Pacific Gas and Electric Company®

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April 11, 2005

Mr. Norman Shopay
Project Manager
California Department of Toxic Substances Control
Geology and Corrective Action Branch
700 Heinz Avenue
Berkeley, California 94710

Subject: *Interim Measures No. 3 Treatment and Extraction System – Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan* - Pacific Gas and Electric Company, Topock Project

Dear Mr. Shopay:

This letter transmits the *Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan* for the new facility at the Pacific Gas and Electric Company (PG&E) Topock site. This document presents the plan and procedures for operating the treatment system at the IM No. 3 facility. Additional information on operation and maintenance of the extraction system and the injection wells is included in separate submittals.

If you have any questions, please do not hesitate to contact me. I can be reached at 805/546-5243.

Sincerely,

Terri Herson
for Yvonne Meeks

Cc: Ning-Wu Chang/DTSC
Rich McCurdy/PG&E

Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Rev. 0

Topock Compressor Station Needles, California

Prepared for

Department of Toxic Substances Control

On behalf of

Pacific Gas and Electric Company

April 2005

CH2MHILL

155 Grand Avenue, Suite 1000
Oakland, CA 94612

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CH2M HILL
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This document was prepared by CH2M HILL under the supervision of:

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Acronyms and Abbreviations

CCR	California Code of Regulations
CRBRWQCB	Regional Water Quality Control Board, Colorado River Basin Region
Cr(VI)	hexavalent chromium
Cr(III)	trivalent chromium
CWG	Consultative Workgroup
DTSC	Department of Toxic Substances Control
F.D.	Forced Draft
Fe(II)	ferrous iron
Fe(III)	ferric iron
HMI	Human Machine Interface
IM	Interim measures
µg/L	micrograms per liter
mg/L	milligrams per liter
O&M	operations and maintenance
PG&E	Pacific Gas and Electric Company
PLC	programmable logic controller
TDS	total dissolved solids
WDR	Waste Discharge Requirements

1.0 Introduction

1.1 Purpose of Plan

This Treatment and Extraction System Operation and Maintenance Plan (O&M Plan) presents the strategy and procedures for performing operations, long-term maintenance, and monitoring of the Interim Measure (IM) No. 3 groundwater extraction and treatment system. It may be updated based on operational experience during plant startup and early operations.

The O&M Plan is one of several documents that describe the overall operation of IM No. 3. Closely-related documents are included as appendices to this document and include:

A Waste Discharge Requirements.
B Mass Balance.
C Process and Instrumentation Diagrams.
D Control System Operations Manual.
E Standard Operating Procedures.
F List of Equipment O&M Manuals.
G Alarms and Troubleshooting Summary.
H Daily Monitoring Checklists.
I Phone List.
J Treatment System Contingency Plan.

Other documents that form the overall Operations Plan are stand-alone documents and are referenced in this document:

- *Hazardous Materials Business Plan* (CH2M HILL pending)
- *Interim Measures No. 3 Injection Well Operation and Maintenance Plan* (CH2M HILL 2005)
- *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area* (CH2M HILL HILL pending)
- *Cultural Resources Management Plan* (Applied Earthworks 2004)
- *Biological Resources Investigations for IM No. 3: Topock Compressor Station Expanded Groundwater Extraction and Treatment System, San Bernardino County, California* (CH2M HILL 2004)
- *Interim Measures No. 3 Treatment and Extraction System Initial Startup Plan* (CH2M HILL pending)

1.2 Interim Measures Objective

The objective of the overall Interim Measures is to provide hydraulic control of the plume boundaries near the Colorado River floodplain to maintain a net landward groundwater gradient.

Hydraulic control will be maintained by pumping groundwater from extraction wells located near the eastern edge of the plume. Treatment of the groundwater has been designed to meet the Waste Discharge Requirements (WDRs) issued by the Colorado River Basin Regional Water Quality Control Board (CRBRWQCB) and employs the best-available treatment technologies.

Groundwater extraction, treatment, and discharge will be performed in compliance with applicable permits and requirements.

The completion criteria of the Interim Measures are as follows:

> *The IM No. 3 groundwater extraction and treatment system will be operated consistent with permits and authorizations until an alternative or permanent measure is implemented and stoppage of the extraction and treatment is authorized by the DTSC.*

1.3 Project Background

Pacific Gas and Electric Company (PG&E) is addressing chromium in groundwater at the Topock Compressor Station under the oversight of the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC). The Topock Compressor Station is located in San Bernardino County, approximately 15 miles southeast of Needles, California (Figure 1-1).

Beginning in August 2003, DTSC and PG&E began working in a collaborative process with affected and interested agencies through the Topock Consultative Work Group (CWG), constituted under California's site designation process. CWG members include:

- DTSC.
- CRBRWQCB.
- United States Fish and Wildlife Service.
- United States Bureau of Land Management.
- United States Bureau of Reclamation.
- Representatives from local Native American Tribes.
- Arizona Department of Environmental Quality.
- Metropolitan Water District of Southern California.
- United States Geological Survey.

In compliance with the DTSC directive of February 9, 2004 (to implement actions termed IM No. 2), PG&E commenced pumping, transport, and disposal of groundwater from the MW-20 bench location in March 2004. Due to the influence of the Colorado River stage on groundwater levels, extracting groundwater at higher rates is necessary to maintain the stated goal of hydraulic control. Space and treatment capacity limitations at the MW-20 bench made the installation of additional facilities to extract, treat, and manage the higher groundwater flows necessary.

In a letter dated June 30, 2004, DTSC directed PG&E to expand existing groundwater extraction and management facilities to maintain hydraulic control of the chromium plume at the Topock site. This activity has been designated IM No. 3. The IM No. 3 project requires PG&E to design and install piping and conveyance of extracted water to a treatment system, an extracted groundwater treatment system, and piping and facilities for management of treated water. Figure 1-2 presents the location of the IM No. 3 groundwater extraction and treatment system.

1.4 Treatment System Permits

This section presents a summary of the permits under which the treatment system is operated. Other requirements applying to the treatment system, including protection of environmental resources and preservation of historic resources, are described in separate documents.

1.4.1 Waste Discharge Requirements

The CRBRWQCB issued permits for three treated water management alternatives, which include:

- Discharge of treated water to subsurface injection wells.
- Discharge/reuse of treated water to the PG&E Topock Compressor Station.
- Discharge to the Colorado River.

Discharge of treated groundwater to subsurface injection wells is PG&E's preferred alternative and is the basis for this O&M Plan. This Plan will be reviewed and updated in the event another treated groundwater management alternative is implemented in the future.

The CRBRWQCB permit R7-2004-103, titled "Waste Discharge Requirements," is presented in Appendix A, along with the related Monitoring and Reporting Program. Key operating requirements include:

- Complying with treated effluent discharge limitations.
- Submitting monthly compliance monitoring reports and semi-annual operation and maintenance reports.
- Obtaining approval by the Executive Officer of the CRBRWQCB before changing or adding treatment system chemicals.
- Maintaining a copy of the WDR on site.
- Training operators regarding the WDR requirements.
- Maintaining documentation of regular system inspections and maintenance.
- Performing non-compliance notifications and reporting.
- Preventing stormwater contamination.

1.4.2 Conditional Authorization Permit

PG&E obtained a grant of Conditional Authorization for treatment of hexavalent chromium [Cr(VI)] in site groundwater under Section 25200.3 of the California Heath and Safety Code. The San Bernardino County Fire Department, the Certified Unified Program Agency with jurisdiction over the Topock site, is responsible for administering and enforcing the requirements of the grant of Conditional Authorization.

PG&E will comply with the operating requirements under the Conditional Authorization permit including:

- Hazardous waste will be managed in compliance with *hazardous waste generator standards* of Title 22 of the California Code of Regulations (CCR), Division 4.5, Chapter 12.
- *Operators will be trained* per 22 CCR 66265.16 and be provided with annual review training.
- The *facility contingency plan* will address the preparedness and prevention requirements of 22 CCR Division 4.5, Chapter 15, Article 3 and the contingency plan and emergency preparedness requirements of 22 CCR Division 4.5, Chapter 15, Article 4.
- Containers of *hazardous waste* will be stored in containment areas meeting the requirements of 22 CCR 66264.175, and spilled or leaked waste will be removed in a timely manner.
- Management of containers and *tanks containing hazardous waste* will be in accordance with 22 CCR, Division 4.5, Chapter 15, Articles 9 and 10. Tanks require documented daily inspections per 22 CCR 66265.195.

1.4.3 Hazardous Materials Business Plan

A Hazardous Materials Business Plan has been prepared for the groundwater extraction and treatment facility and submitted to the San Bernardino County Fire Department in compliance with state and local requirements. The key elements of the plan are a hazardous material and hazardous waste inventory and accompanying location map and a hazardous materials and hazardous waste contingency plan. The inventory will be updated annually.

1.4.4 Mojave Desert Air Quality Management District Permit

The Mojave Desert Air Quality Management District will issue a Permit to Operate the treatment system after startup. There are no monitoring requirements associated with the permit. The permit will be posted in a visible area at the treatment system. In the event that changes are made that would potentially affect air emissions, the Mojave Desert Air Quality Management District will be notified to determine any requirements and submittals.

1.5 Treatment Objectives

Table 1-1 lists numerical wastewater discharge limitations set forth in the WDRs, Order R7-2004-0103 issued by the CRBRWQCB for discharge to injection wells (Appendix A). In addition to the specific numeric limits in Table 1-1, the WDRs contain narrative requirements that prohibit bypassing, overflowing, discharging, or spilling untreated or partially-treated waste, discharging waste in excess of the system capacity, and causing degradation of any water supply.

TABLE 1-1
Order R7-2004-0103, Waste Discharge Requirements - Subsurface Injection Numerical Effluent Limitations
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Effluent Characteristic	Average Monthly Limit	Maximum Daily Limit
Flow (gpm)	*	*
pH (standard pH units)	Not Applicable	6.5 to 8.5
Chromium (VI) (µg/L)	8	16
Chromium (Total) (µg/L)	25	50

* The WDR does not contain a limit on flow. However, PG&E's WDR application described an average flow of 80 gpm and maximum of 200 gpm.
gpm = gallons per minute.
µg/L = micrograms per liter.

Monitoring of the groundwater in the vicinity of the injection wells is addressed in the *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area* (CH2M HILL pending). This document includes the methodology and criteria for confirming that subsurface injection of treated groundwater is not degrading groundwater quality.

Although PG&E has obtained permits for two other treated groundwater management alternatives—discharge to the Colorado River and industrial reuse at the Topock Compressor Station—subsurface injection is PG&E's preferred method for managing treated groundwater. Therefore, these treated groundwater management alternatives are not addressed in this O&M Plan.

1.6 IM No. 3 Groundwater Treatment System Overview

The IM No. 3 project consists of:

- Groundwater extraction system.
- Conveyance system.
- Treatment system.
- Treated water management (Subsurface injection system).

Figure 1-2 shows the location of extraction, conveyance, treatment, and disposal/reuse facilities. Figure 1-3 is a process flow diagram for IM No. 3. Figure 1-4 presents the treatment pad layout. The groundwater treatment and disposal/reuse facilities are located on Parcel 650-151-06, which PG&E purchased from the Metropolitan Water District in 2004. Piping will convey groundwater from extraction wells to the treatment and reuse facilities. Each of the project components is described below.

1.6.1 Groundwater Extraction System

The extraction system is located along the eastern portion of the plume area (Figure 1-2). Multiple groundwater extraction wells may be used to meet the objectives of the interim measure. The two existing extraction wells (TW-2S (shallow) and TW-2D (deep)) are located within the chromium plume, near a road that provides easy access. The wells are capable of accommodating the peak extraction rate. A third extraction well, PE-1, located east of TW-2D, has been recently installed. Piping from PE-1 has not yet been approved or constructed. The installation and use of additional extraction wells has been discussed during CWG technical committee meetings. Two possible additional extraction well locations are shown on Figure 1-2 and include:

- PE-2, located south of TW-2D.
- PE-3, located north of TW-2D.

The new wells would be installed in a manner similar to that used for existing wells and would be screened in appropriate sections of the aquifer at the direction of DTSC.

Well head construction involves submersible pumps placed down-hole and subsurface concrete vaults equipped with instrumentation, valves, and other pipe appurtenances. Underground piping and electrical conduits are connected to the well heads to convey water and provide power and control for the pump and instrumentation. Piping from the extraction wells to the treatment system is secondarily contained to comply with hazardous waste regulations.

1.6.2 Conveyance System

The water conveyance system delivers untreated water from the extraction wells to the treatment facilities, as well as treated water from the treatment facility back to the MW-20 bench and to the injection wells.

Pipelines conveying untreated groundwater will be double-contained high-density polyethylene; treated effluent lines will be single-contained high-density polyethylene for underground lines and epoxy-lined carbon steel for aboveground lines. Piping and appurtenances have been sized to accommodate the anticipated system flow rates. To minimize and avoid impacts to cultural resources, a combination of subsurface and aboveground alignments have been constructed. Electrical utility access vaults are placed at selected points along the alignment.

1.6.3 Treatment System

Extracted groundwater is conveyed to the treatment system. The system is a continuous treatment process that involves:

- Reducing the Cr(VI) to the less-soluble trivalent form Cr(III) by reaction with ferrous chloride.
- Precipitating iron and Cr(III) by the addition of sodium hydroxide and air.
- Removing the majority of precipitated solids by gravity separation in a clarifier.
- Passing the clarified water through a microfilter to provide additional solids removal.
- Lowering the naturally-occurring total dissolved solids (TDS) of the groundwater using reverse osmosis. Reverse osmosis produces two streams: the reverse osmosis permeate (low TDS stream) and the reverse osmosis concentrate stream (high TDS stream). The

reverse osmosis permeate stream can be re-used for industrial process supply, reclaimed for other uses, or injected back into the ground.

- Dewatering settled solids for transport and disposal.

Treatment facilities include process equipment such as storage tanks (influent, effluent, and chemical), pumps, piping, reactors, and instrumentation installed on a concrete slab foundation. Other features will include electrical power supply, security fencing, operator facilities, and equipment storage.

1.6.4 Treated Water Management

The preferred management approach for treated groundwater is subsurface injection in compliance with the WDR R7-2004-0103. A separate O&M manual and monitoring program have been prepared for the subsurface groundwater injection system (CH2M HILL pending). Therefore, subsurface injection is not addressed in this O&M Plan.

1.7 Residuals Management

The two main residual streams from the groundwater treatment system are treatment system waste solids and reverse osmosis concentrate (also commonly called "brine"). Waste solids will likely be a hazardous waste that will require disposal in a permitted hazardous waste treatment, storage, or disposal facility. Reverse osmosis concentrate will likely be a non-hazardous waste and will be disposed of at a permitted facility (possibly including Topock Compressor Station) in accordance with federal, state, and local regulations.

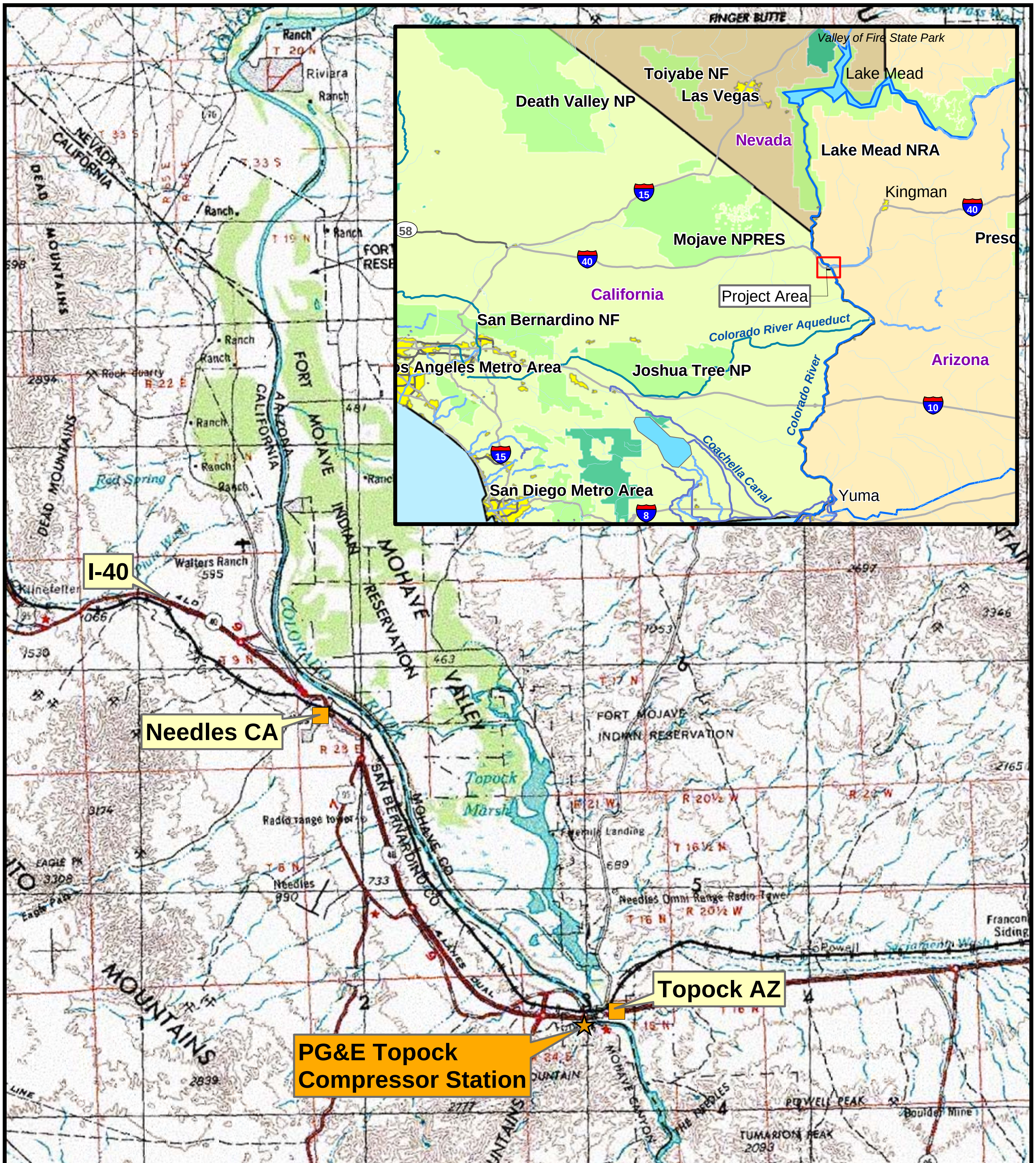

Figure 1-1
Site Location Map

INTERIM MEASURES NO. 3
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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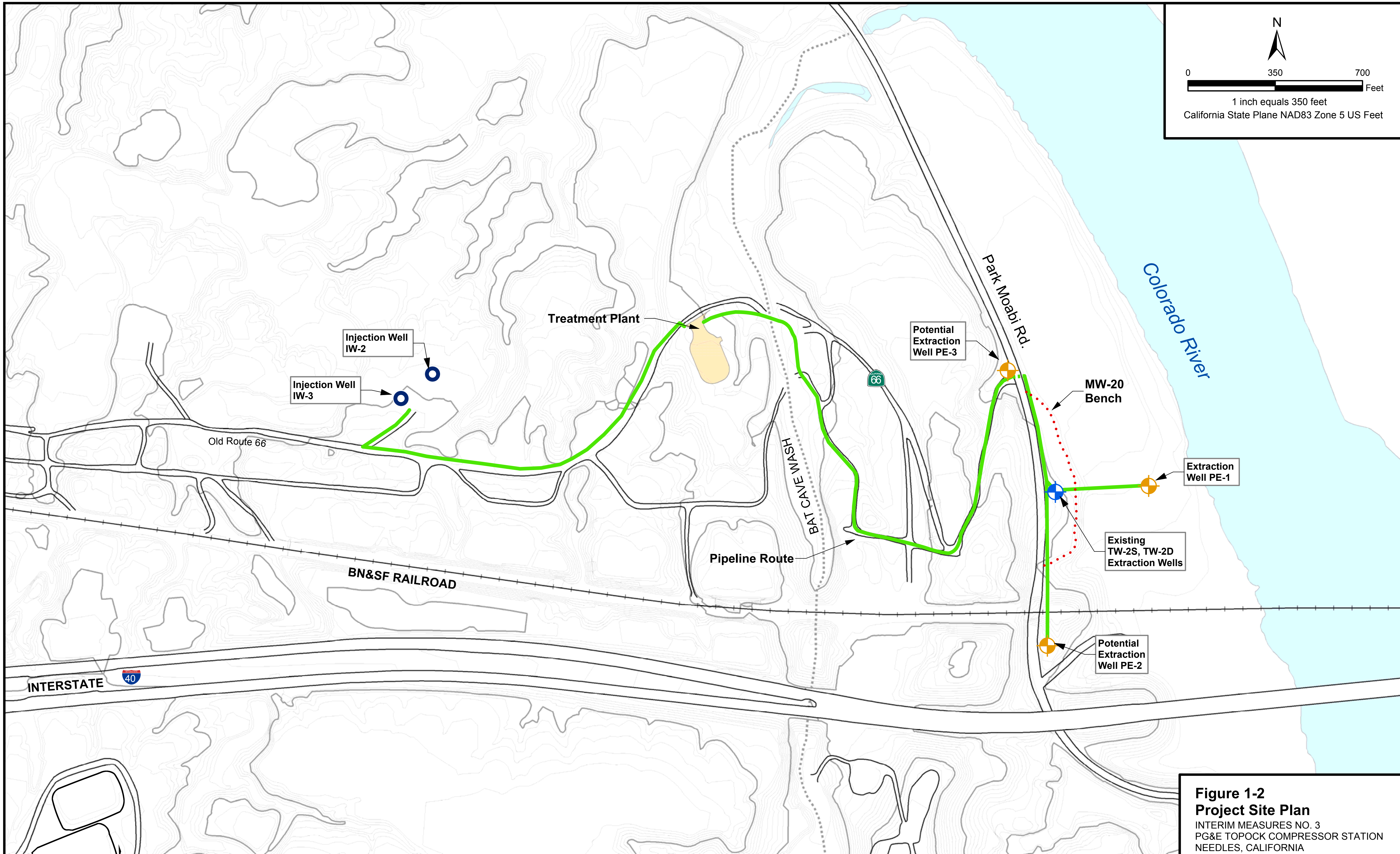

Figure 1-2
Project Site Plan
INTERIM MEASURES NO. 3
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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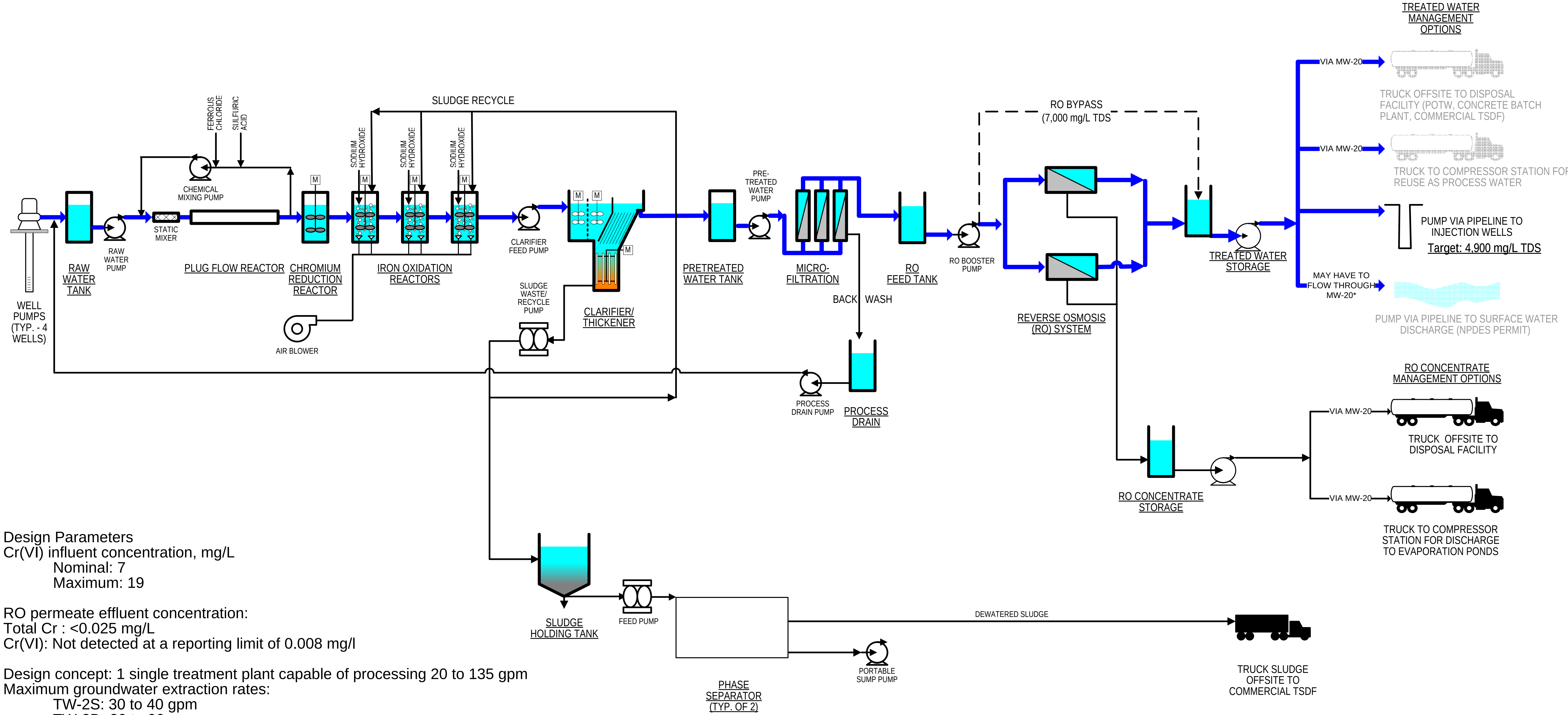

Design Parameters
Cr(VI) influent concentration, mg/L
Nominal: 7
Maximum: 19

RO permeate effluent concentration:
Total Cr : <0.025 mg/L
Cr(VI): Not detected at a reporting limit of 0.008 mg/l

Design concept: 1 single treatment plant capable of processing 20 to 135 gpm
Maximum groundwater extraction rates:
TW-2S: 30 to 40 gpm
TW-2D: 80 to 90 gpm
PE-1: 30 to 40 gpm
Potential PE-2: 30 to 40 gpm
Potential PE-3: 20 to 40 gpm

Notes:
Cr - chromium
Cr(VI) - hexavalent chromium
gpm - gallons per minute
mg/L - milligrams per liter
NPDES - National Pollutant Discharge Elimination System
POTW - Publicly-owned treatment works
RO - Reverse osmosis
TSDF - treatment storage or disposal facility

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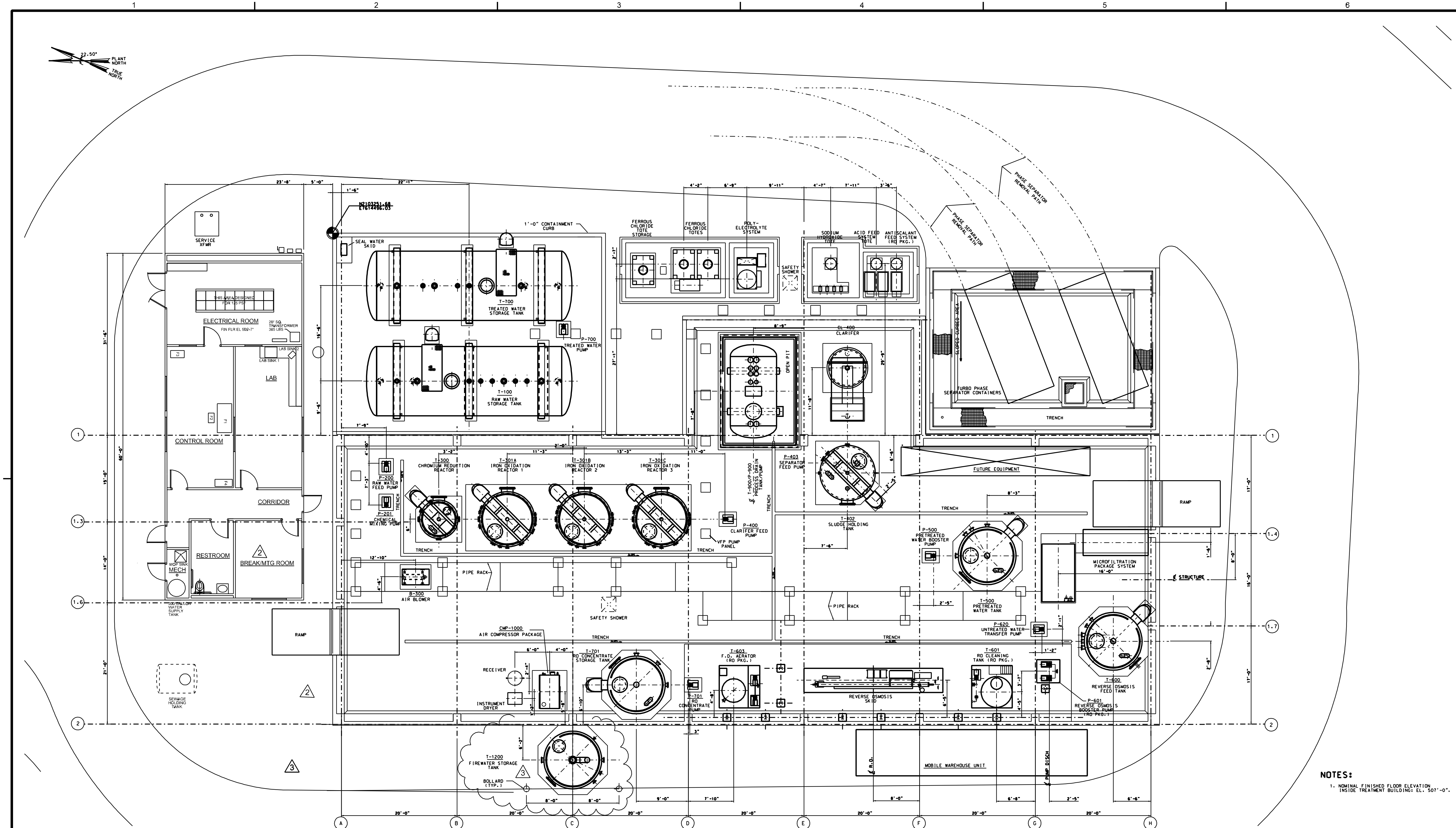
FIGURE 1-3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
PROCESS FLOW DIAGRAM
INTERIM MEASURES NUMBER 3
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



NOTES:

1. NOMINAL FINISHED FLOOR ELEVATION INSIDE TREATMENT BUILDING: EL. 507'-0".

RESPONSIBLE ENGINEER: STEVEN D. HOYER PE# CA M31888

NO.	DATE	REVISION	BY	CHK
0	09/07/04	APPROVED FOR CONSTRUCTION	RKP	SDH
1	10/06/04	PLANT MOVED 5'-0" WEST. MISC. CHANGES	WHD	
2	12/01/04	ADDED FIREWATER STORAGE TANK AND DOUBLE WIDE TRAILER	WHD	RKP
3	01/31/05	REVISED FIREWATER STORAGE TANK. ADDED BOLLARDS	WHD	RKP
	/ /			
	/ /			
	/ /			
	/ /			

REVISION APPROVAL		REV 3	DATE 01/31/05	PRINT DISTRIBUTION	
DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED	DATE	
CIVIL		ELECTRICAL		STATUS	
STRUCTURAL		INST & CONTROL		REV.	
MECHANICAL		ARCHITECTURAL		CLIENT	
PROCESS		ENVIRONMENTAL		FIELD	
PIPING		GEN. ARRANG.		INTRA CO.	

STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY		/ /		
FOR REVIEW AND APPROVAL	C	08/05/04		
APPROVED FOR CONSTRUCTION	0	09/07/04	SDH	TP
REVISED & APPROVED FOR CONSTRUCTION	3	/ /		

SCALE 1/8"=1'-0"

PACIFIC GAS & ELECTRIC CO.
TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

PROJ NO. 315994

CH2MHILL

DWG. NO. TP-GA-10-01-03 REV. 3

BAR IS ONE INCH ON ORIGINAL DRAWING.

FILENAME: tpga100103.dlv PLOT DATE: 14-DEC-2004 PLOT TIME:

2.0 Project Management

Key organizational contacts for the IM No. 3 groundwater extraction and treatment system are presented in Table 2-1. Overall project management is shown in Figure 2-1.

TABLE 2-1
IM No. 3 Groundwater Extraction and Treatment System Key Organizational Contacts

Role	Name	Organization	Phone
PG&E Portfolio Manager	Yvonne Meeks	PG&E	805/546-5243
PG&E Site Project Manager	Richard McCurdy	PG&E	925/974-4079
CH2M HILL Hydrogeology	Martin Barackman	CH2M HILL	530/243-5886, x3401
CH2M HILL Operations Support	Dennis Fink John Porcella Shawn Duffy	CH2M HILL	510/251-2888, x7693 510/251-2888, x7622 530/243-5886, x3303
Facility Operations	Lori DenBeste	DenBeste	800/838-1477

The project organization will change as the project evolves. The table of contacts will be updated periodically to reflect key project team members. Note that the hydrogeologic efforts, which are a critical component of the IM No. 3 remediation project, are addressed in other documents as described Section 1.0.

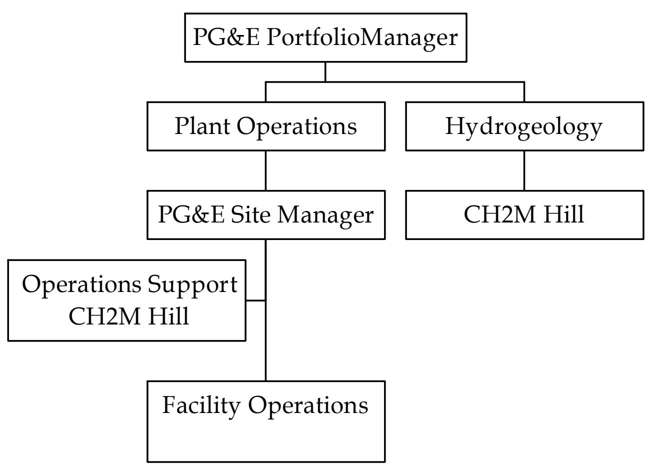


FIGURE 2-1
Project Organization Chart

Updated: 04/08/2005

3.0 System Description

This section describes how the groundwater extraction and treatment system functions. The basic physical/chemical process is described first, followed by a description of the overall process and control of each portion of the system. The treatment system mass balance is presented in Appendix B. Process and Instrumentation Diagrams are presented in Appendix C.

3.1 Physical and Chemical Process Summary

3.1.1 Chromium Reduction and Precipitation Chemistry

Cr(VI) can be chemically reduced to Cr(III), which can be readily precipitated from solution under alkaline conditions. The ferrous form of iron [Fe(II)] is one of several chemical species that will reduce Cr(VI) to Cr(III). The reaction between Cr(VI) and Fe(II) is:

$$\underset{(Cr(VI))}{NaHCrO_4} + \underset{(Fe(II))}{3FeCl_2} + 8H_2O \rightarrow NaCl + \underset{(Cr(III))}{Cr(OH)_3} + \underset{(Fe(III))}{3Fe(OH)_3} + 5HCl \qquad (1)$$

The Cr(VI) and Fe(II) chemical forms are very soluble in water, while the Cr(III) and ferric iron [Fe(III)] forms are very insoluble in water.

The reaction proceeds quickly, and the reaction kinetics or rate of reaction comes from the following relationship (*Environmental Science and Technology.*, Volume 30, No. 5, 1996, pp. 1614 – 1617):

$$\frac{d[Cr(VI)_t]}{dt} = -k_{Cr}[Fe(II)]^{0.6}[Cr(VI)_i]^{1.0} \qquad (2)$$

where:

k_{Cr} = 56.3, millimole$^{-0.6}$ minute^{-1} L$^{0.6}$.

[Cr(VI)] = hexavalent chromium, millimole/L.

[Fe(II)] = initial Fe(II), millimole/L.

i and t = subscripts indicating **i**nitial and elapsed reaction **t**ime, respectively.

In the IM No. 3 system, the pipe reactor and chromium reduction reactor were designed based on these kinetics to provide complete chemical reduction of Cr(VI) in the extracted groundwater.

After Cr(VI) is converted to Cr(III) in the pipe reactor and chromium reduction reactor, the remaining Fe(II) (soluble) will be completely oxidized to Fe(III) (insoluble) so that it does not foul the microfilter, the reverse osmosis unit, or the injection wells. The precipitated iron solids are removed in a clarifier, which is located just upstream of the microfilter. Fe(II) readily oxidizes to Fe(III) upon contact with oxygen provided that the pH is in the neutral or alkaline range. The reaction rate between Fe^{2+} and dissolved oxygen in a mixed tank reactor is given by the following equation (*Environ. Sci. & Technol.*, Volume 14, Number 5, May 1980, pp. 561-568.):

$$\frac{d^2[Fe^{2+}]}{dt^2} = -k[Fe^{2+}][OH^-]^2 pO_2 \qquad (3)$$

where:

$k = \sim 1.348\times10^{13}$ L^2/(atm-min-mole) for 3,800 milligrams per liter (mg/L) TDS groundwater.

$k = \sim 1.445\times10^{12}$ L^2/(atm-min-mole) for 44,125 mg/L TDS groundwater.

$[Fe^{2+}]$ = ferrous iron concentration, mole/L.

$[OH^-] = [10^{(pH-14)}]$ mole/L.

pO_2 = effective oxygen partial pressure 0.15 to 0.18 atm (adjusted for temperature and salinity).

Oxygen is dissolved into the treated groundwater after Cr(VI) is reduced by bubbling air through it. The pH is adjusted with sodium hydroxide. In mixed reactors, the reaction rate equation takes the form

$$C_1 = C_0/(1 + k_1V/Q) \qquad (4)$$

where:

C_1 = concentration of Fe^{2+} in mixed reactor effluent.

C_0 = concentration of Fe^{2+} in mixed reactor influent.

$k_1 = k[OH^-]^2 pO_2$.

V = reactor volume, gallons.

Q = flow rate through the reactor, gallons/minute.

The iron oxidation reactors were designed based on this kinetic relationship. Both the Cr(VI) reduction kinetics and the reaction between Fe(II) and dissolved oxygen formed the basis for determining the ferrous chloride feed rate.

3.1.2 Solids Removal

Particulate removal consists of two steps: clarification, which removes most of the precipitated iron and chromium solids, and microfiltration, which removes the small amount of iron and chromium solids passing through the clarifier.

The clarifier removes most of the solids. Solids removal in the clarifier relies on the density difference between the solids formed in the chemical reduction and iron oxidation reactors and the treated groundwater from which they have precipitated.

Fe(II) is converted to Fe(III), both through reaction with Cr(VI) in the pipe reactor and chromium reduction reactor and through reaction with dissolved oxygen in the iron oxidation reactors. Ferric iron, in the form of ferric hydroxide, is very insoluble and suited for removal in a clarifier. Chromium hydroxide solids (the precipitate forming from chemical reduction of the hexavalent chromium) co-precipitates with ferric hydroxide, and the combined solid (ferric hydroxide and chromium hydroxide) settles out in the clarifier.

Provision has been made for recycling precipitated solids from the clarifier underflow stream to one of the iron oxidation reactors. Sludge recycle improves sludge settleability, promotes metal co-precipitation, and reduces fouling of instrument, pipe, and tank surfaces.

A polyelectrolyte (polymer) may be added to the process stream to coagulate the precipitated solids prior to clarification. Tanks for polymer activation and particle coagulation have been designed into the treatment plant to enhance sludge settleability in the clarifier.

Polyelectrolytes are long-chain acrylate-based polymers with specialized functional groups. The purpose of the functional group is to bind to the solid particles based on the electrical surface charge on precipitated solids or chemical affinity, forming bridges between particles to increase their size. The efficacy of a specific polymer depends on the nature of the solids to be coagulated, on the polymer dosage rate, and may depend on other properties of the wastewater such as pH. Polymers are chosen and dosage rates are initially established through jar tests. Dosage rates are then fine-tuned during startup and periodically re-evaluated during routine operation. Although dosage is dependent on solids concentrations, once the solids concentration is established, polymer typically is added in proportion to the flow rate. Care will be taken to not overfeed polymer, as overfeeding could lead to microfilter membrane fouling.

A small amount of suspended solids (typically less than 5 parts per million) will carry over in the clarifier effluent stream. These solids contain trivalent iron and trivalent chromium and are removed to achieve the very low total chromium treatment objective. Final particulate removal is accomplished by microfiltration. The heart of the microfiltration system consists of hollow-fiber membranes through which clarifier effluent is recirculated under pressure. For this application, membranes have been selected that reject particles with an effective diameter of 0.1 microns or greater. As with any filter, plugging can occur over time. The system uses pre-programmed backwash cycles that are initiated at regular intervals. As the microfilter flux declines or filtration pressure increases over a predetermined amount and performance cannot be restored by backwashing, the system will need to be chemically cleaned to restore the flux rate.

3.1.3 Dissolved Solids Removal

Chromium removal goals should be met after the microfilter process. However, the natural groundwater TDS concentration in the microfilter permeate may be too high for disposal or reuse without some TDS removal. The purpose of the reverse osmosis system is to remove some of the TDS in the microfilter permeate if required.

Reverse osmosis is a process that removes TDS from solution by applying a pressure greater than the solution osmotic pressure, thereby forcing water, but not TDS, across a semi-permeable membrane. The reverse osmosis system generates a low-TDS product stream called the reverse osmosis permeate and a high-TDS waste stream called the reverse osmosis concentrate. The reverse osmosis permeate TDS will likely be lower than treatment limits require. Therefore, a portion of the microfilter effluent will be blended with the reverse osmosis permeate to achieve the target effluent TDS concentration specified in the

Interim Measures No. 3 Injection Well Operation and Maintenance Plan (CH2M HILL 2005). Reverse osmosis concentrate will be pumped to the MW-20 bench for transfer to an off-site disposal facility or the Topock Compressor Station.

Because increasing the TDS concentration of groundwater from the Topock site in the reverse osmosis system can result in the precipitation of scale (mineral deposits), antiscalant chemicals will be added to the reverse osmosis system feed to prevent deposition of precipitates (scale) on the membrane surfaces. The permeate flux (amount of permeate generated per unit of time and membrane surface area) will gradually decrease over time due to a variety of factors. Therefore, periodic chemical cleaning of the reverse osmosis membranes will be required.

3.2 Instrumentation and Controls

The treatment system is controlled by several programmable logic controllers (PLCs). System operation is monitored through two WonderWare® Human Machine Interface (HMI) operator consoles running on Dell™ Workstation personal computers. The software will display process schematic graphic representations of the treatment process. Operators will be able to click on process equipment symbols to obtain information about the status of that equipment. Most rotating process equipment has local or remote hand switches either at the equipment or at the motor control center. When these switches are set to remote, the equipment may be controlled by the operator from the control console. Operators may also review trends in instrument readings and system warnings and alarms. The control system is described in more detail in Appendix D.

3.3 Influent Pumping

3.3.1 Purpose

The purpose of the influent pumping system is to extract groundwater at the wells and convey it to the treatment system. Because the extracted groundwater contains Cr(VI), the pumping and conveyance system has been designed and will be operated to prevent releases of extracted groundwater to the environment.

3.3.2 System Components

The groundwater extraction and conveyance system currently consists of:

- Extraction wells TW-2S and TW-2D.
- Submersible extraction pumps P-100 and P-101.
- Double-containment piping with low-point leak detection sensors.

3.3.3 Process Description

Groundwater is extracted from the extraction wells and is conveyed to the water treatment plant by electrical submersible pumps. Power and instrumentation are provided to each of the extraction well pumps through an underground conduit from the treatment system. The control system is designed to accept up to four extraction wells without any additional programming. Two wells, TW-2S and TW-2D, are currently in operation. A third extraction well, PE-1, has been installed, but piping is not currently in place.

Because of the uncertainties involved in characterizing subsurface hydrology and groundwater chemistry, modifications to the extraction rate or installation of new wells may be required to maintain optimal control of the plume. Periodic review and modification of the groundwater extraction system may be necessary, which could affect operation of the groundwater treatment system and management of treated groundwater.

3.3.4 Control System

Each well pump has a local hand switch that can be set to local or remote operation. Normal operation is in the remote mode. Local instrumentation includes a pump discharge pressure indicator and flow indicator. In remote operation, the pumps are controlled at the treatment system panel. The treatment system panel includes readouts for well level, flow, well pump discharge pressure, and presence of water in the well vault. Warning signals are provided at the control panel for high and low flow rates, well vault water level, well pump discharge pressures, and high and low well levels.

The pump discharge flow rate is controlled by manually setting a control valve in the pump vault. The pumps start and stop to maintain the level in Tank T-100 between level set points. A groundwater level below the pump suction generates a warning at the control panel.

The extracted groundwater is conveyed from the well vault to the treatment plant by double-contained piping with low-point leak detection. Leak detection sensors are located at piping low points and approximately every 500 feet along the pipeline. Leak detection sensors provide warning signals at the leak detection control panel.

3.4 Raw Water Storage Tank

3.4.1 Purpose

The raw water storage tank:

- Provides hydraulic separation between the groundwater extraction pumps and conveyance piping to the treatment system. The raw water storage tank has capacity for 27,000 gallons of extracted groundwater. When the raw water storage tank is full, the treatment system can be operated for up to 3 hours at the peak treatment flow rate of 132 gallons per minute while the well pumps are shut down for maintenance or repairs. Similarly, the tank may be used to store groundwater from the extraction wells while the treatment system is temporarily shut down for maintenance.
- Provides positive suction head for the raw water feed pump.
- Provides storage for off-specification process streams for re-treatment.

3.4.2 System Components

- Raw water storage tank (T-100).
- Raw water feed pump (P-200).

- Control valve (FCV-200).

3.4.3 Process Description

The process objective is to maintain the water level in the raw water tank so that there is storage capacity to receive off-specification water, yet also enough water in the tank to operate the treatment system for a short time with the extraction wells shut down.

The process streams piped to the raw water storage tank include:

- Extraction wells (TW-2S pump P-100 and TW-2D pump P-101).
- Process drain tank (T-900).

Piping and valves have been provided to route flow from the following process tanks back to the raw water tank if required:

- Pretreated water tank (T-500 and P-500).
- Reverse osmosis feed tank (T-600 and P-620).
- Reverse osmosis-treated water (P-605A and P-605B).

The extraction wells provide the primary flow into the raw water tank. The extraction well flow rate can be monitored from the control panel. The raw water tank discharges via the raw water feed pump, which has a discharge recycle loop back to the tank to maintain minimum pump flow. The raw water feed pump discharge flow rate is set slightly below the extraction well flow rate by use of a flow-control valve, so that flow through the treatment plant is continuous. High- and low-level tank set points turn the well pumps on and off.

The 5,000-gallon process drain tank (P-900) discharges to the raw water tank via process drain pump P-900, which is controlled by the level in the process drain tank. This tank is not expected to transfer large volumes of water to the raw water tank. Therefore, the raw water tank level is not interlocked to the process drain pump P-900. The high level warning setting for the raw water tank would alert the operators to shut down the process drain pump P-900 before an overflow situation could occur.

Other flow inputs into the raw water tank are controlled manually by operators. Operators will assess water storage requirements and the available raw water tank capacity before performing manual transfers.

3.4.4 Control System

The raw water storage tank system has the following instrumentation and controls:

- Raw water influent line solenoid valve controlled from the control panel so that inflow to the tank can be immediately stopped. The valve can be actuated at the control panel or locally.

- There is a switch at the raw water feed pump to select local or remote operation. The pump has a local discharge pressure indicator.

- Level instrumentation provides level readout locally and at the control panel. High- and low-level set points turn the extraction pumps on and off. High- and low-level warnings at the control panel signal an imbalance of inflow and outflow at the raw water storage tank requiring operator attention. The low-low level alarm shuts down the treated water transfer pump (P-200). The high-high level alarm shuts down the extraction pumps.

- The flow rate from the raw water feed pump is displayed locally and at the control panel. The operator selects the target flow rate and flow control valve FCV-200 position is modulated to achieve the target flow rate.

3.5 Plug-flow Cr(VI) Reduction (Pipe) Reactor and Ferrous Chloride and Sulfuric Acid Feed Systems

3.5.1 Purpose

The plug-flow Cr(VI) reduction reactor and associated chemical feeds convert Cr(VI) to Cr(III).

3.5.2 System Components

Components of the plug-flow Cr(VI) reduction reactors are:

- Static mixer.
- Serpentine pipe reactor.
- Chemical mixing pump (P-201).
- Sulfuric acid feed pump (P-801).
- Ferrous chloride feed pump (P-800).

3.5.3 Process Description

Untreated groundwater discharged from the raw water pump (P-200) combines with a recycle stream containing ferrous chloride. The combined flow passes though a static mixer and a serpentine plug flow pipe reactor. The pipe reactor residence time is 2 minutes at full flow. The reactor operates at ambient temperature. A portion of the pipe reactor effluent is discharged to the chromium reduction reactor. The remaining volume of pipe reactor effluent enters the recycle line to the chemical mixing pump (P-201). Chemicals are added upstream of the chemical mixing pump. The ferrous iron component of the ferrous chloride reacts with Cr(VI), as described in Section 3.1. Sulfuric acid is added, if needed, to reduce the solution pH to suppress the competing reaction of ferrous iron with oxygen.

The treatment chemicals, ferrous chloride (10- to 20-percent as iron, depending upon commercial availability) and sulfuric acid (35-percent solution), are stored in totes.

The ferrous chloride feed rate is set proportional to the groundwater flow rate indicated by the raw water feed flow meter. The design dosage was based on 200 percent of the stoichiometric requirement for Cr(VI) reduction (3:1 stoichiometric mole ratio), plus the ferrous iron demand imposed by dissolved oxygen in the feed. Periodically, the ferrous chloride concentration in pipe reactor effluent will be checked by plant operators using a field test method, and the feed rate will be adjusted. The initial setpoint will be selected to maintain a ferrous iron excess of approximately 9 mg/L. Excess ferrous chloride ensures all the Cr(VI) is reacted, although it also increases the amount of sludge produced. Accordingly, this setpoint may be adjusted based on operational experience.

The sulfuric acid feed rate is controlled based on the pH measured in the recycle loop. Acid will not be added if the groundwater pH is sufficiently lowered by ferrous chloride addition. The pH in the recycle loop will initially be set in the range of 5.5 to 6.8 with a target of 6.5 to prevent Fe(II) from reacting with dissolved oxygen.

3.5.4 Control System

The control system includes:

- Manual solenoid valve on the system inlet that allows the operator to stop flow to the treatment system from the control panel.
- AE/AIT 201: inline pH and temperature monitor on the discharge line from the raw water pump prior to introduction of the recycle stream from the chemical mixing pump. Values of pH and temperature are displayed both locally and at the control panel.
- AE/AIT 202-1 and AE/AIT 202-2: Two pH and temperature analyzers are located in the recycle loop on the suction side of the chemical mixing pump. Values of pH and temperature are displayed both locally and at the control panel. The control system provides warnings if the pH analyzer values deviate by more than 0.5 units. The control system will alarm at high pH and shut down the raw water feed pump at high-high pH.
- The pH values are indicated locally and at the control panel.
- Ferrous chloride feed pump (P-800) motor speed is automatically adjusted based on the raw water flow rate signal. The actual feed rate is periodically verified with the volumetric flow tube on the feed pump suction. The ferrous chloride dose will need to be determined based on the Cr(VI) concentration in the well(s) being treated and the flow rate from the well(s). The ferrous chloride feed pump flow rate set point is manually adjusted based on the Cr(VI) concentration in the incoming water.
- If required, the sulfuric acid solution feed pump (P-801) motor speed will be automatically adjusted based on the average measured pH value from the two pH probes in the recycle loop.
- A thermal flow switch downstream of the chemical mixing pump provides a signal to the control panel in the event of a low-flow condition. The low-flow signal will provide an operator alarm and will shut down the raw water feed pump.
- The chemical feed pumps can be operated locally or at the control panel.

3.6 Chromium Reduction Reactor (T-300)

3.6.1 Purpose

The chromium reduction reactor (T-300) provides additional residence time of 10 minutes at maximum design flow for Fe(II) and Cr(VI) to react.

3.6.2 System Components

Components of the chromium reduction reactor are:

- Chromium reduction reactor tank (T-300).
- Chromium reduction tank mixer (M-300).

3.6.3 Process Description

Effluent from the pipe reactor flows into the mechanically-agitated chromium reduction reactor (T-300) to provide an additional 10 minutes of residence time at maximum design flow for Cr(VI) reduction to meet the final effluent quality objective. The tank has a floating roof to reduce contact of groundwater with oxygen in the air.

3.6.4 Control System

The control system includes:

- A high-level switch, which will be used to shut down the raw water feed pump to prevent tank overflow.
- The mixer, which can be started locally or from the control panel.
- The pH and temperature of the groundwater in the tank, which are locally indicated and transmitted for display at the control panel.

3.7 Iron Oxidation Reactors (T-301A, T-301B, T-301C)

3.7.1 Purpose

Air is bubbled through the three in-series iron oxidation reactors to oxidize soluble Fe(II) to insoluble Fe(III). If the Fe(II) is not oxidized, it may foul the microfiltration and reverse osmosis membranes and could plug the injection wells.

3.7.2 System Components

Components of the iron oxidation reactors are:

- Iron oxidation reactor tanks (T-301A, T301B, T301C).
- Iron oxidation tank mixers (M-301A, M-301B, M-301C).
- Iron oxidation tank demisters (one per tank).
- Clarifier feed pump (P-400).

3.7.3 Process Description

Effluent from the chromium reduction reactor (T-300) enters the bottom of the first iron oxidation reactor tank (T-301A). Air is introduced at the bottom of the tank through perforated pipe. Air-water contact is enhanced by the iron oxidation tank mixer (M-301A). The Fe(II)-treated aerated groundwater exits via an overflow pipe near the top of the tank and enters the bottom of the second iron oxidation tank. The second and third iron oxidation tanks operate in the same manner as the first tank. Treated groundwater flows between the tanks by gravity.

The reactors were sized and process conditions were selected to reduce dissolved iron from a maximum residual iron (Fe^{2+}) concentration of 44.1 mg/L (at an influent Cr(VI) concentration of 19 mg/L) to less than 0.05 mg/L when high-TDS water (up to 44,000 mg/L of TDS) is being processed. Each reactor provides 40 minutes residence time at full flow. Bypass lines have been installed to allow a tank to be bypassed if operating conditions permit or to be taken out of service for cleaning or maintenance during lower-flow periods.

The iron oxidation rate is pH-dependent and is faster at higher pH conditions. The pH of water in each iron oxidation reactor is raised with sodium hydroxide solution to a point at which Fe(II) will oxidize with atmospheric oxygen in air that is sparged into the reactors. Water TDS concentration affects the iron oxidation reaction. Therefore, the pH may need to be raised with increasing TDS concentrations as shown below:

- TDS <5,000 mg/L pH ≥7.5
- TDS ~25,000 mg/L pH ~8.0

Precipitated solids can be recycled to any one of the three iron oxidation reactors from the bottom of the clarifier by the sludge recycle pump (P-404). The iron oxidation reactor into which the solids are pumped is selected by manual operation of one of three diaphragm valves. Solids recycling increases the reaction rate and reduces the rate of fouling of process equipment, including pH probes.

The demisters minimize drift loss of treated groundwater from the iron oxidation reactors by venting the sparged air through wire mesh packing. Water droplets in the air vented from the iron oxidation reactors impinge on the surface of the packing material. Periodic injections of reverse osmosis permeate water from Tank T-700 into the demisters washes the process water back into the iron oxidation tanks. Blended treated water or microfilter permeate will be used for demister washing in place of reverse osmosis permeate if the reverse osmosis system is out of service.

The Iron Oxidation Reactor 3 (T-301C) has an ultrasonic level meter, local indicator, and transmitter. The level signal is used to adjust the pump speed of the clarifier feed pump through its variable frequency drive to maintain tank level within the acceptable range.

3.7.4 Control System

The control system includes:

- Addition of sodium hydroxide to raise the solution pH in the first and second iron oxidation reactors is flow-paced based on the raw water feed flow rate to the treatment plant. The pH is periodically checked manually, and the chemical feed pump speed is adjusted to maintain the target pH.

- Adjustment of pH in the third iron oxidation reactor is based on the pH signal in the tank.

- Each iron oxidation reactor has dual pH probes. The average of both probes provides the main pH signal. When the pH probe signals differ by more than ~0.5 unit, a warning is indicated at the control panel and the operator cleans and calibrates both probes.

- Each tank has a high-level switch that will shut down the raw water feed pump (P-200) if the liquid level exceeds the set point.
- Demister wash water is controlled by a timer and solenoid valve (SV-302). There is a local hand switch to select local manual or automatic timer control of the demister water solenoid valve.
- Mixers can be operated locally or from the control panel by selecting the operating mode with a local hand switch.
- The iron oxidation tank (T-301C) ultrasonic level element provides a local level indicator and transmits the level signal back to the control panel. The level signal is used to control the variable frequency drive of the clarifier feed pump to maintain a constant level in Tank T-301C.

3.8 Clarifier

3.8.1 Purpose

The chromium reduction and iron oxidation processes feeding the clarifier generate solid precipitates that are removed before final discharge of treated groundwater. The major component of the precipitates is ferric hydroxide. The other significant component is chromium hydroxide, which co-precipitates with the ferric hydroxide.

3.8.2 System Components

Components of the clarifier system are:

- Clarifier (CL-400).
- Mixers (M-400A, M-400B, M-400C).
- Sludge recycle pump (P-404).
- Sludge withdrawal pump (P-401).

3.8.3 Process Description

An inclined-plate clarifier (CL-400) is provided to remove the majority of the chromium hydroxide and iron hydroxide precipitates formed in the upstream reaction. Bench-scale testing of groundwater may be performed periodically at the site to determine the appropriate polymer and dosage rate to obtain a settleable floc. Polymer will be added in a small rapid mix tank, and floc formation will occur in a small flocculation tank, both of which are integral to the clarifier unit. The polymer dose needs to be set carefully to avoid fouling the downstream microfiltration system.

Settled solids will be thickened in a compartment below the clarifier plates. A slow-moving thickening mechanism (M-400C) increases the solids content of the sludge and conveys it to the underflow sludge extraction nozzle.

Sludge will be removed from the clarifier thickening section by the sludge recirculation pump (P-404) and the sludge withdrawal pump (P-401). Both pumps are air diaphragm pumps. The sludge recirculation pump pumps solids back to the iron oxidation reactors.

The sludge withdrawal pump conveys sludge to the sludge holding tank (T-400). The target effluent quality from the clarifier overflow is a solids concentration less than 5 mg/L of total suspended solids.

Control of the level of sludge in the clarifier thickening section is important for balancing sludge thickness for recycle against total suspended solids in the clarifier overflow stream. The sludge level in the thickening section of the clarifier is determined by opening the individual diaphragm valves spaced along the side of the thickening section and visually observing the appearance of the withdrawn liquid. Operators will control the sludge level by adjusting the two withdrawal pumps. The sludge recirculation pump flow rate will be set to achieve a target concentration in the clarifier feed. The sludge discharge pump flow rate will be set to maintain a constant sludge blanket level in the clarifier thickener section. See “Setting Sludge Wasting and Recycling Rates” Standard Operating Procedure.

3.8.4 Controls System

The control system includes:

- A torque indicator will automatically shut down the thickening mechanism and provide a warning at the control panel in the event the mechanism detects high sludge viscosity (high-torque condition).
- The rapid mix compartment mixer (M-400A), flocculation compartment mixer (M-400B), and clarifier thickening mechanism (M-400C) have individual hand switches that allow for control locally or from the control panel.
- Polymer addition from the polyelectrolyte makedown system is controlled from the control panel by a variable frequency drive on the progressing cavity polymer feed pump.
- There is a solenoid valve on the clarifier thickened solids discharge line that opens when either the sludge withdrawal pump or the sludge recycle pump is on and shuts when both pumps are off. The valve can also be locally or remotely operated.
- There are hand switches for the air-supply solenoid valves to the sludge withdrawal pump and sludge recycle pump so that the pumps can be operated locally or from the control panel. For each pump, the operator sets one timer for the desired time duration that the pump runs and a second timer for the desired time interval between the pump operating cycles.

3.9 Sludge Holding Tank and Phase Separators

3.9.1 Purpose

The sludge holding tank is used to accumulate sludge prior to dewatering. The phase separators are used to dewater sludge.

3.9.2 System Components

System components include:

- Sludge holding tank (T-402).
- Separator feed pump (P-403).
- Phase separators (PS-405).
- Phase separator sump pump (P-405).

3.9.3 Process Description

The sludge holding tank (T-402) is an agitated, cone-bottom tank used to accumulate sludge prior to dewatering. The mixer is used if plugging of the discharge nozzle occurs; otherwise, the tank can be left unmixed and the operator will have the option to decant clear water from above the settled sludge level through a series of decant nozzles on the tank. Decanted water drains to the process drain tank (T-900).

The separator feed pump (P-403) is used to transfer sludge from the sludge holding tank to the phase separators. The transfer is a manual operation initiated by the operators. Phase separators are two rolloff bins with disposable sludge filters.

The filtrate from the phase separators is discharged to a sump with a submersible sump pump (P-405), which transfers the filtrate to the process drain tank (T-900).

3.9.4 Control System

The control system includes:

- The sludge holding tank has a level element, level transmitter, and local readout. The sludge holding tank level can be monitored at the control panel. A high-level setting activates an alarm at the control panel and shuts down the sludge withdrawal pump (P-401). A low-level setting activates a warning at the control panel.
- The sludge holding tank mixer has a selector switch that allows for control locally or from the control panel.
- The separator feed pump (air-operated) has a solenoid valve on the air line. Timers for the run and off intervals can be set at the control panel. There is a hand switch that allows for control locally or from the control panel. There is a local pressure indicator on the pump discharge.
- Each phase separator has a high level switch that alarms at the control panel and shuts down the separator feed pump.

3.10 Pretreated Water Tank (T-500)

3.10.1 Purpose

The pretreated water tank provides hydraulic separation between the chromium reduction process and the microfilter, allowing the chromium reduction process to continue to run while the microfilter is temporarily shut down, and the microfilter to run when the chromium reduction process is temporarily shut down.

3.10.2 System Components

System components include:

- Pretreated water tank (T-500).
- Pretreated water transfer pump (P-500).

3.10.3 Process Description

The pretreated water tank receives the overflow effluent from the clarifier (CL-400) at a flow rate set by the clarifier feed pump (P-400). The pretreated water tank level is controlled by modulating a level control valve on the microfiltration skid to control the discharge flow from the pretreated water transfer pump (P-500) that feeds the microfilter. High- and low-level set points start and stop the pretreated water transfer pump to prevent the tank from overflowing or the pump from running dry.

Off-specification water in the pretreated water tank can be returned to the raw water storage tank (T-100) for reprocessing by manually shutting off the diversion valve to the microfilter system and opening the manual valve to the raw water tank. Downstream systems will continue to operate unless the systems are otherwise shut down or the supply of pretreated water falls too low to sustain operations.

3.10.4 Control System

The control system includes:

- The ultrasonic level element in tank T-500 provides a local level readout and displays the level at the control panel. The level signal is used by the control system to modulate a control valve on the discharge line from the pretreated water transfer pump to maintain tank level within set points.
- High-high level in T-500 alarms at the control panel and shuts the flow control valve FV-201. If the valve is shut for more than 10 minutes, the raw water feed pump will shut down.
- The pretreated water transfer pump has a selector switch to provide for control locally or from the control panel.

3.11 Microfiltration System

3.11.1 Purpose

The microfiltration system removes solids in the clarifier effluent over a nominal cut-off diameter of 0.1 microns.

3.11.2 System Components

System components include:

- Feed tank (T-501).
- Recirculation pump (P-501).
- Microfiltration modules.

- Reverse filtration tank (T-502).
- Reverse filtration pump (P-502).
- Control system.

3.11.3 Process Description

The microfiltration system feed tank (T-501) receives flow from the pretreated water transfer pump. The microfiltration system is sized to accommodate flow from this pump. There is a local level indicator at the tank that transmits the level signal back to the microfiltration control panel. The speed of recirculation pump (P-501) is varied to increase flow through the microfilter to maintain the tank level. The microfiltration feed tank has an overflow that is connected to the process drain tank. There is a strainer after the recirculation pump to prevent large particles that inadvertently enter the system from fouling the microfilter membrane elements.

The recirculation pump transfers treated groundwater from the feed tank through the membrane elements and back to the feed tank. A restricting orifice in the return line to the tank pressurizes the recirculation loop, which forces water to pass through the membranes as particulate-free microfilter permeate. The microfilter permeate is discharged to the reverse osmosis feed tank (T-600) and is also used to fill the reverse filtration tank (T-502).

As filtered water (permeate) exits the microfilter system and concentrated solids are returned to the feed tank (T-501), the turbidity, which is continuously monitored, gradually increases. The accumulated solids are blown down to the process drain tank periodically to avoid plugging the microfilter membrane elements. Blowdown is performed automatically by the microfilter system and can be configured to initiate based either on a turbidity set point or on operating time.

When the blowdown cycle initiates, the reverse filtration pump (P-502) pumps filtered water back through the membrane elements. Compressed air cleaning of the membranes is also part of the blowdown sequence. System valves are automatically configured so that the contents of the system and the backwash water are routed to the process drain tank. Note that the microfiltration system is temporarily offline during the blowdown cycle (approximately 2 minutes out of every 20 minutes). The pretreated water tank, pretreated water pump, and microfiltration system are all sized to accommodate this offline time.

It is anticipated that the microfilter membrane elements will need an additional cleaning as frequently as every week. Microfiltration system controls include a cleaning sequence consisting of sequential backflushing of the membrane elements with sulfuric acid, sodium hydroxide, and sodium hypochlorite solutions. Periodic cleaning is described further in the microfiltration system O&M manual.

3.11.4 Control System

The control system includes:

- The microfiltration system will be controlled by the microfiltration local PLC that is supplied with the unit.

- The microfilter feed tank has a level element with a local indicator. The level signal controls the recirculation pump variable frequency drive. The local control panel has warnings for low- and high-tank liquid level that are passed to the control panel.
- The microfilter recirculation loop has pressure elements before and after the strainer, with pressure displayed locally and at the control panel.
- There is a local flow indicator in the recirculation loop after the microfiltration modules.
- There is a flow meter on the microfiltration permeate that displays the flow locally and at the control panel.
- There are turbidity meters on two slip streams, one off the recirculation loop after the strainer and the other on the microfiltration permeate. Both turbidity values are displayed on the control panel. The turbidity meter slipstreams drain to the process drain tank.

3.12 Reverse Osmosis Feed Tank

3.12.1 Purpose

The reverse osmosis feed tank stores microfiltration permeate for further processing by the reverse osmosis unit or for blending with the reverse osmosis permeate to obtain a targeted effluent TDS concentration.

3.12.2 System Components

System components include:

- Reverse osmosis feed tank (T-600).
- Filtered water transfer pump (P-620).
- Reverse osmosis booster pumps (P-601A and P-601B).
- Reverse osmosis system sulfuric acid metering pump.
- Antiscalant feed system.

3.12.3 Process Description

The reverse osmosis feed tank (T-600) receives treated, filtered groundwater (permeate) from the microfiltration system and recycled reverse osmosis permeate and concentrate. The reverse osmosis feed tank liquid level is controlled by controlling the amount of reverse osmosis permeate and concentrate recycled back to the tank. The reverse osmosis recycle stream compensates for the imbalance between the microfiltration permeate flow rate (established by the pretreated water transfer pump) and the reverse osmosis feed tank discharge (established by the reverse osmosis booster pumps and filtered water transfer pump). The conductivity of the reverse osmosis recycle stream is matched to that of the microfiltration permeate by modulating the proportion of reverse osmosis concentrate in the reverse osmosis recycle flow.

The filtered water transfer pump discharge piping is configured to blend microfilter permeate with reverse osmosis permeate to achieve specified conductivity at the treated water storage tank (T-700). The discharge piping of the filtered water transfer pump and the post-treated reverse osmosis permeate pumps (P-605A and B) combine upstream of the treated water storage tank. Conductivity control is achieved by modulating a flow control valve on the filtered water transfer pump discharge (microfilter permeate flow) based on a signal from a conductivity sensor on the combined flow to the treated water storage tank. The conductivity sensor is located downstream of a static mixer.

Operators can also configure the filtered water transfer pump (P-620) controls and discharge valves to recycle off-specification microfilter permeate to the raw water storage tank.

The reverse osmosis booster pumps (P601A and B) convey reverse osmosis feed water through cartridge filters and into the suction side of the reverse osmosis feed pump (P-602) at a pressure sufficient to meet suction head requirements of the reverse osmosis feed pump.

Sulfuric acid and a commercial antiscalant are injected into the transfer line ahead of the cartridge filters.

The cartridge filters remove small particles that may have passed through the microfilter and also promote efficient mixing of the sulfuric acid and antiscalant chemicals in the reverse osmosis feed stream. Cartridge filters are changed when the difference in readings between the upstream and downstream pressure gages exceeds the recommended value specified in the reverse osmosis system O&M manual.

3.12.4 Control System

The control system includes:

- The reverse osmosis feed tank (T-600) level is controlled by modulating a level control valve (LCV-603) on the reverse osmosis permeate recycle line to achieve the tank level set point.
- The reverse osmosis feed tank (T-600) has a level sensor with displays locally and at the control panel. Low tank level shuts down the reverse osmosis booster pump (P-601A and P-601B) and generates an alarm at the control panel. High tank level shuts down the pretreated water transfer pump (P-500) and generates an alarm at the control panel. A falling or low-level signal re-enables operation of the pretreated water transfer pump.
- Conductivity meters are located on the microfiltration permeate stream influent to the reverse osmosis feed tank (microfilter permeate), on the reverse osmosis recycle stream (combined permeate and concentrate flows) to the reverse osmosis feed tank, and on the booster pump discharge. The control system modulates the reverse osmosis concentrate recycle stream flow-control valve (FCV-602) to match the conductivity of the reverse osmosis recycle to the microfiltration permeate. A warning is generated if the post-booster pump conductivity is 10 percent or more higher than the microfilter permeate conductivity. Such a warning condition would indicate that there is a problem with the reverse osmosis recycle stream controls.
- A flow control valve (FCV-615) on the filtered water transfer pump modulates the pump discharge flow rate based on the conductivity sensor (AIT-702) on the combined microfilter permeate and reverse osmosis permeate.

- Sulfuric acid, when used, is fed into the discharge piping of the reverse osmosis booster pumps at a rate determined by the pH set point of the reverse osmosis feed pH controller. The sulfuric acid reduces the pH to ~6.7, a pH sufficiently low that calcium carbonate will not deposit on the membranes during reverse osmosis operation. A pH feedback control loop is used to maintain the proper pH.
- Antiscalant is fed at an appropriate rate in rate proportion to the reverse osmosis reject stream flow rate using a feed-forward loop.
- The filtered water transfer pump has a selector switch for local or remote operation.
- The reverse osmosis booster pumps are operated from the control panel.
- The signal from the inline pH probe between the cartridge filters and the reverse osmosis feed pump controls the reverse osmosis system sulfuric acid feed pump through a feedback loop.

3.13 Reverse Osmosis Unit

3.13.1 Purpose

The purpose of the reverse osmosis system is to control the TDS of the treated groundwater. In the case of treated water management by underground injection, the TDS of the treated groundwater should approximately match the TDS of the formation into which the treated groundwater is injected. In the case of discharge of treated groundwater to the Colorado River, the treated groundwater TDS needs to meet the total dissolved solids discharge limitation. In the case of reuse at the compressor station, the TDS needs to be controlled to a level appropriate for that use.

3.13.2 System Components

The reverse osmosis system components include:

- Reverse osmosis feed pump (P-602).
- Reverse osmosis membrane skid.
- Reverse osmosis cleaning tank (T-601).
- Reverse osmosis cleaning pump.
- Forced Draft (F.D.) aerator (T-603).
- Blower (B-600).
- Post-treated reverse osmosis permeate pumps (P-605A and P-605B).
- Local control panel.

3.13.3 Process Description

The reverse osmosis feed pump (P-602) boosts the flow from the reverse osmosis booster pumps (P-601A and P-601B) up to the operating pressure of the reverse osmosis membranes. The flow through the reverse osmosis membrane modules is controlled by manual operation of a needle valve on the reverse osmosis concentrate discharge. Minimum flow is set by an orifice installed in parallel with the needle valve. The reverse osmosis concentrate is collected for storage in the reverse osmosis concentrate storage tank (T-701).

The reverse osmosis permeate flows to the F.D. aerator (T-603). The aerator is a tank filled with packing. The permeate is distributed over the packing at the top of the tank and flows by gravity to the bottom of the tank. Air that has been filtered through a HEPA filter is blown upward through the packing. The air contacting the permeate strips carbon dioxide, raising the permeate pH above 6.5. The post-treated reverse osmosis permeate pumps convey the pH-adjusted permeate from the F.D. aerator to the treated water storage tank. The pumps cycle on and off based on the liquid level in the aerator.

The reverse osmosis cleaning tank (T-601) is used for periodic reverse osmosis system cleaning. Chemicals are added to the tank manually using a portable transfer pump. Makeup water is supplied from the treated water storage tank (T-700) via the treated water transfer pump (P-700). The cleaning solution is circulated through the reverse osmosis modules and both the concentrated and permeate are diverted back to the reverse osmosis cleaning tank.

3.13.4 Control System

The control system includes:

- The reverse osmosis recovery (permeate flow rate as a percentage of feed flow rate) is manually adjusted via the needle valve on the reverse osmosis concentrate discharge.
- The reverse osmosis feed tank (T-600) level is controlled by modulating a valve on the reverse osmosis permeate recycle line to the reverse osmosis feed tank. Low level in the reverse osmosis feed tank shuts down the reverse osmosis feed pump (P-602). The recycle loop allows the reverse osmosis feed to remain within a tight range.
- The system alarms if the pressure in the permeate line exceeds a preset value, indicating a break in the membrane, and shuts down the reverse osmosis system.
- The level in the F.D. aerator tank (T-603) is displayed at the control panel. There are low-low and high-high level alarms at the panel. The level signal is used to control the flow control valve on the pump discharge to maintain the level within the desired set points. Low tank level causes the post-treated permeate pumps (P-605A and B) to shut down.
- Permeate conductivity is monitored both before and after the F.D. aerator. Signals for pH and temperature are also monitored after the F.D. aerator. The conductivity, pH, and temperature values after the F.D. aerator are displayed at the control panel. The control panel indicates warnings on high conductivity and low and high pH.
- Reverse osmosis permeate is mixed with the microfilter effluent in the line into the treated water storage tank. The final effluent conductivity is controlled using a conductivity meter downstream of this mixing point. The ratio of the two streams is controlled by flow-control valve on the microfilter effluent line (FCV-615).

3.14 Reverse Osmosis Concentrate Storage Tank

3.14.1 Purpose

The reverse osmosis concentrate tank receives reverse osmosis concentrate from the reverse osmosis system and stores it prior to pumping it to tanks at the MW-20 bench.

3.14.2 System Components

System components include:

- Reverse osmosis concentrate storage tank (T-701).
- Reverse osmosis concentrate transfer pump (P-701).

3.14.3 Process Description

The reverse osmosis concentrate tank level set points are selected by the operator to provide storage capacity in the event that transfer pumping to the MW-20 bench must be temporarily stopped. The reverse osmosis concentrate pump automatically cycles on and off to keep the liquid level in the tank between the high- and low-level set points.

3.14.4 Control System

The control system includes:

- Ultrasonic level element with local and control panel level indicators. The pump starts at the low-level set point and turns off at the high-level set point. The high-high alarm shuts down the reverse osmosis system. The low-low alarm shuts down the reverse osmosis concentrate pump.

3.15 Treated Water Storage Tank

3.15.1 Purpose

The treated water storage tank supplies treated groundwater to the seal water system for use within the treatment plant (seal water, chemical makeup water, demister wash, etc.) and provides hydraulic separation between the treatment system and the treated groundwater management system (injection wells, Colorado River Outfall, or MW-20 bench transfer).

3.15.2 System Components

System components include:

- Treated water storage tank (T-700).
- Treated water storage tank transfer pump (P-700).

3.15.3 Process Description

Reverse osmosis permeate is pumped to the treated water storage tank from the F.D. aerator tank (T-603). The treated water transfer pump transfers treated groundwater in the tank to one of the treated water management alternatives (injection wells or MW-20 bench Baker tanks). The pump cycles on and off to maintain the treated water storage tank level between operator-selected set points. Selection of treated water destination is made by setting manual valves.

3.15.4 Control System

The control system consists of:

- The level element in the treated water storage tank provides level indication locally and at the control panel. The level element signal controls the treated water transfer pump by cycling it on and off between the high and low set points. The tank low-low level alarm shuts down the treated water transfer pump. The tank high-high level alarm shuts down the reverse osmosis permeate pump.
- The treated water transfer pump can be operated locally or from the control panel. The control panel provides pump status.
- The treated water transfer pump has a local pressure indicator.

3.16 Seal Water System

3.16.1 Purpose

The treated water storage tank supplies treated groundwater to the seal water system for use within the treatment plant (seal water, makeup water, demister wash, etc.).

3.16.2 System Components

System components include:

- Seal water tank (T-1100).
- Seal water pump (P-1100).

3.16.3 Process Description

The seal water pump uses treated effluent from the treated water storage tank (T-700) to pressurize the seal water tank, which is a pressurized (bladder) tank. The seal water tank pressurizes the supply piping for chemical makeup, flushing hose connections, demister wash water, microfiltration system feed tank, and seal water.

3.16.4 Control System

The control system of this vendor-supplied package consists of:

- The pressure transmitter downstream of the seal water pump controls the seal water pump speed through a variable frequency drive to maintain the pressure in the seal water tank within the set point limits.
- A low-pressure switch is installed in the seal water distribution header that provides a warning at the control panel.

3.17 Process Drain Tank (T-900)

3.17.1 Purpose

The process drain tank receives small incidental flows from various process equipment so it can be returned to the raw water storage tank for reprocessing.

3.17.2 Process Components

Process components include:

- Process drain tank (T-900).
- Process drain pump (P-900).

3.17.3 Process Description

The process drain tank will receive wastewater from:

- Containment areas (accumulated rain water or spills).
- Phase separator pumpout vault.
- Clarifier and sludge holding tank decant.
- Microfiltration backwash.
- Microfiltration system turbidity meters.
- Tank and system drains and overflows.
- Strainer drains.

The tank will be located in a sump so that drains can flow by gravity. Room will be provided between the tank wall and the sump wall to install a portable pump if water accumulates in the sump.

Piping is also provided to pump the tank contents through a fill port into a tanker truck for off-site disposal.

3.17.4 Control System

The control system includes:

- The process drain tank (T-900) has a level element that indicates locally and at the control panel. The level element controls the process drain pump as the tank cycles between high- and low-level set points. There are high- and low-level warnings at the control panel. The low-low level alarms shuts down the process drain pump (P-900).

- The pump can be operated in local or remote mode. The operating mode run status is displayed at the control panel.

- A high-level switch will be used to detect water between the tank wall and the sump wall.

3.18 Chemical Feed Systems

3.18.1 Purpose

The chemical feed systems deliver chemicals to the treatment processes at the appropriate dosage rates.

3.18.2 System Components

System components include:

- Ferrous chloride feed pump (P-800).
- Sulfuric acid feed pump (P-801).
- Sodium hydroxide feed pump 1 (P-802A).
- Sodium hydroxide feed pump 2 (P-802B).
- Sodium hydroxide feed pump 3 (P-802C).
- Sodium hydroxide feed pump 4 (P-802D).
- Sodium hypochlorite pump (P-807).
- Polyelectrolyte make-down system (M-804).

Note that other chemical feed systems that are part of the reverse osmosis system are described in the corresponding section.

3.18.3 Process Description

Chemical totes and drums are stored in areas with secondary containment. Incompatible materials are segregated. Chemical feed pumps operate automatically in response to system instrumentation values as described previously.

3.18.4 Control System

3.18.4.1 Ferrous Chloride Feed Pump

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.
- Operator will be able to start and stop the ferrous chloride pump, P-800, from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode, with the chemical feed rate proportional to the groundwater influent flow rate. The operator will be able to set the required dosing rate, chemical bulk density, and chemical concentration. The PLC will then determine the correct speed to operate the metering pump.

3.18.4.2 Sodium Hydroxide Feed Pump 1 (Feed to Iron Oxidation Reactor 1)

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.

- Operator will be able to start and stop the sodium hydroxide pump (P-802A) from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode with the flow proportional to the groundwater influent flow rate.

3.18.4.3 Sodium Hydroxide Feed Pump 2 (Feed to Iron Oxidation Reactor 2)

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.
- Operator will be able to start and stop the sodium hydroxide pump (P-802B) from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode with the flow proportional to the groundwater influent flow rate.

3.18.4.4 Sodium Hydroxide Feed Pump 3 (Feed to Iron Oxidation Reactor 3)

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.
- Operator will be able to start and stop the sodium hydroxide pump (P-802C) from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode. The chemical feed rate is controlled through a pH feedback control loop at an operator-selected set point based on the tank T-301C pH sensor. The PLC will determine the correct speed to operate the metering pump.

3.18.4.5 Sodium Hydroxide Feed Pump 4 (Reverse Osmosis Permeate pH Adjustment)

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.
- Operator will be able to start and stop the sodium hydroxide pump (P-802D) from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode. The chemical feed rate is controlled through a pH feedback control loop at an operator-selected set point based on the AE-606 pH sensor in the effluent line from T-603. The PLC will determine the correct speed to operate the metering pump.

3.18.4.6 Sulfuric Acid Feed Pump

The control system includes:

- Local indication of chemical pump discharge pressure.
- Warning of pump low-flow condition.

- Operator will be able to start and stop the sulfuric acid pump (P-801) from the HMI screen. An indication of the pump run status will be displayed. The pump will normally operate in the automatic mode. The chemical feed rate is controlled through a pH feedback control loop at an operator-selected set point based on the AE202 pH sensor in the chemical mixing pump (P-201) suction line. The PLC will determine the correct speed to operate the metering pump.

3.18.4.7 Polyelectrolyte Make-down System

The control system includes:

- Warning of low polyelectrolyte level.
- Warning of pump low-flow condition.
- Operator will be able to start and stop the polyelectrolyte skid and adjust its flow rate locally.
- There are no automatic flow-pacing connections to the plant process control system.

3.18.4.8 Sodium Hypochlorite Feed Pump

The control system includes:

- The microfiltration package control system controls this pump.
- When the LOR switch is placed in LOCAL, pump P-807 will operate. When the switch is placed in REMOTE, the microfiltration controller will operate the pump.
- A signal will be sent to the treatment plant PLC when the switch is in the REMOTE position.

3.19 Injection Wells

3.19.1 Purpose

The injections wells are used to introduce treated effluent into the subsurface formation.

3.19.2 System Components

System components include:

- Flow meters (FE-1202 and FE-1203).
- Pressure gauges (PIT-1202 and PIT-1203).
- Well water level sensors (LE-1202 and LE-1203).
- Injection wells (IW-2 and IW-3).

3.19.3 Process Description

Two injection wells (IW-2 and IW-3) are currently installed at the site. Additional wells may be installed in the future if required. The treated water transfer pump (P-700) discharges treated effluent into a header that distributes flow to the injection wells. Distribution and flow rate are controlled by manual adjustment of throttling valves in each injection well line.

In the event of a power outage, treated water will not be discharged to injection wells when running on the backup emergency generator. Solenoid valves are installed near each injection well head. These valves open when P-700 is operating and close when P-700 shuts down in order to hold water in the distribution pipeline.

The injection wells are sealed at the surface with a flange. Injection pipe penetrates through each flange into the wells. Air/vacuum release valves are provided at each injection well head to regulate pressure in the well.

3.19.4 Control System

The control system includes:

- Flow meters that indicate locally and at the control panel.
- Pressure gauges (PIT-1202 and PIT-1203) that indicate locally and at the control panel.
- Solenoid valves (SV-1202 and SV-1203) that open or close based on the operation of the treated water transfer pump (P-700).
- Level elements in the wells that indicate locally and at the control panel.

Additional information on the control and monitoring of the injection wells is included in the *Interim Measures No. 3 Injection Well Operation and Maintenance Plan* (CH2M HILL 2005).

3.20 MW-20 Bench Tanks for Treated Effluent

3.20.1 Purpose

The MW-20 bench tanks store treated effluent for off-site disposal.

3.20.2 System Components

System components include:

- A minimum of two 20,000-gallon tanks (T-701, T-702).

3.20.3 Process Description

Treated effluent can be pumped to the MW-20 bench tanks based upon manual adjustment of valves by the system operator.

3.20.4 Control System

The control system includes:

- Influent flow meter that indicates locally and at the control panel.
- High-level switch in the MW-20 bench tanks that provides a warning at the control panel.

3.21 MW-20 Bench Tanks for Reverse Osmosis Concentrate

3.21.1 Purpose

The MW-20 bench tanks store reverse osmosis concentrate for off-site disposal.

3.21.2 System Components

System components include:

- 20,000-gallon tank (T-703).

3.21.3 Process Description

Reverse osmosis concentrate is pumped by the reverse osmosis concentrate transfer pump (P-701) to the MW-20 bench tanks.

3.21.4 Control System

The control system includes:

- Influent flow meter that indicates locally and at the control panel.
- High-level switch that provides a warning at the control panel.

3.22 Other Systems

The following additional systems that operators will need to monitor and maintain include:

- Instrument air.
- Laboratory facilities.
- Fire suppression.
- Safety showers.
- Intercom.
- Fire alarms.
- Toilets.
- Potable water supply.

4.0 Initial Startup Procedures

Initial startup procedures are presented in the *Interim Measures No. 3 Treatment and Extraction System Initial Startup Plan* (CH2M HILL 2005). The steps involved in initial startup along with the proposed timeline are shown in Table 4-1.

TABLE 4-1
Startup Schedule
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Step	**Before Startup**	**Week**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Preparation											
Pre-commissioning											
Clean Water Startup											
Commission with Groundwater											
Performance Test with Groundwater											
Plant Performance Check											

Operating procedures, including startup and shutdown procedures after initial startup, are presented in Section 5.0 and Appendix E.

5.0 Operating Procedures

Specific information presented in this section includes:

- Control system description and operation.
- Field instrumentation.
- Listing of periodic operations.
- Troubleshooting.
- Process upset conditions.

5.1 Control System Description

See Appendix D for the control systems operations manual. Initial set points are summarized in Table 5-1. These set points may be adjusted by operating personnel (the operations manager) based on plant operating experience.

5.2 Field Instrumentation

Field instruments are listed in Table 5-2.

5.3 Periodic Operation Procedures

Appendix E presents Standard Operating Procedures for periodic operations, including:

- Startup.
- Shutdown.
- Setting clarifier sludge wasting and recycle rates.
- Operation of the sludge holding tank and phase separators.
- Calibration of chemical metering pumps.
- Hexavalent chromium analysis by Hach Method 8023.

Appendix F lists equipment operating manuals, which provide procedures for periodic operations, including:

- Calibration of pH probes.
- Calibration of turbidity meters.
- Microfilter cleaning.
- Reverse osmosis membrane cleaning.
- Cartridge filter replacement.
- Forced draft aerator tower cleaning.

5.4 Troubleshooting

Appendix G presents a summary of system warnings and alarms, along with possible causes and suggested operator interventions.

5.5 Process Upset Prevention, Detection, and Recovery

The treatment plant has been designed with the capability for recycling and retreating system effluent, if necessary, due to an upset or unanticipated condition. A detailed analysis of possible failure modes is presented in Appendix J. Upset conditions linked to compliance with effluent limitations include:

- Elevated hexavalent or total chromium concentration in the final effluent.
- pH values outside of limitation range in the reverse osmosis permeate in WDR R7-2004-0103.
- TDS in the reverse osmosis permeate above the acceptable maximum specified in the *Interim Measures No. 3 Injection Well Operation and Maintenance Plan* (CH2M HILL 2005).

Appendix G describes possible causes of system alarms and possible recovery strategies. In general, recovery from most alarm conditions is achieved by simply restarting the system. In some cases, samples from specific treatment tanks may need to be tested and the system placed in recirculation mode before normal operation can be resumed.

5.5.1 Hexavalent Chromium Upset Condition

5.5.1.1 Prevention of Upset Condition

Critical systems in the reduction of Cr(VI) to Cr(III) are:

- Addition of the proper amount of ferrous chloride.
- pH control of ferrous chloride/groundwater mixture in the proper range.
- Adequate mixing and contact time of ferrous chloride solution and groundwater.

Treatment system design assures adequate mixing and contact time of ferrous chloride with groundwater. The pipe reactor and recycle loop are sized to achieve the target Cr(VI) reduction. Were the chemical mixing pump to cease operation, the control system is configured to shut the entire treatment system down. There is additional mixing and retention time in the chemical reduction reactor (T-300).

If ferrous chloride is not getting to the pipe reactor recycle loop inlet location, as indicated by the low flow switch in the ferrous sulfate feed line, the control system is configured to shut the system down.

There are dual pH probes in the pipe reactor loop and in the chemical reduction tank. The control system will alarm at the control panel and shut down the treatment system if the pH is outside of its target range. Warnings appear at the control panel if the dual pH probe readings differ by more than a specified amount.

Finally, the reverse osmosis system, although not included in the process to remove Cr(VI), would remove approximately 90 percent of the hexavalent chromium in the reverse osmosis feed water.

5.5.1.2 Detection of Upset Condition

The control panel will provide warnings and alarms to the operators in the event of out-of-specification pH and ferrous iron flow conditions. Periodic sampling for Cr(VI) will also be done at points throughout the system, as described in Appendix H.

5.5.2 Trivalent Chromium Upset Condition

5.5.2.1 Prevention of Upset Condition

Critical systems in the removal of Cr(III) are:

- pH control in the iron oxidation reactors to promote co-precipitation of chromium hydroxide with ferric hydroxide.
- Integrity of the microfiltration membranes, which provide a barrier to precipitated chromium hydroxide particles.

There are dual pH probes in the iron oxidation reactors. The control system will alarm at the control panel and shut down the treatment system if the pH is outside of its target range. Warnings appear at the control panel if the dual pH probe readings differ by more than a specified amount.

Turbidity meters are installed in the microfilter permeate discharge line to confirm that the microfilter membranes are operating correctly. The control system will alarm at the control panel and shut down the treatment system if the turbidity exceeds its normal value by more than a predetermined amount.

5.5.2.2 Detection of Upset Condition

The control panel will provide warnings and alarms to the operators in the event of out-of-specification pH and turbidity values. Periodic sampling for total chromium will also be done at points throughout the system, as described in Appendix H.

5.5.3 High or Low pH Upset Condition

5.5.3.1 Prevention of Upset Condition

In the treatment process, the initial pH is adjusted by addition of acid and caustic to optimize treatment chemistry. The final pH is adjusted by carbon dioxide stripping with the option for caustic addition to comply with the pH limitation of the WDRs. The control system is configured to provide warnings at the control panel in the event that any of the pH probes monitoring acid or caustic addition register an out-of-specification value.

5.5.3.2 Detection of Upset Condition

The treatment system has continuous reading pH probes at various process locations that will provide warnings at the control panel in the event that measured values are not within specified ranges.

5.5.4 High TDS Upset Condition

5.5.4.1 Prevention of Upset Condition

TDS is removed from the groundwater by the reverse osmosis process. TDS is monitored in the treatment system through the surrogate parameter of conductivity. The conductivity of the reverse osmosis permeate from the reverse osmosis process and that of the blended (microfilter permeate and reverse osmosis permeate) final effluent is continuously monitored. The system will be shut down if the reverse osmosis permeate or effluent conductivity exceeds a maximum value.

5.5.4.2 Detection of Upset Condition

Conductivity is measured: (1) at the influent to the reverse osmosis feed tank (T-600), (2) at the influent to the reverse osmosis system, (3) on the reverse osmosis permeate before and after the F.D. aerator, (4) on the recycle stream to the reverse osmosis feed tank, and (5) at the inlet to the reverse osmosis concentrate storage tank. The control system warns the operators in the event that conductivity values are outside of acceptable ranges.

5.5.5 Recovery from an Upset Condition

In the event of an upset condition, the treatment system will be shut down. Operators need to identify and document the upset condition, correct the upset condition, manage any out-of-specification groundwater in the system, and restart the system.

5.5.5.1 Identify the Upset Condition

The first step in recovering from an upset condition is to identify and document the nature and cause in the daily operations log. At a minimum, actions that should be taken to identify the nature of the upset condition include:

1. If the shut down was not operator initiated, review the warning and alarm log to identify the event(s) triggering the shutdown.
2. Analyze samples from the reverse osmosis feed tank and treated water storage tank to assess whether the Cr(VI) concentration is above the monthly average permit limit of 8 parts per billion (micrograms/liter or μg/L) and/or the maximum daily limit of 16 μg/L, using on-site laboratory procedures.
3. Review the conductivity data for AIT-606, AIT-610, and AIT-702 to confirm that the treated groundwater entering the treated water storage tank is consistent with the value required for subsurface injection (see the *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area*).
4. Review pH data from AIT-600 to confirm that the pH values are within the acceptable discharge range.

5.5.5.2 Correct the Upset Condition

Once the cause of the upset condition is identified, it should be corrected and the correction documented in the daily log.

5.5.5.3 Manage Out-of-Specification Groundwater

Out-of-specification groundwater in process units up to and including the reverse osmosis feed tank can be re-circulated using the filtered water transfer pump (P-620) back to the raw water storage tank. Out of specification groundwater in the reverse osmosis system can be recirculated to the raw water storage tank by opening valve V-TW-114-02 and closing valve V-TW-105-02.

There may be conditions, such as an overdose of polymer, that require draining selected process units to the off-specification water tank. Equipment drains have been provided with drain-hose fittings for this purpose.

In the event that the water in the treated water storage tank does not meet discharge requirements for subsurface injection and it cannot be re-treated, it can be pumped to Baker tanks at the MW-20 bench for off-site disposal. However, the discharge lines from the treated water storage tank and the reverse osmosis concentrate storage tank are not designed to handle wastewater that is a hazardous waste. In the event of an upset condition that results in either of these tanks containing hazardous wastewater (pH less than 2.0 or greater than 12.5 or total chromium concentration greater than 5 parts per million), the water in the tank will either be re-treated on site or loaded into trucks for transportation to a permitted off-site disposal facility.

5.5.5.4 Restart the Treatment System

The treatment system should be restarted using the start-up Standard Operating Procedure in Appendix E.

TABLE 5-1
Treatment Plant Control Initial Set Point List – April 2005
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Parameter	Set Point	Control Approach
Raw Water Storage Tank T-100 Level	High tank level at 5 feet. Low tank level at 3 feet.	On-Off Control of well pumps.
Treatment Plant Flow Rate at FIC-200	Flow rate selected by operator in the range 20 to 135 gpm	Modulation of Flow Control Valve FCV-200
FeCl Pump P-800 Feed Rate	Dose (ml/gpm) set by operator along with influent flow rate	Adjusts pump speed based on dose set point and influent flow rate
H_2SO_4 Pump P-801 Feed Rate	pH of 6.5 standard units	Adjusts pump speed based on signal from AIT-202
NaOH Pump P-802A Feed Rate	Dose (ml/gpm) set by operator along with influent flow rate	Adjusts pump speed based on dose set point and influent flow rate
NaOH Pump P-802B Feed Rate	Dose (ml/gpm) set by operator along with influent flow rate	Adjusts pump speed adjusted based on dose set point and influent flow rate
NaOH Pump P-802C Feed Rate	pH of 7.8 standard units	Adjusts pump speed based on signal from AIT-301C
NaOH Pump P-802D Feed Rate	pH of 7.0 standard units	Adjusts pump speed based on signal from AIT-606
Polymer System M-800 Feed Rate	Feed rate set by operator at Polymer skid	Periodic jar tests by plant operator
Iron Oxidation Tank C T301C Level	Tank level at 12 ft	Adjusts Variable Frequency Drive on Clarifier Feed Pump P-400

TABLE 5-1
Treatment Plant Control Initial Set Point List – April 2005
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Parameter	Set Point	Control Approach
Demister Water Wash Solenoid Valve SV-302	On every 3 hours On for 30 seconds	Timer Control
Sludge Recycle Flow Rate	Continuous operation	Sludge Recycle Pump P-404 always operating
Clarifier Sludge Transfer to Sludge Holding Tank	On every 60 minutes On for 2 minutes (periodically field-verified)	Sludge Withdrawal Pump P-401 Timer Control– operator-adjusted to maintain sufficient sludge inventory for recycle without impairing clarifier operation
Sludge Storage Tank Level Control Separator Feed Pump P-403	High tank level at 10 ft Low tank level at 3 ft	On/off control of Separator Feed Pump (P-403)
Process Drain Tank T-900 Level	High tank level at 3.5 ft Low tank level at 2.5 ft	On/off control of Process Drain Pump (P-900)
Reverse Osmosis Feed Tank T-600 Level	Tank level at 12 ft	Adjusts Level Control Valve LCV-603 on Reverse Osmosis Permeate Recycle line
Reverse Osmosis Feed Tank Conductivity	AIT-604 to match AIT-600 within ±5 %	Adjusts Flow Control Valve FCV-602 on Reverse Osmosis Conc. Recycle line based on AIT-600 signal
F.D. Aerator Tank T-603 Level	24 inches	Adjusts Level Control Valve LCV-604
Treated Water Storage Tank T-700 Level	High level at 5 ft. Low level at 3 ft.	On/off control of Treated Water Transfer Pump (P-700)
Reverse Osmosis Concentrate Storage Tank Level Control T-701	High tank level at 11 ft Low tank level at 2 ft	On/off control of Reverse Osmosis Conc. Transfer Pump (P-701)

Note: These set points may be adjusted by the plant operations manager based on plant operating experience.

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
1	TP-PR-10-10-03	FE/FIT-100		Magnetic Flowmeter	0-50	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022AW1	2"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
2	TP-PR-10-10-03	FE/FIT-101		Magnetic Flowmeter	0-120	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022AW1	2"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
3	TP-PR-10-10-03	FE/FIT-102		Magnetic Flowmeter	0-50	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022AW1	2"	CH2MHILL	Well Vault No. 4	Analog Input	4-20 mA	LCP-100	NONE
4	TP-PR-10-10-03	FE/FIT-103		Magnetic Flowmeter	0-50	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022AW1	2"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
5	TP-PR-10-10-03	LSH-001		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Valve Vault No. 1	Discrete Input	120 VAC	LCP-100	NONE
6	TP-PR-10-10-03	LSH-002		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Valve Vault No. 1	Discrete Input	120 VAC	LCP-100	NONE
7	TP-PR-10-10-03	LSH-100		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Well Vault No. 2	Discrete Input	120 VAC	LCP-100	NONE
8	TP-PR-10-10-03	LSH-100A		Float Level Switch	----	----		Alarm	OK	Permalert	PWS-LW		CH2MHILL	Well Vault No. 2	Discrete Input	24 VDC	Leak Detection PNL	NONE
9	TP-PR-10-10-03	LSH-101		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Well Vault No. 1	Discrete Input	120 VAC	LCP-100	NONE
10	TP-PR-10-10-03	LSH-101A		Float Level Switch	----	----		Alarm	OK	Permalert	PWS-LW		CH2MHILL	Well Vault No. 1	Discrete Input	24 VDC	Leak Detection PNL	NONE
11	TP-PR-10-10-03	LSH-102		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Well Vault No. 4	Discrete Input	120 VAC	LCP-100	NONE
12	TP-PR-10-10-03	LSH-102A		Float Level Switch	----	----		Alarm	OK	Permalert	PWS-LW		CH2MHILL	Well Vault No. 4	Discrete Input	24 VDC	Leak Detection PNL	NONE
13	TP-PR-10-10-03	LSH-103		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Well Vault No. 3	Discrete Input	120 VAC	LCP-100	NONE
14	TP-PR-10-10-03	LSH-103A		Float Level Switch	----	----		Alarm	OK	Permalert	PWS-LW		CH2MHILL	Well Vault No. 3	Discrete Input	24 VDC	Leak Detection PNL	NONE
15	TP-PR-10-10-03	LSHH-001		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Valve Vault No. 1	Discrete Input	120 VAC	LCP-100	NONE
16	TP-PR-10-10-03	LSHH-002		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	Valve Vault No. 1	Discrete Input	120 VAC	LCP-100	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
17	TP-PR-10-10-03	LT-100		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	Well Vault No. 2	Analog Input	4-20 mA	LCP-100	NONE
18	TP-PR-10-10-03	LT-101		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
19	TP-PR-10-10-03	LT-102		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	Well Vault No. 4	Analog Input	4-20 mA	LCP-100	NONE
20	TP-PR-10-10-03	LT-103		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	Well Vault No. 3	Analog Input	4-20 mA	LCP-100	NONE
21	TP-PR-10-10-03	PE/PIT-100		Pressure Transmitter With Seal	0-100	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
22	TP-PR-10-10-03	PE/PIT-101		Pressure Transmitter With Seal	0-100	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
23	TP-PR-10-10-03	PE/PIT-102		Pressure Transmitter With Seal	0-100	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	Well Vault No. 4	Analog Input	4-20 mA	LCP-100	NONE
24	TP-PR-10-10-03	PE/PIT-103		Pressure Transmitter With Seal	0-100	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	Valve Vault No. 1	Analog Input	4-20 mA	LCP-100	NONE
25	TP-PR-10-10-03	PI-100		Pressure Gauge With Seal	0-100	PSIG				Ashcroft	45-1279-SS-04L-0/100	0.5"	CH2MHILL	Well Vault No. 2	None	NONE	N/A	NONE
26	TP-PR-10-10-03	PI-101		Pressure Gauge With Seal	0-100	PSIG				Ashcroft	45-1279-SS-04L-0/100	0.5"	CH2MHILL	Well Vault No. 1	None	NONE	N/A	NONE
27	TP-PR-10-10-03	PI-102		Pressure Gauge With Seal	0-100	PSIG				Ashcroft	45-1279-SS-04L-0/100	0.5"	CH2MHILL	Well Vault No. 4	None	NONE	N/A	NONE
28	TP-PR-10-10-03	PI-103		Pressure Gauge With Seal	0-100	PSIG				Ashcroft	45-1279-SS-04L-0/100	0.5"	CH2MHILL	Well Vault No. 3	None	NONE	N/A	NONE
29	TP-PR-10-10-04	FE/FIT-200		Magnetic Flowmeter	0-200	GPM				Endress+Hauser	Promag 23P-80 AL1A1AA022AW 1	3"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	LCP-100	NONE
30	TP-PR-10-10-04	FE/FIT-700		Magnetic Flowmeter	0-200	GPM				Endress+Hauser	Promag 23P-80 AL1A1AA022AW 1	3"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	LCP-100	NONE
31	TP-PR-10-10-04	FE-200		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-200	None	NONE	N/A	NONE
32	TP-PR-10-10-04	HS-100A	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
33	TP-PR-10-10-04	LE/LIT-200		Ultrasonic Level Transmitter	0-12	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
34	TP-PR-10-10-04	LE/LIT-700		Ultrasonic Level Transmitter	0-12	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
35	TP-PR-10-10-04	LSH-201A		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
36	TP-PR-10-10-04	LSH-201B		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
37	TP-PR-10-10-04	LSH-201C		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
38	TP-PR-10-10-04	LSH-201D		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
39	TP-PR-10-10-04	LSH-201E		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
40	TP-PR-10-10-04	LSH-201F		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
41	TP-PR-10-10-04	LSH-201G		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
42	TP-PR-10-10-04	LSH-201H		Leak Detection Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	24 VDC	Leak Detection PNL	NONE
43	TP-PR-10-10-04	PI-200		Pressure Gauge With Seal	0-30	PSIG				Ashcroft	45-1279-SS-04L-0/30	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
44	TP-PR-10-10-04	PI-700		Pressure Gauge With Seal	0-100	PSIG				Ashcroft	45-1279-SS-04L-0/100	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
45	TP-PR-10-10-04	PSL-1100		Low Pressure Switch	0-100	PSIG	40 PSIG	Alarm	OK	Ashcroft	PPS-N4-G T 06 XK3 NH 100	0.5"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
46	TP-PR-10-10-04	RO-200		Restriction Orifice	----	----				Daniel	Model 520, 0.5246 INCH diameter	2"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
47	TP-PR-10-10-04	YL-1000		Visual Alarm Strobe	----	----		Off	ON	Federal Signal	131-ST		CH2MHILL	TP-EE-20-01-19	Relay Output	120 VAC	LCP-100	NONE
48	TP-PR-10-10-04	YL-1001		Visual Alarm Strobe	----	----		Off	ON	Federal Signal	131-ST		CH2MHILL	TP-EE-20-01-19	Relay Output	120 VAC	LCP-100	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
49	TP-PR-10-10-04	YL-1002		Visual Alarm Strobe	----	----		Off	ON	Federal Signal	131-ST		CH2MHILL	TP-EE-20-01-19	Relay Output	120 VAC	LCP-100	NONE
50	TP-PR-10-10-04	YL-1003		Visual Alarm Strobe	----	----		Off	ON	Federal Signal	131-ST		CH2MHILL	TP-EE-20-01-19	Relay Output	120 VAC	LCP-100	NONE
51	TP-PR-10-10-04	YL-1004		Audible Alarm Horn	----	----		Off	ON	Federal Signal	350WB		CH2MHILL	TP-EE-20-01-19	Relay Output	120 VAC	LCP-100	NONE
52	TP-PR-10-10-05	AE/AIT-201	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
53	TP-PR-10-10-05	AE/AIT-202-1	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
54	TP-PR-10-10-05	AE/AIT-202-2	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25 "	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
55	TP-PR-10-10-05	AE/AIT-300-1	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25 "	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
56	TP-PR-10-10-05	AE/AIT-300-2	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
57	TP-PR-10-10-05	AE/AIT-301A-1	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
58	TP-PR-10-10-05	AE/AIT-301A-2	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
59	TP-PR-10-10-05	AE/AIT-301B-1	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
60	TP-PR-10-10-05	AE/AIT-301B-2	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
61	TP-PR-10-10-05	AE/AIT-301C-1	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
62	TP-PR-10-10-05	AE/AIT-301C-2	pH/TEMP	PH and Temperature Analyzer	0-14/0-100	pH/deg C				ABB-TBI	TB84pH2000101, TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
63	TP-PR-10-10-05	FE-201		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-201	None	NONE	N/A	NONE
64	TP-PR-10-10-05	FE-400		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-400	None	NONE	N/A	NONE
65	TP-PR-10-10-05	FSL-201		Thermal Flow Switch	0-200	GPM	120 GPM	Alarm	OK	Fluid Components Int'l	FLT93S-1B-1C204C-1B010-00	1"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	120 VAC
66	TP-PR-10-10-05	HS-201	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
67	TP-PR-10-10-05	HS-302	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
68	TP-PR-10-10-05	LE/LIT-301C		Ultrasonic Level Transmitter	0-16	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
69	TP-PR-10-10-05	LSH-300		Vibrating Tuning Fork Level Switch	----	----		Alarm	OK	Endress+Hauser	FTL50-A-GN5-AA-4-E5-A1	1"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	120 VAC
70	TP-PR-10-10-05	LSH-301A		Vibrating Tuning Fork Level Switch	----	----		Alarm	OK	Endress+Hauser	FTL50-A-GN5-AA-4-E5-A1	1"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	120 VAC
71	TP-PR-10-10-05	LSH-301B		Vibrating Tuning Fork Level Switch	----	----		Alarm	OK	Endress+Hauser	FTL50-A-GN5-AA-4-E5-A1	1"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	120 VAC
72	TP-PR-10-10-05	LSH-301C		Vibrating Tuning Fork Level Switch	----	----		Alarm	OK	Endress+Hauser	FTL50-A-GN5-AA-4-E5-A1	1"	CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	120 VAC
73	TP-PR-10-10-05	PI-201		Pressure Gauge With Seal	0-8	PSIG				Ashcroft	45-1188-SS-04L-0/8	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
74	TP-PR-10-10-05	PI-400		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
75	TP-PR-10-10-05	RO-201		Restriction Orifice	----	----				Daniel	Model 520, 2.0000 INCH Diameter	4"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
76	TP-PR-10-10-06	FE-900		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-900	None	NONE	N/A	NONE

TABLE 5-2
Field Instrument Summary
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ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
77	TP-PR-10-10-06	HS-400	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
78	TP-PR-10-10-06	HS-401	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
79	TP-PR-10-10-06	HS-403	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
80	TP-PR-10-10-06	HS-404	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
81	TP-PR-10-10-06	LE/LIT-402		Ultrasonic Level Transmitter	0-12	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
82	TP-PR-10-10-06	LE/LIT-900		Ultrasonic Level Transmitter	0-9	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
83	TP-PR-10-10-06	LSH-405A		Float Level Switch	----	----		Alarm	OK	Anchor Scientific	Type SM15NC		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
84	TP-PR-10-10-06	LSH-405B		Float Level Switch	----	----		Alarm	OK	Anchor Scientific	Type SM15NC		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
85	TP-PR-10-10-06	LSH-900		Float Level Switch	----	----		Alarm	OK	Gems Sensors	LS-270		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
86	TP-PR-10-10-06	PE/PI-401		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
87	TP-PR-10-10-06	PE/PI-403		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
88	TP-PR-10-10-06	PE/PI-404		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
89	TP-PR-10-10-07	FE-500		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-500	None	NONE	N/A	NONE
90	TP-PR-10-10-07	LE/LIT-500		Ultrasonic Level Transmitter	0-16	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
91	TP-PR-10-10-07	PI-500		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
92	TP-PR-10-10-08	AE/AIT-400	TURB	Turbidity Analyzer	0-100	NTU				Great Lakes Instruments	T53A4A1S, 8320T 1A0C3SC	0.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
93	TP-PR-10-10-08	AE/AIT-600	COND	Conductivity Analyzer	0-10,000	uS/cm				ABB-TBI	TB84TC200001, TB404214L2152	1.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
94	TP-PR-10-10-08	AE/AIT-601	COND	Conductivity Analyzer	0-10,000	uS/cm				ABB-TBI	TB84TC200001, TB404214L2152	1.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
95	TP-PR-10-10-08	AE/AIT-604	COND	Conductivity Analyzer	0-10,000	uS/cm				ABB-TBI	TB84TC200001, TB404214L2152	1.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
96	TP-PR-10-10-08	AE/AIT-605	COND	Conductivity Analyzer	0-1,000	uS/cm				ABB-TBI	TB84pH2000101 , TBX55713D21740JB	1.25"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
97	TP-PR-10-10-08	AE/AIT-606	pH/TEMP	Ph/TEMPERATURE ANALYZER	0-14/0-100	pH/Deg C				ABB-TBI	TB84TC200001, TB404214L2152	1.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
98	TP-PR-10-10-08	AE/AIT-701	COND	Conductivity Analyzer	0-40,000	uS/cm				ABB-TBI	TB84TC200001, TB404214L2152	1.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	NONE
99	TP-PR-10-10-08	FE-620		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-620	None	NONE	N/A	NONE
100	TP-PR-10-10-08	FE-701		Rotameter	0-1	GPM				King Instruments	7530-3-1-2-3C02	0.5"	CH2MHILL	Pump P-701	None	NONE	N/A	NONE
101	TP-PR-10-10-08	FIT-601		Flow Transmitter		GPM							ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
102	TP-PR-10-10-08	FIT-611		Flow Transmitter		GPM							ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
103	TP-PR-10-10-08	FIT-612		Flow Transmitter		GPM							ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
104	TP-PR-10-10-08	LE/LIT-600		Ultrasonic Level Transmitter	0-16	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
105	TP-PR-10-10-08	LE/LIT-604		Level Transmitter		FEET							ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
106	TP-PR-10-10-08	LE/LIT-701		Ultrasonic Level Transmitter	0-14	FEET				Endress+Hauser	FDU-8-0-R-N-A-A, FMU-86-0-R-1-E-1-B-81	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
107	TP-PR-10-10-08	PI-620		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
108	TP-PR-10-10-08	PI-701		Pressure Gauge With Seal	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
109	TP-PR-10-10-08	PIT-602		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
110	TP-PR-10-10-08	PIT-603		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
111	TP-PR-10-10-08	PIT-605		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
112	TP-PR-10-10-08	PIT-606		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
113	TP-PR-10-10-08	PIT-607		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
114	TP-PR-10-10-08	PIT-608		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
115	TP-PR-10-10-08	PIT-609		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
116	TP-PR-10-10-08	PIT-610		Electronic Pressure Transmitter		PSIG						0.5"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
117	TP-PR-10-10-08	TIT-604		Electronic Temperature Transmitter		PSIG						0.75"	ECOLOCHEM	TP-EE-20-01-19	Analog Input	4-20 mA	Ethernet	NONE
118	TP-PR-10-10-09	FIT-300A		Thermal Flow Transmitter	0-120	SCFM				Sierra Instruments	640 CSA L06 M1 E2 P3 V4 DD 0	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
119	TP-PR-10-10-09	FIT-300B		Thermal Flow Transmitter	0-120	SCFM				Sierra Instruments	640 CSA L06 M1 E2 P3 V4 DD 0	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
120	TP-PR-10-10-09	FIT-300C		Thermal Flow Transmitter	0-120	SCFM				Sierra Instruments	640 CSA L06 M1 E2 P3 V4 DD 0	1"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	Instrument	120 VAC
121	TP-PR-10-10-09	FSL-800		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
122	TP-PR-10-10-09	FSL-801		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
123	TP-PR-10-10-09	FSL-802A		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
124	TP-PR-10-10-09	FSL-802B		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
125	TP-PR-10-10-09	FSL-802C		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
126	TP-PR-10-10-09	FSL-802D		Low Flow Switch		GPM		Alarm	OK			0.25"	Hamilton Engr	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
127	TP-PR-10-10-09	FSL-804		Low Flow Switch		GPM		Alarm	OK				NALCO	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
128	TP-PR-10-10-09	HS-807	LOR	Hand Switch	----	----				Allen-Bradley	800R-R3HA4RL with 1 NO & 1 NC extra contact		CH2MHILL	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
129	TP-PR-10-10-09	LSL-804		Low Level Switch		FEET		Alarm	OK				NALCO	TP-EE-20-01-19	Discrete Input	120 VAC	LCP-100	NONE
130	TP-PR-10-10-09	PI-1000		Pressure Gauge	0-200	PSIG				Ashcroft	45-1279-SS-04L-0/200	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
131	TP-PR-10-10-09	PI-300A		Pressure Gauge	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
132	TP-PR-10-10-09	PI-300B		Pressure Gauge	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
133	TP-PR-10-10-09	PI-300C		Pressure Gauge	0-15	PSIG				Ashcroft	45-1279-SS-04L-0/15	0.5"	CH2MHILL	TP-EE-20-01-19	None	NONE	N/A	NONE
134	TP-PR-10-10-09	PI-800		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
135	TP-PR-10-10-09	PI-801		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
136	TP-PR-10-10-09	PI-802A		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
137	TP-PR-10-10-09	PI-802B		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
138	TP-PR-10-10-09	PI-802C		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
139	TP-PR-10-10-09	PI-802D		Pressure Gauge With Seal		PSIG						0.25"	Hamilton Engr	TP-EE-20-01-19	None	NONE	N/A	NONE
140	TP-PR-10-10-09	PIT-1000		Electronic Pressure Transmitter	0-150	PSIG				Endress+Hauser	PMC 731-R 5 1P 9 M 2 1N 1	0.5"	CH2MHILL	TP-EE-20-01-19	Analog Input	4-20 mA	LCP-100	NONE
141	TP-PR-10-10-11	FIT-1201		Magnetic Flowmeter	0-25	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022 AW1	2"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
142	TP-PR-10-10-11	FIT-1202		Magnetic Flowmeter	0-25	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022 AW1	2"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
143	TP-PR-10-10-11	FIT-1203		Magnetic Flowmeter	0-25	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022 AW1	2"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
144	TP-PR-10-10-11	FIT-1204		Magnetic Flowmeter	0-25	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022 AW1	2"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
145	TP-PR-10-10-11	FIT-1205		Magnetic Flowmeter	0-25	GPM				Endress+Hauser	Promag 23P-50AL1A1AA022 AW1	2"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE

TABLE 5-2
Field Instrument Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

ID	PID_Number	Instrument Tag	Modifier	Description	Range	ENG Units	Switch Setting	ZERO State	ONE State	Manufacturer	Model_No	Process Conn	Provided_ By	Location Drawing	IO Signal Type	IO Signal Level	IO Signal Power	Field Power
146	TP-PR-10-10-11	LT-1201		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
147	TP-PR-10-10-11	LT-1202		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
148	TP-PR-10-10-11	LT-1203		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
149	TP-PR-10-10-11	LT-1204		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
150	TP-PR-10-10-11	LT-1205		Submersible Level Transmitter	0-345	FEET				Druck	RTX 1830		CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
151	TP-PR-10-10-11	PIT-1201		Pressure Transmitter	0-50	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
152	TP-PR-10-10-11	PIT-1202		Pressure Transmitter	0-50	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
153	TP-PR-10-10-11	PIT-1203		Pressure Transmitter	0-50	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
154	TP-PR-10-10-11	PIT-1204		Pressure Transmitter	0-50	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
155	TP-PR-10-10-11	PIT-1205		Pressure Transmitter	0-50	PSIG				Endress+Hauser	PMP 731-R 5 3P 9 M 29 Y 11	0.5"	CH2MHILL	tbd	Analog Input	4-20 mA	ICP-100	NONE
156	TP-PR-10-10-10	LSH-702		Float Level Switch	----	----		Alarm	OK	Anchor Scientific	Type SM15NC		CH2MHILL	Baker Tank Location	Discrete Input	120 VAC	LCP-100	NONE
157	TP-PR-10-10-10	LSH-703		Float Level Switch	----	----		Alarm	OK	Anchor Scientific	Type SM15NC		CH2MHILL	Baker Tank Location	Discrete Input	120 VAC	LCP-100	NONE
158	none	LSH-1250		Float Level Switch	----	----		Alarm	OK	Anchor Scientific	Type SM15NC		CH2MHILL	Control Bldg Sewage Tank	Discrete Input	120 VAC	LCP-100	NONE

6.0 Description of Maintenance

It is the responsibility of the plant operators to incorporate regular preventive maintenance into the routine work schedule based on the guidelines presented in this plan and the maintenance requirements provided in the manufacturer's manual for each piece of equipment in the plant. Table 6-1 presents a summary of required maintenance tasks. Operators will maintain maintenance records documenting completion of preventative maintenance tasks.

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
Pumps										
1	P-100	Submersible Well	1	Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins	40S30	Denver Ind. Pumps	
2	P-101	Submersible Well	1	Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins	75S100	Denver Ind. Pumps	
3	P-200	Raw Water Feed Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
4	P-201	Chemical Mixing Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
5	P-400	Clarifier Feed Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
6	P-401	Sludge Withdrawal Pump	1	n/a	n/a	n/a	n/a	PX10P	Quadna PSI	
7	P-403	Phase Separator Feed Pump	1	n/a	n/a	n/a	n/a	PX10P	Quadna PSI	
8	P-404	Sludge Recycle Pump	1	n/a	n/a	n/a	n/a	PX10P	Quadna PSI	
9	P-405	Phase Separator Sump Pump	1	Upper Ball Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Periodically	1 hour	Series 5500	Fybroc	
				Check for excessive noise and vibrations	n/a					
				Check Float Switch	n/a					
				Check Flush Line	n/a					
				Check Pressure Gauge	n/a					

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
10	P-500	Pretreated Water Transfer Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
11	P-501	MF Recirculation Pump	1	Motor/Pump/Bearing Lubrication?	____?____	____?____	____?____	____?____	Pall Advanced	
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
12	P-502	MF Reverse Filtration Pump	1	Motor/Pump/Bearing Lubrication?	____?____	____?____	____?____	____?____	Pall Advanced	
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
13	P-601A,B	RO Booster Pump	2	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	SSH	Ecolochem	
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
14	P-602	RO Feed Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Every 3 months	30 mins	-	Ecolochem	
				Pump Bearing Oil Replacement	Lubriplate Antiwear Hydraulic Oil-HO-2A	2000 OH / Every 6 months	4 Hours	-		
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins	-		
15	P-603	RO Cleaning Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	SSH	Ecolochem	
16	P-605A,B	Post-Treated RO Permeate Pump	2	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	SSH	Ecolochem	
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
17	P-606	RO Acid Pump	1	Check the diaphragm for damage	n/a	Every 4 months	30 mins	Prominent	Ecolochem	
				Check Chemical seepage at vent hole	n/a					
				Check the discharge tubing is connected firmly to the liquid end	n/a					

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Check the discharge and suction valves are firmly fixed	n/a					
				Check that the liquid end is generally water tight	n/a					
				Check for correct feed; run the gamma/L run for a short period	n/a					
				Check electrical connection for wear	n/a					
				Check the liquid end screw are fastened tightly	n/a					
18	P-607	RO Antiscalant Pump	1	Check the diaphragm for damage	n/a	Every 4 months	30 mins	Prominent	Ecolochem	
				Check Chemical seepage at vent hole	n/a					
				Check the discharge tubing is connected firmly to the liquid end	n/a					
				Check the discharge and suction valves are firmly fixed	n/a					
				Check that the liquid end is generally water tight	n/a					

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Check for correct feed; run the gamma/L run for a short period	n/a					
				Check electrical connection for wear	n/a					
				Check the liquid end screw are fastened tightly	n/a					
19	P-620	Filtered Water Transfer Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
20	P-700	Treated Water Transfer Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
21	P-701	RO Concentrate Water Pump	1	Motor/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	Series 1530	Fybroc	

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Check Mechanical Seals	n/a	Periodically	n/a			
				Check for excessive vibrations	n/a					
				Check valve installed downstream of pump	n/a	Variable (Press. Drop increase)	30 mins			
22	P-800	Ferrous Chloride Feed Pump	1	Replace LiquiframTM (Diaphragm)	n/a	Annually	4 hours	Milton Roy	Hamilton	
				Replace cartridge valves, seal rings/valve balls and injection check valve spring	n/a	Annually				
23	P-801	Sulfuric Acid Feed Pump	1	Replace LiquiframTM (Diaphragm)	n/a	Annually	4 hours	Milton Roy	Hamilton	
				Replace cartridge valves, seal rings/valve balls and injection check valve spring	n/a	Annually				
24	P-802A,B,C,D	Sodium Hydroxide Feed Pump	4	Replace LiquiframTM (Diaphragm)	n/a	Annually	4 hours	Milton Roy	Hamilton	
				Replace cartridge valves, seal rings/valve balls and injection check valve spring	n/a	Annually				
25	P-803A,B	Polyelectrolyte Feed / Transfer Pump	2	Motor/Pump/Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Annually	15 mins	DF500B-01	Chem Flow	

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Check alignment between pump and motor	n/a	Every 6 months	2 hours			
				Check transfer pump for leakage	n/a					
26	P-900	Process Drain Pump	1	Upper Ball Bearing Lubrication	Exxon Polyrex EM Polyurea Grease	Periodically	1 hour	Series 5500	Fybroc	
				Check for excessive noise and vibrations	n/a					
				Check Float Switch	n/a					
				Check Flush Line	n/a					
				Check Pressure Gauge	n/a					
27	P-1100	Seal Water Feed Pump	1	Motor/Pump/Bearing Lubrication?	____?____	____?____	____?____	HMS	Quadna PSI	
Blowers										
1	B-300	Iron Oxidation Air Blower	1	Remove an inlet or discharge expansion joint or spool piece, inspect impellers, and record all impeller clearances	n/a	Yearly	1 day	5MP SS 4/4	Gardner Denver	
				Check coupling alignment, inspect coupling for wear and repack with fresh grease (if required)	____?____	Yearly				

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Inspect V-belts and V-belt sheaves. Check sheave alignment and tension V-belts with a "tension tester"	n/a	Yearly				
				Measure internal clearances for signs of wear	n/a	Yearly				
				Inspect gear tooth wear pattern; measure gear backlash at four points spaced 90 degrees	n/a	Every 3 years	1 day			
				Check bearing clearance by indicating shaft vertical movement adjacent to the bearing	n/a	Every 3 years				
				Bearing Lubrication	____?____	Every 3 months	n/a			
2	B-600	FD Aerator Blower	1	n/a	n/a	n/a	n/a	-	Ecolochem	
Mixers										
1	M-300	Chromium Reduction Reactor	1	Gear Oil Replacement	AGMA 4 EP, ISO 150	8760 O-H / yearly	2 hours	14Q1.5	Lightin	
				Bearing Lubrication	NLGI 2EP Lithium	Every 6 months	15 to 30 mins			
2	M-301A,B,C	Iron Oxidation Reactor	3	Gear Oil Replacement	AGMA 4 EP, ISO 150	8760 O-H / yearly	2 hours	16Q7.5	Lightin	
				Bearing Lubrication	NLGI 2EP	Every 6 months	15 to 30 mins			

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
					Lithium					
3	M-400A	Clarifier Flash Mixer	1	Gear Oil Replacement	ISO VG220	10,000 OH/Every 2 years	4 hours	-	Nord	
				Bearing Lubrication	NLGI 2EP Lithium	Every 3 months	15 to 30 mins			
4	M-400B	Clarifier Floc Mixer	1	Gear Oil Replacement	ISO VG220	10,000 OH/Every 2 years	4 hours	-	Nord	
				Bearing Lubrication	NLGI 2EP Lithium	Every 3 months	15 to 30 mins			
5	M-400C	Clarifier Sludge Mixer	1	Gear Oil Replacement	ISO VG220	10,000 OH/Every 2 years	4 hours	-	Nord	
				Bearing Lubrication	NLGI 2EP Lithium	Every 3 months	15 to 30 mins			
6	M-402	Sludge Holding Tank Mixer	1	Gear Oil Replacement	AGMA 4 EP, ISO 150	8760 O-H / yearly	2 hours	16Q5	Lightin	
				Bearing Lubrication	NLGI 2EP Lithium	Every 6 months	15 to 30 mins			
7	?	Mixing Tank Dry Polymer Feeder	1	Motor/Pump/Bearing Lubrication?	____?____	____?____	____?____	DF500B-01	Chem Flow	
				Inspect mixer assembly-bearing and mixing blade for wearing	n/a	Every 3 months	2 days			
Treatment Equipment										
1	CMP-1000	Air Compressor	1	Lubricate bearings on motor	?	Every 4 months	15-30 mins	EFB99A	Gardner Denver	

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Change oil filter element	n/a	Every 6 months	15-30 mins			
				Check pressure relief valve for proper operation	n/a	Annually	15-30 mins			
				Change oil separator	n/a	Annually	2 hours			
				Change compressor lubricant, flush system if required	?	Annually	2 hours			
				Replace pilot air filter element	n/a	Annually	15-30 mins	DGH0060		
				Replace desiccant	n/a	Every 3-5 years	15-30 mins			
				Change purge muffler	n/a	Annually	15-30 mins			
2	CL-400	Clarifier	1	Drain clarifier and pressure wash the lamella plates to remove solids buildup	n/a	Annually	2 days	-	Parkson	
3	MF-500	MF System	1	Internal inspection and probable cleaning?	n/a	____?____	____?____	____?____	Pall Advanced	
4	RO-700	RO System	1	Internal inspection and probable cleaning (DI flush, Citric acid, DI rinse, Roclean L211, etc.)	n/a	Variable (Press. Drop increase, Permeate flux decrease, Permeate quality deterioration)	2 days	RO 154	Ecolochem	
5	M-800	Dry Polymer Feeder	1	Inspect and cleaning of wet heads	n/a	Weekly	1 hour	DF500B-01	Chem Flow	
				Flush and clean Mixing	n/a	Monthly	2 days			

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
				Tank						
				Inspect Ultrasonic Level Sensor	n/a	Monthly	1 hour			
				Clean solenoid pilots	n/a	Annually	1 hour			
Tanks										
1	T-100	Clarifier	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
2	T-200	Pipe Reactor	1	Acid wash or roto-rooter	n/a	Annually	1 day	-	-	
3	T-300	Chromium Reduction Reactor	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
4	T-301A,B,C	Iron Oxidation Reactor	3	Internal inspection and probable cleaning(Likely buildup of ferric and chromic hydroxide solids)	n/a	Annually	2 days	-	Palmer	Confined space entry, high pressure wash
5	T-500	Pretreated Water Break Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
6	T-501	MF Feed Tank MF	1	Internal inspection and probable cleaning?	n/a	____?____	____?____	-	Pall Advanced	
7	T-502	Reverse Filtration Tank	1	Internal inspection and probable cleaning?	n/a	____?____	____?____	-	Pall Advanced	
8	T-600	RO Feed Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
9	T-601	RO Cleaning	1	Internal inspection	n/a	Variable	2 days	-	Ecolochem	

TABLE 6-1
Preventative Maintenance Summary
Interim Measures No. 3 Treatment and Extraction System Operation and Maintenance Plan

Item No.	Equipment Tag No.	Equipment Name	Qty.	Description of Maintenance Item	Lubricants	Frequency of Maintenance Item	Estimated System Downtime	Model No.	Vendor	Remarks
		Tank								
10	T-700	Treated Water Storage Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
11	T-701	RO Concentrate Storage Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
12	T-702A,B	Treated Water Storage Tank #2	2	Internal inspection	n/a	Annually	2 days	-	Baker	Confined space entry
13	T-703	RO Concentrate Storage Tank #2	1	Internal inspection	n/a	Annually	2 days	-	Baker	Confined space entry
14	T-900	Drain Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
15	T-402	Sludge Holding Tank	1	Internal inspection	n/a	Annually	2 days	-	Palmer	Confined space entry
Strainer										
1	PS-RW-111-01	Strainer Duplex	1	Internal inspection and cleaning	n/a	Variable	15-30 mins	-	-	
2	PS-TW-127-01	Strainer Simplex	1	Internal inspection and cleaning	n/a	Variable	15-30 mins	-	-	
3	PS-WS-111-01	Strainer Simplex	1	Internal inspection and cleaning	n/a	Variable	15-30 mins	-	-	

7.0 Replacement Schedule for Equipment and Installed Components

Equipment and installed components will be inspected and maintained as described in Section 6.0. Equipment will be replaced as-needed, based on the results of the inspections and preventative maintenance.

Proposed System downtimes for preventative maintenance include:

- Twice a year: 1-week downtime each.
- Twice a year: 4-day downtime each.
- Monthly (in other 8 months): 2-day downtime each.

Maintenance will include activities such as pump lubrication, cleaning the reverse osmosis and microfilter membranes, and other activities described in Section 6.0. These activities are required to keep the plant running without unexpected mechanical failures. Downtimes will be scheduled to occur at low-flow seasons as much as possible.

8.0 Waste Management Plan

Waste streams resulting from operation of the groundwater extraction and treatment system include residual solids, reverse osmosis concentrate, empty containers of treatment chemicals, waste lubricating oil, and off-specification treated groundwater. Management of these wastes is addressed in the Solid Waste Management Plan, which has been prepared as a separate document.

9.0 Sampling and Monitoring

9.1 Process Monitoring

Process monitoring includes:

- Logging alarms and documenting operator interventions.
- Confirming key process set points.
- Recording key local process instrument readings (level, flow, pH, turbidity, pressure, etc.).
- Determining sludge levels in the clarifier, sludge storage tank, and phase separators.
- Assessing treatment chemical volumes.
- Confirming chemical feed rates.
- Monitoring groundwater at various treatment system locations for Fe(II), Cr(VI), total chromium, conductivity, and total suspended solids.
- Documenting general plant conditions.

Process monitoring and inspection checklists are included in Appendix H. Table H-1 details the daily monitoring activities related to the mechanical system operations. Table H-2 details the daily laboratory analyses that are conducted to monitor the treatment system operations.

The chemistry of the treatment process will be monitored using a Hach DR 4000V Spectrophotometer. The Hach DR 4000V will be used to routinely analyze water for Fe(II), Cr(VI), and total chromium. The Hach analyses will be used to monitor and analyze the chromium reduction, iron oxidation, clarification, and microfiltration processes.

9.2 Compliance Sampling

Compliance monitoring activities are required under the WDR for Underground Injection of Treated Groundwater issued by the CRBRWQCB. The WDR is presented in Appendix A. Compliance monitoring guidance is provided in the *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area* (CH2M HILL 2005).

9.3 Hazardous Waste Inspections

Inspections will be performed based on:

- Container storage areas will be inspected at least weekly for leaking containers and for deterioration of the containment system caused by corrosion or other factors (22 CCR 66265.174).

- Hazardous waste tanks will be inspected daily for overfill/spill control equipment, corrosion or releases of waste and, for uncovered tanks, the level of waste in the tank (22 CCR 66265.195).

10.0 O&M Contingency Procedures

The Contingency Plan is included in Appendix J.

11.0 Data Management, Documentation, and Reporting Requirements

11.1 Records

Treatment plant records include:

- Data historian, which contains a log of all PLC inputs.
- Process monitoring records (see Appendix H, Tables H-1 and H-2).
- Maintenance/calibration records (see Section 6.0).
- Conditional Authorization inspection and monitoring records (see the California Health and Safety Code, Section 25200.3).
- Hazardous waste generator records (22 CCR, Section 66262.40).
- Monthly Self-monitoring Reports (see Appendix A, *Monitoring and Reporting Program No. R7-2004-0103,* Reporting Section).
- Semi-Annual Operation and Maintenance Reports (see Appendix A, *Monitoring and Reporting Program No. R7-2004-0103,* Operation and Maintenance Section).
- Reporting of non-compliance.

These records will be retained for a period of at least 5 years.

11.2 Monthly Monitoring Reports

Monthly monitoring reports meeting the requirements of the WDRs, Monitoring and Reporting Program, will be prepared according to the WDR Reporting section and will be submitted to the CRBRWQCB by the dates specified in Item 9 of the WDR Reporting section. Each report will contain the following statement:

> "I declare under the penalty of law that I have personally examined and am familiar with the information submitted in this document, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations."

This statement will be signed by a duly-authorized representative of PG&E.

11.3 Semi-annual Operations and Maintenance Reports

Semi-annual operation and maintenance reports meeting the requirements of the WDRs, Monitoring and Reporting Program, will be prepared according to the WDR Operations and Maintenance section and submitted to the CRBRWQCB twice each year (January 15, covering the period July 1 through December 31 and July 15, covering the period January 1 through June 30). These reports will summarize:

- Monthly analytical results.
- Data regarding daily volumes of groundwater treated.
- Groundwater monitoring data.
- Residual solids generated and disposal facilities used.
- Reverse osmosis concentrate generated and disposal facilities used.
- Summary of WDR violations and corrective actions.
- Summary of operation or maintenance problems that required shutting down the treatment system and corrective actions.
- Summary of any treatment plant modifications that affect the capacity or performance of the extraction and treatment system.

Each report will contain the following statement:

> "I declare under the penalty of law that I have personally examined and am familiar with the information submitted in this document, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations."

This statement will be signed by a duly-authorized representative of PG&E.

11.4 Reporting of Non-compliance

Non-compliance that might endanger human health or the environment will be reported orally to the CRBRWQCB and the Governor's Office of Emergency Services as soon as there is knowledge of the non-compliance, notification is possible, and notification can be performed without impeding cleanup or other emergency measures. A written report will be submitted to the CRBRWQCB within 5 days of the date that occurrence of non-compliance is discovered. The report will contain a description of the non-compliance and its suspected cause, the period of non-compliance, the anticipated time to achieve full compliance, and the steps taken or planned to reduce, eliminate, and prevent recurrence of the non-compliance.

In the event that an immediate or potential threat to human health or the environment is identified, or new releases of hazardous waste or hazardous waste constituents are discovered, or new solid waste management units are discovered, PG&E will notify the DTSC coordinator orally within 48 hours of discovery and will notify the DTSC in writing within 10 days of findings, including the immediacy and magnitude of the potential threat to human health and/or the environment.

12.0 References

Applied Earthworks, Inc. 2004. *Cultural Resources Management Plan.* September.

CH2M HILL. 2004. *Biological Resources Investigations for IM No. 3: Topock Compressor Station Expanded Groundwater Extraction and Treatment System, San Bernardino County, California.* December.

__________. 2005. *Interim Measures No. 3 Injection Well Operation and Maintenance Plan*. April.

__________. Pending. *Hazardous Materials Business Plan.*

__________. Pending. *Groundwater Compliance Monitoring Plan for Interim Measures No. 3 Injection Area.*

__________. Pending. *Interim Measures No. 3 Treatment and Extraction System Initial Startup Plan* (CH2M HILL pending).

Department of Toxic Substances Control (DTSC). 1996. *Corrective Action Consent Agreement (Revised). Pacific Gas and Electric Co.'s Topock Compressor Station, Needles, California EPA ID No. CAT080011729.* February 2.

Appendix A
Waste Discharge Requirements

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
COLORADO RIVER BASIN REGION

ORDER NO. R7-2004-0103

WASTE DISCHARGE REQUIREMENTS
FOR
PACIFIC GAS AND ELECTRIC, OWNER/OPERATOR
GROUNDWATER REMEDIATION FACILITY

Southeast of Needles – San Bernardino County

The California Regional Water Quality Control Board, Colorado River Basin Region (Regional Board) finds that:

1. The Topock Compressor Station is a natural gas compressor station used for transmission of natural gas by pipeline. Pacific Gas and Electric Company (PG&E), 77 Beale Street, San Francisco, CA 94105, is the owner and operator of the Topock Compressor Station and proposed Groundwater Remediation Facility. The proposed location for the Groundwater Remediation Facility is San Bernardino County Assessor's parcel No. 650-151-06. PG&E is currently in the process of purchasing the land from the Metropolitan Water District. PG&E is hereafter referred to either as PG&E or the Discharger.

2. The Topock Compressor Station Class II surface impoundments, proposed groundwater extraction wells and proposed conveyance piping are located on land owned or managed by the U.S. Bureau of Land Management (BLM). BLM is the federal administering agency for the land.

3. From 1951 to 1964, PG&E discharged untreated wastewater containing hexavalent chromium from the compressor station cooling tower to percolation beds in Bat Cave Wash, an ephemeral stream bed draining into the Colorado River.

4. In 1964, PG&E began treatment of blow down water by reduction of hexavalent chromium to trivalent chromium (chrome III) prior to discharge to the percolation beds. On August 14, 1969, the Regional Board adopted Resolution No. 69-25 prohibiting PG&E from discharging wastewater containing hexavalent chromium. At approximately the same time, PG&E began disposing of the treated blow down water by subsurface injection at well PGE8.

5. On November 6, 1970, PG&E submitted a Report of Waste Discharge for disposal of 0.030 million gallons per day (mgd) of industrial wastewater from cooling tower operations into one on-site lined basin designed by a California registered civil engineer.

6. On December 10, 1970, the Regional Board adopted Resolution No. 70-72 to regulate the proposed discharge of cooling tower wastewater into the one on-site lined basin.

7. On September 11, 1975, the Regional Board rescinded Resolution No. 70-72 and adopted Board Order No. 75-52.

8. Board Order No. 75-52 permitted a maximum of 0.030 mgd of industrial wastewater containing chromate to be discharged to four lined evaporative basins. Also, the Board Order prohibited the discharge of wastewater to the Colorado River or to any channel draining to the Colorado River. In addition, the Board Order specified that chemical residues obtained by chemical flocculation or evaporation of process wastewater shall be discharged only at a solid waste disposal site approved to receive these wastes.

9. On October 2, 1985, the Regional Board rescinded Board Order No. 75-52 and adopted Board Order No. 85-99.

10. Board Order No. 85-99, allowed the discharger to replace the hazardous chromate-based cooling tower water treatment process with phosphate-based inhibitors. Phosphate-based inhibitors are in use today.

11. On January 27, 1988, the Regional Board rescinded Board Order No. 85-99 and adopted Board Order No. 88-30, which was revised on March 23, 1988.

12. Revised Board Order No. 88-30 allowed discharge to four new Class II surface impoundments. PG&E closed the four existing lined evaporative basins along with all hazardous waste facilities at the Topock Compressor Station. Closure was done in compliance with closure requirements of 40 CFR Part 265 and Subchapter 15, Chapter 3, Title 23 of the California Code of Regulations

13. On May 14, 1998, Board Order No. 88-30 was rescinded and Board Order No. 98-050 was adopted.

14. The ponds are currently regulated under Waste Discharge Requirements (WDRs) Order No. 98-050.

15. On May 10, 1995, PG&E notified the Regional Board Office that the results of analyses of groundwater samples collected from two abandoned production wells at Topock located approximately 2000 feet northeast of the former percolation ponds and 1700 feet southwest of the Colorado River, indicated concentrations of 2,300 parts per billion (ppb) and 2,850 ppb total chromium and concentrations of 1,480 ppb and 2,340 ppb hexavalent chromium for the two wells respectively. The samples were collected from a depth of approximately 120 feet below ground surface (bgs). The source of pollution is believed to be historical discharges to the Bat Cave Wash and is not associated with the current evaporation basins

16. The California Department of Health Services has set the Maximum Contaminant Level (MCL) for total chromium in drinking water at 50 ppb.

17. On February 26, 1996, the Department of Toxic Substances Control (DTSC) and PG&E entered into a Corrective Action Consent Agreement (CACA) at the Topock Gas Compressor Station due to hazardous levels of chromium found in the groundwater. DTSC is the lead agency in the Resource Conservation and Recovery Act (RCRA) investigation under the CACA.

18. Under the terms of the CACA, PG&E agreed to conduct a RCRA Facility Investigation (RFI), and to implement appropriate corrective action measures. The draft RFI was submitted in May, 2000.Results of the RFI indicated hexavalent chromium in a groundwater plume at concentrations of 13,000 ppb located 600 feet from the Colorado River at monitoring well cluster MW-20.

19. On June 30, 2004 DTSC directed PG&E to prepare and immediately implement Interim Measure No. 3 to expand existing groundwater extraction and management facilities to address hydraulic control of the chromium (VI) plume at the Topock site.

20. On June 30, 2004, DTSC issued a Notice of Exemption (NOE) for the proposed project summarized in Interim Measure No. 3. The NOE addresses the California Environmental Quality Act (CEQA) requirements for an Emergency Project, Title 14, Section 15269(c) providing for actions necessary to prevent an emergency.

21. On July 8, 2004 PG&E submitted Summary of Proposed Project for Interim Measures No.3 – Revision 1 that provided a general summary of the proposed project. The proposal describes the method of treatment to be used and means of disposal of treated water and waste products. They are as follows:

    a. Discharge to Land - Subsurface injection to one or more of three proposed injection well fields. Up to ten injection wells are proposed;

b. Discharge to Topock Compressor Station Class II surface impoundments - Reuse of treated groundwater in the Compressor Station cooling tower;

c. Discharge to Surface Water - Discharge of treated groundwater to the Colorado River under the National Pollutant Discharge Elimination System (NPDES).

22. On July 29, 2004 PG&E submitted an application and Report of Waste Discharge for a permit to discharge treated groundwater by three methods of disposal. A separate application was submitted for each method.

23. This Board Order only addresses discharge by subsurface injection Discharge to the Topock Compressor Station Class II surface impoundments and discharge to the Colorado River are addressed in separate Board Orders.

24. The discharger proposes operation of a treatment facility for implementation of Interim Measures No. 3 to address hydraulic control of the contaminated groundwater plume boundaries and prevent contaminated groundwater from entering the Colorado River. The design flow for the treatment facility is 135 gallons per minute (gpm), with a maximum capacity of 150 gpm of contaminated groundwater.

25. The discharger proposes to discharge a maximum of 135 gallons per minute (gpm) of treated groundwater into one or more of three proposed injection well fields located on San Bernardino County Assessor's parcel No. 650-151-06. PG&E is currently in the process of purchasing the land from the Metropolitan Water District. The final effluent will be composed of RO permeate that may be blended with RO concentrate or microfilter water from the treatment facility. It will be discharged to the groundwater on the west side of Parcel 650-151-06, as indicated on Attachment "A" incorporated herein and made a part of this Board Order.

26. The extracted groundwater will be treated with chemical reduction, precipitation, and solids removal by gravity or clarifier. Ferrous chloride will be used to reduce Cr (VI) to Cr (III). The precipitated solids containing Cr (III) and Fe (III) will be removed by gravity settling and microfiltration. Reverse Osmosis (RO) will be used as a polishing step for the treated water to reduce Total Dissolved Solids (TDS). Under this Order, RO concentrate and liquids may be discharged directly to the lined ponds owned an operated by PG&E at the Topock Compressor Station or to an appropriate disposal facility. Residual solids will be disposed according to federal and state regulations.

27. The discharger proposes to use the following chemicals for the treatment of extracted groundwater:

Name of Chemicals	Purpose
Ferrous Chloride	Chemical Reducing Reagent
Sodium Hydroxide	pH Control
Sulfuric Acid	pH Control
Antiscalant Formulation	Mineral Control
Anionic Polymer	Particle Setting and Solids Dewatering
Sodium Hypochlorite Solution	Microfilter Cleaning
Citric Acid Cleaner	Microfilter and RO Cleaning
Hydrochloric Acid Solution	Microfilter Cleaning

Nonionic Surfactant	Microfilter and RO Cleaning
Sodium Metabisulfite	RO Membrane Preservation
Sodium Bicarbonate	pH Control

28. The Report of Waste Discharge application described the proposed discharge (RO Permeate) as follows:

Parameter	Units	Average	Maximum
Aluminum	mg/L[1]	0.05	0.1
Ammonia (as N)	mg/L	1.5	3.0
Barium	mg/L	0.3	0.98
Boron	mg/L	1.9	3.6
Color	units	15	30
Copper	mg/L	0.02	0.04
Flow	gpm[2]	80	200
Fluoride	mg/L	0.3	0.6
Hexavalent Chromium	mg/L	0.008	0.016
Iron (total)	mg/L	0.3	0.6
Lead	mg/L	0.002	0.004
Manganese	mg/L	0.05	0.1
Molybdenum	mg/L	0.01	0.02
Nickel	mg/L	0.012	0.024
Nitrate/Nitrite as N	mg/L	10	20
pH	units	7.5	8.4
Sulfate	mg/L	250	500
Summer Temperature	° F	80	100
TDS	mg/L	500	1000
Total Chromium	mg/L	0.025	0.050
Turbidity	NTU	5	10
Winter Temperature	° F	80	85
Zinc	mg/L	0.08	0.10

29. The Water Quality Control Plan for the Colorado River Basin Region of California (Basin Plan) as amended to date designates the beneficial uses of ground and surface waters in the Region. The Basin Plan contains water quality objectives for the Colorado River and the Piute Hydrologic Unit.

30. The beneficial uses of the Colorado River are:

a. Municipal supply (MUN)
b. Agricultural supply (AGR)
c. Aquaculture (AQUA)
d. Industrial supply (IND)
e. Groundwater recharge (GWR)
f. Water contact recreation (REC I)
g. Non contact water recreation (REC II)
h. Warm freshwater habitat (WARM)
i. Cold freshwater habitat (COLD)
j. Wildlife habitat (WILD)
k. Hydropower generation (POW)
l. Preservation of rare and endangered species (RARE)

[1] Milligrams per Liter
[2] Gallons per Minute

31. The beneficial uses of ground waters in the Piute Hydrologic Unit are:

    a. Municipal supply (MUN)
    b. Industrial supply (IND)
    c. Agricultural supply (AGR)

32. Federal regulations for storm water discharges were promulgated by the United States Environmental Protection Agency (USEPA) (40 CFR Parts 122, 123, and 124). The regulations require specific categories of facilities which discharge storm water associated with industrial activity to obtain National Pollutant Discharge Elimination System (NPDES) permits and to implement Best Conventional Pollutant Technology (BCT) and Best Available Technology Economically Achievable (BAT) to reduce or eliminate industrial storm water pollution.

33. The State Water Resources Control Board (SWRCB) adopted Order No. 97-03-DWQ (General Permit No. CAS000001), specifying waste discharge requirements for discharges of storm water associated with industrial activities, excluding construction activities, and requiring submittal of a Notice of Intent by industries to be covered under the Permit.

34. The proposed discharge is consistent with the anti-degradation provisions of 40 CFR 131.12 and State Water Resources Control Board Resolution No. 68-16. If terms of the permit are met, the impact on water quality will be insignificant, including potential impacts on a municipal water source, which is the beneficial use most likely affected by the discharge.

35. In accordance with the California Environmental Quality Act (CEQA), DTSC, acting as the lead agency, has filed a Notice of Exemption for the Interim Measure 3 Emergency Groundwater Extraction and Management project at Pacific Gas and Electric Company, Topock Compressor Station. On July 1, 2004, the NOE (SCH#2004078010) was filed with the State Clearing House. The NOE states, in part: "In February 2004, [DTSC] directed [PG&E] to initiate immediate pumping, transport, and disposal of groundwater at the Topock site to ensure that groundwater containing chromium does not reach the Colorado River. Due to the influence of the Colorado River stage on groundwater levels . . . , extracting groundwater at higher rates will be necessary to maintain the stated goal of hydraulic control." The NOE further describes the project as follows: "The critical elements for this proposed project are the piping, conveyance of groundwater, construction of temporary treatment facilities, and development of a disposal method for the treated water.

36. DTSC concludes in the NOE that the project is statutorily exempt under Title 14 CCR Section 15269(c) (and Public Resources Code Section 21080(b)(4)) as an action to prevent or mitigate an emergency. The NOE states: "These project activities are necessary to prevent or mitigate an emergency situation wherein the waters of the Colorado River may be impacted with a hazardous constituent, chromium, which is in contaminated groundwater in close proximity to the river. Immediate action is necessary to contain and reverse the flow of groundwater away from the Colorado River. Commencement of the development of additional extraction, treatment, and treated water disposal capacity is urgent to assure that increased pumping rates will be available to respond to impending fluctuations of the Colorado River level.

37. The Regional Board has reviewed the NOE prepared by DTSC. The Regional Board concurs that an emergency condition exists because the flow of groundwater to the Colorado River has not yet been contained. It is necessary and desirable to have in place alternative disposal options to accommodate increased extraction and treatment rates (resulting in the need for increased disposal capacity) that may be required to contain the groundwater flow to the river. While the duration of the Interim Measures has not been determined, it is appropriate to limit the term of this Order as described in Provision No. 23, by which time it is reasonable to conclude that DTSC will have undertaken an environmental analysis of all disposal alternatives.

38. The Board has notified the discharger and all known interested agencies and persons of its intent to issue waste discharge requirements for this discharge and has provided them with an opportunity for a public meeting and an opportunity to submit comments.

39. The Board, in a public meeting, heard and considered all comments pertaining to this discharge.

IT IS HEREBY ORDERED, that in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, the discharger shall comply with the following:

A. Effluent Limitations

1. Representative samples of wastewater discharged to from the treatment system shall not contain constituents in excess of the limits indicated below. The discharge to the groundwater shall be monitored at a location which is acceptable by the Regional Board's Executive Officer or his designee:

Constituent	Unit	Average Monthly Effluent Limit	Maximum Daily Effluent Limit
Chromium (VI)	µg/L[3]	8	16
Chromium (Total)	µg/L	25	50

2. The hydrogen ion (pH) of the effluent shall be maintained within the limits of 6.5 to 8.4.

3. The effluent shall not contain heavy metals, chemicals, pesticides or other constituents in concentrations toxic to a human health.

B. Prohibitions

1. Bypass, overflow, discharge or spill of untreated or partially treated waste is prohibited.

2. The discharge of waste to land not owned or controlled by the discharger is prohibited.

3. Discharge of treated wastewater at a location or in a manner different from that described in this Board Order is prohibited.

4. The discharger shall not discharge waste in excess of the design treatment capacity of the disposal system.

5. The discharge shall not cause degradation of any water supply.

6. The discharger shall not cause degradation of any water supply in compliance with State Board Resolution No. 68-16.

C. Specifications

1. The treatment or disposal of wastes from the facility shall not cause pollution or nuisance as defined in Section 13050(l) and 13050(m) of Division 7 of the California Water Code.

2. No changes in the type or amount of treatment chemicals added to the process water as described in this Board Order shall be made without the written approval of the Regional Board's Executive Officer.

[3] micrograms per Liter

3. The facility shall be protected from any washout or erosion of wastes or covering material, and from any inundation, which could occur as a result of floods, having a predicted frequency of once in 100 years. The facility includes extraction wells, treatment plant, conveyance system, injection wells, and monitoring wells.

D. Provisions

1. The discharger shall comply with all conditions of this Board Order. Noncompliance constitutes a violation of the Porter-Cologne Water Quality Control Act, and is grounds for enforcement action; for Order termination, revocation and re-issuance, or modification of waste discharge requirements; or denial of an Order renewal application.

2. The discharger shall comply with "Monitoring and Reporting Program No. R7-2004-0103, and future revisions thereto, as specified by the Regional Board's Executive Officer.

3. The discharger shall ensure that all site-operating personnel are familiar with the content of this Board Order, and shall maintain a copy of this Board Order at the site.

4. The discharger shall develop an operation and maintenance plan for the management of the subsurface injection wells and conveyance system and submit a copy of the plan to the Regional Board's Executive Officer, or his designee, for review and approval at least 30 days prior to any discharge.

5. The discharger shall construct a representative groundwater monitoring system, acceptable to the Regional Board's Executive Officer, in the vicinity of the subsurface injection wells, which shall enable groundwater samples to be collected and analyzed as specified in Monitoring and Reporting Program R7-2004-0103 and revisions thereto. The discharger shall begin construction within 60 days of approval of the design plans, barring any extenuating circumstances reported to the Regional Board's Executive officer. The groundwater monitoring system shall include at a minimum one groundwater well up gradient and two groundwater wells down gradient of each injection well field.

6. The design plans for the groundwater monitoring system shall be submitted to the Regional Board's Executive Officer for approval within 45 days of adoption of this Board Order. Either a Professional Engineer (PE), Registered Geologist (RG), Certified Engineering Geologist (CEG), or a Certified Hydro Geologist (CHG) must certify the design plans.

7. The discharger shall, at all times, properly operate and maintain all systems and components of collection, treatment and control which are installed or used by the discharger to achieve compliance with the conditions of this Board Order. Proper operation and maintenance includes effective performance, adequate process controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of this Board Order. All systems both in service and reserved, shall be inspected and maintained on a regular basis. Records shall be kept of the inspection results and maintenance performed and made available to the Regional Board upon demand.

8. A contingency plan detailing mitigation measures in the event of a plant upset shall be submitted for approval by the Regional Board's Executive Officer at least 30 days prior to any discharge. The plan shall provide an analysis of potential causes of system failure, the effect of failure, and the proposed course of corrective action.

9. Unless otherwise approved by the Regional Board's Executive Officer, all analyses shall be conducted at a laboratory certified for such analyses by the California State Department of Health Services. All analyses shall be conducted in accordance with the latest edition of "Guidelines Establishing Test Procedures for Analysis of Pollutants", promulgated by the United States Environmental Protection Agency.

10. The discharger shall report any noncompliance that may endanger human health or the environment. The discharger shall immediately report orally information of the noncompliance as soon as (1) the discharger has knowledge of the discharge, (2) notification is possible, and (3) notification can be provided without substantially impeding cleanup or other emergency measures, to the Regional Board office and the Office of Emergency Services. During non-business hours, the discharger shall leave a message on the Regional Board office voice recorder. A written report shall also be provided within five (5) business days of the time the discharger becomes aware of the incident. The written report shall contain a description of the noncompliance and its cause, the period of noncompliance, the anticipated time to achieve full compliance, and the steps taken or planned, to reduce, eliminate, and prevent recurrence of the noncompliance. The discharger shall report all intentional or unintentional significant spills that occur within the facility to the Regional Board office in accordance with the above time limits.

11. The discharger shall allow the Regional Board, or an authorized representative, upon presentation of credentials and other documents as may be required by law, to:

    a. Enter upon the premises regulated by this Board Order, or the place where records must be kept under the conditions of this Board Order;

    b. Have access to and copy, at reasonable times, any records that shall be kept under the conditions of this Board Order;

    c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Board Order; and

    d. Sample or monitor at reasonable times, for the purpose of assuring compliance with this Board Order or as otherwise authorized by the California Water Code, any substances or parameters at this location.

12. The discharger shall comply with the following:

    a. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

    b. The discharger shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this Board Order, and records of all data used to complete the application for this Board Order, for a period of at least 5 years from the date of the sample, measurement, report or application.

    c. Records of monitoring information shall include:

        1. The date, exact place, and time of sampling or measurements.
        2. The individual(s) who performed the sampling or measurements.
        3. The date(s) analyses were performed.
        4. The individual(s) who performed the analyses.
        5. The results of such analyses.

13. Prior to any change in ownership or management of this operation, the discharger shall transmit a copy of this Board Order to the succeeding owner/operator, and forward a copy of the transmittal letter to the Regional Board.

14. Prior to any modifications in this facility, which would result in material change in the quality or, quantity of wastewater treated or discharged, or any material change in the location of discharge, the discharger shall report all pertinent information in writing to the Regional Board and obtain revised requirements before any modifications are implemented.

15. Adequate measures shall be taken to assure that flood or surface drainage waters do not erode or otherwise render portions of the discharge facilities inoperable.

16. All storm water discharges from this facility must comply with the lawful requirements of municipalities, counties, drainage districts, and other local agencies, regarding discharges of storm water to storm water drain systems or other courses under their jurisdiction.

17. Storm water discharges from the facility shall not cause or threaten to cause pollution or contamination.

18. Storm water discharges from the facility shall not contain hazardous substances equal to or in excess of a reportable quantity listed in 40 CFR Part 117 and/or 40 CFR Part 302.

19. The discharger shall provide a plan as to the method, treatment, handling and disposal of solids waste that is consistent with all State and Federal laws and regulations, including any and all prior approvals required by the Bureau of Land Management, and obtain prior written approval from the Regional Board specifying location and method of disposal, before disposing of treated or untreated solid waste.

20. This Board Order does not authorize violation of any federal, state, or local laws or regulations

21. This Board Order does not convey any property rights of any sort or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, state, or local laws or regulations.

22. The Regional Board directs the Executive Officer to forthwith prepare and file with the Office of Planning and Research, State Clearinghouse, a Notice of Exemption under Public Resources Code Section 21080(b)(4) and Title 14, California Code of Regulations, Section 15269(c).

23. This Board Order expires no later than two years from the date of first discharge, but in no event later than January 31, 2007, unless specifically authorized by a future order of the Regional Board. This Board Order may be modified, rescinded and reissued, for cause. The filing of a request by the discharger for a Board Order modification, rescission and re-issuance, or a notification of planned changes or anticipated noncompliance does not stay any Board Order condition. Causes for modification include the promulgation of new regulations, modification of land application plans, or modification in sludge use or disposal practices, or adoption of new regulations by the State Board or the Regional Board, including revisions to the Basin Plan.

I, Philip A. Gruenberg, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an Order adopted by the Regional Water Quality Control Board, Colorado River Basin Region, on October 13, 2004.

____

Executive Officer

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
COLORADO RIVER BASIN REGION

MONITORING AND REPORTING PROGRAM NO. R7-2004-0103

FOR
PACIFIC GAS AND ELECTRIC COMPANY, OWNER/OPERATOR
GROUNDWATER REMEDIATION FACILITY

Southeast of Needles – San Bernardino County

<u>MONITORING</u>

1. The collection, preservation and holding times of all samples shall be in accordance with United States Environmental Protection Agency (USEPA) approved procedures. Unless otherwise approved by the Regional Board's Executive Officer, all analyses shall be conducted by a laboratory certified by the State Department of Health Services. All analyses shall be conducted in accordance with the latest edition of the "Guidelines Establishing Test Procedures for Analysis of Pollutants" (40 CFR Part 136), promulgated by the USEPA.

2. Pursuant to the California Water Code (CWC) Section 13267, samples taken for Total Chromium shall be analyzed with a method having a method detection limit (MDL) of 1.0 ppb and samples taken for Chromium VI shall be analyzed with a method having a MDL of 0.2 ppb. The analytical results shall be reported consistent with actual observations by a California certified laboratory, and shall be reported in terms of the practical quantitation limit (PQL), if the MDL cannot be achieved. These requirements are necessary to ensure compliance with the Waste Discharge Requirements set forth in Board Order R7-2004-0103, determine the impact on the receiving groundwater, and confirm that the discharge of treated ground water does not violate Waste Discharge Requirements. Ground water monitoring in the area proposed for extraction has shown that these constituents are present at very high levels and the discharge is a potential threat to ground water and to the Colorado River.

3. Samples shall be collected at the location approved by the Regional Board's Executive Officer. If no location is specified, sampling shall be conducted at the most representative sampling point available.

4. If the facility is not in operation, or there is no discharge under this Order during a required reporting period, the discharger shall forward a letter to the Regional Board indicating that there as been no activity during the required reporting period. No sampling or analysis is required during any reporting period if the facility is not operated during that period.

5. The discharger shall monitor the treatment facility influent, effluent, and receiving water in accordance with the following:

<u>TREATMENT FACILITY START UP PHASE AND START UP REPORTING</u>

1. The discharger shall inform the Regional Board in writing of the location of all sampling stations and the expected start up date at least 10 days prior to beginning operational start up.

2. During the start up phase of the ground water treatment facility, sampling of the system influent and effluent must be performed on the first (1^{st}) and third (3^{rd}) days of operation.

    a. On the 1^{st} day of operation, the system shall be allowed to run until at least three (3) extraction well volumes are removed and until three (3) consecutive readings taken at least one (1) hour apart for pH, specific conductivity, and temperature are within five (5) percent of each other. Discharge shall be conveyed to a holding tank or disposed at an offsite, permitted facility.

b. Once these criteria are met, the treatment system effluent shall be sampled and submitted for analysis. During this phase of the start up, all treatment system effluent shall be discharged to a holding tank, or disposed at an offsite, permitted facility until the results of the 1st day analysis show that the effluent is in compliance with the effluent limitations set forth in Board Order R7-2004-0103.

c. If the analyses of the treatment system effluent collected during the 1st day of operation indicate that the effluent is in compliance, the system shall be operated with the treatment system effluent being discharged to the injection wells provided the analyses are received within 48 hours of sampling. If the discharge is not in compliance with the effluent limitations, it shall be conveyed to a holding tank or disposed at an offsite, permitted facility.

d. A second series of samples shall be collected on the 3rd day. If the samples from the 3rd day are in compliance, effluent from the treatment system shall continue to be discharged to the injection wells. If the discharge is not in compliance with the effluent limitations, it shall be conveyed to a holding tank or disposed at an offsite, permitted facility.

3. If the treatment system is shut down for more than 96 hours during start up phase, the start up and sampling procedures must be repeated.

4. A report on the start up phase shall be submitted to the Regional Board no more than fifteen (15) calendar days after completion of the start up phase. The report should contain a summary of all monitoring results, copies of laboratory reports, Chain of custody forms, flow rates, and a description of any changes or modifications to the treatment system.

TREATMENT FACILITY REPORTING AFTER START UP PHASE

1. Upon completion of the start up phase, the discharger shall begin the normal monitoring and reporting for the daily operation and maintenance of the treatment system. The Treatment System Influent and effluent, sludge monitoring and operation and maintenance reporting shall be monitored as listed below in the following sections.

A. Groundwater Treatment System Influent

1. Extracted groundwater shall be analyzed for the following constituents immediately prior to treatment:

Constituents	Units	Type of Sample	Sampling Frequency	Reporting Frequency
Flow	gpm[1]	Metered	Continuous	Monthly
TDS	mg/L[2]	Grab	See Footnote[3]	Monthly
Turbidity	NTU[4]	Grab	See Footnote[3]	Monthly
Specific Conductance	µmhos/cm[5]	Grab	See Footnote[3]	Monthly
pH	pH units	Grab	See Footnote[3]	Monthly
Total Chromium	µg/L[6]	Grab	See Footnote[3]	Monthly
Chromium VI	µg/L	Grab	See Footnote[3]	Monthly
Aluminum	µg/L	Grab	Monthly	Monthly
Ammonia (as N)	mg/L	Grab	Monthly	Monthly
Antimony	µg/L	Grab	Monthly	Monthly

[1] gallons per minute reported as a monthly average
[2] mg/L = milligrams per Liter
[3] Samples shall be taken on the 1st and 3rd days during start up phase. Sampling will continue twice weekly for the first month, weekly for the following two months, and monthly thereafter.
[4] Nephelometric Turbidity Units
[5] micromhos per centimeter
[6] micrograms per Liter

Arsenic	µg/L	Grab	Monthly	Monthly
Barium	µg/L	Grab	Monthly	Monthly
Boron	mg/L	Grab	Monthly	Monthly
Copper	µg/L	Grab	Monthly	Monthly
Fluoride	mg/L	Grab	Monthly	Monthly
Lead	µg/L	Grab	Monthly	Monthly
Manganese	µg/L	Grab	Monthly	Monthly
Molybdenum	µg/L	Grab	Monthly	Monthly
Nickel	µg/L	Grab	Monthly	Monthly
Nitrate/Nitrite (as N)	mg/L	Grab	Monthly	Monthly
Sulfate	mg/L	Grab	Monthly	Monthly
Total Iron	µg/L	Grab	Monthly	Monthly
Zinc	µg/L	Grab	Monthly	Monthly

B. Groundwater Treatment System Effluent

1. Treated groundwater shall be analyzed for the following constituents immediately after treatment:

Constituents	Units	Type of Sample	Sampling Frequency	Reporting Frequency
Flow	gpm	Metered	Continuous	Monthly
TDS	mg/L	Grab	See Footnote[7]	Monthly
Turbidity	NTU	Grab	See Footnote[7]	Monthly
Specific Conductance	µmhos/cm	Grab	See Footnote[7]	Monthly
pH	pH units	Grab	See Footnote[7]	Monthly
Total Chromium	µg/L	Grab	See Footnote[7]	Monthly
Chromium VI	µg/L	Grab	See Footnote[7]	Monthly
Aluminum	µg/L	Grab	Monthly	Monthly
Ammonia (as N)	mg/L	Grab	Monthly	Monthly
Antimony	µg/L	Grab	Monthly	Monthly
Arsenic	µg/L	Grab	Monthly	Monthly
Barium	µg/L	Grab	Monthly	Monthly
Boron	mg/L	Grab	Monthly	Monthly
Copper	µg/L	Grab	Monthly	Monthly
Fluoride	mg/L	Grab	Monthly	Monthly
Lead	µg/L	Grab	Monthly	Monthly
Manganese	µg/L	Grab	Monthly	Monthly
Molybdenum	µg/L	Grab	Monthly	Monthly
Nickel	vg/L	Grab	Monthly	Monthly
Nitrate/Nitrite (as N)	mg/L	Grab	Monthly	Monthly
Sulfate	mg/L	Grab	Monthly	Monthly
Total Iron	µg/L	Grab	Monthly	Monthly
Zinc	µg/L	Grab	Monthly	Monthly

C. Groundwater Monitoring

1. The discharger shall submit an injection well field groundwater monitoring plan to the Regional Board's Executive Officer for approval at least 30 days prior to discharge. The monitoring plan shall include monitoring analytes and frequency.

[7] Samples shall be taken on the 1st and 3rd days during start up phase. Sampling will continue twice weekly for the first month, and weekly thereafter.

D. Groundwater Treatment System Reverse Osmosis Concentrate Monitoring

1. Reverse Osmosis Concentrate shall be analyzed for the following constituents:

Constituents	Units	Type of Sample	Sampling Frequency	Reporting Frequency
Flow	gpm	Metered	Continuous	Monthly
TDS	mg/L	Grab	See Footnote[3]	Monthly
Specific Conductance	µmhos/cm	Grab	See Footnote[3]	Monthly
pH	pH units	Grab	See Footnote[3]	Monthly
Total Chromium	mg/L	Grab	See Footnote[3]	Monthly
Chromium VI	mg/L	Grab	See Footnote[3]	Monthly
Antimony	mg/L	Grab	Monthly	Monthly
Arsenic	mg/L	Grab	Monthly	Monthly
Barium	mg/L	Grab	Monthly	Monthly
Beryllium	mg/L	Grab	Monthly	Monthly
Cadmium	mg/L	Grab	Monthly	Monthly
Cobalt	mg/L	Grab	Monthly	Monthly
Copper	mg/L	Grab	Monthly	Monthly
Fluoride	mg/L	Grab	Monthly	Monthly
Lead	mg/L	Grab	Monthly	Monthly
Molybdenum	mg/L	Grab	Monthly	Monthly
Mercury	mg/L	Grab	Monthly	Monthly
Nickel	mg/L	Grab	Monthly	Monthly
Selenium	mg/L	Grab	Monthly	Monthly
Silver	mg/L	Grab	Monthly	Monthly
Thallium	mg/L	Grab	Monthly	Monthly
Vanadium	mg/L	Grab	Monthly	Monthly
Zinc	mg/L	Grab	Monthly	Monthly

E. Groundwater Treatment System Sludge Monitoring

1. Representative composite sludge samples shall be taken from each treatment tank whose purpose is to accumulate sludge for disposal prior to transportation of the sludge offsite. If sludge is transported offsite more frequently than monthly, a representative sample shall be taken on a monthly or quarterly basis as specified below. Sludge samples shall be tested for the following constituents:

Constituents	Units	Type of Sample	Sampling Frequency	Reporting Frequency
Fluoride	mg/kg[8]	Composite	See Footnote[8a]	Monthly
Total Chromium	mg/kg	Composite	See Footnote[8a]	Monthly
Chromium VI	mg/kg	Composite	See Footnote[8a]	Monthly
Antimony	mg/kg	Composite	See Footnote[8a]	Monthly
Arsenic	mg/kg	Composite	See Footnote[8a]	Monthly
Barium	mg/kg	Composite	See Footnote[8a]	Monthly
Beryllium	mg/kg	Composite	See Footnote[8a]	Monthly
Cadmium	mg/kg	Composite	See Footnote[8a]	Monthly
Cobalt	mg/kg	Composite	See Footnote[8a]	Monthly
Copper	mg/kg	Composite	See Footnote[8a]	Monthly
Lead	mg/kg	Composite	See Footnote[8a]	Monthly

[8] milligrams per kilogram
[8a] Each time sludge is transported offsite, unless sludge is transported offsite more frequently than monthly, in which case the sampling frequency shall be monthly.

Mercury	mg/kg	Composite	See Footnote[8a]	Monthly
Molybdenum	mg/kg	Composite	See Footnote[8a]	Monthly
Nickel	mg/kg	Composite	See Footnote[8a]	Monthly
Selenium	mg/kg	Composite	See Footnote[8a]	Monthly
Silver	mg/kg	Composite	See Footnote[8a]	Monthly
Thallium	mg/kg	Composite	See Footnote[8a]	Monthly
Vanadium	mg/kg	Composite	See Footnote[8a]	Monthly
Zinc	mg/kg	Composite	See Footnote[8a]	Monthly
Bioassay			See Footnote[8b]	Quarterly

2. The discharger shall report quarterly on the quantity, location and method of disposal of all sludge and similar solid materials being produced at the wastewater treatment facility.

3. The discharger shall quarterly collect one representative composite sample of sludge for each treatment tank and have an aquatic bioassay test performed on the samples. Report and select a procedure from the Static Acute Bioassay Procedure for Hazardous Waste Sample by the California Department of Fish and Game, Water pollution Control Laboratory, revised November 1988 or by other test methods approved by the California Department of Fish and Game. The discharger shall provide a report supporting any deviation from a standard procedure and must be approved by the Regional Board's Executive Officer.

OPERATION AND MAINTENANCE

1. The discharger shall inspect and document any operation/maintenance problems by inspecting each unit process. In addition, calibration of flow meters and equipment shall be performed in a timely manner and documented. Operation and Maintenance reports shall be submitted to the Regional Board Office twice-annually.

REPORTING

1. The discharger shall arrange the data in tabular form so that the specified information is readily discernible. The data shall be summarized in such a manner as to clearly illustrate whether the facility is operating in compliance with waste discharge requirements.

2. Records of monitoring information shall include:

   a. The date, exact place, and time of sampling or measurement(s);
   b. The individual(s) who performed the sampling or measurement(s);
   c. The date(s) analyses were performed;
   d. The individual(s) who performed the analyses;
   e. The analytical techniques or method used; and
   f. The results of such analyses.

3. The results of any analysis taken more frequently than required at the locations specified in this Monitoring and Reporting Program shall be reported to the Regional Board.

4. Monitoring reports shall be certified under penalty of perjury to be true and correct, and shall contain the required information at the frequency designated in this monitoring report.

[8b] Each time sludge is transported offsite, unless sludge is transported offsite more frequently than quarterly, in which case the sampling frequency shall be quarterly.

5. Each report shall contain the following statement:

   "I declare under the penalty of law that I have personally examined and am familiar with the information submitted in this document, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations".

6. A duly authorized representative of the discharger may sign the documents if:

   a. The authorization is made in writing by the person described above;

   b. The authorization specified an individual or person having responsibility for the overall operation of the regulated disposal system; and

   c. The written authorization is submitted to the Regional Board's Executive Officer.

7. Reporting of any failure in the facility shall be as described in Provision No. 9 of Board Order R7-2004-0103. Results of any analysis performed as a result of a failure of the facility shall be provided within fourteen (14) days after collection of the samples.

8. The discharger shall attach a cover letter to the Self Monitoring Report. The information contained in the cover letter shall clearly identify violations of the WDRs, discuss corrective actions taken or planned and the proposed time schedule of corrective actions. Identified violations should include a description of the requirement that was violated and a description of the violation.

9. Daily, twice-weekly, weekly, and monthly monitoring reports shall be submitted to the Regional Board by the 15th day of the following month. Quarterly monitoring reports shall be submitted to the Regional Board by January 15, April 15, July 15, and September 15 of each year. semi-annual reports shall be submitted to the Regional Board by January 15 and July 15 of each year.

10. Submit monitoring reports to:

    California Regional Water Quality Control Board
    Colorado River Basin Region
    73-720 Fred Waring, Suite 100
    Palm Desert, CA 92260

Ordered by: ______________________
Executive Officer

____
Date

Appendix B
Mass Balance

IM No. 3
Treatment and Extraction System
Material Balance

Revision H (2/15/2005)

Input Variables

Nominal Influent Flow Rate	100	gpm
Maximum Influent Flow Rate	132	gpm
Nominal Influent Cr(VI) Concentration	7	mg/L
Maximum Influent Cr(VI) Concentration	19	mg/L
Nominal Influent TDS Concentration	5,890	mg/L
Maximum Influent TDS Concentration	7,610	mg/L
Influent TSS Concentration	4	mg/L
Influent Dissolved Oxygen Conc	8.3	mg/L
Influent Alkalinity	56	mg CaCO3/L
Iron-to-Chromium Dose Factor	6	mol/mol
Iron-to-Oxygen Dose Factor	2	mol/mol
$FeCl_2$ Solution, ≈ 32%	3.4	Molar
H_2SO_4 Solution, 35%	4.5	Molar
NaOH Solution, 25%	8.0	Molar
Percentage of NaOH to Oxidation Tank 1	80	%
Percentage of NaOH to Oxidation Tank 2	0	%
Percentage of NaOH to Oxidation Tank 3	20	%
Nominal Clarifier Sludge Removal Rate	99	%
Clarifier Sludge Concentration	3.0	%
Density of Clarifier Sludge	1.02	kg/L
Filter Cake Solids Concentration	15	%
Filter Cake Density	70	lb/ft3
Microfilter TSS Removal Rate	90	%
RO Permeate Recovery	75	%
RO Solids Removal Rate	95	%

Standard Conversions and Constants

Density of Water	1	g/ml
Density of Water	1000	kg/m3
Grams per kilogram	1000	g/kg
Milligrams per gram	1000	mg/g
Pounds per kilogram	2.2	lb/kg
Liters per gallon	3.785	L/gal
Liters per cubic meter	1000	L/m3
Milliliters per liter	1000	ml/L
Minutes per hour	60	min/hr
Hours per day	24	hr/day
Mol Wt of Chromium	51.996	g/mol
Mol Wt of Oxygen	32	g/mol
Mol Wt of Iron	55.84	g/mol
Mol Wt of Chlorine	35.45	g/mol

		Well Water Supply		Pipe Reactor Recycle		Ferrous Chloride		Sulfuric Acid		Chromium Backmix Reactor		Iron Reactor Feed	
		Stream	1	Stream	2	Stream	3	Stream	4	Stream	5	Stream	6
	Units	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min
Water Volumetric Flow Rate	gpm	100	132	100	132					100	132	100	132
Water Mass Flow Rate	lb/hr	49,962	65,950	49,962	65,950					49,962		49,962	
Cr(VI) Mass Flow Rate	lb/hr	0.350	1.253	0.350	1.253					0	0	0	0
Cr(T) Mass Flow Rate	lb/hr	0.350	1.253	0.350	1.253					0.350	1.253	0.350	1.253
Cr(T) Concentration (liquid stream)	mg/L	7	19	7	19					7	19	7	19
Cr(T) Concentration (sludge stream)	mg/kg												
$FeCl_2$ Solution, ≈ 32% Vol Flow Rate	gal/hour					2.3	6.3						
$FeCl_2$ Solution, ≈ 32% Mass Flow Rate	lb/hr					26.2	70.8						
Sodium Hydroxide, 25% solution	gal/hour												
Antiscalant at 50% dilution	gal/hour												
Sulfuric Acid, 35% solution	gal/hour							0.021	0.03				
TDS	mg/L	5,890	7,610										
TSS	mg/L												
Settled Solids Mass Flow Rate	lb/day												
Settled Solids Volumetric Flow Rate	gal/day												
Clarifier Sludge Mass Flow Rate	lb/day												
Clarifier Sludge Volumetric Flow Rate	gal/day												
Filter Cake Mass Generation Rate	lb/day												
Filter Cake Volumetric Generation Rate	ft3/day												
Air Flow	cfm@60°F												
pH	--	7.9		6.8	~4.5					6.8	6.65	>6.8	>6.65
Fe^{2+}	mg/L					190,334	190,334			74	151		
Temperature	°F	77	100										

		Sodium Hydroxide - 1st Oxidation Reactor		Sodium Hydroxide - 2nd Oxidation Reactor		Sodium Hydroxide - 3rd Oxidation Reactor		Air Flow - Chromium Backmix Reactor	
		Stream	7A	Stream	7B	Stream	7C	Stream	8
	Units	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min
Water Volumetric Flow Rate	gpm								
Water Mass Flow Rate	lb/hr								
Cr(VI) Mass Flow Rate	lb/hr								
Cr(T) Mass Flow Rate	lb/hr								
Cr(T) Concentration (liquid stream)	mg/L								
Cr(T) Concentration (sludge stream)	mg/kg								
$FeCl_2$ Solution, ≈ 32% Vol Flow Rate	gal/hour								
$FeCl_2$ Solution, ≈ 32% Mass Flow Rate	lb/hr								
Sodium Hydroxide, 25% solution	gal/hour	0.689	3.047	0.000	0.000	0.172	0.762		
Antiscalant at 50% dilution	gal/hour								
Sulfuric Acid, 35% solution	gal/hour								
TDS	mg/L								
TSS	mg/L								
Settled Solids Mass Flow Rate	lb/day								
Settled Solids Volumetric Flow Rate	gal/day								
Clarifier Sludge Mass Flow Rate	lb/day								
Clarifier Sludge Volumetric Flow Rate	gal/day								
Filter Cake Mass Generation Rate	lb/day								
Filter Cake Volumetric Generation Rate	ft3/day								
Air Flow	cfm@60°F							0	0
pH	--	7.5	8.2			7.5	8.2		
Fe^{2+}	mg/L								
Temperature	°F								

		Air Flow - 1st Iron Oxidation Reactor		Air Flow - 2nd Iron Oxidation Reactor		Air Flow - 3rd Iron Oxidation Reactor		Clarifier Liquid Feed Stream		Clarifier Bottom Solids Stream	
		Stream	9A	Stream	9B	Stream	9C	Stream	10	Stream	12
	Units	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min
Water Volumetric Flow Rate	gpm							100	132	0.51	1.40
Water Mass Flow Rate	lb/hr							49,962	65,950		
Cr(VI) Mass Flow Rate	lb/hr							0.0	0.0		
Cr(T) Mass Flow Rate	lb/hr							0.350	1.253	0.346	1.241
Cr(T) Concentration (liquid stream)	mg/L							7	19		
Cr(T) Concentration (sludge stream)	mg/kg									1,316	1,720
$FeCl_2$ Solution, ≈ 32% Vol Flow Rate	gal/hour										
$FeCl_2$ Solution, ≈ 32% Mass Flow Rate	lb/hr										
Sodium Hydroxide, 25% solution	gal/hour										
Antiscalant at 50% dilution	gal/hour										
Sulfuric Acid, 35% solution	gal/hour										
TDS	mg/L										
TSS	mg/L							160	331	30,000	30,000
Settled Solids Mass Flow Rate	lb/day									189	519
Settled Solids Volumetric Flow Rate	gal/day									22	61
Clarifier Sludge Mass Flow Rate	lb/day									6,315	17,305
Clarifier Sludge Volumetric Flow Rate	gal/day									744	2037
Filter Cake Mass Generation Rate	lb/day										
Filter Cake Volumetric Generation Rate	ft3/day										
Air Flow	cfm@60°F	90	90	90	90	90	90				
pH	--							7.5	8.2	7.5	8.2
Fe^{2+}	mg/L										
Temperature	°F	77	41.7/108.6	77	41.7/108.6	77	41.7/108.6	77	100		

IM No. 3
Treatment and Extraction System
Material Balance

Revision H (2/15/2005)

Input Variables

Nominal Influent Flow Rate	100
Maximum Influent Flow Rate	132
Nominal Influent Cr(VI) Concentration	7
Maximum Influent Cr(VI) Concentration	19
Nominal Influent TDS Concentration	5,890
Maximum Influent TDS Concentration	7,610
Influent TSS Concentration	4
Influent Dissolved Oxygen Conc	8.3
Influent Alkalinity	56
Iron-to-Chromium Dose Factor	6
Iron-to-Oxygen Dose Factor	2
$FeCl_2$ Solution, ≈ 32%	3.4
H_2SO_4 Solution, 35%	4.5
NaOH Solution, 25%	8.0
Percentage of NaOH to Oxidation Tank 1	80
Percentage of NaOH to Oxidation Tank 2	0
Percentage of NaOH to Oxidation Tank 3	20
Nominal Clarifier Sludge Removal Rate	99
Clarifier Sludge Concentration	3.0
Density of Clarifier Sludge	1.02
Filter Cake Solids Concentration	15
Filter Cake Density	70
Microfilter TSS Removal Rate	90
RO Permeate Recovery	75
RO Solids Removal Rate	95

Standard Conversions and Constants

Density of Water	1
Density of Water	1000
Grams per kilogram	1000
Milligrams per gram	1000
Pounds per kilogram	2.2
Liters per gallon	3.785
Liters per cubic meter	1000
Milliliters per liter	1000
Minutes per hour	60
Hours per day	24
Mol Wt of Chromium	51.996
Mol Wt of Oxygen	32
Mol Wt of Iron	55.84
Mol Wt of Chlorine	35.45

		Solids Phase Separator		Separator Filtrate Flow Rate		Microfilter Feed		Filtered Water		Raw RO Feed		Sulfuric Acid	
		Stream		Stream		Stream	11	Stream	13	Stream	14	Stream	15
	Units	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min
Water Volumetric Flow Rate	gpm	0.09	0.25	0.42	1.15	99	131	99	131	99	131		
Water Mass Flow Rate	lb/hr												
Cr(VI) Mass Flow Rate	lb/hr												
Cr(T) Mass Flow Rate	lb/hr					0.003	0.013	0.0003	0.001	0.0003	0.001		
Cr(T) Concentration (liquid stream)	mg/L					0.07	0.19	0.007	0.019	0.007	0.019		
Cr(T) Concentration (sludge stream)	mg/kg	6,579	8,602										
$FeCl_2$ Solution, ≈ 32% Vol Flow Rate	gal/hour												
$FeCl_2$ Solution, ≈ 32% Mass Flow Rate	lb/hr												
Sodium Hydroxide, 25% solution	gal/hour												
Antiscalant at 50% dilution	gal/hour												
Sulfuric Acid, 35% solution	gal/hour											0.022	0.089
TDS	mg/L									6,178	8,193		
TSS	mg/L					1.6	3.3	0.16	0.33				
Settled Solids Mass Flow Rate	lb/day					0.08	0.22	0.01	0.02				
Settled Solids Volumetric Flow Rate	gal/day												
Clarifier Sludge Mass Flow Rate	lb/day												
Clarifier Sludge Volumetric Flow Rate	gal/day												
Filter Cake Mass Generation Rate	lb/day	1,263	3,461										
Filter Cake Volumetric Generation Rate	ft3/day	18.0	49										
Air Flow	cfm@60°F												
pH	--					7.5	8.2	7.5	8.2	7.5	8.2		
Fe^{2+}	mg/L												
Temperature	°F									77	100		

		Scale Inhibitor		RO Feed		RO Permeate		RO Concentrate		Sodium Hydroxide Dosing		Post-Treated RO Permeate	
		Stream	16	Stream	17	Stream	18	Stream	19	Stream	20	Stream	21
	Units	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min	Nominal	Max/Min
Water Volumetric Flow Rate	gpm			99	131	75	98	25	33			75	98
Water Mass Flow Rate	lb/hr			49,707	65,250	37,280	48,938	12,427	16,313			37,280	48,938
Cr(VI) Mass Flow Rate	lb/hr												
Cr(T) Mass Flow Rate	lb/hr			0.0003	0.0013								
Cr(T) Concentration (liquid stream)	mg/L			0.007	0.019								
Cr(T) Concentration (sludge stream)	mg/kg												
$FeCl_2$ Solution, ≈ 32% Vol Flow Rate	gal/hour												
$FeCl_2$ Solution, ≈ 32% Mass Flow Rate	lb/hr												
Sodium Hydroxide, 25% solution	gal/hour									0.028	0.09		
Antiscalant at 50% dilution	gal/hour	0.050	0.07										
Sulfuric Acid, 35% solution	gal/hour												
TDS	mg/L			6,178	8,193	309	410	23,478	31,134			309	410
TSS	mg/L												
Settled Solids Mass Flow Rate	lb/day												
Settled Solids Volumetric Flow Rate	gal/day												
Clarifier Sludge Mass Flow Rate	lb/day												
Clarifier Sludge Volumetric Flow Rate	gal/day												
Filter Cake Mass Generation Rate	lb/day												
Filter Cake Volumetric Generation Rate	ft3/day												
Air Flow	cfm@60°F												
pH	--			6.7	6.1	5.24	4.51	7.29	6.44			6.2	7.0
Fe^{2+}	mg/L												
Temperature	°F												

Appendix C
Process and Instrumentation Diagrams

INSTRUMENT IDENTIFICATION

EXAMPLE SYMBOLS

T RC BB
LLUUS

- FIRST LETTER (S)
- SUCCEEDING LETTERS
- CLARIFYING ABBREVIATIONS
- SET NUMBER (USED WHEN THERE ARE MULTIPLE DEVICES WITH THE SAME UNIT NUMBER)
- UNIT NUMBER
- LOOP NUMBER

INSTRUMENT IDENTIFICATION LETTERS TABLE

	FIRST-LETTER		SUCCEEDING-LETTERS		
LETTER	PROCESS OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS (+)		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE (*)	USER'S CHOICE (*)	USER'S CHOICE (*)
C	USER'S CHOICE (*)			CONTROL	
D	DENSITY (S.G)	DIFFERENTIAL			
E	VOLTAGE		PRIMARY ELEMENT, SENSOR		
F	FLOW RATE	RATIO (FRACTION)			
G	USER'S CHOICE (*)		GLASS, GAUGE VIEWING DEVICE	GATE	
H	HAND (MANUAL)				HIGH
!	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT (PILOT)		LOW
M	MOTION	MOMENTARY			MIDDLE, INTERMEDIATE
N	TORQUE		USER'S CHOICE (*)	USER'S CHOICE (*)	USER'S CHOICE (*)
O	USER'S CHOICE (*)		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD OR PRINT		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED (+)	X AXIS	UNCLASSIFIED (+)	UNCLASSIFIED (+)	UNCLASSIFIED (+)
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION	Z AXIS		DRIVE, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

TABLE BASED ON THE INSTRUMENTATION, SYSTEMS, AND AUTOMATION SOCIETY (ISA) STANDARD.

(+) WHEN USED, EXPLANATION IS SHOWN ADJACENT TO INSTRUMENT SYMBOL. SEE ABBREVIATIONS AND LETTER SYMBOLS.

(*) WHEN USED, DEFINE THE MEANING HERE FOR THE PROJECT

DIGITAL SYSTEM INTERFACES

▲ ANALOG INPUT

▼ ANALOG OUTPUT

△ DISCRETE INPUT

▽ DISCRETE OUTPUT

GENERAL INSTRUMENT OR FUNCTIONAL SYMBOLS

FIELD MOUNTED INSTRUMENT

REAR-OF-PANEL MOUNTED INSTRUMENT

PANEL MOUNTED INSTRUMENT

MOTOR CONTROL CENTER MOUNTED INSTRUMENT

SPECIAL CASES

QL OO — ON AND OFF EVENT LIGHTS

ZL OC — OPENED AND CLOSED POSITION LIGHTS

ZS OC — OPENED AND CLOSED POSITION SWITCHES

HS OO — ON-OFF HAND SWITCH. MAINTAINED CONTACT SWITCH (CONTROLLED DEVICE WILL RESTART ON RETURN OF POWER AFTER POWER FAILURE).

HS SS — STOP-START HAND SWITCH MOMENTARY CONTACT SWITCHES (CONTROLLED DEVICE WILL NOT RESTART ON RETURN OF POWER AFTER POWER FAILURE).

xIC — CONTROL OR DISPLAY FUNCTION VIA THE OPERATOR INTERFACE WITH THE DISTRIBUTED CONTROL SYSTEM (FUNCTION OPERATOR ACCESSIBLE)

2

TRANSDUCERS

A	ANALOG	I	CURRENT
D	DIGITAL	P	PNEUMATIC
E	VOLTAGE	PF	PULSE FREQUENCY
F	FREQUENCY	PD	PULSE DURATION
H	HYDRAULIC	R	RESISTANCE

EXAMPLE:

FY I/P — CURRENT TO PNEUMATIC TRANSDUCER (BACK OF PANEL, IN A FLOW LOOP)

LINE LEGEND

- PROCESS (CLOSED CONDUIT, DASHED LINE INDICATES ALTERNATE FLOW STREAM)
- PROCESS (OPEN CHANNEL)
- —A— ANALOG SIGNAL (4 TO 20 mAdc, ETC.)
- DISCRETE SIGNAL (ON/OFF, ETC.)
- —PD— PULSE DURATION SIGNAL
- —PF— PULSE FREQUENCY SIGNAL
- PNEUMATIC SIGNAL
- —XXXXX— FILLED SYSTEM SIGNAL
- —L—L—L— HYDRAULIC SYSTEM SIGNAL
- BUILDING OR FACILITY BOUNDARY
- (4) (8) (3) PARALLELING LINES (PARENTHETICAL NUMBER INDICATES THE NUMBER OF SIGNALS REPRESENTED)
- CONNECTING LINES
- NON-CONNECTING LINES

INTERFACE SYMBOLS

SHEET CONNECTOR FROM SOURCE OR TO DESTINATION DRAWING

PIPELINE NUMBER

TP-PR-10-10-SS [A1]

1

TO OR FROM DESCRIPTION LINE 1
TO OR FROM DESCRIPTION LINE 2

TP-PR-10-10- SS = DESTINATION OR SOURCE P&ID DRAWING AND SHEET NO.

[A1] = GRID LOCATION OF MATCHING SYMBOL ON CONNECTED SHEET

(N) PROCESS OR SIGNAL LINE CONTINUATION N=1,2,3,ETC

INTERFACE TO OR FROM PROCESS EXTERNAL TO PROJECT

PIPELINE NUMBERING

- PIPELINE SIZE (INCHES)
- SERVICE OR FLOW STREAM
- PIPING LINE NUMBER
- PIPE MATERIAL SPEC
- ELECTRIC HEAT TRACING
- -H = THERMAL INSULATION
- -P = PERSONNEL PROTECTION

4"-RW-100-1KB   4"-RW-100-1HB-E   2

SPEC BREAK: UG | AG — 1KB | 1HB   1

VALVE & EQUIPMENT TAG NUMBERS

- COMPONENT OR FITTING CODE
- SERVICE OR FLOW STREAM
- PIPING LINE NUMBER
- SEQUENCE NUMBER

V-RW-100-01 PROCESS VALVES

V-NNNN NON-PROCESS VALVES

- MATERIAL SPEC NUMBER
- COMPONENT OR FITTING CODE

1

EJ = EXPANSION JOINT
FH = FLEXIBLE HOSE
PS = PERMANENT STRAINER
TS = TEMPORARY STRAINER

D-W-X-Y

D = EQUIPMENT OR VALVE TYPE
W = UNIT PROCESS NUMBER
X = LOOP NUMBER
Y = UNIT NUMBER

TYPE (D)

ARV	AIR RELEASE VALVE
AVRV	AIR AND VACUUM RELEASE VALVE
E	EJECTOR
FCV	FLOW CONTROL VALVE
G	GATE
LCV	LEVEL CONTROL VALVE
M	MECHANICAL EQUIPMENT
P	PUMP
PCV	PRESSURE CONTROL VALVE
PSE	RUPTURE DISK
PSV	PRESSURE RELIEF VALVE
T	TANK
TCV	TEMPERATURE CONTROL VALVE
V	VALVE

PIPELINE MATERIAL LIST

1CV = CARBON STEEL, WITH FLEXIBLE VICTAULIC FITTINGS
1HB = SCHEDULE 80 CPVC
1KA = SINGLE WALL HDPE, SDR 11
1KB = DOUBLE CONTAINMENT HDPE, SDR 11/7
1PV = FBE LINED CARBON STEEL, WITH FLEXIBLE VICTAULIC COUPLINGS
2CA CARBON STEEL, FIRE PROTECTION
3DV = 304L SS WITH VICTAULIC PRESS FIT COUPLINGS
8NA = 316 STAINLESS STEEL TUBING

3

ABBREVIATIONS & LETTER SYMBOLS

AC	ALTERNATING CURRENT
ALKY	ALKALINITY
AM	AUTO-MANUAL
CAM	COMPUTER-AUTO-MANUAL
CCS	CENTRAL CONTROL SYSTEM
CL_2 etc.	CHLORINE (TYPICAL: USE STANDARD CHEMICAL ELEMENT ABBREVIATION)
CM	COMPUTER-MANUAL
COD	CHEMICAL OXYGEN DEMAND
CP-X	CONTROL PANEL NO. X
DC	DIRECT CURRENT
DO	DISSOLVED OXYGEN
EJ	EXPANSION JOINT
FCL_2	FREE CHLORINE RESIDUAL
FH	FLEXIBLE HOSE
FOS	FAST-OFF-SLOW
FOSA	FAST-OFF-SLOW-AUTO
FOSR	FAST-OFF-SLOW-REMOTE
FP-W-X	FIELD PANEL NO. WX (W = UNIT PROCESS NUMBER X = PANEL NUMBER)
FR	FORWARD-REVERSE
HOA	HAND-OFF-AUTO
HOR	HAND-OFF-REMOTE
LOS	LOCKOUT STOP
LOR	LOCAL-OFF-REMOTE
LR	LOCAL-REMOTE
MA	MANUAL-AUTO
MC	MODULATE-CLOSE
MCC-X	MOTOR CONTROL CENTER NO. X
OC	OPEN-CLOSE (D)
OCR	OPEN-CLOSE-REMOTE
OCA	OPEN-CLOSE-AUTO
OO	ON-OFF
OOA	ON-OFF-AUTO
OOR	ON-OFF-REMOTE
ORP	OXIDATION REDUCTION POTENTIAL
OSC	OPEN-STOP-CLOSE
pH	HYDROGEN ION CONCENTRATION
PS	PERMANENT STRAINER
RM-X	REMOTE MULTIPLEXING MODULE NO. X
RTU-X	REMOTE TELEMETRY UNIT NO. X
SF	SLOWER-FASTER
SS	START-STOP
SSC	SUPERVISORY SET POINT CONTROL
TCL_2	TOTAL CHLORINE RESIDUAL
TOC	TOTAL ORGANIC CARBON
TOD	TOTAL OXYGEN DEMAND
TS	TEMPORARY STRAINER
TURB	TURBIDITY
VHC	VOLATILE HYDROCARBONS
VIB	VIBRATION
Δ	DIFFERENCE
Σ	SUM
X	MULTIPLY
$\div$	DIVIDE
f(x)	CHARACTERIZED
X^n	RAISE TO THE Nth POWER
$\sqrt{\ }$	SQUARE ROOT
AVG	AVERAGE
1:1	REPEAT OR BOOST
>	SELECT HIGHEST SIGNAL
<	SELECT LOWEST SIGNAL
$\pm$	BIAS
%	GAIN OR ATTENUATE

GENERAL NOTES

1. COMPONENTS AND PANELS SHOWN WITH A SINGLE ASTERISK (*) ARE TO BE PROVIDED AS PART OF A PACKAGE SYSTEM.
2. COMPONENTS AND PANELS SHOWN WITH A DOUBLE ASTERISK (**) ARE TO BE PROVIDED UNDER DIVISION 16, ELECTRICAL.
3. THIS IS A STANDARD LEGEND. THEREFORE, NOT ALL OF THIS INFORMATION MAY BE USED ON THIS PROJECT.

RESPONSIBLE ENGINEER: Kenneth L. Martins CH4876 Exp. 6-30-05 PE #

NO.	DATE	REVISION	BY	CHK
D	07/28/04	FOR INTERNAL REVIEW	EFC	AJ
0	09/03/04	APPROVED FOR CONSTRUCTION	EFC	AJ
1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
3	02/14/05	REVISED PIPELINE MATERIAL LIST - APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 3 DATE 02/14/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
PIPING		GEN. ARRANG.	

PRINT DISTRIBUTION: DATE, STATUS, REV., CLIENT, FIELD, INTRA CO.

STATUS

ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
FOR REVIEW AND APPROVAL	D	07/28/04		
APPROVED FOR CONSTRUCTION	0	09/03/04	KLM	TP
REVISED & APPROVED FOR CONSTRUCTION	3	/ /		

SCALE NONE

PACIFIC GAS & ELECTRIC CO.
TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

PROJ NO. 315994

CH2MHILL

PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 01
SYMBOLS AND NOMENCLATURE
LEGEND 1 OF 2

DWG. NO. TP-PR-10-10-01 REV. 3

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

FILENAME: tppr101001.dwg PLOT DATE: 14-FEB-2005 PLOT TIME:

VALVE SYMBOLS

- GATE
- KNIFE GATE
- BUTTERFLY
- GLOBE
- BALL
- VEE- BALL
- PLUG
- SEAT PORT ECCENTRIC PLUG
- DIAPHRAGM
- PINCH
- NEEDLE
- SWING CHECK
- BALL CHECK
- SAMPLE
- MUD
- PRESSURE RELIEF
- AIR AND / OR VACUUM RELEASE
- REGULATED SIDE PRESSURE CONTROL VALVE
- BPR BACK PRESSURE REGULATOR
- MULTI-PORT VALVES (BALL VALVE SHOWN. FOR OTHER VALVE TYPES, APPROPRIATE VALVE SYMBOL SHOWN.) ARROWS INDICATE FLOW PATTERN. SEAT PORTS ARE IMPLIED BY INDICATED FLOW PATTERN.
- FIRE HYDRANT

GATE SYMBOLS

- SLUICE
- BUTTERFLY
- FLAP
- FABRICATED SLIDE
- SHEAR

PRIMARY ELEMENT SYMBOLS

- PARSHALL FLUME
- WEIR
- ORFICE PLATE
- FLOW TUBE
- PITOT-STATIC
- VORTEX METER
- ROTAMETER
- ULTRASONIC FLOWMETER (INLINE)
- ELECTROMAGNETIC FLOWMETER
- PROPELLER OR TURBINE METER
- STATIC MIXER
- DENSITY METER (X: N = NUCLEAR, O = OPTICAL, U = ULTRASONIC)
- ULTRASONIC FLOWMETER (CLAMP-ON)
- LEVEL (ULTRASONIC)
- LEVEL (BUBBLER TUBE)
- LEVEL (FLOAT)

ACTUATOR SYMBOLS

- PNEUMATIC W/POSITIONER
- PNEUMATIC W/SOLENOID
- ELECTRIC
- ELECTRIC W/POSITIONER
- ELECTROHYDRAULIC
- HYDRAULIC
- PNEUMATIC WITH VOLUME BOOSTER
- SOLENOID
- MANUAL

NOTE:
ON LOSS OF PRIMARY POWER (PNEUMATIC, ELECTRICAL OR HYDRAULIC)
XX: FO =FAIL OPEN
FC =FAIL CLOSED
FLP=FAIL TO LAST POSITION

MISCELLANEOUS SYMBOLS

- SIGHT GLASS
- DIAPHRAGM SEAL
- BLIND FLANGE
- AIR GAP
- VENT TO ATMOSPHERE
- AERATOR
- PLUG
- RECEPTACLE
- SELF CONTAINED AIR SUPPLY
- COMPOSITE SAMPLER (DIPPER TYPE)
- COMPOSITE SAMPLER (SUCTION TYPE)
- TV CAMERA
- RADIO ANTENNA
- "ON" TIME DELAY B "ON" X-SEC. AFTER A "ON". INSTANT "OFF".
- "OFF" TIME DELAY B "OFF" X-SEC. AFTER A "OFF" INSTANT "ON"
- INTERLOCK. SEE CONTROL DIAGRAMS
- MEMORY ELEMENT S= SET , R= RESET
- AIR SET XX= SUPPLY PRESSURE IN PSIG.
- FILTER/ REGULATOR/ GAUGE SET
- BFP BACK-FLOW PREVENTER
- PERMANENT STRAINER
- TEMPORARY STRAINER
- 120 VOLT, 60 HZ POWER
- 480 VOLT, 60 HZ POWER
- ANNULAR DIAPHRAGM SEAL
- RUPTURE DISK
- PIG INSERT POINT
- PIG CATCH POINT
- MIXER
- ELECTRIC MOTOR
- PRESSURE GAUGE
- TONE TRANSMITTER NO. X
- TONE RECEIVER NO. X
- VOICE COMMUNICATION POINT
- TV MONITOR
- LOGIC ELEMENT: IF A AND NOT B THEN C
- LOGIC ELEMENT: IF A OR B THEN C
- ON/OFF RELAY. INPUT IS CONNECTED TO OUTPUT WHEN SWITCHING SIGNAL IS PRESENT.
- SWITCHING SIGNAL
- SWITCHING RELAY. INPUT WITH DOT IS CONNECTED TO OUTPUT WHEM SWITCHING SIGNAL IS PRESENT
- OTHER INPUT IS CONNECTED TO OUTPUT WHEN SWITCHING SIGNAL IS NOT PRESENT.
- FLUSHING CONNECTION SIZES PER DWG. TP-PI-05-00-06 (V-1690 V-1390 HOSE ADAPTOR)
- SEAL WATER SET (V-1390 1/2" x 3/8")
- FLEXIBLE CONNECTOR (HOSE)
- HOSE CONNECTION

PUMP AND COMPRESSOR SYMBOLS

NOTE: XX: AS = ADJUSTABLE SPEED
CS-1 = CONSTANT SPEED (SINGLE SPEED)
CS-2 = CONSTANT SPEED (TWO SPEED)

- CENTRIFUGAL PUMP (DRY PIT)
- CENTRIFUGAL WET PIT PUMP OR TURBINE PUMP
- CHEMICAL FEED PUMP
- DIAPHRAGM PUMP
- GEAR PUMP OR BLOWER (POSITIVE DISPLACEMENT)
- PISTON PUMP
- PROGRESSIVE CAVITY PUMP
- SUBMERSIBLE SUMP PUMP
- COMPRESSOR (CENTRIFUGAL)
- COMPRESSOR (PISTON)
- BLOWER OR FAN (CENTRIFUGAL)
- EJECTOR

SERVICE OR FLOW STREAM IDENTIFCATION

AHP	AIR,HIGH PRESSURE PROCESS
AI	AIR, INSTRUMENT
AL	ALUM
ALP	AIR, LOW PRESSURE PROCESS
ASH	SODA ASH
B	BRINE
BA	BLOWING AIR
BDS	BLENDED DIGESTED SLUDGE
BFE	BIO-FILTER EFFLUENT
BFI	BIO-FILTER INFLUENT
BFR	BIO-FILTER RECYCLE
BFW	BRINE FEEDWATER
BS	BRINE SLUDGE
BWS	BACKWASH SUPPLY
BYP	BYPASS
C	CARBON SLURRY
CD	CARBON DIOXIDE GAS
CG	CHLORINE GAS (PRESSURE)
CGV	CHLORINE GAS (VACUUM)
CHS	CHEMICAL SLUDGE
CL	CHLORINE LIQUID
CNA	CELL CAUSTIC
CO	CONDENSATE DRAIN
CS	CHLORINE SOLUTION
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
DR	DRAIN (SANITARY)
DAS	DIGESTED ACTIVATED SLUDGE
DG	DIGESTER GAS
DIW	DEIONIZED WATER
DS	DIGESTED SLUDGE
DW	DISTILLED WATER
F	FILTRATE
FC	FERRIC CHLORINE
FE	FILTER EFFLUENT
FI	FILTER INFLUENT
FOR	FUEL OIL RETURN
FOS	FUEL OIL SUPPLY
FTW	FILTER TO WASTE
G	NATURAL GAS
GAS	GASOLINE
GOX	GASEOUS OXYGEN
GOX 1	GOX PRODUCT
GOX 2	GOX PRODUCT
GOX 3	GOX VENT
GOX 4	GOX PRESSURE BUILD
GOX 5	GOX ADDITION
GR	GRIT SLURRY
H	HYDROGEN GAS
HPR	HIGH PRESSURE RETURN (CONDENSATE)
HPS	HIGH PRESSURE STEAM
HS	HEAVY SOLIDS
HWR	HEATING WATER RETURN
HWS	HEATING WATER SUPPLY
IA	INSTRUMENT AIR
LD	DRY LIME
LOX	LIQUID OXYGEN
LPO	LIQUID POLYMER
LPR	LOW PRESSURE RETURN (CONDENSATE)
LPS	LOW PRESSURE STEAM
LS	LIME SLURRY
LSD	LIME SLUDGE
ML	MIXED LIQUOR
MPR	MEDIUM PRESSURE RETURN (CONDENSATE)
MPS	MEDUIM PRESSURE STEAM
NA	SODIUM HYDROXIDE
NT	NITROGEN TRICHLORIDE
OF	OVERFLOW
P	PROPANE GAS
PDS	PRIMARY DIGESTED SLUDGE
PE	PRIMARY EFFLUENT
PI	PRIMARY INFLUENT
PLE	PLANT EFFLUENT
PO	POLYMER SOLUTION
PS	PRESSURE SEWER
PSD	PRIMARY SLUDGE
PSM	PRIMARY SCUM
RAS	RETURN ACTIVATED SLUDGE
RB	RAW BRINE
RCS	RECARBONATION SLUDGE
RCY	RECYCLE
RHW	RECIRCULATED HOT WATER
RS	RAW SEWAGE
RSD	RECIRCULATED SLUDGE
RW	RAW WATER
S	SANITARY SEWER (GRAVITY)
SA	SAMPLE
SAS	SODA ASH SOLUTION
SB	SPENT BRINE
SC	COLD SLUDGE
SDG	SULFUR DIOXIDE GAS
SDL	SULFUR DIOXIDE LIQUID
SDS	SULFUR DIOXIDE SOLUTION
SDV	SULFUR DIOXIDE GAS (VACUUM)
SE	SECONDARY EFFLUENT
SH	HEATED SLUDGE
SSD	SECONDARY DIGESTED SLUDGE
SSM	SECONDARY SCUM
SW	SURFACE WASH
TAS	THICKENED ACTIVATED SLUDGE
TB	TREATED BRINE
TBS	THICKENER BOTTOM SLUDGE
TDS	THICKENED DIGESTED SLUDGE
TPS	THICKENED PRIMARY SLUDGE
TUF	THICKENER UNDERFLOW
TW	TREATED WATER
UD	UNDERDRAIN
VT	VENT
VAC	VACUUM
WAS	WASTE ACTIVATED SLUDGE
WS	WASTE STREAM

RESPONSIBLE ENGINEER: Kenneth L. Martins CH4876 Exp. 6-30-05 PE #

NO.	DATE	REVISION	BY	CHK
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1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL — REV 2 — DATE 01/23/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
PIPING		GEN. ARRANG.	

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SCALE NONE

PACIFIC GAS & ELECTRIC CO.
TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
PROJ NO. 315994

CH2MHILL

PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 02
SYMBOLS AND NOMENCLATURE
LEGEND 2 OF 2

DWG. NO. TP-PR-10-10-02 REV. 2

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

FILENAME: tppr101002.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

RESPONSIBLE ENGINEER: Kenneth L. Martins, PE # CH4876, Exp. 6-30-06

NO.	DATE	REVISION	BY	CHK
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0	09/03/04	APPROVED FOR CONSTRUCTION	EFC	AJ
1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
3	03/16/05	DELETED NOTES, APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL — REV 3 — DATE 03/16/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
PIPING		GEN. ARRANG.	

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 03
EXTRACTION WELLS
PE-1, PE-2, TW-2D AND TW-2S

DWG. NO. TP-PR-10-10-03 REV. 3

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

FILENAME: tppr101003.dwg PLOT DATE: 16-MAR-2005 PLOT TIME:

NOTES

1. PROVIDE LEAK DETECTION AT LOWS AND/OR EVERY 500 FT.

RESPONSIBLE ENGINEER: Kenneth L. Martins CH4876 Exp. 6-30-05

NO.	DATE	REVISION	BY	CHK
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1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
3	02/14/05	ADDED RECIRC. LINE AND PRV VALVE TO T-700 - APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 3 DATE 02/14/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
PIPING		GEN. ARRANG.	

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INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 04
STORAGE AREA

DWG. NO. TP-PR-10-10-04 REV. 3

FILENAME: tppr101004.dwg PLOT DATE: 14-FEB-2005 PLOT TIME:

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 05
CHEMICAL REDUCTION AND COAGULATION SYSTEM

DWG. NO. TP-PR-10-10-05 REV. 2

FILENAME: tppr101005.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

BAR IS ONE INCH ON ORIGINAL DRAWING.

NOTES:

1. USE PORTABLE SUMP PUMP (OPERATIONS SUPPLIED) FOR PUMP OUT

RESPONSIBLE ENGINEER: Kenneth L. Martins Exp. 6-30-05 PE # CH4876

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2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 2 DATE 01/23/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED	PRINT DISTRIBUTION
CIVIL		ELECTRICAL		DATE
STRUCTURAL		INST & CONTROL		STATUS
MECHANICAL		ARCHITECTURAL		REV.
PROCESS		ENVIRONMENTAL		CLIENT
PIPING		GEN. ARRANG.		FIELD
				INTRA CO.

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INTERIM MEASURE 3
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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 06
CLARIFICATION AND
SLUDGE REMOVAL

DWG. NO. TP-PR-10-10-06 REV. 2

FILENAME: tppr101006.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

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CIVIL		ELECTRICAL		STATUS
STRUCTURAL		INST & CONTROL		REV.
MECHANICAL		ARCHITECTURAL		CLIENT
PROCESS		ENVIRONMENTAL		FIELD
PIPING		GEN. ARRANG.		INTRA CO.

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TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM
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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 07
MICROFILTRATION SYSTEM

DWG. NO. TP-PR-10-10-07 REV. 2

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FILENAME: tppr101007.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

RESPONSIBLE ENGINEER: Kenneth L. Martins CH4876 Exp. 6-30-05

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0	09/03/04	APPROVED FOR CONSTRUCTION	EFC	AJ
1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ

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DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED	PRINT DISTRIBUTION
CIVIL		ELECTRICAL		DATE
STRUCTURAL		INST & CONTROL		STATUS
MECHANICAL		ARCHITECTURAL		REV.
PROCESS		ENVIRONMENTAL		CLIENT
PIPING		GEN. ARRANG.		FIELD
				INTRA CO.

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TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION AND TREATMENT SYSTEM

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 08
REVERSE OSMOSIS SYSTEM

DWG. NO. TP-PR-10-10-08 REV. 2

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FILENAME: tppr101008.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

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1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 2 DATE 01/23/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
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TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION
AND TREATMENT SYSTEM

PROJ NO. 315994

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 09
CHEMICAL FEED AND
AIR BLOWER SYSTEMS

DWG. NO. TP-PR-10-10-09 REV. 2

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

FILENAME: tppr101009.dwg PLOT DATE: 23-JAN-2005 PLOT TIME:

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1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	02/15/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 2 DATE 02/15/04

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED
CIVIL		ELECTRICAL	
STRUCTURAL		INST & CONTROL	
MECHANICAL		ARCHITECTURAL	
PROCESS		ENVIRONMENTAL	
PIPING		GEN. ARRANG.	

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CLIENT	
FIELD	
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TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION
AND TREATMENT SYSTEM

PROJ NO. 315994

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 10
MW-20 BENCH FILL STATION

DWG. NO. TP-PR-10-10-10 REV. 2

FILENAME: tppr101010.dwg PLOT DATE: 15-FEB-2005 PLOT TIME:

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

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1	10/13/04	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
2	01/23/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
3	02/14/05	REVISED AND APPROVED FOR CONSTRUCTION	EFC	AJ
4	03/10/05	REMOVED HOLD AND APPROVED FOR CONSTRUCTION	EFC	AJ

REVISION APPROVAL REV 4 DATE 03/10/05

DISCIPLINE	REVIEWED	DISCIPLINE	REVIEWED	PRINT DISTRIBUTION
CIVIL		ELECTRICAL		DATE
STRUCTURAL		INST & CONTROL		STATUS
MECHANICAL		ARCHITECTURAL		REV.
PROCESS		ENVIRONMENTAL		CLIENT
PIPING		GEN. ARRANG.		FIELD
				INTRA CO.

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ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
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PACIFIC GAS & ELECTRIC CO.
TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION
AND TREATMENT SYSTEM

PROJ NO. 315994

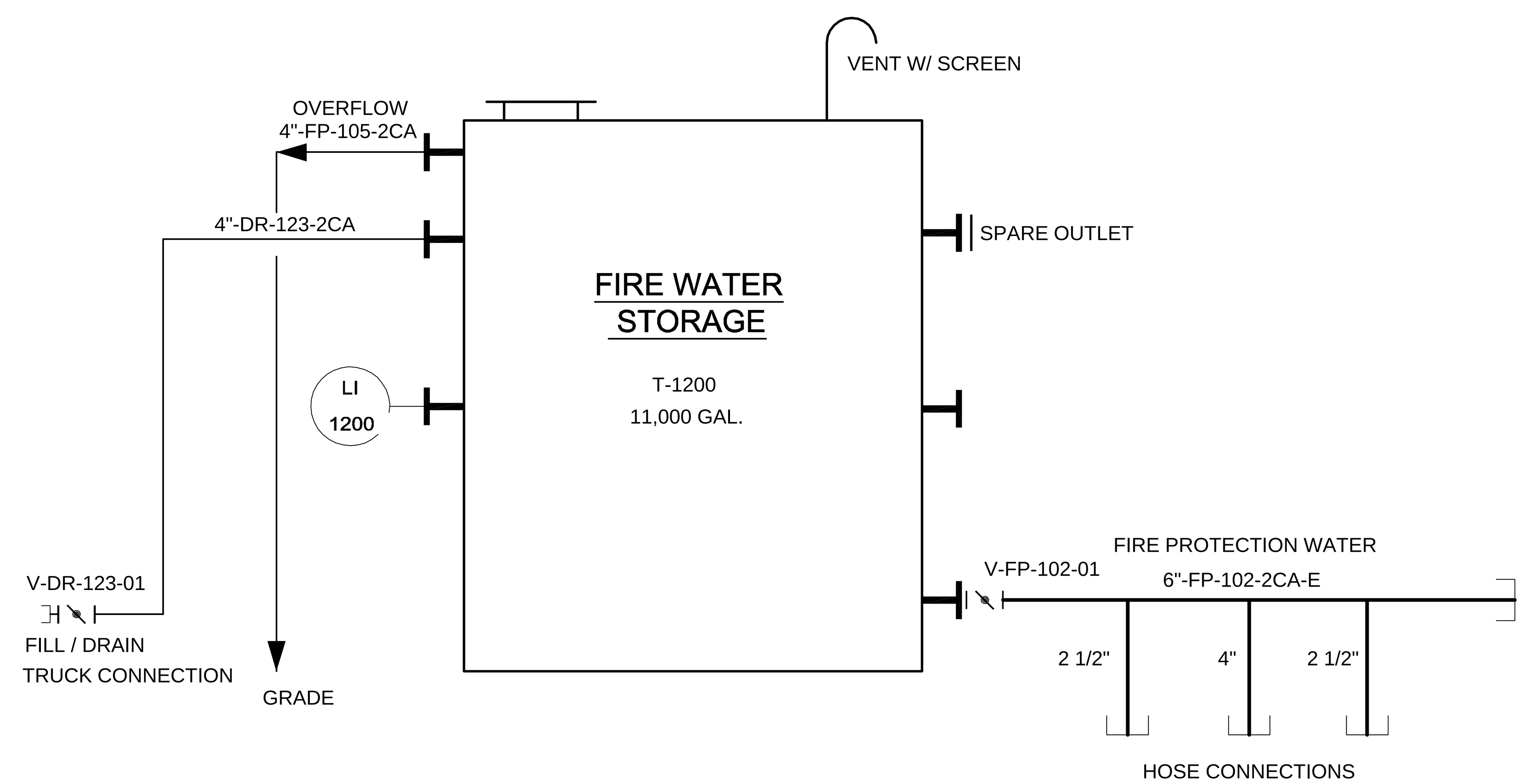
CH2MHILL

PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 11
INJECTION WELLS

DWG. NO. TP-PR-10-10-11 REV. 4

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

FILENAME: tppr101011.dwg PLOT DATE: 10-MAR-2005 PLOT TIME:



RESPONSIBLE ENGINEER: Kenneth L. Martins
PE # CH4876 Exp. 6-30-05

NO.	DATE	REVISION	BY	CHK
C	01/13/05	FOR INTERNAL REVIEW	EFC	AJ
0	02/24/05	APPROVED FOR CONSTRUCTION	EFC	AJ
.	/ /	.	EFC	.

REVISION APPROVAL		REV 0	DATE 02/24/05	PRINT DISTRIBUTION	
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CIVIL		ELECTRICAL		STATUS	
STRUCTURAL		INST & CONTROL		REV.	
MECHANICAL		ARCHITECTURAL		CLIENT	
PROCESS		ENVIRONMENTAL		FIELD	
PIPING		GEN. ARRANG.		INTRA CO.	

STATUS				
ISSUED	REV	DATE	SDE	PEM
PRELIMINARY				
FOR REVIEW AND APPROVAL	C	01/13/05		
APPROVED FOR CONSTRUCTION	0	02/24/05	...	..
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PACIFIC GAS & ELECTRIC CO.
TOPOCK COMPRESSOR STATION
INTERIM MEASURE 3
EXPANDED GROUNDWATER EXTRACTION
AND TREATMENT SYSTEM

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PROCESS AND INSTRUMENTATION DIAGRAM
SHEET 12
FIRE PROTECTION

DWG. NO. TP-PR-10-10-12 REV. 0

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0 1"

FILENAME: tppr101012.dwg PLOT DATE: 24-FEB-2005 PLOT TIME:

Appendix D
Control System Operations Manual

Pacific Gas & Electric

Needles, CA

INTERIM MEASURES No.3

Process Control Systems

OPERATIONS MANUAL

CH2MHILL

Project No. 315994

INTRODUCTION

The purpose of this document is to assist the reader in understanding the control system operation of the Water Treatment Plant (Interim Measures No.3) for the PG&E Topock Compressor Station located in Needles, California. The system is monitored and controlled by two Allen-Bradley SLC5/05™ Programmable Logic Controllers (**PLC**s) provided by CH2M HILL and two Allen-Bradley MicroLogix™ 1500 PLCs provided by equipment vendors (MicroFilter and Reverse Osmosis skids). The system operations from extraction wells through water treatment and back out to injection wells are monitored and controlled by PG&E personnel via two WonderWare® Human Machine Interface (**HMI**) operator consoles running on Dell™ Workstation personal computers (**WS**).

CONTENTS

There are 11 sections in this manual covering the following topics:

1. COMPONENTS OF THE WATER TREATMENT SYSTEM

The WTS consists of the WTS PLC (designated “TOPOCK1” and located in the LCP100 cabinet), the instrumentation that connects directly into the WTS PLC, and the hardwired interface signals between the WTS and other PLCs.

2. COMPONENTS OF THE INJECTION WELL SYSTEM

The IWS consists of the IWS PLC (designated “TOPOCK2” and located in the remote injection well control cabinet) and the instrumentation that connects directly into the IWS PLC (the injection wells).

3. COMPONENTS OF THE MICRO FILTER SYSTEM

The MFS primarily consists of the MFS PLC (designated “TOPOCKMF”) and the instrumentation that connects directly into the MFS PLC (the MF Skid). The MFS is a skid package system provided by PALL Corporation. Please reference the PALL O&M manual for details regarding the operation of the MFS.

4. COMPONENTS OF THE REVERSE OSMOSIS SYSTEM

The ROS primarily consists of the ROS PLC and the instrumentation that connects directly into the ROS PLC (the RO Skid). The ROS is a skid package system provided by Ionics. Please reference the Ionics O&M manual for details regarding the operation of the ROS.

5. COMPONENTS OF THE HMI

The HMI consists of two DELL™ workstation computers linked to the PLCs and each other through an industrial Ethernet switch located in the LCP100 cabinet. The workstations are designated “TOPOCK-WS1” and “TOPOCK-WS2”. TOPOCK-WS1 is both an operator workstation and is also the control system engineering development station. TOPOCK-WS1 is loaded and licensed with the following software tools:

- WonderWare® Intouch™ Runtime version 9.0
    - This is the running HMI application
- WonderWare® Intouch™ Development version 9.0
    - This is the engineering package used to modify the HMI
    - This software can only be accessed by an administrator
- WonderWare® SCADAlarm™
    - This is the auto-dialer alarm system software
    - This program runs in the background and is “transparent”
    - This software can only be accessed by an administrator
- RSLogix500™ engineering software package
    - This software is used to modify the PLC programs
    - This software can only be accessed by an administrator
- Microsoft Office™
    - This is the standard Office™ suite of utility programs
    - These programs can only be accessed by an administrator

6. HMI GRAPHICS LIST

There are 15 process graphics, 1 alarm banner, 5 popup windows and 21 trend displays. The following is a listing of the 15 process graphics:

1. Communications
2. Overview
3. Extraction Wells
4. Raw Water
5. Chrome Reactor
6. Iron Oxidation
7. Clarifier
8. Micro Filter
9. RO
10. RO2
11. Drains
12. Chemical Feed 1
13. Chemical Feed 2
14. Treated Water
15. Injection Wells

The Alarm Banner display appears at the bottom of the HMI screen and continually reports the status of any alarms in the plant process. The Alarm Banner is always shown and cannot be closed.

The 5 “popup” windows are detailed as follows:

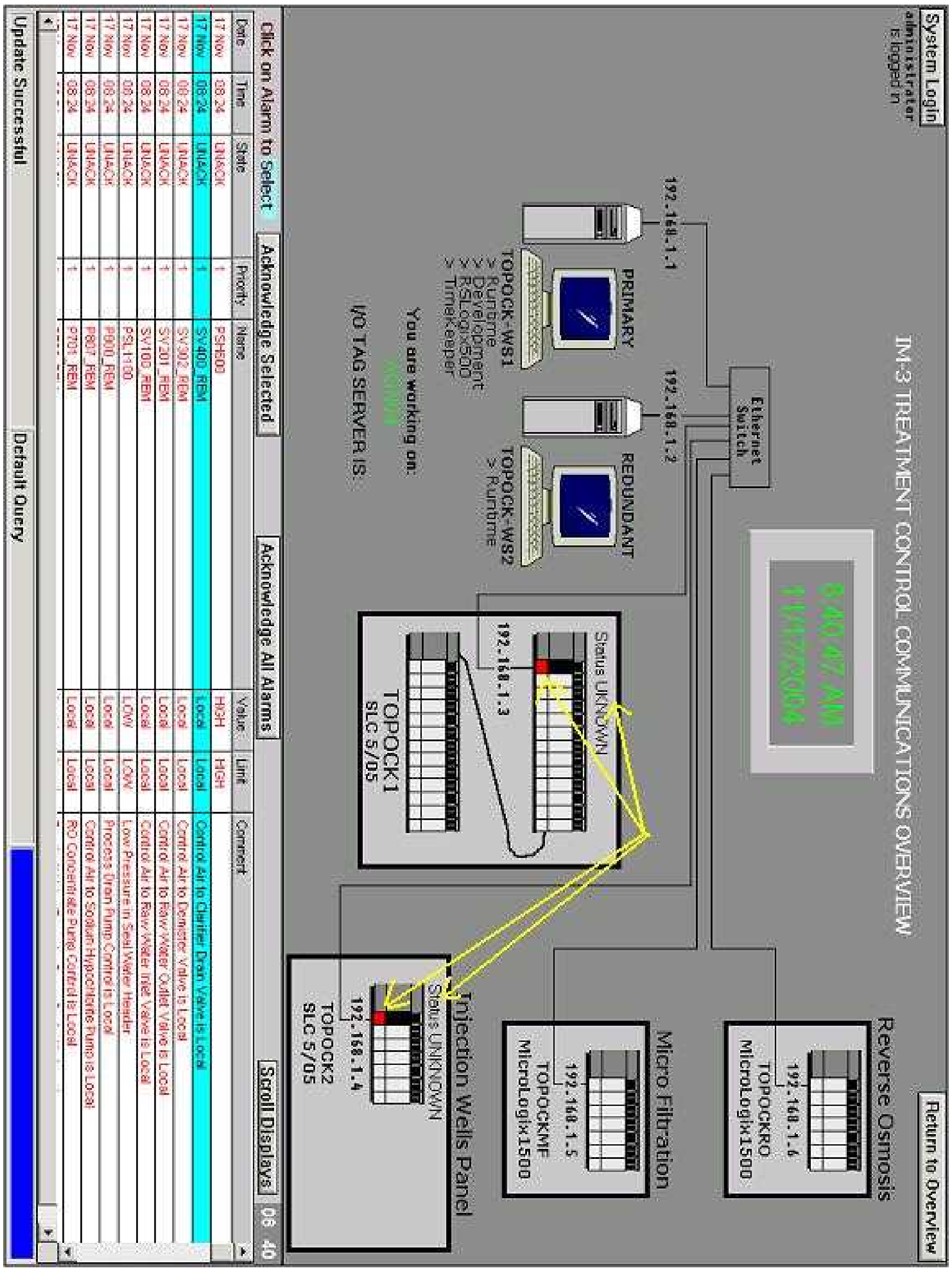
1. Password – this is the login window for operator login. The operator can also change his/her password from this window. This window is also used to logout of the system. A system administrator, once logged in, can use this window to shutdown the HMI application.
2. Select Transmitter – this popup appears when the operator clicks on one of the 10 sets of dual transmitters configured in the system (i.e., pH probes 301C-1 and 301C-2). This window allows the operator to select either one specific transmitter or the average of both transmitters for display and alarming purposes.
3. PID – this popup appears when the operator clicks on a control valve or metering pump configured in the system. The PID window allows the operator to view the process variable, control the state of the loop (Auto versus Manual) and control either the setpoint or the control output when the loop is in either Auto or Manual respectively. This window and PID functionality is explained later in this manual.
4. FDC – this popup appears when the operator clicks the ferrous chloride pump P-800. This window is used to monitor and control the dosing of ferrous into the system. This window is explained later in this manual.
5. Tag Window - this popup appears when the operator clicks on an analog tag value in the display. The tag window appears and provides the operator with specific tag information including tagname, tag description, current process variable and alarm points.

There are 21 Trend displays for calling up the historical data of the various analog signals that come into the system. The 21 displays are as follows:

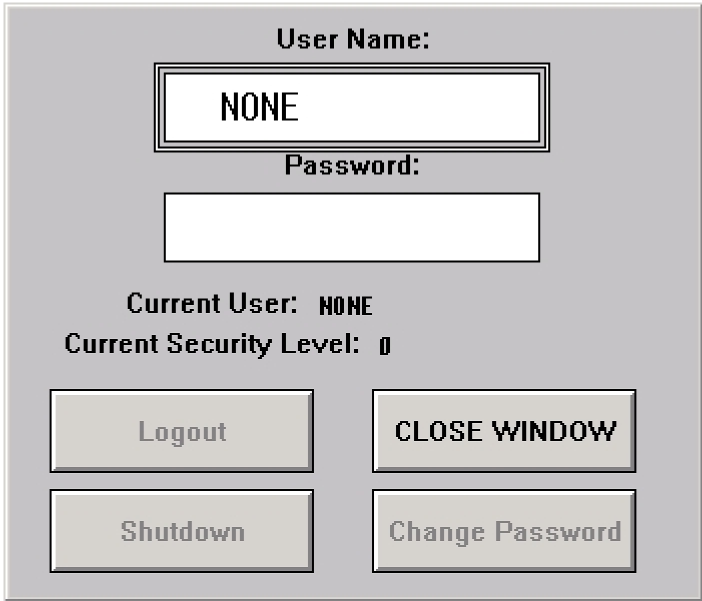
1. Trend Master – This is an overview graphic with links to each trend
2. Trend_01 - Extraction Wells 1
3. Trend_02 - Extraction Wells 2
4. Trend_03 – Raw Water
5. Trend_04 – Chrome Reactor Mixing
6. Trend_05 – Chrome Reactor
7. Trend_06 – Iron Oxidation 1
8. Trend_07 – Iron Oxidation 2
9. Trend_08 – Iron Oxidation 3
10. Trend_09 – Clarifier and Micro Filter Feed
11. Trend_10 – Micro Filter
12. Trend_11 – Reverse Osmosis 1
13. Trend_12 – Reverse Osmosis 2
14. Trend_13 – Reverse Osmosis 3
15. Trend_14 – Reverse Osmosis 4
16. Trend_15 – Treated Water
17. Trend_16 – Chemical Feed
18. Trend_17 – Injection Wells 1
19. Trend_18 – Injection Wells 2
20. Trend_19 – Injections Wells 3
21. Trend_Operator_Settable – This is an operator configurable trend

7. LOGGING INTO THE SYSTEM AND HMI DISPLAY NAVIGATION

After initial startup of the HMI WS, the System Communication graphic is displayed. The communication graphic provides an overview of the HMI/PLC control network and indicates the current status of the PLC processors as well as the status of the communications links. A green box indicates active links while a red box indicates loss of communication to the PLC. Note the yellow arrows in the screen-shot below which point out the PLC status information.

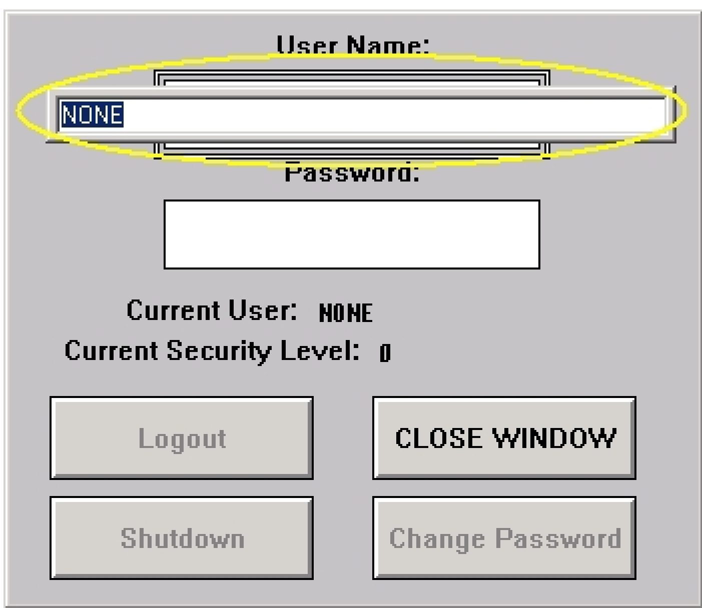


Additionally on system startup, the system login “popup” window is displayed.



USERNAME ENTRY

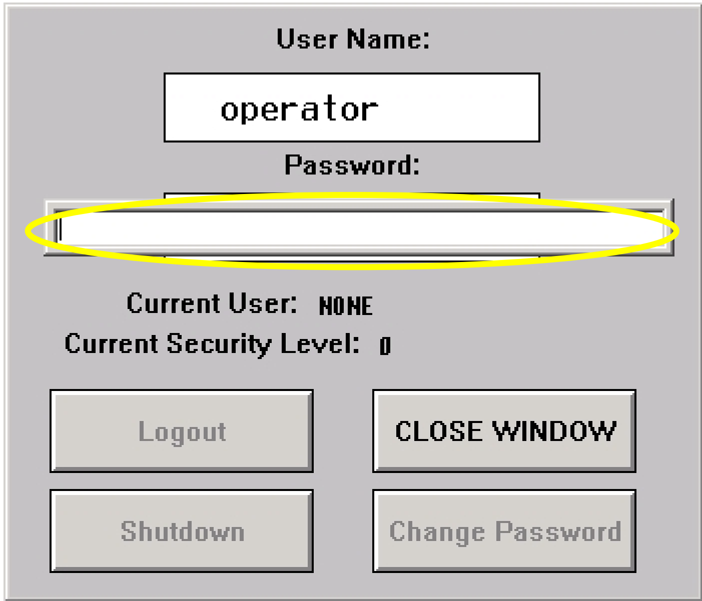
This window allows the operator to log into the system. To login to the system, the operator must enter a username and password. Use the mouse to first click on the white username field and then, using the keyboard, enter a username.



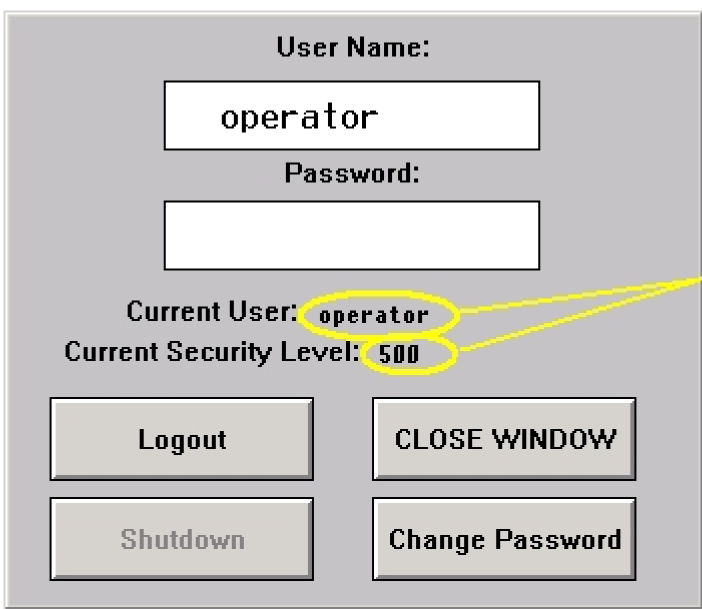
Press the <*Enter*> key after typing the username. The default username for an operator consists of first initial, last name. For example, operator “John Doe” will have a username of “jdoe”.

PASSWORD ENTRY

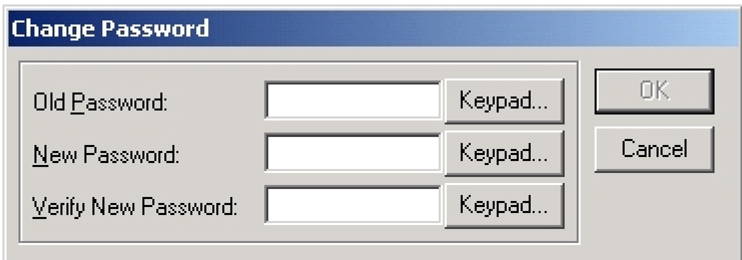
Next, enter in the password for the user by using the mouse to click on the white password field located underneath the username entry field.



Note that keystrokes are not echoed at all in the password field. While typing the password, the password entry field will remain blank. Unlike Windows, Intouch™ does not echo an asterisk (*) character for each keystroke typed in the password field. Once again, the password entry field will remain blank. Press the <*Enter*> key after typing the password. The default password, set for an operator for the very first login, will be the operator's last name. A successful login is indicated by the operator's login name appearing in the "Current User:" field and by the security level changing to "500" as indicated below:



CHANGING PASSWORD
The operator should change their password immediately after logging into the system for the first time. While both username and password are configured to be all small letters (no capitalization), the HMI is not case-sensitive for username or password login. To change the password, click on the “Change Password” button located in the bottom right corner of the login window. Type in the old password, type the new password twice and then click “OK”

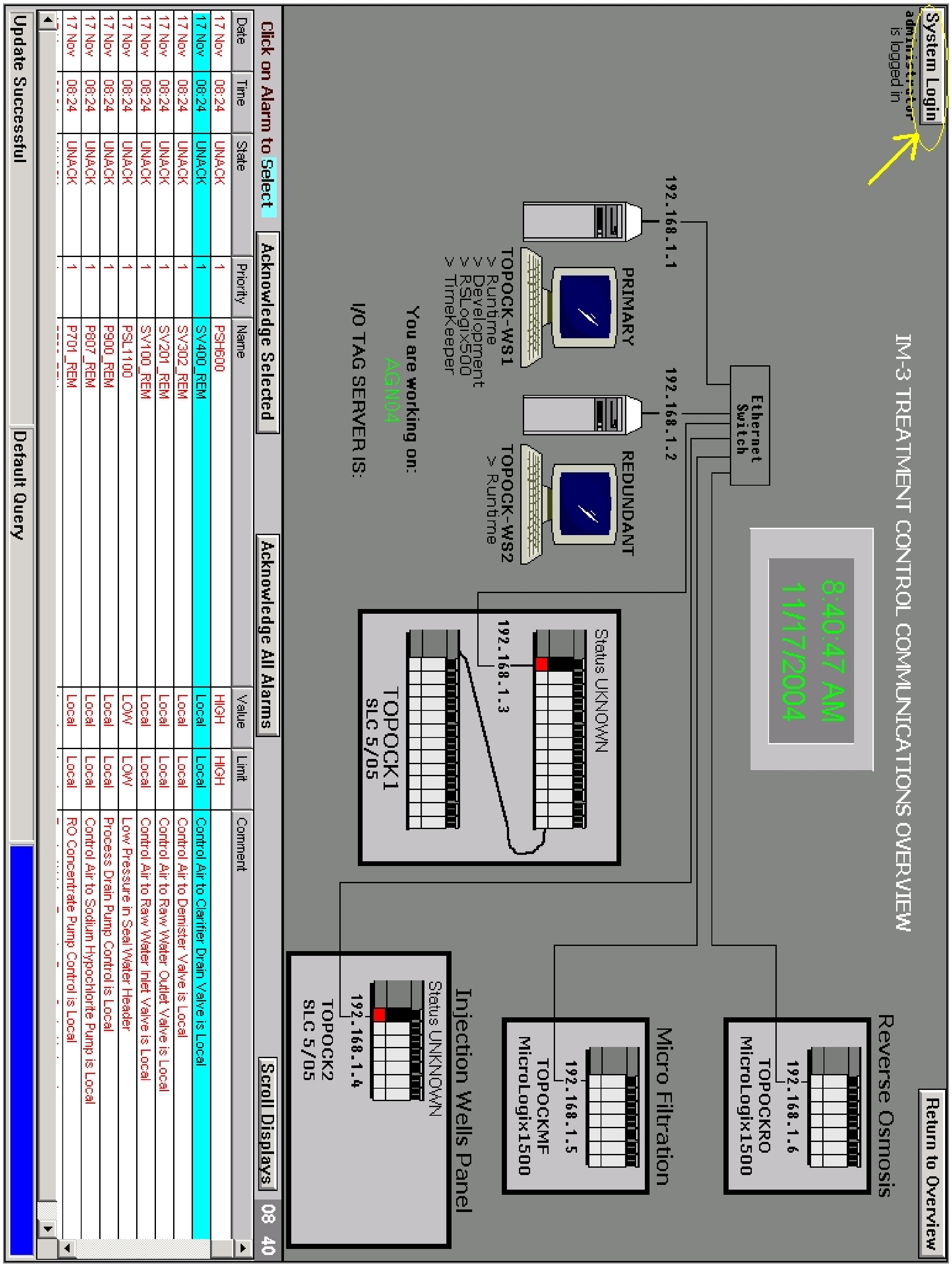


Once an operator is successfully logged into the system, the operator should click on the “CLOSE WINDOW” button of the login window in order to start navigating and monitoring the system.

It is possible to freely move through the display graphics without being logged into the system. However, system control (for instance, stopping or starting a pump or making a setpoint change) is not permitted until an operator (or administrator) is logged into the system.

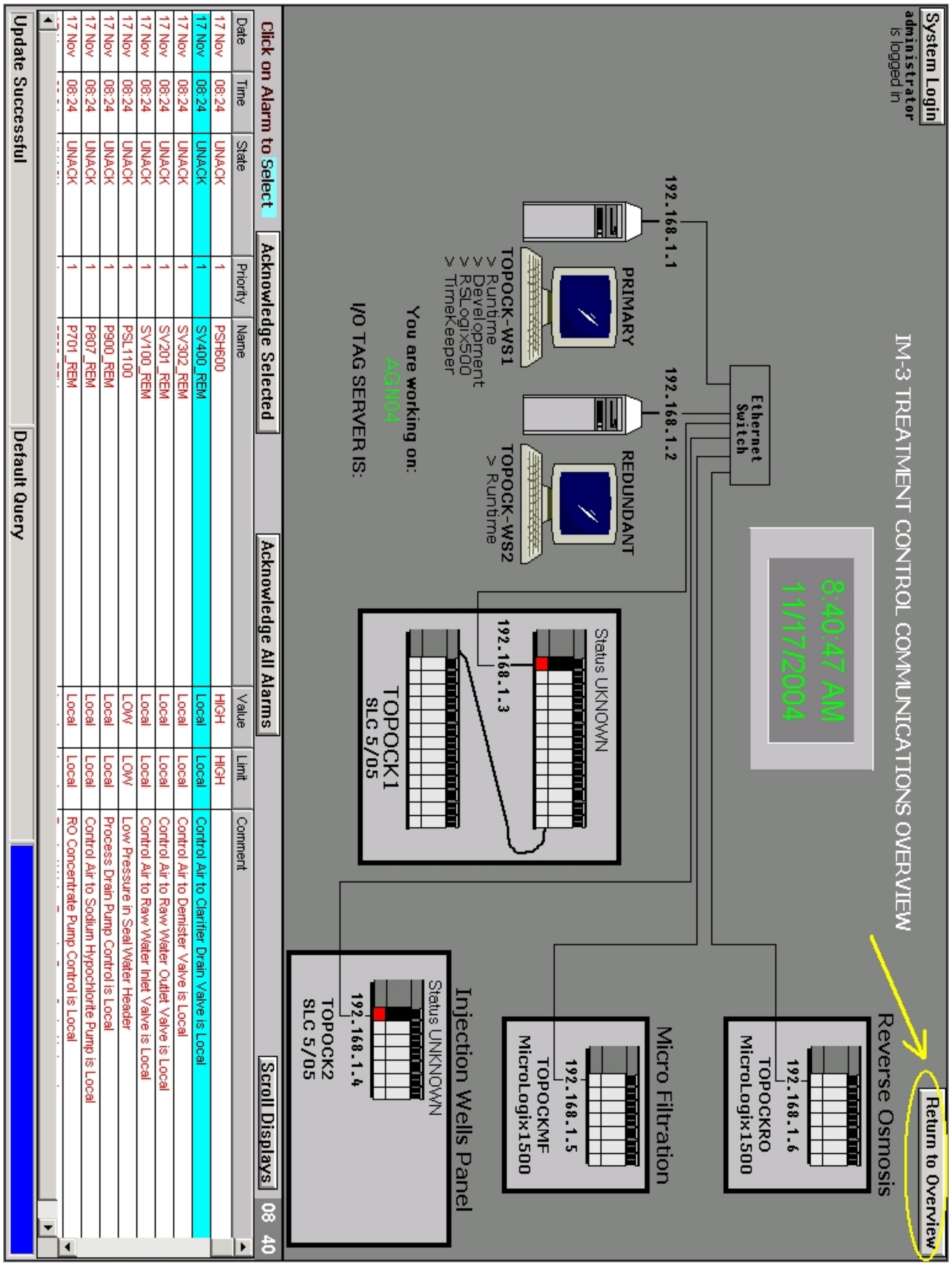
Logging into the system (or logging off) can be initiated from any process area graphic by moving the mouse cursor so that it is over the “System Login” button located in the upper left corner of the HMI display. Use the left mouse button to click on the “System Login” button, which will activate the Password popup login window. From the Password window, an operator can log into the system, change their password once they are logged in, or logout of the system.
Administrators can do all of the above, plus administrators have the option to shut down the HMI application entirely (after logging into the system).

AUTO LOGOFF
As an added security precaution, the HMI will automatically logoff after two hours of in-activity. This auto-logoff feature will occur regardless of whom is logged into the system. To prevent the auto-logoff from occurring, the operator must periodically navigate to a display or click on a display process point. In-activity is defined as a lack of either keystroke or mouse-click occurring on the WS. If an operator is logged off by the system, clicking on the “System Login” button and following the login procedure easily accomplishes logging back on the system.

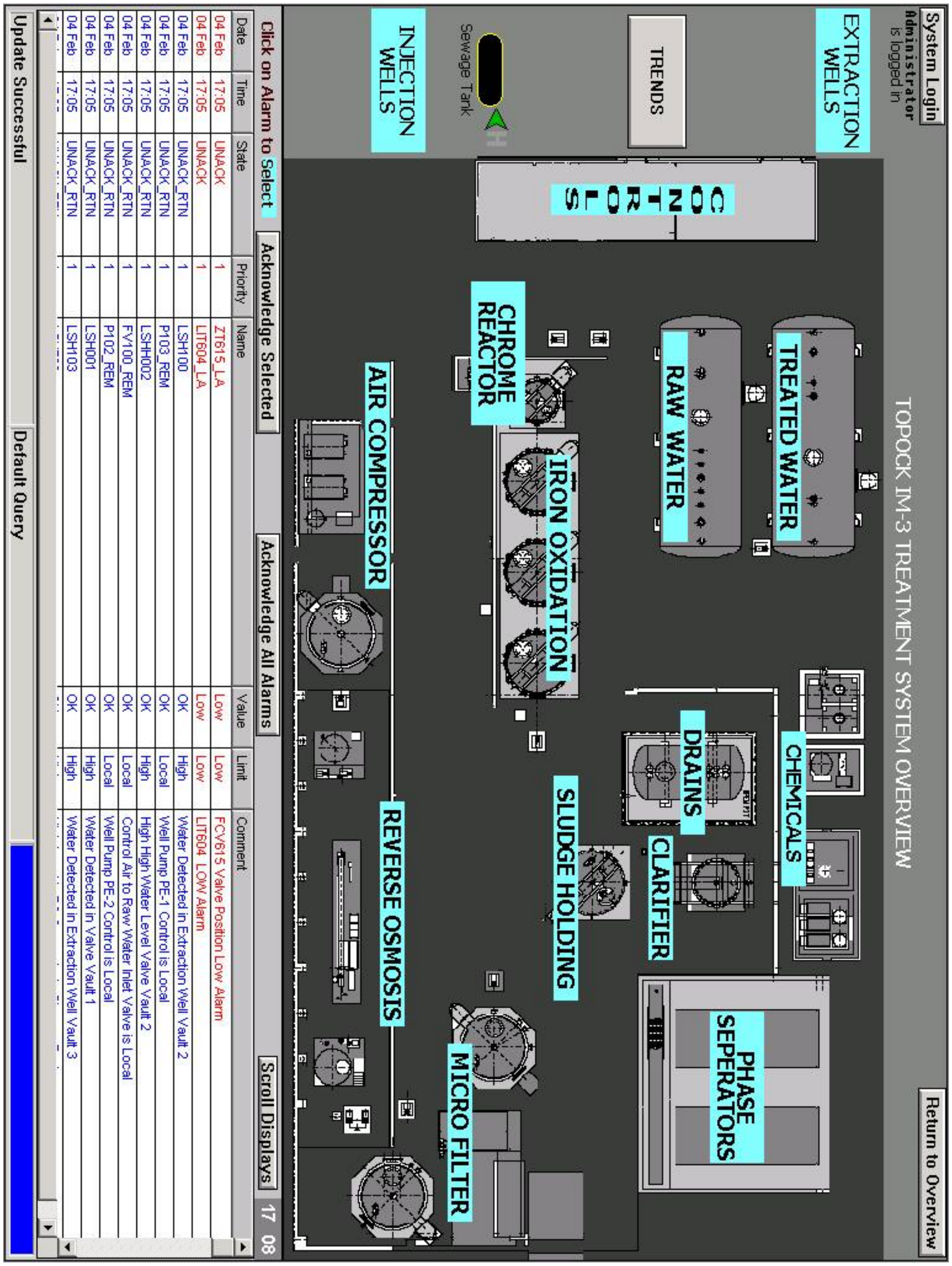


Note that every process graphic has the System Login button located in the same place in the upper left hand corner.

From the communications screen, the operator has two options to start monitoring the plant processes. The first option is to click on the "Return to Overview" button located in the upper right corner of the display.



The second option is to start scrolling the process display graphics, which will be discussed later on in this section.



By clicking on the "Return to Overview" button, the operator will call up the process overview display graphic. The overview display graphic is a master graphic that allows an operator to drill down to a specific process area by moving the mouse cursor over a desired process and then clicking the left mouse button.

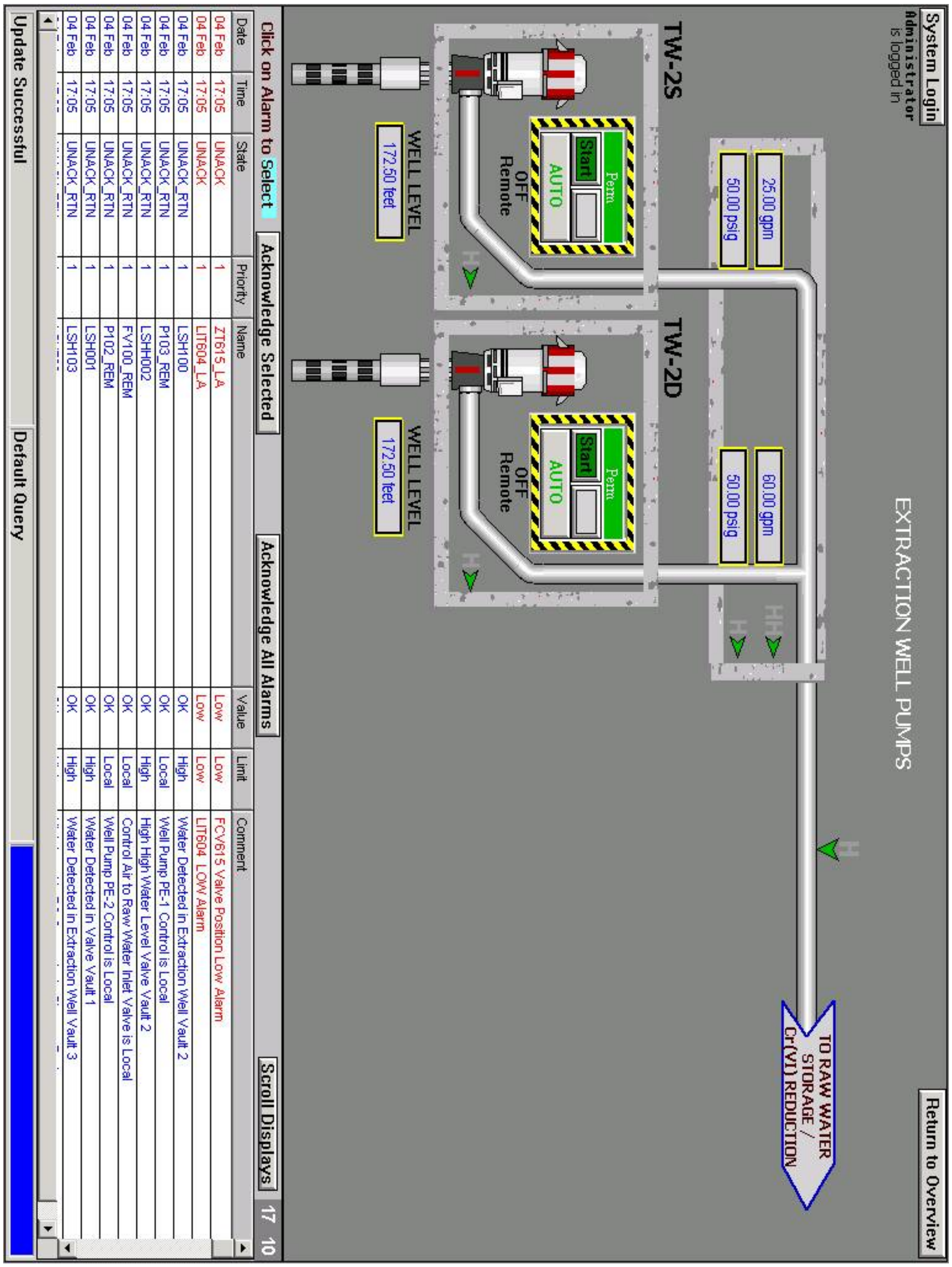
The process overview display was designed to provide an intuitive look and feel and closely mirrors the actual equipment layout of the plant.
All of the process areas are text labeled. Additionally, a white square highlight box will appear (and disappear) as the mouse is moved over the graphic display. Once the operator has selected a process area to monitor by having moved the

mouse cursor over the desired process area on the graphic, a single mouse-click will call up that graphic which will then allow the operator to see specific process details and/or control the equipment in that area. Several examples of the various process graphics are shown on the following pages.

The next several pages review the specific process graphics that are available in the system. Specific details regarding controls are described in the next section "Monitoring and Control".

Process Graphics Screens

The treatment process begins with the extraction wells pumping raw water into the plant. To access the extraction well graphic, the operator must click on the “Extraction Well” button located on the left side of the Overview graphic. The various process points include well level, pump line pressure and flow.



The operator can control how the well pumps turn on and off by clicking the control buttons for a specific pump. For the extraction pumps there are three modes of control: Remote Auto, Remote Manual, and Local.

REMOTE AUTO CONTROL

Normally, the pumps should always be run in the Remote Auto mode. Remote Auto is indicated by the HMI.

The HMI also indicates if the PLC is permitted to run the pump.

In Auto mode, the operator must still issue a start command from the HMI by clicking on the start button.

Once the start command has been issued, the pump will turn on and off automatically as dictated by the PLC programming. In the case of the well pumps, the pumps turn on and off based on level indication of the raw water storage tank T-100. Low-level indication in T-100 will turn on the pumps and high-level indication will turn off the pumps.

REMOTE MANUAL CONTROL

If deemed necessary, the operator can take Manual control of the pump to start and stop the pump. Remote manual control is achieved by clicking on the Auto/Manual toggle button.

Pressing the Auto/Manual toggle button will change the control from Auto to Manual and back again. The current state (Auto or Manual) is always indicated by the HMI.

With the controller in Manual, the operator is responsible for the starting and stopping of the pump.

The last mode, "Local" means that the pump is **not** in PLC control and that the pump can only be turned on/off from the MCC. Visual indication is provided on the HMI when the pump is in local control:

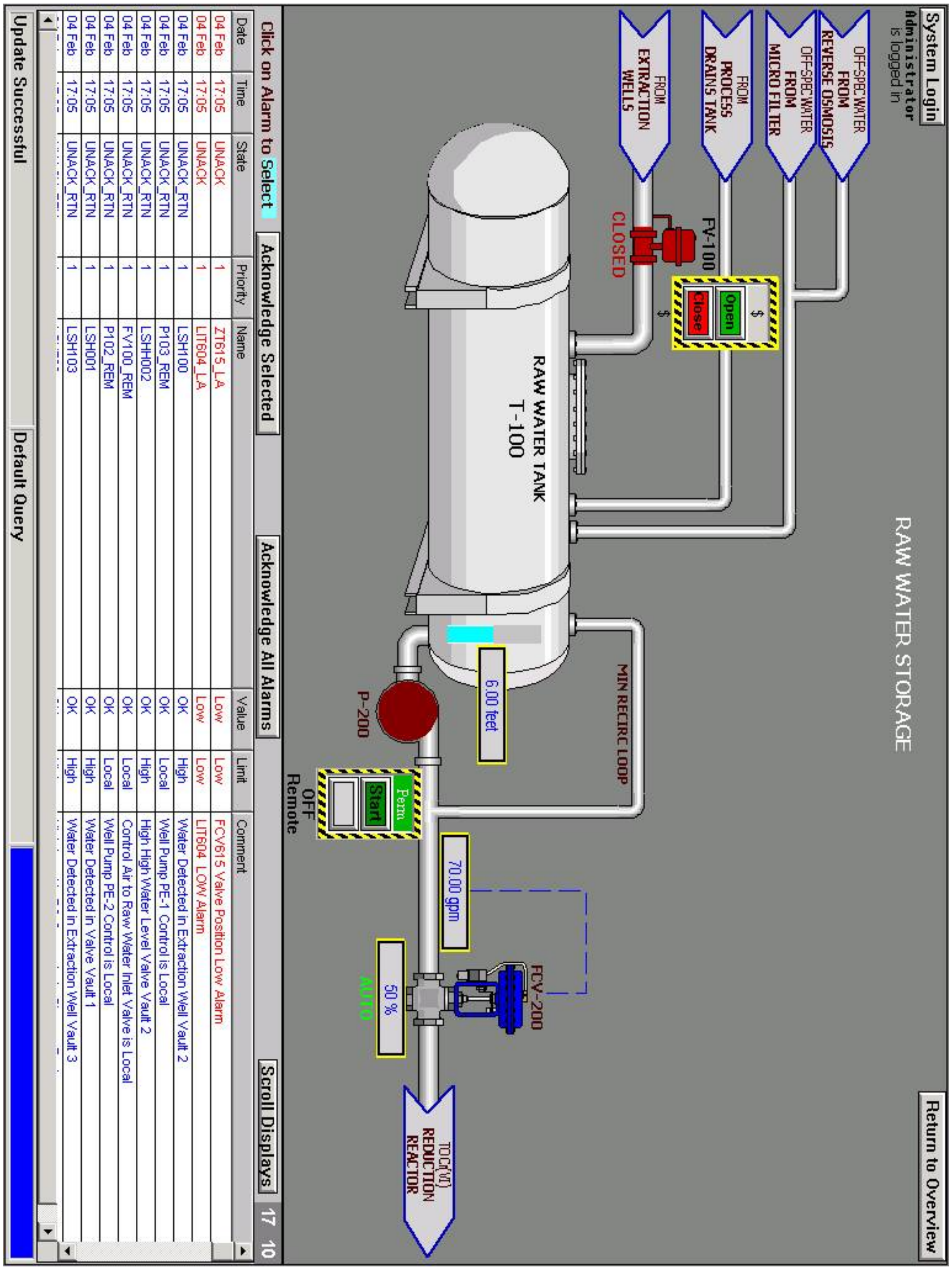
And

Note: the pumps can be run locally from the MCC but it is highly advisable not to do so. If an emergency interlock condition occurs that would normally stop the pump, the pump will **not** stop if it is being run "Local"

Due to possible interlocks being active, the operational status is shown as either "Perm" for permitted or "NoPerm" for not permitted. Permitted means that the operator has complete control over the output from the HMI and can open/close or start/stop at their discretion. Not permitted means that the control point (pump, motor or valve) cannot be controlled by the operator from the HMI and the operator should investigate in order to determine the cause of the loss of control.

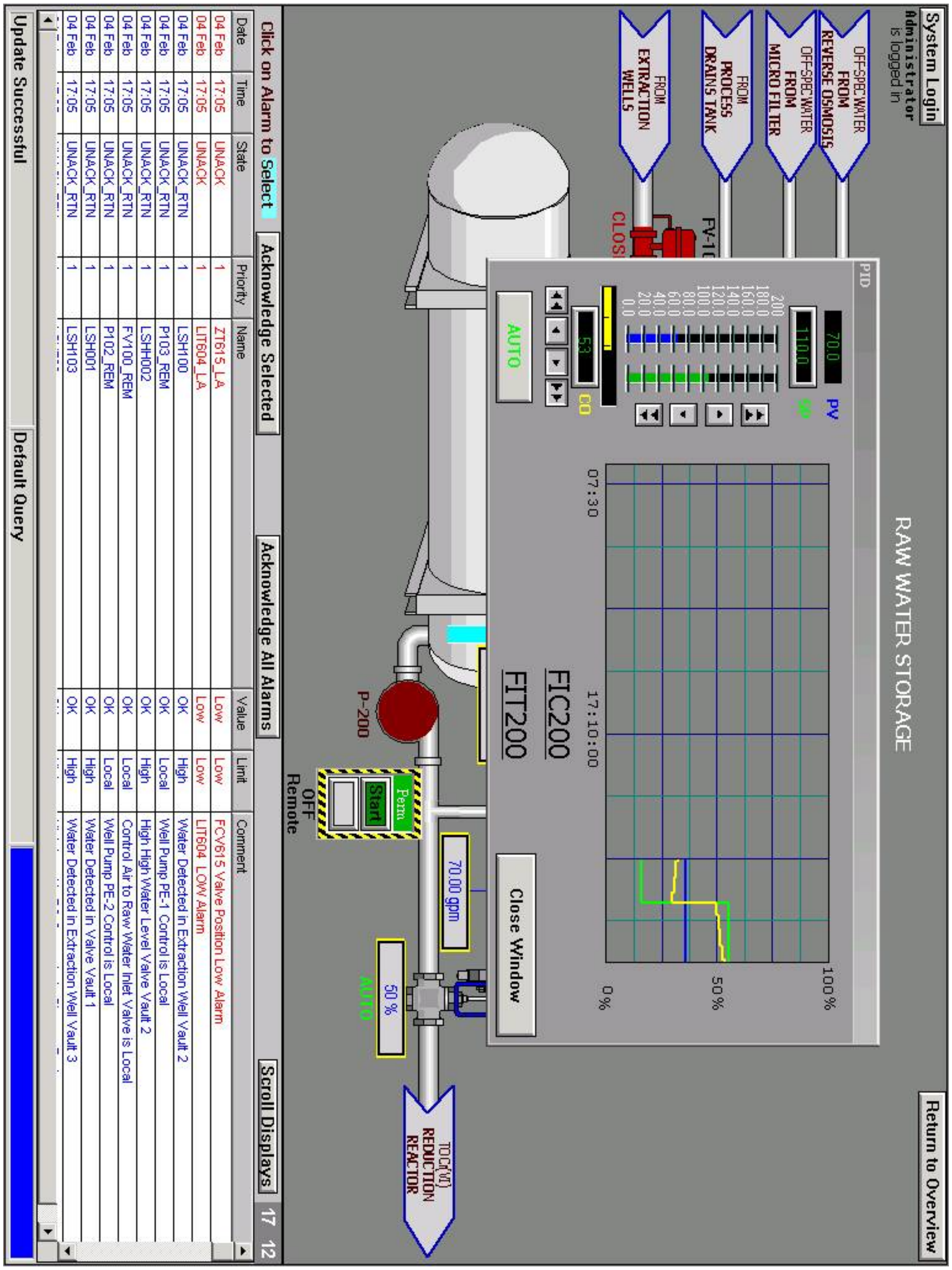
"NoPerm" also means that the PLC cannot start the pump and that PLC command output to the pump starter is held in the off position. Once the interlock(s) clear(s), then the pump can be issued a start command from the HMI.

Once pumped out of the ground, the raw water is transferred to the Raw Water storage tank. The storage tank serves to equalize flow to the treatment system and to allow the pumps to continue to extract ground water even if the plant process is temporarily stopped. The raw water tank feeds the untreated ground water into the plant treatment system via pump P-200 and flow control valve FCV-200.

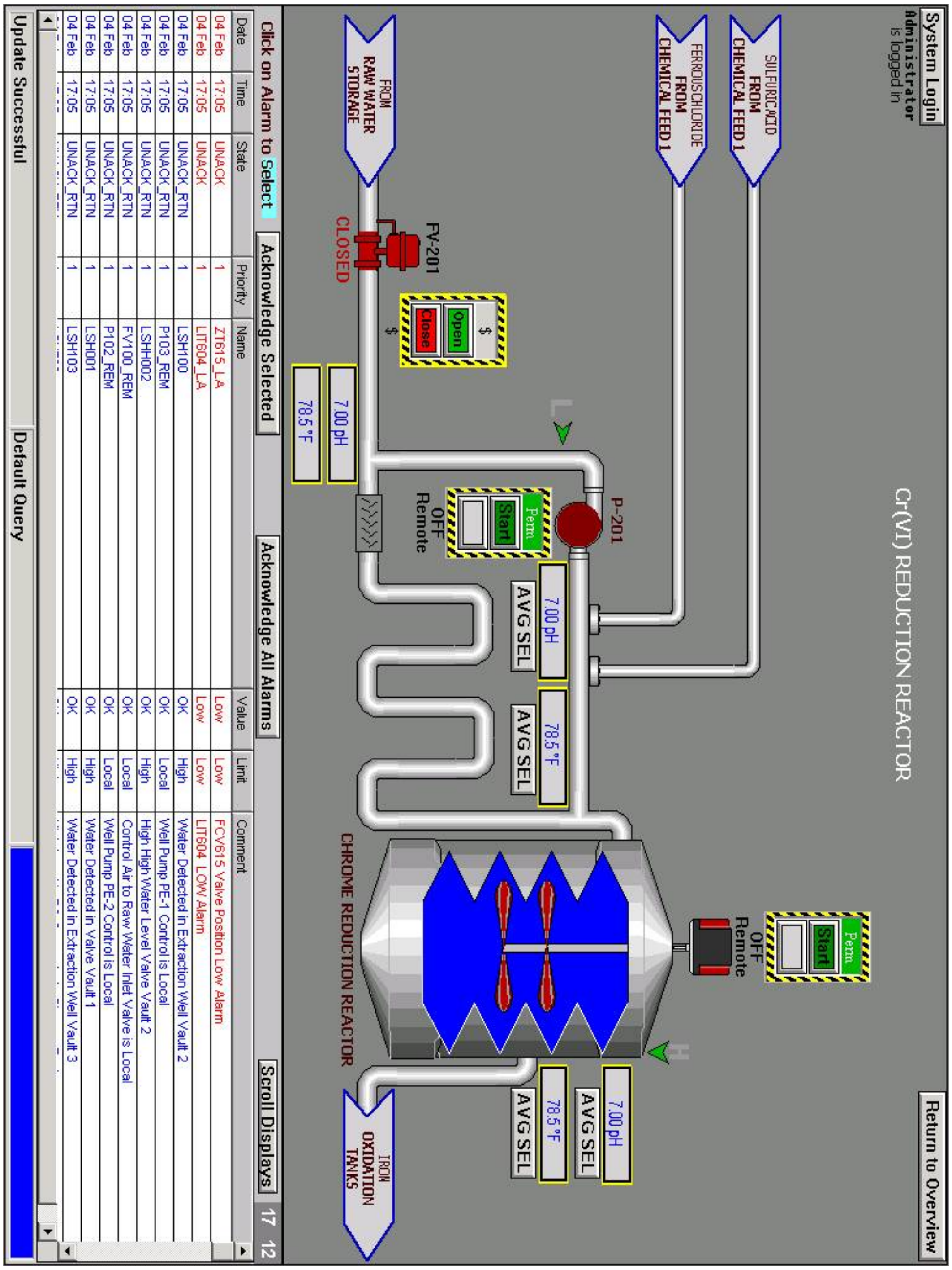


There are three control points for the operator on this screen. The first is flow block valve FV-100 that the operator sets open/closed. The second point is pump P-200 that the operator can start/stop. Note that the valve and pump operation and control buttons are nearly identical to the extraction well pumps. The only difference is that P-200 and FV-100 do not have a Remote Auto mode. The operator is responsible for the control of these two process points.

Flow into the treatment system is automatically maintained at whatever flow rate the operator has set via the HMI. To change the flow control setpoint, the operator must click on the flow control valve. This will activate the PID popup control window. PID control is discussed in Section 8.

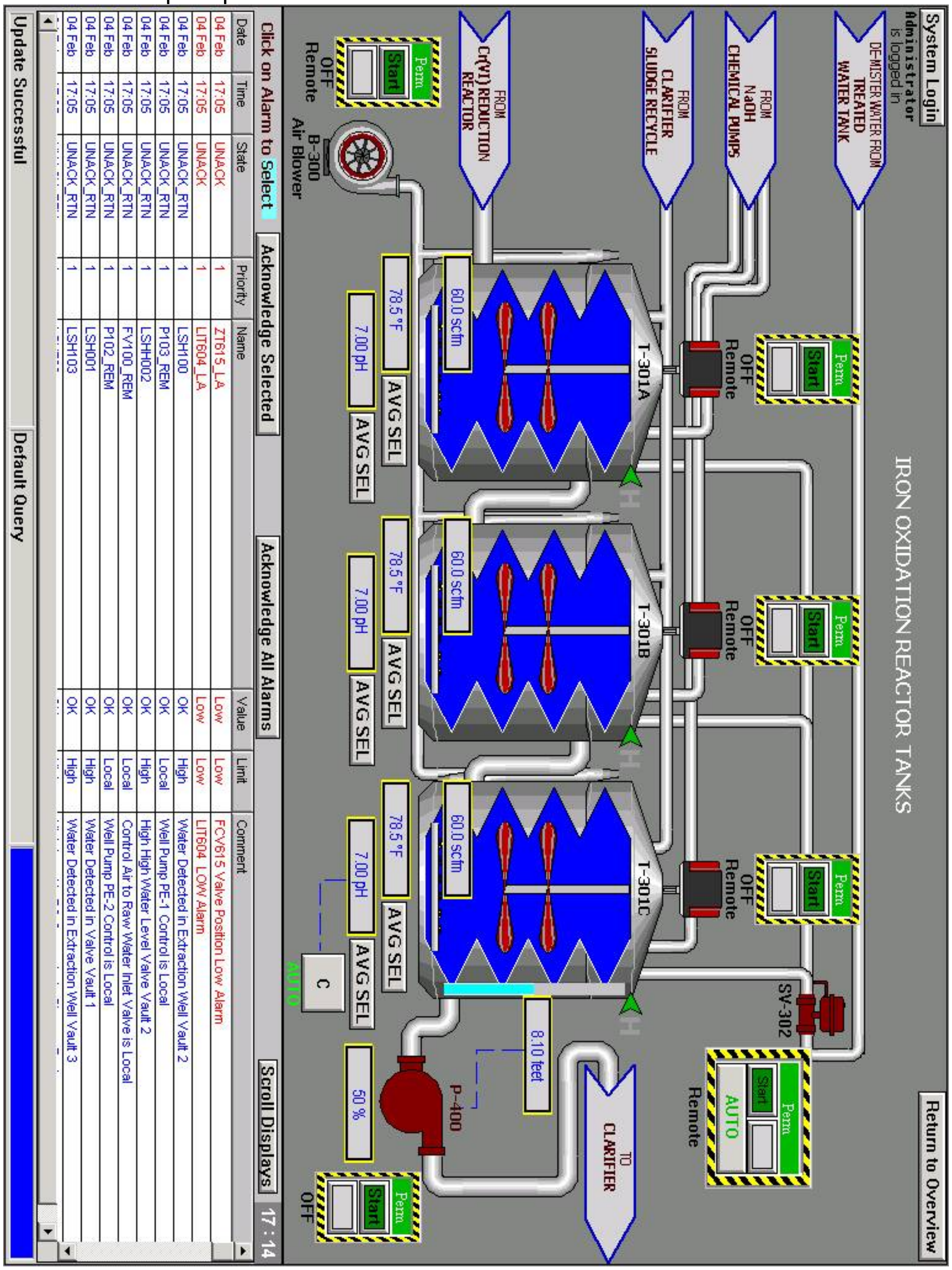


The actual water treatment process begins with the chromium reduction reactor. A ferrous chloride solution is injected into the water treatment stream feeding the chromium reduction reactor. The injection stream consists of serpentine piping that serves the purpose of increasing dwell time thus allowing the ferrous chloride time to react with the chromium.



There are three control points for the operator. The first is water block valve FV-201, the second is chemical mixing pump P-201 and the third is the mixer in the chrome reactor. The primary monitoring points are pH.

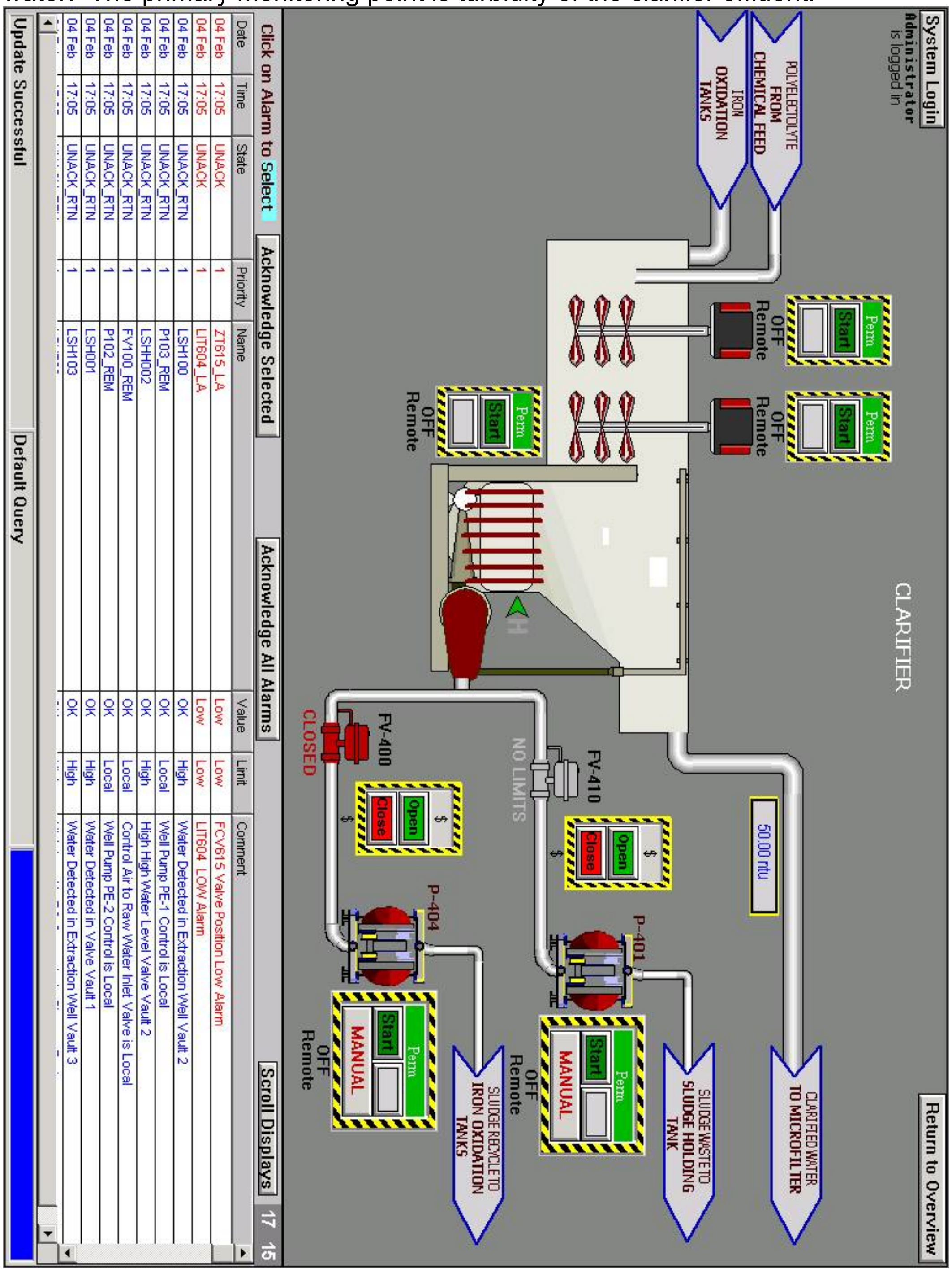
Once pumped into the chrome reactor, the water flow is gravity fed through a series of three (3) iron oxidation tanks. The iron oxidation tanks are injected with air in order to precipitate the reacted ferrous chloride.



There are seven control points for the operator monitor and control. The operator is responsible for the control of the 3 reactor tank mixers and the air blower. In addition, there is a water block valve SV-302 that controls water flow to the de-misters on each tank. SV-302 has 3 modes of operation. Remote Auto, Remote Manual, and Local.

The primary analog controls are pH and the level in reactor 3. The clarifier feed pump (P-400) is a variable speed drive that maintains a level setpoint in reactor 3 by adjusting the speed output of the pump motor.

The process stream continues through the iron oxidation tanks and ends up in a clarifier. The clarifier serves to remove the precipitated iron (the sludge) from the water. The primary monitoring point is turbidity of the clarifier effluent.



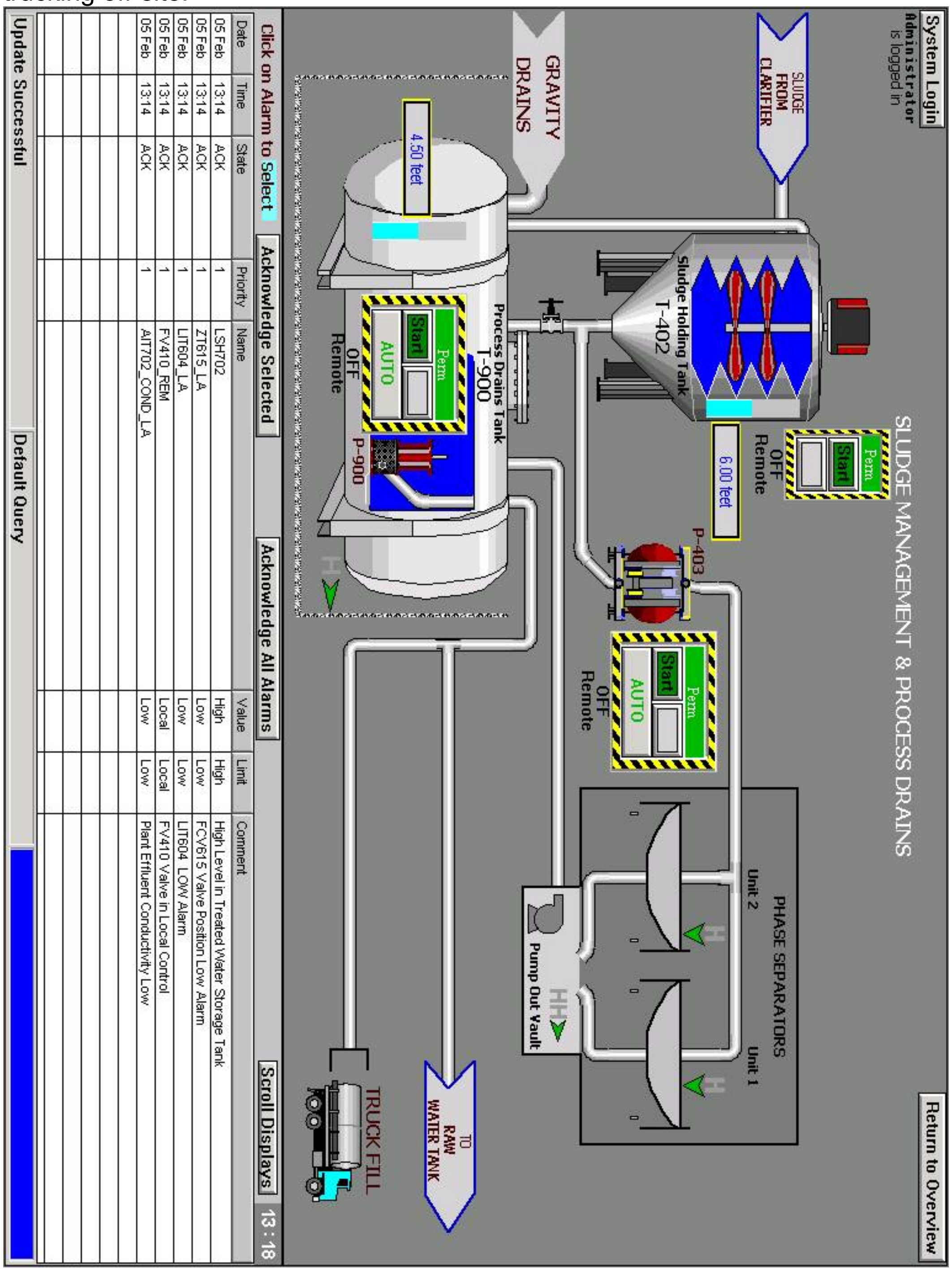
There are seven control points for the operator. There are two mixers and one rake motor on the clarifier. The two sludge block valves FV-400 and FV-410 open automatically whenever their associated pump is activated. If necessary, the operator can open/close these valves at will by clicking on the appropriate command button.

The two sludge-forwarding pumps have three modes of operation similar to the extraction well pumps. The first mode, Remote Auto, is the preferred method of operation. In this mode the pumps start and stop automatically based on limits set in the PLC programming. The second mode, Remote Manual, is available to the operator if it is determined that the pump(s) should be stopped or started independent of the PLC programming limits. The last mode, Local, should not be used to operate the pumps as this mode should only be used for maintenance and troubleshooting.

The primary process flow is the clarifier effluent, which passes on to the MicroFilter skid system for further cleaning.

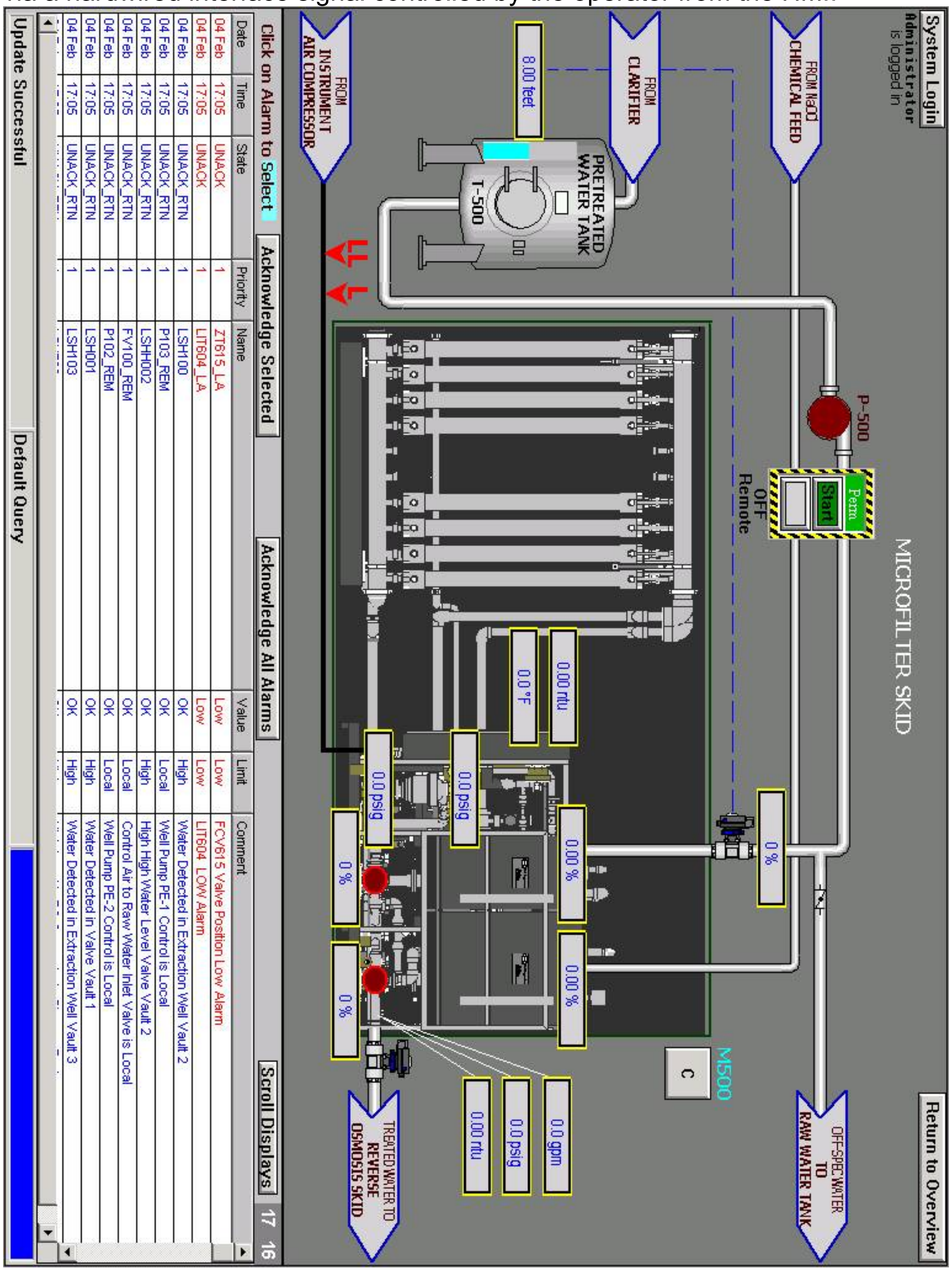
The clarifier sludge is either re-circulated back to the iron oxidation tanks or is sent to the sludge holding tank for further processing and removal.

The sludge holding tank takes the sludge from the clarifier and sends it to the phase separators, which remove most of the suspended solids. Water is then pumped from the separators over to the process drains tank. The process drains tank will be emptied periodically by pumping back to the raw water tank and/or by trucking off-site.



The main points monitored and controlled are the tank levels, the sludge-forwarding pump P-403; the drains pump P-900 and the holding tank mixer. Additionally, the phase separators are monitored for excessive level by 3 different level switches. Tank level is maintained within a specific range by the pumps when the pumps are in Remote Auto control. In Remote Auto, the pumps start and stop automatically based on level indication from the appropriate tank. Remote Auto is the preferred method of operation.

The main process flow (effluent) from the clarifier continues on to the PALL MicroFilter skid. The MicroFilter continues to clean the water stream by filtering out particulate matter. The skid is controlled by a MicroLogix PLC located in the skid panel. The skid receives a remote run/stop command from the main PLC via a hardwired interface signal controlled by the operator from the HMI.

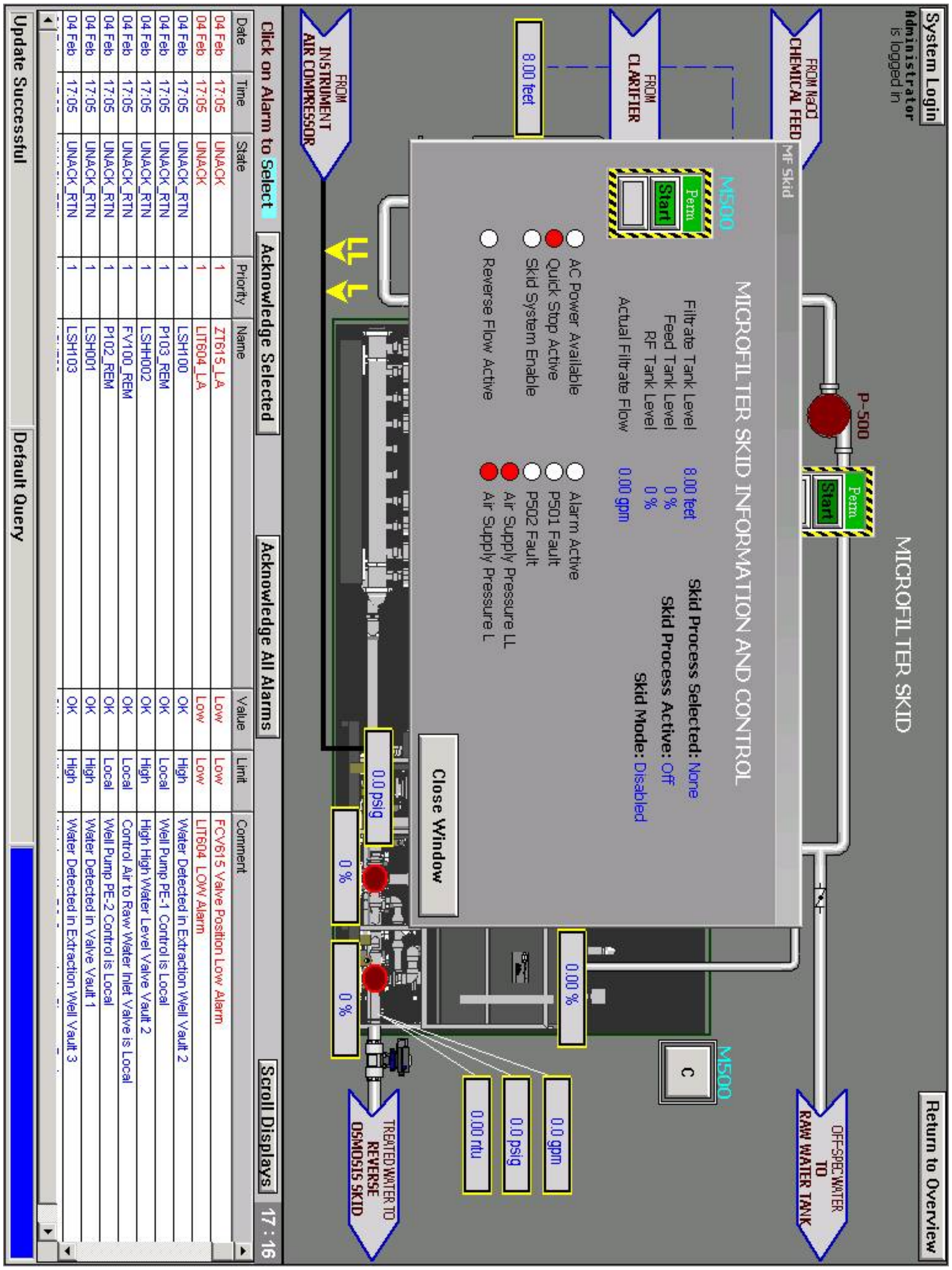


There is only one control point for the operator, the start/stop of pump P-500. The MicroFilter skid PLC controls all other points. The operator cannot directly control the level in the pre-treated water tank T-500. This tank level is maintained by a setpoint set in the MicroFilter skid PLC and can only be changed at the local PLC panel.

Specific details regarding the operation of the MicroFilter skid including the HMI start/stop command output is available by calling up the MicroFilter skid popup skid control window. This window is called up by clicking the “C” control button located under the M500 tag.

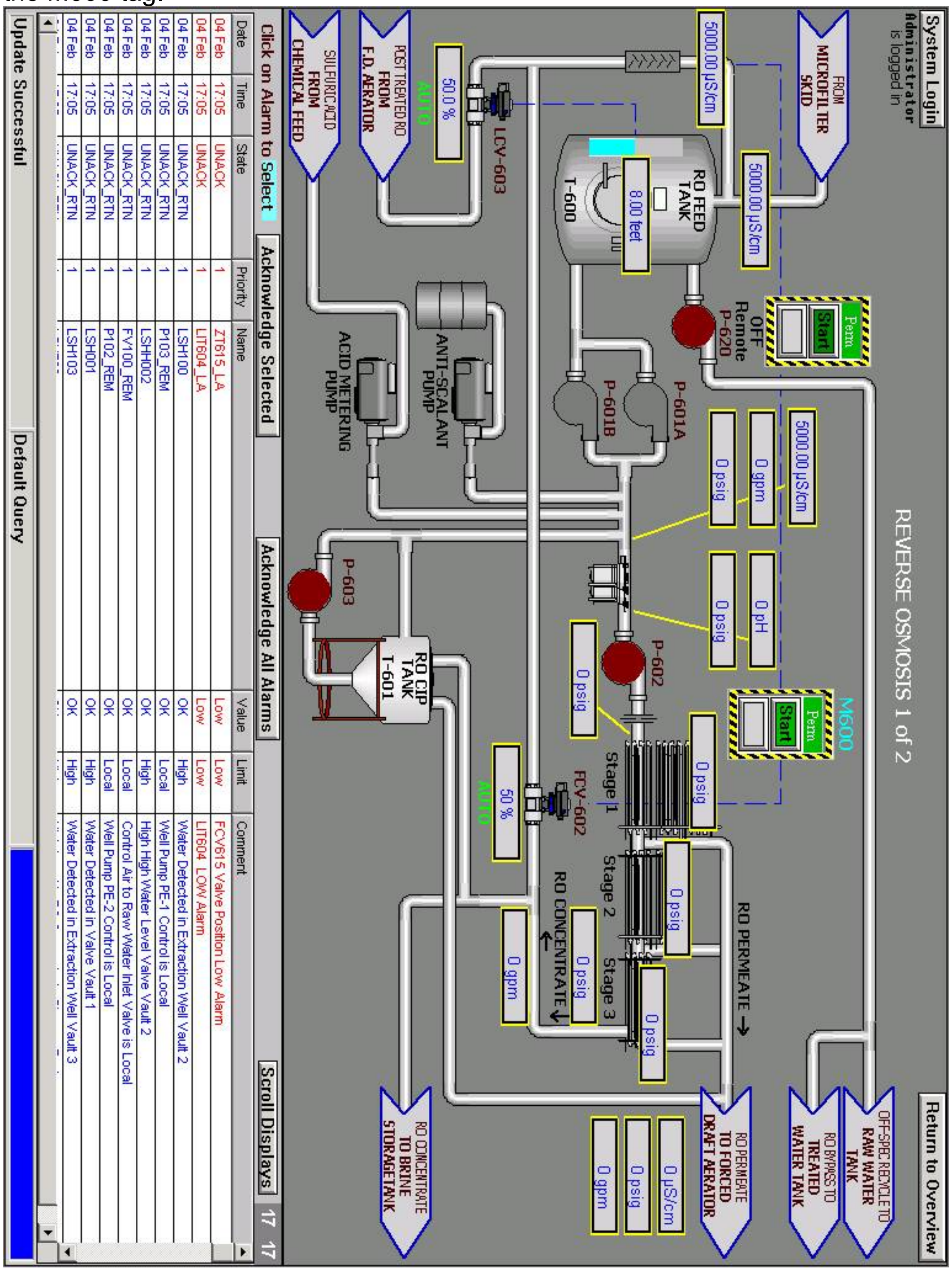
For additional details concerning the operation and control of the MicroFilter system, please refer to the PALL O&M manual.

To remotely start the MF skid, the operator must call up the skid control window and select “Start” from the control button macro.



The main process stream flows through the MicroFilter and continues to the reverse osmosis system.

The reverse osmosis skid is a self-contained skid package that is controlled by a MicroLogix PLC located in the skid panel. The RO skid receives a run/stop command from the main PLC via a hardwired interface signal controlled by the operator from the HMI. The operator can issue a remote skid start/stop command by clicking on the command buttons in the control macro located under the M600 tag.



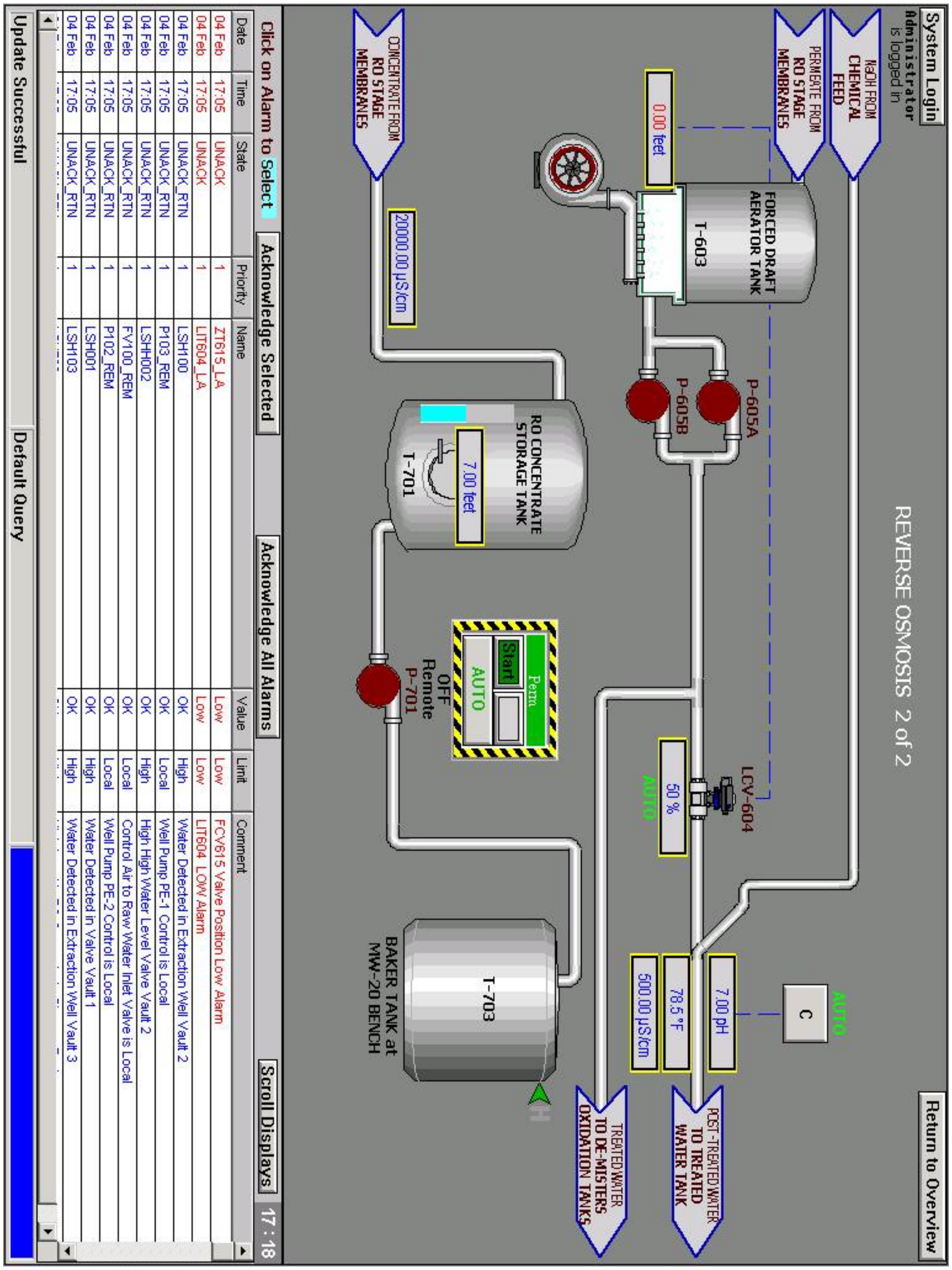
There are two main control points for the operator on the first RO screen. The first control point is the RO feed tank level in tank T-600, which is controlled by

LCV-603. The second control point is RO recirculation conductivity, which is controlled by FCV-602, which regulates RO concentrate flow back into the feed tank in order to match the recirculation conductivity to the process influent conductivity. The operator can access the PID controls for these two points by clicking on the appropriate control valve on the HMI screen.

The other control points for the operator are the remote start/stop of the skid and the control of the P-620 pump.

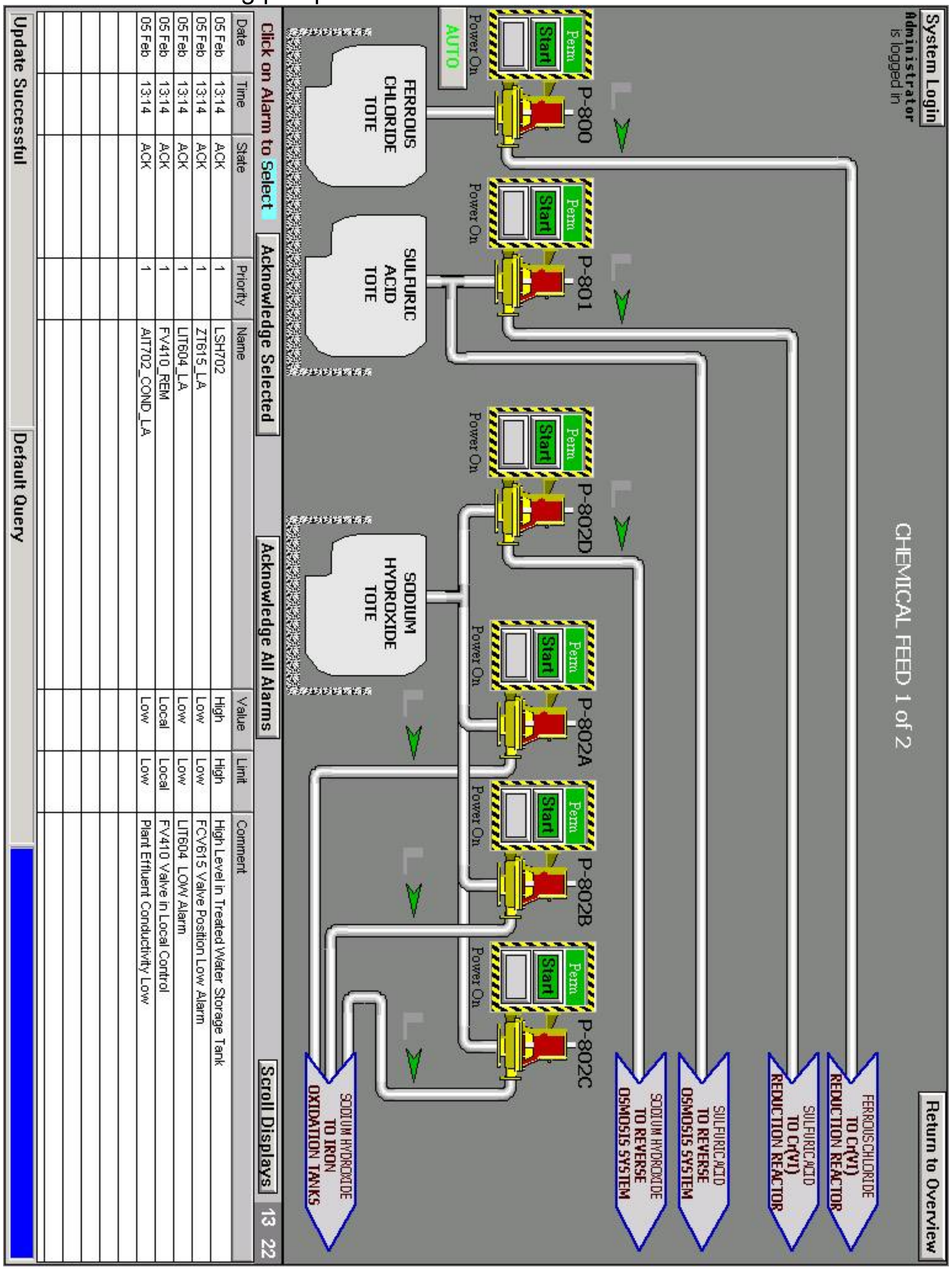
The main purpose of the RO system is to remove salts and other impurities from the water. One of the primary monitors of the RO system is conductivity. In addition, pH, flow and pressure are monitored.

Due to the size of the RO skid, the process is displayed across two process graphics. The RO permeate (clean stream) is sent through a forced draft aerator. The RO concentrate (waste stream or brine) is sent to a small interim storage tank from which, it is pumped into a Baker tank at the MW-20 bench. The brine is manually transferred to transfer trucks for off-site disposal.



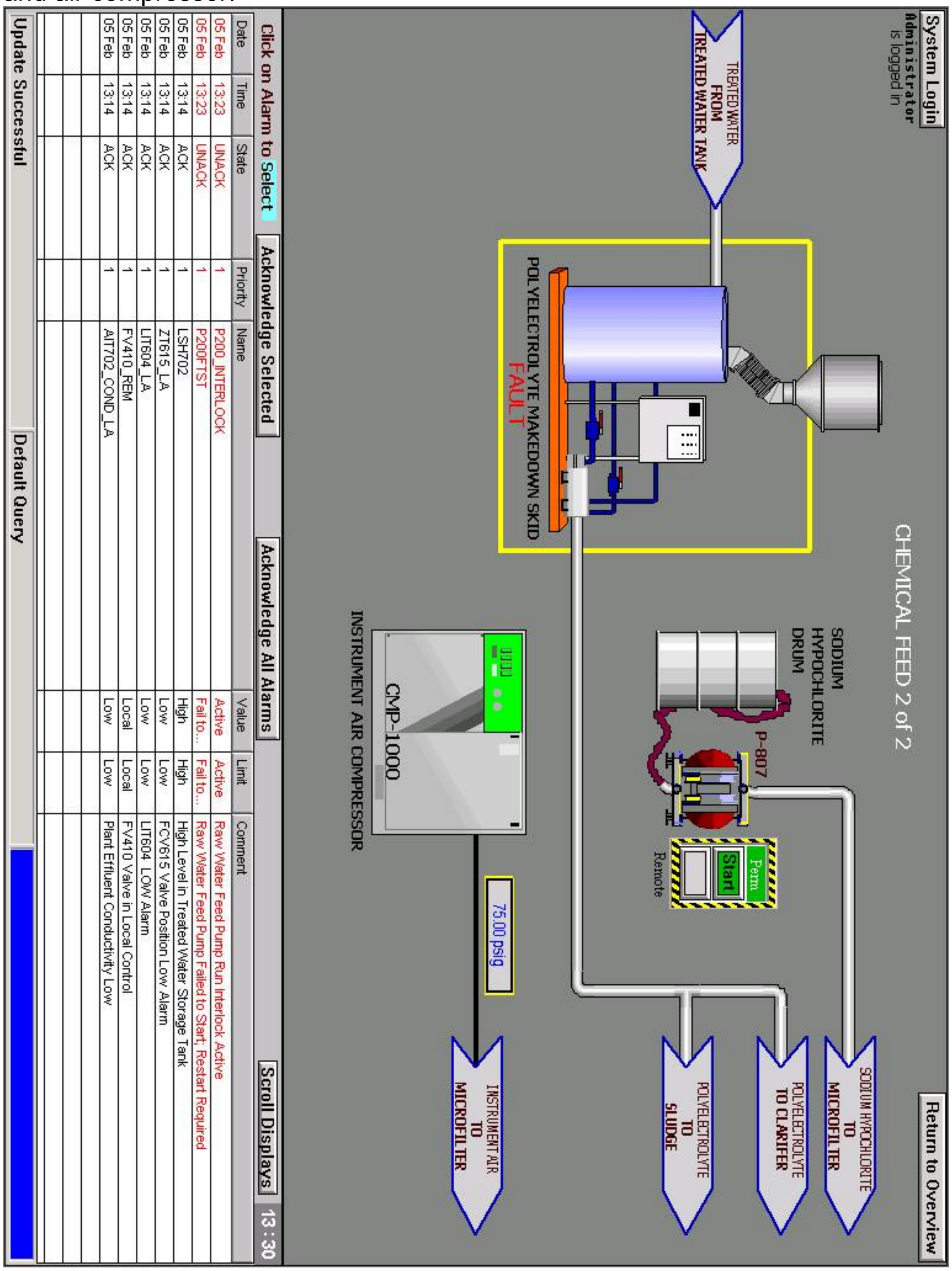
There are two primary control points for the operator. The first is the T-603 tank level, which is controlled by LCV-604. To access the PID control, the operator clicks on the LCV-604 valve. The second control point is permeate pH, which is controlled by metering sodium hydroxide using pump P-802D. To access the PID control, the operator clicks on the "C" control button. PID control of the P-802D is also available from the metering pump HMI screen.

Several chemicals are used during the treatment process. Access to the chemical screens is via page connector links from the appropriate process that uses chemicals or from the overview graphic. The first chemical screen is for the six chemical metering pumps.



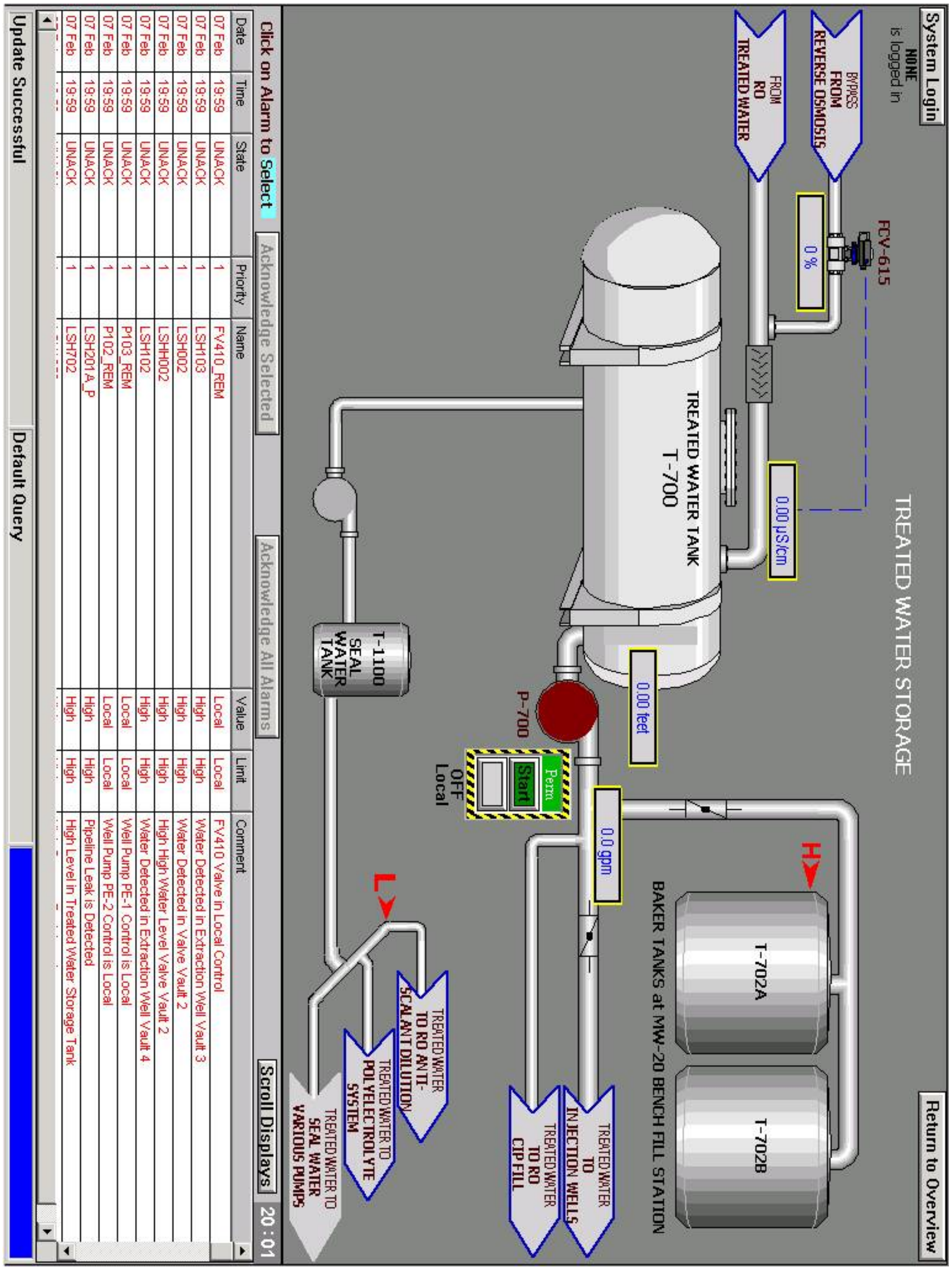
Each metering pump has a control window associated with it. To access a pumps control window, click on the desired metering pump. All pumps must be started/stopped by the operator. The ferrous chloride pump P-800 also has Auto/Manual capability. In the Auto mode, the pump starts and stops by itself based on raw water influent flow (FIT-200) and programming limits set in the PLC program. In Manual mode, the pump is started and stopped by the operator. Specific details regarding chemical metering controls are provided in Section 8.

The second chemical graphic is for the polyelectrolyte skid, sodium hypochlorite and air compressor.



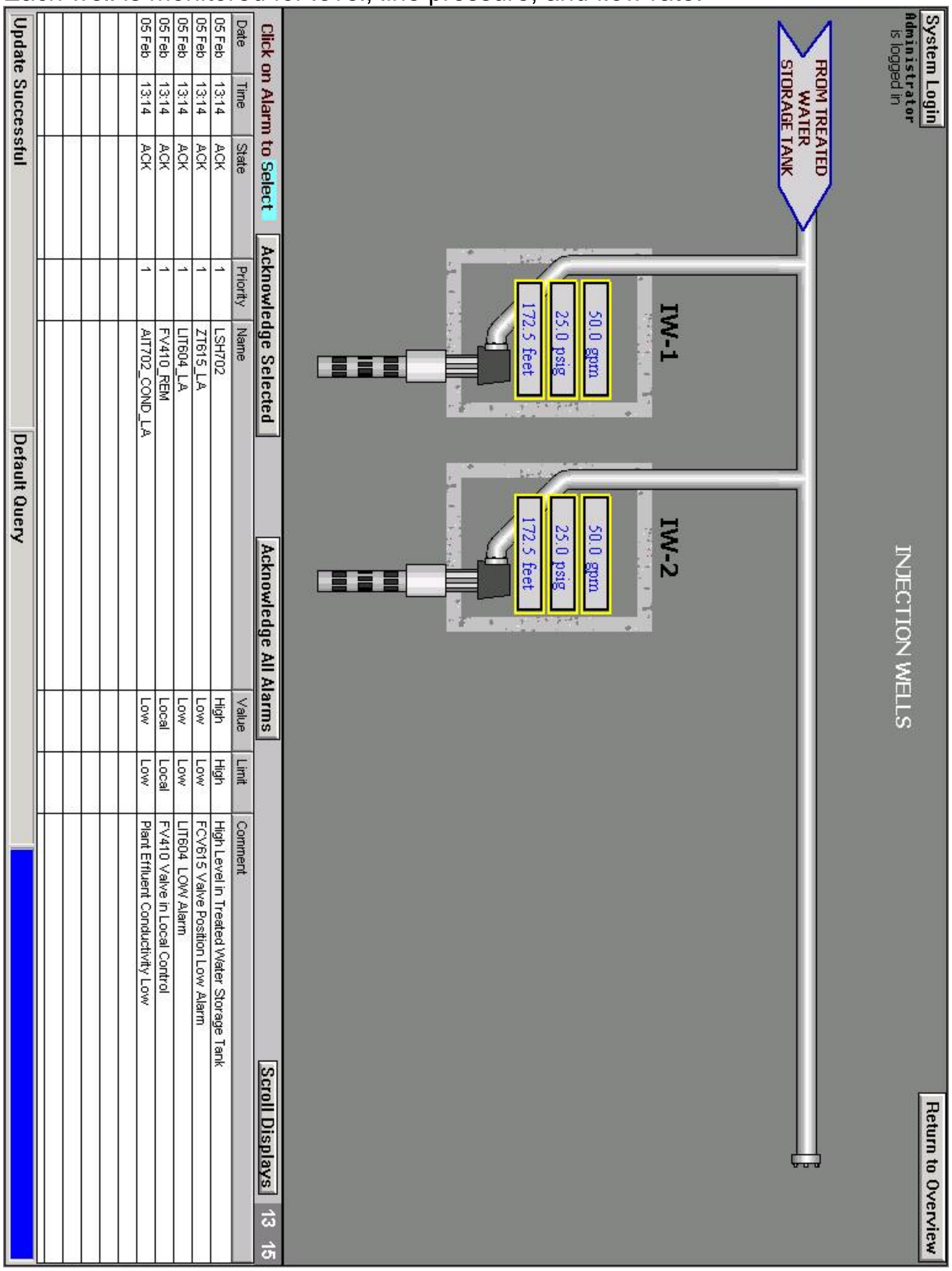
There is only one control point pump P-807. Air pressure is monitored and the compressor and polyelectrolyte skid have fault indication if a skid failure occurs.

After passing through the forced draft aerator, the permeate is stored temporarily in the treated water storage tank. From the treated water storage tank, the RO permeate is either pumped to Baker storage tanks at the MW-20 bench, or it is pumped back into the ground via the injection wells. Flow to either the injection wells or the Baker tanks is controlled manually by the operator adjusting block valves in the field.



The main control points for the operator are the transfer pump control P-700 and the treated water conductivity PID control via FCV-615.

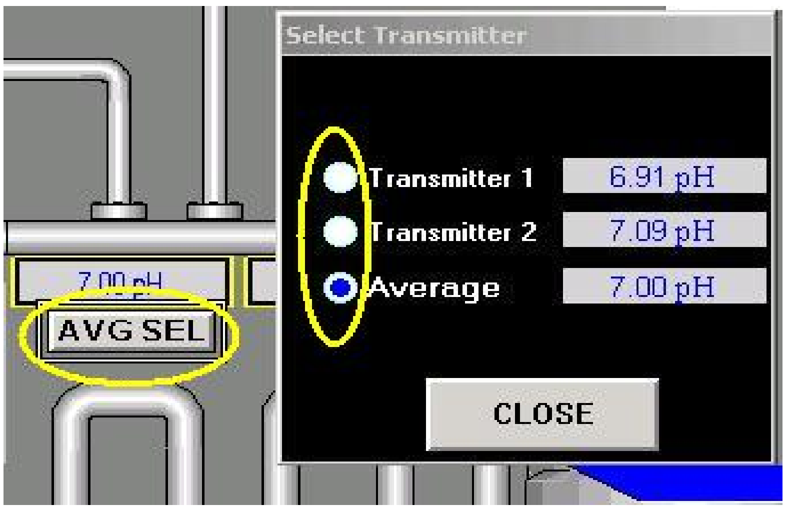
The injection wells take the treated water from the treated water storage tank. Each well is monitored for level, line pressure, and flow rate.



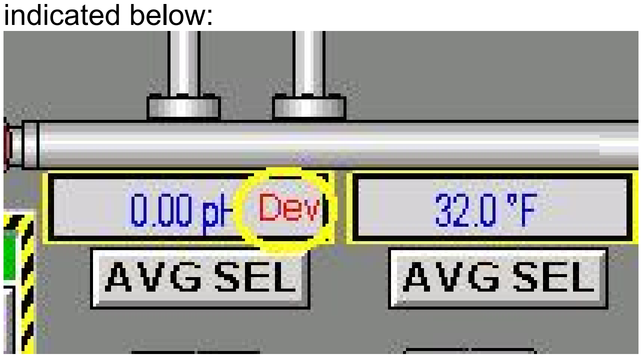
8. MONITORING AND CONTROL

There are numerous process points that can be monitored by the operator. These principally include water flows, pressures and temperatures as well as conductivity and pH.

For critical pH, dual transmitters have been provided. There are three modes available to the operator for these dual transmitters. The operator has the ability to select the transmitter that should be displayed and alarmed on the HMI or the operator can select to display and alarm the average of both transmitters. Average is the preferred operating state. Normally, the dual transmitters should be set to "AVG" from the HMI.



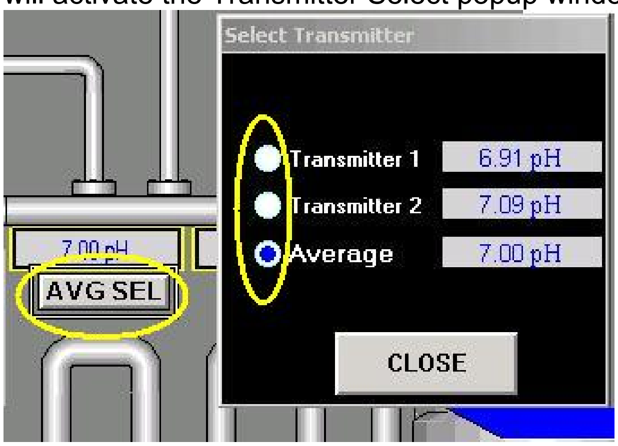
The PLC will alarm the HMI if the two transmitters in a dual transmitter pair deviate from each other by 5% of transmitter span. If a deviation alarm is received by the HMI, the operator should immediately investigate the cause of the deviation. Visual indication of the deviation alarm occurs both on the Alarm Summary found on the bottom of every screen and at the transmitter readout as indicated below:



It may be necessary to take a transmitter out of service in order to repair or replace a defective transmitter. In order to minimize nuisance alarming, the operator can select to display and alarm the good transmitter, which allows the temporary removal from service of the defective transmitter. The defective transmitter should be repaired or replaced as soon as possible and the transmitter selection should then be returned to “AVG”. No control action other than alarming occurs as the result of the transmitter deviation. The system does not automatically transfer from one transmitter to another transmitter.

The operator can always see which transmitter is selected from the HMI by looking at the text displayed in the transmitter select button.

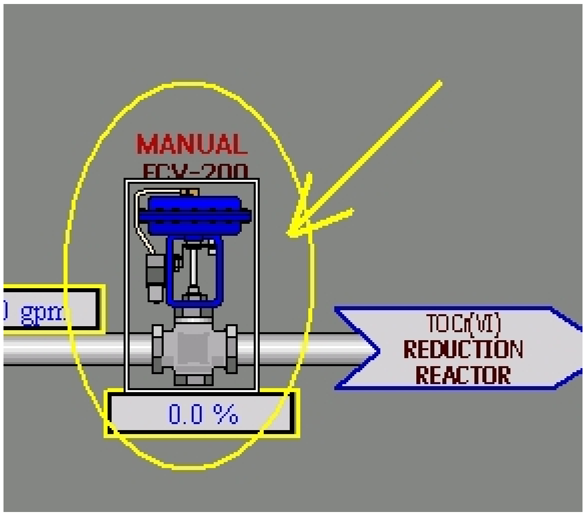
To select the display and alarming of the dual transmitter pairs, the operator must click on the grey transmitter select button under a dual transmitter display, which will activate the Transmitter Select popup window.



The operator then selects one of two transmitters or the average by clicking on the white radial button for the appropriate selection. Once a selection has been made, the operator should then close out the popup window by clicking on the “CLOSE” button.

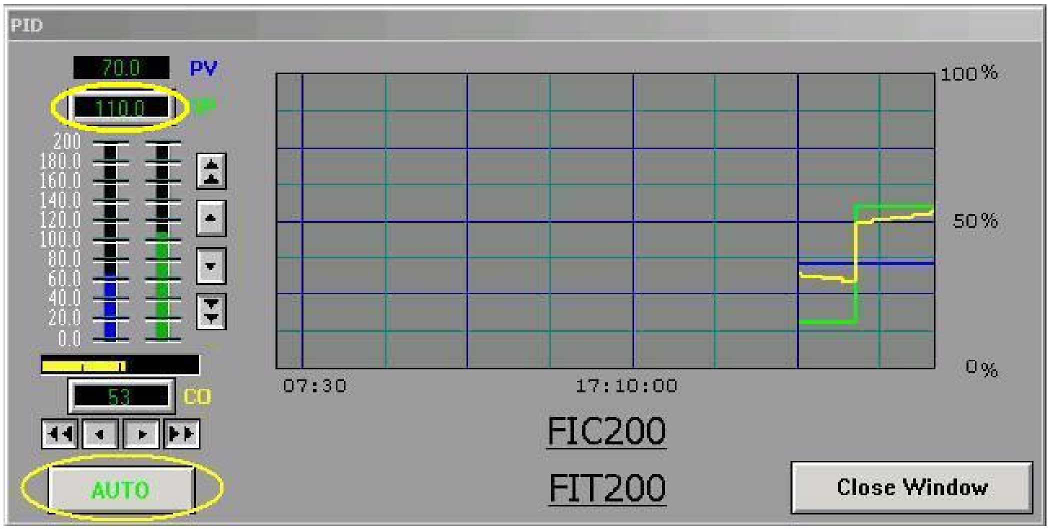
ANALOG CONTROL

There are a few analog control loops that require monitoring and setpoint adjustment by an operator. Analog control loops are controlled from the HMI by using a PID popup window. PID is an acronym for Proportional Integral Derivative, which describes the standard control algorithm. To activate the PID popup window, the operator must click on the control valve on the HMI screen that is to be controlled. In the following example, the PID popup for control valve

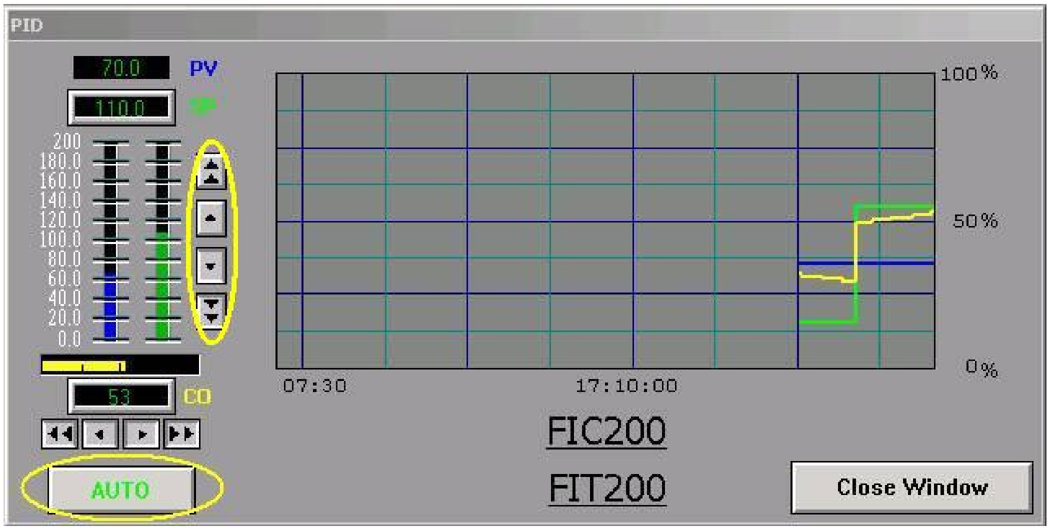


FCV-200 is activated when the mouse is clicked anywhere on top of the FCV-200 valve.

Once the PID popup window is displayed the operator can change the setpoint by entering a specific setpoint value in the setpoint box (circled on top).



Or, the setpoint can also be changed incrementally by bumping the setpoint using the increment buttons (circled on the side).

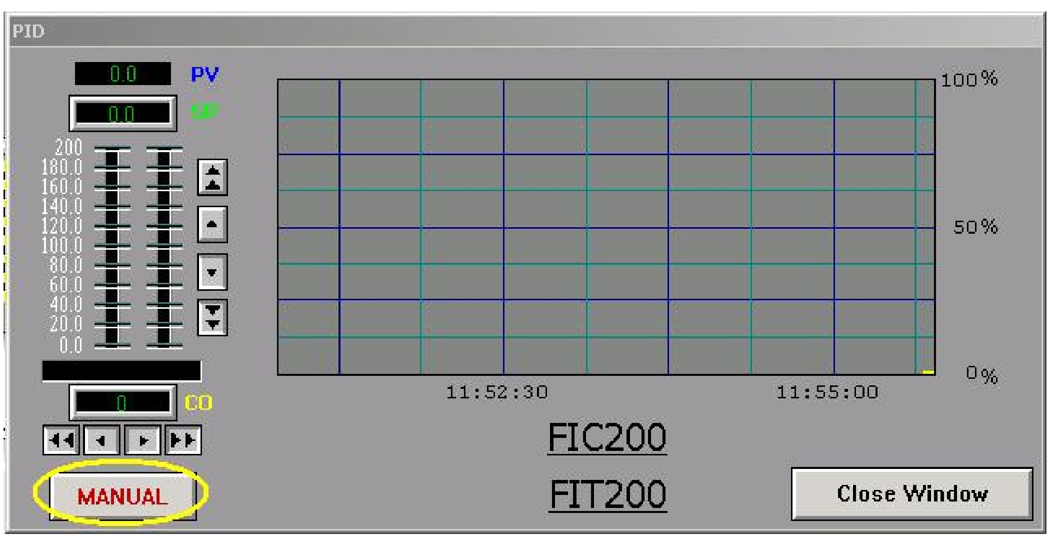


The up arrows increase the setpoint value, while the down arrows will decrease the setpoint value. Once the operator has established the desired setpoint in the controller, the “CLOSE” button should be clicked to close out the PID window.

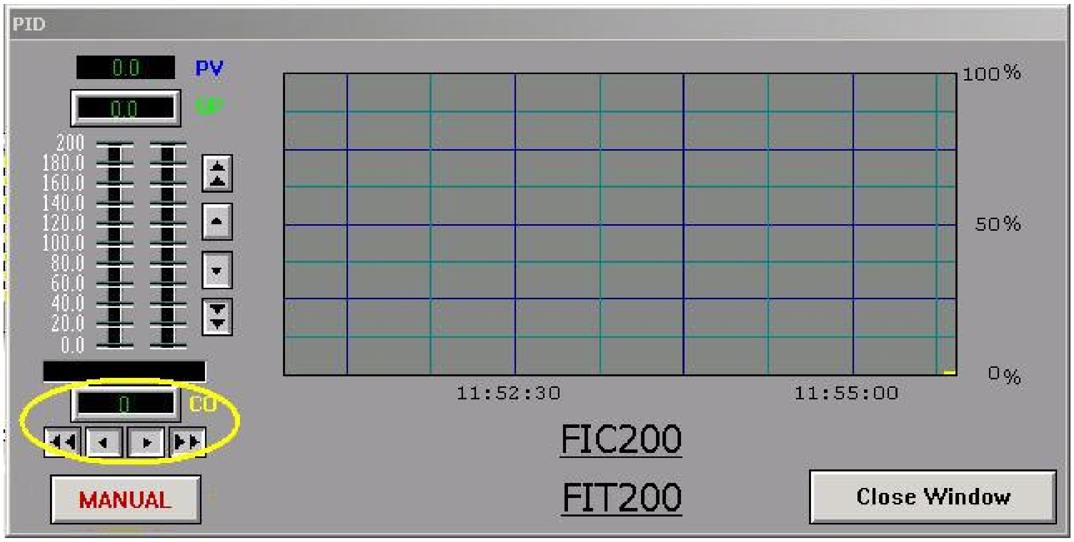
In Auto control, the PLC system continually adjusts the control output (i.e. the control signal to the flow regulating valve) making changes necessary in order to match the process variable signal with the operator-entered setpoint.

In rare cases, the controller may have to be taken out of Auto control and placed into Manual control.

In Manual control, the output to the control valve stays fixed unless changed by the operator. To change between Auto and Manual control, click the Auto/Manual toggle button located on the bottom left of the PID control window.

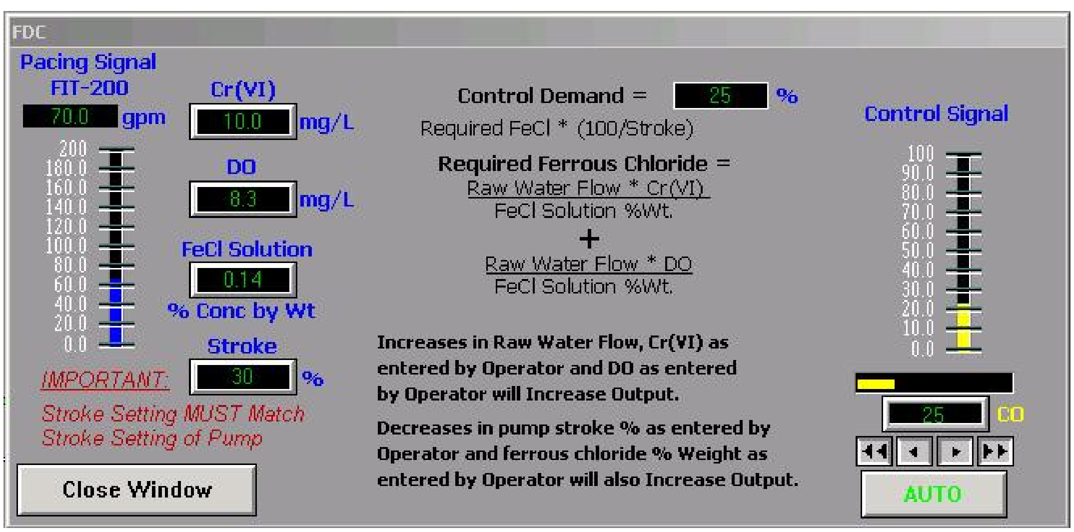


Once the controller is in Manual, the operator can manipulate the output directly by either setting a manual output (as 0-100%) or by incrementally bumping the output up or down using the arrow buttons.



Manual control should only be used for maintenance or troubleshooting purposes.

Ferrous Dosing
Special note should be made regarding the ferrous dosing control. Ferrous dosing control is called up by clicking on the ferrous metering pump P-800 located on the chemical metering pump graphic. Clicking on the metering pump activates the ferrous dosing control popup window.



The flow of ferrous is automatically regulated based on the pacing signal factored by several operator-entered setpoints. The control output signal, which drives the speed of the dosing pump, will change as follows:

The output will increase under the following conditions:

- When the pacing signal (flow rate measured by FIT-200) increases ↑
- When the operator entered value for measured chrome increases ↑
- When the operator entered value for Dissolved Oxygen increases ↑
- When the operator entered value for concentration of ferrous decreases ↓
- When the operator entered value for pump stroke decreases ↓

Special Note: It is very important that the stroke setting value entered into the HMI be the same value that is manually set on the pump. Failure to match the HMI setting to the physical pump setting will result in incorrect dosing of ferrous.

Auto control is the preferred operational method. However, the operator can switch the controller to Manual and set a specific output to the metering pump if necessary for maintenance or troubleshooting.

DISCRETE CONTROL

As previously indicated, the operator can start and stop various pumps by clicking on the start button associated with a pump. Once started, the stop button becomes available. To stop the pump, the operator must click on the stop button. The on/off valves are controlled in a similar manner.

The pump start/stop stations and on/off valves can only be controlled when an operator is logged into the system and then, only when the local hand-switch (LOR) is in the remote position. Control from the HMI is not possible when the field hand-switch is either off or in the local position. Both motor run status and local/remote status are displayed on the HMI:

The on/off valves are controlled in a similar manner. They also have a yellow/black control box. The valves also clearly indicate valve status including “Open”, “Closed”, “No Limits”, “Double Limits”, “Fail to Open”, and “Fail to Close”. Full mismatch logic on valves with limit switches is employed. The valve status will not indicate “Open” unless the open limit switch (ZSO) is closed **and** the closed limit switch (ZSC) is open. “Closed” is not indicated unless the closed limit is closed and the open limit is open. If no limit switch is closed after a 10sec timeout, an alarm is generated and the valve status indicates “No Limits”. If both limit switches indicate closed, then an alarm is immediately generated and the status indicates “Double Limits”.

As with the pump/motor control, if the valve field switch is not in the Remote position, no HMI control is possible.

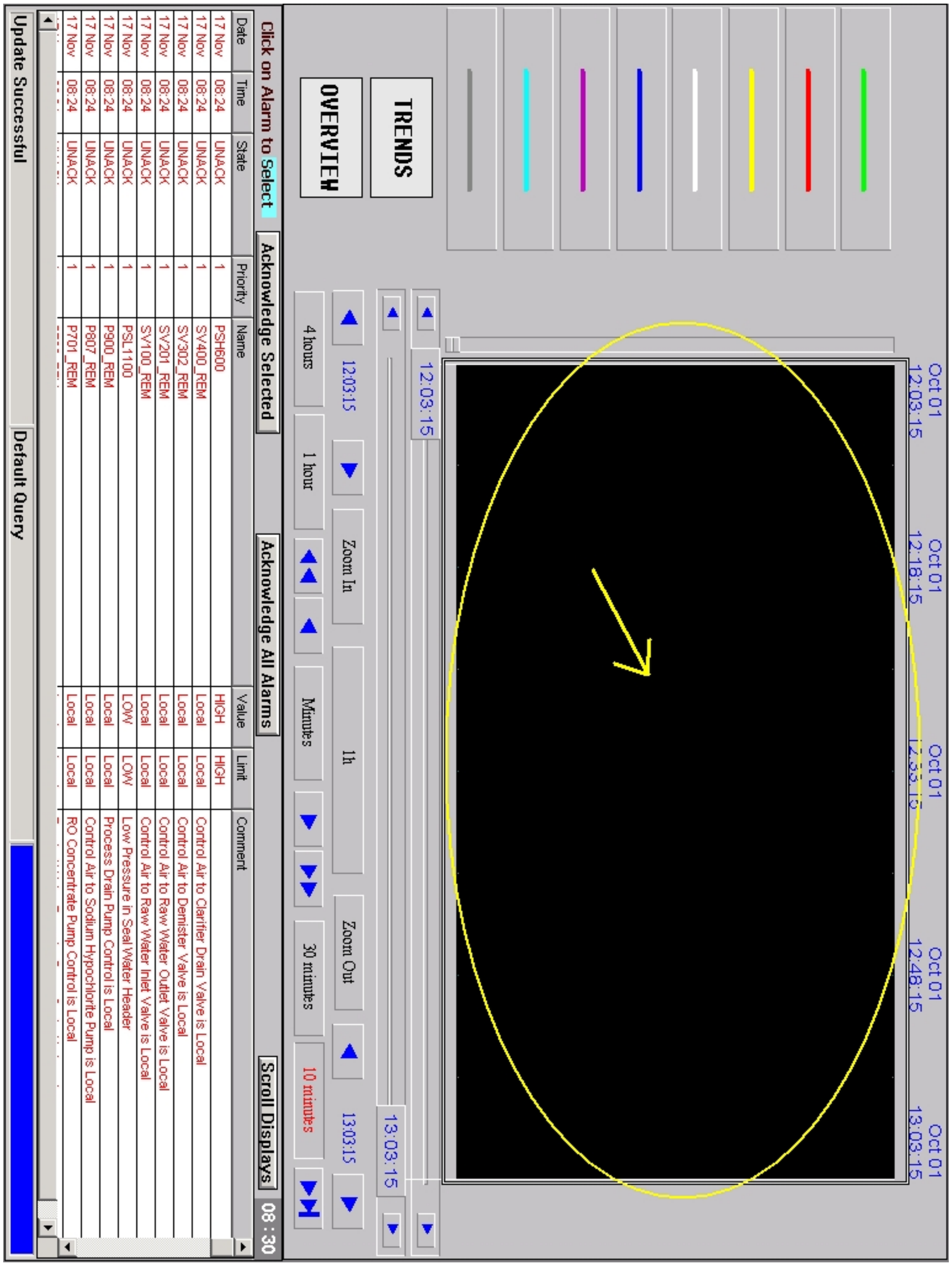
9. TRENDING

There are 20 trend displays available for viewing historical system data. 19 of the 20 displays are fixed with regard to the data points that are called up by the display. 1 trend display is operator-configurable and can be changed at any time by an operator. The configurable trend display can be configured to show any combination of data variables, including discrete on/off data, which are configured to be historically logged in the system.

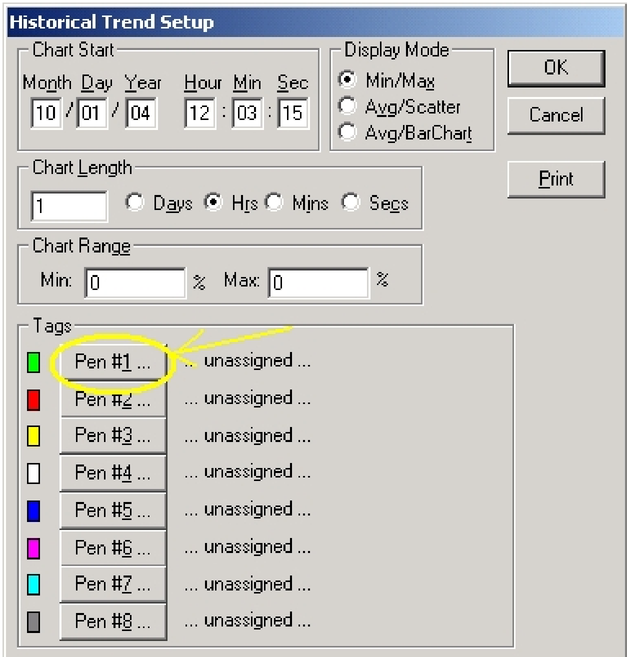
CONFIGURABLE TRENDING

The operator-configurable trend allows the operator to pick up to eight historically trended (logged) tags available from the HMI database for display and comparison purposes.

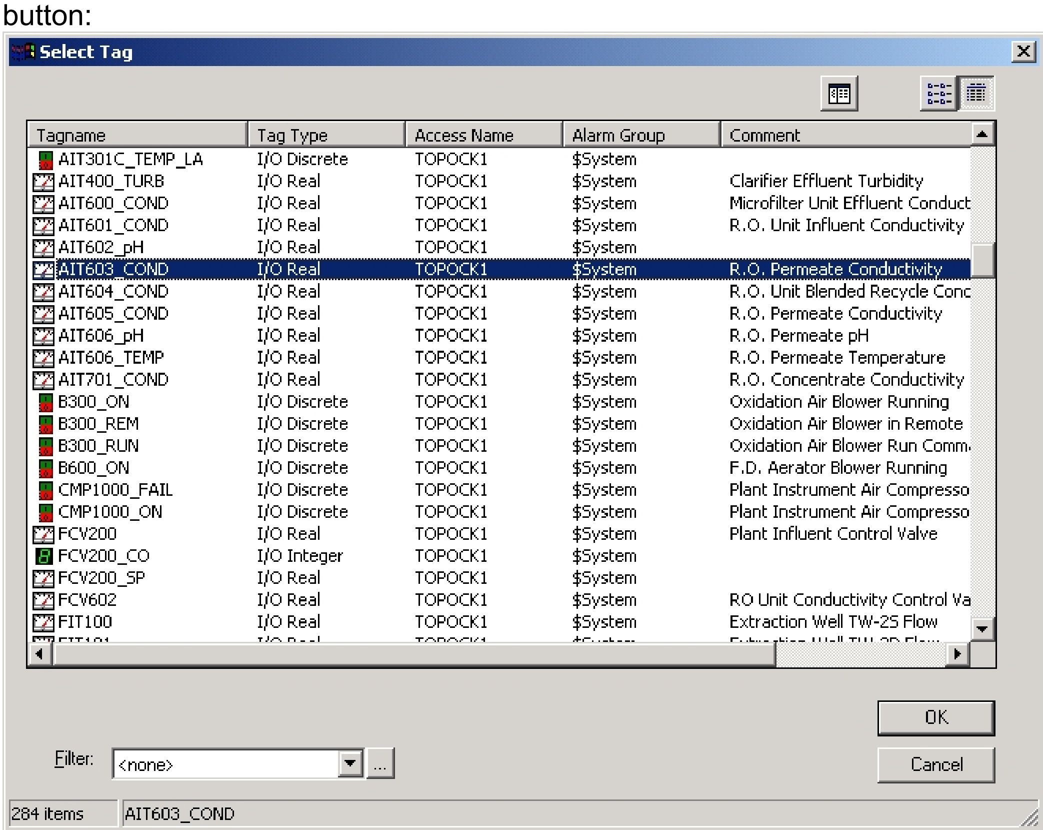
To select tags for display in the settable trend, navigate to the “Operator Settable” trend display from the Master Trend display. When started for the very first time, the trend display will have no tags selected. To view historical trend data, tags must first be selected for display by the operator. Select tags for the trend display by clicking the mouse inside the large trend trace display area (black area) as shown on the next page:



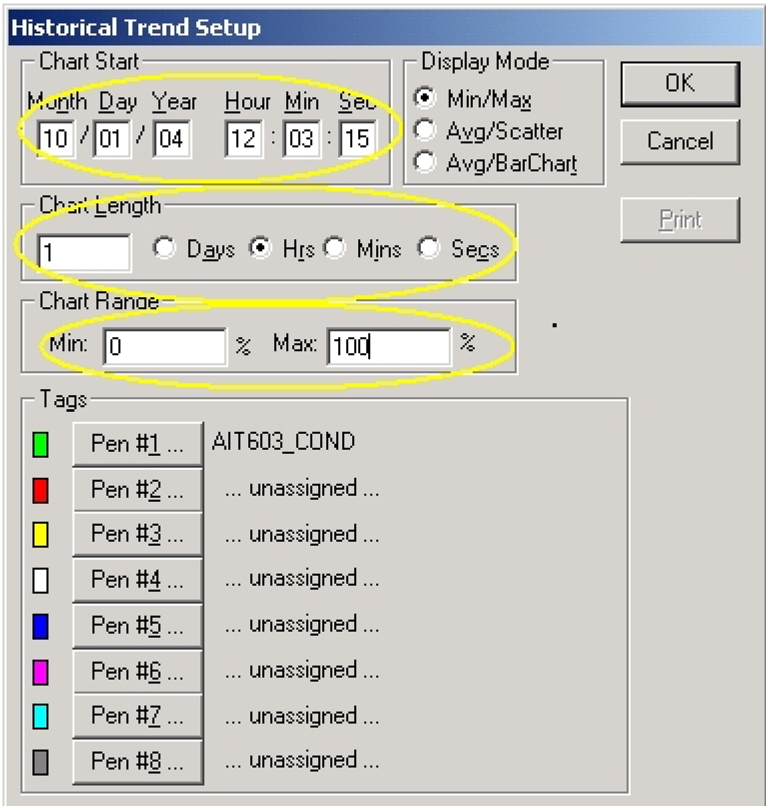
When you click in the trace area of the user configurable trend, a popup widow will appear that can be used to configure trend points for display.



An operator can assign a tag to a pen trace by clicking on any one of the trend "Pen #x" buttons as indicated above. Clicking on the button will cause a second popup window to appear that will allow the operator to select a tag for that button:

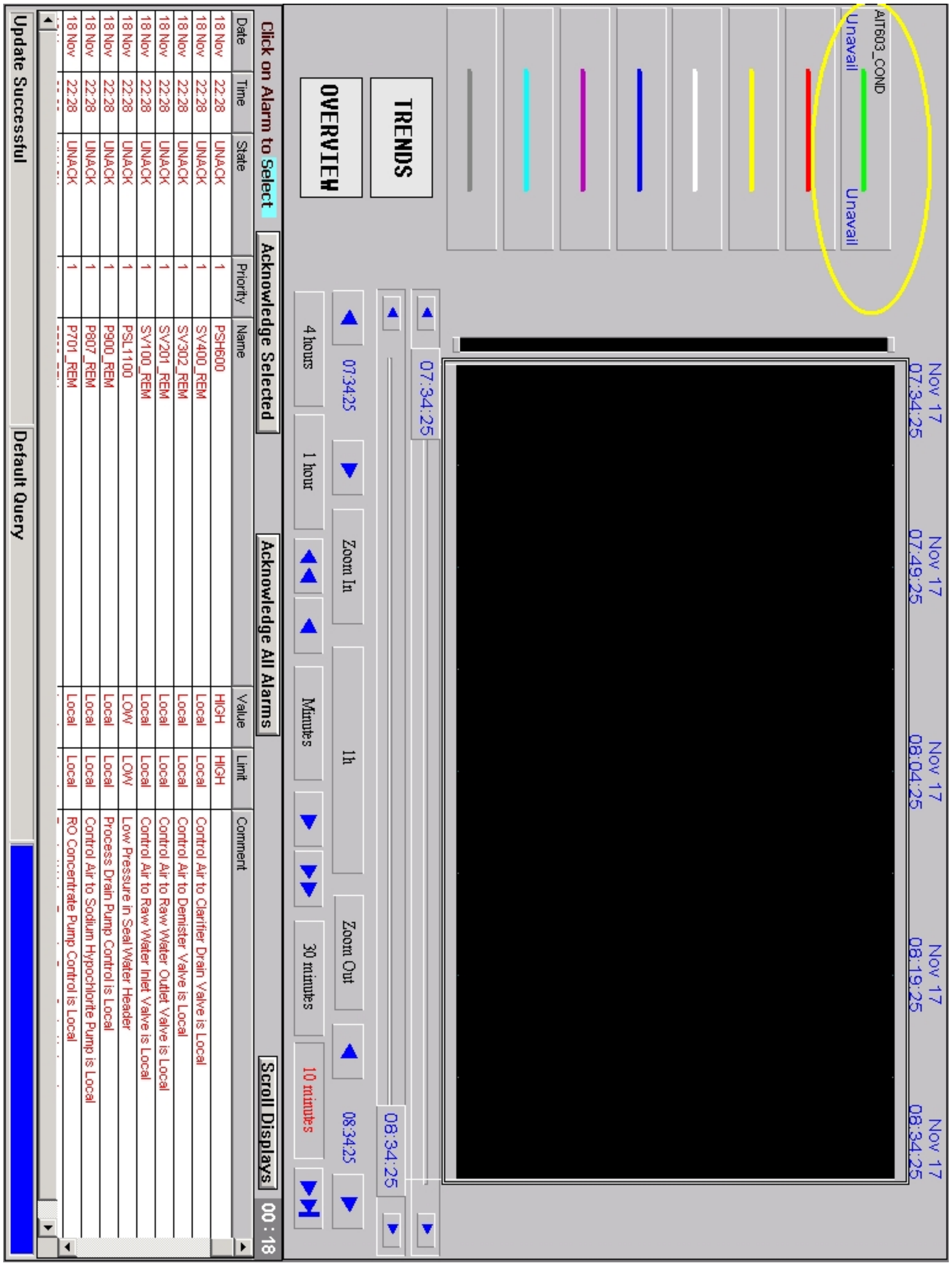


Use the side scroll bar to scroll through the list until the tag that is to be trended is found. Select the tag by clicking on the row for the tag in the list. The tag row will become highlighted in blue (as shown above). Once the tag has been selected, the operator must click on the "OK" button, which will close the tag selection window and return to the trend setup window.



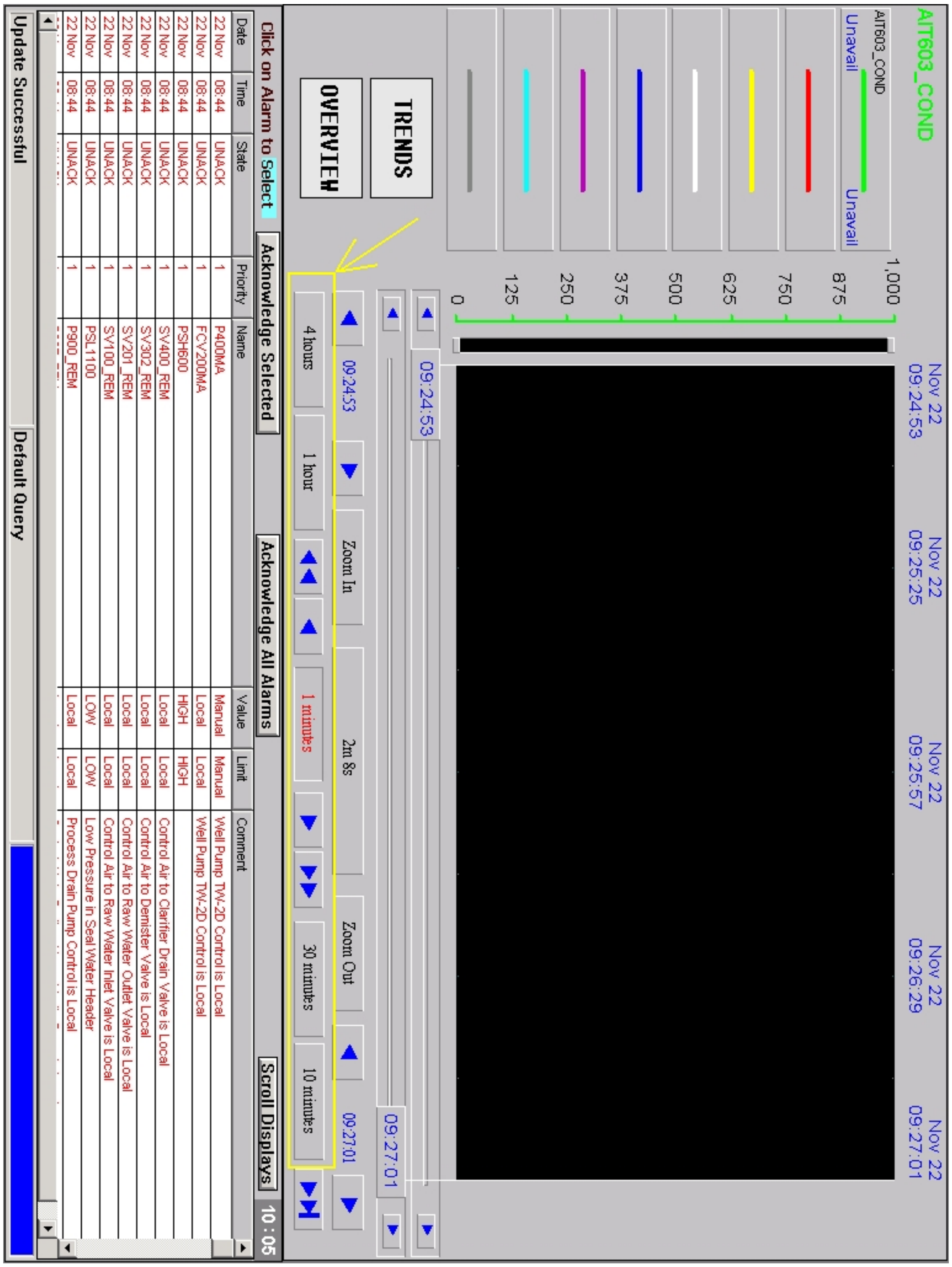
The tag that was selected is now shown next to the pen button. The operator may want to confirm the date, length and range of the chart data to be displayed. These values can be changed by simply clicking in the white entry fields and then by typing a new value for that field.

When all of the tags to be displayed have been selected, click the OK button in the upper right side of the Historical Trend Setup window. The selected trends are now displayed in the trend window. The points selected for the trend will remain until the operator makes changes.

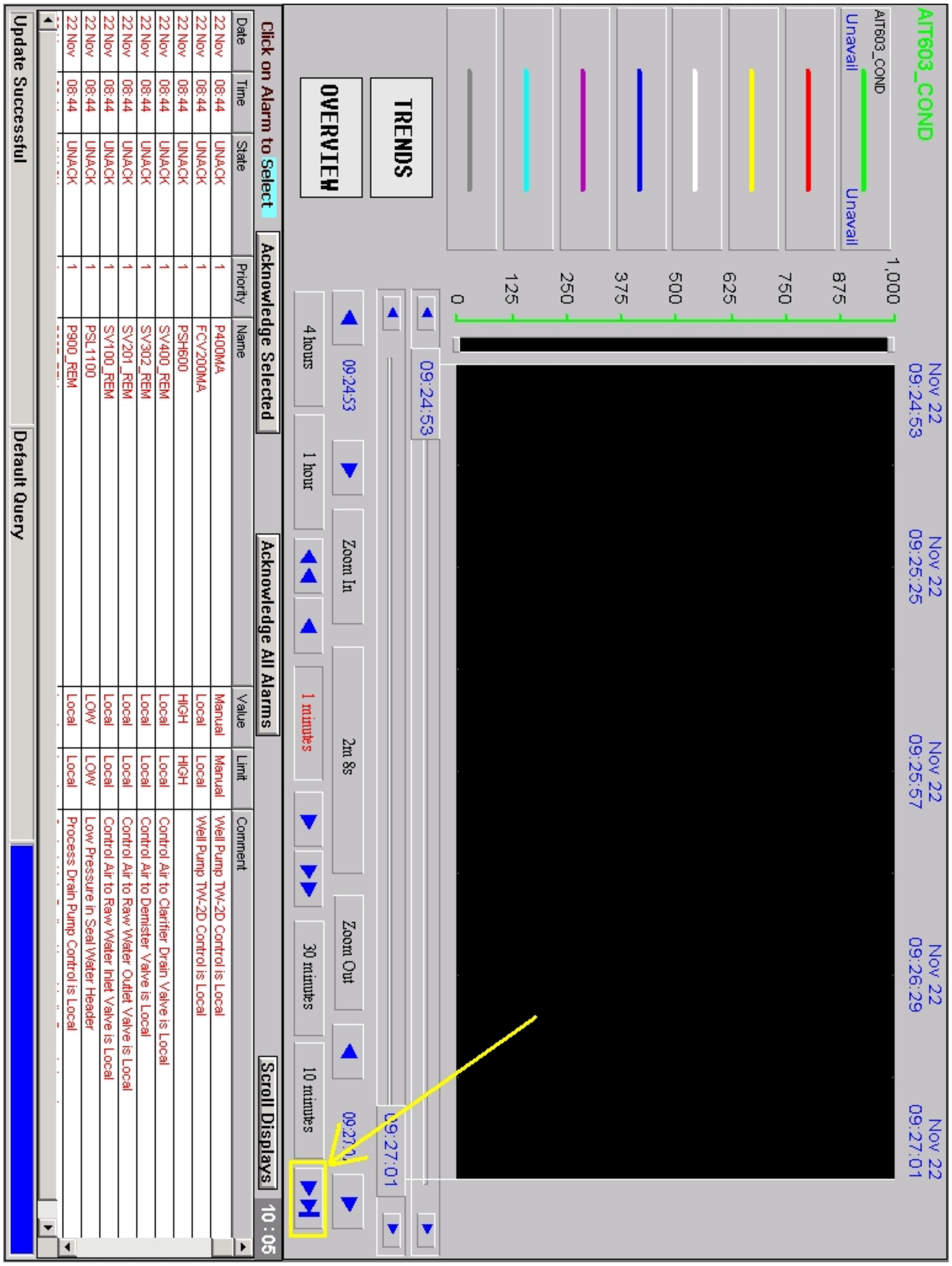


TREND NAVIGATION

The operator can use the buttons on the bottom to move backwards and forward in time. Clicking on the time buttons (4 hours; 1 hour; 30 minutes; 10 minutes) will set the time span increments. The time span increment setting dictates the amount of time that will be panned when the pan buttons (single arrows and



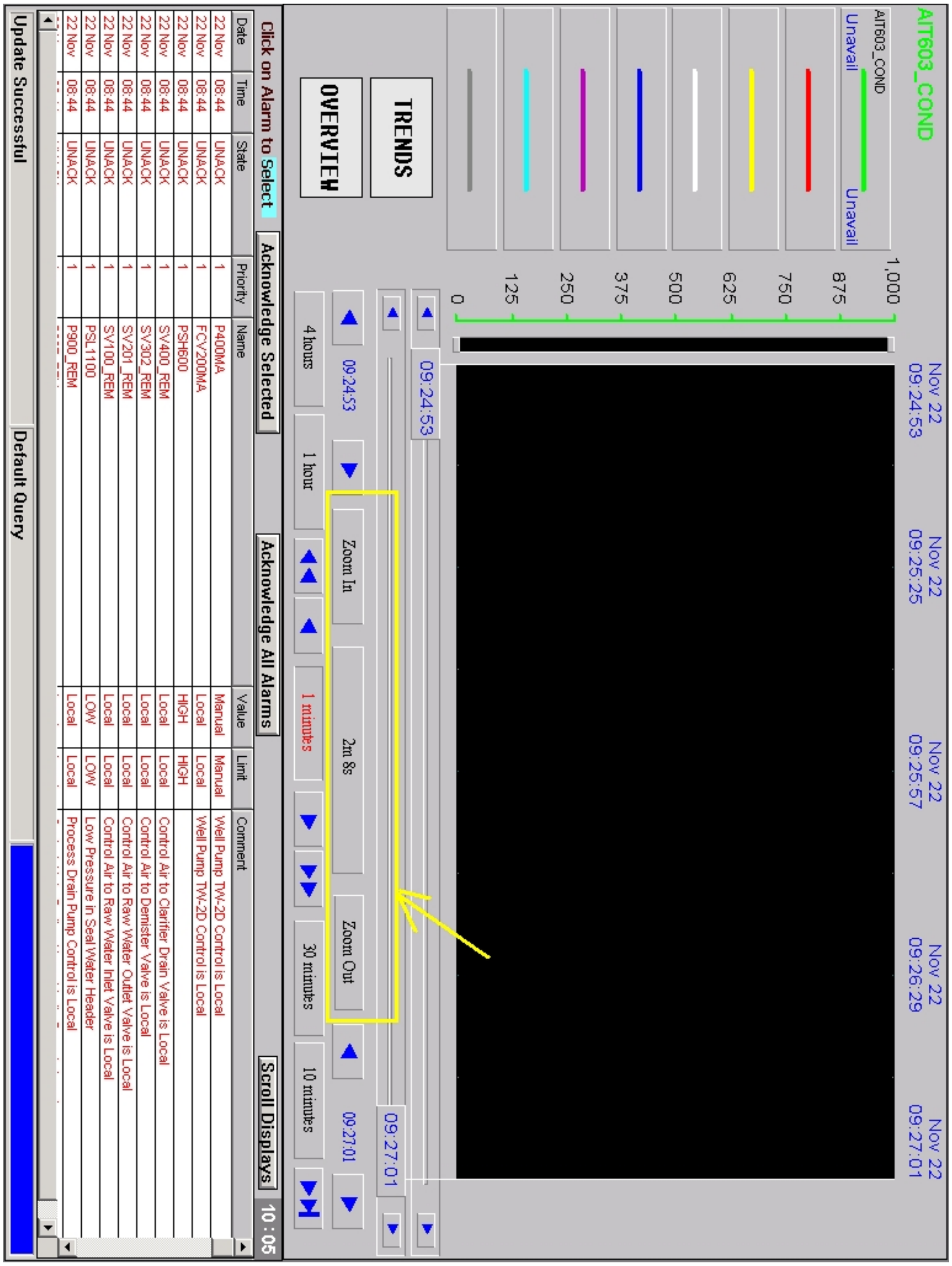
double arrows) are pressed. When the pan buttons are pressed, the historical data shown on the trend moves either backwards in time or forwards in time depending upon whether a backward arrow or forward arrow is pressed. Clicking on a single arrow moves the time slice by the amount indicated in the middle display box. Clicking a double arrow moves the time slice by two times the amount indicated in the middle display box. To display the most recent data, the operator can click on the double arrow bar button located on the far right of the



pan buttons.

The operator can further refine the trend display by zooming in and out.

To zoom the trend display, the “Zoom In” and “Zoom Out” buttons can be pressed. Every press of the “Zoom In” button halves the time slice. In other words, if the time slice was displaying a 1-hour trend, clicking the “Zoom In” button will cause the trend to display a 30-minute time slice. Every press of the “Zoom Out” button doubles the time slice. The time slice value is always indicated in the middle box.



To return to the Trend Master display, the operator can click on the “TRENDS” button. Clicking on the “OVERVIEW” button activates the process overview display graphic.

10. ALARMS, WARNINGS AND THE ALARM PRINTER

The alarm/warning banner is always active and shown, regardless of the process graphic or trend that has been called up. The alarm banner lists the active alarms in the order that they are received by the system. New alarms are always indicated in the top of the list. If any alarms are present and active in the alarm banner when new alarm is generated, the new alarm appears at the top of the list and the previously existing alarms are shifted down one row. New alarms will generate an alert tone to notify the operator that a new process alarm has occurred. The operator can acknowledge alarms either selectively or all at once. To selectively acknowledge alarms, the operator simply clicks on the alarm that is displayed in the alarm banner. Clicking on the alarm once will highlight the alarm in cyan, which indicates that the alarm has been selected for acknowledgement. The operator can then proceed to acknowledge additional alarms in the same manner. Clicking on a highlighted alarm will de-select that alarm and the cyan highlighting will disappear. Once the operator has selected the alarms to be acknowledged, the “Acknowledge Selected” button must be pressed. To acknowledge all alarms at once, simply click on the “Acknowledge All” button.

An Epson dot-matrix printer is connected to the primary WS, “TOPOCK-WS1”. The alarm printer continually prints out alarms and events (for example, changing a control setpoint) as these events occur in the plant. Both HMI workstations continually record electronically not only historical data (trends) but also both the alarms and log events. Historical data is available to the operator in the form of the trend displays. Electronic log data files and the alarm log files are not directly accessible to an operator. The operator’s access to recorded log events and alarms is through review of the alarm printer’s print out. The system administrator can access the electronic files directly. Please refer to the Epson O&M manual for specific details regarding the setup and maintenance of the printer.

11. SCADAlarm™

The SCADAlarm™ system is an alarm notification system designed to alert off-site personnel to alarm conditions when they occur in the plant. The system will use the modem in the workstation to dial either a phone or pager. While the system can be used to acknowledge alarms for the plant, the design philosophy of both the control system and the alarm auto-dialer is to alert off-site personnel to a plant alarm condition with the expectation that the off-site personnel will travel on-site to personally review and correct the conditions that generated the alarm(s). The SCADAlarm™ system operates in the background and cannot be accessed by the operator. When an operator acknowledges and/or corrects an alarm condition on the HMI, the SCADAlarm system is automatically updated. Please refer to the SCADAlarm™ O&M manual for specific details regarding the configuration and capabilities of the SCADAlarm system.

12. Service and Support

For service and support of the control system equipment and software please refer to the specific vendor as detailed below:

- WonderWare® on the web: http://www.wonderware.com/support/mmi/
    - Or call **1-800-WONDER1** (800-966-3371)
- Allen-Bradley on the web at http://support.rockwellautomation.com/
    - Or call local AB office at **(714) 761- 4600**
- DELL™ on the web at http://support.dell.com/
    - Or call **1-800-624-9896**

Appendix E
Standard Operating Procedures

APPENDIX F

List of Equipment O&M Manuals

Equipment O&M Manuals include:

1. Reverse Osmosis System, Ecolochem
2. Microfiltration System, Pall Corporation
3. Centrifugal Pumps, Fybroc Corporation
4. Chemical Metering Pumps, LMI Corporation
5. Air Operated Diaphragm Pumps, Ingersoll Rand
6. Mixers, Lightnin Corporation
7. Air Compressor, Gardner Denver Corp.
8. Air Blower, Gardner Denver Corp.
9. Well Pumps, Grundfos Corporation
10. Dry Polymer Feed System, Nalco Corp.
11. Clarifier, Parkson Corp.
12. Seal Water System, Aquaboost
13. Sump Pump, Fybroc
14. FRP Tanks, Palmer
15. Demister System, Mapco
16. Instrumentation and Controls, Various

These manuals are provided under separate cover.

Standard Operating Procedure
PG&E Topock Groundwater Extraction and Treatment System

Title: System Startup
Number: IM3-SOP-1
Revision Date: 11/15/2004

Scope

The objective of this SOP is to describe the procedure for starting up the groundwater extraction and treatment system.

Precautions/Hazards

Operators should have system training and operating experience before attempting a system startup. Operators will not attempt to start up the system without making the field checks specified in the procedure.

Equipment List

Not applicable.

Procedure

The plant startup sequence will be as follows:

1. The system will be started up in recycle mode to prevent hexavalent chromium from getting to the reverse osmosis system. Manually close valve V-TW-103-03 and V-TW-101-01, and manually open valve V-TW-104-01 to recycle water from the Reverse Osmosis Feed Tank (T-600) to the Raw Water Storage Tank (T-100).
2. Confirm treatment chemical totes are hooked up and have sufficient chemical for startup. Prepare a batch of polymer in the Polyelectrolyte Make-down System.
3. Confirm that the seal water system valves and demister wash water valves are open and that the Seal Water Tank (T-1100) and Treated Water Storage Tank (T-700) have sufficient volume for startup.
4. Energize the air compressor.
5. Review the Microfilter System startup instructions provided by the manufacturer and confirm that the Microfilter System is configured for startup.
6. Review the Reverse Osmosis System startup instructions provided by the manufacturer and confirm that the Reverse Osmosis System is configured for startup.
7. Energize the seal water pump and observe that seal water is reaching Pumps P-200, P-201, P-400, P-500, P-620, and P-701.
8. Energize the LE/LIT 200 Control Loop and the well pumps (P-100 and P-101) in the remote mode.

9. Confirm that the Raw Water Storage Tank level is sufficient for startup (minimum 5 feet).
10. Once the Raw Water Storage Tank level is over 5 feet, confirm startup flow set point and energize the Raw Water Feed Pump in the remote mode.
11. Energize the LE/LIT 300C Control Loop and the Clarifier Feed Pump in the remote mode.
12. Energize the LE/LIT 500 Control Loop and the Pretreated Water Transfer Pump in the remote mode.
13. Enable the Microfilter System.
14. Energize the LE/LIT 600 Control Loop and the Filtered Water Transfer Pump in the remote mode.
15. Energize the Chemical Mixing Pump in the remote mode.
16. Confirm water levels in the Chemical Reduction Reactor, three Iron Oxidation Reactors, and Clarifier are at operating values (sufficient for mixer operation).
17. Energize mixers in the Chemical Reduction Reactor and three Iron Oxidation Reactors in the remote mode.
18. Energize the Chemical Mix Tank mixer, Floc Tank mixer, and clarifier thickener in the remote mode.
19. Energize the Air Blower (B-300) and confirm air flow rates at FIT-300A, FIT-300B, and FIT-300C.
20. Energize pH control loops in Pipe Reactor, Chromium Reduction Reactor, and Iron Oxidation Reactors and review pH probe pair readouts for consistency (AE-202, AE-300, AE-301A-C)
21. Energize Chemical Feed Pumps P-800 (ferrous chloride), P-801 (sulfuric acid), P-802A-D (sodium hydroxide).
22. Energize the polymer feed pump.
23. Check the clarifier sludge level via the thickener section sample taps. If the sludge blanket level is above the third tap from the top, energize the Sludge Withdrawal Pump. Otherwise, monitor the sludge blanket level once per shift and energize the Sludge Withdrawal Pump when the level reaches the third tap from the top.
24. Check the clarifier overflow for visual clarity (no solids carryover).
25. Confirm pH values for AIT-200, AIT-300A, AIT-300B, AIT-300C.
26. Operate the system in recycle configuration for 2.5 hours (three Tank T-600 residence times) or until 3 samples from the sample tap on the Pump P-620 recycle line taken at 30 minute intervals indicate a hexavalent chromium value of less than 25 parts per billion, a ferrous iron concentration less than __ parts per billion, and a turbidity less than __ NTU.

27. Confirm Reverse Osmosis System valve settings
28. Energize F.D. Aerator Blower
29. Manually open valve V-TW-101-01
30. Energize Reverse Osmosis System Instrumentation
31. Energize Reverse Osmosis Booster Pump
32. Energize Reverse Osmosis Feed Pump
33. Energize LE/LIT 604 control loop and Post-Treated Reverse Osmosis Permeate Pumps
34. Energize the Reverse Osmosis Sulfuric Acid Feed Pump
35. Energize the Antiscalant Feed Pump
36. Energize LE/LIT 701 control loop and Reverse Osmosis Concentrate Transfer Pump
37. De-energize Filtered Water Transfer Pump and manually close valve V-TW-104-01
38. Energize LE/LIT 700 control loop and the Treated Water Transfer Pump
39. Confirm pH value for AIT-606
40. Confirm conductivity value for AIT-605
41. Record system instrumentation readings on local reverse osmosis panel.

Standard Operating Procedure
PG&E Topock Groundwater Extraction and Treatment System

Title: System Shutdown
Number: IM3-SOP-2
Revision Date: 11/15/2004

Scope

The objective of this SOP is to shutdown the plant safely and effectively.

Precautions/Hazards

None identified.

Equipment List

Not applicable.

Procedures

The normal plant shutdown procedure will be as follows:

1. De-energize Extraction Well Pumps
2. De-energize Treated Water Transfer Pump
3. Manually open valve V-TW-104-01 and energize Filtered Water Transfer Pump
4. De-energize Reverse Osmosis System Sulfuric Acid Pump
5. De-energize Reverse Osmosis System Antiscalant Pump
6. De-energize Reverse Osmosis Feed Pump
7. De-energize Reverse Osmosis Booster Pump
8. Manually close valve V-TW-101-01
9. De-energize chemical feed pumps
10. De-energize Chemical Mixing Pump
11. De-energize Raw Water Feed Pump
12. De-energize Filtered Water Transfer Pump
13. Disenable level control loops
14. Disenable pH control loops
15. De-energize mixers

Standard Operating Procedure
PG&E Topock Groundwater Extraction and Treatment System

Title: Setting Sludge Wasting and Recycling Rates
Number: IM3-SOP-3
Revision Date: 11/15/2004

Scope

This SOP describes the procedure used to set the sludge wasting and recycling rates.

Precautions/Hazards

Observe the following precautions in performing this procedure:

- Review the sludge properties and hazards
- Take appropriate fall-protection precautions
- Review operations health and safety plan for personal protective equipment

Equipment

The procedure involves the following equipment:

- Sludge wasting pump
- Sludge recycle pump
- Clarifier thickening section decant valves
- Sample tap on the clarifier sludge withdrawal line

Operators should be trained on this equipment before attempting this procedure

Procedure

1. Set the sludge recycle pump to run continuously by setting the frequency of operation timer to one minute and the run time timer to one minute. The Sludge Recycle Pump flow rate and corresponding pump air pressure setting will be established at startup. Confirm that the sludge recycle pump inlet air pressure is correctly set.

2. Determine the sludge blanket height. To determine the sludge blanket height, open the sample taps in order starting from the top and observe whether the liquid is clear (sludge level is below the sample tap) or opaque (sludge level is above the sample tap).

3. Maintain the sludge blanket in the clarifier between the second and third sample taps from the top of the clarifier thickener section by adjusting the timer settings on the sludge withdrawal pumps. The Sludge Withdrawal Pump flow rate and corresponding air pressure setting will be established during startup. Confirm that the sludge withdrawal pump inlet air pressure is correctly set.

4. Adjust the timer settings by changing either the frequency of operation timer or the run time timer. Always start by adjusting the run time timer. Change the run time timer value (increase or decrease) by no more than 20 percent and observe the sludge level over several hours to observe the effect.

Standard Operating Procedure
PG&E Topock Groundwater Extraction and Treatment System

Title: Operation of the Sludge Holding Tank and Phase Separators
Number: IM3-SOP-4
Revision Date: 11/15/2004

Scope

This SOP describes the procedure for decanting the sludge holding tank, preparing the phase separator to receive solids from the sludge storage tank, and switching operation from one separator to another, and preparing a full separator for offsite transport.

Precautions/Hazards

To be determined

Observe the following precautions in performing this procedure:

- Review the sludge properties and hazards.
- Take appropriate fall-protection precautions.
- Review operations health and safety plan for personal protective equipment.

Equipment

- Sludge holding tank
- Phase separators

Sludge Holding Tank Decant Procedure

Open the sample taps on the sludge storage tank in order starting at the top-most sample tap and observe the appearance of the decanted liquid. Clear/transparent liquid indicates that the sludge level is below the sample tap. Cloudy/opaque liquid indicates that the sludge level is above the sample tap. Decant to drain using the second sample tap above the sludge level.

Phase Separator Hookup Procedure

1. Open the phase separator following safety procedures and confirm that the filter cloth is installed.
2. Hook up the flexible filtrate drain hose to the filtrate drain port.
3. Hang the portable high level switch on the inside of the phase separator.
4. When the current phase separator is full, move the flexible inlet hose to the empty phase separator.

Preparation of a Phase Separator for Off-site Disposal

1. Move flexible inlet hose to the other phase separator.
2. Remove the portable high level switch.

3. Disconnect the filtrate line and cap the connection.
4. Close the phase separator cover.
5. Confirm that the separator is properly labeled per the Waste Management Plan.
6. Prepare, sign, and have the transporter sign the waste manifest per the instructions in the Waste Management Plan. Prepare Land Ban forms if required by the Waste Management Plan.

Standard Operating Procedure
PG&E Topock Groundwater Extraction and Treatment System

Title: Calibration of Chemical Metering Pumps
Number: IM3-SOP-5
Revision Date: 1/6/2005

Scope

The objective of this SOP is to describe procedures for calibrating chemical metering pumps and determining chemical dosage rates.

Precautions/Hazards

None identified.

Equipment List

Calibration cylinder or container with volumetric notations, stopwatch or wristwatch with a second hand.

Procedures

The chemical metering pump calibration procedure shall be as follows:

1. Confirm that all materials are compatible for contact with subject chemical.
2. Verify that chemical feed to treatment process may be interrupted for the duration of calibration activities.
3. Proceed with calibration activities according to attached Calibration SOP from LMI Milton Roy Instruction Manual.

8.0 Calibration

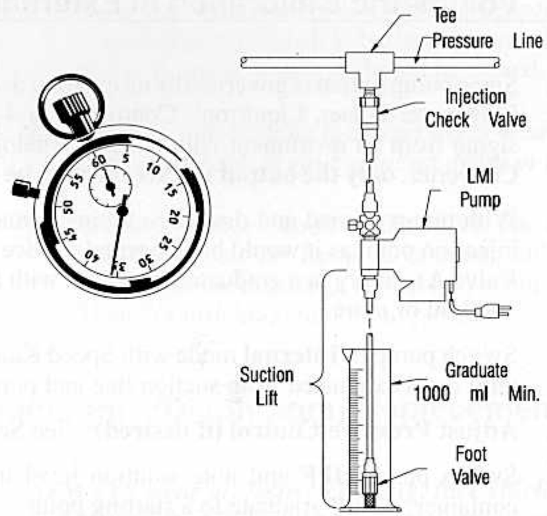
Once installation is complete and the approximate output has been determined, the pump should be calibrated to adjust speed and stroke for your actual desired output. (Calibration cylinders may be purchased from your local LMI distributor, ref. publication 1798.)

1. Be sure the pump is primed, and discharge tubing and Injection Check Valve are installed as they would be in normal service (i.e., including factors such as injection pressure, fluid viscosity, and suction lift).
2. Place the Foot Valve in a graduated container with a volume of 1000 ml or more.
3. Plug in and switch pump to Internal Mode. Pump until all the air is exhausted from the suction line and head.
4. Turn the pump off. Refill graduated container to a level starting point.

Note

If pump is equipped with pressure control, see Section 8.1 before proceeding.

5. Using a stopwatch or timer, turn the pump on for a measured amount of time (50 pump strokes minimum). The longer the time period, the more confident you can be of the results. Be sure to count the number of strokes during the calibration period when making comparisons.
6. Turn the pump off. Note the time elapsed in relation to volume displaced in the graduate. Now, calculate the output in the time unit you choose (minutes, hours, days, etc.).
7. If the output is too low or too great, adjust speed and or stroke, estimating required correction and repeat steps 1-7.

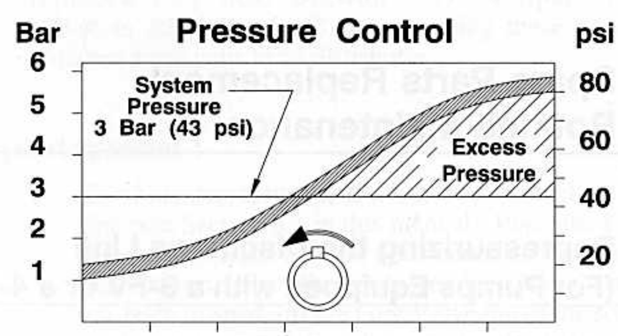


8.1 Pressure Control

Adjust Pressure Control: While unit is running, turn Pressure Control Potentiometer slowly counter-clockwise until unit just begins to stall. From this stall point, now turn Pressure Control Potentiometer clockwise halfway between the stall point and maximum setting. This is the optimum pressure control setting for your application.

Note

Increase setting if back pressure is increased. Adjusting pressure control decreases pressure rating of pump.



Adjust pressure control to reduce heat, shock, and pulsations; and to prolong pump life.

8.2 Calibration Procedure - On-Site Volumetric Calibration in External Mode

1. Since pump output is governed by an external device such as Flowmeter-Pulser, Liquitron™ Controller, or 4-20 mA DC signal from an instrument with an LMI Analog-to-Digital Converter, **only the output per stroke may be calibrated**.
2. With pump primed and discharge tubing connected to the injection point as it would be in normal service, place Foot Valve Assembly in a graduated container with a volume of 1000 ml or more.
3. Switch pump to **Internal** mode with Speed Knob set at 100 until air is exhausted from suction line and pump head.
4. **Adjust Pressure Control (if desired)** - See Section 8.1.
5. Switch pump **OFF** and note solution level in graduated container. Refill graduate to a starting point.
6. Switch pump **ON** and **count the number of strokes** for exactly one minute, then switch pump **OFF**.
7. Note volume pumped during the calibration period of one minute. Divide into this the number of strokes to determine the volume of solution pumped per stroke.

   Example: 500 ml in 100 strokes = 5.0 ml per stroke.

Multiply this by your expected stroke rate per minute, per hour or per day and compare with desired output requirements.

8. Adjust Stroke Length Knob (lower knob) to your best estimate of required correction and repeat calibration procedure.

9.0 Spare Parts Replacement Routine Maintenance

9.1 Depressurizing the Discharge Line (For Pumps Equipped with a 3-FV or a 4-FV only)

CAUTION

ALWAYS wear protective clothing, face shield, safety glasses and gloves when performing any maintenance or replacement on your pump.

CAUTION

Read steps 1 and 2 below before proceeding.

1. Be sure the Injection Check Valve is properly installed and is operating. If a shut off valve has been installed downstream of the Injection Valve, it should be closed.

CAUTION

Be sure your relief tubing is connected to your multi-function valve and runs back to your solution drum or tank.

2. 1/4 turn the black knob on the valve. The discharge line is now depressurized. Keep valve open until solution drains back down the discharge tubing into solution drum or tank. Then 1/4 turn knob to normal position.

9.2 Liquifram™ (Diaphragm) Replacement

CAUTION

ALWAYS wear protective clothing, face shield, safety glasses and gloves when working near or performing any maintenance or replacement on your pump. See MSDS information from solution supplier for additional precautions.

LMI metering pumps are designed for trouble-free operation, yet routine maintenance of elastomeric parts is essential for optimum performance. This involves replacing the Liquifram™, cartridge valves or seal rings/valve balls, multi-function valve cap assemblies and the injection check valve spring. LMI recommends replacing these parts at least once a year; however, frequency will depend on your particular application.

When replacing the Liquifram™ and the cartridge valves or seal rings/valve balls, the injection check valve spring should also be replaced (see next Section 9.3). A Spare Parts Kit (SP-#) or RPM Pro Pac™ kit containing these parts may be obtained from your local distributor.

Replacing the Liquifram™:

1. Carefully depressurize, drain, and disconnect the discharge line (see Section 8.1 in this manual). Place the Foot Valve into a container of water or other neutralizing solution. Turn the pump on to flush the head assembly. Once the pump head has been flushed, lift the Foot Valve out of the solution and continue to pump air into the pump head until the pump head is purged of water or neutralizing solution.

Standard Operating Procedure for Hexavalent Chromium Analysis by Hach Method 8023

This Standard Operating Procedure (SOP) for hexavalent chromium analysis was developed as a supplement for the HACH 8023 method and is NOT a stand alone SOP. The intent of this SOP is to provide the analyst additional guidance and clarification for various steps in the HACH method. The HACH method is an attachment to this document. The SOP will address the following:

- Equipment and supplies
- Step by step procedure for preparation and analysis of standards and samples
- Potential interferences – tests and mitigating activities
- Example Analytical Sequence of events
- Documentation Requirements
- Waste Disposal – not included in this document. Field conditions should dictate adherence with minimal requirements and should be addressed before testing begins.
- Verification of HACH results

Equipment and Supplies

See Hach manual for suggested equipment and supplies. Analyst will need HACH 8023 method, which provides a list of equipment and supplies, and DR/4000 manuel for equipment operation.

Step by Step Procedures

Sample preparation

1. Scrupulously clean all reusable glassware/equipment prior to starting the analysis by performing the following:
    - Soak the glassware in a tub with a phosphate free detergent such as Alconox ® and remove any debris from the glassware using a brush.
    - Rinse the glassware with tap water that has been verified not to contain hexavalent chromium.
    - Rinse the glassware with a dilute nitric acid solution
    - Rinse with deionized water provided by the laboratory
    - Air dry in an area free of contamination if possible.
2. The following types of quality control samples will be prepared along with the field samples:

    Reagent blank: The reagent blank will be the first sample prepared and analyzed. The purpose of this blank is to ensure that the reagents are not contributing to any hexavalent chromium detected. The reagent blank should be prepared daily.

Water blank(s): Water used for glassware cleaning, sample dilution or other analytical activities that must be verified not to contribute to hexavalent chromium concentrations. Water blanks should be prepared each time a new source or lot of water is introduced. For example, if store bought purified water is used for decontamination, each new bottle must be tested.

Reagent spike (CCV): The reagent spike verifies that the overall analytical process is under control. Reagent spikes should be prepared daily for each person performing the analysis.

Sample matrix spike (MS): The sample matrix spike is used to verify that the analytical process is not adversely impacted by potential matrix effects. The sample matrix spike should be prepared for each sample analyzed unless otherwise instructed.

3. Prepare an aliquot of the sample for analysis as follows. QC samples will be prepared in deionized water (DI). It is important to note that the DI should not be taken directly from the carboy or container used to store the DI. The DI should be transferred to a beaker or flask and then the aliquot removed to avoid contaminating the DI source. Field sample aliquots will be obtained by homogenizing the sample removed from the tank. A minimum of 50 mls of DI/sample is required for the QC and field samples.

4. Filter the entire sample through a 0.45 micron filter to remove any particulates. Collect the filtrate in a filtering flask. The flask must be labeled with the contents. For example, " Reagent Spike" or "Sample ABC."

5. Transfer a 10 ml aliquot from the filtered sample into the sample cell using a calibrated pipette. The first sample prepared and analyzed will be the reagent blank (filtered DI water).

6. Add a reagent "powder pillow" (see HACH method description) to the cell and swirl to mix. (note: if hexavalent chromium is present in the sample, at higher concentrations, the color of the solution will turn purple within 8 minutes.)

7. Begin analysis by pressing the "start timer" on the DR/4000. A timer will monitor the required 8 minute reaction.

8. Start preparing the next QC or field sample while the DR/4000 is reading the current sample.

9. It will be likely that analysis of the pretreatment samples will require sample dilution to be performed to obtain accurate readings by this method. Samples that are above the calibration range (0.6 mg/L) will require a dilution. The sample should be diluted to achieve an instrument reading close to the mid-point of the calibration (0.25 – 0.30 mg/L) For example, transfer ~50 mls of DI to a 100ml graduated cylinder, add a 5 ml aliquot of the filtered sample, and then bring the final volume to 100 mls with DI. This is a 1:20 dilution. Additional dilutions may be required to achieve an instrument reading near the mid-point of the calibratio curve.

Preparing Spike Solution for Reagent Spikes and Sample Matrix Spikes

For each sample and the reagent spike, follow steps 3 through 5 outlined above in the "sample preparation" section. Prior to adding the reagent powder pillow in step 6, the sample cell must be spiked with hexavalent chromium. The spike for hexavalent chromium will be prepared as follows:

- Take ~50 mls of DI and place into a 100ml volumetric flask, then add 5 mls of a 50 mg/L hexavalent chromium standard using a pipette. Bring the volume of the flask to 100 mls with DI, cap, and mix thoroughly. The resultant concentration of the standard is 2.5 mg/L. This standard solution can also be used to prepare a matrix spike and a calibration verification standard as outlined below.
- Take 9 mls of DI (reagent spike-CCV) or sample (sample matrix spike-MS) and place into the sample cell. Add 1 ml of the 2.5 mg/L hexavalent chromium standard. Mix by adding the cap and inverting the sample cell. The concentration of hexavalent chromium in the cell is 0.25 mg/L.

Sample Analysis

1. Turn the DR/4000 spectrophotometer on.
2. Select "HACH program" and then enter "1560" on the numeric keypad.
3. After the 8 minute reaction is complete as indicated by a "beep" from the DR/4000, place the cell with the sample in the cell holder.
4. The reagent blank will be analyzed first to zero the instrument. After placing the reagent blank in the sample cell, select "options", "more", "Blank off", and enter the reading obtained from the DR/4000 display and then press "enter". Save the reagent blank for analysis after calibration of the instrument.
5. After instrument calibration, follow step 3 above for all QC and field sample analyses. Results should be documented according to the documentation section below. The units for all measurements are in mg/L.

Instrument Calibration

1. Create a three level calibration according to the directions provided by HACH, and included below:

- Remove 10 mls of a 50 mg/L hexavalent chromium standard using a pipette and place into a 100ml Class A volumetric flask. Cap and mix thoroughly. The resultant concentration of the standard is 5 mg/L.
- Using three different Class A volumetric flasks, pipette 1, 6, and 12 mls of the standard made above. Using DI water, dilute to the 100 ml mark on the volumetric flask. Cap, and mix thoroughly. The resultant calibration curve is 0.05 mg/L, 0.3 mg/L and 0.6 mg/L respectively.
- See the DR/4000 manual page 41 – 45 for procedure to program the ICAL (User-entered Calibration)

2. The calibration curve should have a correlation factor of 0.99 to be used for analysis. After the last standard is analyzed the DR/4000 will display a graphical representation of the curve and the r^2 (correlation factor). The analyst should record the r^2 value. If the r^2 is not 0.99 or greater, re-prep the the standards and re-analyze.

Verification of Calibration

The calibration should be periodically evaluated using the mid level standard (0.25 mg/L)as prepared for the initial calibration as described above. Frequency of calibration verification-CCV analyses should be after every 10 analyses and at the end of the analytical sequence. An example analytical sequence is included below. CCV results should be between 0.2 and 0.3 mg/L. If CCV analyses fails (is not between 0.2 and 0.3 mg/L), prepare a new 0.25 mg/L standard and re-analyze. If CCV still fails, contact the project chemists for further instructions. (Mr. Shawn Duffy 530-229-3303)

Interferences

The most likely interference which shall be encountered will be from the ferrous iron utilized in the cleanup process. High levels of ferrous iron or total iron will result in a negative bias to the data. This is the reason for the performance of sample matrix spikes. In the presence of elevated levels of ferrous iron, hexavalent chromium will not be detected and false negatives could occur.

Example Analytical Sequence

- Reagent Blank used to zero instrument- each new lot of reagent
- Initial Calibration- required at startup and when directed by the project chemists
- Water Blank (to verify source water is free of hexavalent chromium) every new bottle.

Analyzed every day

- Sample Blank
- Calibration verification analysis (CCV) recovered within acceptance limits
- Sample
- Sample matrix spike (as described above)
- Repeat new sample and matrix spike for 5 samples maximum (10 total analyses)
- Calibration verification analysis (CCV) recovered within acceptance limits

CCV results should be between 0.2 and 0.3 mg/L. If CCV analyses fails (is not between 0.2 and 0.3 mg/L), prepare a new 0.25 mg/L standard and re-analyze. If CCV still fails contact the project chemists for further instructions. Do not continue with sample analyses.

Documentation Requirements

A bound, waterproof logbook must be used and all entries recorded in indelible ink. The following information should be recorded to document the analytical effort:

1. Date of sampling

2. Time of sampling
3. Temperature of sample
4. Specify if the sample is "pre"(before cleanup) or "post" Treatment (after cleanup)
5. Room Temperature)
6. Date of analysis
7. Approximate time of analysis
8. Analyst Name
9. Test Analyte Cr^{6+}
10. Sample Name (for example, calibration verification standard or the sample name in the following format:
    Sample Type (either pre, post, or QC sample name), Date, and percentage of tank volume filled or location) For example, "Pre071404-25" refers that the sample was prior to completing the treatment reaction on July 14, 2004 and the reaction tank was 25% full.
11. Volume of sample analyzed
12. Volume of dilution H2O
13. Instrument Reading for sample
14. Corrected Reading
15. Final result corrected for dilution

Verification of HACH Results

Once the analytical procedures verify that the hexavalent chromium is present at levels acceptable for disposal, a sample needs to be submitted in accordance with the PG&E Topock Quality Assurance Program Plan to a fixed based laboratory to verify that the HACH results are accurate. HACH results should be used to determine when the processing is complete and the laboratory data provided to the waste hauler as verification that the water meets disposal criteria.

CHROMIUM, Hexavalent

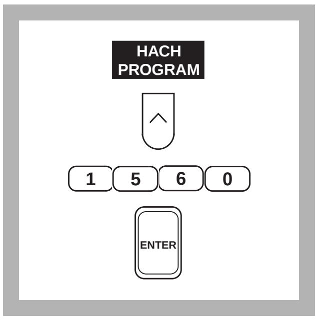
✔ Method 8023 **1,5-Diphenylcarbohydrazide Method***

Powder Pillows or AccuVac® Ampuls **(0 to 0.700 mg/L Cr^{6+})**

Scope and Application: *For water and wastewater;USEPA accepted for reporting for wastewater analyses**. The estimated detection limits for program numbers 1560 and 1570 are 0.006 and 0.005 mg/L Cr^{6+}, respectively.*

* Adapted from Standard Methods for the Examination of Water and Wastewater.
** Procedure is equivalent to USGS method I-1230-85 for wastewater.

Using Powder Pillows



1. Press the soft key under ***HACH PROGRAM***.

Select the stored program for hexavalent chromium (Cr^{6+}) by pressing **1560** with the numeric keys.

Press: **ENTER**

Note: *If samples cannot be analyzed immediately, see Sample Collection, Preservation, and Storage following these steps.*

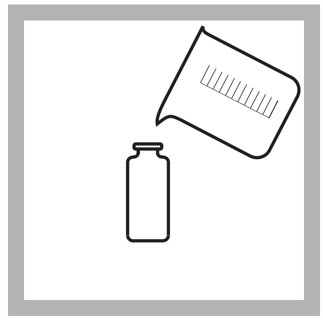
Note: *The Flow Cell and Sipper Modules can be used for this procedure. Use a 25-mL sample volume and reagents for the Flow Cell Module.*

2. The display will show:

HACH PROGRAM: 1560
Chromium, Hex.

The wavelength (λ), **540 nm**, is automatically selected.

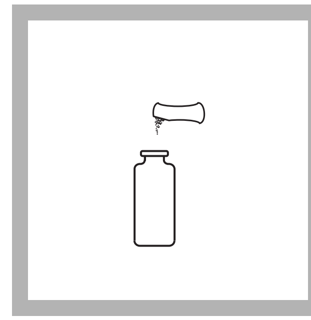
Note: *For best results, determine a reagent blank for each new lot of reagent as follows. Prepare a reagent blank by repeating Steps 3 through 9, using chromium-free deionized water as the sample. Zero the instrument on deionized water by pressing the soft key under **ZERO**. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under **OPTIONS, (MORE)**, and then **BLANK:OFF**. Enter the reagent blank value and press **ENTER**. Repeat for each new lot of reagent.*



3. Fill a sample cell with 10 mL of sample.

Note: *For proof of accuracy, use a 0.25 mg/L hexavalent chromium standard solution (preparation given in the Accuracy Check section) in place of the sample.*

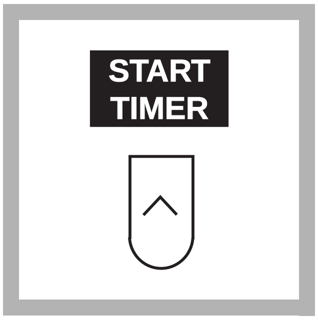
Note: *For samples with extreme pH, see the Interferences section.*



4. Add the contents of one ChromaVer 3 Reagent Powder Pillow to the sample cell (the prepared sample). Swirl to mix.

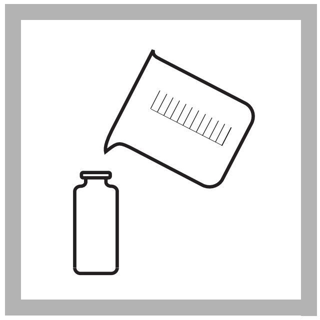
Note: *A purple color will form if hexavalent chromium is present.*

Note: *At high chromium levels a precipitate will form. Dilute sample according to Section* 1.2.6 Sample Dilution Techniques.



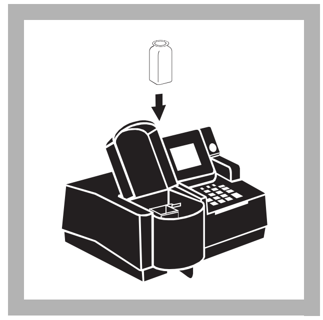
5. Press the soft key under ***START TIMER***.

An 8-minute reaction period will begin.

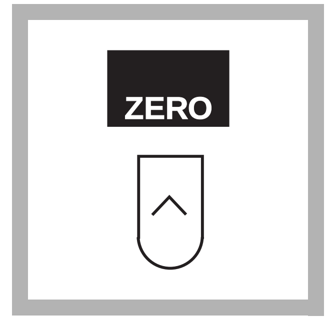


6. Fill another sample cell with 10 mL of sample (the blank).

Note: *For turbid samples, treat the blank with the contents of one Acid Reagent Powder Pillow. This will ensure any turbidity dissolved by the acid in the ChromaVer 3 Chromium Reagent also will be dissolved in the blank.*



7. When the timer beeps, place the blank into the cell holder. Close the light shield.



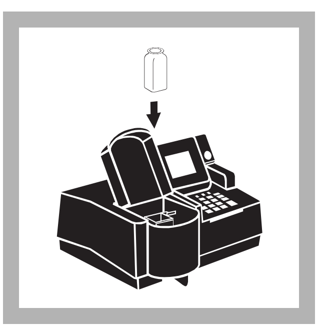
8. Press the soft key under ***ZERO***.

The display will show:

0.000 mg/L Cr^{6+}

Note: *If you are using a reagent blank correction, the display will show the correction.*

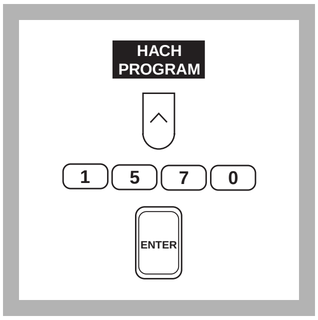
Note: *For alternate concentration units, press the soft key under* ***OPTIONS****. Then press the soft key under* **UNITS** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*



9. Place the prepared sample into the cell holder. Close the light shield. Results in mg/L hexavalent chromium (Cr^{6+}) will be displayed.

Note: *Results may be expressed as chromate (CrO_4^{2-}) or as sodium chromate (Na_2CrO_4), or dichromate ($Cr_2O_7^{2-}$). Press the soft keys under* ***OPTIONS*** *and then* **FORM:** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*

Using AccuVac Ampuls



1. Press the soft key under ***HACH PROGRAM***.

Select the stored program for hexavalent chromium (Cr^{6+}) by pressing **1570** with the numeric keys.

Press: **ENTER**

Note: *If samples cannot be analyzed immediately, see Sample Collection, Preservation, and Storage following these steps.*

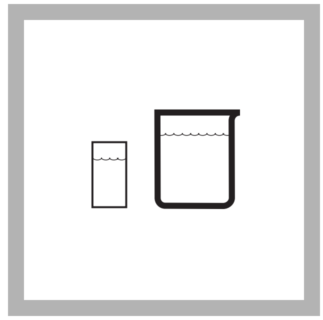
2. The display will show:

HACH PROGRAM: 1570
Chromium, Hex. AV

The wavelength (λ), **540 nm**, is automatically selected.

Note: *For best results, determine a reagent blank for each new lot of reagent as follows. Prepare a reagent blank by repeating Steps 3 through 10, using chromium-free deionized water as the sample. Zero the instrument on deionized water by pressing the soft key under* ***ZERO****. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under* ***OPTIONS, (MORE)****, and then* ***BLANK:OFF****. Enter the reagent blank value and press* **ENTER***. Repeat for each new lot of reagent.*

Note: *For sample with extreme pH, see the Interferences section.*

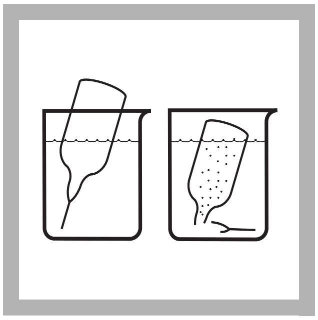


3. Fill the zeroing vial with at least 10 mL of sample (the blank). Collect at least 40 mL of sample in a 50-mL beaker.

Note: *For turbid samples, treat 25 mL of the blank with the contents of one Acid Reagent Powder Pillow. This will ensure any turbidity dissolved by the acid in the ChromaVer 3 Chromium Reagent also will be dissolved in the blank.*

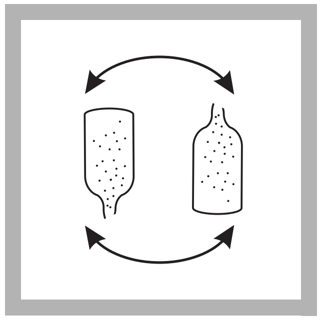
Note: *For proof of accuracy, use a 0.25 mg/L hexavalent chromium standard solution (preparation given in the Accuracy Check section in place of the sample.*

4. Insert the AccuVac Adapter into the sample cell module by sliding it under the thumb screw and into the alignment grooves. Fasten with the thumb screw.



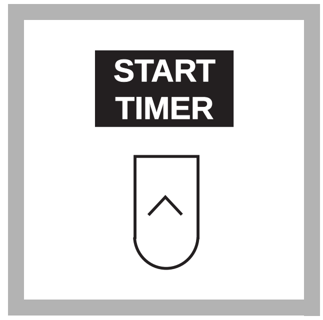
5. Fill a ChromaVer 3 Reagent AccuVac Ampul with sample (the prepared sample).

Note: *Keep the tip immersed while the ampul fills completely.*



6. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

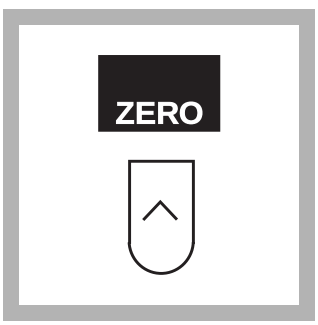
Note: *A purple color will form if hexavalent chromium is present.*



7. Press the soft key under ***START TIMER***.

An 8-minute reaction period will begin.

8. When the timer beeps, place the blank into the cell holder. Close the light shield.



9. Press the soft key under ***ZERO***.

The display will show:

0.000 mg/L Cr^{6+}

Note: *If you are using a reagent blank correction, the display will show the correction.*

Note: *For alternate concentration units, press the soft key under* **OPTIONS**. *Then press the soft key under* **UNITS** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*

10. Place the prepared sample into the cell holder. Close the light shield. Results in mg/L hexavalent chromium (Cr^{6+}) will be displayed.

Note: *Results may be expressed as chromate (CrO_4^{2-}) or as sodium chromate (Na_2CrO_4), or dichromate ($Cr_2O_7^{2-}$). Press the soft keys under* **OPTIONS** *and then* **FORM:** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*

Interferences

Table 1 Interfering Substances and Suggested Treatments

Interfering Substance	Interference Levels and Treatments
Iron	May interfere above 1 mg/L
Mercurous & Mercuric Ions	Interferes slightly
pH	Highly buffered samples or extreme sample pH may exceed the buffering capacity of the reagents and require sample pretreatment; see Section *1.3.1 pH Interference*.
Vanadium	May interfere above 1 mg/L. Wait 10 minutes before reading.

Sample Collection, Preservation, and Storage

Collect samples in a cleaned glass or plastic container. Store at 4 °C (39 °F) up to 24 hours. Samples must be analyzed within 24 hours.

Accuracy Check

Standard Additions Method

a. Leave the unspiked sample in the sample cell compartment. Verify that the units displayed are in mg/L. Select standard additions mode by pressing the soft keys under ***OPTIONS, (MORE)*** and then ***STD ADD***.

b. Press **ENTER** to accept the default sample volume (mL), 25.

c. Press **ENTER** to accept the default standard concentration (mg/L), 12.5.

d. Press the soft key under ***ENTRY DONE***.

e. Snap the neck off a Chromium Voluette Ampule Standard, 12.5-mg/L Cr^{6+}.

f. Use the TenSette Pipet to add 0.1, 0.2 and 0.3 mL of standard, respectively to three 25-mL samples and mix each thoroughly (for AccuVac Ampuls, use 50-mL beakers).

g. Analyze each standard addition sample as described above. Accept the standard additions reading by pressing the soft key under ***READ*** each time. Each addition should reflect approximately 100% recovery.

h. After completing the sequence, the display will show the extrapolated concentration value and the "best-fit" line through the standard additions data points, accounting for matrix interferences.

i. See Section *1.4.1 Standard Additions* for more information.

Standard Solution Method

Prepare a 0.25-mg/L Cr^{6+} standard solution by pipetting 5.00 mL of Hexavalent Chromium Standard Solution, 50-mg/L, into a 1000-mL volumetric flask. Dilute to the mark with deionized water. Prepare this solution daily. Perform the hexavalent chromium procedure as described above.

To adjust the calibration curve using the reading obtained with the 0.25-mg/L standard solution, press the soft keys under ***OPTIONS, MORE*** then ***STD: OFF***. Press **ENTER** to accept the displayed concentration, the value of which depends on the selected units. If an alternate concentration is used, enter the actual concentration and press **ENTER** to return to the read screen. See Section *1.5.5 Adjusting the Standard Curve* for more information.

Method Performance

Precision

Standard: 0.25 mg/L Cr^{6+}

Program	95% Confidence Limits
1560	0.247–0.253 mg/L Cr^{6+}
1570	0.247–0.253 mg/L Cr^{6+}

For more information on determining precision data and method detection limits, refer to Section *1.5*.

Estimated Detection Limit

Program	EDL
1560	0.006 mg/L
1570	0.005 mg/L

For more information on derivation and use of Hach's estimated detection limit, see Section *1.5.2*. To determine a method detection limit (MDL) as defined by the 40 CFR part 136, Appendix B, see Section *1.5.1*.

Sensitivity

Program Number: 1560

Portion of Curve	∆Abs	∆Concentration
Entire Range	0.010	0.0055 mg/L

Program Number: 1570

Portion of Curve	∆Abs	∆Concentration
Entire Range	0.010	0.0060 mg/L

See Section *1.5.3 Sensitivity Explained* for more information.

Calibration Standard Preparation

To perform a hexavalent chromium calibration using the 1,5-Diphenylcarbohydrazide method, prepare a 5.0-mg/L chromium stock solution by pipetting 10.0 mL of a 50-mg/L Chromium Hexavalent Standard Solution into a 100-mL volumetric flask using Class A glassware. Dilute to the mark with deionized water and mix thoroughly.

Prepare calibration standards containing 0.05, 0.30, and 0.60 mg/L Cr^{6+} as follows:

- **a.** Into three different 100-mL Class A volumetric flasks, pipet 1.00, 6.00, and 12.00 mL of the 5.0 mg/L Cr^{6+} stock solution using Class A glassware.
- **b.** Dilute to the mark with deionized water and mix thoroughly.
- **c.** Using the 1,5-Diphenylcarbohydrazide method and the calibration procedure described in the *User-Entered Programs* section of the *DR/4000 Spectrophotometer Instrument Manual*, generate a calibration curve from the standards prepared above.

Summary of Method

Hexavalent chromium is determined by the 1,5-Diphenylcarbohydrazide method using a single dry powder formulation called ChromaVer 3 Chromium Reagent. This reagent contains an acidic buffer combined with 1,5-Diphenylcarbohydrazide, which reacts to give a purple color when hexavalent chromium is present.

Safety

Good safety habits and laboratory techniques should be used throughout the procedure. Consult the *Material Safety Data Sheet* for information specific to the reagents used. For additional information, refer to Section *1*.

Pollution Prevention and Waste Management

The final samples are highly acidic. Neutralize to pH 6–9 and flush down the drain for disposal. For more information on pollution prevention and waste management, refer to Section *1*.

REQUIRED REAGENTS AND STANDARDS (Using Powder Pillows)

Description	Quantity Required per test	Unit	Cat. No.
ChromaVer 3 Chromium Reagent Powder Pillows	1 pillow	100/pkg	12710-99

REQUIRED REAGENTS AND STANDARDS (Using AccuVac Ampuls)

ChromaVer 3 AccuVac Ampuls	1 ampul	25/pkg	25050-25

REQUIRED EQUIPMENT AND SUPPLIES (Using Powder Pillows)

DR/4000 1-Inch Cell Adapter	1	each	48190-00

REQUIRED EQUIPMENT AND SUPPLIES (Using AccuVac Ampuls)

Beaker, 50-mL	1	each	500-41
DR/4000 AccuVac Adapter	1	each	48187-00
Sample Cell, 10-mL with cap (zeroing vial)	1	each	21228-00

OPTIONAL REAGENTS AND SUPPLIES

Description	Unit	Cat. No.
Acid Reagent Powder Pillows	50/pkg	2126-66
Chromium, Hexavalent, Standard Solution, 50-mg/L Cr^{6+}	100 mL	810-42H
Chromium, Hexavalent, Standard Solution, 10-mL Voluette Ampules, 12.5-mg/L Cr^{6+}	16/pkg	14256-10
Chromium, Hexavalent, Standard Solution, 2-mL ampule, 5.0-mg/L Cr^{6+}	20/pkg	26056-20
Nitric Acid, ACS	500 mL	152-49
Nitric Acid Solution, 1:1	500 mL	2540-49
Sodium Hydroxide Standard Solution, 5.0 N	50 mL* DB	2450-26
Water, deionized	4 liters	272-56

OPTIONAL EQUIPMENT AND SUPPLIES

AccuVac Snapper Kit	each	24052-00
Ampule Breaker Kit	each	21968-00
DR/4000 Carousel Module Kit	each	48070-02
DR/4000 Flow Cell Module Kit, 1-inch	each	48070-04
DR/4000 Flow Cell Module Kit, 1-cm	each	48070-05
DR/4000 Sipper Module Kit, 1-inch	each	48090-03
Flask, volumetric, Class A, 25-mL	each	14574-40
Flask, volumetric, Class A, 1000-mL, with glass stopper	each	14574-53
pH Paper, pH 1.0 to 11.0	5 rolls/pkg	391-33
pH Meter, *sension*™*1*, portable	each	51700-00
Pipet, serological, 2-mL	each	532-36
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet Tips, for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 1.00-mL	each	14515-35
Pipet, volumetric, Class A, 5.00-mL	each	14515-37
Pipet, volumetric, Class A, 6.00-mL	each	14515-06
Pipet, volumetric, Class A, 10.00-mL	each	14515-38
Pipet Filler, safety bulb	each	14651-00
Sample Cells, 1-inch, matched pair	2/pkg	26126-02

* Contact Hach for larger sizes.

FOR TECHNICAL ASSISTANCE, PRICE INFORMATION AND ORDERING:
In the U.S.A. – **Call toll-free 800-227-4224**
Outside the U.S.A. – **Contact the HACH office or distributor serving you.**
On the Worldwide Web – **www.hach.com**; E-mail – **techhelp@hach.com**

HACH COMPANY
WORLD HEADQUARTERS
Telephone: (970) 669-3050
FAX: (970) 669-2932

Standard Operating Procedure for Ferrous Iron Analysis by Hach Method 8146

This Standard Operating Procedure (SOP) for ferrous iron analysis was developed based upon HACH method 8146. The intent of this SOP is to provide step by step procedures and additional guidance to the analyst performing the procedure. The SOP will address the following:

- Equipment and supplies
- Step by step procedure for preparation and analysis
- Example Analytical Sequence
- Documentation Requirements

Equipment and Supplies

See Hach manual for suggested equipment and supplies.

Step by Step Procedures

Sample preparation

1. Scrupulously clean all reusable glassware/equipment prior to starting the analysis by performing the following:
    - Soak the glassware in a tub with a phosphate free detergent such as Alconox ® and remove any debris from the glassware using a brush.
    - Rinse the glassware with tap water that has been verified not to contain hexavalent chromium.
    - Rinse the glassware with a dilute nitric acid solution
    - Rinse with deionized water provided by the laboratory
    - Air dry in an area free of contamination if possible.
2. The following types of quality control samples will be prepared along with the field samples:

    Reagent blank: The reagent blank will be the first sample prepared and analyzed. The purpose of this blank is to ensure that the reagents are not contributing to any hexavalent chromium detected. The reagent blank should be prepared daily.

    Water blank(s): Water used for glassware cleaning, sample dilution or other analytical activities must be verified not to contain ferrous iron. Water blanks should be prepared as a new source of water is introduced. For example, if store bought purified water is used for decontamination, each new bottle must be tested.

    Reagent spike: The reagent spike verifies that the analytical process is within control. Reagent spikes should be prepared daily for each person performing the analysis.

Sample matrix spike: The sample matrix spike is used to verify that the analytical process is within control and not adversely impacted from potential interference. The sample matrix spike should be prepared for at least one sample analyzed unless otherwise instructed.

3. Prepare an aliquot for analysis. QC samples will be prepared in deionized water (DI). It is important to note that the DI should not be taken directly from the carboy or container used to store the DI. The DI should be transferred to a beaker or flask and then the aliquot removed to avoid contaminating the DI source. Field sample aliquots will be obtained by homogenizing the sample removed from the tank. A minimum of 100 mls of DI/sample is required for the QC and field samples.

4. Filter the entire sample through a 0.45 micron filter to remove any particulates. Collect the filtrate in a sample bottle or beaker. The sample bottle or beaker must be labeled with the contents. For example, reagent spike or sample, "ABC."

5. Transfer a 25 ml aliquot from the sample bottle into the sample cell using a calibrated pipette. The first sample prepared will be the reagent blank.

6. Add a reagent powder pillow to the cell and swirl to mix. (note: if ferrous iron is present in the sample, the color of the solution will turn orange.)

7. Begin analysis by pressing the "start timer" on the DR/4000. A timer will monitor the required 3 minute reaction.

8. Start preparing the next QC or field sample.

Preparing Spike Solution for Reagent Spikes and Sample Matrix Spikes

For each sample and the reagent spike, follow steps 3 through 5 outlined above in the "sample preparation" section. Prior to adding the reagent powder pillow in step 6, the sample cell must be spiked with ferrous iron. The spike for ferrous iron will be prepared as follows:

- Transfer 23 mls of DI (reagent spike) or sample (sample matrix spike) to the sample cell and add 2 mls of the 22 mg/L ferrous iron standard. Cap and mix. The concentration of ferrous iron in the cell is 1.76 mg/L.

Sample Analysis

1. Turn the DR/4000 spectrophotometer on.

2. Select "HACH program" and then enter "2150" on the numeric keypad.

3. After the 3 minute reaction is complete as indicated by a "beep" from the DR/4000, place the cell with the sample in the cell holder.

4. The reagent blank will be analyzed first to zero the instrument. After placing the reagent blank in the sample cell, select "options", "more", "Blank off:" and enter the reading obtained from the DR/4000 display and then press "enter.

5. Follow step 3 above for all QC and field sample analyses. Results should be documented according to the documentation section below. The units for all measurements are in mg/L.

Verification of Calibration

The calibration should be periodically evaluated using the standard prepared in the "Preparing Spike Solution for Reagent Spikes and Sample Matrix Spikes " above. The calibration verification standard concentration is 1.76 mg/L. Frequency of calibration verification analyses should be after every 10 analyses and at the end of the analytical sequence. An example analytical sequence is included below. CCV results should be between 1.41 and 2.11 mg/L. If CCV analyses fails (is not between 1.41 and 2.11 mg/L), prepare a new 1.76 mg/L standard and re-analyze. If CCV still fails contact the project chemists for further instructions.

Sample Dilution

It will be likely that analysis of the post-treatment samples will require sample dilution to be performed to obtain accurate readings by this method. Results that are obtained over the calibration curve will require dilution. Should we include details how to make the dilution? I can add a probable dilution factor / details after we work it out in the field

Example Analytical Sequence

- Reagent Blank used to zero instrument- each new lot of reagent
- Water Blank (to verify source water is free of hexavalent chromium) every new bottle

Analyzed every day

- Sample Blank
- Calibration verification analysis (CCV) recovered within acceptance limits
- Sample
- Sample matrix spike (Once a day)
- Calibration verification analysis (CCV) recovered within acceptance limits

Documentation Requirements

A bound, waterproof logbook is recommended to be used and all entries should be recorded in indelible ink. The following information should be recorded to document the analytical effort:

1. Date of sampling
2. Time of sampling
3. Date of analysis
4. Approximate time of analysis
5. Analyst Name
6. Test Analyte (Cr^{6+}, Total Cr, Fe^{3+},…)
7. Sample Name (for example, initial calibration std and concentration, sample name, etc..)
8. Volume of sample analyzed
9. Volume of dilution H2O
10. Instrument Reading for sample
11. Corrected Reading

IRON, Ferrous

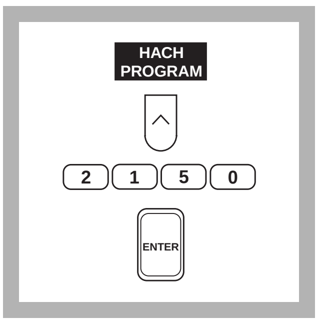
Method 8146 **1,10 Phenanthroline Method***

Powder Pillows or AccuVac® Ampuls **(0 to 3.000 mg/L)**

Scope and Application: *For water, wastewater and seawater. The estimated detection limit for program numbers 2150 and 2155 are 0.008 and 0.007 mg/L Fe^{2+}, respectively.*

* Adapted from *Standard Methods for the Examination of Water and Wastewater,* 15th ed. 201 (1980)

Using Powder Pillows



1. Press the soft key under ***HACH PROGRAM***.

Select the stored program number for ferrous iron (Fe^{2+}), by pressing **2150** with the numeric keys.

Press: **ENTER**

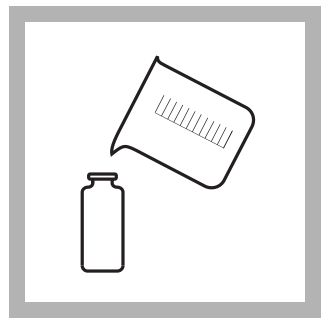
Note: *Analyze samples as soon as possible to prevent air oxidation of ferrous iron to ferric iron, which is not determined. See Sample Collection, Storage and Preservation following these steps.*

Note: *The Flow Cell and Sipper Modules can be used with this procedure.*

2. The display will show:

HACH PROGRAM: 2150
Iron, Ferrous

The wavelength (λ), **510 nm**, is automatically selected.



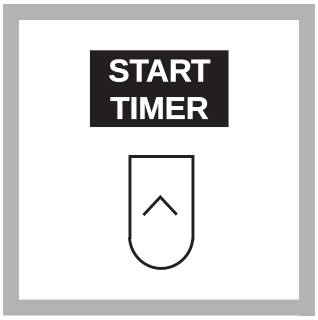
3. Fill a clean sample cell with 25 mL of sample.

Note: *For proof of accuracy, use a 1.0 mg/L ferrous iron standard solution (preparation given in the Accuracy Check section) in place of the sample.*

Note: *For best results, determine a reagent blank for each new lot of reagent as follows. Prepare a reagent blank by repeating steps 3 through 10, using deionized water as the sample. Zero the instrument on deionized water by pressing the soft key under* ***ZERO****. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under* ***OPTIONS, (MORE)****, and then* ***BLANK:OFF****. Enter the reagent blank value and press* **ENTER***. Repeat for each new lot of reagent.*

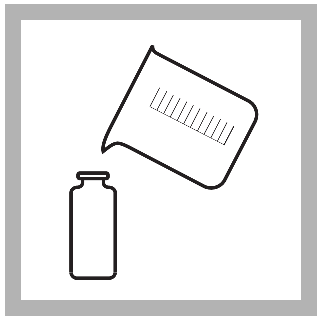
4. Add the contents of one Ferrous Iron Reagent Powder Pillow to the sample cell (the prepared sample). Swirl to mix.

Note: *An orange color will form if ferrous iron is present.*

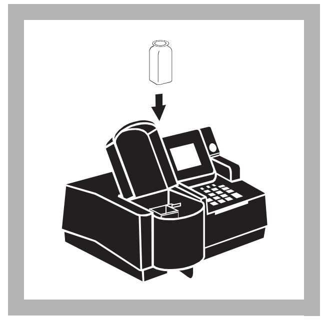


5. Press the soft key under ***START TIMER***.

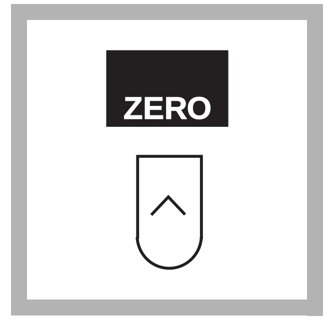
A 3-minute reaction period will begin.



6. Fill a second sample cell with 25 mL of sample (the blank).



7. When the timer beeps, place the blank into the cell holder. Close the light shield.



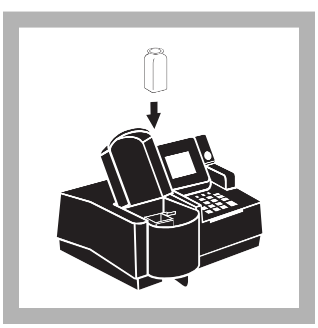
8. Press the soft key under ***ZERO***.

The display will show:

0.000 mg/L Fe^{2+}

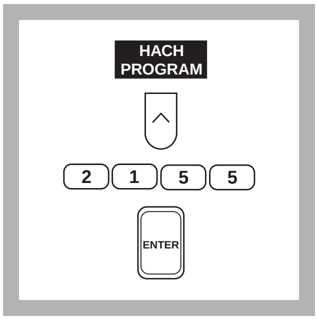
Note: *If you are using a reagent blank correction, the display will show the correction.*

Note: *For alternate concentration units, press the soft key under* ***OPTIONS****. Then press the soft key under* **UNITS** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*



9. Place the prepared sample into the cell holder. Close the light shield. The results in mg/L Fe^{2+} (or chosen units) will be displayed.

Using AccuVac Ampuls



1. Press the soft key under ***HACH PROGRAM***.

Select the stored program number for ferrous iron (Fe^{2+}) by pressing **2155** with the numeric keys.

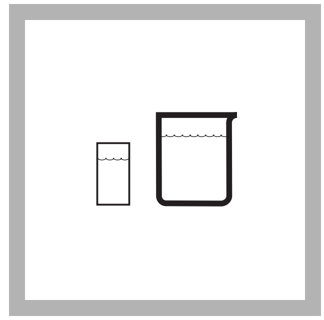
Press: **ENTER**

Note: *Analyze samples as soon as possible to prevent air oxidation of ferrous iron to ferric iron, which is not determined. See Sample Collection, Storage and Preservation following these steps.*

2. The display will show:

HACH PROGRAM: 2155
Iron, Ferrous AV

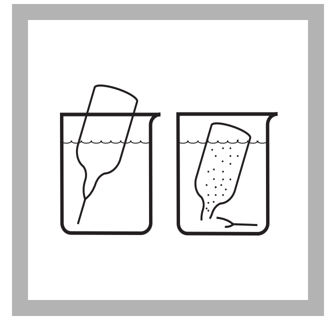
The wavelength (λ), **510 nm**, is automatically selected.



3. Fill a zeroing vial (the blank) with at least 10 mL of sample. Collect at least 40 mL of sample in a 50-mL beaker.

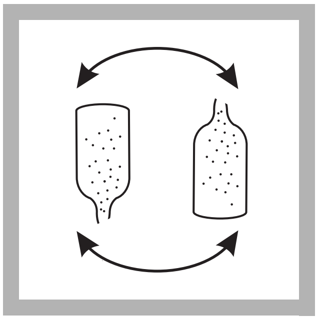
Note: *For proof of accuracy, a 1.0-mg/L ferrous iron standard solution (preparation given in the Accuracy Check section) can be used in place of the sample.*

Note: *For best results, determine a reagent blank for each new lot of reagent as follows. Prepare a reagent blank by repeating Steps 3 through 10, using deionized water as the sample. Zero the instrument on deionized water by pressing the soft key under **ZERO**. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under **OPTIONS, (MORE)**, and then **BLANK:OFF**. Enter the reagent blank value and press **ENTER**. Repeat for each new lot of reagent.*



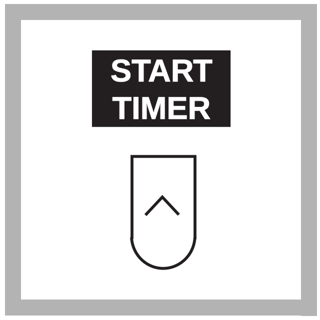
4. Fill a Ferrous Iron AccuVac Ampul with sample.

Note: *Keep the tip immersed while the ampul fills completely.*



5. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

Note: *An orange color will form if ferrous iron is present.*



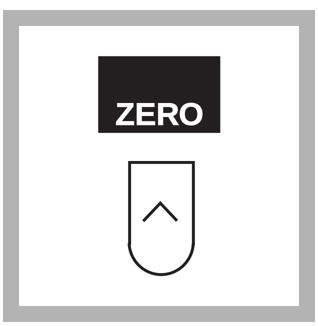
6. Press the soft key under ***START TIMER***.

A 3-minute reaction period will begin.

Note: *Complete Step 7 during the reaction period.*

7. Insert the AccuVac Ampul Adapter into the sample cell module by sliding it under the thumb screw and into the alignment grooves. Fasten with the thumb screw.

8. When the timer beeps place the blank into the cell holder. Close the light shield.



9. Press the soft key under ***ZERO***.

The display will show:

0.000 mg/L Fe^{2+}

Note: *If you are using a reagent blank correction, the display will show the correction.*

Note: *For alternate concentration units, press the soft key under* ***OPTIONS****. Then press the soft key under* ***UNITS*** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*

10. Place the AccuVac Ampul into the cell holder. Close the light shield. Results in mg/L Fe^{2+} (or chosen units) will be displayed.

Sample Collection, Storage and Preservation

Collect samples in plastic or glass bottles. Analyze samples as soon as possible after collection.

Accuracy Check

Standard Solution Method

Prepare a ferrous iron stock solution (100-mg/L Fe^{2+}) by dissolving 0.7022 grams of Ferrous Ammonium Sulfate, hexahydrate, in deionized water. Dilute to one liter in a Class A volumetric flask. In a 100-mL Class A volumetric flask, dilute 1.00 mL of this solution to 100 mL with deionized water to make a 1.0-mg/L standard solution. Prepare this solution immediately before use. Perform the iron procedure as described above.

To adjust the calibration curve using the reading obtained with the 1.0 mg/L Fe^{2+} Standard Solution, press the soft keys under ***METHOD OPTIONS, (MORE)*** then ***STD: OFF***. Press **ENTER** to accept the default concentration, the value of which will depend on the selected units. If an alternate concentration is used, enter the actual concentration and press **ENTER** to return to the read screen. See Section *1.5.5 Adjusting the Standard Curve* for more information.

Method Performance

Precision

Standard: 1.000 mg/L Fe

Program	95% Confidence Limits
2150	0.997–1.003 mg/L Fe
2155	0.997–1.003 mg/L Fe

For more information on determining precision data and method detection limits, refer to Section *1.5*.

Estimated Detection Limit

Program	EDL
2150	0.008 mg/L Fe
2155	0.007 mg/L Fe

For more information on derivation and use of Hach's estimated detection limit, see Section *1.5.2*. To determine a method detection limit (MDL) as defined by the 40 CFR part 136, Appendix B, see Section *1.5.1*.

Sensitivity

Program Number: 2150

Portion of Curve:	∆Abs	∆Concentration
Entire Range	0.010	0.0210 mg/L

Program Number: 2155

Portion of Curve:	∆Abs	∆Concentration
Entire Range	0.010	0.0226 mg/L

See Section *1.5.3 Sensitivity Explained* for more information.

Calibration Standard Preparation

Preparing ferrous standards is difficult. These standards are very unstable and degrade rapidly. Only a trained chemist should prepare these standards.

To perform an ferrous iron calibration using the 1,10 phenanthroline method, prepare calibration standards containing 0.50, 1.00, 2.00, and 3.00 mg/L ferrous iron as follows:

a. Prepare a 100 mg/L ferrous iron stock solution by dissolving 0.7022 grams of Ferrous Ammonium Sulfate, hexahydrate, in deionized water. Dilute to one liter in a Class A volumetric flask. Stopper and invert several times to mix. Prepare this solution just before use.

b. Into four different 100-mL Class A volumetric flasks, pipet 0.50, 1.00, 2.00 and 3.00 mL of the 100-mg/L ferrous iron stock solution. Dilute each flask to volume with deionized water. Stopper and invert each flask to mix. Prepare these standards just before use.

c. Using the 1,10 phenanthroline method and the calibration procedure described in the *User-Entered Programs* section of the *DR/4000 Spectrophotometer Instrument Manual*, generate a calibration curve from the standards prepared above.

Summary of Method

The 1,10 phenanthroline indicator in the Ferrous Iron Reagent reacts with ferrous iron in the sample to form an orange color in proportion to the iron concentration. Ferric iron does not react. The ferric iron (Fe^{3+}) concentration can be determined by subtracting the ferrous iron concentration from the results of a total iron test.

Safety

Good safety habits and laboratory techniques should be used throughout the procedure. Consult the *Material Safety Data Sheet* for information specific to the reagents used. For additional information, refer to Section *1*.

Pollution Prevention and Waste Management

For information on pollution prevention and waste management, refer to Section *1*.

REQUIRED REAGENTS AND STANDARDS (Using Powder Pillows)

Description	Quantity Required per test	Unit	Cat. No.
Ferrous Iron Reagent Powder Pillows	1 pillow	100/pkg	1037-69

REQUIRED REAGENTS AND STANDARDS (Using AccuVac Ampuls)

Ferrous Iron Reagent AccuVac Ampuls	1 ampul	25/pkg	25140-25

REQUIRED EQUIPMENT AND SUPPLIES (Using Powder Pillows)

Clippers, for opening powder pillows	1	each	968-00
DR/4000 1-Inch Cell Adapter	1	each	48190-00

REQUIRED EQUIPMENT AND SUPPLIES (Using AccuVac Ampuls)

Beaker, 50-mL	1	each	500-41
DR/4000 AccuVac Ampul Adapter	1	each	48187-00
Sample Cell, 10-mL, with cap (zeroing vial)	1	each	21228-00

OPTIONAL REAGENTS AND STANDARDS

Ferrous Ammonium Sulfate, hexahydrate, ACS	113 g	11256-14
Water, deionized	4 liters	272-56

OPTIONAL EQUIPMENT AND SUPPLIES

AccuVac Snapper	each	24052-00
Balance, electronic, 110 VAC	each	26104-00
Balance, electronic, 220 VAC	each	26104-02
Clippers, shears, 7 ¼-inch	each	23694-00
DR/4000 Carousel Module Kit	each	48070-02
DR/4000 Flow Cell Module Kit, 1-inch	each	48070-04
DR/4000 Flow Cell Module Kit, 1-cm	each	48070-05
DR/4000 Sipper Module Kit, 1-inch	each	48070-03
Flask, volumetric, 100-mL, Class A	each	14574-42
Flask, volumetric, 1000-mL, Class A, with stopper	each	14574-53
pH Meter, *sension*™*1*, portable	each	51700-00
pH Paper, pH 1.0 to 11.0	5 rolls/pkg	391-33
Pipet, volumetric, 0.50-mL, Class A	each	14515-34
Pipet, volumetric, 1.00-mL, Class A	each	14515-35
Pipet, volumetric, 2.00-mL, Class A	each	14515-36
Pipet, volumetric, 3.00-mL, Class A	each	14515-03
Pipet Filler, safety bulb	each	14651-00

DR/4000
PROCEDURE

CHROMIUM, Total

Method 8024 **Alkaline Hypobromite Oxidation Method***

Powder Pillows **(0 to 0.700 mg/L)**

Scope and Application: *For water and wastewater. See Section 2 for digestion procedure, if necessary. The estimated detection limit for program number 1580 is 0.003 mg/L Cr.*

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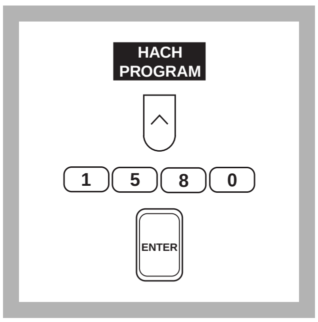
* Adapted from *Standard Methods for the Examination of Water and Wastewater*



1. Press the soft key under ***HACH PROGRAM***.

Select the stored program for total chromium (Cr) by pressing **1580** with the numeric keys.

Press: **ENTER**

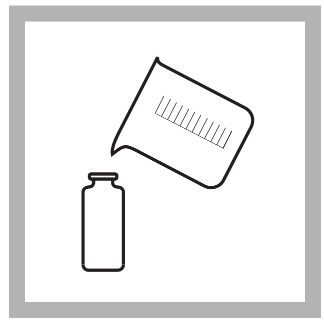
Note: *If samples cannot be analyzed immediately, see Sample Collection, Storage and Preservation following these steps. Adjust the pH of preserved samples before analysis.*

Note: *The Flow Cell and Sipper Modules can be used for this procedure.*

2. The display will show:

HACH PROGRAM: 1580 Chromium, Total

The wavelength (λ), **540 nm**, is automatically selected.

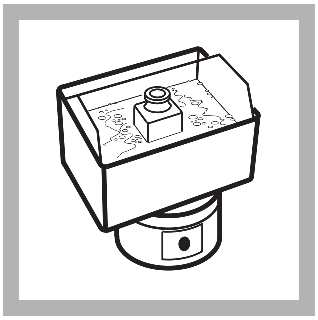


3. Fill a sample cell with 25 mL of sample.

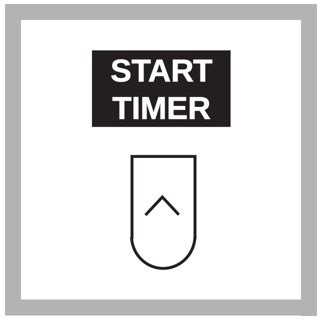
Note: *For proof of accuracy, use a 0.25 mg/L trivalent chromium standard solution (preparation given in the Accuracy Check section) in place of the sample.*

Note: *For best results, determine a reagent blank for each new lot of reagent as follows. Prepare a reagent blank by repeating Steps 3 through 14, using deionized water as the sample. Zero the instrument on deionized water by pressing the soft key under* ***ZERO****. Insert the reagent blank and the blank value will be displayed. Correct for the reagent blank by pressing the soft keys under* **OPTIONS, (MORE)***, and then* **BLANK:OFF***. Enter the reagent blank value and press* **ENTER***. Repeat for each new lot of reagent.*

4. Add the contents of one Chromium 1 Reagent Powder Pillow (the prepared sample). Swirl to mix.

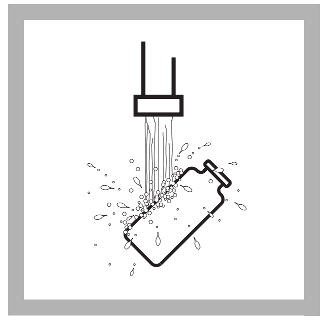


5. Place the prepared sample into a boiling water bath.



6. Press the soft key under ***START TIMER***.

A 5-minute reaction period will begin.



7. When the timer beeps, remove the prepared sample. Using running tap water, cool the cell to 25 °C.

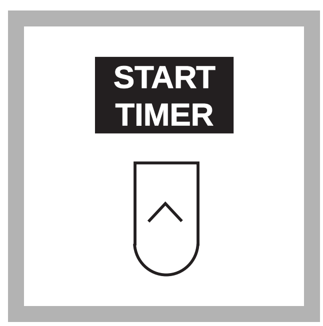
Note: *Use finger cots to handle the hot sample cell.*

8. Add the contents of one Chromium 2 Reagent Powder Pillow. Swirl to mix.

9. Add the contents of one Acid Reagent Powder Pillow. Swirl to mix.

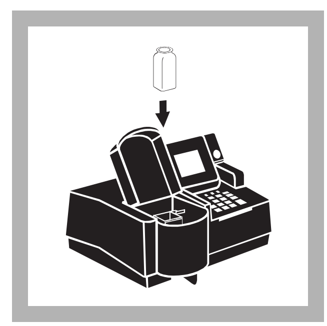
10. Add the contents of one ChromaVer 3 Chromium Reagent Powder Pillow. Swirl to mix.

Note: *A purple color will form if chromium is present.*



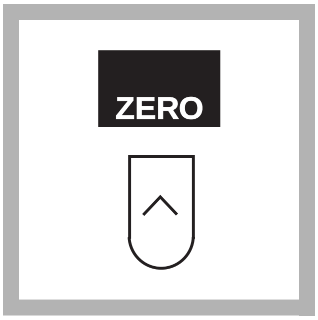
11. Press the soft key under ***START TIMER***.

A 5-minute reaction period will begin.



12. When the timer beeps, fill another sample cell with 25 mL of sample (the blank). Place it into the cell holder. Close the light shield.

Note: *For turbid samples, treat the blank as described in Steps 3 through 9.*



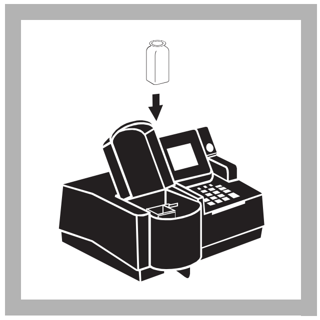
13. Press the soft key under ***ZERO***.

The display will show:

0.000 mg/L Cr

Note: *If you are using a reagent blank correction, the display will show the correction.*

Note: *For alternate concentration units, press the soft key under* **OPTIONS**. *Then press the soft key under* **UNITS** *to scroll through the available options. Press* **ENTER** *to return to the read screen.*



14. Place the prepared sample into the cell holder. Close the light shield. Results in mg/L chromium (or chosen units) will be displayed.

Interferences

Table 1 Interfering Substances and Suggested Treatments

Interfering Substance	Interference Levels and Treatments
Highly buffered samples or extreme sample pH	May exceed the buffering capacity of the reagents and require sample pretreatment; see Section *1.3.1 pH Interference*.
Organic material (large amounts)	May inhibit complete oxidation of trivalent chromium. If high levels of organic material are present, see *Section 2* for instructions on sample digestion. Perform the analysis as described on the digested sample.

Sample Collection, Storage and Preservation

Collect samples in acid-washed glass or plastic containers. To preserve samples, adjust the pH to 2 or less with nitric acid (about 2 mL per liter). Store preserved samples at room temperature up to six months. Adjust the pH to about 4 with 5.0 N Sodium Hydroxide before analysis. Correct the test result for volume additions; see Section *1.2.2 Correcting for Volume Additions*.

Accuracy Check

Standard Additions Method

a. Leave the unspiked sample in the cell compartment. Verify that the units displayed are in mg/L. Select standard additions mode by pressing the soft keys under ***OPTIONS, (MORE)*** and then ***STD ADD***.

b. Press **ENTER** to accept the default sample volume (mL), 25.

c. Press **ENTER** to accept the default standard concentration (mg/L), 12.500.

d. Press the soft key under ***ENTRY DONE***.

e. Snap the neck off a Trivalent Chromium Voluette Ampule Standard, 12.5-mg/L as Cr^{3+}.

f. Use the TenSette Pipet to add 0.1 mL, 0.2 mL and 0.3 mL of standard, respectively to three 25-mL samples and mix each thoroughly.

g. Analyze each standard addition sample as described above. Accept the standard additions reading by pressing the soft key under ***READ*** each time. Each addition should reflect approximately 100% recovery.

h. After completing the sequence, the display will show the extrapolated concentration value and the "best-fit" line through the standard additions data points, accounting for matrix interferences.

i. See Section *1.4.1 Standard Additions* for more information.

Standard Solution Method
Prepare a 0.25-mg/L trivalent chromium standard by diluting 5.00 mL of Trivalent Chromium Standard Solution, 50-mg/L as Cr^{3+}, to 1000 mL with deionized water. Prepare this solution daily.

To adjust the calibration curve using the reading obtained with the 0.25-mg/L standard solution, press the soft keys under ***OPTIONS, MORE*** then ***STD: OFF***. Press **ENTER** to accept the displayed concentration, the value of which depends on the selected units. If an alternate concentration is used, enter the actual concentration and press **ENTER** to return to the read screen. See Section *1.5.5 Adjusting the Standard Curve* for more information.

Method Performance

Precision
Standard: 0.250 mg/L Cr

Program	95% Confidence Limits
1580	0.248–0.252 mg/L Cr

For more information on determining precision data and method detection limits, refer to Section *1.5*.

Estimated Detection Limit

Program	EDL
1580	0.003 mg/L Cr

For more information on derivation and use of Hach's estimated detection limit, see Section *1.5.2*. To determine a method detection limit (MDL) as defined by the 40 CFR part 136, Appendix B, see Section *1.5.1*.

Sensitivity
Program Number: 1580

Portion of Curve	∆Abs	∆Concentration
Entire Range	0.010	0.006 mg/L

See Section *1.5.3 Sensitivity Explained* for more information.

Calibration Standard Preparation

To perform a total chromium calibration using the alkaline hypobromite oxidation method, prepare a 10-mg/L chromium stock solution by pipetting 20 mL of a 50-mg/L Chromium Trivalent Standard Solution (Cat. No. 14151-42) into a 100-mL volumetric flask using Class A glassware. Dilute to the mark with deionized water and mix thoroughly.

Prepare calibration standard containing 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, and 0.7 mg/L Cr^{3+}as follows:

a. Into seven different Class A 100-mL volumetric flasks, pipet 1, 2, 3, 4, 5, 6, and 7 mL of the 10-mg/L Cr^{3+} stock solution using Class A glassware.

b. Dilute to the mark with deionized water and mix thoroughly.

c. Using the alkaline hypobromite oxidation method and the procedure described in the *User-Entered Programs* section of the *DR/4000 Spectrophotometer Instrument Manual*, generate a calibration curve from the standards prepared above.

Summary of Method

Trivalent chromium in the sample is oxidized to the hexavalent form by hypobromite ion under alkaline conditions. The sample is acidified. The total chromium content is determined by the 1,5-Diphenylcarbohydrazide method. Determine trivalent chromium by subtracting the results of a separate hexavalent chromium test from the results of the total chromium test.

Safety

Good safety habits and laboratory techniques should be used throughout the procedure. Consult the *Material Safety Data Sheet* for information specific to the reagents used. For additional information, refer to Section *1*.

Pollution Prevention and Waste Management

The final samples are highly acidic. Neutralize to pH 6–9 and flush to drain for disposal. For information on pollution prevention and waste management, refer to Section *1*.

REQUIRED REAGENTS AND STANDARDS

Description	Quantity Required per test	Unit	Cat. No
Total Chromium Reagent Set (100 Tests)			22425-00
Includes: (1) 2126-99, (2) 12066-99, (1) 2043-99, (1) 2044-99			
Acid Reagent Powder Pillows	1 pillow	100/pkg	2126-99
ChromaVer 3 Chromium Reagent Powder Pillows	1 pillow	100/pkg	12066-99
Chromium 1 Reagent Powder Pillows	1 pillow	100/pkg	2043-99
Chromium 2 Reagent Powder Pillows	1 pillow	100/pkg	2044-99

REQUIRED EQUIPMENT AND SUPPLIES

DR/4000 1-Inch Cell Adapter	1	each	48190-00
Water bath and rack	1	each	1955-55
Select one based on available voltage:			
Hot plate, 3½" diameter, 120 VAC, 50/60 Hz		each	12067-01
Hot plate, 4" diameter, 240 VAC, 50/60 Hz		each	12067-02

OPTIONAL REAGENTS AND STANDARDS

Chromium, Trivalent, Standard Solution, 50-mg/L Cr^{3+}	100 mL	14151-42
Chromium, Trivalent, Standard Solution, 10-mL Voluette Ampule, 12.5-mg/L Cr^{3+}	16/pkg	14257-10
Nitric Acid, ACS	500 mL	152-49
Nitric Acid Solution, 1:1	500 mL	2540-49
Sodium Hydroxide Solution 5.0 N	59 mL* DB	2450-26
Water, deionized	4 liters	272-56

OPTIONAL EQUIPMENT AND SUPPLIES

Cylinder, graduated, polypropylene, 25-mL	each	1081-40
DR/4000 Carousel Module Kit	each	48070-02
DR/4000 Flow Cell Module Kit, 1-inch	each	48070-04
DR/4000 Flow Cell Module Kit, 1-cm	each	48070-05
DR/4000 Sipper Module Kit, 1-inch	each	48090-03
Flask, volumetric, 1000-mL	each	547-53
pH Paper, pH 1.0 to 11.0	5 rolls/pkg	391-33
pH Meter, *sension*™*1*, portable	each	51700-00
Pipet Filler, safety bulb	each	14651-00
Pipet, serological, 2-mL	each	532-36
Pipet, TenSette, 0.1 to 1.0 mL	each	19700-01
Pipet Tips for 19700-01 TenSette Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 5.00-mL	each	14515-37

* Contact Hach for larger sizes.

Conductivity

PROCEDURE

1. Rinse the conductivity probe with distilled water and shake it to remove excess water form the probe.

2. Follow **Figure 1 Steps 1-2** below to measure the a 0.60-mS and 12.8-mS conductivity standard once at the beginning of each shift. *Note: If sample conductivities are < 1 mS/cm or > 30 mS/cm, additional calibration checks are recommended in these ranges (e.g. 0.5-mS/cm and 50-mS/cm).*

3. If the results are within 10% of the true value (11.5 to 14.0 mS) continue with analysis of the samples making sure to rinse the probe with distilled water between samples. Otherwise, recalibrate the meter following **Figure 2 Steps 1-4** and reanalyze the calibration checks (Step 2 above).

4 Follow **Figure 1 Steps 1-2** below for each of the samples after they are brought to between 20°C and 25°C. Record the conductivity result on the bench sheet and <u>include the units</u>. The result is automatically corrected to the reference temperature of 25°C.

Note: The meter automatically changes the units from μS/cm to mS/cm above 1999 μS/cm

CALCULATIONS

To convert from mS/cm to μS/cm multiply the result by 1000.

TDS, mg/L (ppm) is about = Conductivity (μS/cm) * 0.6

PRECAUTIONS, TROUBLESHOOTING, & REMEDIAL ACTIONS

- Make sure the probe is properly rinsed between measurements
- Check to make sure there are no bubbles in cell – be sure to swirl probe in the solution.
- Ensure that the conductivity standard solution is not expired.
- If DI water does not clean the probe, try cleaning the probe as follows: Wash with warm water and laboratory soap and rinse with copious amounts of DI water before use. Alternatively 10% acetic acid or HCl may also be used. Solvents such as acetone or ethanol should only be used as a last resort and then the probe should not be immersed for longer than 5 minutes. Always completely rinse with DI water. Re-calibrated after these cleanings.

QUALITY CONTROL

Activities that will help ensure the accuracy and precision of this method include:

- Making sure the standards and samples are at a stable temperature before beginning analysis.
- Checking calibration of meter daily with standards that bracket the sample conductivities.

APPARATUS

Conductivity meter –
Conductivity Probe –
Sample cups or beakers – 150-mL or larger

Conductivity

REAGENTS

Conductivity Standards – 0.60-mS, 3.0-mS and 12.8-mS
Distilled water

QUALITY CONTROL CRITERIA

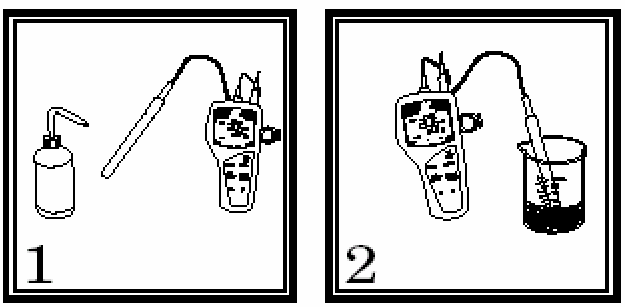
QC Sample	Frequency	Criteria
Electrode calibration	as needed	Subsequent checks are within 10% of the true value
Calibration check	Once at beginning of each shift before samples are analyzed	Within 10% of the true values

REFERENCES

Standard Methods for the Examination of Water and Wastewater, APHA et al, 20th Edition, 1998, Method 2510.

Figure 1

Making a Conductivity Measurement



Rinse the electrode with deionized or distilled water before use to remove any impurities adhering to the electrode body.

Switch on the meter.

The MEAS annunciator together with the auto-ranging annunciator (AUTO) displays on the top center of the LCD.

Obtain the sample; if necessary, heat or cool it to 50-160°F. Dip the electrode into the sample. Take readings. When the reading is stable, a READY annunciator displays.

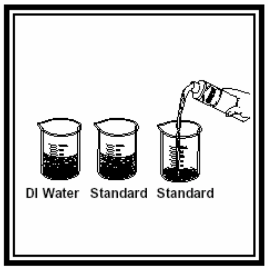
Note: When dipping the electrode into the sample, make sure the tip of the probe is completely immersed into the sample. Stir the electrode gently in the sample to create a homogenous sample. Make sure there are no air bubbles trapped in the slot of the probe. To remove air bubbles, give the probe a gentle shake, making sure the electrode tip is submerged.

Keeping the sample temperature between 20° C and 30°C during conductivity measurements will increase the accuracy of this procedure.

Conductivity

Figure 2
Calibration of the Conductivity Meter

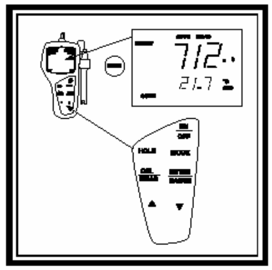
1.



Select a conductivity standard near the sample value you are measuring.

Pour the calibration standard into two separate containers and some tap or deionized water into a third container.

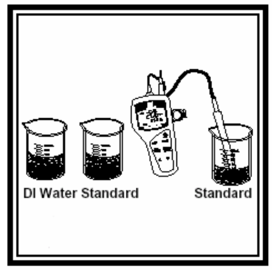
2.



Press: **ON/OFF**

Press: **MODE** and select **COND**.

3.

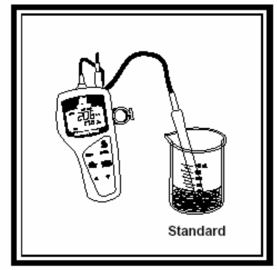


Rinse your electrode with deionized water, then rinse in one of the portions of calibration standard.

Immerse the electrode into the other standard solution, and press: **CAL**

Note: Allow at least 5 minutes for the probes to equilibrate at the solutions temperature. The display shows the CAL mode. "CAL" blinks on the display as long as the calibration mode is on. The primary (larger) display shows the measured reading and the secondary display shows the temperature.

4.



Enter value of your conductivity standard. The meter automatically compensates for temperature differences. Use the ▲ or ▼ to scroll to your chosen standard value.

Confirm calibrations by pressing ENTER/RANGE button.

Upon confirmation, the CAL indicator stops flashing and remains on the screen for 3 seconds. The meter switches back into the measurement mode and the calibrated and temperature compensated value will be updated on the display.

Notes: To exit from this process without confirming the calibrations, press "CAL/MEAS".

For calibrations in other ranges (maximum: 5 ranges) repeat steps (1 through 4). But this time, use a solution with a conductivity in the different ranges.

If you are measuring in ranges greater than 20 mS or conductivity lower than 100 µS, **calibrate** the meter at least once a week to get specified ± 1% F.S. accuracy. If you are measuring in the mid ranges, and you washed the probe in deionized water and stored it dry, calibrate the meter once a month. Wet the probe for 10 minutes before calibrating or taking readings to saturate the probe surface and minimize drift. If you make measurements at extreme temperatures, calibrate at least once a week.

Use only the conductivity probe specified for these meters. If you do not, you must measure the solution temperature separately and manually enter the solution temperature.

Conductivity

Method 8160 **Direct Measurement Method***

Conductivity Meter **(0–199.9 mS/cm)**

Scope and Application: For water and wastewater

* USEPA accepted for reporting. Procedure is equivalent to USEPA Method 120.1 and Standard Method 2510-B for wastewater.

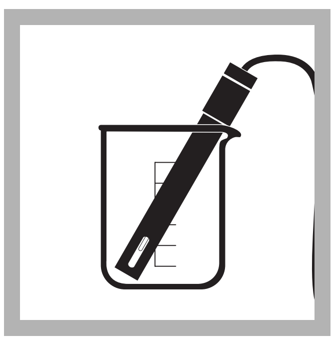
Tips and Techniques

- Collect samples in clean plastic or glass bottles.
- Analyze samples as soon as possible after collection. However, samples may be stored at least 24 hours by cooling to 4 °C (39 °F) or below. The conductivity meter will compensate for any variation of temperature from 20 or 25 °C.
- Water samples containing oils, grease, or fats will coat the electrode and affect the accuracy of the readings. If this occurs, clean the probe with a strong detergent solution, then thoroughly rinse with deionized water.
- Mineral buildup on the probe can be removed with 1:1 Hydrochloric Acid Solution, as directed in the sension™5 Instrument Manual.

Electrochemistry

1. Prepare the *sension*5 Conductivity Meter for operation as directed in the *Operation* section of the instrument manual. The *sension*5 automatically selects the appropriate range.

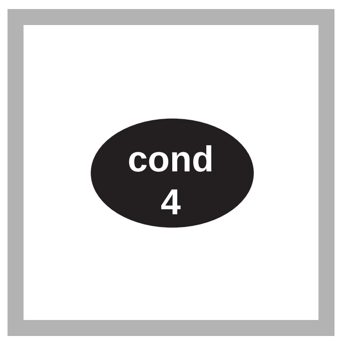
***Note:** If the probe has been in storage, soaking before use may be necessary to ensure the probe is thoroughly wetted.*



2. Immerse the probe in a beaker containing the sample solution. Move the probe up and down and tap it on the beaker to free any bubbles from the electrode area.

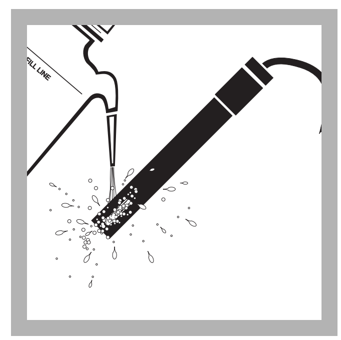
***Note:** The probe must be immersed beyond the vent holes.*

***Note:** The sension5 Portable Conductivity/TDS meter automatically compensates for sample temperature deviation from 20 or 25 °C depending on the reference temperature setting (S-2).*



3. Assure that the meter is in COND mode and read the value in the display.

***Note:** For proof of accuracy, use a known conductivity standard solution in place of the sample (see Accuracy Check following these steps).*



4. Rinse the probe thoroughly with deionized water after each measurement.

***Note:** To display units as TDS press the mode key until the meter is in TDS mode. The sension5 reports TDS in mg/L of Sodium Chloride, estimated from the conductivity of the measurement. Salinity is also a measurement capability of the sension5. Salinity is a relative scale based on a KCl Solution, see the sension5 Instrument Manual for more information.*

Conversions

The following table provides equations for converting the conductivity readings to other units of measure.

Table 1 Conversions

From	To	Use this Equation
mS/cm	µS/cm	mS/cm x 1000
µS/cm	mS/cm	µS/cm x 0.001
µS/cm	µmhos/cm	µS/cm x 1
mS/cm	mmhos/cm	mS/cm x 1
µS/cm	mg/L TDS	µS/cm x 0.5*
g/L TDS	mg/L TDS	g/L TDS x 1000
mS/cm	g/L TDS	mS/cm x 0.5
mg/L TDS	g/L TDS	mg/L TDS x 0.001
mg/L TDS	gpg TDS	mg/L TDS x 0.05842
g/L TDS	gpg TDS	g/L TDS x 58.42
µS/cm	ohms cm	1,000,000 ÷ µS/cm
mS/cm	ohms cm	1,000 ÷ mS/cm

* TDS is an empirically-derived value from the conductivity measurement. A 0.5 value is selected here for simplicity and suitability to a wide variety of waters. The *sension*5 uses a more complex algorithm, based on additional factors, such as temperature, to determine TDS.

Interferences

When measuring conductivity, the following items should be considered in order to ensure accurate results:

- If measuring very low levels of conductivity, protect the sample from atmospheric gases (carbon dioxide, ammonia). These gases dissolve readily in water and may cause a rapid change in conductivity. To minimize these effects, boil the sample, then place in a covered container for cooling.
- If the sample contains high levels of hydroxide (boiler water for example), neutralize to avoid inaccurate high results. Neutralize by adding 4 drops of Phenolphthalein Indicator Solution to 50 mL of sample, then adding Gallic Acid Solution, drop-wise, until the pink color completely disappears.

Accuracy Check

Pour a Sodium Chloride Standard Solution (with a conductivity value in the same range as the sample) into a beaker. Perform the conductivity measurements as described above. The conductivity reading should be the same (within accuracy limits) as listed on the Standard Solution label if the meter is calibrated correctly. Calibration can be performed using this solution. See the *sension*5 Instrument Manual.

Summary of Method

Electrolytic conductivity is the capacity of ions in a solution to carry electrical current and is the reciprocal of the solution resistivity. Current is carried by inorganic dissolved solids (e.g., chloride, nitrate, sulfate, and phosphate anions) and cations (e.g., sodium, calcium, magnesium, iron, and aluminum). Organic material like oils, phenols, alcohols, and sugars do not carry electrical current well and thus do not have enough conductivity for a useful estimate of concentration.

Measuring conductivity is done by measuring the resistance occurring in an area of the test solution defined by the probe's physical design. Voltage is applied between the two electrodes immersed in the solution, and the voltage drop caused by the resistance of the solution is used to calculate conductivity per centimeter. The basic unit of measure for conductivity is the Siemen (or mho), the reciprocal of the ohm in the resistance measurement. Because ranges normally found in aqueous solutions are small, milliSiemens/cm (10^{-3} S or mS/cm) and microSiemens/cm (10^{-6} S or µS/cm) are most commonly used.

Required Reagents

Description	Unit	Cat. No.
*sension*5 Conductivity Meter, portable, (with probe 51975-00)	each	51800-00
Conductivity Probe, 1-meter cable	each	51975-00

Optional Apparatus

Beaker, poly, 100-mL	each	1080-42
Gallic Acid Solution	50 mL SCDB	14423-26
Hydrochloric Acid Solution, 1:1	500 mL	884-49
Low Ionic Strength Chamber (LIS)	each	51899-00
Phenolphthalein Indicator Solution	15 mL SCDB	162-36
Sodium Chloride Standard Solution, 180 ±10 µS/cm, 90 ±1 mg/L TDS	100 mL	23075-42
Sodium Chloride Standard Solution, 1000 ±10 µS/cm, 500 ±5 mg/L TDS	100 mL	14400-42
Sodium Chloride Standard Solution, 1990 ±20 µS/cm, 995 ±10 mg/L TDS	100 mL	2105-42
Sodium Chloride Standard Solution, 18,000 ±50 µS/cm, 9000 ±25 mg/L TDS	100 mL	23074-42
Wash Bottle, 125-mL	each	620-14
Water, deionized	4L	272-56

Turbidity

PROCEDURE

1. Once, at the beginning of each shift, follow the steps in **Figure 1** to check the calibration using the Gelex or Formazin Standards instead of a sample. The result must be within 10% of the true values (upper and lower limits shown) listed below. If not, the meter must be re-calibrated. (Consult instrument manual for recalibration procedure using Formazin).

	True Value	**Lower Limit (-10%)**	**Upper Limit (+10%)**
Gelex 0 – 10 NTU	NTU	NTU	NTU
Gelex 0 – 100 NTU	NTU	NTU	NTU

Note: the true value for the Gelex standards must be determined each time the meter is calibrated using the Formazin standards.

2. Follow the steps in **Figure 1** below for each of the samples. Record the turbidity result on the bench sheet.

CALCULATIONS

The result is reported directly in NTU.

PRECAUTIONS, TROUBLESHOOTING, & REMEDIAL ACTIONS

- Always orient the cell the same way – diamond lining up with mark on instrument.
- Cap the sample cell to prevent spillage of sample into the instrument.
- When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.
- Always close the sample compartment lid during measurement and storage.
- Always use clean sample cells in good condition. Properly clean cells between measurements
- Dirty, scratched, or damaged cells can cause inaccurate readings. Handle cells only by the top to minimize dirt, scratches and fingerprints in the light path.
- <u>Avoid excess coating of oil</u>
- Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.
- Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).
- Make certain hot samples do not evaporate and condense in the sample cell.
- Avoid settling of sample prior to measurement.
- Keep sample compartment lid closed to prevent dust and dirt from entering.

Turbidity

QUALITY CONTROL

Activities that will help ensure the accuracy and precision of this method include:

- **Using Optically matched (or single) cells for Low Level Turbidity** - Precise measurements of low turbidity (< 2 NTU) samples require using a single cell for all measurements or using optically matched cells – *see HACH instruction manual Section 2.3.3 Pages 22-25.*
- **Use Dedicated Cells –** the use of cells dedicated to Turbidity measurement is recommended
- **Removing Trapped Gases** - *see HACH instruction manual Section 2.3.3 Pages 22-25.* This would only be a problem for samples that exhibit foaming or where gas bubbles are observed.
- **Avoid Sample Dilution where possible–** Sample dilution may alter characteristics of the suspended particles and should be avoided if possible. If dilution is performed use only reagent water.
- **Calibration Checks using the Gelex standards –** Once per rotation, measure the 0 to 10 NTU and 0 to 100 NTU Gelex standards.
- **Recalibration Using Formazin standards –** Once every three months, or sooner if the Gelex Calibration check standards indicate a problem, recalibrate using the Formazin standards - *see HACH instruction manual Section 3.6,* pages *35-54.*

APPARATUS

- Model 2100P Portable Turbidimeter
- Sample cells with caps.
- Carrying Case
- Four AA alkaline batteries

REAGENTS

- Formazin Primary Standards - HACH Part # 26594-05, StableCal Standards, <0.1, 20, 100, 800 NTU, ampoules
- Gelex™ Secondary Standards - HACH Part # 24641-05
- Reagent water – ASTM Type I water produced by de-ionization.
- Silicone Oil - HACH Part # 1269-36

QUALITY CONTROL CRITERIA

QAQC Sample	**Frequency**	**Criteria**
Gelex 0 - 10 NTU and 0 – 100 NTU Standard Checks	Each operator checks each shift before samples are analyzed.	90%-110% of expected concentration
Primary Standard re-calibration	As needed or at least every three months	90% - 110% recovery for check of new standard

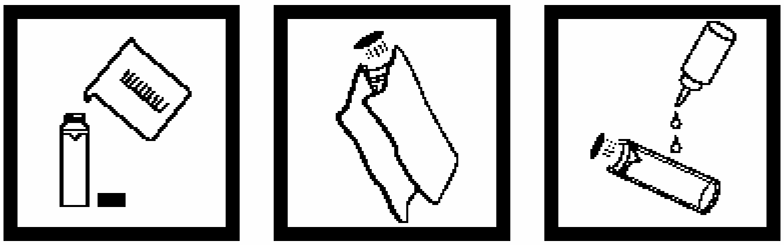
Turbidity

REFERENCES

Standard Methods for the Examination of Water and Wastewater, APHA et al, 20th Edition, 1998, Method 2130 B.

HACH Model 2100P, Instrument and Procedure Manual, CAT. NO. 46500-88, 2004

Figure 1
Making a Turbidity Measurement



1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell. (See *Section 2.3* on page *22* for more information about collecting a representative sample).

Note: The instrument automatically shuts off after 5.5 minutes if no keystrokes occur. To resume operation, press I/O.

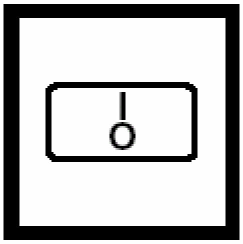
2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.

3. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.

Using silicone oil is optional

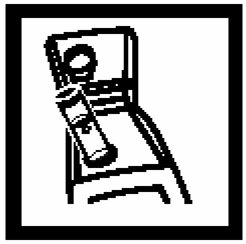
Analyze one sample in duplicate each shift. Results for duplicate analyses should be within 20% of each other.

Figure 1 continued
Making a Turbidity Measurement

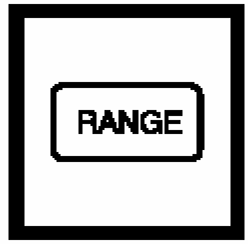


4. Press: I/O.

The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements.

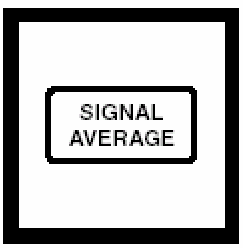


5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
Close the lid.

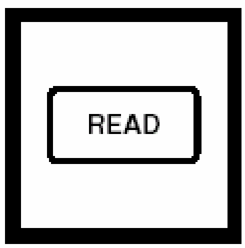


6. Select manual or automatic range selection by pressing the RANGE key. The display will show **AUTO RNG** when the instrument is in automatic range selection.

Use the automatic range mode (**AUTO RNG)** for routine measurements.



7. Select signal averaging mode by pressing the SIGNAL AVERAGE key. The display will show **SIG AVG** when the instrument is using signal averaging. Use signal average mode if the sample causes a noisy signal (display changes constantly).



8. Press: READ

The display will show **- - - - NTU**, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

Note: The instrument defaults to the last operating mode selected. If automatic range mode and signal averaging were used on the previous measurements, these options will automatically be selected for subsequent samples.

Appendix F
List of Equipment O&M Manuals

APPENDIX F

List of Equipment O&M Manuals

Equipment O&M Manuals include:

1. Reverse Osmosis System, Ecolochem
2. Microfiltration System, Pall Corporation
3. Centrifugal Pumps, Fybroc Corporation
4. Chemical Metering Pumps, LMI Corporation
5. Air Operated Diaphragm Pumps, Ingersoll Rand
6. Mixers, Lightnin Corporation
7. Air Compressor, Gardner Denver Corp.
8. Air Blower, Gardner Denver Corp.
9. Well Pumps, Grundfos Corporation
10. Dry Polymer Feed System, Nalco Corp.
11. Clarifier, Parkson Corp.
12. Seal Water System, Aquaboost
13. Sump Pump, Fybroc
14. FRP Tanks, Palmer
15. Demister System, Mapco
16. Instrumentation and Controls, Various

Appendix G
Alarms and Troubleshooting Summary

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
1	LSH100	LCP-001	DI	I:12/0	LSH100	1001	****************	A	Well Vault No. 2 High Water Level	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Leaking connection in well vault.		Accumulated rain water.					
2	LT100	LCP-001	AI	I:1.0		1002	110% normal	A	Extraction Well TW-2S Level High	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Possible pump malfunction. May also see low flow alarm and/or low pressure alarm.	Check pump.	Flow may be obstructed or valve closed. May also have low flow alarm or high pressure alarm.	Check valve settings.				
3	LT100	LCP-001	AI	I:1.0		1003	85% normal	A	Extraction Well TW-2S Level Low	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Throttling valve has been opened. May also have high flow alarm.	Check flow rate and throttle valve position.	Possible leak in primary containment before throttle valve . May have leak detection alarm and/or low flow alarm.	Check Valve Vault No. 1.				
4	PIT100	LCP-001	AI	I:1.1		1004	155 psig	A	Extraction Well TW-2S Line Pressure High	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Flow may be obstructed or valve closed. May also have low flow alarm or high pressure alarm.	Check valve settings.						
5	PIT100	LCP-001	AI	I:1.1		1005	50 psig	A	Extraction Well TW-2S Line Pressure Low	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Possible leak in primary containment before throttle valve . May have leak detection alarm and/or low flow alarm.	Check Valve Vault No. 1.						
6	FIT100	LCP-001	AI	I:1.2		1006	45 gpm	A	Extraction Well TW-2S Flow High	HMI Alarm			Investigate Cause at Extraction Well TW-2S	Throttling valve has been opened or back pressure valve setting has changed.	Check valve settings.	Possible leak in primary containment after the flow meter. May have high level alarm in Valve Vault 1 if leak is there or leak detection system alarm if leak is in double-contained discharge line.	Check Valve Vault No. 1 and leak detection panel.				
7	FIT100	LCP-001	AI	I:1.2		1007	15 gpm	A	Extraction Well TW-2S Flow Low	HMI Alarm			Investigate Cause at Extraction Well TW-2S	One or more valves between pump and Raw Water Tank have been closed.	Check valve settings.	Pump malfunction.	Check pump.				
8	P100 ON	LCP-001	DI	I:12/1		1008	10 sec	A	Extraction Well TW-2S Pump Fail to Start	HMI Alarm			Investigate Cause at Extraction Well TW-2S								
9	P100 ON	LCP-001	DI	I:12/1		1009	10 sec	A	Extraction Well TW-2S Pump Fail to Stop	HMI Alarm			Investigate Cause at Extraction Well TW-2S								
10	LSH101	LCP-001	DI	I:12/3	LSH101	1010	****************	A	Well Vault No. 1 High Water Level	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Leaking connection in well vault.		Accumulated rain water.					
11	LT101	LCP-001	AI	I:1.3		1011	110% normal	A	Extraction Well TW-2D Level High	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Possible pump malfunction. May also see low flow alarm and/or low pressure alarm.	Check pump.	Flow may be obstructed or valve closed. May also have low flow alarm or high pressure alarm.	Check valve settings.				
12	LT101	LCP-001	AI	I:1.3		1012	85% normal	A	Extraction Well TW-2D Level Low	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Throttling valve has been opened. May also have high flow alarm.	Check flow rate and throttle valve position.	Possible leak in primary containment before throttle valve . May have leak detection alarm and/or low flow alarm.	Check Valve Vault No. 1.				
13	PIT101	LCP-001	AI	I:1.4		1013	155 psig	A	Extraction Well TW-2D Line Pressure High	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Flow may be obstructed or valve closed. May also have low flow alarm or high pressure alarm.	Check valve settings.						

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
14	PIT101	LCP-001	AI	I:1.4		1014	50 psig	A	Extraction Well TW-2D Line Pressure Low	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Possible leak in primary containment before throttle valve . May have leak detection alarm and/or low flow alarm.	Check Valve Vault No. 1.						
15	FIT101	LCP-001	AI	I:1.5		1015	95 gpm	A	Extraction Well TW-2D Flow High	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Throttling valve has been opened or back pressure valve setting has changed.	Check valve settings.	Possible leak in primary containment after the flow meter. May have high level alarm in Valve Vault 1 if leak is there or leak detection system alarm if leak is in double-contained discharge line.	Check Valve Vault No. 1 and leak detection panel.				
16	FIT101	LCP-001	AI	I:1.5		1016	45 gpm	A	Extraction Well TW-2D Flow Low	HMI Alarm	Shutdown Pump P-101 after one minute time delay		Investigate Cause at Extraction Well TW-2D	One or more valves between pump and Raw Water Tank have been closed.	Check valve settings.	Pump malfunction.	Check pump.				
17	P101 ON	LCP-001	DI	I:12/4		1017	10 sec	A	Extraction Well TW-2D Pump Fail to Start	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Another alarm condition exists that has shut down the system.	Check other alarm conditions.	Pump malfunction or loss of power..					
18	P101 ON	LCP-001	DI	I:12/4		1018	10 sec	A	Extraction Well TW-2D Pump Fail to Stop	HMI Alarm			Investigate Cause at Extraction Well TW-2D	Pump malfunction.							
37	LSH001	LCP-001	DI	I:12/12	LSH001	1019	****************	A	Valve Vault No. 1 High Water Level	HMI Alarm			Investigate Cause at Valve Vault No. 1	Leaking connection in valve vault.		Accumulated rain water.					
39	LSH002	LCP-001	DI	I:12/14	LSH002	1020	****************	A	Valve Vault No. 2 High Water Level	HMI Alarm			Investigate Cause at Valve Vault No. 2								
41	ZSO100	LCP-001	DI	I:13/0		1021	10 sec	A	Raw Water Storage Tank Block Valve Fail to Open	HMI Alarm			Check Limit Switches on Raw Water Tank Influent Valve	Valve malfunction							
42	ZSC100	LCP-001	DI	I:13/1		1022	10 sec	A	Raw Water Storage Tank Block Valve Fail to Close	HMI Alarm			Check Limit Switches on Raw Water Tank Influent Valve	Valve malfunction							
43		LCP-001				1023	immediate	A	Raw Water Storage Tank Block Valve Double Limits	HMI Alarm			Check Limit Switches on Raw Water Tank Influent Valve	Valve malfunction							
44		LCP-001				1024	10 sec	A	Raw Water Storage Tank Block Valve No Limits	HMI Alarm			Check Limit Switches on Raw Water Tank Influent Valve	Valve malfunction							
46	LIT200	LCP-001	AI	I:2.12		1025	10 ft	A	Raw Water Storage Tank Level High	HMI Alarm			Visually Check Level on Raw Water Storage Tank	Tank level control setpoints incorrect.	Check tank level control setpoints.	Process Drain Pump discharging to tank.	Check process drain tank.				
47	LIT200	LCP-001	AI	I:2.12		1026	2 ft	A	Raw Water Storage Tank Level Low	HMI Alarm			Visually Check Level on Raw Water Storage Tank	Raw Water Feed Pump discharge set higher than well pumps.	Check well pumps and balance flows.	Control valve FCV-200 stuck open.	Check control valve.				
49	P200 ON	LCP-001	DI	I:13/3		1027	10 sec	A	Raw Water Feed Pump Fail to Start	HMI Alarm			Check Raw Water Feed Pump Motor Starter	Pump malfunction.							
50	P200 ON	LCP-001	DI	I:13/3		1028	10 sec	A	Raw Water Feed Pump Fail to Stop	HMI Alarm			Check Raw Water Feed Pump Motor Starter	Pump malfunction.							
51	FIT 200	LCP-001	AI	I:5.0		1029	15 gpm	A	Plant Influent Flow	HMI Alarm			Check Control Valve FCV200 and Setpoint	Control valve malfunction.							
52	FIT 200	LCP-001	AI	I:5.0		1030	150 gpm	A	Plant Influent Flow	HMI Alarm			Check Control Valve FCV200 and Setpoint	Control valve malfunction, other valves closed, line obstruction,	Check valve settings and pump discharge pressure gage.						
54	LIT700	LCP-001	AI	I:4.0		1031	10 ft	A	Treated Water Tank Level High	HMI Alarm			Visually Check Level on Treated Water Storage Tank	Malfunction of Treated Water Transfer Pump	Check pump, valve settings, and discharge pressure gage.						
55	LIT700	LCP-001	AI	I:4.0		1032	3 ft	A	Treated Water Tank Level Low	HMI Alarm			Visually Check Level on Treated Water Storage Tank	Tank level control setpoints incorrect.	Check tank level control setpoints.						

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
57	P700 ON	LCP-001	DI	I:13/5		1033	10 sec	A	Treated Water Transfer Pump Fail to Start	HMI Alarm			Check Treated Water Transfer Pump Motor Starter	Pump malfunction.							
58	P700 ON	LCP-001	DI	I:13/5		1034	10 sec	A	Treated Water Transfer Pump Fail to Stop	HMI Alarm			Check Treated Water Transfer Pump Motor Starter	Pump malfunction.							
59	PSL 1100	LCP-001	DI	I:13/7	PSL 1100	1035	****************	A	Seal Water System Low Pressure	HMI Alarm	Shutdown all Pumps which require seal water after 30 second time delay		Check Pump Seal Flush Water System for Status	Seal water pump malfunction	Check pump.	Seal water system leaks or open line.	Check seal water system for leaks or open line.				
60	FIT 700	LCP-001	AI	I:5.2		1036	150 gpm	A	Plant Effluent Flow to Baker Tank High	HMI Alarm			Check Baker Tank Valve line-up	Improper Valve Line-up		Line Break					
61	FIT 700	LCP-001	AI	I:5.2		1037	15 gpm	A	Plant Effluent Flow to Baker Tank Low	HMI Alarm			Check Baker Tank Valve line-up	Improper Valve Line-up		Line obstruction or incorrect valve setting.	Check pump pressure gage and discharge valves.				
62	ZSO201	LCP-001	DI	I:13/8		1038	10 sec	A	Plant Influent Block Valve Fail to Open	HMI Alarm			Check Limit Switches on Plant Influent Valve	Valve malfunction							
63	ZSC201	LCP-001	DI	I:13/9		1039	10 sec	A	Plant Influent Block Valve Fail to Close	HMI Alarm			Check Limit Switches on Plant Influent Valve	Valve malfunction							
64		LCP-001				1040	immediate	A	Plant Influent Block Valve Double Limits	HMI Alarm			Check Limit Switches on Plant Influent Valve	Valve malfunction							
65		LCP-001				1041	10 sec	A	Plant Influent Block Valve No Limits	HMI Alarm			Check Limit Switches on Plant Influent Valve	Valve malfunction							
66	AIT201pH	LCP-001	AI	I:2.0		1042	8.0 pH	A	Plant Influent pH High	HMI Alarm			Check Plant Influent pH Sensor	pH sensor out of calibration	Recalibrate pH sensor	High pH water being recycled to Raw Water Tank	Check process drain tank pH.				
67	AIT201pH	LCP-001	AI	I:2.0		1043	7.0 pH	A	Plant Influent pH Low	HMI Alarm			Check Plant Influent pH Sensor	pH sensor out of calibration	Recalibrate pH sensor	Low pH water being recycled to Raw Water Tank	Check process drain tank pH.				
68	AIT201TEMP	LCP-001	AI	I:2.1		1044	90 deg F	A	Plant Influent Temperature High	HMI Alarm			Check Plant Influent pH Sensor	pH sensor out of calibration	Recalibrate pH sensor						
69	AIT201TEMP	LCP-001	AI	I:2.1		1045	70 deg F	A	Plant Influent Temperature Low	HMI Alarm			Check Plant Influent pH Sensor	pH sensor out of calibration	Recalibrate pH sensor						
71	P201 ON	LCP-001	DI	I:13/12		1046	10 sec	A	Chemical Mixing Pump Fail to Start	HMI Alarm			Check Chemical Mixing Pump Motor Starter	Pump malfunction.							
72	P201 ON	LCP-001	DI	I:13/12		1047	10 sec	A	Chemical Mixing Pump Fail to Stop	HMI Alarm			Check Chemical Mixing Pump Motor Starter	Pump malfunction.							
74	AIT202-1pH	LCP-001	AI	I:2.2		1048	6.8 pH	A	Chemical Mixing Loop pH #1 High	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
75	AIT202-1pH	LCP-001	AI	I:2.2		1049	5.0 pH	A	Chemical Mixing Loop pH #1 Low	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too low.	Confirm chemical strength.
76	AIT202-1TEMP	LCP-001	AI	I:2.3		1050	90 deg F	A	Chemical Mixing Loop Temperature #1 High	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							
77	AIT202-1TEMP	LCP-001	AI	I:2.3		1051	60 deg F	A	Chemical Mixing Loop Temperature #1 Low	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							
79	AIT202-2pH	LCP-001	AI	I:3.2		1052	6.8 pH	A	Chemical Mixing Loop pH #2 High	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
80	AIT202-2pH	LCP-001	AI	I:3.2		1053	5.0 pH	A	Chemical Mixing Loop pH #2 Low	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too low.	Confirm chemical strength.
81	AIT202-2TEMP	LCP-001	AI	I:3.3		1054	90 deg F	A	Chemical Mixing Loop Temperature #2 High	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							
82	AIT202-2TEMP	LCP-001	AI	I:3.3		1055	70 deg F	A	Chemical Mixing Loop Temperature #2 Low	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							
83		LCP-001				1056	0.5 pH	A	Chemical Mixing Loop pH Transmitter Deviation	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							
84		LCP-001				1057	5 deg	A	Chemical Mixing Loop TEMP Transmitter Deviation	HMI Alarm			Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration							

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
85	M300 ON	LCP-001	DI	I:13/14		1058	10 sec	A	Chromium Reduction Reactor Mixer Fail to Start	HMI Alarm			Check Chromium Reduction Reactor Mixer Motor Starter	Mixer malfunction							
86	M300 ON	LCP-001	DI	I:13/14		1059	10 sec	A	Chromium Reduction Reactor Mixer Fail to Stop	HMI Alarm			Check Chromium Reduction Reactor Mixer Motor Starter	Mixer malfunction							
89	AIT300-1pH	LCP-001	AI	I:2.4		1060	6.8 pH	A	Chromium Reduction Reactor pH #1 High	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
90	AIT300-1pH	LCP-001	AI	I:2.4		1061	5.0 pH	A	Chromium Reduction Reactor pH #1 Low	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too low.	Confirm chemical strength.
91	AIT300-1TEMP	LCP-001	AI	I:2.5		1062	90 deg F	A	Chromium Reduction Reactor Temperature #1 High	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
92	AIT300-1TEMP	LCP-001	AI	I:2.5		1063	60 deg F	A	Chromium Reduction Reactor Temperature #1 Low	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
94	AIT300-2pH	LCP-001	AI	I:3.4		1064	6.8 pH	A	Chromium Reduction Reactor pH #2 High	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
95	AIT300-2pH	LCP-001	AI	I:3.4		1065	5.0 pH	A	Chromium Reduction Reactor pH #2 Low	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too low.	Confirm chemical strength.
96	AIT300-2TEMP	LCP-001	AI	I:3.5		1066	90 deg F	A	Chromium Reduction Reactor Temperature #2 High	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
97	AIT300-2TEMP	LCP-001	AI	I:3.5		1067	70 deg F	A	Chromium Reduction Reactor Temperature #2 Low	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
98		LCP-001				1068	0.5 pH	A	Chromium Reduction Reactor pH Transmitter Deviation	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
99		LCP-001				1069	5 deg	A	Chromium Reduction Reactor TEMP Transmitter Deviation	HMI Alarm			Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration							
100	M301A ON	LCP-001	DI	I:14/2		1070	10 sec	A	Iron Oxidation Reactor No. 1 Mixer Fail to Start	HMI Alarm			Check Iron Oxidation Reactor 1 Mixer Motor Starter	Mixer malfunction							
101	M301A ON	LCP-001	DI	I:14/2		1071	10 sec	A	Iron Oxidation Reactor No. 1 Mixer Fail to Stop	HMI Alarm			Check Iron Oxidation Reactor 1 Mixer Motor Starter	Mixer malfunction							
103	AIT301A-1pH	LCP-001	AI	I:2.6		1072	8.5 pH	A	Iron Oxidation Reactor No. 1 pH #1 High	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
104	AIT301A-1pH	LCP-001	AI	I:2.6		1073	7.5 pH	A	Iron Oxidation Reactor No. 1 pH #1 Low	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
106	AIT301A-1TEMP	LCP-001	AI	I:2.7		1074	90 deg F	A	Iron Oxidation Reactor No. 1 Temperature #1 Low	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							
107	AIT301A-1TEMP	LCP-001	AI	I:2.7		1075	70 deg F	A	Iron Oxidation Reactor No. 1 Temperature #1 Low	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							
108	AIT301A-2pH	LCP-001	AI	I:3.6		1076	8.5 pH	A	Iron Oxidation Reactor No. 1 pH #2 High	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
109	AIT301A-2pH	LCP-001	AI	I:3.6		1077	7.5 pH	A	Iron Oxidation Reactor No. 1 pH #2 Low	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
111	AIT301A-2TEMP	LCP-001	AI	I:3.7		1078	90 deg F	A	Iron Oxidation Reactor No. 1 Temperature #2 High	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							
112	AIT301A-2TEMP	LCP-001	AI	I:3.7		1079	70 deg F	A	Iron Oxidation Reactor No. 1 Temperature #2 Low	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							
113		LCP-001				1080	0.5 pH	A	Iron Oxidation Reactor No. 1 pH Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							
114		LCP-001				1081	5 deg	A	Iron Oxidation Reactor No. 1 Temp Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration							

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
115	M301B ON	LCP-001	DI	I:14/5		1082	10 sec	A	Iron Oxidation Reactor No. 2 Mixer Fail to Start	HMI Alarm			Check Iron Oxidation Reactor 2 Mixer Motor Starter	Mixer malfunction							
116	M301B ON	LCP-001	DI	I:14/5		1083	10 sec	A	Iron Oxidation Reactor No. 2 Mixer Fail to Stop	HMI Alarm			Check Iron Oxidation Reactor 2 Mixer Motor Starter	Mixer malfunction							
118	AIT301B-1pH	LCP-001	AI	I:2.8		1084	8.5 pH	A	Iron Oxidation Reactor No. 2 pH #1 High	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
119	AIT301B-1pH	LCP-001	AI	I:2.8		1085	7.5 pH	A	Iron Oxidation Reactor No. 2 pH #1 Low	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
121	AIT301B-1TEMP	LCP-001	AI	I:2.9		1086	90 deg F	A	Iron Oxidation Reactor No. 2 Temperature #1 High	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
122	AIT301B-1TEMP	LCP-001	AI	I:2.9		1087	70 deg F	A	Iron Oxidation Reactor No. 2 Temperature #1 Low	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
123	AIT301B-2pH	LCP-001	AI	I:3.8		1088	8.5 pH	A	Iron Oxidation Reactor No. 2 pH #2 High	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
124	AIT301B-2pH	LCP-001	AI	I:3.8		1089	7.5 pH	A	Iron Oxidation Reactor No. 2 pH #2 Low Low	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
126	AIT301B-2TEMP	LCP-001	AI	I:3.9		1090	90 deg F	A	Iron Oxidation Reactor No. 2 Temperature #2 High	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
127	AIT301B-2TEMP	LCP-001	AI	I:3.9		1091	70 deg F	A	Iron Oxidation Reactor No. 2 Temperature #2 Low	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
128		LCP-001				1092	0.5 pH	A	Iron Oxidation Reactor No. 2 pH Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
129		LCP-001				1093	5 deg	A	Iron Oxidation Reactor No. 2 Temp Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration							
130	M301C ON	LCP-001	DI	I:14/8		1094	10 sec	A	Iron Oxidation Reactor No. 3 Mixer Fail to Start	HMI Alarm			Check Iron Oxidation Reactor 3 Mixer Motor Starter	Mixer malfunction							
131	M301C ON	LCP-001	DI	I:14/8		1095	10 sec	A	Iron Oxidation Reactor No. 3 Mixer Fail to Stop	HMI Alarm			Check Iron Oxidation Reactor 3 Mixer Motor Starter	Mixer malfunction							
132	LIT301C	LCP-001	AI	I:2.13		1096	14 ft	A	Iron Oxidation Reactor No. 3 Level High	HMI Alarm			Check Iron Oxidation Reactor 3 Level	Sensor malfunction, line obstruction, or discharge valve closed.							
133	LIT301C	LCP-001	AI	I:2.13		1097	10 ft	A	Iron Oxidation Reactor No. 3 Level Low	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor								
136	AIT301C-1pH	LCP-001	AI	I:2.10		1098	8.5 pH	A	Iron Oxidation Reactor No. 3 pH #1 High	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
137	AIT301C-1pH	LCP-001	AI	I:2.10		1099	7.5 pH	A	Iron Oxidation Reactor No. 3 pH #1 Low	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
139	AIT301C-1TEMP	LCP-001	AI	I:2.11		1100	90 deg F	A	Iron Oxidation Reactor No. 3 Temperature #1 High	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							
140	AIT301C-1TEMP	LCP-001	AI	I:2.11		1101	70 deg F	A	Iron Oxidation Reactor No. 3 Temperature #1 Low	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							
141	AIT301C-2pH	LCP-001	AI	I:3.10		1102	8.5 pH	A	Iron Oxidation Reactor No. 3 pH #2 High	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
142	AIT301C-2pH	LCP-001	AI	I:3.10		1103	7.5 pH	A	Iron Oxidation Reactor No. 3 pH #2 Low	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical feed pump in local mode.	Switch pump to remote mode.	Chemical strength too high.	Confirm chemical strength.
144	AIT301C-2TEMP	LCP-001	AI	I:3.11		1104	90 deg F	A	Iron Oxidation Reactor No. 3 Temperature #2 High	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
145	AIT301C-2TEMP	LCP-001	AI	I:3.11		1105	70 deg F	A	Iron Oxidation Reactor No. 3 Temperature #2 Low	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							
146		LCP-001				1106	0.5 pH	A	Iron Oxidation Reactor No. 3 pH Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							
147		LCP-001				1107	5 deg	A	Iron Oxidation Reactor No. 3 Temp Transmitter Deviation	HMI Alarm			Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration							
148	P400 ON	LCP-001	DI	I:14/11		1108	10 sec	A	Clarifier Feed Pump Fail to Start	HMI Alarm			Check Clarifier Feed Pump VFD	Pump or pump control malfunction							
149	P400 ON	LCP-001	DI	I:14/11		1109	10 sec	A	Clarifier Feed Pump Fail to Stop	HMI Alarm			Check Clarifier Feed Pump VFD	Pump or pump control malfunction							
150	P400 FAIL	LCP-001	DI	I:14/13	P400 FAIL	1110	****************	A	Clarifier Feed Pump Drive Fail	HMI Alarm			Check Clarifier Feed Pump VFD	Pump or pump control malfunction							
151	M400A ON	LCP-001	DI	I:14/14		1111	10 sec	A	Clarifier Influent Mixer Fail to Start	HMI Alarm			Check Clarifier Influent Mixer Motor Starter	Mixer malfunction							
152	M400A ON	LCP-001	DI	I:14/14		1112	10 sec	A	Clarifier Influent Mixer Fail to Stop	HMI Alarm			Check Clarifier Influent Mixer Motor Starter	Mixer malfunction							
153	NSH400	LCP-001	DI	I:15/0	NSH400	1113	****************	A	Clarifier Sludge Rake High Torque	HMI Alarm			Check Clarifier Rake For Jamming, Reset High Torque Switch	Clarifier rake drive malfunction							
154	M400B ON	LCP-001	DI	I:15/1		1114	10 sec	A	Clarifier Secondary Mixer Fail to Start	HMI Alarm			Check Clarifier Secondary Mixer Motor Starter	Mixer malfunction							
155	M400B ON	LCP-001	DI	I:15/1		1115	10 sec	A	Clarifier Secondary Mixer Fail to Stop	HMI Alarm			Check Clarifier Secondary Mixer Motor Starter	Mixer malfunction							
156	M400C ON	LCP-001	DI	I:15/3		1116	10 sec	A	Clarifier Sludge Rake Fail to Start	HMI Alarm			Check Clarifier Sludge Rake Motor Starter	Clarifier rake drive malfunction							
157	M400C ON	LCP-001	DI	I:15/3		1117	10 sec	A	Clarifier Sludge Rake Fail to Stop	HMI Alarm			Check Clarifier Sludge Rake Motor Starter	Clarifier rake drive malfunction							
158	ZSO400	LCP-001	DI	I:15/5		1118	10 sec	A	Clarifier Drain Valve Fail to Open	HMI Alarm			Check Clarifier Drain Valve for Jamming, Check Limit Switch	Sludge valve malfunction							
159	ZSC400	LCP-001	DI	I:15/6		1119	10 sec	A	Clarifier Drain Valve Fail to Close	HMI Alarm			Check Clarifier Drain Valve for Jamming, Check Limit Switch	Sludge valve malfunction							
160		LCP-001				1120	immediate	A	Clarifier Drain Valve Double Limits	HMI Alarm			Check Clarifier Drain Valve for Jamming, Check Limit Switch	Sludge valve malfunction							
161		LCP-001				1121	10 sec	A	Clarifier Drain Valve No Limits	HMI Alarm			Check Clarifier Drain Valve for Jamming, Check Limit Switch	Sludge valve malfunction							
162	LSH900	LCP-001	DI	I:15/8	LSH900	1122	****************	A	Process Drain Tank Containment High Level	HMI Alarm			Visually Check Drain Tank Containment Area For Water	Waste accumulating in containment.							
163	LIT900	LCP-001	AI	I:3.0		1123	7 ft	A	Process Drain Tank Level High	HMI Alarm	Shutdown Pump Raw Water Pump P-200		Visually Check Level On Process Drains Tank	Set points incorrect	Check setpoints.	Pump malfunction.	Operate pump manually and confirm discharge at Raw Water Tank	Stuck check valve or downstream valve shut.	Check valve settings.		
164	LIT900	LCP-001	AI	I:3.0		1124	1.5 ft	A	Process Drain Tank Level Low	HMI Alarm			Visually Check Level On Process Drains Tank	Set points incorrect	Check setpoints.	Pump doesn't turn off.	Manually turn off pump.				
166	P900 ON	LCP-001	DI	I:15/9		1125	10 sec	A	Process Sump Drain Pump Fail to Start	HMI Alarm			Check Process Drain Pump Motor Starter	Pump malfunction.							
167	P900 ON	LCP-001	DI	I:15/9		1126	10 sec	A	Process Sump Drain Pump Fail to Stop	HMI Alarm			Check Process Drain Pump Motor Starter	Pump malfunction.							
168	LSH702	LCP-001	DI	I:18/5	LSH702	1127	****************	A	High Level Treated Water Storage Tank (Baker Tank)	HMI Alarm			Visually Check Level On Treated Water Baker Tank								
169	LIT402	LCP-001	AI	I:3.1		1128	11 ft	A	Sludge Holding Tank Level High	HMI Alarm			Visually Check Level On Sludge Holding Tank		Transfer sludge to the Phase Separators.						
170	LIT402	LCP-001	AI	I:3.1		1129	3 ft	A	Sludge Holding Tank Level Low	HMI Alarm			Visually Check Level On Sludge Holding Tank								
171	M402 ON	LCP-001	DI	I:15/12		1130	10 sec	A	Sludge Holding Tank Mixer Fail to Start	HMI Alarm			Check Sludge Holding Tank Mixer Motor Starter	Mixer malfunction							

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
172	M402 ON	LCP-001	DI	I:15/12		1131	10 sec	A	Sludge Holding Tank Mixer Fail to Stop	HMI Alarm			Check Sludge Holding Tank Mixer Motor Starter	Mixer malfunction							
173	LSHH 405	LCP-001	DI	I:16/1	LSHH 405	1132	****************	A	Phase Separator Area High High Level	HMI Alarm			Visually Check For Water in Phase Separator Containment Basin	Water accumulating in phase separator containment basin.							
174	LSH 405A	LCP-001	DI	I:16/2	LSH 405A	1133	****************	A	Phase Separator A High Level	HMI Alarm			Visually Check Level in Phase Separator A	Phase separator full.							
175	LSH 405B	LCP-001	DI	I:16/3	LSH 405B	1134	****************	A	Phase Separator B High Level	HMI Alarm			Visually Check Level in Phase Separator B	Phase separator full.							
177	LIT500	LCP-001	AI	I:2.14		1135	15 ft	A	Pretreated Water Tank Level High	HMI Alarm			Visually Check Level in Pre-Treated Water Storage Tank	P-400 is pumping faster than P-500	Check microfilter system permeate flow rate and strainer backpressure.	Consult microfilter manual if flux is below acceptable range. Clean strainer if clogged. Confirm that P-500 discharge valves are set correctly.					
178	LIT500	LCP-001	AI	I:2.14		1136	3 ft	A	Pretreated Water Tank Level Low	HMI Alarm			Visually Check Level in Pre-Treated Water Storage Tank	P-500 is pumping faster than P-400.	Check overall system flow.						
180	P500 ON	LCP-001	DI	I:16/4		1137	10 sec	A	Pretreated Water Transfer Pump Fail to Start	HMI Alarm			Check Pretreated Water Transfer Pump Motor Starter	Pump malfunction.							
181	P500 ON	LCP-001	DI	I:16/4		1138	10 sec	A	Pretreated Water Transfer Pump Fail to Stop	HMI Alarm			Check Pretreated Water Transfer Pump Motor Starter	Pump malfunction.							
183	LIT600	LCP-001	AI	I:2.15		1139	14 ft	A	Reverse Osmosis Feed Tank Level High	HMI Alarm			Visually Check Level in Reverse Osmosis Feed Tank	Level control set point incorrect.	Confirm level set point.	Membrane elements or cartridge filters may be fouled.	Check RO pressure elements and permeate flow. Consult manual regarding RO element cleaning if indicated. Check cartridge filter backpressure.	Valve settings incorrect.	Check valve settings.	Too much concentrate being recycled.	Check conductivity probes and setpoints.
184	LIT600	LCP-001	AI	I:2.15		1140	3 ft	A	Reverse Osmosis Feed Tank Level Low	HMI Alarm			Visually Check Level in Reverse Osmosis Feed Tank	Level control set point incorrect.	Confirm level set point.	Permeate recycle line obstructed.	Check for recycle flow.	Upstream malfunction.	Confirm upstream systems.		
186	P620 ON	LCP-001	DI	I:16/6		1141	10 sec	A	Filtered Water Transfer Pump Fail to Start	HMI Alarm			Check Filtered Water Transfer Pump Motor Starter	Pump malfunction.							
187	P620 ON	LCP-001	DI	I:16/6		1142	10 sec	A	Filtered Water Transfer Pump Fail to Stop	HMI Alarm			Check Filtered Water Transfer Pump Motor Starter	Pump malfunction.							
188	AIT 600 COND	LCP-001	AI	I:3.12		1143	11000 us/cm	A	Microfilter Unit Effluent Conductivity High High	HMI Alarm			Inspect and/or Clean Conductivity Sensor								
189	AIT 600 COND	LCP-001	AI	I:3.12		1144	10000us/cm	A	Microfilter Unit Effluent Conductivity High	HMI Alarm			Inspect and/or Clean Conductivity Sensor								
190	AIT 601 COND	LCP-001	AI	I:3.13		1145	110% (AIT600)	A	R.O. Unit Influent Conductivity High High	HMI Alarm			Inspect and/or Clean Conductivity Sensor	Excessive RO Concentrate recycle to T-600.	Check AIT604 set point. Check FCV-602.						
191	AIT 601 COND	LCP-001	AI	I:3.13		1146	105%(AIT600)	A	R.O. Unit Influent Conductivity High	HMI Alarm			Inspect and/or Clean Conductivity Sensor	Excessive RO Concentrate recycle to T-600.	Check AIT604 set point. Check FCV-602.						
192	AIT 604 COND	LCP-001	AI	I:3.14		1147	110% (AIT600)	A	R.O. Unit Blended Recycle Conductivity High High	HMI Alarm			Inspect and/or Clean Conductivity Sensor	Excessive RO Concentrate recycle to T-600.	Check AIT604 set point. Check FCV-602.						
193	AIT 604 COND	LCP-001	AI	I:3.14		1148	105%(AIT600)	A	R.O. Unit Blended Recycle Conductivity High	HMI Alarm			Inspect and/or Clean Conductivity Sensor	Excessive RO Concentrate recycle to T-600.	Check AIT604 set point. Check FCV-602.						
195	LIT 604	LCP-001	AI	I:5.3		1149	28 in	A	F.D. Aerator Basin Level High	HMI Alarm			Visually Check Level in FD Aerator Basin	Level control set point incorrect.	Confirm level set point.	Level control valve LCV-604 malfunction.	Check level control valve.				
196	LIT 604	LCP-001	AI	I:5.3		1150	20 in	A	F.D. Aerator Basin Level Low	HMI Alarm			Visually Check Level in FD Aerator Basin	Level control set point incorrect.	Confirm level set point.	Level control valve LCV-604 malfunction.	Check level control valve.				

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
199	LIT701	LCP-001	AI	I:4.1		1151	12.5 ft	A	R.O. Concentrate Tank Level High	HMI Alarm			Visually Check Level in RO Concentrate Storage Tank	Set points incorrect	Confirm level set point.	Pump discharge valves incorrectly set.	Check valve settings.	Pump malfunction.	Check pump.		
200	LIT701	LCP-001	AI	I:4.1		1152	1.5 ft	A	R.O. Concentrate Tank Level Low	HMI Alarm			Visually Check Level in RO Concentrate Storage Tank	Set points incorrect	Confirm level set point.						
202	P701 ON	LCP-001	DI	I:16/13		1153	10 sec	A	RO Concentrate Transfer Pump Fail to Start	HMI Alarm			Check RO Concentrate Transfer Pump Motor Starter	Pump malfunction.							
203	P701 ON	LCP-001	DI	I:16/13		1154	10 sec	A	RO Concentrate Transfer Pump Fail to Stop	HMI Alarm			Check RO Concentrate Transfer Pump Motor Starter	Pump malfunction.							
204	AIT701 COND	LCP-001	AI	I:4.2		1155	35000us/cm	A	R.O. Concentrate Conductivity High High	HMI Alarm			Inspect and/or Clean Conductivity Sensor								
205	AIT701 COND	LCP-001	AI	I:4.2		1156	32500us/cm	A	R.O. Concentrate Conductivity High	HMI Alarm			Inspect and/or Clean Conductivity Sensor								
207	AIT605 COND	LCP-001	AI	I:4.3		1157	650us/cm	A	R.O. Permeate Conductivity High	HMI Alarm			Inspect and/or Clean Conductivity Sensor	Damaged element.							
208	AIT606 pH	LCP-001	AI	I:4.4		1158	8.0 pH	A	R.O. Permeate pH High	HMI Alarm			Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
209	AIT606 pH	LCP-001	AI	I:4.4		1159	7.0 pH	A	R.O. Permeate pH Low	HMI Alarm			Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
210	AIT606 TEMP	LCP-001	AI	I:4.5		1160	90 deg F	A	R.O. Permeate Temperature High	HMI Alarm			Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
211	AIT606 TEMP	LCP-001	AI	I:4.5		1161	70 deg F	A	R.O. Permeate Temperature Low	HMI Alarm			Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
214	P801 ON	LCP-001	DI	I:17/1		1162	****************	A	Sulfuric Acid Pump Power Off	HMI Alarm			Check Status of Pump Power Disconnect Switch	Pump malfunction.							
215	FSL801	LCP-001	DI	I:21/1	FSL801	1163	****************	A	Sulfuric Acid Pump Low Flow	HMI Alarm			Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					
224	M804 FAIL	LCP-001	DI	I:17/12	FSL804	1164	****************	A	Polyelectrolyte System Failed	HMI Alarm			Check Polyelectrolyte System Control Panel	System malfunction							
225	FSL804	LCP-001	DI	I:17/13	FSL804	1165	****************	A	Polyelectrolyte System Low Water Flow	HMI Alarm			Check Polyelectrolyte System Control Panel								
226	LSL804	LCP-001	DI	I:17/14	LSL804	1166	****************	A	Polyelectrolyte System Feed Hopper Low Level	HMI Alarm			Check Polyelectrolyte System Control Panel	Chemical container empty							
227	B300 ON	LCP-001	DI	I:17/15		1167	10 sec	A	Oxidation Air Blower Fail to Start	HMI Alarm			Check Aeration Blower Motor Starter	Blower malfunction							
228	B300 ON	LCP-001	DI	I:17/15		1168	10 sec	A	Oxidation Air Blower Fail to Stop	HMI Alarm			Check Aeration Blower Motor Starter	Blower malfunction							
229	PIT1000	LCP-001	AI	I:5.7		1169	140 psig	A	Plant Instrument Air Pressure High	HMI Alarm			Check Instrument Air Compressor for Proper Shutoff Setting								
230	PIT1000	LCP-001	AI	I:5.7		1170	110 psig	A	Plant Instrument Air Pressure Low	HMI Alarm			Check Instrument Air Compressor, Inspect For Air Leaks								
231	CMP1000 FAIL	LCP-001	DI	I:18/2	CMP1000 FAIL	1171	****************	A	Plant Instrument Air Compressor Fail Alarm	HMI Alarm			Check Instrument Air Compressor Control Panel								
232	FIT 300A	LCP-001	AI	I:4.6		1172	95 scfm	A	Iron Oxidation Reactor No. 1 Air Flow High	HMI Alarm			Check Air Flow Indicator A, Check Butterfly Valve Position								
233	FIT 300A	LCP-001	AI	I:4.6		1173	80 scfm	A	Iron Oxidation Reactor No. 1 Air Flow Low	HMI Alarm			Check Air Flow Indicator A, Check Butterfly Valve Position								
235	FIT 300B	LCP-001	AI	I:4.7		1174	95 scfm	A	Iron Oxidation Reactor No. 2 Air Flow High	HMI Alarm			Check Air Flow Indicator B, Check Butterfly Valve Position								
236	FIT 300B	LCP-001	AI	I:4.7		1175	80 scfm	A	Iron Oxidation Reactor No. 2 Air Flow Low	HMI Alarm			Check Air Flow Indicator B, Check Butterfly Valve Position								
238	FIT 300C	LCP-001	AI	I:4.8		1176	95 scfm	A	Iron Oxidation Reactor No. 3 Air Flow High	HMI Alarm			Check Air Flow Indicator C, Check Butterfly Valve Position								

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
239	FIT 300C	LCP-001	AI	I:4.8		1177	80 scfm	A	Iron Oxidation Reactor No. 3 Air Flow Low	HMI Alarm			Check Air Flow Indicator C, Check Butterfly Valve Position								
241	LSH703	LCP-001	DI	I:18/6	LSH703	1178	****************	A	High Level R O Concentrate Storage Tank (Baker Tank)	HMI Alarm			Visually Check Level on RO Concentrate Baker Tank								
242	LSH201A-P	LCP-001	DI	I:18/4	LSH201A-P	1179	****************	A	Pipeline Leak Detection Control Panel Leak Alarm	HMI Alarm	Shutdown all extraction well pumps	Operator Manual Restart	Check Leak Detection Control Panel For Source of Leak, Repair								
243	AIT400 TURB	LCP-001	AI	I:4.9		1180	30 NTU	A	Clarifier Effluent Turbidity High High	HMI Alarm			Check Turbidimeter, Calibrate if Required	No polymer addition or incorrect dose.	Verify polymer addition	Sludge blanket level in clarifier too high	Increase sludge wasting rate				
244	AIT400 TURB	LCP-001	AI	I:4.9		1181	20 NTU	A	Clarifier Effluent Turbidity High	HMI Alarm			Check Turbidimeter, Calibrate if Required	No polymer addition or incorrect dose.	Verify polymer addition	Sludge blanket level in clarifier too high	Increase sludge wasting rate				
245	LSH1250	LCP-001	DI	I:18/7	LSH1250	1182	****************	A	Sewage Tank High Level	HMI Alarm			Visually Inspect Sewage Tank Level, Call Pump Truck								
246	LT1201 (future)	ICP-001	AI	I:1.0		1183	110% normal	A	Injection Well No. 1 Level High	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
247	LT1201 (future)	ICP-001	AI	I:1.0		1184	85% normal	A	Injection Well No. 1 Level Low	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
248	PIT1201 (future)	ICP-001	AI	I:1.1		1185	110% normal	A	Injection Well No. 1 Line Pressure High	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
249	PIT1201 (future)	ICP-001	AI	I:1.1		1186	85% normal	A	Injection Well No. 1 Line Pressure Low	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
250	FIT1201 (future)	ICP-001	AI	I:1.2		1187	110% normal	A	Injection Well No. 1 Flow High	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
251	FIT1201 (future)	ICP-001	AI	I:1.2		1188	85% normal	A	Injection Well No. 1 Flow Low	HMI Alarm			Investigate Injection Well No 1 Problem at Wellhead								
252	LT1202	ICP-001	AI	I:1.3		1189	110% normal	A	Injection Well No. 2 Level High	HMI Alarm			Investigate Injection Well No 2 Problem at Wellhead								
253	LT1202	ICP-001	AI	I:1.3		1190	85% normal	A	Injection Well No. 2 Level Low	HMI Alarm			Investigate Injection Well No 2 Problem at Wellhead								
254	PIT1202	ICP-001	AI	I:1.4		1191	110% normal	A	Injection Well No. 2 Line Pressure High	HMI Alarm	Shutdown Pump P-700 after one minute time delay		Investigate Injection Well No 2 Problem at Wellhead								
255	PIT1202	ICP-001	AI	I:1.4		1192	85% normal	A	Injection Well No. 2 Line Pressure Low	HMI Alarm			Investigate Injection Well No 2 Problem at Wellhead								
256	FIT1202	ICP-001	AI	I:1.5		1193	110% normal	A	Injection Well No. 2 Flow High	HMI Alarm			Investigate Injection Well No 2 Problem at Wellhead								
257	FIT1202	ICP-001	AI	I:1.5		1194	85% normal	A	Injection Well No. 2 Flow Low	HMI Alarm			Investigate Injection Well No 2 Problem at Wellhead								
258	LT1203	ICP-001	AI	I:1.6		1195	110% normal	A	Injection Well No. 3 Level High	HMI Alarm			Investigate Injection Well No 3 Problem at Wellhead								
259	LT1203	ICP-001	AI	I:1.6		1196	85% normal	A	Injection Well No. 3 Level Low	HMI Alarm			Investigate Injection Well No 3 Problem at Wellhead								
260	PIT1203	ICP-001	AI	I:1.7		1197	110% normal	A	Injection Well No. 3 Line Pressure High	HMI Alarm	Shutdown Pump P-700 after one minute time delay		Investigate Injection Well No 3 Problem at Wellhead								
261	PIT1203	ICP-001	AI	I:1.7		1198	85% normal	A	Injection Well No. 3 Line Pressure Low	HMI Alarm			Investigate Injection Well No 3 Problem at Wellhead								
262	FIT1203	ICP-001	AI	I:1.8		1199	110% normal	A	Injection Well No. 3 Flow High	HMI Alarm			Investigate Injection Well No 3 Problem at Wellhead								
263	FIT1203	ICP-001	AI	I:1.8		1200	85% normal	A	Injection Well No. 3 Flow Low	HMI Alarm			Investigate Injection Well No 3 Problem at Wellhead								

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
264	LT1204	ICP-001	AI	I:1.9		1201	110% normal	A	Injection Well No. 4 Level High	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
265	LT1204	ICP-001	AI	I:1.9		1202	85% normal	A	Injection Well No. 4 Level Low	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
266	PIT1204 (future)	ICP-001	AI	I:1.10		1203	110% normal	A	Injection Well No. 4 Line Pressure High	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
267	PIT1204 (future)	ICP-001	AI	I:1.10		1204	85% normal	A	Injection Well No. 4 Line Pressure Low	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
268	FIT1204 (future)	ICP-001	AI	I:1.11		1205	110% normal	A	Injection Well No. 4 Flow High	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
269	FIT1204 (future)	ICP-001	AI	I:1.11		1206	85% normal	A	Injection Well No. 4 Flow Low	HMI Alarm			Investigate Injection Well No 4 Problem at Wellhead								
270	LT1205 (future)	ICP-001	AI	I:1.12		1207	110% normal	A	Injection Well No. 5 Level High	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
271	LT1205 (future)	ICP-001	AI	I:1.12		1208	85% normal	A	Injection Well No. 5 Level Low	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
272	PIT1205 (future)	ICP-001	AI	I:1.13		1209	110% normal	A	Injection Well No. 5 Line Pressure High	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
273	PIT1205 (future)	ICP-001	AI	I:1.13		1210	85% normal	A	Injection Well No. 5 Line Pressure Low	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
274	FIT1205 (future)	ICP-001	AI	I:1.14		1211	110% normal	A	Injection Well No. 5 Flow High	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
275	FIT1205 (future)	ICP-001	AI	I:1.14		1212	85% normal	A	Injection Well No. 5 Flow Low	HMI Alarm			Investigate Injection Well No 5 Problem at Wellhead								
276	LT1206 (future)	ICP-001	AI	I:1.14		1213	****************	A	Injection Well No. 6 Level High	HMI Alarm											
277	LT1206 (future)	ICP-001	AI	I:1.14		1214	****************	A	Injection Well No. 6 Level Low	HMI Alarm											
278	PIT1206 (future)	ICP-001	AI	I:2.0		1215	****************	A	Injection Well No. 6 Line Pressure High	HMI Alarm											
279	PIT1206 (future)	ICP-001	AI	I:2.0		1216	****************	A	Injection Well No. 6 Line Pressure Low	HMI Alarm											
280	FIT1206 (future)	ICP-001	AI	I:2.1		1217	****************	A	Injection Well No. 6 Flow High	HMI Alarm											
281	FIT1206 (future)	ICP-001	AI	I:2.1		1218	****************	A	Injection Well No. 6 Flow Low	HMI Alarm											
282	LT1207 (future)	ICP-001	AI	I:2.2		1219	****************	A	Injection Well No. 7 Level High	HMI Alarm											
283	LT1207 (future)	ICP-001	AI	I:2.2		1220	****************	A	Injection Well No. 7 Level Low	HMI Alarm											
284	PIT1207 (future)	ICP-001	AI	I:2.3		1221	****************	A	Injection Well No. 7 Line Pressure High	HMI Alarm											
285	PIT1207 (future)	ICP-001	AI	I:2.3		1222	****************	A	Injection Well No. 7 Line Pressure Low	HMI Alarm											
286	FIT1207 (future)	ICP-001	AI	I:2.4		1223	****************	A	Injection Well No. 7 Flow High	HMI Alarm											
287	FIT1207 (future)	ICP-001	AI	I:2.4		1224	****************	A	Injection Well No. 7 Flow Low	HMI Alarm											
288	LT1208 (future)	ICP-001	AI	I:2.5		1225	****************	A	Injection Well No. 8 Level High	HMI Alarm											
289	LT1208 (future)	ICP-001	AI	I:2.5		1226	****************	A	Injection Well No. 8 Level Low	HMI Alarm											
290	PIT1208 (future)	ICP-001	AI	I:2.6		1227	****************	A	Injection Well No. 8 Line Pressure High	HMI Alarm											
291	PIT1208 (future)	ICP-001	AI	I:2.6		1228	****************	A	Injection Well No. 8 Line Pressure Low	HMI Alarm											
292	FIT1208 (future)	ICP-001	AI	I:2.7		1229	****************	A	Injection Well No. 8 Flow High	HMI Alarm											
293	FIT1208 (future)	ICP-001	AI	I:2.7		1230	****************	A	Injection Well No. 8 Flow Low	HMI Alarm											
294	LT1209 (future)	ICP-001	AI	I:2.8		1231	****************	A	Injection Well No. 9 Level High	HMI Alarm											
295	LT1209 (future)	ICP-001	AI	I:2.8		1232	****************	A	Injection Well No. 9 Level Low	HMI Alarm											
296	PIT1209 (future)	ICP-001	AI	I:2.9		1233	****************	A	Injection Well No. 9 Line Pressure High	HMI Alarm											

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
297	PIT1209 (future)	ICP-001	AI	I:2.9		1234	****************	A	Injection Well No. 9 Line Pressure Low	HMI Alarm											
298	FIT1209 (future)	ICP-001	AI	I:2.10		1235	****************	A	Injection Well No. 9 Flow High	HMI Alarm											
299	FIT1209 (future)	ICP-001	AI	I:2.10		1236	****************	A	Injection Well No. 9 Flow Low	HMI Alarm											
300	LT1210 (future)	ICP-001	AI	I:2.11		1237	****************	A	Injection Well No. 10 Level High	HMI Alarm											
301	LT1210 (future)	ICP-001	AI	I:2.11		1238	****************	A	Injection Well No. 10 Level Low	HMI Alarm											
302	PIT1210 (future)	ICP-001	AI	I:2.12		1239	****************	A	Injection Well No. 10 Line Pressure High	HMI Alarm											
303	PIT1210 (future)	ICP-001	AI	I:2.12		1240	****************	A	Injection Well No. 10 Line Pressure Low	HMI Alarm											
304	FIT1210 (future)	ICP-001	AI	I:2.13		1241	****************	A	Injection Well No. 10 Flow High	HMI Alarm											
305	FIT1210 (future)	ICP-001	AI	I:2.13		1242	****************	A	Injection Well No. 10 Flow Low	HMI Alarm											
315	TT1 Fail	Pall	Bit	B22:0/10	TT1 Fail	1243		A	Effluent Temperature Instrument Failure	HMI Alarm			See Microfilter O&M manual								
318	T1 Pause	Pall	Bit	B22:0/13	T1 Pause	1244		A	T-501Level Instrument Pause	HMI Alarm			See Microfilter O&M manual								
319	AIT1 Fail	Pall	Bit	B22:1/4	AIT1 Fail	1245		A	Feed Turbidimeter Failure	HMI Alarm			See Microfilter O&M manual								
322	LT50 Pause	Pall	Bit	B22:2/5	LT50 Pause	1246		A	Filtrate Tank Level Pause	HMI Alarm			See Microfilter O&M manual								
329	DPIT12 High	Pall	Bit	B22:2/14	DPIT12 High	1248		A	RO Membrane High Differential Pressure	HMI Alarm			See Microfilter O&M manual								
331	FIT1 Low	Pall	Bit	B22:3/0	FIT1 Low	1249		A	Pump P-502 Low Flow	HMI Alarm			See Microfilter O&M manual								
332	AIT1 High	Pall	Bit	B22:3/6	AIT1 High	1250		A	Feed Turbidity High	HMI Alarm			See Microfilter O&M manual								
333	AIT1 High High	Pall	Bit	B22:3/7	AIT1 High High	1251		A	Feed Turbidity High High	HMI Alarm			See Microfilter O&M manual								
334	AIT2 High	Pall	Bit	B22:3/8	AIT2 High	1252		A	Effluent Turbidity High	HMI Alarm			See Microfilter O&M manual								
336	LT50 Low	Pall	Bit	B22:4/6	LT50 Low	1253		A	Filtrate Tank Level Low	HMI Alarm			See Microfilter O&M manual								
339	T-2 Not Ready FM	Pall	Bit	B22:4/15	T-2 Not Ready FM	1254		A	Tank T-502 Not Ready for FM	HMI Alarm			See Microfilter O&M manual								
340	IT Press Decay Hi	Pall	Bit	B22:5/0	IT Press Decay Hi	1255		A	IT Pressure Decay High	HMI Alarm			See Microfilter O&M manual								
354	FIT601	Ecolochem	AI	I:3.0		1256	145 gpm	A	RO System Inlet Flow High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
355	FIT601	Ecolochem	AI	I:3.0		1257	135 gpm	A	RO System Inlet Flow Low	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
356	FIT611	Ecolochem	AI	I:3.1		1258	.80 (FIT601)	A	RO System Permeate Flow High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
357	FIT611	Ecolochem	AI	I:3.1		1259	.70 (FIT601)	A	RO System Permeate Flow Low	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
358	FIT612	Ecolochem	AI	I:3.2		1260	(FIT601/FIT612)	A	RO System Concentrate Flow High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
359	FIT612	Ecolochem	AI	I:3.2		1261	(FIT601/FIT612)<	A	RO System Concentrate Flow Low	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
361	AIT604 pH	Ecolochem	AI	I:4.0		1262	8 pH	A	RO System Inlet pH High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
362	AIT604 pH	Ecolochem	AI	I:4.0		1263	6 pH	A	RO System Inlet pH Low	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
363	AIT610 COND	Ecolochem	AI	I:4.1		1264	700 us/cm	A	RO System Outlet Conductivity High High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
364	AIT610 COND	Ecolochem	AI	I:4.1		1265	600 us/cm	A	RO System Outlet Conductivity High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
365	PIT602	Ecolochem	AI	I:5.0		1266	(PIT601-PIT603)	A	RO System Pre Filter Differential Pressure High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
366	PIT606	Ecolochem	AI	I:5.2		1267	125 psig	A	RO System Inlet Pressure High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
367	PIT606	Ecolochem	AI	I:5.2		1268	75 psig	A	RO System Inlet Pressure Low	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
368	PIT606	Ecolochem	AI	I:5.2		1269	(PIT606-PIT607)	A	RO System Stage 1 Differential Pressure High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
369	PIT607	Ecolochem	AI	I:5.3		1270	(PIT607-PIT608)	A	RO System Stage 2 Differential Pressure High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
370	PIT608	Ecolochem	AI	I:6.0		1271	(PIT608-PIT612)	A	RO System Stage 3 Differential Pressure High	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
371	PIT609	Ecolochem	AI	I:6.1		1272	5 psig	A	RO System Final Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
372	PIT609	Ecolochem	AI	I:6.1		1273	0.5 psig	A	RO System Final Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
373	PIT610	Ecolochem	AI	I:6.2		1274	5 psig	A	RO System Permeate Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
374	PIT610	Ecolochem	AI	I:6.2		1275	0.5 psig	A	RO System Permeate Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
375	PIT612	Ecolochem	AI	I:6.3		1276	33 psig	A	RO System Concentrate Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
376	PIT612	Ecolochem	AI	I:6.3		1277	27 psig	A	RO System Concentrate Pressure	HMI Alarm			Investigate Cause at RO Skid and Control Panel								
19	LSH102 (future)	LCP-001	DI	I:12/6	LSH102	1278	****************	A	Well Vault No. 4 High Water Level	HMI Alarm											
20	LT102 (future)	LCP-001	AI	I:1.6		1279	****************	A	Extraction Well PE-2 Level High	HMI Alarm											
21	LT102 (future)	LCP-001	AI	I:1.6		1280	****************	A	Extraction Well PE-2 Level Low	HMI Alarm											
22	PIT102 (future)	LCP-001	AI	I:1.7		1281	****************	A	Extraction Well PE-2 Line Pressure High	HMI Alarm											
23	PIT102 (future)	LCP-001	AI	I:1.7		1282	****************	A	Extraction Well PE-2 Line Pressure Low	HMI Alarm											
24	FIT102 (future)	LCP-001	AI	I:1.8		1283	****************	A	Extraction Well PE-2 Flow High	HMI Alarm											
25	FIT102 (future)	LCP-001	AI	I:1.8		1284	****************	A	Extraction Well PE-2 Flow Low	HMI Alarm											
26	P102 ON (future)	LCP-001	DI	I:12/7		1285	10 sec	A	Extraction Well PE-2 Pump Fail to Start	HMI Alarm											
27	P102 ON (future)	LCP-001	DI	I:12/7		1286	10 sec	A	Extraction Well PE-2 Pump Fail to Stop	HMI Alarm											
28	LSH103 (future)	LCP-001	DI	I:12/9	LSH103	1287	****************	A	Well Vault No. 3 High Water Level	HMI Alarm											
29	LT103 (future)	LCP-001	AI	I:1.9		1288	****************	A	Extraction Well PE-1 Level High	HMI Alarm											
30	LT103 (future)	LCP-001	AI	I:1.9		1289	****************	A	Extraction Well PE-1 Level Low	HMI Alarm											
31	PIT103 (future)	LCP-001	AI	I:1.10		1290	****************	A	Extraction Well PE-1 Line Pressure	HMI Alarm											
32	PIT103 (future)	LCP-001	AI	I:1.10		1291	****************	A	Extraction Well PE-1 Line Pressure	HMI Alarm											
33	FIT103 (future)	LCP-001	AI	I:1.11		1292	****************	A	Extraction Well PE-1 Flow	HMI Alarm											
34	FIT103 (future)	LCP-001	AI	I:1.11		1293	****************	A	Extraction Well PE-1 Flow	HMI Alarm											
35	P103ON (future)	LCP-001	DI	I:12/10		1294	10 sec	A	Extraction Well PE-1 Pump Fail to Start	HMI Alarm											
36	P103ON (future)	LCP-001	DI	I:12/10		1295	10 sec	A	Extraction Well PE-1 Pump Fail to Stop	HMI Alarm											
38	LSHH001	LCP-001	DI	I:12/13	LSHH001	2001	****************	B	Valve Vault No. 1 High High Water Level	HMI Alarm	Shutdown Extraction Well Pumps	Operator Manual Restart	Investigate Cause at Valve Vault No. 1	Leaking connection in valve vault.		Accumulated rain water.					
40	LSHH002	LCP-001	DI	I:12/15	LSHH002	2002	****************	B	Valve Vault No. 2 High High Water Level	HMI Alarm	Shutdown Extraction Well Pumps	Operator Manual Restart	Investigate Cause at Valve Vault No. 2								
45	LIT200	LCP-001	AI	I:2.12		2003	11 ft	B	Raw Water Storage Tank Level High High	HMI Alarm	Shut down Extraction Well Pumps and Drain Pump P-900	1 foot differential auto reset	Visually Check Level on Raw Water Storage Tank	Tank level control setpoints incorrect.	Check tank level control setpoints.	Process Drain Pump discharging to tank.	Check process drain tank.				

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
48	LIT200	LCP-001	AI	I:2.12		2004	1 ft	B	Raw Water Storage Tank Level Low Low	HMI Alarm	Shut down P-200 Raw Water Feed Pump	1 foot differential auto reset	Visually Check Level on Raw Water Storage Tank	Raw Water Feed Pump discharge set higher than well pumps.	Check well pumps and balance flows.	Control valve FCV-200 stuck open.	Check control valve.				
53	LIT700	LCP-001	AI	I:4.0		2005	11 ft	B	Treated Water Tank Level High High	HMI Alarm	Shutdown P-605A/B RO Permeate Pump	1 foot differential auto reset	Visually Check Level on Treated Water Storage Tank	Malfunction of Treated Water Transfer Pump	Check pump, valve settings, and discharge pressure gage.						
56	LIT700	LCP-001	AI	I:4.0		2006	2 ft	B	Treated Water Tank Level Low Low	HMI Alarm	Shut down P-700 Treated Water XFR Pump	1 foot differential auto reset	Visually Check Level on Treated Water Storage Tank	Tank level control setpoints incorrect.	Check tank level control setpoints.						
70	FSL201	LCP-001	DI	I:13/11	FSL201	2007	****************	B	Chemical Mixing Loop Low Flow	HMI Alarm	Shutdown P-200 and P-201 after 15 second time delay	Manual Reset By Operator	Verify Operation of P-201, Check Operation of Flow Switch	Flow switch malfunction, pump malfunction, pump isolation valves closed.	Verify Operation of P-201, confirm pump isolation valves are open, and check operation of flow switch.						
73	AIT202-1pH	LCP-001	AI	I:2.2		2008	7.0 pH	D	Chemical Mixing Loop pH #1 High High	HMI Alarm	Shutdown P-200 & P-201 pumps & Chemical Injection		Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
78	AIT202-2pH	LCP-001	AI	I:3.2		2009	7.0 pH	D	Chemical Mixing Loop pH #2 High High	HMI Alarm	Shutdown P-200 & P-201 pumps & Chemical Injection		Check Chemical Mixing Loop pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
87	LSH300	LCP-001	DI	I:14/1	LSH300	2010	****************	A	Chromium Reduction Reactor High Level	HMI Alarm	Shut down P-200 Raw Water Feed Pump	1 foot differential auto reset	Check Chromium Reduction Reactor Level	Sensor malfunction, line obstruction, or discharge valve closed.							
88	AIT300-1pH	LCP-001	AI	I:2.4		2011	7.0 pH	D	Chromium Reduction Reactor pH #1 High High	HMI Alarm	Shutdown P-200 & P-201 pumps & Chemical Injection		Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
93	AIT300-2pH	LCP-001	AI	I:3.4		2012	7.0 pH	D	Chromium Reduction Reactor pH #2 High High	HMI Alarm	Shutdown P-200 & P-201 pumps & Chemical Injection		Check Chromium Reduction Reactor pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too high.	Confirm chemical strength.		
102	LSH301A	LCP-001	DI	I:14/4	LSH301A	2013	****************	A	Iron Oxidation Reactor No. 1 High Level	HMI Alarm	Shut down P-200 Raw Water Feed Pump	1 foot differential auto reset	Check Iron Oxidation Reactor 1 Level	Sensor malfunction, line obstruction, or discharge valve closed.							
105	AIT301A-1pH	LCP-001	AI	I:2.6		2014	7.0 pH	D	Iron Oxidation Reactor No. 1 pH #1 Low Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		
110	AIT301A-2pH	LCP-001	AI	I:3.6		2015	7.0 pH	D	Iron Oxidation Reactor No. 1 pH #2 Low Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 1 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		
117	LSH301B	LCP-001	DI	I:14/7	LSH301B	2016	****************	A	Iron Oxidation Reactor No. 2 High Level	HMI Alarm	Shut down P-200 Raw Water Feed Pump	1 foot differential auto reset	Check Iron Oxidation Reactor 2 Level	Sensor malfunction, line obstruction, or discharge valve closed.							
120	AIT301B-1pH	LCP-001	AI	I:2.8		2017	7.0 pH	D	Iron Oxidation Reactor No. 2 pH #1 Low Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		
125	AIT301B-2pH	LCP-001	AI	I:3.8		2018	7.0 pH	A	Iron Oxidation Reactor No. 2 pH #2 Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 2 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		
134	LIT301C	LCP-001	AI	I:2.13		2019	12 feet	A	Iron Oxidation Reactor No. 3 Level Low Low	HMI Alarm	Shut down P-400 Clarifier Feed Pump	1 foot differential auto reset	Check Iron Oxidation Reactor 3 pH Sensor								
135	LSH301C	LCP-001	DI	I:14/10	LSH301C	2020	****************	A	Iron Oxidation Reactor No. 3 High High Level	HMI Alarm	Shut down P-200 Raw Water Feed Pump	1 foot differential auto reset	Check Iron Oxidation Reactor 3 pH Sensor								
138	AIT301C-1pH	LCP-001	AI	I:2.10		2021	7.3 pH	D	Iron Oxidation Reactor No. 3 pH #1 Low Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		
143	AIT301C-2pH	LCP-001	AI	I:3.10		2022	7.3 pH	D	Iron Oxidation Reactor No. 3 pH #2 Low Low	HMI Alarm	Shutdown P-200 & P-201 pumps	Manual Reset By Operator	Check Iron Oxidation Reactor 3 pH Sensor	pH sensor out of calibration		Chemical feed pump out of calibration	Check calibration	Chemical strength too low.	Confirm chemical strength.		

Appendix G

Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
165	LIT900	LCP-001	AI	I:3.0		2023	1 ft	A	Process Drain Tank Level Low	HMI Alarm	Shutdown P-900 Process Drain Tank Pump	1 foot differential auto reset	Visually Check Level On Process Drains Tank	Set points incorrect	Check setpoints.	Pump doesn't turn off.	Manually turn off pump.				
176	LIT500	LCP-001	AI	I:2.14		2024	16 ft	A	Pretreated Water Tank Level High High	HMI Alarm	Shut down P-400 Clarifier Feed Pump	1 foot differential auto reset	Visually Check Level in Pre-Treated Water Storage Tank	P-400 is pumping faster than P-499	Check microfilter system permeate flow rate and strainer backpressure.	Consult microfilter manual if flux is below acceptable range. Clean strainer if clogged. Confirm that P-500 discharge valves are set correctly.					
179	LIT500	LCP-001	AI	I:2.14		2025	2 ft	A	Pretreated Water Tank Level Low Low	HMI Alarm	Shut down P-500 Pretreated Water Xfr Pump	1 foot differential auto reset	Visually Check Level in Pre-Treated Water Storage Tank	P-500 is pumping faster than P-400.	Check overall system flow.						
182	LIT600	LCP-001	AI	I:2.15		2026	15 ft	A	Reverse Osmosis Feed Tank Level High High	HMI Alarm	Shutdown Microfilter System	5 foot differential auto reset	Visually Check Level in Reverse Osmosis Feed Tank	Level control set point incorrect.	Confirm level set point.	Membrane elements or cartridge filters may be fouled.	Check RO pressure elements and permeate flow. Consult manual regarding RO element cleaning if indicated. Check cartridge filter backpressure.	Valve settings incorrect.	Check valve settings.	Too much concentrate being recycled.	Check conductivity probes and setpoints.
185	LIT600	LCP-001	AI	I:2.15		2027	2 ft	A	Reverse Osmosis Feed Tank Level Low Low	HMI Alarm	Shutdown P-620 Filtered Water Xfr Pump & RO System	5 foot differential auto reset	Visually Check Level in Reverse Osmosis Feed Tank	Level control set point incorrect.	Confirm level set point.	Permeate recycle line obstructed.	Check for recycle flow.	Upstream malfunction.	Confirm upstream systems.		
194	LIT 604	LCP-001	AI	I:5.3		2028	30 in	A	F.D. Aerator Basin Level High High	HMI Alarm	Shutdown RO System	Manual Operator Restart	Visually Check Level in FD Aerator Basin	Level control set point incorrect.	Confirm level set point.	Level control valve LCV-604 malfunction.	Check level control valve.				
197	LIT 604	LCP-001	AI	I:5.3		2029	18 in	A	F.D. Aerator Basin Level Low Low	HMI Alarm	Shutdown P-605A/B RO Permeate Pumps	1 foot differential auto reset	Visually Check Level in FD Aerator Basin	Level control set point incorrect.	Confirm level set point.	Level control valve LCV-604 malfunction.	Check level control valve.				
198	LIT701	LCP-001	AI	I:4.1		2030	13 ft	A	R.O. Concentrate Tank Level High High	HMI Alarm	Shutdown RO System		Visually Check Level in RO Concentrate Storage Tank	Set points incorrect	Confirm level set point.	Pump discharge valves incorrectly set.	Check valve settings.	Pump malfunction.	Check pump.		
201	LIT701	LCP-001	AI	I:4.1		2031	1.0 ft	A	R.O. Concentrate Tank Level Low Low	HMI Alarm	Shutdown P-701 RO Concentrate XFR Pump	1 foot differential auto reset	Visually Check Level in RO Concentrate Storage Tank	Set points incorrect	Confirm level set point.						
206	AIT605 COND	LCP-001	AI	I:4.3		2032	700us/cm	C	R.O. Permeate Conductivity High High	HMI Alarm	Shutdown RO System	Manual Operator Restart	Inspect and/or Clean Conductivity Sensor	Damaged element.							
212	P800 ON	LCP-001	DI	I:16/15		2033	****************	D	Ferrous Chloride Pump Power Off	HMI Alarm	Shutdown all process pumps,RO system, uFilter system after 30 second time delay	Manual Operator Restart	Check Status of Pump Power Disconnect Switch	Pump malfunction.							
213	FSL800	LCP-001	DI	I:21/0	FSL800	2034	****************	D	Ferrous Chloride Pump Low Flow	HMI Alarm	Shutdown all process pumps,RO system, uFilter system after 30 second time delay	Manual Operator Restart	Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					
216	P802A ON	LCP-001	DI	I:17/3		2035	****************	A	Sodium Hydroxide Pump A Power Off	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Status of Pump Power Disconnect Switch	Pump malfunction.							
217	FSL802A	LCP-001	DI	I:21/2	FSL802A	2036	****************	A	Sodium Hydroxide Pump A Low Flow	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					

Appendix G

Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
218	P802B ON	LCP-001	DI	I:17/5		2037	****************	A	Sodium Hydroxide Pump B Power OFF	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Status of Pump Power Disconnect Switch	Pump malfunction.							
219	FSL802B	LCP-001	DI	I:21/3	FSL802B	2038	****************	A	Sodium Hydroxide Pump B Low Flow	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					
220	P802C ON	LCP-001	DI	I:17/7		2039	****************	A	Sodium Hydroxide Pump C Power Off	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Status of Pump Power Disconnect Switch	Pump malfunction.							
221	FSL802C	LCP-001	DI	I:21/4	FSL802C	2040	****************	A	Sodium Hydroxide Pump C Low Flow	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					
222	P802D ON	LCP-001	DI	I:17/9		2041	****************	A	Sodium Hydroxide Pump D Power Off	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Status of Pump Power Disconnect Switch	Pump malfunction.							
223	FSL802D	LCP-001	DI	I:21/5	FSL802D	2042	****************	A	Sodium Hydroxide Pump D Low Flow	HMI Alarm	Shutdown all process systems after 30 second time delay	Manual Operator Restart	Check Pump Operation, Chemical Level in Tote	Pump malfunction.		Chemical container empty					
234	FIT 300A	LCP-001	AI	I:4.6		2043	70 scfm	D	Iron Oxidation Reactor No. 1 Air Flow Low Low	HMI Alarm	Shutdown all process systems after 1 minute time delay	Manual Operator Restart	Check Air Flow Indicator A, Check Butterfly Valve Position								
237	FIT 300B	LCP-001	AI	I:4.7		2044	70 scfm	D	Iron Oxidation Reactor No. 2 Air Flow Low Low	HMI Alarm	Shutdown all process systems after 1 minute time delay	Manual Operator Restart	Check Air Flow Indicator B, Check Butterfly Valve Position								
240	FIT 300C	LCP-001	AI	I:4.8		2045	70 scfm	D	Iron Oxidation Reactor No. 3 Air Flow Low Low	HMI Alarm	Shutdown all process systems after 1 minute time delay	Manual Operator Restart	Check Air Flow Indicator C, Check Butterfly Valve Position								
306	QSTOP	Pall	Bit	B22:0/1	QSTOP	2046		A	Skid Quick Stop	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
307	FIT1Fail	Pall	Bit	B22:0/2	FIT1Fail	2047		A	Effluent Flow Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
308	LIT1 Fail	Pall	Bit	B22:0/3	LIT1 Fail	2048		A	T-501 Level Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
309	LIT2 Fail	Pall	Bit	B22:0/4	LIT2 Fail	2049		A	T-502 Level Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
310	PSL1	Pall	Bit	B22:0/5	PSL1	2050		A	Instrument Air Pressure Low Low	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
312	PIT1 Fail	Pall	Bit	B22:0/7	PIT1 Fail	2051		A	Strainer Outlet Pressure Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
313	PIT2 Fail	Pall	Bit	B22:0/8	PIT2 Fail	2052		A	Effluent Pressure Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
314	PIT3 Fail	Pall	Bit	B22:0/9	PIT3 Fail	2053		A	Strainer Inlet Pressure Instrument Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
316	VFD1 Fail	Pall	Bit	B22:0/11	VFD1 Fail	2054		A	Pump P-501 VFD Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
317	VFD2 Fail	Pall	Bit	B22:0/12	VFD2 Fail	2055		A	Pump P-502 VFD Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
320	AIT2 Fail	Pall	Bit	B22:1/5	AIT2 Fail	2056		D	Effluent Turbidimeter Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
327	PIT1 High	Pall	Bit	B22:2/12	PIT1 High	2057		A	Strainer Outlet Pressure High	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
328	PIT2 High	Pall	Bit	B22:2/13	PIT2 High	2058		A	Effluent Pressure High	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
335	AIT2 High High	Pall	Bit	B22:3/9	AIT2 High High	2059		A	Effluent Turbidity High High	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
341	IT Press Decay Hi	Pall	Bit	B22:5/1	IT Press Decay Hi Hi	2060		A	IT Pressure Decay High High	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
342	Strainer Backwash	Pall	Bit	B22:5/2	Strainer Backwash Fail	2061		A	Strainer Backwash Failure	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								

Appendix G

Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
343	Fill Cycle Timeout	Pall	Bit	B22:5/3	Fill Cycle Timeout	2062		A	Fill Cycle Watchdog Timeout	HMI Alarm	Shutdown MF Skid	Shutdown Pump P-500	See Microfilter O&M manual								
345	ALARM_SHUTDO	Ecolochem	Bit	B3/2	Shutdown	2063		A	RO System Shutdown	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
346	PSL1	Ecolochem	Timer	T4:2/DN	PSL1	2064	15 sec	A	RO System Inlet Pressure Low	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
347	PSH2	Ecolochem	Timer	T4:4/DN	PSH3	2065	0.1 sec	A	RO System Outlet Pressure High	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
348	TSH3	Ecolochem	Timer	T4:6/DN	TSH4	2066	15 sec	A	RO System Inlet Temperature High	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
349	PHAH/L4	Ecolochem	Timer	T4:8/DN	pHAH/L4	2067	40 sec	A	RO System pH High or Low	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
350	FAH/L5	Ecolochem	Timer	T4:10/DN	FAH/L5	2068	40 sec	A	RO System Flow High or Low	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
351	FAL/ANTISCALE	Ecolochem	Timer	T4:16/DN	FAL/7	2069	15 sec	A	RO System Anti Scalent Flow Low	HMI Alarm	Shutdown RO System										
352	POWER FAIL	Ecolochem	DO	O:2/5	POWER FAIL	2070		A	RO System Power Fail	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
353	LSH6	Ecolochem	Timer	T4:3/DN	LSH6	2071	15 sec	A	RO System FDA Basin Level High	HMI Alarm	Shutdown RO System		Investigate Cause at RO Skid and Control Panel								
360	FIT612	Ecolochem	AI	I:3.2		2072	(FIT601/FIT612)	A	RO System Concentrate Flow Low Low	HMI Alarm	Shutdown all process systems after 1 minute time delay		Investigate Cause at RO Skid and Control Panel								
168	LSHH702	LCP-001	DI	I:18/11	LSHH702	2073	****************	A	High Level Treated Water Storage Tank (Baker Tank)	HMI Alarm	Shutdown transfer pump P-700		Visually Check Level On Treated Water Baker Tank								
241	LSHH703	LCP-001	DI	I:18/12	LSHH703	2074	****************	A	High Level R O Concentrate Storage Tank (Baker Tank)	HMI Alarm	Shutdown brine transfer pump P-701		Visually Check Level on RO Concentrate Baker Tank								
208	AIT606 pH	LCP-001	AI	I:4.4		2075	8.4 pH	C	R.O. Permeate pH High High	HMI Alarm	Shutdown RO. Stop Treated Water discharge pump P-700		Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
209	AIT606 pH	LCP-001	AI	I:4.4		2076	6.5 pH	C	R.O. Permeate pH Low Low	HMI Alarm	Shutdown RO. Stop Treated Water discharge pump P-700		Inspect and/or Clean pH Sensor	pH sensor out of calibration	Check sensor calibration						
377	LSH1202	ICP-001	AI	I:4/0		2077	****************	A	Injection Well No. 2 High Water Level in Vault	HMI Alarm	Shutdown Injection Pump P-700		Investigate Cause at Injection Well No. 2 Vault								
378	LSH1203	ICP-001	AI	I:4/1		2078	****************	A	Injection Well No. 3 high water Level in Vault	HMI Alarm	Shutdown Injection Pump P-700		Investigate Cause at Injection Well No. 3 Vault								
321	LT50 Fail	Pall	Bit	B22:2/4	LT50 Fail	3001		A	Filtrate Tank Level Instrument Failure	HMI Alarm	Pause MF Skid		See Microfilter O&M manual								
323	LIT1 Low	Pall	Bit	B22:2/8	LIT1 Low	3002		A	Tank T-501 Low Level	HMI Alarm	Pause MF Skid		See Microfilter O&M manual								
330	TT1 High	Pall	Bit	B22:2/15	TT1 High	3003		A	Effluent Temperature High	HMI Alarm	Pause EFM/CIP and shutdown all other sequences		See Microfilter O&M manual								
337	LT50 High	Pall	Bit	B22:4/7	LT50 High	3004		A	Filtrate Tank Level High	HMI Alarm	Pause Filtration		See Microfilter O&M manual								
338	LIT2 Change	Pall	Bit	B22:4/14	LIT2 Change	3005		A	Tank T-502 Level Change During CIP	HMI Alarm	Pause CIP/EFM		See Microfilter O&M manual								
324	LIT1 High	Pall	Bit	B22:2/9	LIT1 High	4001		A	Tank T-501 High Level	HMI Alarm	Stop filling tank, pause CIP, Pause EFM		See Microfilter O&M manual								
325	LIT2 Low	Pall	Bit	B22:2/10	LIT2 Low	4002		A	Tank T-502 Low Level	HMI Alarm	Stop AS or RF Cycle		See Microfilter O&M manual								
326	LIT2 High	Pall	Bit	B22:2/11	LIT2 High	4003		A	Tank T-502 High Level	HMI Alarm	Stop Additions to Tank		See Microfilter O&M manual								
344	IT Cycle Timeout	Pall	Bit	B22:5/4	IT Cycle Timeout	5001		A	IT Cycle Watchdog Timeout	HMI Alarm	Abort IT		See Microfilter O&M manual								

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Alarms and Troubleshooting Summary

ID	Tag Number	PLC	I_O Type	Input Address	Alarm	Alarm Number	Set Point	Recovery	Alarm Description	Function 1	Function 2	Function 3	Operator 2	Potential Cause 1	Operator 3	Potential Cause 2	Operator 4	Potential Cause 3	Operator 5	Potential Cause 4	Operator 6
311	PSL2	Pall	Bit	B22:0/6	PSL2	6001		A	Instrument Air Pressure Low	HMI Alarm	Prevent FM Cycle		See Microfilter O&M manual								

Recovery Codes:

A - Warning Only. No shutdown is triggered; therefore no shutdown recovery is required. Operator will need to correct problem while plant operation is ongoing.

B - Operator can restart treatment system per Startup SOP in O&M Manual. No further recovery required.

C - Alarm caused by effluent quality (pH or conductivity meter readings). Because shutdown is immediate upon alarm, downstream water should be within effluent limits. Test conductivity and pH of FD Aeration sump to ensure it is in compliance with limits. If not, recirculate water from FD Aerator back to reverse osmosis Feed Tank for re-treatment through reverse osmosis as detailed in O&M Manual, Section 5.5 "5.5 Process Upset Prevention, Detection, and Recovery"

D - Test water in tanks, proceeding downstream from where the alarm is found for Cr(VI) and Cr(T). If out of Cr is out of range recirculate water from entire plant by re-routing water from the reverse osmosis Feed Tank as detailed in O&M Manual, Section 5.5 "5.5 Process Upset Prevention, Detection, and Recovery"

Appendix H
Daily Monitoring Checklists

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary

DATE:_____________

Component	Task Description	Datum to Record	Indication of potential concern	Initials
Extraction System	Target extraction rate	______ gpm		
Extraction well TW-2D	Record pump rate at wellhead	______ gpm ☐ pump is supposed to be OFF and flow rate is 0 gpm	No flow when pump should be ON	
	Record pipeline pressure at well head (not valve vault)	______ psi ☐ pump is supposed to be OFF and pressure is 0 psi	No pressure when pump should be ON	
Injection wells	Record water level in each well	IW1: ______ ft	Increase of >__ ft over previous reading	
		IW2:______ ft	Increase of >__ ft over previous reading	
	Record injection flow rate	______ gpm	Flow rate varies by >__ gpm from effluent flow rate at plant	
Ferrous chloride feed system	Inspect tank for nozzle obstructions, bugs, and wind-blown and foreign debris	☐ Yes, feed is unobstructed and debris is cleared ◇ No, feed is obstructed	Flow obstructed and/or debris is present.	
	Record feed rate	______ ml/min	No flow reading when ferrous chloride should be feeding the system	
	Check whether ferrous chloride is stratifying	☐ Not stratifying ◇ Yes, it is stratifying	Brown/red on top and green/gray on bottom - may be difficult to see; check mixer for operation	
	Check Fe^{+2} (ferrous iron) concentration in new tote	______ % ferrous by weight ☐ Tote tested previously	Ferrous content does not meet specs on tote/paperwork	
	Inspect level in tote	______ % full	Tote is <10% full or has not changed at expected rate	

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary
DATE:______________

Component	Task Description	Datum to Record	Indication of potential concern	Initials
Sulfuric acid feed system	Inspect tank for nozzle obstructions, bugs, and wind-blown and foreign debris	☐ Yes, feed is unobstructed and debris is cleared ◇ No, feed is obstructed	Flow obstructed and/or debris is present.	
	Inspect level in tote	______ % full	Tote is <5 % full or has not changed at expected rate	
Sodium hydroxide feed system	Inspect tank for nozzle obstructions, bugs, and wind-blown and foreign debris	☐ Yes, feed is unobstructed and debris is cleared ◇ No, feed is obstructed	Flow obstructed and/or debris is present. During cold weather periods, check for the presence of solidified ("frozen") caustic	
	Inspect level in tote	______ % full	Tote is <10 % full or has not changed at expected rate	
Pipe reactor	Check the pH of reactor contents	______ pH units (using pH paper) ______ pH units (using lab pH meter) ______ pH indicated on pH probe #1 ______ pH indicated on pH probe #2	Range on pH readings *will determine allowable range during Startup*	
Chromium reduction tank	Inspect mixer for proper operation	☐ Yes, mixer is operating correctly ◇ No, mixer is malfunctioning		
	Is floating cover in good condition?	☐ Yes ◇ No		
	Check the pH of tank contents	______ pH units (using pH paper) ______ pH units (using lab pH meter) ______ pH indicated on pH probe #1 ______ pH indicated on pH probe #2	Range on pH readings *will determine allowable range during Startup*	

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary
DATE:______________

Component	Task Description	Datum to Record	Indication of potential concern	Initials
Iron oxidation tank #1	Inspect mixer for proper operation	☐ Yes, mixer is operating correctly ◇ No, mixer is malfunctioning		
	Check the pH of tank contents	______ pH units (using pH paper) ______ pH units (using lab pH meter) ______ pH indicated on pH probe #1 ______ pH indicated on pH probe #2	Range on pH readings *will determine allowable range during Startup*	
	Check Total Solids (sludge solids)	______ mg/L	Target 500 to 2,000 mg/L	
Iron oxidation tank #2	Inspect mixer for proper operation	☐ Yes, mixer is operating correctly ◇ No, mixer is malfunctioning		
	Check the pH of tank contents	______ pH units (using pH paper) ______ pH units (using lab pH meter) ______ pH indicated on pH probe #1 ______ pH indicated on pH probe #2	Range on pH readings *will determine allowable range during Startup*	
	Check Total Solids (sludge solids)	______ mg/L	Target 500 to 2,000 mg/L	
Iron oxidation tank #3	Inspect mixer for proper operation	☐ Yes, mixer is operating correctly ◇ No, mixer is malfunctioning		
	Check the pH of tank contents	______ pH units (using pH paper) ______ pH units (using lab pH meter) ______ pH indicated on pH probe #1 ______ pH indicated on pH probe #2	Range on pH readings *will determine allowable range during Startup*	

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE:_____________

Component	Task Description	Datum to Record	Indication of potential concern	Initials
	Check Total Solids (sludge solids)	______ mg/L	Target 500 to 2,000 mg/L	
Clarifier	Evaluate sludge level in clarifier via decant nozzles on sludge thickener	Sludge level is between nozzle # ______ and # ______	If sludge level exceeds nozzle # ______, check sludge pumps for proper operation, increase pump “on” time ***(TBD during startup)***	
	Confirm that water is exiting clarifier only through the effluent flumes	☐ Yes, water is exiting through holes in effluent flumes ◇ No, water is overflowing the lamella plate section into the effluent flume	Overflowing water is a problem requiring troubleshooting	
	Evaluate water quality of clarifier effluent	______ NTU (turbidity – measured in lab) AND ______ quality of floc formation and settling (poor, average, or good)	Turbidity >100 NTU and/or poor floc formation indicates problem requiring troubleshooting	
Microfiltration system	Record change in turbidity through the microfilter	______ NTU of influent water ______ NTU of effluent water	Effluent turbidity > 1.0 NTU	
	Record pressure drop across the microfilter cartridges	______ psi	Pressure drop across the microfilter cartridges is >___ psi	
	Record flow rate through the MF system	______ gpm		
Reverse osmosis system	Record pressure drop across the reverse osmosis membranes	______ psi at location 1 ______ psi at location 2 ______ psi at location 3 ______ psi at location 4	Pressure drop across the reverse osmosis membranes is >______ psi at location 1 ***(TBD during startup)***	
	Record discharge conductivity	______ (µS/cm)	Conductivity is >______ (µS/cm) ***(TBD during startup)***	

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary

DATE:______________

Component	Task Description	Datum to Record	Indication of potential concern	Initials
	Record flow rate through the reverse osmosis system	______ gpm Calculate the normalized specific flow rate using forms from vendor	Normalized specific flowrate to be > 80 percent of start-up value.	
	Record inlet turbidity from Microfilter Package System effluent turbidity meter	______ NTU		
	Measure effluent turbidity	______ NTU		
	Measure inlet Silt Density Index	______ NTU		
Phase separators	Inspect the level of sludge in the separators	____ ft below high level indicator in phase separator #1 ____ ft below high level indicator in phase separator #2		
Entire groundwater extraction and remediation system	Record outages	______ start time for shutdown ______ end time for shutdown Reason for shutdown: ______________________________ ______________________________		
	Evaluate site access/egress via roads	____ condition of roads (good/passable or poor/impassable)	Poor/impassable roads are to be reported and repaired	
	Inspect pump seals	☐ All pump seals in good working order ◇ No, pump(s) __________ have seals that are failing or beginning to fail		

TABLE H-1
Mechanical Monitoring Checklist
Recommended Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary

DATE:_____________

Component	**Task Description**	**Datum to Record**	**Indication of potential concern**	**Initials**
	Inspect system piping for leaks	☐ No leaks detected ◇ Yes, leaks detected in following locations:		
	Record precipitation events	_______ time _______ date _______ inches of precipitation		
	Record ambient temperature	_______ time _______ ^{o}F		
	Verify that 48-to-72 hour weather forecast is conducive to normal operation	☐ Yes, weather will be above freezing and no thunderstorms forecast ◇ No, freezing temperatures or thunderstorms are predicted and precautions may need to be taken.	If system will be shutdown during freezing conditions, aboveground non-heat traced lines should be drained Thunderstorms may interrupt power supply	

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: _____

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
Hexavalent chromium	1/week	Extraction Well TW-2D (if in operation)		µg/L	No target	Log, no shutdown or recovery needed			
	1/week	Extraction Well TW-2S (if in operation)		µg/L	No target	Log, no shutdown or recovery needed			
	1/day	Raw water storage tank (T-100)		µg/L	No target	Log, no shutdown or recovery needed			
	1/day	After chromium reduction process in pipe reactor (before T-300)		µg/L	0-50	1) Recheck sample to verify 2) Increase ferrous iron dosage 3) Ensure P-201 recycle pump is working so that reactor system is well mixed 4) Reduce throughput by reducing P-200 flow rate to increase retention time 5) No shutdown or recovery needed			
	1/day	After entire chromium reduction process (after T-300)		µg/L	0-10	1) Report any detection (even within target range) to process engineers 2) Re-check sample troubleshoot system 3) Recovery Plan A			
	1/day	After iron oxidation process (after T-301C)		µg/L	0-10				
	1/day	Reverse osmosis permeate		µg/L	0-10				

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: ______

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
	1/day	Blended effluent to injection wells		μg/L	0-10				
Total chromium	1/day	After iron oxidation process (after T-301C)		μg/L	0-20	1) Recheck sample to verify 2) Report to process engineer 3) Increase ferrous iron dosage 4) No shutdown or recovery needed			
	1/day	After clarifier		μg/L	0-1500	1) Inspect clarifier throughput to confirm proper operation (e.g., floc carryover) 2) Check polymer dosing 3) No shutdown or recovery needed			
	1/day	Microfiltration permeate		μg/L	0-25	1) Perform inspection and maintenance on MF unit 2) No shutdown or recovery needed			
	1/day	Reverse osmosis reject		μg/L	0-500 0-5,000	1) Report to process engineers 2) No shutdown or recovery needed 3) NOTE: If >5,000 ug/L STOP P-701			

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: _____

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
	1/day	Reverse osmosis permeate		μg/L	0-20	1) Shut down flow to injection wells (stop P-700). 2) Recovery Plan A			
	1/day	Blended effluent to injection wells		μg/L	0-25				
Ferrous iron	1/day	After pipe reactor (before T-300)		μg/L	TBD (initial min. 2,000) to <5,000 **	High: Review causes; no shutdown or recovery needed Low: 1) Recheck sample to verify 2) Check Cr(VI) concentration is in target range 3) Increase ferrous chloride flow rate until concentration is within target range 4) Alert process engineers to this issue 5) No shutdown or recovery needed			
	1/day	After chromium reduction reactor (T-300)		μg/L	TBD (initial min. 2,000) to <5,000 **				
	1/day	After iron oxidation process (after T-301C)		μg/L	0-200	1) Discuss with process engineers 2) No shutdown or recovery needed			

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: _____

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
Electrical Conductivity	1/day	Raw Water Tank		µS/cm	< 12,000	1) Report to process engineers 2) No shutdown or recovery needed			
	1/day	Microfiltration permeate		µS/cm	< 12,000				
	1/day	Reverse osmosis permeate		µS/cm	< 700	1) Check reading to verify 2) Check blended effluent conductivity 3) Report to process engineer 4) No shutdown or recovery needed			
	1/day	Reverse osmosis reject		µS/cm	12,000 – 15,000*	1) Report to process engineers 2) No shutdown or recovery needed			
	1/day	Blended effluent to injection well		µS/cm	< 4,500 (To be revised as needed if TDS limit)	1) Check reading to verify 2) Recovery Plan B			

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: _____

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
Turbidity	1/day	After the clarifier		NTU	< 100	*Turbidity ranges, if appropriate, will be determined during startup. . If needed, responses are:* 1) Notify process engineer 2) Increase ferrous iron 3) Increase aeration from blowers 4) Modify polymer dosage 5) No shutdown or recovery needed			
	1/day	Microfiltration permeate		NTU	< 1.0	1) Notify process engineer 2) Check MF system for membrane failure (with support from manufacturer or engineers) 3) No shutdown or recovery needed			

TABLE H-2
Process Monitoring Analysis During Startup – On-Site Laboratory
Preliminary Approach – Final decision on analysis and frequency will be determined in the field based on plant operating history and performed as necessary DATE: _____

Sample Analysis	Potential Frequency	Sampling Location	Concentration	Units	Target Range	Action and/or Recovery if Outside of Range	Initials	Note #	Collected (24-hr clock)
	1/day	Reverse osmosis permeate		NTU	< 1.0	1) Notify process engineer 2) Check reverse osmosis system for membrane failure (with support from manufacturer or engineers) 3) No shutdown or recovery needed			
	1/day	Blended effluent to injection wells		NTU	< 1.0	See the two rows above			

** - This range will be determined during startup.

Notes:
#1 –
#2 –
#3–

Recovery Plans:
A – Stop extraction flow from wells. Recirculate water back from T-600 (between microfilter and reverse osmosis) to Raw Water Tank until readings are in target range. Also, stop pump P-700 discharge to injection wells until checked water in T-700 is in Target Range. See Section 5.5 "Process Upset Prevention, Detection, and Recovery" and “System Startup” SOP to restart system.

B - Alarm Stop extraction flow from wells. Stop P-700 discharge to injection wells. Recirculate water from F.D. Aerator back to Reverse Osmosis Feed Tank for re-treatment through reverse osmosis as detailed in O&M Manual, Section 5.5 "Process Upset Prevention, Detection, and Recovery."

Appendix I
Phone List

APPENDIX I

Phone List

Key phone numbers for quick reference are provided below.

Item	Vendor	Point of Contact	Phone Number
Suppliers			
Bulk Chemicals Coagulant Polymer	Nalco Chemicals	Monty Liu	909-553-7992
Antiscalent polymer	Avista		760-744-0536
Equipment Manufacturers			
Air Blower	Colorado Compressor	Steve Tyler - Sales	303-297-8100 x3009
Air Compressor	Colorado Compressor	Steve Tyler - Sales Greg Herman - Sales	303-297-8100 x3009 303-297-8100
AOD Pumps (P-401,403,404)	Quadna Pumps	Kelli Steele - Sales Mark Hibl - Sales	303-430-0521
Chem. Feed Skid	Hamilton Engineering	Bob Hamilton - Owner	303-757-7678
Chemical Waste Tank	Tank Equipment	Matt Licknosky - Sales	303-457-0513
Control Room Building	Williams Scotsman	Jenifer Sereno	951-681-0300
De-Mister	Mapco	John Youngston	231-941-5865
Diaphragm Pumps	Quadna Pumps	Kelli Steele - Sales Mark Hibl - Sales	303-430-0521
Dry Polymer Feeder	Nalco/ChemFlo	Elizabeth Garcia	630-543-1911
Firewater Tank	Mark Steel	Fred Elmen	FredE@marksteel.net
FRP Tanks	Palmer	Don Rockwell, Engineer Dave Mason, Designer	800-835-9136
Lightnin Mixers	Centennial Equipment Co.	Byron Bergman - Sales	303-278-8400
Micromedia Filter	PALL Advanced Separations Systems	Patricia Owens	607-753-6041
Miscellaneous Pumps	BF Sales	Jeff Hasse - Sales	303-216-1041
Inline Mist Eliminator	Mapco	JC	231-941-5865
Motor Control Center/Switchgear	Eaton	Bill W. Kasper - Sales	303-738-2328
Clarifier/Gravity Settler	Parkson	Irv Rubenstein	Irv.Rubenstein@Parkson.com
Phase Separator Sump Pump Package	Quadna Pumps	Kelli Steele - Sales	303-430-0521

Item	Vendor	Point of Contact	Phone Number
Plastic Process Tanks	Palmer Mfg & Tank Inc.	Dave Mason	620-275-7461
Process Pump (P-200,201,400,500,620,700,701,900)	BF Sales/Fybroc	Jeff Hasse	303-216-1041
RO Unit	Echolochem	Ed Creecy	Ed.Creecy@ecolochem.com
Seal Water System	Quadna Pumps	Kelli Steele - Sales Mark Hibl - Sales	303-430-0521
Sewer Tanks	Firewater Systems, Inc.	Jonathan Fritz	
Static & Tank Mixers	Centennial Equipment	Dave Daigler - Sales	303-278-8400
Sunshade	G&W Builders, Inc.	Mike Green	714-529-9935
Transfer Switch	Eaton	Bill W. Kasper - Account Rep.	303-738-2328
Well Pumps	Denver Industrial Pumps Inc	Michael Morton	303-233-9255
Regulatory			
Waste Discharge Requirements	Regional Water Quality Control Board	Jose Cortez	760-346-7491
Hazardous Materials Business Plan and Conditional Authorization	San Bernardino Fire Department, Hazardous Materials Division (CUPA)	Kristen Riegel	909-386-8401
Process Support			
System Design	CH2M HILL	Dennis Fink Terry DeBiase	510-251-2426

Appendix J
Contingency Plan

APPENDIX J

PG&E Topock IM No. 3 Treatment Plant Contingency Plan

A contingency plan such as this one is used during design to anticipate potential problems and mitigate them. The objective of the following table is to outline the possible failures of the treatment system in achieving its design objectives: meeting effluent water quality requirements and meeting the design flow (defined currently as maintaining the flows in the DTSC letter of June 30, 2004, assumed to be average gallon/minute flow rates averaged over a given month. This later requirement was modified by the DTSC letter dated February 14, 2005 which requires 50 gpm extraction except during approved maintenance periods or if PG&E seeks DTSC's approval.) Other evaluations done separately so not addressed here include: what will be done if the groundwater hydraulic gradient is not landward; and what will be done with waste and product streams generated at the site.

Causes of potential failures are mitigated in design (e.g., selecting a metallurgy that is better resistant to a corrosive environment), while others are mitigated by operational efforts (e.g., visually inspecting chemical inventory to avoid running out). Operational mitigation descriptions include the condition that an operator would observe and the action he/she would take. A rigorous preventative maintenance schedule is proposed as an overall mitigation step to minimize risk of unexpected failures. The Severity of Effect column denotes the implication of the effect if it were to occur. The mitigation measures described are taken to minimize or eliminate the likelihood of these effects and failures.

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
1. Failure: Extraction Well clogs Effect without Mitigation: The given well will not be able to contribute to meeting extraction rate goals.	a. Fouling of screen		Track water levels		Increase in differential elevation	Could redevelop well, or add acid.	2	0	
2. Failure: Well pump fails Effect without Mitigation: The given well will not be able to contribute to meeting extraction rate goals until the pump is repaired or replaced.	a. Mechanical or electrical failure.		Preventative maintenance schedule	RUN failure light Indication: P100 or P101 OFF		Repair or replace pump	2	0	
3. Failure: Line from extraction well clogs or leaks. Effect without Mitigation: Given pipeline unable to carry water to treatment system.	a. Puncture, crushing	Redundant pipeline installed					3	0	
	b. Solids buildup	Well-developed wells will have low suspended solids					2	0	

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
4. Failure: Cr(VI) not reduced – insufficient ferrous iron Effect without mitigation: If not mitigated may result in incomplete reduction of Cr(VI).	a. $FeCl_2$ feed pump failure	OFF or FAILURE signal from pump.					4a	1[a]	Spare chemical feed pump will be provided on-site.
	b. Leak or clog in $FeCl_2$ feed line from pump to tank	Will add clear length of piping to visually verify chemical is being fed	Inspect $FeCl_2$ tank for nozzle obstructions, bugs, and wind-blown and foreign debris.		Leak - Visible leaking Clog – Visual verification	Fix feed. If not being fed: shut down plant.	4a	1[a]	
	c. $FeCl_2$ feed line leak or clog between tote and pump	Pump (LMI Series AA) has an alarm signal back to the PLC if it has received a signal to run and no chemical flow is detected. Signal shuts down entire plant.					4a	1[a]	
	d. Failure of flow meter that controls $FeCl_2$ feed		Routine inspection of flow meter	Flows through plant not equal to flow set for that time Meter: FIT-200		Replace or repair flow meter	4a	1[a]	
	e. $FeCl_2$ is stratified within tote	Mix using paddle	Visual observation of stratification.		Stratification is observed	Modify mixer	4a	1[a]	New mixer may be added if necessary
	f. $FeCl_2$ batch has a ferrous concentration lower than specified by chemical supplier	Pump (LMI Series AA) has an alarm signal back to the PLC if it has received a signal to run and no chemical flow is detected. Signal shuts down entire plant.	1 - Track Cr(VI) in effluent. 2 - Ferrous sampling of each tote upon delivery		Concentration less than specified	Increase flow of chemical per flow of water, or add new tote	4a	1[a]	May require new totes delivery
	g. $FeCl_2$ tote empty	Pump (LMI Series AA) comes with an alarm signal back to the PLC if it has received a signal to run and no chemical flow is detected.	Daily inspection of $FeCl_2$ level.		Empty tote	Add new tote	4a	1-4	
	h. Low Fe(II) dosage target (due to abrupt rises in Cr(VI) concentrations)		Perform routine tests of inlet Cr(VI) (looking for increased concentration) and could do $FeCl_2$ jar tests		Significant increase in inlet Cr(VI), OR increase in outlet Cr(VI)	Modify Fe(II) dosage	4a	1[a]	One potential source of abrupt changes in Cr(VI) concentration is pumping shifts from the wells. For example, if a low-Cr(VI) well drops in flow, the Cr(VI) concentration may increase.

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations: Mitigation	Observable Condition: PLC	Observable Condition: Human	Action if Cause Occurs	Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
5. Failure: Incomplete reduction of Cr(VI)– pH too high causing reaction kinetics to be too slow for sufficient reduction reaction to occur in available residence time. Effect without Mitigation: If not mitigated may result in incomplete reduction of Cr(VI).	a. Retention time too low	Process: Bench-scale kinetics tests have been conducted to predict the required retention time, safety factor has been applied to provide sufficient time at max design flow.					2	N/A (could function at lower flow). >30 days to install new tanks if needed	First Iron oxidation reactor could potentially be converted to a second Cr reduction reactor if needed.
	b. Mixer failure in Cr Reduction tank		Maintenance and inspection.	Tank not mixed Indication: M300 OFF		Repair or replace mixer	2	1 (repair) to 40 (replace)	Would likely have sufficient mixing in just the Plug Flow Reactor.
	c. Floating cover removed, compromised, or missing		Maintenance and inspection		Cover not moving	Repair or replace cover	1	1 (repair) to 40 (replace). See Note	System could continue to operate (as IM-2 does) but air addition could cause need to use additional FeCl
6. Failure: Incomplete reduction of Cr(VI)– pH too high due to problem with acid feed system causing reaction kinetics to be too slow for sufficient reduction reaction to occur in available residence time. Effect without Mitigation: If not mitigated may result in incomplete reduction of Cr(VI).	a. Sulfuric acid feed pump failure	OFF or FAILURE signal from pump. and pH meter to monitor					2	1[a]	This failure mode does not seem plausible. None of the GW has pH high enough to inactivate Fe(II). Available oxygen should not be sufficient to compete with Cr(VI) for the Fe(II) at currently planned stoichiometry. $FeCl_2$ will also lower pH, so acid may not be needed. Batch plant operations indicate that pH is consistently reduced to less than 5.5 without sulfuric acid addition.
	b. Sulfuric acid feed line leak or clog		Look for obstructions such as bugs and wind-blown debris in tank and acid line.		Acid not fed	Repair or replace feed line	2	1[a]	
	c. Failure/fouling of pH meter that can be used to control acid feed		Routine inspection and cleaning of pH probe (note – this should be less prone to fouling then later in iron oxidation tanks)	Meters found to be have lost calibration Meter: AIT-202-1 and 202-2		Calibrate. Can flow-pace acid feed.	2	1[a]	
	d. Acid tote empty	Pump (LMI Series AA) has an alarm signal back to the PLC if it has received a signal to run and no chemical flow is detected. Signal shuts down entire plant.	Daily inspection of acid level.		Tote empty	Install new tote	2	1-4	
7. Failure: Iron and Cr(III) are not oxidized and precipitated – due to failure to raise pH to range needed to precipitate in available retention time Effect without Mitigation: If not mitigated may result in incomplete precipitation of Cr(III).	a. Sodium Hydroxide feed pump failure	OFF or FAILURE signal from pump and pH meter to monitor					4b	1[a]	
	b. Retention time too low	Bench-scale kinetics tests have been conducted to predict the required retention time, safety factor has been applied to provide sufficient time at max design flow					4b	N/A (could function at lower flow). >30 days to install new tanks if needed	

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
7. continued	c. Sodium Hydroxide feed line leak or clog	pH meter to monitor	Inspect tank for foreign substances in tank nozzle and caustic line.		Caustic not being fed at tanks	Repair or replace feed line	4b	1[a]	
	d. Failure/fouling of pH probe(s) that controls Sodium Hydroxide feed	Process: Could use flow-pacing rather than pH-pacing of sodium hydroxide feed in first two tanks as flow meter less likely to give false reading than pH probe. Process: Recirculating the sludge from clarifier will provide preferential nucleation site to help reduce solids buildup on probes. Design. Will make pH probes accessible to operators.	Routine inspection and cleaning of pH probe		Rapid loss of calibration, visual fouling	Re-calibrate. Could install hot-tap self-cleaning probes	4b	1[a]	
	e. Sodium Hydroxide tote empty	Pump (LMI Series AA) has an alarm signal back to the PLC if it has received a signal to run and no chemical flow is detected. Signal shuts down entire plant.	Daily inspection of Sodium Hydroxide level.		Tote empty	Install new tote	4b	1-4	
	f. Caustic freezes	Mitigate by using lower concentration caustic, less than 30%, which has freezing point lower than water's so should not be encountered at site. Will also heat trace and insulate feed line.					4b	2-5	
	g. Mixer failure in Iron Oxidation tanks	Blower should keep tank agitated to a great extent.	Maintenance and inspection.	Tank not mixing due to motor: Indication: M301A, or M301B, or M301C OFF	Visual inspection periodically (requires removing manway)	Repair or replace mixer	4b	N/A (could function at lower flow). >30 days to install new tanks if needed	

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
8. Failure: Iron and Cr(III) are not oxidized and precipitated – due to insufficient air Effect without Mitigation: If not mitigated may result in incomplete precipitation of Cr(III).	a. Blower failure	Flow meters (FIT-300A, FIT-300B, and FIT-300C) provided. Low flow can signal blower failure. 3 tanks are provided, each with a blower.					2	7	
	b. Failure of backflow valve - Water flows back to blower and shuts it down	Air duct is "looped" above water level to prevent backflow.					2	7	
	c. Air line leak or clog, upstream of flow switch	Flow meters (FIT-300A, FIT-300B, and FIT-300C) provided, can signal stop of flow. Pressure Switch Low as a surrogate measurement					2	1[a]	Given size of air lines, such an obstruction seems extremely unlikely.
	d. Air line leak or clog, downstream of flow switch	Locate flow meters close to tanks					2	1[a]	
9. Failure: Clarifier clogged Effect without Mitigation: Solids carryover – leads to increased solids load on Microfilter and increases frequency of cleaning.	a. Solids "stick" to plates. .	Process. Process control of sludge recirculation will help minimize risk.	Monitor sludge blanket level using decant nozzles on clarifier thickener, control level by changing sludge wastage rate.		Estimate sludge blanket level using the side taps on the sludge section of the clarifier. For example, drain water from taps #2 and #3 and know if the sludge blanket top is between taps #2 and #3.	Clean plates. Evaluate polymer use and sludge recirculation	Initial: 1 Extreme: 2	2-4	In extreme case, could require more frequent system downtime for cleaning, and therefore reduced throughput over time.
	b. Solids wastage rate too low	Set sludge withdrawal based on dual **timer**: "frequency – dwell time" system, and turbidimeter on clarifier overflow for signs of solids carry-over.					Initial: 1 Extreme: 2	1[a]	
	c. Flow to clarifier is not increased gradually during restarts		SOPs require gradual ramp up in flow to clarifier during any system restart.		Overflow	Ramp up slower	Initial: 1 Extreme: 2	1	

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
10. Failure: Excess Floc Carryover Effect without Mitigation: Solids carryover – leads to increased solids load on Microfilter and increases frequency of cleaning.	a. Poor flocculation		Improve chemistry		Poor floc formation and settling	Operator to perform jar tests to select better flocculant dosage	Initial: 1 Extreme: 2	N/A	In extreme case, could require more frequent system downtime for cleaning, and therefore reduced throughput over time.
	b. Low floc density		Improve chemistry		Poor floc formation and settling	Operator to perform jar tests to select better flocculant dosage. Or, increase proportion of sludge recirculated.	Initial: 1 Extreme: 2	N/A	
11. Failure: Sludge is slow in dewatering through separators Effect without Mitigation: Potentially can not dewater all produced sludge with just the 2 in-service separators	a. Sludge characteristics – poorly draining. Polymer not managed properly to optimize dewatering.	Process: provide polymer per manufacturer suggestion to condition sludge for better dewatering Have saved room on pad for filter press, which could process sludge faster if needed.	Could ship sludge with higher moisture content at increased costs				1	2-4	
12. Failure: Microfiltration fouling Effect without Mitigation: Reduced throughput	a. Iron oxide fouling is the more likely type of fouling (Acid-cleanable). Probably not silica.		Periodic MF inspection		Maintenance of MF should include observing foulant buildup	Initiate MF backwash and/or membrane cleaning cycle	2	2-4	
13. Failure: Microfiltration system general failure Effect without Mitigation: Reduced throughput, or treatment system shutdown	a. Membrane rupture	Turbidimeter provided in MF package.	Inspection and maintenance per manufacturer.	Increased turbidity reading Alarm: Microfilter PLC signal AAH2		Inspect MF membranes	3	3-5	
14. Failure: RO membrane fouling Effect without Mitigation: Reduced throughput, or treatment system shutdown	a. Physical/chemical fouling		Maintenance Periodic acid cleaning.	Increased differential pressure Alarm: DPAH606, or DPAH607, or DPAH608		Frequency based on membrane autopsy (Avista Technologies, the inhibitor supplier, excels at these custom and difficult applications) accumulated operating experience.	2	1-3	Fouling will occur, clean-in-place skid provided to remove the fouling
15. Failure: RO – Deterioration of salt-rejecting layer. Effect without Mitigation: Increased TDS in permeate stream	a. Scale formation; membrane abrasion from frequent start-stop operation; and/or flow maldistribution along brine channel (high polarization effect).	Minimize start/stop operation					Initial: 4c Extreme: 3	0-5	Initially plant would not shut down, waste production issue only. In extreme case would need to shut down the system to replace RO membranes.

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations: Mitigation	Observable Condition: PLC	Observable Condition: Human	Action if Cause Occurs	Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
15. Continued	b. Higher TDS influent than expected, or Incorrect ops in blending permeate and untreated water or brine.		Monitor discharge conductivity (AIT-610) (surrogate for TDS)		Increased TDS in periodic discharge monitoring sampling	Correct the blend ratio	Initial: 4c Extreme: 3	N/A	Initially plant would not shut down, waste production issue only. In extreme case would need to shut down the system to replace RO membranes.
16. Failure: RO – Scale formation Effect without Mitigation: Increasing pressure drop across pressure vessels, starting at most concentrated end of RO unit.	a. Failure to feed scale inhibitor; change in water chemistry.		Verify antiscalant feed. Check feed water chemistry, especially calcium, sulfate, fluoride, molybdate-reactive silica, pH, alkalinity, and TDS (or conductivity). Then look at Sr, Ba, Fe, Mn, and Al. Verify correct pressure vessel flow distributions (product can be surrogate for brine). Check operation of pH control system	Increased differential pressure Alarm: DPAH606, or DPAH607, or DPAH608		Autopsy the fouled membrane element (have Avista support).	Initial: 1 Extreme: 3	2-5	In extreme case would need to shut down the system to replace RO membranes.
17. Failure: RO – Reduced Product Water Recovery Effect without Mitigation: Higher handling, storage, transport and disposal costs	a. Flow-ratio controller on RO skid failure, or flow elements failure, or loss of calibration.		Check flow-ratio controller and flow elements on RO feed and product (permeate) for failure or calibration.	Reduced recovery Indication: F-611		Evaluate RO system operations with the manufacturer	1	0-5	Initially plant would not shut down, waste production issue only.
18. Failure: RO – UV damage of membranes Effect without Mitigation: Membrane damage	a. Sunlight	Wall down to ground around RO system to keep sunlight that comes through the 12 foot opening beneath the sidewall, and if needed, a curtain hung around RO skid					Initial: 4c Extreme: 3	5-10	
19. Failure: Power failure Effect without Mitigation: Immediate loss of power which may not allow for systematic shutdown of plant.	a. Power grid, transmission line, or transformer failure. Typically less than 24 hours (based on Needles utility records)	There will be UPS on controls and each computer (2 computers for operator interface), and auto-dialer. Provides 15 minutes to shut down system in orderly manner.					3	1-2	The City of Needles (Ron Myers) checked logs from 8/2003 to 9/2004. It was reported that there were 7 outages, 6 of which were <8 hours and one of 20 hours. These were in the monsoon season of July to Sept due to lightning or wind-downed transmission lines.
20. Failure: Disposal – injection wells (if chosen) insufficient for flow Effect without Mitigation: Reduced system capacity.	a. Unforeseen conditions after installation and testing	Will design injection wells for 150% of max flow and can install more wells.					2	N/A	Plant would not shut down, waste production issue

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations				Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
			Mitigation	Observable Condition		Action if Cause Occurs			
				PLC	Human				
	b. Rapid fouling of screen or formation due to groundwater conditions and injected water quality	Provide "backwash" capability for wells by installing pumps in the wells.	Means to mitigate decreasing flow capacity are described in Interim Measures No. 3 Injection Well Operation and Maintenance Plan				2	N/A	Plant would not shut down, waste production issue
21. <u>Failure</u>: Disposal – sludge trucks unable to access site due to difficult road conditions <u>Effect without Mitigation</u>: Once available sludge holding tank and separators are full will necessitate system flow reduction and finally shutdown	a. Monsoon-caused washouts	Two access routes are provided (from East and from West)	Road maintenance		Road impassible	Repair road	Initial: 2 Extreme: 3	1-5	Initially reduces throughput, eventually will cause shutdown if can not remove sludge.
22. <u>Failure</u>: Closed valves in nearly any line (process, air, vent, chemical feed, and waste) can cause system overflow. In case of chemical feeds, could cause failures described in early sections.	a. Closed manual valves left in wrong position	"Frequent" (user-defined) operation of sump tank pump will signal alarm.	Careful operation, adherence to SOPs, adequate operator training, proper preventative maintenance				3	1[a]	
<u>Effect without Mitigation</u>: System shutdown, capture overflow in plant drain system for reprocessing or off-site disposal.	b. Automatic valves moved or fail to wrong position	Select "fail open" or "fail closed" valves to avoid the negative effect					3	1[a]	
23. <u>Failure</u>: Pump failure <u>Effect without Mitigation</u>: System shutdown; If pump leaks, capture leak in plant drain system for reprocessing or off-site disposal.	a. Seal failure; starter failure (heat at site); and/or mechanical failure.		Care in operations; proper preventative maintenance	Low pressure switch alarm PSL-1100	Pump not working (audible)	Repair or replace. Improve cooling of Electronics room.	3	1-28	
24. <u>Failure</u>: Line leaks, or tank leaks would necessitate stopping treatment process in order to fix. <u>Effect without Mitigation</u>: System shutdown. Capture leak in plant drain system for reprocessing or off-site disposal.	a. Puncture	Level alarm in process sump tank	Visual inspection of plant; proper preventative maintenance		Leaks	Fix leak	3	1-5	
25. <u>Failure</u>: Chemicals – lose their properties due to heat/UV <u>Effect without Mitigation</u>: Loss of pH control and subsequent plant shutdown	a. Extreme heat at site	Put chemicals under separate, lower roof. This area is east of the main building so is shaded from afternoon, western sun.					2	2-4	
26. <u>Failure</u>: Damage from wind-blown dust. <u>Effect without Mitigation</u>: Damage to plant causes shutdown of system	a. High winds in area Blown dust in desert conditions	Wall to within 12 feet of ground to serve as wind barrier will reduce damage. Two doors will provide "air lock" to control dust into Electronics and Control rooms.	Operations: Routine checks of the seals on critical equipment, parts; proper preventative maintenance of mechanical and electrical equipment		Abrasion damage or motors failing	Repair or replace equipment.	3	1-28	

PG&E Topock Failure Mode Effect Analysis

Failure and Effect without Mitigation	Potential Cause	Mitigation – Design	Mitigation - Operations: Mitigation	Observable Condition: PLC	Observable Condition: Human	Action if Cause Occurs	Severity of Effect if Not Mitigated	Estimated Resulting System Downtime (days)	Notes
27. Failure: Seismic damage Effect without Mitigation: Damage to plant may cause shutdown of system	a. Earthquake	Structure rated for seismic zone 3					3	Varies	
28. Failure: Air compressor failure Effect without Mitigation: Microfiltration system shuts down	a. Mechanical failure or high-pressure air line rupture		Proper preventative maintenance of compressor	Low pressure or compressor stops working. Alarm: PAL-1000		Repair or replace equipment.	3	28	
29. Failure: Pipeline to injection field leaks Effect without Mitigation: Release of treated water and plant shutdown once observed	a. Puncture or crushing	Install pipe on edge of road. Use metal pipe rather than plastic.					3	1-14	
30. Failure: Freezing of groundwater Effect without Mitigation:: Flow through plant could stop, could damage pipe or instruments.	a. Cold temperatures	Flowing water should not freeze at conditions seen at this site.	Drain system to remove water		Weather forecast and anticipated outage schedule.	If plant is to be down and record lows for area are forecasted, the system should be drained.	3	1[a]	
31. Failure: Flooding Effect without Mitigation:: Damage to equipment could result in some equipment being shutdown or require replacement	a. Rising water levels in Colorado River	Construct most equipment outside of floodplain. If in floodplain, use watertight valve vault covers.					2	2-14	Only PE-1 is in flood plain
32. Failure: System is damaged due to vandalism Effect without Mitigation:: Damage to equipment could result in some equipment being shutdown or require replacement	a. Vandalism	Fence around treatment system. Further, controls built into the system (alarms, containment, automatic cutoffs and shutdowns) are designed to help mitigate uncontrolled releases or discharges following several types of failures due to vandalism	Periodic inspections of all equipment inside and outside treatment area			Report damage to project management	1 or 3	Varies	

* - Severity of Effect codes:
- 1 – Does not impact water quality or throughput
- 2 – If not mitigated may reduce plant's water throughput
- 3 – If not mitigated may shutdown plant
- 4a – If not mitigated may result in incomplete reduction of Cr(VI).
- 4b - If not mitigated may result in incomplete precipitation of total Cr.
- 4c - If not mitigated may result in reduced TDS removal from RO permeate. Note this would be initially mitigated by decreasing percent of water bypassing RO, which would provide time to correct problem.

[a] – These times are assumed to be one day when plant is manned.

PLC = Treatment system Programmable Logic Controller