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April 9, 2012

Mr. Harold J. Singer
Executive Officer
California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150-7704

Re: PG&E's Replacement Water Feasibility Study Under Ordering Paragraph 2.c. Amended Cleanup and Abatement Order No. R6V-2011-0005A1

Dear Mr. Singer:

Pacific Gas and Electric Company (PG&E) submits the following Replacement Water Feasibility Study Report (Feasibility Study) in response to Ordering Paragraph 2.c. of Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (the "Order"), issued October 11, 2011 for the Hinkley Compressor Station. The Feasibility Study provides PG&E's evaluation of methods to provide replacement water supply for all indoor domestic uses, containing hexavalent chromium at levels below the current laboratory reporting limit of 0.06 µg/L, for all impacted wells within the affected area. The affected area is defined in the Order as including domestic wells within one mile down-gradient or cross-gradient of the plume boundary defined by the current background concentrations (3.1 µg/L hexavalent chromium or 3.2 µg/L total chromium).

As we described in PG&E's November 23, 2011 and December 22, 2011 submittals pursuant to Ordering Paragraph 3.a. of the Order (and in our October 25, 2011 petition for review of the Order), PG&E has found no technically sound statistical method to determine whether PG&E's discharge has affected wells containing hexavalent chromium detections below the current background values. Accordingly, this Feasibility Study evaluates the most feasible options for providing replacement water to those households located down gradient or cross gradient of the plume within the affected area with domestic well detections above the current background concentrations for hexavalent or total chromium.

Concurrent with this Feasibility Study, PG&E is also developing a voluntary program to provide a replacement water supply to those households within the affected area that have detections in their domestic wells below the current background values for hexavalent chromium or total chromium and above non-detect. We believe a voluntary program is the best solution to expeditiously address community concerns that exist regarding domestic well water supplies while the State of California completes its process of determining the safe drinking water standard specifically for hexavalent chromium. PG&E will share the details of our voluntary program with the Water Board and the community shortly. During the community engagement and planning stages of the voluntary program implementation, PG&E will continue to operate our bottled water program.

PG&E has for many years acknowledged with genuine regret its responsibility for its chromium contamination in the Hinkley community. PG&E is committed to working cooperatively with the Water Board to expeditiously clean up groundwater contamination resulting from PG&E's historical operations at the Hinkley Compressor Station. We share the mutual goal of ensuring safe, reliable drinking water for the residents of Hinkley and easing their concerns. The provision of replacement water for all indoor uses is designed to address these community concerns.

Feasibility Study Evaluation and PG&E Recommendations

The Feasibility Study evaluates multiple alternatives which can provide replacement water to those down-gradient or cross-gradient households within the affected area which currently have detections of hexavalent chromium or total chromium above the background values. The Order requires that replacement water contain hexavalent chromium concentrations below the reporting limit of 0.06 µg/L (or hexavalent chromium concentrations less than the final maximum contaminant level, once that standard is adopted). The Order, as written, also requires that the replacement water must meet all California primary and secondary drinking water standards. However, the latter provision would not appear applicable to the situation where PG&E provides a replacement water supply where hexavalent chromium has been removed from well water, leaving only constituents that are not present as a result of PG&E's actions.

As a result, the primary focus of the Feasibility Study was to demonstrate alternatives that will provide water with hexavalent chromium levels below 0.06 µg/L; however, PG&E did also evaluate options that would result in the replacement water meeting all the California primary and secondary standards.

The alternatives evaluated include:

- Replacing individual wells with deeper individual wells,
- Providing storage tanks and hauling water,
- Providing point of entry ("whole house") treatment systems, and
- Providing replacement water from an existing or new community water system.

PG&E conducted a pilot study test from November 2011 until April 2012 to evaluate three point of entry treatment systems using the following technologies: 1) ion exchange, 2) reverse osmosis and 3) hybrid reverse osmosis – ion exchange. Results of the pilot study are included in Appendix B of the Feasibility Study.

As fully described in the document, PG&E is recommending a combination of the options for those down-gradient or cross-gradient households within the affected area with wells above the current background values. The Feasibility Study found that while each of the alternatives evaluated has its own set of advantages and disadvantages, two of the alternatives, a point of entry ion exchange treatment system (with small under-sink reverse osmosis units) or drilling deeper wells (where supported by the hydrogeology), are more practical from a time, efficiency, waste production, cost, permitting and overall implementation standpoint.

PG&E is committed to providing whole house water to those down gradient or cross gradient households currently with detections of hexavalent chromium above background concentrations through the drilling of deeper wells (where feasible) or by providing individual whole house ion exchange treatment systems (supplemented by small under-sink reverse osmosis treatment systems) for a period of up to 5 years or until such time as the California drinking water standard for hexavalent chromium has been adopted. Our commitment includes paying for all costs associated with the drilling of deeper wells or maintenance, operation, and monitoring of the treatment systems. The process of developing the drinking water standard is currently underway and is anticipated to take two to three years. Upon the adoption of the California drinking water standard for hexavalent chromium, or no later than 5 years from implementation, PG&E will review the whole house water program, utilizing all available information including the findings from the background study, new data and information regarding cleanup progress, to determine the future of the program.

Outreach Regarding Recommended Alternatives

PG&E has been actively discussing and presenting the progress of our analysis of water alternatives to the Hinkley community and the Water Board since August 2011 as summarized in the table below. Over the next few months, PG&E will expand these discussions to present our recommended options for residents that are eligible for replacement water through either this Feasibility Study or our larger voluntary program. We understand that eligible residents will want to fully understand their options before we implement the program. Later this month, PG&E will being sending letters and placing phone calls to each of these residents/owners with the goal of scheduling an in-person meeting to gather their input. Upon conclusion of this process, PG&E will summarize the input and provide the summary to the Water Board. PG&E will accelerate activities such as ordering the treatment units to allow for expeditious implementation of the preferred option upon Water Board approval.

In addition to these steps, PG&E will be meeting with the members of the Community Advisory Committee, and the Independent Review Panel (IRP) manager, Ian Webster, to present the Feasibility Study, explain the contents and answer any questions. PG&E plans to fully engage the IRP manager as we gather the input on our recommended options and will discuss the Feasibility Study conclusions at the April 26, 2012 and May 24, 2012 Community Advisory Committee meetings. We will also be conducting community wide outreach activities over the next several months as part of our larger voluntary program. The results of this effort will also be shared with the Water Board and the community upon conclusion.

Engagement Activities to Date

Community and Water Board Engagement Activities	**Description**	**Dates**
Community Advisory (CAC) Committee Meetings	PG&E provided updates, including poster boards depicting the three treatments systems studied in the pilot test of methods to provide replacement water	• September 28, 2011 • November 2, 2011 • December 14, 2011 • February 22, 2012
Community Advisory Committee Pilot Test Site Tours	PG&E has worked with the Hinkley community to establish a Community Advisory Committee. PG&E technical experts hosted two tours/Q&A sessions of the Pilot Test facilities with Committee members and the community's technical expert, Dr. Ian Webster.	• November 9, 2011 • February 22, 2012
Public Tour of Pilot Test Site	Approximately 38 members of the Hinkley community attended a tour/Q&A session of the Pilot Test facility with PG&E technical experts	• February 25, 2012

PG&E looks forward to working with the Water Board, the Community Advisory Committee and the IRP manager as we implement the options proposed in the Feasibility Study as well as our larger voluntary program to provide replacement water. In the interim, PG&E will continue to honor our commitment to provide replacement drinking water to the community through our bottled water program. If you have any questions regarding this report, please feel free to contact me at (415) 973-7601.

Sincerely,

Robert C. Doss

Enclosure

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Pacific Gas and Electric Company

Replacement Water Supply Feasibility Study Report

Hinkley Compressor Station
Hinkley, California

April 2012

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Replacement Water Supply Feasibility Study

Hinkley Compressor Station
Hinkley, California

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering
ANSI	American National Standards Institute
BAP	Base Annual Production
bgs	below ground surface
CAC	Community Advisory Committee
CCR	California Code of Regulations
CDPH	California Department of Public Health
CEQA	California Environmental Quality Act
CHSC	California Health and Safety Code
CPUC	California Public Utilities Commission
CWS	Community Water System
D/DBPR	Disinfectant/Disinfection Byproduct Rule
DWP	CDPH Drinking Water Program
DWSAP	Drinking Water Source Assessment and Protection
DWSP	Domestic Water Supply Permit
DVD	Desert View Dairy
ENR CCI	Engineering News Record Construction Cost Index
FPA	Free Production Allowance
GAMA	Groundwater Ambient Monitoring & Assessment
gpcd	gallons per capita per day
gpm	gallons per minute
GSWC	Golden State Water Company
GWUDI	Groundwater under the direct influence of surface water
IX	ion exchange
LCR	Lead and Copper Rule
LPA	local primacy agency
µg/L	micrograms per liter
MCL	Maximum Contaminant Level
mg/L	milligrams per liter

MWA	Mojave Water Agency
NL	notification level
NPDWR	National Primary Drinking Water Regulations
NSF	National Sanitation Foundation
NTNCWS	Non-Transient Non-Community Water System
NTU	nephelometric turbidity unit
O&M	operations and maintenance
PCA	possible contaminating activity
PG&E	Pacific Gas and Electric Company
POE	point of entry
PWS	public water system
RCF	reduction, coagulation, and filtration
RO	reverse osmosis
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
TCR	Total Coliform Rule
TDS	total dissolved solids
TENORM	Technologically enhanced naturally occurring radiological material
TMF	Technical, management, and financial
TNCWS	Transient Non-Community Water System
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
V	volt
WBA	weak base anion

Executive Summary

On behalf of Pacific Gas and Electric Company (PG&E), ARCADIS has prepared this Replacement Water Feasibility Study Report (Feasibility Study) in response to Ordering Paragraph 2.c. of Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (Order), issued October 11, 2011, for the Hinkley Compressor Station. The Feasibility Study presents an evaluation of methods to provide replacement water supply for all indoor domestic uses, containing hexavalent chromium at levels below the current laboratory reporting limit of 0.06 µg/L for all impacted wells within the affected area. The affected area is defined in the Order as including domestic wells within one mile down-gradient or cross-gradient of the plume boundary defined by the current background concentrations (3.1 µg/L hexavalent chromium or 3.2 µg/L total chromium).

As described in PG&E's November 23, 2011 and December 22, 2011 submittals pursuant to Ordering Paragraph 3.a. of the Order (and in its October 25, 2011 petition for review of the Order), PG&E does not believe there is a credible method to determine the source of hexavalent chromium in domestic wells with detections below the current background values. Accordingly, this Feasibility Study evaluates the most feasible options for providing replacement water to those households located down gradient or cross gradient of the plume within the affected area with domestic well detections above the current background concentrations for hexavalent or total chromium.

Candidate replacement water supply alternatives were developed based on available site and treatment information (e.g., water quality data, treatment technology ability to remove hexavalent chromium to very low concentrations), an initial assessment of the existing and projected future water demands, and technologies and strategies used in similar situations where groundwater has been known to contain one or more comparable constituents with concentrations greater than allowable limits. The initial candidate replacement water supply alternatives were presented at the September 28, 2011 Community Advisory Committee (CAC) meeting. The alternatives included, replacing impacted wells with deeper individual wells, hauling water to individual residences in conjunction with providing on-site storage tanks, providing individual whole-house water treatment systems, and implementing a community water system.

After the initial presentation, these concepts were further refined by gathering additional water quality data, pilot testing appropriate whole-house water treatment technologies, reviewing legal and regulatory requirements, and assessing

environmental impacts. The Hinkley community and Water Board were updated on an ongoing basis to solicit initial feedback. Based on site and treatment technology information and feedback collected, six primary alternatives were identified for further evaluation in this Feasibility Study, representing the range of water supply options for the impacted wells in the affected area:

- Alternative 1 – Connect to an Existing Community Water System (Centralized Treatment and Distribution);
- Alternative 2 – Develop a New Community Water System Utilizing Groundwater Near the Mojave River (Centralized Treatment and Distribution);
- Alternative 3 – Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program (Centralized Treatment and Distribution);
- Alternative 4a-c – Provide Point of Entry Whole-House Water Treatment;
  - 4a: Whole-House Ion Exchange
  - 4b: Whole-House Reverse Osmosis
  - 4c: Whole-House Ion Exchange Plus Undersink Reverse Osmosis
- Alternative 5 – Replace Impacted Wells with Deeper Wells; and,
- Alternative 6 – Truck Water from a Community Water System.

After the six alternatives were identified, the concept for each alternative was further developed by compiling essential information in the following focus areas:

- System configuration and required infrastructure
- System performance
- Applicable legal and regulatory requirements and institutional complexities
- System construction
- Operations, maintenance, and replacement
- Environmental and other considerations

The developed alternatives were subsequently compared using 11 evaluation criteria, as well as on the basis of conceptual level capital and operations and maintenance (O&M) costs. Each alternative was assigned a score for each criterion using a five-point system, depicted as a series of shaded circles. PG&E will propose a recommended option based on all of the evaluation criteria. Community input will be solicited on these options and incorporated into PG&E's implementation plan for providing replacement water. The scores for each alternative relative to all other criteria are shown in Table ES-1.

A summary of the alternatives evaluation relative to key areas is provided as follows:

Technical Feasibility – All six alternatives are technically able to meet the Order requirements of reducing hexavalent chromium concentrations to below the 0.06 µg/L reporting limit while meeting all applicable drinking water standards, in some cases with multiple treatment steps. The biggest technical challenges for the alternatives include brine management (Alternative 4b), designing a centralized treatment and distribution system (Alternatives 1, 2, and 3), and accommodating the variability in water quality throughout the Hinkley Valley.

Capital and O&M Cost – Costs are highly dependent on water quality and quantity of water produced. Alternatives that involve hauling water or brine (Alternatives 4b and 6) will be the most expensive over long periods of time. Because of high capital costs and economies of scale for operation, centralized treatment alternatives (Alternatives 1, 2, and 3) are more economical on a per household basis when large quantities of water are produced (i.e., many connections) and the capital investment can be spread over long periods of time. Point of entry whole house water treatment systems and drilling deeper wells (Alternative 4a, 4c, and 5) are most economical in the short-term and for fewer connections, pending favorable water quality.

Community Water Systems – Because hexavalent chromium has been detected and occurs naturally throughout the Mojave Desert Area, it was assumed that all community water systems would require treatment to bring hexavalent chromium concentrations below the reporting limit required in the Order. If developing a centralized treatment system (Alternative 1, 2, and 3), the water supply should be near the demand to reduce impacts and capital and O&M costs. In the case of Hinkley, using local groundwater from within the plume or near the Mojave River is preferred over connecting to Golden State Water Company (GSWC). This was also recommended in conversations with GSWC. Similarly, treating high quality water (low TDS and other constituents) will reduce impacts and costs significantly over a long period of time. A new community water system for residences dispersed over several square miles can increase environmental impacts and be costly on a per household basis. It would take approximately two to four years to plan, design, permit, construct and perform start-up testing for a new community water system with centralized treatment. If an MCL for hexavalent chromium is established above Hinkley background levels and PG&E is no longer supporting operating costs, residents may find using water from the community water system (CWS) cost prohibitive.

Whole-House Water Treatment – IX and RO whole-house water treatment systems (and other variations tested in the pilot study) were able to reduce hexavalent chromium concentrations to below the 0.06 µg/L reporting limit (Alternatives 4a, 4b, and 4c). IX may remove some additional constituents in the water, particularly nitrate, arsenic, and uranium. RO has a high probability of removing most dissolved constituents, but presents a series of technical challenges that must be vetted and addressed prior to implementation (quantity of water produced, corrosive nature of the produced water, and brine management). IX followed by undersink RO is an alternative for whole-house water treatment that is capable of removing hexavalent chromium for the whole house water and addressing aesthetic concerns such as total dissolved solids (TDS) at the taps. Pending permits and equipment procurement, point of entry water treatment systems could be implemented within one year of approval.

Deeper Wells – Replacing existing impacted wells with deeper wells (Alternative 6) has the potential of avoiding or reducing treatment, is relatively quick to implement, and would require fewer operation and maintenance considerations. Based on water quality data and hydrogeology, there are some areas within Hinkley that may be more conducive to deeper wells, and some areas where it is not feasible. Additional hydrogeological assessments and/or pilot wells may be needed to determine which properties have the highest potential for improved water quality as a result of a deeper well. Pending permits and water treatment system procurement (if needed), drilling deeper wells could be implemented within one year of approval.

Hauling Water – From a logistical and economic standpoint, hauling water (Alternative 6) may not be a feasible replacement water supply. Aside from the significant costs to haul water and the possibility that such a supply may be subject to intermittent unavailability, hauling water carries additional safety risks and environmental concerns associated with increased vehicle transport. Hauling water should be considered primarily as a contingency plan for ensuring uninterrupted water supply to properties with impacted wells. This is consistent with CDPH's position that hauling water is not a long-term water supply strategy.

Implementation Schedule – It may be difficult for any of the alternatives described to be implemented within 90 days of the acceptance of the Plan by the Water Board. The timing to implement any of the replacement water supply alternatives is highly dependent on the permitting and procurement process. Some alternatives can be implemented within a year (whole-house water treatment and drilling deeper wells) while others (centralized water treatment and distribution) would take considerably more time to plan, design, permit, construct, and start-up (two to four years).

Environmental Impacts – Some alternatives present more potential risks to the surrounding environment than others. Centralized treatment and delivery alternatives (Alternatives 1, 2, and 3) present more of a risk during construction (earth disturbances during construction and potential alteration of habitat for the desert tortoise and Mojave ground squirrel). Alternatives involving hauling water or brine (Alternatives 4b and 6) present more risks and safety concerns during operation and maintenance (truck traffic, vehicular emissions, dust control, road damage). Environmental impacts associated with IX whole-house water treatment and drilling deeper wells are expected to be minimal (Alternatives 4a, 4c, and 5).

Community Involvement – PG&E has been actively discussing and presenting the progress of their analysis of water alternatives to the Hinkley community and the Water Board since August 2011. Over the next few months, PG&E will expand these discussions to present their recommended options to residents with impacted wells. In April 2012, PG&E will being sending letters and placing phone calls to each of these residents/owners with impacted wells, with the goal of scheduling an in-person meeting to gather their input. Upon conclusion of this process, PG&E will summarize the input and provide the summary to the Water Board.

In addition to these steps, PG&E will be meeting with the members of the Community Advisory Committee, and the Independent Review Panel (IRP), to present the Feasibility Study, explain the contents and answer any questions. PG&E plans to fully engage the IRP manager as they gather the input on our recommended options and will discuss the Feasibility Study conclusions at the April 26, 2012 and May 24, 2012 Community Advisory Committee meetings.

Other Key Considerations – Additional considerations that should be factored into the selection of a replacement water supply include the following:

- Water quality and quantity are highly variable in the Hinkley area. Domestic well water quality is not regulated by CDPH, and water historically produced from some of the impacted wells may have concentrations of naturally occurring and/or anthropogenic constituents (e.g., arsenic, uranium, nitrate, TDS, sulfate, iron, manganese) that exceed primary and secondary drinking water standards. If a whole-house treatment alternative is selected, each well should be evaluated on a case-by-case basis to determine the best course of action.

- The Order requires a replacement water supply for indoor domestic water; however, this study assumed both indoor and outdoor demands would be served by the new supply (difficult to separate in an existing home). To reduce the quantity of water that requires treatment and give homeowners some additional autonomy over their respective water supplies, new hose bibs for outdoor use could be plumbed to the existing well. Reducing the quantity of water produced would also reduce resin replacements, hauling wastes, power consumption, and other key environmental factors.
- Each impacted well will have unique water quality and hydrogeologic characteristics, which will require consideration in the implementation of a whole-house treatment alternative.

Recommendations and Next Steps

PG&E recommends either installing deep wells or providing a point of entry treatment system for those down-gradient or cross-gradient households within the affected area with wells above the current background values. While each of the alternatives evaluated has its own set of advantages and disadvantages, two of the alternatives, a point of entry ion exchange treatment system (with small under-sink reverse osmosis units) or drilling deeper wells (where supported by the hydrogeology), are more practical from a time, efficiency, waste production, cost, permitting and overall implementation standpoint.

Table ES-1 Replacement Water Supply Alternative Evaluation Matrix

CRITERIA	Community Water Systems			Whole-House Water Treatment					Key Highlights
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b	Alt 4c	Alt 5	Alt 6	
	Connect to GSWC	Mojave River Groundwater	Local Groundwater	IX	RO	IX/ Undersink RO	Deeper Wells	Trucking Water	
Technical Feasibility	Medium	Medium	Medium-Low	Medium-High	Medium	Medium-High	Medium-High	Low	All alternatives are technically feasible; centralized systems would require extensive design and permitting (Alts 1, 2, 3, 6); Whole-house water treatment systems would be innovative but can meet the hexavalent chromium reporting limit (Alts 4a-c, 5); Brine management may present technical challenges (Alt 4b); CDPH indicated that hauling water is not a replacement water supply (Alt 6).
Quantity of Water	Medium-High	Medium-High	Medium-High	Medium	Medium-Low	Medium	Medium	Medium-Low	Alts 4a-c and 5 could be impacted by low production yields from domestic wells; Alternative 6 could be impacted by truck availability and road conditions; Central treatment alternatives may require flushing (Alternatives 1, 2, and 3).
Quality of Water	Medium-High	Medium-High	Medium-High	Medium	Medium	Medium-High	Medium	Medium	Alt 1 and 3 water quality is dependent on GSWC or remediation wells; Alt 2 wells can be targeted for favorable water quality; Central treatment and hauling water alternatives water quality may be compromised due to water age; Water corrosivity is a concern for Alt 4b; Alts 4a and 4c will produce similar or better water quality; Alt 5 water quality is unknown.
Operations, Maintenance, and Replacement	Medium	Medium	Medium	Medium-High	Medium	Medium-High	Medium-High	Medium-Low	Community water systems require certified operator(s); Alts 4a, 4c, and 5 may require frequent resin replacement or maintenance; Alt 4b produces waste that require excessive management. Telemetry systems can be installed on whole-house water treatment systems to communicate system warnings.
By-Products and Waste	High	Medium-High	Medium-High	Medium	Low	Medium	Medium-High	High	Alt 4b produces a large quantity of brine; residuals or wastes resulting from treatment in Barstow (Alts 1 and 6) could be sent to the central sewer system.
Legal, Regulatory, and Institutional Complexity	Medium-Low	Medium-Low	Low	Medium-High	Medium-High	Medium-High	Medium-High	Medium-Low	Alt 1,2, and 3 require DWSPs/amendments and CEQA requirements may apply; CEQA requirements may apply to Alt 6; Alt 3 may require 97-005 compliance; The Water Board would have jurisdiction over Alts 4a-c and 5.
Monitoring, Reporting, and Compliance	Medium-High	Low	Low	Medium-High	Medium-High	Medium-High	Medium-High	Medium-Low	All alternatives will require a monitoring plan; Alts 4a-c will require monitoring at multiple homes; Alts 1 and 6 require only an extension of current GSWC monitoring activities; Alts 4a-c and 5 monitoring and compliance would be coordinated through the Water Board; Alts 2 and 3 require new monitoring plans.
Environmental Considerations	Low	Medium-Low	Medium-Low	High	Low	High	Medium-High	Low	Distribution system construction (Alts 1, 2, 3) could impact desert tortoise/Mojave ground squirrel habitat; Hauling water/brine (Alts 4b and 6) will generate vehicle emissions and may pose a greater risk to road safety in Hinkley.
Timing to Implement	Medium-Low	Medium-Low	Low	High	High	High	High	Medium	Whole house treatment alternatives and deeper wells (Alts 4a-c and 5) could be implemented in less than one year; all other alternatives require design/permitting/construction/agreements that will add multiple years to implementation.
Consistency with the Remedy	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Hydrogeologic conditions in the Hinkley Valley are variable. Outside water sources (Alts 1, 2, 3, 6) may aid in plume containment but only Alt 3 contributes to the remedy; Alts 4a-c and 5 impacts are site-specific and depend on hydrogeologic conditions.
System Redundancy (Contingency Plan)	High	High	High	Medium-High	Medium	Medium-High	Medium-High	Medium-Low	Community water systems have built in redundancy requirements; individual wells are more vulnerable to disruption in service; however, storage is provided to reduce impacts to residents; Hauling water and/or brine (Alts 4b and 6) is highly dependent on the condition of the roads and vehicles.
Cost (Capital and Annual O&M)	Medium-Low	Medium-Low	Medium-Low	High	Low	High	High	Low	Hauling water can be very costly (Alts. 4b and 6); Centralized treatment (Alts 1, 2, 3) has a high capital cost and, with only a few connections, a high O&M cost per connection.

Comparative Rating: Low · Medium-Low · Medium · Medium-High · High

Note:
PG&E continues to conduct community outreach activities. Community input on the Feasibility Study garnered through these planned activities will be used to develop the recommended Plan.

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1. Introduction

On behalf of Pacific Gas and Electric Company (PG&E), ARCADIS has prepared this Replacement Water Feasibility Study Report (Feasibility Study) in response to Ordering Paragraph 2.c. of Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (Order), issued October 11, 2011, for the Hinkley Compressor Station. The Feasibility Study presents an evaluation of methods to provide replacement water supply for all indoor domestic uses, containing hexavalent chromium at levels below the current laboratory reporting limit of 0.06 µg/L for all impacted wells within the affected area. The affected area is defined in the Order as including domestic wells within one mile down-gradient or cross-gradient of the plume boundary defined by the current background concentrations (3.1 µg/L hexavalent chromium or 3.2 µg/L total chromium).

As described in PG&E's November 23, 2011 and December 22, 2011 submittals pursuant to Ordering Paragraph 3.a. of the Order (and in its October 25, 2011 petition for review of the Order), PG&E does not believe there is a credible method to determine the source of hexavalent chromium in domestic wells with detections below the current background values. Accordingly, this Feasibility Study evaluates the most feasible options for providing replacement water to those households located down gradient or cross gradient of the plume within the affected area with domestic well detections above the current background concentrations for hexavalent or total chromium.

1.1 Purpose of Feasibility Study

The Feasibility Study evaluates multiple alternatives which can provide replacement water to those down-gradient or cross-gradient households within the affected area which currently have detections of hexavalent chromium or total chromium above the background values. The Order requires that replacement water contain hexavalent chromium concentrations below the reporting limit of 0.06 µg/L (or hexavalent chromium concentrations less than the final maximum contaminant level, once that standard is adopted). The Order also requires that the replacement water must meet all California primary and secondary drinking water standards. However, the latter provision would not appear applicable to the situation where PG&E provides a replacement water supply where hexavalent chromium has been removed from well water, leaving only constituents that are not present as a result of PG&E's actions.

The Feasibility Study includes the following:

- An evaluation of various methods to provide replacement water supply including, but not limited to, replacing individual wells with deeper wells, hauling and storing water, providing point of entry (POE) treatment systems, and either consolidating with an existing water purveyor or forming a new system
- Discussion of the feasibility and timing to implement each method including the need and timing for permits, approvals, and environmental analyses
- An evaluation of the quantity of water that can be provided by each method and a comparison with typical household supply needs
- An evaluation of the quality of water that can be provided by each method in comparison with California primary and secondary drinking water standards and with levels of hexavalent chromium of less than the 0.06 µg/L reporting limit
- An analysis of by-products or wastes that may be generated by each method and disposal options and costs
- An analysis of operations, maintenance, and (if appropriate) replacement requirements associated with each evaluated method of providing replacement water
- An assessment of recommended water quality monitoring and reporting requirements to verify quality and performance of each method
- A complete cost analysis including construction, operations, maintenance, and replacement
- A contingency plan to ensure uninterrupted replacement water service.

1.2 Key Assumptions

For the purposes of the Feasibility Study, a number of assumptions were made in order to evaluate the technical feasibility of implementing replacement water supply alternatives identified in this document. The key assumptions are described below and are documented throughout the Feasibility Study, where appropriate:

- Any replacement water supply will be consistent with ongoing remediation activities.

- Consistent with the Order, the affected area constitutes one mile down-gradient or cross-gradient of the plume boundary defined by the current background concentrations (3.1 µg/L hexavalent chromium or 3.2 µg/L total chromium).
- For the purposes of this report, “impacted wells” are defined as domestic or community wells in the affected area containing more than 3.1 µg/L hexavalent chromium or more than 3.2 µg/L total chromium (PG&E, 2011).
- The number of impacted wells in the affected area is assumed to be 25 for cost estimating purposes. This number is higher than the current number of impacted wells in the interest of conservancy.
- Treatment technologies, operating costs, and overall strategy feasibility are based on limited domestic well construction, piping, and water quality information. Additional water quality sampling and studies of impacted wells and areas where new community wells could be drilled are advisable prior to the implementation of any replacement water supply.
- No treatment technology has been certified by CDPH or the National Sanitation Foundation (NSF) to remove hexavalent chromium to below the limit specified in the Order (i.e., below the reporting limit of 0.06 µg/L). It is assumed that any issues relating to certification, to the extent that such issues arise, will be resolved prior to the implementation of any replacement water supply.
- Capital, operations, and maintenance costs described in this document are Class 5 conceptual level cost opinions, as defined by the Association for the Advancement of Cost Engineering (AACE), with an expected accuracy range of -20 to -50 percent (%) on the low range and +30 to +100% on the high range. They are intended for comparison purposes only.
- PG&E will conduct community outreach activities as described in Section 3.5.

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2. Site Background and Current Conditions

The community of Hinkley is located in the Mojave Desert approximately 14 miles northwest of Barstow, California (Figure 1). The climate and hydrogeology of the Hinkley Valley is characterized by the arid environment of the Mojave Desert, with rainfall averaging between 4 to 6 inches per year. The following paragraphs provide background information on the hydrogeology, groundwater quality, and domestic groundwater supplies and demands in the Hinkley Valley, relevant to the evaluated water supply alternatives.

2.1 Hydrogeology

The Mojave River Groundwater Basin in the southern and northeastern portions of the Hinkley Valley (the Centro subarea; USGS, 2001) consists of an upper, unconfined aquifer underlain by a lower, confined aquifer separated by lacustrine clay that forms a regional aquitard. To the northwest of Hinkley, the lower aquifer is terminated against bedrock, and groundwater is encountered only in the upper unconfined aquifer. The upper and lower aquifers in the Hinkley Valley can be generally characterized as follows:

- **Upper Aquifer**. The upper floodplain aquifer flows in a northerly direction in unconsolidated coarse-grained sand and fine-grained silt sediments. The depth to groundwater in the upper aquifer ranges from about 75 to 90 feet below ground surface (bgs) with some degree of variability directly adjacent to remedial activities, such as pumping or injection. The upper aquifer ranges in thickness from about 20 to 80 feet, depending on the depth to the underlying lacustrine clay or bedrock. Groundwater velocity in the upper aquifer is variable, depending upon the type(s) of sediments encountered and the local gradients (Haley & Aldrich, 2010).
- **Lower Aquifer.** The lower regional aquifer consists of sediments between the base of the lacustrine clay and the top of the consolidated bedrock. In borings where the lower aquifer was encountered by PG&E, the sediments appear to be composed of weathered bedrock. The thickness of the weathered rock is variable, generally ranging from a few feet to upwards of 20 feet (Haley & Aldrich, 2010).

Groundwater flows primarily north-northwest, generally from the Mojave River toward the northern Hinkley Valley and ultimately to Harper Dry Lake. The Mojave River contributes the majority of the natural groundwater recharge to the Hinkley Valley, with remaining recharge achieved from managed injection/infiltration of State Project Water (Mojave Water Agency, 2012). Recharge to the Mojave River Groundwater Basin from infiltration of precipitation is minimal (USGS, 2001).

2.2 Groundwater Quality

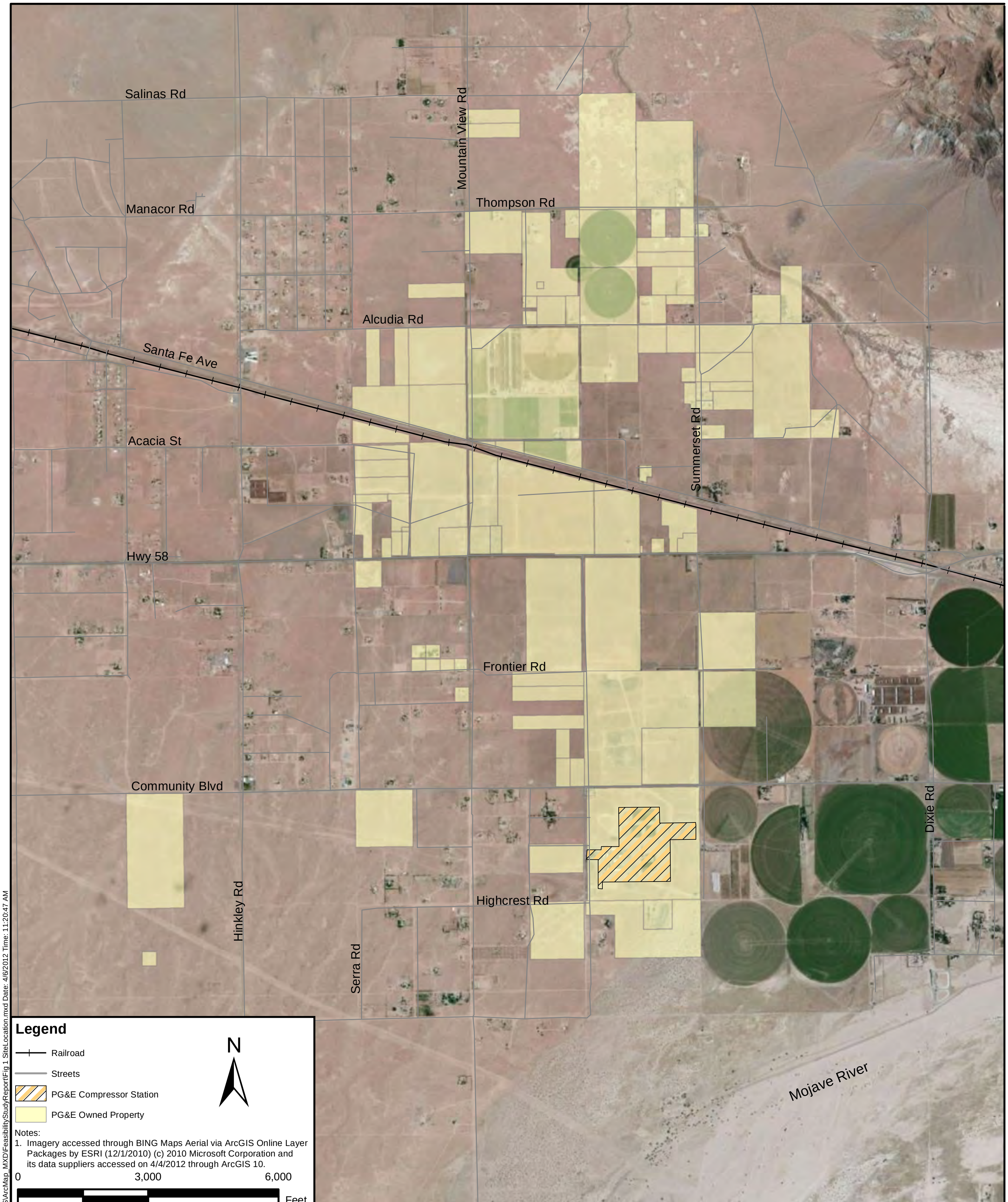
Groundwater quality varies significantly both horizontally and vertically in the Hinkley Valley. Monitoring well data and U.S. Geological Survey (USGS) studies were reviewed to understand the spatial variability in water quality as treatment will vary depending on the unique water quality characteristics in the groundwater produced from different portions of the Mojave River Groundwater Basin.

2.2.1 Background Chromium and Chromium Plume

Low concentrations of hexavalent chromium (i.e., ranging from 1 – 5 µg/L) have been detected in source waters from 39 counties throughout California (CDPH, 2012a). Total chromium above a 10 µg/L detection limit for reporting was detected in one out of ten sources monitored from the 1970s to 2001. During monitoring conducted for the Six Year Review, UEPA detected total chromium at concentrations above 10 µg/L in nearly 18 percent of 159,000 samples from across the country (Eaton, 2012). Recent analysis of Barstow wells showed concentrations of hexavalent chromium ranging from 1.0 to 1.8 µg/L (CDPH, 2012a).

CH2M Hill conducted a statistical analysis of background hexavalent and total chromium concentrations in Hinkley groundwater based on a comprehensive study that included groundwater samples collected during four rounds of sampling in 2006, and from up to 48 wells located outside the plume (CH2M Hill, 2007). The study identified 95th percent upper tolerance limits for hexavalent and total chromium of 3.1 and 3.2 µg/L, respectively. The arithmetic mean concentrations for Cr(VI) and Cr(T) were 1.2 µg/L and 1.5 µg/L, respectively. In Amended Cleanup and Abatement Order No. R6V-2008-0002A1, the Water Board established background concentrations for chromium in Hinkley groundwater based on the CH2M Hill study, specifically:

- Maximum background hexavalent chromium = 3.1 µg/L
- Maximum background total chromium = 3.2 µg/L
- Average background hexavalent chromium = 1.2 µg/L
- Average background total chromium = 1.5 µg/L.



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Program Manager Lisa Cope Project Manager Jenifer Beatty Task Manager Sunil Kommineni Technical Review David Eberle	ARCADIS 100 Montgomery Street, Suite 300 San Francisco, California 94104 Tel: 415 374 2744 Fax: 415 374 2745 www.arcadis-us.com	**Hinkley Site Location Map** Replacement Water Supply Feasibility Study Report Pacific Gas and Electric Company Hinkley, California	FIGURE **1**

The extent of the chromium plume associated with the PG&E compressor station is monitored as part of the Site-Wide Groundwater Monitoring Program, which is being conducted in compliance with cleanup and abatement orders, waste discharge requirements, and other directives issued by the Water Board. As described in the Fourth Quarter 2011 Groundwater Monitoring Report and Domestic Well Sampling Results dated January 30, 2012, hexavalent chromium and total chromium have been detected above the established background concentrations (3.1 and 3.2 µg/L, respectively), in both the upper and lower aquifers. While most of the plume is limited to the upper aquifer, chromium migration to a small portion of the lower aquifer is likely a result of the downward hydraulic gradients produced by groundwater extraction in the lower aquifer in areas where the regional lacustrine clay aquitard is not present (CH2M Hill, 2012).

In general, chromium above the established background concentrations in the upper aquifer is bound by Highcrest Road to the south, Serra Road to the west, and Dixie Road to the east. The extent of chromium in groundwater above established background appears to extend north past Salinas Road; however, the complete extent is not fully delineated by Fourth Quarter 2011 monitoring data. Further refinements and updates to the delineation of chromium in groundwater are forthcoming as more data from existing wells and data from future monitoring wells are incorporated. In the lower aquifer, Fourth Quarter 2011 monitoring data suggest the chromium impacts are localized in one area, south of Desert View Dairy (DVD) along Santa Fe Avenue. A more complete description and delineation of chromium impacts to groundwater are included in the Fourth Quarter Groundwater Monitoring Report (CH2M Hill, 2012).

2.2.2 Other Groundwater Constituents

Other naturally-occurring and/or anthropogenic constituents – including total dissolved solids (TDS), sulfate, chloride, iron, manganese arsenic, uranium, and nitrate – have been detected in monitoring wells in Hinkley and other portions of the Mojave River Groundwater Basin. These constituents can impact replacement water treatment both indirectly (e.g., requiring pre-treatment to improve process performance for chromium removal), and directly if one or more constituents are regulated as in the case of public water systems (PWSs).

The USGS collected 67 groundwater samples in the upper and lower aquifers between 1990 and 1999 to characterize groundwater quality in the Mojave River Basin near the Helendale Fault, 15 miles southwest of Hinkley (Stamos et al., 2003). Results from the USGS study and groundwater monitoring in Hinkley indicate the following trends:

- Naturally-occurring TDS and sulfate exceeding their respective California secondary MCLs (SMCLs) of 500 milligrams per liter (mg/L)[1] and 250 mg/L, respectively, have been detected in both the upper and lower aquifers. TDS in the upper aquifer ranged from 240 to 2,330 mg/L with a median concentration of 825 mg/L in samples collected for the USGS study. Dissolved solids concentrations in the lower aquifer ranged from 480 to 950 mg/L, with a median concentration of 670 mg/L (Stamos et al., 2003). In Hinkley, TDS concentrations are typically lower than the SMCL south of Community Boulevard. Concentrations increase north of Highway 58, ranging from 1,000 to 1,500 mg/L. TDS concentrations above 1,500 mg/L are observed north of the Santa Fe railroad tracks.

- Arsenic is naturally-occurring in the Mojave River Groundwater Basin. Arsenic concentrations measured in USGS samples collected in the upper aquifer near the Helendale Fault ranged from below the 2 µg/L method detection limit to 34 µg/L with a median concentration of 6 µg/L. Arsenic concentrations in the lower aquifer ranged from below the 2 µg/L method detection limit to 130 µg/L with a median concentration of 11 µg/L (compared to the 10 µg/L MCL). Breit et al. (2010) suggest that differences in arsenic concentrations within the arid basins of the Mojave Desert can be attributed to variations in geochemical processes among basins impacting the pH, alkalinity, and reduction potential of the groundwater.

- Uranium and other naturally occurring radioactive materials have been detected in Mojave River Groundwater Basin and are likely attributed to the mineralogy of the granitic rocks observed in the lower regional aquifer (Churchill,1991). Uranium data for the Hinkley Valley groundwater are limited.

- Nitrate exceeding the 10 mg/L (as nitrogen) MCL was detected in one sample from the upper aquifer in the USGS study, and was attributed, in part, to agricultural activities near the Mojave River. In Hinkley, nitrate concentrations are lower south of Community Boulevard (below the primary MCL and in some samples, below the method detection limit). Nitrate concentrations increase north of Highway 58, with concentrations above the 10 mg/L MCL. Nitrate concentrations exceeding 40 mg/L have been detected north of Thompson Road (Haley & Aldrich, 2010).

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[1] The California-recommended SMCL range for TDS is 500 to 1,000 mg/L (Table 64449-B of the 12 CCR §64449(a)).

2.3 Domestic Groundwater Supplies and Demands

Residents of Hinkley rely on groundwater wells for domestic water needs. Wells in the area are classified as domestic (supplying water for the domestic needs of an individual residence or systems of four or less service connections) or agricultural (being used to supply water for irrigation or other agricultural purposes) by the State of California. There are no known community wells in the area, thus all operation, maintenance, and monitoring of wells is the responsibility of the individual well owners. Well operation and production data were not available; historical data for the region was used to estimate typical household water supply needs.

Ordering Paragraph 2.c. of the Order requires PG&E to provide a replacement water supply for all indoor domestic uses. Indoor domestic water use typically accounts for less than half of overall household water use, with the remainder being used for outdoor demands such as light turf irrigation, irrigation of trees/shrubs, and water for pets and livestock. Residential hose bibs are generally plumbed into a home's indoor water supply, making it difficult to separate indoor and outdoor water supplies. While properties can be retrofitted to separate these demands, for conservancy, the Feasibility Study assumed that residential water demands will include all indoor domestic water uses and limited outdoor uses that are consistent with current residential practices of Hinkley residents. However, separating residential indoor and outdoor demands should not be excluded from the evaluation of replacement water supply alternatives.

Historical per capita water use and average household size for the region were used to develop an average household water demand for Hinkley. Hinkley lies within the California South Lahontan Hydrologic Region (Region #9). Based on the 20x2020 Water Conservation Plan (2010), per capita residential water use in 2005 was 176 gallons per capita per day (gpcd). To account for annual fluctuations and variability in outdoor water use, a 25 percent contingency factor was applied to develop an average residential per capita water consumption rate of 220 gpcd. This is consistent with the average per capita water consumption of 212 gpcd for San Bernardino County in 2008 (San Bernardino County, 2010) and 213 gpcd for Barstow in 2010 (Kennedy/Jenks, 2011).

According to the 2010 Census, the average household size for the Hinkley (92347 ZIP Code Tabulation Area) is 2.88 residents per household (U.S. Census Bureau, 2010). For the purposes of this study, an average household size of 3.0 residents per household was assumed. Applying the per capita water consumption rate, the average household water consumption was estimated to be 660 gallons per day.

3. Feasibility Study Development

Consistent with the requirements of the Order, PG&E engaged the Water Board, Community Advisory Committee (CAC), Hinkley residents, and independent consultants in developing the preliminary replacement water supply options for impacted wells in the affected area. Candidate replacement water supply strategies were presented during a CAC meeting in September 2011. This section describes the process for developing and evaluating the replacement water alternatives for impacted wells in Hinkley.

3.1 Identification of Alternatives

Candidate replacement water supply alternatives were developed based on available background information (e.g., groundwater quality data, treatment technology ability to remove hexavalent chromium to very low concentrations), an initial assessment of the existing and projected future water demands, and technologies and strategies used in similar situations where groundwater has been known to contain one or more constituents with concentrations greater than the allowable limits. PG&E presented the following replacement water supply alternatives at the September 28, 2011 CAC meeting, consistent with the Order:

- Replacing individual wells with deeper individual wells
- Hauling water to individual residences, including installing storage tanks at each residence
- Providing individual whole-house water treatment systems
- Implementing an area wide or community water system by:
  - Tying into an existing system operated by a public or private water purveyor
  - Installing and operating a new system (either public or private)
  - Developing a system for two or more residences that may involve a regulated water purveyor

Preliminary advantages and disadvantages were presented for each of the alternatives. Since the presentation, additional data have been collected and analyzed, and variations of the alternatives have been developed (e.g., developing a supply that is consistent with the proposed remedy to address the hexavalent chromium groundwater plume and modifying a whole-house water treatment option to include undersink reverse osmosis).

3.2 Households Requiring Replacement Water Supply

As described in PG&E's November 23, 2011 and December 22, 2011 submittals pursuant to Ordering Paragraph 3.a. of the Order (and in our October 25, 2011 petition for review of the Order), PG&E does not believe there is a credible method to determine the source of hexavalent chromium in domestic wells with detections below the current background values. Accordingly, this Feasibility Study evaluates the most feasible options for providing replacement water to those households located down gradient or cross gradient of the plume within the affected area with domestic well detections above the current background concentrations for hexavalent or total chromium. The number of impacted wells in the affected area was assumed to be 25 for cost estimating purposes. This number is higher than the current number of impacted wells in the interest of conservancy.

3.3 Applicable Legal and Regulatory Requirements

Applicable legal and regulatory requirements were evaluated for each replacement water supply alternative, including relevant drinking water regulations, legal requirements related to groundwater production within the Mojave Basin Area, and environmental regulations. Specific legal and regulatory requirements, as they pertain to each evaluated replacement water supply alternative, are provided in Section 4.

3.3.1 Drinking Water Regulations

Through the Safe Drinking Water Act (SDWA), the U.S. Environmental Protection Agency (USEPA) has established National Primary Drinking Water Regulations (NPDWRs) for chemical and biological constituents in water. NPDWRs are standards that apply to public water systems (PWSs), which are defined by the SDWA as "…system[s] for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals (USEPA, 2012)." PWSs are further delineated as follows:

- ***Community Water System*** **(CWS):** A PWS that supplies water to the same population year-round. An example of a CWS near Hinkley is the Golden State Water Company supplying potable water to Barstow.

- ***Non-Transient Non-Community Water System*** **(NTNCWS)**: A PWS that regularly supplies water to at least 25 of the same people at least 6 months per year, but not year-round. Some examples are schools, factories, and hospitals that have their own water systems.
- ***Transient Non-Community Water System*** **(TNCWS)**: A PWS that provides water in a place such as a gas station or campground where people do not remain for long periods of time.

Based on the number of impacted wells and nature of demands for which it serves, PWSs in the alternatives evaluated would be classified as CWSs.

Neither the USEPA nor California regulates water quality in private domestic wells; therefore, the NPDWRs do not directly apply.

The Order requires that replacement water contain hexavalent chromium concentrations below the reporting limit of 0.06 µg/L (or hexavalent chromium concentrations less than the final maximum contaminant level, once that standard is adopted). The Order also requires that the replacement water must meet all California primary and secondary drinking water standards. However, the latter provision would not appear applicable to the situation where PG&E provides a replacement water supply where hexavalent chromium has been removed from well water, leaving only constituents that are not present as a result of PG&E's actions.

The CDPH has regulatory and enforcement authority for the SDWA in California, and as such, CDPH can adopt a standard equivalent to or more stringent than the NPDWR for a given constituent. Appendix A lists the California primary and secondary drinking water standards set forth under the California Safe Drinking Water Act. Primary MCLs are established to address constituents with public health concerns; SMCLs are set to address constituents that present an aesthetic concern in drinking water (e.g., taste, odor, color). CDPH also establishes notification levels (NLs) for chemicals of concern in water that lack an MCL.

Under §116330 of the California Health and Safety Code (CHSC), the CDPH "…may delegate responsibility for the administration and enforcement of [the California SDWA] within a county to a local health officer authorized by the board of supervisors to assume these duties, by means of a local primacy delegation agreement." CDPH, however, retains "…jurisdiction to administer and enforce [the primary and secondary drinking water standards] for the designated water systems to the extent determined necessary by the department." Pursuant to §116330, CDPH has delegated primacy to

35 local primacy agencies (LPAs) for the regulation of PWSs serving fewer than 200 service connections. The San Bernardino County Health Officer has been designated by CDPH as the LPA for PWSs serving fewer than 200 service connections in the county, but CDPH retains jurisdiction to administer and enforce the SDWA regulations as it deems necessary.

3.3.2 Well Production

The Mojave Basin Area was adjudicated in January 1996 as a result of a lawsuit filed by the City of Barstow and Southern California Water Company motivated by concerns over a regional overdraft condition, where the annual demand on the groundwater resources exceeds the long-term average annual supply. Prior to the lawsuit, the Mojave Basin Area was unadjudicated, and there were no prescribed limits on groundwater extraction. The judgment in *the City of Barstow et al, v. City of Adelanto et al.* resulted in the following requirements for groundwater production from the Mojave Basin Area:

- Each entity considered a water producer (producer using more than 10 acre-feet per year) during 1986 through 1990 was determined to have a certain Base Annual Production (BAP). Because the area does not have enough water for producers to pump their maximum amount, each year a producer is assigned a percentage of its BAP as its Free Production Allowance (FPA). A producers' FPA is the amount of water that can be pumped for free during a year without having to pay for replacement water. If a producer exceeds its FPA, then it must pay for the excess by either arranging to transfer the desired amount from one producer to another or by buying the amount required by the Mojave Water Agency (MWA).
- Well owners who pump less than 10 acre-feet annually are classified as minimal producers, and the MWA is currently preparing an administrative program to address their water use.

A replacement water supply that results in increased production from a water producer (i.e., producer using more than 10 acre-ft per year) may be subject to increased water replenishment fees if a water transfer is not available. Development of a new well, whether categorized as a minimum producer or producing more than 10 acre-ft per year, would need to be registered with the MWA.

3.3.3 Environmental Regulations

The California Environmental Quality Act (CEQA) requires state and local public agencies to identify significant environmental effects of their actions and either avoid or mitigate those significant environmental effects, where feasible. Agencies must comply with CEQA when they undertake an activity defined by CEQA as a "project" (an activity undertaken by a public agency or private activity which must receive some discretionary approval from a government agency which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment). If the activity is classified as a "project", the agency must perform an initial study to identify the environmental impacts of the project and whether the identified impacts are "significant". Exemptions apply (California Natural Resources Agency, 2012).

The Water Board classifies the issuance of the Order as an enforcement action taken by a regulatory agency and is therefore exempt from the CEQA pursuant to California Code of Regulations (CCR), title 14, section 15321, subdivision (a)(2). Additionally, the Water Board indicates that developing a replacement water supply by installing wellhead treatment, establishing deeper domestic wells, or installing above-ground tanks would not have a significant effect on the environment and therefore would be exempt from the CEQA ("common sense exemption"; CCR title 14, section 15061). If, however, a CWS is selected as a replacement water supply, the Water Board, if it is the "lead agency" under CEQA, will address any CEQA requirements as they apply (Water Board, 2011).

3.4 Pilot-Testing

Whole-house water treatment was identified as one of the replacement water supply alternatives. More than two dozen vendors of whole-house water treatment systems were contacted; however, only a few of the vendors claimed to have treatment systems that were capable of removing hexavalent chromium to the low concentrations defined in the Order. Three systems were shortlisted for pilot testing, specifically ion exchange (IX), reverse osmosis (RO), and a hybrid RO – IX system, based on the following criteria:

- Technologies that had the most promise to reliably remove hexavalent chromium to low concentrations (i.e., less than 1 µg/L);

- Technologies that were most likely to meet the CDPH requirements for whole-house water treatment systems (e.g., technologies that required storage of hazardous chemicals were excluded);
- Vendors that offered experience and capabilities to provide turnkey services in Southern California.

Under very tight time constraints, per the Order, a pilot-scale test plan was designed to collect additional data needed to develop a replacement water supply, and submitted to the Water Board for review and comments on September 27, 2011. A summary of the testing plan was presented to the CAC and Water Board on November 2, 2011. Comments from the Water Board were received on December 16, 2012. The ongoing pilot testing incorporated key comments. The pilot test objectives included the following:

- Assess the ability of whole-house water treatment systems to safely, effectively, and reliably remove hexavalent chromium from groundwater to very low concentrations.
- Assess the operability and durability of these systems to perform under local conditions.
- Identify any potential secondary water quality issues associated with leaching of by-products or other materials from the treatment systems, which may affect the treated water quality.
- Confirm the design and operating criteria for the treatment systems, including quantities and qualities of wastes that would be generated and require proper disposal.

Pilot testing began in early November 2011 and was initially conducted for three months. In February 2012, PG&E elected to continue operating the pilot systems until April 2012 to provide additional data and to facilitate additional community outreach opportunities detailed in Section 3.5.

Based on the first three months of pilot-testing, all three whole-house water treatment systems were able to remove hexavalent chromium to below the reporting limit as required in the Order. Results from the pilot-testing were used to develop and evaluate the replacement water supply alternatives described in Sections 4 and 5 of the Feasibility Study. A copy of the pilot test report is included in Appendix B.

3.5 Community and Water Board Engagement Process

PG&E has been actively discussing and presenting the progress of their analysis of water alternatives to the Hinkley community and the Water Board since August 2011, as summarized in the following table. Over the next few months, PG&E will expand these discussions to present their recommended options to residents with impacted wells. In April 2012, PG&E will being sending letters and placing phone calls to each of these residents/owners with impacted wells, with the goal of scheduling an in-person meeting to gather their input. Upon conclusion of this process, PG&E will summarize the input and provide the summary to the Water Board.

In addition to these steps, PG&E will be meeting with the members of the Community Advisory Committee, and the Independent Review Panel (IRP) manager to present the Feasibility Study, explain the contents and answer any questions. PG&E plans to fully engage the IRP manager as they gather the input on our recommended options and will discuss the Feasibility Study conclusions at the April 26, 2012 and May 24, 2012 Community Advisory Committee meetings.

Table 1 Engagement Activities to Date

Community and Water Board Engagement Activities	Description	Dates
Community Advisory (CAC) Committee Meetings	PG&E provided updates, including poster boards depicting the three treatments systems studied in the pilot test, on methods to provide replacement water.	September 28, 2011 November 2, 2011 December 14, 2011 February 22, 2012
Community Advisory Committee Pilot Test Site Tours	PG&E worked with the Hinkley community to establish a Community Advisory Committee. PG&E technical experts hosted tours/Q&A sessions of the Pilot Test facilities with committee members and the community's technical expert.	November 9, 2011 February 25, 2012
Public Tour of Pilot Test Site	Approximately 38 members of the Hinkley community attended a tour/Q&A session of the Pilot Test facility with PG&E technical experts.	February 25, 2012

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4. Description of Replacement Water Supply Alternatives

Six replacement water alternatives, representing the range of water supply options for the impacted wells in the affected area, were developed for comparative purposes. These six alternatives are:

- Alternative 1 – Connect to an Existing Community Water System (Centralized Treatment and Distribution);
- Alternative 2 – Develop a New Community Water System Utilizing Groundwater Near Mojave River (Centralized Treatment and Distribution);
- Alternative 3 – Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program (Centralized Treatment and Distribution);
- Alternative 4a-c – Provide Point of Entry Whole-House Water Treatment (this alternative includes three sub-alternatives);
- Alternative 5 – Replace Impacted Wells with Deeper Wells; and,
- Alternative 6 – Truck Water from a Community Water System.

Each alternative is presented below, with information provided on the following:

- System configuration and infrastructure;
- System performance;
- Applicable legal and regulatory requirements and institutional complexities;
- System construction;
- Operation, maintenance and replacement; and,
- Environment and other considerations.

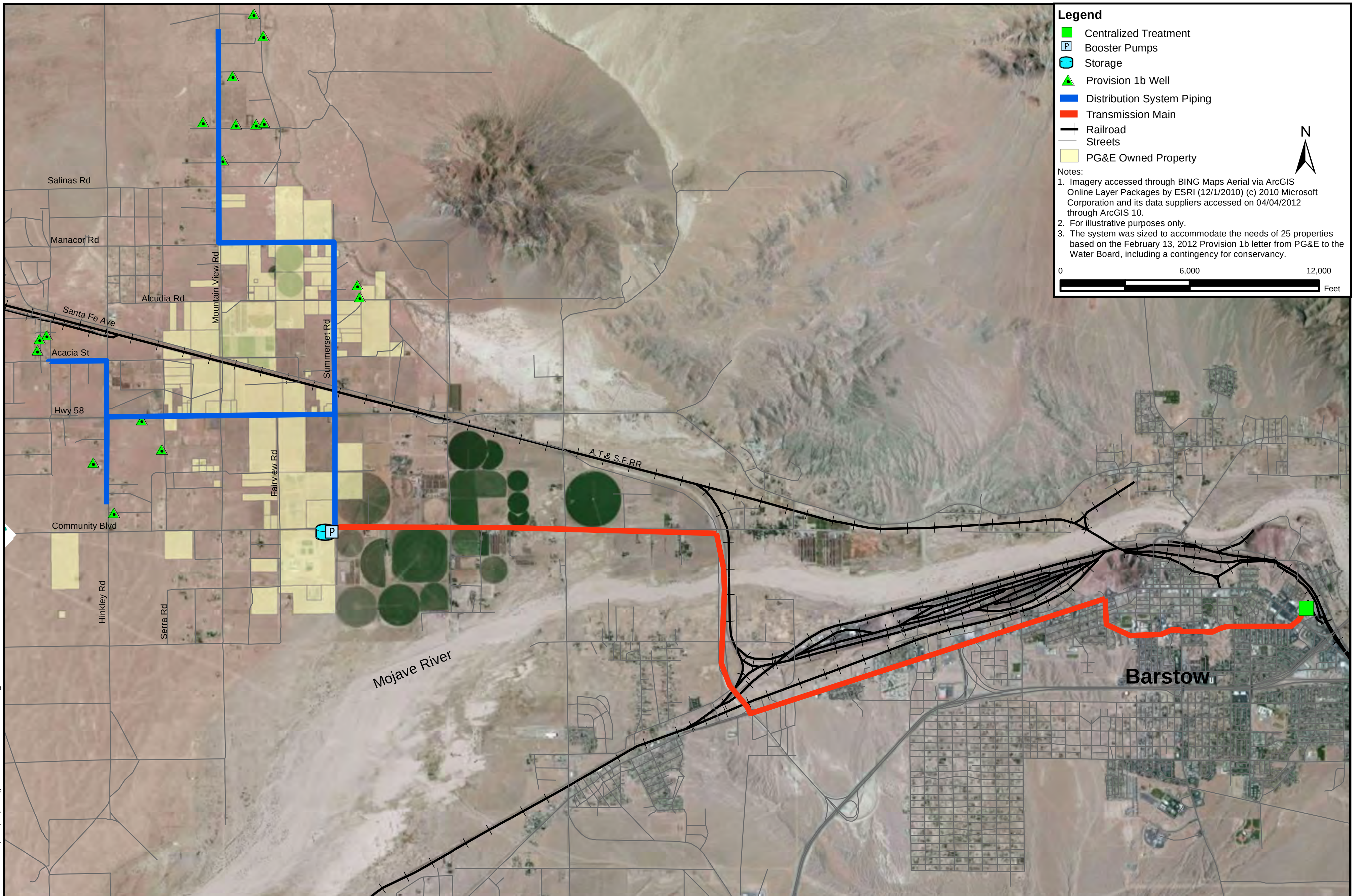
4.1 Alternative 1: Connect to an Existing Community Water System (Centralized Treatment and Distribution)

Under this alternative, replacement water for Hinkley would be supplied through a pipeline from the nearest CWS (Golden State Water Company [GSWC]). A pipeline network would be developed to meet residential water needs of properties in the affected area with impacted wells.

4.1.1 System Configuration and Infrastructure

A conceptual level schematic of the alternative is shown in Figure 2. The following assumptions were used in the development of this alternative:

- The system was sized to accommodate the needs of 25 properties.
- GSWC is interested in and has sufficient infrastructure to provide replacement water to properties with impacted wells.
- Pipelines, pump stations, and storage tanks were sized based on average residential fire flow conditions (500 gallons per minute [gpm] for 2 hours). Because of the low residential demands, fire flow conditions largely dictated the infrastructure sizing.
- GSWC will comply with all applicable drinking water standards.
- GSWC is currently not treating Barstow groundwater for hexavalent chromium. Hexavalent chromium has been detected above the 0.06 µg/L reporting limit in some of the Barstow System wells with concentrations from three wells sampled in January 2011 ranging from 1.0 to 1.8 µg/L (CDPH, 2012b). While this may not reflect the water served to customers, ion exchange treatment (weak base anion [WBA] exchange, with a strong base anion [SBA] exchange polishing step) was assumed for Hinkley properties with impacted wells to reduce hexavalent chromium levels below the reporting limit as required in the Order.



Program Manager Lisa Cope	ARCADIS	**Alternative 1: Connect to an Existing Community Water System Conceptual Layout**
Project Manager Jenifer Beatty	100 Montgomery Street, Suite 300 San Francisco, California 94104 Tel: 415 374 2744 Fax: 415 374 2745 www.arcadis-us.com	Replacement Water Supply Feasibility Study Report Pacific Gas and Electric Company Hinkley, California
Task Manager Sunil Kommineni		
Technical Review David Eberle		

FIGURE

2

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Based on the assumptions listed above, the conceptual treatment train for Alternative 1 (Figure 3) consists of treating GSWC water (prior to chlorine addition)[2] with ion exchange, followed by chlorine disinfection.

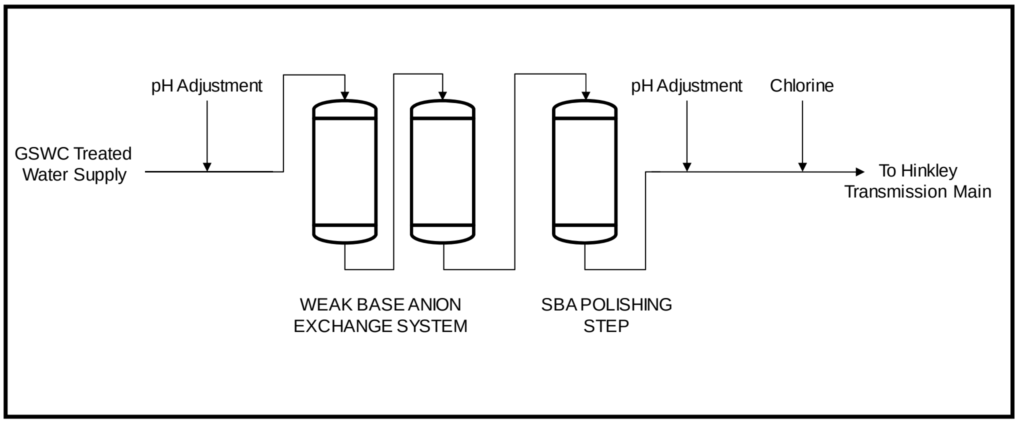


Figure 3 Conceptual Treatment Train for Alternative 1

4.1.2 System Performance

Based on a review of the Barstow 2010 Urban Water Management Plan, GSWC has sufficient water production rights to supply water to the impacted properties (Kennedy/Jenks, 2011). Properties with impacted wells would gain access to a more reliable and abundant water supply. If the number of impacted wells increases beyond 25, GSWC could theoretically supply sufficient water as long as infrastructure is designed to accommodate the higher flow rates and GSWC replenishes water pumped in excess of their base production rights. This would be coordinated through the MWA.

As a CWS, the GSWC Barstow System is subject to county, state, and federal drinking water standards. Water quality is monitored regularly and reported annually to customers. According to the Barstow Water System 2011 Annual Water Quality Report, one MCL exceedance in 2011 was documented for perchlorate. The average reported perchlorate concentration in 2011 was 6 µg/L and ranged from non-detect to 120 µg/L. Bottled water was provided to residents until the issue was resolved by taking three of the 19 affected wells out of service. All other primary MCLs were met in

[2] If chlorinated water from GSWC were used as the source water for ion exchange treatment, a dechlorination step would be required as pre-treatment for optimal ion exchange performance.

2011 for the GSWC Barstow System. The SMCLs for chloride and sulfate were also met; however, no data were available to ascertain the extent that other SMCLs were met for constituents such as TDS, iron, and manganese (GSWC, 2011). Perchlorate, radon, nitrate, manganese, boron, and TDS were identified as presenting a water quality issue or concern in one or more of the Barstow wells (Kennedy/Jenks, 2011).

GSWC is currently responsible for any residuals or wastes generated from the Barstow system. If ion exchange for chromium removal was implemented for properties with impacted wells, GSWC would also assume responsibility for any residuals or wastes generated from the treatment process. Process water (e.g., water resulting from an initial flush of the ion exchange resin) could be sent to the Barstow area sewer (conditional on permitting requirements) or stored and hauled offsite for disposal in an approved manner. Exhausted ion exchange resin would require disposal, meeting all local, state, and federal requirements.

Because of the distance to the plume and the incremental volume of water pumped, it is not likely that increased pumping in the Barstow area will have an appreciable effect on the chromium plume. The effect of decreased pumping of impacted wells in the Hinkley area could reduce the potential to pull the plume off-gradient, dependent on site-specific hydrogeologic conditions. Because water from within the plume will not be pumped or treated as part of this alternative, there will be no direct beneficial effect on remediation of the plume.

4.1.3 Applicable Legal and Regulatory Requirements and Institutional Complexities

The Barstow System is classified as a CWS (CA3610043) operated by GSWC and regulated under the California SDWA, serving potable water to an estimated 30,000 people. Because the system consists of close to 9,000 service connections, it falls under CDPH regulatory jurisdiction, rather than the local primacy agency (County), which regulates systems serving fewer than 200 connections.

Pursuant to the California SDWA, GSWC is required to meet all applicable drinking water standards and demonstrate compliance through CDPH-required monitoring and reporting. Extension of the GSWC Barstow System to serve properties in Hinkley with impacted wells and construction of an ion exchange treatment system would likely trigger the following additional SDWA and system requirements:

- A Domestic Water Supply Permit (DWSP) amendment for operation of an ion exchange treatment system, pursuant to 22 CCR §64556(4)(B)

- A permit amendment if the number of Hinkley service connections increases the permitted service connections by 20 percent or more, pursuant to 22 CCR §64556(5)
- Demonstration of operator certification in accordance with 22 CCR §63765 (Certification of Water Treatment Facility Operation)
- Augmentation of the GSWC Barstow System cross-connection control program to incorporate the extended distribution system
- Additional monitoring and reporting, which may include:
  - Updating the GSWC Barstow System monitoring plan to include sampling and monitoring to demonstrate performance of the ion exchange treatment system. CDPH may also require that the monitoring plan include sampling for resin impurities
  - Submitting a monthly operating report for the ion exchange treatment facility (at the discretion of CDPH)
  - Increasing the number of monitoring samples collected for the Total Coliform Rule (TCR), Stage 2 Disinfectant/Disinfection Byproduct Rule (D/DBPR), and Lead and Copper Rule (LCR).

Additional institutional and permitting considerations that may need to be addressed for this alternative include:

- Coordination of replenishment credits and base production rights through MWA;
- A mitigation plan to minimize the threat to the desert tortoise and Mojave ground squirrel during construction of transmission and distribution system pipelines. Pursuant to the Order, the Water Board would address any CEQA requirements, if it is the "lead agency" under CEQA (Water Board, 2011);
- Right-of-way permits for any jurisdiction the pipeline alignment passes;
- Applicable permits for crossing rivers (e.g., Mojave River) and/or floodplains;
- Air permitting requirements during construction.

As a public water provider, GSWC is regulated by the California Public Utilities Commission (CPUC). Based on a March 18, 2012 phone call with GSWC's Business Development Manager, PG&E has the following options when considering a connection to GSWC:

- PG&E can construct the system infrastructure and transfer ownership to GSWC. Because Hinkley is not in GSWC's current service area, the acquisition would need to go through the county agency and be approved by the CPUC.
- PG&E can construct the system infrastructure and lease it to GSWC for a period of time. Because it is a lease, the CPUC is not involved.
- PG&E and GSWC can come to an agreement on the cost to expand service to Hinkley, and GSWC would construct the necessary infrastructure.

GSWC indicated that the most common and preferred approach is the first one. In all three cases, GSWC would assume responsibility for operations, maintenance, and compliance of the system (phone call GSWC, 2011). The first option would require lead time to obtain CPUC approvals.

4.1.4 System Construction

Prior to design, PG&E and GSWC would need to reach an agreement to provide water to properties with impacted wells. Based on the March 18, 2012 phone call, PG&E could construct the system (ion exchange treatment and distribution system) and transfer ownership to GSWC, pending CPUC approval. The system would need to meet design requirements and conditions set forth by GSWC and other local agencies (e.g., Fire Marshall). Once design is complete, all necessary permits must be obtained, including CEQA requirements (if applicable) and any special permitting required for a pipeline across Mojave River, before approval to construct is granted. CDPH processing time for a DWSP amendment averages approximately 8 months (22 CCR §64402), but can take longer depending on CDPH work backlog and the complexity of the permit application.

Once approval is granted, the construction phase of the project is estimated to take 1 to 2 years for 25 properties. Following construction, start-up, commissioning, and system transfer are expected to take 6 months depending on GSWC and regulatory agency conditions. The entire project length of this alternative is highly dependent on the permitting and approval process (including CEQA applicability). Depending on the permitting and approval process, it is estimated to take approximately 2 to 4 years for planning, preliminary and detailed design, permitting, construction, start-up, commissioning, and turn-over.

4.1.5 Operations, Maintenance, and Replacement

Under this alternative, the new GSWC Hinkley/Barstow System would be governed by the Operations and Maintenance (O&M) Plan developed by GSWC. Qualified GSWC staff would be responsible for system operations, maintenance, and replacement as described in the O&M Plan, including operation of the ion exchange system and response to customer calls. As part of the agreement between PG&E and GSWC, the O&M Plan could be updated to include chromium sampling requirements, performance goals, and reporting requirements.

Compliance points for the Hinkley/Barstow System will be extended into Hinkley. Sampling and reporting of regulated constituents will be dictated by state and federal compliance standards. Because of the relatively low demand in the Hinkley area resulting in a long water age in the distribution system (oversized based on fire flow requirements), the distribution system may need to be flushed periodically to minimize water quality issues and meet the applicable water quality requirements.

4.1.6 Environmental and Other Considerations

Residents with impacted wells would lose some autonomy over their water supply but gain access to a more reliable and abundant supply that meets all applicable drinking water standards. Although no negative impacts are anticipated, Hinkley residents would be responsible for any unintended impacts the new and increased water supply would have on their household plumbing and septic systems (e.g., increased water use may exceed the septic system's current capacity). Responsibility for additional costs associated with an incremental increase in residential water use would also need to be established.

The GSWC Barstow System uses chlorine to meet disinfection requirements and maintain a disinfectant residual throughout the distribution system. Similarly, water from GSWC will likely have a different mineral content than Hinkley residents' domestic wells. While the water will meet all applicable drinking water standards, some residents may potentially observe a new taste or odor. Additional community outreach may be necessary in order to increase awareness of this issue and gain community acceptance.

Additional education and outreach in Barstow may be warranted to address the use of ion exchange for Hinkley properties with impacted wells. Existing GSWC customers in Barstow could express concern over the disparate treatment levels and the perception of inequitable service levels or public health protection, forcing GSWC to remove hexavalent chromium to below the reporting limit in all of its water.

Developing a CWS in the Hinkley area may have a beneficial impact on development and local economy. If ownership of the system is turned over to GSWC, residents without impacted wells may have the option to connect to the CWS, provided that system infrastructure is sized accordingly. This would be based on an agreement between the homeowner and GSWC.

Environmental impacts for this alternative are expected to be minimal. The potential for impacts to state and federally listed animal species (e.g., Mojave ground squirrel and desert tortoise) would be greatest during construction. The pipeline design can take into account road rights-of-way to minimize the impact to wildlife habitat. Daily operation and maintenance of this alternative is not expected to have any adverse effects on the environment.

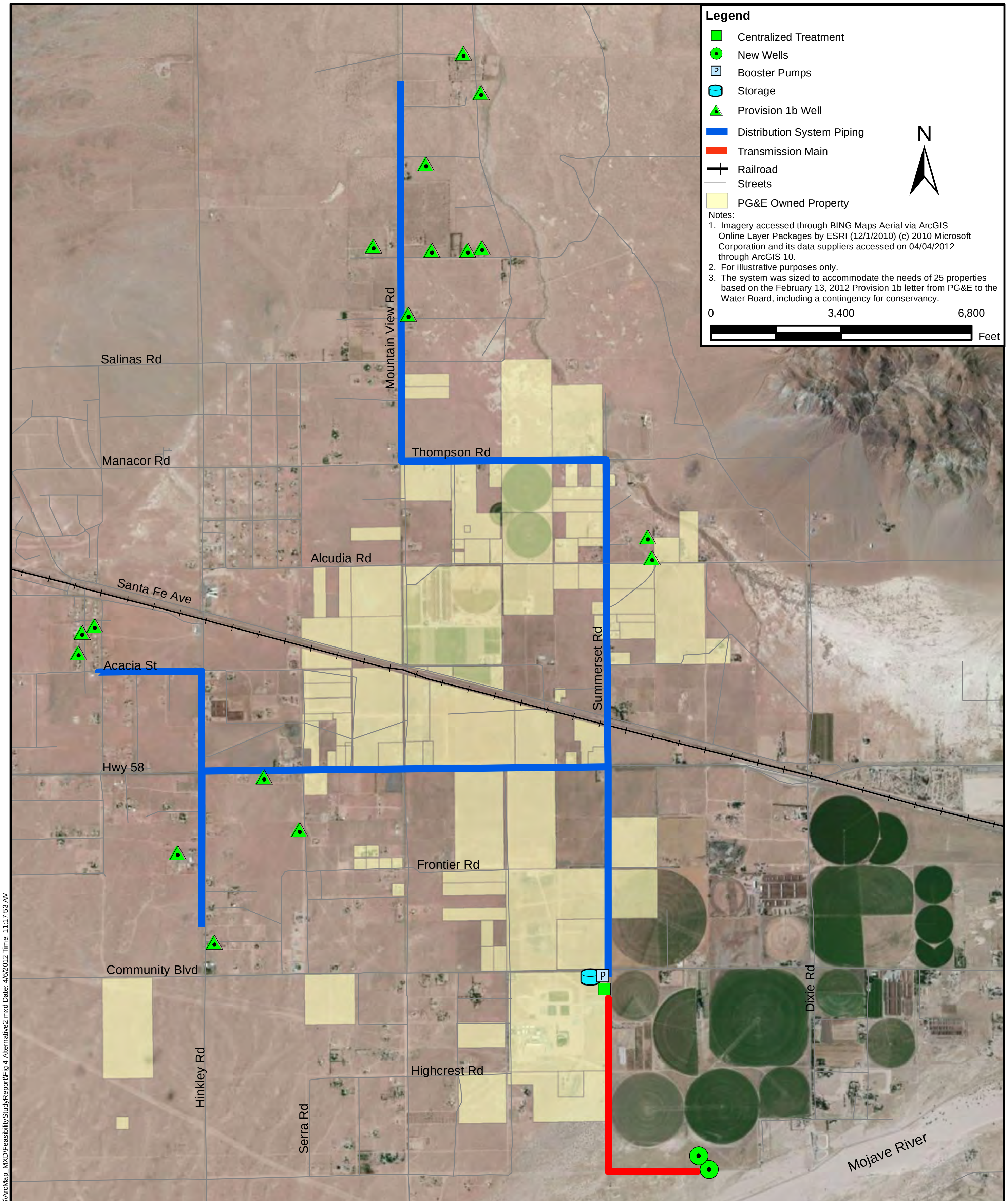
4.2 Alternative 2: Develop a New Community Water System Utilizing Groundwater Near the Mojave River (Centralized Treatment and Distribution)

Under this alternative, replacement water for Hinkley would be supplied from new groundwater wells just north of the Mojave River and directly south of Hinkley. A pipeline network from the wells would be developed to meet residential water needs of properties in the affected area with impacted wells.

4.2.1 System Configuration and Infrastructure

A conceptual level schematic of the alternative is shown in Figure 4. The following assumptions were used in the development of this alternative:

- The system was sized to accommodate the needs of 25 properties with impacted wells.
- The system would be classified as a new, independent CWS.
- Two groundwater wells would be drilled north of the Mojave River (one duty, one standby), yielding sufficient water to serve 25 properties (approximately 20 acre-feet per year).



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Alternative 2: Develop a New Community Water System Utilizing Groundwater Near Mojave River Conceptual Layout

Replacement Water Supply Feasibility Study Report
Pacific Gas and Electric Company
Hinkley, California

FIGURE
4

- Pipelines, pump stations, and storage tanks were sized based on average residential fire flow conditions (500 gpm for 2 hours). Because of the low residential demands, fire flow conditions largely dictated infrastructure sizing.
- PG&E will designate a water provider (such as GSWC) who will operate and maintain the system in compliance with all applicable drinking water standards.
- Groundwater from the proposed wells is conservatively assumed to be classified as groundwater under the direct influence of surface water (GWUDI) based on measured turbidity ranging from 2 to 20 nephelometric turbidity units (NTU) in samples collected from an existing well drawing from the floodplain aquifer adjacent to the Mojave River. Granular media filtration is assumed to be included as part of the treatment system to meet the SDWA requirements for GWUDI systems. If detailed monitoring from production wells were to show that the groundwater is not under the influence of surface water, then filtration could be avoided.
- Greensand filtration is assumed to be required to remove iron and manganese above the SMCL based on limited historical water quality data.
- Because hexavalent chromium has been detected and occurs naturally throughout the Mojave Desert Area (CH2M Hill, 2007), ion exchange treatment (WBA exchange, with an SBA polishing step) was assumed necessary to reduce hexavalent chromium levels below the reporting limit as required in the Order.

Based on the assumptions listed above, the conceptual treatment train for Alternative 2 (Figure 5) consists of granular media filtration, followed by greensand filtration, ion exchange, and chlorine disinfection.

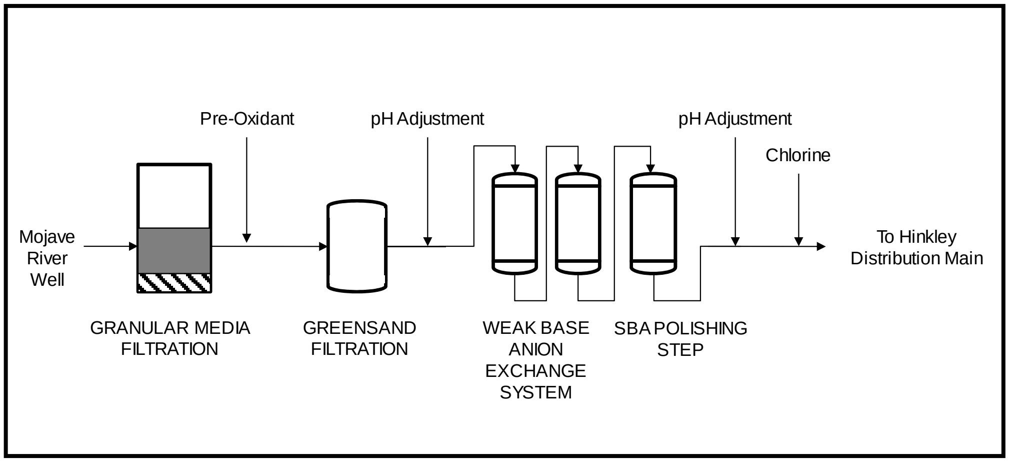


Figure 5 Conceptual Treatment Train for Alternative 2

4.2.2 System Performance

The capacity of Well FW-02, recently drilled in Hinkley north of Mojave River, is in excess of 60 gpm. Another well of this size drilled in the area would be sufficient to meet the water needs of 25 households, which is estimated to be 12 gpm on an annual average basis. To ensure a reliable water supply as part of CWS requirements, an identical well would be drilled. Storage tanks would be used to meet peak hour and fire flow demand conditions in excess of the well's capacity. Properties with impacted wells would gain access to a more reliable and abundant water supply.

The MWA is responsible for managing and replenishing groundwater withdrawal in the Mojave Basin Area. PG&E would purchase water and/or water rights from MWA. If the number of impacted households increases beyond 25, additional wells could be drilled in the area to meet the increased demand.

With more than 15 connections, the Hinkley System would be classified as a CWS (subject to county, state, and federal drinking water standards). Limited historical groundwater quality data for wells in close proximity to the Mojave River suggest the new wells will have low TDS and chromium (i.e., below background levels for total and hexavalent chromium), but could contain iron and manganese at concentrations above the SMCLs. During construction, the wells can be screened to produce the most favorable water quality, reducing treatment needs. Water quality would be monitored on a regular basis to assess system performance and reported annually to customers.

The water provider (e.g., GSWC) would be responsible for any residuals generated during groundwater treatment. Because there is no sewer system or wastewater treatment plant in the area, process water (e.g., water resulting from an initial flush of ion exchange resin) would be stored and hauled offsite for disposal in an approved manner. Exhausted ion exchange resin would also require disposal. The waste classification (i.e., hazardous, non-hazardous, technologically enhanced naturally occurring radioactive material [TENORM]) and associated disposal requirements would need to be verified under site-specific conditions (e.g., groundwater quality, resin type, etc.).

Because of the small volume of water that would be extracted when compared with the large volumes of available water, it is not likely that increased pumping near the Mojave River will have an appreciable effect on groundwater elevations or flow away from the Mojave River drainage. The effect of decreased pumping of impacted wells in the Hinkley area could reduce the potential to pull the plume off-gradient, dependent on site-specific hydrogeologic conditions. Because water from within the plume will not be pumped or treated as part of this alternative, there will be no direct beneficial effect on remediation of the plume.

4.2.3 Applicable Legal and Regulatory Requirements

This alternative would result in the formation of a new CWS, whether it is owned and operated by an existing water purveyor (e.g., GSWC) or a newly-formed entity. Regulatory primacy for the CWS will depend on the system size and CDPH discretion. The San Bernardino County Health Officer has been assigned as the local primacy agency for CWSs serving fewer than 200 connections in the county; however, based on a March 22, 2012 phone call with CDPH, the agency may elect to take over primacy for a CWS in Hinkley. CDPH would have regulatory primacy if the PWS serves more than 200 service connections.

Pursuant to 22 CCR §64552, creation of a new CWS will require submittal of an initial DWSP application prepared by a professional civil engineer registered in California. In addition to the stated requirements, the CDPH has wide discretionary latitude to require studies and impose both conceptual and detailed design features as precursors for permit approval. Table 2 summarizes the studies and reports that may be necessary to obtain CDPH approval for a DWSP, including: demonstration of technical, management, and financial (TMF) capability to operate the system; an operations plan; a disinfection CT (concentration x time) Study (demonstrating adequate disinfection will be provided to meet microbial inactivation requirements); and a water quality monitoring and reporting plan.

Table 2 Summary of DWSP Components

Permit Component	Required?	Description / Necessary Elements
Technical, Managerial, and Financial (TMF) Capacity	Required	Detailed information to demonstrate to the CDPH that the water purveyor has technical, managerial, and financial capacity to deliver potable drinking water to Hinkley in accordance with state regulations
Technical / Engineering Report	Required	Detailed information about the source water, treatment processes, and design, as well as new conveyance and storage associated with the plant and new supply
Operations Plan	Required	Detailed information about the treatment system operations, including system descriptions, design criteria, chemical usage, water quality monitoring, control systems, alarms, staffing, and operational procedures (e.g., startup, shutdown, etc.)
Water Quality Emergency Notification Plan	Required	Description of notification procedures to be followed in the event of a water quality emergency, including contact information for key water agency and CDPH personnel, as well as notification language to be used; See Section 4029 of the CHSC
Distribution System Monitoring Plan	Required	Monitoring plan for compliance with regulations application to distribution system water quality, including the Stage 2 D/DBPR, the TCR, and LCR
Drinking Water Source Assessment and Protection (DWSAP) Program Documentation	Required	Delineation of the area around a drinking water source through which contaminants might move and reach that drinking water supply, an inventory of possible contaminating activities (PCAs) that might lead to the release of microbiological or chemical contaminants within the delineated area, and a determination of the PCAs to which the drinking water source is most vulnerable. Guidelines are provided in CDPH, 2000.
Tracer Study	Required	Determine pathogen inactivation (i.e., CT) achieved in pipelines, treatment processes, and/or storage (e.g., clearwells) in which primary disinfection is applied
CT Analysis	Required	Detailed description of the use of the treatment plant processes to achieve required pathogen control levels (i.e., for *Giardia*, *Cryptosporidium*, and virus) via a combination of physical removal and physical / chemical inactivation

Table 2 Summary of DWSP Components

Permit Component	Required?	Description / Necessary Elements
Operations Maintenance and Monitoring Plan	Required at CDPH Discretion	Detailed operations and maintenance plan for the treatment and conveyance system, including water quality sampling
Chlorine Residual Stability Analysis	Required at CDPH Discretion	Analysis of the chlorine decay profile
DBP Formation and Blending Analysis	Required at CDPH Discretion	Analysis of the formation of disinfection by-products in the chlorinated water
Corrosion Control Analysis	Required at CDPH Discretion	Assessment of corrosion potential of the treated groundwater and measures to control corrosion in the distribution system and household plumbing

The table differentiates those elements that are specifically required by mandate from those that may be required by the CDPH as conditions for permit approval. In addition to the permit components summarized in Table 2, CDPH will also require a review of the preliminary design report and associated drawings for any treatment systems and all related infrastructure (e.g., conveyance, storage tanks, etc.), as well as alarm and control descriptions. Although ion exchange treatment for chromium removal would not be required under the California SDWA, if included to reduce hexavalent chromium to the reporting limit to meet Order requirements, the treatment system would need to be permitted for operation as part of the overall DWSP.

If the groundwater is determined to be under the influence of surface water (based on limited data collected from an existing monitoring well near the Mojave River), the following additional requirements will apply:

- A watershed sanitary survey would be required as part of the DWSP application to meet requirements for GWUDI under 22 CCR §64665.
- 22 CCR §64650 multiple barrier treatment requirements for GWUDI systems would need to be met. The proposed treatment train, including media filtration followed by disinfection, addresses the multiple barrier treatment requirements by providing a series of processes to both remove and inactivate any waterborne pathogens that could be present in groundwater under the influence of surface water.

Additional institutional and permitting considerations that may need to be addressed for this alternative include:

- Coordination of replenishment credits and base production rights through MWA;
- A mitigation plan to minimize the threat to the desert tortoise and Mojave ground squirrel during construction of transmission and distribution system pipelines. Pursuant to the Order, the Water Board would address any CEQA requirements, if it is the “lead agency” under CEQA (Water Board, 2011);
- Right-of-way permits for any jurisdiction the pipeline alignment passes;
- Air permitting requirements during construction;
- CDPH will closely review the TMF report (along with other aspects of the DWSP application) and, based on the March 22, 2012 phone conversation, has indicated that an inability to demonstrate technical, management, and financial capability could hinder CDPH approval. Operation of the new PWS by an existing purveyor, such as GSWC, would quickly facilitate the TMF approval process.

4.2.4 System Construction

The CWS would be designed based on typical guidelines for water systems taking into account any site-specific conditions and input from local agencies (e.g., Fire Marshall). Once design is complete, all necessary permits must be obtained, including well permits and CEQA requirements (if applicable), before approval to construct is granted. CDPH processing time for a DWSP averages approximately 8 months (22 CCR §64002), but can take longer depending on CDPH work backlog and the complexity of the permit application.

Once approval is granted, the construction phase of the project is estimated to take 1 to 2 years for 25 properties. Following construction, startup, commissioning, and system turnover are expected to take 6 months depending on the conditions set forth by CDPH and the Water Board. The entire project length of this alternative is highly dependent on the permitting and approval process (including CEQA applicability). As such, it is estimated to take approximately 2 to 3 years for conceptual and detailed design, permitting, construction, startup, commissioning, and turnover.

4.2.5 Operations, Maintenance, and Replacement

A new O&M Plan would be developed and maintained for the water system, which would include standard operating procedures, schematics and detailed water system drawings, system capacities, chemical dosing requirements, water sampling frequencies and procedures, operator training requirements, and emergency contact information. Qualified staff would be responsible for the Hinkley system as described in the O&M Plan and pursuant to 22 CCR §63765 and §63770, including operation of the ion exchange system and responding to leaks and calls from Hinkley residents. Sampling and reporting of constituents will be dictated by the approved DWSP (i.e., set forth in the monitoring plan submitted as part of the DWSP application process) and regulatory compliance standards. Because of the relatively low demand in the Hinkley area resulting in a long water age in the distribution system (oversized based on fire flow requirements), it is likely that the distribution system may need to be flushed periodically to minimize water quality issues and meet applicable water quality requirements.

4.2.6 Environmental and Other Considerations

Properties with impacted wells would lose some autonomy over their water supply but would gain access to a more reliable and abundant supply that meets all applicable drinking water standards. Disinfection and maintaining a disinfectant residual is mandated for every CWS. Hinkley residents may notice a change in taste/odor as a result of the disinfectant residual or the different mineral content in the water. While all applicable drinking water standards will be met, additional community outreach may be necessary to increase awareness of this issue and gain community acceptance.

Developing a CWS in the Hinkley area may have a beneficial impact on development and local economy. If the ownership of the system is turned over to a water provider, residents without impacted wells may have the option to connect to the CWS, provided that system infrastructure is sized accordingly. Additional connections to the water system would be based on agreements between the homeowner and the water provider.

Similar to all centralized treatment alternatives, environmental impacts for this alternative are expected to be minimal. Potential for impacts to state and federally listed animal species (e.g., Mojave ground squirrel and desert tortoise) would be greatest during construction. The pipeline design can take into account road rights-of-way to minimize the impact to wildlife habitat. Daily operation and maintenance of this alternative is not expected to have any adverse effects on the environment.

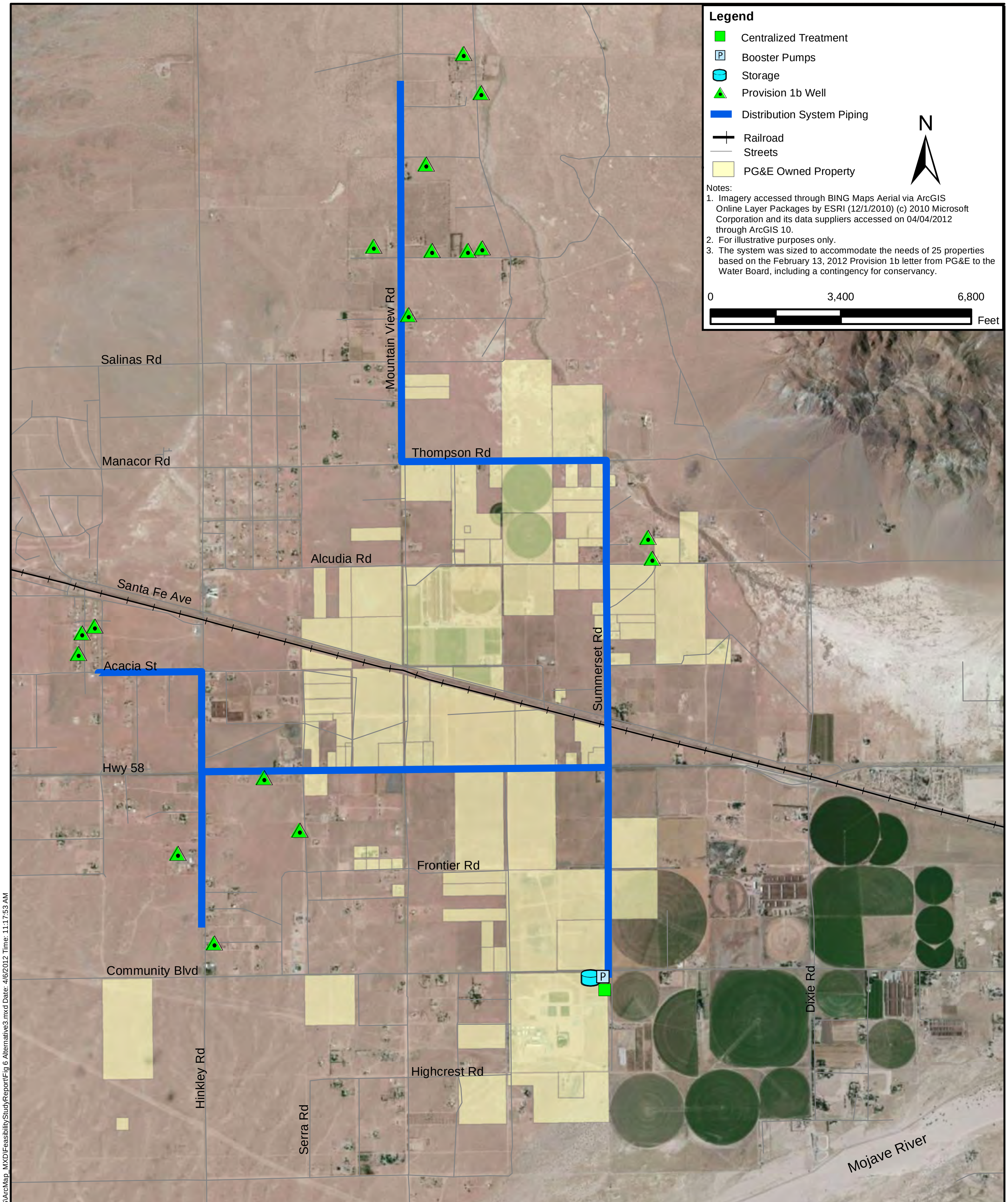
4.3 Alternative 3: Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program (Centralized Treatment and Distribution)

Under this alternative, replacement water for Hinkley would be supplied from local groundwater extracted from within the hexavalent chromium plume, consistent with one of the potential remedial strategies being evaluated (Feasibility Study under State Board Resolution 92-49 for the chromium remediation project [Haley and Aldrich 2010] and subsequent Addenda). Most of the groundwater would be injected back into the aquifer following remediation treatment; however, a portion of the water would receive additional treatment to meet all applicable drinking water standards and requirements for a CWS. A pipeline network would be developed to meet residential water needs of properties in the affected area with impacted wells.

4.3.1 System Configuration and Infrastructure

A conceptual level schematic of the alternative is shown on Figure 6. The alternative assumes construction of one centralized treatment system for provision of replacement water at the proposed remediation site north of the Hinkley Compressor Station. The following assumptions were used in the development of this alternative:

- One of the potential remediation strategies proposed to address the chromium plume assumes that groundwater would be pumped from an area north of the Hinkley Compressor Station at a rate of approximately 200 gpm. It is assumed that remediation infrastructure (wells and treatment) under this proposed alternative would be sufficient to meet the water needs of 25 properties (~12 gpm) and would not require upsizing.
- The potable water treatment and distribution system were sized to accommodate the needs of 25 properties with impacted wells.
- The system would be classified as a new, independent CWS.



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Alternative 3: Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program Conceptual Layout

Replacement Water Supply Feasibility Study Report
Pacific Gas and Electric Company
Hinkley, California

FIGURE
6

- Pipelines, pump stations, and storage tanks were sized based on average residential fire flow conditions (500 gpm for 2 hours). Because of the low residential demands, fire flow conditions largely dictated infrastructure sizing.
- PG&E will designate a water provider (such as GSWC) who will operate and maintain the system in compliance with all applicable drinking water standards.

The remedial alternative proposed in Haley and Aldrich (2010) and subsequent Addenda proposes remediation treatment using reduction, coagulation, and filtration (RCF), which may not be capable of consistently treating chromium to below the reporting limit. Thus, the conceptual treatment train for Alternative 3 (Figure 7) assumes that the remediation treatment system would be followed by ion exchange (WBA exchange, lead-lag vessels, with an SBA polishing step) to reduce hexavalent chromium concentrations to below the reporting limit on water serving the properties with impacted wells. Greensand filtration for iron and manganese removal, if required, and chlorine disinfection would also be included.

Inclusion of multiple treatment barriers for hexavalent chromium removal would be consistent with 97-005 permitting requirements if the groundwater is defined as an extremely impaired source (see Applicable Legal and Regulatory Requirements in Section 4.3.3 below). Alternatively, ion exchange treatment could be considered to achieve both remediation treatment (in lieu of reduction, coagulation, and filtration) and potable water treatment. The ability to treat groundwater from the plume using ion exchange to reduce chromium concentrations to below the reporting limit for the impaired source water would need to be verified by pilot testing.

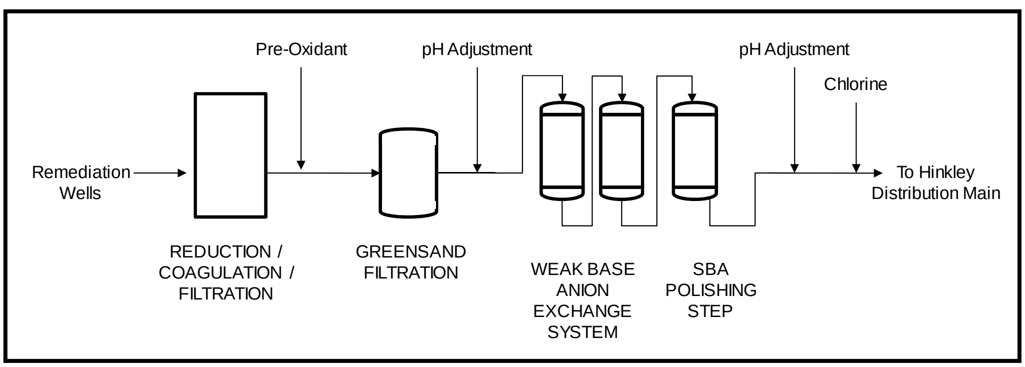


Figure 7 Conceptual Treatment Train for Alternative 3

4.3.2 System Performance

The total capacity of the remediation wells is projected to be 200 gpm. Less than 10 percent of that capacity (12 gpm) would be used to provide replacement water to properties with impacted wells. Using resources and infrastructure to be constructed will likely reduce infrastructure and operating costs, should the *ex-situ* treatment remediation alternative be selected. Storage tanks would be used to meet peak hour and fire flow demand conditions in excess of the well capacity. If sufficient capacity is not available, additional wells could be drilled and outfitted as needed. Properties with impacted wells would gain access to a more reliable and abundant water supply.

The MWA is responsible for managing and replenishing groundwater withdrawal in the Mojave Basin Area. PG&E would purchase water and/or water rights from MWA. If the number of properties with impacted wells increases beyond 25, additional wells could be drilled in the area to meet the increased demand.

Historical well water quality data for wells near the Hinkley Compressor Station suggest the wells will have moderate TDS (within or below the CDPH recommended range of 500 to 1,000 mg/L; Appendix A), iron, manganese, and high concentrations of chromium. During construction, shallow wells will be drilled to maximize extraction of groundwater containing high concentrations of hexavalent chromium. TDS concentrations would also be monitored during development of the remediation wells in consideration of aesthetic requirements for the replacement water supply. Ion exchange would be operated to reduce chromium concentrations to below the reporting limit. Greensand filtration, if required, would be operated to reduce iron and manganese concentrations to below the SMCL. Operational and water quality data would be monitored to track water treatment system performance.

PG&E or the water provider appointed by PG&E would be responsible for any residuals or wastes generated during groundwater treatment. Because there is no sewer system or wastewater treatment plant nearby, process water (e.g., water resulting from an initial flush of ion exchange resin) and reduction / coagulation / filtration process residuals or wastes would be stored and hauled offsite for disposal in an approved manner. Exhausted ion exchange resin would require disposal. The waste classification for the spent resin and associated disposal requirements would need to be verified under site-specific conditions (e.g., groundwater quality, resin type, etc.).

This alternative is consistent with the chromium remediation strategy. The effect of decreased pumping of impacted wells in the Hinkley area could reduce the potential to pull the plume off-gradient, dependent on site-specific hydrogeologic conditions.

4.3.3 Applicable Legal and Regulatory Requirements

Similar to Alternative 2 (centralized treatment and distribution of groundwater near the Mojave River), this alternative to treat and distribute local groundwater would also result in the formation of a new CWS. Regulatory primacy for a new CWS will depend on the system size and CDPH discretion, with either CDPH or the San Bernardino County Health Officer as the primacy agency for a system serving fewer than 200 service connections, and CDPH as the primacy agency if more connections are served.

A DWSP application will need to be prepared by a professional civil engineer registered in California if one treatment system serving more than 15 connections is installed. The DWSP application would need to include all of the required components listed previously in Table 2, and additional information requested at CDPH's discretion (e.g., analysis of disinfectant stability, disinfection by-product formation, and/or a corrosion control study). CDPH will also require a review of the preliminary design report and associated drawings for the treatment systems and all related infrastructure (e.g., conveyance, storage tanks, etc.), as well as alarm and control descriptions.

Groundwater extracted from the remediation wells could be classified as an extremely impaired drinking water source due to the presence of hexavalent chromium at high concentrations. The CDPH defines extremely impaired sources as those that "…contain or are likely to contain high concentrations of contaminants, multiple contaminants, or unknown contaminants (CDHS, 1997)." Recognizing that "…there are extremely impaired sources in California that need to be cleaned up and for which the resulting product water represents a significant resource that should not be wasted," CDPH Policy Memo 97-005 outlines an approach by which the department may evaluate, establish appropriate permit conditions, and approve proposals to use an extremely impaired source as a potable water supply.

Table 3 summarizes the elements that should be included in a 97-005 permit application. Based on the March 22, 2012 phone call with CDPH, a proposal to use groundwater from the remediation wells in Hinkley may only need to follow the first few steps of the 97-005 permit application process. A technical report summarizing those initial findings (i.e., source water assessment, raw water quality characterization, and source protection) may be submitted to CDPH to ascertain whether the groundwater is classified as an extremely impaired source, with additional permitting requirements dependent on the results of that analysis. If the groundwater were classified as an extremely impaired source, the proposed conceptual level treatment train (RCF followed by WBA ion exchange treatment with an SBA polishing step) would meet the CDPH 97-005 multiple barrier treatment requirements.

Table 3 Elements for Inclusion in a 97-005 Permit Application

#	Element	Brief Description (additional information in CDHS, 1997)
1	Source water assessment	The assessment should include a description of the source water, delineation of the source water capture zone, and identification of contaminant sources.
2	Raw water quality characterization	Raw water quality must be fully characterized, including an evaluation of contaminant concentrations as a function of time and pumping rate.
3	Source protection	The permit application should document source water monitoring plans, district programs aimed at controlling the level of contamination, and best management practices for waste handling and reduction. Programs should be in place to prevent the level of contamination from increasing.
4	Effective monitoring and treatment	The description of the proposed monitoring and treatment should include: • Performance standards • An operations plan • Reliability features • A compliance monitoring/reporting program • A notification plan • An extremely impaired source water quality surveillance plan
5	Health risks associated with treatment failure	The permit application should include an assessment of the risks of failure of the proposed treatment system and potential health impacts, taking into account the duration of exposure and potential cumulative risks.
6	Identification of alternative sources	Alternative drinking water sources should be evaluated and compared to the use of the extremely impaired source.
7	CEQA review	A CEQA review must be completed.

Additional institutional and permitting considerations that may need to be addressed for this alternative include:

- Coordination of replenishment credits and base production rights through MWA;
- A mitigation plan to minimize the threat to the desert tortoise and Mojave ground squirrel during construction of transmission and distribution system pipelines. Pursuant to the Order, the Water Board would address any CEQA requirements, if it is the "lead agency" under CEQA (Water Board, 2011);
- Right-of-way permits for any jurisdiction the pipeline alignment passes;
- Air permitting requirements during construction.

4.3.4 System Construction

The CWS would be designed based on typical guidelines for water treatment systems taking into account any site-specific conditions and input from local agencies (e.g., Fire Marshall). As part of the remediation strategy, groundwater extraction and RCF treatment would need to be designed to accommodate system redundancy. Once design is complete, all necessary permits must be obtained, including well permits and CEQA requirements (if applicable), before approval to construct is granted. CDPH processing time for a DWSP averages approximately 8 months (22 CCR §64002), but can take longer depending on CDPH work backlog and the complexity of the permit application.

PG&E, the Water Board, and consultants are currently in the process of developing the remediation strategy and evaluating the environmental impacts. This alternative is conditional on the implementation of the remediation strategy which may not occur for several years. Once approval to construct is granted, the construction phase of the project is estimated to take 1 to 2 years for 25 properties. Following construction, startup, commissioning, and system turnover are expected to take 6 to 12 months depending on the conditions set forth by CDPH and the Water Board. The entire project length of this alternative is highly dependent on the permitting and approval process (including CEQA applicability). As such, it is estimated to take approximately 3 to 5 years for permitting, conceptual and detailed design, permitting, construction, startup, commissioning, and turnover.

4.3.5 Operations, Maintenance, and Replacement

A new O&M Plan would be developed as part of the DWSP application process and maintained for the independent water system, which would include standard operating procedures, schematics and detailed water system drawings, system capacities, chemical dosing requirements, water sampling frequencies and procedures, operator training requirements, and emergency contact information. Qualified staff would be responsible for the Hinkley system as described in the O&M Plan, including operation of the ion exchange system and responding to leaks and calls from Hinkley residents. Sampling and reporting of constituents will be dictated by the approved DWSP (i.e., set forth in the monitoring plan submitted as part of the DWSP application process) and by regulatory compliance standards. Because of the relatively low demand in the Hinkley area resulting in a long water age in the distribution system (oversized based on fire flow requirements), it is likely that the distribution system may need to be flushed periodically to minimize water quality issues and meet applicable water quality requirements.

4.3.6 Environmental and Other Considerations

Properties with impacted wells would lose some autonomy over their water supply but gain access to a more reliable and abundant supply meeting all applicable drinking water standards. Disinfection and maintaining a disinfectant residual is mandated for every CWS. Hinkley residents may notice a change in taste/odor as a result of the disinfectant residual or a change in the water's mineral content. Furthermore, there could be some reluctance on the part of the community to accept treated water from within the chromium plume. While the water will meet all applicable drinking water standards, additional community outreach may be necessary in order to increase awareness of this issue and gain community acceptance.

Developing a CWS in the Hinkley area may have a beneficial impact on development and the local economy. If ownership of the system is turned over to a water provider (e.g., GSWC), residents without impacted wells may have the option to connect to the public water system. This would be based on an agreement between the homeowner and the water provider.

Similar to all centralized treatment alternatives, environmental impacts for this alternative are expected to be minimal. Potential impacts to state and federally listed animal species (e.g., Mojave ground squirrel and desert tortoise) would be greatest during construction. The pipeline design can take into account road rights-of-way to minimize the impact to wildlife habitat. Daily operation and maintenance of this alternative is not expected to have any adverse effects on the environment.

A variation of this alternative could be considered involving the construction of two or more satellite treatment systems, which would be constructed in tandem with proposed remediation activities. Another treatment system could be constructed north of Highway 58 to aide in cleanup in the northern portion of the plume. The treated water would be used to serve properties with impacted wells in the northern portion of Hinkley. Development of two satellite systems, each serving less than 15 connections, may not fall under CDPH jurisdiction according to the narrow definition of a CWS.

4.4 Alternative 4a-c: Provide Point of Entry Treatment Systems (Whole-House Water Treatment)

Pilot testing was conducted at an active agricultural well (Gorman-5R) in Hinkley between early November 2011 through April 2012 to assess the ability of whole house reverse osmosis and ion exchange treatment systems to safely, effectively, and reliably remove hexavalent chromium from groundwater to very low levels. Appendix B presents the test conditions and findings from the pilot study. Initially, three whole house water treatment systems were tested:

- Ion exchange using lead-lag vessels containing Type 1 strong base anion exchange resin (ResinTech SBG1);
- Reverse osmosis treatment using a two-pass configuration (where RO permeate from the first RO unit passes through a second RO unit to further reduce ion concentrations); and,
- A hybrid reverse osmosis – ion exchange system.

Results from the first three months of testing showed that all three systems could consistently remove hexavalent chromium levels below the 0.06 µg/L reporting limit. In February 2012, PG&E elected to continue operating the pilot systems to provide additional data and to facilitate additional community outreach opportunities. The pilot systems were modified at this time to test three additional whole house water treatment configurations:

- Ion exchange using lead-lag vessels containing nitrate selective resin (ResinTech SIR-100-HP) to optimize removal of both chromium and nitrate from the agriculture well;

- RO treatment using a two-stage configuration. In two-stage RO, concentrate from the first RO unit is treated through a second RO unit, with the permeate from the second RO unit blended with the permeate from the first RO unit to enhance process recoveries and reduce the brine volume generated; and,
- Ion exchange followed by undersink RO to remove TDS, chloride, and sulfate.

Conversion from two-pass to two-stage RO increased water recovery from 25 to 69%. The undersink RO consistently reduced TDS, chloride, and sulfate to very low concentrations, enabling the process to meet all the primary and secondary drinking water standards at the kitchen tap. Pilot testing is ongoing on the nitrate-selective resin and an addendum to the Pilot Study Report will be issued at the end of testing.

Based on pilot test results, three different whole-house water treatment systems were considered for impacted wells:

- Alternative 4a: Whole-house ion exchange;
- Alternative 4b: Whole-house reverse osmosis;
- Alternative 4c: Whole-house ion exchange with undersink RO.

Alternative 4a could include installation of either a Type 1 strong-base anion exchange resin or nitrate-selective resin, depending on water quality at the impacted well and the ability of nitrate-selective resin to reduce hexavalent chromium levels below the reporting limit. For comparative purposes, Alternative 4b assumes installation of a two-stage RO system to maximize water recovery. However, based on pilot testing results, any of the RO treatment configurations (i.e., two-pass, two-stage, or RO with an ion exchange polishing step) could be implemented to reduce hexavalent chromium levels below the reporting limit.

4.4.1 System Configuration and Infrastructure

The following assumptions were used in the development of this alternative:

- Existing impacted wells are in proper working order, produce adequate flow, and do not require maintenance or replacement.
- Water quality in private domestic wells is not regulated.
- All whole-house water treatment systems are certified for use as POE treatment devices.

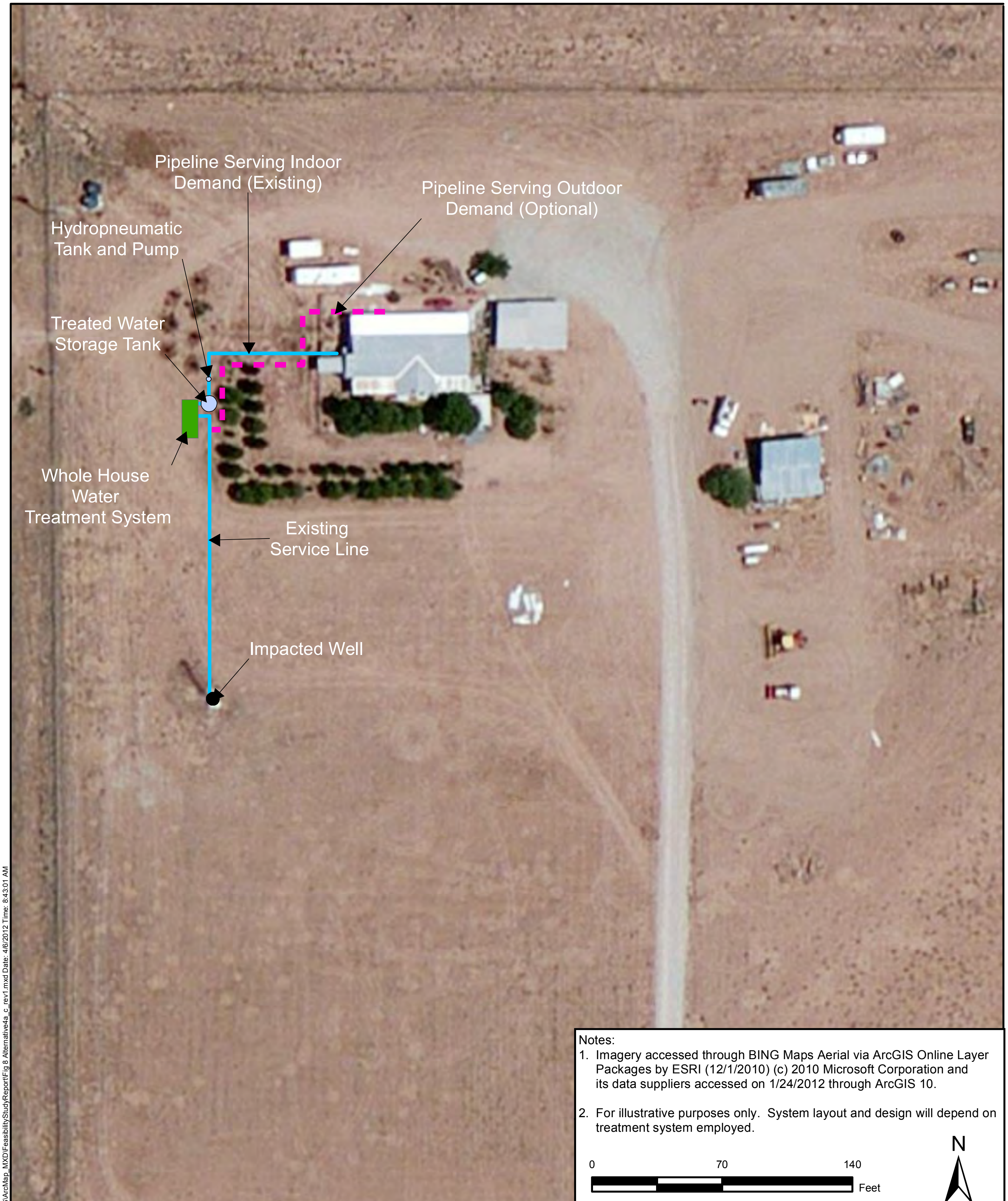
- All residuals generated during treatment (e.g., ion exchange flush water, exhausted ion exchange resin, and RO brine) are classified as non-hazardous.
- Operations, maintenance, replacement frequencies, waste volumes, and finished water quality are based on average water quality conditions described below.

Figure 8 shows a schematic representation of the whole-house water treatment alternative, with provision of a point of entry treatment system, chlorine disinfection, and water storage for each of the households with impacted wells. Figure 9 shows process flow diagrams for Alternative 4a-c.

4.4.2 System Performance

All three systems can consistently treat hexavalent chromium to concentrations below the reporting limit. The systems may offer additional water quality benefits:

- **Alt 4a: IX** – In addition to hexavalent chromium, IX will remove chromium, nitrate, and other anionic species (e.g., arsenic, radionuclides). Other constituents such as TDS, sulfate, and chloride would not be removed and may be in excess of drinking water standards depending on the well water quality.
- **Alt 4b: RO** – RO units are able to remove the same constituents as IX and additionally remove TDS, sulfate, and chloride. Water produced from RO, however, can be corrosive and must be passed through a calcite filter to improve the stability of the water. Pilot-testing suggests that a calcite filter may not be adequate to mitigate the aggressive nature of this water (Appendix B).
- **Alt 4c: IX + Undersink RO** – Ion exchange will remove constituents similar to Alternative 4a for the whole house. Although undersink RO is not required to bring the hexavalent chromium concentration below the 0.06 µg/L reporting limit, it would have the added benefit of removing additional constituents (similar to Alternative 4b) at designated tap. Because RO-treated water is not conveyed through household plumbing, the risk of corrosion is minimal.



Notes:

1. Imagery accessed through BING Maps Aerial via ArcGIS Online Layer Packages by ESRI (12/1/2010) (c) 2010 Microsoft Corporation and its data suppliers accessed on 1/24/2012 through ArcGIS 10.
2. For illustrative purposes only. System layout and design will depend on treatment system employed.

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Alternative 4a-c – Point of Entry Whole-House Water Treatment System Conceptual Layout

Pacific Gas and Electric Company
Hinkley, California

FIGURE
8

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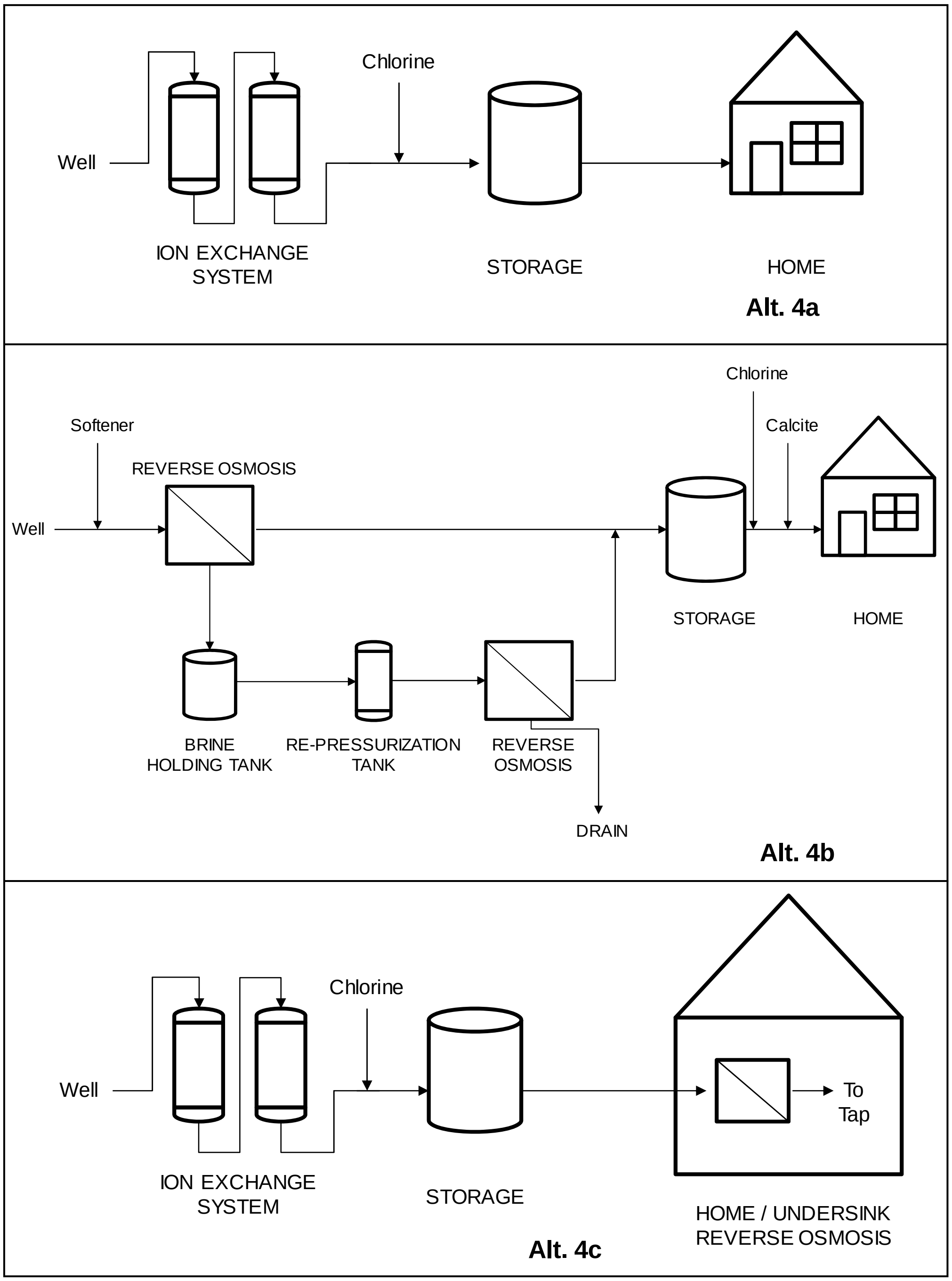

Figure 9 Conceptual Treatment Trains for Alternatives 4a – c

Groundwater quality can impact the performance of the whole-house water treatment systems and varies significantly both horizontally and vertically in the Hinkley Valley. Without specific data for each impacted well, water quality assumptions had to be made to assess system performance. Table 4 summarizes key water quality parameters for waters expected to be encountered in the Hinkley area. Qualitative descriptors of the water quality (i.e., "poor", "average", and "good") were assigned primarily based on:

- Concentrations of nitrate and sulfate, since these constituents can significantly affect ion exchange resin performance by competing for resin adsorption sites, reducing the capacity of the resin for chromium removal, and necessitating frequent resin replacement; and,
- TDS, since salt concentrations also affect ion exchange performance and affect the aesthetic quality of the water.

Table 4 Whole-House Water Treatment – Water Quality Assumptions[1]

Parameter	Unit	"Poor" Water Quality	"Average" Water Quality	"Good" Water Quality
Bicarbonate	mg/L as $CaCO_3$	100	260	70
Calcium	mg/L	360	160	30
Chromium, Hexavalent	µg/L	2	2	2
Chromium, Total	µg/L	3	2	2
Nitrate[2]	mg/L as N	< 8	< 8	< 8
Sulfate	mg/L	750	190	30
Total Dissolved Solids	mg/L	2,800	1,080	270
Magnesium	mg/L	110	30	5
Chloride	mg/L	760	150	40
pH	SU	7	7	7

Notes:
1 Based on analysis of available data for domestic wells in the Hinkley community.
2 Assumes nitrate is less than 80% of the MCL.

Water with "poor" quality may have a combination of high sulfate and/or nitrate and high TDS, whereas "good" quality water has low nitrate, sulfate and TDS. For the purposes of this study, an equal proportion of "poor", "average", and "good' water quality was assumed for the impacted wells.

A summary of the water required for each whole-house water treatment alternative to produce 660 gpd of replacement water is presented in Table 5. Each of the whole-house water treatment systems – ion exchange, reverse osmosis, or ion exchange plus undersink RO – uses process water during operations for initial flushing and/or wasting (e.g., RO brine) in the course of removing constituents. As shown in the table, reverse osmosis can require over 10 times more process water on an annual basis compared to ion exchange. If an impacted well is operating at or near the capacity of the well, the supply of water available to the homeowner may be limited. If capacity of the well is limited by system infrastructure, the well can be retrofitted. If capacity is limited hydrogeologically, a new well may be required.

Table 5 Whole-House Water Treatment – Process Water Requirements and Waste Generation

	Alternative 4a: Ion Exchange	Alternative 4b: Reverse Osmosis	Alternative 4c: Ion Exchange Plus Undersink RO
Household Water Demand (gpd)	660	660	660
BRINE GENERATION			
Overall 2-stage RO Membrane Recovery (%)[1]	-	69%	-
RO Brine Generation (gpd)	-	260	272
Softener Brine Generation (gpd)[1]	-	170	-
Annual Brine Generation (gallons/year)	0	157,000	10,000
EQUIPMENT FLUSHING			
Annual Flushes Needed (#/year)[3]	6	2	6
Flush Volume (gallons/flush)[4]	1,920	720	1,920
Total Flush Volume (gallons/year)	11,500	1,400	11,500
ANNUAL PROCESS WATER REQUIRED (gallons/year)	11,500	158,400	21,500
LIQUID WASTE GENERATED[5] (gpd)	**30**	**430**	**60**

Notes:
1 Based on pilot-testing.
2 Assumes 3 gpd kitchen water usage per resident (9 gpd per household) and a RO membrane recovery of 25%.
3 Assumes RO membranes are replaced once a year; the number of IX resin flushes were based on Envirogen modeling of good, average, and poor water quality; assume undersink RO flush is negligible.
4 Assumes a 4-hour flush at design flow.
5 Based on annual volume of process water divided by 365 days; ion exchange and reverse osmosis flushes occur as needed over a 4-hour time period.

The incremental volume of water pumped from impacted wells will depend on the treatment technology. Impacts to the plume will be site-specific and dependent on hydrogeologic conditions.

All treatment processes will generate residuals which would require appropriate disposal. Based on process water requirements described in Table 5, the quantity of waste will vary as follows:

- **Alt 4a: IX** – IX is estimated to produce 30 gpd of liquid waste (2,000 gallons per flush), which can be disposed of in the septic system. Because an IX flush occurs over the course of 4 hours, an equalization tank may be needed to slow the rate at which the water enters the septic system. This was not considered in this evaluation but should be considered prior to implementation. The small volume is not expected to have a negative impact on home septic systems. Exhausted ion exchange resin would be disposed of offsite, meeting all local, state, and federal requirements.
- **Alt 4b: RO** – RO is estimated to produce 430 gpd of liquid waste. In typical residential applications, this is disposed of in the sewer. Given the volume of RO waste generated, septic systems may not be able to accommodate the incremental flow on a daily basis. Additionally, while RO brine is combined with the RO permeate in the septic system, theoretically producing similar water prior to being treated, residents may be averse to sending this water back to the aquifer. For this reason, it was assumed that this waste would be collected and hauled offsite for disposal, generating substantial truck traffic in the community.
- **Alt 4c: IX + Undersink RO** – Ion exchange + undersink RO generates an estimated 60 gpd of liquid waste. Because only a small volume of RO brine is generated and the RO brine does not contain chromium (removed by IX), the liquid waste can likely be sent to the septic system. Similar to Alternative 4a, an equalization tank may be needed to slow the discharge to the septic system. This was not considered in this evaluation but should be considered prior to implementation. The small volume is not expected to have a negative impact on home septic systems.

4.4.3 Applicable Legal and Regulatory Requirements

Private domestic wells are not regulated. Water quality is governed through the Water Board, pursuant to the Order.

22 CCR §64420 sets forth requirements for CDPH to permit the use of POE treatment for a CWS to comply with one or more MCLs. These regulations do not directly apply to whole-house replacement water supply alternatives because:

- Domestic wells are not classified as a CWS (provided they are not inter-connected to serve more than 15 connections); and,
- No federal or state MCL has been established specifically for hexavalent chromium (the standard by which CDPH and National Sanitation Foundation/American National Standards Institute [NSF/ANSI] certify device performance). However, CDPH is in the process of setting an MCL for hexavalent chromium (CDPH, 2012).

The absence of any CDPH/NSF/ANSI current certification of whole house water treatment to reduce hexavalent chromium levels below the reporting limit will need to be addressed in cooperation with the involved regulatory agencies and the Water Board.

It is anticipated that PG&E would develop a comprehensive compliance plan that would stipulate operations, maintenance, monitoring and reporting requirements for the treatment systems. The pilot testing (described in Appendix B) was designed to provide a basis for the Compliance Plan and to facilitate CDPH approval of the whole-house water treatment systems that would ensure continuous compliance with applicable water quality standards.

Pursuant to the Order, implementation of this replacement water alternative would not require further analysis under CEQA.

4.4.4 System Construction

The design of every whole house water treatment system should be based on additional water quality sampling and site-specific conditions. The overall construction process for the three systems is similar. Once construction permits are received, construction can begin. All treatment infrastructure would be housed in a lockable steel containment unit with climate control to optimize system operation. A 2,000-gallon storage tank, pump, and hydropneumatic tank would be provided. The treatment system would be plumbed into the existing water line. Figure 8 illustrates a generic system layout for this alternative, with specifics described below:

- **Alt 4a: IX** – A waste line will be connected to the septic system.
- **Alt 4b: RO** – A brine storage tank will be installed outside of the steel containment unit.
- **Alt 4c: IX + Undersink RO** – A waste line will be connected to the septic system. An RO unit would be installed under the kitchen sink. If system pressures are not sufficient, a small booster pump will be installed with the undersink RO if sufficient power is available.

The treatment power supply will be separated from the homeowners existing electrical systems to ensure that it does not overload the existing house electrical system or potentially exacerbate unknown or known pre-existing electrical problems within the residence. Additional power will not be provided for undersink RO units. Following resolution of any POE certification or applicable permitting issues, construction and testing is estimated to take up to 1 year for 25 properties.

4.4.5 Operations, Maintenance, and Replacement

Whole-house water treatment operations, maintenance, monitoring and reporting requirements would be stipulated in a Compliance Plan. Operation of the treatment systems would be linked to storage tank water levels. Increased household water use would trigger operation of the well and treatment system. The well and treatment system will only operate during power outages if the homeowner has a sufficient backup power supply.

All maintenance would be performed by a licensed technician to preserve system warranties and minimize homeowner need to manage a treatment system. Maintenance of the systems would be both preventative and as needed. Biannual service calls would be performed to inspect the system for wear, damage, and leaks. A telemetry system would also be installed to notify the maintenance company that the system requires attention. The telemetry system can be linked to a cellular device to minimize disturbance to the homeowner. Routine maintenance may be performed more frequently during the first year until the system and water quality are more thoroughly understood. A more detailed description of operations and maintenance could be developed during the first year of operation.

The life expectancy of the treatment system components, including resin and filters, is highly dependent on environmental conditions and water quality specific to each impacted well. During the first year of service, the units will require frequent monitoring to ensure they meet the requirements of the Order. Sediment filter replacement on the units will be based on water quality but may be required every month (Appendix B). After the first year, quarterly or biannual hexavalent chromium sampling should be sufficient. It is anticipated that periodic reporting of monitoring results and system performance would be provided to the CDPH and/or Water Board.

Key differences in operation, maintenance, and replacement of the alternatives is noted below:

- **Alt 4a: IX** – The IX system requires a 110V power supply. Ion exchange resin replacement would be linked to the telemetry system which monitors flow through the resin. Assuming favorable water quality, the resin may require replacement once a year or, in the case of poor water quality, the resin could require replacement as frequently as once per month.
- **Alt 4b: RO** – The whole-house RO requires a 220V power supply. RO membrane replacement will be dictated by water quality but may requiring replacing annually. A technician would be responsible for monitoring and replacing salt in the water softener, which could occur 1 to 2 times per week.
- **Alt 4c: IX + Undersink RO** – Both the IX and undersink RO systems require a 110V power supply. Resin replacement would be similar to Alternative 4a. Undersink RO membranes and filters would be replaced biannually or as needed.

4.4.6 Environmental and Other Considerations

PG&E would assume responsibility for operation and maintenance of the treatment system to ensure conformance with manufacturer's recommended practices and approved compliance plans. Chlorine, TDS, and mineral content play an important role in water's taste and aesthetics. Some residents may not prefer the new taste. Additional outreach would be necessary to educate residents on water quality and gain community acceptance.

Environmental impacts specific to the alternatives is summarized below:

- **Alt 4a: IX** – While there may be some disturbances during construction, no environmental impacts are anticipated during operation and maintenance of this alternative.

- **Alt 4b: RO** - Based on average water use, approximately 2,000 truck trips annually would be required to haul away the brine created from 25 whole house RO treatment systems. Operation of these trucks would increase the risk of traffic accidents and wear and damage on Hinkley roads. This may present an increased risk to the safety of Hinkley residents and pose an increased threat to state and federally listed animal species (e.g., Mojave ground squirrel and desert tortoise).
- **Alt 4c: IX + Undersink RO** – Similar to Alternative 4a, no environmental impacts are anticipated during operation and maintenance of this alternative.

4.5 Alternative 5: Replace Impacted Wells with Deeper Wells

Under this alternative, deep wells will replace impacted wells, targeting more favorable water quality.

4.5.1 System Configuration and Infrastructure

The following assumptions were used in the development of this alternative:

- Water quantity from the replacement wells would be equal to or greater than existing household needs.
- Private domestic well water quality is not regulated.
- The quality of water produced from the deeper wells would be favorable, meeting all primary and secondary drinking water standards without treatment.
- Ion exchange treatment is provided for hexavalent chromium removal (assumed to be naturally-occurring) to meet the requirements of the Order and is allowable for use as a POE treatment device.

4.5.2 System Performance

Water quality in the lower aquifer and the deep portions of the upper aquifer are highly variable as described in Section 2.2. It was assumed that replacement wells would produce water that meets all primary and secondary drinking water standards; however, based on water quality data from the Gorman-5R agricultural well, deeper wells may result in increased concentrations of arsenic, radionuclides, and other metals at concentrations above the MCL (Appendix B). Ion exchange will help reduce anion concentrations (e.g., nitrate, arsenic, and uranium), but compliance with all primary and secondary drinking water standards will be dependent on actual water quality encountered. Accordingly, an undersink RO unit could be included for an additional barrier of protection. A chlorine disinfectant would be added to minimize biological growth.

The ion exchange treatment process would generate residuals which would require appropriate disposal. The ion exchange resin will require an initial flush, which is assumed to be sent to the homeowner's septic system. Exhausted ion exchange resin would be disposed of offsite. The waste classification (i.e., hazardous, non-hazardous, TENORM) and associated disposal requirements would need to be verified under site-specific conditions (e.g., groundwater quality). Resin change-outs are expected to be relatively infrequent due to the lower levels of hexavalent chromium anticipated in the lower aquifer.

Depending on where and at what depth the deep replacement wells are constructed, there is a potential for groundwater withdrawal from deep replacement wells to affect the extent of chromium-affected groundwater. The extent of the impact would be based on site-specific hydrogeologic conditions at each location.

4.5.3 Applicable Legal and Regulatory Requirements

Domestic wells are not regulated by the CDPH. Regulatory authority for water quality in deeper wells installed to provide replacement water resides with the Water Board, pursuant to the Order.

As discussed under Section 4.4.3, a POE ion exchange system installed to reduce background levels of hexavalent chromium (if detected) to below the reporting limit is not directly subject to 22 CCR §64420 requirements. However, the absence of any CDPH/NSF/ANSI current certification of whole house water treatment system to reduce hexavalent chromium levels below the reporting limit will need to be addressed in cooperation with the involved regulatory agencies and the Water Board. Other institutional and permitting considerations include coordination with MWA to obtain a permit for a replacement well. Note that transfer or replenishment credits are not needed if each well is classified as a minimum producer (i.e., withdrawing less than 10 acre-ft/year).

Pursuant to the Order, implementation of this replacement water alternative would not require further analysis under CEQA.

4.5.4 System Construction

The construction of private domestic wells does not require as much design and agency coordination as a CWS; however, planning is still needed. Well construction will need to be adhere to standards established by the State Water Resources Control Board (SWRCB) and the wells must be drilled by a licensed contractor.

Once well and construction permits are received, construction can begin. When drilling and outfitting the well, well screening can target areas in the aquifer with the most favorable water quality conditions to minimize the chance that supplemental treatment will be required.

Ion exchange treatment infrastructure (if required) would be housed in a lockable, steel container with climate control to optimize system operation. A 2,000-gallon storage tank, pump, and hydropneumatic tank would be provided. All pipelines would be replaced running up to the house. Power for the treatment unit would be run from the homeowner's power box and metered separately. Following resolution of any POE certification or applicable permitting issues, construction and testing is estimated to take up to 1 year for 25 properties.

4.5.5 Operations, Maintenance, and Replacement

A Compliance Plan would be developed, outlining protocols for operations, maintenance, monitoring and reporting. Operation of the system would be linked to storage tank water levels. Increased household water use would trigger operation of the well and ion exchange treatment system. Similar to the current situation in Hinkley, the well will only operate during power outages if the homeowner has an existing backup power supply sufficient for the well and treatment system. The ion exchange system requires a 110V power supply.

All maintenance would be performed by a licensed technician to preserve system warranties and minimize involvement of the homeowner. Maintenance of the system would be both preventative and as needed. Biannual service calls would be performed to inspect the system for wear, damage, and leaks. A telemetry system would also be installed to notify the maintenance company that the system requires attention or the resin requires replacement. The telemetry system can be linked to a cellular device to minimize disturbance to the homeowner. Routine maintenance may be performed more frequently during the first year until the system and water quality are more thoroughly understood. A more detailed description of operations and maintenance could be developed during the first year of operation.

If properly maintained, the life expectancy of a well is more than 30 years. The life expectancy of the treatment system components, including resin and filters, is highly dependent on environmental conditions and water quality specific to each individual well. During the first year of service, the units will require additional monitoring to ensure they meet the requirements of the Order and provide a reliable supply of water to residents. Resin replacement will be linked to the telemetry system, which monitors flow through the resin. Assuming favorable water quality (described for Alternative 4), the resin may require replacement once per year. Sediment filter replacement would be based on water quality but may be required every month (Appendix B).

Private domestic well water quality is not regulated. Frequent monitoring may be necessary in the first year as system performance on the specific well is understood. After the first year, quarterly or biannual chromium sampling should be sufficient. Annual sampling of other water quality constituents of concern is likewise sufficient, as these parameters are not regulated in domestic wells and are not expected to widely fluctuate.

4.5.6 Environmental and Other Considerations

If treatment of the deep well water were required, PG&E would assume responsibility for the treatment system to ensure it is operated and maintained in accordance with manufacturer's recommended practices. Chlorine, TDS, and mineral content play an important role in water's taste and aesthetics. Some residents may not prefer the new taste. Undersink RO units could be provided to help mitigate any taste or odor issues. Residents may also become concerned about one or more constituents in their well that they were previously not aware of, causing an additional concern. Additional outreach would be necessary to educate residents on water quality and gain community acceptance.

There are no anticipated environmental impacts for this alternative (Water Board, 2011). The potential for impacts to state and federally listed animal species (e.g., Mojave ground squirrel and desert tortoise) would be greatest during construction, but existing measures to preserve these species can be used to minimize the risk. Daily operation and maintenance of this alternative is not expected to have any adverse effects on the environment.

4.6 Alternative 6: Truck Water from a Community Water System

Under this alternative, water would be trucked from the nearest CWS (GSWC) to properties with impacted wells. Storage tanks would be provided at each household and filled as needed.

4.6.1 System Configuration and Infrastructure

The following assumptions were used in the development of this alternative:

- GSWC is interested in and has sufficient infrastructure to provide wholesale water to PG&E for the purposes of trucking.
- Water for fire flow is not provided.
- Five thousand gallons of storage at each residence will supply approximately seven days of average water use.
- GSWC is currently not treating Barstow groundwater to remove hexavalent chromium. Hexavalent chromium, however, has been detected above the 0.06 µg/L reporting limit in some of the Barstow system wells (CDPH, 2011b). While this may not reflect water served to customers, ion exchange treatment (weak base anion [WBA] exchange, with an SBA polishing step) was assumed for Hinkley properties with impacted wells only to reduce hexavalent chromium levels below the reporting limit as required in the Order. If a supply could be located near Hinkley that contains hexavalent chromium below the reporting limit, ion exchange would not be required under this alternative.
- GSWC will operate the ion exchange treatment system and will be responsible for compliance with all applicable drinking water standards.
- Increased wear and tear on Hinkley roads as a result of trucking is not included in cost estimates.

Based on the assumptions listed above, the conceptual treatment train for Alternative 6 consists of ion exchange treatment in Barstow (WBA lead-lag vessels) followed by hauling the treated water to individual properties in Hinkley for storage.

4.6.2 System Performance

Based on a review of the Barstow 2010 Urban Water Management Plan, GSWC has sufficient water production rights to supply the water required for the properties with impacted wells (Kennedy/Jenks, 2011). Properties with impacted wells would theoretically gain access to an abundant water supply, limited to the logistics of trucking water from Barstow to Hinkley. Depending on road conditions and frequency of demand, there is an increased risk that homeowners may experience temporary interruption of water service. If the number of properties with impacted wells increases beyond 25, GSWC can supply sufficient water as long as it has sufficient infrastructure and replenishes water pumped in excess of their base production rights. This would be coordinated through the MWA.

As a CWS, the GSWC Barstow System is subject to county, state, and federal drinking water standards. Water quality is monitored regularly and reported annually to customers. According to the Barstow Water System 2011 Annual Water Quality Report, one MCL exceedance (described previously in Section 4.1.2) was documented for perchlorate in 2011. All other primary MCLs were met in 2011 for the GSWC Barstow System. The SMCLs for chloride and sulfate were also met; however, no data were available to ascertain the extent that other SMCLs were met for constituents such as TDS, iron, and manganese (GSWC, 2011). Perchlorate, radon, nitrate, manganese, boron, and TDS were identified as presenting a water quality issue or concern in one or more of the Barstow wells (Kennedy/Jenks, 2011).

It is assumed that GSWC would be responsible for any residuals generated during groundwater treatment, including those from an ion exchange system if one was required. Process water (e.g., water resulting from an initial flush of the ion exchange resin) could be sent to the Barstow area sewer (conditional on permitting requirements) or stored and hauled offsite to a certified disposal site. Exhausted ion exchange resin would require disposal, meeting all local, state, and federal requirements.

Because of the distance to the plume and the incremental volume of water pumped, it is not likely that increased pumping in the Barstow area will have an appreciable effect on the chromium plume. The effect of decreased pumping of impacted wells in the Hinkley area could reduce the potential to pull the plume off-gradient, dependent on site-specific hydrogeologic conditions. Because water from within the plume will not be pumped or treated as part of this alternative, there will be no direct beneficial effect on remediation of the plume.

4.6.3 Applicable Legal and Regulatory Requirements

This alternative would have similar legal and regulatory requirements as Alternative 1 which proposes to convey GSWC Barstow water to properties with impacted wells via a pipeline rather than a truck:

- GSWC Barstow would be responsible for meeting all applicable drinking water standards in the treated water.
- CDPH would be the primacy agency for regulating the quality of water before hauling because GSWC Barstow serves more than 200 connections.
- GSWC would need to submit a DWSP amendment application to operate an ion exchange system, including:
  - Demonstration of operator certification in accordance with 22 CCR §63765 (Certification of Water Treatment Facility Operation)
  - Additional monitoring and reporting, which may include updating the GSWC Barstow System monitoring plan to include sampling and monitoring to demonstrate performance of the ion exchange treatment system.
  - Submitting a monthly operating report for the ion exchange treatment facility (at the discretion of CDPH).

The CDPH Drinking Water Program (DWP) would be responsible for regulating the water up to the point it enters a tanker truck. However, the Food and Drug Branch of CDPH is responsible for regulating the hauled water once it enters the tanker truck. Hauled water is regulated under the Health and Safety Code, Division 104, Part 5, Article 12, Sections 111070 – 111198. Hauled water must be transported by a licensed potable water hauler, defined as "a person who hauls water in bulk (capacities of 250 gallons of water or greater) where there is a likelihood that the water will be used for drinking, culinary or other purposes." Food and Drug Branch License Application Form CDPH 8605 outlines the requirements for potable water haulers to obtain a license to operate in California.

Institutional and permitting considerations for this alternative may include:

- Coordination of replenishment credits and base production rights through MWA;

- A mitigation plan to minimize the threat to the desert tortoise and Mojave ground squirrel during construction of transmission and distribution system pipelines. Pursuant to the Order, the Water Board would address any CEQA requirements, if it is the “lead agency” under CEQA (Water Board, 2011);
- The CDPH DWP has taken a firm position that hauling and storing water should only be a short-term/emergency protocol for providing a water supply (phone conversation with CDPH on March 22, 2012). Under the proposed scenario, that the hauled water is stored at individual properties, CDPH DWP would have limited authority over the hauling and storage operation. However, if the hauled water were instead stored in a central reservoir serving more than 15 connections (e.g., forming a new PWS), the DWP would have regulatory enforcement authority and would not likely authorize continued hauling and storing as a replacement water supply alternative.

4.6.4 System Construction

Prior to design, PG&E and GSWC would need to reach an agreement to provide water to properties with impacted wells. The treatment system would need to meet design requirements and conditions set forth by GSWC and other local agencies. Storage at each household should balance household water needs with water age to prevent the excessive formation of disinfectant by-products and general deterioration in water quality. Once design is complete, all necessary permits must be obtained, including CEQA requirements (if applicable), before approval to construct is granted.

Once approval is granted, the construction phase of the project is estimated to take 1 to 2 years for 25 properties. Construction of infrastructure on private lands may hasten the permitting process. Following construction, startup, commissioning, and system turnover are expected to take 6 months depending on the conditions of GSWC and regulatory agencies. The entire project length of this alternative is highly dependent on the permitting and approval process (including CEQA applicability). As such, it is estimated to take approximately 1 to 3 years for conceptual and detailed design, permitting, construction, startup, commissioning, and turnover.

4.6.5 Operations, Maintenance, and Replacement

Under this alternative, the operation of the ion exchange system would be addressed in the GSWC O&M Plan. Qualified GSWC staff would be responsible for system operations, maintenance, and replacement as described in the O&M Plan. As part of the agreement between PG&E and GSWC, the O&M Plan could be updated to include chromium sampling requirements, performance goals, and reporting requirements agreed upon as part of the settlement of the Order.

A separate O&M Plan would be developed for the hauling of water to properties with impacted wells. Telemetry systems can be set up to monitor tanks levels and notify the trucking company when a household water supply is low. The O&M Plan should include requirements for operator training, truck and storage disinfection, and sampling. Because water service would be highly dependent on trucks and roadways, contingency plans should be prepared for natural disaster situations where roadways are blocked or vehicles are unavailable due to maintenance. CDPH Food and Drug Branch licensing conditions require that periodic disinfection of the storage tanks and trucks be performed to control biological growth.

4.6.6 Environmental and Other Considerations

Under this alternative, households would theoretically gain access to a more abundant supply (pending hauling logistics). Water would meet all applicable drinking water standards prior to hauling, and such hauling would abide by the requirements of the Food and Drug Branch of CDPH.

The GSWC Barstow System uses chlorine to meet disinfection requirements and maintain a disinfectant residual throughout the distribution system. Similarly, water from GSWC will likely have a different mineral content than Hinkley residents' domestic wells. While the water will meet all applicable drinking water standards prior to hauling, some residents may not prefer the new taste. Additional community outreach may be necessary in order to increase awareness of this issue and gain community acceptance.

Based on average water use for the 25 properties, approximately 2,800 truck trips would be required annually. Operation of these trucks would increase the risk of traffic accidents and wear and damage on Hinkley roads. Because the storage tanks would require filling one to two times per week, properties with impacted wells would need to grant permission for the driver to come onto the property as needed.

Environmental impacts and public safety present a concern for all Hinkley residents. CEQA analysis may be required to address air emissions, truck traffic (e.g., safety, wear, and damage), and potential threats to desert tortoise and Mojave ground squirrel habitat. During operation, the presence of large hauling trucks will pose additional risks to Hinkley residents and wildlife.

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5. Comparative Analysis

The candidate alternatives described in Section 4 were compared with respect to 11 evaluation criteria described below in Section 5.1. A conceptual level capital and O&M cost analysis was also performed for each alternative based on providing replacement water to 25 properties. Community acceptance has not been evaluated at this time but will be evaluated through an outreach program to Hinkley residents conducted over the next several months.

5.1 Evaluation Criteria

The 11 criteria used to evaluate the replacement water supply alternatives included:

- Technical feasibility
- Quantity of water
- Quality of water
- Operations, maintenance, and replacement
- By-products and waste
- Legal, regulatory, and institutional complexity
- Monitoring, reporting, and compliance
- Environmental considerations
- Timing to implement
- Consistency with the remedy
- System redundancy (contingency plan).

The following sections briefly describe the criteria and how they were used to assess the replacement water supply alternatives.

5.1.1 Technical Feasibility

Technical feasibility assesses the potential for an alternative to be reasonably implemented based on the current state of knowledge. This criterion is important to evaluate the degree to which each alternative is practical and realistic. Key questions associated with technical feasibility include:

- Has the alternative (or similar variants) been previously employed for a similar purpose?
- Has the alternative been employed on a similar scale for this or other applications?
- Has the alternative been proven to be effective, and can it reliably meet the overall project goals or requirements?
- Are there any fundamental technical issues or other drawbacks that could limit implementation for this particular application or hinder the success of the alternative?

5.1.2 Quantity of Water

The ability to provide sufficient water is fundamental to any alternative. Key questions associated with the quantity of water include:

- Can the alternative provide sufficient quantities of replacement water to meet indoor domestic water needs for residents? (This study assumes a domestic water need of 660 gpd per household.)
- Can the alternative consistently and reliably supply water both currently and in the future (i.e., sustainable water supply)?
- Does the alternative conserve water? (i.e., What is the net yield of treated water as a percentage of the source?)

5.1.3 Quality of Water

The alternative should be able to meet the water quality requirements or objectives. Key questions associated with water quality include:

- Does the alternative meet the water quality regulatory requirements or performance objectives defined in the Order (hexavalent chromium concentrations below the 0.06 µg/L reporting limit)?
- Can the water quality objectives be met on a consistent and reliable basis?

5.1.4 Operations, Maintenance, and Replacement

Alternatives may differ widely in the level of oversight and ongoing maintenance necessary to ensure reliable operation of the system to achieve water quantity and quality goals. Key questions associated with operations, maintenance, and replacement include:

- How labor-intensive and complex are the operational components of the alternative?
- Are specialized operator skills and/or certifications required to operate and maintain the alternative?
- How will the operations and maintenance affect the Hinkley community and residents?
- Does the alternative require the use of consumables (e.g., chemicals, disposable pre-filters) that must be transported and/or stored?
- What is the replacement frequency for significant components (e.g., membranes, resin) that must be periodically replaced?

5.1.5 By-Products and Wastes

One or more of the alternatives may result in the generation of undesirable by-products or waste streams in conjunction with associated treatment processes (as applicable). Quantity and quality of residuals and the potential to form by-products must be considered in the evaluation process. Key questions associated with by-products and wastes include:

- What are the types of wastes (e.g., liquid, solid) generated for each alternative?
- What quantity of waste is generated?
- Is special handling of the waste required? (e.g., Is it classified as hazardous?)
- What is necessary to store, transport, and dispose of the wastes generated?
- What is the potential to create undesirable by-products as a result of this alternative?

5.1.6 Legal, Regulatory, and Institutional Complexity

Complexity of implementation, including number and complexity of required agency approvals and support, potential for regulatory scrutiny or delays, necessary agreements, water exchanges, permits, and future regulatory policies will all play a role in the construction and operation of an alternative. Key questions associated with legal, regulatory, and institutional complexity include:

- Which regulations and permits apply to the alternative, and how long will it take to obtain the necessary approvals to implement the alternative?
- Are any agreements with other entities necessary as part of this alternative?
- What is the complexity of regulatory agency involvement to ensure the success of this alternative?

5.1.7 Monitoring, Reporting, and Compliance

All alternatives will require water quality and operational monitoring, along with commensurate reports to regulatory agencies (e.g., the Water Board and CDPH). However, these requirements can vary significantly depending on the regulatory drivers. Key questions associated with monitoring, reporting, and compliance include:

- How much operational monitoring (if any) is required?
- Can monitoring and compliance requirements be fulfilled at a central location (entry point to the system) or at multiple sites (customer locations)?
- Is monitoring ongoing or intermittent?
- How much data can be collected automatically vs. manually?
- What are the regulatory agency reporting requirements?

5.1.8 Environmental Considerations

There are differing environmental considerations associated with the construction or operation of the various alternatives. These aspects may affect the practicality, desirability, and/or long-term feasibility of an alternative. Key questions associated with environmental considerations include:

- Are there potentially significant adverse environmental impacts, such as sensitive habitat encroachment?
- Is any mitigation expected to be required in conjunction with the alternative?
- Does the alternative necessitate recurring or routine truck traffic, with associated impacts on traffic and/or road condition and repair?
- Are there any noise or air quality impacts?
- Does the alternative increase potential hazards, such as chemicals releases (gas or liquid)?

5.1.9 Timing to Implement

Given the need to develop a replacement water supply in an expedient manner, the timing required to implement a strategy is an important consideration. Key questions associated with implementation timing include:

- How much time is anticipated for the following (as applicable): additional studies, design, permitting, construction, startup, commissioning, and turnover?
- Are there institutional considerations that might delay implementation (e.g., regulatory permitting, water purchase agreements, water right issues)?

5.1.10 Consistency with the Remedy

Some alternatives have the potential to influence the hexavalent chromium plume either positively (e.g., removes hexavalent chromium and/or improves plume containment) or negatively (e.g., pulls the plume, causing spreading or unpredicted migration). Key questions associated with assessing the consistency of any alternative with plume remediation include:

- Is plume containment improved or hindered?
- Does the alternative aid in remediation of the plume?

5.1.11 System Redundancy (Contingency Plan)

To ensure uninterrupted service, it is important for a replacement water supply to incorporate some element of redundancy, particularly for those alternatives that are more vulnerable to service disruptions (e.g., natural disaster that affects roads and/or pipeline conveyance, as applicable). Key questions associated with system redundancy include:

- How vulnerable is the water supply to potential service interruptions?
- Is there a viable contingency plan for providing service in the event of a disruption?
- What additional measures would need to be taken to increase the reliability of the supply?

5.2 Conceptual Level Capital and O&M Cost Opinions

A conceptual level cost analysis was performed for each alternative based on 25 properties receiving replacement water supply. The objective of the conceptual costs was to provide relative costs for comparing alternatives; conceptual costs are not intended for budgetary purposes. Conceptual cost opinions should be refined after the number of impacted wells has been confirmed and a replacement water supply alternative has been selected.

Capital and O&M cost opinions are based on available existing studies, recent projects with similar components, manufacturer's budgetary estimates, standard construction cost estimating manuals, and engineering judgment. Capital and O&M cost opinions for the replacement water alternatives are Class 5 conceptual level cost opinions, as defined by AACE. The expected accuracy range of these opinions is -20 to -50% on the low end and +30 to +100% on the high end. This level of engineering cost estimating is based on 0 to 2% project definition and generally made without detailed engineering data and site layouts, but is appropriate for preliminary evaluations and comparison of alternatives.

Appendix C contains cost information and other assumptions used in this study in the development of costs. Capital costs include materials of construction, installation, and contractor costs (overhead, profit, bonding, mobilization), and a scope of work contingency. A 25 percent factor for engineering design and construction administration is included for centralized treatment and centralized distribution. Operations and maintenance costs include labor/service, maintenance, power, materials (such as resin replacement), chemicals, residuals handling, lab analysis and spare parts. They do not include PG&E coordination or additional engineering studies.

All costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 9,268.

The relative economic feasibility of the alternatives was compared based on an equivalent present worth basis. The equivalent present worth cost for each alternative is the sum of total capital cost plus the estimated annual O&M cost. Present worth costs were developed for both a 5-year and 30-year study period with a discount rate of 0%.

5.3 Comparison of Alternatives

Table 6 presents a qualitative summary of each alternative as it relates to the criteria in Section 5.1 and the capital and O&M costs. Based on this matrix, each alternative was assigned a score for each criterion using a five-point system, depicted as a series of shaded circles. As shown in the criteria scoring key in Table 7, an open circle was used to represent the lowest score, with cumulative quarter-circle steps added to show progressively favorable scoring for the respective criterion. The highest scores are indicated by fully shaded circles. Note that the order in which the criteria are presented below does not reflect any particular degree of importance. Community input is planned to be incorporated into the evaluation prior to the development of the Plan. The alternative scores are presented in Table 8.

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Table 6 Qualitative Summary of Replacement Water Alternatives Based on 11 Evaluation Criteria and Cost Options

	Community Water Systems (Centralized Treatment and Distribution)			Point of Entry Whole-House Water Treatment				
Alternative	**Alternative 1: Connect to an Existing System**	**Alternative 2: Develop a New System (Mojave River Groundwater)**	**Alternative 3: Develop a New System (Utilize Local Water as Part of Remediation)**	**Alternative 4a: Whole-House Ion Exchange**	**Alternative 4b: Whole-House Reverse Osmosis**	**Alternative 4c: Whole-House Ion Exchange with Undersink RO**	**Alternative 5: Replace Impacted Wells with Deeper Wells**	**Alternative 6: Truck Water from a Community Water System**
Technical Feasibility	• Requires treatment and conveyance infrastructure (storage, pump stations etc) to implement • Utilizes effective, proven treatment processes	• Requires multiple treatment steps and conveyance infrastructure (storage, pump stations etc) to implement • Utilizes effective, proven treatment processes • May require additional treatment depending on water quality	• May be classified as a 97-005 impaired source • Requires multiple treatment steps and conveyance infrastructure (storage, pump stations etc) to implement • Utilizes effective, proven treatment processes • May require additional treatment depending on water quality	• Chromium removal with whole-house water treatment is relatively unprecedented • Pilot-testing indicates the technology can remove hexavalent chromium effectively • Not a one size fits all approach	• Chromium removal with whole-house water treatment is relatively unprecedented • Pilot-testing indicates the technology can remove hexavalent chromium effectively • Brine management may hinder success of the project • Not a one size fits all approach	• Chromium removal with whole-house water treatment is relatively unprecedented • Pilot-testing indicates the technology can remove hexavalent chromium effectively • Not a one size fits all approach	• Little information available on quantity/quality of water that would be provided • Chromium removal with whole-house water treatment is relatively unprecedented • Pilot-testing indicates the technology can remove hexavalent chromium • Not a one size fits all approach	• Utilizes effective, proven treatment processes • Traffic and coordination of water deliveries may hinder project success • CDPH indicated that this alternative is not a long-term strategy
Quantity of Water	• Properties with impacted wells would gain access to an abundant and reliable supply • GSWC has sufficient water production rights to supply water to the properties; replenishment may be required.	• Properties with impacted wells would gain access to an abundant and reliable supply • Replenishment may be required through Mojave Water Agency	• Remediation wells could support water need • Properties with impacted wells would gain access to an abundant and reliable supply • Replenishment may be required through Mojave Water Agency	• Quantity of water is limited by well capacity	• Quantity of water is limited by well capacity • Because of excessive brine volumes, water is not conserved	• Quantity of water is limited by well capacity	• Quantity of water is limited by hydrogeologic conditions and well capacity	• Properties with impacted wells would gain access to an abundant and reliable supply • Replenishment may be required • Water deliveries could be impacted by truck availability and road conditions
Quality of Water	• Additional treatment needed to meet hexavalent chromium reporting limit • Meets all primary drinking water standards; compliance with all secondary standards is not known • A long water age may negatively impact water quality in Hinkley (additional disinfectant may be needed)	• Wells can be drilled to target favorable water quality and treated to meet all applicable drinking water standards • Additional treatment needed to meet hexavalent chromium reporting limit	• Water quality will be dependent on the remediation wells • Additional treatment needed to meet hexavalent chromium reporting limit • Additional treatment may be required	• Capable of meeting hexavalent chromium reporting limit • Primary and secondary drinking water standards do not apply • Compliance with primary and secondary standards is dependent on initial well water quality • Minimal impact to homeowner plumbing	• Capable of meeting hexavalent chromium reporting limit • Primary and secondary drinking water standards do not apply • Compliance with primary and secondary standards is dependent on initial well water quality • Corrosive nature of water may impact household plumbing	• Capable of meeting hexavalent chromium reporting limit • Primary and secondary drinking water standards do not apply • Undersink RO provides a reliable source of drinking water • Compliance with primary and secondary standards is dependent on initial well water quality • Minimal impact to homeowner plumbing	• Water quality is unknown and highly variable • Ion exchange treatment will remove chromium and some other constituents • Primary and secondary drinking water standards do not apply • Compliance with primary and secondary standards is dependent on well water quality • Minimal impact to homeowner plumbing	• Additional treatment needed to meet hexavalent chromium reporting limit • Meets all primary drinking water standards; compliance with all secondary standards is not known • A long water age may negatively impact water quality in Hinkley • Compliance is based on point of delivery
Operations, Maintenance, and Replacement	• Operation of a CWS requires specialized operators and may include additional training • A large distribution system must be maintain for a few customers • IX resin is replaced as needed (one location only)	• Operation of a CWS requires specialized operators and may include additional training • A large distribution system must be maintain for a few customers • IX resin is replaced as needed (one location only)	• Operation of a CWS requires specialized operators and may include additional training • A large distribution system must be maintain for a few customers • IX resin is replaced as needed (one location only)	• System does not require specialized operators • Filters can be replaced on a pre-determined schedule; IX resin is replaced as needed (multiple locations) • Telemetry system can be used to communicate system warnings	• System does not require specialized operators • Membranes and filters can be replaced on a pre-determined schedule (multiple locations) • Telemetry system can be used to communicate system warnings • Brine may need to be hauled to a landfill	• System does not require specialized operators • Filters can be replaced on a pre-determined schedule; IX resin is replaced as needed (multiple locations) • Telemetry system can be used to communicate system warnings	• System does not require specialized operators • Filters can be replaced on a pre-determined schedule; IX resin is replaced as needed (multiple locations) • Telemetry system can be used to communicate system warnings	• Operation of a CWS requires specialized operators and may include additional training • Regular O&M required for trucks and storage tanks • IX resin is replaced as needed (one location only)
By-Products and Waste	• Process water from the IX resin forward flush which could be sent to the Barstow sewer • Spent IX resin requires proper disposal • Non-hazardous waste	• Treatment processes would produce residual streams requiring disposal (e.g., media filtration backwash, spent IX resin) • Residuals would stored and hauled off-site • Non-hazardous waste	• Treatment processes would produce residual streams requiring disposal (e.g., greensand filtration backwash, spent IX resin) • Residuals would stored and hauled off-site	• Process water from the IX resin forward flush which could be sent to septic systems • Spent IX resin requires proper disposal • Non-hazardous waste	• Would create a large brine stream that would need to be stored and hauled to a landfill if septic system disposal was not permitted • Non-hazardous waste	• Process water from the IX resin forward flush which could be sent to septic systems • Spent IX resin requires proper disposal • Non-hazardous waste • Undersink RO brine would discharge to septic systems	• Process water from the IX resin forward flush which could be sent to septic systems • Spent IX resin requires proper disposal • Non-hazardous waste • Assumes resin replacement will be infrequent	• Process water from the IX resin forward flush which could be sent to the Barstow sewer • Spent IX resin requires proper disposal • Non-hazardous waste

Table 6 Qualitative Summary of Replacement Water Alternatives Based on 11 Evaluation Criteria and Cost Options

	Community Water Systems (Centralized Treatment and Distribution)			Point of Entry Whole-House Water Treatment				
Alternative	**Alternative 1: Connect to an Existing System**	**Alternative 2: Develop a New System (Mojave River Groundwater)**	**Alternative 3: Develop a New System (Utilize Local Water as Part of Remediation)**	**Alternative 4a: Whole-House Ion Exchange**	**Alternative 4b: Whole-House Reverse Osmosis**	**Alternative 4c: Whole-House Ion Exchange with Undersink RO**	**Alternative 5: Replace Impacted Wells with Deeper Wells**	**Alternative 6: Truck Water from a Community Water System**
Legal, Regulatory, and Institutional Complexity	• Permitting and approvals required to move forward with this alternative (DWSP amendment, CEQA requirements could apply, MWA coordination) • Agreement with Golden State Water Company is necessary	• Extensive permitting requirements for treatment plant (DWSP application, CEQA requirements could apply, MWA coordination) • Formation of new CWS requires demonstration of technical, managerial, and financial capabilities	• Extensive permitting requirements for treatment plant (DWSP application, CEQA and 97-005 requirements could apply, MWA coordination) • Formation of new CWS requires demonstration of technical, managerial, and financial capabilities	• Point of entry certification may require coordination or approval • PG&E would report to the Water Board; no other agreements are necessary	• Point of entry certification may require coordination or approval • PG&E would report to the Water Board; no other agreements are necessary	• Point of entry certification may require coordination or approval • PG&E would report to the Water Board; no other agreements are necessary	• Point of entry certification may require coordination or approval • PG&E would report to the Water Board; no other agreements are necessary	• Permitting and approvals required to move forward with this alternative (DWSP amendment, CEQA requirements could apply, MWA coordination) • An agreement with Golden State Water Company is necessary
Monitoring, Reporting, and Compliance	• Would require increased monitoring and reporting for GSWC	• A monitoring plan will need to be developed and submitted to regulatory agencies • CDPH reporting requirements will need to be addressed for the new CWS	• A monitoring plan will need to be developed and submitted to regulatory agencies • CDPH reporting requirements will need to be addressed for the new CWS	• After the first year of testing, monitoring can be performed as needed to assess compliance • CDPH reporting requirements do not apply	• After the first year of testing, monitoring can be performed as needed to assess compliance • CDPH reporting requirements do not apply	• After the first year of testing, monitoring can be performed as needed to assess compliance • CDPH reporting requirements do not apply	• After the first year of testing, monitoring can be performed as needed to assess compliance • CDPH reporting requirements do not apply	• Monitoring also recommended, and potentially required, at household storage tanks • CDPH reporting requirements would likely not apply
Environmental Considerations	• Construction may pose a threat to protected species; mitigation plan may be required • Caustic chemicals may be used for treatment	• Construction may pose a threat to protected species; mitigation plan may be required • Caustic chemicals may be used for treatment	• Construction may pose a threat to protected species; mitigation plan may be required • Caustic chemicals may be used for treatment	• CEQA requirements do not apply and construction impact will be minimal	• Brine concentrate would require frequent transportation to off-site disposal facility • CEQA requirements do not apply and construction impact will be minimal	• CEQA requirements do not apply and construction impact will be minimal	• CEQA requirements do not apply and construction impact will be minimal	• Significant increase in traffic to and from households may increase accident risk • Traffic may pose a threat to protected species; mitigation plan may be required
Timing to Implement	• 2 – 4 years • Would require time to plan, coordinate, design, permit, and construct the IX treatment and distribution system	• 2 – 3 years • Would require time to plan, coordinate, design, permit, and construct the IX treatment and distribution system	• 3 – 5 years • Would require time to plan, coordinate, design, permit, and construct the IX treatment and distribution system	• <1 year • Relatively minimal time required to install system at households	• <1 year • Relatively minimal time required to install system at households	• <1 year • Relatively minimal time required to install system at households	• <1 year • Relatively minimal time required to install system at households	• 1 – 3 years • Would require time to plan, coordinate, design, permit, and construct the IX treatment system • Minimal time required to organize and begin water delivery
Consistency with the Remedy	• An outside water source in the west may aid in plume containment • Does not aid in remediation of the plume • Numerical flow modeling required to assess impact	• An outside water source in the west may aid in plume containment • Does not aid in remediation of the plume • Numerical flow modeling required to assess impact	• Aids in remediation of the plume • An outside water source in the west may aid in plume containment • Numerical flow modeling required to assess impact	• Impacts would be site-specific • Numerical flow modeling required to assess impact	• Impacts would be site-specific • Numerical flow modeling required to assess impact	• Impacts would be site-specific • Numerical flow modeling required to assess impact	• Impacts would be site-specific • Numerical flow modeling required to assess impact	• An outside water source in the west may aid in plume containment • Does not aid in remediation of the plume • Numerical flow modeling required to assess impact
System Redundancy (Contingency Plan)	• CWSs have built in contingencies to continue provision of potable water to its customers • Contingency plan is to haul water or provide bottled water	• CWSs have built in contingencies to continue provision of potable water to its customers • Contingency plan is to haul water or provide bottled water	• CWSs have built in contingencies to continue provision of potable water to its customers • Contingency plan is to haul water or provide bottled water	• Individual wells/treatment are more vulnerable to service disruptions; storage is provided to minimize impacts to residents • Contingency plan is to haul water or provide bottled water	• Individual wells/treatment are more vulnerable to service disruptions; storage is provided to minimize impacts to residents • Brine disposal is dependent on road/vehicle conditions • Contingency plan is to haul water or provide bottled water	• Individual wells/treatment are more vulnerable to service disruptions; storage is provided to minimize impacts to residents • Contingency plan is to haul water or provide bottled water	• Individual wells/treatment are more vulnerable to service disruptions; storage is provided to minimize impacts to residents • Contingency plan is to haul water or provide bottled water	• CWSs have built in contingencies to continue provision of potable water to its customers • Hauling water is highly dependent on the conditions of the roads and vehicles • Contingency plan is to haul water or provide bottled water
Cost Opinions (Millions)	• Capital = $19.3M • O&M = $0.16M/year • 5-year NPV = $20.1M • 30-year NPV = $24.1M	• Capital = $13.9M • O&M = $0.47M/year • 5-year NPV = $16.3M • 30-year NPV = $28.0M	• Capital = $11.6M • O&M = $0.44M/year • 5-year NPV = $13.8M • 30-year NPV = $24.8M	• Capital = $1.2M • O&M = $0.33M/year • 5-year NPV = $2.9M • 30-year NPV = $11.1M	• Capital = $1.9M • O&M = $3.49M/year • 5-year NPV = $19.4M • 30-year NPV = $106.6M	• Capital = $1.3M • O&M = $0.33M/year • 5-year NPV = $3.0M • 30-year NPV = $11.2M	• Capital = $1.9M • O&M = $0.10M/year • 5-year NPV = $2.4M • 30-year NPV = $4.9M	• Capital = $0.7M • O&M = $1.65M/year • 5-year NPV = $9.0M • 30-year NPV = $50.2M

Table 7 Evaluation Criteria Scoring Key

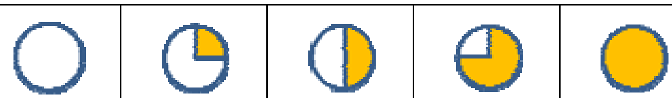
Scoring	Lower Score	Higher Score
Graphical Depiction		
Technical Feasibility	Implemented on a limited or smaller scale; effectiveness is questionable with numerous technical challenges limiting deployment.	Previously implemented in similar applications; demonstrated effectiveness on a comparable scale; minimal technical concerns.
Quantity of Water	Unreliable in terms of delivering the minimum required water supply on a regular basis.	Can supply water in excess of current demands on a consistent basis.
Quality of Water	Does not meet applicable drinking water standards and cannot reduce hexavalent chromium to levels below the reporting limit.	Meets all applicable drinking water standards and reduces hexavalent chromium to levels below the reporting limit.
Operations, Maintenance, and Replacement	A high degree of skilled labor is required; maintenance and/or replacement are required on a regular basis.	O&M is relatively simple and does not require specialized training or a high degree of oversight.
By-Products and Waste	Generates by-products and relatively large quantities of wastes; wastes are either classified as hazardous or cannot be disposed of easily or safely.	Minimal by-products or waste (if any) are generated; wastes are non-hazardous and can be disposed easily and safely.
Legal, Regulatory, and Institutional Complexity	Involves many regulations, agreements, and coordination through multiple agencies.	No agreements necessary; coordinated through one agency.
Monitoring, Reporting, and Compliance	Monitoring and reporting requirements are extensive, and data must be collected manually at multiple locations.	Requires minimal monitoring and reporting, and any necessary data can be collected automatically from a central location.
Environmental Considerations	Substantial environmental impacts that cannot be mitigated or that slow the permitting process.	Minimal environmental impacts; CEQA analysis not required.
Timing to Implement	Implementation is anticipated to be extensive and time-consuming.	Can be quickly implemented with minimal institutional complications.
Consistency with Remedy	Impedes remediation and/or pulls the plume, causing spreading and unpredicted migration.	Removes hexavalent chromium from the plume and helps to prevent or retard plume migration.
System Redundancy (Contingency Plan)	Susceptible to disruption by a variety of potential factors with limited contingency provisions.	Minimal potential for interruption of service.
Cost	High capital and O&M cost.	Low capital and O&M cost.
Community Acceptance	Probability of community support is low.	Probably of community acceptance is high.

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Table 8 Replacement Water Supply Alternative Evaluation Matrix

CRITERIA	Community Water Systems			Whole-House Water Treatment					Key Highlights
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b	Alt 4c	Alt 5	Alt 6	
	Connect to GSWC	Mojave River Groundwater	Local Groundwater	IX	RO	IX/ Undersink RO	Deeper Wells	Trucking Water	
Technical Feasibility	Medium	Medium	Medium-Low	Medium-High	Medium	Medium-High	Medium-High	Low	All alternatives are technically feasible; centralized systems would require extensive design and permitting (Alts 1, 2, 3, 6); Whole-house water treatment systems would be innovative but can meet the hexavalent chromium reporting limit (Alts 4a-c, 5); Brine management may present technical challenges (Alt 4b); CDPH indicated that hauling water is not a replacement water supply (Alt 6).
Quantity of Water	Medium-High	Medium-High	Medium-High	Medium	Medium-Low	Medium	Medium	Medium-Low	Alts 4a-c and 5 could be impacted by low production yields from domestic wells; Alternative 6 could be impacted by truck availability and road conditions; Central treatment alternatives may require flushing (Alternatives 1, 2, and 3).
Quality of Water	Medium-High	Medium-High	Medium-High	Medium	Medium	Medium-High	Medium	Medium	Alt 1 and 3 water quality is dependent on GSWC or remediation wells; Alt 2 wells can be targeted for favorable water quality; Central treatment and hauling water alternatives water quality may be compromised due to water age; Water corrosivity is a concern for Alt 4b; Alts 4a and 4c will produce similar or better water quality; Alt 5 water quality is unknown.
Operations, Maintenance, and Replacement	Medium	Medium	Medium	Medium-High	Medium	Medium-High	Medium-High	Medium-Low	Community water systems require certified operator(s); Alts 4a, 4c, and 5 may require frequent resin replacement or maintenance; Alt 4b produces waste that require excessive management. Telemetry systems can be installed on whole-house water treatment systems to communicate system warnings.
By-Products and Waste	High	Medium-High	Medium-High	Medium	Low	Medium	Medium-High	High	Alt 4b produces a large quantity of brine; residuals or wastes resulting from treatment in Barstow (Alts 1 and 6) could be sent to the central sewer system.
Legal, Regulatory, and Institutional Complexity	Medium-Low	Medium-Low	Low	Medium-High	Medium-High	Medium-High	Medium-High	Medium-Low	Alt 1,2, and 3 require DWSPs/amendments and CEQA requirements may apply; CEQA requirements may apply to Alt 6; Alt 3 may require 97-005 compliance; The Water Board would have jurisdiction over Alts 4a-c and 5.
Monitoring, Reporting, and Compliance	Medium-High	Low	Low	Medium-High	Medium-High	Medium-High	Medium-High	Medium-Low	All alternatives will require a monitoring plan; Alts 4a-c will require monitoring at multiple homes; Alts 1 and 6 require only an extension of current GSWC monitoring activities; Alts 4a-c and 5 monitoring and compliance would be coordinated through the Water Board; Alts 2 and 3 require new monitoring plans.
Environmental Considerations	Low	Medium-Low	Medium-Low	High	Low	High	Medium-High	Low	Distribution system construction (Alts 1, 2, 3) could impact desert tortoise/Mojave ground squirrel habitat; Hauling water/brine (Alts 4b and 6) will generate vehicle emissions and may pose a greater risk to road safety in Hinkley.
Timing to Implement	Medium-Low	Medium-Low	Low	High	High	High	High	Medium	Whole house treatment alternatives and deeper wells (Alts 4a-c and 5) could be implemented in less than one year; all other alternatives require design/permitting/construction/agreements that will add multiple years to implementation.
Consistency with the Remedy	Medium	Medium	High	Medium	Medium	Medium	Medium	Medium	Hydrogeologic conditions in the Hinkley Valley are variable. Outside water sources (Alts 1, 2, 3, 6) may aid in plume containment but only Alt 3 contributes to the remedy; Alts 4a-c and 5 impacts are site-specific and depend on hydrogeologic conditions.
System Redundancy (Contingency Plan)	High	High	High	Medium-High	Medium	Medium-High	Medium-High	Medium-Low	Community water systems have built in redundancy requirements; individual wells are more vulnerable to disruption in service; however, storage is provided to reduce impacts to residents; Hauling water and/or brine (Alts 4b and 6) is highly dependent on the condition of the roads and vehicles.
Cost (Capital and Annual O&M)	Medium-Low	Medium-Low	Medium-Low	High	Low	High	High	Low	Hauling water can be very costly (Alts. 4b and 6); Centralized treatment (Alts 1, 2, 3) has a high capital cost and, with only a few connections, a high O&M cost per connection.
Comparative Rating	Low	Medium-Low		Medium		Medium-High	High		**Note:** PG&E continues to conduct community outreach activities. Community input on the Feasibility Study garnered through these planned activities will be used to develop the recommended Plan.

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6. Conclusions

Six alternatives were evaluated for providing replacement water supply to properties with impacted wells in compliance with the Amended Cleanup and Abatement Order No. R6V 2011-00051A1. The number of impacted wells (domestic wells within one mile down-gradient or cross-gradient of the plume boundary defined by the current background concentrations [3.1 µg/L hexavalent chromium or 3.2 µg/L total chromium]) was assumed to be 25 for this study. The six alternatives were:

- Connect to an Existing Community Water System (Alternative 1);
- Develop a New Community Water System Utilizing Groundwater Near the Mojave River (Alternative 2);
- Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program (Alternative 3);
- Provide Point of Entry Whole-House Water Treatment (Alternatives 4a - 4c);
- Replace Impacted Wells with Deeper Wells (Alternative 5); and,
- Truck Water from a Community Water System (Alternative 6).

6.1 Key Findings

Based on research, data collected, and evaluations performed in the Feasibility Study, the following key findings were made with respect to a replacement water supply for properties with impacted wells in Hinkley:

Technical Feasibility – All six alternatives are technically able to meet the Order requirements of reducing hexavalent chromium concentrations to below the 0.06 µg/L reporting limit while meeting all applicable drinking water standards, in some cases with multiple treatment steps. The biggest technical challenges for the alternatives include brine management (Alternative 4b), designing a centralized treatment and distribution system (Alternatives 1, 2, and 3), and accommodating the variability in water quality throughout the Hinkley Valley.

Capital and O&M Cost – Costs are highly dependent on water quality and quantity of water produced. Alternatives that involve hauling water or brine (Alternatives 4b and 6) will be the most expensive over long periods of time. Because of high capital costs and economies of scale for operation, centralized treatment alternatives (Alternatives 1, 2, and 3) are more economical on a per household basis when large quantities of water are produced (i.e., many connections) and the capital investment can be spread over long periods of time. Point of entry whole house water treatment systems and drilling deeper wells (Alternative 4a, 4c, and 5) are most economical in the short-term and for fewer connections, pending favorable water quality.

Community Water Systems – Because hexavalent chromium has been detected and occurs naturally throughout the Mojave Desert Area, it was assumed that all community water systems would require treatment to bring hexavalent chromium concentrations below the reporting limit required in the Order. If developing a centralized treatment system (Alternative 1, 2, and 3), the water supply should be near the demand to reduce impacts and capital and O&M costs. In the case of Hinkley, using local groundwater from within the plume or near the Mojave River is preferred over connecting to Golden State Water Company (GSWC). This was also recommended in conversations with GSWC. Similarly, treating high quality water (low TDS and other constituents) will reduce impacts and costs significantly over a long period of time. A new community water system for residences dispersed over several square miles can increase environmental impacts and be costly on a per household basis. It would take approximately two to four years to plan, design, permit, construct and perform start-up testing for a new community water system with centralized treatment. If an MCL for hexavalent chromium is established above Hinkley background levels and PG&E is no longer supporting operating costs, residents may find using water from the community water system (CWS) cost prohibitive.

Whole-House Water Treatment – IX and RO whole-house water treatment systems (and other variations tested in the pilot study) were able to reduce hexavalent chromium concentrations to below the 0.06 µg/L reporting limit (Alternatives 4a, 4b, and 4c). IX may remove some additional constituents in the water, particularly nitrate, arsenic, and uranium. RO has a high probability of removing most dissolved constituents, but presents a series of technical challenges that must be vetted and addressed prior to implementation (quantity of water produced, corrosive nature of the produced water, and brine management). IX followed by undersink RO is an alternative for whole-house water treatment that is capable of removing hexavalent chromium for the whole house water and addressing aesthetic concerns such as total dissolved solids (TDS) at the taps. Pending permits and equipment procurement, point of entry water treatment systems could be implemented within one year of approval.

Deeper Wells – Replacing existing impacted wells with deeper wells (Alternative 6) has the potential of avoiding or reducing treatment, is relatively quick to implement, and would require fewer operation and maintenance considerations. Based on water quality data and hydrogeology, there are some areas within Hinkley that may be more conducive to deeper wells, and some areas where it is not feasible. Additional hydrogeological assessments and/or pilot wells may be needed to determine which properties have the highest potential for improved water quality as a result of a deeper well. Pending permits and water treatment system procurement (if needed), drilling deeper wells could be implemented within one year of approval.

Hauling Water – From a logistical and economic standpoint, hauling water (Alternative 6) may not be a feasible replacement water supply. Aside from the significant costs to haul water and the possibility that such a supply may be subject to intermittent unavailability, hauling water carries additional safety risks and environmental concerns associated with increased vehicle transport. Hauling water should be considered primarily as a contingency plan for ensuring uninterrupted water supply to properties with impacted wells. This is consistent with CDPH's position that hauling water is not a long-term water supply strategy.

Implementation Schedule – It may be difficult for any of the alternatives described to be implemented within 90 days of the acceptance of the Plan by the Water Board. The timing to implement any of the replacement water supply alternatives is highly dependent on the permitting and procurement process. Some alternatives can be implemented within a year (whole-house water treatment and drilling deeper wells) while others (centralized water treatment and distribution) would take considerably more time to plan, design, permit, construct, and start-up (two to four years).

Environmental Impacts – Some alternatives present more potential risks to the surrounding environment than others. Centralized treatment and delivery alternatives (Alternatives 1, 2, and 3) present more of a risk during construction (earth disturbances during construction and potential alteration of habitat for the desert tortoise and Mojave ground squirrel). Alternatives involving hauling water or brine (Alternatives 4b and 6) present more risks and safety concerns during operation and maintenance (truck traffic, vehicular emissions, dust control, road damage). Environmental impacts associated with IX whole-house water treatment and drilling deeper wells are expected to be minimal (Alternatives 4a, 4c, and 5).

Community Involvement – PG&E has been actively discussing and presenting the progress of their analysis of water alternatives to the Hinkley community and the Water Board since August 2011. Over the next few months, PG&E will expand these discussions to present their recommended options to residents with impacted wells. In April 2012, PG&E will being sending letters and placing phone calls to each of these residents/owners with impacted wells, with the goal of scheduling an in-person meeting to gather their input. Upon conclusion of this process, PG&E will summarize the input and provide the summary to the Water Board.

In addition to these steps, PG&E will be meeting with the members of the Community Advisory Committee, and the Independent Review Panel (IRP), to present the Feasibility Study, explain the contents and answer any questions. PG&E plans to fully engage the IRP manager as they gather the input on our recommended options and will discuss the Feasibility Study conclusions at the April 26, 2012 and May 24, 2012 Community Advisory Committee meetings.

Other Key Considerations – Additional considerations that should be factored into the selection of a replacement water supply include the following:

- Water quality and quantity are highly variable in the Hinkley area. Domestic well water quality is not regulated by CDPH, and water historically produced from some of the impacted wells may have concentrations of naturally occurring and/or anthropogenic constituents (e.g., arsenic, uranium, nitrate, TDS, sulfate, iron, manganese) that exceed primary and secondary drinking water standards. If a whole-house treatment alternative is selected, each well should be evaluated on a case-by-case basis to determine the best course of action.
- The Order requires a replacement water supply for indoor domestic water; however, this study assumed both indoor and outdoor demands would be served by the new supply (difficult to separate in an existing home). To reduce the quantity of water that requires treatment and give homeowners some additional autonomy over their respective water supplies, new hose bibs for outdoor use could be plumbed to the existing well. Reducing the quantity of water produced would also reduce resin replacements, hauling wastes, power consumption, and other key environmental factors.
- Each impacted well will have unique water quality and hydrogeologic characteristics, which will require consideration in the implementation of a whole-house treatment alternative.

6.2 Recommendations and Next Steps

PG&E recommends either installing deep wells or providing a point of entry treatment system for those down-gradient or cross-gradient households within the affected area with wells above the current background values. While each of the alternatives evaluated has its own set of advantages and disadvantages, two of the alternatives, a point of entry ion exchange treatment system (with small under-sink reverse osmosis units) or drilling deeper wells (where supported by the hydrogeology), are more practical from a time, efficiency, waste production, cost, permitting and overall implementation standpoint. A contingency plan applicable to the recommended approach is outlined below.

6.3 Contingency Plan for Meeting Standards and Replacing Supply

Currently, PG&E has been providing interim replacement water to impacted households, required as part of Ordering Paragraph 1. Additionally, PG&E continues its voluntary provision of bottled water to any resident who lives within 1 mile from the outermost boundary of the plume. During construction of any replacement water supply, properties with impacted wells will continue to receive interim replacement water. After the infrastructure has been constructed, tested, and commissioned, the replacement water supply should be tied into the household water supply.

Community water systems have their own safeguards and redundancies to ensure continued water service. Backup generators, wells, and treatment are standard and are required by Title 22 regulations for CWSs. Whole-house water treatment systems are more susceptible to temporary loss in water supply. Whole-house water treatment systems should be equipped with 2,000-gallon tanks to mitigate the potential for loss of water resulting from a well or treatment system failure.

The contingency plan for the evaluated alternatives is to haul water until the replacement water supply is back in service or a new replacement water supply is developed. Bottled water could also be provided on a short-term basis to meet domestic water needs until the replacement water is back in service.

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Appendix A

California Primary and Secondary Drinking Water Standards

Appendix A

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Table A: California Primary and Secondary Drinking Water Standards and Notification Levels

Constituents	Units	California Title 22 Standards
Primary Standards (MCLs)		
Inorganics		
Aluminum	mg/L	1
Antimony	mg/L	0.006
Arsenic	mg/L	0.010
Asbestos	mg/L	7 MFL[a]
Barium	mg/L	1
Beryllium	mg/L	0.004
Cadmium	mg/L	0.005
Chromium	mg/L	0.05
Copper	mg/L	1.3[b]
Cyanide	mg/L	0.15
Fluoride	mg/L	2
Lead	mg/L	0.05[c] 0.015[b]
Mercury	mg/L	0.002
Nickel	mg/L	0.1
Nitrate	mg/L	(as NO_3) 45
Nitrite (as N)	mg/L	1
Total Nitrate/Nitrite (as N)	mg/L	10
Perchlorate	µg/L	6
Silver	mgL	NA
Selenium	mg/L	0.05
Thallium	mg/L	0.002
Radionuclides		
Uranium	mg/L, pCi/L	(pCi/L) 10
Combined Radium – 226 + 228	pCi/L	5
Gross Alpha particle activity (excluding radon & uranium)	pCi/L	15
Gross Beta particle activity	millirem/yr	4
Strontium-90	pCi/L	8
Tritium	pCi/L	20,000
VOCS		
Benzene	µg/L	1
Carbon Tetrachloride	µg/L	0.5
1,2-Dichlorobenzene	µg/L	600
1,4-Dichlorobenzene	µg/L	5
1,1-Dichloroethane	µg/L	5
1,2-Dichloroethane	µg/L	0.5

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Constituents	Units	California Title 22 Standards
1,1-Dichloroethylene	µg/L	6
Dichloromethane	µg/L	5
1,3-Dichloropropene	µg/L	0.5
1,2-Dichloropropane	µg/L	5
1,3-Dichloropropane	µg/L	NA
Ethylbenzene	µg/L	300
Methyl-tert-butyl ether (MTBE)	µg/L	13
Monochlorobenzene	µg/L	70
Styrene	µg/L	100
1,1,2,2-Tetrachloroethane	µg/L	1
Tetrachloroethylene	µg/L	5
Toluene	µg/L	150
1,2,4 Trichlorobenzene	µg/L	5
1,1,1-Trichloroethane	µg/L	200
1,1,2-Trichloroethane	µg/L	NA
Trichloroethylene	µg/L	5
Trichlorofluoromethane	µg/L	150
1,1,2-Trichloro-1,2,2-Trifluoroethane	µg/L	1,200
Vinyl chloride	µg/L	0.5
Xylenes	µg/L	1,750
SOCs		
Alachlor	µg/L	2
Atrazine	µg/L	1
Bentazon	µg/L	18
Benzo(a) Anthracene	µg/L	10
Benzo(a)pyrene	µg/L	NA
Carbofuran	µg/L	18
Chlordane	µg/L	0.1
Dalapon	µg/L	200
Dibromochloropropane	µg/L	0.2
Di(2-ethylhexyl)adipate	µg/L	400
Di(2-ethylhexyl)phthalate	µg/L	4
Dinoseb	µg/L	7
Diquat	µg/L	20
Endothall	µg/L	100
Endrin	µg/L	2
Ethylene Dibromide	µg/L	0.05
Glyphosate	µg/L	700
Heptachlor	µg/L	0.01
Heptachlor Epoxide	µg/L	0.01

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Constituents	**Units**	**California Title 22 Standards**
Hexachlorobenzene	µg/L	1
Hexachlorocyclopentadiene	µg/L	50
Lindane	µg/L	0.2
Methoxychlor	µg/L	30
Molinate	µg/L	2
Oxamyl	µg/L	50
Pentachlorophenol	µg/L	1
Picloram	µg/L	500
Polychlorinated Biphenyls	µg/L	0.5
Simazine	µg/L	4
Thiobencarb	µg/L	70
Toxaphene	µg/L	3
2,3,7,8-TCDD (Dioxin)	pg/L	30
2,4,5-TP (Silvex)	µg/L	50
Disinfection Byproducts		
Total Trihalomethanes	µg/L	80
Haloacetic Acids (Five)	µg/L	60
Bromate	µg/L	10
Chlorite	mg/L	1
Acrylamide	mg/L	TT[d]
Epichlorohydrin	mg/L	TT[d]
Residual Disinfectant		
Chloramine (as Cl_2)	mg/L	4.0
Chlorine (as Cl_2)	mg/L	4.0
Chlorine Dioxide (as ClO_2)	mg/L	0.8
Microorganisms		
Total coliform	---	5%[e]
E.coli	Presence/ absence	MCL[f]
Cryptosporidium	---	TT
Giardia	---	TT
Secondary Standards (SMCLs)		
Aluminum	mg/L	0.2
Chloride	mg/L	250 / 500 / 600[g]
Color	Color units	15
Copper	mg/L	1.0
Foaming Agents (MBAS)	mg/L	0.5
Iron	mg/L	0.3
Manganese	mg/L	0.05
Methyl-*tert*-butyl ether (MTBE)	mg/L	0.005

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Constituents	Units	California Title 22 Standards
Odor—Threshold	TON	3
pH	SBU	6.5 – 8.5
Silver	mg/L	0.1
Sulfate	mg/L	250 / 500 / 600[g]
Specific Conductance	μS/cm	900 / 1,600 / 2,200[g]
Thiobencarb	mg/L	0.001
Total Dissolved Solids (TDS)	mgL	500 / 1,000 / 1,500[g]
Turbidity	NTU	5
Zinc	mg/L	5.0
Notification Levels		
Boron	mg/L	1
n-Butylbenzene	mg/L	0.26
Sec-Butylbenzene	mg/L	0.26
Tert-Butylbenzene	mg/L	0.26
Carbon Disulfide	mg/L	0.16
Chlorate	mg/L	0.8
2-Chlorotoluene	mg/L	0.14
4-Chlorotoluene	mg/L	0.14
Diazinon	mg/L	0.0012
Dichlorodifluoromethane (Freon 12)	mg/L	1
1,4-Dioxane	mg/L	0.001
Ethylene Glycol	mg/L	14
Formaldehyde	mg/L	0.1
HMX	mg/L	0.35
Isopropylbenzene	mg/L	0.77
Manganese	mg/L	0.50.5
Methyl Isobutyl Ketone (MIBK)	mg/L	0.12
Napthalene	mg/L	0.017
n-Nitrosodiethylamine (NDEA)	mg/L	0.00001
n- Nitrosodimethylamine (NDMA)	mg/L	0.00001
n-Nitrosodi-n-propylamine (NDPA)	mg/L	0.00001
Propachlor	mg/L	0.09
n-Propylbenzene	mg/L	0.26
RDX	mg/L	0.0003
Tertiary Butyl Alcohol (tBA)	mg/L	0.012
1,2,3-Trichloropropane (1,2,3-TCP)	mg/L	0.000005
1,2,4-Trimethylbenzene	mg/L	0.33
1,3,5-Trimethylbenzene	mg/L	0.33
2,4,6-Trinitrotoluene (TNT)	mg/L	0.001
Vanadium	mg/L	0.05

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Notes:
NA – not applicable (no standard)
a. MFL = million fibers per liter, with fiber length > 10 microns.
b. Regulatory Action Level; if system exceeds, it must take certain actions such as additional monitoring, corrosion control studies and treatment, and for lead, a public education program; replaces MCL.
c. The MCL for lead was rescinded with the adoption of the regulatory action level described in footnote b.
d. TT = treatment technique, because an MCL is not feasible.
e. No more than 5.0 percent samples total coliform-positive in a month.
f. A routine sample that is E.coli positive triggers repeat sample. If any repeat sample is total coliform, fecal coliform, or E.coli-positive the system has an acute MCL violation.
g. Recommended / Upper / Short Term

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Appendix B

Whole-House Water Treatment Pilot Test Report

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Pacific Gas and Electric Company

Whole-House Water Treatment Systems Pilot Study Report

Hinkley Compressor Station
Hinkley, California

Replacement Water Supply Alternatives

April 2012

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04/04/2012

Whole-House Water Treatment Systems Pilot Study Report

Replacement Water Supply Alternatives

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Our Ref.:
RC000699.0079

Date:
April 2012

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Acronyms and Abbreviations

µg/L	micrograms per liter
ANSI/NSF	American National Standards Institute/National Sanitation Foundation
CAC	Community Advisory Committee
CALTRANS	California Department of Transportation
CCPP	Calcium Carbonate Precipitation Potential
CCR	California Code of Regulations
CDPH	California Department of Public Health
CWET	California Waste Extraction Test
EBCT	empty bed contact time
EDR	electrodialysis reversal
Envirogen	Envirogen Technologies, Inc., Kingwood, TX
gpd	gallons per day
gpm	gallons per minute
ICPMS	inductively coupled plasma mass spectrometry
IX	ion exchange
Kinetico	Kinetico Water Systems, Newbury, Ohio
LSI	Langelier Saturation Index
MCL	maximum contaminant level
MRL	method reporting limit
NDMA	n-nitrosodimethylamine
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulation
NSF	National Science Foundation
OEHHA	Office of Environmental Health Hazard Assessment
PG&E	Pacific Gas and Electric Company
PHG	Public Health Goal
Pilot Study	Whole House Water Treatment Pilot Study Report
Purolite/ACWA	Purolite, Inc., Bala Cynwyd, PA and ACWA Clear, LLC, Bakersfield, CA

QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
ResinTech	ResinTech, Inc., West Berlin, NJ
RHB	Radiologic Health Branch (CDPH)
RO	Reverse Osmosis
SDWA	Safe Drinking Water Act
STLC	Soluble Threshold Limit Concentration
SVOC	Semi volatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TFC	Thin Film Composite
TIC	Tentatively Identified Compound
TTLC	Total Threshold Limit Concentration
USEPA	U.S. Environmental Protection Agency
USDOT	U.S. Department of Transportation
VOC	volatile organic compound
Water Board	Lahontan Regional Water Quality Control Board

1. Introduction

On October 11, 2011, the California Regional Water Quality Control Board, Lahontan County (Water Board) issued an Amended Cleanup and Abatement Order No. R6V-2011-0005A1 (the Order) to Pacific Gas and Electric Company (PG&E) requiring PG&E to provide interim and replacement water supplies to the residents of Hinkley, California, whose wells were impacted as a result of the discharge of untreated cooling water containing hexavalent chromium to unlined ponds at the Hinkley Compressor Station. The Order consists of four provisions relating to: 1) an interim replacement water supply, 2) a replacement water supply, 3) the determination of impacted wells, and 4) the funding of an independent consultant to advise the community of Hinkley on matters subject to regulation by the Water Board. Whole-house water treatment was identified as one of the methods to be evaluated in the feasibility study to provide replacement water for indoor domestic uses for impacted wells in the affected area, as defined by the Order, in accordance with Ordering Provision 2c. On behalf of PG&E, ARCADIS conducted a Whole-House Water Treatment Pilot Study (Pilot Study) in support of the Feasibility Study and in compliance with Ordering Provision 2c.

1.1 Background

The Order stipulated that, for the purposes of evaluating the performance of the water treatment systems in meeting the PHG, the levels of hexavalent chromium in the treated groundwater supply must be below the analytical laboratory method reporting limit of 0.06 µg/L (the method reporting limit [MRL] is slightly higher than the Public Health Goal (PHG) due to analytical method limitations). The Order, as written, also requires that the replacement water must meet all California primary and secondary drinking water standards. However, the latter provision would not appear applicable to the situation where PG&E provides a replacement water supply where hexavalent chromium has been removed from well water, leaving only constituents that are not present as a result of PG&E's actions.

As a result, the primary focus of the Pilot Study was to demonstrate whole-house treatment alternatives that will provide water with hexavalent chromium levels below 0.06 µg/L while meeting all applicable drinking water standards.[1]

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[1] California primary and secondary drinking water standards do not apply to private domestic wells; primary drinking water standards are mandatory and enforceable in public water systems serving 15 or more connections, while secondary standards are not mandatory or enforceable but were developed as guidelines to assist public water systems in managing aesthetic considerations such as taste, color, and odor.

A Whole-House Water Treatment Pilot Study Test Plan (Test Plan) was submitted to the Lahontan Regional Water Quality Control Board (Water Board) on September 27, 2011. The Test Plan described proposed procedures to evaluate the feasibility of using commercially available whole-house water treatment systems to reduce chromium to very low levels. There are little data available regarding the ability and efficiency of these systems to remove levels of chromium in the range of less than 10 µg/L, as treatment and reporting efforts for water supply have been driven by the State of California (50 µg/L) and Federal (100 µg/L) maximum contaminant levels (MCL) for chromium. An MCL for hexavalent chromium has not been established. An MCL for hexavalent chromium is under development (CDPH, 2012[2]).

ARCADIS performed a literature review, desktop assessment, and engaged in discussions with more than 24 vendors regarding product availability and applicability. However, only a few of the vendors claimed to have treatment systems that were capable of removing hexavalent chromium below the analytical laboratory method reporting limit of 0.06 µg/L as defined in the Order. Based on this review, the Test Plan recommended testing three treatment systems.

A summary of the Test Plan was presented to the Community Advisory Committee (CAC) and Water Board on November 2, 2011. Comments from the Water Board were received on December 16, 2012. The Test Plan was revised to address Water Board comments (Attachment A) and the ongoing pilot testing incorporated key comments.

1.2 Pilot Test Objectives

The pilot study objectives included the following:

- Assess the ability of whole-house water treatment systems to safely, effectively, and reliably remove hexavalent chromium from groundwater to very low levels.
- Assess the operability and durability of these systems to perform under extreme conditions. Heat, pressure, and water demand will vary from house to house.

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2 CDPH, 2012. "Fact Sheet: Chromium-6 in Drinking Water," March 30, 2012. Available at: http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Chromium6-/Cr6FactSheet-03-30-2012.pdfhttp://www.cdph.ca.gov/certlic/drinkingwater/-Documents/Chromium6/Cr6FactSheet-03-30-2012.pdf

- Identify any potential secondary water quality issues associated with leaching of by-products or other materials from the treatment systems, which may affect the treated water quality.
- Confirm the design and operating criteria for the water treatment systems, including quantities and qualities of wastes that would be generated and require proper disposal.

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2. Pilot Study Program

The following sections provide Pilot Study details including treatment system selection, test site selection, treatment system operations, and the monitoring program implemented to evaluate system performance.

2.1 Treatment System Selection

Three whole-house water treatment systems provided by three vendors were selected for testing following an extensive review of commercially available systems with the potential to treat hexavalent chromium to the low levels required by the Order. The whole-house water treatment systems selected for pilot testing included: an ion exchange (IX) system, a reverse osmosis (RO) system, and a hybrid RO – IX system. These technologies and vendors were selected based on the following criteria:

- Technologies that had the most promise to reliably remove hexavalent chromium to low concentrations (i.e., less than 1 µg/L).
- Technologies that were most likely to meet the CDPH requirements for whole-house water treatment systems. (e.g., Technologies that required storage of hazardous chemicals were excluded.)
- Vendors that offered experience and capabilities to provide turnkey services in Southern California.

2.2 Regulatory Requirements for Drinking Water Supply

Through the Safe Drinking Water Act (SDWA), the USEPA has established National Primary Drinking Water Regulations (NPDWRs) for chemical and biological constituents in water. NPDWRs are standards that apply to public water systems (PWSs), which are defined by the SDWA as "…system[s] for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals (USEPA, 2012)."

Neither the USEPA nor the State of California regulates water quality in private domestic wells; therefore, the NPDWRs do not directly apply The Order, as written, also requires that the replacement water must meet all California primary and secondary drinking water standards. However, the latter provision would not appear applicable to the situation where PG&E provides a replacement water supply where hexavalent chromium has been removed from well water, leaving only constituents that are not present as a result of PG&E's actions.

As a result, the primary focus of the Pilot Study was to demonstrate whole-house treatment alternatives that will provide water with hexavalent chromium levels below 0.06 µg/L while meeting all applicable drinking water standards.[3]

The CDPH compliance requirements for whole-house water treatment systems are listed under Title 22, Division 4, Chapter 15, Article 2.5, Section 64417. To comply with CDPH requirements for whole-house water treatment systems, the following requirements must be met:

- Equipment used should conform to the American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61.
- Chemicals used in the treatment process should be ANSI/NSF Standard 60 certified for potable water use.
- RO water treatment systems used should be ANSI/NSF Standard 58 device certified prior to residential installation.
- IX water treatment systems should be ANSI/NSF Standard 53 certified prior to residential installation.

Due to the absence of an MCL for hexavalent chromium (the standard by which CDPH and NSF/ANSI certify device performance), pilot testing was designed to provide a basis for some form of CDPH approval of the whole-house water treatment systems for removal of hexavalent chromium to very low concentrations. This approval process is in a regulatory gray area and will need to be supported by the Water Board to proceed with whole-house water treatment as a solution.

[3] California primary and secondary drinking water standards do not apply to private domestic wells; primary drinking water standards are mandatory and enforceable in public water systems serving 15 or more connections, while secondary standards are not mandatory or enforceable but were developed as guidelines to assist public water systems in managing aesthetic considerations such as taste, color, and odor.

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Pilot System Layout

Pacific Gas and Electric Company
Hinkley, California

Project Number
RC000699.0074

Date
April 2012

Figure
1

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2.3 Test Site Selection

Pilot testing was conducted using groundwater from an active agricultural well (G-5R) located on PG&E property near the intersection of Alcudia Road and Summerset Road (Figure 1). While actual groundwater quality for a given domestic well in Hinkley may vary, the well G-5R was selected for the pilot study for several reasons:

- The test site is secure. Pilot study treatment units are costly and labor-intensive to set up, and a secure site was selected to avoid vandalism.
- The test site is accessible for public tours. Siting the pilot work at an operating domestic well would have likely precluded (without significant intrusion on the domestic well owner/resident) conducting such tours.
- The water quality is within the range that has been observed in the area.
- It is vital to test a relatively "challenging" water quality (in terms of total dissolved solids (TDS], nitrate, and sulfate) to ensure breakthrough of chromium in the IX technologies within the time frame of the Order. Observing breakthrough is necessary to project the frequency of required maintenance and to test the treatment system's ability to treat challenging water quality.

Based on the limited domestic well sampling and monitoring data, the water quality in the Hinkley area can vary significantly from well to well. Because the pilot study has been conducted at only one test well and for limited duration (due to the time requirements of the Order), the results and conclusions should be carefully extrapolated to other well sites. Design and operation of the whole-house water treatment system should be based on individual domestic well water quality and site-specific conditions.

2.4 Treatment System Operations

Pilot testing began in early November 2011 and was conducted for 3 months in accordance with the Test Plan submitted to the Water Board in September 2011. Testing conditions were modified upon receipt of Water Board comments in December 2011. Pilot testing continued under the revised test conditions for more than 30 days as required by the implementation schedule specified by the Water Board. In February 2012, PG&E elected to continue operating the pilot systems to provide additional data and to facilitate additional community outreach opportunities.

Based on the preliminary results of pilot testing for the IX system using Type 1 strong base anion exchange resin; nitrate selective resin pilot testing was added to the original Test Plan, extending the pilot testing of the IX system by an additional month.

The average daily demand for Hinkley was estimated at 660 gallons per day (gpd) (ARCADIS 2012, Replacement Water Supply Feasibility Study Report). To meet the average daily demand, the whole-house water treatment systems were operated at flow rates ranging from 1.4 to 8.5 gallons per minute (gpm). The water treatment units were operated for extended periods each day to simulate the effects of running the systems for periods longer than the 1- to 3-month pilot study test period. For example, the systems were generally operated for 6 to 8 hours per day, whereas the residential system would typically be operated for 2 to 4 hours per day to meet the daily demand. This was done to rigorously test system performance and achieve concentration breakthrough, signaling time for maintenance and/or resin change-outs.

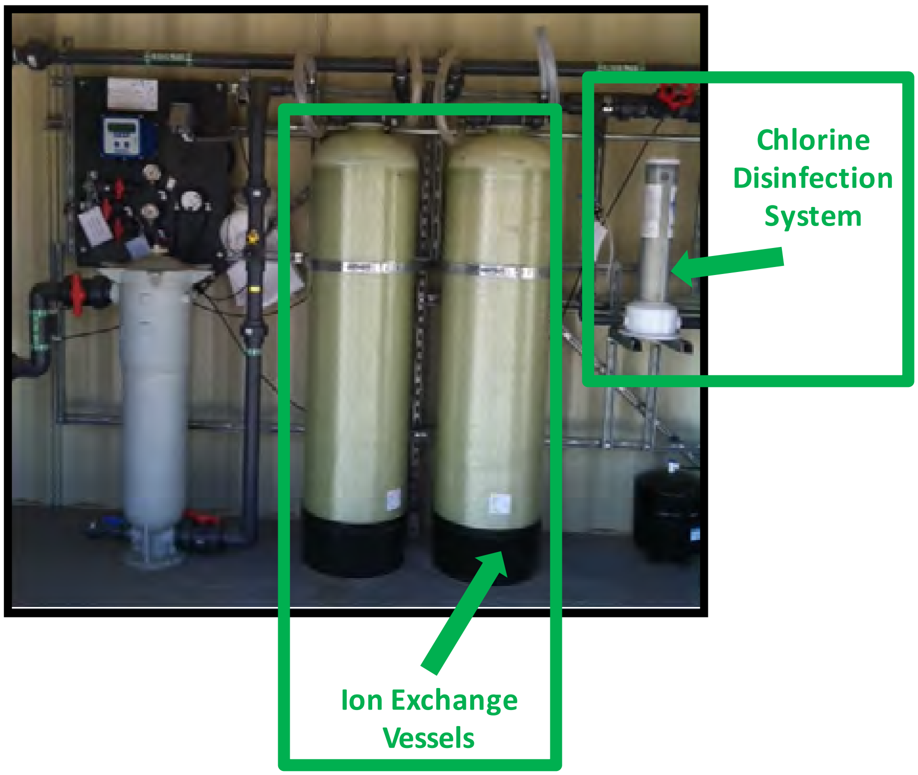
The following sections describe each of the whole-house water treatment systems tested to meet pilot study objectives.

2.4.1 Ion Exchange System

- Type 1 Strong Base Anion Exchange Resin

  Envirogen Technologies, Inc. (Kingwood, TX) (Envirogen) provided the IX treatment system (Model # A-0142, utilizing FlexSorb™) for pilot testing shown in the figure below.

Ion Exchange System



This IX treatment system is configured to operate in a lead-lag mode, and it is capable of treating flows of up to 8 gpm. The system has a fabric pre-filter of 10 micron pore size prior to the unit for particulate removal. The selected resin, SBG1 manufactured by ResinTech, Inc. (West Berlin, NJ), is a high-capacity, shock-resistant gel, Type 1, strong base anion exchange resin supplied in the chloride or hydroxide form. A chlorine disinfection unit is provided to disinfect water prior to residential application. A service indicator light comes on to notify the homeowner to place a service call for replacement of IX vessels.

The IX system was operated at a 7.5 gpm flow rate for 6 hours each day, producing 2,700 gpd (equivalent to approximately four days of average household water use). Pilot testing of the IX treatment unit was conducted for 15 weeks.

ResinTech SBG1 is NSF/ANSI 61 certified. Envirogen's system is constructed with NSF 61 certified materials. Attachment A provides system details for Envirogen's whole-house water treatment system.

- Nitrate Selective Strong Base Anion Exchange Resin

  Preliminary pilot testing results indicated significant impact on the IX resin operational run length due to nitrate peaking and/or breakthrough. Nitrate peaking is a phenomenon in which nitrate removed by the IX resin at the beginning and during the middle of a run is released at the end of the run because another anion (e.g., sulfate) is preferred by the resin over nitrate. This can result in effluent nitrate greater than the influent concentrations for a short period of time.

  Given the potential for nitrate peaking and the potential for domestic well water in the Hinkley Area to contain concentrations of nitrate near or above the primary MCL (ARCADIS 2012, Replacement Water Supply Feasibility Study Report), a nitrate-selective resin was subsequently tested. The objectives of this test were: 1) to address nitrate peaking in strong base anion exchange resin, 2) to optimize operation of the IX system for groundwater with nitrate concentrations above the primary MCL, and 3) to confirm that the treated water could meet the regulatory standard for nitrate, if necessary.

  A nitrate-selective resin was operated at a flow rate of 7.5 gpm for six hours per day using the Envirogen IX system. The system was operated for 4 weeks. The selected resin, SIR-100-HP manufactured by ResinTech, Inc. (West Berlin, NJ), is a high-capacity, nitrate-selective strong base anion exchange resin supplied in the chloride form.

  ResinTech SIR-100-HP is NSF/ANSI 61 certified.

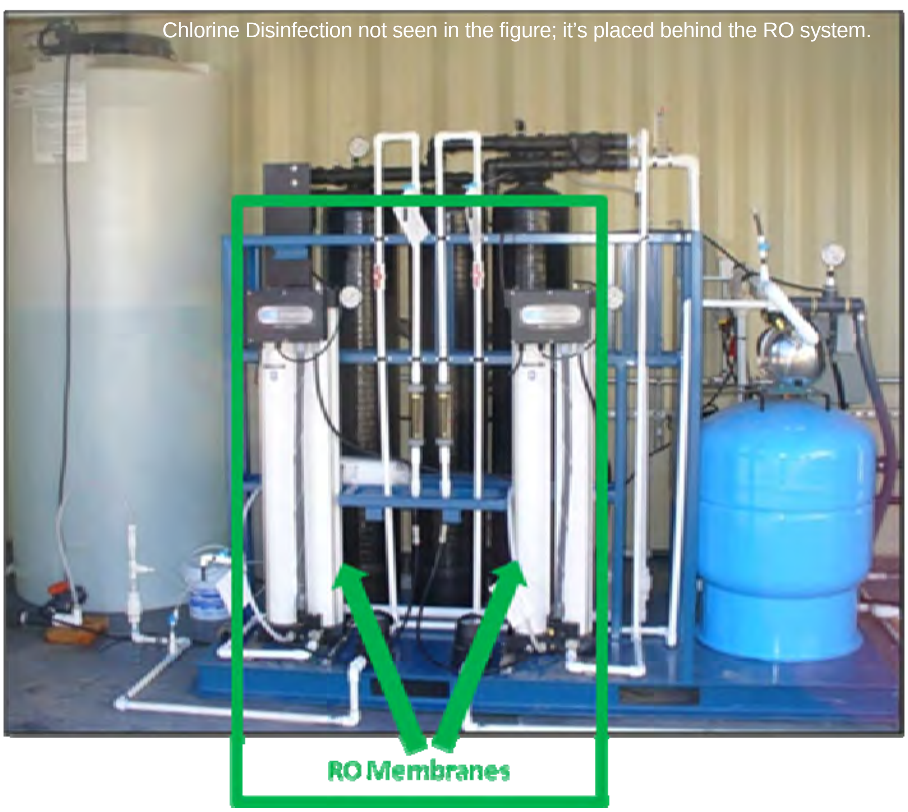
2.4.2 Reverse Osmosis System

Both a two-pass and a two-stage RO system were tested. For the two-pass system, the groundwater pumped from the well was first softened. Water from the softener was pumped through the first RO pass. Permeate from the first pass was collected and pumped through a second RO pass. A chlorine disinfection unit was provided to disinfect water treated with RO prior to residential application. Two-pass RO generated significant brine volumes. To reduce the volume of brine generated, the two-pass system was modified to operate as a two-stage RO system. In the two-stage system, water from the softener was passed through the first RO stage. RO brine from the first stage was collected in a holding tank and pumped through the second RO stage. Permeate from the second stage was blended with the first stage permeate. The blended permeates (or treated water) were disinfected using chlorine and stabilized using calcite. In addition to the RO brine streams from the RO, the softener also generates brine that needs to be disposed. The softener produces 102 gallons of softener brine waste per 572 gallons of processed water (unless there are modifications to the metering disc). The system is set for the inlet hardness. Depending on the individual domestic well hardness concentrations, the system can be set to maximize the efficiency of salt usage.

Two-Pass RO

Kinetico Water Systems (Newbury, Ohio) (Kinetico) provided a two-pass RO system for pilot testing shown below.

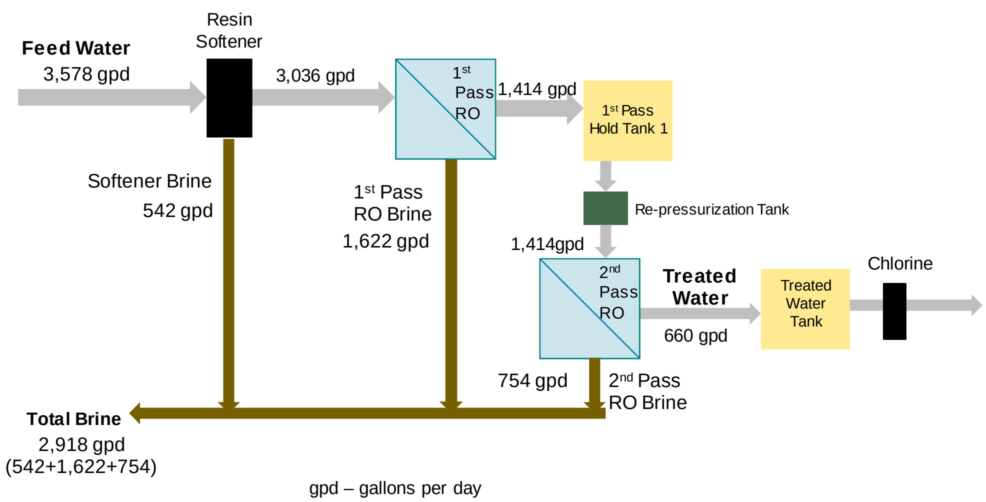
Two-Pass Reverse Osmosis



The RO membranes pilot tested were 4-inch diameter and 40-inch long thin film composite (TFC) membranes that are typically used in whole-house water treatment systems. The Dow-Filmtec RO membranes used in conjunction with the Kinetico system were provided by The Dow Chemical Company (Midland, Michigan). The RO treated water was stabilized by passing the treated water through a bed of calcite medium (to help manage leaching of undesired metals from domestic piping). A carbon pre-filter and softener were installed prior to the RO to remove particulate matter and calcium, respectively.

The diagram below depicts the two-pass RO system operation.

Two-Pass Reverse Osmosis



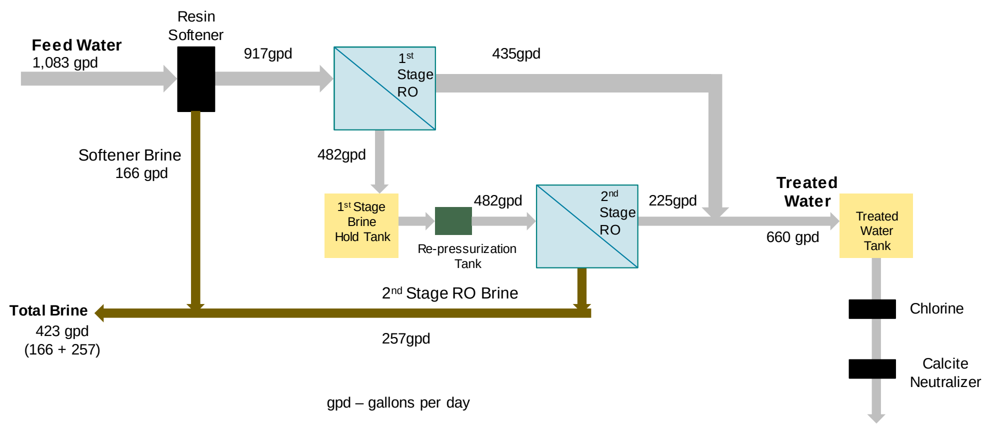
The two-pass RO system was operated for 8 hours each day, producing 660 gpd for a period of 15 weeks.

The RO membranes were NSF 61 certified. The Kinetico's Mach 2060 S (softener), Dechlorinator 1060 (carbon filter) and Neutralizer 1100 (calcite filter) that were pilot tested were NSF 61 certified. Though the RO membranes were NSF certified; Kinetico's commercial grade RO system (TX 1440) does not have NSF 61 certification. The RO system should be NSF 61 certified prior to deployment for residential application for drinking water.

Two-Stage RO

A carbon pre-filter and softener were installed prior to the two-stage RO to remove particulate matter and calcium, respectively. The following diagram depicts a two-stage RO configuration and operation.

Two-Stage Reverse Osmosis



The two-stage RO system was operated for 8 hours each day, producing at total combined treated water of 1,344 gpd for a period of 4 weeks. This change from two-pass to two-stage RO reduced the brine generation by a significant quantity.

Attachment A provides system details for the Kinetico's whole-house water treatment system(s).

2.4.3 Hybrid RO/IX or IX/RO System

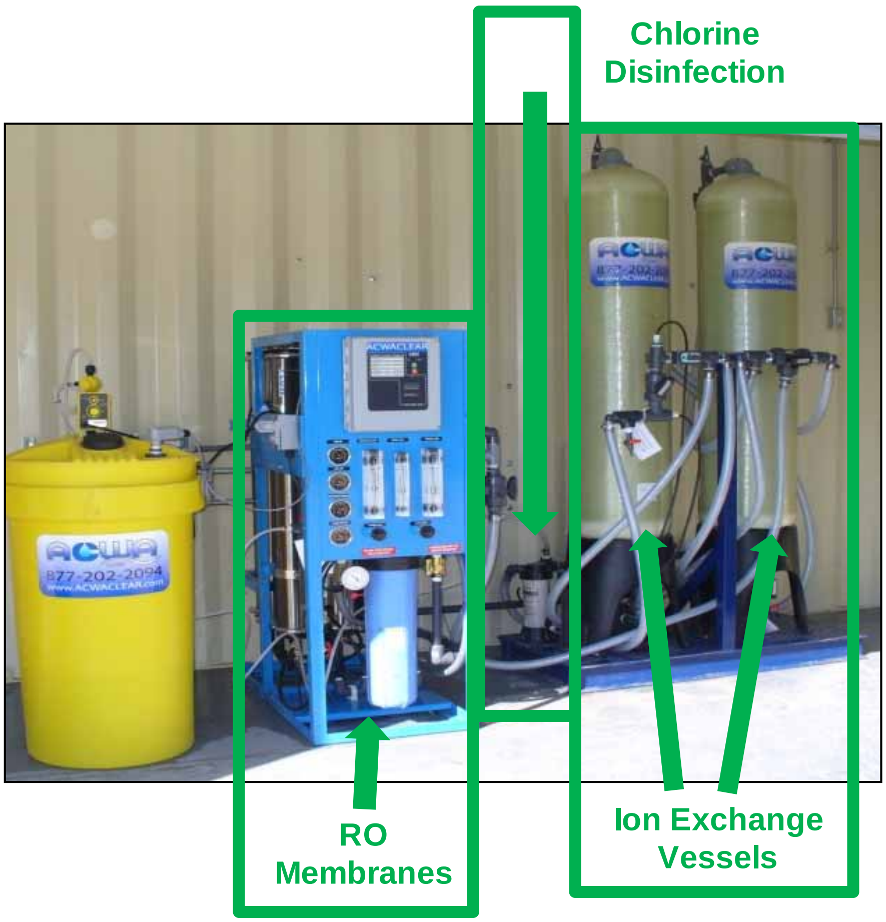
Whole-House Hybrid Reverse Osmosis and Ion Exchange System

Purolite, Inc. (Bala Cynwyd, PA) and ACWA Clear, LLC (Bakersfield, CA) (Purolite/ACWA) provided a hybrid RO – IX system for pilot testing.

A fabric pre-filter of 10 micron pore size was installed to remove particulate matter prior to RO – IX treatment. The RO unit was a single-pass RO (L-84A); the IX system was Purolite's A600E/9149 with A600 HC resin. The RO membranes pilot tested were 4-inch diameter and 40-inch long TFC membranes typically used in whole-house water treatment systems. The supplier of the RO membranes for Purolite/ACWA system was

Applied Membranes, Incorporated (Vista, CA). A600 HC is a clear gel Type 1 strong base anion exchange resin supplied in the chloride form as spherical beads. A chlorine disinfection unit was provided to disinfect water treated with IX system prior to residential application.

Hybrid Reverse Osmosis – Ion Exchange System



The Hybrid RO-IX system was operated at 8.5 gpm flow rate for 6 hours each day, producing 3,060 gpd for a period of 15 weeks.

The RO-IX system was initially operated at 58 percent recovery, which was then optimized to 80 percent recovery to reduce the volumes of RO brine generated in the process. The system is equipped with flow-adjustment valves, settings of which for recirculation flow and concentrate flow can be modified to achieve the desired system recovery. This change reduced RO brine generation by up to 50 percent when compared to the original pilot configuration.

The RO membranes were NSF 61 certified. Purolite's A600E/9149 resin was NSF/ANSI 61 certified. ACWA's proposed whole-house water treatment system was NSF 61 certified.

Attachment A provides system details for the Purolite/ACWA's whole-house water treatment system.

Whole-House Ion Exchange System and Undersink RO

Early observations underscored (as expected) that IX does not remove TDS, chloride, and sulfate constituents regulated by secondary MCLs due to their impact on the aesthetic quality of drinking water.

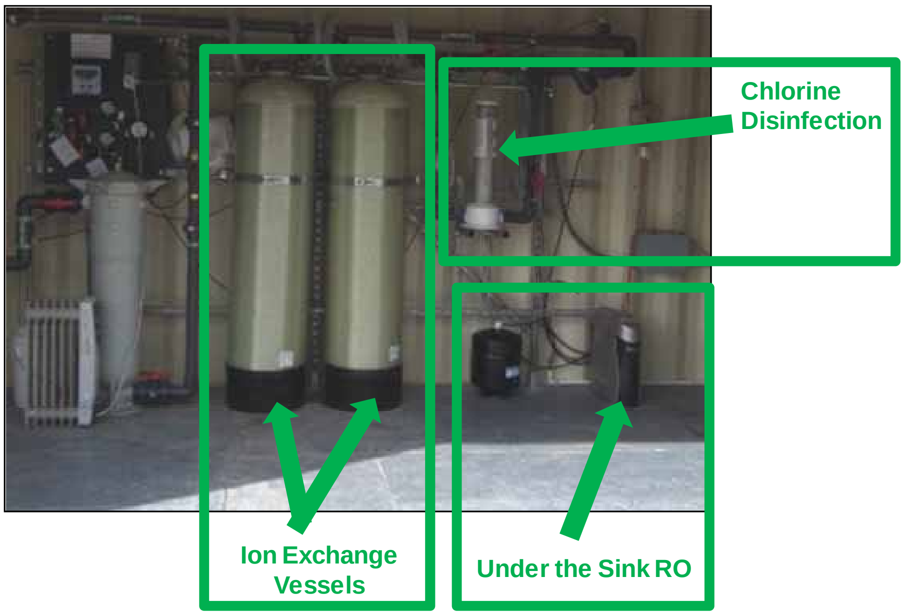
As a possible additional step, if deemed necessary, undersink RO treatment was added to the whole-house IX treatment system and tested to determine the efficacy of the combined treatment system to meet the California primary and secondary drinking water standards. The figure on next page shows an image of the IX system followed by an undersink RO system.

Such a configuration would treat the whole-house water supply for hexavalent chromium and the kitchen tap (or other designated taps inside the homes) for the remaining primary or secondary water standards. The undersink RO system produces approximately 40 gpd of treated water and 120 gpd of RO brine; making it 25 percent efficient. Typically, the small volume of RO brine from the undersink treatment systems is discharged to the septic system. Hence, pilot testing also evaluated the quality of the brine generated from the undersink RO treatment.

The undersink RO system was operated at 40 gpd for a period of 4 weeks.

The undersink RO system (K-5 drinking water station) provided by Kinetico is NSF-61 certified.

Whole-House Ion Exchange System and Undersink RO



2.5 Water Quality Monitoring

Water quality and operating data were collected from the test well and treatment systems throughout the pilot testing following the procedures outlined in the *Whole House Water Treatment Pilot Study – Test Plan* (Attachment A). Table 1 provides an overview of the parameters monitored, methods used, MRLs, and primary and secondary drinking water standards. The field and laboratory water quality monitoring parameters that were used to evaluate the treatment systems performance are shown in Table 2.

The figure below shows an image of the sampling and monitoring locations for the pilot study under the initial Pilot Study Test Plan.

The Modified system configuration and sampling locations based on preliminary pilot test results and Water Board comments is shown in the figure thereafter.

Table 1 Water Quality Monitoring Plan Overview

Parameter	Unit	MCL/ SMCL[1]	Method	MRL
Alkalinity, Total	mg/L as $CaCO_3$	-	Field	2
Specific Conductance	µS/cm	900[2]	Field	4
Hardness, Total	mg/L as $CaCO_3$	-	Field	10
pH	pH units	6.5 – 8.5[2]	Field	0.01
Total Dissolved Solids	mg/L	500[2]	SM 2540C	10
Total Solids, Suspended	mg/L	-	SM 2540D	10
Total Organic Carbon	mg/L	-	5310C	0.25
Turbidity	NTU	1	Field	0.05
Chloride	mg/L	250[2]	USEPA 300.0	1
Nitrate-N	mg/L	10	USEPA 353.2	0.1
Sulfate	mg/L	250[2]	USEPA 300.0	0.1
Aluminum	µg/L	1,000	USEPA 200.7	2
Arsenic, Total	µg/L	6	USEPA 200.8	2
Barium	µg/L	1,000	USEPA 200.8	2
Boron	µg/L	-	USEPA 200.8	5
Calcium	mg/L	-	USEPA 200.7	1
Chromium	µg/L	50	USEPA 200.8	0.1
Iron	mg/L	0.3[2]	USEPA 200.7	0.05
Magnesium	mg/L	-	USEPA 200.8	0.1
Manganese	µg/L	0.5[2]	USEPA 200.8	2
Silica, Total	mg/L	-	USEPA 200.7	0.5
Strontium	µg/L	-	USEPA 200.8	0.3
Uranium	µg/L	30	USEPA 200.8	1
Gross Alpha	pCi/L	15	7110B	3
Gross Beta	pCi/L	4	7110B	4
Radium-226	pCi/L	combined	7500 Ra B	1
Radium-228	pCi/L	< 5pCi/L	7500 Ra D	1
Radon-222	pCi/L	-	7500 Rn B	25
VOCs and TICs	µg/L	- [4]	USEPA 524.2	- [5]
BNA SVOCs	µg/L	- [4]	USEPA 526 and 525.2Ext	- [5]

Parameter	Unit	MCL/ SMCL[1]	Method	MRL
Nitrosamines	µg/L	- [4]	USEPA 521	- [5]
Aldehydes/Ketones	µg/L	- [4]	USEPA 556	- [5]
Heterotrophic Plate Count	MPN/mL	< 500	SimPlate	2
Escherichia coli	MPN/100 mL	zero	Quanti-Tray/2000	1
Total Coliform	MPN/100 mL	*less than 5.0% samples total coliform-positive in a month*	Quanti-Tray/2000	1

Notes:
1 MCLs and SMCLs are from CDPH's Titles 17 and 22 California Code of Regulations for Drinking Water.
2 SMCL for the listed contaminant.
3 Action level.
4 There are different MRL and MCL for various compounds; there are reported along with results.

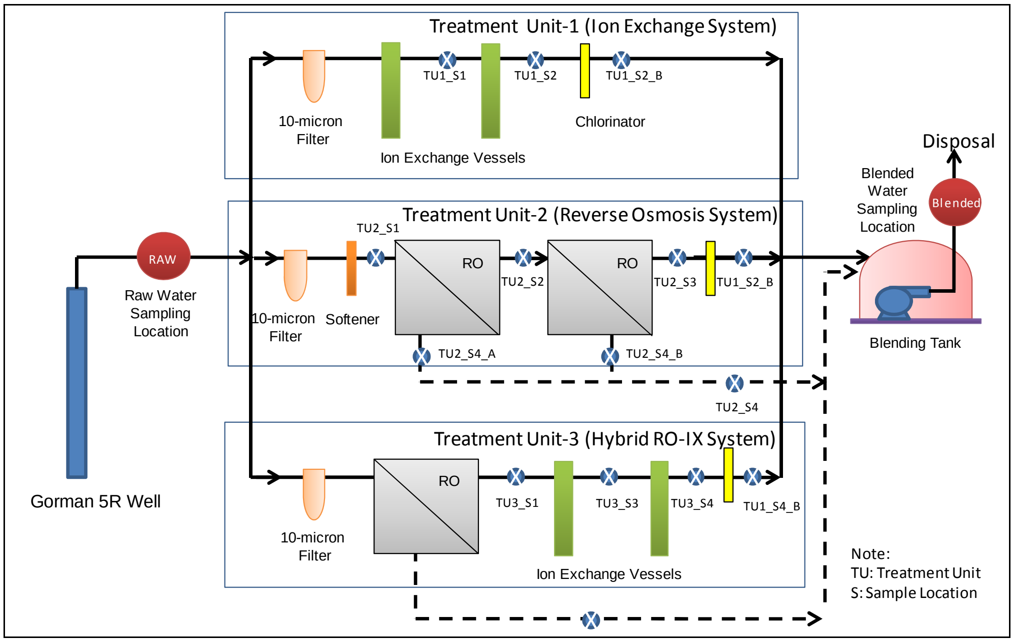
Abbreviations:
µg/L = micrograms per liter
µS/cm = microSeimens per centimeter
CDPH = California Department of Public Health
mg/L = milligrams per liter
MCL = maximum contaminant level
MPN = maximum possible number
MRL = method reporting limit
NTU = nephelometric turbidity units
pCi/L = picoCuries per liter
SMCL = secondary maximum contaminant level
USEPA = U.S. Environmental Protection Agency

Table 2 Field and Laboratory Water Quality Monitoring Parameters

Field Parameters	Laboratory Parameters
Alkalinity	Aluminum
Total Hardness	Barium
Conductivity	Boron
Chlorine	Chloride
pH	Chromium (Total)
Temperature	Copper
Turbidity	Hexavalent Chromium
Flow	Iron
Pressure	Manganese
Power	Nitrate
	Nitrosamines
	Strontium
	Silicate
	Sulfate
	Total Dissolved Solids (TDS)
	Total Organic Carbon (TOC)
	Total Suspended Solids (TSS)
	Total Phosphate
	Turbidity
	Uranium
	BNA SVOCs
	VOCs and TICs
	Aldehydes/Ketones

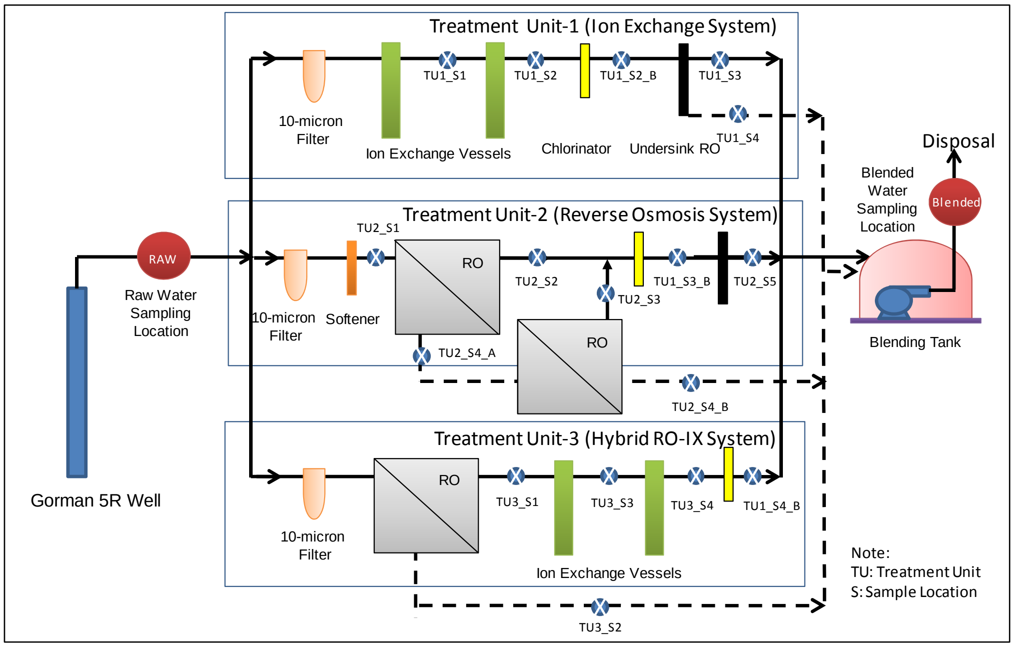
Abbreviations:
BNA SVOC = Base, neutral, acid semi-volatile organic compounds including phenol and TICs.
TIC = tentatively identified compound

Pilot Sampling and Monitoring Locations – Pilot Study Test Plan



Sample Locations		
• Raw Water (G- 5R) • Blended Water • Ion Exchange System (TU1) Locations o Lead Vessel Effluent (TU1_S1) o Lag Vessel Effluent (TU1_S2) o Undersink RO Permeate (TU1_S3) o Undersink RO Brine (TU1_S4)	• Reverse Osmosis System (TU2) Locations o Softener Effluent (TU2_S1) o 1st Pass RO Permeate (TU2_S2) o 2nd Pass RO Permeate (TU2_S3) o 1st Pass (or Stage) RO Brine (TU2_S4_A) o 2nd Pass (or Stage) RO Brine (TU2_S4_B)	• Hybrid RO- IX System (TU3) Locations o RO Permeate (TU3_S1) o RO Brine (TU3_S2) o Lead Vessel Effluent (TU3_S3) o Lag Vessel Effluent (TU3_S4)

Modified Pilot Sampling and Monitoring Locations



Sample Locations		
• Raw Water (G-5R) • Blended Water • Ion Exchange System (TU1) Locations o Lead Vessel Effluent (TU1_S1) o Lag Vessel Effluent (TU1_S2) o Undersink RO Permeate (TU1_S3) o Undersink RO Brine (TU1_S4)	• Reverse Osmosis System (TU2) Locations o Softener Effluent (TU2_S1) o 1st Stage RO Permeate (TU2_S2) o 2nd Stage RO Permeate (TU2_S3) o 1st Pass (or Stage) RO Brine (TU2_S4_A) o 2nd Pass (or Stage) RO Brine (TU2_S4_B) o Calcite Filtered Water (TU2_S5)	• Hybrid RO- IX System (TU3) Locations o RO Permeate (TU3_S1) o RO Brine (TU3_S2) o Lead Vessel Effluent (TU3_S3) o Lag Vessel Effluent (TU3_S4)

When the IX resin is introduced, some compounds may be initially released, such as nitrosamines, formaldehyde, and others. Hence, these compounds were measured during startup (at fixed time intervals up to the first 4 hours and after 24 hours) and at midpoint through operation to assess any leaching that may occur. In addition, a broad scan for tentatively identified compounds (TICs) for both volatile organic compounds (VOCs) and semi volatile organic compounds (SVOCs) were conducted initially and at midpoint through operation to assess whether IX treatment introduces any additional contaminants of concern.

ARCADIS field personnel were responsible for field monitoring and laboratory sampling. Field duplicates were collected to provide quality assurance and control (QA/QC). ARCADIS personnel prepared chain-of-custody forms and the samples were analyzed for laboratory parameters by the Underwriters Laboratory (Southbend, IN). QA/QC certification for the contract laboratory is provided in Attachment B.

Data collected from the field and laboratory monitoring were processed and reviewed weekly. Senior technical experts of ARCADIS reviewed the data for QA/QC purposes.

2.6 Residuals and Waste Characterization

2.6.1 Spent Ion Exchange Resin

The spent IX resins were analyzed for accumulated constituents using the toxicity characteristic leachate procedure (TCLP) and California waste extraction test (CWET) procedures. Additional tests were also conducted for radionuclides and uranium quantification on the resins. The spent resin was analyzed for the following:

- Eight Resource Conservation and Recovery Act (RCRA) metals using TCLP.
- Seventeen State regulated metals (California Title 22 – Soluble Threshold Limit Concentration [STLC] and Total Threshold Limit Concentration [TTLC] analyses).
- Radiologicals (gross alpha, gross beta, uranium, and thorium concentrations). Spent resin is classified as a regulated radioactive waste if the uranium concentration exceeds 0.05 percent by weight.

The exhausted resin was sampled, tested, and returned to the resin vendor for appropriate disposal.

2.6.2 RO Brine

A special round of monitoring was conducted to analyze RO brine samples for National Pollutant Discharge Elimination System (NPDES) permit parameters. Table 3 lists the laboratory analyses performed. Additionally, brine sample were submitted for analysis using the toxicity characteristic leaching procedure (TCLP) and California Waste Extraction Test (CWET) to determine the nature and classification of the waste generated. RO brine samples were also analyzed for radiological parameters including gross alpha, gross beta, uranium, and thorium.

2.7 Energy Monitoring

Power meters were installed on each whole-house water treatment system to measure energy consumption. Power meter readings were recorded daily during the pilot testing.

Table 3 RO Brine Water Quality Monitoring Plan

General Parameters	
BOD (5 day)	pH
Chemical BOD (5 day)	Temperature
COD	Total organic carbon (TOC)
Chlorine residual	Total organic nitrogen
Color (PCU)	Total phosphorus
Fecal coliforms	
Nitrification Parameters	**Anions**
Ammonia - N	Bromide
Nitrate - N	Chloride
Nitrite - N	Fluoride
	Sulfate
Metals	
Total aluminum	Total manganese
Total antimony	Total mercury
Total arsenic	Total molybdenum
Total barium	Total nickel
Total beryllium	Total potassium
Total boron	Total selenium
Total cadmium	Total silica
Total calcium	Total silver
Total chromium	Total sodium
Total cobalt	Total strontium
Total copper	Total thallium
Total iron	Total tin
Total lead	Total titanium
Total magnesium	Total zinc
Other Parameters	
Cyanide	
Oil and grease	
Sulfide as S	
Sulfite as SO_3	
Surfactants	
Hexavalent chromium	

Abbreviations:
BOD = biological oxygen demand
COD = chemical oxygen demand
PCU = platinum-cobalt units

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3. Pilot Study Results

3.1 Test Well Water Quality

A summary of the water quality data collected for the test well (well G-5R) from November 2011 through February 2012 is provided in Table 4. In addition to the general water quality parameters, known parameters that may impact the IX and RO performance were analyzed (e.g., Silica, phosphate, nitrate, and sulfate are known to impact the IX performance by competing with contaminants on the IX medium). Key parameters that impact RO performance include hardness, TDS, chloride, and metals (e.g., aluminum, barium, boron, iron, manganese, silica, and strontium).

The average total chromium and hexavalent chromium concentrations from the test well were 4.2 µg/L and 4.9 µg/L, respectively[4]. Water quality data also indicate exceedances of MCLs for uranium, gross alpha, and gross beta activity (naturally occurring radioactive materials) and secondary MCL exceedances for TDS, chloride, and sulfate.

G-5R well water can be categorized as groundwater containing moderate nitrate and high sulfate, TDS, radionuclides (uranium), and metals. The sulfate and nitrate can impact the run lengths (time between resin replacements for an IX system). The high concentrations of calcium, barium, strontium, and silica impact the RO performance by fouling the membranes and limiting the membranes recoveries (product water to feed water ratio).

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[4] The hexavalent chromium results are higher than total chromium results. The inductively coupled plasma mass spectrometry (ICPMS) value was influenced by the sample matrix (the internal standard recovered at 113 percent). While within acceptance recovery windows, this occurrence likely indicates a physical interference from solution to plasma. Additionally, chromium at the determinative mass has polyatomic interferences from argon gas that are adjusted by a correction equation. These interferences tend to lower the calculated response for total chromium. The contracted laboratory has a feature on its ICPMS called “collision cell technology” that mitigates the ICPMS interferences and lowers the detection limit further, but the U.S. Environmental Protection Agency (USEPA) does not allow its use for drinking water compliance work at this time. The technique used for hexavalent chromium measurement does not suffer from this interference.

3.2 Ion Exchange System

3.2.1 Trends for Key Contaminants

Figures 2 through 8 provide trend plots for a few key constituents in the IX treated water versus operational duration of the IX whole-house water treatment system. Attachment D provides detailed water quality monitoring results for the IX system.

Based on the results of the pilot study, the IX system can remove several contaminants including total chromium, hexavalent chromium, uranium, and arsenic to very low concentrations. Notable testing results include the following:

- Hexavalent chromium concentrations in the lag (second) IX vessel effluent were consistently below 0.02 μg/L during the testing (Figure 3). Total chromium concentrations in the lag vessel effluent were below 0.5 μg/L.
- Operating two vessels in series allowed consistently achieving low concentrations of hexavalent chromium in treated water (even under conditions of initial breakthrough in the lead vessel).
- Uranium is present in the G-5R well water at concentrations exceeding the MCL. However, the concentrations in the lag (second) IX vessel treated water were consistently below 1 μg/L (Figure 4).
- Strong base anion exchange resin will remove nitrate along with hexavalent chromium until the resin reaches its nitrate capacity. Nitrate breakthrough occurred within a short time after the IX system was operational (Figure 5). Standard Type 1 strong base anion resins may not be optimal for chromium removal if nitrate removal is also needed. For the domestic wells with moderate to high nitrate concentrations; the strong base anion resin will not be able to remove nitrate to low concentrations thus exceeding the nitrate MCL over time. Hence, nitrate-selective resin is a potential option to remove nitrate (if necessary) and hexavalent chromium to low concentrations. Pilot testing is ongoing on nitrate-selective resin, and an addendum report will be submitted at the end of testing.
- TDS, chloride and sulfate are not removed by IX treatment (Figures 6, 7 and 8). TDS increased slightly (up to 10 percent) following replacement of a resin vessel, which will initially release some chloride. These constituents impact the aesthetic quality of the water and have secondary MCLs.

Table 4 G-5R Well Water Quality

Parameter	Unit	MCL/SMCL[1]	MRL	Number of Sample Points	Results			
					Minimum	Average	95th Percentile	Maximum
General								
Alkalinity, Total	mg/L as $CaCO_3$	-	2	15	15	145	228	343
Specific Conductance	µS/cm	900[2]	4	15	1,547	2,083	3,724	7,199
Hardness, Total	mg/L as $CaCO_3$	-	10	15	560	699	872	895
pH	pH units	6.5 – 8.5[2]	0.01	15	7	7.1	7.2	7.3
Total Dissolved Solids	mg/L	500[2]	10	12	1,006	1,077	1,145	1,204
Total Solids, Suspended	mg/L	-	10	3	<10	<10	<10	<10
Total Organic Carbon	mg/L	-	0.25	2	0.87	0.95	1.02	1.03
Turbidity	NTU	1	0.05	15	0.19	0.67	2	2.03
Temperature	°C	-	0.1	15	17.8	19.9	22	21.9
Anions								
Chloride	mg/L	250[2]	1	5	180	188	198	290
Nitrate-N	mg/L	10	0.1	5	6.3	6.7	6.9	6.9
Sulfate	mg/L	250[2]	5	5	270	278	288	290
Metals - Total								
Aluminum	µg/L	1000	25	4	<2	2.15	2.19	2.2
Arsenic	µg/L	6	2	12	2	2.26	2.44	2.5
Barium	µg/L	1000	2	4	88	95	100	100
Boron	µg/L	-	5	4	340	365	379	380
Calcium	mg/L	-	1	13	67	74	80	82
Chromium	µg/L	50	0.1	23	3.3	4.2	5	5.1
Iron	mg/L	0.3[2]	0.05	5	0.03	0.07	0.16	0.19
Hexavalent Chromium	µg/L	-	0.02	23	4.1	4.9	5.2	5.3
Magnesium	mg/L	-	0.1	13	18	21.3	22	22
Manganese	µg/L	0.5[2]	2	4	2.7	3.15	3.7	3.8
Silica, Total	mg/L	-	0.5	5	31	31.6	32	32
Strontium	µg/L	-	0.3	4	2,000	2,225	2,385	2,400

Table 4 G-5R Well Water Quality

Parameter	Unit	MCL/SMCL[1]	MRL	Number of Sample Points	Results			
					Minimum	Average	95th Percentile	Maximum
Uranium	µg/L	30	1	8	35	36.9	38.8	39.2
Radionuclides								
Gross Alpha	pCi/L	15	3	2	19.6 ±3.4	[redacted]	[redacted]	48.8 ±2.9
Gross Beta	pCi/L	4	4	2	5.0 ± 1.2	[redacted]	[redacted]	6.0 ± 3.8
Radium-226	pCi/L	combined	1	2	0.28 ± 0.22	[redacted]	[redacted]	0.56 ±.26
Radium-228	pCi/L	< 5pCi/L	1	2	0.02 ±0.48	[redacted]	[redacted]	1.1 ± 0.6
Combined Radium	pCi/L			2	0.30 ± 0.53	[redacted]	[redacted]	1.66 ± 0.65
Radon-222	pCi/L	-	25	2	307 ± 21	[redacted]	[redacted]	318 ±20

Notes:
1 MCLs and SMCLs are from California Department of Public Health's Titles 17 and 22 California Code of Regulations for Drinking Water.
2 SMCL for the listed contaminant.
3 Action Level.

Abbreviations:
µg/L = micrograms per liter
MRL = method reporting limit
µS/cm = microSeimens per centimeter
NTU = nephelometric turbidity units
mg/L = milligrams per liter
pCi/L = picoCuries per liter
MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
MPN = most probable number
USEPA = U.S. Environmental Protection Agency

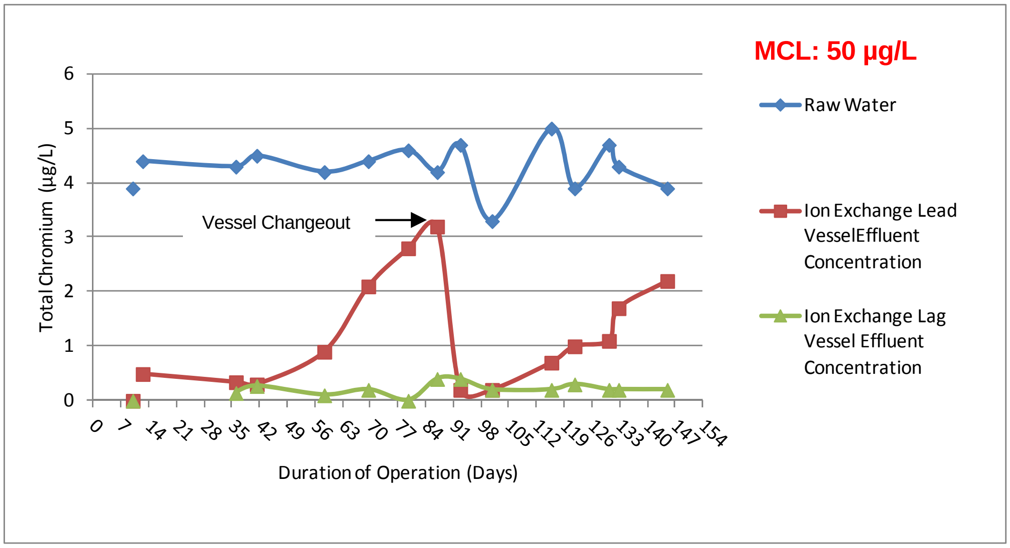

Figure 2 Ion Exchange System – Total Chromium Trends

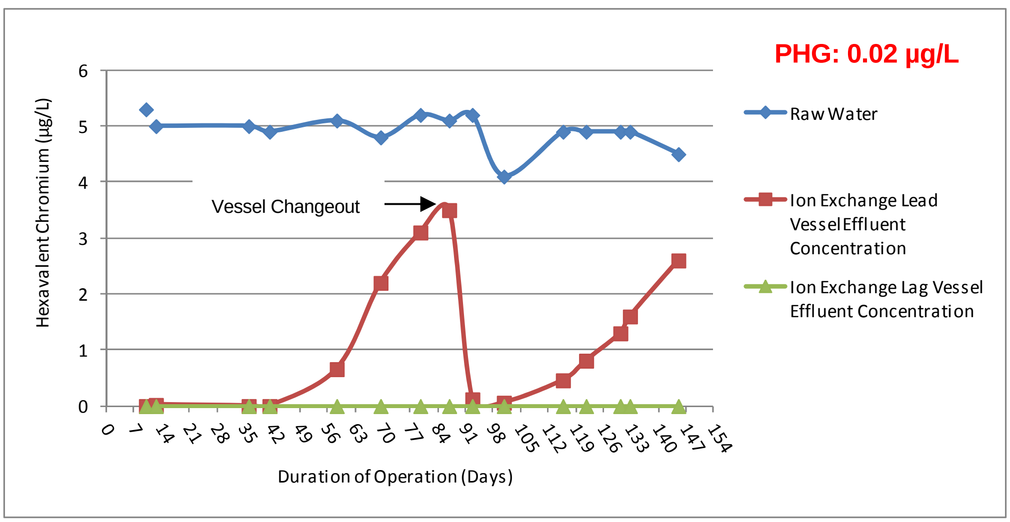

Figure 3 Ion Exchange System – Hexavalent Chromium Trends

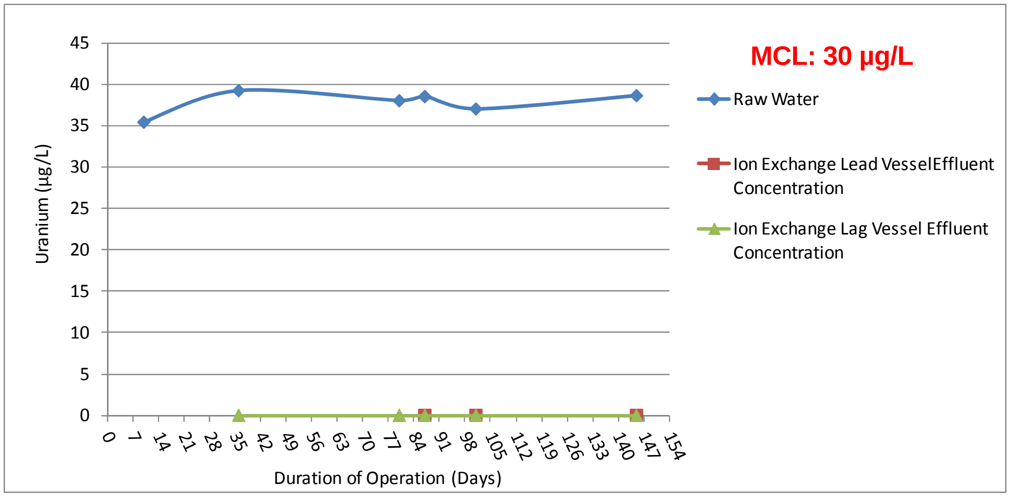

Figure 4 **Ion Exchange System – Uranium Trends**

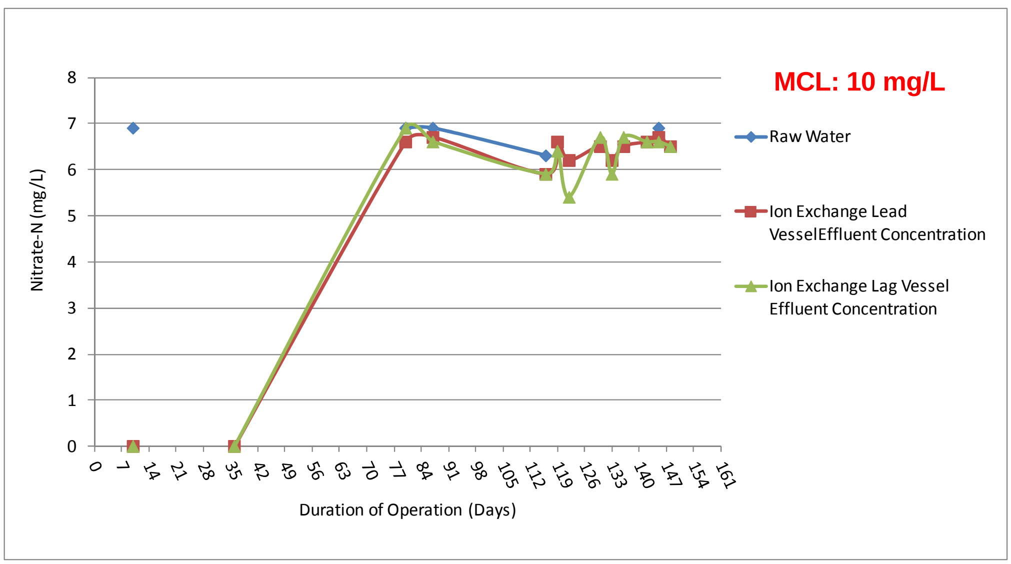

Figure 5 **Ion Exchange System – Nitrate Trends**

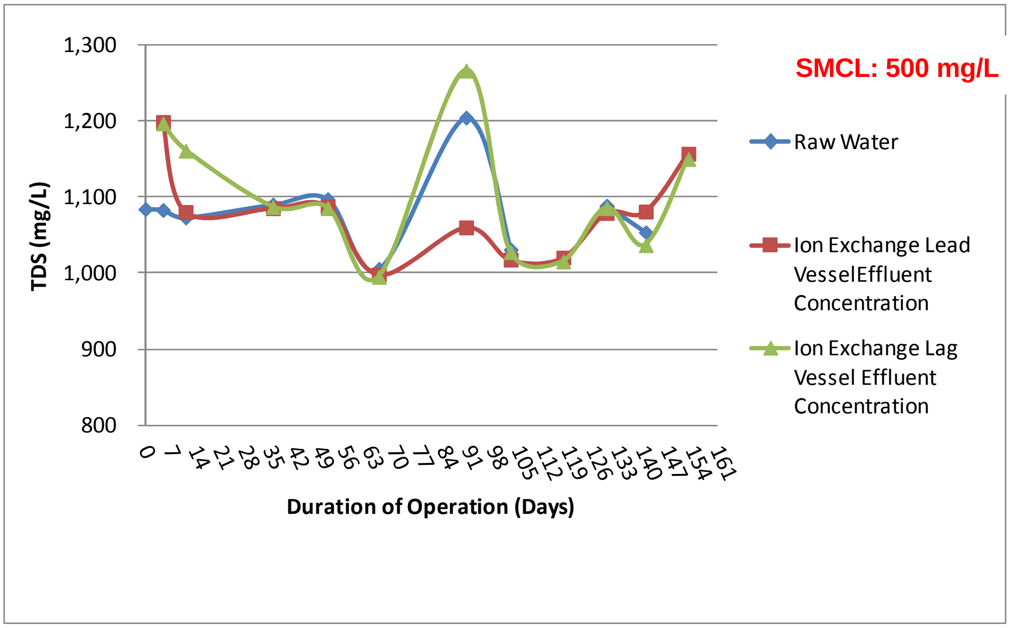

Figure 6 Ion Exchange System – Total Dissolved Solids Trends

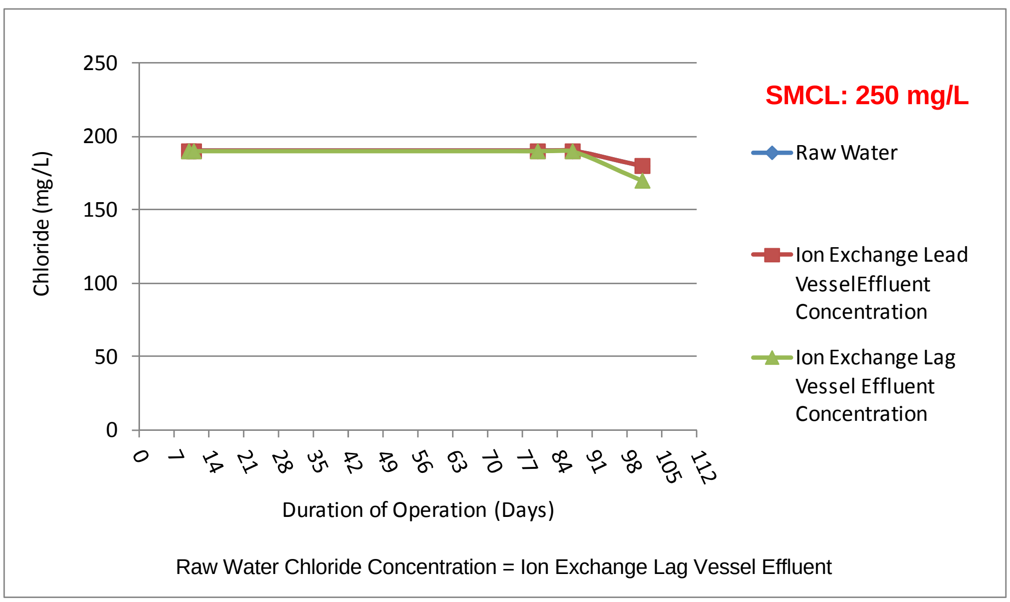

Figure 7 Ion Exchange System – Chloride Trends

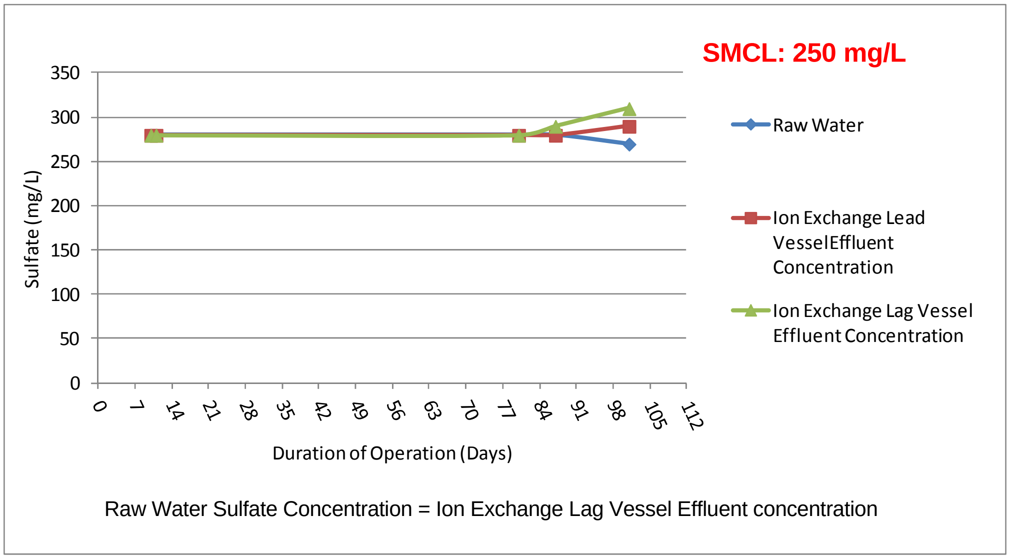

Figure 8 Ion Exchange System – Sulfate Trends

The IX resin initially leached formaldehyde, acetaldehyde, cyclohexanone, and n-nitrosodimethylamine (NDMA) at low concentrations during startup. However, the concentrations for these compounds and all other constituents were reduced to below detection limits by the 4 hour sampling event (corresponding to 19 bed volumes since each vessel has an empty bed contact time [EBCT] of 6.4 minutes; with a total EBCT for the system of 12.8 minutes). Similarly, no additional contaminants were released at midpoint of operation (after 10 weeks of testing). These results imply that IX resin flushing will be required for the initial 2 to 4 hours to remove these compounds prior to bringing the IX system online for whole-house use at the startup and after each IX vessel replacement. In addition, the IX system vendor should flush the resin before installation to minimize leachable compounds. Attachment C provides detailed water quality analysis for the special monitoring conducted for these constituents at startup and midpoint of testing. Normally, the IX system needs to be flushed for the initial 1 to 2 hours to remove these leachable compounds. Another round of special monitoring was conducted by collecting frequent samples to determine the actual flush time required for the IX system during vessel change out to remove these leachable compounds.

Nitrate-Selective Resin Results

A nitrate-selective resin was pilot tested to assess whether nitrate breakthrough can be controlled, as shown in Figure 5 and discussed above. This test began March 22, 2012.

This section will be updated when results become available. Final results will be submitted as an Addendum to the Water Board upon completion of testing.

3.2.2 Spent IX Resin Characterization

Table 5 present the results for analysis of the spent IX resin medium. All metals were below the TCLP regulatory limits, suggesting that the resin would not be considered a federal (i.e., RCRA) hazardous waste. In addition, the TTLC and STLC analyses for metals indicate that the results are below the regulatory limits. Hence, the spent IX resin medium waste is not a hazardous waste in California per the California Code of Regulations (CCR) 66261.23(a) (1) and (2).

The resin sample was also tested for radioactivity, total uranium, and thorium. Uranium and thorium are considered "source material"[5] (California Health and Safety Code, Section 114985(e)) and are subject to California State licensing and regulation. However, materials containing up to 0.05 percent by weight of source material are exempt from California State licensing and regulation, according to CCR, Title 17, Division 1, Chapter 5, Section 30180(c)(2). The resin sample contained total uranium of 1.68E+4 micrograms per kilogram (µg/kg; i.e., 0.00168 percent by weight). Thorium was non-detect in the resin sample. Thus, the sum of uranium and thorium was below the regulatory limit of 0.05 percent (by weight) for radioactive waste. Therefore, the spent IX resin would not be considered a regulated radioactive waste. However, because the resin is a TENORM[6], it still needs to be disposed at a landfill that accepts TENORM waste.

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5 Source material means (1) uranium, thorium, or any other material which the CDPH Radiologic Health Branch (RHB) declares by rule to be source material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such; or (2) ores containing one or more of the foregoing materials, in such concentration as the department declares by rule to be source material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material in such concentration to be source material. (California Codes Health and Safety Code, Section 114985 (e))

6 TENORM is defined as naturally occurring materials, such as rocks, minerals, soils, and water, whose radionuclide concentrations or potential for exposures to humans or the environment is enhanced as a result of human activities such as water treatment (USEPA 2005).

Table 5 Ion Exchange System – Spent Resin Analysis – Metals

Metals	TCLP (mg/L)		STLC (mg/L)		TTLC (mg/kg)	
	Regulatory Limit	Result	Regulatory Limit	Result	Regulatory Limit	Result
Antimony	-	-	15	< 0.2	500	< 10
Arsenic	5	< 0.2	5	< 0.2	500	< 2
Barium	100	< 0.2	100	< 0.2	10,000[1]	< 1
Beryllium	-	-	0.75	< 0.08	75	< 0.5
Cadmium	1	< 0.1	1	< 0.1	100	< 0.5
Chromium	5	< 0.1	5	< 0.1	2,500	**7.3**[2]
Cobalt	-	-	80	< 0.2	8,000	< 1
Copper	-	-	25	< 0.2	2,500	< 2
Lead	5	< 0.1	5	< 0.4	1,000	< 2
Mercury	0.2	< 0.02	0.2	< 0.02	20	**0.024**[2]
Molybdenum	-	-	350	< 0.4	3,500	< 2
Nickel	-	-	20	< 0.2	2,000	< 2
Selenium	1	< 0.1	1	< 0.2	100	< 2
Silver	5	< 0.2	5	< 0.2	500	< 1
Thallium	-	-	7	< 0.2	700	< 10
Vanadium	-	-	24	< 0.2	2,400	**1.6**[2]
Zinc	-	-	250	< 0.4	5,000	< 5

Notes:
1 Excluding barium sulfate
2 Bolded values indicate concentration detected above method reporting limit.
Abbreviations:
mg/kg = milligrams per kilogram
mg/L - milligrams per liter
STLC = Soluble Threshold Limit Concentration
TCLP = Toxicity Characteristic Leaching Procedure
TTLC = Total Threshold Limit Concentration

Table 6 Ion Exchange System – Spent Resin Analysis – Radiological

Parameter	Units	Result
Gross Alpha	pCi/g	5.66 ± 1.6
Gross Beta	pCi/g	1.26 E+02 ± 1.5 E+01
Total Uranium	µg/kg	1.68 E+0.4 ± 2.0 E+03
Uranium -234	pCi/g	7.52 E+0.0 ± 1.2 E+00
Uranium -235	pCi/g	2.39 E-01 ± 6.2 E-02
Uranium -238	pCi/g	5.79 E+00 ± 9.3 E-01
Thorium -228	pCi/g	1.53 E-02 ± 6.5 E-03
Thorium -230	pCi/g	1.49 E-02 ± 8.9 E-03
Thorium -232	pCi/g	1.49 E-02 ± 6.4 E-03

Abbreviations:
µg/kg = micrograms per kilogram
pCi/g = picoCuries per gram

3.3 Reverse Osmosis System

3.3.1 Trends for Key Contaminants

Figures 9 through 15 show trend plots for the selected key constituents in water treated using the two-pass RO system. Figures 16 through 22 show trend plots for the selected key constituents in water treated using a two-stage RO system. Attachment C provides detailed water quality results for RO treatment performance.

Data collected during the pilot test show that the whole-house RO treatment system can remove several contaminants, including total chromium, hexavalent chromium, nitrate, uranium, chloride, sulfate, arsenic, and TDS to very low concentrations.

Notable testing results include the following:

- Hexavalent chromium concentrations in the RO permeate were consistently below 0.02 µg/L during the testing (Figures 10 and 17). Total chromium concentrations in the RO permeate were below 0.1 µg/L. The results for hexavalent chromium and total chromium were below the MRL for two-pass RO and two-stage RO.
- Uranium is present in the G-5R well water at concentrations exceeding the MCL of 30 µg/L. However, the concentrations in the RO permeate were consistently below 1 µg/L (Figures 11 and 18).
- Nitrate and sulfate were removed to below detection limit (Figures 12 and 15 and 19 and 22, respectively); while TDS and chloride were removed to very low concentrations (Figures 13, 14, 20, and 21, respectively).

Sampling results from the first RO unit of the two-pass RO system (e.g., data points for 1st pass RO effluent in Figures 9-15) indicated that single-pass RO can reliably meet, if deemed necessary, the primary and secondary drinking water standards. However, a significant amount of brine was generated that will be required to be disposed off site. To address this brine disposal issue, the two-pass RO system was modified to operate as a two-stage RO. This change in configuration reduced the RO brine generation volumes by a significant quantity. The 2-stage RO produced 423 gpd of total brine (two-stage RO brine + softener brine) compared to 2,918 gpd of total brine (two-pass RO brine + softener) for two-pass whole-house RO treatment (for the water quality tested). The two-stage RO approach, if deemed necessary, also met primary and secondary drinking water standards.

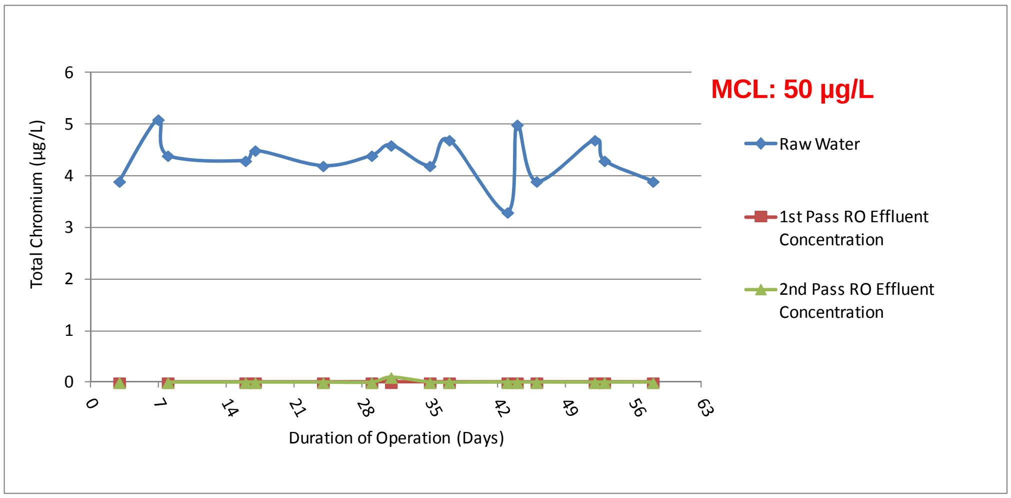

Figure 9 Two-Pass Reverse Osmosis System – Total Chromium Trends

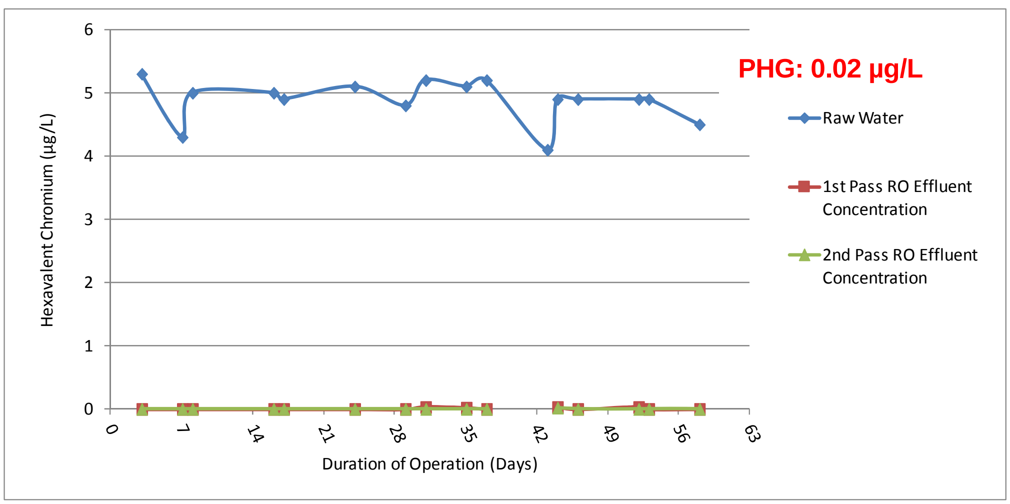

Figure 10 Two-Pass Reverse Osmosis System – Hexavalent Chromium Trends

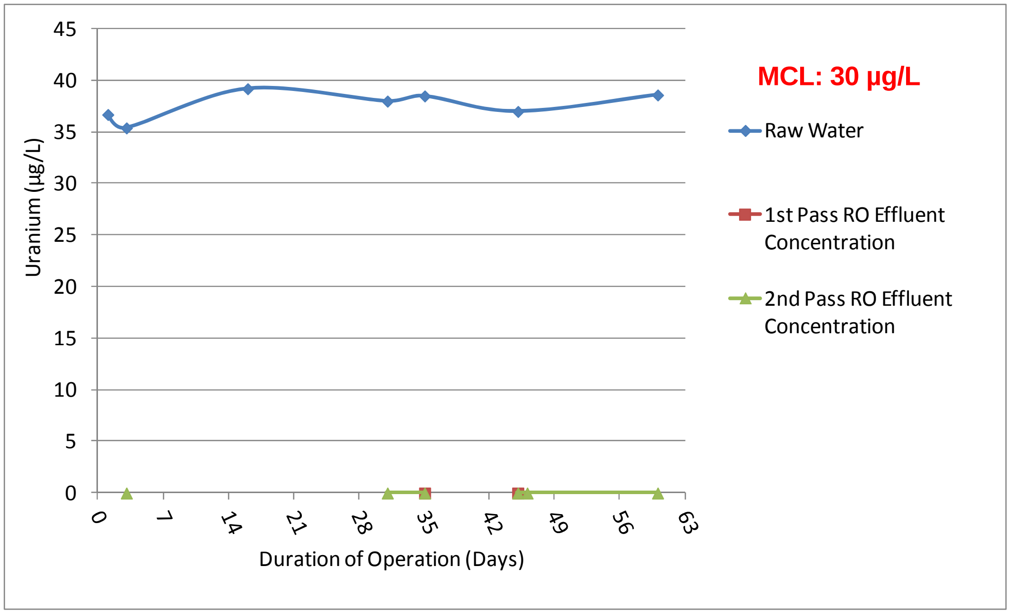

Figure 11 Two-Pass Reverse Osmosis System – Uranium Trends

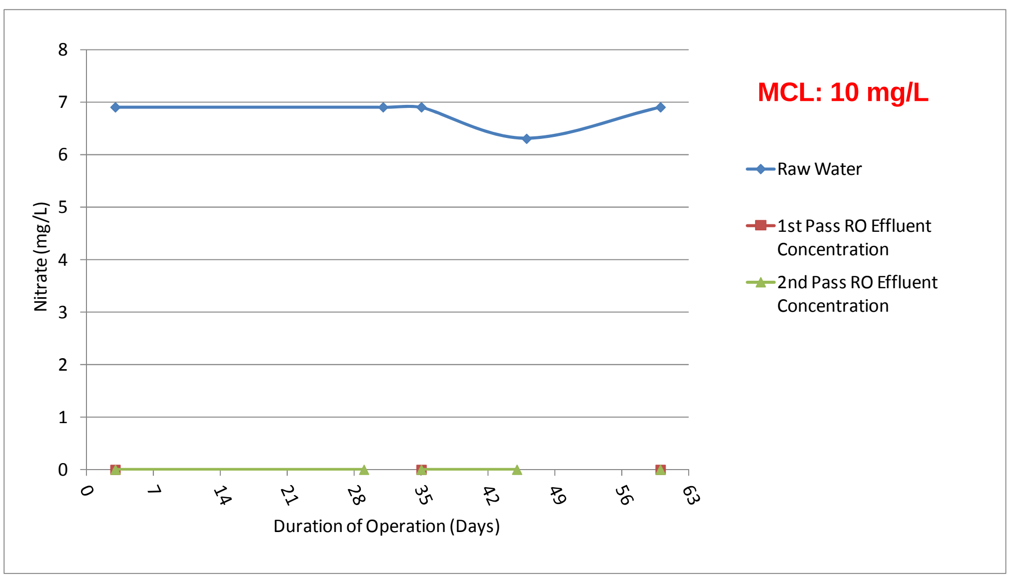

Figure 12 Two-Pass Reverse Osmosis System – Nitrate Trends

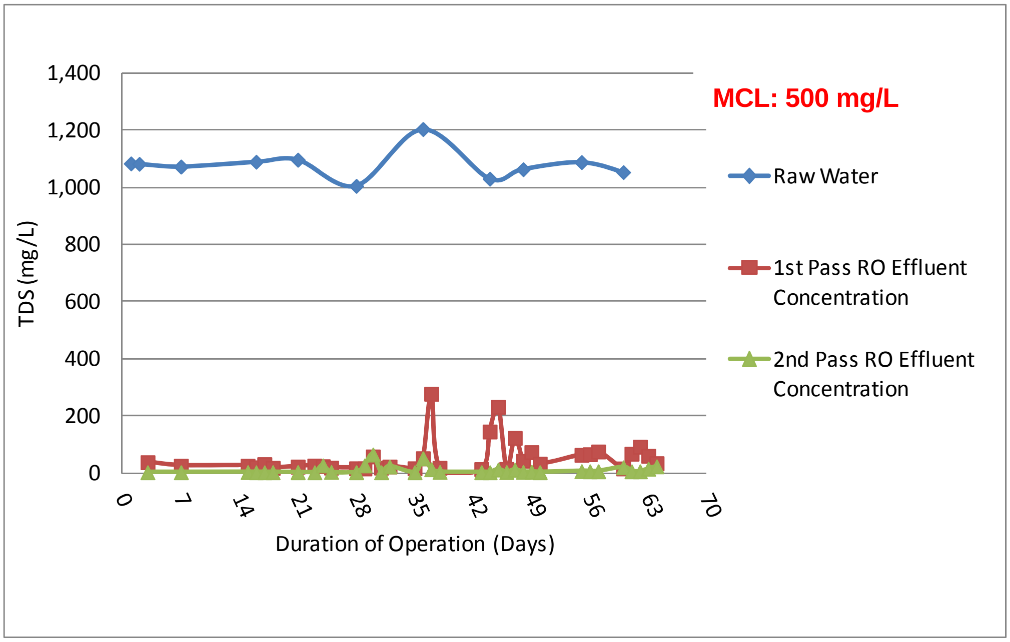

Figure 13 Two-Pass Reverse Osmosis System – Total Dissolved Solids Trends

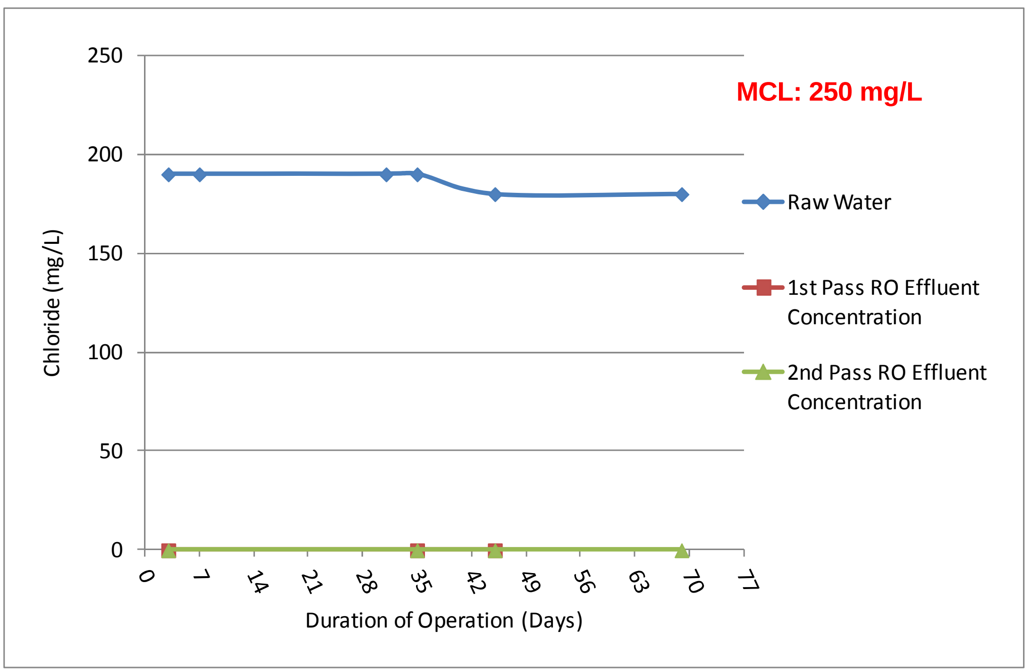

Figure 14 Two-Pass Reverse Osmosis System – Chloride Trends

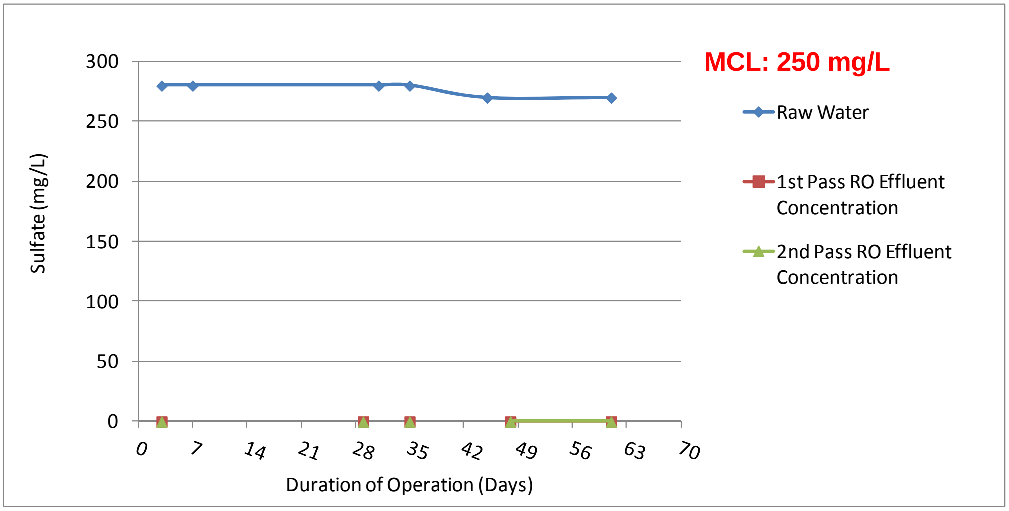

Figure 15 **Two-Pass Reverse Osmosis System – Sulfate Trends**

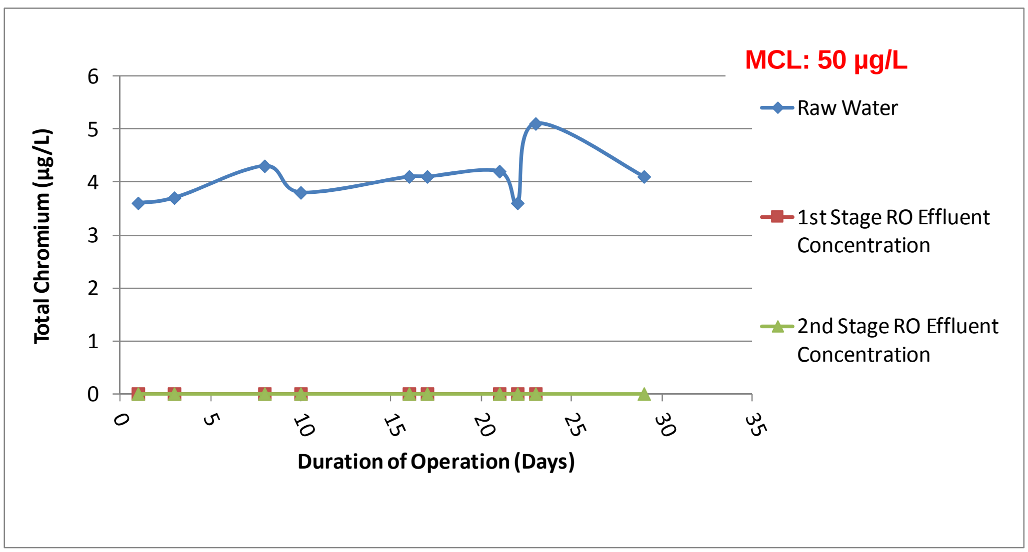

Figure 16 **Two-Stage Reverse Osmosis System – Total Chromium Trends**

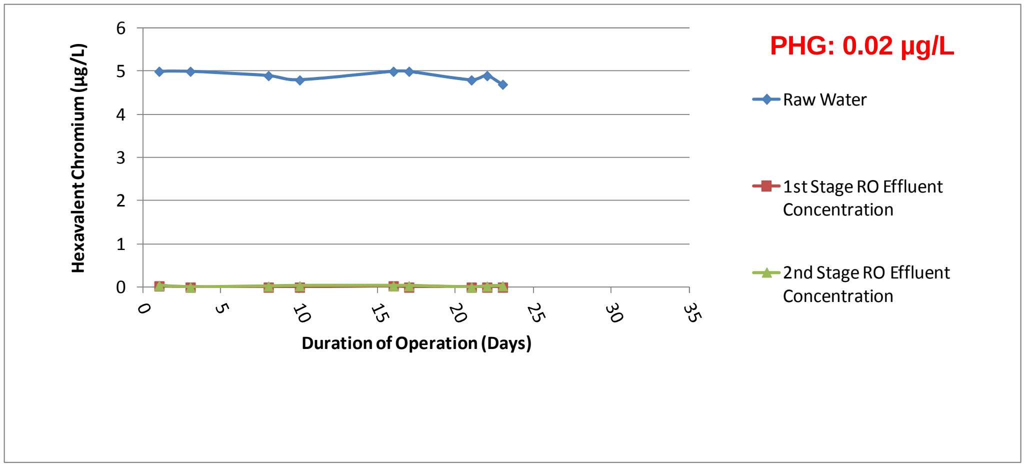

Figure 17 Two-Stage Reverse Osmosis System – Hexavalent Chromium Trends

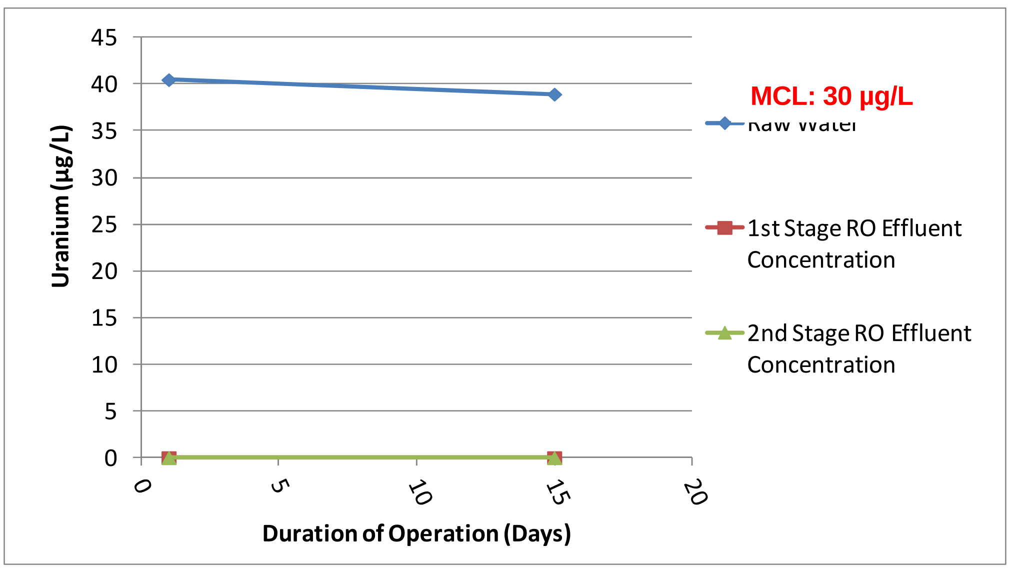

Figure 18 Two-Stage Reverse Osmosis System – Uranium Trends

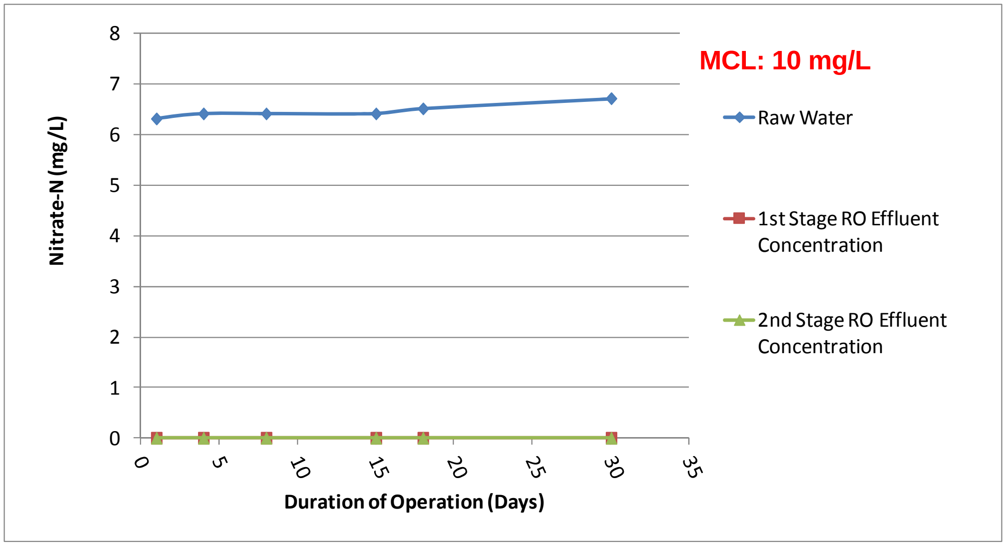

Figure 19 Two-Stage Reverse Osmosis System – Nitrate Trends

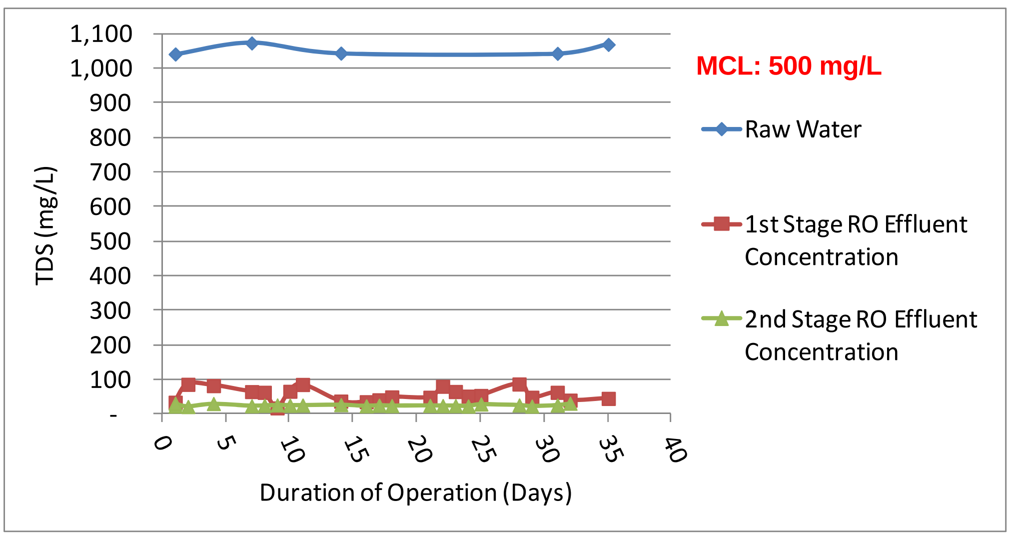

Figure 20 Two-Stage Reverse Osmosis System – Total Dissolved Solids Trends

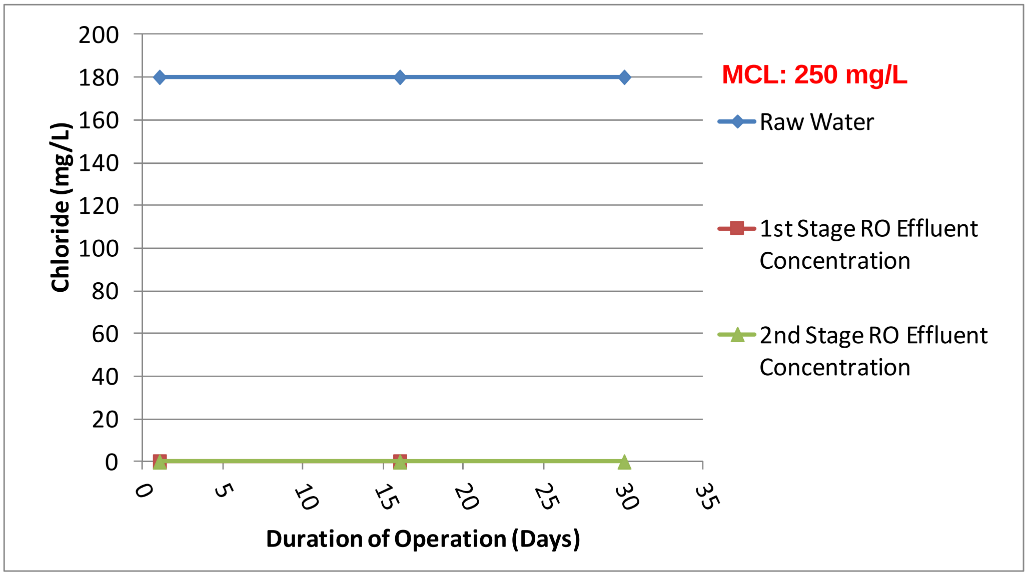

Figure 21 Two-Stage Reverse Osmosis System – Chloride Trends

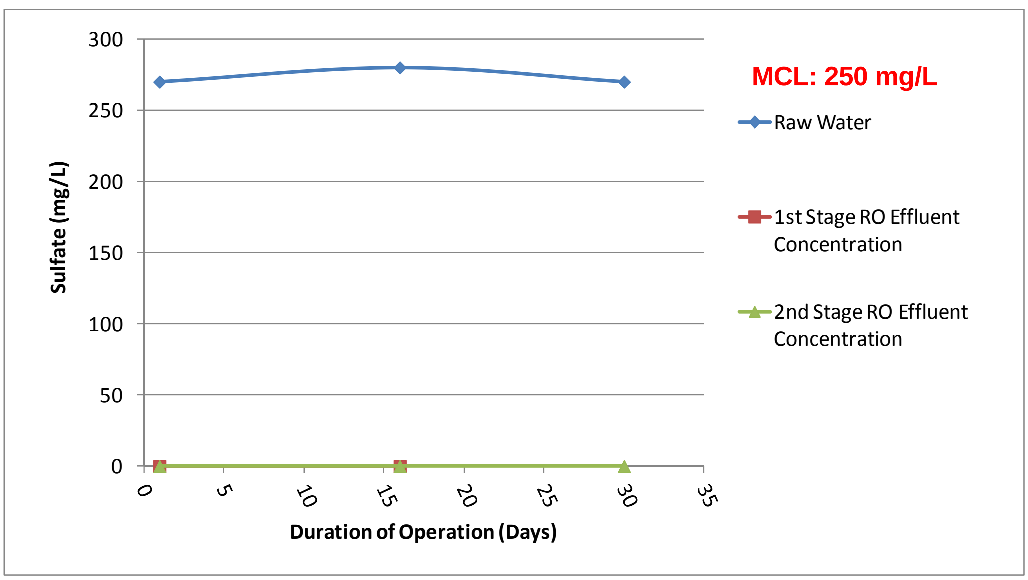

Figure 22 Two-Stage Reverse Osmosis System – Sulfate Trends

3.3.2 Calcite Filter Addition

Table 7 provides a summary of the data collected to evaluate the performance of a two-stage RO system with calcite filter addition. Detailed calcite filter data are provided in Attachment C.

Water from RO treatment systems is low in alkalinity and calcium, and is therefore typically stabilized prior to introduction into the home. One means of stabilizing the water is to pass the RO treated water through a bed of calcite medium. Stabilizing the water reduces the potential for leaching of undesired metals from the domestic piping. Such stabilization is not required or commonly practiced for undersink RO because the RO treated water is connected to a dedicated tap using a new plastic pipe; therefore, piping corrosion and leaching is not a concern.

The Langelier Saturation Index (LSI) and Calcium Carbonate Precipitation Potential (CCPP) were used to evaluate RO treated water stability with calcite filter addition. The LSI is an indicator of the corrosivity of water. A positive LSI indicates scale-forming water, and a negative LSI indicates aggressive or scale-dissolving water. The recommended range for LSI is between +0.1 and +0.3 (or +0.2 ± 0.1). The CCPP is a water stability index that provides a quantitative measure of the calcium carbonate deficit or excess of the water, more accurately estimating the likely extent of calcium carbonate precipitation. The recommended range for CCPP is 4 to 10 milligrams per liter (mg/L).

The calculated LSI and CCPP (Table 7) indicate that calcite filtered water continues to be corrosive. Additional stabilization techniques, like addition of commonly used corrosion inhibitors or depression of pH before water goes into the calcite filter, may be necessary to improve the RO water stability for whole-house use. Additional testing would be required to investigate this issue more thoroughly should RO treatment be appropriate.

RO Brine Analysis

Final results for the RO brine sample analysis for NPDES permit parameters will be submitted as an Addendum to the Water Board in May 2012.

Table 7 Two-Stage RO System with Calcite Filter Addition

Parameter	Number of Samples	First-Stage RO Permeate	Second - Stage RO Permeate	Calcite Filtered Water
		Average Condition	Average Condition	Average Condition
pH, SU	22	6.7	6.02	7.33
Temperature, °C	22	22	22.38	21.8
Alkalinity, mg/L as $CaCO_3$	5	< 10	< 10	41
Calcium, mg/L	6	< 0.1	< 0.1	20
Total Chromium, µg/L	6	< 0.1	< 0.1	< 0.1
Hexavalent Chromium, µg/L	6	< 0.02	< 0.02	< 0.02
Arsenic, µg/L	6	< 2	< 2	< 2
Uranium, µg/L	5	< 1	< 1	< 1
TDS, mg/L	22	57	38	454
Nitrate, mg/L	6	< 0.1	< 0.1	0.68
Chloride, mg/L	6	< 2	< 2	5.6
Sulfate, mg/L	6	< 5	< 5	< 5
Heterotrophic Plate Count, MPN/mL	6	[redacted]		109.6
Escherichia coli , MPN/100 mL	6			< 1
Total Coliform, MPN/100 mL	6			< 1
LSI	6			-1.19
CCPP, mg/L	6			-8.86

Abbreviations:
µg/L = micrograms per liter
CCPP = Calcium Carbonate Potential
LSI = Langelier Saturation Index
mg/L = milligrams per liter
mL = milliliters
MPN = most probable number
RO = reverse osmosis
SU = standard units

Waste Disposal Characterization

Table 8 and Table 9 present results of softener brine and RO brine analysis for two-pass RO system. Tables 10 and 11 present results of softener brine and RO brine analysis for two-stage RO system. The STLC and TTLC analyses indicate that softener brine and RO brine metal concentrations are below the state regulatory limits. Hence, the softener and RO brine are not hazardous waste per CCR 66261.23(a) (1) and (2). Similarly, the TCLP analysis reported that all RCRA metals analyzed were below detection limits; thus, classifying them as non-RCRA waste. Radionuclides and uranium were detected in the RO brine, but the concentrations were significantly lower than regulatory limits to classify as radioactive waste. However, because the brine is a TENORM, it still needs to be disposed at a site that accepts TENORM waste.

Table 8 Two-Pass Reverse Osmosis System – Brine Analysis – Metals

Metals	TCLP (mg/L)				STLC (mg/L)				TTLC (mg/L)		
	Regulatory Limit	First-Stage RO	Second-Stage RO	Softener Brine	Regulatory Limit	First-Stage RO	Second-Stage RO	Softener Brine	First-Stage RO	Second-Stage RO	Softener Brine
Antimony		-	-	-	15	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	5	< 0.2	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	100	< 0.2	< 0.2	< 0.2	100	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Beryllium		-	-	-	0.75	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Cadmium	1	< 0.1	< 0.1	< 0.1	1	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	5	< 0.1	< 0.1	< 0.1	5	< 0.005	< 0.005	< 0.005	**0.0071**	< 0.005	**0.0051**
Cobalt		-	-	-	80	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper		-	-	-	25	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	**0.01**
Lead	5	< 0.1	< 0.1	< 0.1	5	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.005
Mercury	0.2	< 0.02	< 0.02	< 0.02	0.2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Molybdenum		-	-	-	350	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Nickel		-	-	-	20	< 0.01	< 0.01	< 0.01	**0.02**	< 0.01	< 0.01
Selenium	1	< 0.1	< 0.1	< 0.1	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	5	< 0.2	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium		-	-	-	7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Vanadium		-	-	-	24	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc		-	-	-	250	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Notes:
Bolded values indicate concentration detected above method reporting limit.
Abbreviations:
mg/L = milligrams per liter
RO = reverse osmosis
STLC = Soluble Threshold Limit Concentration
TCLP = Toxicity Characteristic Leaching Procedure
TTLC = Total Threshold Limit Concentration

Table 9 Two-Pass Reverse Osmosis System – Brine Analysis – Radiologicals

Parameter	Units	First-Pass RO Brine	Second-Pass RO Brine	Softener Brine
Gross Alpha	pCi/L	3.92E+01 ± 1.6E+01	9.51E-01 ± 5.1E-01	1.47E+01 ± 5.9E+00
Gross Beta	pCi/L	1.02E+01± 6.1E+00	1.89E+00 ± 1.1E+00	2.06E+01 ± 8.4E+00
Total Uranium	pCi/L	5.94E+01 ± 6.9E+00	8.41E-02 ± 8.7E-03	2.84E+01 ± 3.3E+00
Uranium-233/234	pCi/L	2.70E+01 ± 4.6E+00	1.88E-01 ± 1.7E-01	1.40E+01 ± 2.7E+00
Uranium-235/236	pCi/L	8.16E-01 ± 3.7E-01	1.72E-01 ± 7.6E-02	6.03E-01 ± 3.3E-01
Uranium-238	pCi/L	1.91E+01 ± 3.4E+00	1.51E-01 ± 1.1E-01	1.10E+01 ± 2.2E+00
Thorium-228	pCi/L	2.01E-01 ± 1.5E-01	2.18E-01 ± 1.9E-01	2.09E-01 ± 1.3E-01
Thorium-230	pCi/L	1.73E-01 ± 1.2E-01	2.13E-01 ± 1.8E-01	1.79E-01 ± 1.3E-01
Thorium-232	pCi/L	1.73E-01 ± 8.6E-02	2.13E-01 ± 9.1E-02	1.79E-01 ± 8.9E-02

Abbreviations:
pCi/L = picoCuries per liter
RO = reverse osmosis

Table 10 Two-Stage Reverse Osmosis System – Brine Analysis – Metals

	TCLP (mg/L)				STLC (mg/L)				TTLC (mg/L)		
Metals	Regulatory Limit	First-Pass RO Brine	Second-Pass RO Brine	Softener Brine	Regulatory Limit	First-Pass RO Brine	Second-Pass RO Brine	Softener Brine	First-Pass RO Brine	Second-Pass RO Brine	Softener Brine
Antimony		-	-	-	15	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	5	< 0.2	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	100	< 0.2	< 0.2	< 0.2	100	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Beryllium		-	-	-	0.75	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Cadmium	1	< 0.1	< 0.1	< 0.1	1	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	5	< 0.1	< 0.1	< 0.1	5	< 0.005	< 0.005	< 0.005	**0.011**	**0.015**	**0.0054**
Cobalt		-	-	-	80	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper		-	-	-	25	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead	5	< 0.1	< 0.1	< 0.1	5	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.005
Mercury	0.2	< 0.02	< 0.02	< 0.02	0.2	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Molybdenum		-	-	-	350	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Nickel		-	-	-	20	< 0.01	< 0.01	< 0.01	< 0.01	**0.027**	< 0.01
Selenium	1	< 0.1	< 0.1	< 0.1	1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	5	< 0.2	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium		-	-	-	7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Vanadium		-	-	-	24	< 0.01	< 0.01	< 0.01	**0.01**	**0.013**	< 0.01
Zinc		-	-	-	250	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Note:
Bolded values indicate concentration detected above method reporting limit.
Abbreviations:
mg/L = milligrams per liter
RO = reverse osmosis
STLC = Soluble Threshold Limit Concentration
TCLP = Toxicity Characteristic Leaching Procedure
TTLC = Total Threshold Limit Concentration

Table 11 Two-Stage Reverse Osmosis System – Brine Analysis – Radiologicals

Parameter	Units	First-Stage RO Brine	Second-Stage RO Brine	Softener Brine
Gross Alpha	pCi/L	5.40E+01 ± 7.8E+00	5.98E+01 ± 1.5E+01	2.24E+01 ± 4.8E+00
Gross Beta	pCi/L	1.93E+01± 4.0E+00	1.78E+01 ± 5.3E+00	8.37E+00 ± 1.9E+00
Total Uranium	pCi/L	3.28E+01 ± 1.94E+00	4.25E-02 ± 2.5E+00	1.94E+01 ± 1.14E+00
Uranium-233/234	pCi/L	2.66E+01 ± 2.2E+00	3.83E+01 ± 3.2E+00	1.40E+01 ± 2.7E+00
Uranium-235/236	pCi/L	7.13E-01 ± 1.6E-01	9.22E-01 ± 1.9E-01	6.03E-01 ± 3.3E-01
Uranium-238	pCi/L	2.00E+01 ± 1.7E+00	3.07E+01 ± 2.6E+00	1.10E+01 ± 2.2E+00
Thorium-228	pCi/L	1.19E-01 ± 9.6E-02	0.00E-01 ± 5.5E-02	1.38E-01 ± 1.1E-01
Thorium-230	pCi/L	3.18E-02 ± 5.5E-02	0.00E-01 ± 5.4E-02	4.53E-02 ± 7.9E-02
Thorium-232	pCi/L	-1.06E-02 ± 5.4E-02	5.31E-02 ± 5.4E-02	6.04E-02 ± 7.7E-02

Abbreviations:
pCi/L = picoCuries per liter
RO = reverse osmosis

3.4 Hybrid Systems

3.4.1 Whole-House Hybrid Reverse Osmosis and Ion Exchange System

Trends for Key Contaminants

The hybrid RO-IX system was initially operated at a recovery of 58 percent (recovery indicates the proportion of product water to feed water). During the course of the pilot testing, the recovery was increased to 75 to 80 percent by increasing the recirculation flow. This increased recovery reduced RO brine generation by approximately 50 percent.

Figures 23 through 29 show trend plots for the key contaminants and their removal using the RO – IX whole-house water treatment system. Figures 30 through 36 show trend plots for the key contaminants when operating the system at 80 percent RO system recovery. Attachment C provides detailed water quality results for RO - IX treatment.

The data collected during the pilot study indicate that the whole-house hybrid RO - IX system effectively removed total chromium, hexavalent chromium, nitrate, uranium, TDS, chloride, sulfate, and arsenic to very low concentrations. Notable testing results include the following:

- Hexavalent chromium concentrations in the RO permeate and lag (second) IX vessel effluent were consistently below 0.02 μg/L during testing (Figures 24 and 31). Total chromium concentrations in the RO permeate and the lag vessel effluent were below 0.1 µg/L (Figures 23 and 30).
- Uranium is present in the G-5R well water at concentrations exceeding the MCL of 30 µg/L. However, the concentrations in the RO permeate and the lag IX vessel effluent were consistently below 1 µg/L (Figures 25 and 32).
- Nitrate and sulfate were removed to below detection limit (Figures 26 and 29, respectively); TDS and chloride were removed to very low concentrations (Figures 33 and 36, respectively).

Based on the results, the RO system alone is capable of reducing hexavalent chromium concentrations below the detection limit and if deemed necessary, meet the primary and secondary drinking water standards.

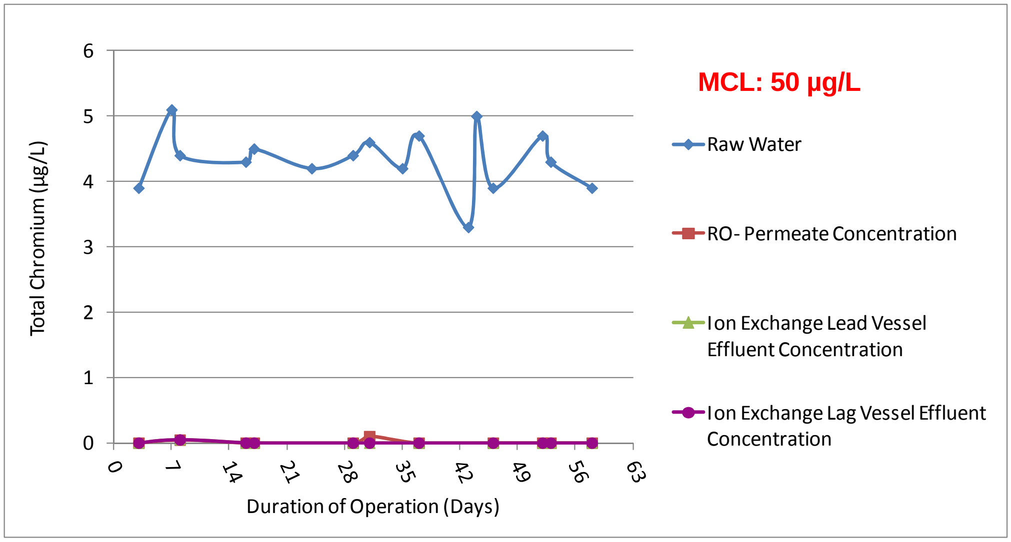

Figure 23 Hybrid RO - IX System – Total Chromium Trends

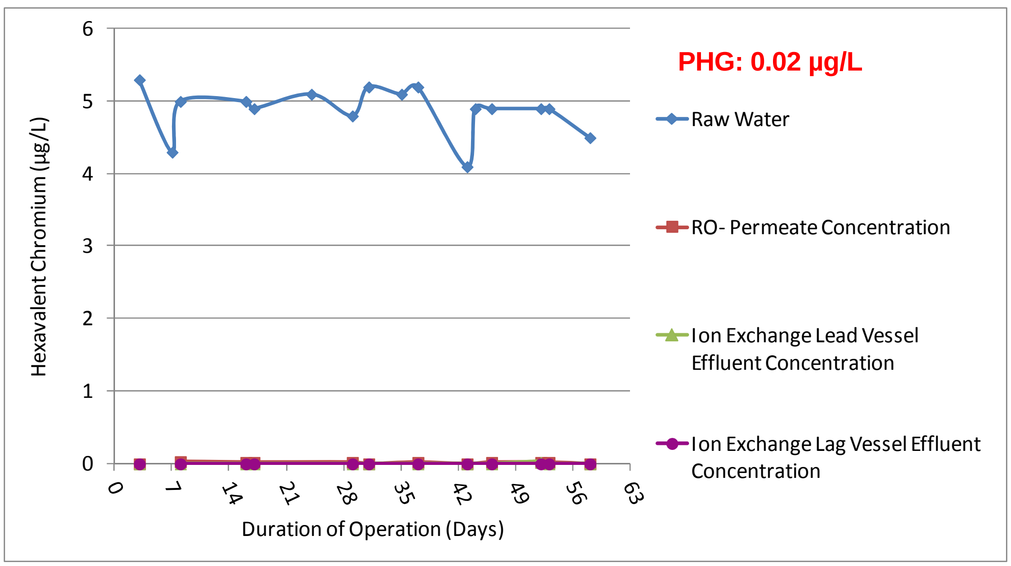

Figure 24 Hybrid RO - IX System – Hexavalent Chromium Trends

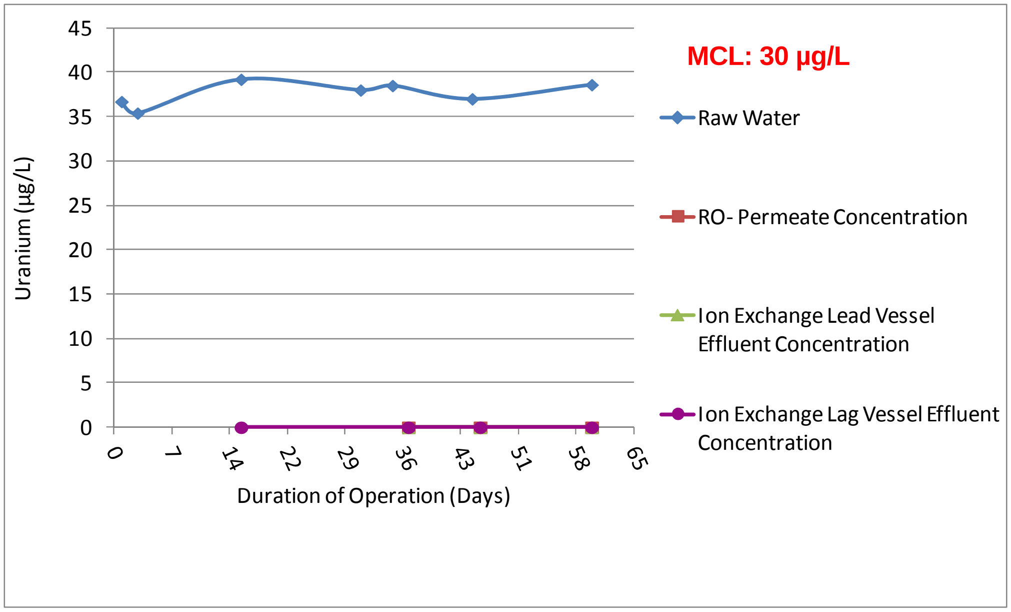

Figure 25 Hybrid RO - IX System – Uranium Trends

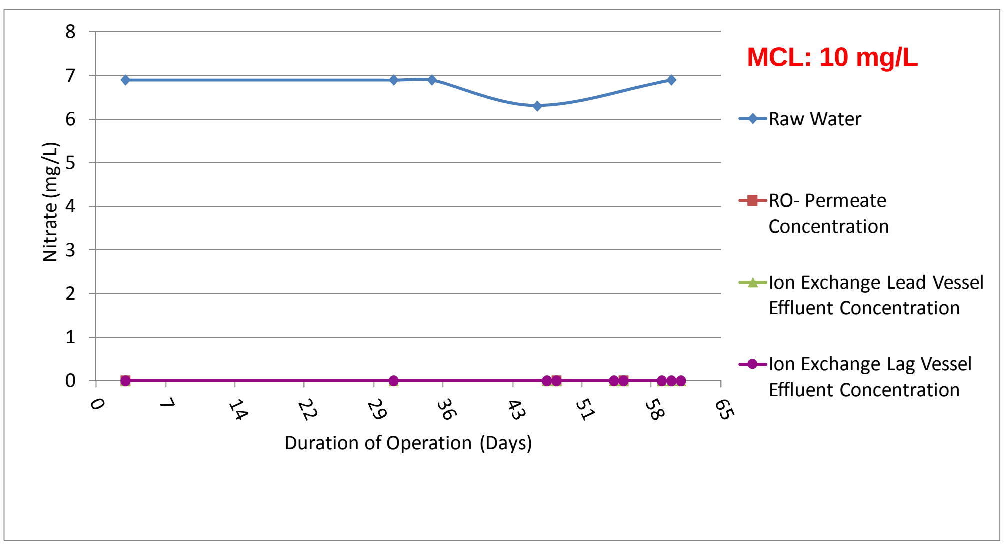

Figure 26 Hybrid RO - IX System – Nitrate Trends

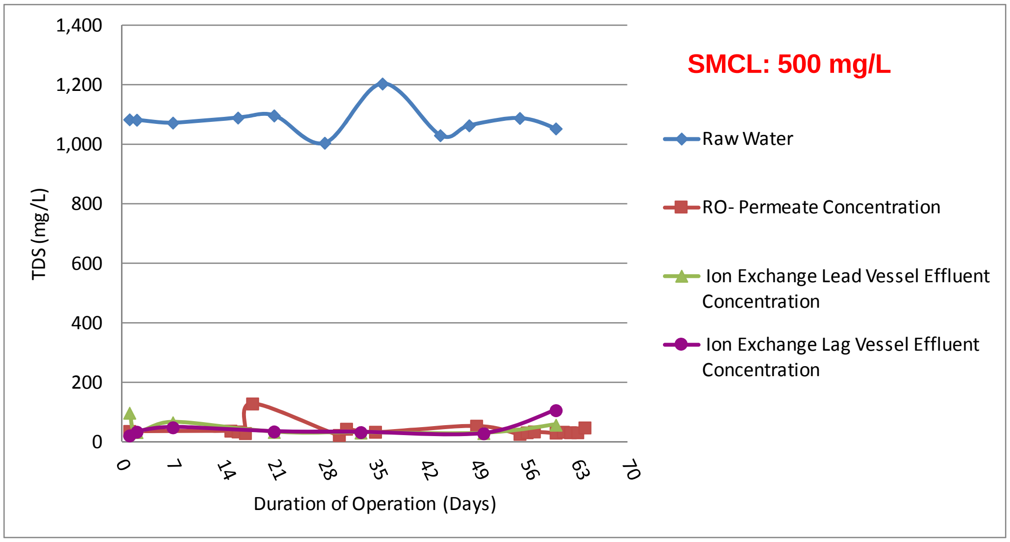

Figure 27 Hybrid RO - IX System – Total Dissolved Solids Trends

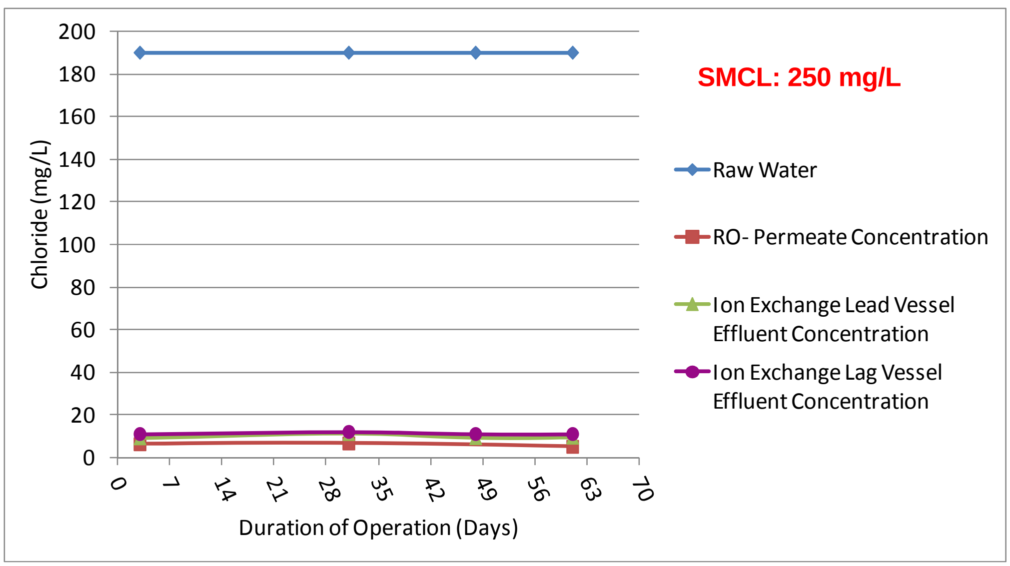

Figure 28 Hybrid RO - IX System – Chloride Trends

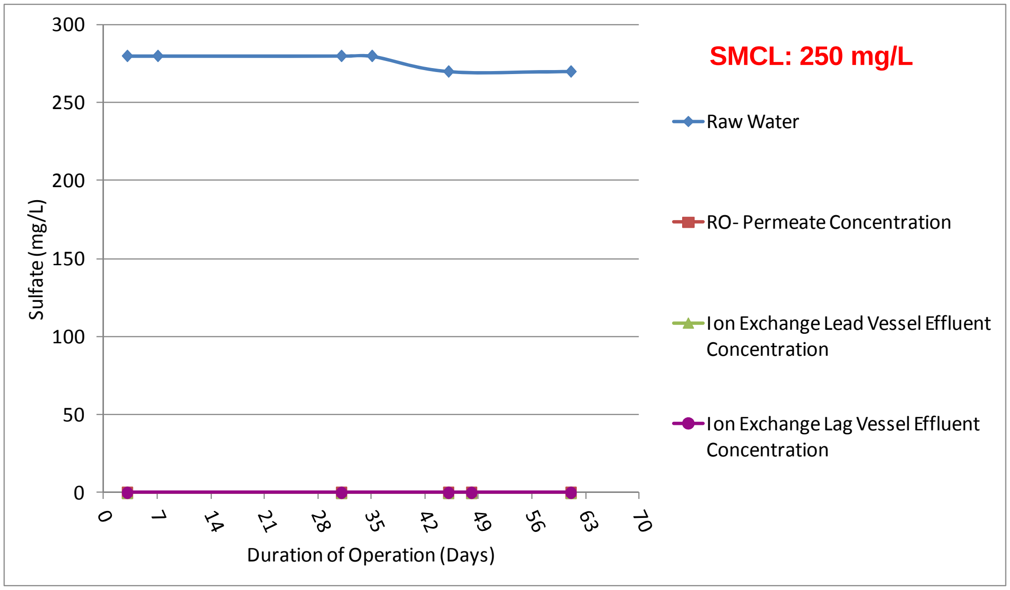

Figure 29 Hybrid RO - IX System – Sulfate Trends

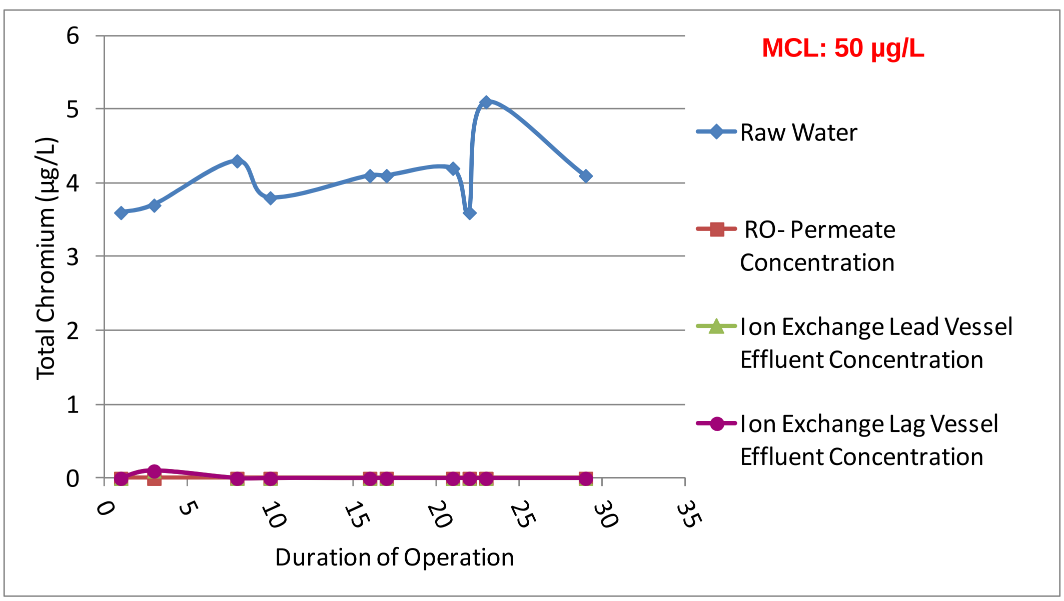

Figure 30 Hybrid RO - IX System – Total Chromium Trends (80% RO Recovery)

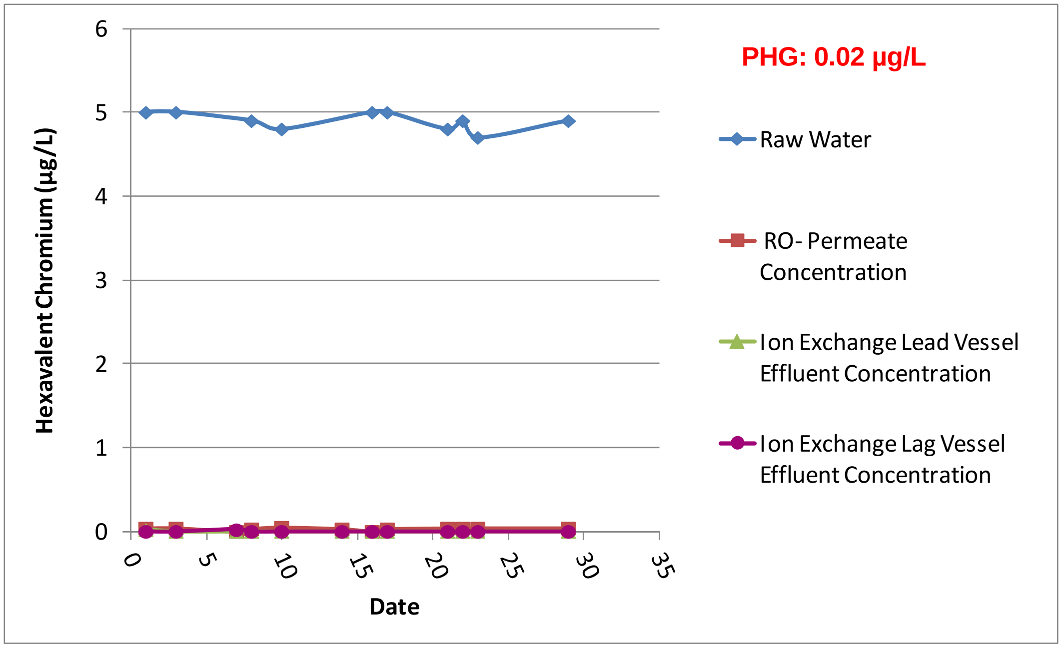

Figure 31 Hybrid RO - IX System – Hexavalent Chromium Trends (80% RO Recovery)

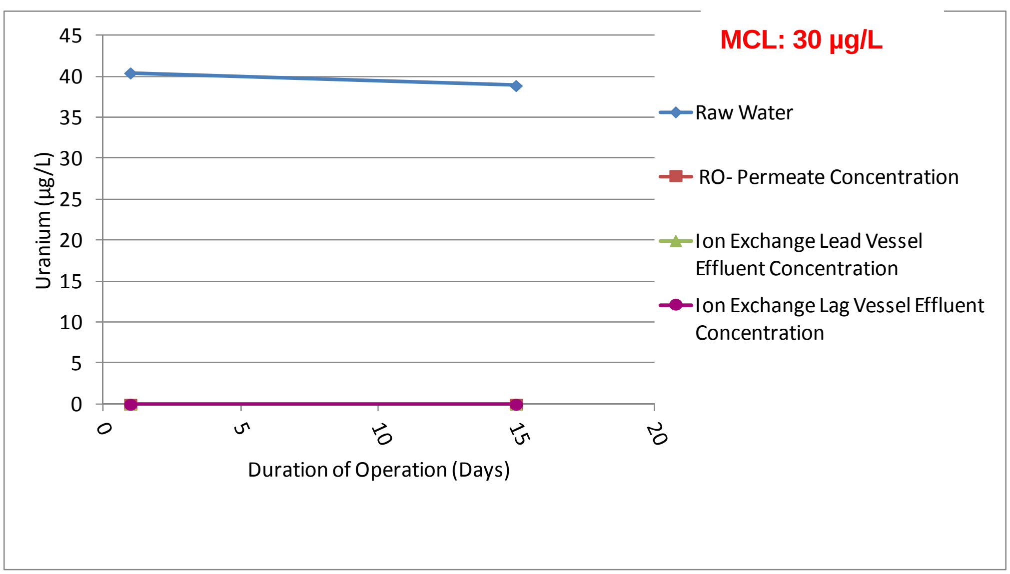

Figure 32 Hybrid RO - IX System – Uranium Trends (80% RO Recovery)

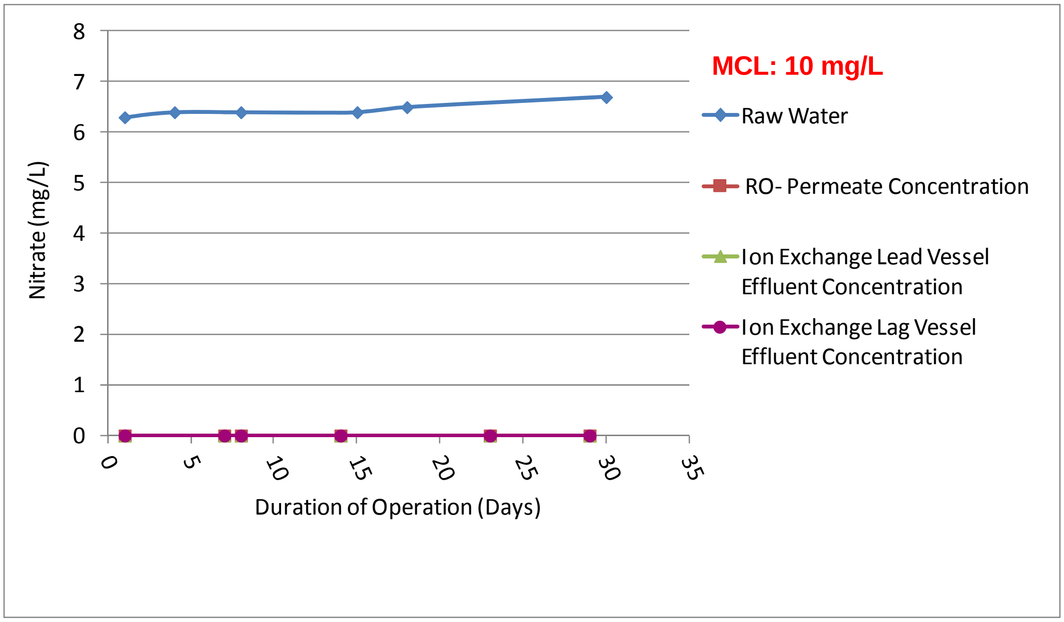

Figure 33 **Hybrid RO - IX System – Nitrate Trends (80% RO Recovery)**

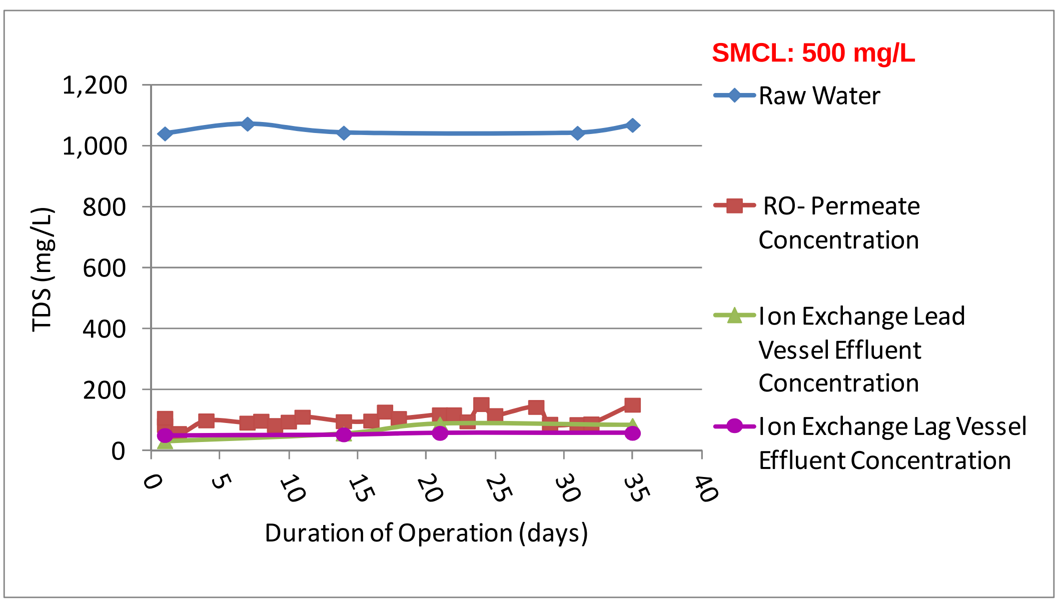

Figure 34 **Hybrid RO - IX System – Total Dissolved Solids Trends (80% Recovery)**

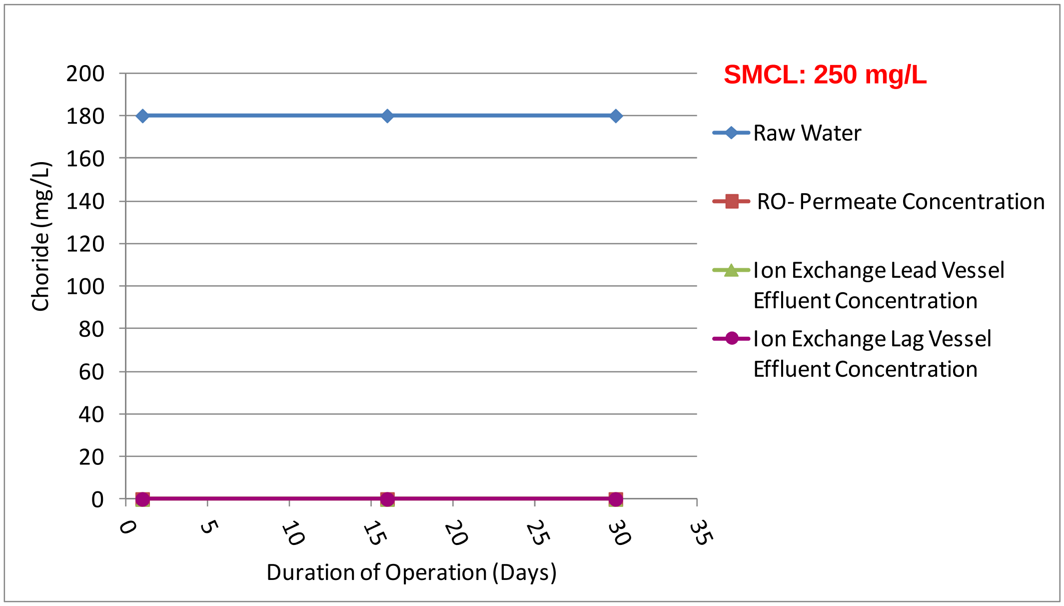

Figure 35 Hybrid RO - IX System – Chloride Trends (80% Recovery)

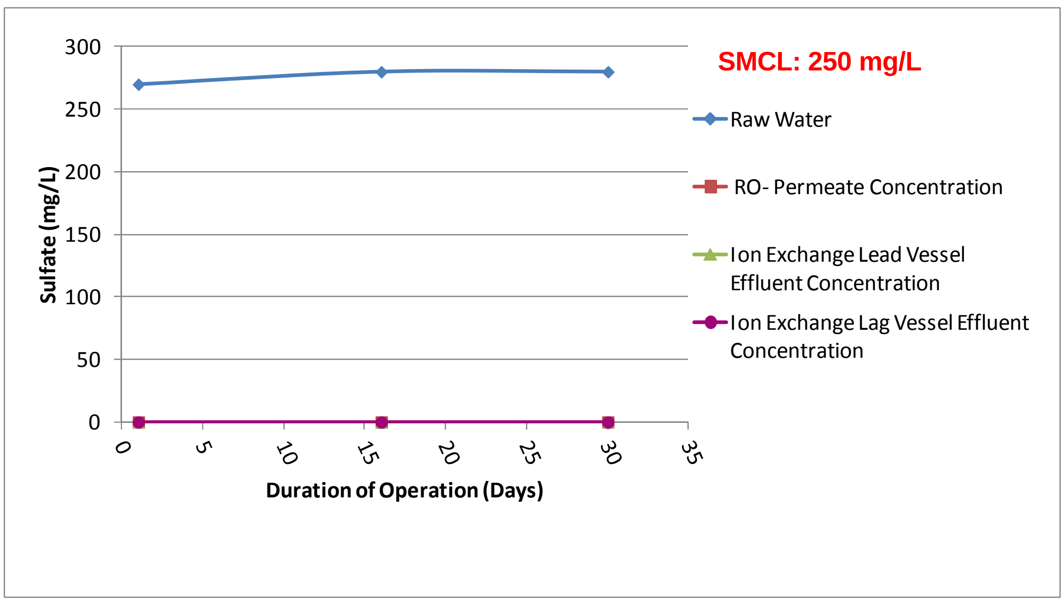

Figure 36 Hybrid RO - IX System – Sulfate Trends (80% Recovery)

The IX component in the hybrid RO – IX system yielded detections of 2-butanone, toluene, bisphenol A, dimethylphthalate, phenol, propanal, and cyclohexanone at low concentrations during initial startup sampling. However, the concentrations for these compounds were reduced to below detection limits by the 4 hour sampling event (corresponding to 35 bed volumes since each vessel has an EBCT of 3.5 minutes; with a total EBCT for the system of 7 minutes). Similarly, no leached constituents were observed at the operational midpoint sampling event (after 10 weeks of operation). This implies that the IX resin flushing will be required for the initial 2 to 4 hours to remove these compounds prior to bringing the IX system online for whole-house use. In addition, the IX system vendor should flush the resin before installation to minimize leachable compounds. Attachment C provides detailed water quality analysis data for the special monitoring conducted for these constituents at startup and midpoint of testing. Normally it takes 1 to 2 hours of flush time to remove the leachable compounds; hence more frequent sampling is recommended to determine flushing volume if the system were installed.

Brine Characterization

Final results for the RO brine sample analysis for NPDES permit parameters will be submitted as an Addendum to the Water Board in May 2012.

The STLC and TTLC metals analyses indicate that RO brine metal concentrations are below the state regulatory limits (Table 12). Hence, the RO brine is not a hazardous waste per CCR 66261.23(a)(1) and (2). Similarly, the TCLP analysis reported that all RCRA metals tested were below detection limits; thus classifying it as non-RCRA hazardous waste. Radionuclides and uranium were detected in the RO brine at concentrations significantly lower than the regulatory limits to classify as radioactive waste (Table 13). Based on the pre-disposal analysis, the RO brine is non-hazardous waste and can be hauled off site for appropriate disposal. However, because the brine is a TENORM, it still needs to be disposed at a site that accepts TENORM waste.

Spent IX Resin Characterization

Final results for the Spent IX resin analysis will be submitted as an Addendum to the Water Board in May 2012.

Table 12 Hybrid RO – IX System - RO Brine Analysis – Metals

Metals	TCLP (mg/L)			STLC (mg/L)			TTLC (mg/L)	
		RO Brine			RO Brine		RO Brine	
	Regulatory Limit	Recovery of 58%	Recovery of 80%	Regulatory Limit	Recovery of 58%	Recovery of 80%	Recovery of 58%	Recovery of 80%
Antimony				15	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	5	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01
Barium	100	0.2	0.2	100	< 0.01	< 0.01	**0.2**	**0.15**
Beryllium				0.75	< 0.004	< 0.004	< 0.004	< 0.004
Cadmium	1	< 0.1	< 0.1	1	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	5	< 0.1	< 0.1	5	< 0.005	< 0.005	**0.0079**	**0.0075**
Cobalt				80	< 0.01	< 0.01	< 0.01	< 0.01
Copper				25	< 0.01	< 0.01	< 0.01	< 0.01
Lead	5	< 0.1	< 0.1	5	<0.005	<0.005	<0.005	<0.005
Mercury	0.2	< 0.02	< 0.02	0.2	< 0.02	< 0.02	< 0.02	< 0.02
Molybdenum				350	< 0.02	< 0.02	< 0.02	< 0.02
Nickel				20	< 0.01	< 0.01	< 0.01	< 0.01
Selenium	1	< 0.1	< 0.1	1	< 0.01	< 0.01	< 0.01	< 0.01
Silver	5	< 0.2	< 0.2	5	< 0.01	< 0.01	< 0.01	< 0.01
Thallium				7	0.01	0.01	< 0.01	< 0.01
Vanadium				24	< 0.01	< 0.01	**0.011**	< 0.01
Zinc				250	< 0.02	< 0.02	< 0.02	**0.022**

Note:

Bolded values indicate concentration detected above method reporting limit.

Abbreviations:

mg/L = milligrams per liter

RO = reverse osmosis

RO-IX = reverse osmosis-ion exchange

STLC = Soluble Threshold Limit Concentration

Table 13 Hybrid RO – IX System - RO Brine Analysis – Radiologicals

Parameter	Units	RO Brine Recovery	
		58%	80%
Gross Alpha	pCi/L	4.26E+01 ± 1.1E+01	5.19E+01 ± 8.6E+00
Gross Beta	pCi/L	1.71E+01 ± 5.6E+00	2.27E+01 ± 2.9E+00
Total Uranium	pCi/L	4.57E+01 ± 5.3E+00	2.87E+01 ± 1.7E+00
Uranium-233/234	pCi/L	2.64E+01 ± 4.6E+00	2.28E+01 ± 2.0E+00
Uranium-235/236	pCi/L	1.26E+00 ± 4.8E-01	8.21E-01 ± 1.8E-01
Uranium-238	pCi/L	2.04E+01 ± 3.6E+00	1.83E+01 ± 1.6E+00
Thorium-228	pCi/L	3.46E-01 ± 2.6E-01	-3.18E-02 ± 8.3E-02
Thorium-230	pCi/L	2.45E-01 ± 9.0E-02	0.00E+00 ± 8.0E-02
Thorium-232	pCi/L	2.07E-01 ± 8.8E-02	0.00E-01 ± 8.0E-02

Abbreviations:
pCi/L = picoCuries per liter
RO = reverse osmosis
RO-IX = reverse osmosis-ion exchange

3.4.2 Ion Exchange System and Undersink RO System

Table 14 summarizes water quality analysis for the undersink RO unit. Figures 37 through 43 show trend plots for the key contaminants and their removal using the RO – IX whole-house water treatment system. Attachment C provides detailed water quality results for RO - IX treatment performance.

The undersink RO was operated beyond the breakthrough for chromium for ion exchange to challenge the system. The undersink RO was able to lower the total and hexavalent chromium to very low concentrations even when operated beyond the breakthrough (Figures 37 and 38). The undersink RO consistently reduces TDS, chloride, and sulfate to very low concentrations at the kitchen and other designated taps (Figures 41, 42, and 43). The addition of undersink RO post-IX will enable the process, if necessary, to meet the primary and secondary drinking water standards at the kitchen and other designated taps.

Table 14 Undersink RO Water Quality

Parameters	Units	MRL	Undersink RO Permeate				Undersink RO Brine			
			No. of Samples	Min.	Avg.	Max.	No. of Samples	Min.	Avg.	Max.
General										
Alkalinity, Total	mg/L as $CaCO_3$	2	3	0	0	0	[redacted]			
Specific Conductance	µS/cm	4	3	350	355	364				
Hardness, Total	mg/L as $CaCO_3$	10	3	40	42	45				
pH	pH units	0.01	19	7.1	7.7	7.9	17	7	7.3	7.5
Total Dissolved Solids	mg/L	10	19	97	222	380	17	1,139	1,652	2,042
Temperature	(°C)	0.1	19	13.1	18.9	25.7	17	12.4	18.8	25.3
Anions										
Chloride	mg/L	1	7	12	17	27	7	190	360	570
Nitrate-N	mg/L	0.1	7	0.5	1.06	1.6	7	2.5	6.49	8.2
Sulfate	mg/L	5	7	5.3	6.5	8.8	7	68	305	440
Metals - Total										
Aluminum	µg/L	2	7	2.3	3.1	4.2	7	2.6	12.2	59
Arsenic	µg/L	2	7	< 2	< 2	< 2	7	2.4	3.23	4.3
Barium	µg/L	2	7	9	22.2	36	7	82	132	160
Boron	µg/L	5	7	< 5	< 5	5.3	7	130	333	410
Calcium	mg/L	1	7	2.8	7.2	13	7	77	114	270
Chromium	µg/L	0.1	7	< 0.1	< 0.1	0.3	7	< 0.1	0.34	0.5
Hexavalent Chromium	µg/L	0.02	7	< 0.02	< 0.02	< 0.02	7	< 0.02	0.12	0.3
Iron	mg/L	0.02	7	< 0.02	< 0.02	< 0.02	7	< 0.02	< 0.02	< 0.02
Magnesium	mg/L	0.1	7	1.2	3.7	5.9	7	21	30	41
Manganese	µg/L	2	7	2.3	6.8	11	7	< 2	3.1	3.5
Silica, Total	mg/L	0.5	7	7.6	10.6	17	7	33	46.1	51
Strontium	µg/L	0.3	7	43	109.3	190	7	1,600	2,943	3,500
Uranium	µg/L	1	7	< 1	< 1	< 1	7	14	19.6	24

Abbreviations:

µg/L = micrograms per liter
mg/L = milligrams per liter
RO - reverse osmosis
µS/cm = microSiemens per centimeter
NTU = Nephelometric Turbidity Units

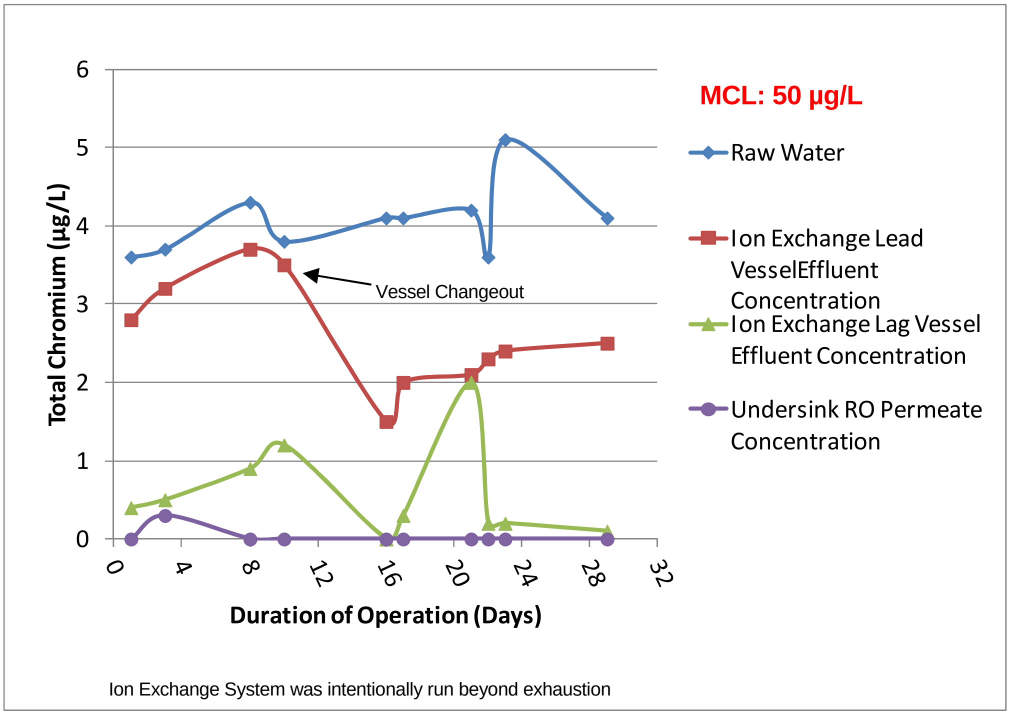

Figure 37 **Ion Exchange - Undersink RO System – Total Chromium Trends**

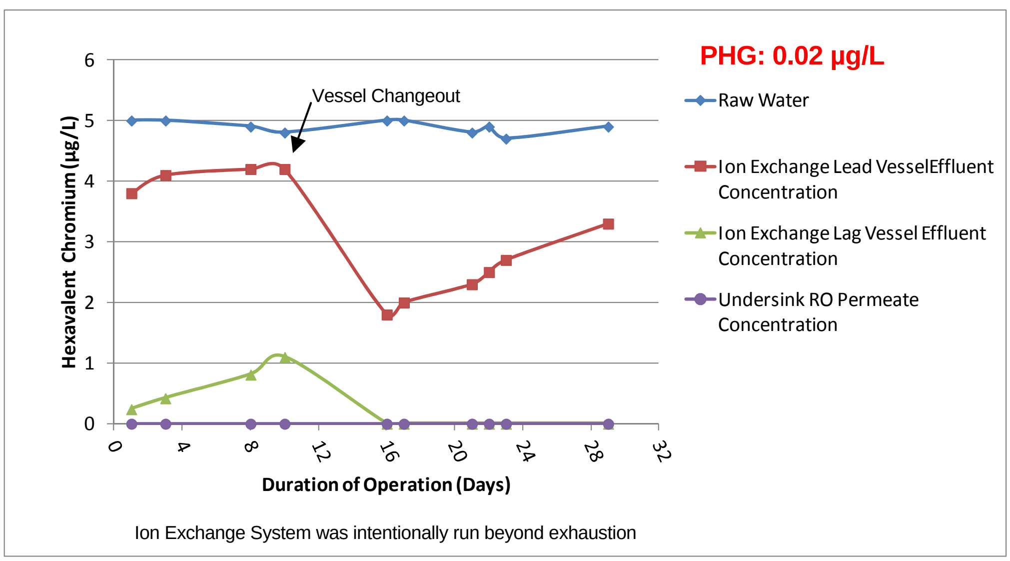

Figure 38 **Ion Exchange - Undersink RO System – Hexavalent Chromium Trends**

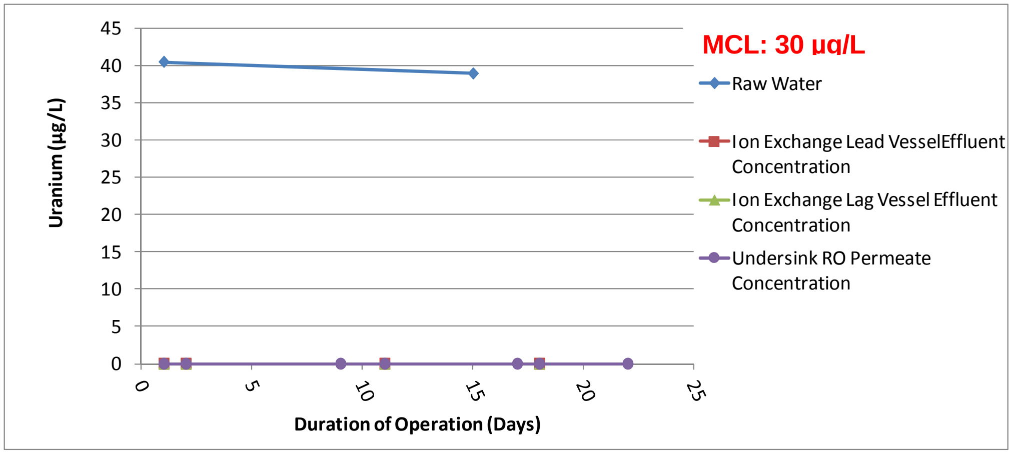

Figure 39 **Ion Exchange - Undersink RO System – Uranium Trends**

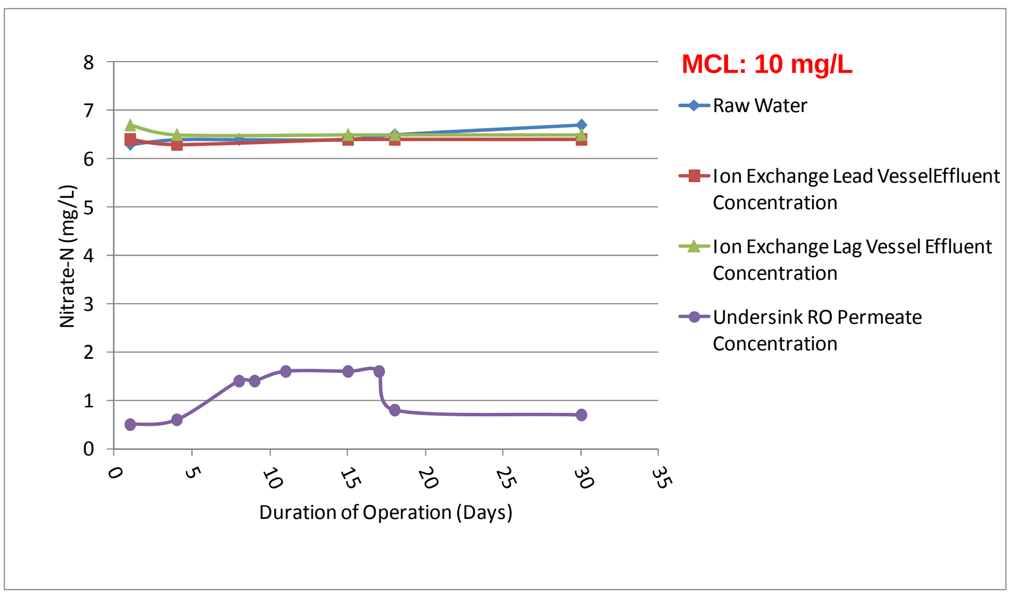

Figure 40 **Ion Exchange - Undersink RO System – Nitrate Trends**

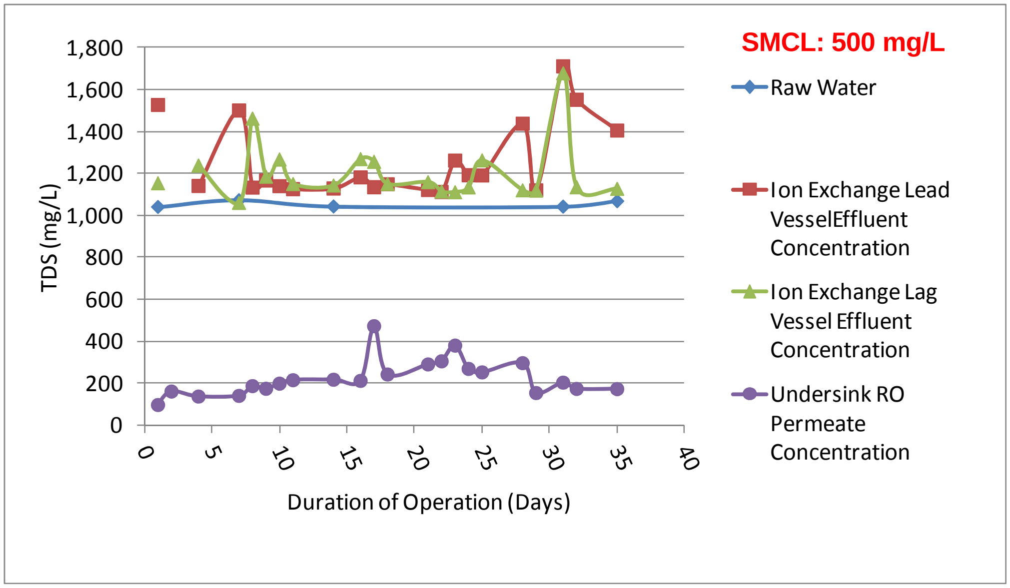

Figure 41 **Ion Exchange - Undersink RO System – Total Dissolved Solids Trends**

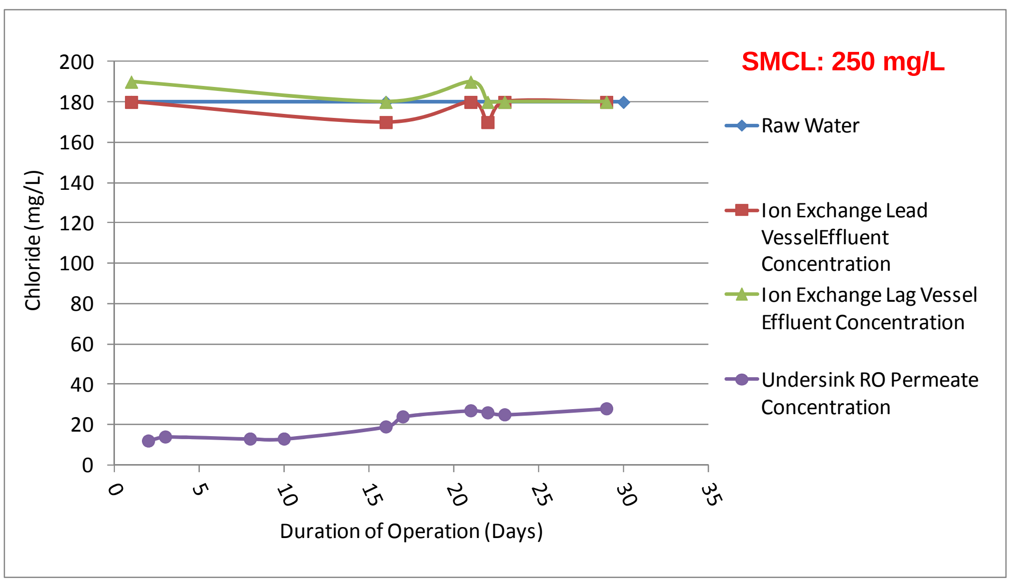

Figure 42 **Ion Exchange - Undersink RO System – Chloride Trends**

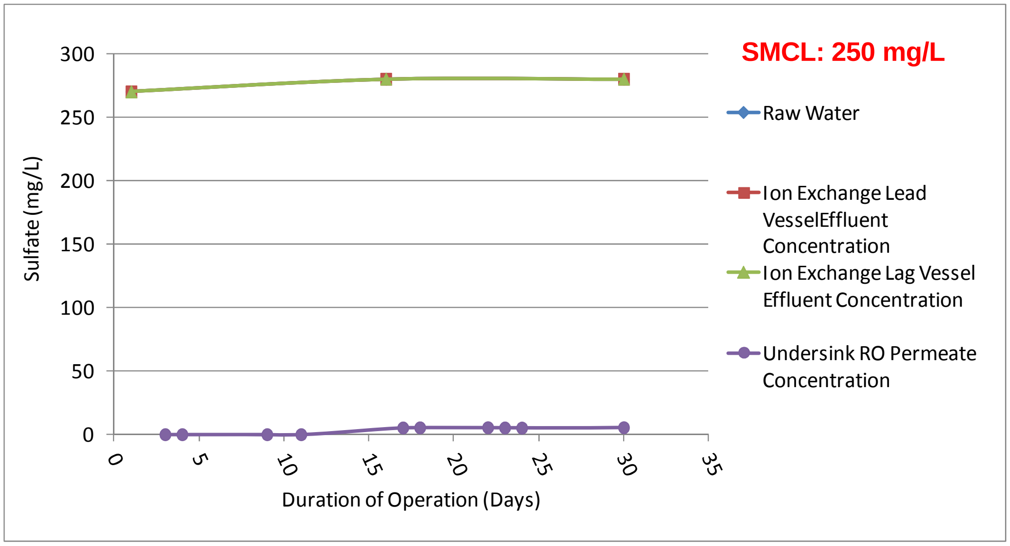

Figure 43 Ion Exchange - Undersink RO System – Sulfate Trend

4. Discussion

Results of the pilot test indicate that all three whole-house water treatment systems were able to remove hexavalent chromium to very low concentrations. In addition, results indicate that the whole-house RO and the hybrid RO-IX systems can meet the primary and secondary drinking water standards, if necessary, for the water quality tested. Post-IX, undersink RO treatment, if deemed necessary, will allow meeting the primary and secondary drinking water standards at the kitchen and other designated taps.

The effectiveness of the treatment is expected to depend on the groundwater quality, which is variable in Hinkley. It is anticipated that each installation will be unique, requiring assessment prior to installation. The pilot study provided design and operational criteria considerations for the whole-house water treatment systems. Results from the pilot testing were used to develop and evaluate the replacement water supply alternatives described in the Feasibility Study.

The following discussion focuses on the installation, startup, and operational considerations should these systems be considered for whole-house use.

4.1 Ion Exchange System

4.1.1 Installation and Startup Considerations

Data collected during the pilot study suggests that the IX resin flushing will be required for the initial 2 to 4 hours prior to bringing the IX system online for whole-house use at startup and after each IX vessel replacement (Section 3.2.1). Flushing involves running the system for 2 or 4 hours whenever a resin vessel is replaced with a new vessel and discharging this IX treated water to waste. Additionally, the IX system provider should flush the resins prior to installation.

4.1.2 Spent IX Resin Disposal

Based on the pre-disposal analysis performed during the pilot study the spent resin is non-hazardous waste and can be sent back to resin supplier’s facility for appropriate handling and disposal.

4.1.3 IX System Whole-House Treatment Deployment Considerations

The results show that IX can reduce hexavalent chromium to the very low concentrations specified in the Order and meet primary MCLs for some additional contaminants of concern, including arsenic and uranium. However, if all primary and secondary MCLs were required to be met, including for wells currently exceeding SMCLs for TDS, chloride, or sulfate, IX may need to be augmented with RO treatment. Whole-house IX treatment followed by whole-house RO (or whole-house RO as a standalone treatment system) presents significant brine management challenges. However, an IX system augmented with undersink RO (Section 3.4.2), would address the TDS, chloride, and sulfate concerns for drinking water and meet the primary and secondary standards for drinking water at the kitchen and other designated taps. Undersink RO would treat the aesthetic water quality parameters for the water used for drinking and cooking (at the kitchen tap).

4.2 Reverse Osmosis System

4.2.1 Installation and Operational Considerations

Several installation and operational considerations need to be accounted for prior to whole-house use of RO. These installation and operational needs include:

- The RO system has a carbon pre-filter to remove particulate matter from the well water prior to water being treated by the softener, then by two-stage RO. This pre-filter needs to be replaced at least once a month for satisfactory operation of the system.
- The salt tank on the water softener needs to be refilled with salt every 5 to 10 days.
- The RO pumps are relatively noisy (greater than 70 dB); a noise shield is necessary to manage noise levels (less than 20 dB).

4.2.2 RO Brine Containment and Disposal

RO Brine Generation

The water softener system generates 100 to 250 gpd of softener brine depending on the raw water hardness. Wastewater volume produced by the whole-house RO treatment system is approximately 2,918 gpd for two-pass (one-stage) RO and 423 gpd for two-stage RO based on the water quality tested in this study.

RO Brine Containment

Typically, the liquid waste streams from RO and water softeners are sent to sewers or septic systems. Given the relatively large volumes of brine generated for whole-house RO treatment, it is recommended that whole-house treatment systems should contain RO brine generated in above ground storage tanks for offsite disposal. An above ground onsite storage tank of 4,000 gallons capacity is required for brine containment generated for a whole-house RO treatment. The daily volume of softener and RO brine requiring trucking and disposal from households with two-stage RO treatment is 423 gallons and a 4,000 gallons capacity onsite brine containment storage tank is recommended to reduce the truck trips for off-site hauling, as discussed below.

RO Brine Disposal Options

Based on the results of the pilot study, the whole-house RO brine and the softener brine are classified as a non-RCRA, , non- hazardous (California) waste and can be disposed of by: 1) transporting RO brine from the two-pass RO directly to a disposal site or 2) further concentrating the RO reject water through a two-stage RO whole-house treatment system for transport directly to a disposal site, Table 15 provides estimated truck trips per household to haul RO brine to a disposal site. Based on the RO brine generation, a waste truck up to 3,000 gallons of capacity[7] would be required two times per week for a two-stage RO to haul RO brine off site from each household. A licensed waste hauler would transport the RO brine off site for disposal.

[7] The actual volume of the contents is dependent upon the weight of the loaded truck as it relates to CALTRANS and USDOT requirements.

Table 15 Reverse Osmosis System - Estimated Truck Trips to Haul Liquid Wastes

Parameter	Two-Stage RO
Treated Water Flow (gpd)	660
RO Waste Flow (gpd)	257
Softener Waste Flow (gpd)	166
Total Waste Flow (gpd)	**423**
Septic Truck Volume (gal)	3,000
Allowable Volume for Hauling (gallons) without exceeding weight limits[8]	2,000
Estimated Brine Disposal Truck Trip per Week	**2**

Abbreviations:
gal = gallons
gpd - gallons per day
RO = reverse osmosis

4.3 Hybrid IX/RO or RO/IX System

4.3.1 Installation and Operational Considerations

Whole-House Hybrid Reverse Osmosis and Ion Exchange System

- The RO system has a fabric pre-filter to remove particulate matter from the well water prior to being treated by single pass RO. This pre-filter needs to be replaced at least once per month for satisfactory operation of the system.
- The RO system uses an NSF certified, potable-grade anti-scalant to inhibit upstream scale formation as result of the precipitation of sparingly soluble salts including calcium carbonate, calcium sulfate, barium sulfate, and strontium sulfate. Less common but equally problematic are silica and calcium fluoride scales. Anti-scalant inhibits scale formation and helps extend the RO system run times, reduce cleaning frequencies, and increase the overall productive life of the RO elements. The anti-scalant consumption rate for the product tested is typically 10 gallons per month for a 3,000 gpd system that was tested. The usage rate of anti-scalants will vary based on anti-scalant used.
- The RO pumps are relatively noisy (greater than 70 dB); a noise shield is necessary to manage noise levels (less than 20 dB).

8 Calculation based on 5,000 mg/L TDS and density of 69.59 lb/cf for that strength brine solution

- The IX resin will require flushing for the initial 2 to 4 hours to remove the leachable compounds prior to bringing the IX system online for whole-house use (Section 3.4.1). In addition, the IX system vendor should flush the resin before installation to minimize leachable compounds.

RO Brine Generation

The whole-house hybrid RO-IX system generated approximately 132 to 277 gpd of RO brine for this study during operation at 80% and 58% recovery respectively, based on the production of 660 gpd of treated water.

RO Brine Containment

Typically, the liquid waste streams from RO and water softeners are sent to sewers or septic systems. Given the relatively large volumes of brine generated for whole-house RO treatment, it is recommended that whole-house treatment systems should contain RO brine generated in above ground onsite storage tanks (4,000 gallons capacity) for off site disposal. A licensed waste hauler would transport the RO brine off site for disposal.

RO Brine Disposal Options

Based on pilot study data, the whole-house RO brine is classified as non-RCRA, non-hazardous (California) waste and can be disposed of by transporting RO brine directly to a disposal site, Table 16 provides estimated truck trips per household to haul RO brine to a disposal site. Based on the RO brine generation, a waste hauler truck up to 3,000 gallons of capacity[9] would be required once every two weeks to haul RO brine off site from each household.

Ion Exchange System and Undersink RO

Section 4.1 provides installation and operational considerations for the whole-house IX system.

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[9] The actual volume of the contents is dependent upon the weight of the loaded truck as it relates to CALTRANS and USDOT requirements.

Undersink RO Brine Generation

The undersink RO system generates approximately 120 gpd of RO brine based on the production of 40 gpd of RO treated water.

Undersink RO Brine Disposal Options

Typically, the liquid waste streams from undersink RO is sent to sewers or septic systems. The undersink RO brine analysis (Table 14) indicates the concentrations of the brine constituents are acceptable to be discharged to the septic systems based on whole-house and kitchen water use. Combining whole-house ion exchange with undersink RO can minimize RO brine generation as the volume of water generated for drinking and cooking is relatively small compared to whole-house needs. Undersink RO produces about 3 gallons of brine for every 1 gallon of treated water produced. This small volume is not expected to have a negative impact on home septic systems. The estimated undersink RO brine generated is 27 gpd per household for a daily demand of 3 gpd per resident and 3 residents per household.

Table 16 Hybrid RO-IX System - Estimated Truck Trips to Haul Liquid Wastes

Parameter	RO and IX
Treated Water Flow (gpd)	660
RO Waste Flow (gpd)	132
Total Waste Flow (gpd)	**132**
Septic Truck Volume (gal)	3,000
Allowable Volume for Hauling (gallons) without exceeding weight limits[10]	2,000
Estimated Waste Disposal Truck Trips Every Two Weeks	**1**

Abbreviations:
gal = gallons
gpd = gallons per day
IX = ion exchange
RO = reverse osmosis

4.4 Water Quality Monitoring Program Recommendations

This section provides water quality monitoring recommendations to maintain satisfactory performance of the whole-house water treatment systems. Water quality in the first year of operation would need to be monitored more frequently; monitoring

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[10] Calculation based on 5,000 mg/L TDS and density of 69.59 lb/cf for that strength brine solution

could decrease in subsequent years as water chemistry is better understood and the system operation is further optimized. The monitoring frequency for each system is recommended to monitor the performance of the technology for the removal of contaminants and any impacts of treatment on the water quality. If the replacement water has to meet the primary and secondary drinking water standards[11] then additional water quality monitoring is necessary.

4.4.1 Ion Exchange System

The proposed water quality monitoring for the IX treated product water includes:

- Biweekly monitoring (once every 2 weeks) for the first 6 months – total chromium, hexavalent chromium, and nitrate. Monitoring frequency for these parameters can be significantly reduced (monthly or quarterly) after obtaining the initial performance data for each individual well (e.g., resin replacement timelines).
- Additional monitoring may include:
    - Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

4.4.2 Reverse Osmosis System

The proposed water quality monitoring for the RO treated product water includes:

- Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for total chromium and hexavalent chromium.
- Additional monitoring may include:

---

11 California primary and secondary drinking water standards do not apply to private domestic wells; primary drinking water standards are mandatory and enforceable in public water systems serving 15 or more connections, while secondary standards are not mandatory or enforceable but were developed as guidelines to assist public water systems in managing aesthetic considerations such as taste, color, and odor.

- Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

4.4.3 Hybrid System

Whole-House Hybrid Reverse Osmosis and Ion Exchange System

The proposed water quality monitoring for the RO treated product water includes:

- Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for total chromium and hexavalent chromium.
- Additional monitoring may include:
    - Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

The proposed water quality monitoring for the IX treated product water includes:

- Monthly monitoring for the first 6 months – total chromium, hexavalent chromium, and nitrate. Monitoring frequency for these parameters can be significantly reduced (monthly or quarterly) after obtaining the initial performance data for each individual well (e.g., resin replacement timelines).
- Additional monitoring may include:
    - Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

Ion Exchange System and Undersink RO

The proposed water quality monitoring for the IX treated product water includes:

- Biweekly monitoring (once every 2 weeks) for the first 6 months – total chromium, hexavalent chromium, and nitrate. Monitoring frequency for these parameters can be significantly reduced (monthly or quarterly) after obtaining the initial performance data for each individual well (e.g., resin replacement timelines).
- Additional monitoring may include:
  - Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

The proposed additional water quality monitoring for the undersink RO treated product water includes:

- Quarterly monitoring at 25 percent of the installations – Monitor 25 percent of the installed systems each quarter for pH, alkalinity, TDS, chloride, sulfate, arsenic, and uranium, and rotation of the sampling locations to obtain full coverage of all systems in a year.

4.5 Operations and Maintenance

Throughout the year, the whole-house water treatment systems will require varying forms of preventative maintenance. Below is a summary of what customers can typically expect for each system. A telemetry system to monitor the RO and IX units can be installed. The frequency and duration of service calls will ultimately depend on water quality and use at each household. Service calls may be more frequent in the first year of operation, but will likely decrease in subsequent years as water chemistry is better understood and system operation is further optimized. All of the whole-house water treatment systems will need to be housed in temperature-controlled enclosures to prevent any damages to the system as a result of extreme weather conditions including but not limited to freezing temperatures, dust storms, high temperature conditions, and other events.

4.5.1 Ion Exchange System

The pilot testing indicates that the vessel replacement will occur approximately every 30 to 45 days based on breakthrough for hexavalent chromium (Figure 3) for wells with water quality like G-5R; higher quality wells will require less frequent vessel replacement. The domestic wells with high nitrate concentrations may require more frequent vessel replacement.

A red light on the IX vessels will indicate that the vessel requires replacement. When the indicator light comes online the service company will be notified (via telemetry) that a vessel replacement is required. The vendor will contact the homeowner and an appointment will be scheduled to replace the vessel. During the visit, the technicians will also check the system for leaks and perform any additional preventative maintenance as needed. The pre-filter on the system for particulate removal would require replacement every month.

4.5.2 Reverse Osmosis System

RO membranes are maintained and replaced on a pre-determined schedule (6 months to 1 year). The vendor would contact the homeowner to set up an appointment to maintain or replace the membranes. During the service call, the technician would check the system for leaks and replace equipment as needed. The salt tank on the water softener would need to be filled when the indicator light is illuminated. Addition of salt to the tank is required every 5 to 10 days. The pre-filter on the system for particulate removal would require replacement as well. Replacement frequency for pre-filter depends on the water quality.

4.5.3 Hybrid System

Whole-House Hybrid Reverse Osmosis and Ion Exchange System

The RO system and IX system would be maintained and replaced on a pre-determined schedule. The vendor representatives would contact the homeowner to set up an appointment for maintenance and/or replacement. During the visit, the technician would also check the system for leaks and perform any additional preventative maintenance on the RO unit as needed. Additional controls can be implemented to notify the service company that the RO unit requires maintenance or the IX resin vessel requires replacement.

Ion Exchange System and Undersink RO

The operation and maintenance for the IX system is similar to that described in Section 4.5.1 above. The undersink RO system includes a replaceable treatment component critical to the efficiency of the system. The vendor representatives would contact the homeowner to set up an appointment for maintenance and/or replacement every quarter. The filter life indicator tracks the filter capacity. Upon reaching full capacity, the flow from the faucet would shut off or slow to a trickle. This shutdown would prevent the effluent contaminant level from exceeding the USEPA's maximum contaminant level or acceptable drinking water standard under normal operating conditions. During site visits, the vendor representative would test the product water to verify that the system is performing satisfactorily. The vendor representative would replace both the pre-filter and post-filter cartridges and any auxiliary cartridges to restore service. Annual replacement of the membranes is recommended to maintain satisfactory and reliable operation of the system.

4.5.4 Energy Requirements

Based on daily energy monitoring during the pilot testing, the IX system had the lowest daily power usage of the systems, at approximately 0.7 kilowatt-hours per day (kWh/day) to meet the daily water demand (660 gpd). The RO system consumed 15 kWh/day of power to meet the daily water demand; while the hybrid RO-IX system consumed 3 kWh/day to meet the daily water demand. For whole-house installation, additional power consumption anticipated for daily usage is 10 kWh/day to account for baseline power use (e.g., including baseline telemetry, lighting), ancillary equipment including booster pumps to provide treated water for whole-house use, and heating and cooling for the system. The daily power consumption for the whole-house water treatment units can range from approximately 11 kWh/day to 25 kWh/ day depending on the system in use.

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5. Rationale for Deployment of Whole-House Water Treatment Systems

5.1 Domestic Well Water Quality and Treatment Goal

The deployment of whole-house water treatment systems will require tailoring the treatment to individual homes based on the domestic water quality and treatment goals. For instance, domestic wells with moderate nitrate (< 8 mg/L as N) and TDS concentrations (< 500 mg/L) can implement a whole-house IX system and remove hexavalent chromium to less than 0.06 µg/L. Domestic wells with moderate to high nitrate (> 8 mg/L as N) and TDS concentrations (> 500 mg/L), if necessary, will require additional treatment to meet the primary and secondary standards for drinking water. IX and undersink RO can be a potential solution, if necessary, meet all the primary and secondary MCLs at the kitchen tap and other designated taps.

5.2 Device Certification

All of the equipment and materials pilot tested are NSF/ANSI 61 and NSF/ANSI 60 certified for drinking water application. However, because there is no MCL for hexavalent chromium, none of the whole-house water treatment units have CDPH device certification for hexavalent chromium removal.

CDPH point-of-entry (POE) device certification requirements set forth under 22 CCR §64420 do not strictly apply for whole-house treatment at an individual well (i.e., due to the absence of an MCL for hexavalent chromium and because private domestic wells are not regulated by CDPH). If POE certification is required, CDPH would need to approve the technology based on the pilot test results.

5.3 Deployment Guidance Matrix

Table 17 provides an overview of technologies evaluated during this study summarizing the performance of each system.

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ARCADIS

Attachment A

Whole-House Water Treatment Pilot Study – Test Plan and Responses to Comments

ARCADIS

Whole House Water Treatment Pilot Study – Test Plan

ARCADIS

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MEMO

To:
Lauri Kemper, Assistant Executive Officer
California Regional Water Quality Control Board
Lahontan Region

Copies:
Kevin Sullivan
Jeff McCarthy
Drew Page
Bob Doss
Edward Means
Jennifer Beatty

From:
Sunil Kommineni
Bhavana Karnik

Date:
September 27, 2011

ARCADIS Project No.:
RC000699.0074

Subject:
Pilot Testing of Whole House Water Treatment Systems
PG&E Hinkley Compressor Station, Hinkley, California

1. Introduction

This plan describes proposed procedures to evaluate the feasability of using commercially available whole house treatment systems for chromium removal in Hinkley, California. This test is necessary as there is very little data available on the ability and efficiency of these systems to remove levels of chromium in the range of less than 10 micrograms per liter (µg/L).

Based on literature review, desktop assessment, and discussions with several vendors on product availability and applicability, ARCADIS has recommended pilot testing three systems: one ion exchange (IX), one reverse osmosis (RO) and one hybrid RO – IX. Pilot testing of these systems will be conducted for a period of up to three months at a location near the Hinkley Compressor Station. Three months of pilot testing will allow obtaining critical performance information such as run times or run lengths for breakthrough of Cr(VI) for IX systems. Pilot testing will be performed using water from one of the active Gorman wells (Gorman 1R) and the systems will be designed to treat 1-10 gallons per minute (gpm), indicative of a whole house treatment system.

The California Department of Public Health (CDPH), Title 22 requirements do not apply to private wells with no interconnects. The CDPH requirements are only applicable for systems that supply water to more than 15 connections with a central treatment and distribution system or for interconnects among the private wells. The CDPH compliance requirements for whole house treatment systems are listed under Title 22, Division 4, Chapter 15, Article 2.5, Section 64417. According to CDPH, the equipment used in the pilot study will have to conform to the American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 and chemicals have to be ANSI/NSF Standard 60 certified for potable water use. In addition, CDPH requires that the RO systems used for whole house treatments have Standard 58 device certification and ion exchange systems have Standard 53 certification prior to residential installations. ARCADIS has requested the whole house equipment vendors to acquire and provide these certifications prior to residential installation.

1.1. Testing Objectives

The pilot testing objectives include the following:

- Assess the ability of whole house treatment systems to safely, effectively, and reliably remove Cr(VI) from groundwater to very low concentrations.
- Assess the operability and durability of these systems to perform under extreme conditions. As each installation would be unique, heat, pressure, and water demand will vary from house to house.
- Identify any potential secondary water quality issues associated with leaching of by-products or other materials from the treatment systems, which may affect the treated water quality.
- Confirm the design and operating criteria for the treatment systems and their disposal options, including quantities and qualities of residuals that would be generated and their ulitmate disposal options.

1.2. Source Water Quality

Table 1 summarizes the water quality results for the Gorman 1R test well from a grab sample collected in August 2011. In addition to the general water quality parameters, known parameters that may impact the IX and RO performance were analyzed. Silica, phosphate, nitrate and sulfate are some of the known parameters that impact the IX performance by competing with contaminants on the ion exchange media. Similarly, key parameters that impact RO performance include hardness, total dissolved solids (TDS), chloride, and metals (e,g., aluminum, barium, boron, iron, manganese, silica, and strontium). Gorman 1R well water can be categorized as groundwater containing high nitrate, sulfate, TDS, radionuclides (uranium) and metals. The sulfate and nitrate will impact the run lengths for breakthrough for IX systems. The high concentrations of calcium, barium, strontium and silica impact the RO performance by fouling the membranes and limiting the membranes recoveries (product water to feed water ratio). Total chromium and Cr(VI) concentrations from the sampled well were 3.5 µg/L and 4.2 µg/L, respectively. Water quality data indicates exceedances of current maximum contaminant level (MCL) for uranium and gross alpha activity. Results also indicate exceedances of aesthetic goals or secondary MCLs for TDS, chloride and sulfate.

In preliminary discussions with the Water Board staff, there was interest expressed in locating the pilot test on another supply well. The concern expressed was that the use of the lower-quality Gorman 1R well might produce results that underestimate the performance of the treatment system(s). ARCADIS understands this concern,and reviewed the water quality of the wells along the Sommerset and Thompson Road. The TDS concentrations in the monitoring wells along the Sommerset and Thompson Road varied between 1,100-2,000 milligrams per liter (mg/L). The TDS concentration in the Gorman 1R well is 1,900 mg/L which is within the range of TDS observed in the wells along Sommerset and Thompson. The whole house treatment systems should be able to handle variability in water quality including TDS.

2. Pilot System Description

This section provides a description of the proposed pilot units.

2.1. Test Site Overview

Pilot testing will be conducted near the Hinkley Compressor Station using water from the Gorman 1R well, currently used for agricultural irrigation. While actual ground water quality for a given domestic well in the Town of Hinkley may vary, the Gorman 1R was selected based on its challenging water chemistry, respresentative of a “worst case scenario”. The Gorman 1R well is currently pumped at 50 gallons per minute (gpm) at a pressure of 60-100 pounds per square inch (psi). Figure 1 illustrates the current piping configuration of Gorman 1R well.

During pilot study, the influent and effluent streams will be monitored for key water quality parameters to determine the performance of each whole house treatment system. Following sampling, the treated water and brine streams from the pilot units will be collected, blended, monitored and disposed. Because the treated and brine streams will be combined, the blended stream will have similar water quality to the water initially pumped from the well. Figure 2 provides an overview of the pilot facility connections for the three pilot systems.

2.2. Envirogen Anionic Exchange System

Envirogen Technologies, Inc. (Envirogen) will provide the IX treatment system (Model # A-0142, utilizing FlexSorb™) for pilot testing. The proposed Envirogen unit is an IX system configured in a lead-lag setup, capable of treating a flow up to 8 gpm. The system will have a pre-filter prior to the unit for any particulate removal. The selected resin, SBG1 manufactured by Resintech, Inc., is a high capacity, shock resistant, gel, Type 1, strongly base anion exchange resin supplied in the chloride or hydroxide form. Exhausted resin will be returned to Envirogen for appropriate analysis and disposal. Resintech SBG1 is NSF/ANSI 61 certified. Envirogen's system is constructed with NSF 61 certified materials. Envirogen has to apply for the CDPH device certification using the information collected from the pilot study. Attachment A.1 has additional details of the Envirogen whole house water treatment system.

2.3. Kinetico Reverse Osmosis System

Kinetico Water Systems (Kinetico) will provide a two-pass RO system for pilot testing. A carbon pre-filter and softener will be installed prior to the RO to remove particulate matter and calcium, respectively. Water from the softener will pass through the first pass RO. Permeate from the first pass will be collected and pumped through a second pass RO. Kinetico's Mach 2060 S and Dechlorinator 1060 are NSF 61 certified. Kinetico's commercial grade RO system TX 1440 does not have NSF 61 certification. Kinetico will have to apply for the CDPH device certification and possibly use the information collected from this pilot study for the application. Attachment A.1 provides system details for the Kinetico's whole house water treatment system.

2.4. Purolite/ACWA Hybrid System

Purolite, Inc. and ACWA Clear, LLC will provide a hybrid RO – IX system for pilot testing in a lead-lag configuration. A pre-filter will be installed to remove particulate matter prior to RO – IX treatment. The RO unit will be single pass RO (L-84A); the IX system will use Purolite's A600E/9149 (A600 HC) resin. A600 HC is a clear gel Type 1 strong base anion exchange resin with high operating capacity supplied in the chloride form as spherical beads. The exhausted resin will be returned to Purolite/ACWA for appropriate testing and disposal. Purolite's A600E/9149 resin is NSF/ANSI 61 certified. ACWA's proposed whole house treatment system is NSF 61 certified. Purolite/ACWA will have to apply for the CDPH device certification and possibly use the test results from this study for the application. Attachment A.1 provides system details for the Purolite/ACWA's whole house water treatment system.

3. Pilot Test Program

The three whole house water treatment systems will be tested over a period of three months (see Table 2 for detailed schedule). PG&E may extend the pilot testing of one or more units beyond three months if deemed necessary to evaluate the performance of the treatment systems for same, similar or different source waters or if required to satisfy any additional requirements of CDPH or Regional Water Quality Control Board.

This section provides details of the proposed pilot test program.

3.1. Sampling and Monitoring Plan

The water quality monitoring parameters to track the treatment systems performance are shown in Table 3. Supplies needed to conduct the field monitoring, including names of suppliers and catalog numbers are summarized in Table 4. ARCADIS field technicians will be responsible for procuring the necessary supplies for testing and conducting the field monitoring. ARCADIS field technicians will also collect, prepare chain of custodies, and send laboratory samples for analysis to the Underwriters Laboratory (Southbend, IN) .

Figure 3 shows sampling and monitoring locations for the pilot study. Table 5 provides sampling and monitoring plan for the raw water and the blended water (prior to disposal). Table 6 provides the sampling and monitoring plan for the Envirogen's whole house water treatment system. Table 7 provides the sampling and monitoring plan for the Kinetico's whole house water treatment system. Table 8 provides the sampling and monitoring plan for the Purolite/ ACWA's whole house water treatment system.

Critical water quality parameters for ion exchange systems that will be measured include Cr(VI), total chromium, nitrate, sulfate, silicate, phosphate, uranium, and pH. Other chemical and physical parameters, including temperature, conductivity, turbidity, and alkalinity will be routinely measured to fully characterize water quality and evaluate system performance. Nitrosamines (including N-ntirosodimethylamine (NDMA)) and formaldehyde, which have been found to leach from ion exchange resins, will also be measured during startup (after 4 and 24 hours) and at midpoint through operation to assess any leaching that may occur. In addition, a broad scan for tentatively identified compounds (TICs) for both volatile organic compounds (VOCs) and synthetic volatile organic compounds (SVOCs) will be conducted initially and at midpoint through operation to ensure that IX treatment does not introduce any additional contaminants of concern. Besides chemical and physical water quality analyses, operating parameters will be recorded to monitor operating conditions for the ion exchange systems. Monitored operating parameters include flow rate, empty bed contact time (EBCT), and breakthrough bed volumes.

Critical water quality parameters for RO systems that will be measured include Cr(VI), total chromium, alkalinity, total hardness, total organic carbon (TOC), total dissolved solids (TDS), total suspended solids (TSS), chloride, radionuclides and select metals. Other chemical and physical parameters, including permeate and brine flow, feed pressure, concentrate pressure and permeate pressure, temperature, conductivity and pH will be routinely measured to fully characterize water quality and evaluate system performance.

3.1.1. Additional Monitoring

RO Brine

One round of special monitoring will be conducted for the RO brine streams. The water quality information from special monitoring will facilitate brine disposal evaluation. Table 9 lists the laboratory parameters that will be monitored during special monitoring of RO brine.

Spent Ion Exchange Resin

The spent ion exchange resins will be analyzed for leachates using the toxicity characteristic leaching procedure (TCLP) and California Waste Extraction Test (CWET). Additional tests will also be conducted for radionuclides and uranium. Spent resin will be classified as a regulated radioactive waste if the uranium concentration exceeds 0.05 percent by weight. The results of the spent resin tests will assist in the evaluation of alternatives for waste handling and disposal.

3.2. Data Analysis

3.2.1. Data Collection

All the data field and laboratory data will be collected in accordance with the plan described in this document. Operational logs will be maintained during testing to track system operation. The operational logs will include any data collected during the bi-weekly field monitoring and any changes in operating parameters, as well as documentation of any significant events or shutdowns.

3.2.2. Data Processing

Data collected from the field and laboratory monitoring will be processed and reviewed on a weekly basis. Senior technical experts from the project team will review the data for quality assurance/quality control (QA/QC) purposes. This information will be transcribed into an electronic database. The data will be summarized in tables and graphs and presented in a final report.

3.2.3. Quality Assurance/Quality Control (QA/QC)

Cr(VI) and total Cr will be analyzed using ion chromatography (EPA Method 218.6) and ICP-MS methods (EPA Method 200.8), respectively, by an Environmental Laboratory Accreditation Program (ELAP)-certified laboratory. For Cr(VI), the method detection limit (MDL) is 0.020 µg/L and the method reporting limit (MRL) is 0.05 µg/L. The total Cr MRL should be 1 µg/L or lower.

All field and laboratory parameters will be analyzed using approved methods. All field and process equipment will be calibrated in accordance with manufacturer specifications for each instrument. Certified standard solutions and QA/QC procedures will be used to test the functionality and accuracy of each instrument within the range of measurements and a frequency specified by the manufacturer, or at least once per month. Process equipment, such as pumps and flow meters, will be calibrated by the equipment vendors before the pilot units are brought online to avoid disturbing the operation of the units during the test period unless unexpected results warrant recalibration.

3.3. Pilot Report

The information collected during the pilot study will be documented by ARCADIS in a draft pilot report submitted to PG&E. Comments will be incorporated into the draft and a final report prepared for submittal to the California Regional Water Quality Control Board.

Attachments

A.1	Cutsheets and Layout for Whole House WaterTreatment Systems
A.2	NSF Certificates for Whole House Water Treatment Systems

Tables

1	Gorman 1R Well Water Quality (August 2011)
2	Pilot Test Schedule
3	Field and Laboratory Water Quality Monitoring Parameters
4	Field Monitoring Instruments and Test Kits
5	Sampling and Monitoring Plan for Raw Water and Blended Water
6	Sampling and Monitoring Plan for Envirogen's Whole House Water Treatment System
7	Sampling and Monitoring Plan for Kinetico's Whole House Water Treatment System
8	Sampling and Monitoring Plan for Purolite/ACWA's Whole House Water Treatment System
9	RO Comprehensive Brine Water Quality Monitoring Plan

Figures

1	Gorman 1R Well Connection to Connection Details
2	Pilot System Schematic
3	Pilot Sampling and Monitoring Locations

Tables

Table 1 Gorman 1R Well Water Quality (August 2011)

Parameters	Unit	Result	MCL/ SMCL[1]
General			
Alkalinity, Total	mg/L as $CaCO_3$	161	-
Color	Pt/Co units	5	15[2]
Hardness, Total	mg/L as $CaCO_3$	1,100	-
Specific Conductance	µS/cm	3,100	900[2]
pH	pH units	7.4	7.4
Total Dissolved Solids (TDS)	mg/L	1,900	500[2]
Total Suspended Solids (TSS)	mg/L	10	-
Total Organic Carbon (TOC)	mg/L	1.39	-
Turbidity	NTU	1.00	1
Total Ammonia -N	mg/L	0.10	-
Anions			
Chloride	mg/L	520	250[2]
Fluoride	mg/L	0.2	2.0
Nitrate-N	mg/L	8.4	10
Nitrite-N	mg/L	< 0.01	1
Sulfate	mg/L	450	250[2]
Metals – Total			
Aluminum	µg/L	2	1,000
Barium	µg/L	72	1,000
Boron	µg/L	340	-
Calcium	mg/L	340	-
Chromium	µg/L	3.50	50
Copper	µg/L	1.40	1,300[3]
Iron	mg/L	0.02	0.3[2]
Lead	µg/L	1.00	15[3]
Magnesium	mg/L	56	-
Manganese	µg/L	2	0.5[2]
Nickel	µg/L	5.2	100
Potassium	mg/L	5.2	-
Silica, Total	mg/L	29	-
Sodium	mg/L	160	-

Parameters	Unit	Result	MCL/ SMCL[1]
Strontium	µg/L	3,800	-
Uranium	µg/L	46	30
Zinc	µg/L	88	5,000
Radionuclides			
Gross Alpha	pCi/L	43.6 +/- 3.2	15
Gross Beta	pCi/L	9.4 +/- 1.1	4
Radium-226	pCi/L	0.84 +/- 0.52	combined < 5pCi/L
Radium-228	pCi/L	0.64 +/- 0.53	
Radon-222	pCi/L	372 +/- 22	-
Additional			
Phosphorus, Total as P	mg/L	< 0.05	-
Cyanide, Total	mg/L	0.02	0.15
Hexavalent Chromium	µg/L	4.20	0.02[4]
Mercury	µg/L	0.1	0.002
Perchlorate	µg/L	0.76	6
Arsenic, Total	µg/L	2	6
Arsenic, Dissolved	µg/L	2	-
Atrazine	µg/L	0.1	1
Simazine	µg/L	0.07	4

Notes:

1. MCLs and SMCLs are from CDPH's Titles 17 and 22 California Code of Regulations for Drinking Water.
2. SMCL for the listed contaminant.
3. Action Level.
4. CDPH's Public Health Goal.

Table 2 Pilot Test Schedule

Tasks	Anticipated Timelines
Pilot Test Plan Preparation	Weeks of September 12, 2011 – September 19, 2011
Pilot Unit Fabrication	Weeks of September 19, 2011 – October 17, 2011
Pilot Unit Delivery and Setup	Weeks of October 24, 2011 – October 31, 2011
Pilot System Startup, Leak Testing and Troubleshooting	Week of October 31, 2011
Conduct Pilot Testing	November 4, 2011 – February 4, 2012 (3 months)
Receive Final Laboratory Results	Week of February 13, 2012
Submit Pilot Test Draft Report	Week of March 12, 2012

Table 3 Field and Laboratory Water Quality Monitoring Parameters

Field Parameters	**Laboratory Parameters**
• Alkalinity • Total Hardness • Conductivity • Chlorine • pH • Temperature • Turbidity	• Aluminum • Barium • Boron • Chloride • Chromium (Total) • Copper • Hexavalent Chromium • Iron • Manganese • Nitrate • Nitrosamines • Strontium • Silicate • Sulfate • Total Dissolved Solids (TDS) • Total Organic Carbon (TOC) • Total Suspended Solids (TSS) • Total Phosphate • Turbidity • Uranium • BNA SVOCs • VOCs and TICS • Aldehydes / Ketones

Notes:

BNA SVOC = base, neutral, acid semi-volatile organic compounds including phenol and tentatively identified compounds (TICs)

Table 4 Field Monitoring Instruments and Test Kits

Item	Test Kit/Reagent	Catalog Number
pH, Temperature, Conductivity and TDS		
1	Myron L Company, Ultrameter II	6PIISI
Chlorine		
2	Hach DR-890	4847000
3	Hach DPD Free Chlorine Reagent	2105569
Alkalinity and Total Hardness		
4	Hach AL-DT Digital Titrator	2063700
5	Hach Hardness Reagent Set	2272100
6	Hach Alkalinity Reagent Set	2271900
Turbidity		
7	Hach 2100Q Portable Turbidimeter	2100Q01

Table 5 Sampling and Monitoring Plan for Raw Water and Blended Water

Parameter	Monitoring Location	
	Raw Water	Blended Water
Field Monitoring		
Flow	2xW	2xW
Alkalinity	W	W
Conductivity	W	W
pH	W	W
Temperature	W	W
Total Hardness	W	W
Turbidity	W	W
Laboratory Monitoring		
Aldehydes/Ketones	S,MP	–
Anions - Chloride, Sulfate, Nitrate	BW	BW
BNA SVOCs	S,MP	–
Cr(VI)	2xW	2xW
Metals – Al, Ba, B, Ca, Fe, Mg, Mn, Si, Sr, U	BW	BW
Nitrosamines	S,MP	–
Phosphate (PO_4^{3-})	BW	BW
Radionuclides	M	M
Total Cr	2xW	2xW
TOC	M	M
TDS	M	M
TSS	M	M
VOCs and TICs	S,MP	–

Notes:
W: Weekly; BW: Once every two weeks; M: Monthly; S: Start-up (first 2 days);
MP – Midpoint through test period.
Radionuclides analysis will be conducted on water samples to measure gross alpha, gross beta particles radium and uranium.

Table 6 Sampling and Monitoring Plan for Envirogen's Whole House Water Treatment System

Parameter	Monitoring Location	
	TU1_S1	**TU1_S2**
Location Description	**Effluent from Lead IX Vessel**	**Effluent from Lag IX Vessel**
Field Monitoring		
Flow	2xW	2xW
Alkalinity	W	W
Conductivity	W	W
pH	W	W
Temperature	W	W
Total Hardness	W	W
Turbidity	W	W
Laboratory Monitoring		
Aldehydes/Ketones	–	S,MP
Anions - Chloride, Sulfate, Nitrate	BW	BW
BNA SVOCs	–	S,MP
Cr(VI)	2xW	2xW
Metals – Al, Ba, B, Ca, Fe, Mg, Mn, Si, Sr, U	M	BW
Nitrosamines	–	S*,MP
Phosphate (PO_4^{3-})	BW	BW
Radionuclides	M	M
Total Cr	2xW	2xW
VOCs and TICs	–	S,MP

Notes:
W: Weekly; BW: Once every two weeks; M: Monthly; S: Start-up (first 2 days);
MP – Midpoint through test period.
* Nitrosamines sampling will be conducted at first flush, after 4 hours, after 24 hours, and midpoint through the test period.
Radionuclides analysis will be conducted on water samples to measure gross alpha, gross beta particles radium and uranium.

Table 8 Sampling and Monitoring Plan for Purolite/ACWA's Whole House Water Treatment System

Parameter	Monitoring Locations			
	TU3_S1	TU3_S2	TU3_S3	TU3_S4
Location Description	**Permeate from RO**	**Brine from RO**	**Effluent from Lead IX Vessel**	**Effluent from Lag IX Vessel**
Field Monitoring				
Flow	2xW	2xW	2xW	2xW
Alkalinity	W	W	W	W
Conductivity	W	W	W	W
pH	W	W	W	W
Temperature	W	W	W	W
Total Hardness	W	W	W	W
Turbidity	–	–	W	W
Laboratory Monitoring				
Aldehydes/Ketones	–	–	–	S,MP
Anions - Chloride, Sulfate, Nitrate	BW	–	BW	BW
BNA SVOCs	–	–	–	S,MP
Cr(VI)	2xW	2xW	2xW	2xW
Metals – Al, Ba, B, Ca, Fe, Mg, Mn, Si, Sr, U	M	M	M	BW
Nitrosamines	–	–	–	S*,MP
Phosphate (PO_4^{3-})	BW	–	BW	BW
Radionuclides	BW	M	M	M
Total Cr	2xW	2xW	2xW	2xW
TOC	–	M	–	–
TDS	W	W	–	–
TSS	–	M	–	–
VOCs and TICs	–	–	–	S,MP

Notes: W: Weekly; BW: Once every two weeks; M: Monthly; S: Start-up (first 2 days); MP – Midpoint through test period.
* Nitrosamines sampling will be conducted at first flush, after 4 hours, after 24 hours, and midpoint through the test period. Radionuclides analysis will be conducted on water samples to measure gross alpha, gross beta particles radium and uranium.

Table 9 RO Comprehensive Brine Water Quality Monitoring Plan

General Parameters

- Biological Oxygen Demand (BOD) - 5 day
- Chemical BOD (5 day)
- Chemical Oxygen Demand (COD)
- Chlorine residual
- Color (PCU)
- Fecal Coliforms
- pH
- Solids, Dissolved
- Temperature
- Total Organic Carbon (TOC)
- Total Organic Nitrogen
- Total Phosphorus

Nitrification Parameters

- Ammonia-N
- Nitrate – N
- Nitrite-N

Anions

- Bromide
- Chloride
- Fluoride
- Sulfate

Metals

- Total Aluminum
- Total Antimony
- Total Arsenic
- Total Barium
- Total Beryllium
- Total Boron
- Total Cadmium
- Total Calcium
- Total Chromium
- Total Cobalt
- Total Copper
- Total Iron
- Total Lead
- Total Magnesium
- Total Manganese
- Total Mercury
- Total Molybdenum
- Total Nickel
- Total Potassium
- Total Selenium
- Total Silica
- Total Silver
- Total Sodium
- Total Strontium
- Total Thallium
- Total Tin
- Total Titanium
- Total Zinc

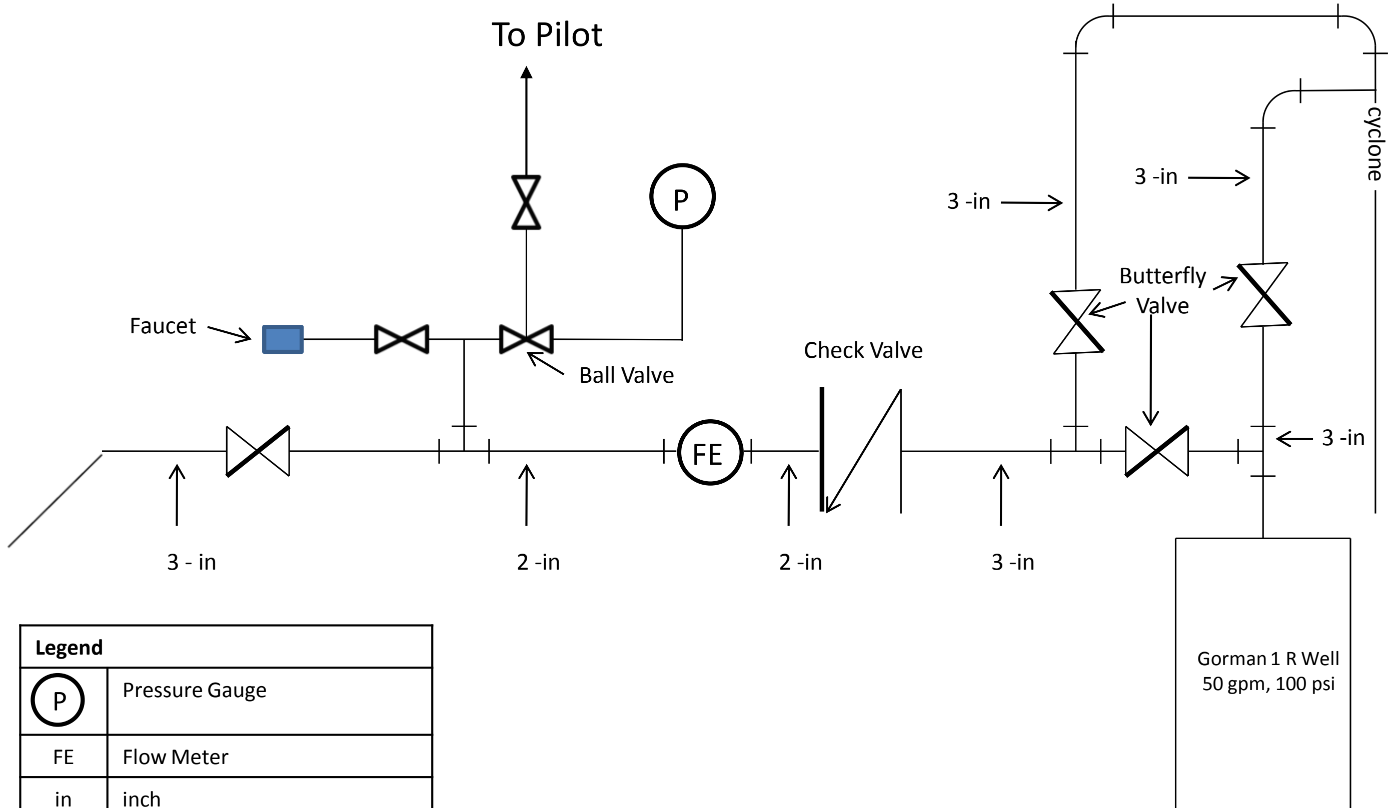
Additional Parameters

- Cyanide
- Oil and Grease
- Sulfide as S
- Sulfite as SO_3
- Surfactants
- Hexavalent Chromium

Figures

ARCADIS

Lauri Kemper
September 27, 2011



Legend	
P	Pressure Gauge
FE	Flow Meter
in	inch
gpm	gallons per minute

Pilot Testing of Whole House Water Treatment Systems
PG&E Hinkley Compressor Station, Hinkley, California
GORMAN 1R WELL CONNECTION DETAILS

Figure 1

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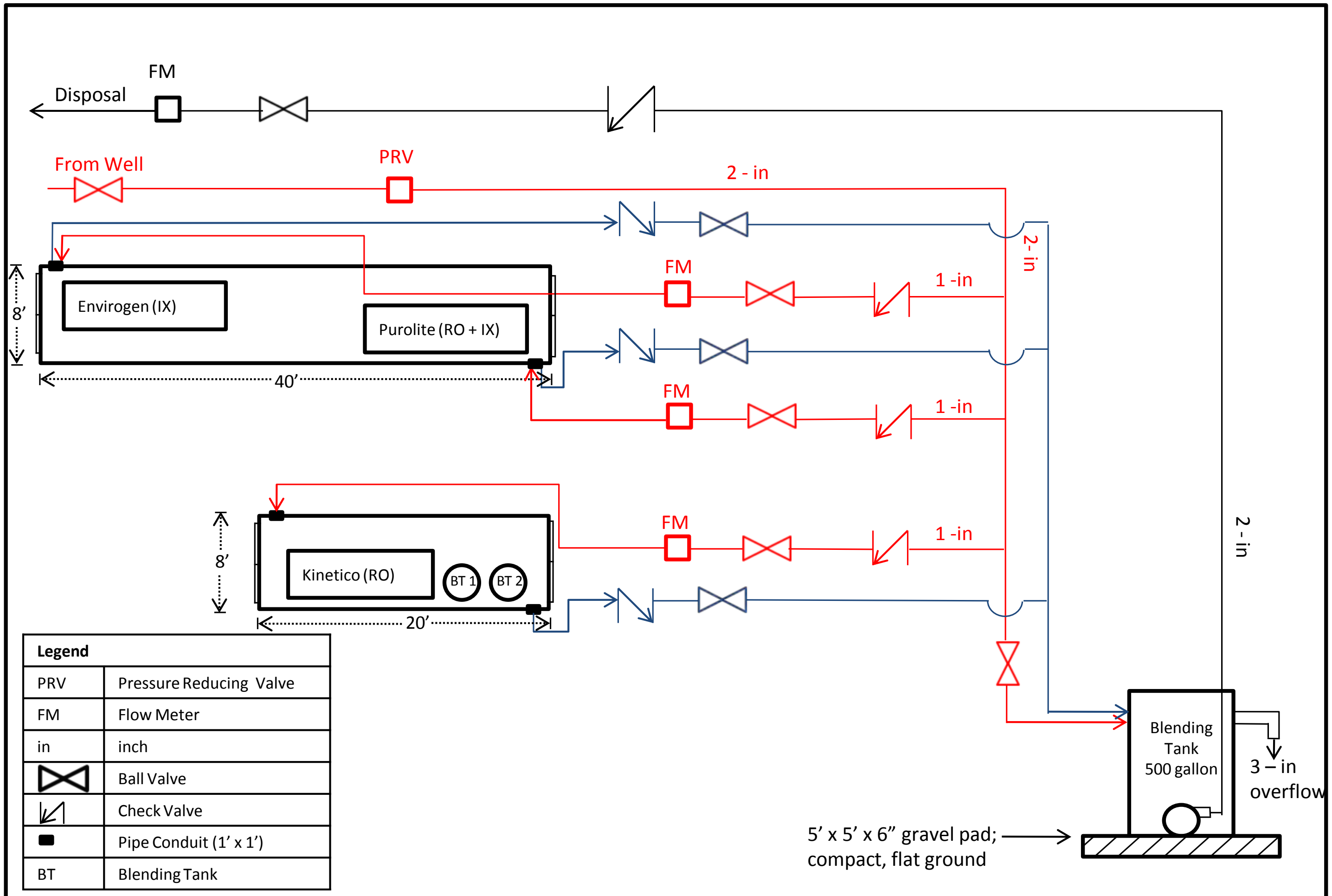
September 27, 2011



Pilot Testing of Whole-House Water Treatment Systems
PG&E Hinkley Compressor Station, Hinkley, California
PILOT SYSTEM SCHEMATIC

Figure 2

Table 7 Sampling and Monitoring Plan for Kinetico's Whole House Water Treatment System

Parameter	Monitoring Location			
	TU2_S1	TU2_S2	TU2_S3	TU2_S4
Location Description	**Effluent from Softener**	**Permeate from First Pass RO**	**Permeate from Second Pass RO**	**Combined Brine Stream from Two Pass RO**
Field Monitoring				
Flow	–	2xW	2xW	2xW
Alkalinity	–	W	W	W
Conductivity	–	W	W	W
pH	–	W	W	W
Temperature	–	W	W	W
Total Hardness	W	W	W	W
Laboratory Monitoring				
Anions - Chloride, Sulfate, Nitrate	–	–	BW	–
Cr(VI)	–	2xW	2xW	2xW
Metals – Al, Ba, B, Ca, Fe, Mg, Mn, Si, Sr, U	W‡	M	M	M
Phosphate (PO_4^{3-})	–	–	M	–
Radionuclides	–	–	BW	M
Total Cr	–	2xW	2xW	2xW
TOC	–	–	M	M
TDS	–	W	W	W
TSS	–	–	M	M

Notes:
W: Weekly; BW: Once every two weeks; M: Monthly; S: Start-up (first 2 days); MP – Midpoint through test period.
* Nitrosamines sampling will be conducted at first flush, after 4 hours, after 24 hours, and midpoint through the test period.
Radionuclides analysis will be conducted on water samples to measure gross alpha, gross beta particles radium and uranium.
‡Softener effluent will be moniotored for Ca and Mg on a weekly basis.

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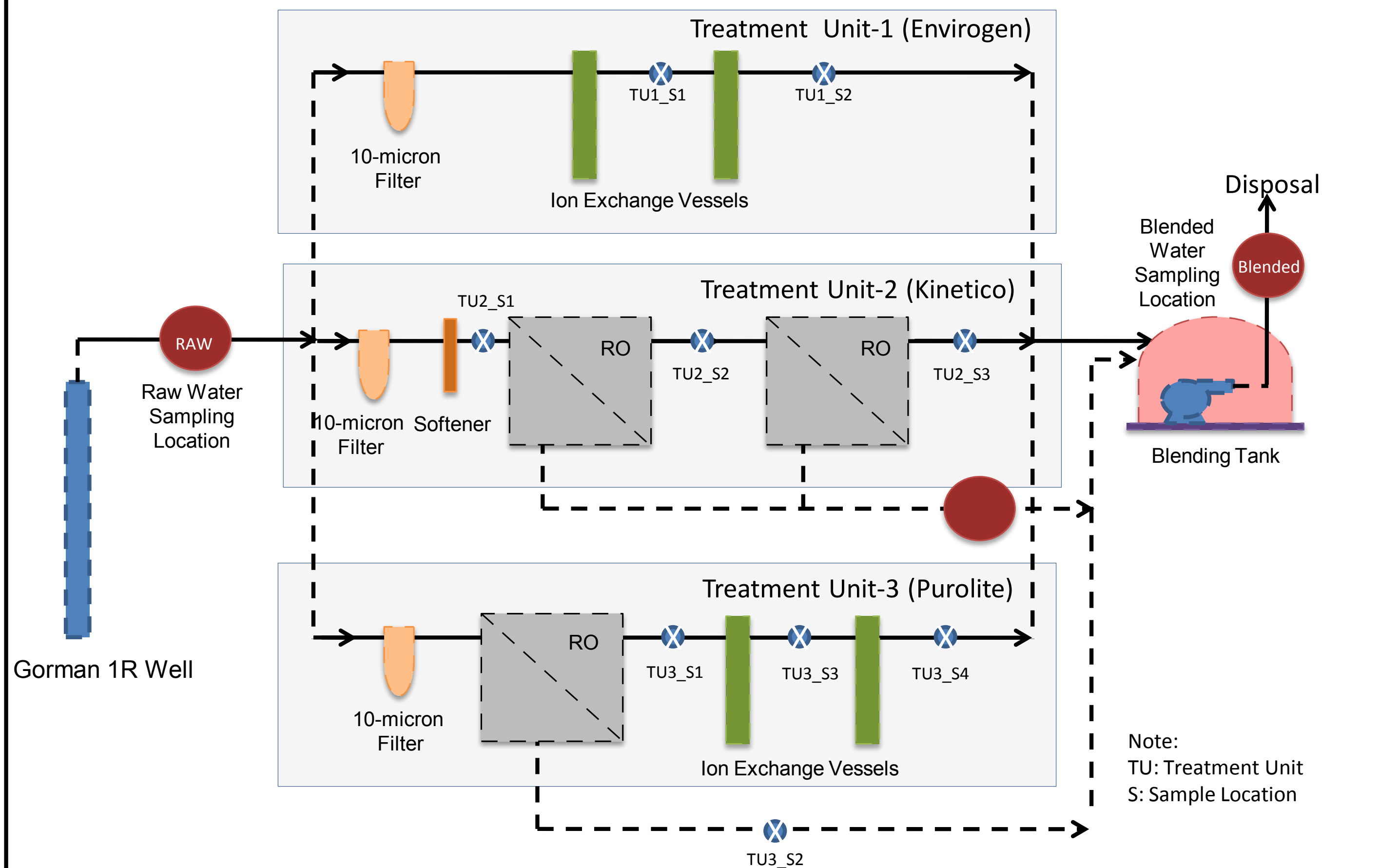
September 27, 2011



Pilot Testing of Whole House Water Treatment Systems, PG&E Hinkley Compressor Station, Hinkley, California PILOT SAMPLING AND MONITORING LOCATIONS	Figure 3

ARCADIS

Attachment A.1

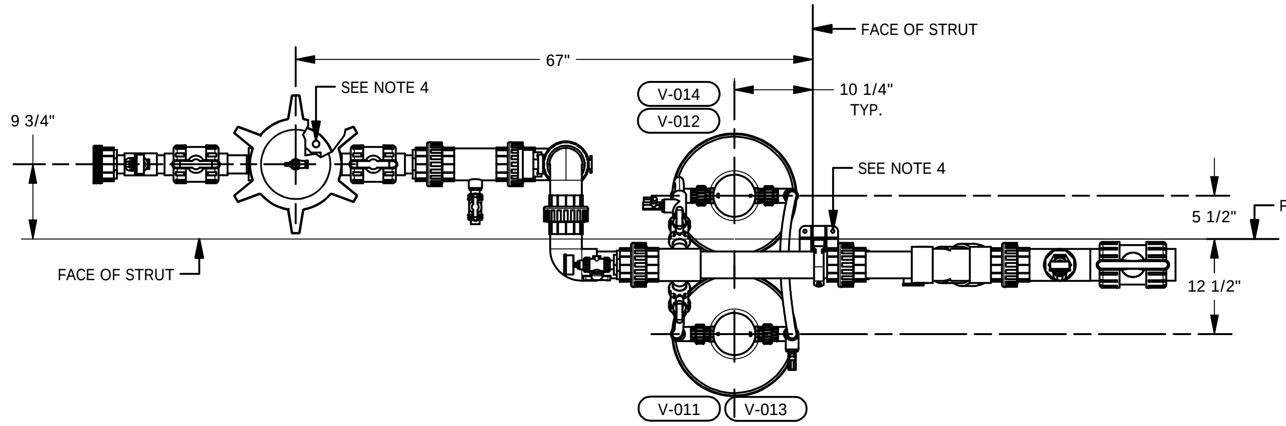
Cutsheets and Layouts for Whole House Water Treatment Systems

ARCADIS

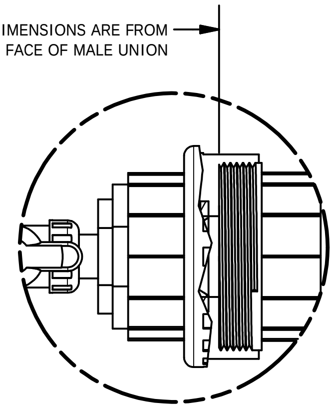
Envirogen Pilot System

ITEM	PART NUMBER	DESCRIPTION	QTY
1	A1-0152	INFLUENT PIPING ASSEMBLY, 16" VESSELS 1/ FILTER (SMALL SYSTEMS)	1
2	A1-0155	Y-STRAINER / EFFLUENT PIPING ASSEMBLY (SMALL SYSTEMS)	1
3	A1-0160	HEADER, 3" INFLUENT 1 BED (SMALL SYSTEMS)	1
4	A1-0161	HEADER, 3" EFFLUENT 1 BED (SMALL SYSTEMS)	1
5	A2-0357	VESSEL ASSEMBLY, 16"x65" (W/ 2 PORT MANIFOLD & DISTRIBUTOR)	2
6	A2-0369	GAUGE / UNION ASSEMBLY MALE 0-160 PSI (SMALL SYSTEMS)	1
7	A2-0370	GAUGE / UNION ASSEMBLY FEMALE 0-160 PSI (SMALL SYSTEMS)	1
8	A2-0382	STRUT SUPPORT ASSEMBLY, SINGLE (LENGTH AS REQUIRED)	1
9	A2-0389	SMALL SYSTEMS, VESSEL TO VESSEL HOSE CONNECTION	1
10	GENERAL SUPPLIER	CLAMP, 3" PIPE	2

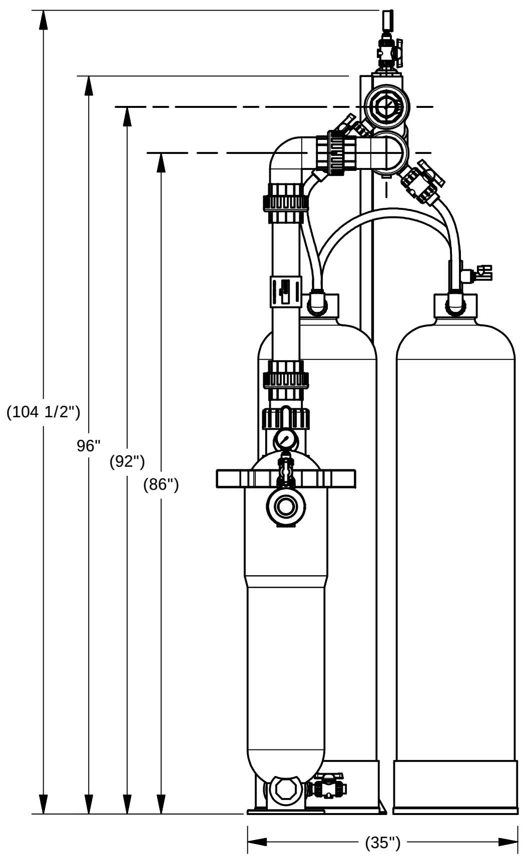
NOTES:
1) 3" INFLUENT
2) 3" EFFLUENT
3) TYPICAL FILTER MEDIA VOLUME PER VESSEL IS 6 CU/FT.
4) CONTRACTOR SHALL ANCHOR TO FLOOR AS REQUIRED.
5) (XXX-XXX) INDICATES REQUIRED COMPONENT LABEL.
6) LABEL COMPONENTS AS SHOWN, USE LABEL MAKER WITH 1/2" WIDE TAPE AND 1/4" LETTERS.



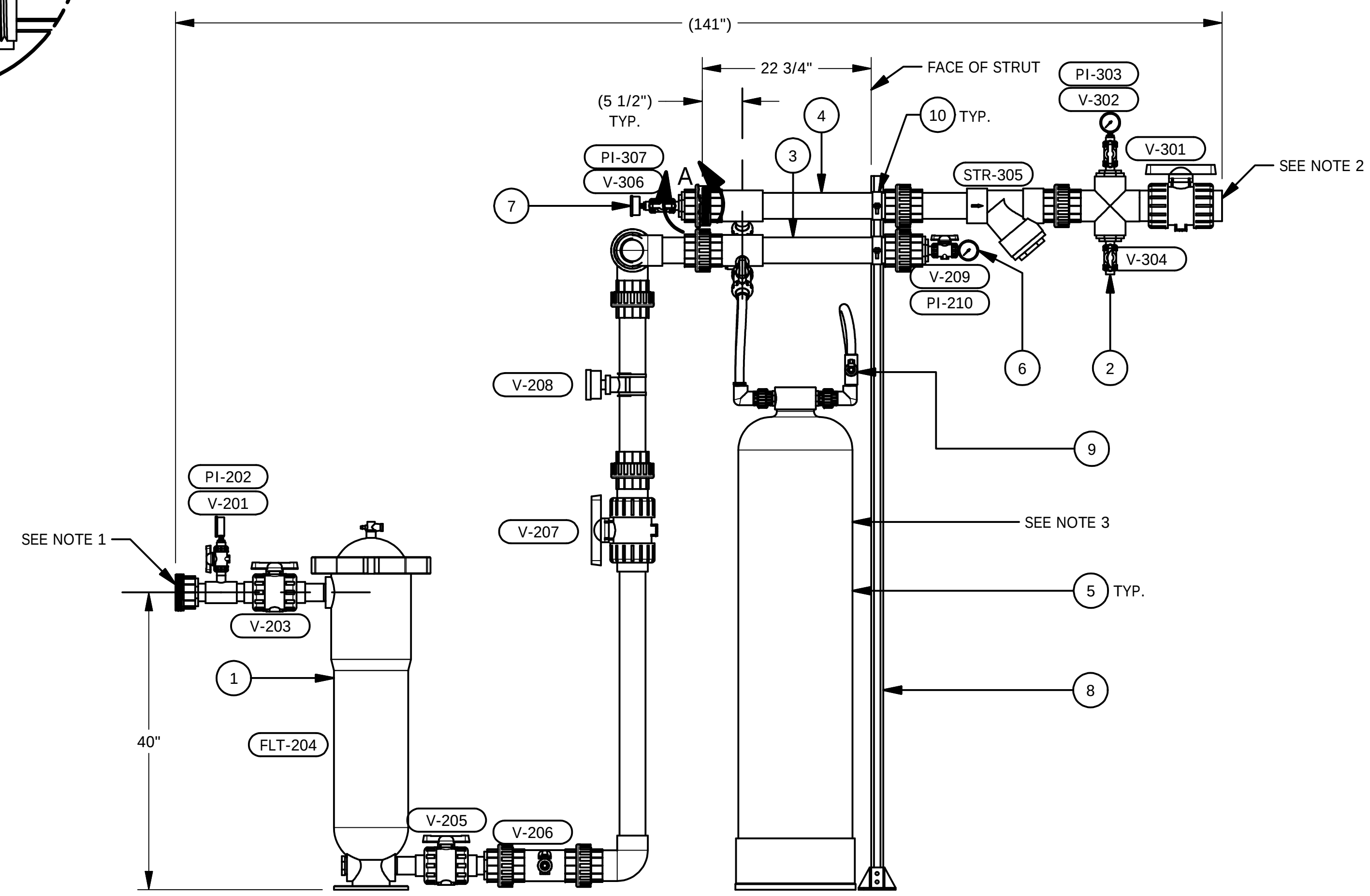
TOP VIEW



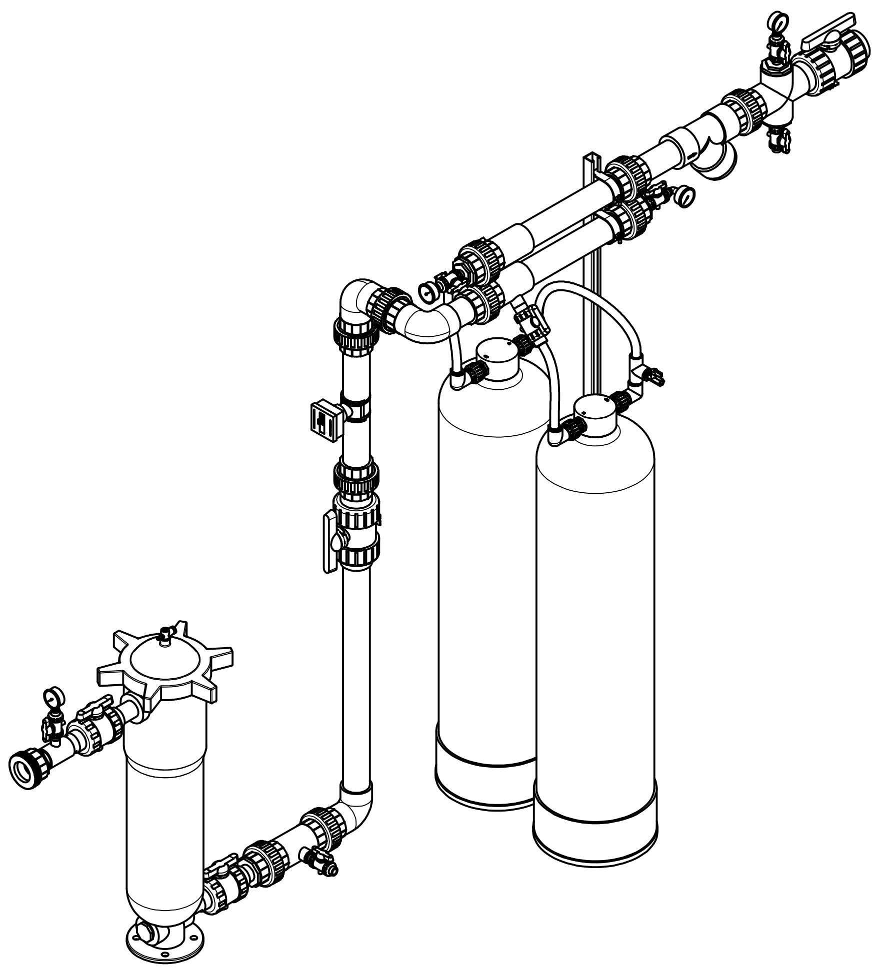
DETAIL A
SCALE 1:5



SIDE VIEW



FRONT VIEW



ISOMETRIC VIEW

REV	DATE	DESCRIPTION OF REVISION	REVISED BY	CHECKED
A	10/08/09	UPDATED COMPANY BORDER	AJN	AWS
NC	11/18/08	ORIGINAL DRAWING	DFL	DAS

ENVIROGEN TECHNOLOGIES
P.O. BOX 1400
RANCHO CUCAMONGA, CA 91729
A Lifecycle Performance Company
A member of The Amplio Group

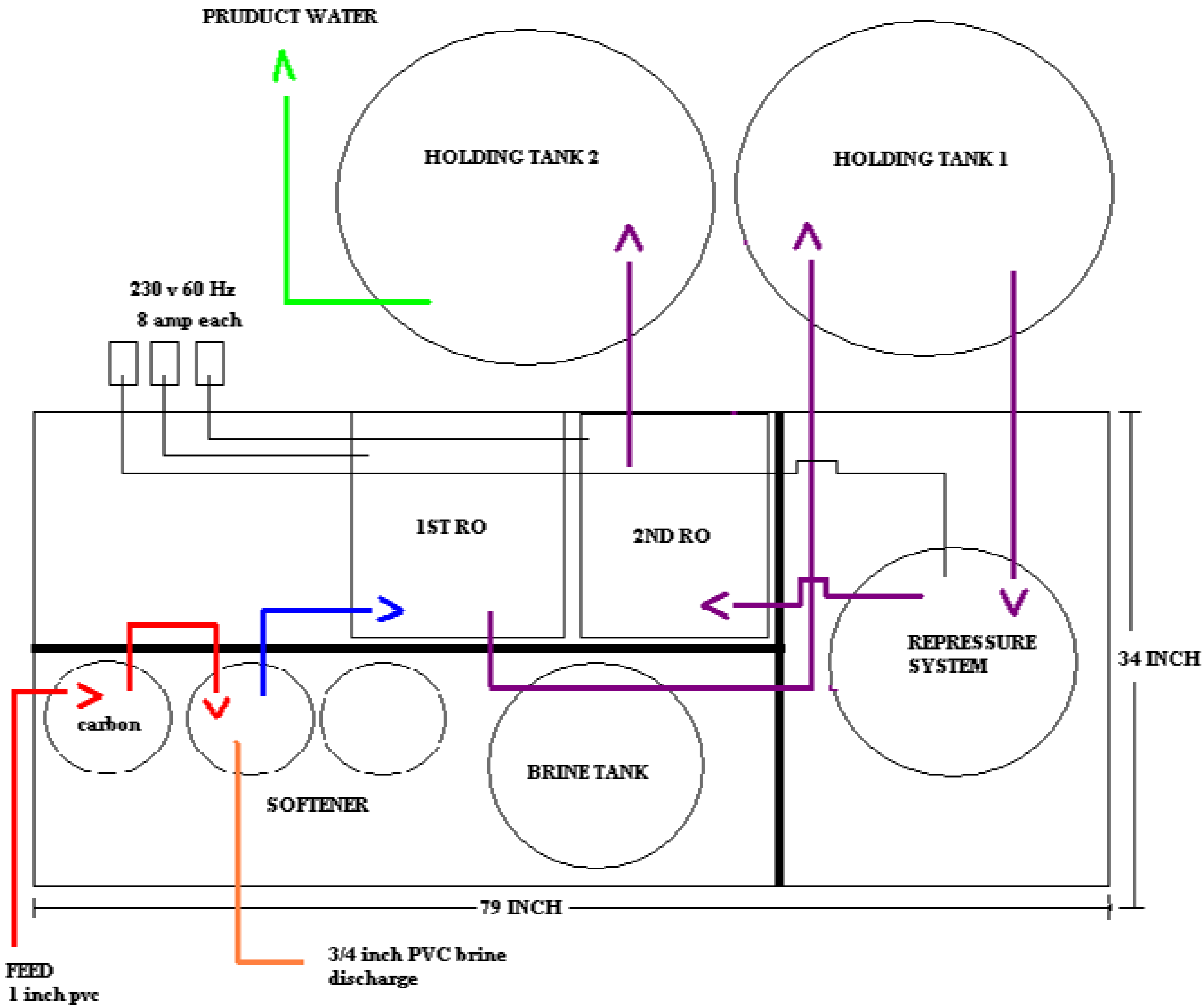
APPROVED BY:
DRAWING SCALE 1:25
DESIGNED BY/DATE DAS
DRAWN BY/DATE DFL
CHECKED BY/DATE DAS

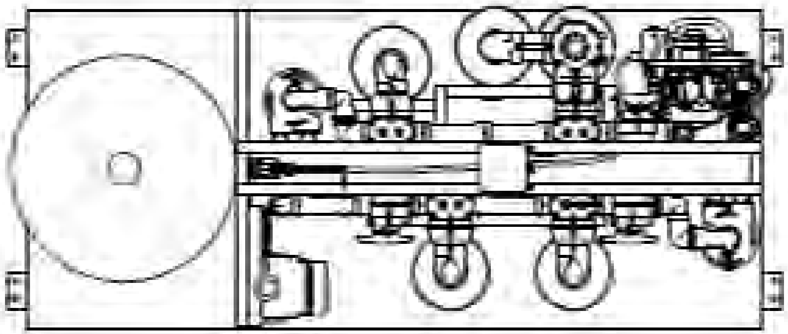
SMALL SYSTEMS, 10 GPM (2 BED) 16" VESSEL STAGGERED LEAD-LAG W/ FILTER

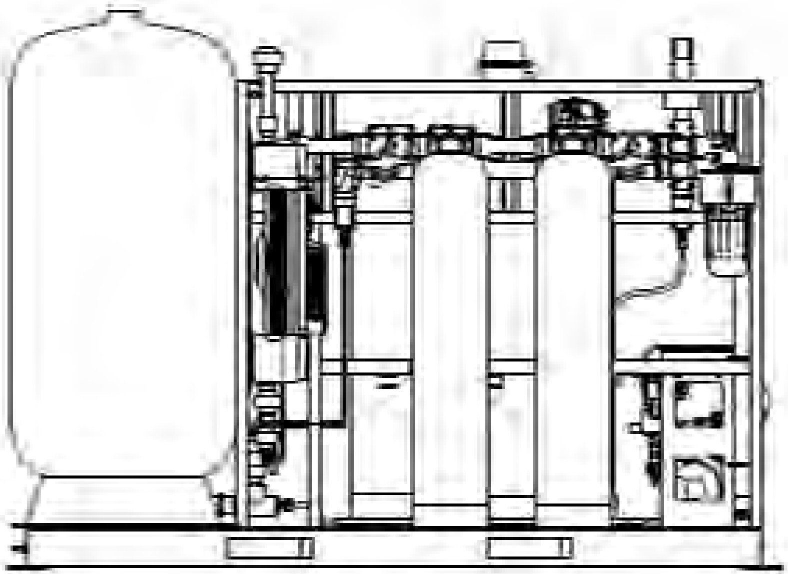
SHEET SIZE B
REVISION A
SHEET 1 OF 1
DRAWING # A-0142
FILE # A-0142.iam

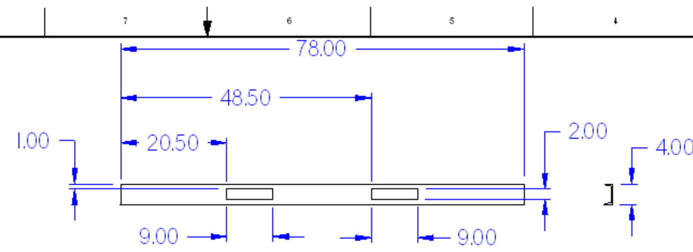
ARCADIS

Kinetico Pilot System

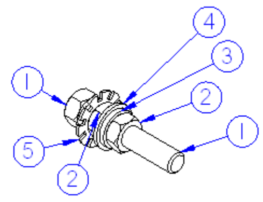

PRUDUCT WATER
HOLDING TANK 2
HOLDING TANK 1
230 v 60 Hz
8 amp each
1ST RO
2ND RO
REPRESSURE SYSTEM
34 INCH
carbon
SOFTENER
BRINE TANK
79 INCH
FEED
1 inch pvc
3/4 inch PVC brine discharge





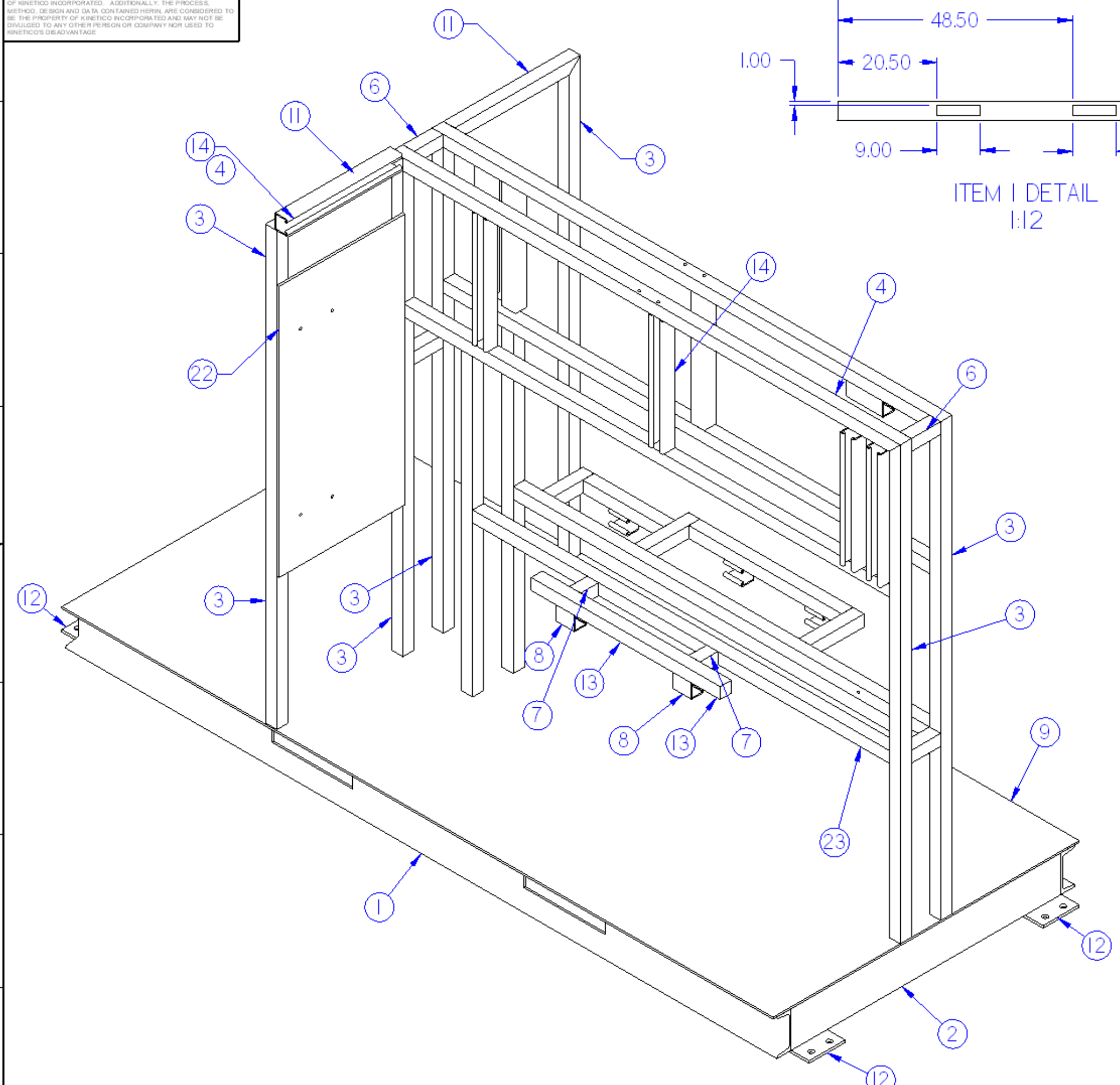


ITEM 1 DETAIL
1:12

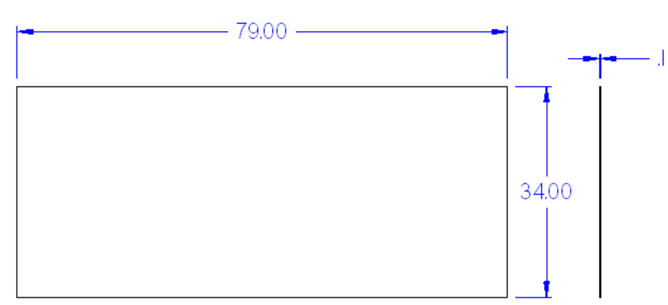


GROUND LUG
DETAIL

Item Number	45	Quantity	Description	Part #
1	0	1	HEX HEAD CAP SCREW 3/8-16 UNC x 2.0 LNG (ZINC)	69735
2	-	2	HEX NUT 3/8-16 UNC	69736
3	0	1	REGULAR LOCK WASHER	71495
4	0	1	PLAIN WASHER NARROW 3/8	71496
5	-	1	.38 LOCK WASHER	69734



ISOMETRIC VIEW



ITEM #10
1:10

SHEET 4 OF 4

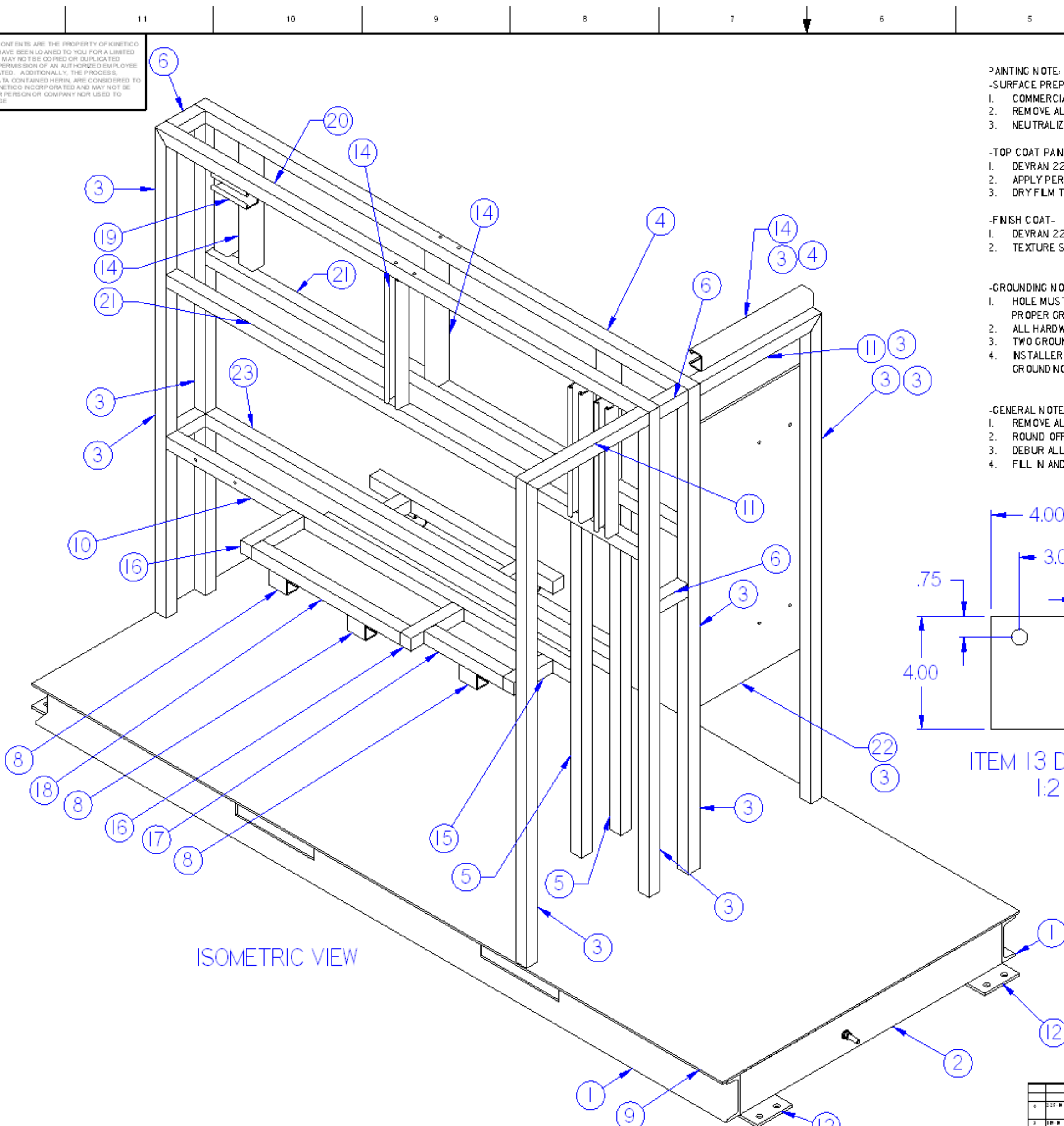
KINETICO®
10845 Kinsman Road
Newbury, Ohio 44065

DRAWN / DATE: JLH 3-11-8
DESIGNED / DATE: JLH 3-11-8

TOLERANCES:

DO NOT SCALE THIS DRAWING

PROJECT: HP 600P & 1200P HIGH PURITY SYSTEM
DRAWING TITLE: FRAME WELDMENT
SCALE: AS NOTED
SIZE: D
DRAWING NUMBER: 13026B



ISOMETRIC VIEW

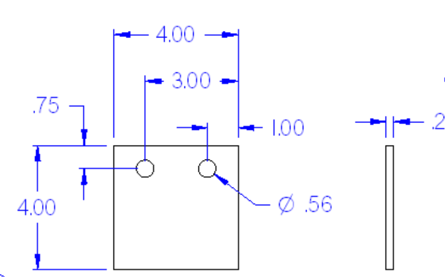
PAINTING NOTE:
-SURFACE PREPARATION-
1. COMMERCIAL BLAST TO SSPC-SP-6 SPECIFICATION
2. REMOVE ALL OIL, GREASE, AND CONTAMINATION
3. NEUTRALIZE SURFACES WITH ACID OR ALKALI

-TOP COAT PAINT-
1. DEVRAN 224HS – COLOR NATIONAL BLUE
2. APPLY PER MANUFACTURER'S INSTRUCTIONS
3. DRY FILM THICKNESS – 4.0 MILS MIN.

-FINISH COAT-
1. DEVRAN 224HS – COLOR NATIONAL BLUE
2. TEXTURE SURFACE AFTER FIRST COAT TACKS UP

-GROUNDING NOTE-
1. HOLE MUST BE TAPPED AND CLEANED TO INSURE PROPER GROUNDING CONTINUITY
2. ALL HARDWARE MUST BE INSTALLED PRIOR TO PAINTING
3. TWO GROUNDING ASSEMBLIES REQUIRED PER SKID
4. INSTALLER TO TERMINATE ALUMINUM #4 AWG GROUNDING CABLE TO ALL SKIDS

-GENERAL NOTE-
1. REMOVE ALL FLUX, SLAG, AND SPLATTER
2. ROUND OFF ALL SHARP EDGES R 1/32 MIN
3. DEBUR ALL HOLES
4. FILL IN AND GRIND FLUSH ALL DEFECTS



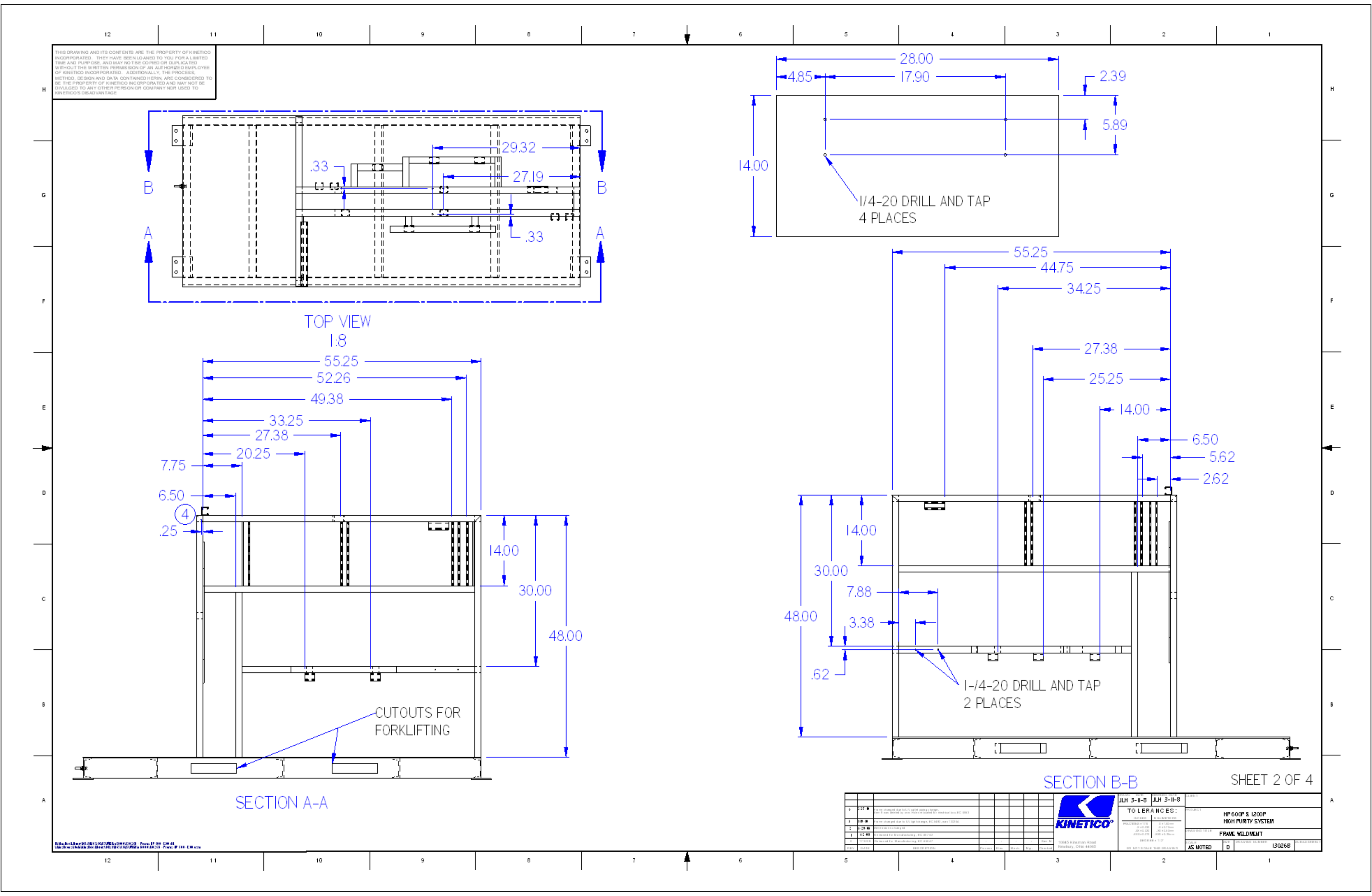
ITEM 13 DETAIL
1:2

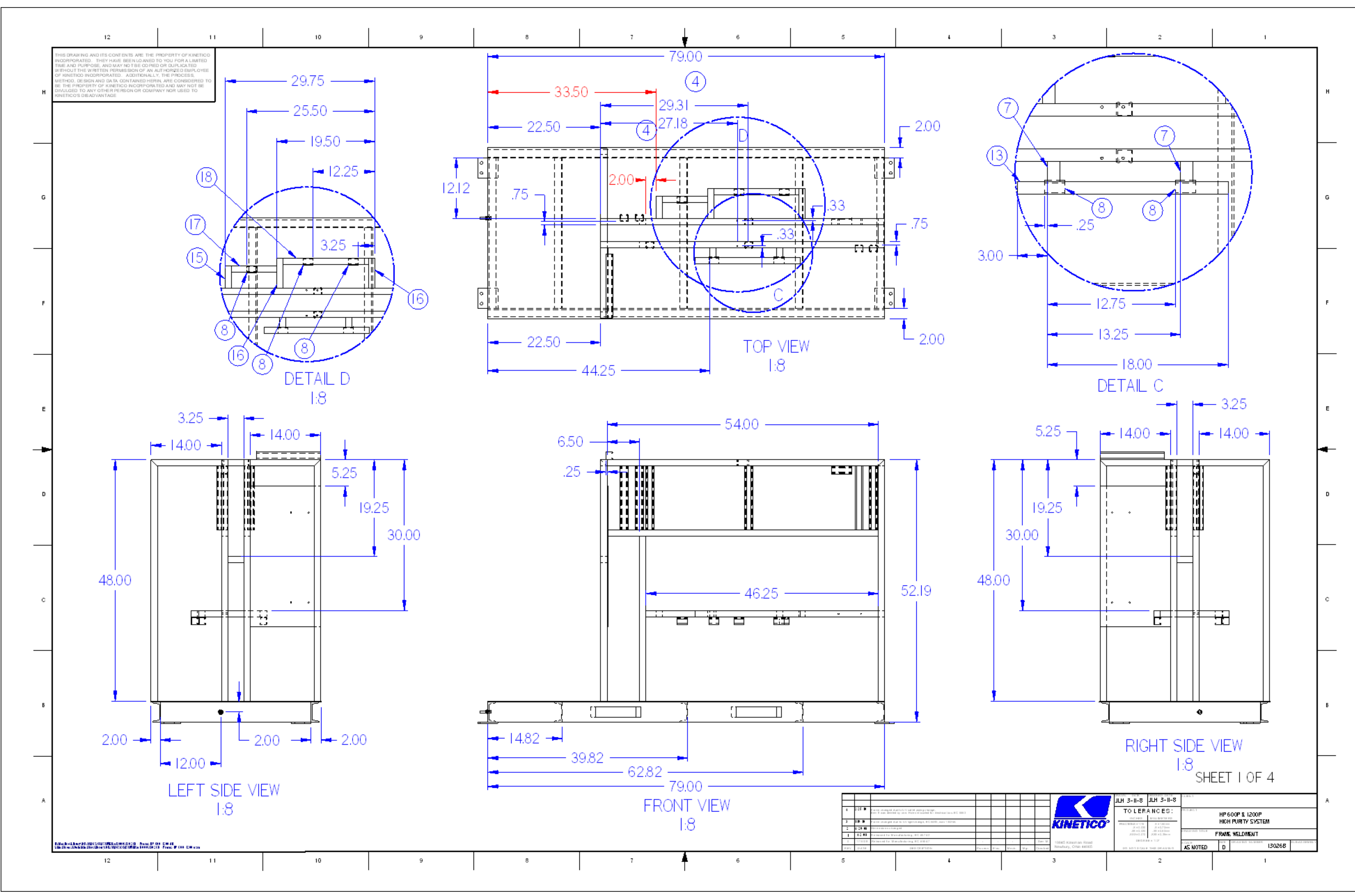
	Item Number	LENGTH	45	Quantity	DESCRIPTION	PART NUMBER
	1	79	0	2	C4 x 5.4 CHANNEL	57294
	2	30	0	5	C4 x 5.4 CHANNEL	57294
3	3	48	1	6	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
4	4	56.50	2	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	5	32.75	0	2	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	6	3.25	0	4	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	7	2	0	2	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	8	2	0	5	1-5/8 x 1-3/8 UNISTRUT	62062
	9	79 x 34	0	1	3/16 PLATE	59286
	10	46.25	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
3	11	14	1	2	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	12	4	0	4	4 x 1/4 FLAT STOCK	57606
	13	21	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
3	14	12.75	0	8	1-5/8x1-3/8 UNISTRUT	62062
	15	4.50	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	16	6.00	0	2	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	17	9	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	18	17	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	19	4	0	1	1-5/8 x 1-3/8 UNISTRUT	62062
	20	56.50	2	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
	21	54	0	2	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291
3	22	28 x 14	0	1	1/4 PLATE	57736
	23	46.25	0	1	1-1/4 x 1-1/4 x 1/8 SQUARE TUBE	57291

SHEET 3 OF 4

DRAWN / DATE	JLH 3-11-8
DESIGNED / DATE	JLH 3-11-8
TOLERANCES:	
PROJECT	HP 600P & 1200P HIGH PURITY SYSTEM
DRAWING TITLE	FRAME WELDMENT
SCALE	AS NOTED
SIZE	D
DRAWING NUMBER	13026B

KINETICO
10845 Kinsman Road
Newbury, Ohio 44065


THIS DRAWING AND ITS CONTENTS ARE THE PROPERTY OF KINETICO INCORPORATED. THEY HAVE BEEN LOANED TO YOU FOR A LIMITED TIME AND PURPOSE, AND MAY NOT BE COPIED OR DUPLICATED WITHOUT THE WRITTEN PERMISSION OF AN AUTHORIZED EMPLOYEE OF KINETICO INCORPORATED. ADDITIONALLY, THE PROCESS, METHOD, DESIGN AND DATA CONTAINED HERIN, ARE CONSIDERED TO BE THE PROPERTY OF KINETICO INCORPORATED AND MAY NOT BE DIVULGED TO ANY OTHER PERSON OR COMPANY NOR USED TO KINETICO'S DISADVANTAGE
TOP VIEW
1:8
29.32
27.19
.33
.33
28.00
4.85
17.90
2.39
5.89
14.00
1/4-20 DRILL AND TAP
4 PLACES
SECTION A-A
55.25
52.26
49.38
33.25
27.38
20.25
7.75
6.50
.25
14.00
30.00
48.00
CUTOUTS FOR
FORKLIFTING
SECTION B-B
55.25
44.75
34.25
27.38
25.25
14.00
6.50
5.62
2.62
14.00
30.00
48.00
7.88
3.38
.62
1-/4-20 DRILL AND TAP
2 PLACES
SHEET 2 OF 4
KINETICO
10845 Kinsman Road
Newbury, Ohio 44065
JLH 3-11-8
JLH 3-11-8
TOLERANCES:
DO NOT SCALE THIS DRAWING
HP 600P & 1200P
HIGH PURITY SYSTEM
FRAME WELDMENT
AS NOTED
D
130268


DETAIL D
1:8
TOP VIEW
1:8
DETAIL C
LEFT SIDE VIEW
1:8
FRONT VIEW
1:8
RIGHT SIDE VIEW
1:8
SHEET 1 OF 4
79.00
33.50
29.31
27.18
22.50
12.12
2.00
.75
.33
44.25
29.75
25.50
19.50
12.25
3.25
18.00
13.25
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3.00
.25
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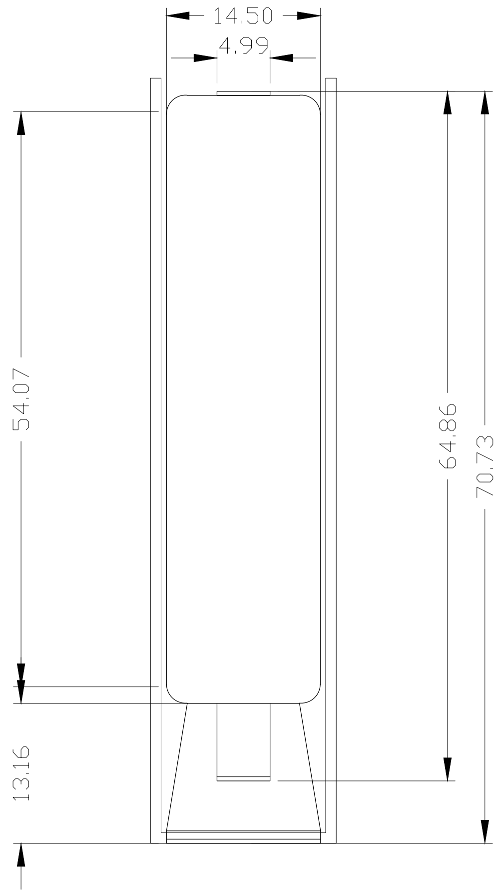
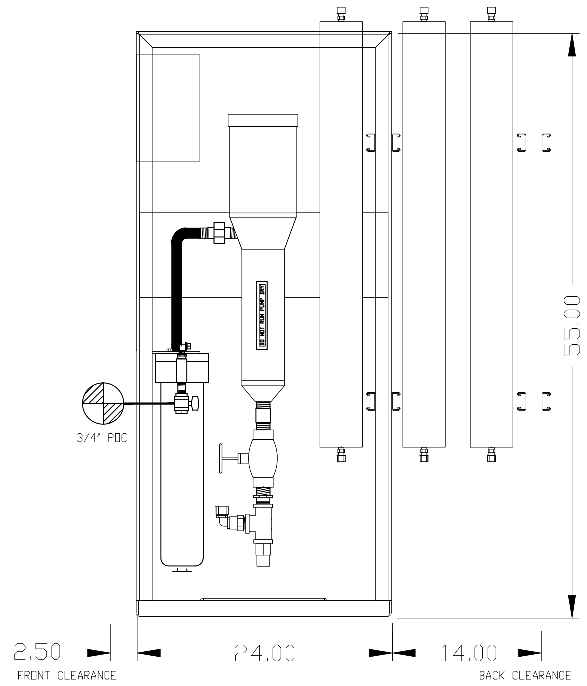
19.25
30.00
48.00
12.00
54.00
6.50
46.25
52.19
14.82
39.82
62.82
KINETICO
JLH 3-11-8
TOLERANCES:
10845 Kinsman Road
Newbury, Ohio 44065
HP 600P & 1200P
HIGH PURITY SYSTEM
FRAME WELDMENT
AS NOTED
D
130268

ARCADIS

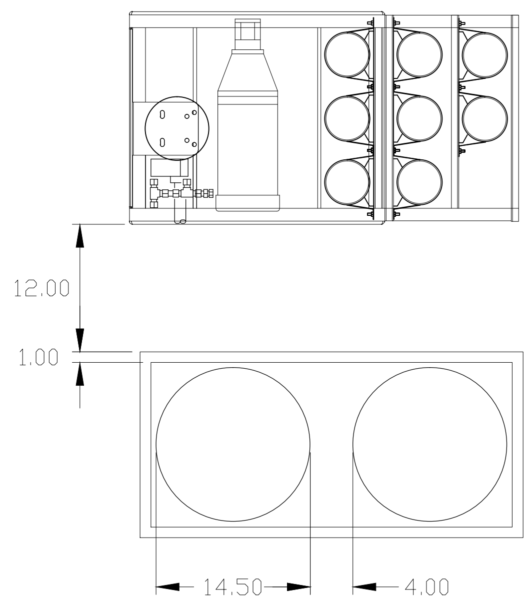
Purolite/ACWA Pilot System



ELEVATION OF ION EXCHANGE SKID



ELEVATION OF RO SKID



PLAN VIEW

ACWA DRAWING NO. 11-14 101 | REVISION 0

NOTES

CURRENT REVISION

DATE	DRWN	CHKD	REVD	ISSUE	
27-09-11	HMC	PB	PB	O	ORIGINAL ISSUE

FOR TENDER PURPOSES ONLY

ACWA CLEAR

ACWA CLEAR, LLC
4104 UNION AVENUE,
BAKERSFIELD, CA 93305
Email: enquiry@acwaclear.com Web: www.acwaclear.com
Tel: 877 202 2094 Fax: 661 322 4206

CLIENT/SUPPLIER DRAWING NO. | ISSUE

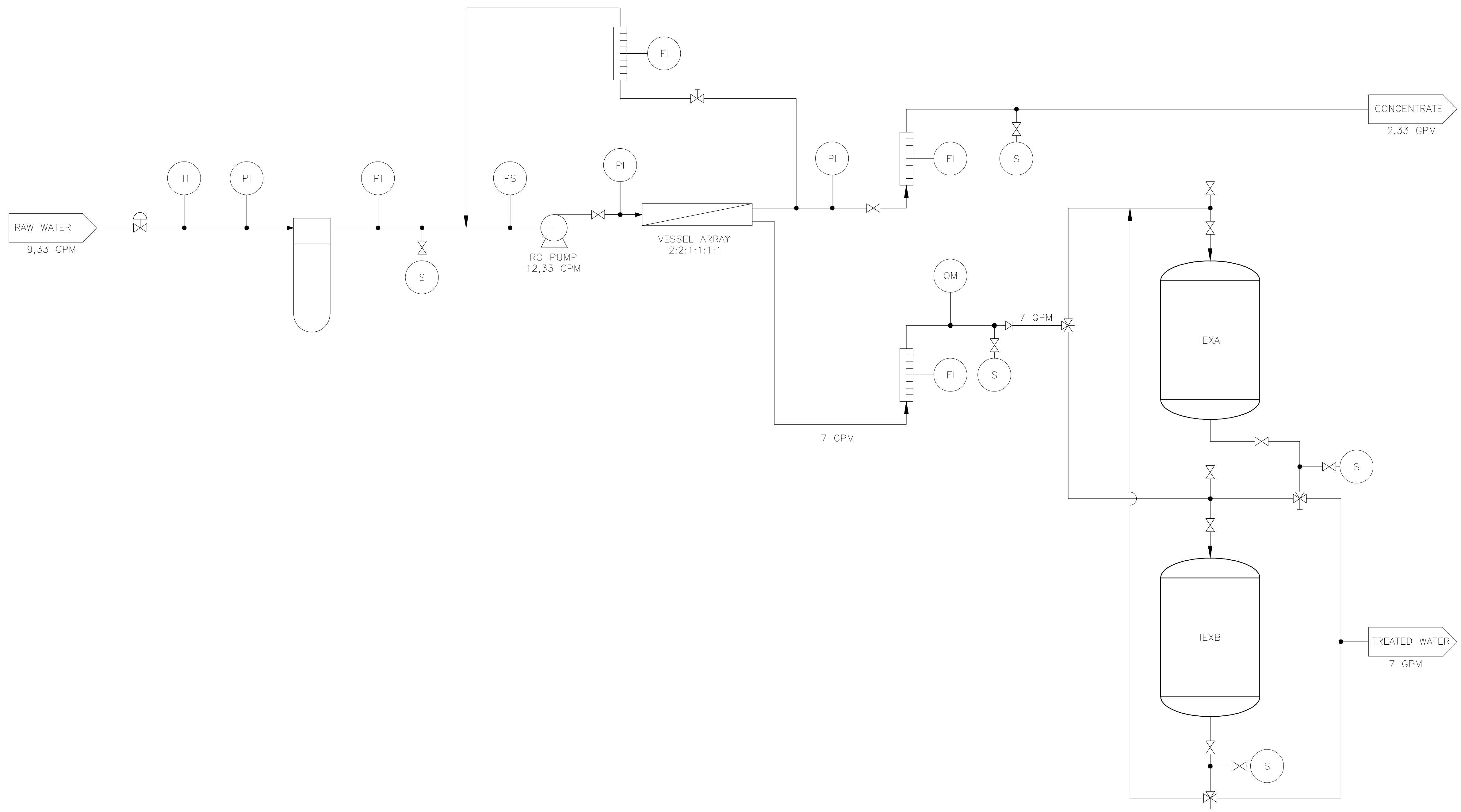
PROJECT TITLE: ARCADIS

DRAWING TITLE: PILOT PLANT PROPOSED LAYOUT

SITE LOCATION | SITE AREA -

ACWA CONTRACT NUMBER 11-14 | SCALE NTS | MASTER SIZE A1

ACWA DRAWING NO. 11-14 101 | ISSUE 0



ACWA DRAWING NO. 11-14 001 | REVISION 0

NOTES

CURRENT REVISION

DATE	DRWN	CHKD	REVD	ISSUE	
27-09-11	HMC	PB	PB	O	ORIGINAL ISSUE

FOR TENDER PURPOSES ONLY

ACWA CLEAR, LLC
4104 UNION AVENUE,
BAKERSFIELD, CA 93305
Email: enquiry@acwaclear.com Web: www.acwaclear.com
Tel: 877 202 2094 Fax: 661 322 4206

CLIENT/SUPPLIER DRAWING NO. | ISSUE

PROJECT TITLE: ARCADIS

DRAWING TITLE: P&ID FOR PILOT PLANT

SITE LOCATION | SITE AREA -

ACWA CONTRACT NUMBER 11-14 | SCALE NTS | MASTER SIZE A1

ACWA DRAWING NO. 11-14 001 | ISSUE 0

APPLIED® SYSTEMS

Series L – 300 to 19,000 GPD RO Systems

Reverse Osmosis Systems 300 to 19,000 Gallons/Day For feed water TDS 500 to 1000 PPM

Designed to produce low dissolved solids water from tap or well water, these RO systems use high efficiency reverse osmosis membranes. Part of the L-series family (other systems include XL and HL series), these RO systems are designed to work at pressures of 200-250 psi for higher TDS water and use TW reverse osmosis membranes. The TW RO membranes offer higher salt removal and the higher operating pressure overcomes the loss of membrane flow due to higher TDS level.

These reverse osmosis systems use the proven, reliable components and are mounted on a sturdy powder-coated metal frame. There are numerous design details learned from years of experience that are incorporated in our water filtration systems. Our process and fluid design ensures an optimum membrane life and minimizes the membrane fouling.

Key Features

- Over 25 years of experience is reflected in our quality
- Compact, Heavy Duty, Powder Coated Frame
- Proven components used throughout the system
- Conservatively engineered for reliable long term performance
- Factory tested to ensure trouble-free operation

Applications

- Spot Free Rinse/Car Wash
- Water Stores
- Whole House
- Labs
- Large Office
- Institutions
- Ice Makers
- Humidification
- Misting
- Manufacturing
- Rinse Water
- A Wide Variety of Other Applications

Why Applied Membranes?

- Over 10,000 commercial/industrial systems in operation
- Our products are being used in over 100 countries worldwide
- Our customers include major national and international companies in every field of application
- We stock more components for all sizes of RO systems than any other company
- We have earned an enviable reputation for our product quality, performance reliability and business integrity.

(760) 727-3711 • FX: (760) 727-4427
www.appliedmembranes.com
sales@appliedmembranes.com

APPLIED® SYSTEMS

Series L – 300 to 19,000 GPD RO Systems

Standard Equipment

- Thin Film Composite Membranes
- Stainless steel membrane pressure vessels
- 5 micron 20" cartridge filter & housing
- Feed water temperature gauge
- Automatic inlet feed solenoid valve
- Permeate, Concentrate & Recycle Flowmeters
- System control valve
- Recycle control valve
- Low pressure pump protection
- High pressure RO pump
  - L-12521 – L-24A: Brass Rotary Vane
  - L-34A – L-124A : SS multistage with throttling valve
- Automatic membrane flush
- 4) Liquid filled pressure gauges for filter in/out and system pressures
- Feed and permeate TDS displayed on controller LED with percent rejection
- System on/off with 2-level tank floats
- Powder coated carbon steel frame
- Boxed and palletized for shipment

Microprocessor Controller for Automatic Operation

Monitors and/or Controls:

- Inlet valve
- Delayed start-up of high pressure pump
- Feed water flush at system shut-down
- Low pressure switch
- On/Off with tank level
- Pre-treatment backwash/lockout
- Feed & permeate TDS with % rejection
- Water temperature
- Operating hours

Controller Features:

- Backlit LED Display
- Multi-Function keypad
- Audible alarm & silence key
- Visual indicator alarm light
- Programmable time delays, set-points and flush mode
- Low pressure automatic restart

UL508A Labeled

LED Display:

- Permeate TDS
- Operating Status
- Alarm Condition

Ordering Information

Model No.	System Capacity		Membrane Elements		Line Sizes (NPT, Inches)			System Dimensions (in/cm)			Approx. Shipping Weight (Lb/Kg)
	GPD	m³/day	Qty.	Size (Dia.×L)	Inlet	Perm.	Conc.	Length	Depth	Height	
L-12521A	300	1	1	2.5" × 21"	¾"	⅜"	⅜"	20/51	24/61	55/140	230/104
L-125A	600	2	1	2.5" × 40"	¾"	⅜"	⅜"	20/51	24/61	55/140	240/109
L-225A	1,200	5	2	2.5" × 40"	¾"	⅜"	⅜"	20/51	24/61	55/140	250/113
L-14A	1,800	7	1	4" × 40"	¾"	½"	½"	20/51	24/61	55/140	275/125
L-24A	3,000	12	2	4" × 40"	¾"	½"	½"	20/51	24/61	55/140	300/136
L-34A	5,500	21	3	4" × 40"	¾"	½"	½"	20/51	32/82	55/140	325/147
L-44A	7,000	27	4	4" × 40"	¾"	½"	½"	20/51	32/82	55/140	350/159
L-54A	8,500	32	5	4" × 40"	¾"	½"	½"	20/51	32/82	55/140	375/170
L-64A	10,000	38	6	4" × 40"	¾"	½"	½"	20/51	32/82	55/140	400/181
L-74A	11,500	44	7	4" × 40"	¾"	½"	½"	20/51	40/102	55/140	441/200
L-84A	13,000	49	8	4" × 40"	¾"	½"	½"	20/51	40/102	55/140	466/211
L-94A	14,400	55	9	4" × 40"	¾"	½"	½"	20/51	40/102	55/140	491/223
L-104A	16,000	60	10	4" × 40"	¾"	½"	½"	20/51	46/117	55/140	516/234
L-114A	17,300	66	11	4" × 40"	¾"	½"	½"	20/51	46/117	55/140	541/245
L-124A	19,000	72	12	4" × 40"	¾"	½"	½"	20/51	46/117	55/140	566/257

Notes and Voltage/ Ordering Information

- **Recommended Pre-Treatment Equipment:** *All pretreatment equipment and SDI test kits are available from Applied Membranes.*
  - **Carbon Filter:** Chlorine must be removed if present in feed water prior to RO.
  - **Water Softener:** Hardness must be removed if present in feed water prior to RO to avoid scaling the membranes.
  - **Multimedia filter:** If feed water exceeds <1 NTU turbidity, or silt density index (SDI) of 3, media filter pretreatment recommended.
- **Capacity Basis:** 24 hrs/day
- **Systems rated at:** 77°F (25°C) using 1000 ppm sodium chloride solution operating at approx. 200 psi (14 kg/cm²) pressure. For feed water with higher TDS refer to our Series HL brochure.
  Minimum feed pressure to RO System: 40-60 PSI. System capacity changes significantly with water temperature
- **Voltage:** *Please add our voltage codes to the end of the model number when ordering. Example: L-12521-**116** = 110v, 1 ph, 60 hz.*

  Voltage Codes:
  - **116** = 110v, 1ph, 60hz (up to L-24A only)
  - **216** = 220/230v, 1ph, 60hz
  - **215** = 220/230v, 1ph, 50hz

  Three Phase Not Available
- All dimensions and weights are approximate.

(760) 727-3711 • FX: (760) 727-4427
www.appliedmembranes.com
sales@appliedmembranes.com

ARCADIS

Attachment A.2

NSF Certificates for Whole House Water Treatment Systems

ARCADIS

Envirogen Certificates

Water Quality Association
International Headquarters & Laboratory

4151 Naperville Road
Lisle, Illinois 60532-3696 USA
Phone 630 505 0160
Fax 630 505 9637
www.wqa.org

A not-for-profit organization

GOLD SEAL CERTIFICATE

This is to certify that the drinking water system component herein has been independently tested and certified by the Water Quality Association in accordance with "Drinking Water System Components - Health Effects," NSF/ANSI-61. The material safety of the component listed has earned the Gold Seal.

Manufacturer:	ResinTech, Inc.
Address:	160 Cooper Road West Berlin, NJ 08091-9243
Model:	SBG1-HP
Brand:	N/A
Product Type:	Ion Exchange Resin
Size:	16 - 50 mesh
Water Contact Temp:	CLD 23
Water Contact Material:	SYN
Listing Notes:	Anion Resin

Certificate Type:	Final
Issue Date:	Wednesday, May 21, 2008
Expiration Date:	Monday, January 21, 2013
Test Unit Number/ Conformance Method:	6179.0803C.02
Certificate Number:	CRT.052108.61790803C02

Joseph F. Harrison

Joseph F. Harrison, P.E., CWS-VI

29 May 2008

Effective Date

ARCADIS

Kinetico Certificates

State of California
Department of Public Health

Water Treatment Device Certificate Number 04- 1667

Date Issued: October 13, 2009

Trademark/Model Designation
Mach 2060 S

Replacement Elements
None

Manufacturer: Kinetico Incorporated

The water treatment device(s) listed on this certificate have met the testing requirements pursuant to Section 116830 of the Health and Safety Code for the following health related contaminants:

Microbiological Contaminants and Turbidity
None

Organic Contaminants
None

Inorganic/Radiological Contaminants
Barium
Radium 226/228

Rated Service Capacity: Not Applicable

Rated Service Flow: 11.5 gpm

Conditions of Certification:
Do not use with water that is microbiologically unsafe or of unknown quality, without adequate disinfection before or after the system.

NSF Product and Service Listings

These NSF Official Listings are current as of **Monday, September 12, 2011** at 12:15 a.m. Eastern Time. Please contact NSF International to confirm the status of any Listing, report errors, or make suggestions.

Alert: NSF is concerned about fraudulent downloading and manipulation of website text. Always confirm this information by clicking on the below link for the most accurate information:
http://www.nsf.org/Certified/PwsComponents/Listings.asp?Company=21860&Standard=061&

NSF/ANSI STANDARD 61
Drinking Water System Components - Health Effects

NOTE: Unless otherwise indicated for Materials, Certification is only for the Water Contact Material shown in the Listing. Click here for a list of Abbreviations used in these Listings.

Kinetico Incorporated

10845 Kinsman Road
P.O. Box 193
Newbury, OH 44065
United States
440-564-9111
Visit this company's website

Facility : Newbury, OH

Mechanical Devices

Trade Designation	Size	Water Contact Temp	Water Contact Material
Dechlorinators[2]			
1030 Dechlorinator	7" x 35"	CLD 23	MLTPL
1060 Dechlorinator	8" x 40"	CLD 23	MLTPL
1100 Dechlorinator	10" x 54"	CLD 23	MLTPL
1175 Dechlorinator	13" x 54"	CLD 23	MLTPL

[2] This product is not Certified for contaminant reduction or structural integrity by NSF International.

Valves			
Hydrus Valve[1] [G]	2"	CLD 23	MLTPL

ARCADIS

Purolite/ACWA Certificates

Water Quality Association

09/16/2011

NSF/ANSI-61 International Standard for Drinking Water Additives

NSF/ANSI-61 Drinking Water System Components - Health Effects

This Standard establishes minimum health effects requirements for the chemical contaminants and impurities that are indirectly imparted to drinking water from products, components, and materials used in drinking water systems. This Standard does not establish performance, taste and odor, or microbial growth support requirements for drinking water systems products, components, or materials.

Drinking Water Treatment Products certified to NSF/ANSI 61 have not been tested or evaluated for contaminant reduction performance. Contaminant reduction testing and certification claims shall be evaluated via the industry's residential drinking water treatment standards.

Purolite Company (The)
150 Monument Road
Suite 202
Bala Cynwyd, PA 19004
Phone: (610) 668-9090
http://www.puroliteusa.com

Product Type: Ion Exchange Resin

Brand Name	*Model*	*Water Contact Temp*	*Water Contact Material*	*Size*
	A600E	CLD 23	SYN	N/A
	A860	CLD 23	SYN	16-50 mesh
	S108	CLD 23	SYN	
N/A	A300E	CLD 23	SYN	16 - 50 mesh
N/A	A-400E [1]	CLD23	SYN	16 - 50 mesh
N/A	A-500P	CLD 23	SYN	16 - 50 mesh
N/A	A-520E [2]	CLD 23	SYN	16-50 mesh
N/A	A530E	CLD 23	SYN	16 - 50 mesh
N/A	A532E	CLD 23	SYN	16-50
N/A	A-850FL [1]	CLD 23	SYN	16-50 mesh
N/A	C100 [3]	CLD 23	SYN	16-50 Mesh
N/A	C100E [3]	CLD 23	SYN	16-50 Mesh

N/A	C100E/1420 [3]	CLD 23	SYN	16-50 Mesh
N/A	C100E/9042 [3]	CLD 23	SYN	16-50 Mesh
N/A	C100EB [3]	CLD 23	SYN	16-50 Mesh
N/A	C100EDK [3]	CLD 23	SYN	16 -50 Mesh
N/A	C100EF [3]	CLD 23	SYN	30-40 Mesh
N/A	C100EFLT [3]	CLD 23	SYN	20-40 Mesh
N/A	C100EFM [3]	CLD 23	SYN	30-70 Mesh
N/A	C100EG [3]	CLD 23	SYN	16-35 Mesh
N/A	C100ELT [3]	CLD 23	SYN	20-40 Mesh
N/A	C104E H/9111 [4]	CLD 23	SYN	16 - 50
N/A	D-4170	CLD 23	SYN	16 - 50
N/A	D4600/NCAL	CLD 23	SYN	16 - 50 mesh
N/A	D5130 [3]	CLD 23	SYN	40-70 Mesh
N/A	PFC100 [3]	CLD 23	SYN	25-40 Mesh
N/A	PFC100E [3]	CLD 23	SYN	25-40 Mesh
N/A	SST60 [3]	CLD 23	SYN	16-50 Mesh
N/A	SST60E [3]	CLD 23	SYN	16-50 Mesh
N/A	SST80 [3]	CLD 23	SYN	20-40 Mesh
N/A	SST80DL [3]	CLD 23	SYN	20-40 Mesh
N/A	SST80E [3]	CLD 23	SYN	20-40 Mesh
N/A	ArsenXnp Regenerated [5]	CLD 23	SYN	14 - 52
N/A	C100FM [3]	CLD 23	SYN	30-70 Mesh
N/A	FerrIX™A33E	CLD 23	SYN	-16+40
N/A	FerrIX™A33E Regenerated [5]	CLD 23	SYN	-16+40

1: This product is certified with a minimum flow restriction of .64 gpm per cubic foot of media.

2: The Certification of this media is only for applications with minimum flow greater than or equal to 0.28 gpm per cubic foot of resin.

3: The certification of this media is only for applications with a minimum flow greater than or equal to 0.29 gpm per cubic foot of resin.

4: This product is certified with a minimum flow rate requirement of 0.42 gpm per cubic foot of media.

5: The Certification of this media is only for applications with minimum flow greater than or equal to 1.0 gpm per cubic foot of resin.

Disclaimer:

Listing in these directories does not constitute an endorsement, guarantee, or warranty of any kind by Water Quality Association or its members of any of the products contained in them.
Every effort has been made to verify the accuracy of all listings in this directory. The association can assume no liability for errors or omissions.

Water Quality Association: Back

Fri, Sep 16, 2011

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Lisle, IL 60532-3696
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Disclaimers

NSF Product and Service Listings

These NSF Official Listings are current as of **Friday, September 16, 2011** at 12:15 a.m. Eastern Time. Please contact NSF International to confirm the status of any Listing, report errors, or make suggestions.

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http://www.nsf.org/Certified/DWTU/Listings.asp?Company=29120&

Note: Certain claims, such as Arsenic (Pentavalent) Reduction, appear as active links, allowing you to access additional information regarding the specific contaminants.

NSF/ANSI STANDARD 058
Reverse Osmosis Drinking Water Treatment Systems

NOTE: All Replacement Modules Are Components.

Applied Membranes Inc.

2325 Cousteau Court
Vista, CA 92081
United States
800-321-9321
760-727-3711
Visit this company's website

Facility : Vista, CA

COMPONENTS: Membranes[1] [2]
100 GPD TFC
110009
110017
110019
110020
12 GPD TFC
18 GPD TFC
24 GPD TFC
36 GPD TFC
50 GPD TFC
75 GPD TFC
F26048
FM110015M
FM110018M
M-T1512A12
M-T1512A18

M-T1512A18-NL
M-T1512A18-WET
M-T1810R12
M-T1810R24
M-T1810R24-RS
M-T1810R50
M-T1810RMU24
M-T1810RMU50
M-T1812A100
M-T1812A100-NL
M-T1812A100DIM
M-T1812A100FI
M-T1812A100ID
M-T1812A24
M-T1812A24-NL
M-T1812A24-WET
M-T1812A36
M-T1812A36-NL
M-T1812A36-WET
M-T1812A50
M-T1812A50-NL
M-T1812A50DIM
M-T1812A75
M-T1812A75-NL
M-T1812A75DIM
M-T1812A75FI
M-T1812A75ID
M-T1812AC24
M-T1812AC36
M-T1812AC36-NL
M-T1812AC50
M-T1812AC75
M-T1812ACMU36
M-T1812AF100
M-T1812AF50
M-T1812AF75
M-T1812ASRL100
M-T1812Q24
M-T1812Q30
M-T1812Q50
TLC-15
TLC-25
TLC-35
TLC-50

[1] Conforms to material requirements only. Membranes require a 24 hour flushing procedure.
[2] These elements have been tested for the reduction of Arsenic, Barium, Cadmium, Chromium (Hexavalent), Chromium (Trivalent), Copper, Cysts, Turbidity, Fluoride, Lead, Radium 226/228, Selenium, and TDS. The test data results may be transferred to other manufacturer's systems, if the systems meet the requirements contained on the document entitled, "Transfer of Performance Claims for Applied Membranes, Inc.™ Reverse Osmosis Elements NSF/ANSI 58", dated 5/18/2009. This document is available from Applied Membranes.

NOTE: These components do not bear the NSF Mark. Evidence of Certification will appear on the manufacturer's literature and packaging.

Number of matching Manufacturers is 1
Number of matching Products is 60
Processing time was 0 seconds

ARCADIS

Comments from the Water Board

California Regional Water Quality Control Board
Lahontan Region

Matthew Rodriquez
Secretary for Environmental Protection

2501 Lake Tahoe Boulevard, South Lake Tahoe, California 96150
(530) 542-5400 • FAX (530) 544-2271
http://www.waterboards.ca.gov/lahontan

Edmund G. Brown Jr.
Governor

December 16, 2011

Tom Wilson
Director, Remediation Program Office
Pacific Gas and Electric Company
3401 Crow Canyon Road
San Ramon, CA 94105-1814

COMMENTS ON PILOT TESTING OF WHOLE HOUSE WATER TREATMENT SYSTEMS, PACIFIC GAS AND ELECTRIC COMPANY (PG&E), HINKLEY COMPRESSOR STATION, SAN BERNARDINO COUNTY

Water Board staff is providing comments on the September 27, 2011document, *Pilot Testing of Whole House Water Treatment Systems (Pilot Test)*, for chromium contaminated groundwater from the PG&E Hinkley Compressor Station. We apologize for the delay in getting these comments to you but we waited so as to also include comments from the California Department of Public Health (DPH).

While the Pilot Test document was submitted prior to issuance of Cleanup and Abatement Order (CAO) R6V-2011-0005A1, Water Board staff believes the document may be incorporated into a workplan for a feasibility study required in Order No. 2a, provided it includes the comments below.

Background

The Pilot Test describes procedures for evaluating commercially available whole house treatment systems for removing chromium from domestic well water in Hinkley. Three systems have been selected to be pilot tested: a strongly base anion exchange resin filter, a two-pass reverse osmosis system, and a hybrid of the resin filter and reverse osmosis. Pilot testing will be performed using upper-aquifer water from one of the agricultural wells (Gorman 1R) on the former Gorman field property. The test will run using continuous flow for three months to allow collection of system information, such as chromium efficiency removal and breakthrough performance. A report containing data and results of the pilot test will be submitted to the Water Board.

COMMENTS

Selection of Proposed Systems
The Pilot Test document states that ARCADIS, PG&E's consultant, is recommending pilot testing of the above-mentioned three proposed systems based upon literature review, desktop assessment, and discussions with vendors on product availability and

applicability. The document, however, does not discuss the specific selection criteria used for the three proposed systems. Nor does the document state why other systems known to remove chromium from water were not included in the pilot test. For instance, according to the Water Quality Association, other technologies, such as distillation and weakly based anion resin filters, can be used as point-of-use to whole house treatment. PG&E should state why such technologies will not be included in pilot testing.

CA DPH Comments
The DPH advises that the Pilot Test document follow ANSI/NSF standards for home use. Such standards differ from standards established for public water systems and point-of-use, some of which are cited in PG&E's Pilot Test document. Refer to specific comments by DPH staff in the enclosed electronic message.

Gorman 1R Well
As mentioned in the Pilot Test, Water Board staff has expressed concern about using the Gorman 1R well in the pilot test. One concern is for the poor water quality from the well. Table 1 in the Pilot Test shows that water from Gorman 1R exceeds drinking water standards for chloride, sulfate, uranium, gross alpha activity, specific conductance, and total dissolved solids (TDS). The well represents the "worst case scenario" of water quality within the chromium plume area. Our concern is that this water quality does not represent an average water quality scenario of domestic wells potentially affected by PG&E's waste chromium and likely to receive whole house replacement water. Thus, Water Board staff is recommending that the pilot test be simultaneously conducted on a second supply well that represents an average water quality scenario for all constituents other than hexavalent chromium.

The other concern expressed by Board staff is that the high pumping rate at Gorman 1R of 50 gallons per minute (gpm), which is also not consistent with that of residential domestic wells, may affect pilot test results. Pumping of typical domestic wells is generally between 5 to 10 gpm. The Pilot Test states that water from Gorman 1R will be split for the different pilot test systems and each test will range from 1 to 10 gpm. Board staff recommends that a flow meter be installed for each pilot test system so that flow is monitored to verify the rate is consistent with that of typical residential domestic wells.

Reverse Osmosis
Board staff has a number of concerns about the proposed testing using reverse osmosis. The first concern is that in domestic home settings, reverse osmosis is typically reserved for one faucet, often in the kitchen. Commercially available reverse osmosis systems are generally not considered an acceptable treatment system for the entire house due to corrosive issues of pipes. If reverse osmosis pilot testing is for consideration in a whole-house setting, testing must include collecting samples at end of pipe in a house-like setting and account for both hot and cold water. Be sure that laboratory analyses include metals that could potentially leach from pipes.

The second concern is that the Pilot Test should specify the type of membrane to be used in the pilot test, such as TFC or CTA. Because filters can concentrate chemicals and compounds and lead to breakthrough, laboratory analyses of treated water must include constituents identified in well water. The third concern is that, in addition to the flow meter at the start of the reverse osmosis process, Board staff recommends that a flow meter be also installed at the end of the process to determine the amount of treated water being produced. Our last concern relates to the description of the reverse osmosis process following treatment. The Pilot Test states treated water and brine stream will be sampled, blended, monitored, and disposed. It is believed that combined water streams should end up having similar water quality to the water initially pumped from the well.

Please note that combined water intended for discharge must be sampled beforehand and placed in a storage facility until the results of water samples are known. Due to water from Gorman 1R exceeding drinking water standards for many constituents, the disposed water should not be done in a manner that forms standing water, such pools and puddles, that could attract wildlife or lead to exposure to humans. In the event that combined water reflects water quality having concentrations exceeding that of the initial well water, the Water Board may consider the water to contain wastes and require it be removed off site to a facility licensed to receive such waste.

Testing Protocol

The testing protocol of the proposed pilot tests call for the in-home systems to be tested under continuous operation mode. While this may be a typical protocol for public water systems, it is not acceptable for in-home use testing, due to high variability in use patterns (i.e, high usage during morning and evening periods, with extended rest periods between those times). Current ANSI/NSF standards for home use require sampling following rest periods to ensure that treated water quality remains acceptable.

Implementation Schedule

We understand that PG&E implemented the pilot test in November 2011 and plans to comply with the feasibility study reporting deadline of April 9, 2012, specified in R6V-2011-0005A1.

As previously stated, Water Board staff has no objection to the proposed schedule, so long as technical reports incorporate the comments included in this letter. Since pilot testing has already been underway, revised testing shall be conducted for no less than one month.

REQUIREMENTS

Water Board staff will anticipate reviewing and evaluating the following information for determining compliance of CAO R6V-2011-0005A1:

- Description of specific selection criteria used to determine systems to be used or not used in the pilot test.
- Water quality information from Gorman 1R well. A sample must be collected within 30 days if implementing the pilot test using water from the well or another well.
- Description of supply well having average water quality concentrations of domestic wells potentially affected by PG&E's waste chromium.
- Flow rate going to each system being tested.
- Type of reverse osmosis membrane being used in testing.
- Volume of treated water produced from reverse osmosis pilot test.
- Revised testing protocol from continuous operation testing to testing following rest periods, to account for typical household usage patterns
- Water quality results of treated water from each pilot test system, including end-of-pipe testing in a whole-house setting.
- Water quality results for combined water streams from reverse osmosis process.
- Description of storage container used while awaiting laboratory results of treated water.
- Disposal description of all wastes created or generated from pilot testing.
- Any unexpected or unplanned findings or results.
- Map(s) showing all locations involved in pilot testing, storage, and disposal.
- Summary and conclusions of testing results.
- The stamp and signature of a state licensed civil engineer.

Please contact me at 542-5436 or Lisa Dernbach at (530) 542-5424 or ldernbach@waterboards.ca.gov, if you should have any questions.

for: LAURI KEMPER
ASSISTANT EXECUTIVE OFFICER

Enclosure: Department of Public Health December 9, 2011 Email

cc: PG&E Technical Mail List and lyris list (and web posting)

LSD/clhT: PG& whole house pilot test 12-11
file: WDID No. 6B369107001 (VVL)

CDPH initial comments

From: "Bartson, Mark (CDPH-DDWEM)" <Mark.Bartson@cdph.ca.gov>
To: <LKemper@waterboards.ca.gov>
CC: "Wilhelm, Kim (CDPH-PS-DDWEM)" <Kim.Wilhelm@cdph.ca.gov>
Date: Friday - December 9, 2011 11:04 AM
Subject: CDPH initial comments
Attachments: Mime.822

Here are our comments in rough format, for now.

* CDPH / ANSI/NSF standards do not currently certify Cr+6 for removal to the PHG level.

* Since there is no MCL for Cr+6 at this time, there is no health claim that can be made. Thus, CDPH regulations do not apply.

* For the test protocol, the proposed systems are tested under continuous operation mode. This is typical of PWS but not for in-home use.

* For in-home use, the typical use pattern is high usage during mornings and evenings with extended period of rest periods. Current ANSI/NSF standards for home use require sampling following rest periods to ensure that the treated water quality remains acceptable. (TDS creep for RO systems.)

Plus previous comments:

Technical Feasibility

1. Point-of-Entry RO treatment is not a practical solution due to corrosion problems for plumbing inside the house. However, Point-of-Use RO treatment or combination RO/IX treatment will likely be the best option.

2. Point-of-Entry Anion Exchange treatment with lead-lag configuration may be possible as a whole house treatment solution for homes with nitrate concentration below the MCL. However, testing frequency at the mid-point will need to be sufficiently high to prevent breakthrough. Due to high variability of source water quality, additional pilot/commissioning testing will need to be done (at least monthly samples).

3. For homes with nitrate > MCL or other source water quality problems, POE Anion Exchange for Cr+6 may be an incomplete solution. It may reduce Cr+6 but there could be high nitrate or other contaminants in the treated water. Most IX media tested to date are quite ion-selective.

Issues with Memo

1. Section 64417 that is referenced in the memo is for POU devices.

2. ANSI/NSF 58 Standard is only applicable for POU devices. The proposed POE devices can't be tested to the standard.

3. ANSI/NSF 53 Standard is applicable for both POU/POE entry devices. However, the current versions of ANSI/NSF 53 and 58 standards do not certify products to below 0.1 mg/L (100 ug/L) of Cr+6. (See Table 8 below.)

4. Both standards have specific testing requirements and the proposed pilot tests do not meet the requirements for device certification. (Due to specific requirements for challenge water conditions.)

ARCADIS

Responses to the Comments from the Water Board

Response to Comments
We have extracted the comments of the Water Board in italics below and prepared responses for each.

Water Board Comment: Selection of Proposed Systems
The document . . . does not discuss the specific selection criteria used for the three proposed systems. Nor does the document state why other systems known to remove chromium from water were not included in the pilot test. For instance, according to the Water Quality Association, other technologies, such as distillation and weakly based anion resin filters, can be used as point-of-use to whole house treatment. PG&E should state why such technologies will not be included in pilot testing.

Response: We contacted more than two dozen vendors of whole house water treatment systems. There were only a few vendors and technologies that were capable of treating hexavalent chromium to the low concentrations for the whole house water supply. We shortlisted the technologies and vendors based on the following criteria:

- Technologies that had the most promise to reliably lower the hexavalent chromium concentrations to low concentrations.
- Technologies that had the most potential to meet the State requirements for whole house water treatment systems (e.g., we ruled out technologies that required storage of hazardous chemicals). For example, weakly based anion resin filters would require pH adjustment using acid which is not practical in whole house treatment settings.
- Vendors that had experience and capabilities to provide turnkey services in Southern California.

Water Board Comment: Gorman 1 R Well
As mentioned in the Pilot Test, Water Board staff has expressed concern about using the Gorman 1 R well in the pilot test. One concern is for the poor water quality from the well. Table 1 in the Pilot Test shows that water from Gorman 1 R exceeds drinking water standards for chloride, sulfate, uranium, gross alpha activity, specific conductance, and total dissolved solids (TDS). The well represents the "worst case scenario" of water quality within the chromium plume area. Our concern is that this water quality does not represent an average water quality scenario of domestic wells potentially affected by PG&E's waste chromium and likely to receive whole house replacement water. Thus, Water Board staff is recommending that the pilot test be simultaneously conducted on a second supply well that represents an average water quality scenario for all constituents other than hexavalent chromium. The other concern expressed by Board staff is that the high pumping rate at Gorman 1 R of 50 gallons per minute (gpm), which is also not consistent with that of residential domestic wells, may affect pilot test results. Pumping of typical domestic wells is generally between 5 to 10 gpm. The Pilot Test states that water from Gorman 1 R will be split for the different pilot test systems and each test will range from 1 to 10 gpm. Board staff recommends that a flow meter be installed for each pilot test system so that flow is monitored to verify the rate is consistent with that of typical residential domestic wells.
Response: Please note that since the time of submitting the Pilot Test Plan, the pilot test well location has been changed from Gorman 1R to Gorman 5R. Table 1 has a comparison of the water quality information for Gorman 1R and 5R. Gorman 5R is an active agricultural well that

screens in the upper aquifer and it is in proximity to the domestic wells on Sommerset Road and Thompson Road. Gorman 5R was selected for several reasons:

1. The site is secure. These pilot units are costly, labor intensive to set up and must operate in a narrow compliance window. Vandalism must be avoided in order to meet the time frames in the CAO.
2. The well site is accessible for tours. Siting the pilot work at an operating domestic well would have likely precluded (without significant intrusion on the domestic well owner/resident) conducting such tours.
3. The water quality is within the range of qualities that have been observed in the area.
4. It is vital to test a relatively "challenging" water quality so as to ensure breakthrough of chromium in the ion exchange technologies within the time frame of the CAO. Otherwise we would be unable to develop accurate life cycle costs (i.e. accurate operations and maintenance costs would not be able to be calculated)

Table 1 contains a comparison of the water quality in the Gorman 1R and the 5R wells.

Table 1. Comparison of Water Quality for Gorman 1R and 5R

Parameters	Unit	MRL	Gorman 1R	Gorman 5R
Sampling Date			**8/24/2011**	**10/25/2011**
General				
Alkalinity, Total	mg/L as $CaCO_3$	2	161	190
Color	Pt/Co units	3	5	5
Specific Conductance	µS/cm	4	3,100	2,500
Hardness, Total	mg/L as $CaCO_3$	10		790
pH	pH units	0.01	7.4	7.2
Total Dissolved Solids	mg/L	10	1,900	1600
Total Solids, Suspended	mg/L	10	10	10
Total Organic Carbon	mg/L	0.25	1.39	1.36
Turbidity	NTU	0.05	1.00	1.00
Total Ammonia -N	mg/L	0.1	0.10	0.1
Anions				
Chloride	mg/L	1	520	280
Fluoride	mg/L	0.1	0.20	0.20
Nitrate-N	mg/L	0.1	8.40	14
Nitrite-N	mg/L	0.1	< 0.01	0.01
Sulfate	mg/L	0.5	450	460
Metals - Total				
Aluminum	µg/L	2	2	2.4
Barium	µg/L	2	72	67
Boron	µg/L	5	340	540
Calcium	mg/L	1	340	250
Chromium	µg/L	2	3.50	4.4[1]
Copper	µg/L	1	1.40	2.8

Parameters	Unit	MRL	Gorman 1R	Gorman 5R
Sampling Date			**8/24/2011**	**10/25/2011**
Iron	mg/L	0.05	0.02	0.025
Lead	µg/L	1	1.00	1
Magnesium	mg/L	0.1	56	41
Manganese	µg/L	2	2	4.9
Nickel	µg/L	1	5.2	3.3
Potassium	mg/L	1	5.2	5.3
Silica, Total	mg/L	0.5	29	32
Sodium	mg/L	1	160	210
Strontium	µg/L	0.3	3,800	2,500
Uranium	µg/L	1.0	46	56
Zinc	µg/L	5	88	62
Radionuclides				
Gross Alpha	pCi/L	3.0	43.6 +/- 3.2	81.8 +/- 5.0
Gross Beta	pCi/L	4.0	9.4 +/- 1.1	7.9 +/- 1.5
Radium-226	pCi/L	1.0		0.37 +/- 0.3
Radium-228	pCi/L	1.0		0.8 +/- 0.52
Combined Radium	pCi/L			1.17 +/- 0.60
Radon-222	pCi/L	25	372 +/- 22	386 +/- 25
Additional				
Phosphorus, Total as P	mg/L	0.05	< 0.05	0.05
Cyanide, Total	mg/L	0.02	0.02	0.02
Hexavalent Chromium	µg/L	0.02	4.20	4.9[1]
Mercury	µg/L	0.1	0.10	0.1
Perchlorate	µg/L	0.5	0.76	0.69
Arsenic, Total	µg/L	2	2	2
Arsenic, Dissolved	µg/L	2	2	2
Atrazine	µg/L	0.05		0.1
Simazine	µg/L	0.05		0.07

Note: 1. Average concentrations based on six sets of independent samples collected over a period of two months.

The water quality of the Gorman 5R well is within the ranges of water quality observed in the domestic wells (see Figures 1 and 2). Figure 1 illustrates the statistical parameters shown in a box-and-whisker plot. The box represents 50 percent of the data, i.e., the spread in data from 25th percentile to 75th percentile. The whiskers represent 10th percentile and 90th percentile values. The solid line within the box represents the median or 50th percentile and the triangle represents the average value for Gorman 5R. The average hexavalent and total chromium concentrations in the Gorman 5R well are slightly higher than the concentrations observed in the domestic wells (see selection rationale item #4 above). The total dissolved solids and sulfate concentrations for Gorman 5R well are within the 25th and 75th percentile values. The alkalinity and nitrate concentrations for Gorman 5R well are close to the 25th percentile values.

The selected technology or technologies should be able to treat waters of variable quality from the domestic wells. Based on the limited information gathered to date, we are encouraged by the performance of the shortlisted technologies as it relates to hexavalent chromium removal. It is not possible to conduct simultaneous pilot testing since it would take several months to plan, fabricate treatment systems and conduct testing on a second supply well. Therefore, we do not feel that it is possible within the current time frame required by the CAO to conduct pilot testing on a second supply well.

We agree that the pumping rate of the domestic wells will be below that of the Gorman 5R well. However, the pumping rate should have minimal or negligible impact on the pilot test results.

We are monitoring the flow rates and flows through each individual whole house treatment system. We will report the flow rates and flows for each treatment system in the *Permanent Replacement Water Supply Feasibility Study Status Report* (CAO R6V-2011-0005A1, 2.b) due on January 27, 2012.

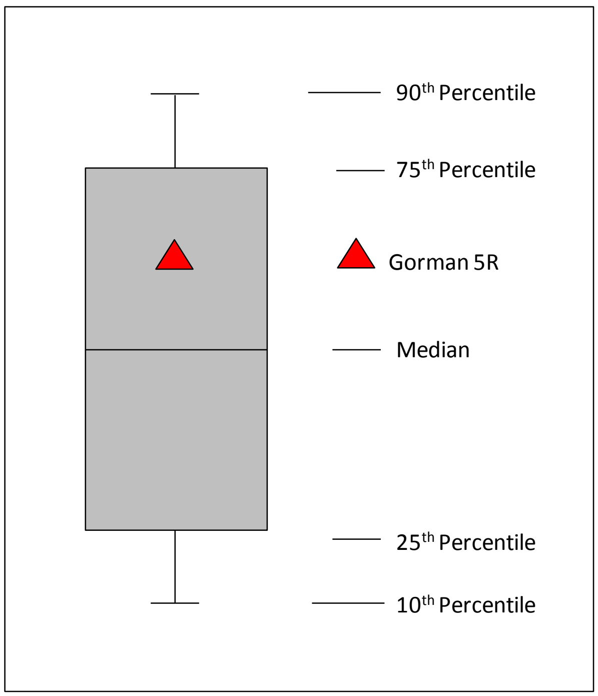

Figure 1. Illustration of Statistical Information in Box-and-Whisker Plots

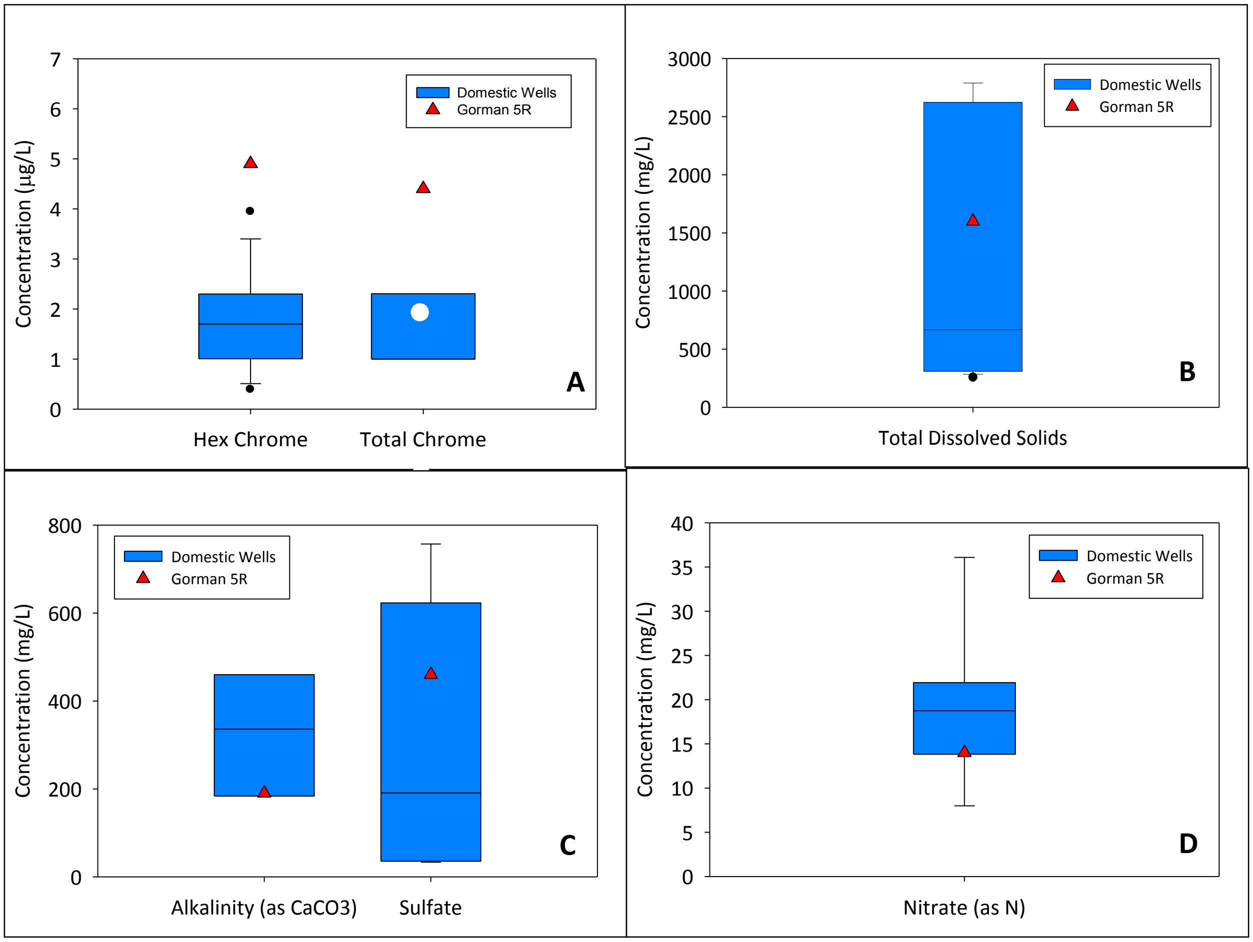

Figure 2. Comparison of Key Water Quality Information for the Gorman 5R Test Well and Domestic Wells

Responses to Water Board Comments

Water Board Comment: Reverse Osmosis

Board staff has a number of concerns about the proposed testing using reverse osmosis. The first concern is that in domestic home settings, reverse osmosis is typically reserved for one faucet, often in the kitchen. Commercially available reverse osmosis systems are generally not considered an acceptable treatment system for the entire house due to corrosive issues of pipes. If reverse osmosis pilot testing is for consideration in a whole-house setting, testing must include collecting samples at end of pipe in a house-like setting and account for both hot and cold water. Be sure that laboratory analyses include metals that could potentially leach from pipes.

Response: Please note that the treated water from the reverse osmosis (RO) treatment systems will be stabilized using appropriate stabilization techniques such as passing through bed of calcite media. We understand the importance of stable water quality to prevent leaching of undesired metals from the domestic piping.

Conducting pipe loop testing will require expanding the test period by several (4-5) months. To obtain meaningful results, pipe loop studies have to be conducted for a minimum of 3 months. Planning, harvesting pipes from homes and setting-up of the pipe loops will take an additional month. Obtaining and processing results will take an additional month. Our consulting team members performed numerous evaluations and pipe loop studies for other water providers that include City of Tucson, City of Scottsdale, City of Carlsbad, West Basin Municipal Water District and others and in case RO emerges as the chosen technology, we will use the "lessons-learned" from those previous studies to guide the stabilization techniques. Also, such stabilization techniques have been used in numerous other RO applications nationally and internationally.

The second concern is that the Pilot Test should specify the type of membrane to be used in the pilot test, such as TFC or CTA. Because filters can concentrate chemicals and compounds and lead to breakthrough, laboratory analyses of treated water must include constituents identified in well water.

Response: The RO membranes that are being pilot tested are thin film composite (TFC) membranes. They are NSF certified, 40-inch long elements that are typically used in whole house water treatment systems. The supplier of the RO membranes for Kinetico system is Dow-Filmtec. The supplier of the RO membranes for ACWA/Purolite system is Applied Membranes, Incorporated. Our test plan includes the monitoring locations (RO feed water, product water and brine streams), monitoring parameters and monitoring frequency.

The third concern is that, in addition to the flow meter at the start of the reverse osmosis process, Board staff recommends that a flow meter be also installed at the end of the process to determine the amount of treated water being produced.

Response: We are measuring the RO feed, product and brine flows for the whole house treatment systems supplied by Kinetico and ACWA/Purolite.

Our last concern relates to the description of the reverse osmosis process following treatment. The Pilot Test states treated water and brine stream will be sampled, blended, monitored, and disposed. It is believed that combined water streams should end up having similar water quality to the water initially pumped from the well. Please note that combined water intended for discharge must be sampled beforehand and placed in a storage facility until the results of water samples are known. Due to water from Gorman 1 R exceeding drinking water standards for many constituents, the disposed water should not be done in a manner that forms standing water, *such pools and puddles, that could attract wildlife or lead to exposure to humans. In the event that combined water reflects water quality having concentrations exceeding that of the initial well water, the Water Board may consider the water to contain wastes and require it be removed off site to a facility licensed to receive such waste.*

Response: As you are aware, prior to the pilot test water from Gorman 5R, Gorman 1R and Gorman 2R was pumped via a common header pipe and distributed to two drag drip pivots. During summer operation, the irrigation rates ranged between 200 and 250 gpm per pivot. The pilot test used a small side stream of the water from Gorman 5R. The treated Gorman 5R water and brine streams from the whole house treatment systems are blended with the by-passed, excess well water in a 500-gallon storage tank. The blended water is sampled and analyzed for a suite of parameters. There is no ponding of the water. The average water quality for key parameters for the untreated Gorman 5R well water and the blended water prior to irrigation use is summarized in Table 2. Based on water quality information gathered to date and unsurprisingly, we are observing a slight decrease in hexavalent chromium, total chromium and uranium concentrations in the blended water compared to the well water currently being applied for irrigation due to the removal of these parameters by the ion exchange media. We are also observing a modest increase in total dissolved solids concentration of the blended water due to the brine that is being used to regenerate the softener in the Kinetico system.

Table 2. Comparison of Average Gorman 5R and Blended Water Qualities

Parameter	Gorman 5R Well Water	Blended Water (Prior to Discharge)
Hexavalent Chromium, µg/L	4.9	2.2
Total Chromium, µg/L	4.4	1.9
Arsenic, µg/L	2.3	<2.0[1]
Total Dissolved Solids, mg/L	1,600	1,712[2]
Uranium, µg/L	37.1	<30[3]

Note: 1. *Less than the method detection limit.*
2. *Based on field measurement. Data need to be verified using laboratory measurements.*
3. *Less than the maximum contaminant level (MCL).*

Water Board Comment: Testing Protocol

The testing protocol of the proposed pilot tests call for the in-home systems to be tested under continuous operation mode. While this may be a typical protocol for public water systems, it is not acceptable for in-home use testing, due to high variability in use patterns (i.e., high usage during morning and evening periods, with extended rest periods between those times). Current ANSI/NSF standards for home use require sampling following rest periods to ensure that treated water quality remains acceptable.

Response: Note that in a whole house environment, the treatment systems would fill a storage tank with treated water. The storage tank would supply the potable water needed for domestic purposes. The well and the treatment system will be in operation whenever the water level in the storage tank drops to the low level setting.

During pilot testing, the whole house water treatment systems are being operated in an intermittent manner to simulate the potential operation in home environment. Envirogen's two-stage ion exchange system and ACWA/Purolite's RO/ion exchange system are being operated for 6 hours each day on weekdays. Kinetico's two-pass RO system is being operated for 8 hours each day on weekdays. Following the overnight rest periods, water samples are being collected when the whole house water treatment systems are started-up in the mornings. The treatment systems are kept offline during the weekends to simulate the potential downtimes from residents leaving the town for the weekends. Water samples are also being collected on Mondays of each week to evaluate any impacts on treatment performance from extended rest periods.

Water Board Comment: Implementation Schedule
We understand that PG&E implemented the pilot test in November 2011 and plans to comply with the feasibility study reporting deadline of April 9, 2012, specified in R6V-2011-000SA 1.
As previously stated, Water Board staff has no objection to the proposed schedule, so long as technical reports incorporate the comments included in this letter. Since pilot testing has already been underway, revised testing shall be conducted for no less than one month.
Response: We believe that it is not necessary to conduct end of pipe or pipe loop tests. If we need to conduct pipe loop studies it will add an additional 4-5 months to the test period.

We believe that the additional pilot testing with average water quality well water is not necessary to make a determination as to the feasibility of the whole house water treatment as a potential water supply solution. Conducting additional pilot testing add 4-6 months to the schedule (one month to build systems, one month to set-up, one month run time, one month for lab analysis and one month for report preparation).

Preliminary hexavalent chromium removal results of ongoing pilot testing are encouraging. Upon examination of the pilot test results, if the Water Board feels additional testing and corresponding schedule adjustment is necessary then we could perform additional testing in a sequential manner.

REQUIREMENTS: The Water Board has asked for the following information for determining compliance with CAO R6V-2011-000SA 1:
Description of specific selection criteria used to determine systems to be used or not used in the pilot test.
Response: We contacted more than two dozen vendors of whole house water treatment systems. There were only a few vendors and technologies that were capable of treating hexavalent chromium to the low concentrations for the whole house water supply. We shortlisted the technologies and vendors based on the following criteria:

- Technologies that had the most promise to reliably lower the hexavalent chromium concentrations to low concentrations.
- Technologies that had the most potential to meet the State requirements for whole house water treatment systems (e.g., we ruled out technologies that required storage of hazardous chemicals). For example, weakly based anion resin filters would require pH adjustment using acid which is not practical in whole house treatment settings.
- Vendors that had experience and capabilities to provide turnkey services in Southern California.

Water quality information from Gorman 1 R well. A sample must be collected within 30 days if implementing the pilot test using water from the well or another well.

Response: Please note that the test well location has been changed from Gorman 1R to Gorman 5R (see our earlier response). We have been collecting water quality information from Gorman 5R per the test plan.

Description of supply well having average water quality concentrations of domestic wells potentially affected by PG&E's waste chromium.
Response: The water quality of the Gorman 5R is within the ranges of water quality observed in the domestic wells (see Figures 1 and 2). The average hexavalent and total chromium concentrations in the Gorman 5R are slightly higher than the concentrations observed in the domestic wells. The TDS and sulfate concentrations for Gorman 5R are within the 25th and 75th percentile values. The alkalinity and nitrate concentrations for Gorman 5R are close to the 25th percentile values.

Flow rate going to each system being tested.
Response: We are monitoring the flow rates and flows through each individual whole house treatment system. We will report the flow rates and flows for each treatment system in the *Permanent Replacement Water Supply Feasibility Study Status Report* (CAO R6V-2011-0005A1, 2.b) due on January 27, 2012.

Type of reverse osmosis membrane being used in testing.
Response: The RO membranes that are being pilot tested are thin film composite (TFC) membranes. They are 4-inch diameter and 40-inch long elements, NSF certified that are typically used in whole house water treatment systems. The supplier of the RO membranes for Kinetico system is Dow-Filmtec. The supplier of the RO membranes for ACWA/Purolite system is Applied Membranes Incorporated.

Volume of treated water produced from reverse osmosis pilot test.
Response: We are monitoring the flow rates and flows through each individual whole house treatment system. We will report the flow rates and flows for each treatment system in the *Permanent Replacement Water Supply Feasibility Study Status Report* (CAO R6V-2011-0005A1, 2.b) due on January 27, 2012.

Revised testing protocol from continuous operation testing to testing following rest periods, to account for typical household usage patterns
Response: Note that in a whole house environment, the treatment systems would fill a storage tank with treated water. The storage tank would supply the potable water needed for domestic purposes. The well and the treatment system will be in operation whenever the water level in the storage tank drops to the low level setting.

During pilot testing, the whole house water treatment systems are being operated in an intermittent manner to simulate the potential operation in home environment. Envirogen's two-stage ion exchange system and ACWA/Purolite's RO/ion exchange system are being operated for 6 hours each day on weekdays. Kinetico's two-pass RO system is being operated for 8 hours each day on weekdays. Following the overnight rest periods, water samples are being collected when the whole house water treatment systems are started-up in the mornings. The treatment systems are kept offline during the weekends to simulate the potential downtimes from residents leaving the town for the weekends. Water samples are also being collected on Mondays of each week to evaluate any impacts on treatment performance from extended rest periods.

Water quality results of treated water from each pilot test system, including end-of-pipe testing in a whole-house setting.
Response: We are monitoring the water quality for each whole house water treatment system per the frequency specified in the pilot test plan. We will submit the results as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Water quality results for combined water streams from reverse osmosis process.
Response: We are monitoring the water quality of the blended water per the frequency specified in the pilot test plan. We will submit the results as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Description of storage container used while awaiting laboratory results of treated water.
Response: The treated water and brine streams from the whole house treatment systems are blended with the by-passed, excess well water in a 500-gallon storage tank. The blended water is sampled and analyzed for a suite of parameters. The average water quality for key parameters for the Gorman 5R well water and the blended water are summarized in Table 2.

Disposal description of all wastes created or generated from pilot testing.
Response: We are monitoring the quantities and qualities of all the waste streams generated by the whole house water treatment systems. We will submit the results of the monitoring as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Any unexpected or unplanned findings or results.
Response: We will report any unexpected or unplanned findings as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Map(s) showing all locations involved in pilot testing, storage, and disposal.
Response: We will present site layouts and schematics of the pilot systems as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Summary and conclusions of testing results.
Response: We will report the summary of findings, conclusions and recommendations as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

The stamp and signature of a state licensed civil engineer.
Response: The *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012 will be signed and sealed by state licensed civil engineer.

CDPH Comments

CDPH 1 ANSIINSF standards do not currently certify Cr+6 for removal to the PHG level.

Response: Agreed and this reality is directly related to our petition to the State Board. Public Health Goals (PHGs) were never intended to be the basis for enforcement or certification in California.

Since there is no MCL for Cr+6 at this time, there is no health claim that can be made. Thus, CDPH regulations do not apply.
Response: Agreed.

For the test protocol, the proposed systems are tested under continuous operation mode. This is typical of PWS but not for in-home use.
Response: Note that in a whole house environment, the treatment systems would fill a storage tank with treated water. The storage tank would supply the potable water needed for domestic purposes. The well and the treatment system will be in operation whenever the water level in the storage tank drops to the low level setting.

During pilot testing, the whole house water treatment systems are being operated in an intermittent manner to simulate the potential operation in home environment. Envirogen's two-stage ion exchange system and ACWA/Purolite's RO/ion exchange system are being operated for 6 hours each day on weekdays. Kinetico's two-pass RO system is being operated for 8 hours each day on weekdays. Following the overnight rest periods, water samples are being collected when the whole house water treatment systems are started-up in the mornings. The treatment systems are kept offline during the weekends to simulate the potential downtimes from residents leaving the town for the weekends. Water samples are also being collected on Mondays of each week to evaluate any impacts on treatment performance from extended rest periods.

For in-home use, the typical use pattern is high usage during mornings and evenings with extended period of rest periods. Current ANSIINSF standards for home use require sampling following rest periods to ensure that the treated water quality remains acceptable. (TDS creep for RO systems.)
Response: During pilot testing, the whole house water treatment systems are being operated in an intermittent manner to simulate the potential operation in home environment. Envirogen's two-stage ion exchange system and ACWA/Purolite's RO/ion exchange system are being operated for 6 hours each day on weekdays. Kinetico's two-pass RO system is being operated for 8 hours each day on weekdays. Following the overnight rest periods, water samples are being collected when the whole house water treatment systems are started-up in the mornings. The treatment systems are kept offline during the weekends which simulates the potential downtimes from residents leaving the town for the weekend. Water samples are also being collected on Mondays of each week to evaluate any impacts on treatment performance from extended rest periods.

According to NSF/ANSI 53 (2011), water treatment systems shall be operated on 50 percent (%) on and 50% off cycle basis with a 15-40 minute cycle, 16-hours per 24-hour period, followed by an 8-hour rest under pressure. Water treatment system manufacturers can request a 10% on and 90% off cycle. The on/off operation cycles mentioned in the NSF/ANSI 53 (2011) are more appropriate for under-the-sink or point of use (POU) treatment systems and not applicable for whole house or point of entry (POE) systems. We believe that the whole house water treatment systems with downstream storage of treated water will be operated close to the scenario that is being pilot tested.

Point-of-Entry RO treatment is not a practical solution due to corrosion problems for plumbing inside the house. However, Point-of-Use RO treatment or combination ROIIX treatment will likely be the best option.
Response: Please note that the treated water from the reverse osmosis (RO) treatment systems will be stabilized using appropriate stabilization techniques such as passing through bed of calcite media. We understand the importance of stable water quality to prevent leaching of undesired metals from the domestic piping.

Point-of-Entry Anion Exchange treatment with lead-lag configuration may be possible as a whole house treatment solution for homes with nitrate concentration below the MCL. However. Testing frequency at the mid-point will need to be sufficiently high to prevent breakthrough. Due to high variability of source water quality, additional pilot/commissioning testing will need to be done (at least monthly samples).
Response: Our pilot study results will help in developing a monitoring plan for the whole house treatment solutions. We agree that monitoring of anions such as nitrate will be necessary if ion exchange emerges as the preferred solution.

For homes with nitrate> MCL or other source water quality problems, POE Anion Exchange for Cr+6 may be an incomplete solution. It may reduce Cr+6 but there could be high nitrate or other contaminants in the treated water. Most IX media tested to date are quite ion-selective.
Response: We understand the potential for chromatographic peaking of anions such as nitrate from the ion exchange process. The average nitrate concentration in Gorman 5R well water is 14 mg/L as N which is within the range of nitrate concentrations observed in the domestic wells (see Figure 2). We are monitoring for anions including nitrate in the lead and lag vessels of the Envirogen's ion exchange process on a bi-weekly basis. We will report the results for nitrate and other contaminants as part of the *Permanent Replacement Water Supply Feasibility Study Report* (CAO R6V-2011-0005A1, 2.c) due on April 6, 2012.

Section 64417 that is referenced in the memo is for POU devices.
Response: Noted.

ANSIINSF 58 Standard is only applicable for POU devices. The proposed POE devices can't be tested to the standard.
Response: Noted.

ANSI/NSF S3 Standard is applicable for both POU/POE entry devices. However, the current versions of ANSIINSF 53 and 58 standards do not certify products to below 0.1 mg/L (100 ug/L) of Cr+6 (See Table 8 below.)
Response: We understand that ANSI/NSF 53 and 58 standards cannot certify whole house treatment systems to the Public Health Goal. The ANSI/NSF 53 and 58 guidelines for testing and certification are based on the current maximum contaminant levels. According to the information described in Table 8 of NSF/ANSI 58 (2009) testing should be conducted using water with influent hexavalent chromium concentration of 300 μg/L and the maximum allowable product water concentration is 100 μg/L. Note that the objectives of the ongoing pilot testing is to study the feasibility of whole house treatment technologies and systems to lower the

hexavalent chromium concentration in Hinkley groundwaters (see Figure 2 for the anticipated influent concentrations) to very low levels.

Both standards have specific testing requirements and the proposed pilot tests do not meet the requirements for device certification. (Due to specific requirements for challenge water conditions.)

Response: Please note that we will not be able to obtain the ANSI/NSF device certifications for hexavalent chromium removal from the pilot study since ANSI/NSF will not certify the whole house treatment systems to less than the current maximum contaminant level of 100 µg/L. We are running the pilot study using the test well water (see Figure 2) to remove the hexavalent chromium concentrations to very low concentrations. If we have to meet the ANSI/NSF 53 and 58 standard requirements then we would have to spike the test well water with hexavalent chromium of 300 µg/L. Running spiked tests will not be useful for this study and may create other unwarranted environmental issues.

Moreover, ANSI/NSF certification requires conducting tests using a public water supply with specific characteristics listed under Section 7.4.2.5 of NSF/ANSI 53 (2011). The Hinkley groundwater characteristics do not match or meet the typical public water supply water quality requirements for alkalinity, hardness and total dissolved solids.

References

NSF/ANSI 58 – 2009, Reverse Osmosis Drinking Water Treatment Systems. NSF International, Ann Arbor. Michigan.

NSF/ANSI 53 – 2011, Drinking Water Treatment Units – Health Effects. NSF International, Ann Arbor. Michigan.

ARCADIS

Attachment B

Underwriters Laboratories QA/QC Certification

March 19, 2012

Ms. Bhavana Karnik
Malcolm Pirnie
2929 Briarpark Drive
Suite #300
Houston, TX
77042

Dear Ms. Karnik,

UL LLC in South Bend, Indiana specializes in Drinking Water Analytical Services and is proud of the fact that the laboratory is certified in all 50 States and Puerto Rico. Our NELAC certification through the State of Florida is especially satisfying for the organization. NELAC uses standards for certification that are quite challenging and employs an on-site assessment process on a regular basis. The assessments conducted by the State of Florida are comprehensive, thorough, technically oriented, and valuable to UL LLC to use for continuous improvement of our Quality Management System.

One of the key requirements found in the NELAC Standard is as follows:

5.4.9.1 The laboratory shall have a policy and procedures that shall be implemented when any aspect of its environmental testing work, or the results of this work, do not conform to its own procedures or the agreed requirements of the client. The policy and procedures shall ensure that:

a) the responsibilities and authorities for the management of nonconforming work are designated and actions (including halting of work and withholding of test reports, as necessary) are defined and taken when nonconforming work is identified;
b) an evaluation of the significance of the nonconforming work is made;
c) corrective actions are taken immediately, together with any decision about the acceptability of the nonconforming work;
d) where the data quality is or may be impacted, the client is notified;
e) the responsibility for authorizing the resumption of work is defined.

UL LLC is in full compliance with this requirement. Our analytical reports include a "Narrative" section when and if any of the quality control samples do not meet the

UL LLC
110 S. Hill St., South Bend, IN 46617-2702 USA
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requirements of the analytical method. This procedure has been followed, when applicable, for all of the reports produced for the Hinkley Project in California.

We previously provided our certificates and scopes of certification for the States of California and Florida (NELAC) for your files. All of the analytical methods listed on these documents and ordered by Malcolm Pirnie comply with the requirement quoted above.

It is a pleasure to perform analytical services for clients who are concerned about the quality of the results in addition to the services that we provide. The business relationship between Malcolm Pirnie and UL LLC appears to be “working” for both of us. If there is anything that I can do, personally to assist you or to improve our business relationship please let me know.

Sincerely,

Eugene Klesta

Eugene Klesta
Regional Quality Manager
574-472-5580
eugene.j.klesta@ul.com

cc: T. Chlebowski
N. Trowbridge
Malcolm Pirnie File

NELAP - RECOGNIZED

CALIFORNIA STATE

ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM BRANCH

CERTIFICATE OF NELAP ACCREDITATION

Is hereby granted to

Underwriters Laboratories Inc.

110 South Hill Street

South Bend, IN 46617

Scope of the Certificate is limited to the
"NELAP Fields of Accreditation"
which accompany this Certificate.

Continued accredited status depends on successful
ongoing participation in the program.

This Certificate is granted in accordance with provisions of
Section 100825, et seq. of the Health and Safety Code.

Certificate No.: **01136CA**

Expiration Date: **4/30/2012**

Effective Date: **5/1/2011**

Richmond, California
subject to forfeiture or revocation

George C. Kulasingam

George C. Kulasingam, Ph.D., Chief
Environmental Laboratory Accreditation Program Branch

Underwriters Laboratories Inc.
110 South Hill Street
South Bend, IN 46617
Phone: (574) 233-4777

Primary AA: FL E87775

Certificate No.: 01136CA
Renew Date: 4/30/2012

102 - Inorganic Chemistry of Drinking Water

102.020	001	EPA 180.1	Turbidity
102.030	001	EPA 300.0	Bromide
102.030	002	EPA 300.0	Chlorate
102.030	003	EPA 300.0	Chloride
102.030	004	EPA 300.0	Chlorite
102.030	005	EPA 300.0	Fluoride
102.030	006	EPA 300.0	Nitrate
102.030	010	EPA 300.0	Sulfate
102.040	004	EPA 300.1	Bromate
102.045	001	EPA 314.0	Perchlorate
102.047	001	EPA 331.0	Perchlorate
102.050	001	EPA 335.4	Cyanide
102.060	001	EPA 353.2	Nitrate calc.
102.061	001	EPA 353.2	Nitrite
102.100	001	SM2320B	Alkalinity
102.110	001	SM2330B	Corrosivity (Langlier Index)
102.120	001	SM2340B	Hardness
102.130	001	SM2510B	Conductivity
102.140	001	SM2540C	Total Dissolved Solids
102.163	001	SM4500-Cl G	Chlorine, Free and Total
102.200	001	SM4500-F C	Fluoride
102.212	001	EPA 150.1	pH
102.240	001	SM4500-P E	Phosphate, Ortho
102.262	001	SM5310C	Total Organic Carbon
102.263	001	SM5310C	DOC
102.280	001	SM5910B	UV254
102.410	001	Technicon 380-75WE	Fluoride
102.520	001	EPA 200.7	Calcium
102.520	002	EPA 200.7	Magnesium
102.520	003	EPA 200.7	Potassium
102.520	004	EPA 200.7	Silica
102.520	005	EPA 200.7	Sodium
102.520	006	EPA 200.7	Hardness (calc.)

102.545	001	EPA 317.0	Bromate
102.564	001	Quickchem 10-204-00-1-X	Cyanide

103 - Toxic Chemical Elements of Drinking Water

103.130	001	EPA 200.7	Aluminum
103.130	009	EPA 200.7	Iron
103.130	011	EPA 200.7	Manganese
103.130	015	EPA 200.7	Silver
103.140	001	EPA 200.8	Aluminum
103.140	002	EPA 200.8	Antimony
103.140	003	EPA 200.8	Arsenic
103.140	004	EPA 200.8	Barium
103.140	005	EPA 200.8	Beryllium
103.140	006	EPA 200.8	Cadmium
103.140	007	EPA 200.8	Chromium
103.140	008	EPA 200.8	Copper
103.140	009	EPA 200.8	Lead
103.140	010	EPA 200.8	Manganese
103.140	012	EPA 200.8	Nickel
103.140	013	EPA 200.8	Selenium
103.140	014	EPA 200.8	Silver
103.140	015	EPA 200.8	Thallium
103.140	016	EPA 200.8	Zinc
103.160	001	EPA 245.1	Mercury

104 - Volatile Organic Chemistry of Drinking Water

104.030	001	EPA 504.1	1,2-Dibromoethane
104.030	002	EPA 504.1	1,2-Dibromo-3-chloropropane
104.040	001	EPA 524.2	Benzene
104.040	002	EPA 524.2	Bromobenzene
104.040	003	EPA 524.2	Bromochloromethane
104.040	006	EPA 524.2	Bromomethane
104.040	007	EPA 524.2	n-Butylbenzene
104.040	008	EPA 524.2	sec-Butylbenzene
104.040	009	EPA 524.2	tert-Butylbenzene
104.040	010	EPA 524.2	Carbon Tetrachloride
104.040	011	EPA 524.2	Chlorobenzene
104.040	012	EPA 524.2	Chloroethane
104.040	014	EPA 524.2	Chloromethane
104.040	015	EPA 524.2	2-Chlorotoluene
104.040	016	EPA 524.2	4-Chlorotoluene
104.040	018	EPA 524.2	Dibromomethane
104.040	019	EPA 524.2	1,3-Dichlorobenzene

104.040	020	EPA 524.2	1,2-Dichlorobenzene
104.040	021	EPA 524.2	1,4-Dichlorobenzene
104.040	022	EPA 524.2	Dichlorodifluoromethane
104.040	023	EPA 524.2	1,1-Dichloroethane
104.040	024	EPA 524.2	1,2-Dichloroethane
104.040	025	EPA 524.2	1,1-Dichloroethene
104.040	026	EPA 524.2	cis-1,2-Dichloroethene
104.040	027	EPA 524.2	trans-1,2-Dichloroethene
104.040	028	EPA 524.2	Dichloromethane
104.040	029	EPA 524.2	1,2-Dichloropropane
104.040	030	EPA 524.2	1,3-Dichloropropane
104.040	031	EPA 524.2	2,2-Dichloropropane
104.040	032	EPA 524.2	1,1-Dichloropropene
104.040	033	EPA 524.2	cis-1,3-Dichloropropene
104.040	034	EPA 524.2	trans-1,3-Dichloropropene
104.040	035	EPA 524.2	Ethylbenzene
104.040	036	EPA 524.2	Hexachlorobutadiene
104.040	037	EPA 524.2	Isopropylbenzene
104.040	038	EPA 524.2	4-Isopropyltoluene
104.040	039	EPA 524.2	Naphthalene
104.040	040	EPA 524.2	Nitrobenzene
104.040	041	EPA 524.2	N-propylbenzene
104.040	042	EPA 524.2	Styrene
104.040	043	EPA 524.2	1,1,1,2-Tetrachloroethane
104.040	044	EPA 524.2	1,1,2,2-Tetrachloroethane
104.040	045	EPA 524.2	Tetrachloroethene
104.040	046	EPA 524.2	Toluene
104.040	047	EPA 524.2	1,2,3-Trichlorobenzene
104.040	048	EPA 524.2	1,2,4-Trichlorobenzene
104.040	049	EPA 524.2	1,1,1-Trichloroethane
104.040	050	EPA 524.2	1,1,2-Trichloroethane
104.040	051	EPA 524.2	Trichloroethene
104.040	052	EPA 524.2	Trichlorofluoromethane
104.040	053	EPA 524.2	1,2,3-Trichloropropane
104.040	054	EPA 524.2	1,2,4-Trimethylbenzene
104.040	055	EPA 524.2	1,3,5-Trimethylbenzene
104.040	056	EPA 524.2	Vinyl Chloride
104.040	057	EPA 524.2	Xylenes, Total
104.040	058	EPA 524.2	Hexachloroethane
104.045	001	EPA 524.2	Bromodichloromethane
104.045	002	EPA 524.2	Bromoform

104.045	003	EPA 524.2	Chloroform	
104.045	004	EPA 524.2	Dibromochloromethane	
104.045	005	EPA 524.2	Trihalomethanes	
104.050	002	EPA 524.2	Methyl tert-butyl Ether (MTBE)	
104.050	004	EPA 524.2	tert-Amyl Methyl Ether (TAME)	CA Primary
104.050	005	EPA 524.2	Ethyl tert-butyl Ether (ETBE)	CA Primary
104.050	006	EPA 524.2	Trichlorotrifluoroethane	CA Primary

105 - Semi-volatile Organic Chemistry of Drinking Water

105.010	004	EPA 505	Chlordane
105.010	014	EPA 505	Toxaphene
105.010	015	EPA 505	PCBs as Aroclors (screen)
105.082	001	EPA 515.3	2,4-D
105.082	002	EPA 515.3	Dinoseb
105.082	003	EPA 515.3	Pentachlorophenol
105.082	004	EPA 515.3	Picloram
105.082	005	EPA 515.3	2,4,5-TP
105.082	006	EPA 515.3	Bentazon
105.082	007	EPA 515.3	Dalapon
105.082	008	EPA 515.3	Dicamba
105.090	001	EPA 525.2	Alachlor
105.090	002	EPA 525.2	Aldrin
105.090	003	EPA 525.2	Atrazine
105.090	004	EPA 525.2	Benzo(a)pyrene
105.090	005	EPA 525.2	Butachlor
105.090	007	EPA 525.2	Dieldrin
105.090	008	EPA 525.2	Di(2-ethylhexyl) Adipate
105.090	009	EPA 525.2	Di(2-ethylhexyl) Phthalate
105.090	010	EPA 525.2	4,4'-DDD
105.090	011	EPA 525.2	4,4'-DDE
105.090	012	EPA 525.2	4,4'-DDT
105.090	013	EPA 525.2	Endrin
105.090	014	EPA 525.2	Heptachlor
105.090	015	EPA 525.2	Heptachlor Epoxide
105.090	016	EPA 525.2	Hexachlorobenzene
105.090	017	EPA 525.2	Hexachlorocyclopentadiene
105.090	018	EPA 525.2	Lindane
105.090	019	EPA 525.2	Methoxychlor
105.090	020	EPA 525.2	Metolachlor
105.090	021	EPA 525.2	Metribuzin
105.090	022	EPA 525.2	Molinate
105.090	024	EPA 525.2	Propachlor

105.090	025	EPA 525.2	Simazine
105.100	001	EPA 531.1	Aldicarb
105.100	002	EPA 531.1	Aldicarb Sulfone
105.100	003	EPA 531.1	Aldicarb Sulfoxide
105.100	004	EPA 531.1	Carbaryl
105.100	005	EPA 531.1	Carbofuran
105.100	006	EPA 531.1	3-Hydroxycarbofuran
105.100	007	EPA 531.1	Methomyl
105.100	008	EPA 531.1	Oxamyl
105.120	001	EPA 547	Glyphosate
105.140	001	EPA 548.1	Endothall
105.150	001	EPA 549.2	Diquat
105.170	001	EPA 551.1	Bromochloroacetonitrile
105.170	005	EPA 551.1	Chloral Hydrate
105.170	007	EPA 551.1	Chloropicrin
105.170	008	EPA 551.1	Dibromoacetonitrile
105.170	012	EPA 551.1	Dichloroacetonitrile
105.170	013	EPA 551.1	1,1-Dichloro-2-propanone
105.170	015	EPA 551.1	Trichloroacetonitrile
105.170	018	EPA 551.1	1,1,1-Trichloro-2-propanone
105.175	001	EPA 551.1	Bromodichloromethane
105.175	002	EPA 551.1	Bromoform
105.175	003	EPA 551.1	Chloroform
105.175	004	EPA 551.1	Dibromochloromethane
105.200	001	EPA 552.2	Bromoacetic Acid
105.200	002	EPA 552.2	Bromochloroacetic Acid
105.200	003	EPA 552.2	Chloroacetic Acid
105.200	005	EPA 552.2	Dibromoacetic Acid
105.200	006	EPA 552.2	Dichloroacetic Acid
105.200	007	EPA 552.2	Trichloroacetic Acid
105.200	009	EPA 552.2	Haloacetic Acids
105.230	001	EPA 1613	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)

106 - Radiochemistry of Drinking Water

106.080	001	EPA 906.0	Tritium
106.092	001	EPA 200.8	Uranium
106.260	001	SM7110B	Gross Alpha
106.260	002	SM7110B	Gross Beta
106.270	001	SM7110C	Gross Alpha
106.340	002	SM7500-Ra B	Radium-226
106.360	001	SM7500-Ra D	Radium-228

ARCADIS

Attachment C

Whole-House Water Treatment Pilot Study – Water Quality Monitoring Data

Table C1. Water Quality for G-5R

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
General							
Alkalinity, Total	mg/L as $CaCO_3$	2	15	145	228	343	395
Specific Conductance	µS/cm	4	15	1547	2083.23	3724	7199
Hardness, Total	mg/L as $CaCO_3$	10	15	560	698.9	872	895
pH	pH units	0.01	15	7.05	7.13	7	7.27
Total Dissolved Solids	mg/L	10	12	1006	1077	1145	1204
Total Solids, Suspended	mg/L	10	3	<10	<10	<10	<10
Total Organic Carbon	mg/L	0.25	2	0.87	0.95	1.02	1.03
Turbidity	NTU	0.05	15	0.19	0.67	2	2.03

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Temperature	(°C)		15	17.8	19.90	22	21.9
Anions							
Chloride	mg/L	1	5	180	188	198	290
Nitrate-N	mg/L	0.1	5	6.3	6.7	6.9	6.9
Sulfate	mg/L	0.5	5	270	278	288	290
Metals - Total							
Aluminum	µg/L	2	4	<2	2.15	2.195	2.2
Barium	µg/L	2	4	88	95	100	100
Boron	µg/L	5	4	340	365	378.5	380
Calcium	mg/L	1	13	67	74.4	80.8	82
Chromium	µg/L	0.1	23	3.3	4.2	4.97	5.1
Iron	mg/L	0.05	5	0.034	0.0724	0.1632	0.19
Magnesium	mg/L	0.1	13	18	21.3	22	22

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Manganese	µg/L	2	4	2.7	3.15	3.70	3.80
Silica, Total	mg/L	0.5	5	31	31.6	32	32
Strontium	µg/L	0.3	4	2000	2225	2385	2400
Uranium	µg/L	1.0	8	35	36.90	38.84	39.20
Radionuclides							
Gross Alpha	pCi/L	3.0	2	19.6 +/- 3.4	[redacted]	[redacted]	48.8 +/- 2.9
Gross Beta	pCi/L	4.0	2	5.0 +/- 1.2	[redacted]	[redacted]	6.0 +/- 3.8
Radium-226	pCi/L	1.0	2	0.28 +/- 0.22	[redacted]	[redacted]	0.56 +/- .26
Radium-228	pCi/L	1.0	2	0.02 +/- 0.48	[redacted]	[redacted]	1.1 +/- 0.6
Combined Radium	pCi/L		2	0.30 +/- 0.53	[redacted]	[redacted]	1.66 +/- 0.65
Radon-222	pCi/L	25	2	307 +/- 21	[redacted]	[redacted]	318 +/- 20

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Additional							
Phosphate	mg/L	0.05	4	<0.05	0.06	0.06	0.06
Hexavalent Chromium	µg/L	0.02	23	4.1	4.9	5.2	5.3
Arsenic, Total	µg/L	2	12	2	2.26	2.44	2.5

Table C2. Water Quality for Blended Water

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
General							
Alkalinity, Total	mg/L as $CaCO_3$	2	14	120	217.36	273.50	280
Specific Conductance	µS/cm	4	14	1568	2659.07	5110.70	6698
Hardness, Total	mg/L as $CaCO_3$	10	14	400	680.57	1283	1400
pH	pH units	0.01	14	7.05	7.22	7.30	7.31
Total Dissolved Solids	mg/L	10	13	1019.20	1526.45	2700.49	2766.40
Total Solids, Suspended	mg/L	10	2	<10	<10	<10	<10
Total Organic Carbon	mg/L	0.25	2	0.651	3.53	6.12	6.41
Turbidity	NTU	0.05	14	0.19	0.40	1.01	2.09

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Temperature	(°C)		14	13.70	19.33	21.74	21.80
Anions							
Chloride	mg/L	1	5	170	298	646	760
Nitrate-N	mg/L	0.1	5	5.8	6.2	6.48	6.5
Sulfate	mg/L	0.5	5	250	268	280	280
Metals - Total							
Aluminum	µg/L	2	4	<2	<2	<2	<2
Barium	µg/L	2	4	60	85	106.4	110
Boron	µg/L	5	4	330	357.5	377	380
Calcium	mg/L	1	13	59	69.31	80.4	90
Chromium	µg/L	0.1	23	0.5	2.20	2.88	2.90
Iron	mg/L	0.05	5	0.021	0.028	0.0357	0.036
Magnesium	mg/L	0.1	13	15	19.30	26.2	31

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Manganese	µg/L	2	4	2.3	2.875	3.82	4
Silica, Total	mg/L	0.5	5	27	29.8	31.6	32
Strontium	µg/L	0.3	4	1400	1875	2480	2600
Uranium	µg/L	1.0	5	8.2	19.55	24	24
Radionuclides							
Gross Alpha	pCi/L	3.0	2	9.3 +/- 2.1	[redacted]	[redacted]	13.9 +/- 2.6
Gross Beta	pCi/L	4.0	2	15.7 +/- 1.9	[redacted]	[redacted]	35.7 +/- 1.8
Radium-226	pCi/L	1.0	2	0.13 +/- 0.16	[redacted]	[redacted]	0.52 +/- 0.30
Radium-228	pCi/L	1.0	2	0.28 +/- 0.53	[redacted]	[redacted]	0.39 +/- 0.60
Combined Radium	pCi/L	1.0	2	0.41 +/- 0.55	[redacted]	[redacted]	0.91 +/- 0.67

Parameters	Unit	MRL	Number of Sample Points	Results			
				Minimum	Average	95th Percentile	Maximum
Radon-222	pCi/L	25	2	184 +/- 18	[redacted]		198 +/- 17
Additional							
Phosphate	mg/L	0.05	4	<0.05	0.06	0.06	0.06
Hexavalent Chromium	µg/L	0.02	23	0.52	2.52	3.2	3.5
Arsenic, Dissolved	µg/L	2	13	2	2.083	2.25	2.3

Table C3. Water Quality for Envirogen Systems (11/15/12 to 1/27/12)

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	10	115	205	250.5	255	10	50	171.30	229.25	245
Specific Conductance	µS/cm	4	10	1536	1647	1767	1844	10	1531	1685.60	1899.85	1948
Hardness, Total	mg/L as $CaCO_3$	10	10	530	655	832.75	880	10	475	630	869.75	935
pH	pH units	0.01	11	7.08	7.20	7.33	7.36	11	6.09	7.06	7.26	
Total Dissolved Solids	mg/L	10	11	998.4	1078.70	1177.80	1198.60	11	995.15	1100.58	1231.43	1266.20
Turbidity	NTU	0.05	11	0.08	0.17	0.25	0.27	10	0.34	1.11	2.78	3.56
Temperature	(°C)		11	13.00	18.55	21.50	21.60	11	11.60	19.01	21.35	21.40
Anions												

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	7	170	185.71	190	190	7	170	184.29	190	190
Nitrate-N	mg/L	0.1	14	6.1	6.47	6.65	6.7	14	5.4	6.40	6.79	6.9
Sulfate	mg/L	0.5	7	250	275.71	287	290	7	250	281.43	304	310
Metals - Total												
Aluminum	µg/L	2	3	<2	<2	<2	<2	4	<2	<2	<2	<2
Barium	µg/L	2	1	100	100	100	100	4	88	95	100	100
Boron	µg/L	5	1	380	380	380	380	4	350	365	378.5	380
Calcium	mg/L	1	9	67	73.63	81.30	82	8	66	72.75	78.85	82
Chromium	µg/L	0.1	16	0.2	1.27	2.94	3.2	16	0.1	0.34	0.82	1.3
Iron	mg/L	0.05	2	<0.02	<0.02	<0.02	<0.02	5	0.058	0.10	0.18	0.19
Silica, Total	mg/L	0.5	3	32	32	32	32	4	31	31.75	32	32
Strontium	µg/L	0.3	1	2200	2200	2200	2200	4	2100	2200	2300	2300

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Uranium	µg/L	1.0	2	<1	[redacted]	[redacted]	33.3	5	<1	<1	<1	<1
Radionuclides												
Gross Alpha	pCi/L	3.0	1	3.3 +/- 1.1	3.3 +/-1.1	3.3 +/-1.1	3.3 +/-1.1	1	2.0 +/-1.0	2.0 +/-1.0	2.0 +/-1.0	2.0 +/-1.0
Gross Beta	pCi/L	4.0	1	4.9 +/- 1.2	4.9 +/- 1.2	4.9 +/- 1.2	4.9 +/- 1.2	1	3.4 +/- 1.2	3.4 +/- 1.2	3.4 +/- 1.2	3.4 +/- 1.2
Radium-226	pCi/L	1.0	1	0.56 +/- 0.27	0.56 +/- 0.27	0.56 +/- 0.27	0.56 +/- 0.27	1	0.24 +/- 0.22	0.24 +/- 0.22	0.24 +/- 0.22	0.24 +/- 0.22
Radium-228	pCi/L	1.0	1	0.29 +/- 0.64	0.29 +/- 0.64	0.29 +/- 0.64	0.29 +/- 0.64	1	0.43 +/- 0.52	0.43 +/- 0.52	0.43 +/- 0.52	0.43 +/- 0.52
Combined Radium	pCi/L		1	0.85 +/- 0.69	0.85 +/- 0.69	0.85 +/- 0.69	0.85 +/- 0.69	1	0.67 +/- 0.56	0.67 +/- 0.56	0.67 +/- 0.56	0.67 +/- 0.56
Radon-222	pCi/L	25	1	356 +/- 21	356 +/- 21	356 +/- 21	356 +/- 21	1	307 +/- 19	307 +/- 19	307 +/- 19	307 +/- 19
Additional												

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Phosphate	mg/L	0.05	4	<0.05	<0.05	<0.05	<0.05	4	<0.05	<0.05	<0.05	<0.05
Hexavalent Chromium	µg/L	0.02	17	<0.02	1.37	3.28	3.5	16	<0.02	<0.02	<0.02	<0.02
Arsenic, Total	µg/L	2	9	<2	2.20	2.29	2.3	7	<2	2.32	2.88	3

Table C4. Water Quality for Envirogen Systems (2/6/12 to 2/29/12)

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	3	200	200.33	200.90	201	3	150	155	159.50	160
Specific Conductance	µS/cm	4	3	1460	1533	1578	1580	3	1460	1533	1578	1580
Hardness, Total	mg/L as $CaCO_3$	10	3	580	590	599	600	3	530	553.33	577	580
pH	pH units	0.01	20	6.95	7.12	7.24	7.28	20	6.73	7.09	7.28	7.34
Total Dissolved Solids	mg/L	10	19	1112	1253	1578	2045	19	1060	1185	1288	1462
Turbidity	NTU	0.05	3	0.14	0.16	0.18	0.18	3	0.80	0.80	0.81	0.81
Temperature	(°C)		20	14.20	19.95	24.92	25.30	20	18.90	20.88	22.42	24.70
Anions												

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	1	180	180	180	180	1	180	180	180	180
Nitrate-N	mg/L	0.1	4	6.3	6.4	6.49	6.5	4	6.3	6.5	6.67	6.7
Sulfate	mg/L	0.5	1	260	260	260	260	1	260	260	260	260
Metals - Total												
Aluminum	µg/L	2	1	<2	<2	<2	<2	0				
Barium	µg/L	2	1	64	64	64	64	0				
Boron	µg/L	5	1	360	360	360	360	0				
Calcium	mg/L	1	5	77	77.8	78.8	79	4	77	77.25	77.85	79
Chromium	µg/L	0.1	7	1.5	2.71	3.64	3.7	7	0.3	0.66	1.14	1.2
Iron	mg/L	0.05	1	<0.02	<0.02	<0.02	<0.02	0				
Magnesium	mg/L	0.1	5	22	22.20	22.80	23	4	21	21.75	22.0	22
Manganese	µg/L	2	1	2.7	2.7	2.7	2.7	0				

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Silica, Total	mg/L	0.5	1	32	32	32	32	0	[redacted]	[redacted]	[redacted]	[redacted]
Strontium	µg/L	0.3	1	2100	2100	2100	2100	0	[redacted]	[redacted]	[redacted]	[redacted]
Uranium	µg/L	1.0	1	<1	<1	<1	<1	0	[redacted]	[redacted]	[redacted]	[redacted]
Radionuclides												
Gross Alpha	pCi/L	3.0	1	2.0 +/- 1.0	2.0 +/- 1.0	2.0 +/- 1.0	2.0 +/- 1.0	0	[redacted]	[redacted]	[redacted]	[redacted]
Gross Beta	pCi/L	4.0	1	4.3 +/- 1.7	4.3 +/- 1.7	4.3 +/- 1.7	4.3 +/- 1.7	0	[redacted]	[redacted]	[redacted]	[redacted]
Radium-226	pCi/L	1.0	1	0.07 +/- 0.16	0.07 +/- 0.16	0.07 +/- 0.16	0.07 +/- 0.16	1	0.28 +/- 0.20	0.28 +/- 0.20	0.28 +/- 0.20	0.28 +/- 0.20
Radium-228	pCi/L	1.0	1	0.02 +/- 0.62	0.02 +/- 0.62	0.02 +/- 0.62	0.02 +/- 0.62	1	0.28 +/- 0.58	0.28 +/- 0.58	0.28 +/- 0.58	0.28 +/- 0.58
Combined Radium	pCi/L		1	0.09 +/- 0.63	0.09 +/- 0.63	0.09 +/- 0.63	0.09 +/- 0.63	1	0.56 +/- 0.61	0.56 +/- 0.61	0.56 +/- 0.61	0.56 +/- 0.61
Radon-222	pCi/L	25	1	330 +/- 22	330 +/- 22	330 +/- 22	330 +/- 22	1	339 +/- 22	339 +/- 22	339 +/- 22	339 +/- 22

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU1_S1) Results					Ion Exchange Lag Vessel Effluent (TU1_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Additional												
Hexavalent Chromium	µg/L	0.02	7	1.8	3.23	4.20	4.2	7	0.24	0.64	1.06	1.1
Arsenic, Total	µg/L	2	5	<2	2.18	2.29	2.3	4	2.2	2.3	2.39	2.4

Table C5. Water Quality for Envirogen Systems - Undersink RO (TU1_S3 and TU1_S4) for period 2/6/12 to 2/29/12

Parameters	Unit	MRL	Undersink RO Permeate (TU1_S3) Results					Undersink RO Brine (TU1_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	3	0	0	0	0	0	[redacted]			
Specific Conductance	µS/cm	4	3	350.10	355.01	362.61	363.90	0				
Hardness, Total	mg/L as $CaCO_3$	10	4	40	42.33	44.70	45	0				
pH	pH units	0.01	19	7.12	7.71	7.93	7.98	17	7.03	7.25	7.43	7.48
Total Dissolved Solids	mg/L	10	19	96.67	231.49	389.16	472.50	17	1139	1651.29	2006	2042
Turbidity	NTU	0.05	3	1.02	6.06	14.60	16.10	0	[redacted]			
Temperature	(°C)		19	13.10	18.88	24.98	25.70	17	12.40	18.76	24.66	25.30
Anions												

Parameters	Unit	MRL	Undersink RO Permeate (TU1_S3) Results					Undersink RO Brine (TU1_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	8	12	17.43	26.10	27	8	190	360	564	570
Nitrate-N	mg/L	0.1	8	0.5	1.06	1.60	1.6	8	2.5	6.49	8.17	8.2
Sulfate	mg/L	0.5	7	5.3	6.50	8.46	8.8	7	68	304.71	440	440
Metals - Total												
Aluminum	µg/L	2	7	2.3	3.07	4.02	4.2	7	2.6	12.17	43.10	59
Barium	µg/L	2	7	9	22.24	35.40	36	7	82	131.70	157	160
Boron	µg/L	5	7	<5	<5	<5	5.3	7	130	332.86	407	410
Calcium	mg/L	1	7	2.8	7.16	12.4	13	7	77	114.14	216.60	270
Chromium	µg/L	0.1	7	<0.1	<0.1	<0.1	0.3	7	<0.1	0.34	0.48	0.5
Iron	mg/L	0.05	7	<0.02	<0.02	<0.02	<0.02	7	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/L	0.1	7	1.2	3.67	5.78	5.9	7	21	30	38	41
Manganese	µg/L	2	7	2.3	6.76	11	11	7	<2	3.06	3.46	3.5

Parameters	Unit	MRL	Undersink RO Permeate (TU1_S3) Results					Undersink RO Brine (TU1_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Silica, Total	mg/L	0.5	7	7.6	10.61	15.20	17	7	33	46.14	50.40	51
Strontium	µg/L	0.3	7	43	109.29	187	190	7	1600	2942.86	3440	3500
Uranium	µg/L	1.0	7	<1	<1	<1	<1	7	14	19.57	24.00	24
Additional												
Hexavalent Chromium	µg/L	0.02	7	<0.02	<0.02	<0.02	< 0.02	7	<0.02	0.12	0.27	0.3
Arsenic, Total	µg/L	2	7	<2	<2	<2	<2	7	2.4	3.23	4.15	4.3

Table C6. Water Quality for Kinetico Systems (TU2_S1 and TU2_S2) period 11/15/12 to 1/27/12

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Pass RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	10	140	251.30	503.75	515	10	0	21.51	53.75	65
Specific Conductance	µS/cm	4	10	1336	1793.70	2237.05	2548	10	17.4	31.83	62.04	80.55
Hardness, Total	mg/L as $CaCO_3$	10	10	60	163	351.50	500	10	45	93.30	173.25	225
pH	pH units	0.01	12	7.03	7.18	7.25	7.26	37	5	5.82	6.52	6.61
Total Dissolved Solids	mg/L	10	6	0.46	882.37	1221.6	1230	34	14.74	57.28	176.11	278
Turbidity	NTU	0.05	10	0.07	0.17	0.38	0.46	10	0.05	0.13	0.34	0.37
Temperature	(°C)		14	12.90	18.64	21.60	21.70	37	8.50	20.82	22.94	23.10
Metals - Total												

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Pass RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Aluminum	µg/L	2	0	[redacted]				1	<2	<2	<2	<2
Barium	µg/L	2	0	[redacted]				1	<2	<2	<2	<2
Boron	µg/L	5	0	[redacted]				1	260	260	260	260
Calcium	mg/L	1	6	0.2	0.225	0.285	0.3	1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	0.1	14	1.8	2.84	3.61	3.8	15	<0.1	<0.1	<0.1	<0.1
Iron	mg/L	0.05	0	[redacted]				1	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/L	0.1	4	<0.1	<0.1	<0.1	<0.1	1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	2	0	[redacted]				1	<2	<2	<2	<2
Silica, Total	mg/L	0.5	0	[redacted]				1	0.5	0.5	0.5	0.5
Strontium	µg/L	0.3	0	[redacted]				1	<2	<2	<2	<2
Uranium	µg/L	1.0	2	35.5	36	36.45	36.45	1	<1	<1	<1	<1
Additional												

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Pass RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Hexavalent Chromium	µg/L	0.02	14	1.8	3.17	4.07	4.2	15	0.02	0.27	0.03	0.03
Arsenic, Total	µg/L	2	5	<2	2.15	2.2	2.2	6	<2	<2	<2	<2

Table C7. Water Quality for Kinetico Systems (TU2_S1 and TU2_S2) period 2/6/12 to 2/29/2012

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Stage RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	3	145	165.33	195.9	201	3	0	11.67	31.5	35
Specific Conductance	µS/cm	4	3	1739	1809	1844.8	1845	3	31.5	65.18	83.62	84.01
Hardness, Total	mg/L as $CaCO_3$	10	2	71	115.5	155.55	160	2	0	40	76	80
pH	pH units	0.01	2	7.15	7.28	7.40	7.41	20	6.06	6.71	7.261	7.85
Total Dissolved Solids	mg/L	10	1	<10	<10	<10	<10	20	17.52	89.41	117.05	695.5
Turbidity	NTU	0.05	3	0.08	0.14	0.17	0.17	3	0.06	0.14	0.19	0.19
Temperature	(°C)		2	19.1	20.25	21.29	21.4	20	18.1	21.91	23.5	23.5
Metals - Total												

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Stage RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Aluminum	µg/L	2	0	[redacted]				1	<2	<2	<2	<2
Barium	µg/L	2	0					1	<2	<2	<2	<2
Boron	µg/L	5	0					1	470	470	470	470
Calcium	mg/L	1	4	0.2	0.225	0.285	0.3	1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	0.1	6	3.4	3.84	4.1	4.1	7	<0.1	<0.1	<0.1	<0.1
Iron	mg/L	0.05	0	[redacted]				1	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/L	0.1	4	<0.1	<0.1	<0.1	<0.1	1	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	2	0	[redacted]				1	<2	<2	<2	<2
Silica, Total	mg/L	0.5	0					1	0.5	0.5	0.5	0.5
Strontium	µg/L	0.3	0					1	<2	<2	<2	<2
Uranium	µg/L	1.0	0					1	<1	<1	<1	<1
Additional												

Parameters	Unit	MRL	Softener Effluent (TU2_S1) Results					1st-Stage RO Permeate (TU2_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Hexavalent Chromium	µg/L	0.02	6	4.3	4.7	4.95	5	7	<0.02	0.03	0.03	0.03
Arsenic, Total	µg/L	2	4	2.1	2.17	2.28	2.3	5	<2	<2	<2	<2

Table C8. Water Quality for Kinetico Systems (TU2_S3) for 11/15/11 to 1/27/12

Parameters	Unit	MRL	Number of Sample Points	Two-Pass RO Permeate (TU2_S3) Results			
				Minimum	Average	95th Percentile	Maximum
General							
Alkalinity, Total	mg/L as $CaCO_3$	2	10	0	13.20	35.50	40
Specific Conductance	µS/cm	4	10	3.20	7.81	18.67	22.86
Hardness, Total	mg/L as $CaCO_3$	10	10	40	79.80	102.75	105
pH	pH units	0.01	37	4.52	5.06	5.65	5.76
Total Dissolved Solids	mg/L	10	34	3.10	12.16	36.08	65.56
Total Solids, Suspended	mg/L	10	1	<10	<10	<10	<10
Total Organic Carbon	mg/L	0.25	1	<0.5	<0.5	<0.5	<0.5
Turbidity	NTU	0.05	10	0.06	0.13	0.29	0.30

Parameters	Unit	MRL	Number of Sample Points	Two-Pass RO Permeate (TU2_S3) Results			
				Minimum	Average	95th Percentile	Maximum
Temperature	(°C)		37	10	20.75	24.50	25.20
Anions							
Chloride	mg/L	6	<2	<2	<2	<2	<2
Nitrate-N	mg/L	0.1	5	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/L	0.5	5	<5	<5	<5	<5
Metals - Total							
Barium	µg/L	2	1	<2	<2	<2	<2
Boron	µg/L	5	1	130	130	130	130
Calcium	mg/L	1	1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	0.1	15	<0.1	<0.1	<0.1	<0.1
Iron	mg/L	0.05	1	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/L	0.1	2	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	2	1	<2	<2	<2	<2

Parameters	Unit	MRL	Number of Sample Points	Two-Pass RO Permeate (TU2_S3) Results			
				Minimum	Average	95th Percentile	Maximum
Silica, Total	mg/L	0.5	1	<0.1	<0.1	<0.1	<0.1
Strontium	µg/L	0.3	1	<2	<2	<2	<2
Uranium	µg/L	1.0	5	0	0.3	0.3	0.3
Radionuclides							
Gross Alpha	pCi/L	3.0	5	1.2 +/- 1.3	[redacted]	[redacted]	2.3 +/- 1.5
Gross Beta	pCi/L	4.0	5	-3.5 +/- 2.5	[redacted]	[redacted]	7.2 +/- 3.1
Radium-226	pCi/L	1.0	5	0.02 +/- 0.05	[redacted]	[redacted]	0.36 +/- 0.25
Radium-228	pCi/L	1.0	5	-0.43 +/- 0.53	[redacted]	[redacted]	0.68 +/- 0.52
Combined Radium	pCi/L			-30 +/- 0.54	[redacted]	[redacted]	0.83 +/- 0.54
Radon-222	pCi/L	25	5	46.8 +/- 12.7	[redacted]	[redacted]	110 +/- 15
Additional							

Parameters	Unit	MRL	Number of Sample Points	Two-Pass RO Permeate (TU2_S3) Results			
				Minimum	Average	95th Percentile	Maximum
Hexavalent Chromium	µg/L	0.02	15	<0.02	<0.02	<0.02	<0.02
Arsenic, Total	µg/L	2	6	16	16	16	16

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Table C9. Water Quality for Kinetico Systems (TU2_S3 and TU2_S5) period 2/6/12 to 2/29/2012

Parameters	Unit	MRL	Two-Stage RO Permeate (TU2_S3) Results					Calcite Filtered Water (TU2_S5) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	3	0	9.67	26.1	29	4	40	41.5	44.4	45
Specific Conductance	µS/cm	4	3	4.31	32.60	47.67	47.9	4	150.7	266.18	381.49	381.8
Hardness, Total	mg/L as $CaCO_3$	10	2	0	45	85.5	90	3	189	279.67	329	330
pH	pH units	0.01	20	5.7	6.0	6.41	6.7	19	6.54	7.36	7.75	7.8
Total Dissolved Solids	mg/L	10	20	21.55	42.41	97.25	311.1	19	75.75	481.96	1125.89	5570
Turbidity	NTU	0.05	3	0.05	0.17	0.23	0.23	4	0.5	1.04	1.59	1.6
Temperature	(°C)		20	18	22.60	25.01	25.2	19	17.9	21.92	23.73	24
Anions												

Parameters	Unit	MRL	Two-Stage RO Permeate (TU2_S3) Results					Calcite Filtered Water (TU2_S5) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	0	[redacted]	[redacted]	[redacted]	[redacted]	6	4.3	5.55	8.1	8.9
Nitrate-N	mg/L	0.1	0	[redacted]	[redacted]	[redacted]	[redacted]	6	0.6	0.68	0.775	0.8
Sulfate	mg/L	0.5	0	[redacted]	[redacted]	[redacted]	[redacted]	6	<5	<5	<5	<5
Metals - Total												
Aluminum	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]
Barium	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]
Boron	µg/L	5	1	470	470	470	470	0	[redacted]	[redacted]	[redacted]	[redacted]
Calcium	mg/L	1	1	0.7	0.7	0.7	0.7	6	14	20	37.75	45
Chromium	µg/L	0.1	7	<0.1	<0.1	<0.1	<0.1	6	<0.1	<0.1	<0.1	<0.1
Iron	mg/L	0.05	1	<0.02	<0.02	<0.02	<0.02	0	[redacted]	[redacted]	[redacted]	[redacted]
Magnesium	mg/L	0.1	1	0.2	0.2	0.2	0.2	6	0.2	0.55	1.775	2.3
Manganese	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]

Parameters	Unit	MRL	Two-Stage RO Permeate (TU2_S3) Results					Calcite Filtered Water (TU2_S5) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Silica, Total	mg/L	0.5	1	0.7	0.7	0.7	0.7	0	[redacted]			
Strontium	µg/L	0.3	1	9.7	9.7	9.7	9.7	0	[redacted]			
Uranium	µg/L	1.0	1	<1	<1	<1	<1	6	<1	<1	<1	<1
Additional												
Hexavalent Chromium	µg/L	0.02	7	< 0.02	< 0.02	< 0.02	0.02	6	0.02	0.055	0.13	0.16
Arsenic, Total	µg/L	2	5	<2	<2	<2	<2	6	<2	<2	<2	<2

Table C10. Water Quality for Kinetico Systems (Brine) 11/15/12 to 1/27/12

Parameters	Unit	MRL	Two-Pass RO Brine (TU2_S4) Results					1st – Pass RO Brine (TU2_S4_A) Results					2nd – Pass RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg	95th Percentile	Max.	No. of Sample Points	Min.	Avg	95th Percentile	Max.
General																	
Alkalinity, Total	mg/L as $CaCO_3$	2	10	90	221.20	394	475										
Specific Conductance	µS/cm	4	10	1264	1845	2328.15	2388										
Hardness, Total	mg/L as $CaCO_3$	10	10	4	110.80	299.25	450										
pH	pH units	0.01	12	4.91	6.99	7.31	7.31	29	7.14	7.34	7.41	7.48	29	5.65	6.58	7.33	7.51
Total Dissolved Solids	mg/L	10	2	4.34	4.34	4.34	4.34	29	20.86	1763.12	2418.60	2470	34	30.37	261.92	1109.98	3063
Turbidity	NTU	0.05	10	0.07	0.12	0.21	0.21	0					0				
Total Solids,	mg/L	10	1	<10	<10	<10	<10	0					0				

Parameters	Unit	MRL	Two-Pass RO Brine (TU2_S4) Results					1st – Pass RO Brine (TU2_S4_A) Results					2nd – Pass RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg	95th Percentile	Max.	No. of Sample Points	Min.	Avg	95th Percentile	Max.
Suspended									[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
Total Organic Carbon	mg/L	0.25	1	1.33	1.33	1.33	1.33	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Temperature	(°C)		13	14.20	19.34	22.01	22.10	29	7.80	20.11	22.70	23.30	29	9.40	18.97	22.82	24.70
Nitrate-N	mg/L	0.1	1	1	1	1	1	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Metals - Total																	
Barium	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Boron	µg/L	5	1	370	370	370	370	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Calcium	mg/L	1	1	0.5	0.5	0.5	0.5	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Chromium	µg/L	0.1	12	2	3.04	3.89	4	4	2.8	4.93	5.78	5.8	5	<1	0.33	0.56	0.6
Iron	mg/L	0.05	1	<0.02	<0.02	<0.02	<0.02	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Magnesium	mg/L	0.1	1	<0.1	<0.1	<0.1	<0.1	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Manganese	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]

Parameters	Unit	MRL	Two-Pass RO Brine (TU2_S4) Results					1st – Pass RO Brine (TU2_S4_A) Results					2nd – Pass RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg	95th Percentile	Max.	No. of Sample Points	Min.	Avg	95th Percentile	Max.
Silica, Total	mg/L	0.5	1	59	59	59	59	0					0				
Strontium	µg/L	0.3	1	7.8	7.8	7.8	7.8	0					0				
Uranium	µg/L	1.0	4	37.6	43.35	64.85	66.6	0					0				
Radionuclides																	
Gross Alpha	pCi/L	3.0	1	28.1 +/- 2.8			28.1 +/- 2.8	0					0				
Gross Beta	pCi/L	4.0	1	10.9 +/- 1.5			10.9 +/- 1.5	0					0				
Radium-226	pCi/L	1.0	1	0.10 +/- 0.15			0.10 +/- 0.15	0					0				
Radium-228	pCi/L	1.0	1	-0.07 +/- 0.50			-0.07 +/- 0.50	0					0				
Combined Radium	pCi/L		1	0.03 +/-			0.03 +/-	0					0				

Parameters	Unit	MRL	Two-Pass RO Brine (TU2_S4) Results					1st – Pass RO Brine (TU2_S4_A) Results					2nd – Pass RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg	95th Percentile	Max.	No. of Sample Points	Min.	Avg	95th Percentile	Max.
				0.52	[redacted]	[redacted]	0.52		[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
Radon-222	pCi/L	25	1	159 +/- 15	[redacted]	[redacted]	159 +/- 15	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Additional																	
Hexavalent Chromium	µg/L	0.02	11	2	3.21	4.3	4.5	3	6.7	6.97	7.42	7.5	5	0.03	0.066	0.124	0.13
Arsenic, Total	µg/L	2	6	2	2.57	3.53	3.8	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]

Table C11. Water Quality for Kinetico Systems (Brine) (2/6/12 to 2/29/2012)

Parameters	Unit	MRL	Two-Stage RO Brine (TU2_S4) Results					1st – Stage RO Brine (TU2_S4_A) Results					2nd – Stage RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max
General																	
Alkalinity, Total	mg/L as $CaCO_3$	2	3	410	416.67	420	420	0					0				
Specific Conductance	µS/cm	4	3	1720	3369.67	4238.1	4249	0					0				
Hardness, Total	mg/L as $CaCO_3$	10	2	40	85	125.5	130	0					0				
pH	pH units	0.01	3	7.45	7.50	7.55	7.56	20	7.13	7.34	7.48	7.61	19	7.4	7.56	7.65	7.67
Total Dissolved Solids	mg/L	10	4	2200	2300	2300	2500	20	2007	2230	2316.95	2506	19	3150	3651.64	4070.7	5679
Turbidity	NTU	0.05	3	0.07	0.23	0.32	0.33	0					0				
Total Solids, Suspended	mg/L	10	1	<10	<10	<10	<10	0					0				
Total Organic	mg/L	0.25	0					1	1.49	1.49	1.49	1.49	1	3.68	3.68	3.68	3.68

Parameters	Unit	MRL	Two-Stage RO Brine (TU2_S4) Results					1st – Stage RO Brine (TU2_S4_A) Results					2nd – Stage RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max
Carbon				[redacted]	[redacted]	[redacted]	[redacted]										
Temperature	(°C)		4	21.4	21.73	22.3	22.4	20	17.6	20.72	23.04	23.8	19	15.2	21.3	24.22	24.4
Metals - Total																	
Aluminum	µg/L	2	1	<2	<2	<2	<2	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Barium	µg/L	2	1	14	14	14	14	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Boron	µg/L	5	1	510	510	510	510	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Calcium	mg/L	1	1	24	24	24	24	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Chromium	µg/L	0.1	4	7.5	8.35	9.65	9.9	7	5.3	6.03	6.87	6.9	7	7	7.6	8.21	8.3
Iron	mg/L	0.05	1	<0.02	<0.02	<0.02	<0.02	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Magnesium	mg/L	0.1	1	9.9	9.9	9.9	9.9	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Manganese	µg/L	2	1	2.4	2.4	2.4	2.4	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Silica, Total	mg/L	0.5	1	56	56	56	56	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]

Parameters	Unit	MRL	Two-Stage RO Brine (TU2_S4) Results					1st – Stage RO Brine (TU2_S4_A) Results					2nd – Stage RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max
Strontium	µg/L	0.3	1	470	470	470	470	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Uranium	µg/L	1.0	1	49.9 +/- 5.4	49.9 +/- 5.4	49.9 +/- 5.4	49.9 +/- 5.4	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Radionuclides																	
Gross Alpha	pCi/L	3.0	1	35.5 +/- 2.5	35.5 +/- 2.5	35.5 +/- 2.5	35.5 +/- 2.5	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Gross Beta	pCi/L	4.0	1	20.7 +/- 2.6	20.7 +/- 2.6	20.7 +/- 2.6	20.7 +/- 2.6	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Radium-226	pCi/L	1.0	1	0.02 +/- 0.08	0.02 +/- 0.08	0.02 +/- 0.08	0.02 +/- 0.08	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]
Radium-228	pCi/L	1.0	1	0.29 +/- 0.59	0.29 +/- 0.59	0.29 +/- 0.59	0.29 +/- 0.59	0	[redacted]	[redacted]	[redacted]	[redacted]	0	[redacted]	[redacted]	[redacted]	[redacted]

Parameters	Unit	MRL	Two-Stage RO Brine (TU2_S4) Results					1st – Stage RO Brine (TU2_S4_A) Results					2nd – Stage RO Brine (TU2_S4_B) Results				
			No. of Sample Points	Min	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max	No. of Sample Points	Min.	Avg.	95th Percentile	Max
Radon-222	pCi/L	25	1	32.6 +/- 13.0	32.6 +/- 13.0	32.6 +/- 13.0	32.6 +/- 13.0	0					0				
Additional																	
Hexavalent Chromium	µg/L	0.02	3	7.2	9.3	10.87	11	7	7.6	8.33	8.98	9.1	7	7.5	10.1	11.7	12
Arsenic, Total	µg/L	2	5	4.1	4.58	4.92	5	0					0				

Table C12. Water Quality for ACWA-Purolite Systems (TU3_S1 and TU3_S2) period 11/15/11 to 1/27/12

Parameters	Unit	MRL	RO Permeate (TU3_S1) Results					RO Brine (TU3_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	7	0	28.14	80	95	7	290	335.71	415	450
Specific Conductance	µS/cm	4	8	42.66	61.92	95.46	98.67	8	1792	2474	3480	3985
Hardness, Total	mg/L as $CaCO_3$	10	7	50	76.43	114.50	125	7	795	1029.29	1581	1800
pH	pH units	0.01	23	5.09	5.74	6.16	6.70	19	6.43	7.20	7.39	7.39
Total Solids, Suspended	mg/L	10	0	[redacted]				2	<10	<10	<10	<10
Total Organic Carbon	mg/L	0.25	0	[redacted]				2	4.67	5.59	6.41	6.51
Total Dissolved Solids	mg/L	10	17	24.50	44.92	93.89	130.10	16	32.05	1741.86	2724.75	2886

Parameters	Unit	MRL	RO Permeate (TU3_S1) Results					RO Brine (TU3_S2) Results				
			No. of Sample Points	Minimum	Average	95^{th} Percentile	Maximum	No. of Sample Points	Minimum	Average	95^{th} Percentile	Maximum
Turbidity	NTU	0.05	9	0.12	0.20	0.28	0.30	9	0.14	0.39	0.75	0.82
Temperature	(°C)		23	19.10	20.90	21.89	22.40	19	16.30	19.91	22.24	22.60
Anions												
Chloride	mg/L	1	3	6.1	6.3	6.56	6.6	0				
Nitrate-N	mg/L	0.1	3	1.2	1.27	1.3	1.3	0				
Sulfate	mg/L	0.5	3	<5	<5	<5	<5	0				
Metals - Total												
Barium	µg/L	2	2	<2	<2	<2	<2	2	160	175	188.5	190
Boron	µg/L	5	3	320	330	339	340	5	380	455	522.5	530
Calcium	mg/L	1	7	0.2	0.21	0.27	0.3	7	78	87	96.7	97
Chromium	µg/L	0.1	13	< 0.1	< 0.1	< 0.1	< 0.1	11	5.8	7.22	9.66	9.8
Iron	mg/L	0.02	2	<0.02	<0.02	<0.02	<0.02	2	<0.02	<0.02	<0.02	<0.02

Parameters	Unit	MRL	RO Permeate (TU3_S1) Results					RO Brine (TU3_S2) Results				
			No. of Sample Points	**Minimum**	**Average**	**95th Percentile**	**Maximum**	**No. of Sample Points**	**Minimum**	**Average**	**95th Percentile**	**Maximum**
Magnesium	mg/L	0.1	7	<0.1	<0.1	<0.1	<0.1	7	25	29.29	31.7	32
Manganese	µg/L	2	2	<2	<2	<2	<2	2	3.8	4.5	5.13	5.2
Silica, Total	mg/L	0.5	2	0.7	0.75	0.79	0.80	2	51	53	54.8	55
Strontium	µg/L	0.3	2	2.7	2.75	2.79	2.80	2	3300	3450	3585	3600
Uranium	µg/L	1.0	5	-0.005	[redacted]	[redacted]	0.009 +/- 0.001	4	54.18	70.76	93.74	97.5
Radionuclides												
Gross Alpha	pCi/L	3.0	3	-0.66 +/- 1.02	[redacted]	[redacted]	1.6 +/- 1.7	2	66.6 +/- 4.2	[redacted]	[redacted]	74.7 +/- 4.4
Gross Beta	pCi/L	4.0	3	-8.4 +/- 1.1	[redacted]	[redacted]	4.2 +/- 3.5	2	4.6 +/- 0.8	[redacted]	[redacted]	8.9 +/- 1.7
Radium-226	pCi/L	1.0	3	0.02 +/- 0.05	[redacted]	[redacted]	1.4 +/- 0.6	2	0.44 +/- 0.23	[redacted]	[redacted]	2.3 +/- 0.8
Radium-228	pCi/L	1.0	3	-0.47 +/- 0.53	[redacted]	[redacted]	0.42 +/- 0.58	2	0.62 +/- 0.6	[redacted]	[redacted]	1.1 +/- 0.6

Parameters	Unit	MRL	RO Permeate (TU3_S1) Results					RO Brine (TU3_S2) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Combined Radium	pCi/L		3	-0.45 +/- 0.53	[redacted]	[redacted]	0.98 +/- 0.83	2	1.54 +/- 0.63	[redacted]	[redacted]	2.92 +/- 1.0
Radon-222	pCi/L	25	3	276 +/- 27	[redacted]	[redacted]	317 +/- 20	1	354 +/- 20	[redacted]	[redacted]	354 +/- 20
Additional												
Hexavalent Chromium	µg/L	0.02	12	<0.02	0.021	0.026	0.03	12	7	8.89	11	11
Arsenic, Total	µg/L	2	8	<2	<2	<2	<2	7	2.7	3.41	3.74	3.8

Table C13. Water Quality for ACWA-Purolite Systems (TU3_S1 and TU3_S2) period 2/6/12 to 2/29/2012

Parameters	Unit	MRL	TU3_S1 Results					TU3_S2 Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	2	0	0	0	0	2	260	297.5	331.25	335
Specific Conductance	µS/cm	4	2	92.39	98.65	104.27	104.9	2	2241	2312.5	2376.85	2384
Hardness, Total	mg/L as $CaCO_3$	10	2	0	50	95	100	2	880	892.5	903.75	905
pH	pH units	0.01	20	6.27	6.85	7.13	7.37	20	7.01	7.14	7.25	7.3
Total Dissolved Solids	mg/L	10	20	58.39	105.74	144.38	153.4	20	1509	1801.3	2278	2416
Turbidity	NTU	0.05	2	0.22	0.315	0.40	0.41	2	0.16	0.19	0.226	0.23
Temperature	(°C)		20	19.5	21.05	22.42	22.7	20	13.3	19.8	24.78	25.0
Metals - Total												

Parameters	Unit	MRL	TU3_S1 Results					TU3_S2 Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Calcium	mg/L	1	4	0.3	0.45	0.58	0.6	4	88	93	98.4	99
Chromium	µg/L	0.1	7	<0.1	<0.1	<0.1	<0.1	7	5.1	5.5	5.8	5.8
Magnesium	mg/L	0.1	4	<0.1	<0.1	<0.1	<0.1	4	28	29.25	31.55	32
Additional												
Hexavalent Chromium	µg/L	0.02	7	<0.02	<0.02	<0.02	<0.02	7	6.5	8.52	9.73	10
Arsenic, Total	µg/L	2	4	<2	<2	<2	<2	4	2.9	3.25	3.57	3.6

Table C14. Water Quality for ACWA-Purolite Systems (TU3_S3 and TU3_S4) period 11/15/11 to 1/27/12

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	7	0	15	40.5	45	7	0	10.71	28.5	30
Specific Conductance	µS/cm	4	8	47.40	74.67	134..99	152.10	8	35.23	70.84	135.73	165.70
Hardness, Total	mg/L as $CaCO_3$	10	7	20	77.86	132	135	7	16	81.57	127.5	135
pH	pH units	0.01	8	4.85	5.74	6.90	7.37	8	4.81	5.40	6.67	7.18
Total Dissolved Solids	mg/L	10	8	30.81	48.54	87.74	98.87	8	22.90	46.05	88.22	107.71
Turbidity	NTU	0.05	8	0.06	1.37	6.43	9.74	8	0.07	0.38	1.34	1.70
Temperature	(°C)		8	16.80	20.16	22.32	22.60	8	16.80	19.99	22.29	22.50
Anions												

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	3	9.1	9.8	10.83	11	3	11	11.33	11.9	12
Nitrate-N	mg/L	0.1	9	<0.1	<0.1	<0.1	<0.1	8	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/L	0.5	3	<5	<5	<5	<5	3	<5	<5	<5	<5
Metals - Total												
Aluminum	µg/L	2	2	<2	<2	<2	<2	2	<2	<2	<2	<2
Barium	µg/L	2	2	<2	<2	<2	<2	3	<2	<2	<2	<2
Boron	µg/L	5	2	330	335	339.5	340	3	320	330	339	340
Calcium	mg/L	1	7	0.2	0.27	0.55	0.7	6	0.2	0.22	0.275	0.3
Chromium	µg/L	0.1	11	<0.1	<0.1	<0.1	<0.1	11	<0.1	<0.1	<0.1	<0.1
Iron	mg/L	0.05	2	<0.02	<0.02	<0.02	<0.02	3	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/L	0.1	7	<0.1	<0.1	<0.1	<0.1	6	<0.1	<0.1	<0.1	<0.1
Manganese	µg/L	2	2	<2	<2	<2	<2	3	<2	<2	<2	<2

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Silica, Total	mg/L	0.5	2	0.7	0.75	0.79	0.8	3	0.7	0.8	0.89	0.9
Strontium	µg/L	0.3	2	2.6	2.65	2.69	2.7	3	3	3.5	4.27	4.4
Uranium	µg/L	1.0	2	0.002 +/- 0.001	[redacted]		0.002 +/- 0.001	5	-0.004 +/- 0.003	[redacted]		40.4
Radionuclides												
Gross Alpha	pCi/L	3.0	2	0.02 +/- 1.06	[redacted]		0.74 +/- 1.36	2	-0.99 +/- 1.22	[redacted]		-0.26 +/- 0.99
Gross Beta	pCi/L	4.0	2	-0.66 +/- 1.84			3.6 +/- 2.3	2	0.92 +/- 2.42			1.6 +/- 2.0
Radium-226	pCi/L	1.0	2	-0.02 +/- 0.13			0.60 +/- 0.4	1	1.5 +/- 0.7			1.5 +/- 0.7
Radium-228	pCi/L	1.0	2	-0.56 +/- 0.54			0.32 +/- 0.53	0				
Combined Radium	pCi/L		2	0.04 +/- 0.66			0.30 +/- 0.55	1	0.94 +/- 0.87			0.94 +/- 0.87

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Radon-222	pCi/L	25	1	314 +/- 20	314 +/- 20	314 +/- 20	314 +/- 20	1	288 +/- 19	288 +/- 19	288 +/- 19	288 +/- 19
Additional												
Hexavalent Chromium	µg/L	0.02	12	<0.02	<0.02	<0.02	<0.02	12	<0.02	<0.02	<0.02	<0.02
Arsenic, Total	µg/L	2	7	<2	<2	<2	<2	6	<2	<2	<2	<2

Table C15. Water Quality for ACWA-Purolite Systems (TU3_S3 and TU3_S4) period 2/6/12 to 2/29/12

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
General												
Alkalinity, Total	mg/L as $CaCO_3$	2	2	0	0	0	0	2	0	0	0	0
Specific Conductance	µS/cm	4	2	87.64	112.67	135.19	137.7	2	83.54	87.20	90.48	90.85
Hardness, Total	mg/L as $CaCO_3$	10	2	75	80	84.5	85	2	0	30	57	60
pH	pH units	0.01	2	6.14	6.47	6.77	6.8	2	5.84	5.96	6.07	6.08
Total Dissolved Solids	mg/L	10	1	33	33	33	33	1	19	19	19	19
Turbidity	NTU	0.05	2	0.15	0.17	0.18	0.19	2	0.36	0.38	0.39	0.4
Temperature	(°C)		2	21.3	21.55	21.78	21.8	2	21.1	21.45	21.77	21.8
Anions												

Parameters	Unit	MRL	Ion Exchange Lead Vessel Effluent (TU3_S3) Results					Ion Exchange Lag Vessel Effluent (TU3_S4) Results				
			No. of Sample Points	Minimum	Average	95th Percentile	Maximum	No. of Sample Points	Minimum	Average	95th Percentile	Maximum
Chloride	mg/L	1	1	21	21	21	21	1	20	20	20	20
Nitrate-N	mg/L	0.1	4	<0.1	<0.1	<0.1	<0.1	4	<0.1	<0.1	<0.1	<0.1
Sulfate	mg/L	0.5	1	<5	<5	<5	<5	1	<5	<5	<5	<5
Metals - Total												
Calcium	mg/L	1	6	0.3	0.45	0.58	0.6	4	0.3	0.48	0.6	0.6
Chromium	µg/L	0.1	7	<0.1	<0.1	<0.1	<0.1	6	<0.1	<0.1	<0.1	<0.1
Additional												
Hexavalent Chromium	µg/L	0.02	7	<0.02	<0.02	<0.02	<0.02	7	<0.02	<0.02	<0.02	<0.02
Arsenic, Total	µg/L	2	4	<2	<2	<2	<2	4	<2	<2	<2	<2

Table C16. Special Monitoring – Ion Exchange System

Parameter	Units	MCL	Raw Water	Ion Exchange System Lag Vessel (TU2_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
Nitrosamines							
N-Nitrosopyrrolidine (NPYR)	ng/L		< 2	< 2	< 2	< 2	< 2
N-Nitrosodi-N-butylamine (NDBA)	ng/L		< 4	< 4	< 4	< 4	< 4
N-Nitrosodiethylamine (NDEA)	ng/L		<5	<5	<5	<5	<5
N-Nitrosodimethylamine (NDMA)	ng/L		<2	**35**	<2	<2	<2
N-Nitrosodi-N-propylamine (NDPA)	ng/L		<7	<7	<7	<7	<7
N-Nitrosomethylethylamine (NMEA)	ng/L		<3	<3	<3	<3	<3
N-Nitrosopiperridine (NPIP)	ng/L		<2	**2.3**	<2	<2	<2
Volatile Organic Chemicals + TIC			< MRL				< MRL
2-Butanone (MEK)	µg/L			14,000			
Chlorobenzene	µg/L	100					
Chloroform	µg/L			12			

Parameter	Units	MCL	Raw Water	Ion Exchange System Lag Vessel (TU2_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
Cyclohexanone	µg/L		[redacted]	4,600	[redacted]	[redacted]	[redacted]
Dibromochloromethane	µg/L		[redacted]	1	[redacted]	[redacted]	[redacted]
Total Trihalomethane	µg/L	80	[redacted]	14	[redacted]	[redacted]	[redacted]
1,2 - Dichloroethane	µg/L	5	[redacted]	4.4	[redacted]	[redacted]	[redacted]
Ethyl acrylate	µg/L		[redacted]	1.5	[redacted]	[redacted]	[redacted]
Methyl methacrylate	µg/L		[redacted]	4.0	[redacted]	[redacted]	[redacted]
tert-Butyl alcohol	µg/L		[redacted]	9.2	[redacted]	[redacted]	[redacted]
Tetrahydrofuran	µg/L		[redacted]	48,000	[redacted]	[redacted]	[redacted]
Toluene	µg/L	1,000	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6-methyl-2-heptene	µg/L		[redacted]	3	[redacted]	[redacted]	[redacted]
oleic acid	µg/L		[redacted]	2	[redacted]	[redacted]	[redacted]
1-ethyl-2 hexene	µg/L		[redacted]	3.65	[redacted]	[redacted]	[redacted]
2,6,11-trimethyl-Dodecane	µg/L		[redacted]	1.15	[redacted]	[redacted]	[redacted]

Parameter	Units	MCL	Raw Water	Ion Exchange System Lag Vessel (TU2_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
unknown	µg/L		[redacted]	4.127	[redacted]	[redacted]	[redacted]
Semi-volatile Organic Chemicals			< MRL				< MRL
Acetophenone	µg/L		[redacted]	1.8	[redacted]	[redacted]	[redacted]
Bisphenol A	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Di (2-ethylhexyl)phthalate	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Dimethylphthalate	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Phenol	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Aldehydes and Ketones	µg/L		< MRL	[redacted]	[redacted]	[redacted]	[redacted]
Acetaldehyde	µg/L		[redacted]	6.4	< 5	< 5	< 5
Benzaldehyde	µg/L		[redacted]	< 5	< 5	<5	<5
Butanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Crotonaldehyde	µg/L		[redacted]	< 5	< 5	< 5	< 5
Cyclohexanone	µg/L		[redacted]	**5,700**	**33**	< 5	< 5

Parameter	Units	MCL	Raw Water	Ion Exchange System Lag Vessel (TU2_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
Decanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Formaldehyde	µg/L		[redacted]	**35**	<5	< 5	< 5
Glyoxal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Heptanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Hexanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Methyl glyoxal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Nonanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Octanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Pentanal	µg/L		[redacted]	< 5	< 5	< 5	< 5
Propanal	µg/L		[redacted]	< 5	< 5	< 5	< 5

Notes: MRL- Minimum Reporting Limit

Table C17. Special Monitoring – Hybrid RO- IX System

Parameter	Units	MCL	Raw Water	Hybrid RO-IX System Ion Exchange System Lag Vessel (TU3_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
N-Nitrosopyrrolidine (NPYR)	ng/L		< 2	< 2	< 2	< 2	< 2
N-Nitrosodi-N-butylamine (NDBA)	ng/L		< 4	< 4	< 4	< 4	< 4
N-Nitrosodiethylamine (NDEA)	ng/L		<5	<5	<5	<5	<5
N-Nitrosodimethylamine (NDMA)	ng/L		<2	<2	<2	<2	<2
N-Nitrosodi-N-propylamine (NDPA)	ng/L		<7	<7	<7	<7	<7
N-Nitrosomethylethylamine (NMEA)	ng/L		<3	<3	<3	<3	<3
N-Nitrosopiperridine (NPIP)	ng/L		<2	<2	<2	<2	<2
Volatile Organic Chemicals + TIC			< MRL	[redacted]	[redacted]	[redacted]	< MRL
2-Butanone (MEK)	µg/L		[redacted]	72	[redacted]	[redacted]	[redacted]
Chlorobenzene	µg/L	100	[redacted]	1.5	[redacted]	[redacted]	[redacted]
Chloroform	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Parameter	Units	MCL	Raw Water	Hybrid RO-IX System Ion Exchange System Lag Vessel (TU3_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
Cyclohexanone	µg/L		[redacted]	51	[redacted]	[redacted]	[redacted]
Dibromochloromethane	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total Trihalomethane	µg/L	80	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1,2 - Dichloroethane	µg/L	5	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Ethyl acrylate	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Methyl methacrylate	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
tert-Butyl alcohol	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Tetrahydrofuran	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Toluene	µg/L	1,000	[redacted]	45	[redacted]	[redacted]	[redacted]
6-methyl-2-heptene	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
oleic acid	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1-ethyl-2 hexene	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Parameter	Units	MCL	Raw Water	Hybrid RO-IX System Ion Exchange System Lag Vessel (TU3_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
2,6,11-trimethyl-Dodecane	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
unknown	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Semi-volatile Organic Chemicals			< MRL				< MRL
Acetophenone	µg/L		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Bisphenol A	µg/L		[redacted]	6	[redacted]	[redacted]	[redacted]
Di (2-ethylhexyl)phthalate	µg/L		[redacted]	0.7	[redacted]	[redacted]	[redacted]
Dimethylphthalate	µg/L		[redacted]	110	[redacted]	[redacted]	[redacted]
Phenol	µg/L		[redacted]	15	[redacted]	[redacted]	[redacted]
Aldehydes and Ketones	µg/L		BRL	[redacted]	[redacted]	[redacted]	[redacted]
Acetaldehyde	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Benzaldehyde	µg/L		[redacted]	[redacted]	<5	<5	<5
Butanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5

Parameter	Units	MCL	Raw Water	Hybrid RO-IX System Ion Exchange System Lag Vessel (TU3_S4) Results			
			Raw	0 Hr	4 Hr	24 Hr	Midpoint Testing (10 weeks)
Crotonaldehyde	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Cyclohexanone	µg/L		[redacted]	**49**	< 5	< 5	< 5
Decanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Formaldehyde	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Glyoxal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Heptanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Hexanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Methyl glyoxal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Nonanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Octanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Pentanal	µg/L		[redacted]	[redacted]	< 5	< 5	< 5
Propanal	µg/L		[redacted]	**18**	< 5	< 5	< 5

Notes: MRL- Minimum Reporting Limit

Table C18. Whole-House Pilot System – Phase 1 Treated Volumes

Date	Ion Exchange System Total Flow (gallons)		Reverse Osmosis System Total Flow (gallons)				Hybrid RO- IX System Total Flow (gallons) Recovery 58%	
	Run Time (hrs)	Treated Water	Run Time (hrs)	Influent	1st Pass RO	2nd Pass RO	Run Time (hrs)	Treated Water
11/16/2011	6	3,348	6				8.5	3,579
11/17/2011	6	6,698	6	4,943	2,024	832	6	4,583
11/18/2011	6	8,288	6				6	5,309
11/21/2011								
11/22/2011	8	16,227	8	8,397	3,496	1,508	8	9,901
11/23/2011	8	17,307	8	8,921	3,705	1,614	8	11,202
11/28/2011	3	19,858	System shutdown - Pivot break				3	13,707
11/29/2011	8	21,219	8	10,479	4,350	1,866	8	17,115
11/30/2011	8	24,242	8	11,365	4,710	2,078	8	22,472
12/1/2011	8	27,802	8	13,658	5,677	2,543	8	30,173
12/2/2011	6	30,054	8	15,499	6,437	2,885		39,363
12/5/2011	6	34,649	8	17,688	7,351	3,289		
12/6/2011	Riser Leaks – Systems Offline							
12/7/2011	6	35,156	8	18,751	7,753	3,387		
12/8/2011	6	39,281	8	20,289	8,421	3,735		
12/9/2011	6	41,708	6	21,405	8,881	3,874		
12/12/2011	6	44,390		22,279	9,254	4,028		39,363
12/13/2011	6	46,766	8	23,124	9,604	4,207	8	41,193
12/14/2011	6	50,002	8	24,930	10,345	4,540	6	44,286
12/15/2011	6	53,552	8	27,080	11,245	4,944	6	
12/16/2011	6	54,769	8	28,662	11,820	5,158	6	44,286
12/19/2011	6	58,479	8	30,374	12,526	5,455	6	48,845
12/20/2011	6	60,969	8	32,171	13,274	5,788	6	48,845
12/21/2011	6	62,425	8	33,566	13,867	6,053	6	54,902

Date	Ion Exchange System Total Flow (gallons)		Reverse Osmosis System Total Flow (gallons)				Hybrid RO- IX System Total Flow (gallons) Recovery 58%	
	Run Time (hrs)	Treated Water	Run Time (hrs)	Influent	1st Pass RO	2nd Pass RO	Run Time (hrs)	Treated Water
12/22/2021	6	65,596	8	35,727	14,758	6,349	[redacted]	
12/27/2011	6	67,815	8	36,626	15,134	6,589		
12/28/2011	6	69,454	8	38,155	15,794	6,875		
12/29/2011	6	72,095	8	39,399	16,503	7,161		
12/30/2011	6	74,011	8	39,888	16,808	7,306		
12/31/2011	Riser Leak Systems - offline 12/31/2011 - 1/9/2012							
1/10/2012	6	77,907	8	42,589	17,941	7,818	[redacted]	
1/11/2012	6	79,454	8	43,764	18,448	8,026	6	63,871
1/12/2012	6	81,862	8	45,754	19,288	8,418	6	73,720
1/13/2012	6	85,397	8	47,975	20,211	8,838	6	77,337
1/18/2012	6	87,700	8	49,883	21,011	9,166	6	82,660
1/19/2012	6	89,349	8	51,823	21,826	9,525	6	89,163
1/20/2012	6	91,489	8	52,999	22,339	9,754	6	97,215
1/23/2012	6	95,137	8	55,102	23,227	10,164	6	104,641
1/24/2012	6	97,819	8	57,129	24,056	10,529	6	107,360
1/25/2012	6	99,303	8	61,613	25,974	11,392	6	110,487
1/26/2012	6	101,688	8	62,554	26,358	11,577	6	115,710
1/27/2012	6	103,234	8	63,747	26,822	11,750	6	122,228

Note: Phase 1 - Reverse Osmosis System operated as two-pass system
Hybrid RO-IX System operated at 58% recovery

Table C19. Whole-House Pilot System – Phase 2 Treated Volumes

Date	Ion Exchange System Total Flow (gallons)		Reverse Osmosis System Total Flow (gallons)				Hybrid RO- IX System Total Flow (gallons) Recovery 80%	
	Run Time (hrs)	Treated Water	Run Time (hrs)	Influent	1st Stage RO	2nd Stage RO	Run Time (hrs)	Treated Water
2/6/2012	6	106,206	8	65,193	27,384	11,978	6	122,328
2/7/2012	6	108,798	8	66,393	27,843	12,146	6	124,126
2/8/2012	6	111,259	8	67,392	28,236	12,384	6	127,716
2/10/2012	6	115,102	8	69,104	28,930	12,705	6	134,048
2/13/2012	6	118,043	8	70,441	29,461	12,943	6	142,385
2/14/2012	6	121,542	8	72,020	30,077	13,247	6	143,142
2/15/2012	6	124,060	8	73,058	30,494	13,441	6	155,588
2/16/2012	6	126,805	8	74,196	30,951	13,643	6	169,620
2/17/2012	6	128,377	8	74,882	31,210	13,764	6	184,630
2/20/2012	6	130,140	8	76,647	31,909	14,095	6	202,028
2/22/2012	6	133,969	8	77,965	32,453	14,345	6	227,178
2/23/2012	6	135,970	8	78,925	32,839	14,524	6	251,687
2/24/2012	6	137,746	8	80,045	33,297	14,737	6	253,706
2/27/2012	6	141,672	8	81,966	34,063	15,093	6	272,925
2/28/2012	6	143,458	8	82,804	34,398	15,247	6	298,590
2/29/2012	6	144,580	8	84,087	34,895	15,468	6	305,770
3/1/2012	6	145,838	8	84,628	35,131	15,579	6	313,722
3/2/2012	6	146,148	8	84,859	35,186	15,602	6	321,857
3/5/2012	6	148,000	8	85,692	35,545	15,769	6	331,123
3/6/2012	6	149,622	8	86,515	35,876	15,926	6	344,354
3/8/2012	6	151,836	8	87,618	36,296	16,125	6	356,098
3/9/2012	6	153,070	8	88,212	36,539	16,235	6	368,711
3/12/2012	6	155,620	8	89,362	37,001	16,454	6	382,784

Date	Ion Exchange System Total Flow (gallons)		Reverse Osmosis System Total Flow (gallons)				Hybrid RO- IX System Total Flow (gallons) Recovery 80%	
	Run Time (hrs)	Treated Water	Run Time (hrs)	Influent	1st Stage RO	2nd Stage RO	Run Time (hrs)	Treated Water
3/20/2012	6	158,887	8	90,924	37,615	16,735	6	398,974
3/21/2012	6	160,194	8	91,596	37,880	16,849	6	415,989
3/22/2012	6	161,043	8	92,451	38,214	16,999	6	434,020
3/23/2012	6	163,611	8	93,552	38,668	17,223	6	453,396
3/26/2012	6	165,640	8	94,460	39,033	17,397	6	478,551
3/27/2012	6	167,935	8	95,510	39,457	17,580	6	500,322
3/28/2012	6	170,145	8	96,643	39,922	17,798	6	523,447
3/29/2012	6	172,479	8	97,707	40,349	18,008	6	547,833

Note: Phase 2 – Ion Exchange System augmented with undersink RO unit
Reverse Osmosis System operated as two-stage system
Hybrid RO-IX System operated at 80% recovery

Table C20. Whole-House Pilot System – Power Meter Readings

Date	Ion Exchange System (kWh)	Reverse Osmosis System (kWh)	Hybrid RO-IX System (kWh)
12/13/2011	201.98	1188.67	178.4
12/14/2011	230.73	1243.13	188.82
12/15/2011	261.46	1302.73	
12/16/2011	285.45	1347.78	
12/19/2011	376.1	1473.03	200.79
12/20/2011	406.63	1525.56	
12/21/2011	435.6	1572.06	213.29
12/22/2021	468.99	1628.28	
12/27/2011	627.76	1806.89	228.63
12/28/2011	655.87	1853.63	228.64
12/29/2011	688.74	1905.23	228.64
12/30/2011	717.85	1944.7	228.64
Riser Leak Systems - offline 12/31/2011 - 1/9/2012			
1/10/2012	1062.27	2346.21	228.66
1/11/2012	1091.6	2389.45	237.61
1/12/2012	1124.28	2446.91	253.65
1/13/2012	1151.81	2506.06	274.52
1/18/2012	1315.08	2696.71	288.76
1/19/2012	1344.54	2749.45	298.66
1/20/2012	1372.75	2793.77	311.49
1/23/2012	1466.33	2920.49	333.29
1/24/2012	1497.86	2975.81	348.92
1/25/2012	1526.37	3055.19	352.16
1/26/2012	1558.19	3100.84	368.72
1/27/2012	1584.56	3143.92	1584.88
2/6/2012	1895.15	3501.45	394.89
2/7/2012	1924.54	3546.52	411.33
2/8/2012	1955.54	3594.58	427.89

Date	Ion Exchange System (kWh)	Reverse Osmosis System (kWh)	Hybrid RO-IX System (kWh)
2/10/2012	2012.08	3677.32	453.13
2/13/2012	2103.26	3794.07	471.57
2/14/2012	2138.07	3850.36	493.79
2/15/2012	2168.28	3895.55	509.51
2/16/2012	2201.79	3944.63	524.92
2/17/2012	2229.9	3982.85	524.36
2/20/2012	2317.17	4107.3	558.39
2/22/2012	2372.33	4189.13	590.01
2/23/2012	2394.49	4231.46	631.33
2/24/2012	2394.48	4277.59	605.42
2/27/2012	2402.96	4401.28	576.82
2/27/2012	2433.2	4444.65	643.33
2/29/2012	2464.65	4494.03	659.51
3/1/2012	2493.78	4531.77	667.83
3/2/2012	2524.66	4566.85	669.88
3/5/2012		4678.51	682.17
3/6/2012	2640.83	4718.6	693.12
3/8/2012	2701.98	4799.98	707.94
3/9/2012	2727.81	4836.41	717
3/12/2012	2728.09	4549.75	732.46
3/20/2012	2728.84	5225.7	755.49
3/21/2012	2728.93	5264.2	764.48
3/22/2012	2729.01	5274.87	775.82
3/23/2012	2729.11	5289.47	791.25
3/26/2012	2729.39	5343.13	804.42
3/27/2012	2729.49	5370.5	818.89
3/28/2012	2729.58	5399.06	834.51

Note: The power meter reading includes power consumed by the system and the space heaters

Table 17 Whole House POE Deployment Guidance Matrix

	SBA Type 1 Resin[1] Ion Exchange System	Reverse Osmosis System[1]	Hybrid Reverse Osmosis – Ion Exchange System[1]	Hybrid Ion Exchange System with Undersink Reverse Osmosis System[2]
Does the system remove constituents to meet the water quality standards?				
Hexavalent Chromium[3]	Yes	Yes	Yes	Yes
TDS (if necessary)	No	Yes	Yes	Yes
Nitrate (if necessary)	Removal depends on water quality	Yes	Yes	Yes
Chloride (if necessary)	No	Yes	Yes	Yes
Sulfate (if necessary)	No	Yes	Yes	Yes
Uranium (if necessary)	Yes	Yes	Yes	Yes
Operation and Maintenance Considerations				
Easy to operate?	Yes	Moderate	Moderate	Yes
Quiet?	Yes	Noise shield required	Noise shield required	Yes
Daily power usage[4]	11 kWh	25 kWh	13 kWh	11 kWh
Required power equipment	Relay indicator Repressurization system	Reverse osmosis pump Repressurization system	Relay indicator Repressurization system	Relay indicator Repressurization system
Service requirements	Replace pre-filter Replace IX vessel when exhausted	Replace pre-filter Dispose brine twice per week	Replace pre-filter Replace IX vessel annually Refill anti-scalant quarterly Dispose brine weekly	Replace pre-filter Replace IX vessel when exhausted. Replace reverse osmosis membrane annually (every 6- 12 months) Perform maintenance quarterly
Residual Waste				
Resin[5]	Yes	No	Yes	Yes
	1 resin vessel/replacement		1 resin vessel/replacement	1 resin vessel/replacement
Brine	No	Yes[6, 7]	Yes[6]	Yes[6]
Softener Brine	No	100 to 250 gallons/day	No	No
RO Brine	No	300 gallons/day for two-stage system 3,000 gallons per day for two-pass system	100 to 300 gallons/day	100 to 200 gallons/day

Table 17 Whole House POE Deployment Guidance Matrix

	SBA Type 1 Resin[1] Ion Exchange System	Reverse Osmosis System[1]	Hybrid Reverse Osmosis – Ion Exchange System[1]	Hybrid Ion Exchange System with Undersink Reverse Osmosis System[2]
System Features				
Chlorination for disinfection	Yes	Yes	Yes	Yes
Pre-filter for particulate removal	Yes	Yes	Yes	Yes
Indicator Light	Yes	Yes	Yes	Yes

Notes:
SBA = Strong Base Anionic
kWh = kilo Watt hours
1 Treats the whole-house supply.
2 Treats the whole-house supply for hexavalent chromium and the kitchen tap for the primary or secondary water standards.
3 The system is required to remove hexavalent chromium to very low concentrations.
4 Total power for the system including systems consumption, ancillary equipment, pumps, telemetry, heating and cooling
5 Spent ion exchange resin is classified as non-RCRA, non-hazardous waste and is not a regulated radioactive waste.
6 Reverse osmosis brine is classified as non-RCRA, non-hazardous waste; however, it does contain elevated concentrations of TDS, hexavalent chromium, nitrate, arsenic, sulfate, and other constituents. Residual waste is determined in part by raw water hardness and quality.
7 Softener brine is classified as non-RCRA, non-hazardous waste; however, it does contain elevated concentrations of TDS, nitrate, arsenic, sulfate, and other constituents. Hexavalent chromium and total chromium are close to the raw water, since softener is removing approximately half of the chromium and lowering the concentrations to reverse osmosis. Residual waste is determined in part by raw water hardness and quality.

ARCADIS

Appendix C

Cost Opinion Assumptions and Tables

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 1: Connect to an Existing Community Water System (Centralized Treatment and Distribution) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Assumes current production from GSWC is sufficient to provide flow required.
Treatment – Chromium	$ 310,000	Includes a lead-lag WBA ion exchange system with an SBA polishing step to reduce background levels of Cr to below the reporting limit, acid and caustic addition for pre- and post-pH adjustment, backwash tank, and chlorine disinfection of IX effluent, concrete pad for IX system (20' x 15'), and chemical building (10' x 10'). Includes miscellaneous work (20% of project cost), general conditions (15%), contractor overhead and profit (20%), and engineering/admin (25%). Does not include dechlorination to remove chlorine residual from GSWC finished water prior to WBA treatment; system would need to be pilot tested to demonstrate chromium removal to below the reporting limit; pilot testing costs are not included.
Treatment – Other	$ -	Included in GSWC rate, if applicable.
Transmission Main	$ 8,000,000	Includes ~55,000 feet (10 miles) of 4-inch pipe sized for maximum day of water use, of which an estimated 700 feet was assumed to be drilled horizontally and 600 feet assumed to be carried along a bridge; Assumes GSWC will have sufficient capacity to pump to Hinkley.
Distribution System	$ 11,000,000	Includes ~52,000 feet (10 miles) of 6- and 8-inch pipe sized for fire flow, one pump station, and ~90,000 gallons of storage at Hinkley.
Sampling, Monitoring, and Compliance	$ -	Assumes annual sampling plan included in O&M will accommodate sampling required during start up.
TOTAL CAPITAL COST	**$ 19,300,000**	**RANGE = $13,500,000 to $29,000,000**
O&M COSTS		
Wells	$ -	Maintenance of GSWC wells is assumed to be covered in GSWC water rates.
Treatment – Chromium	$ 80,000	Includes labor (one 0.5-time operator to maintain and monitor the treatment system), power ($0.10/kWh), IX resin replacement and disposal, backwash waste disposal, chemicals, and other consumables.
Treatment – Other	$ -	Assumed to be included in GSWC rates. Does not include costs incurred if flushing is required to reduce water age and maintain good water quality in the Hinkley system.
Transmission Main	$ -	Assumed to be included in GSWC rates. Does not include costs incurred if flushing is required to reduce water age and maintain good water quality in the Hinkley system.
Distribution System	$ -	Assumed to be included in GSWC rates. Does not include costs incurred if flushing is required to reduce water age and maintain good water quality in the Hinkley system.
Replenishment/Water Payment	$ 27,000	Based on GSWC rate ($2.72765/748 gallons) for average household water usage of 660 gpd and a 3/4" household meter fee ($15.45/month); assumes additional replenishment charges are not incurred.
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 48,000	Based on sampling to monitor performance of the IX system.
TOTAL O&M COSTS	**$ 160,000**	**RANGE = $110,000 to $240,000**
NET PRESENT WORTH		
5-year NPV	**$ 20,100,000**	0% discount rate
30-year NPV	**$ 24,100,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on a 12 gallon per minute (gpm) system serving 25 connections.

(3) Costs do not include pilot testing, which is recommended to demonstrate capability of proposed treatment to achieve hexavalent chromium below the laboratory reporting limit under site-specific conditions.

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 2: Develop a New Community Water System Utilizing Groundwater Near Mojave River (Centralized Treatment and Distribution) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ 400,000	Includes construction and outfitting of two new wells, each capable of producing ~20 gpm.
Treatment – Chromium	$ 310,000	Includes a lead-lag WBA ion exchange system with an SBA polishing step to reduce background levels of Cr to below the reporting limit, acid and caustic addition for pre- and post-pH adjustment, backwash tank, and chlorine disinfection of IX effluent, concrete pad for IX system (20' x 15'), and chemical building (10' x 10'). Includes miscellaneous work (20% of project cost), general conditions (15%), contractor overhead and profit (20%), and engineering/admin (25%). Does not include dechlorination to remove chlorine residual from GSWC finished water prior to WBA treatment; system would need to be pilot tested to demonstrate chromium removal to below the reporting limit; pilot costs are not included.
Treatment – Other	$ 660,000	Includes media filtration to meet GWUDI requirements and greensand filtration with a backwash system, cost estimates based on vendor quotations. Includes building to house the greensand filtration system (5' x 10') and concrete pad for the media filtration system.
Transmission Main	$ 1,500,000	Includes ~11,000 feet (2 miles) of 4-inch pipe sized for maximum day.
Distribution System	$ 11,000,000	Includes ~52,000 feet (10 miles) of 6- and 8-inch pipe sized for fire flow, one pump station, and ~90,000 gallons of storage at Hinkley.
Sampling, Monitoring, and Compliance	$ -	Assumes annual sampling plan included in O&M will accommodate sampling required during start up.
TOTAL CAPITAL COST	**$ 13,900,000**	**RANGE = $9,700,000 to $20,900,000**
O&M COSTS		
Wells	$ 20,000	Includes regular well maintenance and pumping costs to the treatment system ($0.10/kWh).
Treatment – Chromium	$ 180,000	Includes labor (one 0.5-time operator to maintain and monitor the treatment system and one operator to maintain the distribution system, conduct necessary monitoring, prepare regulatory compliance reports), power, IX resin replacement and disposal, backwash waste disposal, chemicals, and other consumables.
Treatment – Other	$ 70,000	Includes labor (one 0.5-time operator to maintain and monitor the media and greensand filtration systems), power ($0.10/kWh) to operate media and greensand filtration, greensand media replacement and backwash waste, chemicals. Assumes media filtration backwash will be recycled.
Transmission Main	$ 8,000	Includes pipeline maintenance.
Distribution System	$ 60,000	Includes pumping costs and maintenance of distribution system.
Replenishment/Water Payment	$ 7,000	Water will be replenished through MWA ($400/AF).
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 120,000	Based on sampling to monitor performance of the IX, greensand, and media filtration system and to meet compliance requirements for a GWUDI CWS system.
TOTAL O&M COSTS	**$ 470,000**	**RANGE = $330,000 to $710,000**
NET PRESENT WORTH		
5-year NPV	**$ 16,300,000**	0% discount rate
30-year NPV	**$ 28,000,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on a 12 gallon per minute (gpm) system serving 25 connections.

(3) Costs do not include pilot testing, which is recommended to demonstrate capability of proposed treatment to achieve hexavalent chromium below the laboratory reporting limit under site-specific conditions.

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 3: Develop a New Community Water System Utilizing Local Groundwater as Part of the Chromium Remediation Program (Centralized Treatment and Distribution) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Assumes proposed remediation wells will be able to supply 12 gpm average day for replacement water treatment.
Treatment – Chromium	$ 310,000	Includes a lead-lag WBA ion exchange system with an SBA polishing step to reduce background levels of Cr to below the reporting limit, acid and caustic addition for pre- and post-pH adjustment, backwash tank, and chlorine disinfection of IX effluent, concrete pad for IX system (20' x 15'), and chemical building (10' x 10'). Includes miscellaneous work (20% of project cost), general conditions (15%), contractor overhead and profit (20%), and engineering/admin (25%). Does not include dechlorination to remove chlorine residual from GSWC finished water prior to WBA treatment; system would need to be pilot tested to demonstrate chromium removal to below the reporting limit; pilot costs are not included.
Treatment – Other	$ 290,000	Includes greensand filtration with a backwash system, cost estimates based on vendor quotations. Includes building to house the greensand filtration system (5' x 10').
Transmission Main	$ -	Not applicable.
Distribution System	$ 11,000,000	Includes ~52,000 feet (10 miles) of 6- and 8-inch pipe sized for fire flow, one pump station, and ~90,000 gallons of storage at Hinkley.
Sampling, Monitoring, and Compliance	$ -	Assumes annual sampling plan included in O&M will accommodate sampling required during start up.
TOTAL CAPITAL COST	**$ 11,600,000**	**RANGE = $8,100,000 to $17,400,000**
O&M COSTS		
Wells	$ -	Included as part of the remediation alternative.
Treatment – Chromium	$ 182,000	Includes labor (one 0.5-time operator to maintain and monitor the treatment system and one operator to maintain the distribution system, conduct necessary monitoring, prepare regulatory compliance reports), power ($0.10 kWh), IX resin replacement and disposal, backwash waste disposal, chemicals, and other consumables.
Treatment – Other	$ 68,000	Includes labor (one 0.5-time operator to maintain and monitor the greensand filtration system), power, greensand media replacement and backwash waste, chemicals.
Transmission Main	$ -	Not applicable.
Distribution System	$ 59,000	Includes pumping and pipeline, pump station, and storage maintenance.
Replenishment/Water Payment	$ 7,000	Water will be replenished through MWA ($400/AF).
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 120,000	Based on sampling to monitor performance of the IX, greensand, and to meet compliance requirements for a CWS and a 97-005 impaired source.
TOTAL O&M COSTS	**$ 440,000**	**RANGE = $310,000 to $660,000**
NET PRESENT WORTH		
5-year NPV	**$ 13,800,000**	0% discount rate
30-year NPV	**$ 24,800,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on a 12 gallon per minute (gpm) system serving 25 connections.

(3) Costs do not include pilot testing, which is recommended to demonstrate capability of proposed treatment to achieve hexavalent chromium below the laboratory reporting limit under site-specific conditions.

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 4a: Provide Point of Entry Whole-House Water Treatment (Ion Exchange) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Not applicable.
Treatment – Chromium	$ 1,200,000	Based on 25 treatment systems including storage. Treatment includes a pre-filter, IX resin, inline chlorination, a basic telemetry system, a 2,000-gallon storage tank and a hydropneumatic tank, and a steel containment unit to house the IX system; installation includes running electrical, tying in to the existing service line, and vendor coordination/startup. Assumes flush water is sent to property septic system.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 25,000	Includes increased monitoring for the first year of operation (e.g., initial flush from resin, spent resin analysis for waste disposal options, more frequent chromium and nitrate monitoring to develop breakthrough curves for specific well water quality).
TOTAL CAPITAL COST	**$ 1,200,000**	**RANGE = $800,000 to $1,800,000**
O&M COSTS		
Wells	$ -	Cost incurrent by homeowner.
Treatment – Chromium	$ 285,000	Includes media replacement and disposal costs, service visits, power ($0.10 kWh) for system operation, and other consumables; media replacement frequency based on average water quality for 25 homes.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Replenishment/Water Payment	$ -	Does not apply to existing wells.
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 45,000	Based on an annual monitoring budget of $1,800 per household after the first year of extensive testing, with households monitored on a rotational basis.
TOTAL O&M COSTS	**$ 330,000**	**RANGE = $230,000 to $500,000**
NET PRESENT WORTH		
5-year NPV	**$ 2,900,000**	0% discount rate
30-year NPV	**$ 11,100,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on 25 whole house treatment systems.

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 4b: Provide Point of Entry Whole-House Water Treatment (Reverse Osmosis) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Not applicable.
Treatment – Chromium	$ 1,850,000	Based on 25 treatment systems including storage. Includes reverse osmosis equipment (i.e., pre-filter, softener, membranes, and a basic telemetry system), 2,000 gallon storage tank and hydropneumatic tank, steel containment unit for RO system, brine storage tank, inline chlorination, and installation.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 12,500	Includes increases monitoring for the first year of operation (e.g., RO brine analysis for waste disposal options, more frequent chromium monitoring).
TOTAL CAPITAL COST	**$ 1,900,000**	**RANGE = $1,300,000 to $2,900,000**
O&M COSTS		
Wells	$ -	Cost incurrent by homeowner.
Treatment – Chromium	$ 198,000	O&M expenses include power ($0.10 kWh) for operation, membrane replacement, anti-softener regenerant solution, cartridge filter replacements, and service visits.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Storage	Included	Included in chromium treatment system costs.
Replenishment/Water Payment	$ -	Does not apply to existing wells.
Water/Brine Hauling	$ 3,280,000	Brine is hauled to Los Angeles for disposal; 2-stage RO treatment operates at 69% recovery; based on a truck capacity of 2,000 gallons; assumes 1 hour for loading/unloading and 4.8 hours travel to and from the house to Los Angeles (120 miles at 50 mph); includes a truck ($120/hr), supervisor ($70/hr), and miscellaneous (per diem, lodging, a utility truck, $20/hr); $0.20/gal disposal fee.
Sampling, Monitoring, and Compliance	$ 15,000	Based annual sampling at each home.
TOTAL O&M COSTS	**$ 3,490,000**	**RANGE = $2,440,000 to $5,240,000**
NET PRESENT WORTH		
5-year NPV	**$ 19,400,000**	0% discount rate
30-year NPV	**$ 106,600,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on 25 whole house treatment systems.

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 4c: Provide Point of Entry Whole-House Water Treatment (Ion Exchange + Undersink RO) Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Not applicable.
Treatment – Chromium	$ 1,250,000	Based on 25 treatment systems including storage. Treatment includes a pre-filter, IX resin, inline chlorination, a basic telemetry system, undersink RO unit, a 2,000 gallon storage tank and hydropneumatic tank, and a steel containment unit to house the IX system; installation includes running electrical, tying in to the existing service line, and vendor coordination/startup.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 25,000	Includes increases monitoring for the first year of operation (e.g., initial flush from resin, spent resin analysis for waste disposal options, more frequent chromium and nitrate monitoring to develop breakthrough curves for specific well water quality).
TOTAL CAPITAL COST	**$ 1,300,000**	**RANGE = $900,000 to $2,000,000**
O&M COSTS		
Wells	$ -	Cost incurrent by homeowner.
Treatment – Chromium	$ 285,000	Includes media replacement and disposal costs, service visits, power ($0.10 kWh) for system operation, and other consumables; media replacement frequency based on average water quality for 25 homes. Assumes flush water is sent to property septic system.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Replenishment/Water Payment	$ -	Does not apply to existing wells.
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 45,000	Based on an annual monitoring budget of $1,800 per household after the first year of extensive testing, with households monitored on a rotational basis.
TOTAL O&M COSTS	**$ 330,000**	**RANGE = $230,000 to $500,000**
NET PRESENT WORTH		
5-year NPV	**$ 3,000,000**	0% discount rate
30-year NPV	**$ 11,200,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.
(2) Costs based on 25 whole house treatment systems.

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 5: Replace Impacted Wells with Deeper Wells Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ 625,000	$25,000/well; includes drilling and outfitting
Treatment – Chromium	$ 1,200,000	Based on 25 treatment systems including storage. Includes a pre-filter, IX resin, inline chlorination, a basic telemetry system, a 2,000 gallon storage tank and hydropneumatic tank, and a steel containment unit to house the IX system; installation includes running electrical, tying in to the existing service line, and vendor coordination/startup. Assumes flush water is sent to property septic system.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 25,000	Includes increases monitoring for the first year of operation (e.g., initial flush from resin, spent resin analysis for waste disposal options, more frequent chromium and nitrate monitoring to develop breakthrough curves for specific well water quality).
TOTAL CAPITAL COST	**$ 1,900,000**	**RANGE = $1,300,000 to $2,900,000**
O&M COSTS		
Wells		
Treatment – Chromium	$ 59,000	Includes media replacement and disposal costs, service visits, power ($0.10 kWh) for system operation, and other consumables; media replacement frequency based on good water quality for 25 homes.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Not applicable.
Distribution System	$ -	Not applicable.
Replenishment/Water Payment	$ -	Does not apply to replacement wells.
Water/Brine Hauling	$ -	Not applicable.
Sampling, Monitoring, and Compliance	$ 45,000	Based on an annual monitoring budget of $1,800 per household after the first year of extensive testing, with households monitored on a rotational basis.
TOTAL O&M COSTS	**$ 100,000**	**RANGE = $70,000 to $150,000**
NET PRESENT WORTH		
5-year NPV	**$ 2,400,000**	0% discount rate
30-year NPV	**$ 4,900,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on 25 whole house treatment systems.

Appendix C

Replacement Water Supply Feasibility Study
Pacific Gas and Electric Company
Hinkley Compressor Station, Hinkley, California

Alternative 6: Truck Water from a Community Water System Cost Opinion

	Cost	Notes
CAPITAL COST		
Wells	$ -	Assumes current production from GSWC is sufficient for 25 homes.
Treatment – Chromium	$ 635,000	Includes 5,000 gallon storage tank at each home, a hydropneumatic tank/pump, and installation. Includes a lead-lag WBA ion exchange system with an SBA polishing step to reduce background levels of Cr to below the reporting limit, acid and caustic addition for pre- and post-pH adjustment, backwash tank, and chlorine disinfection of IX effluent, concrete pad for IX system (20' x 15'), and chemical building (10' x 10'). Includes miscellaneous work (20% of project cost), general conditions (15%), contractor overhead and profit (20%) and engineering/admin (25%). Does not include dechlorination to remove chlorine residual from GSWC finished water prior to WBA treatment; system would need to be pilot tested to demonstrate chromium removal to below the reporting limit; pilot costs are not included.
Treatment – Other	$ -	Included in GSWC rate if applicable.
Transmission Main	$ -	Water will be hauled to homes.
Distribution System	$ -	Water will be hauled to homes.
Sampling, Monitoring, and Compliance	$ 48,000	
TOTAL CAPITAL COST	**$ 700,000**	**RANGE = $500,000 to $1,100,000**
O&M COSTS		
Wells	$ -	Maintenance of GSWC wells is assumed to be covered in GSWC water rates.
Treatment – Chromium	$ 83,000	Includes labor (one 0.5-time operator to maintain and monitor the treatment system), power ($0.10 kWh), IX resin replacement and disposal, backwash waste disposal, chemicals, and other consumables.
Treatment – Other	$ -	Not applicable.
Transmission Main	$ -	Assumed to be included in GSWC rates.
Distribution System	$ -	Assumed to be included in GSWC rates.
Replenishment/Water Payment	$ 35,000	Based on GSWC rate ($2.72765/748 gallons), an average household water usage of 660 gpd, and a 6" meter fee ($1,087/month); assumes additional replenishment charges are not incurred.
Water/Brine Hauling	$ 1,470,000	660 gpd per household; 2,200 gallons per trip; 2.5 hours to fill, haul and deliver water; rate includes a truck ($120/hr), supervisor ($70/hr), and miscellaneous (per diem, lodging, a utility truck, $20/hr).
Sampling, Monitoring, and Compliance	$ 60,000	Based on sampling to monitor performance of the IX system; includes limited sampling of storage tanks.
TOTAL O&M COSTS	**$ 1,650,000**	**RANGE = $1,160,000 to $2,480,000**
NET PRESENT WORTH		
5-year NPV	**$ 9,000,000**	0% discount rate
30-year NPV	**$ 50,200,000**	0% discount rate

Assumptions:

(1) AACE Level 5 costs with an expected accuracy range of -30% to +50%; all costs are in March 2012 dollars referenced to an Engineering News Record Construction Cost Index of 9,268.

(2) Costs based on a 12 gpm treatment system and hauling/storing to serve 25 connections.

(3) Costs do not include pilot testing, which is recommended to demonstrate capability of proposed treatment to achieve hexavalent chromium below the laboratory reporting limit under site-specific conditions.