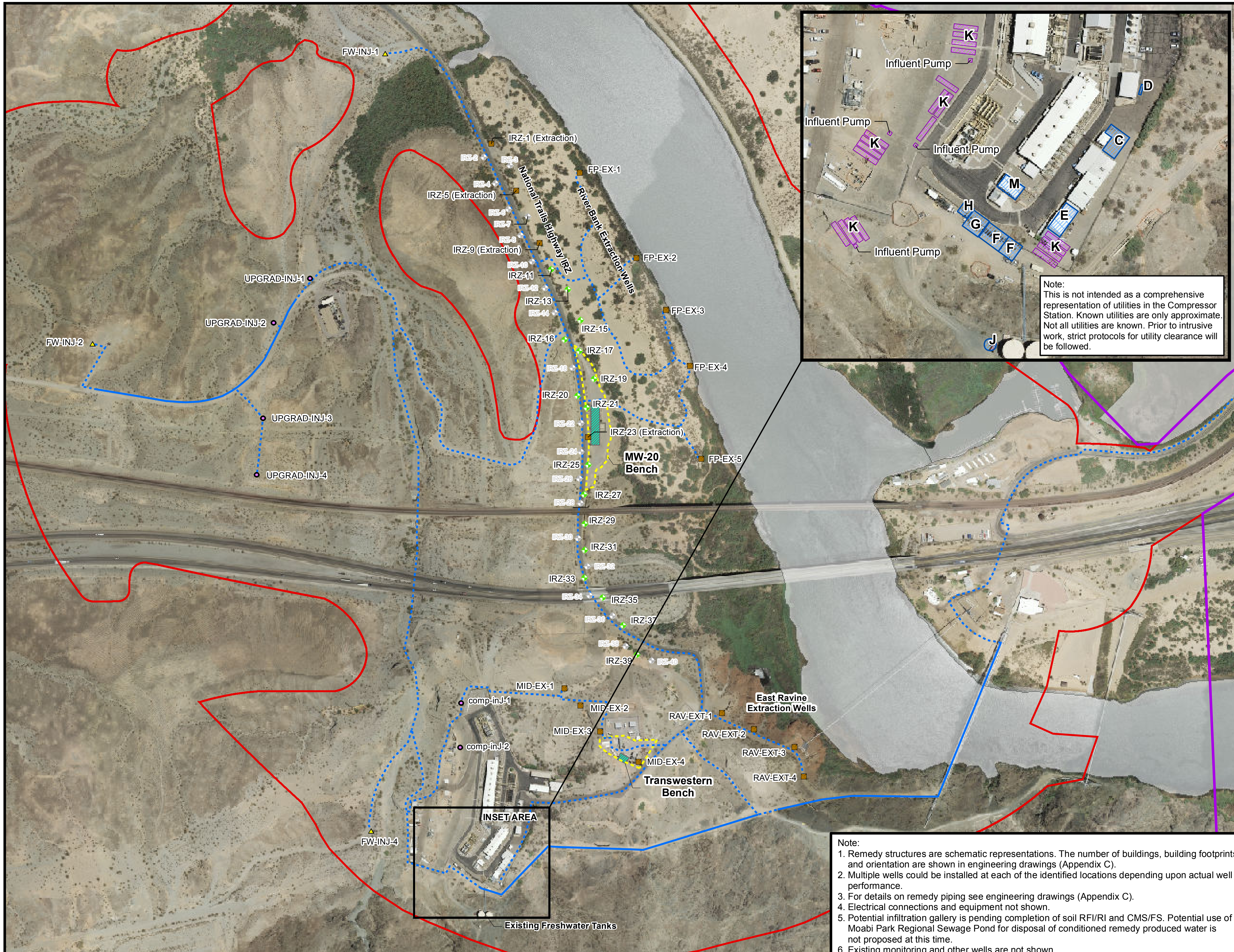
Remedy-produced Water Conditioning and Reuse/Disposal

The remedy-produced water conditioning aspect is divided into the three components that are used to evaluate and design the system: quantity of remedy-produced water, quality of remedy-produced water, and the degree of conditioning required.

Estimate of Remedy-produced Water Quantity

The initial quantity of remedy-produced water was estimated to range from 3 to 16 million gallons (MG) per year (CH2M HILL 2011). Subsequent evaluation has resulted in modified assumptions, and the current estimate is approximately 7.3 MG per year, as shown in Table F-1. Backwash operation is the largest contributor to the annual volume, with over 60 percent of the total amount. Rehabilitation operation is the second largest contributor at 2.5 MG per year, or about 30 percent. The remaining remedy-produced water (< 5 percent) includes rainwater that falls within remedy facility containment and monitoring well purge and sampling equipment decontamination water. These estimates will be further refined through the design and the operational experience to be gained from injection wells at PG&E's Hinkley site.

A variable that will have a significant impact on the volumes produced is the frequency of backwash events. Backwashes will be more frequent than rehabilitations, and will result in a large cumulative volume of remedy-produced water. But the backwashing process requires less time and effort than rehabilitations, and can reduce the frequency of more labor-intensive and obtrusive well maintenance activities. The IM-3 injection wells have been backwashed about twice monthly or more frequently based on well performance since early 2008. Backwashing frequency has been based on the measured injection well performance to maintain injection well capacity. The current assumption is that backwashing will be performed weekly for 30 minutes at a rate of twice the injection rate. Injection rates were assumed to be the average of the type of well. For example, there are four freshwater injection wells with a total flow of 600 gallons per minute (gpm). This is an average of 150 gpm per well injection rate, and at a rate of twice the injection rate gives a backwashing rate of 300 gpm for the injection wells. Pumping or backwashing at this rate for 30 minutes results in 9,000 gallons of remedy-produced water.



LEGEND

- Area of Potential Effects (APE)
- EIR Project Area
- Future Provisional Wells
- IRZ Recirculation Well
- Freshwater Supply Well
- Extraction Well
- Freshwater Injection
- Injection Well for both Carbon Amended Water and Freshwater
- MW-20 Bench Area
- Remedy Faciltiy

Pipeline for Remedy

- Aboveground Pipe
- Underground Pipe

Remedy Facilities

- Remediation Building
- Potential Influent Water Storage Location

C - Relocated Hazardous Waste Storage

D - Relocated Septic Tank

E - Operations Building

F - Remedy-Produced Water Conditioning Plant

G - Maintenance Shop

H - Relocated Pipe Storage Area

J - Conditioned Water Storage

K - Potential Influent Water Storage Location

L - Transfer Switch Gear, Control, and Transformer Building

Note:
1. Remedy structures are schematic representations. The number of buildings, building footprints and orientation are shown in engineering drawings (Appendix C).
2. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
3. For details on remedy piping see engineering drawings (Appendix C).
4. Electrical connections and equipment not shown.
5. Potential infiltration gallery is pending completion of soil RFI/RI and CMS/FS. Potential use of Moabi Park Regional Sewage Pond for disposal of conditioned remedy produced water is not proposed at this time.
6. Existing monitoring and other wells are not shown.

FIGURE F-1
GENERAL REMEDY SYSTEM LAYOUT - CALIFORNIA PORTION

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
PRELIMINARY (30%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

D:\Projects\Topock\MapFiles\2011\CMS\BOD\GeneralRemedySystem_CA_11X17

TABLE F-1
Current Estimate of Remedy-produced Water Quantity During Groundwater Remedy Implementation
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Source	Wells	Events/ Year/ Well	Volume/ Event/ Well (gal)	Annual Volume (MG)	Anticipated Quality of Remedy-produced Water [a]
Backwash [b]					
Fresh Water Injection Wells	3	52	12,000	1.9	Similar to water from Arizona aquifer, plus sediment
Carbon-amended Injection Wells	4	52	9,000	1.9	Similar to water from riverbank extraction wells, plus sediment and IRZ byproducts [c]
TCS Injection Wells	2	52	2,250	0.23	Similar to water from the East Ravine and extraction wells northeast of the TCS plus sediment and IRZ byproducts [c]
IRZ Wells	32	30	750	0.72	Similar to water in the aquifer at well, plus sediment and IRZ byproducts [c]
Well Rehabilitation [f]					
Fresh Water Injection Wells	3	1	175,000	0.6	Similar to water from the Arizona aquifer, plus sediment and rehabilitation chemicals [g]
Carbon-amended Injection Wells	4	1	36,000	0.14 [e]	Similar to water from the riverbank extraction wells, plus sediment, IRZ byproducts [c], and rehabilitation chemicals [g]
TCS Injection Wells	2	1	36,000	0.07 [e]	Similar to water from the East Ravine and the extraction wells northeast of the TCS plus sediment and IRZ byproducts [c], and rehabilitation chemicals [g]
IRZ Wells	32	1 [d]	36,000	1.2	Similar to water from the aquifer at well, plus sediment, IRZ byproducts [c], and rehabilitation chemicals [g]
Extraction – Floodplain (Riverbank Extraction Wells)	5	0.2	75,000	0.08	Similar to water from the aquifer at well, plus sediment, IRZ byproducts [c], and rehabilitation chemicals [g]
Fresh Water Supply Well (Extraction)	1	0.2	75,000	0.02	Similar to water from Arizona aquifer, plus sediment and rehabilitation chemicals [g]
Extraction – East Ravine/Northeast of TCS	8	0.2	30,000	0.05	Similar to water from the aquifer at well, plus sediment, IRZ byproducts [c], and rehabilitation chemicals [g]

Source	Annual Volume (MG)	Anticipated Quality of Remedy-produced Water
Other Water		
Rainwater from containment areas	0.3	Anticipated to contain trace amounts of chemicals stored in remedy facility containment areas
Sampling well purge water and equipment decontamination	0.1	Similar to water from aquifer at wells; may include chromium, IRZ byproducts, hydrocarbons [c]
Wastewater from construction of wells in the future	Variable [h]	Similar to drilling water, water from aquifer at well, could contain residues from drilling such as hydrocarbons or organic carbon
Total	**7.3** [d, e]	

TABLE F-1
Current Estimate of Remedy-produced Water Quantity During Groundwater Remedy Implementation
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Notes:

gal = gallons; IRZ = in-situ remediation zone; MG = million gallons; TCS = Topock Compressor Station.

[a] Water removed from wells during well backwash and rehabilitations will be primarily the water in the surrounding aquifer. For injection wells, the water quality will essentially be determined by the injection source and other components as listed in this column.

[b] Volumes are calculated by assuming the backwash rate is twice the injection rate and backwashing will last for 30 minutes per event. Injection rates are calculated by dividing the total design flow for a well type by the number of wells of that type (based on the Corrective Measures study/Feasibility Study [CMS/FS] [CH2M HILL 2009]). For example, there are 4 freshwater injection wells pumping 600 gpm resulting in an average of 150 gpm per well. The backwash rate is then 2 times 150 gpm, or 300 gpm. The average design flow rate for carbon-amended wells is 150 gpm, for the TCS carbon-amended wells it is 37.5 gpm, and for the IRZ wells it is 10 gpm. IRZ wells are assumed to be in service 6 months every 2 years, so 30 backwashes are assumed per well.

[c] IRZ byproducts = iron, arsenic, manganese, organic carbon.

[d] Ongoing testing of IRZ well maintenance schemes at Hinkley may lead to backwashing less, but rehabilitating wells more.

[e] Well count is based on flow and fate and transport modeling (see Basis of Design Report). The number of wells could increase or decrease based on scenarios evaluated during the ongoing groundwater modeling efforts.

[f] Well rehabilitation volumes are estimated based on experience at Topock or other sites with similar wells. IRZ and injection wells are assumed to require annual rehabilitations, while extraction wells are assumed to need rehabilitation every 5 years.

[g] The potential well maintenance reagents include acids (some with dispersants) to dissolve mineral deposits and break up biofilms (muriatic acid, phosphoric acid, glycolic acid, etc.); oxidizing agents to disinfect and degrade microbial biofilms (hydrogen peroxide, chlorine); biocides to inhibit microbial growth (Tolcide®); and chelating agents to aid acid and disinfectant penetration, remove mineral deposits, and break down and disperse biofilms (e.g., citric acid). More details will be provided in the forthcoming O&M Plan (CMI/RD Work Plan, CH2M HILL 2011).

[h] Future well construction will produce water roughly comparable to the volumes produced during a rehabilitation of that type of well. It is assumed that large well rehabilitations and development of new wells will not both need to be managed simultaneously by the remedy-produced water management system.

For rehabilitation, it is assumed that the injection and IRZ wells will undergo one rehabilitation event per year and the extraction wells will undergo one rehabilitation event every 5 years.[1] The estimated quantity of water produced from rehabilitation was derived from operational experience of injection wells associated with the interim measure at Topock and other sites. Since early 2008, the IM-3 injection wells have undergone rehabilitation every one to two years (mostly mechanical rehabilitation events with one chemical rehabilitation event in 2010).

Actual well maintenance requirements of the remediation wells at Topock will not be known until actual operation begins. An important performance metric, specific injectivity (height of water column during injection versus static water levels divided by the injection rate), will be used to gauge well performance.

As part of PG&E's chromium remediation using an IRZ at Hinkley, the optimization of backwashing frequency of IRZ wells is still being studied. Backwashing frequency will be adjusted to learn the effects on well fouling rates and well performance, as measured by specific capacity. This evaluation is intended to determine whether the use of routine backwashing will extend the time period of satisfactory well performance before rehabilitating the well becomes necessary. As the testing is ongoing, the results will be presented in future design submittals. At this time, weekly backwashing is assumed to be adequate.

Estimate of Remedy-produced Water Quality

Water quality varies depending upon whether the stream is from backwashing or rehabilitation, the type of well, and the water source, as indicated by the information shown in Table F-1. Another way to evaluate water quality is

[1] The IM-3 extraction wells are scheduled for rehabilitation late in 2011 or early in 2012, approximately 6 years after startup.

shown in Table F-2, which presents a summary of the constituents likely to be found in the waste streams of the various types of wells. Water quality will be used to determine the appropriate conditioning process and also match the waste streams with possible disposal/reuse options. In keeping with the objective to have a flexible approach to managing the remedy-produced water, it is helpful to discuss the cleaning activities in a broader way and the effects on water quality.

The backwash stream will contain sediment that either is carried in injected water or in aquifer materials drawn into the well during backwashing. This is a result of vigorous pumping and surging similar to what occurs during well development. High pumping rates can draw accumulated solids from inside the filter pack or aquifer material surrounding the filter pack to recover some of the well capacity. Dissolved constituents present in the aquifer around the remediation well or in the injected water stream could be found in the backwash stream. The backwash stream from the IRZ and carbon-amended injection wells is anticipated to contain carbon and in-situ byproducts (iron, manganese, and arsenic).

TABLE F-2
Summary of Constituents Expected in Water Streams of Various Well Types
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Wells	Sediment	Chromium	Iron	Manganese	Arsenic	Organic Carbon	Acid	Other Rehabilitation Chemicals
Fresh water injection	B, R	-	-	-	-	-	R	R
Carbon-amended injection	B, R	?	B, R	B, R	B, R	B, R	R	R
In-situ reactive zone (IRZ)	B, R	?	B, R	B, R	B, R	B, R	R	R
Extraction - floodplain	B, R	B, R	B, R*	B, R*	B, R*	B, R*	R	R
Extraction - freshwater	B, R	B, R	-	-	B, R	-	R	R
Extraction - bedrock	B, R	B, R	B, R	?	B, R	-	R	R
Monitoring well purge	-	Some	Some	Some	Some	-	-	-

Notes:
B = Well backwash
R = Well rehabilitation
? = uncertain
* Initially but may decrease over the period of operation.

The rehabilitation streams can be thought of as having two distinct water quality characteristics – one at the beginning and the other at the end of the rehabilitation process. Based on experience with the chemical rehabilitation of injection wells at Topock in October-November 2010, the initial step used acid to lower the pH so that mineral deposits can be dissolved, and as a result, the first flush will be at very low pH (pH 2.0 – 3.0) and will contain high concentrations of solid ionic materials (e.g., part per million levels of total chromium, manganese, iron, and nickel) and rehabilitation chemicals. No hazardous waste (pH < 2.0) is expected to be generated. The next steps involve pumping and cleaning the well using mechanical methods such as swabbing and jetting. As remedy-produced water continues to be pumped from the well, the water quality becomes more similar to that of the aquifer water. Eventually, this water quality will be more similar to backwash water and can be managed in a similar manner.

In October 2011, samples were collected from tanks used to haul IM-3 injection well backwash water. These samples were collected to characterize the backwash water and the results are shown on Table F-3.

TABLE F-3
IM-3 Injection Well Backwash Water Characterization – IW-2 and IW-3
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Analyte	Units [a]	Result [b]
Nitrate as N	mg/L	2.7
Sulfate	mg/L	490
Alkalinity	mg/L	32
Alkalinity, Bicarbonate (As $CaCO_3$)	mg/L	32-41
Alkalinity, Carbonate (As $CaCO_3$)	mg/L	<5
Alkalinity, Hydroxide (As $CaCO_3$)	mg/L	<5
Suspended Solids (Residue, Non-Filterable)	mg/L	<10 - 11
pH	pH Units	7.4 – 7.68
Antimony, dissolved	µg/L	<10
Barium, dissolved	µg/L	13 - 14
Beryllium, dissolved	µg/L	<1
Cadmium, dissolved	µg/L	<3
Calcium, dissolved	µg/L	140,000
Cobalt, dissolved	µg/L	<3
Copper, dissolved	µg/L	7.8 - 10
Iron, dissolved	µg/L	47 - 84
Lead, dissolved	µg/L	<10
Magnesium, dissolved	µg/L	29,000
Manganese, dissolved	µg/L	<10
Molybdenum, dissolved	µg/L	16
Nickel, dissolved	µg/L	<5
Silver, dissolved	µg/L	<3
Sodium, dissolved	µg/L	1,400,000-1,900,000
Vanadium, dissolved	µg/L	<3
Zinc, dissolved	µg/L	<10 – 110
Arsenic, dissolved	µg/L	0.16 - 0.31
Chromium, dissolved	µg/L	0.96 – 4.7
Selenium, dissolved	µg/L	3.2
Thallium, dissolved	µg/L	<2.5
Mercury, dissolved	µg/L	<0.2

Notes:
[a] µg/L = micrograms per liter; mg/L = milligrams per liter
[b] <n = less than the reporting limit value shown

Since June 2011, a pilot test has been underway at Hinkley to evaluate whether increasing backwash frequency at the IRZ well SA-RW-19 provides benefits and to characterize the quality of backwash water. Table F-4 shows the analytical results of the backwash water samples collected from the effluent of the settling tanks (mounted on pickup trucks). One notable observation is that frequent backwashing appears to reduce the buildup of solids and organic carbon in the tested well. The solids are attributed to buildup of biomass, which uses the carbon for growth and absorbs particulate matter. It was observed that the biomass settles quickly in the settling tanks. The testing is ongoing, and the data will be incorporated into the design as they become available.

Degree of Conditioning Required

The degree of conditioning needed is a function of how the remedy-produced water will be reused or disposed of, and the discharge requirements that are imposed. The options under evaluation are as follows:

1. Trucking off-site
2. Discharge to TCS evaporation ponds
3. Reuse by blending with freshwater and use in TCS cooling towers
4. Reuse by blending with carbon-amended water and injection into uplands carbon amendment or IRZ injection wells
5. Discharge to an infiltration gallery built in Bat Cave Wash near the Compressor Station – this option is deferred until the Soil Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation (RFI/RI) and Corrective Measures study/Feasibility Study (CMS/FS) are complete and will not be carried into the design at this time (see Table F-5 for details)
6. Discharge to Moabi Regional Park wastewater ponds – this option is deferred (preserved for potential future use) and will not be carried into the design at this time (see Table F-5 for details)

Three options previously considered and subsequently eliminated from further consideration are blending conditioned produced water with freshwater for freshwater injection, discharge to ground surface, and use of designated well(s) for disposal. Blending conditioned produced water with freshwater for freshwater injection was eliminated because the water quality may not suitable for re-injection outside the plume or may cause operational (well fouling) issues.

Ground surface discharge was eliminated due to concerns over high visual impact, stakeholder and regulatory acceptance, and permitting challenges. The use of a designated well or wells for disposal of remedy-produced water, while technically viable, could negatively affect the number of wells available for use in the groundwater remediation and therefore constrain the remedy.

Table F-5 summarizes the options under evaluation and provides information available to date. Given the constraints and uncertainties discussed above, the design approach is to use a combination of multiple reuse/disposal options to provide operational flexibility and to ensure that the remedy-produced water management system does not prevent proper maintenance of the groundwater remedy system.

The conditioning of produced water can be accomplished with fixed and/or mobile units. Mobile conditioning equipment may be used during well maintenance periodically for filtration, but not for conditioning of dissolved metals. The primary reason is that the amount of equipment required for such conditioning would exceed the available space in the areas where wells are likely to be installed. Furthermore, using mobile equipment for full conditioning could increase the potential for leaks and spills. A fixed conditioning system could be in a building shared with other functions required by the remedy, such as onsite laboratory, remedy control center, electrical building, and/or carbon-amendment controls. The conditioning system will be designed as a “for continuous operation” system so as to reduce the size of the equipment needed and space requirements.

TABLE F-4
Summary of Backwash Sample Analytical Results – Hinkley IRZ SA-RW-19
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

	Sample Date (2011)							
Analyte	**6/29**	**7/12**	**7/19**	**7/26**	**8/2**	**8/9**	**8/18**	**9/1**
Alkalinity Hydroxide, mg/L[a]	<5[b]	<5	<5	<5	-[c]	-	-	-
Alkalinity, Bicarb. as $CaCO_3$, mg/L	170	170	200	170	180	210	220	210
Alkalinity, Carb. as $CaCO_3$, mg/L	<5	<5	<5	<5	<5	<5	<5	<5
Alkalinity, Total as $CaCO_3$, mg/L	170	170	200	170	180	210	220	210
Chloride, mg/L	39	37	38	37	-	-	-	-
Nitrate as Nitrogen, mg/L	<0.5	<0.05	<0.05	<0.05	-	-	-	-
Nitrite as Nitrogen, mg/L	<0.5	<0.05	<0.05	<0.05	-	-	-	-
Sulfate, mg/L	46	42	27	53	-	-	-	-
Orthophosphate, Dissolved, mg/L	<0.1	<0.02	<0.02	<0.02	-	-	-	-
Calcium, mg/L	51	44	46	43	45	55	62	67
Calcium (Dissolved), mg/L	50	50	50	52	44	54	64	65
Iron, mg/L	8.2	6.6	6.7	4.5	2.2	2.1	1.1	1.3
Iron (Dissolved), mg/L	3	1.6	0.97	1.5	0.03	0.026	0.041	0.17
Iron, 0.1µ Filter[d], Dissolved, mg/L	1.7	1.5	1	1.5	-	-	-	-
Magnesium, mg/L	9.3	9.6	10	8.6	9.2	11	11	11
Magnesium (Dissolved), mg/L	8.8	9.6	8.8	9.3	8.6	10	11	11
Sodium, mg/L	56	-	-	-	-	-	-	-
Sodium (Dissolved), mg/L	56	-	-	-	-	-	-	-
Arsenic, µg/L[e]	4.6	3.4	2.7	11	6	4.7	2.4	3.5
Arsenic (Dissolved), µg/L	1.9	1.6	0.57	0.98	1.9	1.6	1.6	1.8
Manganese, mg/L	1.1	1	0.82	2.3	1.5	1.1	0.33	0.5
Manganese (Dissolved), mg/L	0.47	0.46	0.66	0.3	0.062	0.13	0.11	0.22
Hexavalent Chromium, µg/L	-	-	-	-	-	-	47	36
Total Chromium (Recoverable), µg/L	130	130	130	490	220	160	88	120
Total Dissolved Chromium, µg/L	14	30	10	47	55	52	58	39
Total Dissolved Solids (TDS), mg/L	580	410	410	400	380	420	470	480
Total Suspended Solids (TSS), mg/L	540	210	130	510	56	120	24	44
pH, pH Units	-	-	-	-	7	7.3	7.2	7.2
Dissolved Organic Carbon, mg/L	100	130	120	200	15	16	3	1.1
Total Organic Carbon, mg/L	110	94	140	170	52	66	9.6	12

Notes:
[a] mg/L = milligrams per liter
[b] <n = less than the reporting limit value shown
[c] "-" = no sample collected
[d] 0.1 micron (µ)
[e] µg/L = micrograms per liter

TABLE F-5
Summary of Disposal/Reuse Options Under Evaluation
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Disposal/Reuse Options	Description	Infrastructure Required Prior to Use
Trucking off-site	Transport unconditioned produced water to a permitted facility off-site.	Trucking off-site would require constructing a loading station at TCS or the MW-20 bench. This would be equipped with pumps, hoses, secondary containment, and controls, located inside a secured facility.
Discharge to TCS evaporation ponds	The Compressor Station's lined evaporation ponds receive cooling tower blowdown water and evaporate it as part of normal Compressor Station operations. Solids are removed from the ponds periodically. The ponds operate under Waste Discharge Requirements (WDRs) issued by the California Regional Water Quality Control Board (Water Board). Excess capacity of the ponds is estimated to be 1,000,000 gallons per year. The WDRs for the ponds or its equivalent substantive requirements will need to be revised in order for the ponds to accept remedy-produced water.	Conveying remedy-produced water to the TCS evaporation ponds can be accomplished by installing a pipeline on TCS property that connects to the existing cooling tower blowdown pipeline that discharges to the ponds.
Reuse by blending with freshwater and use in TCS cooling towers	The cooling towers use fresh water to cool compressed natural gas. The water is re-circulated in the tower and the volume is reduced through evaporation. Make-up water is added so the cooling demand is met. Water is blown down (discharged) from the system to control concentration of dissolved salts or other impurities in the circulating water. The blowdown discharges to the existing evaporation ponds through an existing pipeline. Conditioned remedy-produced water with low dissolved and suspended solids concentrations is likely to be suitable for use in the cooling towers, and may be beneficial to cooling tower operation. In addition, as the circulating water is currently treated to prevent fouling and corrosion in the cooling towers, this reuse option will be evaluated/ designed to ensure a similar level of protectiveness. The cooling tower water usage between January 2009 and March 2011 ranged from 11 to 110 gpm (using monthly water volumes converted to instantaneous rates).TCS cooling towers cannot accept remedy-produced water with high levels of dissolved iron and manganese.	Conveying remedy-produced water to the TCS cooling towers can be accomplished by installing a connection to the existing cooling tower makeup pipe that feeds freshwater to the cooling towers.
Reuse by blending with carbon-amended water and injection into carbon amendment wells	The carbon-amended injection or IRZ injection wells could take remedy-produced water with minimal conditioning, except for solids removal. This may benefit the remedy in further accelerating the plume movement toward the IRZ line on National Trails Highway (NTH). However, it is not known how much excess capacity the wells could take without affecting the plume movement. The groundwater modeling being performed will be used as a tool to understand the relative difference in the allowable fresh water and carbon-amended injection rates so that flow ranges can be defined for effective operation.	Re-injecting remedy-produced water with carbon-amended water would require a connection to the carbon-amended and IRZ injection pipelines. Remedy-produced water flow would be metered in, so as to not disrupt the remedy system hydraulics. As of this writing, the additional flow allowable without disrupting the system hydraulics has not been estimated.

TABLE F-5
Summary of Disposal/Reuse Options Under Evaluation
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Disposal/Reuse Options	Description	Infrastructure Required Prior to Use
Discharge to an infiltration gallery built in Bat Cave Wash near the Compressor Station	An injection gallery in Bat Cave Wash is another potential method to dispose of conditioned water. This also has the advantage of accelerating the plume movement toward the IRZ line along NTH. At this point, this option will be deferred until the soil RFI/RI and CMS/FS process is complete. For the purpose of the remedy design, the option will be preserved for potential use in the future (see Basis of Design Report for more details).	An infiltration gallery is similar to a septic leach field with buried slotted or perforated piping that delivers remedy-produced water across the gallery area. Fill around the pipes needs to be coarse enough to allow the remedy-produced water to exit the pipes and by gravity infiltrate into the subsurface. At Topock, the fill would likely be gravel or crushed rock. Since the concept is to install it in Bat Cave Wash, an active natural stormwater channel, it would be necessary to bury the pipe sufficiently deep to prevent stormwater scour/moving rocks or other storm-related effects from damaging the pipe. The exact depth has not been analyzed yet, but it can be expected to be 6 feet or more below surface. Other design data needed includes percolation rates to calculate the area needed for remedy-produced water disposal and limits on the amount of water that can be infiltrated without disrupting remedy system hydraulics.
Discharge to Moabi Regional Park wastewater ponds	The Moabi Regional Park sewage treatment system ponds receive the wastewater from the Moabi Regional Park facilities and Pirate's Cove resort. Four ponds have been constructed, although only one pond appears to be in service at any one time, suggesting that there is significant excess capacity in this system. In this option, conditioned remedy-produced water would be pumped in a pipeline running along NTH to an outfall directly at the ponds, or would be connected to another portion of the sewage treatment system. PG&E contacted San Bernardino County and obtained the following information about the ponds: • The ponds apparently are clay lined and evaporation rates are high. • To date, the ponds are strictly sewage wastewater ponds. Future plan is to continue to use the ponds to meet the sewerage needs of Moabi Regional Park. • There appears to be excess capacity; however, expansion plans from current concession tenant will need to be factored in to assess the true excess capacity. For the purpose of the design, this option will be preserved for potential future use. A pipe connector will be designed as a tie-in point along NTH for the potential future use of this option.	Conveying remedy-produced water to the Moabi Regional Park wastewater ponds could be done by extending the conditioned remedy-produced water pipeline underground along National Trails Highway to a tie-in to the Moabi Regional Park wastewater sewer line.

In summary, the degree of conditioning required for the remaining options to carry forward into the design is described below.

- Trucking off-site to permitted disposal facility –No onsite conditioning is assumed for this option; any conditioning that is required for management of the remedy-produced water is assumed to be performed by the permitted receiving facility. All remedy-produced water sources are assumed to be acceptable to one or more offsite facilities
- Discharge to TCS evaporation ponds – Remedy-produced water discharged to the evaporation ponds must not be hazardous. The only anticipated parameter with the potential to be hazardous is pH (acidic conditions); water with pH less than or equal to 2.0 (characteristic waste level) cannot be directly discharged to the ponds.
- Reuse by blending with freshwater and use in TCS cooling towers – The cooling towers need relatively clean water to keep the cooling towers operating effectively. Therefore neutral pH, low concentrations of dissolved iron, silica, and manganese, similar water quality to the current supply which has low total dissolved solids, and low solids concentrations are preferred to prevent fouling. The plan is to achieve low dissolved iron, silica, and manganese by only sending remedy-produced water low in these constituents (such as freshwater injection well backwash) to the tower. Therefore, no conditioning for removal of dissolved iron, silica, and manganese is anticipated.
- Reuse by blending with carbon-amended water and injection into carbon-amended wells or IRZ wells – These wells will have elevated levels of IRZ byproducts, carbon, and possibly chromium because they will be located within the chromium plume. Injection wells need similar water to the formation water (i.e., near-neutral water [pH 6.5 to 8.5]) to not cause adverse geochemical reactions that might precipitate or dissolve minerals. Therefore, pH adjustment is required if the pH is acidic (such as from a well rehabilitation). Elevated levels of IRZ byproducts and low chromium levels are acceptable since they will be taken care of in the reducing zone. Therefore no conditioning for removal of organic carbon or dissolved iron and manganese is anticipated. Solids need to be filtered to prevent clogging.

Preliminary Remedy-produced Water Management Plan

The reuse/disposal plans for the various types of remedy-produced water differ. Multiple options are maintained where possible to provide operational flexibility. Table F-6 describes the preliminary management plan. The plan is subject to change if underlying assumptions prove incorrect (such as assuming that injecting back into amended-water wells would not require removal of dissolved constituents). This plan is intended to be flexible and to evolve with operational experience during the groundwater remedy implementation.

This analysis indicates that the following minimal options need to be available for onsite disposal/re-use:

- For disposal, TCS ponds are made available, or some of the remedy-produced water will have to be transported offsite.
- Re-use will occur by injection into amended water wells.

The rationale as embodied in Table F-6 is based in large part on diverting the most impacted water to the TCS evaporation ponds (provided its pH is greater than 2.0, as noted above) or trucking it offsite for disposal. Cleaner water is pumped to the following options, listed in order of preference:

1. TCS cooling towers – Will not affect the remedy wells directly and will reduce TCS water usage. However, the remedy-produced water will be blended with cooling tower make-up water and the total must not exceed the cooling requirements of the compressors. Any excess water has to be diverted elsewhere.
2. Carbon-amended and IRZ injection wells – Flow limits to maintain system hydraulics, iron, and manganese could also foul wells and increase frequency of maintenance.

TABLE F-6
Reuse/Disposal Management Plan for Water Produced During Groundwater Remedy
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Source	Estimate (MG/year)	Management Plan – Listed in Order of Preference
Backwash of freshwater injection wells	1.9	1. Compressor station cooling towers 2. Carbon-amended and IRZ injection wells Note: It is possible that during the first few months of operations, the water around the freshwater injection wells may have levels of chromium that will necessitate managing backwash water differently, such as sending to carbon-amended wells or trucking offsite.
Backwash of IRZ well and carbon-amended injection wells	2.85 [a]	1. Carbon-amended and IRZ injection wells
Well rehabilitation (all wells) - first flush	0.65 [a]	1. TCS ponds 2. Trucked offsite
Well rehabilitation (all wells) – after first flush	1.5 [a]	Same as backwash from corresponding well (i.e., freshwater or IRZ/carbon-amended)
Other water – cleaner streams	0.3	Relatively clean water, such as rainwater in containment and some decontamination water, will be managed by the same means as the backwash water from freshwater injection wells.
Other water – some purge and decontamination water	0.1	1. TCS ponds 2. Trucked offsite
Other water – produced water from construction of wells in the future	Variable	High-solids water: TCS ponds or truck offsite Low-solids water: carbon-amended and IRZ injection wells

Notes:
MG = million gallons
[a] Ongoing testing of IRZ well maintenance schemes may lead to use of fewer backwash events but more frequent well rehabilitations. Assumed that roughly 30% of rehabilitation water will be high-solids or low-pH "first flush" water. Remainder assumed to be similar in nature to backwash water.

Possible Future Changes

As the Topock groundwater remedy operation progresses over its expected multi-decade life, PG&E may find the need to optimize or otherwise change the system. Possible examples of changing conditions include new sources or characteristics of remedy-produced water, the need to further condition the water produced, new disposal or reuse options, or new waste discharge restrictions. These changing conditions may necessitate a change to the remedy-produced water management system, such as different, larger conditioning processes, which will in turn trigger the need for agencies' approval and stakeholders' involvement.

Remedy-produced water Management System Design

Preliminary Design Criteria

Water produced during the remedy implementation will require some conditioning for most of the reuse/disposal options. Three possible water conditioning systems, representing the range required by the varying options, are:

- **Solids removal.** Solids must be removed if water is to be re-injected into the aquifer to minimize impact on well injectivity loss due to plugging. In this case, if low-pH water needed to be neutralized, it would be conditioning at the well head and would be transported to the centralized management facility for solids removal.

- **Solids removal and neutralization.** If low-pH water from well rehabilitation is to be re-injected into the aquifer, it must be neutralized to prevent mobilization of minerals and/or precipitation of solids in the aquifer, which would cause a loss of well injectivity. Neutralization will also be performed to meet waste discharge requirements.
- **Solids removal, neutralization, and dissolved constituent removal.** If strict water quality requirements are mandated for re-injection options, removal of dissolved constituents (such as arsenic, manganese, iron, calcium, and selenium) may be required.

The preferred system is **solids removal with neutralization.** Figure F-2 shows the currently planned conceptual process schematic for this system. This is based on the following assumptions:

- Remedy-produced water that has significantly higher concentrations of constituents than what exists in the aquifer water will be sent to the TCS evaporation ponds, or transported offsite for disposal. The preferred approach is to send the water produced at the beginning of rehabilitation events to the TCS ponds (or truck offsite) and to manage the water produced later in the rehabilitation process by the same means as for backwash water. The cutover from "early" stage to "later" stage is proposed to be defined through easily measured onsite water quality tests such as pH, turbidity, and conductivity.
- Flexibility for neutralizing non-hazardous low-pH water (pH less than about 6.5 but greater than 2.0) from well rehabilitations will be provided either through the remedy-produced water management system by caustic addition to the equalization tanks or by an alternative approach. Alternatives include sending the water to the TCS evaporation ponds, transporting to offsite disposal, or neutralizing with temporary portable systems at the well head.
- Under the management plan presented in Table F-6, removal of dissolved constituents will not be required because the injected water quality will be similar to the aquifer water quality in/near the carbon-amended wells, the IRZ wells, and the freshwater injection wells. Temporary fluctuations in water quality that may occur within the remedy footprint during remedy implementation will ultimately result in achieving background water quality for hexavalent chromium when the remedy is complete, and institutional controls will prevent use of affected groundwater while the remedy is being implemented. Furthermore, contaminant migration to the river that could potentially affect water quality goals or beneficial uses will not occur during remedy implementation because of the groundwater extraction along the river bank. PG&E believes that this interpretation is consistent with the requirements of the anti-degradation provisions of 40 CFR 131.12 and State Water Resources Control Board Resolution No. 68-16.

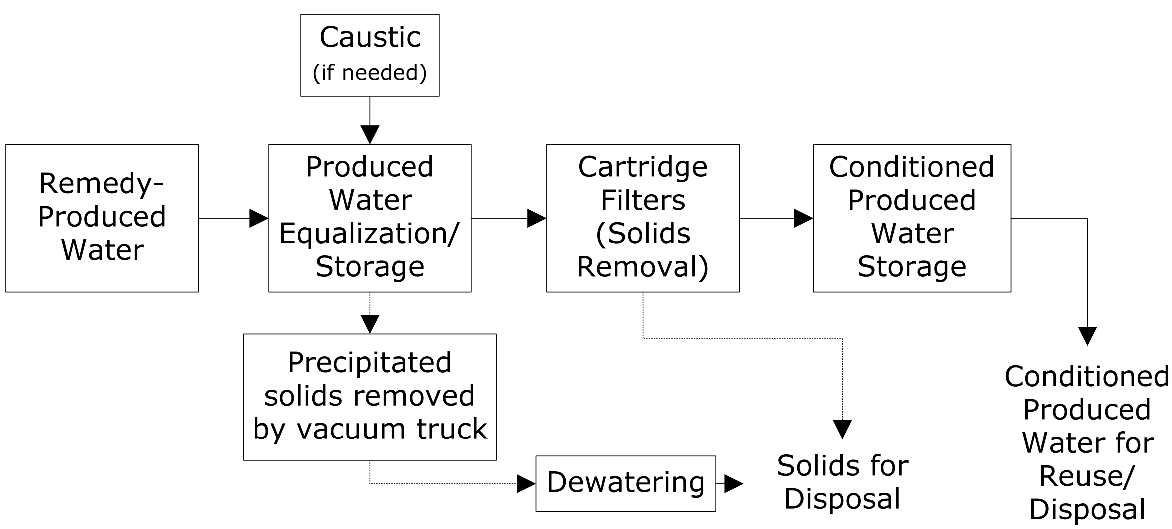


FIGURE F-2
Conditioning Process Schematic
Management of Water Produced During Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Table F-7 summarizes the preliminary design criteria for the remedy-produced water management system.

TABLE F-7
Remedy-produced water Management System Design Criteria
Management of Water Produced from Operation and Maintenance of Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Design Criteria	Value	Notes
Flow – Average	20 gpm	Best current estimate is 7.3 million gallons per year. If 80% uptime, system would process 18 gallons per minute while running.
Flow – Peak	35 gpm	To manage 50,000 gallons per day.
Equalization volume	>50,000 gal 4 tanks	Largest projected daily production of water is 50,000 gallons per day (during rehabilitation of largest injection well). Provide multiple tanks to allow segregation of varying types of remedy-produced water. At least one of the tanks will be fitted with mixers to aid in pH adjustment.
Effluent water quality requirements	Total suspended solids (TSS) - < 5 microns pH – 6.5-8.5	Effluent TSS will be < 5 microns to limit injectivity loss in wells used for re-injection. Based on experience at Interim Measure No. 3 (IM-3), Hinkley, and other re-injection sites. Effluent pH will be 6.5 to 8.5 to achieve near neutral pH and not cause adverse geochemical reactions
Solids dewatering	One dewatering system available at all times	Use phase separators (such as at IM-3) for dewatering solids precipitated in pH adjustment steps. Could also be used for the disposal of spent filter cartridges and solid wastes from future sampling.
Influent solids loading	Typical: 60 mg/L TSS	Estimated value consistent with Hinkley results.
Degree of automation	Full	System is to be able to run un-manned (such as nights, weekends, and holidays). Automated to detect non-compliant effluent and shut down system.
Uptime	80%	System can be down for extended periods (~1 week) without jeopardizing well injectivity. Therefore, full system redundancy is not provided. However, where needed to facilitate operation, parallel systems will be installed, such as by installing parallel cartridge filters.
Operating time	24 hours per day	Using automation, the system will be able to run full time while unattended. The system will be designed for continuous and intermittent operation based on levels in the influent tanks.
Effluent discharge	Ability to convey water to all reuse/disposal options	Include connections to allow for trucking of produced water from system effluent tanks.

Notes:
gpm = gallons per minute; mg/L = milligrams per liter

System Sizing

The remedy-produced water conditioning system will be sized for solids-removal and neutralization equipment (pumps, filters, and caustic storage) to meet the design criteria shown on Table F-7. Space will be reserved within the system’s building for equipment that may be needed in the future. This includes additional cartridge filters to remove smaller particles (1 micron) if this proves necessary to protect remediation wells, and portable granular activated carbon units if needed to remove trace hydrocarbons from rainwater or decontamination water. Buildings for other supporting functions such as an onsite laboratory, operators’ control room, and equipment storage will also be provided.

The conditioning equipment will be housed in a building; the required space is an area 25 feet by 20 feet. It should be noted that the total footprint of the system is larger, due to the water equalization requirements and the supporting functions (e.g., operator's facilities, control building, equipment storage). Due to space constraints at the TCS, the remedy-produced water tanks and buildings cannot be fit into a single area but will instead be placed at locations around the station, integrated with existing compressor station facilities.

References

CH2M HILL. 2009. *Final Groundwater Corrective Measures Study/ Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, Pacific Gas and Electric Company Topock Compressor Station, Needles, California*. *Prepared for PG&E.* December.

CH2M HILL. 2011. *Draft Groundwater Corrective Measures Implementation/Remedial Design Work Plan for SWMU 1/AOC 1 and AOC 10, Pacific Gas and Electric Company Topock Compressor Station, Needles, California*. *Prepared for PG&E.* May 2.

U.S. Department of the Interior Review Comments on the Draft Remedy-produced water Management Technical Memorandum

DOI Review Comments and PG&E Responses

Location	DOI Comment	PG&E Response
General	The TM provides a lot of useful information and it is clear much thought has gone into it. However, the TM is difficult to follow because there are so many options for disposal/reuse, and it is not known at this time whether they are viable from a regulatory perspective (e.g., capacity or other regulatory approval constraints), or what the water quality requirements are for discharge. It is recommended that the likelihood of regulatory approval and a presentation of more specific water quality requirements for discharge be known when this information is presented in the 30% design submittal. This will allow the formulation of well defined alternatives for treatment and disposal, and the evaluation of each relative to technical feasibility and costs. Also, if reuse versus evaporation is an important selection criterion, this needs to be clearly stated. This would negatively influence selection of disposal of all or some of the wastewater in the TCS evaporation ponds. Lastly, please also note that the use of a infiltration gallery in Bat Cave Wash cannot fully be considered until the completion of the soil investigation and related future evaluation documents (RFI/RI, CMS/FS). The schedule for completion of these documents would seem to preclude this option.	Comment noted.
Table 1, footnote f	It states that injection wells need rehabilitation every 5 years but it should be extraction wells.	The word "injection" was replaced by "extraction".
Table 2	Table 2 is informative and serves as a good planning tool. Water quality of the various streams is evidently a master variable in the overall Waste Water Management Plan. At what stage(s) in the design (e.g., 30%, 60%) will refinement of Table 2 be expected and at what stage will clarification of waste water quality become a critical parameter affecting design and remedy decisions?	This Table will be refined at each stage of design.
Section "Degree of Treatment Required"	Why is reuse by blending with freshwater for freshwater injection not an option? If it is due to the presence of residual substrate in the wastewater, and there is no intention to remove the substrate, this should be so stated.	Reuse of remedy-produced water by blending with freshwater for freshwater injection is not included as an option because the water quality may not be suitable for re-injection outside the plume and may cause operational (well fouling) issues.
Section "Degree of Treatment Required"	The degree of treatment required is not sufficiently presented in this section and in Table 3. For example, what degree of treatment is required for discharge to the TCS evaporation ponds, use in the TCS cooling towers, discharge to Bat Cave Wash, and discharge to the Moabi wastewater ponds?	Additional text on degree of water conditioning required has been included in the Tech Memo.

DOI Review Comments and PG&E Responses

Location	DOI Comment	PG&E Response
Table 3, Reuse by blending with carbon-amended water and injection into carbon-amended wells	Solids removal only as a treatment requirement is a little misleading. Low pH wastewater and wastewater with high levels of manganese and iron would not be suitable for reinjection.	For clarification, no treatment for dissolved manganese and iron is planned. It is anticipated that if the remedy-produced water has higher levels of manganese and iron than is already present in the water going to the carbon-amended or IRZ wells during normal operations, then the remedy-produced water would not be reinjected.
Table 3, Reuse by blending with carbon-amended water and injection into carbon-amended wells	It is not clear why disposal of wastewater in the carbon-amended wells would add additional flow to these wells. It would appear that wastewater would simply replace an equivalent flow of extracted groundwater.	Text has been added to clarify that carbon-amended wells include IRZ wells.
Table 4 and Discussion	Table 4 indicates that PG&E's preferred option for several waste streams is to use the BCW infiltration gallery because the waste water flow would be hydraulically beneficial to the remedy and the waste water would require nominal treatment (although it would seem solids removal would be necessary even for an infiltration gallery, and biofouling from residual substrate in the wastewater would be an issue). This option may face significant regulatory and institutional constraints. These constraints could include, but may not be limited to; possible State or Federal reinjection, aquifer protection or similar limitations, soil impact to groundwater and related soil characterization/evaluation issues, and stakeholder concerns. If use of an infiltration gallery option is a substantial component of the Waste Water Management Plan, PG&E should anticipate significant planning, integration, and implementation efforts.	Comment noted. This option is deferred and preserved until the Soil RFI/RI and CMS/FS are complete.
Table 4 and Discussion	It would seem that discharge to the TCS evaporation ponds for all waste streams would be the preferred option. It is likely no treatment would be required (only piping infrastructure). If this is not being considered due to the evaporative losses and the need to conserve water, this should be stated.	Agreed. The TCS evaporation ponds are, however, limited in available capacity to a long-term average of a few gallons per minute, which is less than the anticipated production of remedy-produced water.

DOI Review Comments and PG&E Responses

Location	DOI Comment	PG&E Response
Section – "Remedy-produced water Management System Design"	Because water quality requirements for discharge are not stated or not known at this time, it seems premature to select solids removal and neutralization as a preferred treatment option. Dissolved constituent removal may be required for some disposal options. Also, low pH water (pH<2 – there is a typographical error in the text) is only expected during the first flush from rehabilitation of wells, and the preferred option for this water is disposal in the TCS evaporation ponds. If this option is feasible, it would appear there is no need for waste water neutralization.	Water quality requirements for discharge have been added to the tech memo. The necessary conditioning is a function of the incoming remedy-produced water and the selected reuse/disposal option. Low-pH water would be suitable for the TCS ponds, but not necessarily for the carbon-amended injection wells, cooling towers, or infiltration gallery. The only water that is proposed to be neutralized onsite is water with pH below about 6.5 but above pH 2.0. This water would be considered non-hazardous but would need neutralization prior to injection to prevent mobilization of minerals in the aquifer surrounding the injection wells.
Section – "Remedy-produced water Management System Design"	The process flow diagram should show a precipitated solids waste stream off of the Wastewater Equalization/Storage box with solids dewatering and disposal. This will render Table 5 more clear on this subject.	The process flow diagram has been revised as requested.
Table 5 – Solids Dewatering	How would a phase separator be used to manage cartridge filters and other solid wastes?	Spent filter cartridges would be put in the phase separator to drain excess liquids from them prior to disposal. The phase separator would also be used to drain liquids from other solids vacuumed or pumped from the influent tanks.
Table 5 – Effluent Water Quality Requirements	pH adjustment only seems premature at this time. What are the water quality requirements for reinjection of wastewater into the aquifer?	Low-pH water (between pH 6.5 and 2.0) would need neutralization prior to injection to prevent mobilization of minerals in the aquifer surrounding the injection wells. The target pH after neutralization would need to be close to the pH of the aquifer at the injection wells (which is near neutral pH range).
Figure 2 and discussion.	It appears that the treatment process may need to be run in batch and/or semi continuous mode in order to maintain a combination of multiple reuse / disposal options (discussed on page 9). Will this require additional interim storage and or surge capacity equipment? If so, please show on Figure 2 and add discussion.	Agreed. The information will be updated in the intermediate design submittal if found to be necessary.

California Department of Toxic Substances Control Review Comments on the Draft Remedy-produced Water Management Technical Memorandum

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
1.	Page 2, Wastewater Transport, 3rd paragraph	*The piping for wastewater may also serve as a backup for the main pipes carrying water to or from the wells.*	Why is this necessary?	The primary benefit for piping of remedy-produced water is that it reduces labor and trucking, and allows for automated backwashes of wells. The secondary benefit for piping of remedy-produced water is it provides backup piping for operations of the remedy. For example, if a pipe carrying freshwater to a freshwater injection well became unusable, the remedy-produced water pipe (after appropriate flushing) can be used to carry freshwater while the primary pipe is repaired. Having this backup minimizes unplanned downtime.
2.	Page 2, Wastewater Transport, 3rd paragraph	*To minimize disturbance from construction, all piping will be installed in common trenches, to the extent practicable, with other pipes and utilities serving the wells. …Pipe sizes could range from 2 to 12 inches in diameter. Future design submittals will provide more detailed information on the design basis and criteria for remedy wastewater piping.*	PG&E discussed the preference for creating a loop in the pipeline to reduce "friction and conserve power." However, PG&E also recognizes the need to minimize disturbance. PG&E will need to present the rationale and preference to balance these seemingly opposite approach. Although DTSC understands that additional design details will be submitted in the future, please note that PG&E should use double wall piping or other leak protection method for transporting contaminated waste water across area without soil contamination.	The benefit of a looped system is included in Section 3.3 (Freshwater Supply) of the Basis of Design Report. Double-wall piping will be installed if necessary to meet regulatory requirements or if PG&E determines this is an appropriate risk management approach.
3.	Page 3, Estimate of Remedy-produced water Quantity, last sentence.	*These estimates will be further refined through the design and the operational experience to be gained from injection wells at PG&E's Hinkley site.*	This statement seems inconsistent with the 1st sentence of page 1. *"The information presented here has been developed from PG&E's experience maintaining the Interim Measure No. 3 injection wells and operation of the IRZ system at the Hinkley site."* DTSC's understanding is that PG&E has operated and maintained an in-situ system pilot study with injections at Hinkley for years. Similarly, PG&E has also maintained the IM-3 injection wells for years. PG&E should provide the relevant data as supporting information for the Topock design.	The design information presented is a snapshot in time and represents the current knowledge. As stated during the July 2011 RCRA/CERCLA meeting, ongoing testing of different well maintenance schemes at for carbon-amended injection wells at Hinkley will be incorporated into future design submittals.

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
4.	Table 1	*Water Quality Summary Column*	What does "Source =" mean? The information presented suggests knowledge of water quality, but none was provided for evaluation. What is the relationship of the superscript "a" with the Water Quality Summary column?	The word "Source =" indicates that the quality of the water is projected to be fairly similar to the surrounding aquifer water (especially for backwash water, but also applies to rehabilitation water). Additional text was added to provide this clarification. The superscript "a" corresponds to Note "a" in the Notes section of the table, which explains the information in the column.
5.	Table 1		It seems counter intuitive that fresh water injection wells would need more maintenance volume per well than the carbon-amended wells. It would appear that fouling would be more problematic with carbon injection than fresh water.	As described in Note b, the amount of produced water projected is directly related to flow to the wells during normal operation. Freshwater injection wells are larger in diameter and have a much larger capacity than carbon-amended wells. It should be noted that backwash and rehab frequency presented are only estimates; actual frequency requirements will be determined during operation.
6.	Table 1, qualifier "e"		Since PG&E has already evaluated them, PG&E should provide the modeling results of the "preliminary flow and fate and transport modeling" as exhibit(s) to the tech memo; especially because the number of wells ultimately would be used for the remedy can dramatically change the quantity of wastewater requiring management.	Appendix B to the BOD Report contains information on the fate and transport modeling performed to date and the results used to support design.
7.	Table 1, qualifier "f"		Typographical error. Second "injection wells" should have been "extraction wells."	The word "injection" was replaced by "extraction".
8.	Table 1, qualifier "g"	*Other pre-approved chemicals*	Pre-approved by whom? PG&E has provided a list of generic chemical types for rehabilitation chemicals in the response to CMI/RD work plan comments. At a minimum that same list should have been included in this Technical Memorandum.	The following text has been added to Note g: "The potential well maintenance reagents include acids (some with dispersants) to dissolve mineral deposits and break up biofilms (muriatic acid, phosphoric acid, glycolic acid, etc.); oxidizing agents to disinfect and degrade microbial biofilms (hydrogen peroxide, chlorine); biocides to inhibit microbial growth (Tolcide®); and chelating agents to aid acid and disinfectant penetration, remove mineral deposits, and break down and disperse biofilms (e.g., citric acid). More details will be provided in the forthcoming O&M Plan (CMI/RD Work Plan; CH2M HILL 2011)."

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
9.	Page 7, 2nd paragraph	*For rehabilitation, it is assumed that the injection and IRZ wells will undergo one rehabilitation event per year and the extraction wells will undergo one rehabilitation event every 5 years. The estimated quantity of rehabilitation wastewater was derived from operational experience of injection wells associated with the interim measure at Topock and other sites.*	Since information exist for maintenance of IM-3 and Hinkley injection and extraction wells, this information should have been presented and evaluated by PG&E as part of this Technical Memorandum instead of a generic statement of assumption. As presented, there is very little technical rationale submitted to support the statements and conclusions presented by this memorandum. At a minimum, this information should be provided and evaluated as part of the 30% design and design basis report.	Additional information about Topock IM-3 injection wells maintenance and Hinkley pilot test of IRZ well backwash have been added to the text.
10.	Page 7, 4th paragraph		Although DTSC understands that the maintenance schedule and process is being optimized at Hinkley, PG&E should still provide sufficient information on current operating rates, fouling rates, maintenance activities and schedule to support preliminary assumptions. Same for IM-3 maintenance activities.	Additional information about Topock IM-3 injection wells maintenance and Hinkley pilot test of IRZ well backwash have been added to the text.
11.	Table 2		While this table provides a conceptual summary of the category of constituents in various waste streams, it would be far more helpful to have actual chemistry data with range of concentrations from IM-3 and Hinkley for similar well types. DTSC understands that actual quality of the wastewater cannot be verified until actual operation. Nevertheless, DTSC believes that PG&E has collected much information regarding groundwater chemistry as a result of the in-situ pilot tests at Hinkley and Topock, as well as from the operation of the IM-3. These chemistry should be provided and used as a basis for evaluation.	Additional information about Topock IM-3 injection wells maintenance and Hinkley pilot test of IRZ well backwash have been added to the text.

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
12.	Page 9, list of waste water management options		Evaluations of water usage and necessity for waste water treatment were part of the certified Environmental Impact Report. DTSC approved the proposed project based largely on the analyses conducted in the EIR. Please note that these analyses are based on information provided by PG&E at the time of preparation and DTSC found in Section 4.11.3.1 of the EIR that the proposed project "would not require the construction or expansion of new wastewater treatment facilities. Therefore no impacts would occur, and this threshold is not considered further in this EIR." Furthermore, for water supply analysis, DTSC concluded that the consumptive use associated with the in situ treatment has a net consumptive use of approximately zero, only very small quantities would be consumed for maintenance as a result of monitoring well purging and sampling. Based on these findings, PG&E should prioritize options based on meeting the criteria of these analyses. Additional waste water management options should only be proposed with justification why options that could meet these requirements would not be viable.	The Final EIR stated in section 4.11.3.1 both that the project included the construction of water treatment facilities, and that the project would not substantially increase the amount of wastewater generated, such that construction of new wastewater treatment facilities would not be required. Also, the Final EIR noted in the project description that the remedy did not include construction of a new treatment plant. The Final EIR concluded that the potential impact of exceeding wastewater treatment requirements was less than significant and that no mitigation was required. As with all analyses in the EIR, this was based on the conceptual design at the time, and the EIR stated in the project description that the specific facilities would be evaluated through the design process, and that when the final design is completed, DTSC would review the environmental impacts of the final design to ensure that the impacts are consistent with the analysis in the Final EIR (e.g., EIR page 3-12). The remedy-produced water management options and water conditioning contained in this design have been proposed to meet the EIR analyses and criteria, and to be consistent with mitigation requirements in the EIR, including Mitigation Measure CUL-1a-9, establishing that PG&E, in selecting the design, should give priority to facilities that can be constructed in previously disturbed areas, and should give priority to re-use of existing facilities, to reduce impacts. The water conditioning facilities proposed in this design meet these criteria and are consistent with the analysis in the EIR. The facilities will be housed in a structure within the existing Topock Compressor Station. The appearance of the structure will be consistent with the existing structures within the Station. Consistent with the EIR analysis, construction will be within an existing industrial facility. Also, the EIR evaluation did include the construction of a new freshwater treatment system, and that system is not currently proposed for the project. The EIR analyses, and the EIR conclusions regarding significance of impacts and mitigation, were based on a project that included that treatment system, which is larger than the water conditioning system that is proposed in the preliminary

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
				(30%) design. In summary, the housing of the proposed water conditioning facilities within an industrial facility (the Topock Compressor Station), and the deletion of the freshwater treatment system that was included in the EIR, demonstrate that the design meets the criteria set forth in the EIR, and is consistent with the EIR conclusion that impacts related to remedy-produced water management or a new water conditioning facility are less than significant. With regard to the Water Supply Analysis in the EIR, the conclusions in the EIR evaluation (that the project will not exceed PG&E's existing entitlements) remain accurate. Under the proposed management plan (see Table F-6), most of the remedy-produced water will be re-injected into the ground or re-used in cooling towers. An estimated 0.8 million gallons (800,000 gallons) of water will be used consumptively, that is, by sending water either to the TCS ponds or trucking the water offsite. In the highly unlikely scenario that all 7.3 million gallons of remedy-produced water (23 acre-feet per year) were to be used consumptively, that volume is well within PG&E's river water allocation of 422 acre-feet per year.
			DTSC also question the rationale and logic for dismissing the use of designated well(s) for disposal of wastewater since injection wells are part of the remedial design. PG&E should provide additional evaluation and rationale before dismissal of this option.	The use of a designated well or wells for disposal of produced water, while technically viable, could negatively affect the number of wells available for use in the groundwater remediation and therefore constrain the remedy.
13.	Table 3	*Infrastructure Required Prior to Use*	DTSC will reserve comments on the information contained in this column until PG&E provides the design criteria and basis report.	Comment noted.

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
14.	Table 3, reuse option by blending with carbon-amended water and injection into wells	*It is not known how much excess capacity the wells could take without affecting the plume movement. The groundwater modeling being performed will be used as a tool to understand the relative difference in the allowable fresh water and carbon-amended injection rates so that flow ranges can be defined for effective operation.*	The assumed reinjection flow rate provided by PG&E for the project is approximately 640 gallons per minute. Based on this technical memorandum, PG&E is expecting an average waste water generation rate of only 15 gpm, suggesting ample capacity for the remedy system to blend in the extracted maintenance water. DTSC, however, agrees that PG&E should be diligent in evaluating and balancing the water quality for injection.	Comment noted.
15.	Table 3, reuse option by discharge to infiltration gallery		As discussed recently, agencies cannot fully evaluate this option without completing the soil investigation and coordination with the regulatory process for the soil remedy.	Comment noted.
16.	Table 3, discharge to Moabi Regional Park Ponds		Since the ponds are strictly for sewage wastewater, the viability of this option will depend on permitting for discharge of other water and understanding of the waste water quality.	Comment noted.
17.	Table 4		See “list of waste water management option” comment # 12 above.	Comment noted.

DTSC Comments and PG&E Responses

Comment No.	Location in Tech Memo	Reference Text	DTSC Comment	PG&E Response
18.	Page 14, 2nd bullet	*Removal of dissolved constituents will not be required*	Why not? PG&E has not provided rationale for this assumption. If this assumption is not true, the treatment train, the system design and size would be significantly altered.	See response below – the following text has been added to the text. "Under the management plan presented in Table F-6, removal of dissolved constituents will not be required because the injected water quality will be similar to the aquifer water quality in/near the carbon-amended wells, the IRZ wells, and the freshwater injection wells. Temporary fluctuations in water quality that may occur within the remedy footprint during remedy implementation will ultimately result in achieving background water quality for hexavalent chromium when the remedy is complete, and institutional controls will prevent use of affected groundwater while the remedy is being implemented. Furthermore, contaminant migration to the river that could potentially affect water quality goals or beneficial uses will not occur during remedy implementation because of the groundwater extraction along the river bank. PG&E believes that this interpretation is consistent with the requirements of the anti-degradation provisions of 40 CFR 131.12 and State Water Resources Control Board Resolution No. 68-16."
19.	Page 14, last bullet, Remedy Waste Water Management System Design	*The preferred approach is to send the water produced at the beginning of rehabilitation events to the TCS ponds*	DTSC notes that the TCS ponds had leaked in the recent past. What additional safeguards will PG&E implement to protect groundwater? In addition, the TCS ponds are currently not specified within the approved project area.	The ponds are monitored in accordance with Waste Discharge Requirements (WDRs) issued by the Water Board. The ponds were built in the late 1980s with two synthetic liners over a clay liner. A third synthetic liner has been added at two of the four ponds. The leak noted by DTSC was in the top synthetic liner only, was detected by the leak detection system, and was fully contained by the lower synthetic liner. No release to the environment occurred as a result of the leak. The leak detection and containment system functioned as designed. No additional safeguard is warranted at this time. PG&E agrees that the TCS ponds are located outside of the EIR project area, but are still inside the Area of Potential Effects (APE). Sending water to the TCS ponds would be done by running a pipe to the existing cooling tower blowdown system. This new pipe would be located on the TCS property. So, no construction would occur outside the approved project area.

Appendix G
Evaluation of Arched Bridge Integrity

TOPOCK BRIDGE (Old Trails Bridge) ASSESSMENT

TO

ASSESS SUITABILITY OF TOPOCK BRIDGE
TO SUPPORT A NEW 12" WATERLINE
TO BE OWNED BY
PACIFIC GAS & ELECTRIC COMPANY

AT

Topock, Arizona

Old Route 66 Arch Bridge Crossing Rio Colorado
Between Arizona and California

October 3, 2011

PREPARED BY:

Danielle Martin, El Paso Corporation Engineering Intern
Juan C. McLane, P.E., El Paso Corporation

INTRODUCTION

The purpose of this report is to assess the structural capacity of the Topock Bridge (Old Trails Bridge) to support a proposed 12-inch waterline supported by the bridge. The bridge is owned by El Paso Natural Gas Company (EPNG) and it currently carries two (2) 30-inch pipelines transporting natural gas. Pacific Gas and Electric Company (PG&E) plans on installing a 12-inch waterline on the Topock Bridge that would be owned and maintained by PG&E. PG&E has asked EPNG to conduct this assessment of the Topock Bridge prior to PG&E installing the proposed new waterline. The report contains that assessment and is separated into the following sections:

a) A background narrative.
b) Pipe materials data.
c) Results and Discussion.
d) A conclusion and recommendation.
e) References.

BACKGROUND

The Topock Bridge (Old Trails Bridge) was constructed in 1914 and is located in Topock which is an unincorporated community in Mohave County, Arizona. The bridge was part of the Transcontinental National Old Trails Road, and by 1926, was part of Route 66 that crossed the Colorado River. The bridge carried vehicle traffic up until 1947. The bridge was only one lane and was rated at 11 Tons. Then, in 1948, the deck was removed so the bridge could accommodate a natural gas pipeline. (1)

The bridge currently carries two such 30-inch natural gas transmission pipelines. EPNG transports natural gas on its interstate transmission pipeline system on Line 1104 to the middle of the bridge where custody of the gas and ownership of the pipeline transfers to PG&E. The second natural gas pipeline on the bridge, which is known as Line 1900, is owned by Mojave Pipeline Company, L.L.C. which is an affiliate of EPNG.

DATA

1. SEPTEMBER 1914 BRIDGE DESIGN LOADS

   Truck load 10-Ton (2) (See Exhibit 1)
   *Note: "Lane Load" concept did not develop until 1923 and the "Truck Train Loading" and equivalent load was developed in 1929(2).

2. HISTORICAL INSPECTIONS

   On June 28, 2010, EPNG hired Acuren Inspection, from Denver, Colorado to inspect the bridge. The Acuren inspection consisted of a visual inspection that included: inspection of the pipelines coatings, inspection of pipeline supports and supporting structures, and insertion of horizontal and vertical alignments. A few pipe supports were found to be have some corroded areas but with sufficient integrity to support the bridge as well as the current and anticipated loads. The inspection report evaluates the bridge as in "good condition." As of the date of this report, EPNG is evaluating bids to have the entire bridge painted and the corrosion spots repaired.

3. EXISTING AND PROPOSED BRIDGE LOADS

   a. Existing 30-inch pipeline, 194 lbs/ft pipeline Number 1104.
   b. Existing 30-inch pipeline, 194 lbs/ft pipeline Number 1900.
   c. Proposed 12" waterline, 88 lbs/ft. (pipe and fluid for testing)
   d. Assume 1000 lbs point load for pipe supports and fittings.

4. ASSUMPTIONS AND CLARIFICATIONS

   For purposes of this report, the following assumptions and clarifications apply:

   a. Although the bridge was rated at 11-Ton at the time, a 10-Ton vehicle was used for the design. This assumption is a bit more conservative in the sense that the calculations are comparing the proposed loading to lower bridge design stresses produced by the 10-Ton vehicular load.

   b. The bridge loading concept developed in 1929 was a calculated determination. (See Exhibit A, 3 of 3). This concept involves placing concentrated loads and an equivalent load such that they produce the largest moment or shear on the structure. Although the concentrated and equivalent loads application produced the largest moment, the single truck load was used to evaluate the bridge (See Results and Discussion section). Again, this is conservative approach.

   c. No wind or earthquake evaluation was done. It is assumed that the original Topock bridge design did not include any seismic loading. In 1933, however, it became mandatory to include 8 percent of the weight for seismic design [(4)]. Similarly, it was not until 1927 when the Uniform Building Code was published that wind load was included. There is no record that the bridge was ever analyzed for wind and earthquake loads [(5)] to bring the bridge to Code compliance.

   d. Vehicular impact loading was not added to the vehicle loads. The calculation is more conservative without applying the vehicular impact loads in the sense that the calculations are comparing the proposed loading to lower bridge design stresses.

   e. The deck span of the bridge is 592 ft. long (See attached drawing PB3-EB6-6). It is supported by cables within the arch portion of the bridge and supported by columns on the cantilever portion of the bridge at every 18.5 ft. It is assumed that the supports are the critical element in the bridge. Thus an 18.5 ft section of the bridge was used to compare the original design capacity of the bridge with the proposed loading (pipelines).

   f. Assume 1000 lbs. point load for pipe supports and fittings.

RESULTS AND DISCUSSION

The bridge is an arched three hinged structure. As stated in the assumptions, the deck is supported at 18.5 ft. intervals; the bridge was analyzed: (1) by loading one 18.5 ft section of the bridge with the 10-Ton design vehicle used in 1914, (2) by loading the same 18.5 ft section with the proposed pipeline loads, and (3) by loading the 18.5 ft section with the concentrated and distributed load concept. The results were compared to assess the bridge structural capacity.

1. PROPOSED BRIDGE LOADING CALCULATIONS – (2) 30” gas pipelines and (1) 12” waterline full with water.

   The calculations show that the design moment is equal to 25.1 ft-k, and the design shear is equal to 4.9 kips (See Exhibit A, 1 of 3)

2. ORIGINAL BRIDGE DESIGN CALCULATIONS – 10-Ton Design Truck

   The calculations show that the design moment is equal to 45.2 ft-k, and the design shear is equal to 13.9 kips (See Exhibit A, 3 of 3)

3. CONCENTRATED AND DISBRIBUUTED LOAD CONCERPT (from 1929)

   The calculations show that the design moment is equal to 110.6 ft-k, and the design shear is equal to 18.9 kips (See Exhibit A, 3 of 3)

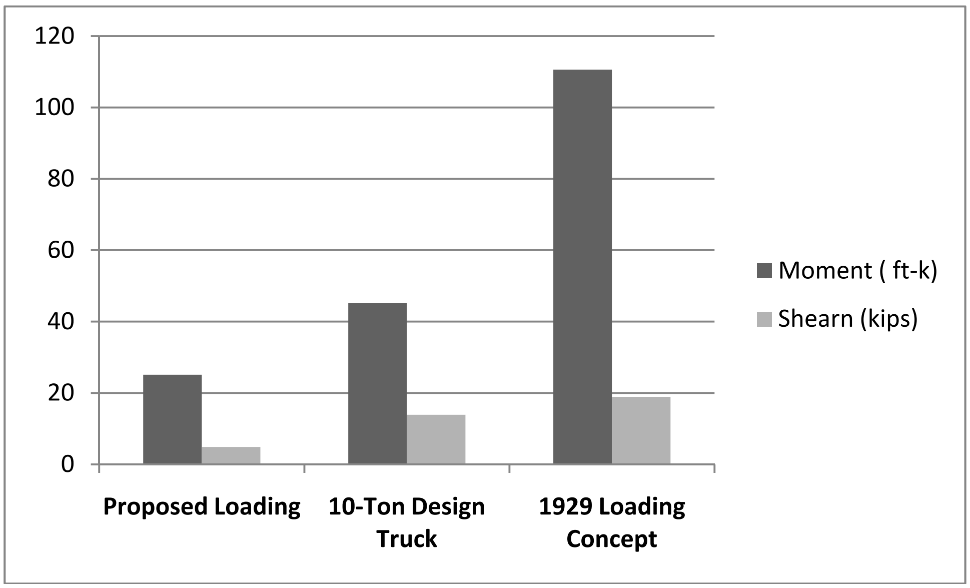


TABLE 1

Table 1 shows the stress comparison among the proposed loading, the original 10-Ton bridge design, and the 1929 loading concept. The stress comparison between the proposed loading of (12” waterline and two 30” pipelines) and the 10-Ton truck loading produces a moment that is 55% percent of the original 10-Ton truck bridge design moment capacity and a shear that is 36% of the original 10-Ton truck bridge design shear capacity. The 1929 loading concept is shown for reference. The latter is not used in the recommendation.

CONCLUSIONS

The proposed 12-inch waterline load on the bridge will be within acceptable design loads for the Topock Bridge. The proposed loading produces a moment that is 55 percent of the design moment and produces a shear that is 36 percent of the design shear. The structural analysis results for the bridge are conservative since the design truck impact loads and the lane loading pattern were not included in the calculation.

RECOMMENDATIONS

It is recommended that during construction, equipment larger than 16 kips not be used in any 18.5 ft. long deck section. Additionally, the bridge deck supports shall be visually inspected prior to construction.

REFERENCES

1. National Park Service, US Department of the Interior, Webpage http://www.nps.gov/nr/travel/route66/old_trails_bridge_topock.html

2. Kulicki, John M. PhD, University of Buffalo, "*Evolution of the AASHTO Bridge Design Specification"* presentation, Pg.31.

3. El Paso Gas Company, Record Drawings archives, Houston, TX.

4. Elnashai, Amr S., "*A very brief history of earthquake engineering with emphasis on developments in and from the British Isles",* Imperial College of Science, Technology and Medicine, Department of Civil and Environmental Engineering, London, 2001.

5. Structural Engineers Association of Southern California, *"Study of Historical and Design Wind Speeds in the Los Angeles Area," 2010*

Appendix H
Updated Cost Estimate

APPENDIX H

Updated Cost Estimate

This Appendix describes details of the updated cost estimate including 1) the basis of estimate for construction, and 2) operations and maintenance and post-remedial action activities. As discussed in Section 9, the comparison point for this estimate was the CMS/FS Report. The purpose of the cost estimate in the CMS/FS Report was to compare alternatives, and it was based on a 2 to 10% design. Subsequent work in the preliminary design has resulted in fleshing out more details, which result in additional scope and increased cost. Table H-1 is a comparison of the construction costs from the CMS/FS report. Additional detail about the scope changes are shown in Tables H-2 and H-3. There are 3 attachments below that provide more detail on the construction cost estimate.

TABLE H-1

Comparison of Construction Cost Estimates

Preliminary (30%) Design

PG&E Topock Compressor Station, Needles, California

CONSTRUCTION COSTS DESCRIPTION	CMS/FS Values QTY	UNIT	UNIT COST	TOTAL	PRELIMINARY DESIGN QTY	UNIT COST	UNIT TOTAL	NOTES
Wells								
Injection & Extraction Wells	1	LS	$5,701,860	$5,700,000	1	$10,241,900	$10,200,000	
Monitoring	28	WELL	$60,800	$1,700,000	28	$60,800	$1,700,000	
New well survey	1	LS	$0	$0	1	$20,000	$20,000	Well survey for new wells assumed
SUBTOTAL				$7,400,000			$11,920,000	
In Situ Systems								
IRZ	1	LS	$4,034,500	$4,030,000	1	$2,492,100	$2,490,000	Piping removed from this item (was included in CM
				$0			$0	
SUBTOTAL				$4,030,000			$2,490,000	
Ex Situ Treatment								
Treatment plant	0		$10,000,000	$0	1	$2,959,078	$2,960,000	Remedy-produced water conditioning plant
SUBTOTAL				$0			$2,960,000	
Infrastructure								
Pipelines & Conduit / Wire & Trench	1	LS	$8,860,766	$8,860,000	1	$5,259,798	$5,260,000	
Access Roads	3	1,000 LF	$16,200	$50,000	1	$23,504	$23,500	Lump sum for 800 feet
Fresh water								
Wells	1	LS	$158,700	$160,000	0	$0	$0	No well required - use existing HNWR-1
Pipeline	1.6	1,000 LF	$100,000	$160,000	0	$0	$0	Freshwater pipeline included with all pipelines
Electrical Power - wells	0			$0	1	$2,518,912	$2,520,000	Power distribution system
SCADA	0			$0	1	$1,250,000	$1,250,000	Remedy system controls
Install Power Station - (Electrical Generator)	0	LS	$158,700	$0	1	$607,153	$610,000	New generator at TCS in new building/enclosure
Start-up & Test	0	LS	$100,000	$0	1	$193,278	$190,000	
SUBTOTAL				$9,230,000			$9,850,000	
Remove IM3 Treatment Plant								
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	1	$1,600,000	$1,600,000	
SUBTOTAL				$1,600,000			$1,600,000	
SUBTOTAL				$22,300,000			$28,800,000	
Prime Contractor Cost Factors [a]								
General Conditions (sub mob, sub GC)	10%			$2,230,000			$2,880,000	
Field Construction Management and Engineer SDC	10%			$2,450,000			$3,170,000	
Pre-construction (work plans, design, as-builts)	14%			$3,780,000			$4,880,000	
Project Management	5%			$1,540,000			$1,990,000	
Contractor Markup (G&A, fee)	21%			$6,780,000			$8,760,000	
SUBTOTAL			75%	$16,800,000			$21,700,000	
Miscellaneous								
Institutional Controls and other Administrative Approvals	1	Constr Phases	$1,000,000	$1,000,000	1	$1,000,000	$1,000,000	
Biological Monitoring	1	Constr Yrs	$330,000	$330,000	1	$330,000	$330,000	
Cultural Monitoring	1	Constr Yrs	$330,000	$330,000	1	$330,000	$330,000	
Regulatory Oversight	1	Constr Yrs	$300,000	$300,000	1	$300,000	$300,000	
Soil Cuttings	1	Constr Phases	$200,000	$200,000	1	$200,000	$200,000	
SUBTOTAL				$41,300,000			$52,700,000	
Contingency	25%			$10,300,000			$13,200,000	
TOTAL CAPITAL COST				**$51,600,000**			**$65,900,000**	

Notes:

CMS/FS Estimate Values taken from Table D-6 CMS/FS (CH2M Hill, 2009)

a. USEPA costing guidance EPA-540-R-00-002

TABLE H-2
Summary of Scope Changes from CMS/FS to Preliminary Design
Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

Cost Element	Preliminary Design Change from CMS/FS	Rationale
Wells	One additional remediation well (54 vs. 53 in CMS/FS), but they are larger and more costly (depth and diameter have increased). See Table H-3 below.	Larger diameter wells required to house all equipment needed especially backwashing pumps. EIR mandated limits on number of wells requires dual screens in a single borehole. Deeper wells needed based on results of groundwater modeling. No plastic casings were assumed because of the need for long well life.
Piping, conduit and trenching	1. Total pipe length increased from about 24,000 to 61,000 feet, but all double contained piping (11,000 feet) was eliminated. 2. Conduit length increased from about 24,000 to almost 38,000 feet. 3. Trench length reduced slightly from 21,000 to 19,000 feet.	These changes are a result of the groundwater modeling and preliminary design work
Trenchless crossing	3 trenchless crossings are included	To reach Arizona supply well and serve wells located west of Bat Cave Wash. The leg through Bat Cave Wash improved system reliability
Remedy produced water management	This involves additional equipment and structures to store and treat the produced water.	This was identified during PG&E team discussions before the design began and is considered an important part of effective remedy performance.
SCADA [a]	A central control system not included in the CMS/FS estimate will be built at the Compressor Station.	This is important for proper remedy monitoring and control and evolved as part of the preliminary design.
Electrical power distribution system	A distributed power system originating from TCS including local electrical transformers and equipment to supply power to remote remedy equipment and facilities.	This system and approach evolved as part of the preliminary design.
Electrical supply	A new natural gas fired generator in an enclosure will be installed to supply power in the event TCS generators are at maximum capacity	This was learned as part of the preliminary design effort in discussion with TCS gas operations personnel

TABLE H-3
Comparison of Remedy Wells

Preliminary (30%) Design
PG&E Topock Compressor Station, Needles, California

CMS/FS [a]				Final Remedy			
Diameter	**Casing/Screen Material**	**Number**	**Depth, feet**	**Diameter**	**Casing/Screen Material**	**Number**	**Depth [b], feet**
4-inch Subtotal		33		4-inch	-	-	
	PVC/PVC	18	130	-	-	-	N/A
	PVC/PVC	15	220	-	-	-	N/A
4-inch	SS/SS	2	220	4-inch	-	-	N/A
6-inch Subtotal		8		6-inch	-	-	
	SS/SS	6	130	-	-	-	N/A
	SS/SS	2	220	-	-	-	N/A
8-inch	SS/SS	5	220	8-inch	SS	-	N/A
10-inch	SS/SS	5 [c]	220	10-inch	SS	-	N/A
12-inch	SS/SS	-	N/A	12-inch Subtotal		51	
				12-inch	CS/SS	16	210
				12-inch	CS/SS	5	130
				12-inch	CS/SS	3	110
				12-inch	CS/SS	8	400
				12-inch	CS/SS	5	310
				12-inch	CS/SS	4	330
				12-inch	CS/SS	4	160
				12-inch	CS/SS	4	160
				12-inch	CS/SS	2	280
14-inch	-	-	N/A	14-inch	CS/SS	3	330
Total Number of Wells		53				54	

Notes:
a. Adapted from CMS/FS Table D-20 (CH2M Hill, 2009)
b. Depths are assumed based on an evaluation of hydrostratigraphy. Actual depths may be adjusted during installation.
c. One additional 10-inch diameter well was included for freshwater supply
PVC = polyvinyl chloride
CS = carbon steel
SS = stainless steel

Attachment A – Basis of Estimate

PG&E Topock Compressor Station

Topock Groundwater Remediation Project

Needles, CA

BASIS OF ESTIMATE

Estimate ID:	PG&E Topock - Groundwater Remediation Project
Project Name:	Topock Groundwater Remediation Project
Class Estimate:	Class 4
Requested By:	John Porcella/BAO
Estimated By:	Bruce Stevens/BAO, Jim Flood/ATL
Estimator Phone:	707-258-9818
Estimate Date:	11/15/11
CCI Index:	
Material Index:	

Jim Flood/Bruce Stevens
ESTIMATORS

Purpose of Estimate

The purpose of this Engineer's Estimate for Construction Cost is to establish an Engineer's opinion of probable cost at 30% design. This estimate will be used by the Pacific Gas and Electric Company (PG&E) to document financial assurance per California Code of Regulations Title 22 §66264 and §66265.

General Project Description

The Groundwater Remediation Project is to remediate chromium in groundwater at the PG&E Topock Compressor Station in San Bernardino County, California. The existing chromium contamination in groundwater near the Compressor Station is largely attributable to the historical wastewater discharge from Compressor Station operations to Bat Cave Wash, and within the East Ravine, designated as AOC 10. Other cleanup actions that may be required due to other historical operations at the Compressor Station are not within the scope of this estimate.

PG&E is implementing the groundwater remedy at the Compressor Station in conformance with the requirements of the Resource Conservation and Recovery Act (RCRA) Corrective Action and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) is the state lead agency overseeing corrective actions at the Compressor Station in accordance with the RCRA Corrective Action. In February 1996, PG&E and DTSC entered into a Corrective Action Consent Agreement (CACA) pursuant to Section 25187 of the California Health and Safety Code (DTSC, 1996). The United States Department of the Interior (DOI) is the lead federal agency overseeing response actions on or emanating from land under its jurisdiction, custody, or control near the Compressor Station pursuant to CERCLA. In July 2005, PG&E and the federal agencies entered into an Administrative Consent Agreement (DOI, 2005).

The groundwater remedy uses in-situ remediation methods. The scope of the project includes twenty-one extraction and thirty-three injection wells including above and below ground piping (approximately 60,000 LF), mechanical and electrical equipment, organic substrate amendment facilities, remedy produced water conditioning plant, operations building, natural gas generator, and supervisory control and data acquisition (SCADA) system.

The reference or comparison point for this estimate is the Corrective Measures Study/Feasibility Study[1] (CMS/FS).

[1] CH2M Hill, 2009. Final Groundwater Corrective Measure Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California. Prepared for PG&E. December.

Overall Construction Costs

The estimated construction cost is $65,900,000. See reports in attachments to this Appendix for additional detailed information.

Markups and Contingency

The following contractor markups and contingency were applied to the Cost Estimate in the same fashion as the CMS/FS:

1.	Subcontractor mobilization and general conditions	10%
2.	Field Construction Management and Engineering Services	10%
3.	Preconstruction Workplans, Design, As Builts	14%
4.	Project Management	5%
5.	Contractor Overhead & Profit (i.e., general & administrative costs plus fee)	21%
6.	Estimate Contingency	25%

The first five are applied in a compound fashion so that the total markup is 75%. These factors are cumulative so they add to more than the sum of list (i.e., 75 percent rather than 60 percent in this case).

The contingency is applied after the miscellaneous costs are added to the subtotals.

Miscellaneous

The CMS/FS report miscellaneous costs were carried forward to the construction estimate and include the following:

- Institutional Controls and Other Administrative Approvals
- Biological Monitoring
- Cultural Monitoring
- Regulatory Oversight
- Soil Cuttings Management

For additional description, see the CMS/FS Report (CH2M Hill, 2009).

Market Conditions

The current market condition is very competitive given the state of the national and local economy. Many Engineers' Estimates have been notably higher due to the fact that many construction companies are in need of work quickly. Because of the slow economy, material prices have deflated considerably and vendors have expressed considerable interest in bidding this work. Despite the estimator's best practices and adjustments, bids are being driven by current market conditions. A detailed analysis of local market conditions should be made. This could be performed by a review of upcoming and current similar projects around the region of this project site. This market adjustment factor is above and beyond the typical contractor mark-ups, normal estimating contingency and current but normal escalation factors.

Estimate Classification

This cost estimate prepared is considered a Feasibility or Class 4 estimate as defined by the American Association of Cost Engineering (AACE). It is considered accurate to -30% to +50%, based upon a 30% design deliverable.

The cost estimates shown have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final cost of the project will depend upon the actual labor and material costs, competitive market conditions, final project costs, implementation schedule and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding. Our estimate is based on material, equipment, and labor pricing as October 2011. The client should be cautioned that such prices are highly subject to variation as a result of shortages resulting from recent natural disasters.

Cost Resources

The following is a list of the various cost resources used in the development of the cost estimate.

- R.S. Means
- Richardson Process Plant Estimating Standards
- National Electrical Contractors Association - Labor Unit Manual (NECA)
- CH2M HILL Historical Data
- Estimator Judgment
- Budgetary Vendor Quotations

Estimate Methodology

This cost estimate is considered a bottom rolled up type estimate with detailed cost items and breakdown of Labor, Materials, and Equipment. The estimate includes allowance cost and unit costs for certain estimate components.

Labor Costs

The Construction estimate is based on working five, 10 hour days per week and includes 2 hours per day overtime. Rates used are based upon Davis-Bacon prevailing wage for San Bernardino County and include fringe benefits and payroll taxes & insurance. Per diem was included at $125 per person per day.

Sales Tax

Sales tax of 8% is included in the estimate.

Allowance Costs

The cost estimate includes the following allowances within the cost estimate:

- The SCADA system and related programming was estimated as a lump sum allowance.
- Instrumentation for raw water tanks, filter system, caustic liquid phase, and treated water was based on 68 IO points.

Major Assumptions

The estimate is based on the assumption the work will be done on a competitive bid basis and the contractor will have a reasonable amount of time to complete the work. All contractors are equal, with a reasonable project schedule, overtime at 2 hours per day, constructed as under a single contract, no liquidated damages.

This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that much of the fabricated equipment will be shipped from the mainland USA.

- Temporary fencing is not required.
- It is assumed that there will be no change in existing contours for work. Existing grades will be final grades. Import or export of soil (besides pipe volume) is included for underground pipe bedding.
- Additional insurance required for railroad crossings is excluded.
- HDPE and Mortar Lined Carbon Steel pipe is priced based on vendor quotations (HDPE from Mascall Pipe, Fontana, Ca. and mortar lined carbon steel from Imperial Pipe, Riverside, Ca.)
- Confined space work and / or requirements and training are excluded.
- HDPE pipe installation is based on 50′ stock lengths.
- Hydroseeding used as proxy for re-vegetation as those requirements haven't been defined.
- No new freshwater storage tank is included
- Only the base IRZ wells are installed (i.e., no grayed-out wells) - 20 out of 40 locations or 32 wells.
- Twenty-two non-IRZ) remediation wells are installed including 13 extraction and 9 injection wells.
- The number of new monitoring wells is the same for CMS/FS and current estimate (28). No additional infrastructure or equipment is included in the estimate, so the previous cost estimate still applies.
- Access roads require minor grading and no cut and fill.
- Startup is 4 weeks

- Costs for additional labor during IRZ establishment is not included
- Field drilling oversight is assumed to be covered under construction management (cost factor).
- No additional mitigation measures are included in these estimates.
- No HNWR-1 well retrofit costs are included. This is expected to be small.
- IM-3 deconstruction and site restoration costs are based on the CMS/FS with no change.
- Assume a single remedy produced water influent storage tank farm is built.
- The natural gas generator will be installed in a new enclosure. Generator quote provided by Holt of California, Sacramento, California.

Excluded Costs

The cost estimate excludes the following costs:

- Landscaping.
- No rock excavation included

Schedule

The construction schedule is assumed to last 10 months. Sequencing will be defined during the 60% design and the estimate will be revised in accordance with the sequencing.

Design Reference Documents

1. Drawings dated 10/26/2011 to 11/13/2011.

Dwg. No.	Title
G-1	Title Sheet, Vicinity Map & Location Map
G-2	Drawing Index
G-3	Abbreviations
G-4	Legend and Symbols
G-5	Process Schematic (FW Injection & Remedy WW)
G-6	Process Schematic (WWTP)
G-7	Process Flow Schematics NTH IRZ Extraction Well Network
G-8	Process Flow Schematics Inner Recirculation Loop
G-9	Process Flow Schematics Carbon Substrate Amendment and Clean-In-Place Systems
G-10	Process Flow Schematics NTH IRZ Injection Well Network
G-10A	Process Flow Schematic TCS Recirculation Loop
G-12	Hydraulic Profiles Freshwater Injection System
G-13	Hydraulic Profiles Freshwater Injection System
G-14	Design Criteria

Dwg. No.	Title
C-1	General Notes
C-2	Pipeline Key Map
C-3	Pipe and Trench Schedule
C-3A	Pipe Schedule
C-4	Typical Trench Detail
C-5	Building and Structures Key Map
C-6	NTH IRZ Carbon Amendment Area Plan
C-7	TW Bench Carbon Amendment Area Plan
C-8	Plan and Profile -Pipeline "A" - Sta 10+00 to Sta 21+00
C-9	Plan and Profile -Pipeline "A" - Sta 21+00 to Sta 28+00
C-10	Plan and Profile -Pipeline "A" - Sta 28+00 to Sta 40+80
C-11	Plan and Profile -Pipeline "A" - Sta 40+80 to Sta 53+00
C-12	Plan and Profile -Pipeline "A" - Sta 53+00 to Sta 61+50
C-12A	Plan and Profile -Pipeline "I" - Sta 10+00 to Sta 16+53
C-13	TCS Area Plan 1
C-14	TCS Area Plan 2
C-15	Plan and Profile -Pipeline "A" - Sta 72+80 to Sta 85+07
C-16	Plan and Profile -Pipeline "B" - Sta 10+00 to Sta 19+80
C-17	Plan and Profile -Pipeline "B" - Sta 19+80 to Sta 31+80
C-18	Plan and Profile -Pipeline "B" - Sta 31+80 to Sta 44+00
C-19	Plan and Profile -Pipeline "B" - Sta 44+00 to Sta 54+30
C-20	Plan and Profile -Pipeline "B" - Sta 54+30 to Sta 66+21
C-21	Plan and Profile -Pipeline "D" - Sta 10+00 to Sta 22+00
C-21A	Plan and Profile -Pipeline "D" - Sta 22+00 to Sta 28+40
C-22	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-23	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-24	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-25	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-26	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-27	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-28	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water

Dwg. No.	Title
C-29	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-30	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-31	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
C-32	Plan and Profile - Freshwater, Wastewater, Carbon Amended Water, Treated Water, IRZ water, Extracted water
A-1	General Architectural Notes and Details
A-1A	Overall Architectural Site Plan
A-1B	Architectural Area Plans TCS Architectural Site Plan
A-1C	Architectural Elevations - North
A-1D	Architectural Elevations - West
A-3	Operations Building Floor Plans and Elevations
A-7	Remedy WWTP Building Floor Plan and Elevations
A-11	Electrical Building Floor Plans and Elevations
A-14	M-20 Bench Carbon Amendment Building Plans and Elevations
A-15	M-20 Bench Well Maintenance Building Plans and Elevations
A-16	TW Bench Carbon Amendment Building Plans and Sections
A-17	Electrical Node Building Plans and Elevations
A-19	Hazardous Materials Storage Floor Plan
A-22	Relocated Maintenance Shop Floor Plan and Elevations
A-25	Relocated Pipe Storage Floor Plan
S-1	General Structural Notes
S-2	General Structural Details
S-15	Injection well and pipe - meter vault - plans and sections
S-17A	Injection Well Valve Vault
S-17B	Injection Well Vault
S-17C	Extraction Well Valve Vault
S-17D	Extraction Well Vault
M-1	General Mechanical Notes and Symbols
M-7	Remedy WWTP plan and sections
M-11	Injection well vault plans and sections
M-11A	Freshwater Injection Well Construction Details
M-13A	Injection well construction details
M-13B	Injection well construction details
M-13C	Extraction well construction details
M-13D	Extraction well construction details
M-14A	Injection Well Valve Vault
M-14B	Injection Well Vault

Dwg. No.	Title
M-14C	Extraction Well Valve Vault
M-14D	Extraction Well Vault
M-15	Mechanical Layout - NTH IRZ Carbon Amendment Building
M-16	Mechanical Layout - NTH IRZ Well Maintenance Building
M-17	Mechanical Layout - TW Carbon Amendment Building
M-18	Mechanical Layout - Electrical Building
E-1	Electrical Symbols and Abbreviations
E-4	Exist. Generator Switchboard One Line Diagram and Elevation
E-5	Remedy Power Distribution One Line Diagram and Elevation
E-6	Single Line Diagram Node 1
E-7	Single Line Diagram Main Control Building
E-8	Single Line Diagram Node 3
E-9	Single Line Diagram Node 4
E-10	Single Line Diagram Node 5
E-11	SCADA Network Diagram
E-18	Overall Electrical Site Plan
E-21	Electrical Building Electrical Plan
I-1	Instrumentation Symbols and Abbreviations
I-2	Piping and Instrumentation Diagram Legend #1
I-3	Piping and Instrumentation Diagram Legend #2
I-4	Injection Well P & ID
I-6	Remedy Wastewater Tank P & ID
I-7	Filter System P & ID
I-8	Treated Water P & ID
I-9	Caustic System and Liquid Phase Separator P & ID
I-9	P & ID for NTH IRZ Extraction Wells
I-10	P & ID for NTH Carbon Amendment Building
I-11	P & ID for NTH IRZ Well Maintenance Building
I-12	P & ID for NTH IRZ Injection Wells
I-13	P & ID for Riverbank Extraction and Upland Injection Wells
I-14	P & ID for TCS Area Extraction and Injection Wells
I-15	P & ID for TW Area Carbon Amendment Building
I-15A	P & ID Remedy Well ID Schedule
I-11	SCADA Block Diagram

2. Draft Basis of Design Report including Appendix C, Design Criteria, dated 10/28/11.

Attachment B – Final Groundwater Remedy - Preliminary Design O&M and Post-Remediation Cost Estimate Update

Final Groundwater Remedy - Preliminary Design O&M and Post-Remediation Cost Estimate Update

PREPARED FOR: Pacific Gas & Electric Company

PREPARED BY: John Porcella

DATE: November 18, 2011

PROJECT NUMBER: 415087.01.05.02

This memorandum presents the updated operations and maintenance (O&M) and post-remediation costs for the Pacific Gas & Electric Company, Topock Compressor Station, Final Groundwater Remedy Project. The site is located in San Bernardino County, California near Needles. This memorandum is a companion document to the Basis of Estimate document for the construction cost. Both documents are appended to the Preliminary Basis of Design Report issued for the project. For a more detailed description of the project, see the report.

The reference or comparison point for this estimate is the Corrective Measures Study/Feasibility Study (CMS/FS) (CH2M Hill, 2009) and a copy of Table D-6 is included as Attachment 1. For brevity, the reader is referred to the CMS/FS for detailed discussion of assumptions and design basis. Exceptions to the assumptions and design basis are discussed below.

Operations and Maintenance Costs

O&M costs in the CMS/FS included primarily in situ reduction system O&M and monitoring and reporting costs. The duration of the project is assumed to be 29 years plus 10 years of post-remediation monitoring. As the changes to the O&M portion of the costs are limited to 4 items, those will be discussed below.

- In situ reduction – O&M costs were revised based on changes in flow rates, uptime for carbon injection, and target carbon concentrations. The original estimate shown on Table D-14 of the CMS is revised and included as Attachment 2 to this memorandum. The annual cost is $977,500 before application of the contingency.
- As part of the preliminary design, a remedy produced water conditioning system will be built and operated to treat remedy well maintenance fluids from well backwashing and rehabilitation. The estimated cost for operating the system is 340,000 per year. This assumes all remedy produced water is conditioned and either disposed of or re-used on-site.
- Two line items covered well maintenance and replacement. These two items were updated based on the cost of the well installation. For injection wells, the cost was assumed to be 20% of installation costs and for extraction and IRZ wells it was assumed to be 10% of installation costs (see Table 1).
- Freshwater extraction well electricity costs for pumping were updated to reflect the higher extraction rate of 600 gpm.
- Access road maintenance was updated to reflect the change in length to 800 linear feet (from 3,000).
- The cost for water rights was adjusted based on the assumption that all 7.3 million gallons of remedy produced water was used consumptively.

Table 1 shows the estimated O&M costs and identifies any scope changes from the CMS/FS estimate (under the Comments column). This estimate will be updated in the future design submittals. The annual O&M cost is $5.13 million and the annual long-term maintenance (LTM) cost is $0.9 million (no change from CMS/FS).

Post-Remediation Costs

As part of the CMS/FS, the post-remediation activities include restoring disturbed areas and deconstructing facilities and wells associated with the remedy. The only change was to add costs to deconstruct the remedy produced water system and carbon amendment facilities. The result is that the cost increased to $10.8 million and the details are shown on Table 2.

Overall Costs

Present value were calculated based on the project costs discussed above and the construction costs shown in Appendix H. Table 3 below shows the results. As described in the CMS/FS (CH2M Hill, 2009), present value costs were calculated using a discount factor of 3.17 percent. The best estimate is $168 million present value.

References

CH2M Hill, 2009. *Final Groundwater Corrective Measure Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California*. Prepared for PG&E. December.

TABLE 1								
Operations and Maintenance Cost Estimate								
Preliminary (30%) Design								
PG&E Topock Compressor Station, Needles, California								
			CMS/FS Estimate Values					
DESCRIPTION	**UNITS**	**UNIT COST**	**O&M**	**Long-Term Mon.**	**CMS/FS Source Notes**	**Updated Cost**		**Comments**
		Duration:	**29 years**	**10 years**		**O&M**	**LTM**	
Ex Situ Treatment Plant O&M	YR					$340,420	$0	Remedy Produced Water
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$55,542	$0	500 gpm of freshwater. Cost is for electricity for pumping, and maintaining the well.	$66,650	$0	600 gpm
IRZ	YR	See Note	$1,031,500	$0	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.	$977,500	$0	Updated estimate - see Attachment 2
IRZ Well Replacement	10%	Capital Cost of Wells	$106,596	$0	Replacement based on 10% of capital cost of wells.	$546,390	$0	Based on replacing 32 IRZ wells
Maintenance of Wells (Non IRZ)	See Note		$1,023,251	$393,341	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.	$1,168,791	$393,341	28 new MWs, 9 injection/13 extraction wells plus 110 existing MWs
Groundwater/Surface Water Monitoring	YR	See Note	$158,276	$67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.	$158,276	$67,500	Assume no change
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$121,241	$60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.	$121,241	$60,000	Assume no change
Reporting - Performance	YR	See Note	$50,000	$25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.	$50,000	$25,000	Assume no change
Other Facilities - Road maintenance	3 x 1,000 LF	$ 700	$2,126	$0		$560	$0	800 LF
Other O&M Costs								
Permit Compliance	YR	See Note	$360,000	$72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.	$360,000	$72,000	Assume no change
Groundwater ICs	YR	$ 20,000	$20,000	$20,000	Allowance	$20,000	$20,000	Assume no change
Biological Surveys	YR	See Note	$100,000	$20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.	$100,000	$20,000	Assume no change
Cultural Surveys	YR	See Note	$50,000	$10,000	Annual allowance. 20% assumed during LTM.	$50,000	$10,000	Assume no change
Reg/stakeholder oversight	YR	See Note	$100,000	$20,000	Annual allowance. 20% assumed during LTM.	$100,000	$20,000	Assume no change
Water rights	$/ac-ft	$ 27	$8,694	$0	Based on current invoices from the City of Needles	$605	$0	Assume 7.3 MG/year are used
5-year reviews	YR	$ 15,000	$15,000	$15,000	$75,000/review based on cost at other sites; done once per 5 years.	$15,000	$15,000	Assume no change
SUBTOTAL			$3,200,000	$703,000		$4,100,000	$703,000	
Contingency	25%		$800,000	$176,000		$1,025,000	$176,000	
SUBTOTAL			$4,000,000	$879,000		$5,125,000	$879,000	
Total			$4,000,000	$900,000		$5,130,000	$900,000	
Assumptions:								
CMS/FS Estimate Values taken from Table D-6 CMS/FS (CH2M Hill, 2009)								
All remedy produced water is re-used or disposed of on-site.								
No additional mitigation measures are included in these estimates.								
29 years active remediation followed by 10 years of post remediation long term monitoring (LTM).								

TABLE 2

Post-Remediation Deconstruction Costs

Preliminary (30%) Design

PG&E Topock Compressor Station, Needles, California

Description	Qty	Unit	Unit Cost	Total	Notes
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Same as CMS/FS
Deconstruct roads and small structures	1	LS	$700,000	$700,000	Same as CMS/FS
Deconstruct wells	138	WELL	$30,000	$4,140,000	Same as CMS/FS
Deconstruct Remedy WW treatment plant + IRZ Facilities	1	LS	$2,800,000	$2,800,000	Use IM-3 deconstruction estimate for Remedy WWTP, and carbon amendment facilities at MW-20 and Transwestern Metering Station Benches.
Subtotal				$8,640,000	
Contingency	25%			$2,160,000	
Total Post-Remediation Deconstruction Cost				$10,800,000	

TABLE 3

Present Value Costs

Preliminary (30%) Design

PG&E Topock Compressor Station, Needles, California

Length of Phase, Year	Remedial Phase	Total Cost	Total Cost Per Year	Discount Factor [a]	Present Value
0	Capital Cost, Year 0	$65,800,000	-	1.000	$65,800,000
29	Annual O&M Cost, Year 1-30		$5,130,000	18.785	$96,364,737
10	Long Term Monitoring, Year 31-40		$900,000	3.421	$3,078,878
41	Post-Remediation Deconstruction, Year 41	$10,800,000	-	0.278	$3,004,229
	Total Project Cost				$168,000,000

Notes: a. Discount factor of 3.17% per year is used

Attachment 1 – Table D-6, Final CMS/FS

TABLE D-6

Alternative E

Remedial Alternative Cost Summary - In-Situ Treatment with Freshwater Flushing

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL		NOTES
Wells						
Injection & Extraction Wells	1	See Note	$5,701,860	$5,700,000		See Table D-12. Does not include freshwater extraction wells.
Monitoring	28	WELL	$60,800	$1,700,000		28 new wells assumed
SUBTOTAL				$7,400,000		
In Situ Systems						
IRZ	1	LS	$4,034,500	$4,030,000		See Table D-13c
SUBTOTAL				$4,030,000		
Ex Situ Treatment						
Treatment plant	0			$0		
SUBTOTAL				$0		
Infrastructure						
Pipelines & Conduit / Wire & Trench	1	See Note	$8,860,766	$8,860,000		See Table D-16
Access Roads	3	1,000 LF	$16,200	$50,000		
Fresh water						
Wells	1	LS	$158,700	$160,000		Assumed one 10" diameter well (shown on Table D-12)
Pipeline	1.6	1,000 LF	$100,000	$160,000		1,600 feet of 10" steel pipe running across existing pipe bridge and supports.
SUBTOTAL				$9,230,000		
Remove IM3 Treatment Plant						
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000		See Table D-17
SUBTOTAL				$1,600,000		
SUBTOTAL				$22,300,000		
Prime Contractor Cost Factors[1]						
General Conditions (sub mob, sub GC)	10%			$2,230,000		
Field Construction Management and Engineer SDC	10%			$2,450,000		
Pre-construction (work plans, design, as-builts)	14%			$3,780,000		USEPA costing guidance EPA-540-R-00-002
Project Management	5%			$1,540,000		
Contractor Markup (G&A, fee)	21%			$6,780,000		
SUBTOTAL			75%	$16,800,000		
Miscellaneous						
Institutional Controls and other Administrative Approvals	1	CONSTR PHASES	$1,000,000	$1,000,000		Allowance
Biological Monitoring	1	CONSTR YRS	$330,000	$330,000		Allowance
Cultural Monitoring	1	CONSTR YRS	$330,000	$330,000		Allowance
Regulatory Oversight	1	CONSTR YRS	$300,000	$300,000		Allowance
Soil Cuttings	1	CONSTR PHASES	$200,000	$200,000		Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$41,300,000		
Contingency	25%			$10,300,000		
TOTAL CAPITAL COST				**$51,600,000**		
			Low Range		High Range	
			$36,100,000		**$77,400,000**	

Alternative E

Remedial Alternative Cost Summary - In-Situ Treatment with Freshwater Flushing

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST		O&M	Long-Term Mon.	NOTES
		Duration:		29 years	10 years	
Ex Situ Treatment Plant O&M	YR					
Freshwater well maintenance & pumping	100 gpm	$ 11,108		$ 55,542	$ -	500 gpm of freshwater. Cost is for electricity for pumping, and maintaining well.
IRZ	YR	See Note		$ 1,031,500	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.
IRZ Well Replacement	10%	Capital Cost of Wells		$ 106,596	$ -	Replace 10% of wells each year.
Maintenance of Wells (Non IRZ)	See Note			$ 1,023,251	$ 393,341	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note		$ 158,276	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note		$ 121,241	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note		$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	3.0 x 1,000 LF	$ 700		$ 2,126	$ -	
Other O&M Costs						
Permit Compliance	YR	See Note		$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000		$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note		$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note		$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note		$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27		$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000		$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL				$ 3,200,000	$ 703,000	
Contingency	25%			$800,000	$176,000	
SUBTOTAL				$4,000,000	$879,000	
TOTAL O&M COST				**$4,000,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	138	WELL	$30,000	$4,140,000	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS			
SUBTOTAL				$5,840,000	
Contingency	25%			$1,460,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$7,300,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$51,600,000	-	1.000	$51,600,000	$51,600,000	
29	ANNUAL O&M COST, YEAR 1-30		$4,000,000	18.785	$75,138,196	$116,000,000	
10	LONG TERM MONITORING, YEAR 31-40		$900,000	3.421	$3,078,878	$9,000,000	
41	POST-REMEDIATION DECONSTRUCTION, YEAR 41	$7,300,000	-	0.278	$2,030,637	$7,300,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$132,000,000**		
				Low Range		High Range	
				$92,000,000		**$198,000,000**	
Total Nominal Cost					**$184,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

Attachment 2 - Estimate of Probable Cost - IRZ Yearly O&M

Attachment 2
PG&E Topock Compressor Station
Estimate of Probable Cost - IRZ Yearly O&M
NTH & Transwestern Injection and Extraction Systems
Needles, CA
Revision 2
Revision Date: October 29, 2011

Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	26	WK	$11,000.00	$286,000.00	Operations and office support for operations. No PM, data evaluation, or reporting.
Carbon	43,000	Gallons	$5.50	$236,500.00	Based on 672 gpm maximum flow @ 100 mg/L TOC for 26 weeks of operation.
Miscellaneous Materials/Equipment and Subs	26	WK	$17,500.00	$455,000.00	Spare parts, maintenance, well redevelopment, pipe cleaning.
			Annual O&M Subtotal (O&M):	***$977,500.00***	

Attachment C - Construction Cost Reports

BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
41030	Install Access Roads		800.000	LF	29.38	23,504.00
41040	Survey for New Wells		1.000	LS	20,000.00	20,000.00
	Install New Injection/Extraction Wells/Develop					
41061	Nested Dual Screen Injection Wells		8.000	EA	322,100.00	2,576,800.00
41062	Dual Screen Injection Wells		7.000	EA	164,342.86	1,150,400.02
41063	Single Screen Injection Wells		7.000	EA	212,642.86	1,488,500.02
41064	Nested Dual Screen Extraction Wells		4.000	EA	465,900.00	1,863,600.00
41066	Single Screen Extraction Wells		13.000	EA	138,576.92	1,801,499.96
41067	Install New Freshwater Injection Wells		3.000	EA	453,700.00	1,361,100.00
		Total Injection/Extraction Wells				$10,241,900.00
	Install New Pipeline					
41071	Trenching And Backfill		18,505.000	LF	46.30	856,781.50
41072	HDPE Pipe		18,505.000	LF	38.47	711,887.35
41073	Mortar Lined Carbon Steel Pipe		16,683.000	LF	157.17	2,622,067.11
41075	Segment 6 Bore and Jack		225.000	LF	1,038.18	233,590.50
41076	Segment 8 Bore and Jack		340.000	LF	944.27	321,051.80
41077	Segment 15 Bore and Jack		286.000	LF	988.11	282,599.46
41083	Bridge Attachment Pipe		850.000	LF	272.73	231,820.50
		Total Install New Pipeline				$5,259,798.22
41085	Install New Monitoring Wells		1.000	LS	1,702,400.00	1,702,400.00
	Install Equipment and Controls System					

BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
41091	Organ Carbon Sunst Amend Sys (MW-20)		1.000	LS	1,659,200.00	1,659,200.00
41092	Organ Carbon Subst Amend Sys (Transwest Meter Sta)		1.000	LS	832,900.00	832,900.00
41093	Remedy WWTP		1.000	LS	2,959,077.52	2,959,077.52
41096	Elect power - wells		1.000	LS	2,518,912.38	2,518,912.38
41097	SCADA, Incl Programming		1.000	LS	1,250,000.00	1,250,000.00
	Total Install Equipment and Control Systems					$9,220,089.90
41100	Start Up and Test		1.000	LS	193,277.99	193,277.99
41150	Install Power Station (Electrical Generator)		1.000	LS	607,153.28	607,153.28
			Bid Total	========>		$27,268,123.39

**Notes:
Items in italics are Non-Additive.

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
*** 41030	**Install Access Roads**				Takeoff:		800.00 LF		Bid:	800.00 LF		
4103001	Grading and Surfacing	800.00	LF	50	10.00	12,413	4,536		3,256	3,302		23,507
Mh: 150.00	Shifts: 3.0	Mh/Un: 0.1875		Un/Sh:	266.6667	15.52	5.67		4.07	4.13		29.38
**********Biditem/Category	**41030**	**********				12,413	4,536		3,256	3,302		23,507
Mh: 150.00	Mh/Un: 0.1875					15.52	5.67		4.07	4.13		29.38
*** 41040	**Survey for New Wells**				Takeoff:		1.00 LS		Bid:	1.00 LS		
41040	Survey For New Wells	1.00	LS	510	10.00						20,000	20,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							20,000.00	20,000.00
**********Biditem/Category	**41040**	**********									20,000	20,000
Mh:	Mh/Un:										20,000.00	20,000.00
*** 41061	**Nested Dual Screen Injection Wells**				Takeoff:		8.00 EA		Bid:	8.00 EA		
41061	Nested Dual Screen Injecti	8.00	EA	510	10.00			2,576,800				2,576,800
Mh:	Shifts:	Mh/Un:		Un/Sh:				322,100.00				322,100.00
**********Biditem/Category	**41061**	**********						2,576,800				2,576,800
Mh:	Mh/Un:							322,100.00				322,100.00
*** 41062	**Dual Screen Injection Wells**				Takeoff:		7.00 EA		Bid:	7.00 EA		
41062	Dual Screen Injection Wel	7.00	EA	510	10.00			1,150,400				1,150,400
Mh:	Shifts:	Mh/Un:		Un/Sh:				164,342.86				164,342.86
**********Biditem/Category	**41062**	**********						1,150,400				1,150,400
Mh:	Mh/Un:							164,342.86				164,342.86
*** 41063	**Single Screen Injection Wells**				Takeoff:		7.00 EA		Bid:	7.00 EA		
41063	Single Screen Injection W	7.00	EA	510	10.00			1,488,500				1,488,500
Mh:	Shifts:	Mh/Un:		Un/Sh:				212,642.86				212,642.86
**********Biditem/Category	**41063**	**********						1,488,500				1,488,500
Mh:	Mh/Un:							212,642.86				212,642.86

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
*** 41064	**Nested Dual Screen Extraction Wells**					Takeoff:	4.00 EA		Bid:	4.00 EA		
41064	Nested Dual Screen Extra	4.00	EA	510	10.00			1,863,600				1,863,600
Mh:	Shifts:	Mh/Un:		Un/Sh:				465,900.00				465,900.00
**********Biditem/Category	**41064**	**********						1,863,600				1,863,600
Mh:	Mh/Un:							465,900.00				465,900.00
*** 41066	**Single Screen Extraction Wells**					Takeoff:	13.00 EA		Bid:	13.00 EA		
41066	Single Screen Extraction	1.00	EA	510	10.00			1,801,500				1,801,500
Mh:	Shifts:	Mh/Un:		Un/Sh:				1,801,500.00				1,801,500.00
**********Biditem/Category	**41066**	**********						1,801,500				1,801,500
Mh:	Mh/Un:							138,576.92				138,576.92
*** 41067	**Install New Freshwater Injection Wells**					Takeoff:	3.00 EA		Bid:	3.00 EA		
41050	Install New Freshwater W	3.00	EA	510	10.00			1,361,100				1,361,100
Mh:	Shifts:	Mh/Un:		Un/Sh:				453,700.00				453,700.00
**********Biditem/Category	**41067**	**********						1,361,100				1,361,100
Mh:	Mh/Un:							453,700.00				453,700.00
*** 41071	**Trenching And Backfill**					Takeoff:	18,505.00 LF		Bid:	18,505.00 LF		
4107100	Sawcut and remove Aspha	68,700.00	SF	510	10.00	8,926		527	1,590	2,549	41,000	54,592
Mh: 120.00	Shifts: 1.5	Mh/Un: 0.0017		Un/Sh:	45,800.0000	0.13		0.01	0.02	0.04	0.60	0.79
4107101	1, 2 Pipe Trench and Back	4,457.00	LF	50	10.00	43,675	22,816		13,127	17,563		97,180
Mh: 557.14	Shifts: 11.1	Mh/Un: 0.1250		Un/Sh:	400.0180	9.80	5.12		2.95	3.94		21.80
4107102	3, 4, 5 Pipe Trench and Ba	9,228.00	LF	50	10.00	103,336	93,683		35,819	44,084		276,921
Mh: 1,318.21	Shifts: 26.4	Mh/Un: 0.1428		Un/Sh:	350.0228	11.20	10.15		3.88	4.78		30.01
4107103	6, 7, 8 Pipe Trench and Ba	1,000.00	LF	50	10.00	22,919	11,599		7,751	8,999		51,269
Mh: 280.00	Shifts: 4.0	Mh/Un: 0.2800		Un/Sh:	250.0000	22.92	11.60		7.75	9.00		51.27
4107105	Replace Base and Paveme	68,700.00	SF	510	10.00						318,850	318,850
Mh:	Shifts:	Mh/Un:		Un/Sh:							4.64	4.64
4107106	Revegetation	20.00	AC	510	10.00						58,000	58,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							2,900.00	2,900.00

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
**********Biditem/Category	**41071**	**********				178,855	128,098	527	58,287	73,194	417,850	856,812
Mh: 2,275.35	Mh/Un: 0.1230					9.67	6.92	0.03	3.15	3.96	22.58	46.30
*** 41072	**HDPE Pipe**					Takeoff:	18,505.00 LF		Bid:	18,505.00 LF		
4107201	String HDPE Pipe	18,505.00	LF	510	10.00	12,525		804	1,023	1,629		15,982
Mh: 165.00	Shifts: 3.0	Mh/Un: 0.0089		Un/Sh: 6,168.3333		0.68		0.04	0.06	0.09		0.86
4107203	HDPE Pipe 4"	17,950.00	LF	50	10.00	78,898	68,834		17,014	5,891		170,637
Mh: 897.51	Shifts: 29.9	Mh/Un: 0.0500		Un/Sh: 600.0134		4.40	3.83		0.95	0.33		9.51
4107202	HDPE Pipe 2"	13,000.00	LF	50	10.00	34,284	14,040		7,393	2,560		58,277
Mh: 390.00	Shifts: 13.0	Mh/Un: 0.0300		Un/Sh: 1,000.0000		2.64	1.08		0.57	0.20		4.48
4107204	HDPE Pipe 6"	9,400.00	LF	50	10.00	66,108	98,474		14,256	4,936		183,774
Mh: 752.01	Shifts: 25.1	Mh/Un: 0.0800		Un/Sh: 375.0100		7.03	10.48		1.52	0.53		19.55
4107205	HDPE Pipe 8"	1,520.00	LF	50	10.00	13,363	24,296		2,882	998		41,538
Mh: 152.01	Shifts: 5.1	Mh/Un: 0.1000		Un/Sh: 300.0395		8.79	15.98		1.90	0.66		27.33
4107206	HDPE Pipe 12"	3,360.00	LF	50	10.00	32,491	119,750		7,006	2,426		161,674
Mh: 369.60	Shifts: 12.3	Mh/Un: 0.1100		Un/Sh: 272.7273		9.67	35.64		2.09	0.72		48.12
4107207	Concrete Thrust Blocks	20.00	LOC	510	10.00						80,000	80,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							4,000.00	4,000.00
**********Biditem/Category	**41072**	**********				237,669	325,394	804	49,574	18,440	80,000	711,882
Mh: 2,726.13	Mh/Un: 0.1473					12.84	17.58	0.04	2.68	1.00	4.32	38.47
*** 41073	**Mortar Lined Carbon Steel Pipe**					Takeoff:	16,683.00 LF		Bid:	16,683.00 LF		
4107290	Clear/Prepare Pipe Routr	5,000.00	LF	510	10.00	6,322		397	1,670	1,268		9,657
Mh: 75.00	Shifts: 2.5	Mh/Un: 0.0150		Un/Sh: 2,000.0000		1.26		0.08	0.33	0.25		1.93
4107300	Furnish & Install Precast S	400.00	EA	510	10.00	25,377	648,000		4,920	6,785		685,081
Mh: 300.00	Shifts: 10.0	Mh/Un: 0.7500		Un/Sh: 40.0000		63.44	1,620.00		12.30	16.96		1,712.70
4107301	String CS Pipe	15,833.00	LF	510	10.00	10,716		688	876	1,394		13,674
Mh: 141.17	Shifts: 2.6	Mh/Un: 0.0089		Un/Sh: 6,170.3040		0.68		0.04	0.06	0.09		0.86
4107302	2" CS Mortar Lined Pipe	13,000.00	LF	510	10.00	181,062	53,244	11,297	10,528	18,585	19,500	294,216
Mh: 2,078.00	Shifts: 52.0	Mh/Un: 0.1598		Un/Sh: 250.2406		13.93	4.10	0.87	0.81	1.43	1.50	22.63
4107303	4" CS Mortar Lined Pipe	18,000.00	LF	510	10.00	263,482	276,601	16,440	15,320	27,045	40,500	639,388
Mh: 3,023.92	Shifts: 75.6	Mh/Un: 0.1680		Un/Sh: 238.1015		14.64	15.37	0.91	0.85	1.50	2.25	35.52
4107304	6" CS Mortar Lined Pipe	9,400.00	LF	510	10.00	245,871	208,889	15,341	14,296	25,238	28,200	537,835
Mh: 2,821.80	Shifts: 70.5	Mh/Un: 0.3002		Un/Sh: 133.2483		26.16	22.22	1.63	1.52	2.68	3.00	57.22

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
4107305	8" CS Mortar Lined Pipe	1,520.00	LF	510	10.00	47,470	49,674	2,962	2,760	4,873	6,080	113,818
Mh: 544.80	Shifts: 13.6	Mh/Un: 0.3584		Un/Sh:	111.6006	31.23	32.68	1.95	1.82	3.21	4.00	74.88
4107306	12" CS Mortar Lined Pipe	2,906.00	LF	510	10.00	121,519	159,407	7,582	7,066	12,473	20,342	328,389
Mh: 1,394.64	Shifts: 34.9	Mh/Un: 0.4799		Un/Sh:	83.3477	41.82	54.85	2.61	2.43	4.29	7.00	113.00
************Biditem/Category**	**41073**	**********				901,818	1,395,815	54,708	57,435	97,660	114,622	2,622,059
Mh: 10,379.33	Mh/Un: 0.6222					54.06	83.67	3.28	3.44	5.85	6.87	157.17
*** 41075	**Segment 6 Bore and Jack**					Takeoff:	225.00 LF		Bid:	225.00 LF		
4107501	Jacking Pit Installation	1.00	LS	510	10.00	13,906		2,160	1,937	2,347		20,349
Mh: 180.00	Shifts: 3.0	Mh/Un: 180.0000		Un/Sh:	0.3333	13,905.54		2,160.00	1,936.80	2,346.90		20,349.24
4107502	Receiving Pit Installation	1.00	LS	510	10.00	6,462		1,080	1,291	1,565		10,398
Mh: 80.00	Shifts: 2.0	Mh/Un: 80.0000		Un/Sh:	0.5000	6,461.96		1,080.00	1,291.20	1,564.60		10,397.76
4107503	Pipe Jacking Operation	225.00	LF	510	10.00	83,261	19,440		17,377	13,327		133,405
Mh: 1,055.25	Shifts: 15.1	Mh/Un: 4.6900		Un/Sh:	14.9254	370.05	86.40		77.23	59.23		592.91
4107504	HDPE Pipe & Conduits	225.00	LF	510	10.00	18,757	12,191		3,915	2,663		37,525
Mh: 237.73	Shifts: 3.4	Mh/Un: 1.0566		Un/Sh:	66.2544	83.37	54.18		17.40	11.83		166.78
4107506	Grout Casing	225.00	LF	510	10.00	5,479	2,934		305	628		9,346
Mh: 67.92	Shifts: 1.7	Mh/Un: 0.3019		Un/Sh:	132.5088	24.35	13.04		1.36	2.79		41.54
4107507	Jacking Pit Closure	1.00	LS	510	10.00	9,270			1,621	2,005		12,896
Mh: 120.00	Shifts: 2.0	Mh/Un: 120.0000		Un/Sh:	0.5000	9,270.36			1,620.78	2,004.50		12,895.64
4107508	Receiving Pit Closure	1.00	LS	510	10.00	6,953			1,216	1,503		9,672
Mh: 90.00	Shifts: 1.5	Mh/Un: 90.0000		Un/Sh:	0.6667	6,952.78			1,215.59	1,503.43		9,671.80
************Biditem/Category**	**41075**	**********				144,088	34,565	3,240	27,661	24,038		233,591
Mh: 1,830.90	Mh/Un: 8.1373					640.39	153.62	14.40	122.94	106.83		1,038.18
*** 41076	**Segment 8 Bore and Jack**					Takeoff:	340.00 LF		Bid:	340.00 LF		
4107601	Jacking Pit Installation	1.00	LS	510	10.00	13,906		2,160	1,937	2,347		20,349
Mh: 180.00	Shifts: 3.0	Mh/Un: 180.0000		Un/Sh:	0.3333	13,905.54		2,160.00	1,936.80	2,346.90		20,349.24
4107602	Receiving Pit Installation	1.00	LS	510	10.00	6,462		1,080	1,291	1,565		10,398
Mh: 80.00	Shifts: 2.0	Mh/Un: 80.0000		Un/Sh:	0.5000	6,461.96		1,080.00	1,291.20	1,564.60		10,397.76
4107603	Pipe Jacking Operation	340.00	LF	510	10.00	125,817	29,376		26,259	20,139		201,590
Mh: 1,594.60	Shifts: 22.8	Mh/Un: 4.6900		Un/Sh:	14.9254	370.05	86.40		77.23	59.23		592.91
4107604	HDPE Pipe & Conduits	340.00	LF	510	10.00	28,345	18,517		5,916	4,024		56,801

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
Mh: 359.24	Shifts: 5.1	Mh/Un: 1.0566		Un/Sh:	66.2510	83.37	54.46		17.40	11.83		167.06
4107606	Grout Casing	225.00	LF	510	10.00	5,479	2,934		305	628		9,346
Mh: 67.92	Shifts: 1.7	Mh/Un: 0.3019		Un/Sh:	132.5088	24.35	13.04		1.36	2.79		41.54
4107607	Jacking Pit Closure	1.00	LS	510	10.00	9,270			1,621	2,005		12,896
Mh: 120.00	Shifts: 2.0	Mh/Un: 120.0000		Un/Sh:	0.5000	9,270.36			1,620.78	2,004.50		12,895.64
4107608	Receiving Pit Closure	1.00	LS	510	10.00	6,953			1,216	1,503		9,672
Mh: 90.00	Shifts: 1.5	Mh/Un: 90.0000		Un/Sh:	0.6667	6,952.78			1,215.59	1,503.43		9,671.80
**********Biditem/Category	41076	**********				196,231	50,827	3,240	38,544	32,211		321,052
Mh: 2,491.76	Mh/Un: 7.3287					577.15	149.49	9.53	113.36	94.74		944.27
*** 41077	Segment 15 Bore and Jack					Takeoff:	286.00 LF		Bid:	286.00 LF		
4107701	Jacking Pit Installation	1.00	LS	510	10.00	13,906		2,160	1,937	2,347		20,349
Mh: 180.00	Shifts: 3.0	Mh/Un: 180.0000		Un/Sh:	0.3333	13,905.54		2,160.00	1,936.80	2,346.90		20,349.24
4107702	Receiving Pit Installation	1.00	LS	510	10.00	6,462		1,080	1,291	1,565		10,398
Mh: 80.00	Shifts: 2.0	Mh/Un: 80.0000		Un/Sh:	0.5000	6,461.96		1,080.00	1,291.20	1,564.60		10,397.76
4107703	Pipe Jacking Operation	286.00	LF	510	10.00	105,834	24,710		22,088	16,941		169,573
Mh: 1,341.34	Shifts: 19.2	Mh/Un: 4.6900		Un/Sh:	14.9254	370.05	86.40		77.23	59.23		592.91
4107704	HDPE Pipe & Conduits	286.00	LF	510	10.00	23,843	15,628		4,976	3,385		47,832
Mh: 302.19	Shifts: 4.3	Mh/Un: 1.0566		Un/Sh:	66.2651	83.37	54.64		17.40	11.84		167.25
4107706	Grout Casing	286.00	LF	510	10.00	6,964	3,730		388	798		11,880
Mh: 86.33	Shifts: 2.2	Mh/Un: 0.3019		Un/Sh:	132.5301	24.35	13.04		1.36	2.79		41.54
4107707	Jacking Pit Closure	1.00	LS	510	10.00	9,270			1,621	2,005		12,896
Mh: 120.00	Shifts: 2.0	Mh/Un: 120.0000		Un/Sh:	0.5000	9,270.36			1,620.78	2,004.50		12,895.64
4107708	Receiving Pit Closure	1.00	LS	510	10.00	6,953			1,216	1,503		9,672
Mh: 90.00	Shifts: 1.5	Mh/Un: 90.0000		Un/Sh:	0.6667	6,952.78			1,215.59	1,503.43		9,671.80
**********Biditem/Category	41077	**********				173,232	44,068	3,240	33,516	28,543		282,599
Mh: 2,199.86	Mh/Un: 7.6918					605.70	154.09	11.33	117.19	99.80		988.11
*** 41083	Bridge Attachment Pipe					Takeoff:	850.00 LF		Bid:	850.00 LF		
41083	Pipe On Bridge	850.00	LF	510	10.00	68,803	81,281		13,338	18,396	50,000	231,818
Mh: 813.38	Shifts: 27.1	Mh/Un: 0.9569		Un/Sh:	31.3514	80.94	95.62		15.69	21.64	58.82	272.73
**********Biditem/Category	41083	**********				68,803	81,281		13,338	18,396	50,000	231,818

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
Mh: 813.38	Mh/Un: 0.9569					80.94	95.62		15.69	21.64	58.82	272.73
*** 41085		**Install New Monitoring Wells**				Takeoff:	1.00 LS		Bid:	1.00 LS		
41085	Install New Monitoring W	28.00	WELL	510	10.00						1,702,400	1,702,400
Mh:	Shifts:	Mh/Un:		Un/Sh:							60,800.00	60,800.00
**********Biditem/Category	**41085**	**********									1,702,400	1,702,400
Mh:	Mh/Un:										1,702,400.00	1,702,400.00
*** 41091		**Organ Carbon Sunst Amend Sys (MW-20)**				Takeoff:	1.00 LS		Bid:	1.00 LS		
321112	NTH System	1.00	LS	510	10.00			1,659,200				1,659,200
Mh:	Shifts:	Mh/Un:		Un/Sh:				1,659,200.00				1,659,200.00
**********Biditem/Category	**41091**	**********						1,659,200				1,659,200
Mh:	Mh/Un:							1,659,200.00				1,659,200.00
*** 41092		**Organ Carbon Subst Amend Sys (Transwe**				Takeoff:	1.00 LS		Bid:	1.00 LS		
321112	TW System	1.00	LS	510	10.00			832,900				832,900
Mh:	Shifts:	Mh/Un:		Un/Sh:				832,900.00				832,900.00
**********Biditem/Category	**41092**	**********						832,900				832,900
Mh:	Mh/Un:							832,900.00				832,900.00
*** 41093		**Remedy WWTP**				Takeoff:	1.00 LS		Bid:	1.00 LS		
34220.10	Raw Water Tanks (Infuent	1.00	LS	510	10.00	28,351	73,170		1,846	3,207	202,500	309,074
Mh: 320.00	Shifts: 8.0	Mh/Un: 320.0000		Un/Sh:	0.1250	28,350.94	73,170.00		1,846.40	3,206.72	202,500.00	309,074.06
34220.15	Instrumentation, Raw Wat	1.00	LS	510	10.00						31,500	31,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							31,500.00	31,500.00
34220.20	Remedy WWTP Buidling	1.00	LS	510	10.00						500,000	500,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							500,000.00	500,000.00
34220.30	Remedy WWTP Building	1.00	LS	510	10.00	85,116	151,470		3,693	6,413		246,692
Mh: 960.00	Shifts: 16.0	Mh/Un: 960.0000		Un/Sh:	0.0625	85,116.07	151,470.00		3,692.80	6,413.44		246,692.31
34220.35	Instrumentation, Filter Sys	1.00	LS	510	10.00						30,000	30,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							30,000.00	30,000.00
34220.40	Treated Water Tanks	1.00	AL	510	10.00		16,200					16,200

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
Mh:	Shifts:	Mh/Un:		Un/Sh:			16,200.00					16,200.00
34220.50	Truck fill stations	1.00	AL	510	10.00		81,000					81,000
Mh:	Shifts:	Mh/Un:		Un/Sh:			81,000.00					81,000.00
34220.60	Caustic system	1.00	AL	510	10.00		81,000					81,000
Mh:	Shifts:	Mh/Un:		Un/Sh:			81,000.00					81,000.00
34220.70	Liquid phase separator	2.00	EA	510	10.00	42,558	324,000		1,846	3,207		371,611
Mh: 480.00	Shifts: 8.0	Mh/Un: 240.0000		Un/Sh:	0.2500	21,279.02	162,000.00		923.20	1,603.36		185,805.58
34220.75	Instruments Caustic/ Liqui	1.00	LS	510	10.00						16,500	16,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							16,500.00	16,500.00
34220.80	Relocated pipe storage are	338.00	SF	510	10.00						36,000	36,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							106.51	106.51
34220.82	Construct Retaining Wall	166.00	LF	510	10.00						82,500	82,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							496.99	496.99
34220.85	Operations Building	1,200.00	SF	510	10.00						420,000	420,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							350.00	350.00
34220.90	Maintenance shop - buildi	1.00	LS	510	10.00						250,000	250,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							250,000.00	250,000.00
34220.92	Elec Equip & Gen - remod	1,000.00	SF	510	10.00						175,000	175,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							175.00	175.00
34220.93	Hazardous Waste	1,000.00	SF	510	10.00						288,000	288,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							288.00	288.00
34220.95	Instrumentation Treated H	1.00	LS	510	10.00						24,000	24,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							24,000.00	24,000.00
**********Biditem/Category	**41093**	**********				156,025	726,840		7,386	12,827	2,056,000	2,959,078
Mh: 1,760.00	Mh/Un: 1,760.0000					156,025.04	726,840.00		7,385.60	12,826.88	2,056,000.00	2,959,077.52
*** 41096	**Elect power - wells**				Takeoff:		1.00 LS		Bid:	1.00 LS		
35104.05	Ground water switchboard	1.00	LS	510	10.00	2,384	8,100		109	156		10,749
Mh: 32.00	Shifts: 0.8	Mh/Un: 32.0000		Un/Sh:	1.2500	2,383.77	8,100.00		109.12	155.64		10,748.53
35104.11	XFMR 099	1.00	EA	510	10.00	7,643	83,700		1,462	1,729	16,000	110,533
Mh: 96.00	Shifts: 1.6	Mh/Un: 96.0000		Un/Sh:	0.6250	7,642.63	83,700.00		1,462.08	1,728.68	16,000.00	110,533.39
35104.12	West loop disconnect	1.00	LS	510	10.00		21,600					21,600
Mh:	Shifts:	Mh/Un:		Un/Sh:			21,600.00					21,600.00
35104.14	East loop disconnect	1.00	LS	510	10.00		21,600					21,600

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
Mh:	Shifts:	Mh/Un:		Un/Sh:			21,600.00					21,600.00
35104.16	XFMR 001 dist loop	2,600.00	LF	510	10.00						390,000	390,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							150.00	150.00
35104.18	XFMR 001	1.00	EA	510	10.00	6,218	22,140		484	613	4,000	33,455
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	22,140.00		484.16	612.78	4,000.00	33,455.10
35104.20	XFMR 002 dist loop	1,750.00	LF	510	10.00						262,500	262,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							150.00	150.00
35104.22	XFMR 002	1.00	EA	510	10.00	6,218	27,540		484	613	4,000	38,855
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	27,540.00		484.16	612.78	4,000.00	38,855.10
35104.24	XFMR 003 dist loop	1,050.00	LF	510	10.00						157,500	157,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							150.00	150.00
35104.26	XFMR 003	1.00	EA	510	10.00	6,218	27,540		484	613	4,000	38,855
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	27,540.00		484.16	612.78	4,000.00	38,855.10
35104.28	XFMR 004 dist loop	1,650.00	LF	510	10.00						247,500	247,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							150.00	150.00
35104.30	XFMR 004	1.00	EA	510	10.00	6,218	27,540		484	613	4,000	38,855
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	27,540.00		484.16	612.78	4,000.00	38,855.10
35104.32	XFMR 006 dist loop	1,700.00	LF	510	10.00						255,000	255,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							150.00	150.00
35104.34	XFMR 006	1.00	EA	510	10.00	6,218	22,140		484	613	4,000	33,455
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	22,140.00		484.16	612.78	4,000.00	33,455.10
35104.36	XFMR 005 dist loop	4,000.00	LF	510	10.00						825,000	825,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							206.25	206.25
35104.38	XFMR 005	1.00	EA	510	10.00	6,218	22,140		484	613	4,000	33,455
Mh: 80.00	Shifts: 1.6	Mh/Un: 80.0000		Un/Sh:	0.6250	6,218.16	22,140.00		484.16	612.78	4,000.00	33,455.10
**********Biditem/Category	**41096**	**********				47,335	284,040		4,476	5,561	2,177,500	2,518,913
Mh: 608.00	Mh/Un: 608.0000					47,335.36	284,040.00		4,476.16	5,561.00	2,177,500.00	2,518,912.52

*** 41097 **SCADA, Incl Programming** Takeoff: 1.00 LS Bid: 1.00 LS

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
35302	SCADA	1.00	LS	510	10.00						1,250,000	1,250,000
Mh:	Shifts:	Mh/Un:		Un/Sh:							1,250,000.00	1,250,000.00
**********Biditem/Category	**41097**	**********									1,250,000	1,250,000
Mh:	Mh/Un:										1,250,000.00	1,250,000.00

Activity Unit Price Summary

Biditem Activity	Description	Quantity	Unit	Calendar WC	Hrs/Shift	Labor	Perm Material	Constr Exp.	Equip. Cost	Equip. Ops.	S/C	Total
*** 41100	**Start Up and Test**					Takeoff:	1.00 LS		Bid:	1.00 LS		
4100	Startup and Test	1.00	LS	510	10.00	129,279		9,056	4,886	15,058	35,000	193,278
Mh: 2,400.00	Shifts: 20.0	Mh/Un: 2,400.0000		Un/Sh:	0.0500	129,278.85		9,055.94	4,885.60	15,057.60	35,000.00	193,277.99
************Biditem/Category**	**41100**	**************				129,279		9,056	4,886	15,058	35,000	193,278
Mh: 2,400.00	Mh/Un: 2,400.0000					129,278.85		9,055.94	4,885.60	15,057.60	35,000.00	193,277.99
*** 41150	**Install Power Station (Electrical Generator**					Takeoff:	1.00 LS		Bid:	1.00 LS		
41150	Generator pad	225.00	SF	510	10.00						7,500	7,500
Mh:	Shifts:	Mh/Un:		Un/Sh:							33.33	33.33
415002	Receive & set nat gas gen	1.00	LS	510	10.00	6,538	548,101		3,894	2,396		560,928
Mh: 96.00	Shifts: 2.4	Mh/Un: 96.0000		Un/Sh:	0.4167	6,537.59	548,101.08		3,893.52	2,395.51		560,927.70
415003	Nat gas generator control -	1.00	LS	510	10.00	7,151	30,780		327	467		38,726
Mh: 96.00	Shifts: 2.4	Mh/Un: 96.0000		Un/Sh:	0.4167	7,151.32	30,780.00		327.36	466.89		38,725.57
************Biditem/Category**	**41150**	**************				13,689	578,881		4,221	2,862	7,500	607,153
Mh: 192.00	Mh/Un: 192.0000					13,688.91	578,881.08		4,220.88	2,862.40	7,500.00	607,153.27
Mh: 27,826.71	*****REPORT TOTALS*****					**2,259,437**	**3,654,346**	**12,808,815**	**302,579**	**332,091**	**7,910,872**	**27,268,141**

N = Activity not adjusted to bid quantity

COST REPORT

BID ITEM = 41030 Land Item SCHEDULE: 1 100
Description = Install Access Roads Unit = LF Takeoff Quan: 800.000 Engr Quan: 800.000

Summary Codes:

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
4103001	**Grading and Surfacing**		**Quan: 800.00 LF**		**Hrs/Shft: 10.00**	**Cal: 50**	**WC: NONE**					
A	Custom Crew		30.00 CH	Eff: 100.00	**Prod: 3.0000 S**		Lab Pcs: 5.00		Eqp Pcs: 5.00			
2AB11	Class II Aggregat@10		120.00 CY		37.800		4,536					4,536
8BDZR04G	Bulldozer Cat D4G X	1.00	30.00 HR		47.503				804	621		1,425
8CPRB10	COMPACT STONE	1.00	30.00 HR		22.218				276	390		667
8LDRW950	Loader Cat 950H 4C	1.00	30.00 HR		74.142				1,117	1,108		2,224
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	30.00 HR		19.634				138	451		589
8TW10	DIESEL 3K GALTR	1.00	30.00 HR		55.096				920	732		1,653
EO01	Oper - Foreman	1.00	30.00 MH *		92.016	2,760						2,760
EO03	Oper - Dozer >50hp	1.00	30.00 MH *		90.663	2,720						2,720
EO06	Oper - FEL <2cy	1.00	30.00 MH *		90.663	2,720						2,720
LA10	Labor General	2.00	60.00 MH *		70.210	4,213						4,213
$23,506.62	0.1875 MH/LF		150.0000 MH		[7.133]	12,413	4,536		3,256	3,302		23,507
26.6667 Units/H	266.6667 Un/Shift		5.3333 Unit/M			15.52	5.67		4.07	4.13		29.38
=====> Item Totals:	**41030 - Install Access Roads**											
$23,506.62	0.1875 MH/LF		150.00 MH		[7.133]	12,413	4,536		3,256	3,302		**23,507**
29.383	800 LF					15.52	5.67		4.07	4.13		29.38

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41040 Land Item SCHEDULE: 1 100
Description = Survey for New Wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

41040	**Survey For New Wells**	**Quan: 1.00 LS**			**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4SURVEY	Survey Crew	8.00	DAY		2,500.000						20,000	20,000

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41061 Land Item SCHEDULE: 1 100
Description = Nested Dual Screen Injection Wells Unit = EA Takeoff Quan: 8.000 Engr Quan: 8.000

Summary Codes:

41061 Nested Dual Screen Injection Wells Quan: 8.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5A02	NTH IRZ	8.00	EA		322,100.000			2,576,800				2,576,800

=====> Item Totals: 41061 - Nested Dual Screen Injection Wells

$2,576,800.00		[ ]			2,576,800			**2,576,800**
322,100.000	8 EA				322,100.00			322,100.00

COST REPORT

Activity Resource	Description	Quantity Pcs	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41062	Land Item	SCHEDULE: 1	100								
Description = Dual Screen Injection Wells		Unit = EA		Takeoff Quan: 7.000		Engr Quan: 7.000					
Summary Codes:											
41062	**Dual Screen Injection Wells**	**Quan: 7.00 EA**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
5A03	TCS Loop	2.00 EA		236,700.000			473,400				473,400
5A04	NTH IRZ	5.00 EA		135,400.000			677,000				677,000
$1,150,400.00				[ ]			1,150,400				1,150,400
							164,342.86				164,342.86
=====> Item Totals:	**41062 - Dual Screen Injection Wells**										
$1,150,400.00				[ ]			1,150,400				**1,150,400**
164,342.857	7 EA						164,342.86				164,342.86

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41063 Land Item SCHEDULE: 1 100
Description = Single Screen Injection Wells Unit = EA Takeoff Quan: 7.000 Engr Quan: 7.000

Summary Codes:

41063 Single Screen Injection Wells Quan: 7.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5A05	NTH IRZ	3.00	EA		115,500.000			346,500				346,500
5A05A	Inner Loop	4.00	EA		285,500.000			1,142,000				1,142,000
$1,488,500.00					[ ]			1,488,500				1,488,500
								212,642.86				212,642.86

=====> Item Totals: 41063 - Single Screen Injection Wells

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
$1,488,500.00					[ ]			1,488,500				**1,488,500**
212,642.857	7 EA							212,642.86				212,642.86

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41064 Land Item SCHEDULE: 1 100
Description = Nested Dual Screen Extraction Wells Unit = EA Takeoff Quan: 4.000 Engr Quan: 4.000
Summary Codes:

41064 Nested Dual Screen Extraction Wells Quan: 4.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5A06	NTH IRZ	4.00	EA		465,900.000			1,863,600				1,863,600

=====> Item Totals: 41064 - Nested Dual Screen Extraction Wells

$1,863,600.00		[ ]		1,863,600	**1,863,600**
465,900.000	4 EA			465,900.00	465,900.00

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41066 Land Item SCHEDULE: 1 100
Description = Single Screen Extraction Wells Unit = EA Takeoff Quan: 13.000 Engr Quan: 13.000

Summary Codes:

41066 Single Screen Extraction Wells Quan: 1.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5A09	TCS Loop	4.00	EA		121,000.000			484,000				484,000
5A10	East Ravine	4.00	EA		135,000.000			540,000				540,000
5A11	Inner Loop	5.00	EA		155,500.000			777,500				777,500
$1,801,500.00					[ ]			1,801,500				1,801,500
								1,801,500.00				1,801,500.00

=====> Item Totals: 41066 - Single Screen Extraction Wells

$1,801,500.00					[ ]			1,801,500				**1,801,500**
138,576.923	13 EA							138,576.92				138,576.92

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41067 Land Item SCHEDULE: 1 100
Description = Install New Freshwater Injection Wells Unit = EA Takeoff Quan: 3.000 Engr Quan: 3.000

Summary Codes:

41050 Install New Freshwater Wells Quan: 3.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5A01	Inner Loop	3.00	EA		453,700.000			1,361,100				1,361,100

=====> Item Totals: 41067 - Install New Freshwater Injection Wells

$1,361,100.00		[ ]			1,361,100			**1,361,100**
453,700.000	3 EA				453,700.00			453,700.00

COST REPORT

BID ITEM = 41071 Land Item SCHEDULE: 1 100
Description = Trenching And Backfill Unit = LF Takeoff Quan: 18,505.000 Engr Quan: 18,505.000

Summary Codes:

4107100 Sawcut and remove Asphalt Quan: 68,700.00 SF Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 15.00 CH Eff: 100.00 **Prod: 1.5000 S** Lab Pcs: 8.00 Eqp Pcs: 6.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
3ADD02	Add for Small Tools/		8,925.62	%	0.050			446				446
3LVLD	Level D Supplies@10		75.00	HR	1.080			81				81
4RF	Recycle Fee		205.00	LOAD	200.000						41,000	41,000
8DEMO18	BHL Cat 426 C W/Br	1.00	15.00	HR	64.524				578	390		968
8LDRW930	Loader Cat 930H 2.6	1.00	15.00	HR	52.041				374	407		781
8TD16	E/DUMP TRK 12 CY	3.00	45.00	HR	50.767				531	1,753		2,285
8TPUC14	F-150 FOREMAN PI	1.00	15.00	HR	7.100				107			107
EO01	Oper - Foreman	1.00	15.00	MH *	92.017	1,380						1,380
EO04	Oper - Excavator <3c	2.00	30.00	MH *	90.663	2,720						2,720
LA10	Labor General	2.00	30.00	MH *	70.210	2,106						2,106
TM02	Truck Driver - Tande	3.00	45.00	MH *	60.427	2,719						2,719
$54,592.37	0.0017 MH/SF		120.0000	MH	[0.061]	8,926		527	1,590	2,549	41,000	54,592
4,580.0000 Units/H	45,800.0000 Un/Shift		572.5016	Unit/M		0.13		0.01	0.02	0.04	0.60	0.79

4107101 1, 2 Pipe Trench and Backfill Quan: 4,457.00 LF Hrs/Shft: 10.00 Cal: 50 WC: NONE

A Custom Crew 111.42 CH Eff: 100.00 **Prod: 40.0000 UH** Lab Pcs: 5.00 Eqp Pcs: 7.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2BDPZ	Bedding/Pipe Zone@		668.55	CY	32.400		21,661					21,661
2DTT	Detection Tape@108		13,371.00	LF	0.086		1,155					1,155
8BHLD446	BHL Cat 446D 1.5CY	1.00	111.43	HR	60.490				3,698	3,042		6,740
8CPST22	COMPT TRENCH B	1.00	111.43	HR	10.824				635	571		1,206
8LDRW930	Loader Cat 930H 2.6	1.00	111.43	HR	52.041				2,779	3,020		5,799
8TD16	E/DUMP TRK 12 CY	1.00	111.43	HR	50.767				1,316	4,341		5,657
8TRKGS10	Flatbed Truck 15K 20	1.00	111.43	HR	26.561				766	2,194		2,960
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	111.43	HR	19.634				514	1,674		2,188

COST REPORT

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41071 Land Item SCHEDULE: 1 100
Description = Trenching And Backfill Unit = LF Takeoff Quan: 18,505.000 Engr Quan: 18,505.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8TW10	DIESEL 3K GALTR	1.00	111.43	HR	55.096				3,419	2,720		6,139
EO04	Oper - Excavator <3c	1.00	111.43	MH *	90.663	10,103						10,103
EO07	Oper - FEL >2cy	1.00	111.43	MH *	90.663	10,103						10,103
LA10	Labor General	3.00	334.28	MH *	70.210	23,470						23,470
$97,180.18	0.1250 MH/LF		557.1400	MH	[4.409]	43,675	22,816		13,127	17,562		97,180
40.0018 Units/H*	400.0180 Un/Shift		7.9998	Unit/M		9.80	5.12		2.95	3.94		21.80

4107102 3, 4, 5 Pipe Trench and Backfill Quan: 9,228.00 LF Hrs/Shft: 10.00 Cal: 50 WC: NONE

A Custom Crew 263.64 CH Eff: 100.00 **Prod: 35.0017 UH** Lab Pcs: 5.00 Eqp Pcs: 7.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2BDPZ	Bedding/Pipe Zone@		2,768.40	CY	32.400		89,696					89,696
2DTT	Detection Tape@108		46,140.00	LF	0.086		3,987					3,987
8CPST22	COMPT TRENCH B	1.00	263.64	HR	10.824				1,503	1,351		2,854
8EXC315	Excavator Cat 315D L	1.00	263.64	HR	66.050				10,274	7,139		17,413
8LDRW950	Loader Cat 950H 4C	1.00	263.64	HR	74.142				9,813	9,734		19,547
8TD16	E/DUMP TRK 12 CY	1.00	263.64	HR	50.767				3,114	10,271		13,384
8TRKGS10	Flatbed Truck 15K 20	1.00	263.64	HR	26.561				1,811	5,191		7,003
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	263.64	HR	19.634				1,215	3,961		5,176
8TW10	DIESEL 3K GALTR	1.00	263.64	HR	55.096				8,089	6,436		14,525
EO04	Oper - Excavator <3c	1.00	263.64	MH *	90.663	23,902						23,902
EO07	Oper - FEL >2cy	1.00	263.64	MH *	90.663	23,902						23,902
LA10	Labor General	3.00	790.93	MH *	70.210	55,531						55,531
$276,920.51	0.1428 MH/LF		1,318.2100	MH	[5.039]	103,336	93,683		35,819	44,084		276,921
35.0023 Units/H*	350.0228 Un/Shift		7.0004	Unit/M		11.20	10.15		3.88	4.78		30.01

4107103 6, 7, 8 Pipe Trench and Backfill Quan: 1,000.00 LF Hrs/Shft: 10.00 Cal: 50 WC: NONE

A Custom Crew 40.00 CH Eff: 100.00 **Prod: 25.0000 UH** Lab Pcs: 7.00 Eqp Pcs: 8.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2BDPZ	Bedding/Pipe Zone@		350.00	CY	32.400		11,340					11,340
2DTT	Detection Tape@108		3,000.00	LF	0.086		259					259
8CPRB10	COMPACT STONE	1.00	40.00	HR	22.218				368	521		889

COST REPORT

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41071			Land Item		SCHEDULE: 1	100						
Description = Trenching And Backfill					Unit = LF	Takeoff Quan: 18,505.000			Engr Quan:	18,505.000		
8CPST22	COMPT TRENCH B	1.00	40.00	HR	10.824				228	205		433
8EXC330	Excavator Cat 330D L	1.00	40.00	HR	159.514				3,508	2,873		6,381
8LDRW950	Loader Cat 950H 4C	1.00	40.00	HR	74.142				1,489	1,477		2,966
8TD16	E/DUMP TRK 12 CY	1.00	40.00	HR	50.767				472	1,558		2,031
8TRKGS10	Flatbed Truck 15K 20	1.00	40.00	HR	26.561				275	788		1,062
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	40.00	HR	19.634				184	601		785
8TW10	DIESEL 3K GALTR	1.00	40.00	HR	55.096				1,227	977		2,204
EO04	Oper - Excavator <3c	1.00	40.00	MH *	90.663	3,627						3,627
EO07	Oper - FEL >2cy	1.00	40.00	MH *	90.663	3,627						3,627
EO10	Oper - Roller	2.00	80.00	MH *	90.514	7,241						7,241
LA10	Labor General	3.00	120.00	MH *	70.210	8,425						8,425
$51,268.71	0.2800 MH/LF		280.0000	MH	[10.479]	22,919	11,599		7,751	8,999		51,269
25.0000 Units/H*	250.0000 Un/Shift		3.5714 Unit/M			22.92	11.60		7.75	9.00		51.27
4107105	**Replace Base and Pavement**		**Quan: 68,700.00 SF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
A	Custom Crew		0.00	CH	Eff: 100.00 **Prod: 0.0000**		Lab Pcs: 0.00		Eqp Pcs: 0.00			
4ABII	ABII In Place		2,800.00	TON	28.000						78,400	78,400
4AC	Asphalt Concrete 6"		68,700.00	SF	3.500						240,450	240,450
$318,850.00					[ ]						318,850	318,850
											4.64	4.64
4107106	**Revegetation**		**Quan: 20.00 AC**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4HS	Hydroseeding Sub		20.00	AC	2,900.000						58,000	58,000
=====> Item Totals: 41071	**- Trenching And Backfill**											
$856,811.77	0.1229 MH/LF		2,275.35	MH	[4.367]	178,855	128,098	527	58,287	73,194	417,850	**856,812**
46.302	18505 LF					9.67	6.92	0.03	3.15	3.96	22.58	46.30

COST REPORT

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41072 Land Item SCHEDULE: 1 100
Description = HDPE Pipe Unit = LF Takeoff Quan: 18,505.000 Engr Quan: 18,505.000
Summary Codes:

4107201 String HDPE Pipe Quan: 18,505.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		30.00	CH	Eff: 100.00	**Prod: 3.0000 S**		Lab Pcs:	5.50	Eqp Pcs:	2.50		
3ADD02	Add for Small Tools/		12,525.31	%		0.050			626				626
3LVLD	Level D Supplies@10		165.00	HR		1.080			178				178
8LDRW930	Loader Cat 930H 2.6	1.00	30.00	HR		52.041				748	813		1,561
8TRKGS10	Flatbed Truck 15K 20	1.00	30.00	HR		26.561				206	591		797
8TRKPU15	Pickup 4x4 3/4 Ton G	0.50	15.00	HR		19.634				69	225		295
EO01	Oper - Foreman	0.50	15.00	MH *		92.017	1,380						1,380
EO06	Oper - FEL <2cy	1.00	30.00	MH *		90.663	2,720						2,720
LA10	Labor General	4.00	120.00	MH *		70.210	8,425						8,425
$15,982.34	0.0089 MH/LF		165.0000	MH		[0.301]	12,525		804	1,023	1,629		15,982
616.8333 Units/H	6,168.3333 Un/Shift		112.1516	Unit/M			0.68		0.04	0.06	0.09		0.86

4107203 HDPE Pipe 4" Quan: 17,950.00 LF Hrs/Shft: 10.00 Cal: 50 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
PIPEHD	HDPE Pipe Crew		299.16	CH	Eff: 100.00	**Risk %: 100.00 RF**		Lab Pcs:	3.00	Eqp Pcs:	2.00		
2HDPE04	4" HDPE, SDR 11@1		17,950.00	LF	0.0500	3.564		63,974					63,974
2MISC	Misc Material@108%		1.80	LOT		2,700.000		4,860					4,860
8TRKGS10	Flatbed Truck 15K 20	1.00	299.17	HR		26.561				2,055	5,891		7,946
8XSTHDPE	HDPE Fusion Machin	1.00	299.17	HR		50.000				14,959			14,959
PF01	Pipefitter Foreman	1.00	299.17	MH *		90.124	26,962						26,962
PF02	Pipefitter	1.00	299.17	MH *		88.794	26,565						26,565
PF03	Pipefitter Helper	1.00	299.17	MH *		84.806	25,371						25,371
$170,636.89	0.0500 MH/LF		897.5100	MH		[2.136]	78,898	68,834		17,014	5,891		170,637
60.0013 Units/H	600.0134 Un/Shift		19.9998	Unit/M			4.40	3.83		0.95	0.33		9.51

COST REPORT

BID ITEM = 41072 Land Item SCHEDULE: 1 100
Description = HDPE Pipe Unit = LF Takeoff Quan: 18,505.000 Engr Quan: 18,505.000

Activity / Resource	Description	Pcs	Quantity Unit	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
4107202	**HDPE Pipe 2"**					**Quan: 13,000.00 LF**	**Hrs/Shft: 10.00**		**Cal: 50**	**WC: NONE**			
PIPEHD	HDPE Pipe Crew		130.00	CH	Eff: 100.00	**Risk %: 100.00 RF**		Lab Pcs: 3.00		Eqp Pcs: 2.00			
2HDPE02	2" HDPE, SDR 11@1		13,000.00	LF	0.0300	1.080		14,040					14,040
2MISC	Misc Material@108%		0.00	LOT		0.000							
8TRKGS10	Flatbed Truck 15K 20	1.00	130.00	HR		26.561				893	2,560		3,453
8XSTHDPE	HDPE Fusion Machin	1.00	130.00	HR		50.000				6,500			6,500
PF01	Pipefitter Foreman	1.00	130.00	MH *		90.124	11,716						11,716
PF02	Pipefitter	1.00	130.00	MH *		88.794	11,543						11,543
PF03	Pipefitter Helper	1.00	130.00	MH *		84.806	11,025						11,025
$58,277.09	0.0300 MH/LF		390.0000	MH		[1.282]	34,284	14,040		7,393	2,560		58,277
100.0000	Units/H		1,000.0000	Un/Shift	33.3333	Unit/M	2.64	1.08		0.57	0.20		4.48
4107204	**HDPE Pipe 6"**					**Quan: 9,400.00 LF**	**Hrs/Shft: 10.00**		**Cal: 50**	**WC: NONE**			
PIPEHD	HDPE Pipe Crew		250.66	CH	Eff: 100.00	**Risk %: 100.00 RF**		Lab Pcs: 3.00		Eqp Pcs: 2.00			
2HDPE06	6" HDPE, SDR 11@1		9,400.00	LF	0.0800	7.776		73,094					73,094
2MISC	Misc Material@108%		9.40	LOT		2,700.000		25,380					25,380
8TRKGS10	Flatbed Truck 15K 20	1.00	250.67	HR		26.561				1,722	4,936		6,658
8XSTHDPE	HDPE Fusion Machin	1.00	250.67	HR		50.000				12,534			12,534
PF01	Pipefitter Foreman	1.00	250.67	MH *		90.124	22,591						22,591
PF02	Pipefitter	1.00	250.67	MH *		88.794	22,258						22,258
PF03	Pipefitter Helper	1.00	250.67	MH *		84.806	21,258						21,258
$183,773.68	0.0800 MH/LF		752.0100	MH		[3.417]	66,108	98,474		14,256	4,936		183,774
37.5010	Units/H		375.0100	Un/Shift	12.4998	Unit/M	7.03	10.48		1.52	0.53		19.55
4107205	**HDPE Pipe 8"**					**Quan: 1,520.00 LF**	**Hrs/Shft: 10.00**		**Cal: 50**	**WC: NONE**			
PIPEHD	HDPE Pipe Crew		50.66	CH	Eff: 100.00	**Risk %: 100.00 RF**		Lab Pcs: 3.00		Eqp Pcs: 2.00			
2HDPE08	8" HDPE, SDR 11@1		1,520.00	LF	0.1000	13.284		20,192					20,192
2MISC	Misc Material@108%		1.52	LOT		2,700.000		4,104					4,104

COST REPORT

BID ITEM = 41072 Land Item SCHEDULE: 1 100
Description = HDPE Pipe Unit = LF Takeoff Quan: 18,505.000 Engr Quan: 18,505.000

Activity / Resource	Description	Pcs	Quantity / Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8TRKGS10	Flatbed Truck 15K 20	1.00	50.67 HR		26.561				348	998		1,346
8XSTHDPE	HDPE Fusion Machin	1.00	50.67 HR		50.000				2,534			2,534
PF01	Pipefitter Foreman	1.00	50.67 MH *		90.124	4,567						4,567
PF02	Pipefitter	1.00	50.67 MH *		88.794	4,499						4,499
PF03	Pipefitter Helper	1.00	50.67 MH *		84.806	4,297						4,297
$41,537.91	0.1000 MH/LF		152.0100 MH		[4.272]	13,363	24,296		2,882	998		41,538
30.0039 Units/H	300.0395 Un/Shift		9.9993 Unit/M			8.79	15.98		1.90	0.66		27.33
4107206	**HDPE Pipe 12"**		**Quan: 3,360.00 LF**			**Hrs/Shft: 10.00**		**Cal: 50**	**WC: NONE**			
PIPEHD	HDPE Pipe Crew		123.20 CH	Eff: 100.00	**Risk %: 100.00 RF**		Lab Pcs: 3.00		Eqp Pcs: 2.00			
2HDPE12	12" HDPE SDR 9@1		3,360.00 LF	0.1100	32.940		110,678					110,678
2MISC	Misc Material@108%		3.36 LOT		2,700.000		9,072					9,072
8TRKGS10	Flatbed Truck 15K 20	1.00	123.20 HR		26.561				846	2,426		3,272
8XSTHDPE	HDPE Fusion Machin	1.00	123.20 HR		50.000				6,160			6,160
PF01	Pipefitter Foreman	1.00	123.20 MH *		90.124	11,103						11,103
PF02	Pipefitter	1.00	123.20 MH *		88.794	10,939						10,939
PF03	Pipefitter Helper	1.00	123.20 MH *		84.806	10,448						10,448
$161,673.51	0.1100 MH/LF		369.6000 MH		[4.699]	32,491	119,750		7,006	2,426		161,674
27.2727 Units/H	272.7273 Un/Shift		9.0909 Unit/M			9.67	35.64		2.09	0.72		48.12
4107207	**Concrete Thrust Blocks**		**Quan: 20.00 LOC**			**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4CTB	Concrete Thrust Bloc		200.00 CY		400.000						80,000	80,000
=====> Item Totals: 41072	**- HDPE Pipe**											
$711,881.42	0.1473 MH/LF		2,726.13 MH		[6.213]	237,669	325,394	804	49,574	18,439	80,000	**711,881**
38.470	18505 LF					12.84	17.58	0.04	2.68	1.00	4.32	38.47

COST REPORT

BID ITEM = 41073 Land Item SCHEDULE: 1 100
Description = Mortar Lined Carbon Steel Pipe Unit = LF Takeoff Quan: 16,683.000 Engr Quan: 16,683.000

Summary Codes:

4107290 Clear/Prepare Pipe Routr Quan: 5,000.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 25.00 CH Eff: 100.00 **Prod: 200.0000 UH** Lab Pcs: 3.00 Eqp Pcs: 2.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
3ADD02	Add for Small Tools/		6,322.23	%	0.050			316				316
3LVLD	Level D Supplies@10		75.00	HR	1.080			81				81
8BDZR06R	Bulldozer Cat D6T X	1.00	25.00	HR	110.408				1,493	1,268		2,760
8TPUC14	F-150 FOREMAN PI	1.00	25.00	HR	7.100				178			178
EO01	Oper - Foreman	1.00	25.00	MH *	92.016	2,300						2,300
EO03	Oper - Dozer >50hp	1.00	25.00	MH *	90.663	2,267						2,267
LA10	Labor General	1.00	25.00	MH *	70.210	1,755						1,755
$9,657.04	0.0150 MH/LF		75.0000	MH	[0.586]	6,322		397	1,670	1,268		9,657
200.0000 Units/H*	2,000.0000 Un/Shift		66.6667	Unit/M		1.26		0.08	0.33	0.25		1.93

4107300 Furnish & Install Precast Supports Quan: 400.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

PF Pipefitter Crew 100.00 CH Eff: 100.00 **Prod: 4.0000 UH** Lab Pcs: 3.00 Eqp Pcs: 2.50

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2PPS	Ptrcast Pipe Supp@10		400.00	EA	1,620.000		648,000					648,000
8CRANERT525	Crane Grove RT525E	1.00	100.00	HR	80.667				4,002	4,065		8,067
8TRKGS10	Flatbed Truck 15K 20	1.00	100.00	HR	26.561				687	1,969		2,656
8TRKPU15	Pickup 4x4 3/4 Ton G	0.50	50.00	HR	19.634				231	751		982
LA10	Labor General	0.50	50.00	MH *	70.210	3,510						3,510
PF01	Pipefitter Foreman	0.50	50.00	MH *	90.124	4,506						4,506
PF02	Pipefitter	1.00	100.00	MH *	88.794	8,879						8,879
PF03	Pipefitter Helper	1.00	100.00	MH *	84.806	8,481						8,481
$685,081.23	0.7500 MH/EA		300.0000	MH	[30.24]	25,377	648,000		4,920	6,785		685,081
4.0000 Units/H*	40.0000 Un/Shift		1.3333	Unit/M		63.44	1,620.00		12.30	16.96		1,712.70

COST REPORT

BID ITEM = 41073 Land Item SCHEDULE: 1 100
Description = Mortar Lined Carbon Steel Pipe Unit = LF Takeoff Quan: 16,683.000 Engr Quan: 16,683.000

4107301 String CS Pipe Quan: 15,833.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 25.66 CH Eff: 100.00 **Prod: 2.5668 S** Lab Pcs: 5.50 Eqp Pcs: 2.50

Activity Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
3ADD02	Add for Small Tools/		10,716.32	%		0.050			536				536
3LVLD	Level D Supplies@10		141.18	HR		1.080			152				152
8LDRW930	Loader Cat 930H 2.6	1.00	25.67	HR		52.040				640	696		1,336
8TRKGS10	Flatbed Truck 15K 20	1.00	25.67	HR		26.561				176	505		682
8TRKPU15	Pickup 4x4 3/4 Ton G	0.50	12.83	HR		19.633				59	193		252
EO01	Oper - Foreman	0.50	12.83	MH *		92.016	1,181						1,181
EO06	Oper - FEL <2cy	1.00	25.67	MH *		90.663	2,327						2,327
LA10	Labor General	4.00	102.67	MH *		70.210	7,208						7,208
$13,674.17	0.0089 MH/LF		141.1700	MH		[0.301]	10,716		688	876	1,394		13,674
617.0304 Units/H	6,170.3040 Un/Shift		112.1557	Unit/M			0.68		0.04	0.06	0.09		0.86

4107302 2" CS Mortar Lined Pipe Quan: 13,000.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

PIPE Piping Crew 519.50 CH Eff: 100.00 **Risk %: 100.00 RF** Lab Pcs: 4.00 Eqp Pcs: 3.50

Activity Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2PCSLI02	Pipe, Lined Carbo@1		13,000.00	LF	0.1200	3.942		51,246					51,246
2PCSW02	Weld Carbon Steel@		370.00	EA	1.4000	5.400		1,998					1,998
3ADD02	Add for Small Tools/		181,061.64	%		0.050			9,053				9,053
3LVLD	Level D Supplies@10		2,078.00	HR		1.080			2,244				2,244
4PP02	Paint 2" Pipe		13,000.00	LF		1.500						19,500	19,500
8LF02	TH63 1.5tn Telescopi	0.50	259.75	HR		30.410				4,804	3,095		7,899
8TRKGS10	Flatbed Truck 15K 20	1.00	519.50	HR		26.561				3,569	10,229		13,798
8VX400	400amp Welding Mac	2.00	1,039.00	HR		7.137				2,155	5,260		7,415
PF01	Pipefitter Foreman	1.00	519.50	MH *		90.124	46,819						46,819
PF02	Pipefitter	1.00	519.50	MH *		88.794	46,129						46,129
PF03	Pipefitter Helper	2.00	1,039.00	MH *		84.806	88,114						88,114
$294,215.69	0.1598 MH/LF		2,078.0000	MH		[6.726]	181,062	53,244	11,297	10,528	18,585	19,500	294,216
25.0241 Units/H	250.2406 Un/Shift		6.2560	Unit/M			13.93	4.10	0.87	0.81	1.43	1.50	22.63

COST REPORT

BID ITEM = 41073 Land Item SCHEDULE: 1 100
Description = Mortar Lined Carbon Steel Pipe Unit = LF Takeoff Quan: 16,683.000 Engr Quan: 16,683.000

4107303 4" CS Mortar Lined Pipe Quan: 18,000.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
PIPE	Piping Crew		755.98	CH	Eff: 100.00	Risk %: 100.00 RF		Lab Pcs:	4.00	Eqp Pcs:	3.50		
2PCSLI04	Pipe, Lined Carbo@1		18,000.00	LF	0.1600	15.120		272,160					272,160
2PCSW04	Weld Carbon Steel@		514.00	EA	0.2800	8.640		4,441					4,441
3ADD02	Add for Small Tools/		263,482.11	%		0.050			13,174				13,174
3LVLD	Level D Supplies@10		3,023.92	HR		1.080			3,266				3,266
4PP04	Paint 4" Pipe		18,000.00	LF		2.250						40,500	40,500
8LF02	TH63 1.5tn Telescopi	0.50	377.99	HR		30.410				6,991	4,504		11,495
8TRKGS10	Flatbed Truck 15K 20	1.00	755.98	HR		26.561				5,194	14,886		20,080
8VX400	400amp Welding Mac	2.00	1,511.96	HR		7.137				3,136	7,655		10,791
PF01	Pipefitter Foreman	1.00	755.98	MH *		90.124	68,132						68,132
PF02	Pipefitter	1.00	755.98	MH *		88.794	67,127						67,127
PF03	Pipefitter Helper	2.00	1,511.96	MH *		84.806	128,224						128,224
$639,388.06	0.1679 MH/LF		3,023.9200	MH		[7.068]	263,482	276,601	16,440	15,320	27,045	40,500	639,388
23.8102 Units/H		238.1015 Un/Shift			5.9525 Unit/M		14.64	15.37	0.91	0.85	1.50	2.25	35.52

4107304 6" CS Mortar Lined Pipe Quan: 9,400.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
PIPE	Piping Crew		705.45	CH	Eff: 100.00	Risk %: 100.00 RF		Lab Pcs:	4.00	Eqp Pcs:	3.50		
2PCSLI06	Pipe, Lined Carbo@1		9,400.00	LF	0.1800	21.913		205,984					205,984
2PCSW06	Weld Carbon Steel@		269.00	EA	4.2000	10.800		2,905					2,905
3ADD02	Add for Small Tools/		245,870.88	%		0.050			12,294				12,294
3LVLD	Level D Supplies@10		2,821.80	HR		1.080			3,048				3,048
4PP06	Paint 6" Pipr		9,400.00	LF		3.000						28,200	28,200
8LF02	TH63 1.5tn Telescopi	0.50	352.73	HR		30.410				6,523	4,203		10,727
8TRKGS10	Flatbed Truck 15K 20	1.00	705.45	HR		26.561				4,846	13,891		18,737
8VX400	400amp Welding Mac	2.00	1,410.90	HR		7.137				2,926	7,143		10,070
PF01	Pipefitter Foreman	1.00	705.45	MH *		90.124	63,578						63,578
PF02	Pipefitter	1.00	705.45	MH *		88.794	62,640						62,640

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41073 Land Item SCHEDULE: 1 100
Description = Mortar Lined Carbon Steel Pipe Unit = LF Takeoff Quan: 16,683.000 Engr Quan: 16,683.000

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
PF03	Pipefitter Helper	2.00	1,410.90 MH *		84.806	119,653						119,653
$537,834.76	0.3001 MH/LF		2,821.8000 MH		[12.631]	245,871	208,889	15,341	14,296	25,238	28,200	537,835
13.3248 Units/H	133.2483 Un/Shift		3.3312 Unit/M			26.16	22.22	1.63	1.52	2.68	3.00	57.22

4107305 8" CS Mortar Lined Pipe Quan: 1,520.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

PIPE Piping Crew 136.20 CH Eff: 100.00 **Risk %: 100.00 RF** Lab Pcs: 4.00 Eqp Pcs: 3.50

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2PCSLI08	Pipe, Lined Carbo@1		1,520.00 LF	0.2000	32.313		49,117					49,117
2PCSW08	Weld Carbon Steel@		43.00 EA	5.6000	12.960		557					557
3ADD02	Add for Small Tools/		47,469.87 %		0.050			2,373				2,373
3LVLD	Level D Supplies@10		544.80 HR		1.080			588				588
4PP08	Paint 8" Pipe		1,520.00 LF		4.000						6,080	6,080
8LF02	TH63 1.5tn Telescopi	0.50	68.10 HR		30.410				1,259	811		2,071
8TRKGS10	Flatbed Truck 15K 20	1.00	136.20 HR		26.561				936	2,682		3,618
8VX400	400amp Welding Mac	2.00	272.40 HR		7.137				565	1,379		1,944
PF01	Pipefitter Foreman	1.00	136.20 MH *		90.124	12,275						12,275
PF02	Pipefitter	1.00	136.20 MH *		88.794	12,094						12,094
PF03	Pipefitter Helper	2.00	272.40 MH *		84.806	23,101						23,101
$113,818.30	0.3584 MH/LF		544.8000 MH		[15.081]	47,470	49,674	2,962	2,760	4,873	6,080	113,818
11.1601 Units/H	111.6006 Un/Shift		2.7900 Unit/M			31.23	32.68	1.95	1.82	3.21	4.00	74.88

4107306 12" CS Mortar Lined Pipe Quan: 2,906.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

PIPE Piping Crew 348.66 CH Eff: 100.00 **Risk %: 100.00 RF** Lab Pcs: 4.00 Eqp Pcs: 3.50

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2PCSLI12	Pipe, Lined Carbo@1		2,906.00 LF	0.2400	54.237		157,614					157,614
2PCSW12	Weld Carbon Steel@		83.00 EA	8.4000	21.600		1,793					1,793
3ADD02	Add for Small Tools/		121,518.67 %		0.050			6,076				6,076
3LVLD	Level D Supplies@10		1,394.64 HR		1.080			1,506				1,506
4PP12	Paint 12" Pipe		2,906.00 LF		7.000						20,342	20,342
8LF02	TH63 1.5tn Telescopi	0.50	174.33 HR		30.410				3,224	2,077		5,301
8TRKGS10	Flatbed Truck 15K 20	1.00	348.66 HR		26.561				2,395	6,865		9,261

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41073 Land Item SCHEDULE: 1 100
Description = Mortar Lined Carbon Steel Pipe Unit = LF Takeoff Quan: 16,683.000 Engr Quan: 16,683.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8VX400	400amp Welding Mac	2.00	697.32	HR	7.137				1,446	3,531		4,977
PF01	Pipefitter Foreman	1.00	348.66	MH *	90.124	31,423						31,423
PF02	Pipefitter	1.00	348.66	MH *	88.794	30,959						30,959
PF03	Pipefitter Helper	2.00	697.32	MH *	84.806	59,137						59,137
$328,388.92	0.4799 MH/LF		1,394.6400	MH	[20.193]	121,519	159,407	7,582	7,066	12,473	20,342	328,389
8.3348 Units/H		83.3477 Un/Shift		2.0837 Unit/M		41.82	54.85	2.61	2.43	4.29	7.00	113.00

=====> Item Totals: 41073 - Mortar Lined Carbon Steel Pipe

$2,622,058.17	0.6221 MH/LF	10,379.33 MH	[26.061]	901,818	1,395,815	54,708	57,434	97,660	114,622	**2,622,058**
157.169	16683 LF			54.06	83.67	3.28	3.44	5.85	6.87	157.17

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41075 Land Item SCHEDULE: 1 100
Description = Segment 6 Bore and Jack Unit = LF Takeoff Quan: 225.000 Engr Quan: 225.000

Summary Codes:

4107501 Jacking Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		30.00 CH	Eff: 0.00	**Prod: 3.0000 S**	Lab Pcs:	6.00		Eqp Pcs: 3.00			
3SHRENT	Sheet Piling Rent@10		8.00 TON		270.000			2,160				2,160
8EXC322	Excavator Cat 322C L	1.00	30.00 HR		96.595				1,592	1,305		2,898
8TRKGS10	Flatbed Truck 15K 20	1.00	30.00 HR		26.561				206	591		797
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	30.00 HR		19.634				138	451		589
EO01	Oper - Foreman	1.00	30.00 MH *		92.016	2,760						2,760
EO04	Oper - Excavator <3c	1.00	30.00 MH *		90.663	2,720						2,720
LA10	Labor General	4.00	120.00 MH *		70.210	8,425						8,425
$20,349.24	180.0000 MH/LS		180.0000 MH		[6229.08]	13,906		2,160	1,937	2,347		20,349
0.0333 Units/H	0.3333 Un/Shift		0.0056 Unit/M			13,905.54		2,160.00	1,936.80	2,346.90		20,349.24

4107502 Receiving Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		20.00 CH	Eff: 0.00	**Prod: 2.0000 S**	Lab Pcs:	4.00		Eqp Pcs: 3.00			
3SHRENT	Sheet Piling Rent@10		4.00 TON		270.000			1,080				1,080
8EXC322	Excavator Cat 322C L	1.00	20.00 HR		96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00 HR		26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00 HR		19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00 MH *		92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00 MH *		90.663	1,813						1,813
LA10	Labor General	2.00	40.00 MH *		70.210	2,808						2,808
$10,397.76	80.0000 MH/LS		80.0000 MH		[2945.8]	6,462		1,080	1,291	1,565		10,398
0.0500 Units/H	0.5000 Un/Shift		0.0125 Unit/M			6,461.96		1,080.00	1,291.20	1,564.60		10,397.76

4107503 Pipe Jacking Operation Quan: 225.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		150.75 CH	Eff: 100.00	**Prod: 14.9254 US**	Lab Pcs:	7.00		Eqp Pcs: 5.00			

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41075			Land Item		SCHEDULE: 1	100						
Description = Segment 6 Bore and Jack					Unit = LF	Takeoff Quan:	225.000		Engr Quan:	225.000		
2P24.375	Carbon Steel Pipe@1		225.00 LF		86.400		19,440					19,440
8DRBC	HORIZONTAL BOR	1.00	150.75 HR		60.000				7,538	1,508		9,045
8EXC322	Excavator Cat 322C L	1.00	150.75 HR		96.595				8,002	6,560		14,562
8TRKGS10	Flatbed Truck 15K 20	1.00	150.75 HR		26.561				1,036	2,968		4,004
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	150.75 HR		19.634				695	2,265		2,960
8W300	WELDER 300 AMP	1.00	150.75 HR		0.887				107	27		134
EO01	Oper - Foreman	1.00	150.75 MH *		92.016	13,871						13,871
EO04	Oper - Excavator <3c	1.00	150.75 MH *		90.663	13,667						13,667
LA10	Labor General	4.00	603.00 MH *		70.210	42,337						42,337
ME07	Welder	1.00	150.75 MH *		88.794	13,386						13,386
$133,405.28	4.6900 MH/LF	1,055.2500	MH		[168.228]	83,261	19,440		17,377	13,327		133,405
1.4925 Units/H	14.9254 Un/Shift *		0.2132 Unit/M			370.05	86.40		77.23	59.23		592.91
4107504	**HDPE Pipe & Conduits**		**Quan: 225.00 LF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
A	Custom Crew		33.96 CH	Eff: 100.00	**Prod: 3.3962 S**		Lab Pcs: 7.00		Eqp Pcs: 5.00			
2CENT	Centralizer Fabri@10		34.00 EA		162.000		5,508					5,508
2HDPE6	6" HDPE@108%		500.00 LF		3.240		1,620					1,620
2RGS2	2" Conduit, RGS@10		625.00 LF		8.100		5,063					5,063
8EXC322	Excavator Cat 322C L	1.00	33.96 HR		96.595				1,803	1,478		3,280
8TRKGS10	Flatbed Truck 15K 20	1.00	33.96 HR		26.561				233	669		902
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	33.96 HR		19.634				157	510		667
8W300	WELDER 300 AMP	1.00	33.96 HR		0.886				24	6		30
8XSTHDPE	HDPE Fusion Machin	1.00	33.96 HR		50.000				1,698			1,698
EO01	Oper - Foreman	1.00	33.96 MH *		92.016	3,125						3,125
EO04	Oper - Excavator <3c	1.00	33.96 MH *		90.662	3,079						3,079
LA10	Labor General	4.00	135.85 MH *		70.210	9,538						9,538
ME07	Welder	1.00	33.96 MH *		88.794	3,015						3,015
$37,524.86	1.0565 MH/LF	237.7300	MH		[37.899]	18,757	12,191		3,915	2,663		37,525
6.6254 Units/H	66.2544 Un/Shift		0.9465 Unit/M			83.37	54.18		17.40	11.83		166.78

COST REPORT

BID ITEM = 41075 Land Item SCHEDULE: 1 100
Description = Segment 6 Bore and Jack Unit = LF Takeoff Quan: 225.000 Engr Quan: 225.000

4107506 Grout Casing **Quan: 225.00 LF** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 16.98 CH Eff: 100.00 **Prod: 1.6981 S** Lab Pcs: 4.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2GROUT	Cement Grout@108%		679.25	CF		4.320		2,934					2,934
8CP622	GROUT PUMP 40 G	1.00	16.98	HR		8.769				110	39		149
8TRKGS10	Flatbed Truck 15K 20	1.00	16.98	HR		26.561				117	334		451
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	16.98	HR		19.634				78	255		333
EO01	Oper - Foreman	1.00	16.98	MH *		92.016	1,562						1,562
EO08	Oper - General Equip	1.00	16.98	MH *		90.216	1,532						1,532
LA10	Labor General	2.00	33.96	MH *		70.210	2,384						2,384
$9,346.19	0.3018 MH/LF		67.9200	MH		[11.088]	5,479	2,934		305	628		9,346
13.2509	Units/H		132.5088	Un/Shift	3.3127 Unit/M		24.35	13.04		1.36	2.79		41.54

4107507 Jacking Pit Closure **Quan: 1.00 LS** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 20.00 CH Eff: 0.00 **Prod: 2.0000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8CPH22	COMPACTOR PLAT	1.00	20.00	HR		5.432				31	77		109
8CPRB10	COMPACT STONE	1.00	20.00	HR		22.218				184	260		444
8CPST22	COMPT TRENCH B	1.00	20.00	HR		10.824				114	102		216
8EXC322	Excavator Cat 322C L	1.00	20.00	HR		96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00	HR		26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00	HR		19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00	MH *		92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00	MH *		90.663	1,813						1,813
LA10	Labor General	4.00	80.00	MH *		70.210	5,617						5,617
$12,895.64	120.0000 MH/LS		120.0000	MH		[4152.72]	9,270			1,621	2,005		12,896
0.0500	Units/H		0.5000	Un/Shift	0.0083 Unit/M		9,270.36			1,620.78	2,004.50		12,895.64

4107508 Receiving Pit Closure **Quan: 1.00 LS** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 15.00 CH Eff: 0.00 **Prod: 1.5000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41075			Land Item	SCHEDULE: 1		100						
Description = Segment 6 Bore and Jack				Unit = LF		Takeoff Quan: 225.000			Engr Quan: 225.000			
8CPH22	COMPACTOR PLAT	1.00	15.00	HR	5.432				24	58		81
8CPRB10	COMPACT STONE	1.00	15.00	HR	22.218				138	195		333
8CPST22	COMPT TRENCH B	1.00	15.00	HR	10.824				86	77		162
8EXC322	Excavator Cat 322C L	1.00	15.00	HR	96.595				796	653		1,449
8TRKGS10	Flatbed Truck 15K 20	1.00	15.00	HR	26.561				103	295		398
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	15.00	HR	19.634				69	225		295
EO01	Oper - Foreman	1.00	15.00	MH *	92.017	1,380						1,380
EO04	Oper - Excavator <3c	1.00	15.00	MH *	90.663	1,360						1,360
LA10	Labor General	4.00	60.00	MH *	70.210	4,213						4,213
$9,671.68	90.0000 MH/LS		90.0000	MH	[3114.54]	6,953			1,216	1,503		9,672
0.0667 Units/H		0.6667 Un/Shift		0.0111 Unit/M		6,952.78			1,215.58	1,503.32		9,671.68
=====> Item Totals:	**41075 - Segment 6 Bore and Jack**											
$233,590.65	8.1373 MH/LF		1,830.90	MH	[290.29]	144,088	34,565	3,240	27,661	24,037		**233,591**
1,038.181	225 LF					640.39	153.62	14.40	122.94	106.83		1,038.18

COST REPORT

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41076 Land Item SCHEDULE: 1 100

Description = Segment 8 Bore and Jack Unit = LF Takeoff Quan: 340.000 Engr Quan: 340.000

Summary Codes:

4107601 Jacking Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		30.00	CH	Eff: 0.00	**Prod: 3.0000 S**	Lab Pcs: 6.00		Eqp Pcs: 3.00				
3SHRENT	Sheet Piling Rent@10		8.00	TON		270.000			2,160				2,160
8EXC322	Excavator Cat 322C L	1.00	30.00	HR		96.595				1,592	1,305		2,898
8TRKGS10	Flatbed Truck 15K 20	1.00	30.00	HR		26.561				206	591		797
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	30.00	HR		19.634				138	451		589
EO01	Oper - Foreman	1.00	30.00	MH *		92.016	2,760						2,760
EO04	Oper - Excavator <3c	1.00	30.00	MH *		90.663	2,720						2,720
LA10	Labor General	4.00	120.00	MH *		70.210	8,425						8,425
$20,349.24	180.0000 MH/LS		180.0000	MH		[6229.08]	13,906		2,160	1,937	2,347		20,349
0.0333 Units/H	0.3333 Un/Shift		0.0056 Unit/M				13,905.54		2,160.00	1,936.80	2,346.90		20,349.24

4107602 Receiving Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		20.00	CH	Eff: 0.00	**Prod: 2.0000 S**	Lab Pcs: 4.00		Eqp Pcs: 3.00				
3SHRENT	Sheet Piling Rent@10		4.00	TON		270.000			1,080				1,080
8EXC322	Excavator Cat 322C L	1.00	20.00	HR		96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00	HR		26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00	HR		19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00	MH *		92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00	MH *		90.663	1,813						1,813
LA10	Labor General	2.00	40.00	MH *		70.210	2,808						2,808
$10,397.76	80.0000 MH/LS		80.0000	MH		[2945.8]	6,462		1,080	1,291	1,565		10,398
0.0500 Units/H	0.5000 Un/Shift		0.0125 Unit/M				6,461.96		1,080.00	1,291.20	1,564.60		10,397.76

4107603 Pipe Jacking Operation Quan: 340.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		227.80	CH	Eff: 100.00	**Prod: 14.9254 US**	Lab Pcs: 7.00		Eqp Pcs: 5.00				

Activity Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41076 Land Item SCHEDULE: 1 100
Description = Segment 8 Bore and Jack Unit = LF Takeoff Quan: 340.000 Engr Quan: 340.000

Activity Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2P24.375	Carbon Steel Pipe@1		340.00 LF		86.400		29,376					29,376
8DRBC	HORIZONTAL BOR	1.00	227.80 HR		60.000				11,390	2,278		13,668
8EXC322	Excavator Cat 322C L	1.00	227.80 HR		96.595				12,092	9,913		22,004
8TRKGS10	Flatbed Truck 15K 20	1.00	227.80 HR		26.561				1,565	4,486		6,051
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	227.80 HR		19.634				1,050	3,422		4,473
8W300	WELDER 300 AMP	1.00	227.80 HR		0.887				162	40		202
EO01	Oper - Foreman	1.00	227.80 MH *		92.016	20,961						20,961
EO04	Oper - Excavator <3c	1.00	227.80 MH *		90.663	20,653						20,653
LA10	Labor General	4.00	911.20 MH *		70.210	63,975						63,975
ME07	Welder	1.00	227.80 MH *		88.794	20,227						20,227
$201,590.23	4.6900 MH/LF	1,594.6000	MH		[168.228]	125,817	29,376		26,258	20,139		201,590
1.4925 Units/H		14.9254 Un/Shift *		0.2132 Unit/M		370.05	86.40		77.23	59.23		592.91

4107604 HDPE Pipe & Conduits **Quan: 340.00 LF** **Hrs/Shft: 10.00** **Cal: 510** **WC: NONE**

Activity Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
A	Custom Crew		51.32 CH	Eff: 100.00	**Prod: 5.1321 S**	Lab Pcs:	7.00	Eqp Pcs:	5.00			
2CENT	Centralizer Fabri@10		52.00 EA		162.000		8,424					8,424
2HDPE6	6" HDPE@108%		755.00 LF		3.240		2,446					2,446
2RGS2	2" Conduit, RGS@10		944.00 LF		8.100		7,646					7,646
8EXC322	Excavator Cat 322C L	1.00	51.32 HR		96.595				2,724	2,233		4,957
8TRKGS10	Flatbed Truck 15K 20	1.00	51.32 HR		26.561				353	1,011		1,363
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	51.32 HR		19.634				237	771		1,008
8W300	WELDER 300 AMP	1.00	51.32 HR		0.887				36	9		45
8XSTHDPE	HDPE Fusion Machin	1.00	51.32 HR		50.000				2,566			2,566
EO01	Oper - Foreman	1.00	51.32 MH *		92.016	4,722						4,722
EO04	Oper - Excavator <3c	1.00	51.32 MH *		90.663	4,653						4,653
LA10	Labor General	4.00	205.28 MH *		70.210	14,413						14,413
ME07	Welder	1.00	51.32 MH *		88.794	4,557						4,557
$56,800.68	1.0565 MH/LF	359.2400	MH		[37.899]	28,345	18,517		5,916	4,024		56,801
6.6251 Units/H		66.2510 Un/Shift		0.9464 Unit/M		83.37	54.46		17.40	11.83		167.06

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41076 Land Item SCHEDULE: 1 100
Description = Segment 8 Bore and Jack Unit = LF Takeoff Quan: 340.000 Engr Quan: 340.000

4107606 Grout Casing **Quan: 225.00 LF** **Hrs/Shft: 10.00** **Cal: 510 WC: NONE**

A Custom Crew 16.98 CH Eff: 0.00 **Prod: 1.6981 S** Lab Pcs: 4.00 Eqp Pcs: 3.00

Resource	Description	Pcs	Quantity	Unit	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2GROUT	Cement Grout@108%		679.25	CF	4.320		2,934					2,934
8CP622	GROUT PUMP 40 G	1.00	16.98	HR	8.769				110	39		149
8TRKGS10	Flatbed Truck 15K 20	1.00	16.98	HR	26.561				117	334		451
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	16.98	HR	19.634				78	255		333
EO01	Oper - Foreman	1.00	16.98	MH *	92.016	1,562						1,562
EO08	Oper - General Equip	1.00	16.98	MH *	90.216	1,532						1,532
LA10	Labor General	2.00	33.96	MH *	70.210	2,384						2,384
$9,346.19	0.3018 MH/LF		67.9200	MH	[11.088]	5,479	2,934		305	628		9,346
13.2509 Units/H	132.5088 Un/Shift		3.3127	Unit/M		24.35	13.04		1.36	2.79		41.54

4107607 Jacking Pit Closure **Quan: 1.00 LS** **Hrs/Shft: 10.00** **Cal: 510 WC: NONE**

A Custom Crew 20.00 CH Eff: 0.00 **Prod: 2.0000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

Resource	Description	Pcs	Quantity	Unit	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8CPH22	COMPACTOR PLAT	1.00	20.00	HR	5.432				31	77		109
8CPRB10	COMPACT STONE	1.00	20.00	HR	22.218				184	260		444
8CPST22	COMPT TRENCH B	1.00	20.00	HR	10.824				114	102		216
8EXC322	Excavator Cat 322C L	1.00	20.00	HR	96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00	HR	26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00	HR	19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00	MH *	92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00	MH *	90.663	1,813						1,813
LA10	Labor General	4.00	80.00	MH *	70.210	5,617						5,617
$12,895.64	120.0000 MH/LS		120.0000	MH	[4152.72]	9,270			1,621	2,005		12,896
0.0500 Units/H	0.5000 Un/Shift		0.0083	Unit/M		9,270.36			1,620.78	2,004.50		12,895.64

4107608 Receiving Pit Closure **Quan: 1.00 LS** **Hrs/Shft: 10.00** **Cal: 510 WC: NONE**

A Custom Crew 15.00 CH Eff: 0.00 **Prod: 1.5000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

COST REPORT

BID ITEM = 41076 Land Item SCHEDULE: 1 100
Description = Segment 8 Bore and Jack Unit = LF Takeoff Quan: 340.000 Engr Quan: 340.000

Activity Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8CPH22	COMPACTOR PLAT	1.00	15.00	HR	5.432				24	58		81
8CPRB10	COMPACT STONE	1.00	15.00	HR	22.218				138	195		333
8CPST22	COMPT TRENCH B	1.00	15.00	HR	10.824				86	77		162
8EXC322	Excavator Cat 322C L	1.00	15.00	HR	96.595				796	653		1,449
8TRKGS10	Flatbed Truck 15K 20	1.00	15.00	HR	26.561				103	295		398
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	15.00	HR	19.634				69	225		295
EO01	Oper - Foreman	1.00	15.00	MH *	92.017	1,380						1,380
EO04	Oper - Excavator <3c	1.00	15.00	MH *	90.663	1,360						1,360
LA10	Labor General	4.00	60.00	MH *	70.210	4,213						4,213
$9,671.68	90.0000 MH/LS		90.0000	MH	[3114.54]	6,953			1,216	1,503		9,672
0.0667 Units/H	0.6667 Un/Shift		0.0111	Unit/M		6,952.78			1,215.58	1,503.32		9,671.68

=====> Item Totals: 41076 - Segment 8 Bore and Jack

$321,051.42	7.3287 MH/LF	2,491.76 MH	[261.824]	196,231	50,827	3,240	38,544	32,210		**321,051**
944.269	340 LF			577.15	149.49	9.53	113.36	94.74		944.27

COST REPORT

BID ITEM = 41077 Land Item SCHEDULE: 1 100
Description = Segment 15 Bore and Jack Unit = LF Takeoff Quan: 286.000 Engr Quan: 286.000

Summary Codes:

4107701 Jacking Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 30.00 CH Eff: 0.00 **Prod: 3.0000 S** Lab Pcs: 6.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
3SHRENT	Sheet Piling Rent@10		8.00 TON		270.000			2,160				2,160
8EXC322	Excavator Cat 322C L	1.00	30.00 HR		96.595				1,592	1,305		2,898
8TRKGS10	Flatbed Truck 15K 20	1.00	30.00 HR		26.561				206	591		797
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	30.00 HR		19.634				138	451		589
EO01	Oper - Foreman	1.00	30.00 MH *		92.016	2,760						2,760
EO04	Oper - Excavator <3c	1.00	30.00 MH *		90.663	2,720						2,720
LA10	Labor General	4.00	120.00 MH *		70.210	8,425						8,425
$20,349.24	180.0000 MH/LS		180.0000 MH		[6229.08]	13,906		2,160	1,937	2,347		20,349
0.0333 Units/H		0.3333 Un/Shift		0.0056 Unit/M		13,905.54		2,160.00	1,936.80	2,346.90		20,349.24

4107702 Receiving Pit Installation Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 20.00 CH Eff: 0.00 **Prod: 2.0000 S** Lab Pcs: 4.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
3SHRENT	Sheet Piling Rent@10		4.00 TON		270.000			1,080				1,080
8EXC322	Excavator Cat 322C L	1.00	20.00 HR		96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00 HR		26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00 HR		19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00 MH *		92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00 MH *		90.663	1,813						1,813
LA10	Labor General	2.00	40.00 MH *		70.210	2,808						2,808
$10,397.76	80.0000 MH/LS		80.0000 MH		[2945.8]	6,462		1,080	1,291	1,565		10,398
0.0500 Units/H		0.5000 Un/Shift		0.0125 Unit/M		6,461.96		1,080.00	1,291.20	1,564.60		10,397.76

4107703 Pipe Jacking Operation Quan: 286.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

A Custom Crew 191.62 CH Eff: 100.00 **Prod: 14.9254 US** Lab Pcs: 7.00 Eqp Pcs: 5.00

COST REPORT

BID ITEM = 41077 Land Item SCHEDULE: 1 100
Description = Segment 15 Bore and Jack Unit = LF Takeoff Quan: 286.000 Engr Quan: 286.000

Activity Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2P24.375	Carbon Steel Pipe@1		286.00	LF	86.400		24,710					24,710
8DRBC	HORIZONTAL BOR	1.00	191.62	HR	60.000				9,581	1,916		11,497
8EXC322	Excavator Cat 322C L	1.00	191.62	HR	96.595				10,171	8,338		18,510
8TRKGS10	Flatbed Truck 15K 20	1.00	191.62	HR	26.561				1,316	3,773		5,090
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	191.62	HR	19.634				883	2,879		3,762
8W300	WELDER 300 AMP	1.00	191.62	HR	0.887				136	34		170
EO01	Oper - Foreman	1.00	191.62	MH *	92.016	17,632						17,632
EO04	Oper - Excavator <3c	1.00	191.62	MH *	90.663	17,373						17,373
LA10	Labor General	4.00	766.48	MH *	70.210	53,814						53,814
ME07	Welder	1.00	191.62	MH *	88.794	17,015						17,015
$169,572.95	4.6900 MH/LF		1,341.3400	MH	[168.228]	105,834	24,710		22,088	16,940		169,573
1.4925 Units/H	14.9254 Un/Shift *		0.2132	Unit/M		370.05	86.40		77.23	59.23		592.91

4107704 HDPE Pipe & Conduits **Quan: 286.00 LF** **Hrs/Shft: 10.00** **Cal: 510** **WC: NONE**

A Custom Crew 43.16 CH Eff: 100.00 **Prod: 4.3170 S** Lab Pcs: 7.00 Eqp Pcs: 5.00

Activity Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2CENT	Centralizer Fabri@10		44.00	EA	162.000		7,128					7,128
2HDPE6	6" HDPE@108%		636.00	LF	3.240		2,061					2,061
2RGS2	2" Conduit, RGS@10		795.00	LF	8.100		6,440					6,440
8EXC322	Excavator Cat 322C L	1.00	43.17	HR	96.595				2,291	1,879		4,170
8TRKGS10	Flatbed Truck 15K 20	1.00	43.17	HR	26.561				297	850		1,147
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	43.17	HR	19.634				199	649		848
8W300	WELDER 300 AMP	1.00	43.17	HR	0.887				31	8		38
8XSTHDPE	HDPE Fusion Machin	1.00	43.17	HR	50.000				2,159			2,159
EO01	Oper - Foreman	1.00	43.17	MH *	92.016	3,972						3,972
EO04	Oper - Excavator <3c	1.00	43.17	MH *	90.662	3,914						3,914
LA10	Labor General	4.00	172.68	MH *	70.210	12,124						12,124
ME07	Welder	1.00	43.17	MH *	88.794	3,833						3,833
$47,832.39	1.0566 MH/LF		302.1900	MH	[37.9]	23,843	15,628		4,976	3,385		47,832
6.6265 Units/H	66.2651 Un/Shift		0.9464	Unit/M		83.37	54.64		17.40	11.83		167.25

COST REPORT

BID ITEM = 41077 Land Item SCHEDULE: 1 100
Description = Segment 15 Bore and Jack Unit = LF Takeoff Quan: 286.000 Engr Quan: 286.000

4107706 Grout Casing **Quan: 286.00 LF** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 21.58 CH Eff: 100.00 **Prod: 2.1585 S** Lab Pcs: 4.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2GROUT	Cement Grout@108%		863.40	CF	4.320		3,730					3,730
8CP622	GROUT PUMP 40 G	1.00	21.58	HR	8.769				140	49		189
8TRKGS10	Flatbed Truck 15K 20	1.00	21.58	HR	26.561				148	425		573
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	21.58	HR	19.633				99	324		424
EO01	Oper - Foreman	1.00	21.58	MH *	92.016	1,986						1,986
EO08	Oper - General Equip	1.00	21.58	MH *	90.216	1,947						1,947
LA10	Labor General	2.00	43.17	MH *	70.210	3,031						3,031
$11,879.46	0.3018 MH/LF		86.3300	MH	[11.087]	6,964	3,730		388	798		11,879
13.2530 Units/H	132.5301 Un/Shift		3.3129	Unit/M		24.35	13.04		1.36	2.79		41.54

4107707 Jacking Pit Closure **Quan: 1.00 LS** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 20.00 CH Eff: 0.00 **Prod: 2.0000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8CPH22	COMPACTOR PLAT	1.00	20.00	HR	5.432				31	77		109
8CPRB10	COMPACT STONE	1.00	20.00	HR	22.218				184	260		444
8CPST22	COMPT TRENCH B	1.00	20.00	HR	10.824				114	102		216
8EXC322	Excavator Cat 322C L	1.00	20.00	HR	96.595				1,062	870		1,932
8TRKGS10	Flatbed Truck 15K 20	1.00	20.00	HR	26.561				137	394		531
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	20.00	HR	19.634				92	300		393
EO01	Oper - Foreman	1.00	20.00	MH *	92.016	1,840						1,840
EO04	Oper - Excavator <3c	1.00	20.00	MH *	90.663	1,813						1,813
LA10	Labor General	4.00	80.00	MH *	70.210	5,617						5,617
$12,895.64	120.0000 MH/LS		120.0000	MH	[4152.72]	9,270			1,621	2,005		12,896
0.0500 Units/H	0.5000 Un/Shift		0.0083	Unit/M		9,270.36			1,620.78	2,004.50		12,895.64

4107708 Receiving Pit Closure **Quan: 1.00 LS** **Hrs/Shft:** 10.00 **Cal: 510 WC: NONE**

A Custom Crew 15.00 CH Eff: 0.00 **Prod: 1.5000 S** Lab Pcs: 6.00 Eqp Pcs: 6.00

COST REPORT

Activity Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41077			Land Item		SCHEDULE: 1	100						
Description = Segment 15 Bore and Jack			Unit = LF			Takeoff Quan:	286.000		Engr Quan:	286.000		
8CPH22	COMPACTOR PLAT	1.00	15.00	HR	5.432				24	58		81
8CPRB10	COMPACT STONE	1.00	15.00	HR	22.218				138	195		333
8CPST22	COMPT TRENCH B	1.00	15.00	HR	10.824				86	77		162
8EXC322	Excavator Cat 322C L	1.00	15.00	HR	96.595				796	653		1,449
8TRKGS10	Flatbed Truck 15K 20	1.00	15.00	HR	26.561				103	295		398
8TRKPU15	Pickup 4x4 3/4 Ton G	1.00	15.00	HR	19.634				69	225		295
EO01	Oper - Foreman	1.00	15.00	MH *	92.017	1,380						1,380
EO04	Oper - Excavator <3c	1.00	15.00	MH *	90.663	1,360						1,360
LA10	Labor General	4.00	60.00	MH *	70.210	4,213						4,213
$9,671.68	90.0000 MH/LS		90.0000	MH	[3114.54]	6,953			1,216	1,503		9,672
0.0667 Units/H		0.6667 Un/Shift		0.0111 Unit/M		6,952.78			1,215.58	1,503.32		9,671.68
=====> Item Totals: 41077 - Segment 15 Bore and Jack												
$282,599.12	7.6918 MH/LF		2,199.86	MH	[274.705]	173,232	44,068	3,240	33,516	28,543		**282,599**
988.109	286 LF					605.70	154.09	11.33	117.19	99.80		988.11

COST REPORT

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41083 Land Item SCHEDULE: 1 100
Description = Bridge Attachment Pipe Unit = LF Takeoff Quan: 850.000 Engr Quan: 850.000

Summary Codes:

41083 Pipe On Bridge Quan: 850.00 LF Hrs/Shft: 10.00 Cal: 510 WC: NONE

PF Pipefitter Crew 271.12 CH Eff: 100.00 **Risk %: 100.00 RF** Lab Pcs: 3.00 Eqp Pcs: 2.50

Activity / Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2PCS12	Pipe, steel, blac@108		850.00 L.F.	0.8890	88.020		74,817					74,817
2PCSCP12	Coupling, steel, @108		45.00 EA.	0.7500	143.640		6,464					6,464
2PCSGV12	Pipe, cut one gro@10		45.00 EA.	0.5330	0.000							
4FABSUPPORT	Fab Installation Roller		1.00 LS		50,000.000						50,000	50,000
8CRANERT525	Crane Grove RT525E	1.00	271.13 HR		80.667				10,851	11,021		21,871
8TRKGS10	Flatbed Truck 15K 20	1.00	271.13 HR		26.561				1,863	5,339		7,201
8TRKPU15	Pickup 4x4 3/4 Ton G	0.50	135.56 HR		19.634				625	2,037		2,662
LA10	Labor General	0.50	135.56 MH *		70.210	9,518						9,518
PF01	Pipefitter Foreman	0.50	135.56 MH *		90.124	12,217						12,217
PF02	Pipefitter	1.00	271.13 MH *		88.794	24,075						24,075
PF03	Pipefitter Helper	1.00	271.13 MH *		84.806	22,994						22,994
$231,818.15	0.9569 MH/LF		813.3800 MH		[38.583]	68,803	81,281		13,338	18,396	50,000	231,818
3.1351 Units/H	31.3514 Un/Shift		1.0450 Unit/M			80.94	95.62		15.69	21.64	58.82	272.73

=====> Item Totals: 41083 - Bridge Attachment Pipe

$231,818.15	0.9569 MH/LF		813.38 MH		[38.583]	68,803	81,281		13,338	18,396	50,000	**231,818**
272.727	850 LF					80.94	95.62		15.69	21.64	58.82	272.73

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41085 Land Item SCHEDULE: 1 100
Description = Install New Monitoring Wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
41085	**Install New Monitoring Wells**	**Quan: 28.00**	**WELL**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**						
4MW	Install Monitoring We	28.00	EA		60,800.000						1,702,400	1,702,400

COST REPORT

Activity Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41091 Land Item SCHEDULE: 1 100
Description = Organ Carbon Sunst Amend Sys (MW-20) Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

321112 NTH System Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
5NTH	NTH System	1.00	LS		1,659,200.000			1,659,200				1,659,200

=====> Item Totals: 41091 - Organ Carbon Sunst Amend Sys (MW-20)

$1,659,200.00		[ ]		1,659,200				**1,659,200**
1,659,200.000	1 LS			1,659,200.00				1,659,200.00

COST REPORT

Activity / Resource	Description	Quantity / Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41092 Land Item SCHEDULE: 1 100
Description = Organ Carbon Subst Amend Sys (Transwest Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

Activity / Resource	Description	Quantity / Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
321112	**TW System**	**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
5TW	TW System	1.00	LS		832,900.000			832,900				832,900

=====> Item Totals: 41092 - Organ Carbon Subst Amend Sys (Transwest

$832,900.00		[ ]			832,900	**832,900**
832,900.000	1 LS				832,900.00	832,900.00

COST REPORT

BID ITEM = 41093 Land Item SCHEDULE: 1 100
Description = Remedy WWTP Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

34220.10 Raw Water Tanks (Infuent Storage Tanks) Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

PROC01 Process equip install crew 80.00 CH Eff: 0.00 **Prod: 0.0000** Lab Pcs: 4.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2CHMPIPE	Caustic piping@108		150.00	LF		5.400		810					810
2CHMPIPEFIT	Causftic pipe val@10		1.00	LS		1,620.000		1,620					1,620
2FLMTR	4" Flow meter@108%		4.00	EA		3,780.000		15,120					15,120
2MAGMTR	4" Mag meter@108%		1.00	EA		16,200.000		16,200					16,200
2PFILTER	To filter system @108		300.00	LF		27.000		8,100					8,100
2PFLTERVF	To filter sys val@108		1.00	LS		1,620.000		1,620					1,620
2PIPE	4" PVC Raw Water		150.00	LF		16.200		2,430					2,430
2PSOLSEP	Solid separator p@10		150.00	LF		27.000		4,050					4,050
2PSOLSEPVF	Solid sep valves @10		1.00	LS		1,620.000		1,620					1,620
2PU001	Raw water influen@1		1.00	EA		16,200.000		16,200					16,200
2TRKCON	Truck connection@10		1.00	LS		1,620.000		1,620					1,620
2VLV	4" PVC valves & f@1		1.00	LS		3,780.000		3,780					3,780
4CONC0010	Concrete sub, conc in		65.00	CY		500.000						32,500	32,500
4TAFR	Frac storage tanks		4.00	EA		42,500.000						170,000	170,000
8FORK02	Forklift Cat TH220B	1.00	80.00	HR		30.411				1,184	1,249		2,433
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	80.00	HR		18.177				282	1,173		1,454
8TRKPU30	PU Crew 4x2 3/4 Ton	1.00	80.00	HR		14.576				381	785		1,166
EO07	Oper - FEL >2cy	1.00	80.00	MH	*	90.663	7,253						7,253
PF01	Pipefitter Foreman	1.00	80.00	MH	*	90.124	7,210						7,210
PF02	Pipefitter	1.00	80.00	MH	*	88.794	7,104						7,104
PF03	Pipefitter Helper	1.00	80.00	MH	*	84.806	6,785						6,785
$309,074.06	320.0000 MH/LS		320.0000	MH		[13685.76]	28,351	73,170		1,846	3,207	202,500	309,074
0.0125 Units/H	0.1250 Un/Shift		0.0031	Unit/M			28,350.94	73,170.00		1,846.40	3,206.72	202,500.00	309,074.06

COST REPORT

BID ITEM = 41093 Land Item SCHEDULE: 1 100
Description = Remedy WWTP Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
34220.15	**Instrumentation, Raw Water Tanks**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4ICIO	I/O		21.00	EA	1,500.000						31,500	31,500
34220.20	**Remedy WWTP Buidling (houses fitlers)**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4BUILD	Building subcontracte		2,000.00	SF	250.000						500,000	500,000
34220.30	**Remedy WWTP Building - Fitler System**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
PROCEQ	Process equip install crew		160.00	CH	Eff: 0.00 **Prod: 0.0000**		Lab Pcs:	6.00	Eqp Pcs:	3.00		
2FLTR	Coarse filters@108%		2.00	EA	27,000.000		54,000					54,000
2FLTR1	Fine filters@108%		2.00	EA	27,000.000		54,000					54,000
2MAGMTR1	Filter mag meter@10		1.00	EA	8,100.000		8,100					8,100
2PIPE1	Filter piping@108%		200.00	LF	54.000		10,800					10,800
2PIPE2	To Treated Water @1		150.00	LF	27.000		4,050					4,050
2PIPE2VF	To Treat Wtr Tank@		1.00	LS	1,620.000		1,620					1,620
2PIPEVF	Filter pipe valve@108		1.00	LS	2,700.000		2,700					2,700
2PU002	Filter feed pumps@10		2.00	EA	8,100.000		16,200					16,200
8FORK02	Forklift Cat TH220B	1.00	160.00	HR	30.411				2,368	2,498		4,866
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	160.00	HR	18.177				563	2,345		2,908
8TRKPU30	PU Crew 4x2 3/4 Ton	1.00	160.00	HR	14.576				762	1,571		2,332
EO07	Oper - FEL >2cy	1.00	160.00	MH *	90.663	14,506						14,506
PF01	Pipefitter Foreman	1.00	160.00	MH *	90.124	14,420						14,420
PF02	Pipefitter	3.00	480.00	MH *	88.794	42,621						42,621
PF03	Pipefitter Helper	1.00	160.00	MH *	84.806	13,569						13,569
$246,692.31	960.0000 MH/LS		960.0000	MH	[41275.52]	85,116	151,470		3,693	6,413		246,692
0.0063 Units/H	0.0625 Un/Shift		0.0010	Unit/M		85,116.07	151,470.00		3,692.80	6,413.44		246,692.31
34220.35	**Instrumentation, Filter System**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4ICIO	I/O		20.00	EA	1,500.000						30,000	30,000

COST REPORT

BID ITEM = 41093 Land Item SCHEDULE: 1 100
Description = Remedy WWTP Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
34220.40	**Treated Water Tanks**		**Quan: 1.00**	**AL**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
2XXAL	Allow - Treat Wtr@1		1.00	AL	16,200.000		16,200					16,200
34220.50	**Truck fill stations**		**Quan: 1.00**	**AL**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
2XXAL3	Truck fill statio@108		1.00	AL	81,000.000		81,000					81,000
34220.60	**Caustic system**		**Quan: 1.00**	**AL**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
2XXAL2	Caustic system al@10		1.00	AL	81,000.000		81,000					81,000
34220.70	**Liquid phase separator**		**Quan: 2.00**	**EA**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
PROCEQ	Process equip install crew		80.00	CH Eff: 0.00	**Prod: 0.0000**		Lab Pcs: 6.00		Eqp Pcs: 3.00			
2MECHLPS	Liquid phase sepa@1		2.00	EA	162,000.000		324,000					324,000
8FORK02	Forklift Cat TH220B	1.00	80.00	HR	30.411				1,184	1,249		2,433
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	80.00	HR	18.177				282	1,173		1,454
8TRKPU30	PU Crew 4x2 3/4 Ton	1.00	80.00	HR	14.576				381	785		1,166
EO07	Oper - FEL >2cy	1.00	80.00	MH *	90.663	7,253						7,253
PF01	Pipefitter Foreman	1.00	80.00	MH *	90.124	7,210						7,210
PF02	Pipefitter	3.00	240.00	MH *	88.794	21,311						21,311
PF03	Pipefitter Helper	1.00	80.00	MH *	84.806	6,785						6,785
$371,611.15	240.0000 MH/EA		480.0000	MH	[10318.88]	42,558	324,000		1,846	3,207		371,611
0.0250 Units/H	0.2500 Un/Shift		0.0042	Unit/M		21,279.02	162,000.00		923.20	1,603.36		185,805.58
34220.75	**Instruments Caustic/ Liquid Phase Sep.**		**Quan: 1.00**	**LS**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4ICIO	I/O		11.00	EA	1,500.000						16,500	16,500
34220.80	**Relocated pipe storage area - SOG & PEB**		**Quan: 338.00**	**SF**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4CONC0010	Concrete sub, conc in		12.00	CY	500.000						6,000	6,000
4PEB	Pre Engineered Bldg		400.00	SF	75.000						30,000	30,000

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41093	Land Item SCHEDULE: 1 100											
Description = Remedy WWTP	Unit = LS	Takeoff Quan: 1.000	Engr Quan: 1.000									
$36,000.00					[ ]						36,000	36,000
											106.51	106.51
34220.82	**Construct Retaining Wall**	**Quan: 166.00 LF**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4CONC	Concrete Sub	75.00	CY		1,100.000						82,500	82,500
34220.85	**Operations Building**	**Quan: 1,200.00 SF**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4BLDG2	Operations Building	1,200.00	SF		350.000						420,000	420,000
34220.90	**Maintenance shop - building**	**Quan: 1.00 LS**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4BUILD1	Maintenance shop	1,000.00	SF		250.000						250,000	250,000
34220.92	**Elec Equip & Gen - remod exist TCS build**	**Quan: 1,000.00 SF**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4BUILDREMOD	Elec & gen bld - exist	1,000.00	SF		175.000						175,000	175,000
34220.93	**Hazardous Waste**	**Quan: 1,000.00 SF**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4BUILD3	Hazardous waste buil	1,152.00	SF		250.000						288,000	288,000
34220.95	**Instrumentation Treated H2O Distribution**	**Quan: 1.00 LS**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**							
4ICIO	I/O	16.00	EA		1,500.000						24,000	24,000
=====> Item Totals:	**41093 - Remedy WWTP**											
$2,959,077.52	1,760.0000 MH/LS	1,760.00	MH		[75599.04]	156,025	726,840		7,386	12,827	2,056,000	**2,959,078**
2,959,077.520	1 LS					156,025.04	726,840.00		7,385.60	12,826.88	2,056,000.00	2,959,077.52

COST REPORT

BID ITEM = 41096 Land Item SCHEDULE: 1 100
Description = Elect power - wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

35104.05 Ground water switchboard Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

ELEC01 Electrical crew 8.00 CH Eff: 0.00 **Prod: 0.0000** Lab Pcs: 4.00 Eqp Pcs: 2.00

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2ELECBRKR	Breaker, 800 amp @1		1.00	EA		5,400.000		5,400					5,400
2ELECWRG	Conduit, wiring, @10		1.00	EA		2,700.000		2,700					2,700
8SLIFT30	Scissor Lift 30' 1500#	1.00	8.00	HR		14.917				81	38		119
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	8.00	HR		18.177				28	117		145
ELEC	Electrical Journeyman	1.00	8.00	MH *		75.809	606						606
ELEC1	Electrician apprentice	2.00	16.00	MH *		74.493	1,192						1,192
ELEC2	Electrical apprentice	1.00	8.00	MH *		73.176	585						585
$10,748.49	32.0000 MH/LS		32.0000	MH		[1270.72]	2,384	8,100		109	156		10,748
0.1250 Units/H	1.2500 Un/Shift				0.0313 Unit/M		2,383.77	8,100.00		109.12	155.60		10,748.49

35104.11 XFMR 099 Quan: 1.00 EA Hrs/Shft: 10.00 Cal: 510 WC: NONE

ELECSI Electrical site crew 16.00 CH Eff: 0.00 **Prod: 0.0000** Lab Pcs: 5.00 Eqp Pcs: 3.00

Activity / Resource	Description	Pcs	Quantity	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
2ELECSWTCH	Switchbrd, breake@1		1.00	EA		43,200.000		43,200					43,200
2ELECWRG	Conduit, wiring, @10		1.00	EA		2,700.000		2,700					2,700
2ELECXFMR04	Xfmr, 750 kVA@108		1.00	EA		37,800.000		37,800					37,800
4BOLL	6" bollards in place		8.00	EA		1,500.000						12,000	12,000
4CONC0010	Concrete sub, conc in		8.00	CY		500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00	HR		35.463				266	301		567
8CRANERT700	Crane Grove RT700E		16.00	HR		130.863				978	1,116		2,094
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00	HR		14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00	HR		18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00	MH *		75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00	MH *		74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00	MH *		73.177	1,171						1,171

COST REPORT

BID ITEM = 41096 Land Item SCHEDULE: 1 100
Description = Elect power - wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
EO04	Oper - Excavator <3c	1.00	16.00	MH *	90.663	1,451						1,451
OPCR24	Op Eng 2- Crane 20-4		16.00	MH *	89.029	1,424						1,424
$110,533.34	96.0000 MH/EA		96.0000	MH	[3921.28]	7,643	83,700		1,462	1,729	16,000	110,533
0.0625 Units/H	0.6250 Un/Shift		0.0104	Unit/M		7,642.63	83,700.00		1,462.08	1,728.63	16,000.00	110,533.34
35104.12	**West loop disconnect**		**Quan: 1.00**	**LS**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**					
2ELECMISC	Electrical miscel@10		1.00	LS	21,600.000		21,600					21,600
35104.14	**East loop disconnect**		**Quan: 1.00**	**LS**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**					
2ELECMISC	Electrical miscel@10		1.00	LS	21,600.000		21,600					21,600
35104.16	**XFMR 001 dist loop**		**Quan: 2,600.00**	**LF**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**					
4ELECUG02	Elec UG, cond, wriing		2,600.00	LF	150.000						390,000	390,000
35104.18	**XFMR 001**		**Quan: 1.00**	**EA**	**Hrs/Shft: 10.00**	**Cal: 510**	**WC: NONE**					
ELECSI	Electrical site crew		16.00	CH Eff: 0.00	**Prod: 0.0000**	Lab Pcs: 5.00		Eqp Pcs: 3.00				
2ELECPNL	XFMR Control pane		1.00	EA	5,940.000		5,940					5,940
2ELECXFMR03	150KVA transforme		1.00	EA	16,200.000		16,200					16,200
4CONC0010	Concrete sub, conc in		8.00	CY	500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00	HR	35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00	HR	14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00	HR	18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00	MH *	75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00	MH *	74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00	MH *	73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00	MH *	90.663	1,451						1,451
$33,455.05	80.0000 MH/EA		80.0000	MH	[3228.19]	6,218	22,140		484	613	4,000	33,455
0.0625 Units/H	0.6250 Un/Shift		0.0125	Unit/M		6,218.16	22,140.00		484.16	612.73	4,000.00	33,455.05

COST REPORT

BID ITEM = 41096 Land Item SCHEDULE: 1 100
Description = Elect power - wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
35104.20	**XFMR 002 dist loop**		**Quan: 1,750.00**	**LF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4ELECUG02	Elec UG, cond, wriing		1,750.00	LF	150.000						262,500	262,500
35104.22	**XFMR 002**		**Quan: 1.00**	**EA**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
ELECSI	Electrical site crew		16.00	CH	Eff: 0.00 **Prod: 0.0000**		Lab Pcs: 5.00		Eqp Pcs: 3.00			
2ELECPNL	XFMR Control pane		1.00	EA	5,940.000		5,940					5,940
2ELECXFMR02	225KVA transforme		1.00	EA	21,600.000		21,600					21,600
4CONC0010	Concrete sub, conc in		8.00	CY	500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00	HR	35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00	HR	14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00	HR	18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00	MH *	75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00	MH *	74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00	MH *	73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00	MH *	90.663	1,451						1,451
$38,855.05	80.0000 MH/EA		80.0000	MH	[3228.19]	6,218	27,540		484	613	4,000	38,855
0.0625 Units/H	0.6250 Un/Shift		0.0125 Unit/M			6,218.16	27,540.00		484.16	612.73	4,000.00	38,855.05
35104.24	**XFMR 003 dist loop**		**Quan: 1,050.00**	**LF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4ELECUG02	Elec UG, cond, wriing		1,050.00	LF	150.000						157,500	157,500
35104.26	**XFMR 003**		**Quan: 1.00**	**EA**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
ELECSI	Electrical site crew		16.00	CH	Eff: 0.00 **Prod: 0.0000**		Lab Pcs: 5.00		Eqp Pcs: 3.00			
2ELECPNL	XFMR Control pane		1.00	EA	5,940.000		5,940					5,940
2ELECXFMR02	225KVA transforme		1.00	EA	21,600.000		21,600					21,600
4CONC0010	Concrete sub, conc in		8.00	CY	500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00	HR	35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00	HR	14.916				162	77		239

COST REPORT

BID ITEM = 41096 Land Item SCHEDULE: 1 100
Description = Elect power - wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00	HR	18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00	MH *	75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00	MH *	74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00	MH *	73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00	MH *	90.663	1,451						1,451
$38,855.05	80.0000 MH/EA		80.0000	MH	[3228.19]	6,218	27,540		484	613	4,000	38,855
0.0625 Units/H	0.6250 Un/Shift		0.0125	Unit/M		6,218.16	27,540.00		484.16	612.73	4,000.00	38,855.05
35104.28	**XFMR 004 dist loop**		**Quan: 1,650.00**	**LF**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4ELECUG02	Elec UG, cond, wriing		1,650.00	LF	150.000						247,500	247,500
35104.30	**XFMR 004**		**Quan: 1.00**	**EA**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
ELECSI	Electrical site crew		16.00	CH	Eff: 0.00 **Prod: 0.0000**		Lab Pcs: 5.00		Eqp Pcs: 3.00			
2ELECPNL	XFMR Control pane		1.00	EA	5,940.000		5,940					5,940
2ELECXFMR02	225KVA transforme		1.00	EA	21,600.000		21,600					21,600
4CONC0010	Concrete sub, conc in		8.00	CY	500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00	HR	35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00	HR	14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00	HR	18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00	MH *	75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00	MH *	74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00	MH *	73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00	MH *	90.663	1,451						1,451
$38,855.05	80.0000 MH/EA		80.0000	MH	[3228.19]	6,218	27,540		484	613	4,000	38,855
0.0625 Units/H	0.6250 Un/Shift		0.0125	Unit/M		6,218.16	27,540.00		484.16	612.73	4,000.00	38,855.05
35104.32	**XFMR 006 dist loop**		**Quan: 1,700.00**	**LF**	**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4ELECUG02	Elec UG, cond, wriing		1,700.00	LF	150.000						255,000	255,000

COST REPORT

Activity Resource	Description	Pcs	Quantity Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41096 Land Item SCHEDULE: 1 100
Description = Elect power - wells Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

35104.34	**XFMR 006**		**Quan: 1.00 EA**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
ELECSI	Electrical site crew		16.00 CH	Eff: 0.00	**Prod: 0.0000**		Lab Pcs: 5.00		Eqp Pcs: 3.00			
2ELECPNL	XFMR Control pane		1.00 EA		5,940.000		5,940					5,940
2ELECXFMR01	75KVA transofrmer@		1.00 EA		16,200.000		16,200					16,200
4CONC0010	Concrete sub, conc in		8.00 CY		500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00 HR		35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00 HR		14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00 HR		18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00 MH *		75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00 MH *		74.493	2,384						2,384
ELEC2	Electrical apprentice	1.00	16.00 MH *		73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00 MH *		90.663	1,451						1,451
$33,455.05	80.0000 MH/EA		80.0000 MH		[3228.19]	6,218	22,140		484	613	4,000	33,455
0.0625 Units/H	0.6250 Un/Shift		0.0125 Unit/M			6,218.16	22,140.00		484.16	612.73	4,000.00	33,455.05
35104.36	**XFMR 005 dist loop**		**Quan: 4,000.00 LF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
4ELECUG02	Elec UG, cond, wriing		5,500.00 LF		150.000						825,000	825,000
35104.38	**XFMR 005**		**Quan: 1.00 EA**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
ELECSI	Electrical site crew		16.00 CH	Eff: 0.00	**Prod: 0.0000**		Lab Pcs: 5.00		Eqp Pcs: 3.00			
2ELECPNL	XFMR Control pane		1.00 EA		5,940.000		5,940					5,940
2ELECXFMR01	75KVA transofrmer@		1.00 EA		16,200.000		16,200					16,200
4CONC0010	Concrete sub, conc in		8.00 CY		500.000						4,000	4,000
8BHLD416	BHL Cat 416E 1CY	1.00	16.00 HR		35.463				266	301		567
8SLIFT30	Scissor Lift 30' 1500#	1.00	16.00 HR		14.916				162	77		239
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	16.00 HR		18.176				56	235		291
ELEC	Electrical Journeyman	1.00	16.00 MH *		75.809	1,213						1,213
ELEC1	Electrician apprentice	2.00	32.00 MH *		74.493	2,384						2,384

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41096	Land Item	SCHEDULE: 1		100							
Description = Elect power - wells		Unit = LS		Takeoff Quan: 1.000		Engr Quan: 1.000					
ELEC2	Electrical apprentice	1.00	16.00 MH *	73.177	1,171						1,171
EO04	Oper - Excavator <3c	1.00	16.00 MH *	90.663	1,451						1,451
$33,455.05	80.0000 MH/EA	80.0000	MH	[3228.19]	6,218	22,140		484	613	4,000	33,455
0.0625 Units/H	0.6250 Un/Shift	0.0125 Unit/M			6,218.16	22,140.00		484.16	612.73	4,000.00	33,455.05
=====> Item Totals:	**41096 - Elect power - wells**										
$2,518,912.13	608.0000 MH/LS	608.00	MH	[24561.14]	47,335	284,040		4,476	5,561	2,177,500	**2,518,912**
2,518,912.130	1 LS				47,335.36	284,040.00		4,476.16	5,560.61	2,177,500.00	2,518,912.13

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41097 Land Item SCHEDULE: 1 100
Description = SCADA, Incl Programming Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

35302 SCADA Quan: 1.00 LS Hrs/Shft: 10.00 Cal: 510 WC: NONE

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
4SCADA	SCADA subcontract	1.00	LS		1,250,000.000						1,250,000	1,250,000

COST REPORT

Activity Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41100 Land Item SCHEDULE: 1 100
Description = Start Up and Test Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

4100	**Startup and Test**	**Quan: 1.00 LS**			**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**				
A	Custom Crew	200.00	CH	Eff: 100.00	**Prod: 20.0000 S**		Lab Pcs: 0.00		Eqp Pcs: 0.00			
3ADD02	Add for Small Tools/	129,278.85	%		0.050			6,464				6,464
3LVLD	Level D Supplies@10	2,400.00	HR		1.080			2,592				2,592
4VA	Vendor Assistance Sta	1.00	LS		35,000.000						35,000	35,000
8TGS10	FLAT DECK TRK 2	400.00	HR		42.758				2,046	15,058		17,103
8TPUC14	F-150 FOREMAN PI	400.00	HR		7.100				2,840			2,840
EL01	Electrician Foreman	200.00	MH *		27.830	5,566						5,566
EL02	Electrician	400.00	MH *		25.300	10,120						10,120
EL03	Electrician Helper	200.00	MH *		18.975	3,795						3,795
LB02	Common Laborer	800.00	MH *		49.118	39,294						39,294
PF01	Pipefitter Foreman	200.00	MH *		90.124	18,025						18,025
PF02	Pipefitter	400.00	MH *		88.794	35,518						35,518
PF03	Pipefitter Helper	200.00	MH *		84.806	16,961						16,961
$193,277.99	2,400.0000 MH/LS	2,400.0000	MH		[68939.2]	129,279		9,056	4,886	15,058	35,000	193,278
0.0050 Units/H		0.0500 Un/Shift		0.0004 Unit/M		129,278.85		9,055.94	4,885.60	15,057.60	35,000.00	193,277.99

=====> Item Totals: 41100 - Start Up and Test

$193,277.99	2,400.0000 MH/LS	2,400.00	MH	[68939.2]	129,279		9,056	4,886	15,058	35,000	**193,278**
193,277.990	1 LS				129,278.85		9,055.94	4,885.60	15,057.60	35,000.00	193,277.99

COST REPORT

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total

BID ITEM = 41150 Land Item SCHEDULE: 1 100
Description = Install Power Station (Electrical Genera Unit = LS Takeoff Quan: 1.000 Engr Quan: 1.000

Summary Codes:

Activity / Resource	Description	Pcs	Quantity	Unit MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
41150	**Generator pad**		**Quan: 225.00**	**SF**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
4CONC0010	Concrete sub, conc in		10.00	CY	750.000						7,500	7,500
415002	**Receive & set nat gas gen**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
CONEQ1	Constr equip / tower crane		24.00	CH Eff: 0.00	**Prod: 0.0000**		Lab Pcs:	4.00	Eqp Pcs:	1.00		
2ELECBRKR	Breaker, 800 amp @1		1.00	EA	5,400.000		5,400					5,400
2ELECGEN	Nat gas gen set;3@10		1.00	EA	540,000.000		540,000					540,000
2ELECWRG	Conduit, wiring, @10		1.00	EA	2,700.000		2,700					2,700
2XMISC	Miscellaneous@108%		1.00	EA	1.080		1					1
8CRANEC150	Crane Manitowoc 777	1.00	24.00	HR	262.042				3,894	2,396		6,289
LA10	Labor General	2.00	48.00	MH *	70.210	3,370						3,370
LFORMN	Laborer-Foreman	1.00	24.00	MH *	42.950	1,031						1,031
OPCR100	Op Eng 1A- Crane 10	1.00	24.00	MH *	89.030	2,137						2,137
$560,927.69	96.0000 MH/LS		96.0000	MH	[3260.13]	6,538	548,101		3,894	2,396		560,928
0.0417 Units/H	0.4167 Un/Shift			0.0104 Unit/M		6,537.59	548,101.08		3,893.52	2,395.50		560,927.69
415003	**Nat gas generator control - P Unit 6**		**Quan: 1.00**	**LS**		**Hrs/Shft: 10.00**		**Cal: 510**	**WC: NONE**			
ELEC01	Electrical crew		24.00	CH Eff: 0.00	**Prod: 0.0000**		Lab Pcs:	4.00	Eqp Pcs:	2.00		
2ELECSW	Nat gas gen switc@10		1.00	EA	27,000.000		27,000					27,000
2ELECSW1	Ground water swit@1		1.00	EA	3,780.000		3,780					3,780
8SLIFT30	Scissor Lift 30' 1500#	1.00	24.00	HR	14.917				243	115		358
8TRKPU10	Pickup 4x2 3/4 Ton G	1.00	24.00	HR	18.177				84	352		436
ELEC	Electrical Journeyman	1.00	24.00	MH *	75.809	1,819						1,819
ELEC1	Electrician apprentice	2.00	48.00	MH *	74.493	3,576						3,576
ELEC2	Electrical apprentice	1.00	24.00	MH *	73.177	1,756						1,756
$38,725.55	96.0000 MH/LS		96.0000	MH	[3812.16]	7,151	30,780		327	467		38,726

COST REPORT

Activity / Resource	Description	Quantity / Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
BID ITEM = 41150		Land Item	SCHEDULE: 1			100						
Description = Install Power Station (Electrical Genera			Unit = LS			Takeoff Quan:	1.000		Engr Quan:	1.000		
0.0417 Units/H	0.4167 Un/Shift	0.0104 Unit/M				7,151.32	30,780.00		327.36	466.87		38,725.55
=====> **Item Totals:**	**41150**	**- Install Power Station (Electrical Genera**										
$607,153.24	192.0000 MH/LS	192.00 MH			[7072.29]	13,689	578,881		4,221	2,862	7,500	**607,153**
607,153.240	1 LS					13,688.91	578,881.08		4,220.88	2,862.37	7,500.00	607,153.24

COST REPORT

Activity / Resource	Description	Quantity Pcs	Unit	MH/U	Unit Cost	Labor	Perm Material	Const Expense	Equip. Cost	Equip. Ops.	Sub-Contract	Total
$**27,268,138.20**	*** **Report Totals** ***	27,826.71	MH			2,259,437	3,654,346	12,808,815	302,579	332,089	7,910,872	**27,268,138**

>>> **indicates Non Additive Activity**
------Report Notes:------
The estimate was prepared with TAKEOFF Quantities.
This report shows TAKEOFF Quantities with the resources.

Actual Unit Cost is used, which includes taxes, escalation, etc.

Bid Date: Owner: Engineering Firm:
Estimator-In-Charge:

* on units of MH indicate average labor unit cost was used rather than base rate.
[ ] in the Unit Cost Column = Labor Unit Cost Without Labor Burdens
In equipment resources, rent % and EOE % not = 100% are represented as XXX%YYY where XXX=Rent% and YYY=EOE%
------Calendar Codes------
Calendars are found in crew and labor codes and have the format XXXdY where
XXX = The Calendar and Y = The Starting Day of the Week with Day 1 = Monday, etc.

50	50hr week 5x10
510	5 - 10 hour days