Section 3.1
Water Resources and Water Quality

3.1 Water Resources and Water Quality

3.1.1 Introduction

This section describes the existing conditions and regulatory setting for water resources in the project area. This section also presents significance criteria for determining impacts to water resources, describes those impacts that may result from implementation of the project alternatives, and identifies mitigation measures that would reduce identified significant impacts.

This section analyzes potential impacts in both the remedial project area (OU1, OU2, and OU3) and the entire study area, which includes areas outside the remedial project area that may be affected by impacts to water resources and water quality due to remedial activities. ~~As discussed in Chapter 2, *Project Description*, the study area was defined by the limits of the groundwater model.~~ The study area and the remedial project area are shown on Figure 2-2a in Chapter 2, *Project Description*.

Groundwater is the primary water resource in the project area and is used both for domestic and agricultural supply. Surface waters in the remedial project area are limited to dry washes that either drain north to Harper Lake or south to the Mojave River. The Mojave River is located 1 mile south of the PG&E Compressor Station, but this stretch of the river flows only during major storms.

Additional information about water resources related to the groundwater modeling, historical water elevations, water quality measurements, and prior remedial activities is provided in Appendix A, *Groundwater and Remediation Supporting Documentation*. Growth-inducing and cumulative impacts on water resources are discussed in Chapter 4, *Other CEQA Analyses*.

This section refers to the "chromium plume" as the locations where, at this time, Cr[VI] concentrations are greater than the adopted maximum background values of 3.1 parts per billion (ppb) or where Cr[T] concentrations are greater than 3.2 ppb. Reference to different forms of chromium such as Cr[VI], Cr[T] or Cr[III] are made where appropriate.

In the section below, the following terminology is used:

- Background = Water quality conditions unrelated to PG&E's discharge or remedial actions. Can include both naturally occurring and man-made constituents.
- Baseline = CEQA baseline. Usually defined by conditions as of the Fourth Wuarter of 2012. The conditions at the time of preparation of the EIR.
- Pre-remedial reference levels = Water quality conditions at a remedial location before the remediation effort is initiated.

Table 3.1-1 presents a summary of the impacts of the project alternatives on water resources and recommended mitigation measures that would reduce identified significant impacts. Table 3.1-2 presents a summary of the key differences between project alternatives in terms of water resource impacts.

Table 3.1-1. Summary of Water Resource Impacts

Impact	Applicable Alternative	Significance before Mitigation	Mitigation Measures	Significance after Mitigation
Groundwater Drawdown				
WTR-1a: Groundwater Drawdown Effects on the Regional Water Supply	No Project Alternative	Less than Significant	N/A	--
	All Action Alternatives	Significant	WTR-MM-1: Purchase of New Water Rights to Comply with Basin Adjudication	Less than Significant
WTR-1b: Groundwater Drawdown Effects on the Local Water Supply	No Project Alternative	Less than Significant	N/A	--
	All Action Alternatives	Significant	WTR-MM-2: Water Supply Program for Wells that are Affected by Remedial Activities	Less than S~~s~~ignificant
WTR-1c: Groundwater Drawdown Effects on Aquifer Compaction	No Project Alternative	Less than Significant	N/A	_
	All Action Alternatives	~~Potentially~~Less than Significant	~~WTR-MM-2~~N/A	~~Potentially significant and unavoidable for the Aquifer~~ Less than Significant ~~for Water Supply Wells~~
Water Quality				
WTR-2a: Containment and Treatment of Existing Chromium Contamination	All Alternatives	Beneficial	N/A	--
WTR-2b: Conversion of Hexavalent Chromium to Trivalent Chromium	All Alternatives	Less than Significant	N/A	--
WTR-2c: Water Quality Effects due to use of Tracer Compounds	All Alternatives	Less than Significant	N/A	--
WTR-2d: Temporary Localized Chromium Plume Expansion ("Bulging") due to Remedial Activities	No Project Alternative	Less than Significant	N/A	--
	All Action Alternatives	Potentially Significant	WTR-MM-2 (see above)	Potentially Significant and Unavoidable for the Aquifer

Impact	Applicable Alternative	Significance before Mitigation	Mitigation Measures	Significance after Mitigation
			WTR-MM-3: ~~Boundary Control Monitoring, Enhancement and Maintenance of Hydraulic Control and Plume Water Balance~~Incorporate Measures to Prevent~~ or~~, Reduce and Control Potential Temporary Localized Chromium Plume Bulging Into Overall Plume Control and Monitoring	Less than Significant for Water Supply Wells
WTR-2e: Increase in Total Dissolved Solids, Uranium and other Radionuclides due to Agricultural Treatment	All Alternatives	Significant (TDS)	WTR-MM-2 (see above)	Potentially Significant and Unavoidable for the Aquifer (TDS)
	All Action Alternatives	Potentially Significant (Uranium/other Radionuclides)	WTR-MM-4: Restoration of the Hinkley Aquifer Affected by Remedial Activities for Beneficial Uses	Potentially Significant and Unavoidable for the Aquifer (Uranium/Other Radionuclides)
			WTR-MM-5: Investigate and Monitor Total Dissolved Solids, Uranium and Other Radionuclide levels in relation to Agricultural Treatment and Take Contingency Actions	Less than Significant for Water Supply Wells
WTR-2f: Change in Nitrate Levels due to Agricultural Treatment	No Project Alternative	Less than significant	N/A	--
	All Action Alternatives	Beneficial for the Aquifer (removal of nitrate overall)		Beneficial for the Aquifer overall
		Potentially Significant (localized increases of nitrate due to injection)	WTR-MM-6: Monitor Nitrate Levels and Manage Agricultural Treatment to Avoid Significant Increases in Nitrate Levels	Less than Significant for Water Supply Wells

Impact	Applicable Alternative	Significance before Mitigation	Mitigation Measures	Significance after Mitigation
WTR-2g: Increase in Other Secondary Byproducts (Dissolved Arsenic, Iron and Manganese) due to In-Situ Remediation	No Project Alternative	Less than Significant	N/A	--
	All Action Alternatives	Significant	WTR-MM-2 (see above) WTR-MM-4 (see above) WTR-MM-7: Construction and Operation of Additional Extraction Wells to Control Carbon Amendment In-situ Byproduct Plumes	Temporarily Potentially Significant and Unavoidable for the Aquifer Less than Significant for Water Supply Wells
WTR-2h: Potential Degradation of Water Quality due to Freshwater Injection	All Alternatives	Potentially Significant	WTR-MM-8: Ensure Freshwater Injection Water Does not Degrade Water Quality	Less than significant
WTR-2i: Taste and Odor Impacts due to Remedial Activities	No Project Alternative	Less than significant	N/A	--
	All Action Alternatives	Significant	WTR-MM-2 (see above) WTR-MM-4 (see above)	Less than significant
Drainage				
WTR-3: Impacts Related to Drainage Patterns and Runoff	All Alternatives	Less than Significant	N/A	--
Flooding				
WTR-4: Impacts Related to Flooding	All Alternatives	Less than Significant	N/A	--
Secondary Impacts of Water Supply Mitigation				
WTR-5: Secondary Impacts of Water Supply Mitigation	All Alternatives	Potentially Significant	Project Mitigation (see text)	Less than significant

Note:
The overall comparison of the No Project Alternative to Action Alternatives (Alternatives 4B, 4C-2 through 4C-5) follows in Table 3.1-2, below.

Table 3.1-2. Comparison of Water Resource Impacts by Alternatives

Impact	No Project	Alternative 4B	Alternative 4C-2	Alternative 4C-3	Alternative 4C-4	Alternative 4C-5
Groundwater Drawdown						
WTR-1a: Aquifer Drawdown- Regional	No change from e~~E~~xisting use of 1,774 acre-feet, which is less than allowance.	Up to 3,863 acre-feet of annual AU use. Requires acquisition of rights of up to 1,919 acre-feet.	Up to 5,109 acre-feet of annual AU use. Requires acquisition of rights of up to 3,165 acre-feet.	Up to 7,078 acre-feet of annual AU use. Requires acquisition of rights of up to 5,134 acre-feet.	Up to 7,078 acre-feet of annual AU use. Requires acquisition of rights of up to 5,134 acre-feet.	Up to 5,109 acre-feet of annual AU use. Requires acquisition of rights of up to 3,165 acre-feet.
WTR-1b: Aquifer Drawdown -Localized	No change from Existing	Up to 50 to 70 feet of drawdown potentially affecting up to 85 or more domestic wells.	Up to 50 to 70 feet of drawdown potentially affecting up to 108 or more domestic wells.	Up to 60 to 80 feet of drawdown potentially affecting up to 94 or more domestic wells.	Up to 70 to 100+ feet of drawdown potentially affecting up to 133 or more domestic wells.	Up to 50 to 70 feet of drawdown potentially affecting up to 108 or more domestic wells.
WTR-1c: Aquifer Compaction	No change from Existing	~~May exceed historic drawdown in northern part of aquifer and~~Unlikely to result in aquifer compaction	~~May exceed historic drawdown in northern part of aquifer and~~Unlikely to result in aquifer compaction	~~May exceed historic drawdown in northern part of aquifer and~~Unlikely to result in aquifer compaction	~~May exceed historic drawdown throughout the aquifer and~~Unlikely to result in aquifer compaction	~~May exceed historic drawdown in northern part of aquifer and~~Unlikely to result in aquifer compaction
Water Quality						
WTR-2a: Containment and Treatment of Existing Chromium Contamination						
Years to 50 ppb Cr[VI]	6	6	6	4	3	20
Years to 3.1 ppb Cr[VI]	75 - 150/1,000[a]	40	39	36	29	50
Years to 1.2 ppb Cr[VI]	~~325~~130 - 220/1,000[a]	95	90	85	75	95
Years to 80% Conversion or Removal	10 - 13	10	7	6	6	15
WTR-2b: Conversion of Hexavalent Chromium to Trivalent Chromium	Agricultural treatment and in-situ remediation in all alternatives would leave Cr[III] in ground with low potential for reconversion to Cr[VI].Alternative 4C-3 would provide above ground treatment in winter which would remove some Cr[VI] from the aquifer. Alternative 4C-5 would provide above-ground treatment of the source area which would also remove the most Cr[VI] from the aquifer of all alternatives.					

Impact	No Project	Alternative 4B	Alternative 4C-2	Alternative 4C-3	Alternative 4C-4	Alternative 4C-5
WTR-2c: Tracer Compounds	Tracer compounds used in all alternatives would be non-toxic/non-reactive and expected to dissipate before affecting domestic wells.					
WTR-2d: Temporary Localized ~~Spreading of~~ Chromium Expansion ("Bulging") due to Remedial Activities	No change from existing injection for in-situ remediation (190 gpm)	Injection for in-situ remediation, higher pumping rate (431 gpm) increases potential for plume "bulging."	Injection for in-situ remediation, higher pumping rate (431 gpm) increases potential for plume "bulging." However, additional southern extraction for agricultural treatment in OU1 decreases the potential for bulging.	Injection for in-situ remediation, higher pumping rate (431 gpm) increases potential for plume "bulging." However, additional southern extraction for agricultural treatment in OU1 decreases the potential for bulging.	Injection for in-situ remediation, higher pumping rate (431 gpm) increases potential for plume "bulging." However, additional southern extraction for agricultural treatment in OU1 decreases the potential for bulging.	Injection for in-situ remediation, higher pumping (244 gpm) than existing increases potential for plume "bulging", but lower than other alternatives.
WTR-2e: Increase in Total Dissolved Solids, uranium, and Other Radio Nuclides due to Agricultural Treatment	No change from existing AU treatment flows (1,100 gpm)	Increase of AU Treatment flows (up to 2,395 gpm) increases TDS levels.	Increase of AU Treatment flows (up to 3,167 gpm) increases TDS levels	Increase of AU Treatment flows (up to 4,388 gpm) increases TDS levels	Increase of AU Treatment flows (up to 4,388 gpm) increases TDS levels	Increase of AU Treatment flows (up to 3,167 gpm) increases TDS levels.
WTR-2f: Change in Nitrate Levels due to Agricultural Treatment	No change from existing AU treatment flows (1,100 gpm)	Increase of AU Treatment flows (up to 2,395 gpm) potentially increases local nitrate levels.	Increase of AU Treatment flows (up to 3,167 gpm) potentially increases local nitrate levels	Increase of AU Treatment flows (up to 4,388 gpm) potentially increases local nitrate levels	Increase of AU Treatment flows (up to 4,388 gpm) potentially increases local nitrate levels	Increase of AU Treatment flows (up to 3,167 gpm) potentially increases local nitrate levels
WTR-2g: Increase in Other Byproducts due to In-Situ Remediation	No change from existing injection for in-situ remediation (190 gpm)	Injection for in-situ remediation (431 gpm) increases potential for byproducts.	Injection for in-situ remediation (431 gpm) increases potential for byproducts.	Injection for in-situ remediation (431 gpm) increases potential for byproducts.	Injection for in-situ remediation (431 gpm) increases potential for byproducts.	Injection for in-situ remediation (244 gpm) increases potential for byproducts, but less than other alternatives
WTR-2h: Degradation of Water Quality due to Freshwater Injection	No change from existing injection (80 gpm). Possible change in future water source/quality.	No change from existing injection (80 gpm). Possible change in future water source/quality.	No change from existing injection (80 gpm). Possible change in future water source/quality.	No change from existing injection (80 gpm). Possible change in future water source/quality.	No change from existing injection (80 gpm). Possible change in future water source/quality.	No change from existing injection (80 gpm). Possible change in future water source/quality.
WTR-2i: Taste and Odor Impacts due to Remedial Activities	All Alternatives could affect taste and odor due to agricultural treatment (increased TDS) and in-situ remediation (potential iron, manganese and arsenic effects).					

Impact	No Project	Alternative 4B	Alternative 4C-2	Alternative 4C-3	Alternative 4C-4	Alternative 4C-5
Drainage						
WTR-3: Potential Impacts on Local Drainage	All Alternatives would have less than significant effects on drainage.					
Flooding						
WTR-4: Potential Impacts on Flooding	All Alternatives would have less than significant effects on flooding.					
Secondary Impacts of Water ~~Supply~~Resources and Water Quality Mitigation						
WTR-5: Impacts of Water Supply and Water Quality Mitigation						
WTR-5a: Secondary Impacts Water Right Purchase	No impacts (No new water right purchase)	Potential for indirect conversion of important farmland to non agricultural uses due to water right purchase is mitigated by Mitigation Measure LU-MM-2 (see Section 3.2, Land Use, Agriculture, Population and Housing)				
WTR-~~5~~5b: Secondary Impacts of Water Supply ~~Mitigation~~Replacement	Least need for alternative water supply due to groundwater drawdown but more need for alternative water supply replacement due to incomplete remediation of chromium plume	Lowest need for water supply mitigation of action alternatives due to groundwater drawdown and remedial byproducts from agricultural treatment. Same potential for water supply mitigation as 4C-2, 4C-3, and 4C-4 due to in-situ remediation byproducts.	More need for water supply mitigation due to groundwater drawdown and remedial byproducts from agricultural treatment than 4B, but less than 4C-3 and 4C-4. Same potential for water supply mitigation as 4C-2, 4C-3, and 4C-4 due to in-situ remediation byproducts.	Highest need for water supply mitigation due to groundwater drawdown and remedial byproducts from agricultural treatment. Same potential for water supply mitigation as 4C-2, 4C-3, and 4C-4 due to in-situ remediation byproducts.	Highest need for water supply mitigation due to groundwater drawdown and remedial byproducts from agricultural treatment. Same potential for water supply mitigation as 4C-2, 4C-3, and 4C-4 due to in-situ remediation byproducts.	Same need for water supply mitigation due to groundwater drawdown and remedial byproducts from agricultural treatment as 4C-2. Lower potential for water supply mitigation than all other action alternatives due to in-situ remediation byproducts.
WTR-5c: Secondary Impacts of Boundary and Plume Control	All alternatives include boundary and plume control that would not result in additional secondary impacts above the impacts disclosed for primary remedial approaches included in each alternative.					
WTR-5d: Secondary Impacts of Agricultural Treatment Byproduct Mitigation	No new agricultural treatment; thus no need for byproduct mitigation above CEQA baseline conditions.	Least amount of new agricultural treatment and byproduct generation. AU byproduct mitigation could require additional facilities and land disturbance, with associated impacts	More new agricultural treatment than 4B, but less than 4C-4. AU byproduct mitigation could require additional facilities and land disturbance, with associated impacts	More new agricultural treatment than 4B, but less than 4C-4. AU byproduct mitigation could require additional facilities and land disturbance, with associated impacts	Most amount of new agricultural treatment and byproduct generation. AU byproduct mitigation could require additional facilities and land disturbance, with associated impacts	More new agricultural treatment than 4B, but less than 4C-4. AU byproduct mitigation could require additional facilities and land disturbance, with associated impacts

Impact	No Project	Alternative 4B	Alternative 4C-2	Alternative 4C-3	Alternative 4C-4	Alternative 4C-5
WTR-5e: Secondary Impacts of IRZ Byproduct Mitigation	Least level of IRZ treatment; thus lowest need for byproduct mitigation.	IRZ activities are the same for these 4 alternatives and IRZ byproduct mitigation could require additional facilities and land disturbance, with associated impacts.				Would have less IRZ treatment than other action alternatives and thus less IRZ byproduct generation and need for byproduct mitigation.
WTR-5f: Secondary Impact of Freshwater Injection Water Quality Control	All alternatives include continuation of existing freshwater injection program and thus would not result in new secondary impacts above CEQA baseline conditions.					

Notes:

[a] The No Project Alternative is defined as limited to actions to address the 2008–2010 plume area. As such, it would only result in remediation of this smaller plume area and would not address the wider plume (assumed to be 15% larger than the Q4 2011 plume for evaluation in this EIR). As such, the timeframes shown for cleanup to 3.1 ppb Cr[VI] or 1.2 ppb Cr[VI] are shown in two ways. The first number is for cleanup of the 2008–2010 plume and the second is for the expanded plume studied in this EIR. Thus for cleanup to 3.1 ppb Cr[VI], the cleanup time for the 2008–2010 plume is estimated to range between 75 to 150 years (based on Feasibility Study estimated cleanup timeframes for Alternative 4) and for the entire plume is 1,000 years or more (based on Feasibility Study Alternative 1–natural attenuation).4A in the 2010 Feasibility Study and the 2011 Addendum No. 1, as the No Project Alternative is similar to those two alternatives). For cleanup to 1.2 ppb Cr [VI], the cleanup time for the 2008–2010 plume is 325130 to 220 years (based on Feasibility Study Alternative 4) andestimated cleanup timeframes for Alternative 4 and 4A). For the entire plume, the estimated cleanup timeframe is identified as 1,000 years or more (based on Feasibility Study Alternative 1).

3.1.2 Terminology

In the section below, the concentrations of constituents in groundwater are described in the following ways:

- 1 milligram per liter (mg/L) is equivalent to one part per million (ppm)
- 1 microgram per liter (µg/L) is equivalent to one part per billion (ppb)
- 1 nanogram per liter (ng/L) is equivalent to one part per trillion (ppt)
- 1 ppm = 1,000 ppb = 1,000,000 ppt
- 1 ppb = 0.001 ppm = 1,000 ppt
- 1 picoCurie per liter (pCi/L) = x/ug/L

In the section below, the concentrations of constituents in soil are described in the following ways:

- 1 milligram per kilogram (mg/kg) is equivalent to one part per million (ppm).
- 1 microgram per kilogram (µg/kg) is equivalent to one part per billion (ppb)

In the section below, the following acronyms are commonly used:

- As =Arsenic
- af = acre-feet (= approximately 326,000 gallons (actually 325,851 gallons) which is sufficient to cover one acre with one foot of water)
- afy = acre-feet per year
- AU =agricultural treatment units, also referred to in some remedial documents as land treatment units (LTUs)
- CAO = Cleanup and Abatement Order
- FS = The 2010 Feasibility Study prepared by PG&E for remediation of the Hinkley plume.
- gpm = gallons per minute
- IRZ = In-situ remediation zone
- SCRIA IRZ = South Central Reinjection Area In-situ Remediation Zone
- SAIRZ = Source Area In-situ Remediation Zone
- CAIRZ = Central Area In-situ Remediation Zone
- MCL = Maximum Contaminant Level
- Mn = Manganese
- PHG = Public Health Goal
- RWQCB = Regional Water Quality Control Board, or more commonly, Water Board
- TDS = Total Dissolved Solids
- EPA = U.S. Environmental Protection Agency
- U = Uranium

- WDR = Waste Discharge Requirement

In the section below, the following convention is commonly used:

- Unless otherwise noted below, all references to nitrate concentrations are as nitrogen.

3.1.3 Regulatory Setting

The State Water Resources Control Board (State Water Board) is the state agency with primary responsibility for implementation of state and federally established regulations relating to water resource issues. Typically, all regulatory requirements related to water quality are implemented by the State Water Board through nine Regional Water Quality Control Boards (RWQCBs, also called Water Boards) established through the Porter-Cologne Water Quality Act. The Lahontan Water Board regulates water quality in the Mojave River watershed and the Mojave River Groundwater Basin.

3.1.3.1 Federal Regulations

Federal Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act was passed in 1974 to protect drinking water quality. The U.S. Environmental Protection Agency (EPA) establishes the national standards for drinking water quality.

Maximum Contaminant Levels (MCLs)

Maximum Contaminant Levels are federal enforceable limits for contaminants in drinking water. The federal rules for chromium include a Maximum Contaminant Level of 100 parts per billion (ppb) for total chromium. ~~There is no established federal Maximum Contaminant Level for Cr[VI].~~While total chromium comprises the sum of hexavalent chromium Cr[VI] and trivalent chromium Cr(III) concentrations, the federal MCL for total chromium did not take into account the health effects associated with ingestion of Cr[VI] as health studies concerning ingestion were not completed and the health effects from ingestion were not well understood at the time of MCL adoption. Subsequent study after adoption of the federal MCL has raised concerns about health effects from ingestion of Cr[VI]. Federal Maximum Contaminant Levels are presented below in Table 3.1-3.

Secondary Maximum Contaminant Levels (SMCLs)

Secondary Maximum Contaminant Levels (SMCLs) are established under the federal Safe Drinking Water Act to protect the public welfare. Such regulations apply to contaminants in drinking water that adversely affect its odor, taste or appearance. Secondary Maximum Contaminant Levels are not based on direct adverse health effects associated with the contaminant, although some contaminants may have both a primary and a secondary Maximum Contaminant Level. Secondary Maximum Contaminant Levels are considered as desirable goals and are not federally enforceable. Federal Secondary Maximum Contaminant Levels~~, which~~ are shown in Table 3.1-3.

Clean Water Act

The federal Clean Water Act (CWA) is the primary federal law that protects the quality of the nation's surface waters when they are traditionally navigable waters, are tributary or adjacent to traditionally navigable waters, or are interstate waters. Waters under the jurisdiction of the Clean

Water Act are referred to as “waters of the United States.” The U.S. Army Corps of Engineers regulates fill in waters of the United States under Section 404 of the Clean Water Act. Under Section 401 of the Clean Water Act, state agencies review permits issued by the Corps for their effects on Water Quality. Point source discharges to waters of the United States are regulated under Section 402 of the Clean Water Act through National Pollution Discharge Elimination System (NPDES) permits; in California the regional Water Boards have been delegated the authority to issue NPDES permits. ~~Under Section 401 of the Clean Water Act, state agencies review permits issued by the Corps for their effects on Water Quality.~~

The only surface waters in the study area are the Mojave River, small desert washes that flow south to the Mojave River, and desert washes that flow north to Harper Lake during infrequent large rain events.

The Mojave River flows eastward from the project vicinity to Soda Lake and Silver Lake. The U.S. Army Corps of Engineers has previously determined that the Mojave River is a water of the United States.[1] As a result, for this EIR, tributaries to the Mojave River, including desert washes, are presumed to also be waters of the United States.

Harper Lake is a dry lake except immediately during and after storm events and surface water either evaporates or infiltrates at the lake. Although the U.S. Army Corps of Engineers has not conducted a delineation of the specific study area described in the EIR, they have made a determination for the Abengoa Solar project (Mojave Solar) near Lockhart, that Harper Lake or drainages to it were not waters of the U.S.

Where the project may involve fill to drainages to the Mojave River, then the Clean Water Act would apply and PG&E would be required to complete a formal delineation to confirm federal jurisdiction under Section 404 of the Clean Water Act. If the Corps takes jurisdiction, then PG&E would need to get a permit from the U.S. Army Corps of Engineers under Section 404 and a water quality certification from the Lahontan Water Board, under Section 401. Where discharges of pollutants other than fill would occur, the ~~regional board~~Water Board would determine jurisdiction under the Clean Water Act.

For the drainages to Harper Lake, which are the bulk of the drainages in the study area, they are considered state waters and are subject to state jurisdiction under the Porter-Cologne Water Quality Control Act, as discussed below.

The Federal Resource Conservation and Recovery Act

The State implements the federal Resource Conservation and Recovery Act’s (RCRA’s) Subtitle C (Hazardous Waste Regulations for Treatment, Storage, and Disposal) through the California Department of Toxic Substances Control. For the current project, the only activities that would come under the authority of RCRA would be potential use, generation, storage and transportation of hazardous wastes in relation to above-ground treatment which is included in two of the action alternatives.

[1] The Army Corps of Engineers issued jurisdictional determinations that the Mojave River is a water of the United States prior to the U.S. Supreme Court ruling in the Rapanos case. Subsequent to the Rapanos ruling, the Corps has not made any formal determination for the Mojave River. For this EIR, the prior determinations are considered in effect.

3.1.3.2 State Regulations

Public Health Goals

The California Safe Drinking Water Act of 1996 (Health and Safety Code, Section 116365) requires the Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and adopt Public Health Goals for contaminants in drinking water based exclusively on public health considerations. Public Health Goals are based upon a risk assessment to identify a level at which no known or anticipated adverse effects on health will occur, with an adequate margin of safety.

Public Health Goals are used by the California Department of Health Services in establishing Maximum Contaminant Levels, but the Public Health Goals are not a legally enforceable standard (Health and Safety Code 116365(c)). Thus, Public Health Goals are not developed as target levels for cleanup of ground or ambient surface water contamination and may not be applicable for such purposes, given the regulatory mandates of other environmental programs (OEHHA 2010).

Whereas Public Health Goals are to be based solely on scientific and public health considerations, drinking water standards or Maximum Contaminant Levels adopted by California Department of Public Health are to consider economic factors and technical feasibility. Each primary drinking Maximum Contaminant Level adopted by California Department of Public Health is required to be set at a level that is as close as feasible to the corresponding Public Health Goal, with emphasis on the protection of public health (OEHHA 2010).

State Public Health Goals are shown in Table 3.1-3 below.

Maximum Contaminant Levels

Maximum Contaminant Levels (MCLs)

Maximum Contaminant Levels established by California Department of Public Health must be at least as stringent as the federal Maximum Contaminant Level, if one exists. State Maximum Contaminant Levels are presented below in Table 3.1-3 below

Secondary Maximum Contaminant Levels (SMCLs)

Secondary Maximum Contaminant Levels are established under state water quality law to protect the public welfare. Such regulations apply to contaminants in drinking water that adversely affect its odor, taste or appearance. California does enforce Secondary Maximum Contaminant Levels, which are shown in Table 3.1-3 below. Narrative State water quality objectives for taste and odor are described in Table 3.1-4.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (1967) (Porter-Cologne Act) is the primary law governing California's water quality regulations. The Porter-Cologne Act is established and implemented by the State Water Board and nine regional Water Boards. The State Water Board is the primary state agency responsible for protecting the quality of the state's surface and groundwater supplies. Under this act, the state is required to adopt a water quality control policy to be implemented by the State Water Board and nine regional Water Boards. The regional Water Boards carry out State Water Board policies and procedures throughout the state.

The State Water Board also approves water quality control plans (or Basin plans) prepared by the regional Water Boards. Basin plans designate beneficial uses for specific surface water and groundwater resources and establish water quality objectives to protect those uses. The basin plans define surface and groundwater quality objectives for multiple constituents. Some objectives are narrative, but many are quantitative with specific limits for constituents in various surface streams or specified groundwater basins.

State Maximum Contaminant Levels are shown in Table 3.1-3.

Table 3.1-3. Maximum Contaminant Levels and Public Health Goals for Constituents in Groundwater

Constituent	Primary MCL Federal	Primary MCL State	Secondary MCL Federal	Secondary MCL State	Public Health Goal (OEHHA)
Hexavalent chromium (Cr[VI])	NA	NA	NA	NA	0.02 ppb
Trivalent chromium (Cr[III])	NA	NA	NA	NA	NA
Total chromium (Cr[T])	100 ppb	50 ppb	NA	NA	NA
Arsenic	10 ppb	10 ppb	NA	NA	0.004 ppb
Iron	NA	NA	300 ppb	300 ppb	NA
Manganese	NA	NA	50 ppb	50 ppb	NA
Uranium	30 ppb	20 pCi/L	NA	NA	0.43 pCi/L
Gross Alpha		15 pCi/L	NA	NA	NA
Total Dissolved Solids (TDS)	NA	NA	500 ppm	500 ppm[a]/ 1,000 ppm[b]	NA
Nitrate	45 ppm (as NO_3)	10 ppm (as N)	N/A	Nitrate	45 ppm (as NO_3)

N/A—None adopted
MCL—Maximum Contaminant Level
~~As~~ N = ~~as~~ nitrogen
NO_3 = nitrate
ppm = parts per million = milligrams per liter (mg/L) in water
ppb = parts per billion = micrograms per liter (µg/L) in water
pCi/L = picoCurie per liter
[a] Recommended
[b] Upper limit
Sources: California Department of Public Health 2011; CCR Title 22, Division 4. Environmental Health. Chapter 15.

State Water Board Resolution No. 92-49, "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges"

Groundwater contamination is investigated and remediated following the provisions in the State Water Board Resolution No. 92-49, "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges." The five basic elements are:

- **Preliminary site assessment:** To confirm the discharge and identity of dischargers; to identify affected or threatened waters of the State and their beneficial uses; and to develop preliminary information of the nature, and horizontal and vertical extent of the discharge.
- **Soil and water investigation:** To determine the source, nature, and extent of the discharge with sufficient detail to provide the basis for decisions regarding subsequent cleanup and abatement actions, if any are determined by the Water Board to be necessary.

- **Proposal and selection of cleanup action:** To evaluate feasible and effective cleanup and abatement actions, and to develop preferred cleanup and abatement alternatives.
- **Implementation of cleanup action:** To implement the selected alternative and verify progress via monitoring.
- **Monitoring:** To confirm short- and long-term effectiveness of cleanup and abatement.

State Water Board Resolution No. 92-49 also requires conformance with State Water Board Resolution No. 68-16 “Statement of Policy with Respect to Maintaining High Quality of Waters in California” (~~Non~~Anti-Degradation Policy). The overall cleanup ~~level~~goals and objectives established for a water body ~~is~~are based on its most sensitive beneficial use (i.e., domestic and municipal use, abbreviated as “MUN”). In all cases, the Water Board first considers ~~high quality or naturally occurring “~~background~~”~~[2] concentration objectives as the cleanup levels for polluted groundwater. Generally, compliance with approved cleanup levels must occur at all points within the plume of pollutants. Groundwater cleanup levels are approved on a case-by-case basis by the Water Boards.

The cleanup and abatement must be done in a manner that promotes attainment of background water quality, or the highest water quality that is reasonable if background levels of water quality cannot be restored. The determination of what is reasonable must consider all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible, and intangible. Approved cleanup levels above background concentrations will consider the mobility, toxicity, and volume of pollutants. Any cleanup level less stringent than background levels must be consistent with maximum benefit to the people of the state and not unreasonably affect present and anticipated beneficial uses of such water. Where cleanup to background is infeasible, cleanup standards will be set at the lowest concentrations for the individual pollutants that:

- are technically and economically achievable;
- do not exceed the maximum concentrations allowable under applicable statutes and regulations for individual pollutants;
- do not to pose a hazard to health or to the environment; and
- consider cumulative risks taking into account different routes of exposure and other pollutants.

State Board Resolution No. 88-63, “Sources of Drinking Water”

This resolution provides that all surface and groundwaters of the state are considered suitable or potentially suitable for municipal or domestic water supply with the exception of the following:

- waters with TDS greater than 3,000 ppm that are not reasonably expected to supply a public water systems;
- contaminated waters, either by natural processes or human activity (not related to the pollution incident) that cannot be reasonably treated for domestic use;

[2] “Background” is defined as the water quality present prior to a discharge. Background water quality can include both naturally-occurring levels of constituents as well as man-made influences that are unrelated to and predate a discharge.

- water sources that do not provide sufficient water to supply a single well with a sustainable yield of 200 gallons per day;
- surface water that is part of collection and treatment of municipal, industrial, or mining wastewater or stormwater or is designed specifically for conveying of holding agricultural drainage waters; or
- groundwater where the aquifer is regulated as geothermal energy sources or has been exempted for the purpose of production of hydrocarbon or geothermal energy.

If groundwater meets one of these exceptions, a site-specific de-designation may be appropriate, but is not automatic and requires a Basin Plan amendment.

State Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California" (~~Non~~Anti-Degradation Policy)

This resolution establishes that it is state policy to maintain the highest water quality consistent with maximum benefit to the people of the State as follows:

- where existing water quality is better than established water policies, the existing water quality will be maintained until it is demonstrated that any change is consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses, and will not result in water quality less than that prescribed in policies; and
- discharges to such waters will be required to meet WDRs that result in the best practicable treatment or control necessary to assure that pollution or nuisance will not occur and the highest water quality consistent with maximum benefit will be maintained.

Waste Discharge Requirements

Under the Porter-Cologne Act, the ~~Regional~~regional Water Boards regulate the "discharge of waste" to "waters of the state." All persons proposing to discharge waste that could affect waters of the state must file a report of waste discharge with the appropriate water board. The Water Board may respond to the report of waste discharge by issuing waste discharge requirements (WDRs) in a public hearing, or by waiving WDRs (with or without conditions) for that proposed discharge. The Water Boards issue WDRs for surface, sub-surface and land discharges.

As described in Chapter 1, *Introduction*, PG&E is currently implementing remedial activities in the Hinkley area in compliance with WDRs, which serve as both permits for individual projects (see list of WDRs in Chapter 1) and as a general permit for multiple remediation activities (General Permit—Order No. R6V-2008-0014). Implementation of the proposed alternatives (with the exception of the No Project Alternative) will require the Water Board to adopt new WDRs that will address discharges related to new and expanded remedial activities.

Water Quality Control Plan for the Lahontan Region (Basin Plan)

The Basin Plan for the Lahontan Region is the basis for the Water Board's regulatory program. It sets forth water quality standards for the surface and groundwater of the region, which include both designated beneficial uses of water and the narrative and numerical objectives that must be maintained to protect those uses. It identifies general types of water quality problems that can threaten beneficial uses in the region and lists required or recommended control measures for these problems. In some cases, it prohibits certain types of discharges in particular areas. The Basin Plan incorporates applicable provisions of State Water Board policies.

The 1995 Lahontan Basin Plan includes beneficial uses and water quality objectives for groundwater. The Hinkley chromium plume is located in the ~~middle reach of the~~ Mojave River Groundwater Basin. The beneficial uses for this basin are:

- municipal and domestic supply (MUN);
- agricultural supply (AGR);
- industrial service supply (IND);
- freshwater replenishment (FRSH); and
- aquaculture (AQUA).

Narrative and numerical water quality standards have been established for protection of these uses. The most sensitive use is municipal and domestic supply. As shown in Table 3.1-3, the current federal Maximum Contaminant Level for Cr[T] is 100 ppb, and the state Maximum Contaminant Level for Cr[T] is 50 ppb. There is no Maximum Contaminant Level established for Cr[VI] in groundwater for the prescribed beneficial uses, however there is a Public Health ~~goal~~Goal of 0.02 ppb. As described above, State Board Resolution 92-49 ~~limits~~requires cleanup to background levels unless it can be shown that background is not attainable. For the purposes of this EIR, the current applicable maximum background levels for chromium are ~~is~~ 3.1 ppb of Cr[VI] and 3.2 ppb of Cr[T],~~.~~ and the average background levels for chromium are 1.2 ppb of Cr[VI] and 1.5 ppb of Cr[T]. These are the estimated ~~maximum~~ background levels ~~which~~that were adopted by the Water Board in 2008 based on sampling by PG&E in the Hinkley area in 2006, as discussed further below in Section 3.1.4.3, Hinkley Valley Groundwater Quality. Therefore, cleanup of chromium to background levels is expected to achieve beneficial use of groundwater within the Hinkley Valley, as defined by the Lahontan Basin Plan. This background level may be adjusted by the Water Board in the future if and when additional technical information becomes available. At this time, it is not known whether the background level will be adjusted and if it is, whether the revised level would be higher or lower than the currently adopted level. If the background level is revised to a higher level, then the amount of needed remedial action may be less than that assumed in this EIR. If the background level is revised to a lower level, then the amount of needed remedial action may be more than that assumed in this EIR. If and when the background levels are revised, the Water Board will need to examine whether the analysis in this EIR fully captures the environmental effects of needed remedial action or not.

There are no groundwater quality objectives established specifically for the Mojave River Groundwater Basin~~, water~~. Water quality objectives that apply to all the Lahontan Region's groundwater basins, as specified in the Lahontan Basin Plan, are shown in Table 3.1-4.

Table 3.1-4.Groundwater Quality Objectives for all Groundwater Basins in the Lahontan Basin Plan

Constituent	Concentration
Bacteria, Coliform	In ground waters designated as MUN, the median concentration of coliform organisms over any seven-day period shall be less than 1.1/100 mL.
Chemical constituents	Ground waters designated as MUN shall not contain concentrations of chemical constituents in excess of the Maximum Contaminant Level or Secondary Maximum Contaminant Level based upon drinking water standards specified in the following provisions of Title 22 of the California Code of Regulations (CCR). Waters designated as AGR shall not contain concentrations of chemical constituents in amounts that adversely affect the water for beneficial uses (i.e., agricultural purposes). Ground waters shall not contain concentrations of chemical constituents that adversely affect the water for beneficial uses.
Radioactivity	Ground waters designated as MUN shall not contain concentrations of radionuclides in excess of the limits specified in Table 4 of Section 64443 (Radioactivity) of Title 22 of the CCR.
Taste and Odor	Ground waters shall not contain taste or odor-producing substances in concentrations that cause nuisance or that adversely affect beneficial uses. For ground waters designated as municipal (MUN), at a minimum, concentrations shall not exceed adopted Secondary Maximum Contaminant Levels.

Hinkley Compressor Station Chromium Cleanup and Abatement Orders

The Water Board has directed PG&E to undertake corrective actions through issuance of cleanup and abatement orders (CAOs) requiring investigation, cleanup, monitoring, and reporting. In response to these CAOs, PG&E has submitted a number of reports describing corrective actions, including plume definition, cleanup pilot projects, and remedial activities conducted under WDRs. Past CAOs and related orders from the Water Board are summarized in Chapter 1, *Introduction*. The major actions and requirements in each CAO are also listed in Chapter 1. Key CAOs concerning the current remedial actions are summarized below.

CAO R6V-2008-0002

The Water Board issued the 2008 CAO (CAO No. R6V-2008-0002) to PG&E on August 6, 2008, requiring PG&E to cleanup and abate the effects of waste discharges containing Cr[VI] and Cr[T] to waters of the State. The key requirements of the 2008 CAO are as follows.

- **Chromium Plume Containment**—PG&E was required to contain the chromium plume. The CAO defines containment as no further migration or expansion of the chromium plume to locations where Cr[VI] is below 4 ppb and where Cr[T] is below 50 ppb.
- **Interim Chromium Remediation**—PG&E was required to continue the in-situ corrective actions in the Central Area IRZ (In-situ Remediation Zone) and the Source Area IRZ.
- **Final Cleanup Actions—**PG&E was required to submit ~~an~~a feasibility study report by September 1, 2010, to evaluate remediation strategies and propose a comprehensive and complete groundwater remediation alternative.

The 2008 CAO has been amended ~~three~~four times:

- Amendment R6V-2008-0002A1 established background levels for Cr[VI] and Cr[T] in groundwater for the purpose of the final cleanup actions. These background levels were based on the *Groundwater Background Study Report, Hinkley Compressor Station* (2007 Background Study Report) (Pacific Gas and Electric 2007). The amended CAO required that the feasibility study include an evaluation of each remedial alternative's ability to achieve background water quality.

- Amendment R6V-2008-0002A2 allowed for 1,000-feet lateral migration of the 4 ppb Cr[VI] plume on the eastern boundary as a result of the injection of pumped groundwater taken from the north and enhanced with a carbon reagent, into the South Central Reinjection Area.SCRIA. The amendment requires the area of potential plume expansion to return to 2009 pre-boundaries conditions within 10 years after completing the SCRIA project.

- Amendment CAO R6V-2008-0002A3 requires PG&E to implement additional hydraulic containment of the plume south of Thompson Road by maintaining hydraulic containment on a year round basis and conducting monthly monitoring and reporting of water levels year-round to insure inward gradients. The amendment also requires additional actions to reduce plume migration in the area north of Thompson Road by conducting groundwater extraction starting in summer 2012, evaluating the need for more extraction and other methods, as necessary to implement further chromium removal.

- Amendment CAO R6V-2008-0002A4 requires PG&E to define the entire chromium plume in the upper aquifer where it is still unknown. The Order includes requirements for chromium plume mapping and potentiometric maps showing groundwater flow direction in monitoring reports.

CAO R6V-2011-0005

CAO No. R6V-2011-0005 (issued January 2011) requires PG&E to expand the domestic well sampling program and to supply uninterrupted replacement water service (i.e., bottled water or equivalent) to any domestic wells with more than 3.1 ppb of Cr[VI]/3.2 ppb Cr[T]detected or any wells within 3,000 feet of the chromium plume boundary, based upon the most current quarterly site-wide groundwater monitoring report.

Amendment CAO R6V-2011-0005A1 (issued October 2011) required PG&E to submit a plan to provide permanent replacement water for all indoor domestic uses (referred to as "whole house water") for all wells impacted by PG&E's discharge within the "affected area" (defined as the area within 1 mile downgradient or cross gradient from the plume). PG&E has completed a pilot study and a feasibility study to evaluate water treatment technologies for purposes of providing whole house water replacement to affected residences.

Amendment CAO R6V-2011-0005A2 (issued June 2012) modified the previous orders in consideration of PG&E's implementing a Voluntary Whole House Replacement Water Program that met certain requirements. The Order suspended several provisions of the previous Order as long as PG&E met certain requirements, including completing a community involvement process and providing whole house replacement water to all domestic or community wells located laterally within one mile of the plume boundary that have detectable levels of hexavalent chromium.

On January 11, 2013, the Water Board issued Investigative Order No. R6V-2013-001 requiring additional reporting and accepting a change to the replacement water program testing program in response to violations of CAO No. R6V-2011-0005A1.

AB 685 (2012)/Water Code Section 106.3

AB 685 (Water Code Section 106.3) was approved in 2012 and states that it is the established policy of the state that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes. The bill would require all relevant state agencies, including the Department of Water Resources, the State Water Resources Control Board, and the State Department of Public Health, to consider this state policy when revising, adopting, or establishing policies, regulations, and grant criteria when those policies, regulations, and grant criteria are pertinent to the uses of water described above.

SB 610

SB 610 (Water Code Section 10912) is a state law that supports planning between water suppliers and local cities and counties. SB 610 requires a preparation of a water supply assessment for certain large projects, including those that have the demand for an amount of water equivalent to, or greater than, the amount of water required by a 500 dwelling unit project. When a city or county is the CEQA lead agency, the assessment must be considered during the CEQA process. If there is insufficient water, the city or County must include that determination in its findings for the project.

SB 610 only applies to cities and counties in their capacity as a CEQA lead agency. As such, SB 610 does not apply to the Water Board, which is a state agency. Thus, a formal water supply assessment pursuant to SB 610 was not prepared for this project. However, the analysis in this section has examined the long-term water supply issues for this project, including the ability to support the proposed project’s use, the regulations governing groundwater use in the area, and the potential impacts of groundwater use proposed by the project. Thus, this section provides the substantive information that will be used by the Water Board in considering water supply issues as decisions are made concerning this project.

3.1.3.3 Local Regulations

Mojave River Basin Adjudication

The Mojave River Basin Adjudication is based on the stipulated judgment in *City of Barstow, et al vs. City of Adelanto, et al* and related complaints (Case No. 2008568). The stipulated judgment, issued in 1996, addresses water shortages in the Mojave Basin Area through a designation of five subareas, all of which were found to be in overdraft, and each having an amount of groundwater that can be extracted by all parties based on a court-determined Production Safe Yield to maintain proper water balances within each subarea. The Mojave Water Agency (MWA) is the designated water master, and is responsible for administering the judgment, which involves measuring and tracking aquifer conditions and water use information in the Mojave River Basin. The Mojave Water Agency manages the recharge of the State Water Project water into the watershed, including a spreading basin located along the Mojave River upstream of the study area at Hodge and slightly downstream at Lenwood (both upstream of Barstow).

The Judgment assigned Base Annual Production rights to each producer using 10 acre-feet per year (afy) or more, based on historical production during the period 1986-1990. Parties to the Judgment are assigned a variable Free Production Allowance, which is the amount of water that may be produced (pumped or diverted) from a subarea. The Free Production Allowance is a uniform percentage of the Base Annual Production set for each subarea each year by the Watermaster that is reduced or "ramped-down" over time until total allowance comes into balance with the Production Safe Yield. Any amount of water that is taken beyond the allowance is subject to a replacement obligation.

The study area within this EIR is located within the Centro subarea of the Mojave Basin Area adjudicated boundary. The Free Production Allowance for the Centro subarea for water year 2010-2011 ~~is~~was 39,519 afy (MWA 2012) with verified production of 21,130 afy, indicating a surplus of 18,389 afy (MWA 2012). The Production Safe Yield for the Centro subarea has been identified as 33,375 afy, indicating a surplus of 12,245 afy over the safe yield in the 2010-2011 water year. A review of production estimates from 1993 indicates that the actual 5-year production averages have been less than the current Free Production Allowance and less than the sustainable yield. Over the last five water years (2006–2011), the verified production has averaged 25,193 afy, indicating a surplus over the Free Production Allowance of 14,329 afy and a surplus over the safe yield of 8,182 afy.

Most of the agricultural water users near the Hinkley Compressor Station are included in the Mojave River Groundwater Basin adjudication agreement. PG&E is a designated water user, owns water rights totaling approximately 2,429 afy and, based on the 2010–2011 Watermaster Annual Report, has a current base annual allowance of 1,944 afy (MWA 2012). The Gorman property (in the middle of the existing plume) was not a party to the adjudication and had been pumping at historical levels of about 250–300 gallons per minute (gpm) until it was purchased by PG&E in 2010. PG&E now owns the former Gorman property for agricultural treatment but pumping now falls under adjudication and is similar to prior levels (approximately 285 gpm).

San Bernardino County General Plan

The San Bernardino County General Plan (San Bernardino County 2007) includes goals and policies to safeguard surface and groundwater quality in San Bernardino County, mostly related to flood protection and stormwater runoff. These provisions are intended to reduce erosion and limit surface water quality impacts (which, as discussed below, are not concerns for this project).

San Bernardino County has a Stormwater Management Program, as a part of its municipal Phase I NPDES permit, for the portion of the County that drains to the Santa Ana River. In the Mojave River watershed, San Bernardino County, along with the town of Apple Valley, and the cities of Victorville and Hesperia have been issued a Phase II NPDES permit for those urbanized portions of the Mojave River watershed. The project area is not covered under a municipal NPDES permit.

3.1.4 Existing Conditions

This section discusses the existing conditions related to water resources (groundwater quantity and water quality) in the study area. Existing conditions are defined as the physical conditions on the ground as of late ~~2011~~ 2012 (wherever possible) as described in Section 2.4. In some cases, existing conditions are based on 2011 to 2012 conditions depending on available data. The existing conditions ~~are~~include the ~~2011~~existing groundwater levels, water use patterns (for domestic and agricultural supply wells), the average and maximum background concentrations of minerals, nutrients, and metals in the groundwater of the Hinkley Valley, and the existing Cr[VI] concentrations in the plume of contamination from the PG&E Hinkley Compressor Station.

The summary of remedial components under existing conditions is described in Chapter 2. Because the proposed alternatives all include agricultural treatment and in-situ remediation~~, the~~ monitoring results from previous testing and operations of these remedial measures are also summarized. Further technical details about the historical, existing, and likely future groundwater conditions and the modeling approach, assumptions, and results are provided in Appendix A. Recent groundwater quality data and chromium plume and treatment monitoring results for the agricultural treatment units, Desert View Dairy treatment unit and IRZs are also included in Appendix A.

3.1.4.1 Sources of Information

The key sources of data and information used in the preparation of this section are listed and briefly described below.

- The Lahontan Basin Plan (1995, as amended) includes all of the beneficial uses, water quality standards, implementation plans, and policies for the Water Board. The beneficial uses for groundwater and implementation procedures for groundwater cleanup projects are included.
- The Feasibility Study Report (Pacific Gas and Electric Company 2010a) and its 2011 addenda (Pacific Gas and Electric Company 2011a[3], 2011b[4], and 2011c[5]) prepared for PG&E pursuant to the Cleanup and Abatement Order No. R6V-2008-0002 were the major sources of information for site-specific groundwater conditions, including existing groundwater pumping and injection associated with the containment and in-situ treatment of the Cr[VI] plume.
- The Mojave River Basin Groundwater Model Report, prepared by U.S. Geological Survey (USGS) (Stamos et al. 2001) in cooperation with the Mojave Water Agency was used to characterize the regional aquifer conditions, including the aquifer near Hinkley.
- The 2010–11 Mojave Basin Area Watermaster Annual Report, prepared by the Mojave Water Agency (MWA 2012) was used to characterize the conditions of the Centro Subarea and PG&E's adjudicated rights within the subarea.
- *Harper Lake Basin, San Bernardino County, California Hydrogeological Report* (Laton et al. ~~Cal State University, Fullerton,~~ 2007) was used to characterize historic drawdown levels in the Hinkley aquifer and the Harper Lake basin.
- *Chromium, Chromium Isotopes and Selected Trace Elements, Western Mojave Desert, USA* (U.S. Geological Survey 2008) was used to characterize the range of regional concentrations of chromium.
- *Groundwater Background Study Report Hinkley Compressor Station, Hinkley California*. (Pacific Gas and Electric 2007) provides results from chromium sampling of about 50 wells in the Hinkley area that indicate background concentrations in the Hinkley Valley aquifer.
- PG&E Status Reports (Pacific Gas and Electric 2008, 2009a, 2009b, 2010b, 2010c, 2011i, 2011j, 2012d) for the Desert View Dairy Land Treatment Unit (referred to in this EIR as an agricultural treatment unit), plume containment, and for in-situ remediation zones (IRZs) prepared for the Water Board. These status reports contain information derived from the two ongoing

[3] PG&E 2011a. Addendum #1 to the Feasibility Study Pacific Gas and Electric Company Compressor Station Hinkley, California. January 31.

[4] PG&E 2011b. Addendum #2 to the Feasibility Study Pacific Gas and Electric Company Compressor Station Hinkley, California. March 3.

[5] PG&E 2011c. Addendum #3 to the Feasibility Study Pacific Gas and Electric Company Compressor Station Hinkley, California. September 15.

remediation programs at Hinkley: agricultural treatment and in-situ remediation, as well as freshwater injection wells, which is not technically a remediation program, but which is used to help contain the plume migration on the northwest edge.

- PG&E Quarterly Monitoring Reports (2011e)2011 and 2012 all available at http://geotracker.waterboards.ca.gov/). PG&E conducts quarterly monitoring of groundwater and reports the results on the current location, extent, stability, and concentrations of chromium found in Hinkley.

3.1.4.2 Groundwater Basins

Mojave River Groundwater Basin

The project is located in South Lahontan Hydrologic Region within the Centro Subarea of the Mojave River Groundwater Basin. The immediate study area is located within the Hinkley Valley aquifer west of Barstow and north of the Mojave River.

The Mojave River Groundwater Basin has a surface area of 1,400–square miles (DWR 2003). The aquifer system (i.e., water-bearing rocks and sediments) consists of unconsolidated alluvial materials such as gravel, sand, silt, and clay deposited by the recent Mojave River and the Pliocene-Pleistocene ancestral Mojave River. Also present are deposits of fine sand, silt and clay that accumulated in lakes and playas along the margins of the basin. The water-bearing deposits form two aquifers—a floodplain aquifer and a regional aquifer underlying and surrounding the floodplain aquifer. The floodplain aquifer is more productive than the regional aquifer, yielding most of the groundwater pumped from the basin. These alluvial deposits are 100 to 200 feet thick and are within about 1 mile ofextend outward from the Mojave River. Wells drilled in the river deposits typically yield between 100 and 2,000 gpm. Most of the water contained in the floodplain aquifer is recharge from the Mojave River.

Harper Lake is a terminal dry lake with no outlet. in the Harper Dry Lake Valley. Harper Lake contained water and a natural marsh into the early 20th century, until agricultural development depleted the groundwater that sustained its level. Groundwater in the valley, like in all valleys in the Mojave Desert, was greatly overdrafted. In 2003, owners of a recently constructed solar power plant located just west of the lake began to deliver up to 75 afy from local groundwater that is managed by the BLM and transferred to the lake as part of the mitigation agreement for solar field expansion (BLM 2004).

The Lockhart fault extends in a northwest to southeast direction, and is located near the southwest corner of the PG&E Compressor Station (Pacific Gas and Electric 2011c). The Lockhart fault extends through the northern part of Iron Mountain and south of Harper Lake through Hinkley Valley and into the unconsolidated rocks south of the Mojave River. This fault appears to impede the movement of groundwater in the regional and the floodplain aquifers, although there is no evidence of this effect in the floodplain aquifer along the river (Stamos et al. 2001). The fault is considered to be a zone of low hydraulic conductivity and appears to provide considerable resistance to westward flow from the Compressor Station (Pacific Gas and Electric 2011c).that has been known to create a steep drop in elevation as groundwater moves from the southwest to the northeast direction, but does not apparently impede all flow from the southwest to northeast direction. The Lockhart fault is considered active within Holocene time (past 11,000 years) but has no obvious surface expression.

The Mount General fault also extends northwest-to-southeast along the northeast model boundary. There is no evidence of this fault extending into the north Hinkley Valley or that it is active.

The Mojave River Groundwater Basin is essentially a closed basin –very little groundwater enters or exists the basin. However, within the basin groundwater movement occurs between the different subareas, as well as surface-groundwater water and groundwater-atmosphere interchanges. Natural inflows to, or recharge of, the groundwater basin is from direct precipitation, ephemeral streamflow, infrequent surface flow of the Mojave River, and underflow of the Mojave River into the basin from the southwest (DWR 2003). Over 90 percent of the basin groundwater recharge originates in the San Gabriel and San Bernardino Mountains (MWA 2011-). Average precipitation varies across the basin from 4 to 11 inches with the average for the basin near 6 inches (DWR 2003). Precipitation in the Barstow area is approximately 4 inches per year (Stamos et al. 2001).

Groundwater is recharged into the basin predominantly by infiltration of water from the Mojave River, which accounts for approximately 80 percent of the total basin natural recharge (MWA 2011). However, the recharge from the Mojave River is very episodic, occurring only in periods of high runoff and flooding. The recharge to the portion of the Mojave River alluvial aquifer in the Hinkley Valley can be roughly estimated for the years when surface flow reaches Barstow. The Mojave River alluvial channel is periodically recharged (every 5–10 years) during major runoff events. The water levels ~~along~~immediately adjacent to the Mojave River channel may be recharged by as much as 20 to 40 feet during these surface flow events (Stamos et al. 2001). However, as you move away from the area immediately adjacent to the river, the effect of Mojave River runoff events on groundwater levels in the Hinkley Valley diminishes rapidly (Lines 1996). Based on data for the high flow period between November 1992 and March 1993, water table rises in the project study area were roughly 16 feet to over 48 feet beneath and immediately adjacent to the Mojave River, 8 feet to 16 feet up to 0.75 mile north of the river, 4 feet to 8 feet up to 1.25 miles north of the river, and 1 foot to 4 feet up to 1.75 miles north of the river (Lines 1996)[6]. Recent years with some recharge in the Hinkley Valley portion of the Mojave River aquifer are 1983, 1993, 1998, 2005, and 2010.

Some of the Mojave River recharge water flows into the Hinkley Valley aquifer north of the river, over a period of several years following the recharge event. The recharge events also can be identified from increasing water levels in wells along the river, as described in Appendix A. Sources of artificial recharge include irrigation return flows, waste water discharge, and enhanced recharge with imported water (Stamos et al. 2001). Groundwater is discharged from the basin primarily by well pumping, evaporation through soil, transpiration by plants, seepage into dry lakes where accumulated water evaporates, and seepage into the Mojave River.

In addition to natural recharge, the Mojave River Pipeline, a project of the MWA that brings State Water Project (SWP) water from the California Aqueduct, provides groundwater recharge for use in many communities (primarily in the area of Barstow) to offset the growing depletion of groundwater supplies in the basin (MWA 2013). The pipeline extends 76 miles from the California Aqueduct in the Phelan area, roughly parallels the Mojave River, and delivers SWP water to four recharge sites: Hodge, Lenwood, Daggett/Yermo, and Newberry Springs at the project terminus. The pipeline's recharge capacity is approximately 45,000 acre-feet per year (MWA 2013). While this

[6] Estimates of water table changes and distances from the Mojave River should not be considered exact as they were very roughly scaled by hand from a figure in Water Resources Investigations Report 95-4189, showing water table rises along the Mojave River (Lines 1996).

project helps with regional recharge, the project does not include specific recharge affecting the Hinkley aquifer.

Hinkley Valley Groundwater Basin

Figure 3.1-1 shows the upper portion of the Mojave River Groundwater Basin from between the San Bernardino Mountains and east of Barstow including the project study area. The Centro Subarea of the Mojave River Groundwater Basin includes the area from north of Victorville to Barstow and includes the project study area and the Harper Lake watershed. The Hinkley Valley Groundwater Basin (referred to as the Hinkley Valley aquifer in this EIR) is located north of the Mojave River between Iron Mountain on the west and Mt. General on the east and extends north to the approximate location of Red Hill at the north end of Hinkley Valley. Figure 3.1-2 shows the rough outline of the Hinkley Valley aquifer and the location of the chromium plume as of late ~~2011.~~2012 The Hinkley Valley aquifer is about 40 square miles (25,600 acres). The east side of Hinkley Valley may have been a previous route for the Mojave River and is thought to have coarser alluvial sediments.

Figure 3.1-3 shows a diagram of the Hinkley aquifer, drawn as a cross section along the 3.1 ppb Cr[VI] plume centerline, starting at the Mojave River and continuing north ~~about 6 miles~~ to the underflow toward Harper Valley and Harper Dry Lake (the dry lake is also referred as a "playa") (shown as Cross Section A' in Figure 3.1-2). The ground elevation at the Mojave River is approximately 2,200 feet above mean sea level (amsl) and about 2,150 feet amsl north of Hinkley. The depth to bedrock is about 200 feet, and apparently slopes with the ground surface. The measured groundwater elevation generally follows this same elevation gradient. The groundwater contour elevations for February 2006 were about 2,150 feet amsl at the Mojave River, about 2,125 feet amsl at the Compressor Station, about 2,075 amsl north of the Cr[VI] plume at Thompson Road and about 2,050 at the north end of the Hinkley Valley. In total, t~~T~~his data represents a groundwater elevation drop of 100 feet between the Mojave River and the north end of the Hinkley Valley. The measured water table gradient is about 20 feet per mile (0.004). The aquifer porosity is about 20%; if there is a 75-foot saturated depth of the upper aquifer, the water contained in the aquifer is equivalent to a 15-foot column of water only. Figure 3.1-4 presents the groundwater elevation contours for the upper aquifer, discussed below, in the aquifer surrounding the plume.

As described in the USGS modeling study (Stamos et al. 2001), the saturated upper aquifer thickness (i.e., the aquifer material that is filled with water) of the Hinkley Valley aquifer is about 75–125 feet, and the depth to groundwater is about 75–100 feet below the ground surface. Throughout most of the Hinkley Valley, there are two parts to the aquifer: an upper aquifer and a lower aquifer which are respectively located above and below the confining clay layer called the blue clay.

The upper aquifer near the Hinkley Compressor Station is above the blue clay layer. The blue clay ranges in thickness up to 40 feet and becomes thinner with distance from the Mojave River. Where the blue clay layer and lower aquifer thins out near above ground bedrock features (primarily, the northwestern site area), all saturated deposits above bedrock are part of the upper aquifer (Pacific Gas and Electric Company 2011e). Appendix A presents a simplified accounting of the Hinkley aquifer accounting for elevations and groundwater flow.

The upper and lower aquifer sediments have variable grain size and properties. Grain size can vary from coarse to fine over short distances laterally and vertically but generally become finer-grained away from the Mojave River. The upper aquifer is an unconfined aquifer while the lower aquifer is

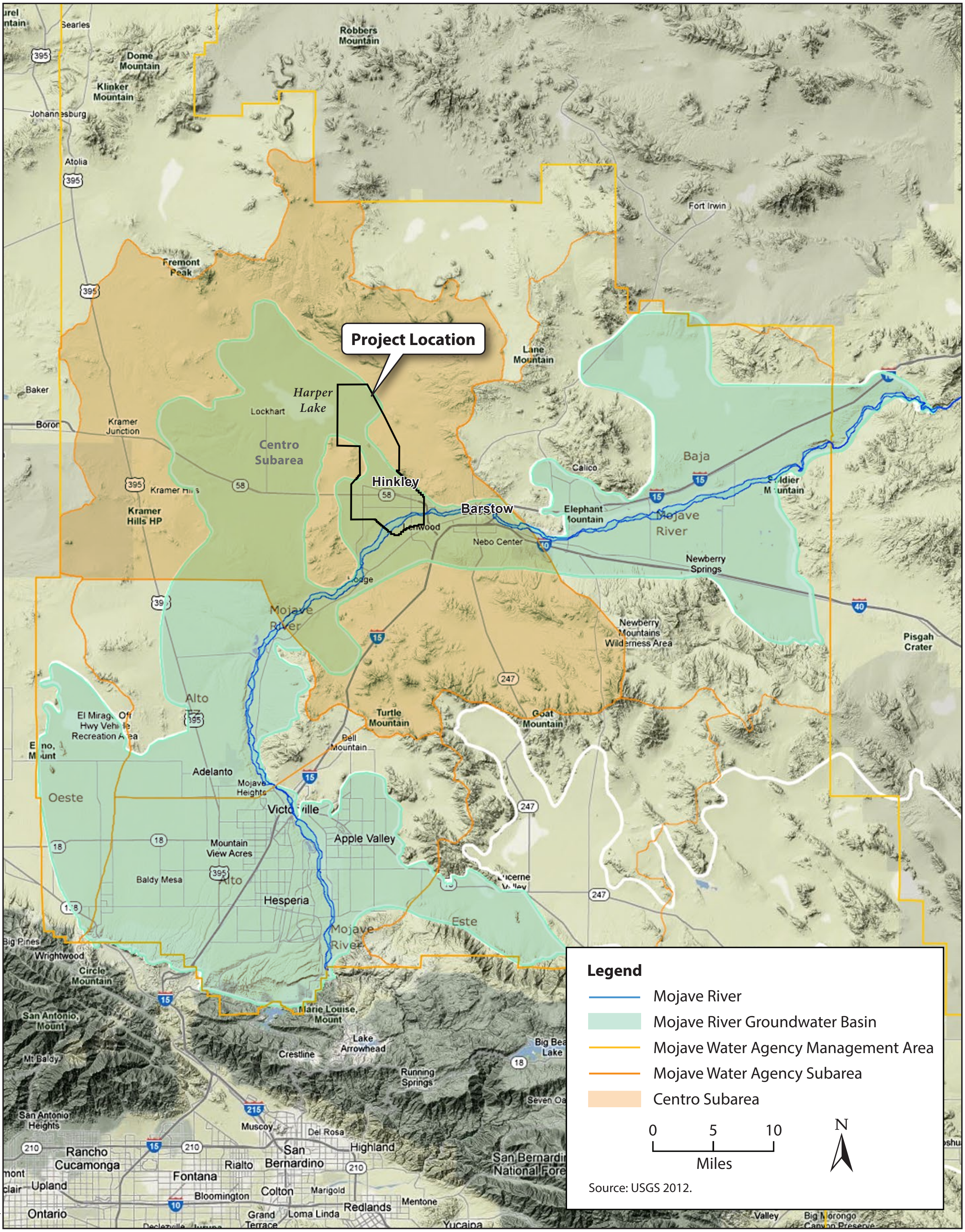

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Figure 3.1-1
Mojave River Groundwater Basin

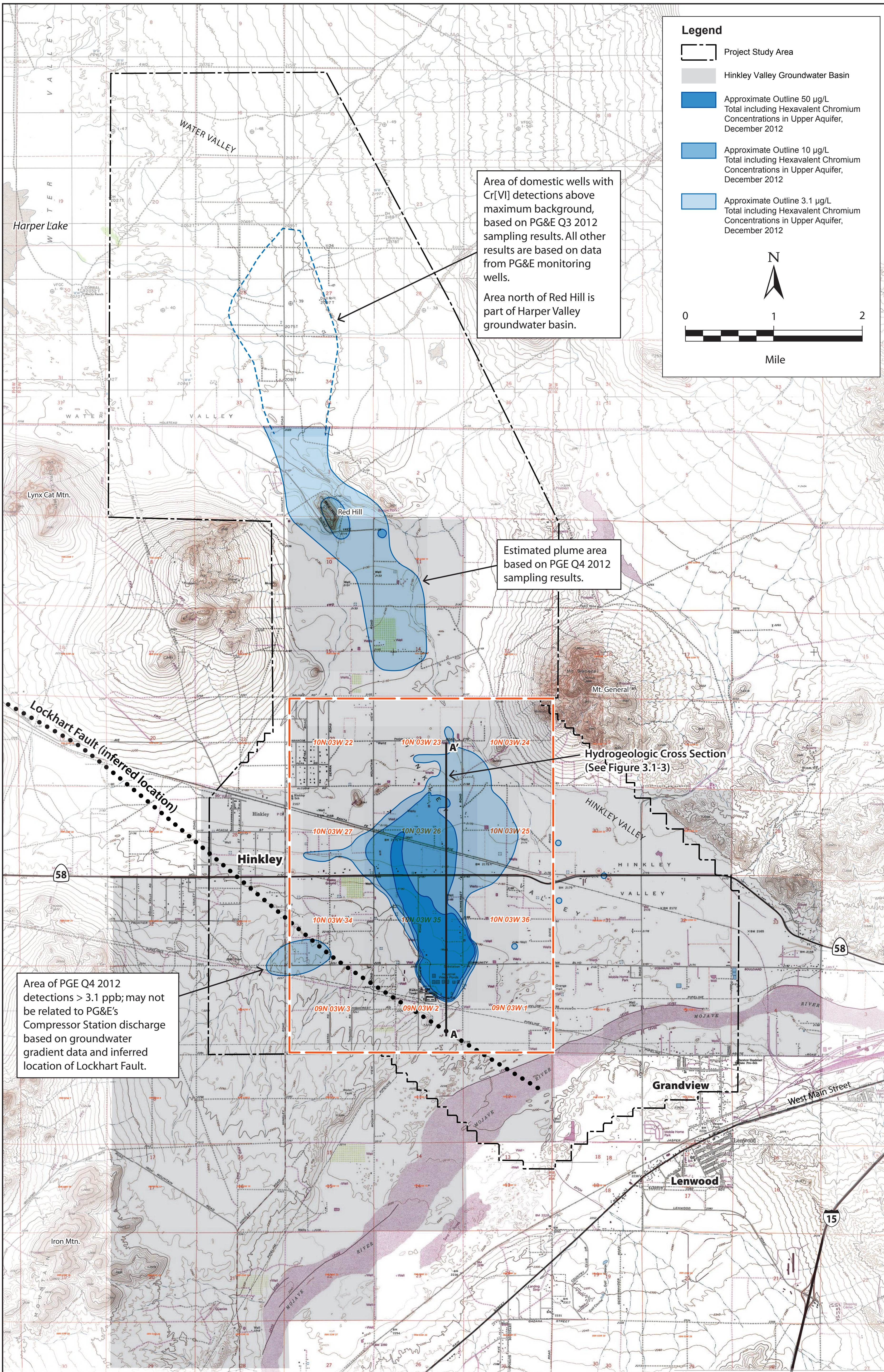


Figure 3.1-2
Hinkley Valley Groundwater Basin

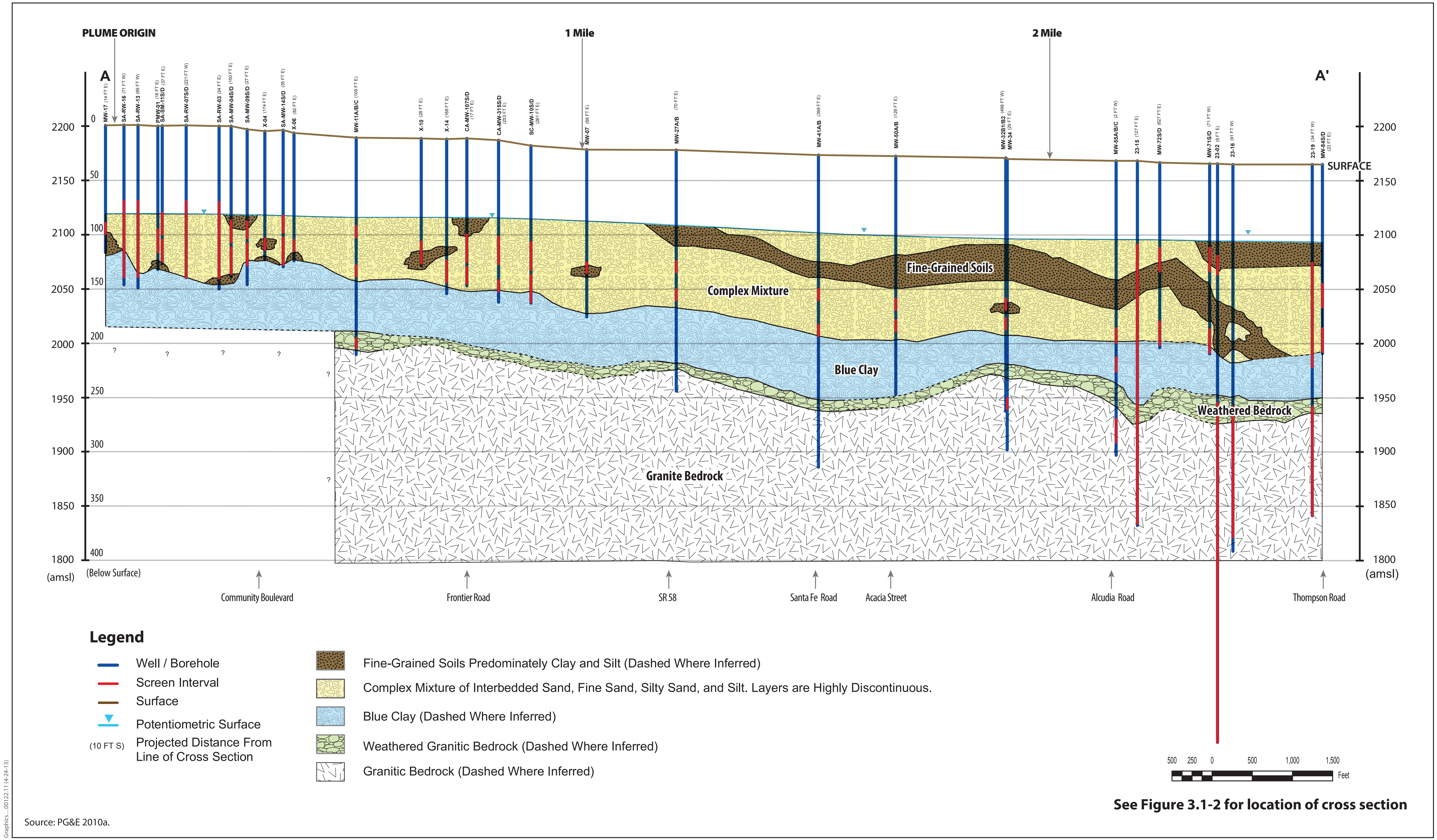
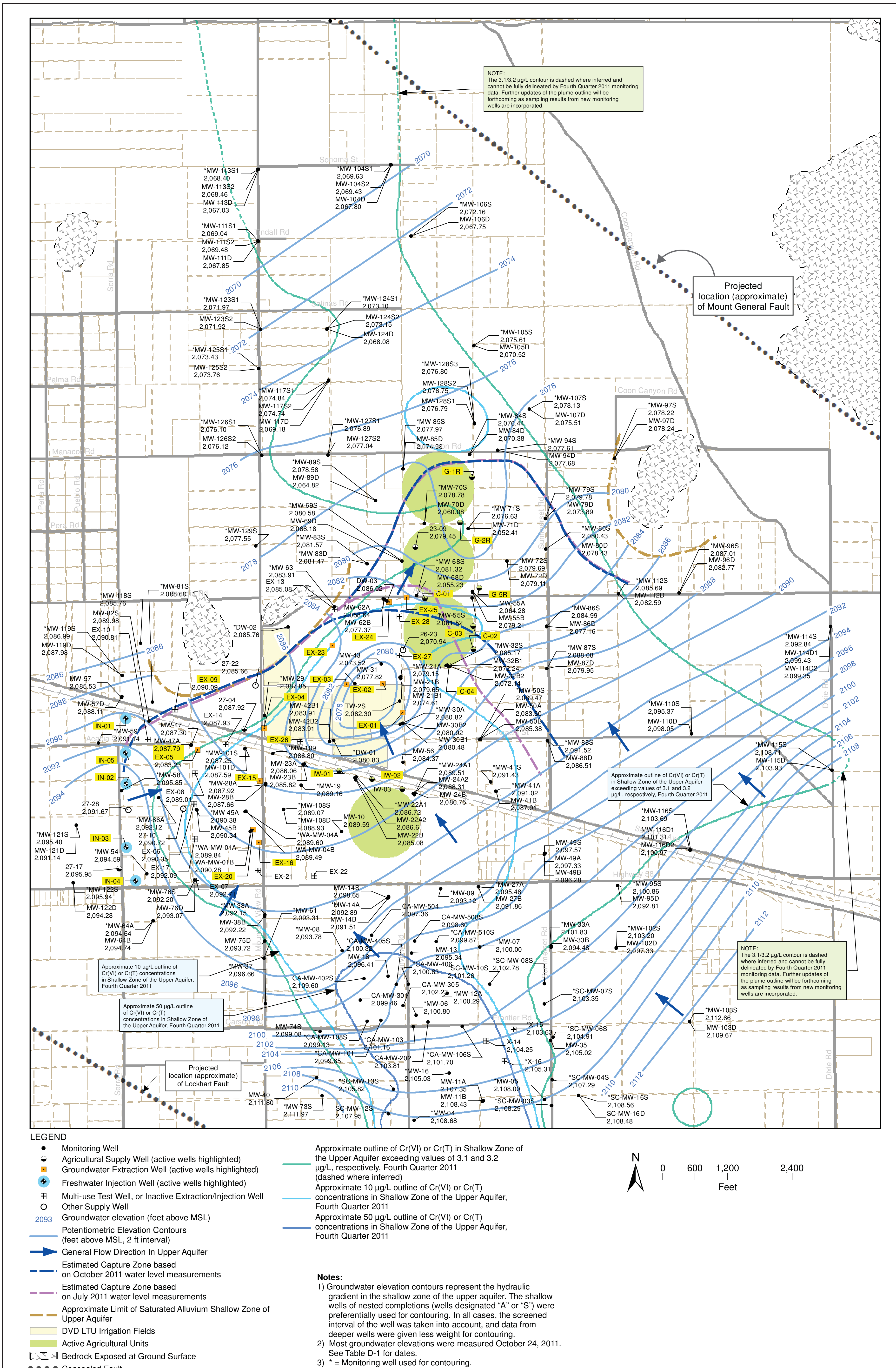
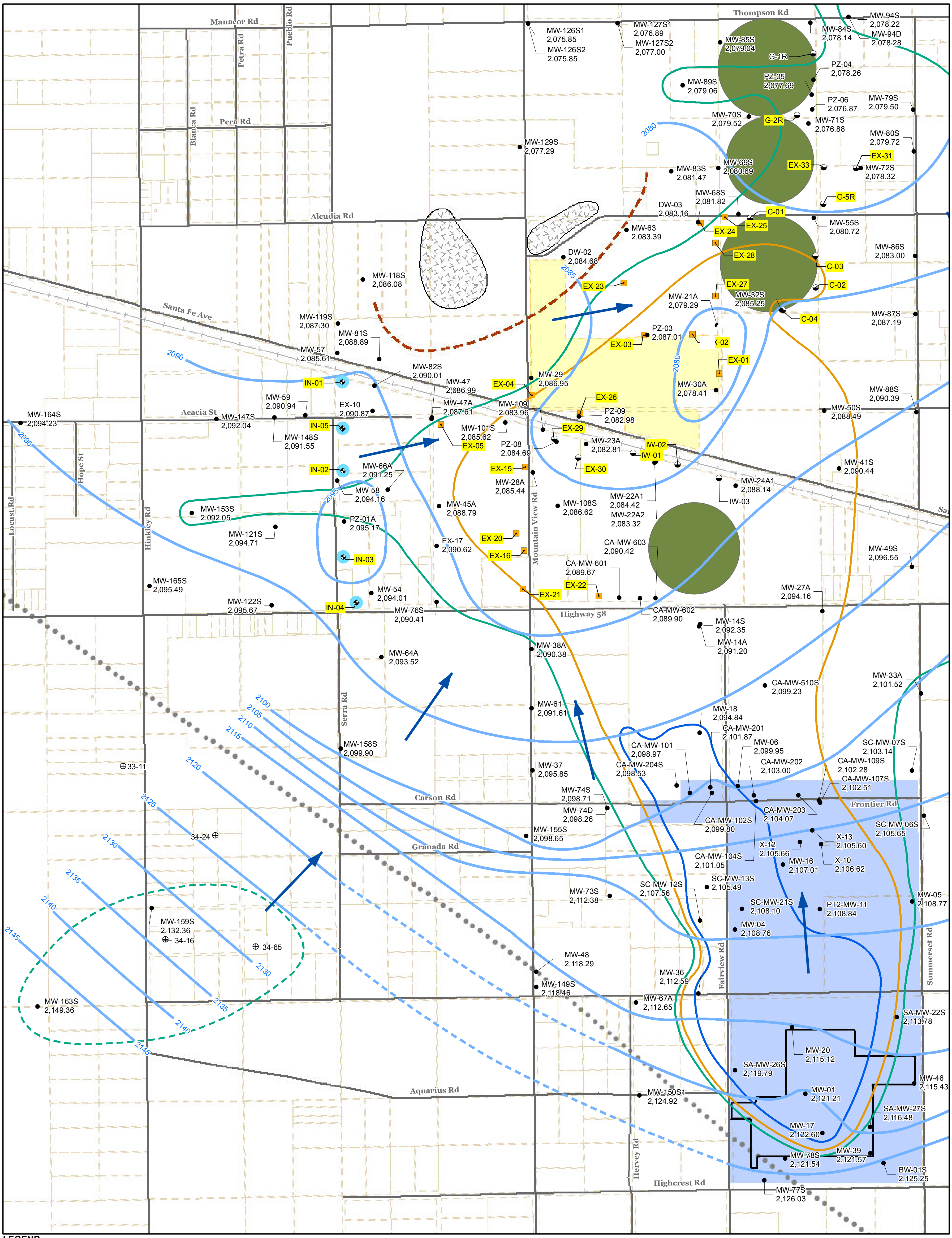


Figure 3.1-3
Hinkley Valley Groundwater Basin Hydrogeologic Cross Section



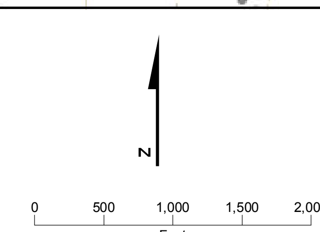
Source: PG&E 2011e.

Figure 3.1-4a
Groundwater Elevation Contours in the Vicinity of the Chromium Plume



LEGEND

- Monitoring Well
- Domestic Supply Well
- Agricultural Supply Well (active wells highlighted yellow)
- Groundwater Extraction Well (active wells highlighted yellow)
- Freshwater Injection Well (active wells highlighted yellow)
- Approximate outline of Cr(VI) or Cr(T) in Shallow Zone of the Upper Aquifer exceeding background values of 3.1 and 3.2 µg/L, respectively, Fourth Quarter 2012
- Approximate 10 µg/L outline of Cr(VI) or Cr(T) concentrations in Shallow Zone of the Upper Aquifer, Fourth Quarter 2012
- Approximate 50 µg/L outline of Cr(VI) or Cr(T) concentrations in Shallow Zone of the Upper Aquifer, Fourth Quarter 2012
- Potentiometric Elevation Contours, Dashed Where Inferred (feet above mean sea level, 5 ft contour interval)
- General Groundwater Flow Direction
- Approximate Limit of Saturated Alluvium in Shallow Zone of Upper Aquifer
- Active Agricultural Units
- In Situ Reactive Zone
- DVD LTU Irrigation Fields
- PG&E Compressor Station
- County Parcels
- Bedrock Exposed at Ground Surface
- Approximate Surface Trace of Lockhart Fault (Stamos et al., 2001)



Note: Groundwater elevations calculated using manual water level measurements collected in October and November 2012

Source: PG&E 2013c. Fourth Quarter Groundwater Elevations Maps. Prepared upon request from ICF on behalf of Lahontan Water Board.

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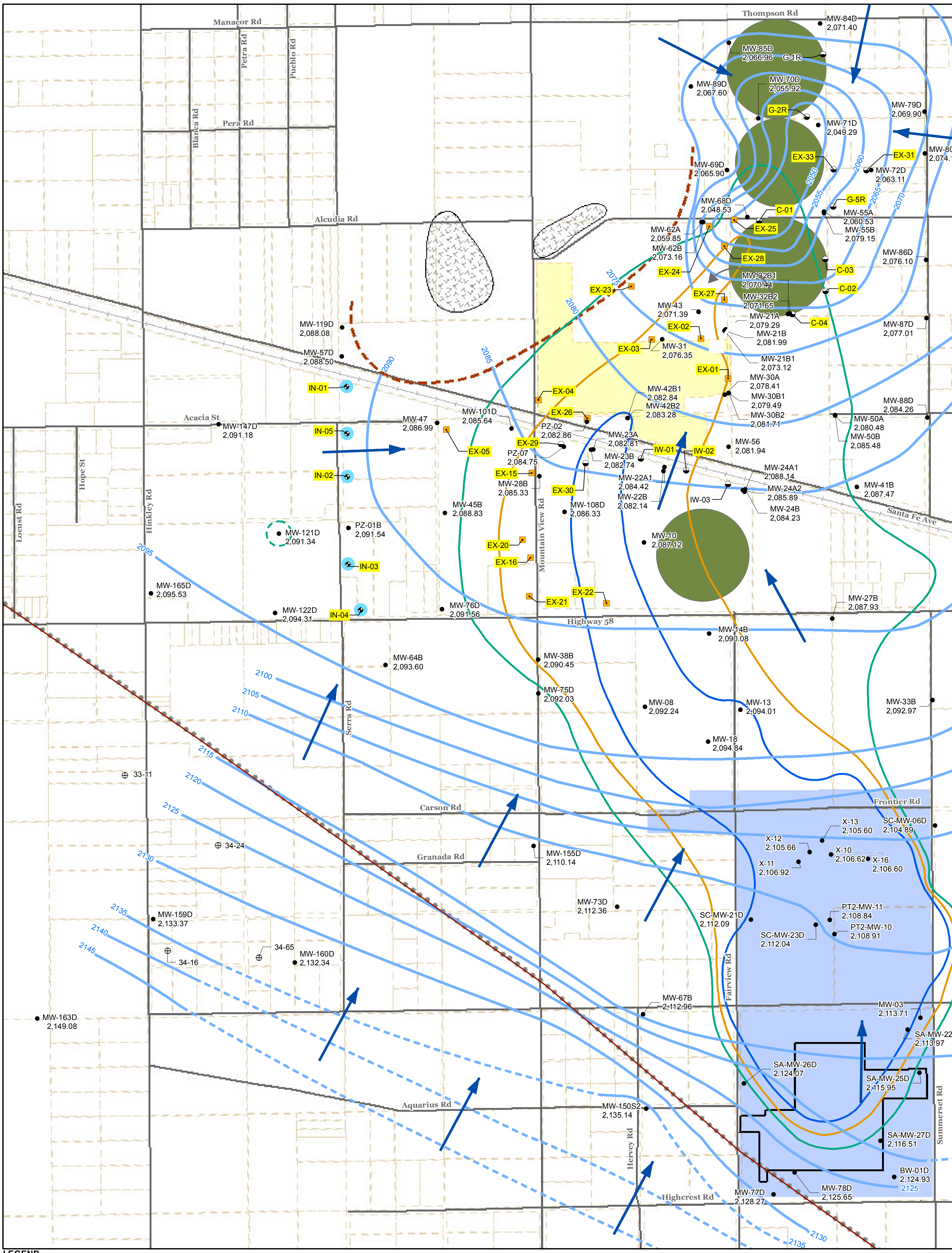
Figure 3.1-4b
Groundwater Elevations in Shallow Zone of Upper Aquifer



LEGEND

- Monitoring Well
- Domestic Supply Well
- Agricultural Supply Well (active wells highlighted yellow)
- Groundwater Extraction Well (active wells highlighted yellow)
- Freshwater Injection Well (active wells highlighted yellow)
- Lockhart_Fault
- Approximate outline of Cr(VI) or Cr(T) in Deep Zone of the Upper Aquifer exceeding background values of 3.1 and 3.2 µg/L, respectively, Fourth Quarter 2012
- Approximate 10 µg/L outline of Cr(VI) or Cr(T) concentrations in Deep Zone of the Upper Aquifer, Fourth Quarter 2012
- Approximate 50 µg/L outline of Cr(VI) or Cr(T) concentrations in Deep Zone of the Upper Aquifer, Fourth Quarter 2012
- Potentiometric Elevation Contours, Dashed Where Inferred (feet above mean sea level, 5 ft contour interval)
- General Groundwater Flow Direction
- Approximate Limit of Saturated Alluvium in Deep Zone Upper Aquifer
- Active Agricultural Units
- In Situ Reactive Zone
- DVD LTU Irrigation Fields
- PG&E Compressor Station
- County Parcels
- Bedrock Exposed at Ground Surface
- Approximate Surface Trace of Lockhart Fault (Stamos et al., 2001)

N

0 500 1,000 1,500 2,000
Feet

Note: Groundwater elevations calculated using manual water level measurements collected in October and November 2012

Source: PG&E 2013c. Fourth Quarter Groundwater Elevations Maps. Prepared upon request from ICF on behalf of Lahontan Water Board.

Graphics ... 00122.11 (5-7-2013)

Figure 3.1-4c
Groundwater Elevations in Deep Zone of Upper Aquifer

confined beneath the blue clay layer. These variable geological conditions influence the movement and distribution of chromium in the groundwater beneath the site. Because the upper aquifer is unconfined and less condensed than the lower aquifer, groundwater flow is more transmissive (free flowing) in the upper aquifer than it is in the lower aquifer. The upper aquifer groundwater elevations generally slope (indicating some groundwater movement) from the Mojave River toward the north, with flow moving towards Harper Valley and playa. ~~It is calculated that at least 10% of groundwater from the Hinkley Basin flows into the Harper Valley.~~

Water levels in the Centro Subarea have been relatively stable with seasonal fluctuations and declines during dry years followed by recovery during wet periods. Minimal water level changes in the Harper Lake area indicate a slow recovery following significant reductions ~~in~~from pumping during ~~the~~ past ~~several~~ years of agricultural practices. Water level declines in wells in the Hinkley vicinity (away from the river) prior to the adjudication of the Mojave River Groundwater Basin show the effects of pumping and limited recharge, primarily due to agriculture (MWA 2011). Water levels in Hinkley have been stabilizing and recovering since the 1996 adjudication (see further discussion below).

Hinkley Valley Water Supplies

All of the existing water supplies in the Hinkley Valley and nearby Barstow are pumped groundwater~~.~~ from water supply wells[7]. Historical water uses in the Hinkley Valley were dominated by agricultural use from the 1940s to the 1990s. There are an estimated 500 domestic wells in the Hinkley Valley, but the volume of water used for residential properties is generally small in comparison to agricultural use. After the chromium plume was reported in 1987, a number of drinking water wells were abandoned following property purchase by PG&E. The standard practice has been to seal these domestic wells, although a few were left to serve as monitoring wells.

PG&E's primary groundwater supply consumption within the study area is twofold: industrial supply for the Compressor Station and current remedial actions for chromium. The latter involves different scenarios affecting the aquifer. In the case of in-situ remediation and fresh water injection, water that is extracted is re-injected into the subarea, and therefore, the activities do not alter the net groundwater balance. However, groundwater extraction for agricultural treatment results in loss of water due to high evapotranspiration rates during warmer months of the year (late spring to early fall). A portion of the extracted water percolates through the soil and returns to the aquifer during cooler months of the year (winter). On a year-round basis, agricultural return to the water table is approximately 30% of the pumped amount (Stamos et al. 2001).

Through its water supply program ordered by the Water Board, PG&E is now providing many homeowners, the Senior Center, and the Hinkley Elementary School with bottled water. Thus, less aquifer water is currently being pumped by domestic wells in much of the Hinkley Valley for drinking and cooking purposes. This, however, is only a small amount of pumped water compared to other domestic uses, such as bathing, laundry, appliances, and landscaping. In addition, the local school district recently voted to close the Hinkley School in summer 2013, which will lower water use associated with the school. However, if the school is used for another use, the water use may or

[7] For the purposes of the project and this EIR, water supply wells are those that provide water for agricultural, domestic or industrial uses, and include those that are used to supply water for freshwater injection. Water supply wells do not include remediation monitoring wells.

may not change compared to existing conditions. ~~In addition, the use of bottled water will soon end and both the whole house water for residents and the alternate water supply for the Hinkley School will be from the Hinkley basin.~~ ~~As noted above,~~ PG&E is currently planning to provide whole house water to residences within the affected area as required by CAO R6V-2011-0005, as amended. PG&E ~~also recently~~ previously agreed to provide an alternative water supply to the Hinkley Elementary School as part of a legal settlement related to alleged violations of a prior Water Board order requiring containment of the chromium plume. The Water Board has not yet determined how the settlement may be affected by the proposed school closing. At this time, PG&E is proceeding with the required water supply project.

Effects of Existing and Historic Pumping on Groundwater Aquifer Levels

Groundwater pumping causes a localized drawdown of water elevations around the well because a pressure gradient (i.e., water slope) is needed for the groundwater to move through the aquifer material to the well (see Appendix A). This is sometimes called a "cone of depression." The size of this cone of depression will increase with higher pumping and/or less transmissive aquifer materials, such as very fine sand, silt and clay. Cones of depression within the study area change in response to variations in seasonal and intra-seasonal pumping rates, including changes in agricultural operations (Pacific Gas and Electric 2011c).

Historical pumping in the Hinkley Valley generally caused groundwater elevations to decline by as much as 90 feet or more from between 1930 and the late 1980s (Stamos et al. 2001, Laton et al. ~~Cal State Fullerton~~ 2007). The center of the Harper Lake basin had declines up to 100 feet, and the northeast portion of the Harper Lake basin (within the project area) had declines over 50 feet (Laton et al. ~~Cal State Fullerton~~ 2007). After the Mojave River Basin groundwater adjudication in ~~1995~~1996, pumping for irrigation in the Hinkley Valley (and the Harper Lake basin) has been reduced. As a result there has been some recovery in groundwater levels, although groundwater elevations in 1999 were still 30 to 50 feet or more below their 1930s levels in the Hinkley Valley (PG&E 2013a) and in 2004 were still perhaps 40 feet below 1930s levels in the part of the northeast portion of Harper Lake basin in the project study area (Laton et al. ~~Cal State Fullerton,~~ 2007). Groundwater levels are also influenced by periodic dry periods (Laton et al. ~~Cal State Fullerton,~~ 2007). As described previously, the Hinkley Valley aquifer currently has relatively stable regional groundwater conditions, characterized ~~as~~by nearly constant elevations and northward flow, as shown in Figure 3.1-4.

Current groundwater pumping in the vicinity of the plume is generally limited to agricultural supply for farming, Compressor Station water supply, remedial supply by PG&E, and individual domestic water supply associated with rural residential land use. Groundwater extraction by PG&E and others, primarily for agriculture and secondarily for Compressor Station supply, has the greatest potential to influence localized groundwater flow and chromium movement. Domestic wells pump only a small amount of water (between 200 and 600 gallons per day) each year in comparison and therefore have the least influence on groundwater flow.

The pumping rates for agriculture can be estimated from the irrigated acreage and the typical evaporation rates of more than 5 feet per year. The USGS modeling study (Stamos et al. 2001) estimates irrigation pumping requirements at about 8 to 10 afy per acre. For a typical irrigation "pivot", or agricultural treatment unit, on a 40-acre field with about 30 acres irrigated (a circle within a square), the seasonal pumping would be 240 afy, which is equivalent to a pumping rate of about 180 gpm. There are a small number of orchards to the north and east of the Hinkley site and a large number of alfalfa fields to the east. The irrigated farming acreage to the east of the plume (owned and operated by others) is multiple times larger than the current acreage used for plume control by PGE. The Compressor Station water supply pumping rate is equivalent to about one-quarter of a 30-acre agricultural field.

Effects of Existing and Historic Pumping on Groundwater Movement

The regional movement of groundwater in the Hinkley Valley depends on the groundwater elevations along the Mojave River (increased by recharge events) and the underflow through the alluvial channel at the north end (towards Harper Valley). This regional water movement (together with the aquifer properties) will cause a pattern of groundwater elevation gradients (i.e., groundwater elevation contours) within the valley. Pumping will modify (increase) the regional groundwater movement and change the groundwater elevation patterns.

Groundwater movement through the Hinkley Valley alluvial channel is controlled by the aquifer geology, hydraulic conductivity and groundwater elevation. Because the Mojave River is located along the southern end of the Hinkley Valley, a majority of this recharge water flows to the north and increases groundwater elevations throughout the Hinkley Valley. Groundwater in the upper and lower aquifers generally flows in a north-northwesterly direction, from the Compressor Station to the northern end of the Hinkley Valley. Horizontal gradients in the upper aquifer, in the absence of pumping or injection, generally range from 0.002 to 0.004 feet per foot (ft/ft) as identified in the ~~(PG&E~~ *Proposed Work P~~p~~lan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley, Pacific Gas and Electric Company's Hinkley Compressor Station* ~~Study~~(Pacific Gas and Electric Company 2012a).

Groundwater will move along pathways with the least resistance, and will flow preferentially along gravel and/or sand deposits. Tracer studies can also help determine groundwater movement along an aquifer. The USGS groundwater modeling (Stamos et al 2001) estimated the average flow towards Harper Valley to be about 3,000 afy for 1930–1995. USGS assessed a two-mile portion of the aquifer, with an assumed depth of 75 feet and a porosity of 20%, and estimated flow would be about 825 feet per year (or 2.53 feet per day) and eventually reach Harper Lake. A similar value was found by PG&E based on tracer studies completed as part of remedial activities that determined groundwater velocity (not influenced by gradients induced by pumping or injection) ranges from approximately <1 to 2 feet per day (PG&E ~~Proposed Workplan Background Study~~ 2012a). This general flow pattern is further confirmed by the measured groundwater gradient and the relatively slow northward spread of the chromium plume. The northern edge of the plume has been moving progressively northward since the chromium release reached groundwater beginning in about 1960 or later. At present, the plume is thought to be ~~at least 5.5~~6 to 9 miles north of the Compressor Station, but the northern boundary is not fully delineated yet. ~~The~~More information on the northern area is provided in the description of the existing chromium contamination plume in Section 3.1.4.3, *Hinkley Valley Groundwater Quality*. Ongoing assessment is being conducted to further delineate the plume boundary. Besides natural flow conditions, the plume length~~, however, was greatly~~ has been influenced by pumping and movement by others ~~instead of under natural conditions.~~. The Water Board issued Amended CAO in January 2013 requiring that PG&E conduct additional investigation to delineate the plume to the current maximum background levels of 3.1 ppb Cr[VI] and 3.2 ppb Cr[T]. Those new results should be known in fall 2013.

Figures 3.1-1 and 3.1-2 show the Hinkley Valley aquifer. Groundwater movement towards the Harper Valley can be represented as pumping from the two sections at the north end of the Hinkley Valley. Although there may not be complete records of the locations and volumes of the historical pumping for irrigation in the Hinkley Valley, the location and magnitude of the existing groundwater pumping can be used to approximate the expected future movement of the chromium plume.

Effects of Historic Pumping on the Physical Environment

Long-term groundwater drawdown (also referred to as groundwater overdraft) where the pumping rate exceeds the recharge rate can lead to land subsidence and surface soil cracking due to compaction of the aquifer material. If aquifer compaction occurs, finer-grained soils such as silts and clays may never again hold as much water and the land surface can subside (i.e., sink) permanently. Land subsidence within the Mojave River Groundwater Basin has not been an issue historically because the aquifer is made up primarily of coarser sediments, ~~such as~~mostly sands ~~and~~ with some gravels, which are not as prone to compaction and possibly because subsidence beneath agricultural fields is not noticed as much. ~~However,~~Although aquifer compaction and land subsidence associated with groundwater-level declines has been recognized as a potential problem in parts of the Mojave Desert (Sneed et al. 2003),~~.~~ no specific evidence of actual prior subsidence in the Hinkley Groundwater Basin was located in literature on the area reviewed as part of the EIR preparation. This section addresses the potential for aquifer compaction and its effect on water supply whereas Section 3.4, *Geology and Soils*, addresses the potential impact of land subsidence.

3.1.4.3 Hinkley Valley Groundwater Quality

The geochemistry of the Hinkley Valley aquifer is somewhat typical of the Mojave River Basin alluvial aquifer. Water quality sampling results for pH, chromium, arsenic, iron, manganese, nitrate, and salinity (i.e., TDS) from previous monitoring, including the background chromium groundwater study conducted in 2006, are discussed in Appendix A and summarized in this section. Water quality standards for these groundwater constituents have been established by the Water Board in the Basin Plan and are listed in the regulatory setting section.

Chromium in the Environment

Chromium is a metallic element in the periodic table. It is odorless and tasteless. Chromium is found naturally in rocks, plants, soil and volcanic dust, humans and animals. The most common forms of chromium in the environment are trivalent (Cr[III]), hexavalent (Cr[VI]) and the metallic form (Cr[0]). Cr[III] occurs naturally in many vegetables, fruits, meats, grains and yeast (U.S. Environmental Protection Agency 2011a). Cr[VI] is found in nature dissolved in water from the erosion of natural deposits of Cr[III], typically from mafic rocks containing dark and heavy minerals. Major sources of anthropogenic Cr[VI] in drinking water are discharges from steel and pulp mills, and historic use of Cr[VI] as an anti-corrosion agent in the past (as at Hinkley),~~.~~ (U.S. Environmental Protection Agency 2010).

Source of Chromium Contamination

The Hinkley Compressor Station began operating in 1952 and added Cr[VI] to cooling tower water to prevent corrosion. The cooling towers are used to cool the compressed natural gas heated by friction before returning it to the pipeline. The untreated cooling tower water was discharged to unlined ponds until 1964. In 1965, phosphate replaced Cr[VI] as the corrosion inhibitor. While the ~~ponds were taken out of service in 1966 and~~ chromium-based corrosion inhibitor was replaced with a phosphate-based corrosion inhibitor in 1966, and the unlined ponds were replaced with double-lined ponds~~,~~ in 1974 (U.S. Department of Health and Human Services 2000), chromium wastewater continued percolating through the unsaturated zone to groundwater for years. In 1987, PG&E reported to the Water Board that on-site monitoring wells, located to the north of the lined ponds, showed total chromium concentrations in groundwater exceeding the California Maximum Contaminant Level of 50 ppb. In 1988, as required by Water Board Cleanup and Abatement Order No. 6-87-160, PG&E completed a site characterization to investigate the extent of chromium in soil and groundwater on and near the Compressor Station. Soil samples were taken in areas of suspected chromium discharges, including the former unlined ponds, and other impoundments or conveyances. Soil samples were collected at depths up to 80 feet below ground surface (Ecology and Environment, Inc. 1988). Based on results of that sampling, c~~C~~hromium-contaminated soil ~~since has been~~was excavated from shallow depths in some of the area of the former unlined ponds, ~~pipelines~~discharge trench, and beneath tanks (Lahontan Water Board 2008). ~~In 1987, PG&E reported to the Water Board that off-site monitoring wells, located to the north of the facility, showed total chromium concentrations in groundwater exceeding the California Maximum Contaminant Level of 50 ppb.~~ Amended CAO 6-87-160A1 found that the soils cleanup was successfully completed.

Existing Chromium Contamination Plume

Upper Aquifer

Figure 3.1-5 shows the chromium plume as presented in PG&E's Fourth Quarter (Q4) ~~2011 Monitoring Report (2011e). The chromium plume of concentrations 3.1 ppb of Cr[VI] or greater covered about 2,949 acres in late 2011.~~ 2012 Fourth Quarter Monitoring Report (PG&E 2013b) as supplemented by ICF. The Q4 2012 monitoring report identifies the chromium plume of concentrations 3.1 ppb of Cr[VI] or greater covering about 3,112 acres in late 2012. This includes the latest detections between Serra Road and Hinkley Road, north of SR 58, connected to the main contiguous plume. The monitoring report however did not map a potential plume area north of the Mountain General Road (north of Red Hill). PG&E's Third Quarter (Q3) 2012 Monitoring Report (PG&E 2012e) indicated nine domestic wells with detections above 3.1 ppb of Cr[VI] located several miles north of Mountain General Road (north of Red Hill). Cleanup and Abatement Order R6V-2008-0002A4, issued in January 2013, requires PG&E to conduct additional investigations to determine the horizontal and vertical extent of the chromium plume above the maximum background levels where it is still undefined, including the area north of Red Hill. Because of this, an additional area of roughly 1,250 acres north of Mountain General Road (north of Red Hill) is included in the project area, based on domestic well detections above 3.1 ppb of Cr[VI] and the surface elevation contours. Including this area, the plume may cover approximately 4,362 acres, as of late 2012.

In contrast, in the third quarter of 2008, the plume (defined at that time by the 4.0 ppb contour) was only 1,230 acres. However, the portion of the plume with concentrations greater than 10 ppb Cr[VI] has had only a limited expansion since 2008; and the plume "core," with concentrations greater than 50 ppb of Cr[VI], ~~have had less expansion~~ is roughly the same or smaller than ~~the lower concentration plume in the upper aquifer~~2008, probably due to remedial actions implemented to date. The highest concentrations of Cr[VI] are still almost directly below the former unlined ponds at the PG&E Compressor Station, 45 years after the Cr[VI] discharge (infiltration from ponds) was stopped in 1965. ~~Chromium at the source area, either fixed to soil particles or trapped as wastewater in soil pores, appears to act as a continuing source affecting groundwater.~~ South of the Compressor Station property (i.e., up-gradient of the chromium plume), groundwater is considered outside of the Cr[VI] plume (based on consistent monitoring well detections less than 3.1 ppb of

Cr[VI]) and is used for freshwater supply for Compressor Station operations and remedial activities (from PGE-14, FW-01, and FW-02).

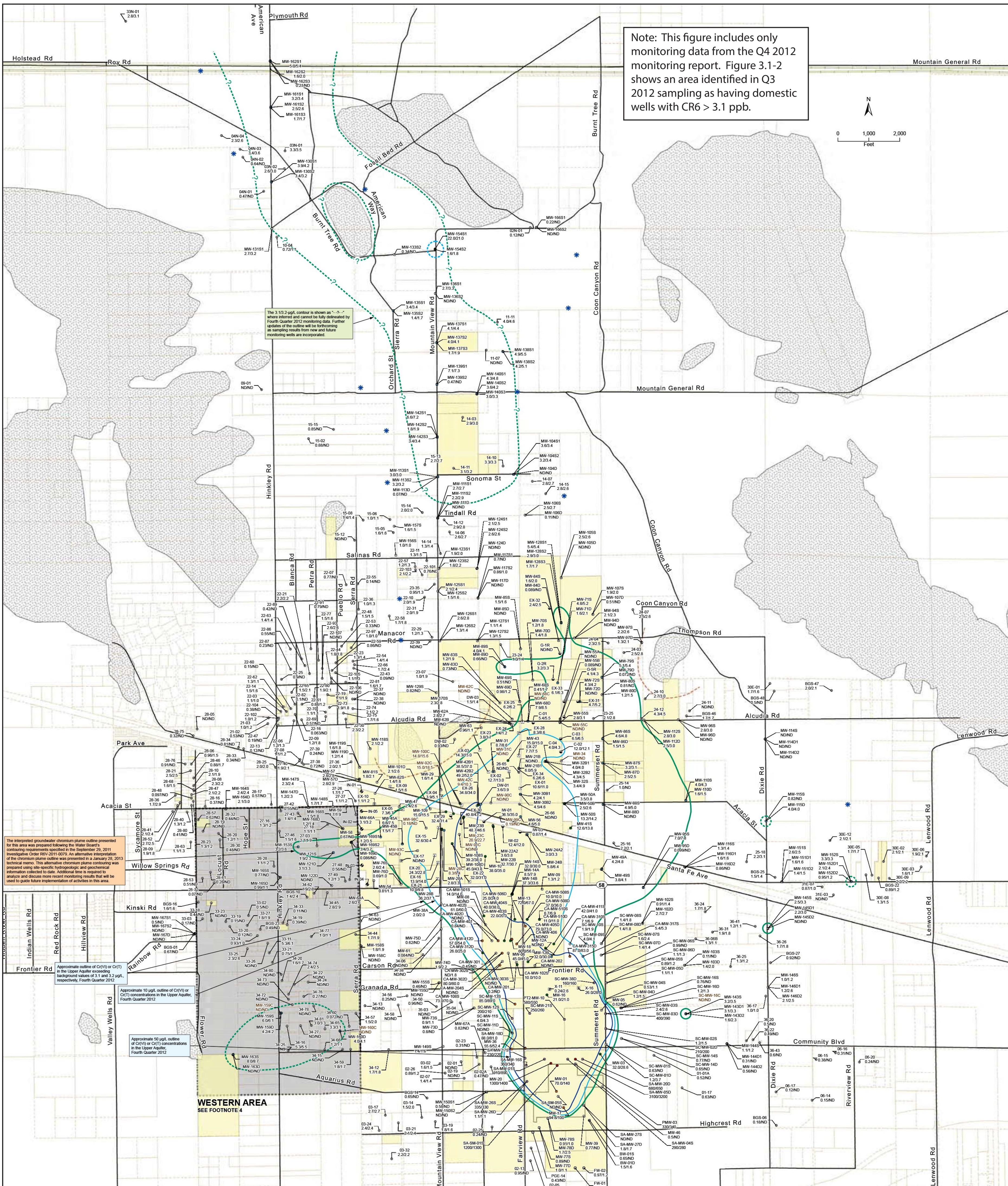
The volume of water (measured as acre-feet) in the chromium plume can be conservatively estimated from these plume areas by assuming that there is about a minimum of 15 feet of water in the saturated upper aquifer (depth of about 75-feet with porosity of about 20%). Therefore, the water volume is ~~simply~~approximately 15 times the acreage of the plume. Because the PG&E–identified plume covered about ~~2,950~~3,112 acres in late ~~2011~~2012, with an assumed water depth of 15 feet, the total plume volume can be estimated at about ~~44,250~~ 47,000 acre-feet. If the additional 1,250 acres -in the north were added, then the total plume volume could be approximately 65,000 acre-feet.

One additional area has been identified as having detections greater than 3.1 ppb Cr[VI] in the monitoring and domestic wells. The area, located near the intersection of Hinkley Road and Community Boulevard, contains chromium detections that may not be related to PG&E's historic waste discharges from the Compressor Station because they are located on the west side of the Lockhart Fault (PG&E 2013a). The fault is considered to impede flow from east to west, but not to prevent groundwater flowing in the northeast direction from the Mojave River (Stamos et al. 2001). Thus, chromium detections on the west side of the fault are likely not from the Compressor Station, where the upgradient groundwater flow is from the Mojave River in south. Ongoing assessment is being conducted by PG&E, and a revised background study is currently under development that will help further delineate the plume boundary.

The area and direction of plume movement is shown in Figures 2-2b through 2-2d which presents the change in the plume over time from 3rd Quarter 2008 to 4th Quarter 2012. As evidenced by the changes in the chromium plume since 2008, there have been substantial changes in the 3.1 ppb Cr[VI] plume area on the order of a number of miles over the last 4 years, including substantial changes between different quarters within a year. These figures also represent the spread of the plume area in the past 4 years. However, because hydraulic conditions of the groundwater aquifer are not uniform across the entire project area and the plume shape is affected by extraction and agricultural wells, the future rate of plume growth cannot be predicted with complete precision (as described above in Section 3.1.4.2, *Effects of Existing and Historic Pumping on Groundwater Movement*).

Lower Aquifer

PG&E conducted an investigation of the lower aquifer in response to the Water Board's Investigative Order R6V-2010-0055. Results of the investigation indicate that chromium concentrations increase in the vicinity of monitoring well MW-23, which is located south of the Desert View Dairy agricultural treatment unit and Santa Fe Avenue and east of Mountain View Road. The Fourth Quarter ~~2011~~2012 Monitoring Report shows chromium levels exceeding 10 ppb in the lower aquifer (Figure 3.1-6). The maximum detected Cr[VI] concentration was ~~41.6~~20.9 ppb. The Cr[VI] plume of 3.1 ppb or greater in the lower aquifer covers a one-half mile wide area extending from the southern portion of the Desert View Dairy agricultural treatment unit to near SR 58. Chromium migration from the upper aquifer into the lower aquifer appears to have occurred where the regional blue clay layer is thin or not present. This chromium migration is likely a result of the downward hydraulic gradients produced by groundwater extraction in the lower aquifer to the east/northeast of MW-23C from the Desert View Dairy and the Gorman property. PG&E has since removed some agricultural wells ~~screen~~screened from the lower aquifer on these properties to reduce the force



Legend

- Groundwater Monitoring Well
- Agricultural Supply Well
- Domestic Supply Well
- Other Supply Well
- Groundwater Extraction Well (active)
- Multi-use Test Well, or Inactive Extraction/Injection Well
- Freshwater Injection Well
- Step-Out Monitoring Wells Planned or Under Construction
- PG&E-Owned Property
- PG&E Compressor Station
- County Parcels
- Transmission Lines
- Approximate Limit of Saturated Alluvium Upper Aquifer
- Bedrock Exposed at Ground Surface
- Western Area

MW-102S Well ID
0.91/1.4 Cr(VI)/Cr(T) concentrations in micrograms per liter (µg/L); maximum of primary and duplicate samples during Fourth Quarter 2012 sampling

Cr(VI) = Hexavalent Chromium
Cr(T) = Total Dissolved Chromium
ND = Not Detected; NS = Not Sampled

Groundwater Cr(VI) Concentrations in Monitoring Wells

- > 1,000 µg/L
- 100 - 1,000 µg/L
- 50 - 100 µg/L
- 10 - 50 µg/L
- 3.1 - 10 µg/L
- < 3.1 µg/L or ND

Notes:

1. Chromium results are shown for site-wide Groundwater Monitoring Program and domestic wells sampled in the Fourth Quarter (October-December) 2012 monitoring period. Fourth Quarter 2012 results for selected In situ Reactive Zone (IRZ) monitoring wells are shown to aid in plume mapping. For wells sampled multiple times during the reporting period, the most recent results are shown.

2. The concentration contours are based on Fourth Quarter 2012 chromium results for the groundwater monitoring and extraction wells that are completed in the shallow zone and deep zone of the Upper Aquifer as noted on Figures 3-2 and 3-3. Results for domestic wells and lower aquifer monitoring wells (brown colored labels) were not used for chromium plume contouring.

3. Concentration contours represent the maximum extent of either Cr(VI) or Cr(T) at any depth within the upper aquifer based on Fourth Quarter 2012 chromium results. Some chromium results for wells within the 50-, 10-, and 3.1/3.2-µg/L chromium contours are less than the contoured concentrations.

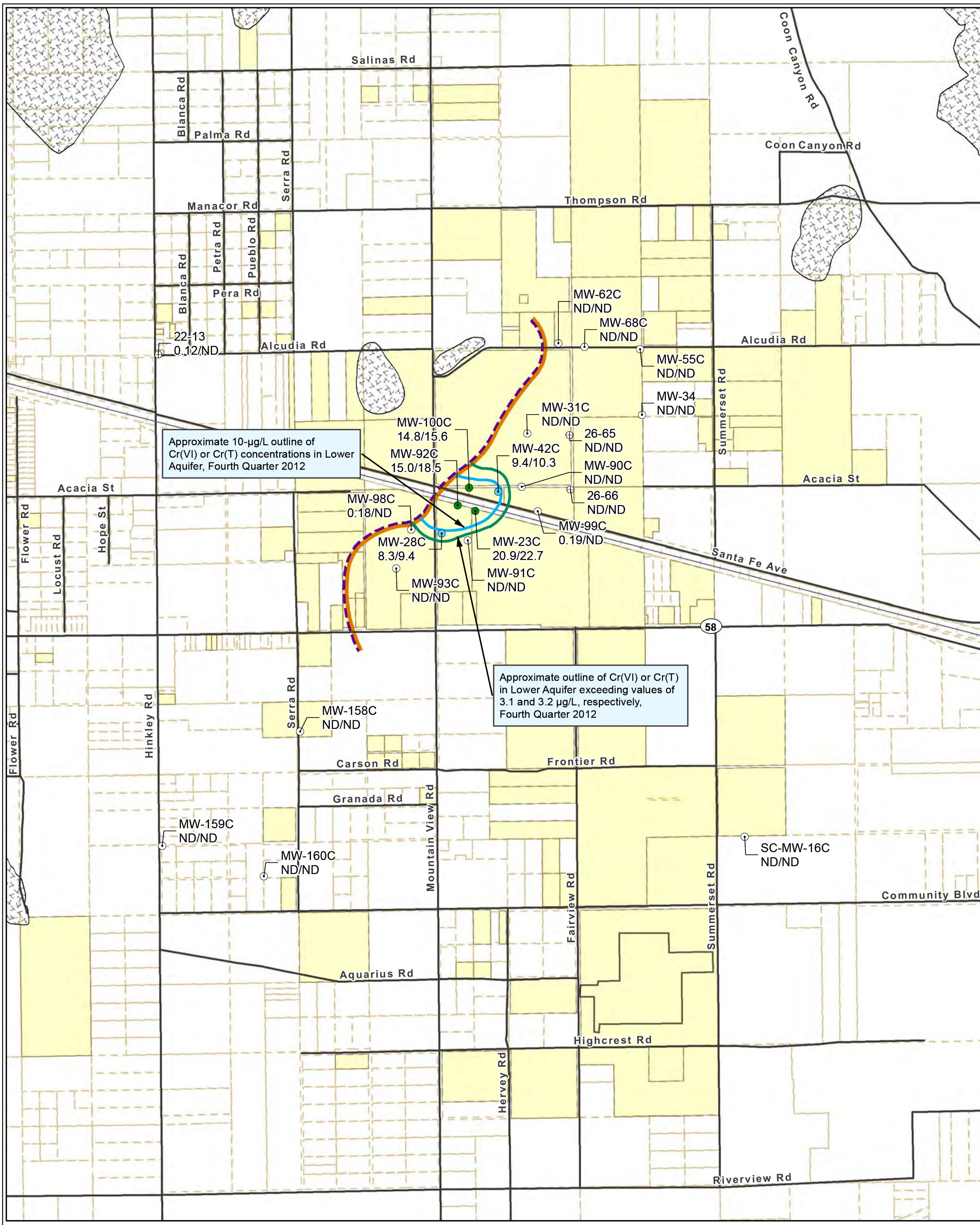
4. An evaluation of available hydrogeologic and groundwater quality data for the shaded "Western Area" shown on this figure was included in the January 14, 2013 document titled Conceptual Site Model for Groundwater Flow and the Occurrence of Chromium in Groundwater of the Western Area Report (CH2MHILL and Stantec, 2013). The findings of the January 14 report indicate that groundwater in the "Western Area" contains naturally occurring chromium.

* Monitoring well MW-154S1 is completed in low permeability sediments across the water table. This well purges dry during sampling and is very slow to recharge. Groundwater samples from this well may not be representative of the groundwater conditions in the upper aquifer as sampled in other wells in this area.

Source: PG&E 2013b.

Graphics ... 00122.11 (4-10-2013)

Figure 3.1-5
Existing Chromium Plume Boundaries and Concentrations for the Upper Aquifer, Fourth Quarter 2012



LEGEND

- Lower Aquifer Groundwater Monitoring Well
- Water Supply Well Completed in Lower Aquifer with Fourth Quarter 2012 Sampling Results
- Bedrock Exposed at Ground Surface
- Approximate Western Limit of Blue Clay Aquitard (Blue Clay extent indicated by shading)
- PG&E-Owned Property
- PG&E Compressor Station

MW-92C Well ID
34.3/39.2 Cr(VI)/Cr(T) concentrations in micrograms per liter (µg/L); maximum of primary and duplicate samples during Fourth Quarter 2012 sampling

Groundwater Cr(VI) Concentrations in Monitoring Wells

- 10 - 50 µg/L
- 3.1 - 10 µg/L
- < 3.1 µg/L or ND

Cr(VI) = Hexavalent Chromium
Cr(T) = Total Dissolved Chromium
ND = Not Detected

1) Chromium concentration contours are based on October - December 2012 sampling of groundwater monitoring wells completed in the Lower Aquifer (saturated zone below the Blue Clay aquitard). Where the Blue Clay is not present, all saturated deposits above bedrock are part of the Upper Aquifer.

2) The western limit of the Blue Clay aquitard is based on available drilling information.

N

0 1,000 2,000
Feet

Source: PG&E 2013b.

Graphics ... 00122.11 (4-10-2013)

Figure 3.1-6
Existing Chromium Plume Boundaries and Concentrations for the Lower Aquifer, Fourth Quarter 2012

acting on the chromium plume (Pacific Gas and Electric 2011e). PG&E has since installed two extraction wells in the upper aquifer to reverse to downward migration to the lower aquifer. Pumped water from extraction wells are applied to PG&E agricultural fields. The Third Quarter 2012 Monitoring Report shows Cr[VI] levels at or exceeding 10 ppb in the lower aquifer (Figure 3.1-4) in four monitoring wells. The maximum detected Cr[VI] concentration was 22.6 ppb. The decrease in chromium concentrations implies that migration from the upper aquifer to the lower aquifer has ceased.

Background Chromium Concentrations

In 2006, sampling was conducted by CH2MHill for PG&E to characterize existing background levels of chromium in the Hinkley Valley. In 2007, PG&E submitted the *Groundwater Background Study Report, Hinkley Compressor Station, Hinkley, California* (hereafter, the 2007 Background Study Report), summarizing results of the sampling done in 2006 to determine the range of background levels of chromium in groundwater.

Forty-eight wells in the Hinkley Valley were sampled for Cr[T] and Cr[VI]as part of the Background Study (Pacific Gas and Electric Company 2007). About 90% of the wells sampled were domestic wells and the remainder were agricultural wells (Lahontan Regional Water Quality Control Board 2008). The number of sampling events for each well ranged from one to four during the year on a quarterly basis. However, water quality was not distinguished between the upper aquifer versus the lower aquifer or between different layers of the upper aquifer (Pacific Gas and Electric 2011c). Besides chromium, the water samples were analyzed for geochemical similarities, temporal trends, and outliers. As stated in Section 2.3, this study found that the average and maximum likely background concentrations within the Hinkley Valley aquifer outside the PG&E plume influence are those described in Table 3.1-5 below.

Table 3.1-5. Background Study Results for Cr[T] and Cr[VI] found in the Hinkley Valley Groundwater

Type of Concentration	Cr[VI] Concentration (ppb)	Cr[T] Concentration (ppb)
Average	1.2	1.5
Maximum	3.1	3.2

Source: CH$_2$HMHill 2007

The Cr[T] and Cr[VI] concentrations were at low or undetectable levels near the Mojave River and increased with distance away from the river.

Some contaminants have no natural background concentrations because the chemical originates from a manufacturing process, so the only detectable concentrations would be from a waste discharge. However, chromium is a common element in the earth's crust, and thus Cr[VI] ~~is~~can be present in ~~many~~ groundwater basins~~.~~ due to solely due to naturally-occurring conditions. Cr[VI] in groundwater basins can also be due to a combination of naturally-occurring conditions as well as due to human-caused sources of Cr[VI].

Water quality data collected by the California Department of Public Health, the SWRCB, and the United States Geological Survey (USGS) confirm that Cr[VI] is naturally present in groundwater throughout California, including the Mojave Desert area and in the immediate vicinity of the Hinkley Valley (Pacific Gas and Electric 2011c). The California Department of Public Health conducted sampling for Cr[VI] from drinking water wells throughout California and found 35% had concentrations above 5 ppb (California Department of Public Health 2011).

A detailed study of groundwater conducted by the USGS in 2008 also confirmed that Cr[VI] is present in groundwater throughout the Mojave area at concentrations up to 16 ppb, consistent with the SWRCB data. Drinking water extracted from the Alto subarea (containing Victorville and Hesperia approximately 25 to 30 miles south of Hinkley) and Este subarea (around Lucerne Valley approximately 30 miles southeast of Hinkley) of the Mojave River Basin show Cr[VI] at levels higher than those determined in the 2007 Background Study Report. The reason for the higher chromium levels in those locales ~~were~~was due to their close proximity to the San Gabriel and San Bernardino Mountains, both which contain mafic rocks~~.~~, Which can include chromate. Cr[VI] concentrations in groundwater downgradient of the mountains ranged up to 5.1 ppb in the Desert View System and up to 6.3 ppb in the Apple Valley South system (both systems serve areas near Apple Valley, approximately 30 miles southeast of Hinkley). These data indicate the presence of natural Cr[VI] in groundwater throughout the Mojave River watershed, upgradient of the Hinkley Site. (Pacific Gas and Electric 2011c).

There are technical limitations in identifying the precise lateral extent of the Hinkley chromium plume near the edges, where the concentrations are less than or equal to the maximum background concentrations of 3.1/3.2 ppb. Because background concentrations could vary from non-detect to 3.1/3.2 ppb, positive detections of Cr[VI] or Cr[T] below these maximum levels could be natural or ~~could be~~ due to spread of the chromium plume or a combination. Using standard sampling methods at present, the origin of chromium, whether man-made or natural, cannot be determined chemically. However, as part of the reexamination of the 2007 Background Study Report, the Water Board is examining potential new methods that may be able to look at different isotopes of chromium to potentially differentiate between man-made and natural chromium detections. The Water Board's ~~is requiring~~ existing orders require that the 3.1 ppb (for Cr[VI]) contour be used to detect the existing contaminant plume and any future spreading.

In 2011, the Water Board requested a peer review study of the 2007 Background Study Report. Water Board staff received peer review comments in October 2011. The peer reviewers' criticisms are grouped into four categories:

- lack of aquifer-specific sampling;
- statistical methods and assumptions;
- uncertainty regarding historic plume migration; and
- sample analysis quality control procedures.

In February 2012, PG&E submitted the Proposed Work Plan for Evaluation of Background Chromium in the Upper Aquifer of the Hinkley Valley (dated February 22, 2012). The work plan proposes the collection and evaluation of additional data to expand on the 2007 Background Study Report, and to address comments that were provided by the peer reviewers. A background study Technical Working Group (TWG) consisting of Water Board staff, PG&E staff and its consultants, Hinkley Community Advisory Committee members and its consultants, and staff of the USGS began monthly meetings in January 2013. The TWG is reviewing and revising PG&E's proposed new background study~~,~~ and ~~considering the need for peer review and/or consultation with other experts, such as~~incorporating technical assistance from the ~~US Geological Survey~~USGS, so that any new study will yield a valid, credible and defensible result.

For the purpose of this EIR, the Water Board is using the values derived from the 2007 Background Study Report to define the chromium plume and as interim cleanup levels pending ~~recalculation of background levels and/or~~ completion of a new background study. It is important to note that any future changes to the adopted background concentrations would not affect the types of cleanup technologies or alternatives that would be analyzed in the EIR. If adopted background levels are revised, the main change of doing so may be the estimates of the time needed to achieve complete cleanup, and the area over which cleanup would occur. If any such changes in the background level result in a significant extension of project duration or a significant expansion of the project area, those changes might need to be further evaluated under ~~CEQA~~additional CEQA analysis, such as a subsequent EIR, supplemental EIR, or addendum to the EIR, per CEQA Guidelines 15162, 15163, 15164.

Total Dissolved Solids Concentrations

"Total dissolved solids" is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are calcium, magnesium, sodium, potassium, carbonate, hydrogen carbonate, chloride, sulfate, and nitrate (World Health Organization 2003a). On irrigated lands, salts concentrate in the soil due to evapotranspiration. When too much irrigation is applied, the excess water percolates through the soil carrying the dissolved solids to the water table. On dairy lands, animal wastewater and manure contribute significant levels of TDS to the soil and groundwater. Besides TDS, other constituents seen in groundwater on dairy lands at levels often exceeding drinking water standards are chloride, sodium, sulfate, and sometimes bacteria. The state of California has set a secondary Maximum Contaminant Level for TDS in drinking water at 500 ppm for a lower limit and 1,000 ppm as an upper limit.

Agricultural uses have affected the salt (total dissolved solids, or TDS) concentrations in the groundwater below irrigated and agricultural lands in the Hinkley Valley. Agricultural activities, primarily as irrigated crops and dairy operations, have been the major causes of increased TDS in the Hinkley Valley groundwater. While natural dissolution of salts from geologic materials (i.e., aquifer sediments) does occur as the water moves from the Mojave River toward the north, such concentrations are significantly less than that contributed by irrigated lands and dairy operations. The TDS limit in the existing General Permit (Order No. R6V-2008-0014) reflects the lower of either (1) the most restrictive beneficial use standard or existing water quality if presently higher than the most restrictive beneficial use standard; or, (2) a 25 percent increase above the background conditions if existing water quality is presently below the most restrictive beneficial use standard.

The ~~background~~ water quality entering the Hinkley Valley from the Mojave River is considered to be excellent. However, water quality ranges from good to very poor as groundwater migrates through the valley northward, mostly due to anthropogenic sources. TDS concentrations in groundwater are lower in the south nearest the recharge area along the Mojave River, and in the ~~west along the channel leading north to Harper Lake~~southwest portion of the project area. The 2007 Background Study Report found TDS levels in the areas sampled range from 90 ppm near the Mojave River up to 2,390 ppm near a former dairy or confined-animal property but are generally less than 1,000 ppm in most areas (Pacific Gas and Electric 2007).

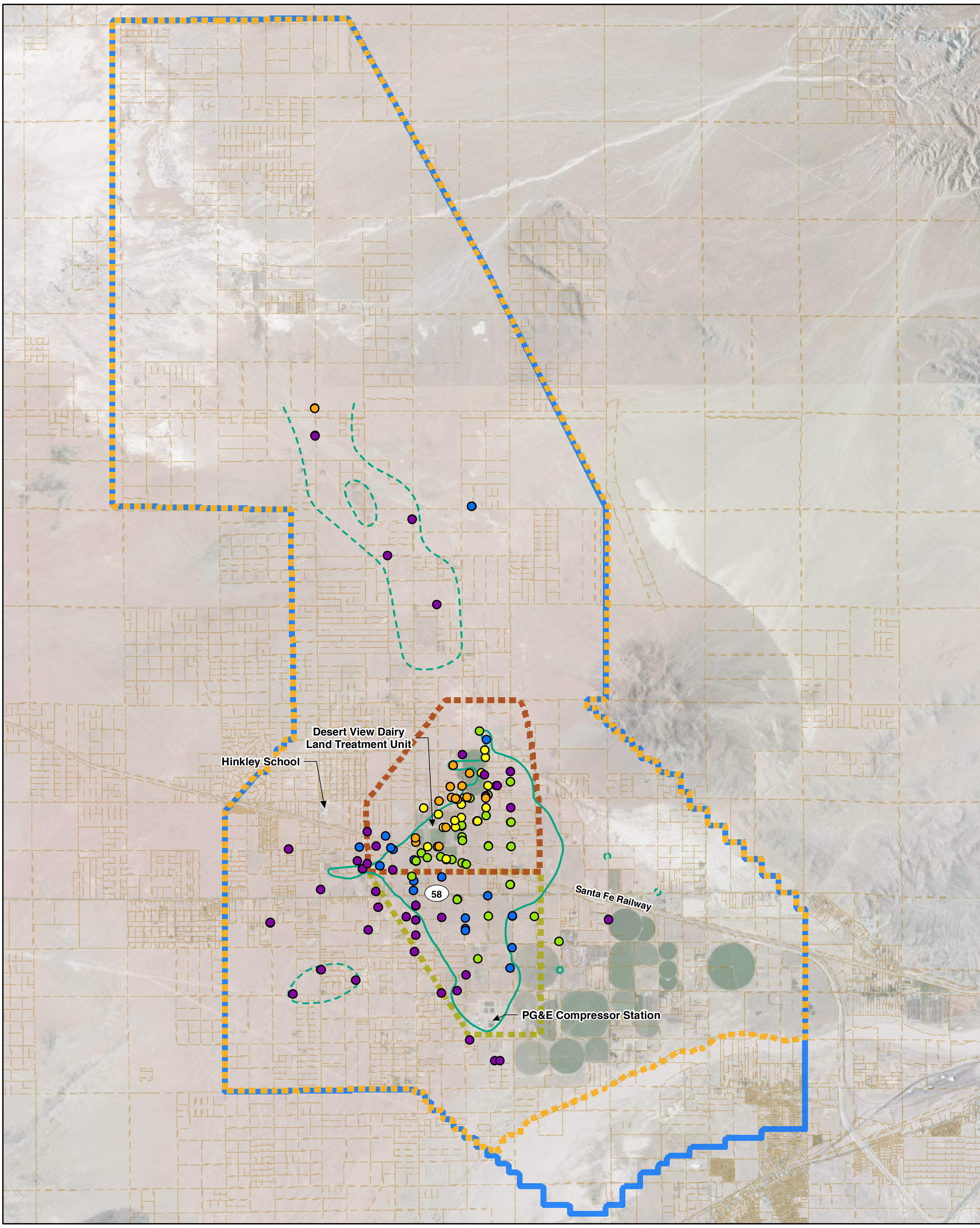
Along the chromium plume, TDS concentrations range from less than 400 ppm to 5,800 ppm roughly on a south to north gradient (Pacific Gas and Electric Company 2011e). TDS concentrations increase starting at the Compressor Station in the south to Salinas Road in the north. The increasing concentrations are due to active and historic dairy operations, active and historic land treatment units operated for chromium removal, and prior agricultural activity (at the Gorman property). ~~While the Compressor Station is not considered to be a source of TDS, the station supply wells have pulled the TDS plume from the former Mojave Dairy southwards (upgradient) and affected groundwater beneath the Compressor Station. This same process also explains why high chromium concentrations are detected on the Compressor Station's southern property line, which is upgradient of the area of former chromium releases to ground.~~

Water quality data collected from the monitoring wells at the Desert View Dairy indicate that active dairy operations account for the greatest increase in TDS along the chromium plume; the average TDS concentration detected in the monitoring wells increased from 3,257 ppm (2005 data) to 5,800 ppm (Fourth quarter 2011 data). The land treatment units used to convert Cr[IV] to Cr[III] have also added to the TDS plume. This combined TDS plume has been pulled to the northeast direction by the agricultural wells on the Gorman fields, which may also be contributing to higher TDS levels in groundwater. TDS pollution has been detected in residential wells at and north of the Desert View Dairy, to Salinas Road. Most of these residents are provided bottled water supplied by PG&E for the chromium program. One of these residential well owners receives alternate water supply in the form of an above ground storage tank from the Dairy operator under orders by the Water Board for nitrate pollution.

The above discussions point to active dairy or confined-animal operations as contributing the greatest amount of TDS to groundwater. This is likely followed by contribution from former dairies and then irrigated lands. For clarification, irrigated land using dairy waste water, such as occurs at the Desert View Dairy, is ~~considered to provide the same~~also a major contribution of TDS impacts to groundwater quality~~ as an active confined-animal operation~~. The conditions discussed here are considered to be the CEQA baseline prior to project implementation. Figure 3.1-7 shows current TDS levels in the project area, based on available ~~data~~Third and Fourth Quarter 2012 data at PG&E monitoring wells. In the future, the greatest source of TDS to groundwater is expected to continue to be from active dairy operations at the Desert View Dairy.

While groundwater from properties in the Hinkley Valley having irrigation or dairy operations may not meet the secondary Maximum Contaminant Level for TDS, the groundwater is generally suitable for irrigation of alfalfa and other fodder crops which can tolerate high salt levels.

Because previously authorized land treatment was identified as having the potential to increase TDS levels, ~~a baseline~~an annual average reference level for groundwater was established as 1,310 ppm TDS for the Desert View Dairy land treatment unit in 2010 in order to identify changes in water quality due to land treatment. The permit (R6V-2004-0034A2) allowed for a 25 percent increase for TDS to 1,713 ppm. This ~~threshold~~reference concentration is calculated using a 12-month average for all monitoring wells. ~~The Board order allowing prior land treatment acknowledges that should these levels increase during the project, mitigation and remedial measures must return concentrations to be no higher than the thresholds listed by the end of the project.~~ The ~~First~~ Third Quarter ~~2011~~2012 Desert View Dairy monitoring report shows that the 12-month average for TDS was 1,~~743~~762 ppm which is slightly above the ~~threshold~~reference level (Pacific Gas and Electric 2011e). PG&E~~'s~~ estimates that it takes about 5 to 6 years for percolation to reach the water table. So the levels reflect ground surface activities back to at least 2006. TDS concentrations are expected to slowly increase over time. By the end of the ~~first~~third quarter of 2012, PG&E was implementing mitigation by way of containment for the chromium plume, which also acted to contain the TDS plume~~ which puts~~; therefore, PG&E ~~into~~is in compliance with the Board Order.



LEGEND

- Approximate outline of Cr(VI) or Cr(T) in Upper Aquifer exceeding values of 3.1 and 3.2 μg/L, respectively, Fourth Quarter 2012
- Study Area
- OU1
- OU2
- OU3
- County Parcel Boundary

TDS (mg/L)

- 25 - 500
- 500 - 1000
- 1000 - 1500
- 1500 - 3000
- 3000 - 5900

N

0 2,000 4,000 6,000 8,000 10,000
Feet

Notes:
Fourth Quarter 2012 laboratory-measured TDS data are shown. If TDS data were not collected in a well within Fourth Quarter 2012, but were collected within Third Quarter 2012, then Third Quarter 2012 data are shown.

Data shown are from PG&E monitoring and/or remediation wells where available.

Graphics ... 00122.11 (4-15-2013)

Source: PG&E 2013e.

Figure 3.1-7
Existing TDS Concentrations within the Project Area

The increase in TDS concentrations over the years may be attributed to supply well capture of constituents from former and current agricultural activities on nearby properties. More studies may be necessary to determine the exact contribution of nearby land uses upon the supply wells.

Nitrate Concentrations

Nitrates and nitrites are formed through the decomposition of organic materials in soil, which release ammonia. This ammonia oxidizes to form nitrate and nitrite; of the two, nitrate is more common. The primary beneficial use of nitrates is as a fertilizer used to add nutrients to crops. Often ~~times~~, excess nitrate resides in the soil of agricultural fields following fertilizer application. Nitrate can percolate with irrigation water or precipitation to reach groundwater. Irrigation with high-nitrate water pumped from agricultural wells has the added beneficial use of providing more nutrients for crops. However, since crop irrigation is typically seasonal, nitrate plumes will migrate with natural groundwater flow during periods of non-irrigation and affect other beneficial uses, such as domestic and municipal wells and agricultural wells for confined animals.

The ~~background~~ nitrate concentrations in groundwater in the Hinkley Valley are generally less than a few parts per million. As mentioned above in the section discussing TDS, ~~background~~the quality of water entering the Hinkley groundwater basin from the Mojave River is considered to be excellent water quality. The primary Maximum Contaminant Level for nitrate in California drinking water is 10 ppm. The 2007 Background Study Report found nitrate levels ~~in background areas~~ to range from less than 0.5 ppm (equal to the method detection level) up to 21 ppm. Five out of forty-seven wells sampled had one or more detections of nitrate greater than 10 ppm (Pacific Gas and Electric 2007). These five wells, however, were located near former or active dairies and an active heifer ranch, which were likely sources of nitrate pollution rather than reflective of ~~background~~naturally-occurring conditions.

As discussed above with TDS, nitrate exists in groundwater beneath the Desert View Dairy at high concentrations, primarily due to dairy operations. Nitrate in groundwater applied to the Dairy's agricultural treatment unit has ranged in concentrations over the years from just about 9 ppm to 18 ppm (Pacific Gas and Electric Company 2010a). Data from lysimeters at 20-foot depths indicate that this nitrate is being effectively reduced by the treatment process at the agricultural treatment units~~.~~ during the growing months. The resulting ~~pore~~ water that percolates through the soil beneath the Desert View Dairy to groundwater is generally at lesser concentrations for nitrate than that which was applied.

PG&E has calculated that the land application of pumped groundwater at the Desert View Dairy agricultural treatment unit has removed over 40 tons of nitrate from the environment between 2004 and 2009 (Pacific Gas and Electric Company 2010a). Historical lysimeter monitoring (2005–2010) indicates that nitrate applied at concentrations of approximately 15 ppm generally is reduced below the root zone. Current data (Fourth Quarter 2012) from the agricultural treatment unit reveals that ~~about half~~ five of the 12 of the samples from lysimeters in the alfalfa fields have nitrate concentrations of ~~less than 1 ppm, and half of the samples have nitrate concentrations of~~ more than 10 ppm. Thus, current and prior agricultural treatment, while reducing nitrate levels at the Desert View Dairy, has not necessarily reduced them to below the Maximum Contaminant Level of 10 ppm.

Nitrate and TDS contamination in groundwater tends to stay near the upper portion of the affected aquifer unless deeper wells act to pull the contamination lower in depth. In the Hinkley Valley, nitrate and TDS affected water occurs in the upper aquifer. Because the lower aquifer is isolated from the upper aquifer by the blue clay in most of the valley, the lower aquifer has not likely been affected by historical agricultural uses. The origin of the high nitrate is likely animal waste from historical dairy operations, either from animal confinement areas or from waste water or manure applied to the fields as a soil amendment and fertilizer. While groundwater from properties in the Hinkley Valley having irrigation or dairy operations may not meet the drinking water Maximum Contaminant Levels for nitrate, the groundwater is generally suitable for irrigation of alfalfa and other fodder crops.

In the area of the chromium plume, nitrate concentration in groundwater, just as with TDS, is highest between SR 58 to Salinas Road. Nitrate in this area has been detected up to 142 ppm, exceeding the 10 ppm Maximum Contaminant Level by fourteen times (Pacific Gas and Electric Company 2011f). Nitrate pollution has been detected in residential wells at and north of the Desert View Dairy. Under orders from the Water Board, the Dairy operator provided alternate water supply to affected well owners. ~~Only one of these off-site residential well owners continues to receive alternate water supply while the remaining well owners sold their properties to PG&E and moved away~~Figure 3.1-8 shows current nitrate levels in the project area, based on available Third and Fourth Quarter 2012 data at PG&E monitoring wells.

~~Figure 3.1-8 shows current nitrate levels in the project area, based on available data.~~

As described above, because previously authorized land treatment (per Board Order R6V-2004-0034A2) was identified as having the potential to increase nitrate levels, ~~a baseline~~an annual average reference level for groundwater was established in 2010 of 9.0 ppm nitrate (as N) for the Desert View Dairy land treatment unit in 2010 in order to measure water quality changes. The permit allowed for a 10 percent increase for nitrate (as N) to 9.9 ppm so that it didn't exceed the 10 ppm Maximum Contaminant Level. The ~~threshold~~reference concentration is calculated using a 12-month average for all monitoring wells. The ~~Fourth~~Third Quarter ~~2011~~2012 Desert View Dairy monitoring report shows that the nitrate 12-month average was calculated at ~~10~~18.5 ppm of nitrate (as N), which is above the ~~threshold~~reference level. Nitrate concentrations have been increasing in groundwater at the Desert View Dairy with time. By the end of the ~~first~~third quarter of 2012, PG&E was implementing mitigation by way of containment for the chromium plume, which also acted to contain the nitrate (as N) plume which puts PG&E back into compliance with the Board Order.

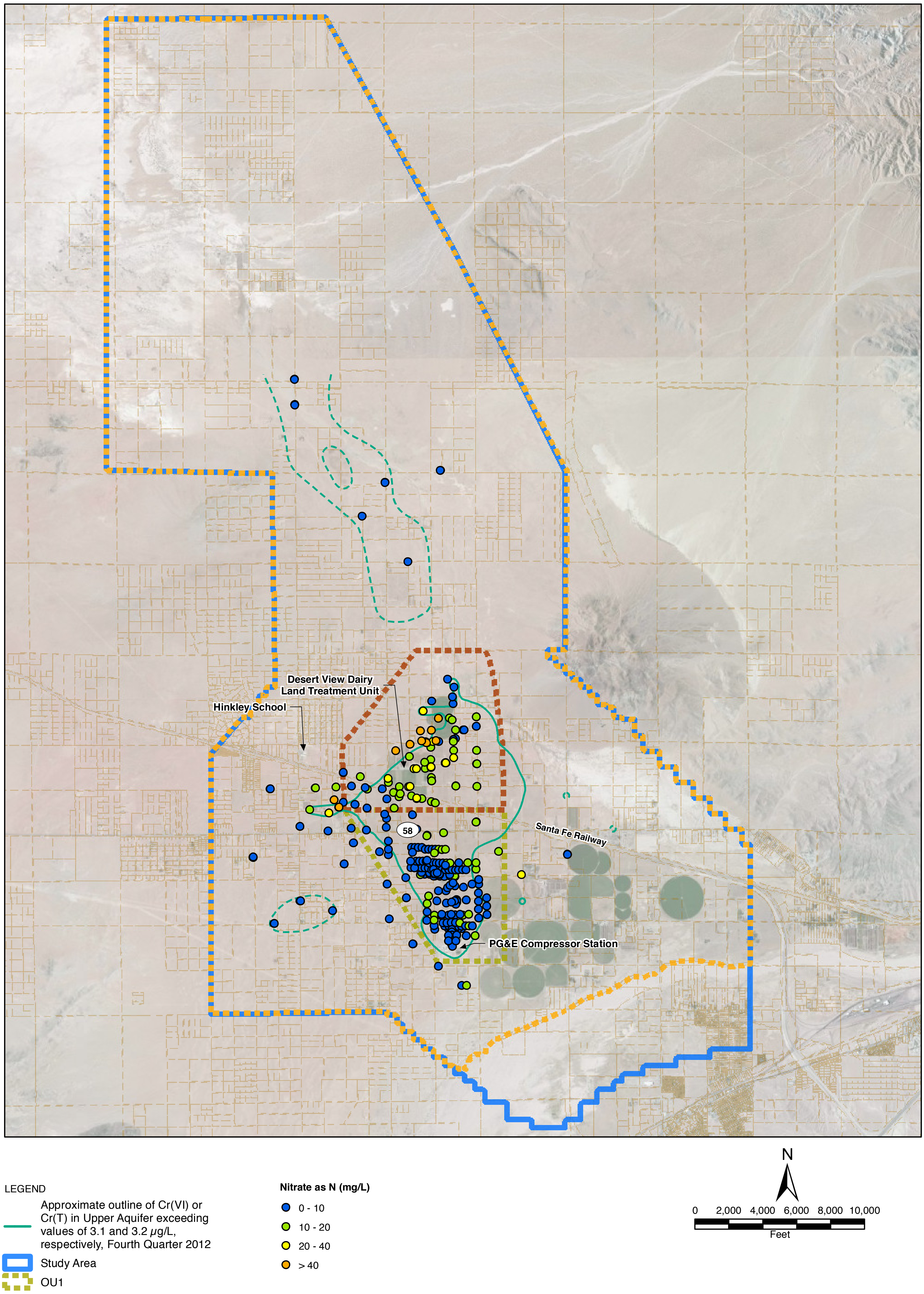
Concentrations of Other Constituents

The existing levels of other constituents are discussed below based on general water quality assessments and site sampling. The constituents discussed (arsenic, iron, manganese and uranium) are those that could be affected by implementation of the proposed remediation.

Arsenic

Background levels

Arsenic is a naturally occurring element in the earth's crust and is widely distributed in the environment. The USGS conducted sampling for various constituents in wells in the Mojave Water Agency management area from 1991 to 1997, including wells in the Hinkley area (Christensen 2001). Naturally-occurring arsenic concentrations in water from wells in the western Mojave Desert commonly exceed 10 ppb and a few exceed 100 ppb. Along the Mojave River upgradient of the PG&E Compressor Station, the study found arsenic in wells (up to 200 feet in depth) ranging from less than 1 ppb to 12 ppb with most concentrations under 10 ppb. In the Hinkley area, within approximately 0.5 mile of SR 58, the study found concentrations of arsenic in



Notes:
Fourth Quarter 2012 laboratory-measured Nitrate data are shown. If Nitrate data were not collected in a well within Fourth Quarter 2012, but were collected within Third Quarter 2012, then Third Quarter 2012 data are shown.

Data shown are from PG&E monitoring and/or remediation wells where available.

Source: PG&E 2013e.

Graphics ... 00122.11 (4-15-2013)

Figure 3.1-8
Existing Nitrate as N
Within the Project Area

three wells ranging from 3 ppb to 12 ppb. One to two miles north of SR 58, the study found arsenic in two wells ranging from less than 1 ppb to 2 ppb. Approximately four miles north of SR 58, the study found arsenic in one well at a concentration of 52 ppb. While the USGS study was conducted after the release of chromium from the Hinkley Compressor Station, sampling occurred before the use of carbon-amendment injections to groundwater, and thus reflects levels prior to in-situ remediation. ~~The federal and state Maximum Contaminant Level for arsenic is 10 ppb~~In addition, as previously discussed in Section 2.0, *Project Description*, groundwater is extracted from three supply wells (PGE-14, FW-01,FW-02) located south (upgradient) of the plume, where background arsenic present at levels greater than 10 ppb are filtered through an ion exchange system for arsenic removal prior to freshwater injection remedial activities.

The federal and state Maximum Contaminant Level for arsenic is 10 ppb.

The 2007 Background Study Report for the Hinkley Compressor Station (Pacific Gas and Electric 2007) found arsenic levels in ~~background~~ areas (outside the chromium plume) to range from less than 5 ppb (method detection level) up to 22 ppb (with one outlier sample at 200 ppb). Twenty out of forty-seven wells sampled had one or more detections of arsenic greater than 10 ppb.

Concentrations within IRZ Areas

As described in the 2010 Feasibility Study (Pacific Gas and Electric Company 2010a), pilot and extended-scale in-situ remediation of the chromium plume has resulted in temporary and localized increase of arsenic concentrations in parts of the plume area. Based on experience with in-situ remediation, arsenic (and other byproducts) concentration increases in correlation to the amount of injected organic carbon and then decreases in time as the organic carbon is consumed by microbial action. Arsenic levels in groundwater increase from less than 1 ppb to 15 ppb in areas up to 500 feet downgradient of the carbon injection point. A description of the chemical reaction process and techniques involved in in-situ remediation is provided in Section 3.1.5.2, *In-Situ Remediation*.

Studies have concluded that, in addition to the being dependent on organic carbon concentration, the generation of dissolved arsenic is also related to the location of treatment within the IRZ area (Pacific Gas and Electric Company 2010a). In the Central Area and SCRIA there are much lower concentrations of dissolved arsenic than in the Source Area, which may be attributed to differences in arsenic mineralogy in the area (Pacific Gas and Electric Company 2010a). This result may indicate that arsenic generation within the Source Area IRZ may be a focal area of concern within the footprint of the IRZ area.

As shown in Figure 9 in PG&*E's Assessment of In-Situ Reactive Zone Treatment Byproduct*s (PG&E 2012h), elevated arsenic (> 13 ppb) due to IRZ operations is found in the immediate 500 foot vicinity of IRZ carbon injection locations, but wells further away from the injection locations show much lower concentrations (usually below 5 ppb). With wells upgradient of the PG&E Compressor Station that are outside the zone of influence of IRZ operations having arsenic levels between 1 and 12 ppb, it can be shown that arsenic levels in the IRZ area are declining back to pre-IRZ reference levels within the IRZ treatment area within the chromium plume area.

Prior studies have indicated that after carbon amendment ceases, in-situ remedial byproducts declined back toward initial levels within several months up to two ~~to over a~~ years as organic carbon levels dropped. ~~Current data shows arsenic as by product only within the chromium plume and not beyond the plume boundaries.~~ When organic carbon is injected for remediation and then consumed by microbial action, the concentrations of arsenic begin to return to pre-dosing concentrations through a number of processes including dilution, sorption, precipitation and coprecipitation. The return of aerobic conditions in the treatment area (due to mixing of groundwater with dissolved oxygen content) further decreases arsenic concentrations.

Figure 6 in Appendix C of the 2010 PG&E Feasibility Study shows the cycle of increase and decrease in arsenic concentrations due to carbon amendment for in-situ remediation. As shown therein, arsenic levels rose from less than 5 ppb to between 10 and 15 ppb, and then dropped back to pre-carbon amendment levels below 5 ppb as total organic carbon levels dissipated and the timeframe to return to pre-amendment levels is on the order of several months up to two years (PG&E 2010a).

Community samples collected from wells west of the chromium plume indicated arsenic levels ranging from non-detect up to 170 ppb, with 8 wells having concentrations above the MCL of 10 ppb. Water Board samples collected from wells west of the chromium plume indicated arsenic levels ranging from non-detect up to 51 ppb, with 5 wells having concentrations above the MCL of 10 ppb. Considering the pattern of arsenic detections related to the IRZ, with declines in levels as one proceeds downgradient to under 10 ppb before leaving the chromium plume; wells upgradient of the PG&E compressor station having concentrations that exceed the MCL; and groundwater flow directions, the evidence does not support a connection between the detections in domestic wells west of the chromium plume and IRZ operations.

In conclusion, current data shows arsenic as IRZ byproduct only within the 3.1ppb chromium plume south of SR 58 and not beyond the plume boundaries.

Figure 3.1-9 shows current dissolved arsenic levels in the project area, based on available ~~data~~Third and Fourth Quarter 2012 data at PG&E monitoring wells.

Iron

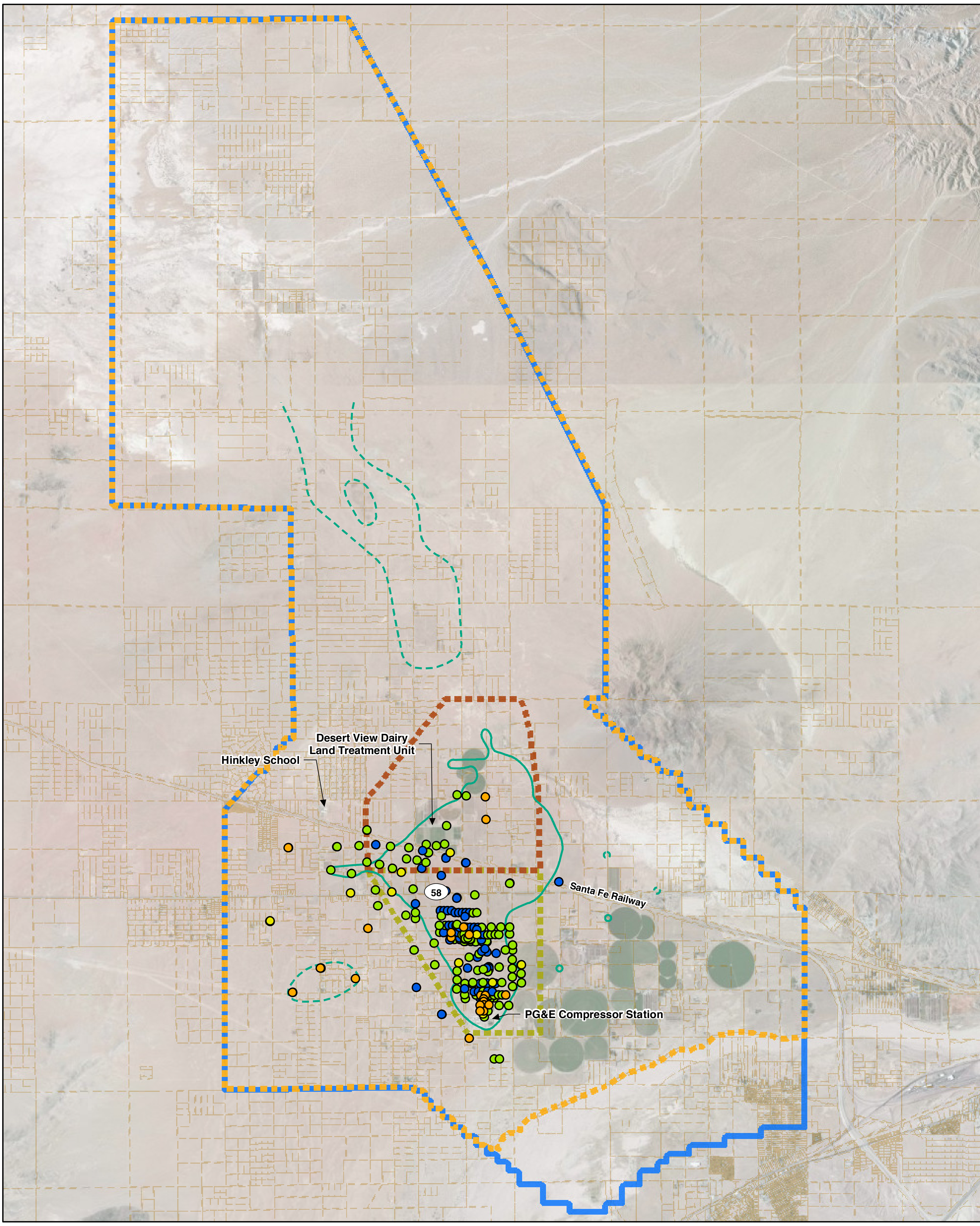
Background levels

Iron is the second most abundant metal in the earth's crust, and accounts for about 5% of the mass of the earth's crust. Oxidation of dissolved iron particles in water can ultimately change the iron to red-brown solid particles (precipitates) that settle out of the water. Iron that does not form particles large enough to settle out and that remains suspended (colloidal iron) leaves the water with a red tint. In addition, water can be affected by bacteria that feed on iron that occur in soil, shallow aquifers, and some surface waters. These bacteria form red-brown (iron) slime in storage tanks and other household fixtures and can clog water systems.

The 2007 Background Study Report (Pacific Gas and Electric 2007) found dissolved iron levels in forty-seven ~~background~~ wells at less than 500 ppb (the method detection level was 500 ppb). The secondary Maximum Contaminant Level for iron is 300 ppb.

Concentrations within IRZ Areas

As described in the September 2010 Feasibility Study (Pacific Gas and Electric Company 2010a), dissolved iron levels in groundwater increased from less than 500 ppb up to over 5,000 ppb in areas up to 1,000 feet downgradient of the carbon injection point and then declined back toward initial levels over time and distance as organic carbon levels dropped. The same or similar situation is expected to occur following implementation of the project alternatives and is not expected to have a significant or long-term impact upon the environment. Current data shows iron as by product only within the 3.1 ppb chromium ~~plume~~ contour south of SR 58 and not beyond the plume boundaries.



LEGEND

- Approximate outline of Cr(VI) or Cr(T) in Upper Aquifer exceeding values of 3.1 and 3.2 μg/L, respectively, Fourth Quarter 2012
- Study Area
- OU1
- OU2
- OU3
- County Parcel Boundary

Dissolved Arsenic Concentrations (μg/L)

- 0-1
- 1-6
- 6-10
- >10

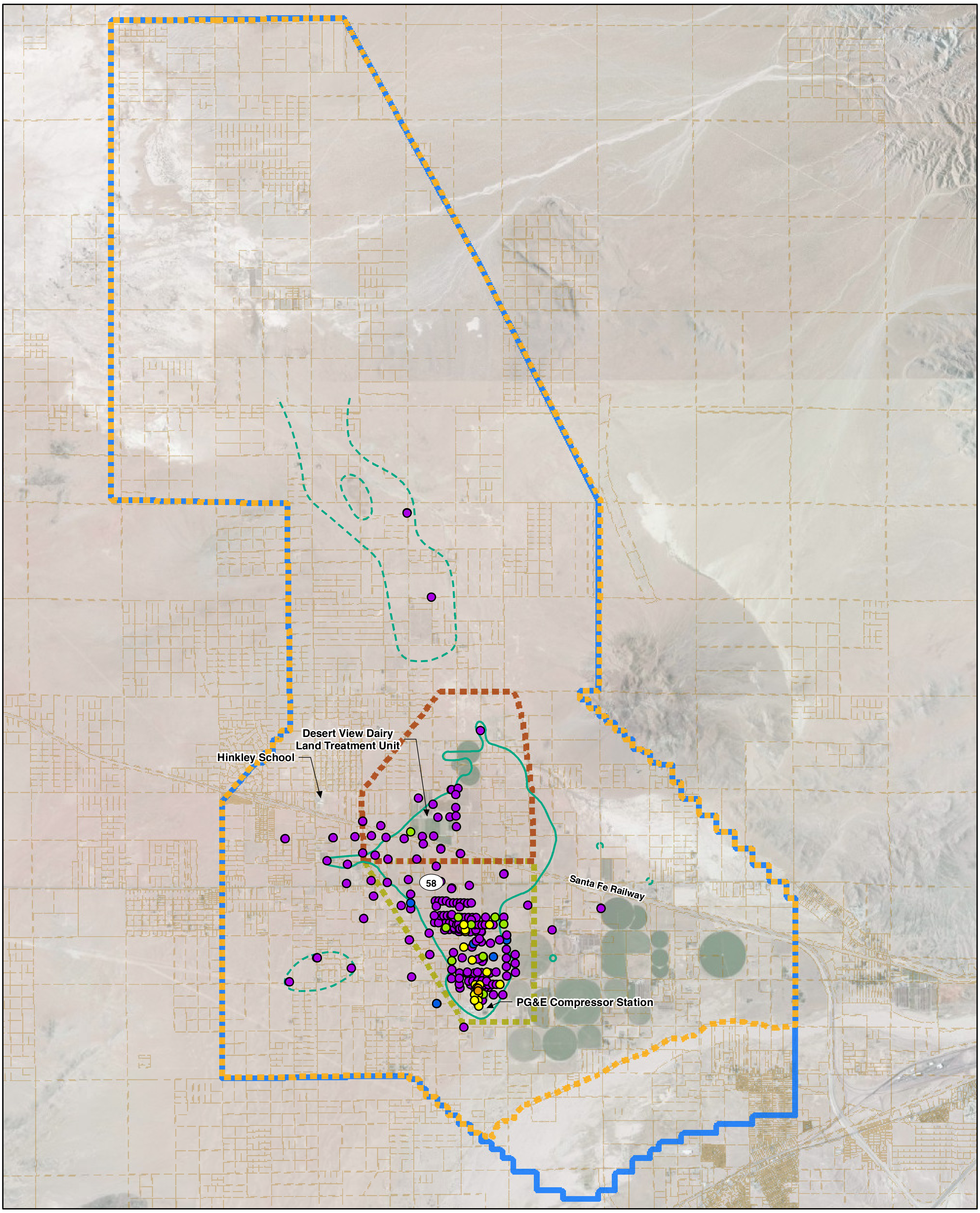
Notes:
Fourth Quarter 2012 laboratory-measured Arsenic data are shown. If Arsenic data were not collected in a well within Fourth Quarter 2012, but were collected within Third Quarter 2012, then Third Quarter 2012 data are shown.

Data shown are from PG&E monitoring and/or remediation wells where available.

Source: PG&E 2013e.

Graphics ... 00122.11 (4-15-2013)

Figure 3.1-9
Existing Dissolved Arsenic within the Project Area



LEGEND

- Approximate outline of Cr(VI) or Cr(T) in Upper Aquifer exceeding values of 3.1 and 3.2 μg/L, respectively, Fourth Quarter 2012
- Study Area
- OU1
- OU2
- OU3
- County Parcel Boundary

Total Dissolved Iron Concentration (mg/L)

- 0.0-0.1
- 0.1-0.3
- 0.3-1.0
- 1.0-6.0
- >6

N

0 2,000 4,000 6,000 8,000 10,000
Feet

Notes:
Fourth Quarter 2012 laboratory-measured Iron data are shown. If Iron data were not collected in a well within Fourth Quarter 2012, but were collected within Third Quarter 2012, then Third Quarter 2012 data are shown.

Data shown are from PG&E monitoring and/or remediation wells where available.

Graphics ... 00122.11 (4-15-2013)

Source: PG&E 2013e.

Figure 3.1-10
Existing Total Dissolved Iron within the Project Area

Figure 3.1-10 shows current dissolved iron levels in the project area, based on available dataThird and Fourth Quarter 2012 data at PG&E monitoring wells. A description of the chemical reaction process and techniques involved in in-situ remediation is provided in Section 3.1.5.2, *In-Situ Remediation*.

Manganese

Background Levels

Manganese is a naturally-occurring element that is common in the air, soil, and water. In addition to natural sources (i.e., geology), manganese levels can also be influenced by anthropogenic sources, such as dairy runoff, leaking septic tanks, or individual well fouling. Manganese is usually dissolved in water at low concentrations, although some shallow wells contain colloidal manganese (black tint). These sediments are responsible for the staining properties of water containing high concentrations of manganese and may be severe enough to plug water pipes. In addition, manganese in water can be affected by bacteria that feed on manganese that occur in soil, shallow aquifers and some surface waters. These bacteria form black-brown (manganese) slime in toilet tanks and pipelines and can clog water systems.

The 2007 Background Study Report (Pacific Gas and Electric 2007) found dissolved manganese levels in background areasareas outside the defined chromium plume to range from less than 1 ppb (method detection level of 1 ppb) up to 48 ppb. Five out of forty-seven wells sampled had one or more detections of manganese greater than 10 ppb.

The state secondary Maximum Contaminant Level for manganese is 50 ppb.

Concentrations within IRZ Areas

PG&E tested manganese levels in the IRZ area prior to initiating IRZ testing and operations and found manganese levels to range up to a maximum of 210 ppb in the Central Area of IRZ operations (PG&E 2012l). Pre-IRZ monitoring in the Source Area had identified a concentration up to 34 ppb at Pilot Study Test Cell 1 in one part of the Source Area and up to 55 ppb at Pilot Study Test Cell 2 north of the Source Area (PG&E 2005).

Similar to arsenic concentrations, carbon injections in the IRZ area have the potential to locally increase manganese concentrations as a reduction byproduct in the groundwater. However, carbon increases are expected to be consumed by microorganisms and eventually reduce in concentration and return to pre-IRZ levels when constituents reach oxygenated groundwater outside of the remediation area. A description of the chemical reaction process and techniques involved in in-situ remediation is provided in Section 3.1.5.2, *In-Situ Remediation*.

As described in the September 2010 Feasibility Study (Pacific Gas and Electric Company 2010a), manganese levels in groundwater increased from less than 226 ppb up to over 4,000 ppb in areas downgradient of the carbon injection point and then declined back toward initial levels over time and distance as organic carbon levels dropped. In February 2011,the Fourth Quarter 2012 dissolved manganese was detected at concentrations up to 1,300750 ppb at twoone contingency monitoring wells,(CA-MW-505), located approximately 1,600 feet downgradient of the Central AreaCAIRZ in-situ remediation system (Pacific Gas and Electric Company 2013b). Because the manganese levels for existing in-situ remediation exceed the levels in the WDRs for the current remediation PG&E is required to implement the Manganese Mitigation Plan (Pacific Gas and Electric Company 2011h).

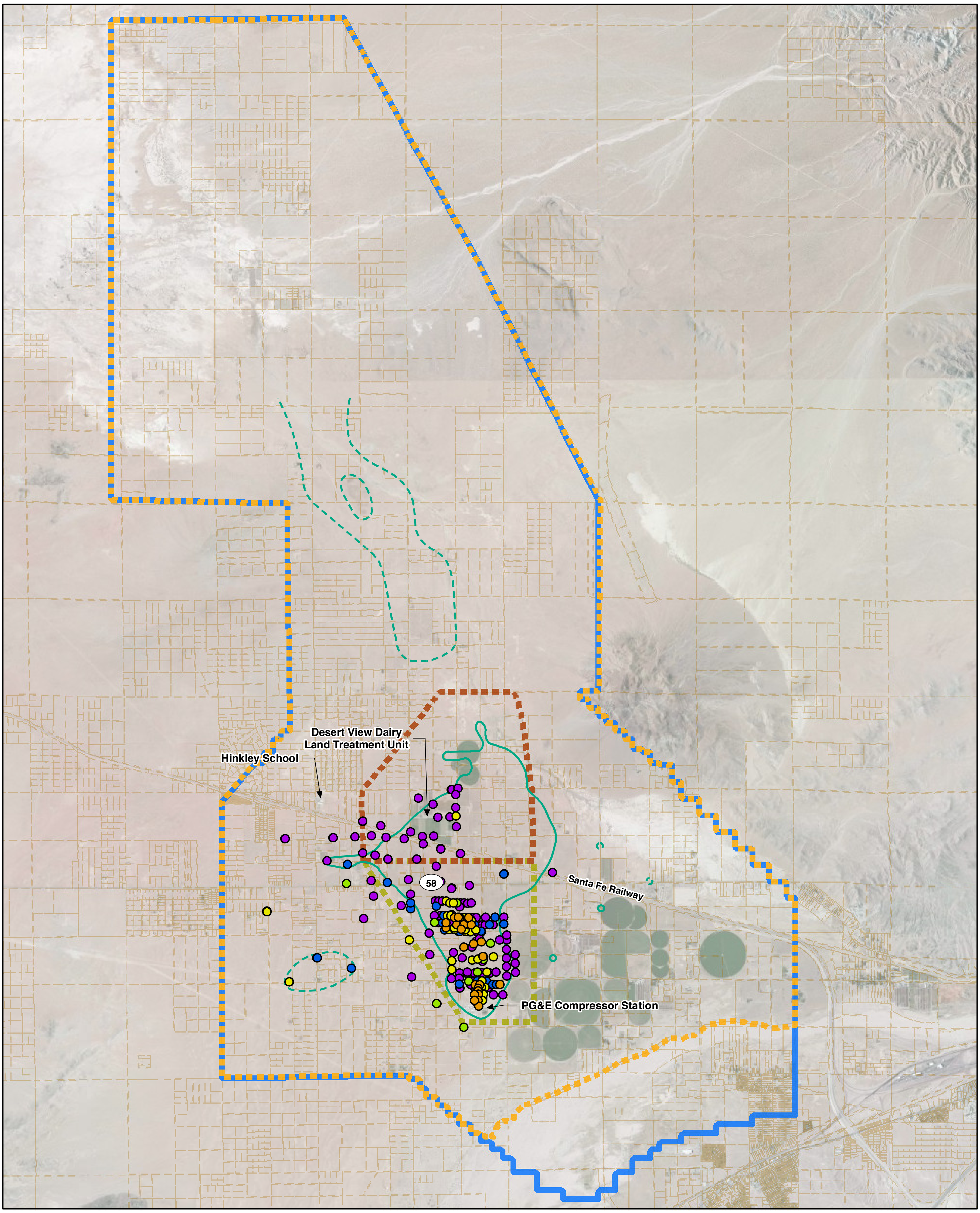
~~Current data shows manganese as by product only within the chromium plume and not beyond the plume boundaries~~In more recent data from the IRZ area, concentrations of manganese in groundwater rose as high as 7,800 ppb (= 7.8 ppm) (Third Quarter, 2012 IRZ monitoring) during remedial operations, but such concentrations will later attenuate back to pre-carbon amendment levels between several months up to two years after carbon amendment ceases.

The Water Board solicited data from community members (at public meetings and through a public notice in early November 2012) to gather available information on the occurrences of metals in groundwater, to help compare metals detections and patterns in domestic wells west of the chromium plume versus PG&E monitoring wells. Water Board staff collected their own data at domestic wells, as well as received data and information from various sources. The Water Board has also reviewed historical and recent (2011-2012) monitoring data results for manganese from the Hinkley Community, Water Board, Mojave Water Agency, PG&E, and San Bernardino County (Project Navigator 2012; PG&E 2012h; San Bernardino County 2013). Hinkley community samples taken west of the IRZ ranged from non-detect (below method detection levels) to over 1,000 ppb with the highest concentration of 140,000 ppb. Water Board samples from the same wells with the highest concentrations (> 1,000 ppb) uniformly found much lower levels of manganese than found in community collected samples. Of the 17 manganese samples collected and analyzed by the Water Board, 8 were below method detection levels; and others ranged from 12 to 146 ppb with one sample containing 789 ppb manganese. Water Board samples in the southeastern and southwestern portion of the study area were all below method detection levels.

The Water Board also released an Investigative Order (No. R6V-2012-0060) on December 21, 2012, directing PG&E to submit a workplan to the Water Board for fully defining and monitoring byproduct manganese plumes created from the IRZ operations in Hinkley. While PG&E believes that performance monitoring data collected since 2007 has confirmed that elevated manganese associated with the IRZ is limited to the IRZ treatment area, PG&E submitted a workplan on February 15, 2013, to conduct additional manganese sampling and investigations. The workplan was conditionally accepted by the Water Board on March 26, 2013. A summary of the review of the available 2011-2012 manganese data is as follows:

- **Monitoring Results:** The preliminary monitoring results indicate that the manganese distribution within and outside of the IRZ area does not support a conclusion that manganese has migrated from the IRZ to areas outside the plume. There are instances of manganese levels at lower concentrations within the edge of the IRZ area than at some of the domestic wells west of the chromium plume. As shown in Figure 3.1-11, in the 4th Quarter 2012, all manganese data results greater than 1 ppm were found within the IRZ area (along with lower detections), whereas areas north of the IRZ area north of SR 58 had manganese levels up to 50 ppb. In areas further north (near the Desert View Dairy), detections were usually below 10 ppb, although there was one detection between 100 and 1,000 ppb.

- **Groundwater Movement:** Groundwater movement through the Hinkley Valley is controlled by aquifer geology, hydraulic conductivity and changes in groundwater elevations (groundwater inflows and outflows). Tracking the movement of the chromium plume and groundwater tracer studies also help understand groundwater flow patterns. Regional groundwater flow in the Hinkley Valley generally moves in a north-northwesterly direction, toward Harper Lake Valley. However, in the immediate vicinity of the Compressor Station, groundwater flow is generally more to the north or northeast (PG&E 2012g~~i~~). This flow direction is not favorable for migration of manganese from the IRZ to domestic wells located west of the plume.



LEGEND

- Approximate outline of Cr(VI) or Cr(T) in Upper Aquifer exceeding values of 3.1 and 3.2 μg/L, respectively, Fourth Quarter 2012
- Study Area
- OU1
- OU2
- OU3
- County Parcel Boundary

Dissolved Manganese Concentrations (mg/L)

- 0.00-0.01
- 0.01-0.05
- 0.05-0.10
- 0.10-1.00
- >1

N

0 2,000 4,000 6,000 8,000 10,000

Feet

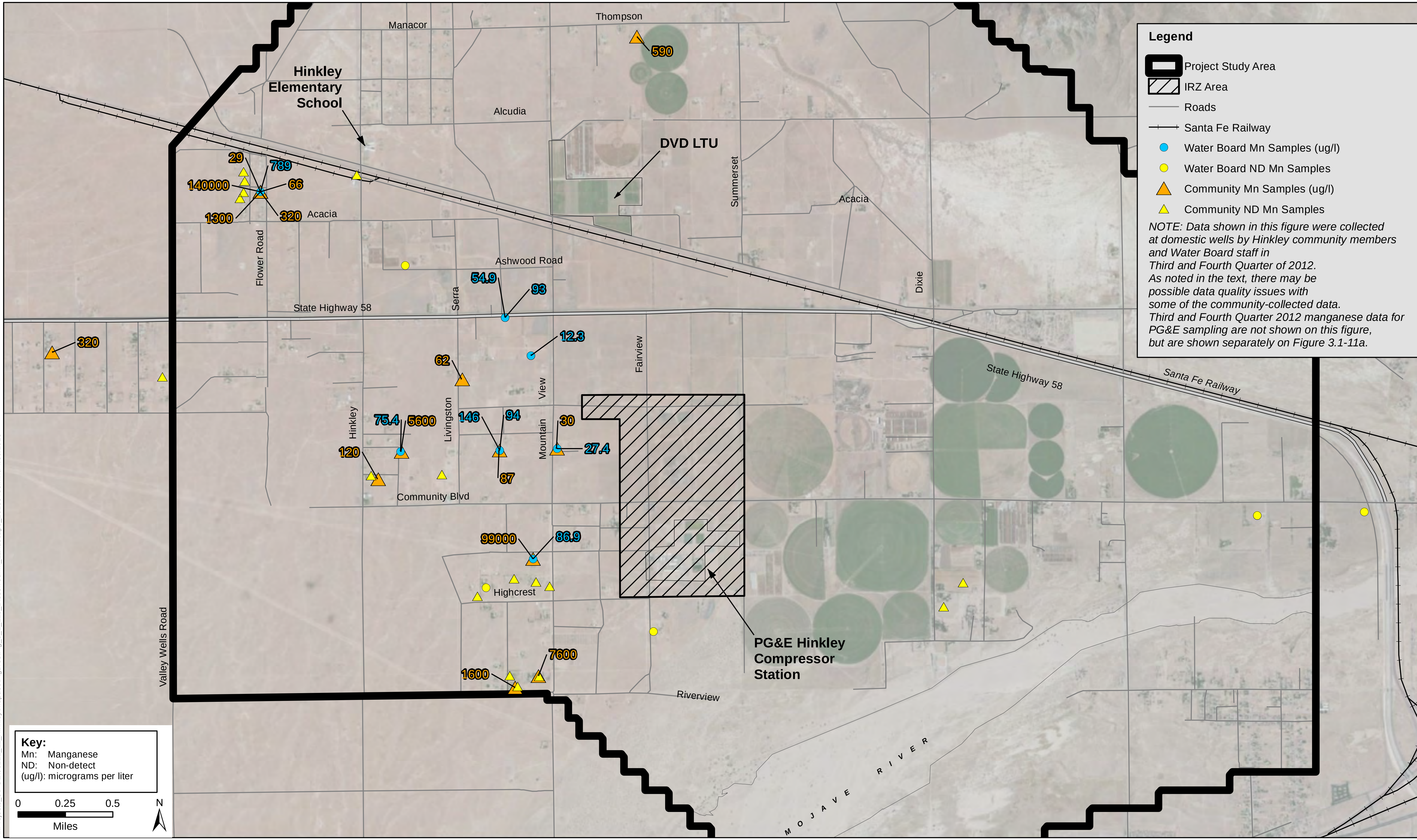
Notes:
Fourth Quarter 2012 laboratory-measured Manganese data are shown. If Manganese data were not collected in a well within Fourth Quarter 2012, but were collected within Third Quarter 2012, then Third Quarter 2012 data are shown.

Data shown are from PG&E monitoring and/or remediation wells where available.

Graphics ... 00122.11 (4-15-2013)

Source: PG&E 2013e.

Figure 3.1-11a
Existing Dissolved Manganese within the Project Area (PG&E Data)



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Source: GIS data provided by Project Navigator on April 9, 2013. GIS data developed by Project Navigator using Water Board and community sampling data for Q3/Q4, 2012.

Figure 3.1-11b
Existing Dissolved Manganese within the Project Area (Community Sampling and Water Board data)

- **Data Quality:** For the community-collected samples, which had the highest detections of manganese in domestic wells west of the chromium plume (with a number of samples over 1,000 ppb of manganese), no sampling quality plan or description of sampling methods has been provided. Samples subsequently taken by the Water Board from the same wells with substantially elevated results (> 1,000 ppb) reveal substantially lower levels of manganese. This raises the possibility that some of the samples may have quality control issues, such as containing high levels of solids, which may indicate that the elevated results may reflect solid concentrations of manganese as opposed to dissolved concentrations in the aquifer itself.
- **Pre-IRZ levels:** As discussed previously, maximum manganese levels detected in the IRZ area prior to the implementation of IRZ remediation activities ranged up to 210 ppb. There is also the possibility that elevated manganese in domestic wells west of the chromium plume could be due to natural sources (i.e., geology) or other non-PG&E anthropogenic sources (i.e., dairy runoff, leaking septic tanks, or individual well fouling).

Efforts to further understand the relationship between these constituents and IRZ remediation activities are still underway. However, at this time, the evidence does not support a conclusion that the manganese detections in domestic wells west of the chromium plume are due to IRZ operations. Current data shows manganese as a byproduct only within the 3.1 ppb chromium plume south of SR58 and not beyond the plume boundaries. Figure 3.1-11 shows current dissolved manganese levels in the project area, based on available ~~data~~Third and Fourth Quarter 2012 data at PG&E monitoring wells.

Uranium and Other Radionuclides

Background levels

Uranium (238U), a radionuclide, is a naturally occurring radioactive element in rocks, soil, water, plants, animals and humans. Uranium is typically measured in picocuries per liter (pCi/L). A curie is a standard unit of radioactivity, where 1 curie is the radioactivity associated with 1 gram of radium. A picocurie is one trillionth (10^{-12}) of a curie. However, uranium is also expressed in ppm, and thus both units may be used in discussing uranium concentrations. The average concentration of uranium is on the order of 2.7 ppm in the earth's crust (Skeppstrom and Olofsson 2007).

~~Uranium data for the Hinkley Valley groundwater are limited.~~ Naturally occurring uranium (approximately 4 ~~ppb~~ppm) has been found in rocks in a number of locations in the Mojave Desert (USGS 2008). 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 in sediments leaches into groundwater in oxidizing environments, but is more strongly adsorbed in mineral complexes under anaerobic (oxygen-poor) conditions.

Besides uranium, gross alpha has also been detected in Hinkley Valley groundwater. Alpha radiation is a type of energy released when certain radioactive elements (such as uranium or radon) decay or break down[8]. Alpha radiation normally exists everywhere: in soil, in the air, and also in water. Because the earth's bedrock contains varying amounts of radioactive elements, such as uranium and

[8] Alpha radiation from "alpha decay" is due to the release of an alpha particle (two protons and two neutrons) from an atomic nucleus.

thorium, the amount of alpha radiation can also vary. Gross alpha refers to a group of radionuclides, in which radium is usually a main constituent. The alpha radiation in drinking water can be in the form of dissolved minerals, or in the case of radon, as a gas. Like uranium, gross alpha is measured in picocuries per liter (pCi/L).

There are both natural and man-made beta emitting radionuclides (EPA 2012a). Thus, the detection of beta radiation[9] in groundwater per se, is not absolute evidence of man-made contamination. The levels of beta radiation must be compared to nearby naturally occurring levels prior to being able to make a determination that a particular detection may be man-made contamination or not. Like uranium, gross beta is also measured in picocuries per liter (pCi/L).

In response to Order No. R6V-2012 – 0057, PG&E submitted a Radionuclide Data Summary Report on November 30, 2012. PG&E data on freshwater supply wells (PGE-14, FW-01, and FW-02) located upgradient (south) of the chromium plume and of the IRZ and agricultural treatment areas had total uranium levels up to 4.1 pCi/L, up to 8.5 pCi/L for gross alpha, and up to 23.3 pCi/L for gross beta (PG&E 2012j). These concentrations are less than the corresponding MCLs.

Concentrations within Agricultural Treatment Units

Uranium was originally detected in the project area at the Gorman agricultural supply wells during PG&E's pilot testing of whole house water treatment systems in August 2011. In the February 2012 Agricultural Unit Monitoring Report, nine groundwater samples from combined agricultural supply were analyzed for uranium and/or gross alpha and gross beta particle activity. The maximum reported uranium and gross alpha and gross beta activities were 59.1 pCi/L (Cottrell Pivot), 75.1 pCi/L (Gorman-North Pivot), and 26.8 pCi/L (Gorman-North Pivot), respectively. These concentrations are greater than the California Maximum Contaminant Level of 20 pCi/L (equivalent to 30 ppb) for uranium and 15 pCi/L for gross alpha. In addition, PG&E has reported a detection of 34 pCi/L uranium and 34 pCi/L gross alpha particle activity at the former Ranch land treatment unit. These concentrations also exceed the Maximum Contaminant Levels. Detected uranium concentrations were found to increase from south to north (opposite the plume concentration gradient). Because the concentrations of these radionuclides are higher than the Maximum Contaminant Level but have only been found in one area to date, additional monitoring from more wells in the vicinity of Hinkley will be needed to fully characterize existing natural conditions.

Uranium is not a constituent associated with PG&E's waste discharge (uranium or its byproducts were not used by PG&E in its compressor station operations). However, PG&E's agricultural pumping for remediation could transport or mobilize background uranium concentrations. A description of the chemical reaction process and techniques involved in agricultural treatment is provided in Section 3.1.5.1, *Agricultural Treatment*.

In a study on groundwater effects on uranium in the San Joaquin Valley in California, a possible link was found between increased bicarbonate concentrations in water from summer agricultural irrigation and the mobilization and migration of uranium to deeper aquifers tapped by water supply wells that may otherwise be sequestered under natural conditions (Jurgens. et al 2009). According to the authors of this study, development of the groundwater resource in the last 100 years has caused two major changes that may have resulted in the increased mobilization of uranium

[9] Beta radiation from beta decay is due to the release of a beta particle (an electron or a positron from an atomic nucleus.

concentrations that may otherwise be sequestered under natural conditions: (1) changes in the chemistry of recharge water and (2) increases in the rate of downward groundwater flow (Jurgens et al 2009).

The Water Board investigated uranium levels in the aquifer through collection of existing data and through a November 12, 2012, request to PG&E for their information (Investigative Order No. R6V-2012 – 0057). As noted above, in response to Order No. R6V-2012 – 0057, PG&E submitted a Radionuclide Data Summary Report on November 30, 2012. PG&E had collected limited radionuclide groundwater samples for wells associated with agricultural irrigation supply, freshwater supply, and the domestic well sampling program. The report did not include data for domestic and private supply wells located on property not owned by PG&E. Data from agricultural unit supply wells and pivot effluent sampling indicated total uranium levels of 25 to 59 pCi/L, 27 to 81 pCi/L for gross alpha and below 4 to 27 pCi/L for gross beta. Upper aquifer monitoring wells had total uranium levels from 3 to 32 pCi/L, 7 to 34 pCi/L for gross alpha and 6 to 9 pCi/L for gross beta. Lower aquifer monitoring wells had dissolved uranium levels from 1 to 2 pCi/L, 3 to 4 pCi/L for gross alpha and less 4 to 5 pCi/L for gross beta.

Uranium data was also collected from sources other than PG&E. San Bernardino County Department of Public Health provided copies of sampling results for two Hinkley area water systems permitted by San Bernardino County in which uranium levels ranged from 4.5 to 21.4 pCi/L in 2011 and 2012 samples.

Periodic sampling by the State of California of drinking water at the Hinkley School from 2008 to 2011 indicated uranium levels ranging from 0.46 pCI/L to 24.9 pCi/L, with an average of 16.4 pCi/L (SWRCB 2013). A search of GAMA for portions of San Bernardino County indicated uranium levels in wells as follows:

- Upper Mojave River Valley (Victor Valley and Lucerne Valley) – up to 11 pCi/L.
- Lower Mojave River Valley (Barstow, Newberry Springs, Calico area) - up to 22 pCi/L
- Helendale (south of Barstow and Hinkley) – up to 20 pCi/L
- Wrightwood (San Gabriel Mountains) – up to 25 pCi/L
- Crestline Area (San Bernardino Mountains) – up to 81 pCi/L
- Roaring Springs Area (San Bernardino Mountains) – up to 330 pCi/L
- Big Bear Lake (San Bernardino mountains - up to 33 pCi/L

As shown by the data cited above, it is not unprecedented for groundwater in the Mojave Desert to contain uranium levels that are above the MCL of 20 pCi/L.

Reviewing the data specifically available for the Hinkley aquifer, wells upgradient of the chromium plume contain uranium up to 4 pCi/L, wells in and near agricultural units have uranium levels in a range of 25 to 59 pCi/L, and the Hinkley school (outside the plume) has uranium levels of up to 22 pCi/L. As the data set provided by PG&E does not include groundwater samples immediately upgradient of agricultural units or prior to establishment of the agricultural units, it cannot be concluded at this time whether agricultural treatment is or is not affecting pre-agricultural treatment unit uranium levels. In addition, the data set does not include soil or plant sampling results so there is no information on the fate of uranium after extracted groundwater is applied to crop fields.

It should be noted that remedial agricultural units operate exactly the same as non-remedial irrigated agricultural fields. Thus, if it is shown that agricultural treatment is affecting uranium levels, then current agricultural activities (not related to PG&E) outside the chromium plume, as well as prior agricultural activities throughout Hinkley Valley, are also likely to have affected uranium levels. This will represent a challenge to isolating the effect of the remedial agricultural treatment units from the non-remedial agricultural activities.

At this time, there is insufficient information to assess whether or not prior and ongoing agricultural irrigation in the Hinkley area or the current remedial agricultural treatment has had any influence on uranium levels in the Hinkley Valley.

3.1.5 Previous and Existing Remediation Efforts

A review of the previous plume containment and cleanup efforts will be helpful for evaluating the project alternatives, which include the continuation or acceleration of these efforts to complete the chromium plume cleanup. A more detailed description of the remedial processes is included in Appendix A. Chapter 2 describes the existing remediation facilities.

The primary plume containment efforts by PG&E have been through agricultural treatment (also called land treatment) of chromium-contaminated groundwater and freshwater injection. Cleanup of the chromium plume has primarily been implemented by in-situ remediation and agricultural treatment.

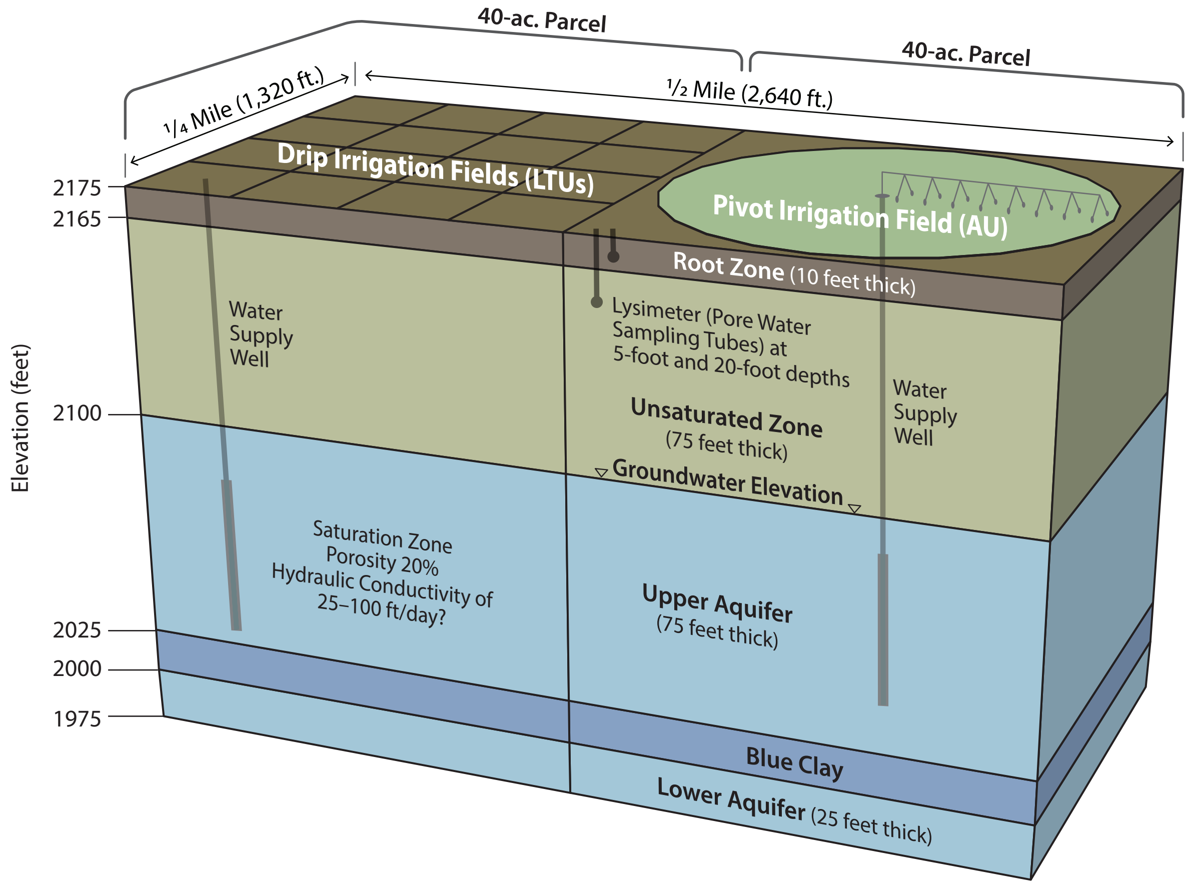
3.1.5.1 Agricultural Treatment

Agricultural activities for chromium treatment involve groundwater extraction and irrigation of crops in agricultural treatment units (also called AUs). Agricultural treatment units were first designed where extracted water containing chromium was sprayed onto crops from a center pivot sprinkler system~~.~~ beginning in 1992.. Following public concern of ~~hexavalent chromium~~Cr[VI] in air emissions, agricultural treatment was ceased for three years from 2001 to 2004, until converted to a subsurface drip irrigation system. This latter system ~~was~~is effective at water delivery but ~~was~~is maintenance-intensive. This system continues today at the Desert View Dairy.

Beginning in 2011, PG&E has switched from a broadcast irrigation system to a central-pivot irrigation system with attached drag-drip lines. The intent of this system was to deliver water to the fields without creating air emissions or puddles to minimize human exposure to treatment water. This different irrigation method was applied on four additional fields started up by PG&E: Gorman-north, Gorman-south, Cottrell, and Ranch. More information on health risks related to chromium is provided in Section 3.1.6, *Health Effects of Constituents in Groundwater*.

Figure 3.1-12 shows a diagram of an agricultural treatment unit. Water from extraction wells sent to agricultural treatment units provide for plume containment as well as treatment of the chromium contamination. The Cr[VI] in the groundwater is treated as it passes through the soil and root zone, through the following mechanisms:

- Cr[VI] in water interacts with electron donors in soil and organic matter and is reduced to solid Cr[III];
- Cr[VI] in water is taken up by plant roots and reduced to Cr[III];



Water Budget for Irrigated Land Treatment (acre feet per acre per year) [1]

Groundwater Pumping	8 af/ac/yr
Applied Water	8 af/ac/yr
Evapo-Transpiration Loss	5 af/ac/yr (assumed)
Seepage through Root Zone	3 af/ac/yr (treatment zone)
Deep Percolation to Saturated Zone	3 af/ac/yr
Net Water from Groundwater	5 af/ac/yr (assumed)

1 Acre feet per acre per year = acre-ft/acre/yr = ft/yr. Therefore, pumping values refer to depth (feet) of water per year for the parcel. All of the values apply to the area of land being considered (acres). Therefore, for a 40-acre parcel the pumping rate would be 40 acres x 8 ft/yr = 320 af/yr.

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Source: Based on information from PG&E 2010a.

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Figure 3.1-12
Diagram of Land Treatment for Cr (VI) Reduction to Cr (III) in Irrigated Root Zone

- Cr[VI] adheres (or "adsorbs") onto organic matter in the root zone, and subsequent reactions involving soil microbes results in reduction to Cr[III]; and
- Cr[VI] forms compounds with organic elements and compounds involved in the reduction.

Pumping groundwater from the plume creates a "cone of depression" around the extraction wells and draws (or pulls) the chromium plume in groundwater toward the wells. The size of the capture zone typically increases with higher pumping, and/or finer-grained layers (such as silt and clay), and shallower saturated zones. Pumping for agricultural treatment prevents or slows expansion of the plume from spreading in the vicinity of the extraction wells. As shown in Figure 3.1-12, the water budget for agricultural treatment indicates a rather large net water loss. Of the amount applied to land during summer, on average approximately 80% evaporates and 20% infiltrates back to the saturated zone. These numbers essentially reverse during colder times of the year.

PG&E began groundwater extraction and agricultural treatment in ~~1991~~1992. Groundwater from several small wells (about 150 gpm) was applied to the East agricultural treatment unit, a 29-acre central pivot irrigation system located just north of Community Boulevard and west of Summerset Road. The East agricultural unit was located at the former Mojave Dairy, across the street from the Compressor Station, and thus was very close to the chromium plume core. Chromium concentrations in water applied to land were typically in the thousands of parts per billion.

In 1997, groundwater (up to 250 gpm) was also extracted and applied to crops at the Ranch agricultural treatment unit, a 52-acre facility with spray irrigation fields, located east of Mountain View Road and north of SR 58. The Ranch agricultural treatment unit was located at the former Nelson Dairy, approximately 1.5 miles north of the Compressor Station. Chromium levels in water applied to crops at the Ranch agricultural treatment unit were less (in the hundreds of parts per billion) than those levels applied at the East agricultural treatment unit. PG&E discontinued the groundwater extraction systems at both agricultural treatment units in June 2001 in response to a Water Board cleanup and abatement order stating concerns over the potential for airborne Cr[VI] from center-pivot spray irrigation and for PG&E to cease creating potential nuisance conditions.

Following three years of no actions for plume containment or cleanup, in 2004 PG&E started up (under a WDR from the Water Board) a more extensive agricultural treatment unit at the Desert View Dairy. Chromium-contaminated groundwater from four on-site extraction wells is applied to crops via a subsurface drip irrigation system, designed to prevent spray that could become airborne. Since the Desert View Dairy is located 2 miles north of the Compressor Station, chromium levels in groundwater were less than those levels seen at the former East and Ranch agricultural treatment unit but still above the Maximum Contaminant Level of 50 ppb total chromium. Since early 2007, chromium levels in groundwater near the Desert View Dairy have decreased to less than the Maximum Contaminant Level. The Desert View Dairy is an active dairy that uses the alfalfa grown in the fields. Under the WDR, soil and crop samples are periodically analyzed for chromium but so far have not had a finding above the detection limit. The Desert View Dairy agricultural treatment unit is primarily used today for plume containment and restoration of the aquifer to background conditions prior to the chromium release.

Over seven years of performance monitoring have demonstrated the Desert View Dairy agricultural treatment unit to be successful at treating Cr[VI] in extracted groundwater. Cr[VI] and Cr[T] concentrations in pore water (water in between soil particles) percolating through the soil below the root zone have remained well below the limits set forth in the Board Order R6V-2004-0034 (July 2004). Monitoring data indicate that the Desert View Dairy agricultural treatment unit operation has not resulted in significant accumulation of chromium in soils, because the concentrations of Cr[VI] in the applied water are less than 50 ppb, while the natural soil concentrations of Cr[T] are 5–10 ppm (100–200 times higher). The Cr[T] and Cr[VI] concentrations in plant tissue samples also have been consistently below the WDR limits of 100 mg/kg. Comparison of the Cr[VI] concentrations in the applied irrigation water with the Cr[VI] concentrations in the pore water collected from 5 feet below ground surface indicates Cr[VI] removal rates generally greater than 95% across the majority of the Desert View Dairy agricultural treatment unit. Data from some of the irrigation fields with higher sand content exhibit lower removal efficiencies.

Table 3.1-6. Performance Summary for Cr[VI] to Cr[III] Conversion for the East, Ranch and Desert View Dairy Agricultural Treatment Units

Agricultural Treatment Units Summary Data	East Agricultural Treatment Units	Ranch Agricultural Treatment Units	Desert View Dairy Agricultural Treatment Units
Area (acres)	30	52	80
Period of Operation	1991–2001	1998–2001	2004~~5~~–ongoing
Amount of extracted groundwater over life of treatment (af)	2,400	1,050	550
Average Cr[VI] concentration [a] in extracted water (ppb) after treatment (concentrations before treatment were higher)	130	13	20
Reduction of Cr[VI] (lbs.) in extracted water to Cr[III] in soil	850	40	174
Cr[VI] Reduction Efficiencies[a]	95%	95%	>95%

Source: 2002 Feasibility Study (Pacific Gas and Electric 2002), 2010 Feasibility Study (Pacific Gas and Electric Company 2010a).

Notes:

[a] Efficiencies were calculated by PG&E based on sampling of water from lysimeters beneath the agricultural treatment units.

Results from measurements below the irrigated fields of the East, Ranch, and Desert View Dairy agricultural treatment units demonstrate the performance of the agricultural treatment units in converting Cr[VI] to Cr[III], and the results are summarized in Table 3.1-6. However, the limitation of the technology was the lack of extracted water during three months after crop harvest in the fall. With the exception of the year 2012, the agricultural treatment units operated 75% of the year for the first 17 years in operation. During the other 25% of the year, the chromium plume migrated with natural groundwater flow. While the migration distance was probably not great, low pumping in the early spring for establishing crops was unable to fully capture the plume back to the location of the agricultural fields. This enabled plume spreading. To consider the technology for comprehensive site cleanup, the Water Board required that full plume containment occur on a year-round basis, using either agricultural treatment, another technology, or a combination of technologies.

Starting in 2012, o~~O~~peration of the Desert View Dairy and four additional fields having agricultural treatment unit extraction wells, ~~which~~ have seen ~~a general~~ increasing ~~trend in~~ extraction rates as new wells have been installed, ~~is~~ generating a large area of declining water levels ("cone of depression"). which This larger drawdown area is now present in the upper aquifer in the area of the Dairy and Cottrell properties and appears to be controlling plume migration. In general, greater pumping results in large cones of depression and thus large zones of hydraulic control. Because summer pumping rates are greatest during the summer, summer cones of depression are larger than those in other months. In unconfined alluvial systems that exist at the Desert View Dairy, steady-state water level conditions typically develop within weeks of adding new pumping. The challenge however will be to maintain enough capture so that plume containment is year round. The alternatives for comprehensive chromium cleanup discuss different approaches for achieving this goal.

3.1.5.2 In-Situ Reduction Treatment

PG&E has completed pilot-scale testing for in-situ treatment methods (i.e., in-place cleanup) and is now implementing full-scale cells in the core (high concentrations) of the plume throughout OU1.

In-Situ Treatment Mechanisms

In Hinkley, in-situ treatment involves the injection of carbon-containing compounds (i.e., ethanol) to stimulate microbial and chemical processes which convert Cr[VI] to Cr[III] through a chemical reaction known as "reduction." Reduction occurs when electrons are added to an element that makes its electric charge more negative. For example, when in-situ remediation results in reduction of Cr[VI], the chemical reaction results in addition of three electrons to Cr[VI],changing it to Cr[III] as its electric charge is changed from + 6 to +3. The opposite reaction is known as "oxidation" and occurs when electrons are removed from an element and the electric charge is made more positive. This process is referred to as oxidation because it usually occurs through a chemical reaction involving oxygen or compounds containing oxygen or elements that chemically act like oxygen. In-situ remediation includes actions by microbes in the soil in an "anaerobic" environment, which means an environment lacking oxygen.

The Cr[VI] to Cr[III] conversion process involves both microbial reaction and chemical reduction. The injection of carbon essentially provides "food" for microbes, which break down the carbon and in the process creates favorable conditions to promote reduction of Cr[VI] to Cr[III]. Cr[III] is removed from groundwater through precipitation of relatively insoluble chromium hydroxides and iron-chromium hydroxides. The Cr[III] is adsorbed onto the aquifer matrix (sediments such as sand, silt and clay) but is very stable (i.e., it is bound to the mineral deposits on the sand, silt and clay) and is not expected to reconvert back to Cr[VI] and dissolved back into the groundwater because it is bound within the mineral deposits (Palmer and Puls 1994). Also refer to Appendix A.3, *Potential for Reconversion of Trivalent Chromium to Hexavalent Chromium at the PG&E Hinkley Groundwater Remediation Project*.

PG&E is implementing two techniques for injecting a carbon-based amendment to stimulate microbial growth and anaerobic (oxygen-poor) biochemical processing of the Cr[VI] to insoluble Cr[III]:

- Carbon-amendment and injection in a recirculation loop configuration ("barrier well IRZ"). Extraction wells and injection wells are separated by a relatively short distance (100–200 feet) to induce treated water movement between these wells and allow natural groundwater movement between the wells.

- Extraction, carbon-amendment and injection (also referred to as "dosed-injection IRZ"). Water is extracted from a well, dosed with a carbon source, and injected into another well (or extracted and re-injected into the same well using an extract, amend, store, and inject sequence). Injections are passive, meaning not under active pressure, and move with natural groundwater flow which is subject to the heterogeneities of the aquifer materials.

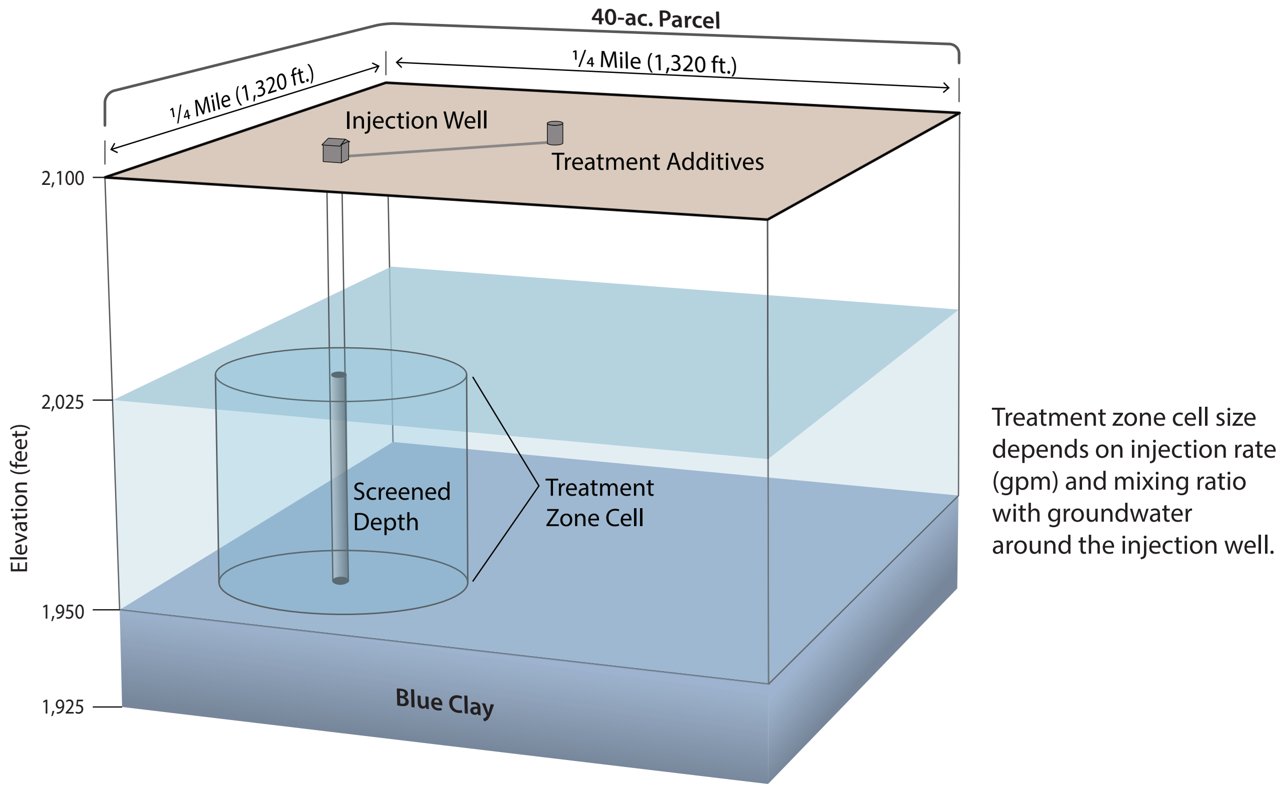
In-Situ Treatment Experience to Date

Three pilot and three full-scale IRZ "cells" have been implemented: (1) Source Area IRZ, (2) the South Central Reinjection Area IRZ, and (3) the Central Area IRZ. The general IRZ results can be summarized as:

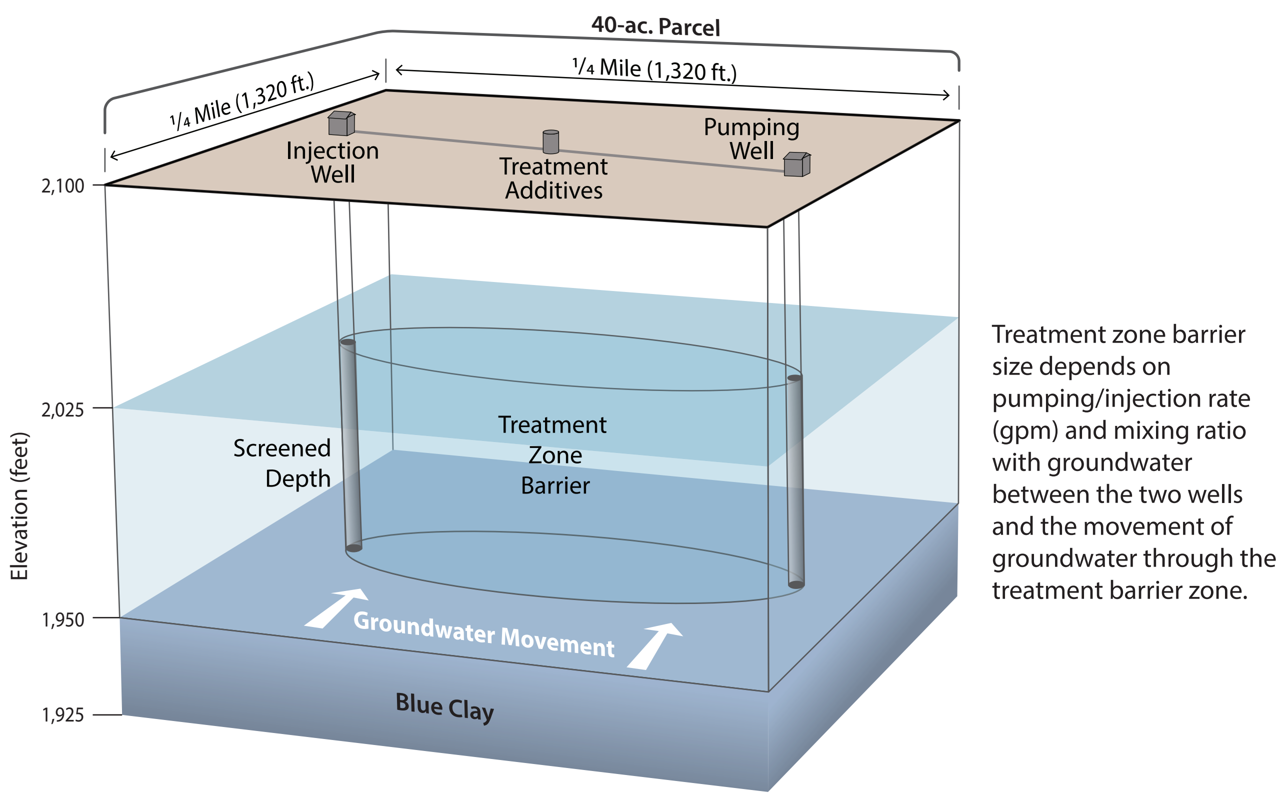
- Injection of organic carbon substrates ~~is an effective technology~~ for converting Cr[VI] in groundwater into Cr[III] in the soil. Several organic compounds (including ethanol, lactate, and emulsified vegetable oil) were shown to be effective reagents ~~(ethanol is now favored)~~. Ethanol is the preferred amendment because it has shown to distribute more effectively in the aquifer, which means that it would have greater effectiveness in reducing Cr[VI] to Cr[III] in the aquifer
- Separated extraction and injection wells (barrier well IRZ) are effective means of distributing amendment (i.e., organic carbon substrates), establishing IRZs, treating Cr[VI], and generating a clean water front with Cr[VI]concentrations that are less than background at some locations.
- The extent of amendment distribution and Cr[VI] treatment in the aquifer varies across the treatment area because of geologic heterogeneities and spatial variations in groundwater movement. Meaning, Cr[VI] treatment is best in preferential pathways such as coarse-grained sediments within the aquifer.
- Carbon injection in the study area has the potential to locally increase concentrations of total organic carbon and secondary byproducts, such as arsenic, ~~dissolved~~ manganese, and iron in the groundwater within IRZs. Over time, t~~T~~otal organic carbon will decrease ~~with time~~back to ~~background conditions by~~ pre-IRZ levels due to consumption ~~due to~~ by bacteria (this process takes a matter of months up to two years from the time carbon amendment is ended).The secondary byproducts also tend to reduce over time and distance from the reducing zone when exposed to oxidizing conditions in non-treated groundwater.

Figure 3.1-13 shows a diagram of a typical dosed injection well IRZ and a barrier well IRZ. The size of the treatment zone depends on the injection rate and the amount of mixing with the surrounding groundwater. For example, a 10-gpm dosed injection well operated for a year would create a treatment zone within the 75-foot upper aquifer of about 1 acre. The treatment zone for the barrier well IRZ design depends on the distance between the pumping and injection wells, the pumping rate, and the movement (ft/year) of groundwater between the wells.

Because there are only limited data from other remediation sites using in-situ bio-reduction IRZs elsewhere, the success of this treatment method had to be demonstrated from the pilot studies results in Hinkley. These results are summarized in the 2010 Feasibility Study and are described in further detail in Appendix A because this is a primary component of the final cleanup alternatives. Overall, injection of organic carbon substrates has been effective for removing Cr[VI] from groundwater (Pacific Gas and Electric Company 2010a) and leaving Cr[III] in soil. In-situ treatment to background chromium concentrations has been achieved at approximately 50% of the treated wells in the Central Area IRZ and approximately 60% of the treated wells in the Source Area IRZ as of ~~2010~~2011, affecting a total of about 54 acres (Pacific Gas and Electric Company 2010a).



A. Dosed-Injection Treatment Zone



B. Recirculation Loop Configuration Treatment Zone

Source: Based on information from PG&E 2010a.

Graphics...00122.11 (5-7-2013)

Figure 3.1-13
Diagram of In-Situ Reduction Zone Treatment for Contaminated Chromium Plume

In-Situ Treatment Byproducts and Control

As stated before, the injection of carbon into the aquifer can result in the formation of byproducts, including dissolved metals such as manganese, iron, and arsenic. These byproducts are reduced out of ~~groundwater from leaching of the~~ aquifer sediments to groundwater. Groundwater flow then carries these ~~naturally occurring~~dissolved metals temporarily until they reach oxygenated water that converts them back to their original chemical state. For example, dissolved manganese is Mn[II] and when in contact with oxygenated conditions, forms the dark mineral manganese oxide as MnO_2.

Based on the experience with IRZs to date, elevated concentrations of byproducts occur in correlation to the level of organic carbon in the water: rising with the increased carbon and falling with the decrease of carbon. The time for return to initial levels is estimated as between months and several years based on analytical results for wells downgradient of IRZ injection locations to date. Dissolved byproduct metals are expected to oxidize and precipitate onto the aquifer sediments once the carbon has been depleted and/or the metals are exposed to aerobic (oxygen rich) groundwater conditions. The oxidized conditions will not cause the Cr[III] in the aquifer to be oxidized to Cr[VI] because the Cr[III] is incorporated in relatively low solubility chromium hydroxides and iron-chromium hydroxides. Based on prior IRZ experience, elevated byproduct concentrations at levels above primary or secondary Maximum Contaminant Levels have been detected at distances greater than 1,600 feet downgradient of injection points. If organic carbon injection rates are higher and/or groundwater movement is locally faster than in the IRZs implemented to date, then the area affected by elevated concentrations of byproducts will likely be greater than 1,600 feet experienced previously.

Byproducts are monitored with an extensive monitoring program that includes several lines of closely spaced designated monitoring wells. Preliminary results from byproduct monitoring are described in Appendix A.

Current permit requirements mandate that PG&E contain the spread of byproducts to the in-situ remediation area. For example, in response to detections of manganese at monitoring wells at concentrations above the ~~threshold~~reference concentration established in the General Permit for the IRZ, PG&E drafted a manganese mitigation plan~~s~~ during June 2011 and another revised plan in ~~March~~September 2011 and May 2012. The final mitigation plan, ~~scheduled for implementation~~implemented in ~~summer~~fourth quarter 2012, includes the following components for wells where manganese exceedances are observed:

- installation and operation of a groundwater extraction well to capture groundwater with concentrations of dissolved manganese that exceed the ~~threshold~~reference concentration;
- aeration of the extracted groundwater in an above ground system;
- percolation of treated groundwater via dry wells or an infiltration gallery; and
- installation of three new monitoring wells on the north side of SR 58 to monitor manganese in groundwater.

3.1.5.3 Plume Containment by Freshwater Injection

PG&E is using clean groundwater injections as another means to prevent the plume from migrating in one direction and deflecting plume movement to another direction. The freshwater injection area, located along Serra Road and south of Santa Fe Avenue, prevents plume migration to the west where sensitive nearby receptors, such as the Hinkley School, are located. Groundwater is extracted from three freshwater supply wells (PGE-14, FW-01, and FW-02) located south of the Compressor Station (i.e., up-gradient of the plume), conveyed about two-miles north through an underground pipeline, and re-injected at a flow rate of up to 80 gpm into five injection wells directly adjacent to the western boundaries of OU1 and OU2. The northwest reinjection system began operation in March 2010. Water from the supply wells is filtered through a granular ferric hydroxide (GFH) media system to remove ~~naturally occurring~~ arsenic present at concentrations that exceed its Maximum Contaminant Level for drinking water (10 ppb). ~~Freshwater~~Until recently, freshwater injection has been effective at locally controlling plume migration towards the west and deflecting plume migration towards the Desert View Dairy agricultural treatment unit.

In fourth quarter 2012, a thin chromium "finger" migrated through the injection barrier toward the west. The chromium detections above the maximum background levels for hexavalent and total chromium were detected in three monitoring wells west of Serra Road: MW-169, MW-121, and MW-153. Plume migration appears to be a result of two actions: pumping from an agricultural well near Hinkley Road and significant decreased freshwater injection into well IN-03. The Water Board will be requiring that PG&E conduct corrective actions to re-establish the freshwater barrier and contain plume migration back to the original configuration.

3.1.6 Health Effects of Constituents in Groundwater

This section provides a brief overview of the potential health effects of chromium in groundwater and other constituents that may be affected by the proposed groundwater remediation at the PG&E Hinkley site. Information in this section is derived from California and federal agency assessments of the toxicology and health effects of different constituents. This section is intended to provide information on the current understanding of health effects in general, and does not provide a specific assessment of health effects that may occur to individuals in the Hinkley area. Background levels of these constituents were discussed earlier in this section.

3.1.6.1 Chromium

Chromium is a heavy metal that occurs throughout the environment. The trivalent form is a required nutrient and has very low toxicity. The hexavalent form, also commonly known as "chromium 6~~,~~" or ~~(~~Cr[VI]~~)~~, is more toxic and has been known to cause cancer when inhaled. In recent scientific studies in laboratory animals, hexavalent chromium has also been linked to cancer when ingested. ~~Soluble (i.e., dissolvable in water)Cr[VI]is relatively toxic, while the less-soluble Cr[III] has very low toxicity and is a required nutrient.~~ Cr[VI] can convert into Cr[III] and vice-versa in the environment depending on the specific conditions present in groundwater and soil (OEHHA 2010). Cr[VI] is soluble (dissolvable in water), but Cr[III] is less soluble.

Hexavalent chromium found in drinking water can be naturally occurring, reflecting its presence in geological formations throughout the state. However, there are areas of contamination in California from historic industrial use such as the manufacturing of textile dyes, wood preservation, leather tanning, and anti-corrosion coatings or from discharges ~~of chromium~~ (such as from the PG&E Compressor Station) where hexavalent chromium--contaminated waste has migrated into the underlying groundwater.

~~While~~ Cr[VI] has long been recognized as a cancer-causing substance (also referred to as a "carcinogen") via inhalation in occupational and industrial settings~~,~~. Review of occupational studies in which humans were exposed to Cr[VI] primarily by the inhalation route, identified reports of significantly increased risk of lung cancer. It is estimated that exposure to airborne Cr[VI] is 1,000 times more potent than exposure from drinking water (OEHHA 2009). T~~t~~here is sufficient evidence that Cr[VI] is also carcinogenic by the oral route of exposure (meaning drinking or consuming~~),~~), based on studies in rats and mice conducted by the National Toxicology Program (OEHHA 2010). Mice that ingested drinking water containing high doses (14,000 ppb or greater) of Cr[VI] had statistically significant increases in stomach, oral cavity, and intestine tumors compared to control subjects (OEHHA 2010).

Following oral consumption of Cr[VI] by humans or oral administration to experimental animals, increased levels of chromium in whole blood and plasma were observed, while little change was observed following trivalent chromium consumption or administration. Increases in blood/plasma total chromium levels following oral Cr[VI] administration show that the hexavalent form is available to interact with tissue (referred to as “bioavailability”), potentially causing harmful effects (OEHHA 2010). In addition to the ingestion of drinking water, exposure to Cr[VI] in a domestic water supply can occur due to inhalation of water droplets and skin (“dermal”) contact with water during bathing, but dermal exposure does not appear to contribute significantly to the overall risk ~~exposure~~ (OEHHA 2010).The short duration of normal bathing is not enough to create a significant risk of exposure to hexavalent chromium in water.

~~Mice that ingested drinking water containing high doses (14,000 ppb or greater) of Cr[VI] had statistically significant increases in stomach, oral cavity, and intestine tumors compared to control subjects (OEHHA 2010). Review of occupational studies in which humans were exposed to Cr[VI] primarily by the inhalation route identified reports of significantly increased risk of lung cancer. It is estimated that exposure to airborne Cr[VI] is 1000 times more potent than exposure from drinking water (OEHHA 2009).~~

In response to a query from the Water Board concerning the Hinkley site, OEHHA concurred with a conclusion that swamp coolers do not constitute an inhalation health risk based on findings in scientific literature that swamp coolers would not increase the concentration of airborne Cr[VI] (OEHHA 2011~~, August 17, 2011 letter to Lahontan Water Board~~). The study found that indoor air quality was better from use of a swamp cooler, which has the capacity to filter and therefore reduce particles in air, when maintain properly.

Existing California and EPA Maximum Contaminant Levels of total chromium in drinking water are 50 ppb and 100 ppb, respectively. Although total chromium is additive of Cr[VI] and Cr[III], the Maximum Contaminant Level does not include health risks of Cr[VI] due to the ingestion route because health studies had not yet been conducted and the risks were unknown at the time relative to the ingestion route of exposure. Thus, n~~N~~either of these regulatory levels are specific for Cr[VI], and neither involves the assumption of potential carcinogenicity of Cr[VI] due to the ingestion route.

A public health assessment (PHA) was conducted by the U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Health Investigations Branch (EHIB) of the California Department of Health Services (now called CDPH) in December 2000. The study was conducted to determine the health effects of chromium exposures on past, current, and future residents and workers in the vicinity of the Hinkley site and the associated land treatment fields. The PHA also characterized current/future risks as they existed in 2000, and some of the current/future exposure pathways, like irrigation methods, have changed in ways that have changed risks (drag-drip irrigation minimizes inhalation risk for example). There has also been research done since 2000 that have improved the understanding of Cr[VI] toxicity, particularly related to ingestion risk through an oral route of exposure, and therefore some of the information in the assessment is considered to be outdated. Notwithstanding these limitations, the PHA results are summarized below for informational purposes (U.S. Department of Health and Human Services 2000)

- Past Exposures (Exposures to chromium Pre-1988)
  - Residents
    - Groundwater ingestion: 2.6 X 10^{-3} cancer risk (2.6 in a thousand risk of cancer incidence)
    - Ambient Air/Land Treatment and Mojave Dairy – Incomplete Pathway (due to lack of data)
    - Swimming Pool Use – Eliminated pathway (water used in PG & E pool found to not be from plume)
    - Ambient Air/Cooling Towers – Incomplete Pathway (due to lack of data)
  - Site Workers
    - Soil, wastewater, air, groundwater for the ponds, cooling tower, land treatment and Mojave Dairy: Incomplete Pathway (due to lack of data)
    - Mojave Dairy Irrigation Inhalation: 2.9 X 10^{-5} cancer risk (noted as conservative overestimate)
    - Ambient Air/Cooling Towers – Incomplete Pathway (due to lack of data)
  - Consumers
    - Milk, meat, organs from dairy cows – Eliminated pathway (within normal background levels)
- Current And Future Exposures (based on exposures as of 2000)
  - Residents
    - Groundwater ingestion: 5.2 X 10^{-5} cancer risk (5.2 in 100,000 cancer incidence)
    - Ambient Air/Site Characterization inhalation: 3.3 X 10^{-8} cancer risk (3.3 in 100 million cancer risk)
    - Ambient Air/Land Treatment – Incomplete Pathway (due to lack of data)
    - Soil: Eliminated pathway (soil chromium within background levels)
    - Air/Cooling Towers: Eliminated pathway (no current or future Cr[VI] use)
  - Workers
    - Ambient Air/Site Characterization inhalation: 3.3 X 10^{-8} cancer risk (3.3 in 100 million cancer risk)
    - Ambient Air/Land Treatment – Incomplete Pathway (due to lack of data)
    - Soil/Land Treatment Fields: Eliminated pathway (below comparison values)
    - Air/Cooling Towers: Eliminated pathway (no current or future Cr[VI] use)

- Consumers
  - Milk, meat, organs from dairy cows: Eliminated pathway (within normal background levels). See discussion below.

Since conditions have changed since 2000, the results of the PHA are considered only applicable at the time of the study and do not necessarily reflect current conditions or risks. For example, chromium levels in water used for drinking and cooking were different (and higher) in 2000 than at present. In addition, PG&E has been providing bottled water to residents since 2011 (under Water Board order) and treatment activities (such as spray irrigation in 2000 vs. drag-drip irrigation today) have changed.

The California Public Health Goal for Cr[VI], set in 2011, is 0.02 ppb, which OEHHA estimates is the "one in one million" lifetime cancer risk level. This means that for every million people who drink two liters of water with that level of Cr[VI] daily for 70 years, no more than one person would be expected to develop cancer from exposure to Cr[VI]. A Public Health Goal is not a regulatory level of a drinking water standard. It reflects the potential risk from long-term exposure to a contaminant and is not intended to estimate risks from short-term or acute exposure or to set cleanup levels (OEHHA 2009).

Research continues on the potential health impacts from Cr[VI]. Following the National Toxicology Program rodent study that utilized high doses of Cr[VI] (14,000 ppb or greater), recent research has focused on the mechanism of action and potential impacts from lower doses of Cr[VI]. In 2008, the EPA began a comprehensive review of chromium health effects and produced a draft update to their Toxicological Profile for chromium in September 2010 which then underwent external peer review including a peer review panel workshop open to the public in May 2011. Based on feedback from that peer review panel, the EPA delayed the finalization of that profile in order to await publication of emerging studies aimed at further understanding the mechanism of action of chromium ~~and its impact on their assessment of the model by which they will consider a revised Maximum Contaminant Level for Cr[VI]~~.

3.1.6.2 Total Dissolved Solids

The presence of dissolved solids in water may affect its taste. The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 ppm; good, between 300 and 600 ppm; fair, between 600 and 900 ppm; poor, between 900 and 1,200 ppm; and unacceptable, greater than 1200 ppm (World Health Organization 2003a).

Water containing TDS concentrations below 1,000 ppm is usually acceptable to consumers, although acceptability may vary according to circumstances. However, the presence of high levels of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances (WHO 2006).

Due to the lack of data on toxicity of TDS, neither the EPA nor California has established a health-based standard for TDS in drinking water. However the EPA adopted a secondary Maximum Contaminant Level of 500 ppm (and California adopted a recommended secondary Maximum Contaminant Level of 500 pm and an upper limit secondary Maximum Contaminant Level of 1,000 ppm respectively) for taste and scaling reasons.

Individual compounds that additively make up TDS, such as sodium, chloride and sulfate, may themselves create problems at certain concentrations. At present there are no national or California primary or secondary Maximum Contaminant Levels for sodium. However, the US EPA has established a Health Advisory level of 20 ppm for people on a restricted low-sodium diet and a Drinking Water Advisory Taste and Odor ~~threshold~~level of 30 ppm. Both numbers are to be used as guidance rather than regulatory standards.

There is a federal secondary Maximum Contaminant Level for aesthetics (i.e. taste and odor) for chloride of 250 ppm. In California, the secondary Maximum Contaminant Level for chloride includes a recommended level of 250 ppm and an upper limit of 500 ppm. Sodium and chloride together make salt as sodium chloride (~~$NACl_2$~~ NaCl). High salt intake has the ability to make the body retain fluids and create high blood pressure (hypertension). When considering the health importance of sodium and chloride in order to determine whether or not to adopt water quality standards, US EPA assumed that water users consume two liters of water per day, and found that 10% or less of a person's daily sodium intake comes from drinking water with the rest usually coming from food. One of the reasons the EPA has not adopted a water quality standard to date is that it is easier and less expensive to make a dietary change than to excessively purify drinking water. This explains the EPA recommended sodium levels not exceed 20 mg/L for those persons on a physician-prescribed "no salt diet." This is the same level recommended by the American Heart Association. Many foods normally consumed can contain substantial amounts of sodium or sodium chloride.

Health concerns regarding sulfate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulfate. Of particular concern are groups within the general population that may be at greater risk from the laxative effects of sulfate when they experience an abrupt change from drinking water with low sulfate concentrations to drinking water with high sulfate concentrations. The federal secondary Maximum Contaminant Level for sulfate is 250 ppm for aesthetic effects (i.e., taste and odor). In California, the secondary Maximum Contaminant Level for sulfate includes a recommended level of 250 ppm and an upper limit of 500 ppm.

3.1.6.3 Nitrate and Nitrite

Human exposure to nitrates and nitrites results primarily from dietary ingestion, particularly from vegetables and cured meats. Once taken into the body, nitrates are converted to nitrites (EPA ~~2011c~~2011b). The average adult daily intake from food in the United States has been estimated to be 40 to 100 mg/day for nitrate, and 0.3 to 2.6 mg/day for nitrite. Exposure estimates indicate that for more than 99% of the adult population in the United States, only 1 to 3% of nitrate and nitrite intake comes from drinking water. Drinking water becomes an important contributor to total nitrate exposure only in areas of notable contamination. For infants, the exposure scenarios are somewhat different. For breast-fed infants, total nitrate exposure is negligible. For bottle-fed infants consuming drinking water used to prepare their formula, drinking water can be a substantial exposure pathway (OEHHA 1997).

Methemoglobinemia (a blood disorder in which an abnormal amount of a protein called hemoglobin builds up in the blood) is the primary adverse health effect associated with human exposure to nitrate or nitrite. Infants are generally recognized as the subpopulation most susceptible to nitrate-induced methemoglobinemia. When infants are affected by high nitrate levels, this is commonly referred to as "blue-baby syndrome." There are other individuals who may be predisposed to the development of nitrate-induced methemoglobinemia (OEHHA 1997).

More recent research shows that high nitrate concentrations can lead to a host of other health problems, such as hypertension, birth defects, diabetes, and non-Hodgkin's lymphoma (~~see~~ Rosen ~~and others,~~et al. 2006~~ for references~~). In addition, a recent report by the National Cancer Institute for the first time links nitrates directly to thyroid cancer in humans (Ward et al. 2010).

OEHHA developed Public Health Goals of 45 ppm for nitrate (equivalent to 10 ppm nitrate-nitrogen), 1 ppm for nitrite-nitrogen and 10 ppm for joint nitrate/nitrite (expressed as nitrogen) in drinking water. The calculation of these Public Health Goals is based on the protection of infants from the occurrence of methemoglobinemia, the principal toxic effect observed in humans exposed to nitrate or nitrite. California's current Maximum Contaminant Level for nitrate ~~are~~ is the same as the Public Health Goal~~s~~ and ~~were~~was adopted by the California DHS in 1994 from the EPA's Maximum Contaminant Levels promulgated in 1991. The current federal and state Maximum Contaminant Levels for nitrate do not incorporate up-to-date research showing additional risk to human health from nitrates.

3.1.6.4 Arsenic

All humans are exposed to microgram quantities of arsenic (inorganic and organic) largely from food (25 to 50 micrograms per day) and to a lesser degree from drinking water and air. Some edible seafood may contain higher concentrations of arsenic which is predominantly in less acutely toxic organic forms. In certain geographical areas, natural mineral deposits may contain large quantities of arsenic and this may result in higher levels of arsenic in water. Waste chemical disposal sites may also be a source of arsenic contamination of water supplies. Burning of fossil fuels also produces low levels of arsenic emissions. Arsenic may also be found in low levels in tobacco smoke. Most ingested arsenic is quickly absorbed through the gastrointestinal tract into the blood stream. Most of the organic arsenic is excreted unchanged or metabolized. The inorganic arsenic which is absorbed is converted by the liver to methylated forms which may be more toxic and more efficiently excreted in the urine. Arsenic does not have a tendency to accumulate in the body at low environmental exposure levels (OEHHA 2005).

Many scientific studies conclude that long-term exposure to inorganic arsenic through drinking water is associated with relatively high risks of cancer of the lungs and bladder and, to a lesser extent, with an increased risk of cancer of the skin, liver, and kidneys. Recent studies have also associated chronic arsenic exposure through drinking water with a number of other serious health effects, including developmental defects, stillbirth, and spontaneous abortion as well as heart attacks, strokes, diabetes mellitus, and high blood pressure. Arsenic can also cause liver damage, nerve damage, and skin abnormalities (e.g., discoloration and unusual growths, which may eventually turn cancerous). Poor nutrition may play a contributing role in arsenic's most serious health effects, and some effects may take years to develop. The International Agency for Research on Cancer has classified arsenic as a carcinogen since 1980, and, in 1987, arsenic was one of the first chemicals placed on California's Proposition 65 list of chemicals known to cause cancer or reproductive harm (OEHHA 2003).

OEHHA proposed a Public Health Goal of 4 ppt (parts per trillion) for arsenic in drinking water based upon human studies of hundreds of thousands of patients in Taiwan, Chile, and Argentina with lung and bladder cancer caused by arsenic-contaminated drinking water. Exposure to arsenic at this level in drinking water results in a risk of less than one additional case of these forms of cancer in a population of one million people drinking two liters daily of the water for 70 years. While the Public Health Goal is based primarily on data from cancer studies, no other adverse health effects are expected to arise from arsenic at the level of the proposed Public Health Goal (OEHHA 2003). The Public Health Goal was formally adopted in 2005.

Existing California and EPA Maximum Contaminant Levels of arsenic in drinking water are 10 ppb.

3.1.6.5 Iron

Iron occurs as a natural constituent in plants and animals. Liver, kidney, fish, and green vegetables contain 20–150 mg/kg, whereas red meats and egg yolks contain 10–20 mg/kg. Rice and many fruits and vegetables have low iron contents (1–10 mg/kg). Reported daily intakes of iron in food—the major source of exposure—range from 10 to 14 mg/day. Drinking water containing 0.3 ppm (300 ppb) would contribute about 0.6 mg to the daily intake. Intake of iron from air is about 25 micrograms/day in urban areas (World Health Organization 2003b).

Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg/day (World Health Organization 2003b).

Taste is not usually noticeable at iron concentrations below 0.3 ppm, although turbidity and color may develop in piped systems at levels above 0.05–0.1 ppm. Laundry will stain at iron concentrations above 0.3 ppm (World Health Organization 2003b).

Due to the low level of toxicity of iron and its role as an essential nutrient, neither the EPA nor California has established a health-based standard for drinking water. However, the EPA and California adopted secondary Maximum Contaminant Levels of 300 ppb (0.3 ppm) for taste and appearance reasons.

3.1.6.6 Manganese

Manganese is an essential nutrient for humans and animals. Adverse health effects can be caused by inadequate intake or over exposure. Manganese deficiency in humans is thought to be rare because manganese is present in many common foods. The greatest exposure to manganese is usually from food. Adults consume between 0.7 and 10.9 mg/day in the diet, with even higher intakes being associated with vegetarian diets (U.S. Environmental Protection Agency 2004).

Manganese intake from drinking water is normally substantially lower than intake from food. At the median drinking water level of 10 ppb determined in the National Inorganic and Radionuclide Survey (NIRS), the intake of manganese from drinking water would be 20 μg/day for an adult, assuming a daily water intake of 2 liters. Exposure to manganese from air is generally several orders of magnitude less than that from the diet, typically around 0.04 nanograms per day (ng/day) on average, although this can vary substantially depending on proximity to a manganese source (U.S. Environmental Protection Agency 2004).

Although manganese is an essential nutrient at low doses, chronic exposure to high doses may be harmful. The health effects from over-exposure of manganese are dependent on the route of exposure, the chemical form, the age at exposure, and an individual's nutritional status. There are no studies that associated exposure to elevated inorganic manganese with cancer in humans. Cancer studies in animals have provided equivocal results. Therefore, there are little data to suggest that inorganic manganese is carcinogenic (EPA 2004).

The most common health problems in workers exposed to high levels of manganese (through inhalation) involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. This combination of symptoms when sufficiently severe is referred to as "manganism." Other less severe nervous system effects, such as slowed hand movements, have been observed in some workers exposed to lower concentrations in the work place. The inhalation of a large quantity of dust or fumes containing manganese may cause irritation of the lungs which could lead to pneumonia. Loss of sex drive and sperm damage has also been observed in men exposed to high levels of manganese in workplace air. The manganese concentrations that cause effects, such as slowed hand movements in some workers, are approximately twenty thousand times higher than the concentrations normally found in the environment. Manganism has been found in some workers exposed to manganese concentrations about a million times higher than normal air concentration of manganese (U.S. Department of Health and Human Services 2012).

Studies in children have suggested that extremely high levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember. In some cases, these same manganese exposure levels have been suspected of causing severe symptoms of manganism disease (including difficulty with speech and walking). It is not known for certain that these changes were caused by manganese alone or if these changes are temporary or permanent. It is also not known whether children are more sensitive than adults to the effects of manganese, but there is some indication from experiments in laboratory animals that they may be (U.S. Department of Health and Human Services 2012).

Studies of manganese in workers have not found increases in birth defects or low birth weight in their children. No birth defects were observed in animals exposed to manganese. In one human study where people were exposed to very high levels of manganese from drinking water, infants less than 1 year of age died at an unusually high rate. However, it is not clear whether these deaths were attributable to the manganese level of the drinking water. The manganese toxicity may have involved exposures to the infant that occurred both before (through the mother) and after they were born (U.S. Department of Health and Human Services 2012).

~~Due to the low level of toxicity of manganese and its role as an essential nutrient, n~~Niether the EPA nor California has established a health-based standard for manganese in drinking water. However, the EPA and California have both adopted secondary Maximum Contaminant Levels of 50 ppb (0.05 ppm) ~~for~~to address aesthetic considerations such as taste and staining~~ reasons~~. Secondary drinking water standards may apply to any contaminant in drinking water that may adversely affect the taste, odor or appearance of the water. However, as noted above, manganese at higher levels can have toxic effects. The EPA~~'s~~ has a lifetime health advisory ~~level, which is advisory in nature, is~~ for water of 300 ppb (0.3 ppm) for water and an acute 10-day health advisory of 1,000 ppb (1 ppm)(U.S. Department of Health and Human Services 2012)~~which is substantially higher than the secondary Maximum Contaminant Level~~.

3.1.6.7 Uranium and Alpha Radiation

The health effects of uranium in drinking water are chronic rather than acute. Uranium is a weak chemical poison than can cause kidney damage when ingested continuously over time. This damage is dosage dependent and somewhat reversible. The uranium ion (uranyl) can also deposit on bone surfaces and may be detected in bone matrix for several years following exposure.

Uranium has been identified as a toxic substance that affects the kidneys by the World Health Organization (WHO), and it is more harmful due to its toxic nature rather than its radioactivity. WHO recommends a uranium concentration drinking water limit of 15 ppb (approximately equivalent to about 10 pCi/L). The federal primary Maximum Contaminant Level for uranium is 30 ppb and the state primary Maximum Contaminant Level is 20 pCi/L (which is approximately equivalent to 30 ppb).

There are no immediate health risks from drinking water that contains alpha radiation. However, it may cause problems over time. Because alpha radiation loses energy rapidly, it does not pass through skin and is not a hazard outside the body. Yet, if an individual eats or drinks something containing alpha radiation or breathes it in, the radiation may be harmful. Over a long period of time, and at elevated levels, radium, and thus alpha radiation, increases one's risk of bone cancer and uranium increases one's risk of kidney damage. In addition, if radon is released into air from groundwater, elevated levels inside a home can be harmful. Actions such as showering, doing laundry, or running the dishwasher can increase radon levels inside a structure. Breathing air with elevated levels of radon over a lifetime increases a person's risk of getting lung cancer (Vermont Department of Health, n.d).

3.1.7 Significance Criteria

The State CEQA Guidelines Appendix G (14 CCR 15000 et seq.) have identified significance criteria to be considered when determining whether a project could have significant effects on existing water resources within the study area. The project significance criteria for this section are based on the criteria in Appendix G of the CEQA guidelines, Section VIII, Hydrology and Water Quality.

For this analysis, an impact pertaining to water resources was considered significant under CEQA if it would result in any of the following general environmental effects compared to existing conditions:

Groundwater Drawdown[10]

Would the project:

- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge, resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?
    - For this project, a significant impact was identified if any of the following were to occur due to –the project:
        - groundwater use by the project were to result or contribute to a regional exceedance of the adjudicated production amounts determined by the Mojave Water Agency for the Centro Area Subarea and thus cause regional aquifer drawdown;
        - groundwater use by the project were to result in localized drawdown of aquifer levels in the Hinkley Valley such that domestic or agricultural wells were to experience water supply shortages and require alternative water supplies; or

[10] CEQA Guidelines, Appendix G, Criteria VIII (b).

- groundwater drawdown caused by the project were to result in permanent aquifer compaction that would substantially alter the physical capacity of the aquifer to store groundwater for domestic and agricultural use.

Water Quality[11]

Would the project:

- Violate any water quality standards or Waste Discharge Requirements or otherwise substantially degrade water quality?

  For this project, a significant water quality impact was identified based on whether *remedial actions*[12] would result in exceedance of the following criteria:

  - **Water Supply Well Impacts (Hexavalent Chromium):** There is no current MCL for hexavalent chromium. For hexavalent chromium, the Public Health Goal has been set at 0.02 ppb indicating the potential for health effects to occur at levels less than the maximum background level (~~currently defined as maximum of~~ 3.1 ppb of Cr[VI]). Because background levels of Cr[VI] are found in the Hinkley Valley at levels above the PHG and it is difficult to establish whether Cr[VI] levels below background levels are due to naturally occurring conditions or due to man-made conditions, the significance criteria is set at the maximum background level. The background level may change depending on further evaluation; if it does, the most recent background level adopted by the Water Board applies.

    - Impacts to water supply wells are considered significant when remedial actions cause concentrations of hexavalent chromium in a water supply well that was previously below maximum background levels to exceed maximum background levels.
    - If water supply wells already contain hexavalent chromium that exceed maximum background levels, and remedial actions cause an increase in concentration by 10% or more, this is also considered significant. The discharger can present evidence to the Water Board if it believes in a specific instance that the increase is not statistically significant.
    - If and when California adopts a MCL for hexavalent chromium, if the MCL exceeds the Hinkley Valley maximum background level, then the maximum background level shall continue to be used as the significance criteria due to the evidence of potential health effects from concentrations above the PHG. Under CEQA, a project impact is only identified when the project causes a physical change in the environment that is in excess of background conditions. If the MCL is less than the Hinkley Valley maximum background level, then the maximum background level shall also continue to be used as the significance criteria ~~because PG&E is only responsible for levels that exceed background levels~~.
    - ~~Because the plume is defined by the maximum background hexavalent chromium level, it is possible that wells may be affected by hexavalent chromium contamination due to~~

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[11] CEQA Guidelines, Appendix G, Criteria VIII (a) and (f).

[12] Impacts associated with the chromium plume itself that are unrelated to the remedial actions are regulated by the Water Board under applicable requirements of state water law. See Chapter 2, *Project Description*, for the chromium cleanup and water replacement requirements related to the chromium plume.

~~remedial action at detectable levels below the maximum background level. Thus,~~ I~~i~~mpacts are also considered significant when remedial actions are determined to cause an increase in concentrations of hexavalent chromium within a water supply well within 1 mile of the defined chromium plume. The Water Board will consider the trend of chromium detections in the water supply well, the duration of the increase, groundwater flow directions, plume dynamics at the time of the change in chromium levels, data on chromium levels in other nearby monitoring or domestic wells, and any other relevant information in making a determination whether the increase is or is not related to remedial actions. This criterion is ~~also~~ designed to address the potential for wells to become affected in a short period of time (i.e., a matter of months) after detection of increased ~~hexavalent chromium~~ Cr[VI] levels in groundwater nearby that are believed to be due to remedial actions. This criterion is to provide an adequate buffer around the chromium plume during remediation in order to avoid the potential for remedial actions to result in rapid changes in chromium levels in adjacent domestic wells.

- **Water Supply Well Impacts (Total Chromium):** The existing California MCL for total chromium of 50 ppb is not used as a significance criterion for this EIR because (1) the ratio of hexavalent to total chromium in the Hinkley Valley is high (PG&E's groundwater monitoring report data show that 85 to 100% of the chromium detected in monitoring wells is in the hexavalent form) and (2) the MCL ~~is outdated as it does~~was adopted in 1997 and thus could not consider the more recent health data and information for hexavalent chromium particularly as it concerns oral ingestion routes of exposure; therefore, the MCL for total chromium is not adequately sensitive to determine significant impacts. Instead, the maximum background level for total chromium (currently 3.2 ppb Cr[T]) will be used as a significance criterion.

    - Impacts to water supply wells are considered significant when remedial actions cause concentrations of total chromium in a water supply well that was previously below maximum background levels to exceed maximum background levels.

    - ~~Because the plume is defined by the maximum background total chromium level, it is possible that wells may be affected by chromium contamination due to remedial action at detectable levels below the maximum background level. Thus, impacts~~If water supply wells already contain total chromium that exceed maximum background levels, and remedial actions cause an increase in concentration by 10% or more, this is also considered significant. The discharger can present evidence to the Water Board if it believes the increase in a specific instance is not statistically significant.

    - Impacts are also considered significant when remedial actions cause an increase in concentrations of total chromium within a water supply well within 1 mile of the defined chromium plume. The Water Board will consider the trend of chromium detections in the water supply well, the duration of the increase, groundwater flow directions, plume dynamics at the time of the change in chromium levels, data on chromium levels in other nearby monitoring or domestic wells, and any other relevant information in making a determination whether the increase is or is not related to remedial actions. This criterion is designed to address the potential for wells to become affected in a short period of time (i.e., a matter of months) after detection of increased Cr[T] levels in groundwater nearby that are believed to be due to remedial actions. This criterion provides an adequate buffer around the chromium plume during remediation in order to avoid the potential for remedial actions to result in rapid changes in chromium levels in adjacent domestic wells.

- **Water Supply Well Impacts (Remediation Byproducts: Arsenic, Nitrate, Uranium, Other Radionuclides).** The following are considered significant:
  - If a water supply well has concentrations of these remediation byproducts that are currently less than a California primary Maximum Contaminant Level (see Table 3.1-3) and remedial actions cause the concentrations of one or more of these constituents to exceed~~ed~~ these standards in a water supply well.
  - If a water supply well has concentrations of these remediation byproducts that currently exceed a California primary Maximum Contaminant Level (see Table 3.1-3), then a 10% increase above current levels in a water supply well is considered significant~~ (unless it can be demonstrated that an increase is statistically significant at a different level)~~. This criterion is set to address the significance threshold of substantial degradation to water quality, and the 10% increase level is set conservatively to recognize the known and recognized health risks associated with these constituents in drinking water. The discharger can present evidence to the Water Board if it believes the increase in a specific instance is not statistically significant.
  - If a water supply well has concentrations of these remediation byproducts that are currently less than a California primary Maximum Contaminant Level (see Table 3.1-3) then a 20% increase above current contaminant levels in a water supply well is considered significant~~ (unless it can be demonstrated that an increase is statistically significant at a different level)~~. This criterion is set to address the significance threshold of substantial degradation to water quality, and the 20% increase level is set to comply with the State Board Resolution 68-16 and the ~~Nondegradation~~Anti-degradation Objective (Lahontan Basin Plan 1996~~ at~~, p. 3-14). The ~~Nondegradation~~Anti-degradation Objective is an integral part of the water quality objectives contained in the Lahontan Basin Plan, and provides that where the existing quality of water is better than that needed to protect all beneficial uses, that existing high quality is an appropriate goal to be maintained. The discharger can present evidence to the Water Board if it believes the increase in a specific instance is not statistically significant.
  - Due to the inability to have 100 percent barrier monitoring network, the mobility of these constituents in groundwater, fluctuations in concentrations in groundwater, and the need for precaution, it is also considered a significant impact when any of the above conditions are found in monitoring wells within one-half mile upgradient or one quarter-mile cross gradient of a water supply well. This criterion is designed to ~~address~~provide an adequate buffer around a water supply well during remediation in order to avoid the potential for wells to become affected in a short (i.e. a matter of months) period of time after detection of these byproducts ~~nearby.~~in adjacent monitoring wells. These distances from monitoring wells (one-half mile upgradient or one quarter-mile cross gradient of a water supply well) are based on the evidence to date of the migration and migration rates of these different constituents.
- **Water Supply Well Impacts (Remediation Byproducts: TDS, Iron, and Manganese).** The following are considered significant:

- If a water supply well has concentrations of these remediation byproducts that are currently less than a Federal or California secondary Maximum Contaminant Level (see Table 3.1-3) or water quality objectives (see Table 3.1-4) and remedial actions causes the concentrations in a water supply well to exceed these standards.

- If ~~remediation byproduct levels in~~ a water supply well has concentrations of these remediation byproducts that currently exceed a Federal or California secondary Maximum Contaminant Level (see Table 3.1-3) or water quality objective (see Table 3.1-4), then a 20% increase above current levels in a water supply well is considered significant ~~(unless it can be demonstrated that an increase is statistically significant at a different level)~~. This criterion is set to address the significance threshold of substantial degradation to water quality. The criterion is set at 20% increase because there are no primary MCLs for these contaminants, only Secondary MCLs. Secondary MCLs are based on taste, odor, and visual thresholds rather than on adverse health effects, and so a higher significance threshold is appropriate. The discharger can present evidence to the Water Board if it believes the increase in a specific instance is not statistically significant.

- If remediation byproduct levels are currently less than a Federal or California secondary Maximum Contaminant Level (see Table 3.1-3) or water quality objective (see Table 3.1-4), then a 20% increase above current levels in a water supply well is considered significant ~~(unless it can be demonstrated that an increase is statistically significant at a different level)~~. This criterion is set to address the significance threshold of substantial degradation to water quality, and the 20% increase level is set to comply with the State Board Resolution 68-16 and the ~~Nondegradation~~Anti-degradation Objective (Lahontan Basin Plan 1996, ~~at~~ p. 3-14). The ~~Nondegradation~~Anti-Degradation Objective is an integral part of the water quality objectives contained in the Lahontan Basin Plan, and provides that where the existing quality of water is better than that needed to protect all beneficial uses, that existing high quality is an appropriate goal to be maintained. The discharger can present evidence to the Water Board if it believes in a specific instance that the increase is not statistically significant.

- Due to the inability to have a 100 percent barrier monitoring network, the mobility of these constituents in groundwater, fluctuations in concentrations in groundwater, and the need for precaution, it is also considered a significant impact when any of the above conditions are found within a monitoring well within one-half mile upgradient or one-quarter mile cross gradient of a water supply well. This criterion is designed to ~~address~~provide an adequate buffer around a water supply well during remediation in order to avoid the potential for wells to become affected in a short (i.e. a matter of months) period of time after detection of these byproducts ~~nearby~~in adjacent monitoring wells.

○ **Aquifer Impact (Remediation Byproducts, Drawdown Byproducts, Other Chemicals or Compounds Detected):** The following are considered significant:

- Remedial actions result in groundwater concentrations that will exceed California primary or secondary Maximum Contaminant Level (see Table 3.1-3) or water quality objectives (see Table 3.1-4) after completion of chromium plume remediation for any constituent used or created during the course of remedial actions and that prevents beneficial uses of the aquifer after completion of the proposed project.

- If baselinepre-remedial reference groundwater conditions already exceed California primary or secondary Maximum Contaminant Levels (see Table 3.1-3) and remedial action will resulted in water quality levels greater than baselinereference levels after completion of chromium plume remediation.

Drainage[13]

For this project, a significant drainage impact was identified based on whether remedial actions would:

- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial or potentially substantial erosion or siltation onsite or offsite;
- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase, or have the potential to substantially increase the rate or amount of surface runoff in a manner that would result in flooding onsite or offsite; or
- create or contribute, or potentially create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?.

Flooding[14]

For this project, a significant flooding impact was identified based on whether remedial actions would:

- place housing within a 100-year flood hazard area, as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map;
- place within a 100-year flood hazard area structures that would impede or redirect floodflows;
- expose people or structures to a significant or potentially significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam; or
- contribute to inundation by seiche, tsunami, or mudflow.

3.1.8 Impacts

This section describes the impact analysis relating to groundwater quantity and quality for the project alternatives. It describes the methods used to determine the impacts of the project alternatives and relates the impact analysis to the thresholds (as defined by the significance criteria above) to conclude whether an impact would be significant. Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant impacts accompany each impact discussion. Several of the mitigation measures include monitoring with adaptive control measures.

[13] CEQA Guidelines, Appendix G, Criteria VIII (c), (d) and (e).

[14] CEQA Guidelines, Appendix G, Criteria VIII (g), (h), (i) and (j).

This impact analysis compares all project alternatives to existing conditions, which is the CEQA baseline. This section provides a general summary of the potential impacts, detailed impact analysis by alternative, and mitigation measures.

Mitigation measures are referenced in text where appropriate and are described in Section 3.1.9.

3.1.8.1 Groundwater Drawdown Impacts

This section discusses impacts to groundwater quantity due to remedial action including potential effects on the regional water supply, local water supply, and aquifer compaction due to groundwater drawdown. Water quality impacts to groundwater are discussed separately in the next section, 3.1.8.2, Water Quality.

Impacts related to the groundwater drawdown (overdraft) are analyzed in three different ways:

- *Regional Water Supply*: Evaluation of impacts on regional water supplies within the Mojave Basin Centro Subarea
- *Local Water Supply:* Evaluation of local water supplies (i.e., private domestic and agricultural wells) within the study area based on PG&E groundwater drawdown modeling results, surface elevations, current groundwater elevations, and wetted well screen depths of private domestic and agricultural wells
- *Aquifer Compaction:* Evaluation of potential physical aquifer impacts (i.e., compaction or subsidence) due to groundwater drawdown, based on studies conducted in the Mojave Desert and Hinkley Valley aquifer characteristics (i.e., depth and composition).

Impact WTR-1a: Groundwater Drawdown Effects on the Regional Water Supply (Mojave River Basin, Centro Subarea) (Less than Significant, No Project Alternative; Less than Significant with Mitigation, All Action Alternatives)

Methodology

Groundwater drawdown could affect regional water supplies in the Centro Subarea of the Mojave River Basin. The Mojave Water Agency oversees the Mojave River Basin Adjudication, which allocates an annual allowance called the Free Production Allowance (FPA or allowance) to each water user within a designated subarea that participated in the adjudication. Groundwater drawdown effects on the Centro Subarea were evaluated by determining the amount of agricultural treatment pumping necessary for the project alternatives and comparing it to the amount of Free Production Allowance held by PG&E at present. This impact is deemed significant if PG&E's projected annual water use (or production) exceeds their annual allowance; however, the impact can be mitigated if PG&E increases their allowance by acquiring water rights through purchase or transfer.

The feasibility of mitigation was evaluated by determining what recent groundwater production rates have been in the Centro Subarea and whether or not there is available surplus that could be purchased by PG&E if they do not possess adequate water rights.

Localized groundwater drawdown effects on wells in the Hinkley Valley are evaluated separately below under Impact WTR-1b.

Overview of Impacts

As described above under 3.1.3.3, *Local Regulations, Mojave River Basin Adjudication*, in the Centro subarea, verified production has been less than the Free Production Allowance and less than the sustainable yield since ~~1993~~1996. In the last five years, production has been less than the Free Production Allowance by approximately 14,329 afy and less than the Production Safe Yield by 8,182 afy.

Total annual agricultural treatment pumping volumes for each of the alternatives were estimated for the average annual agricultural treatment pumping rates (estimated assuming up to 15% plume growth beyond the Q4/2011 plume for the purposes of the EIR) with the exception of that for the No Project Alternative, which is based on current pumping rates. The expected agricultural treatment pumping volumes are shown in Table 3.1-7 below.

Total agricultural treatment pumping quantities for each alternative were compared to PG&E's current Free Production Allowance. As noted above, PG&E currently owns 2,429 afy of water rights and has a current Free Production Allowance of 1,944 afy. Although this analysis is conducted based on the current water rights, recent property purchases are likely to gain an additional 729 afy for a total of 3,158 afy (which would increase their Free Production Allowance to 2,526 afy). In order to comply with the Basin Adjudication, PG&E will have to acquire additional water rights in order to maintain the flows estimated in Table 3.1-7. Since there has been a consistent surplus over the Free Production Allowance and the Production Safe Yield that is greater than the maximum amount of water use in Table 3.1-7, there is adequate unused allowance available that PG&E could acquire to achieve the pumping volumes for any of the alternatives.

It is feasible to acquire water rights from other owners. A recent example is the recent large-scale acquisition of water rights and allowances to support new projects. The Abengoa Solar project (now Mojave Solar project) near Lockhart in the Harper Lake Valley acquired water rights of primarily former agricultural land in the amount of approximately 10,500 afy (Free Production Allowance of 8,400 afy).

If PG&E acquires unused allowances through outright purchase or yearly transfer, then this would not result in any displacement of other land uses in the Centro subarea. However, if PG&E were to acquire allowances in use, such as for current agricultural use, then the acquisition could result in possible abandonment or displacement of the current supported land use. This potential land use impact is discussed in Section 3.2, *Land Use, Agriculture, Population, and Housing*.

No Project Alternative: Effects on Regional Water Supply

The No Project Alternative would involve continued implementation of plume containment and reduction of the Cr[VI] plume concentrations. The primary differences between the No Project Alternative and existing conditions are increased in-situ remediation and associated infrastructure and activities. The No Project Alternative would not increase agricultural extractions and irrigation above existing conditions and would thus not result in increased drawdown of the aquifer compared to late 2011 conditions when these analyses were considered.

Table 3.1-7. Annual Agricultural Treatment Pumping Amounts Compared to PG&E's Current Mojave Basin Adjudication Free Production Allowance

Alternative	Average Annual Agricultural Treatment Units Pumping Flow (gpm)	Total Annual Agricultural Treatment Units Pumping Volume (afy)[a]	Volume of Pumping Above PG&E's Current FPA (1,944 afy)
No Project	1,100	1,774	Flow is below FPA
Alternative 4B	2,395	3,863	1,919
Alternative 4C-2	3,167	5,109	3,165
Alternative 4C-3	4,388	7,078	5,134
Alternative 4C-4	4,388	7,078	5,134
Alternative 4C-5	3,167	5,109	3,165

Key:
afy: Acre-feet per year
FPA: Free Production Allowance
Notes:
[a] Total annual agricultural treatment pumping rates are scaled according to methodology described in Chapter 2, with the exception of the No Project Alternative, which is based on continued implementation of existing pumping rates.

As shown in Table 3.1-7, pumping rates for the No Project Alternative are within PG&E's allowance, and thus are not expected to contribute to regional groundwater drawdown. In addition, extraction is designed such that existing private wells do not experience a decrease in water level that results in a loss of yield for existing or potential beneficial uses. Given the apparent surplus in groundwater conditions within the Centro Subarea, and the fact that the remediation will extract groundwater within PG&E's allowance, approved remedial activities would not deplete groundwater supplies in the project vicinity. Therefore, the No Project Alternative will have no impact on regional groundwater supplies compared to existing conditions.

Alternative 4B: Effects on Regional Water Supply

Agricultural treatment water use would be greater under Alternative 4B (up to 3,863 acre-feet per year) than existing conditions (1,774 afy) because summer pumping for agricultural treatment would increase in proportion to the increased irrigated acreage for agricultural treatment. On a regional scale, the total pumping by PG&E from the Hinkley Valley aquifer with Alternative 4B would be greater than PG&E's current allowance under the Mojave River Basin Adjudication (Table 3.1-7).

In order to implement this alternative and comply with the Basin Adjudication, PG&E must acquire sufficient water rights to allow the proposed water use with agricultural treatment. As noted above, there is a present surplus above the regional Free Production Allowance, indicating it is feasible to acquire additional water rights while avoiding regional drawdown. Provided PG&E keeps its overall water use within the assigned allowances from the Mojave Water Agency, the project will not impair the Production Safe Yield of the Centro Subarea overall. PG&E will be required to demonstrate to the Water Board that it has acquired the necessary water rights before ramping up agricultural treatment (per **Mitigation Measure WTR-MM-1**). Therefore, impacts associated with this alternative would be less than significant with the implementation of **Mitigation Measure WTR-MM-1**.

Alternative 4C-2: Effects on Regional Water Supply

Alternative 4C-2 would include additional agricultural treatment water use (up to 5,109 afy) compared to existing conditions (1,774 afy). It involves similar components to Alternative 4B, with the exception of increased number of agricultural treatment units and year-round operation of agricultural treatment, through the addition of winter crops (winter rye or similar crop) to most of the existing and new agricultural treatment units.

Due to increased agricultural treatment activities, particularly during the winter months, Alternative 4C-2 would result in greatly increased annual groundwater extraction rates compared to existing conditions.

As shown in Table 3.1-7, annual agricultural treatment pumping volumes would be greater under Alternative 4C-2 than PG&E's current allowance by 3,165 afy. The implementation of **Mitigation Measure WTR-MM-1** (PG&E water right purchase) would reduce this impact to less than significant.

Alternative 4C-3: Effects on Regional Water Supply

Alternative 4C-3 involves~~has~~ similar components as Alternative 4C-2, but has substantially greater agricultural treatment water use ~~as Alternative 4C-2 and substantially greater~~ (7,078 afy) ~~use~~ compared to Alternative 4C-2 (up to 5,109 afy) and to existing conditions (up to 1,774 afy).

Above-ground treatment would return treated water to the aquifer via injection wells and would thus have no effect on groundwater levels unless the point of reinjection was substantially different from the point of extraction. ~~However, this would likely not have a significant impact on regional groundwater drawdown compared to agricultural treatment activities.~~

As shown in Table 3.1-7 annual agricultural treatment pumping volumes would be greater under Alternative 4C-3 than PG&E's current allowance by 5,134 afy. The implementation of **Mitigation Measure WTR-MM-1** (PG&E water rights purchases) would reduce this impact to less than significant.

Alternative 4C-4: Effects on Regional Water Supply

This alternative involves similar components as Alternative 4C-2, with the exception of a large increase in agricultural treatment. Alternative 4C-4 would have substantially higher agricultural treatment water use (up to 7,078 afy) than existing conditions (1,774 afy) and the same water volume use as Alternative~~s~~ 4C-3.

As shown in Table 3.1-7, annual agricultural treatment pumping volumes would be much greater under Alternative 4C-4, by 5,134 afy, than PG&E's current allowance. The implementation of **Mitigation Measure WTR-MM-1** (PG&E water rights purchases) would reduce this impact to less than significant.

Alternative 4C-5: Effects on Regional Water Supply

This alternative involves more agricultural treatment flows than Alternative 4B, the same agricultural treatment flows as Alternative 4C-2, but less than Alternatives 4C-3 and 4C-4. Alternative 4C-5 would have substantially higher agricultural treatment water use (up to 5,109 afy) than existing conditions (1,774 afy).

Similar to Alternative 4C-3, this alternative involves above-ground treatment that would ~~return~~ reinject treated water to the aquifer and would thus have no effect on groundwater levels unless the point of reinjection was substantially different from the point of extraction. Overall, Alternative 4C-5 would have less of a significant impact on regional groundwater drawdown compared to Alternatives 4C-3 and 4C-4 but the same significant impact as Alternative 4C-2.

As shown in Table 3.1-7, annual agricultural treatment pumping volumes would be greater under Alternative 4C-5 than PG&E current allowance by 3,165 afy. The implementation of **Mitigation Measure WTR-MM-1** (PG&E water rights purchases) would reduce this impact to less than significant.

Impact WTR-1b: Groundwater Drawdown Effects on the Local Water Supply (Hinkley Valley Aquifer) (Less than Significant, No Project Alternative; Less than Significant with Mitigation, All Action Alternatives)

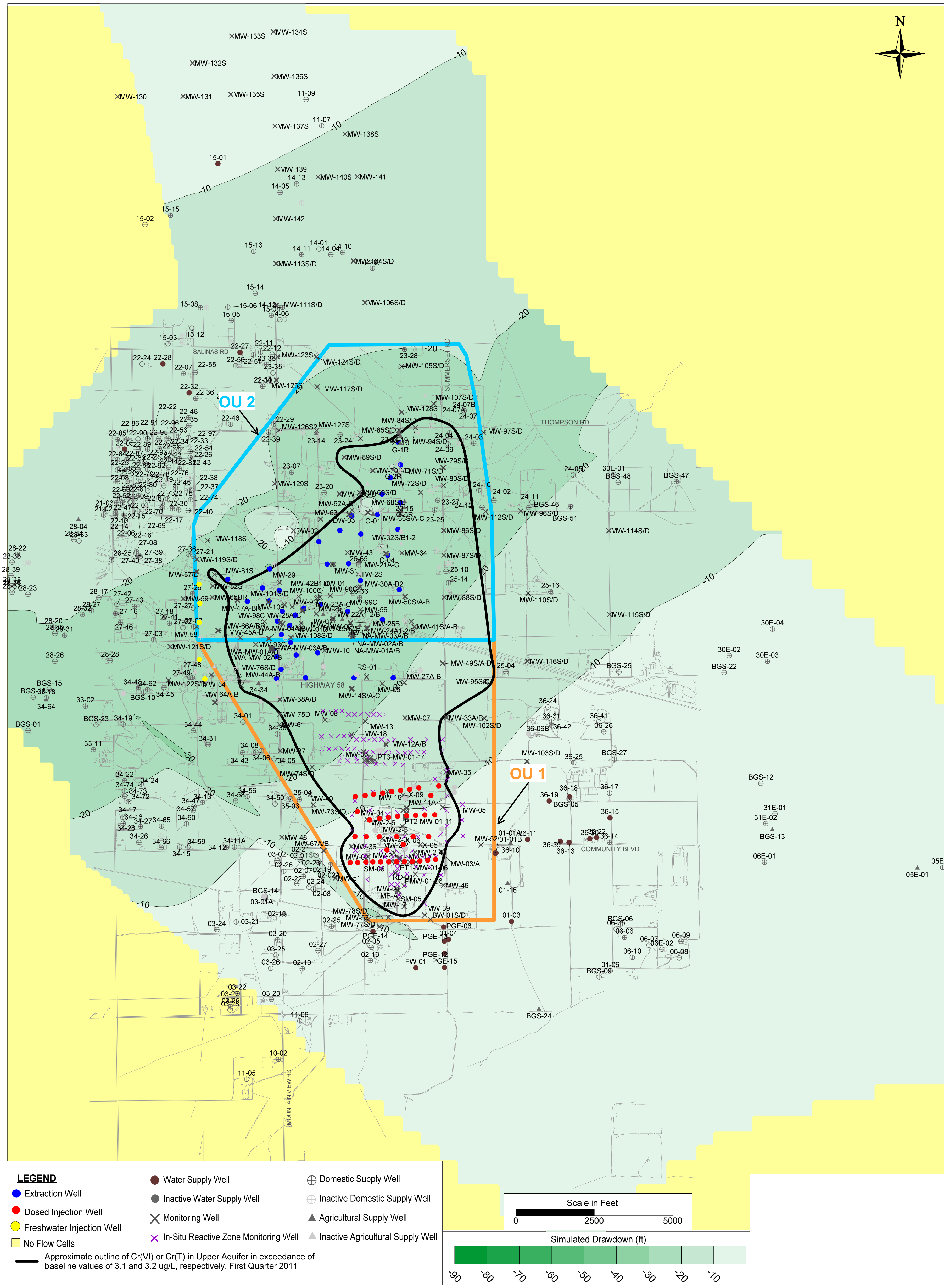
Methodology

Impacts of project alternatives on groundwater drawdown within the localized area of Hinkley Valley were evaluated using the following data:

- PG&E's groundwater drawdown modeling results;
- existing surface elevations for the study area;
- existing groundwater elevations for the study area; and
- wetted screen depths for water supply wells.

Potential effects of regional drawdown on individual private domestic and agricultural wells in the study area were evaluated by comparing wetted well screen depths to forecasted groundwater drawdown depth contours generated by PG&E's groundwater model. This analysis was conducted for the maximum extent of groundwater drawdown forecasted for all the alternatives and thus represents the worse-case scenarios. Results are expressed in the percent of private wells partially (25%–75% of total wetted screen depth) and fully (76%–100% of total wetted screen depth) affected by maximum groundwater drawdown. The analysis was conducted by first determining the following two items:

- **Groundwater drawdown elevations relative to each well.** PG&E's groundwater drawdown model estimated maximum drawdown for Alternatives 4B through 4C-5 using a steady state simulation. The steady state estimates are worst-case scenario predictions, provided to compare maximum potential drawdown among alternatives for the EIR. The exact timeframe for full drawdown is difficult to predict, because there are uncertainties in recharge due to variations in climate (e.g., rainfall and Mojave River flow) and basin management practices.
- **Wetted sScreen depth elevations for each well.** Existing ground surface elevations and groundwater elevations were used as the CEQA baseline for comparison of drawdown depths with the depths and extents of wetted well screens. Wells with a top of wetted screen located within the maximum drawdown depth ~~below the datum~~ were evaluated for potential impacts ~~on water supplies for each alternative~~.

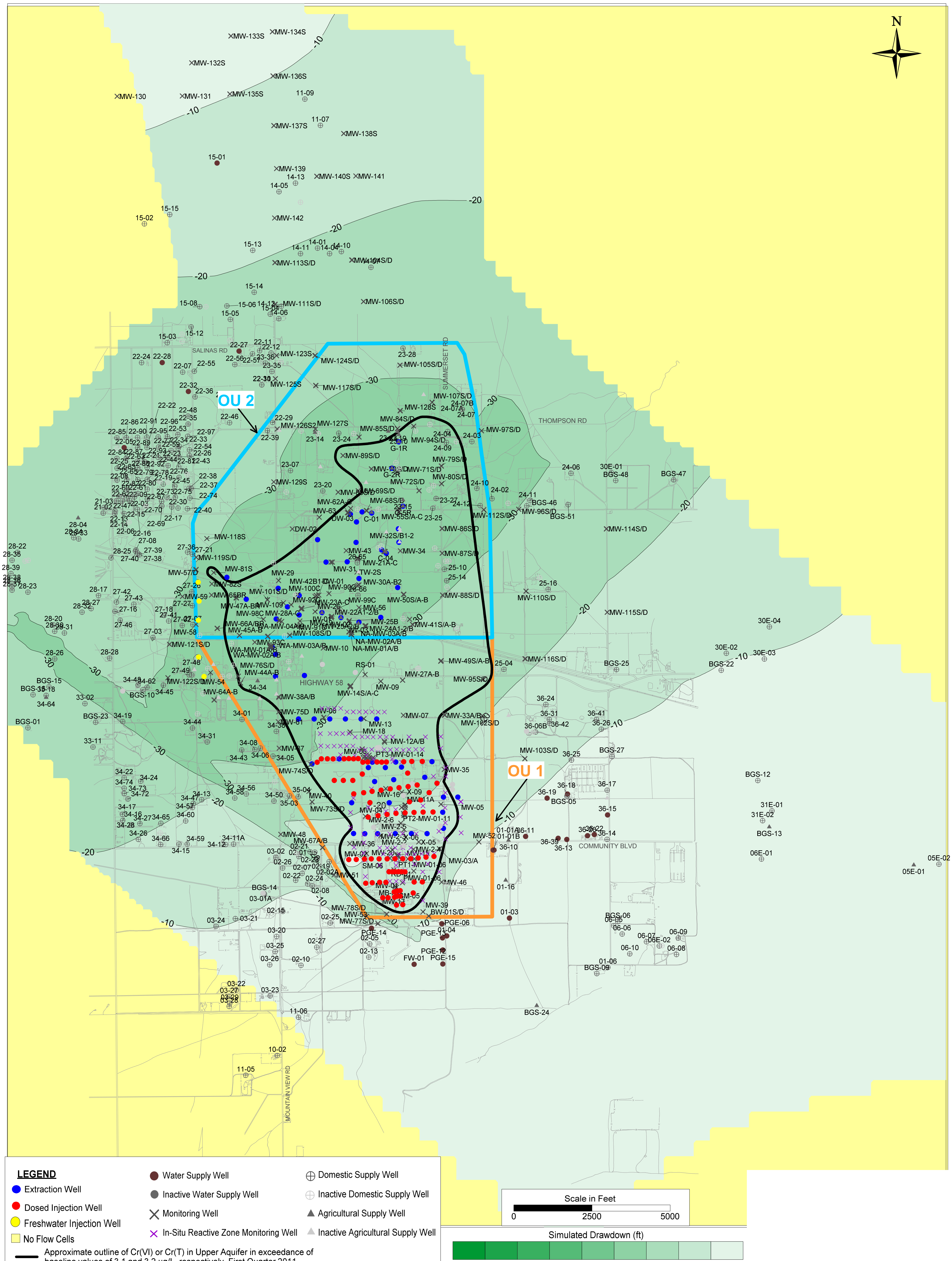


Note: Simulated drawdown shown for extraction rates from the Feasibility Study/Addenda for this alternative. The drawdown amounts shown on the figure are the maximum drawdown levels for the FS/Addenda extraction rates after many years of operations; these levels would likely not be achieved for 10 to 15 years. As described in text, in order to treat the expanded plume area, AU extraction rates will likely exceed FS/Addenda rates and groundwater drawdown may be greater than shown on this figure.

Source: PG&E 2011c.

Graphics ... 00122.11 (3-8-13)

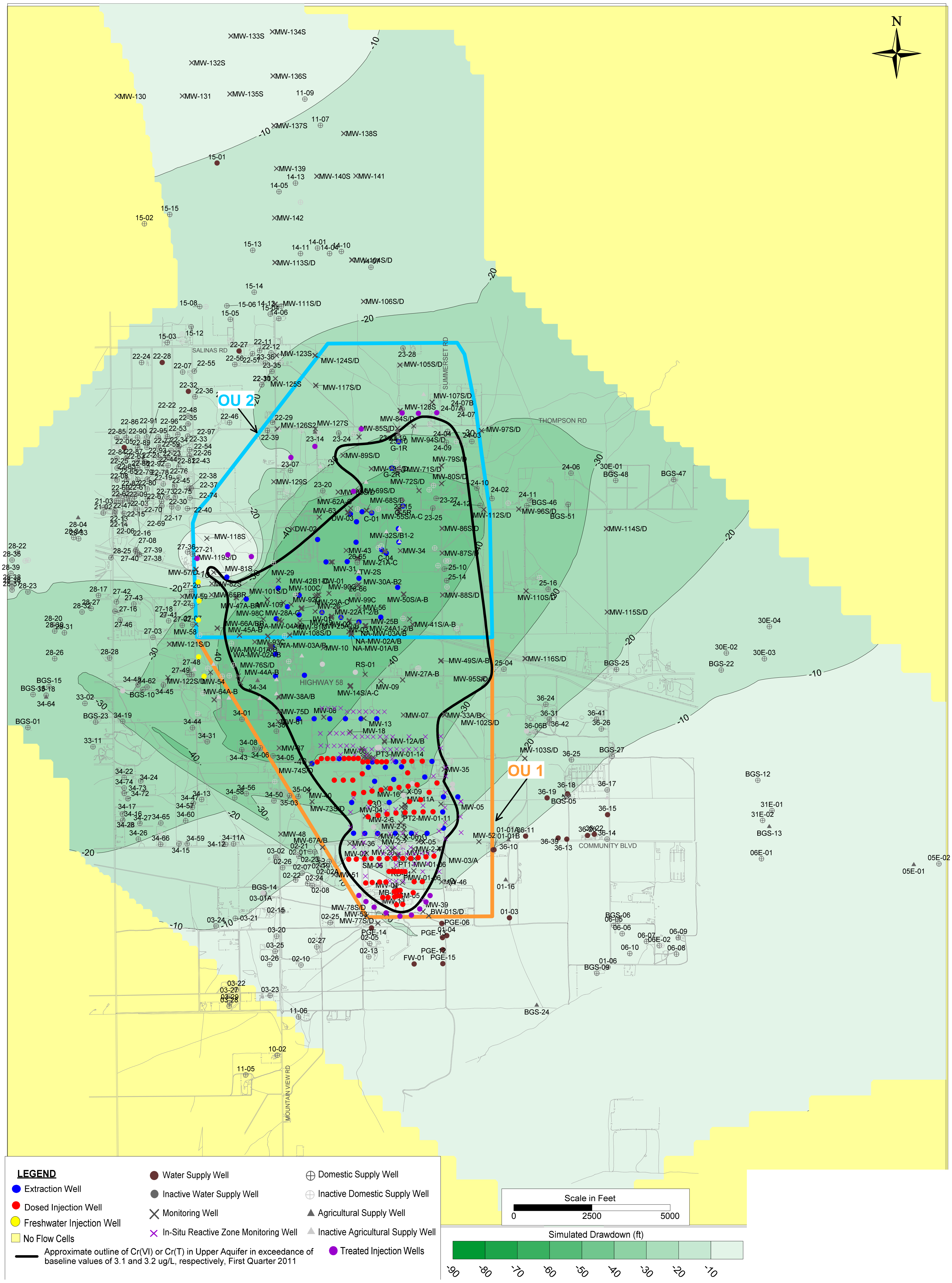
Figure 3.1-14
Simulated Groundwater Drawdown for Alternative 4B



Note: Simulated drawdown shown for extraction rates from the Feasibility Study/Addenda for this alternative. The drawdown amounts shown on the figure are the maximum drawdown levels for the FS/Addenda extraction rates after many years of operations; these levels would likely not be achieved for 10 to 15 years. As described in text, in order to treat the expanded plume area, AU extraction rates will likely exceed FS/Addenda rates and groundwater drawdown may be greater than shown on this figure.

Source: PG&E 2011c.

Figure 3.1-15
Simulated Groundwater Drawdown for Alternative 4C-2

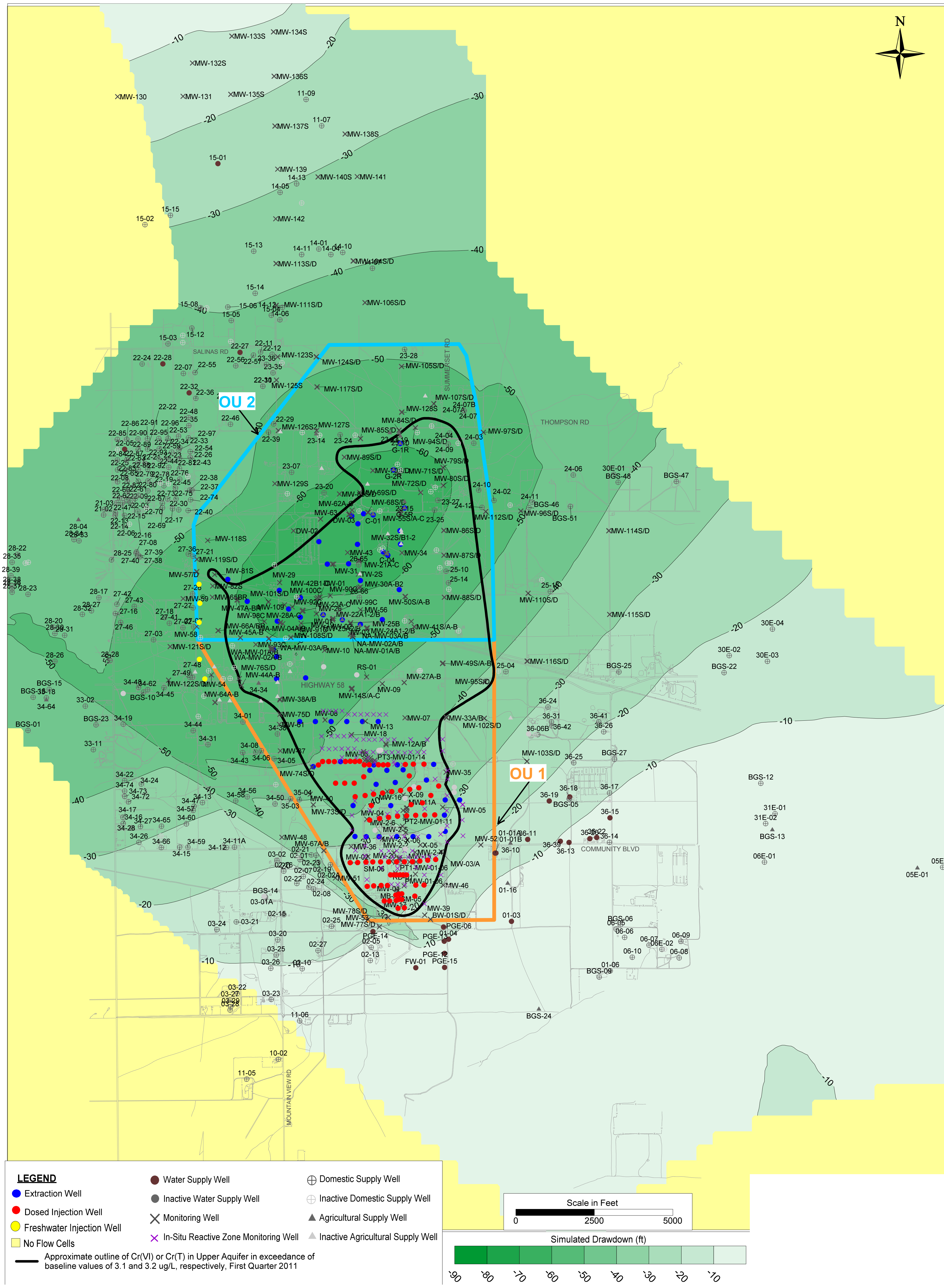


Note: Simulated drawdown shown for extraction rates from the Feasibility Study/Addenda for this alternative. The drawdown amounts shown on the figure are the maximum drawdown levels for the FS/Addenda extraction rates after many years of operations; these levels would likely not be achieved for 10 to 15 years. As described in text, in order to treat the expanded plume area, AU extraction rates will likely exceed FS/Addenda rates and groundwater drawdown may be greater than shown on this figure.

Source: PG&E 2011c.

Graphics ... 00122.11 (3-8-13)

Figure 3.1-16
Simulated Groundwater Drawdown for Alternative 4C-3

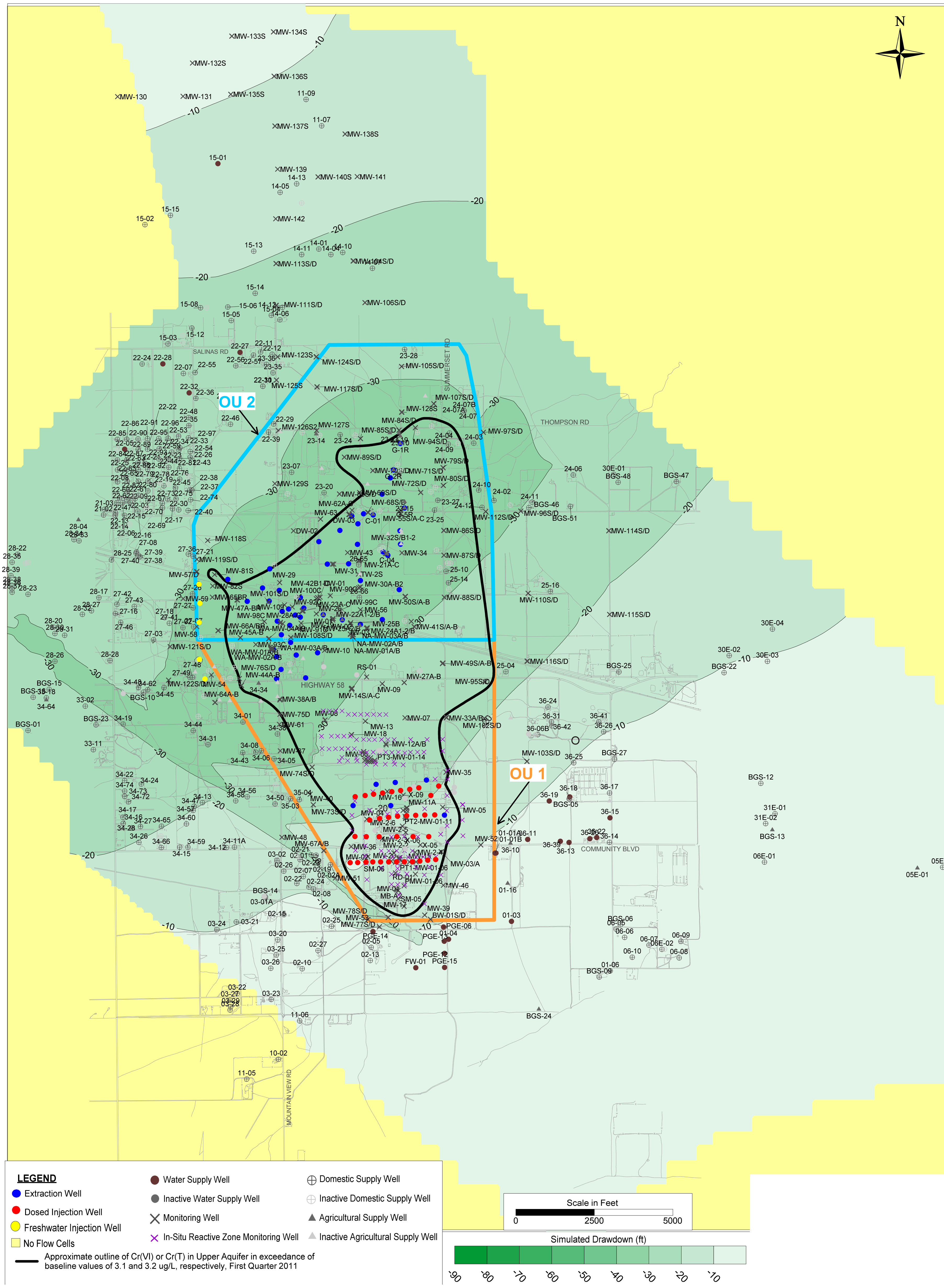


Note: Simulated drawdown shown for extraction rates from the Feasibility Study/Addenda for this alternative. The drawdown amounts shown on the figure are the maximum drawdown levels for the FS/Addenda extraction rates after many years of operations; these levels would likely not be achieved for 10 to 15 years. As described in text, in order to treat the expanded plume area, AU extraction rates will likely exceed FS/Addenda rates and groundwater drawdown may be greater than shown on this figure.

Source: PG&E 2011c.

Graphics ... 00122.11 (3-8-13)

Figure 3.1-17
Simulated Groundwater Drawdown for Alternative 4C-4



Note: Simulated drawdown shown for extraction rates from the Feasibility Study/Addenda for this alternative. The drawdown amounts shown on the figure are the maximum drawdown levels for the FS/Addenda extraction rates after many years of operations; these levels would likely not be achieved for 10 to 15 years. As described in text, in order to treat the expanded plume area, AU extraction rates will likely exceed FS/Addenda rates and groundwater drawdown may be greater than shown on this figure.

Source: PG&E 2011c.

Graphics 00122.11 (3-8-13)

Figure 3.1-18
Simulated Groundwater Drawdown for Alternative 4C-5

Overview of Impacts

As shown in Table 3.1-7, the magnitude of groundwater use of the upper aquifer in the study area increases with increasing agricultural treatment units pumping rates. The extent of groundwater drawdown for each alternative is shown in Figures 3.1-14 through 3.1-18. These drawdown estimates are for the flows included in the Feasibility Study/Addenda which are 55 to 90% less than the scaled flows estimated for the expanded plume. The No Project Alternative would have no increased drawdown over existing conditions as extraction rates would not increase.

Table 3.1-8. Maximum Localized Groundwater Drawdown in the Hinkley Valley Alternative

Alternative	Maximum Drawdown at Feasibility Study flows (feet below water existing GW elevation)~~[b]~~[a]	Maximum Drawdown at Scaled Flows (feet below water existing GW elevation)[b]	Estimated Time to Reach Maximum Drawdown Predicted by Steady State Model (years)
No Project	--	--	--
Alternative 4B	32	50–70	10–15
Alternative 4C-2	40	50–70	10–15
Alternative 4C-3	50	60–80	10–15
Alternative 4C-4	69	70–100+	15–25
Alternative 4C-5	39	50–70	10–15

Notes:

[a] Based on Feasibility Study pumping rates, which do not account for the expanded plume.

[b] Based on scaled pumping rates identified in Table 3.1-~~6~~7 and roughly estimated using drawdown analysis for the Feasibility Study. It is unknown if the scaled flows for Alternatives 4C-3 and 4C-4 can be sustained, thus these levels may overstate the impact. In addition, extraction points are likely to be distributed throughout the plume rather than put in one central area which may lessen some of the drawdown effects predicted by the scaling analysis.

GW = Groundwater

The modeling results indicate increasing magnitude and extent of drawdown as pumping rates are increased from Alternative 4B through 4C-2, 4C-3, and 4C-4 (4C-5 is similar to 4C-2). In all likelihood, the maximum extent of drawdown for Alternatives 4C-3 and 4C-5 would not occur since treated groundwater in above-ground treatment facilities would return nearly 100% of extracted groundwater to the aquifer, unlike agricultural activities which return on average only 30% of extracted groundwater to the aquifer.

Continuous pumping for alternatives 4C-3 and 4C-4 were evaluated with constant pumping rates, consistent with how the alternatives were developed for Addendum #3 of the Feasibility Study. In practice, continuous pumping scenarios such as 4C-3 and 4C-4 would not likely be run at the modeled extraction rates over long timeframes. As the aquifer would begin to dewater, pumping rates would be adjusted, while maintaining capture. For example, the geologic unit with Cr[VI] in groundwater in the Summerset Road area between MW-87S/D and MW-79S/D, has a saturated thickness of 30 to 40 feet thick (Pacific Gas and Electric 2011g). Maximum drawdown in this area for Alternatives 4C-3 and 4C-4 is predicted to be more than 30 to 40 feet. In implementation, pumping would be optimized and rates would be reduced as the Cr[VI]-impacted layer in this area is drawn down to establish the designed plume capture zone, while minimizing aquifer dewatering. Thus, the analysis in this EIR represents the worst-case drawdown depth scenario ~~that~~and is unlikely to occur.

Potential impacts of drawdown on private domestic and agricultural wells within the study area were evaluated using wetted well screen depth data. Well screen depth data were available for 173 of the 360 domestic and agricultural wells located within the study area. As shown in Table 3.1-9, the number of private wells that are both partially and fully affected by maximum drawdown varies by alternative.

Table 3.1-9. The Number of Existing Private Wells Affected by Drawdown for Each Project Alternative in the Hinkley Valley (Using Feasibility Study Extraction Rates and Available Data)

Alternative	Maximum drawdown based on Feasibility Study Extraction Rates(feet)	Number of Private Wells Partially Affected by maximum groundwater drawdown			Number of Private Wells Fully Affected by maximum groundwater drawdown		
		Water Supply	Agricultural	Domestic	Water Supply	Agricultural	Domestic
No Project	No change	N/A	N/A	N/A	N/A	N/A	N/A
Alternative 4B	32	6	0	75	5	0	10
Alternative 4C-2	40	7	0	94	5	0	14
Alternative 4C-3	50	6	0	82	5	0	12
Alternative 4C-4	~~60~~69	6	1	83	7	0	50
Alternative 4C-5	39	7	0	93	5	0	15

Notes:

Well data was only available for 173 of the 360 domestic and agricultural wells located within the study area included in PG&E's well database as of late 2011. As a result, the actual number of partially or fully affected private wells may differ and may be higher, since the well database only included approximately half of the wells thought to exist in the study area.

Wells "partially" affected were analyzed as 25%~~–~~ to 75% or more of the wetted well screen depth being reduced by drawdown. It was presumed that less than 25% drawdown within ~~a~~the wetted well screen would not result in substantial disruption of well productivity.

Wells "fully" affected were analyzed as 76% to 100% or more of the wetted well screen depth being reduced by drawdown.

Based on Feasibility Study Extraction Rates; As shown in Table 3.1-8, extraction rates may be higher than identified in the Feasibility Study in order to address the expanded plume.

Since well construction data was only available for perhaps half of the wells in the project study area, the number of affected wells could be higher than shown in Table 3.1-9 or have no change following PG&E's 2012 property purchase program. In addition, it is possible that over time there may be new water supply wells installed on occupied or vacant ~~wells~~land that could also be affected by remedial activity-caused drawdown.

The drawdown levels shown above are the projected maximum drawdown based on feasibility study extraction rates. Modeling by PG&E indicates that these maximum drawdown levels could be reached within 10 to 15 years of commencing large-scale groundwater extractions for agricultural treatment and then would stabilize at these levels for as long as groundwater extraction continues at these increased levels. The action alternatives include agricultural treatment for 30 to 50 years to get to 3.1 ppb Cr[VI] and 75 to 95 years to get to 1.2 ppb Cr[VI]. After groundwater extraction for agricultural treatment is ceased, it will take a number of years for groundwater levels to recover to ~~baseline~~pre-remedial reference conditions. The post-project recovery period will depend on climate, precipitation and aquifer recharge events from the Mojave River, and the level of other pumping in the aquifer at the time and is difficult to predict with great accuracy, but recovery could take many years. As such, groundwater drawdown effects could occur for perhaps 75 to 95 years and even longer in a worse-case scenario.

Mitigation will be required to provide alternative water supply for wells that are substantially affected or have the potential to be substantially affected by groundwater drawdown per **Mitigation Measure WTR-MM-2**. A substantial effect is defined as groundwater drawdown that would be more than 25% of the wetted screen depth of any affected well. Alternative water supplies could be derived from deeper wells (below the projected drawdown level), from storage tanks and hauled water, or from water delivered via pipeline from an off-site source, including a community supply. Based on the maximum number of domestic wells affected in Table 3.1-9 (133 domestic wells partially or fully affected for Alternative 4C-4), if all the water had to be provided from an off-site source, and assuming each domestic well needed to supply 0.8 afy, a total of 106 afy could be required. The feasibility study for the alternative water supply required by CAO R6V-2011-0005 described needing a 12 gpm yield to supply 25 residences~~.~~ (PG&E 2012k). The PG&E ~~well~~supply wells south of the Compressor Station ~~being~~ used to provide water for freshwater injection on the west side of plume is providing up to 80 gpm (sufficient to supply over 160 residences), indicating that yields near the Mojave River should be adequate to provide an alternative water supply of community water for all affected residences should an offsite water source be needed. Thus, provision of alternative water supplies is feasible to address this impact.

No Project Alternative: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

Remedial pumping rates for the No Project Alternative would be the same as those for existing conditions and groundwater drawdown would not be increased over existing conditions. However, groundwater extraction at existing remedial wells could result in temporary reductions in local groundwater levels at nearby domestic or agricultural wells that will ultimately be replenished from sources of groundwater recharge.

PG&E is currently required to monitor water levels at several monitoring wells during extraction for remedial purposes, and adjusts pumping rates, as necessary, to maintain beneficial uses. PG&E will continue to employ these measures to address potential temporary groundwater level lowering at nearby water supply wells.

Therefore, the No Project Alternative will not cause significant aquifer drawdown that would adversely local water supply wells.

Alternative 4B: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

The additional pumping for increased agricultural treatment for Alternative 4B could have impacts on individual wells. As shown in Table 3.1-9, the estimated number of private domestic and agricultural wells affected by the maximum groundwater drawdown (32 feet) estimated for Alternative 4B (for feasibility study flows of 1,270 gpm) is 81 (partially affected) and 15 (fully affected), respectively within a 10-15 year period. Without mitigation, such drawdown could disrupt domestic or agricultural supply, forcing construction of deeper wells, use of alternative water supplies, or abandonment of domestic/agricultural activity. As described in Chapter 2, in order to address the expanded plume, groundwater extraction for corrective actions (such as agricultural treatment units) may need to be increased above the Feasibility Study/Addenda amounts. Thus, groundwater drawdown for Alternative 4B may exceed 32 feet over the 10-15 year period due to the estimated scaled extraction rate of up to 2,395 gpm needed. At this rate, the drawdown over that period would likely be somewhere between 50 and 70 feet and the affected wells could be similar to the feasibility study flow effects described below for Alternative 4C-3 and 4C-4.

To address local groundwater drawdown effects, PG&E would provide alternative water supply for wells that are affected by localized drawdown impacts from remedial activities (per **Mitigation Measure WTR-MM-2**)**,** which would reduce impacts to a less than significant level.

Alternative 4C-2: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

As shown in Table 3.1-9, based on feasibility study level flows (2,042 gpm) and estimated drawdown (40 feet) the number of private domestic and agricultural wells affected by the maximum groundwater drawdown estimated for Alternative 4C-2 is 101 (partially affected) and 19 (fully affected), respectively. As described in Chapter 2, in order to address the expanded plume, agricultural treatment units and groundwater extraction may need to be increased above the Feasibility Study/Addenda amounts. Thus, groundwater drawdown for Alternative 4C-2 may exceed 40 feet due to the estimated scaled extraction rate of up to 3,167 gpm. At this rate, the drawdown would likely be somewhere between 50 and 70 feet and the number of affected wells could be similar to that estimated for the feasibility study flows for Alternative 4C-4.

To address local groundwater drawdown effects, PG&E would provide alternative water supply for wells that are affected by localized drawdown impacts from remedial activities (per **Mitigation Measure WTR-MM-2**), which would reduce impacts to a less than significant level.

Alternative 4C-3: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

Similar to the prior Alternatives, Alternative 4C-3 would include increased groundwater extraction for agricultural units, but would also add two above-ground treatments facilities for winter operations to ensure plume capture. As shown in Table 3.1-9, the number of private domestic and agricultural wells partially and fully affected by the maximum groundwater drawdown (50 feet) estimated for Alternative 4C-3 for feasibility study level flows (2,829 gpm) is 88 (partially affected) and 17 (fully affected). As described in Chapter 2, in order to address the expanded plume, agricultural treatment units and associated groundwater extraction may need to be increased above the Feasibility Study/Addenda amounts. Thus, groundwater drawdown for Alternative 4C-3 may exceed 50 feet due to the estimated scaled extraction rate of up to 4,388 gpm needed. At this rate, the drawdown could be somewhere between 60 and 80 feet and the number of affected wells could be similar to that or greater than that estimated for the feasibility study flows for Alternative 4C-4.

Extraction for above-ground treatment will not affect local drawdown because water would be directly injected back into the aquifer.

To address local groundwater drawdown effects, PG&E would provide alternative water supply for wells that are affected by localized drawdown impacts from remedial activities (per **Mitigation Measure WTR-MM-2),** which would reduce impacts to a less than significant level.

Alternative 4C-4: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

As shown in Table 3.1-8, maximum groundwater drawdown for Alternative 4C-4 is greater than all of the other alternatives and significantly greater than for existing conditions. PG&E's groundwater drawdown model results suggest that the proposed pumping rates under Alternative 4C-4 may not be sustainable at all extraction wells, as they may drawdown groundwater levels to the base of the upper aquifer in some locations. If selected, pumping rates would be adjusted to balance flow, plume capture, and drawdown. The actual groundwater pumping rates may need to be adjusted during operation if long-term drawdown reduces sustainable yields from wells.

As shown in Table 3.1-9, the number of private domestic and agricultural wells affected by the maximum groundwater drawdown (69 feet) estimated for Alternative 4C-4 for feasibility study flows (2,829 gpm) is 90 (partially affected) and 57 (fully affected). As described in Chapter 2, in order to address the expanded plume, agricultural treatment units and groundwater extraction may need to be increased above the Feasibility Study/Addenda amounts. Thus, groundwater drawdown for Alternative 4C-4 may exceed 69 feet due to the estimated scaled extraction rate of up to 4,388 gpm needed. At this rate, the drawdown could be greater than 100 feet and the number of affected wells would be higher. As noted above, this level of flow and drawdown may not be sustainable or physically achievable.

To address local groundwater drawdown effects, PG&E would provide alternative water supply for wells that are affected by localized drawdown impacts from remedial activities (per **Mitigation Measure WTR-MM-2**), which would reduce impacts to a less than significant level.

Alternative 4C-5: Aquifer Drawdown Affecting Local Water Supply Wells (Hinkley Valley)

Alternative 4C-5 is similar to Alternative 4C-3, except only one above-ground treatment facility would be used instead of two; and it would operate year-long in the Source Area to remove chromium from the aquifer. The agricultural treatment extraction rates for this alternative would be the same as Alternative 4C-2. As shown in Table 3.1-8, groundwater drawdown for Alternative 4C-5 would be similar to Alternative 4C-2.

As shown in Table 3.1-9, the number of private domestic and agricultural wells affected by the maximum groundwater drawdown (39 feet) estimated for Alternative 4C-5 feasibility study flows (2,042 gpm) is 100 (partially affected) and 20 (fully affected). As described in Chapter 2, in order to address the expanded plume, agricultural treatment units and groundwater extraction may need to be increased above the Feasibility Study/Addenda amounts. Thus, groundwater drawdown for Alternative 4C-5 may exceed 39 feet due to the estimated scaled extraction rate of up to 3,167 gpm. At this rate, the drawdown would likely be somewhere between 50 and 70 feet and the number of affected wells could be similar to that estimated for the feasibility study flows for Alternative 4C-4.

Extraction for above-ground treatment will not affect local drawdown because water would be directly injected back into the aquifer.

To address local groundwater drawdown effects, PG&E would provide alternative water supply for wells that are affected by localized drawdown impacts from remedial activities (per **Mitigation Measure WTR-MM-2**), which would reduce impacts to a less than significant level.

Impact WTR-1c: Groundwater Drawdown Effects on Aquifer Compaction (Less than Significant, ~~No Project Alternative; Potentially Significant, All Action Alternative~~All Alternatives)

Methodology

Aquifer compaction within the Mojave River Groundwater Basin has not been an issue in general where the aquifer is predominantly made up of sand which is less vulnerable to compaction than are smaller particles, such as silt and clay. But where silts and clay ~~occur more often~~dominate in ~~the~~an aquifer~~ with distance from the river~~, compaction may indeed become an issue.

Increased pumping rates for agricultural treatment and above-ground treatment could have long-term effects on the capacity of the aquifer if it lowers groundwater levels and if it results in compaction of the aquifer. Therefore, an evaluation of potential aquifer compaction ~~due to pumping for agricultural treatment~~considering long-term pumping and the vulnerability of aquifer substrates to compaction was conducted.

This evaluation of potential physical impacts of aquifer compaction is based on the following studies on groundwater conditions and land subsidence in the Mojave Desert:

- USGS Water Resources Investigations Report 03-4015 on Detection and Measurement of Land Subsidence using Interferometric Synthetic Aperture Radar and Global Positioning System, San Bernardino County, Mojave Desert, California (Sneed et al. 2003).
- Stamos et al. (2001). Water Supply in the Mojave River Ground-Water Basin, 1931–99, and the Benefits of Artificial Recharge.
- Laton et al. ~~Cal State University, Fullerton,~~(2007). Harper Lake Basin, San Bernardino Bounty, California Hydrogeological Report.
- Pacific Gas and Electric Company. 2011g. Technical Report—Response to Investigative Order No. R6V-2011-0043. Delineation of Chromium in the Upper Aquifer. Pacific Gas and Electric Company's Hinkley Compressor Station, Hinkley, California. September 1.
- Pacific Gas and Electric Company. 2012~~b~~c. Technical Memorandum—Update to Upper Aquifer Groundwater Investigation Activities-Pacific Gas and Electric Company's Hinkley Compressor Station, Hinkley California. February 8.
- Historic aerial photographs of the Hinkley Valley area to identify areas of past agricultural activity.
- Review of available monitoring well bore logs to identify substrates present in different parts of the project area.

Overview of Impacts

Overall pumping in the Mojave River Basin peaked in the mid-1980s at approximately 240,000 afy, but then declined by 1998 to 150,000 afy due to adjudication. In the Centro Subarea, peak pumping approached 60,000 afy in the mid-1950s which was sustained more or less until 1990 and then declined to approximately 25,000 afy by 2000. Groundwater drawdown modeling by Stamos et al. (2001) indicates that groundwater levels in the Hinkley Valley began to decline in the 1950s and reached a peak drawdown by 1990 of more than 90 feet in the Hinkley Valley (compared to ~~the baseline year of~~ 1930levels). The Cal State Fullerton watershed study indicated drawdown levels up to 100 feet in the Hinkley Valley by the 1980s (Laton et al. ~~Cal State Fullerton~~ 2007). In 1996 the Mojave Water Agency adjudication was adopted, limiting pumping levels in the various subareas of the Mojave River Basin in order to restore groundwater levels, including in the Hinkley Valley. By 1999, water levels had recovered partially from their earlier ~~lower~~low levels but some areas still had drawdown levels of over 50 feet (compared to 1930 ~~baseline~~levels). Since ~~1993~~1996, pumping has been reduced due to the requirements of the adjudication which has allowed groundwater levels to recover.

Between 1993 and 2011, average pumping within the Centro subarea has been approximately 28,000 afy with a recent 5-year average between 2006 and 2011 of 25,000 afy. The Free Production

Allowance from the Mojave Water Agency totals 39,000 afy, indicating that there has been, on average a surplus of approximately 14,000 afy in recent years.

Based on the historic changes in groundwater levels from 1931 to 1990, the aquifer in the ~~southern and central parts of~~ Hinkley Valley ~~(where agricultural activity occurred during this period based on historic aerial photographs)~~ has been previously "stressed" due to ~~more than~~ 90 to 100 feet of historic drawdown. Agricultural wells in the study area have apparently retained their productive ability but the effect upon production of individual domestic wells between 1930 and after 1990 is not fully known. Due to the lack of identified evidence of prior subsidence despite the prior stressing of the aquifer through substantial groundwater drawdown in the Hinkley Groundwater Basin and the predominance of large amounts of sandy substrates throughout the project study area, it is unlikely that substantial wide-spread compaction has occurred due to prior drawdown.

In the portion of the Harper Lake basin within the project study area, drawdown levels from the 1930s to the 1980s are indicated as 50 feet or more while drawdown levels in the center of the Harper Lake basin (west of the project study area) are indicated as up to 100 feet (Laton et al. ~~Cal State Fullerton~~ 2007).This information suggests a hypothesis that historic groundwater drawdown may not have resulted in substantial aquifer compaction in the Hinkley Valley area, however compaction that may have occurred in the subsurface below open fields or desert may not have been noticed or reported.

Research literature (Galloway et al. 1999) seems to indicate that aquifer compaction is more of a concern in relatively thick semi-consolidated silt and clay layers.

A review of PG&E's monitoring well bore logs was conducted to characterize the variability in aquifer sediments in the Hinkley Valley:

- The upper zone of the Upper Aquifer (A1) is generally between 80 and 120 feet bgs. The brown clay layer that separates the A1 and A2 in the Upper Aquifer is generally located within 120 and 140 feet bgs and the lower zone of the Upper Aquifer (A2) is generally between 140 and 160 bgs.
- In the southern Hinkley Valley near the Mojave River, soils are made up of mostly sand ~~or mixed soils (~~with interspersed sand/silt/clay layers~~)~~.
- In the central Hinkley Valley in 2012, there is a pronounced current hydraulic depression in the lower zone of the Upper Aquifer (A2) beneath the Desert View Dairy and extending northward to the Gorman AU and eastward to the Cottrell AU. The hydraulic depression is due to remediation pumping in the area. To the east of the depression, there is the exposed bedrock that differentiates the North and South Hinkley Valleys, and south of the depression, there is no brown clay layer present so there is no separation between the upper and lower zones (A1 and A2) of the Upper Aquifer.
- ~~Although the site stratigraphy varies throughout the project area, in the northern part of the project area, the brown clay layer is thicker and more abundant, such as near Burnt Tree Road, where clay soils (fine-grained soils) are present between 80 and 150 feet bgs.~~
- In the northern part of the Hinkley Valley, north of Thompson Road along some transects, there are some discrete areas of the brown clay layer that are thicker than some areas in the southern area; however, the pattern is not consistent. Data also suggests that there is substantial thickness (greater than that of the brown clay layer) of A1 sandy deposits in the northern part of

the valley. In some areas, sandy deposits have three to four times the thickness of the clay layer, indicating a dominance of course substrate in the northern part of the valley as well.

- The confined lower aquifer is composed of more consolidated weathered granite, sands, and finer-grained sediments and may be less subject to compaction.

Based on the data review, the upper aquifer ~~at~~in the Hinkley Valley generally includes a mix of unconsolidated coarser-grained material (medium- to coarse-grained sand) and finer-grained (primarily silt with some clay) sediments. ~~In the floodplain depositional environment in the Hinkley Valley, sediments making up the aquifer generally become smaller in size with distance from the river. Farther from the river, there are more areas containing finer-grained sediments that may have more potential for compaction.~~ Throughout the aquifer, coarser-grained sediments are likely to be the primary water-bearing strata and are not likely to suffer permanent compaction. ~~However, where fine sediments dominate, there is greater potential for compaction and adverse effects on aquifer yields.~~

In the northeast portion of the Harper Lake basin, which is east of Harper Lake and north of Red Hill and contains a portion of the project study area, sediments are described as predominately alluvium above the water table and the predominately older alluvium of unconsolidated to moderately consolidated deposits with interbedded gravel, sand, silt, and clay below the water table (Laton et al. ~~Cal State Fullerton~~ 2007).

As described above, there has been historic groundwater drawdown due to agricultural irrigation between the 1930s and early 1990s that reportedly resulted in up to 90 to 100 feet of prior groundwater drawdown in the Hinkley Valley with partial recovery in recent years due to the MWA adjudication. Yet, groundwater elevations are still perhaps up to 50 feet or more below 1930s levels (Stamos et al 2001; Laton et al. ~~Cal State Fullerton~~ 2007; PG&E 2013~~y~~a). The northeast part of the Harper Lake Basin (north of Red Hill) experienced perhaps 50 or more feet of drawdown and groundwater elevations were still perhaps 40 feet below 1930s levels in 2004 (Laton et al. ~~Cal State Fullerton,~~ 2007). The ~~likely~~ overall area of this drawdown ~~is between~~extended from the Mojave River ~~and Thompson Road based on historic areas of agricultural use over this period~~to north of Red Hill into the northeast part of Harper Lake basin (Laton et al. ~~Cal State Fullerton~~ 2007, PG&E 2013~~y~~a). In these areas, the ~~substrate~~aquifer has ~~likely~~ been "pre-stressed" by prior historic drawdown, such that ~~any~~if substrates susceptible to aquifer compaction were present, they would likely have already ~~occurred~~experienced compaction in the past. As described above, T~~t~~his area ~~also~~ contains substrates that are dominated by coarse materials (such as sand) that are less susceptible to compaction and associated subsidence. ~~In these areas, substantial aquifer compaction due to new groundwater drawdown is not considered likely.~~ However, evidence of compaction (such as land subsidence) is often difficult to detect in active agricultural areas (due to frequent plowing which can make localized subsidence difficult to observe). In addition, compaction and associated land subsidence may have occurred in open desert areas and may not have been noticed or reported. ~~The southern and central portions of the project area contain limited localized areas containing the "brown clay" layer of fines and thus there may still be limited potential for land subsidence in the southern and central portions of the project area.~~

~~The northern portions of the project area (in OU-3) contain areas where the substrate has a higher percentage of fine silts and clays that may be more susceptible to aquifer compaction. In addition, since the historic areas of agriculture extended from the Mojave River to around Thompson Road, areas further north of Thompson Road are less likely to have been "pre-stressed" by historic~~

~~groundwater drawdown compared to the southern and central portions of the project area. Although large areas of the northern portion of the project area contain coarse substrates dominated by sand (such as along Mountain View Road between Sonoma Road and Mountain General Road), there are also some areas where the substrate has large intervals of fines, such as near Burnt Tree Road. Thus, there is a greater potential for aquifer compaction to occur in the northern portion of the project site.~~

As shown in Table 3.1-7, the No Project Alternative would not increase agricultural extractions and irrigation pumping volumes above existing conditions, and therefore, would not result in an increase in groundwater drawdown that ~~would~~could potentially cause aquifer compaction.

As shown in Table 3.1-7 all of the action alternatives would increase groundwater pumping above existing conditions and would result in groundwater drawdown in portions of Hinkley Valley. Based on scaled pumping volumes and qualitative extrapolation of associated maximum drawdown depths and extents based on groundwater drawdown figures (Figures 3.1-14 through 3.1-18), as shown in Table 3.1-10, only Alternative 4C-4 is estimated to result in more than ~~90~~100 feet of drawdown with FS level flows which would exceed the historic drawdown in ~~the southern and central parts of~~ the project area. However, with scaled flows, all action alternatives would result in drawdown that would be ~~affect the northern part of the project area, possibly~~ in excess of that resulting from historic agricultural activities.

Table 3.1-10. Estimated Effects of Groundwater Drawdown ~~on Potential Aquifer Compaction~~Compared to Historic Drawdown

Alternative	Potential drawdown exceeding historic levels in ~~southern and central part of~~ project area with FS flows?[a,b]	Potential drawdown exceeding historic levels in ~~northern part of~~ project area with scaled flows?[a,c]
No Project	No	No
Alternative 4B	No	Yes
Alternative 4C-2	No	Yes
Alternative 4C-3	No	Yes
Alternative 4C-4	Yes	Yes
Alternative 4C-5	No	Yes

Notes:

[a] As discussed in text, the local aquifer has not fully recovered to 1930s levels and current groundwater levels may be 50 feet or below 1930s level. Thus, if maximum historic drawdown was 100 feet and there is 50 feet of remnant drawdown, then project drawdown of more than 50 feet could result in drawdown beyond historic levels.

[b] Based on Feasibility Study pumping rates, which do not account for the expanded plume.

[c] Based on scaled pumping rates identified in Table 3.1-7 and roughly estimated using drawdown analysis for the Feasibility Study. It is unknown if the scaled flows for Alternatives 4C-3 and 4C-4 can be sustained, thus these levels may overstate the impact. In addition, extraction points are likely to be distributed throughout the plume rather than put in one central area which may ameliorate some of the drawdown effects predicted by the scaling analysis.

The areas of expected groundwater drawdown are shown in Figures 3.1-14 to 3.1-18 based on the feasibility study levels of groundwater extraction and drawdown that may affect additional areas with the potential levels of groundwater extraction necessary to address the expanded plume.

Considering the specific characteristics of the upper aquifer in the Hinkley Valley and the historic drawdown ~~in excess of 90~~up to perhaps 100 feet in most of the Hinkley Valley due to historic agricultural pumping, the evidence supports the following conclusions:

- The aquifer has been previously ~~pre-~~ stressed down possibly to ~~at least 90~~100 feet and ~~possibly~~maybe deeper in the ~~southern and central parts of~~ Hinkley Valley. It is possible that drawdown affected domestic wells that were unreported to authorities. And it is possible that subsidence at open fields or desert may have gone unnoticed or were not reported in the past. Based on FS flow levels, a~~A~~ll alternatives, other than Alternative 4C-4, should not result in groundwater drawdown levels that may exceed historic drawdown levels in the ~~southern and central parts of~~ Hinkley Valley and thus should not result in new stress levels ~~to the aquifer~~. Based on scaled flows, all the action alternatives could result in ~~areas that have not been "pre-stressed" due to prior~~ groundwater drawdown below the historic drawdown levels which could place stress on the aquifer.
- The Hinkley Valley aquifer ~~near the Mojave River~~ continues to be productive today despite the prior historic drawdown, likely indicating that the productive capacity of the aquifer ~~at this location was likely~~was not substantially affected by prior compaction, if it occurred at all.
- ~~However, since all of the alternatives include agricultural treatment units in the central part of the project area and all will include extraction for agricultural treatment in the northern part of the project area, there is the potential for significant compaction in the northern part of the project area which has relatively greater fines in the aquifer than areas closer to the river. It is possible that drawdown in this area of the Hinkley Valley could result in permanent compaction of part of the upper aquifer, resulting in permanent loss of aquifer water yield.~~
- The project alternatives may result in groundwater drawdown that exceeds historic levels in portions of the project area. The dominant sediments in the Hinkley Valley and in the northeast part of the Harper Lake basin are coarser materials that are less susceptible to compaction. Project aquifer drawdown is not considered likely to result in substantial aquifer compaction that would substantially lower aquifer storage capacity or cause land subsidence because the substrate materials are at lower risk of compaction in the first place.

The EIR has used a linear scaling up of potential groundwater drawdown levels from those estimated using Feasibility Study flows. The potential to actually reach such scaled up maximum drawdown levels across the aquifer is low. Extraction points will be distributed across the large expanse of the plume, which means that cones of depression will be distributed in many areas as opposed to being located in one central location. In addition, rapid and extreme levels of drawdown could leave potentially contaminated aquifer layers above the water table and thus not be susceptible to extraction for treatment. As such, it is a low order probability that the maximum scaled flows will be sustained over lengthy periods of time or will be achieved in a centralized area. In addition, since more water would be returned to the aquifer in Alternatives 4C-3 and 4C-5 from above-ground treatment facilities than from other alternatives, achieving the worse-case scenario in these alternatives is unlikely. This means that groundwater drawdown levels will likely be less than the scaled up amounts, which would further reduce the potential to exceed historic drawdown levels and lower risk of placing new stress on aquifer structure.

~~The areas of expected groundwater drawdown are shown in Figures 3.1-14 to 3.1-18 based on the feasibility study levels of groundwater extraction and drawdown that may affect additional areas with the potential levels of groundwater extraction necessary to address the expanded plume.~~

~~Given the available data about aquifer sediments in the project area and the prior historic groundwater drawdown, the overall potential for groundwater drawdown to result in substantial aquifer compaction is considered to be low, but the data do not support a definitive conclusion that compaction will not occur in the northern part of the project area or in localized other parts of the project areas where fine substrates may be present in portions of the substrate. Aquifer compaction can often only be detected after it occurs (due to changes in surface elevation or changes in aquifer yield) and it will be difficult to detect aquifer compaction due to remedial action. Given these facts, this is considered a potentially significant impact.~~

Due to the lack of evidence of prior compaction and land subsidence, the evidence that the aquifer is dominated by coarse-grained sediments in the water bearing strata, and the evidence that the aquifer has been pre-stressed by agricultural pumping-derived drawdown throughout the Hinkley Valley (and into the Harper Lake basin), and the low likelihood of sustained groundwater extraction flows actually resulting in scaled maximum drawdown levels, aquifer compaction is considered unlikely (land subsidence is addressed separately in Section 3.4, *Geology and Soils*, which concludes that land subsidence is also unlikely for the same reasons).

~~The environmental impact of aquifer compaction is considered significant because of the potential for loss of aquifer storage capacity and its effect on water supply (land subsidence is addressed separately in Section 3.4, *Geology and Soils*).~~ Although this impact is identified as less than significant, **Mitigation Measure WTR-MM-2** would still be required to address ~~monitoring of~~ groundwater drawdown, modification of remedial actions to address drawdown and/or provision of replacement water. Water replacement for affected wells would be required for the duration of significant impairment due to drawdown~~including in perpetuity if remedial actions were to be identified to result in a significant permanent loss of aquifer capacity. The mitigation would reduce impacts to water supply to a less than significant level, but if aquifer capacity is diminished permanently this would be considered a significant and unavoidable impact~~.

No Project Alternative

Current agricultural treatment extractions are reportedly resulting in localized drawdown of about 10 feet. As described above, aquifer compaction would be less than significant for the No Project Alternative, because it would not increase agricultural extractions and irrigation pumping volumes above existing conditions. Therefore, this impact is less than significant.

All Action Alternatives~~Alternative 4B~~: Aquifer Compaction

As shown in Table 3.1-10, all action alternatives could result in groundwater drawdown in the Hinkley Valley exceeding historic levels; however, aquifer compaction is not likely to occur and this impact is considered less than significant. ~~the maximum estimated groundwater drawdown for Alternative 4B (up to 70 feet) would not result in groundwater drawdown exceeding historic drawdown depths in the southern and central part of Hinkley and thus would not cause new "stress" which could result in aquifer compaction in this portion of the aquifer. However, Alternative 4B could result in groundwater drawdown in the northern part of the Hinkley Valley that may exceed historic levels and could result in aquifer compaction in this area, which is considered potentially significant. **Mitigation Measure WTR-MM-2** would reduce the impact to water supply wells to less than significant, but the impact to the aquifer may be significant and unavoidable.~~

~~**Alternative 4C-2: Aquifer Compaction**~~

~~As shown in Table 3.1-10, the maximum estimated groundwater drawdown for Alternative 4B (up to 70 feet) would not result in groundwater drawdown exceeding historic drawdown depths in the southern and central parts of Hinkley Valley and thus would not cause new "stress" which could result in aquifer compaction in this portion of the aquifer. However, Alternative 4C-2 could result in groundwater drawdown in the northern part of the Hinkley Valley that may exceed historic levels and could result in aquifer compaction in this area, which is considered potentially significant. **Mitigation Measure WTR-MM-2** would reduce the impact to water supply wells to less than significant, but the impact to the aquifer may be significant and unavoidable.~~

~~**Alternative 4C-3: Aquifer Compaction**~~

~~As shown in Table 3.1-10, the maximum estimated groundwater drawdown for Alternative 4B (up to 80 feet) would not result in groundwater drawdown exceeding historic drawdown depths in the southern and central part of Hinkley Valley and thus would not cause new "stress" which could result in aquifer compaction in this part of the aquifer. However, Alternative 4C-3 could result in groundwater drawdown in the northern part of the Hinkley Valley that may exceed historic levels and could result in aquifer compaction in this area, which is considered potentially significant. **Mitigation Measure WTR-MM-2** would reduce the impact to water supply wells to less than significant, but the impact to the aquifer may be significant and unavoidable.~~

~~**Alternative 4C-4: Aquifer Compaction**~~

~~As shown in Table 3.1-10, Alternative 4C-4 may, in theory, result in groundwater drawdown levels (> 100 feet) in excess of historic drawdown levels (>90 feet). This alternative has the greatest potential of all the alternatives to cause physical "stress" which could result in aquifer compaction in the Hinkley Valley aquifer. As discussed above, compaction is more likely to affect semi-consolidated finer-grained sediments than coarse-grained sediments. Given that the Hinkley Valley aquifer specific yield is dominated by coarse-grained sediment near the Mojave River, any compaction that might occur would likely be located farther in the downgradient flow direction or to the north. Since a large part of project implementation for Alternative 4C-4 will occur north of Highway 58, there is greater potential for significant compaction of the aquifer as one proceeds northward from the river.~~

~~As a consequence, Alternative 4C-4 may result in groundwater drawdown exceeding historic drawdown levels that may lead to permanent compaction of portions of the upper aquifer where fines dominate. This may result in permanent loss of aquifer water yield causing this impact to be considered potentially significant. **Mitigation Measure WTR-MM-2** would reduce the impact to water supply wells to less than significant, but the impact to the aquifer may be significant and unavoidable.~~

~~**Alternative 4C-5: Aquifer Compaction**~~

~~As shown in Table 3.1-10, the maximum estimated groundwater drawdown for Alternative 4C-5 (up to 70 feet) would not result in groundwater drawdown exceeding historic drawdown depths in the southern and central part of the Hinkley and thus would not cause new "stress" which could result in aquifer compaction in this part of the aquifer. However, Alternative 4C-5 could result in groundwater drawdown in the northern part of the Hinkley Valley that may exceed historic levels and could result in aquifer compaction in this area, which is considered potentially significant.~~

~~**Mitigation Measure WTR-MM-2** would reduce the impact to water supply wells to less than significant, but the impact to the aquifer may be significant and unavoidable.~~

3.1.8.2 Water Quality Impacts

This section discusses the following impacts to groundwater quality~~.~~:

- containment and treatment of existing chromium contamination, which is a beneficial impact of remediation;
- conversion of hexavalent chromium to trivalent chromium;
- use of tracer compounds;
- ~~incidental~~ temporary localized chromium plume expansion due to remedial actions (i.e., plume "bulging");
- increase in TDS (i.e., salts), uranium and other radionuclides due to agricultural treatment;
- increase in nitrate due to agricultural treatment;
- increase in iron, manganese, arsenic, or other constituents as byproducts due to in-situ remediation;
- potential degradation of water quality due to freshwater injection; and
- taste and odor effects on groundwater supply due to remedial actions.

Impact WTR-2a: Containment and Treatment of Existing Chromium Contamination (Beneficial Impact, All Alternatives)

All of the remedial action alternatives would reduce chromium contamination in the groundwater aquifer relative to existing conditions, which would be a beneficial effect on the environment, although the ~~methods,~~ scale~~,~~ and time to cleanup are different for each alternative. The remedial action alternatives themselves would not increase chromium contamination nor be the cause of downgradient migration (except in the case of plume "bulging" which is considered a project impact and is addressed under Impact WTR-2d below).

Figure 3.1-5 shows the fourth quarter ~~2011~~ 2012 (Q4 ~~2011~~2012) plume boundaries. Any future movement and spreading cannot be predicted exactly, but without additional plume containment and treatment, the chromium plume will likely continue to spread ~~since current containment is only to Thompson Road~~. This existing condition is considered to be a risk to water quality and public health and would result in exposing additional domestic and agricultural wells to chromium-contaminated groundwater without further action. The health risks associated with chromium were previously discussed in Section 3.1.6, *Health Effects of Constituents in Groundwater*.

The "project" being analyzed in this EIR is the remediation of the chromium plume caused by a release to ground beginning more than 50 years ago. Since all the alternatives would result in varying degrees of remediation beyond that occurring at present, they would all provide an environmental benefit with respect to chromium. With the obvious concern about reducing current risks associated with the chromium plume, the analysis under this impact is focused on the differences between the alternatives in terms of how much benefit they would provide in terms of how fast they would clean up the Hinkley Valley aquifer.

Impacts related to chromium plume containment and remediation~~ of the chromium plume~~ were determined using PG&E's Groundwater Flow Model developed by CH2MHILL in March 2010. The conceptual model is used to forecast likely future chromium plume movement (described in more detail in Appendix A and in PG&E's Feasibility Study and Addenda). This conceptual model was derived from the previous measurements of groundwater elevations and Cr[VI] concentrations, from the measured movement and concentrations of the Cr[VI] plume during the 20 years of intermittent remediation efforts (1991–2010), and from the results of PG&E modeling of groundwater elevations, movement, and Cr[VI] concentrations for treatment alternatives (Pacific Gas and Electric Company 2010a).

All of the remedial action alternatives would ultimately contain the entire plume, with the exception of the No Project Alternative. Data submitted to the Water Board at the end of 2011 show that the northern portion of the chromium plume past Thompson Road is not being captured by PG&E's current groundwater extraction (Pacific Gas and Electric Company 2011a).

The No Project Alternative is limited to actions to address the 2008–2010 plume area, as authorized in previous permits and environmental documents, and thus cannot contain the full plume. The recently issued CAO R6V-2008-0002A3 states that, as part of its effort to prevent further migration of chromium-affected groundwater, PG&E shall operate and maintain the existing groundwater extraction system (as of January 15, 2012) to achieve and maintain hydraulic capture within targeted areas on a year-round basis (Lahontan Regional Water Quality Control Board 2012). As shown in Table 3.1-11, with no new remedial measures, the timeframe for remediation of the entire chromium plume to the interim cleanup levels with the No Project Alternative could be closer to 1,000 years for areas outside the Q1/2010 plume. During this time, it is ~~possible~~likely that the plume could ~~reach as far as ~~extend farther in the Harper Lake Valley ~~(approximately 5 miles north of the current known northern location of the chromium plume)~~.

As shown in Table 3.1-11, the alternatives vary in the estimated time periods to reach the maximum background levels of 3.1 ppb for Cr[VI] and 3.2 ppb for Cr[T] and to achieve cleanup of the high concentration (>50 ppb) Cr[VI] area of the plume. Treatment of the lower concentration portion of the plume is addressed by agricultural treatment, whereas treatment of the high concentration (> 50 ppb) and some of the medium concentration (>10 ppb) portions of the plume are addressed with alternatives using in-situ remediation and ex-situ remediation with above-ground treatment facilities. The alternatives with the greatest area of agricultural treatment activities are expected to be more effective at treating the low concentration plume~~ whereas~~. In comparison, the alternatives with the greatest emphasis on in-situ and ex-situ remediation are expected to be more effective at treating the higher and medium portions of the plume.

Of the action alternatives, Alternative 4C-4 would have the shortest time period for treatment of the chromium plume because of the combination of in-situ treatment with the greatest extraction rate for agricultural treatment. Alternative 4C-5 would have the slowest time to remediation of the plume, but would remove the most mass of chromium from the aquifer instead of converting Cr[VI] to Cr[III] like the other alternatives. Alternative 4C-3 will also remove some chromium mass from the environment but not nearly to the extent as Alternative 4C-5.

Table 3.1-11. Estimated Time to Reach Cleanup of the ~~Chromium (~~Cr[VI]~~)~~ Plume

Alternatives	No Project	4B	4C-2	4C-3	4C-4	4C-5
Time to 50 ppb	6[a]	6	6	4	3	20
Time to 3.1 ppb cleanup	75-150/ 1,000[b]	40	39	36	29	50
Time to 1.2 ppb cleanup	~~325/~~130-220/ 1,000[b]	95	90	85	75	95
Time to 80% Cr[VI] Mass Conversion to Cr[III] or Removal	10-13[a]	10	7	6	6	15

Notes:

[a] Based on Feasibility Study Alternative No. 4 cleanup times because Feasibility Study Addendum No. 3 did not identify cleanup times for No Project conditions.

[b] The No Project Alternative has a projected cleanup time to 3.1 ppb of 75 to 150 years and to 1.2 ppb of ~~325~~110 to 220 years (based on PG&E's estimated timeframes for original Alternative 4 and Alternative 4A in the Feasibility Study and addendum, as the No Project Alternative 4~~,~~is similar to those two alternatives), but this time is limited to addressing the 2008—2010 plume. The time to cleanup areas outside of the Q1 2010 plume is estimated as > 1,000 years based on Feasibility Study Alternative 1.

As a beneficial impact, containment and remediation of the chromium plume relative to existing conditions is not an adverse water quality effect under CEQA and is not analyzed further in this section. However, the differences in containment, remedial methods, and timeframes to cleanup will be considerations for the Water Board when determining cleanup requirements in the new Cleanup and Abatement Order and associated WDRs for this site.

Impact WTR-2b: ~~Conversion~~Potential Reconversion of Trivalent Chromium to Hexavalent Chromium ~~to Trivalent Chromium~~ Following Remediation (Less than Significant, All Alternatives)

All of the alternatives involve conversion of dissolved Cr(VI) to solid Cr(III) through IRZ and agricultural unit operations. In the case of IRZ operations, the conversion happens in the groundwater aquifer. In the case of agricultural units, it happens in the soil strata over the aquifer.

One of the ~~ways that~~concerns about the proposed remedial ~~activities could alter chromium concentrations~~methods is ~~via~~the potential reconversion of Cr[III] to the Cr[VI] within the aquifer ~~post~~after remedial treatment. Cr[III] is common in soils and naturally occurs at levels of 0.5 to 6 mg/kg in the Hinkley area (Pacific Gas and Electric Company 2011c). PG&E estimated in Feasibility Study Addendum No. 3 that the potential contribution of in-situ remediation to Cr[III] levels would be approximately 0.01 to 0.8 mg/kg and thus would only change soil levels in a minimal way compared to existing naturally occurring levels (Pacific Gas and Electric Company 2011c). The greatest mass of Cr[III] left in the environment from in-situ remediation will be in OU-1, at and just north of the Compressor Station. This mass would be left at the depth of the water table and deeper, or 75 to 105 feet below ground surface. Agricultural treatment will leave Cr[III] mass in soil at lesser concentrations within the top 5 feet of the soil, and over a wider area farther north in OU-2 and possibly OU-3.

Cr[III] is relatively stable in ~~soil~~the environment unless oxidizing agents (such as manganese oxides or dissolved oxygen ~~at~~in high pH groundwater) are present. There are many pathways for the reduction of Cr[VI] in the environment to the less toxic Cr[III], but very few mechanisms for the oxidation of Cr[lll] to Cr[VI]. The oxidation reaction for chromium is a slower process than that of reduction. Treated groundwater will be dominated by a reducing environment, with minimal to no oxidants present in the soil to convert Cr[III] to Cr[VI]. Cr[III] is a cation (positively charged molecule) with a strong affinity for a diverse array of anions (negatively-charged molecules) in the soil. As a result, Cr[III] is tightly bound to negatively-charged soil particles present at the site. The presence of organics in the shallow soils, and slightly alkaline soil pH with low natural oxidants in the soil, indicate that the Cr[III] will be unlikely to re-oxidize to Cr[VI] in the project area under normal conditions.

Significant conversion from Cr[III] back to Cr[VI] will only take place if there are changes in geochemical conditions beyond current conditions, such as a significant changecombination of changes in dissolved oxygen, pH and reduction potential (Eh) levels. There can, however, be a limited reconversion as a result of natural geochemical processes, which typically result in overall Cr[VI] levels in groundwater at or around the natural background concentration. The only constituents that occur naturally in the environment that are known to oxidize Cr[III] to Cr[VI] are dissolved oxygen and manganese oxides (Stanin and Pirnie 2004). Although dissolved oxygen could potentially act as a chromium oxidizer, studies have shown chromium oxidation from dissolved oxygen alone to be extremely minimal or non-existent (Palmer and Puls 1994) and negligible (Stanin and Pirnie 2004). For dissolved oxygen to oxidize Cr[III], other chemical conditions are required, such as an alkaline pH. For example, areas in the western Mojave Desert (i.e., Surprise Spring and Sheep Creek) have high naturally occurring Cr[VI] concentrations due to high dissolved oxygen levels and alkaline pH values (greater than 8.0 and occasionally greater than 9.0), as well as significant amounts of mafic rock (Izbicki et al. 2008) due to the close proximity to the San Gabriel and San Bernardino Mountains (PG&E 2011c).

Two impacts from project remediation activities may affect the amount of oxidized chromium (Cr[VI]) in the area: 1) an overall increase in Cr[III] in surface and aquifer soils, and 2) mobilization of dissolved manganese, which is a byproduct of the in-situ treatment remediation processes. While additional Cr[III] in the environment will not change the natural oxidation and reduction processes or the rates at which these occur, it may result in increased Cr[VI] simply by providing additional Cr[III] for oxidation. As previously discussed, chromium (Cr[III]) hydroxides are highly insoluble and readily sorb to the soil greatly limiting their mobility, that along with relatively neutral pH groundwater values limit access to manganese oxides that could act as oxidizers. Therefore the slight increases in Cr[III] are unlikely to increase Cr[VI] concentrations.

As stated previously, manganese oxides under certain conditions may act as chromium oxidizers. Conditions known to promote Cr[III] oxidation via manganese oxides, including alkaline pH and the presence of mafic rock (dark-colored rocks containing abundant iron and magnesium), are not abundant at Hinkley. One of the byproducts of IRZs is dissolved manganese, as the manganese that is naturally present in the soil is mobilized as a result of anaerobic groundwater conditions. Chromium oxidation is associated with Mn [III/IV] oxide compounds, which are largely insoluble. Native Mn(III/IV) compounds in aquifer sediments that are capable of oxidizing trivalent chromium are reduced to manganese oxide, Mn(II) during remediation. This process enhances mobilization of total manganese and causes increase in dissolved Mn(II) concentrations. However Mn(II) at any concentration is not capable of oxidizing trivalent chromium. When the Mn(II) compounds reprecipitate as Mn(III/IV) oxides downgradient from the reducing environment, it will not result in net increase of Mn(III/IV) oxide concentrations in the aquifer. Prior experience with in-situ remediation has shown that concentrations of remedial byproducts like dissolved Mn[II] return to pre-IRZ levels as the injected carbon is consumed by microbial processes and is diluted with downgradient migration. Manganese concentrations are expected to return to pre-injection levels following the end of the carbon injection. The result is no net substantial increase in Mn [III/IV] oxides in the area that could result in chromium oxidation.

In summary, several factors limit the re-conversion of Cr[III] to Cr[VI] after in-situ reduction: the minimal amount of Cr[III] added to the soil due to remediation when compared to naturally occurring levels, the limited solubility of the Cr[III] formed, and the lack of reactivity of an adequate oxidizer. Together, these factors are expected to limit reconversion of Cr[III] to Cr[VI]to levels similar to ~~natural~~ background conditions. The Department of Toxic Substances (2011) also identified the general stability of Cr[III] in soil in their review of the Feasibility Study.

~~Therefore, there will be a less than significant impact to groundwater quality due to reduction of Cr[VI] to Cr[III] with agricultural treatment or in-situ remediation.~~ICF has also prepared a more detailed technical review of the potential for substantial reconversion of CR[III] to Cr[VI] (See Appendix A.3). This review included more than 6,000 data points from more than 300 site groundwater sampling locations in Hinkley to characterize parameters that indicate chromium speciation including pH, eh, manganese and dissolved oxygen. ICF's review concluded that more than 99% of the site groundwater parameter data reviewed demonstrated predominance of trivalent species. It was noted that while significant oxidation to Cr[VI] was unlikely, there may be localized potential for oxidation to occur due to localized presence of other chemical constituents and biological processes. However, a review of the existing data did not indicate any areas of sustained conditions favorable for Cr[VI] species; the less than 1% of data points indicating more favorable conditions for CR[VI] reflecting a single transitory quarterly event in a few wells with conditions before and after the transitory event reflecting conditions favorable for Cr[III] species. Thus the data does not support a conclusion that there is a sustained localized potential to substantially affect chromium stability on a broader basis relative to remedial efforts overall.

Based on these considerations, a less than significant impact to groundwater quality is identified for substantial net "reconversion of Cr[III]. This conclusion applies equally to all alternatives.

Impact WTR-2c: Water Quality Effects due to Use of Tracer Compounds (Less than Significant, All Alternatives)

Tracers, such as bromide and fluorescent dyes, are ~~infrequently~~sometimes injected to groundwater to characterize flow conditions within the treatment areas. These tracer compounds are non-toxic and not expected to be reactive with ~~current contaminants to be treated or other~~chromium or compounds used in the remediation process. For example, potassium bromide, a salt, is injected into the groundwater as a tracer compound at a concentration of approximately 500 ppm. The tracer is diluted during groundwater recirculation in the Source Area IRZ and passive movement, elsewhere. As the tracer moves with groundwater, it decreases in concentration with distance from the injection point and should achieve water quality standards within the remedial cell boundaries. Similarly, fluorescent dyes that are used are also non-toxic and would dilute during recirculation and passive movement with groundwater and would not affect water quality or result in staining for domestic or agricultural wells. Therefore, the tracer impacts on water quality are short term and will not affect beneficial uses outside the remedial cells during or after remediation activities. Therefore, there will be a less than significant impact to groundwater quality due to use of tracer compounds. This conclusion applies equally to all alternatives.

Impact WTR-2d: Temporary Localized Chromium Plume Spreading ("Bulging") Due to Remedial Activities (Less than Significant, No Project Alternative; Significant and Unavoidable for Aquifer and Less than Significant with Mitigation for Water Supply Wells, All Action Alternatives)

Methodology

As described above, increased remediation activities are intended to stop the spreading of the chromium plume and reduce concentrations in the drinking water aquifer. The long-term benefit of implementation of the project would be cleanup of the chromium plume to background levels and restoration of beneficial uses. However, in the following cases, remedial activities could cause the temporary spreading (referred to as "bulging") of the chromium beyond existing plume boundaries:

- direct injection into the aquifer of reductant compounds and contaminated groundwater (IRZs);
- direct injection of uncontaminated groundwater (freshwater injections); and
- agricultural unit irrigation that occurs on the plume margins[15].

These plume movement occurrences are evaluated by examining the potential to alter the distribution of the plume (i.e., "bulge" effect).

This impact is considered significant if:

- remedial actions cause concentrations of hexavalent or total chromium in a water supply well to increase from below maximum background levels to above maximum background levels or increase by 10% or more if current levels ~~are~~ exceed the maximum background level unless it is proven otherwise; or
- remedial actions cause an increase in concentrations of hexavalent or total chromium within a water supply well within 1 mile of the defined chromium plume.

Impact Overview

With the implementation of increased agricultural treatment and in-situ remediation, compared to existing conditions, temporary localized chromium plume bulging in the upper aquifer could occur in limited areas. ~~Increased injection and irrigation could cause localized bulging.~~ (Pacific Gas and Electric 2011c). However, additional extraction for agricultural treatment may decrease the potential for bulging in localized areas due to the "cone of depression" effect described previously. This is particularly applicable to Alternatives 4C-2, 4C-3, and 4C-4 which include agricultural unit extraction points in the southern part of the plume near the IRZ operational areas which may offset localized bulging potential.

Current freshwater injection is designed to avoid spreading of the plume to the west by creating higher water level elevations on the west side of the plume (i.e., hydraulic barrier) between the Desert View Dairy and the Hinkley School. However, this does not mean the plume area is necessarily decreased as a result. In the area of current freshwater injection, the resultant direction of groundwater flow due to freshwater injection is deflected to the northeast toward the chromium

[15] As shown in figures in Chapter 2, *Project Description*, most agricultural treatment units are currently proposed in the center of the plume area. However, it is possible that irrigation at the plume margin could result in plume bulging to the addition of water that would infiltrate to the aquifer.

plume. By adding water in this area, there is a potential for the increased plume movement downgradient to the north or east. However, the agricultural treatment extraction wells to the north and east of the freshwater injection locations help to limit the potential for these additional plume flows as a result of freshwater injection activities. In addition, all alternatives include the same freshwater injection activities as present (with a 15% contingency), and thus none of the alternatives are expected to result in plume bulging due to freshwater injection activities above CEQA baseline conditions.

For the No Project Alternative, continued implementation of plume containment measures required under Cleanup and Abatement Order R6V-2008-0002A3 will require adaptive measures (increased pumping or clean water injection) to maintain or reduce the existing plume boundaries.

Groundwater modeling for Alternatives 4C-2, 4C-3, 4C-4, and 4C-5 using the ~~feasibility study~~Feasibility Study injection and extraction rates did not indicate increased potential for plume bulging, given the balance of injection and extraction rates and the addition of extraction for agricultural treatment in the in-situ remediation area in these alternatives. However, remediation of the expanded plume will likely require greater extraction rates and possible changes in IRZ injection rates~~ and thus it~~. It is possible that the balance of injection and extraction rates may ultimately not be completely effective at avoiding plume bulging in all locations at all times during remediation. Although hydraulic control (through groundwater extraction) can be used to prevent spread of chromium on a large-scale basis from remedial actions, in order to feasibly complete the remediation, localized plume bulging may at times be necessary to allow for effective operations. Where plume bulging results in any expansion of the plume, this is considered a potentially significant and unavoidable temporary impact to the aquifer. This impact is considered temporary as the Water Board will require all areas with chromium above background levels, whether due to the original chromium plume or due to remedial actions, to be remediated to background levels pursuant to its authority under California water law. Mitigation measures to control these impacts include: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and provision of alternative water supply to affected wells (**Mitigation Measure WTR-MM-2**), as necessary. As the plume begins shrinking in size, mitigation measures could cease with time or at the end of final cleanup.

With the implementation of plume containment monitoring, control, and alternative water supply as mitigation measures, this impact would be alleviated to a less than significant level for domestic and agricultural wells for all alternatives. The impact to the aquifer within the localized plume bulging areas will remain potentially significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels and mitigation measures are no longer needed.

No Project: Spreading of Chromium Plume Due to Remedial Activities

The No Project Alternative would not meet project objectives to fully remediate the chromium plume. This alternative would not increase agricultural treatment irrigation over existing conditions. Localized expansion of the plume may occur in certain locations due to injection of water associated with in-situ remediation. This localized expansion would be controlled through plume containment measures required under Cleanup and Abatement Order R6V-2008-0002A3 and modification of extraction rates and/or through provision of whole house replacement water to any affected residences required by existing Water Board orders.

Alternative 4B: Spreading of Chromium Plume Due to Remedial Activities

With the implementation of increased agricultural treatment irrigation and in-situ remediation injection with Alternative 4B, compared to existing conditions, temporary localized chromium plume bulging in the upper aquifer could occur. Alternative 4B would have greater agricultural treatment extraction and irrigation (up to 2,395 gpm compared to 1,100 gpm) and ~~substantially~~ higher in-situ remediation injection flows (up to 431 gpm compared to 190 gpm) compared to existing conditions. Thus, with increased irrigation and injection, there is a greater potential for localized plume bulging to occur during implementation.

Mitigation measures to control these impacts include: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and alternative water supply (**Mitigation Measure WTR-MM-2**), as necessary. With these mitigation measures, this impact will be less than significant for domestic and agricultural wells. The impact to the aquifer within the plume bulging areas will remain potentially significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels and mitigation measures can cease.

Freshwater injection for plume control would be similar to ~~increased~~existing conditions.

Alternative 4C-2: Spreading of Chromium Plume Due to Remedial Activities

With the implementation of increased agricultural treatment irrigation and in-situ remediation injection with Alternative 4C-2, compared to existing conditions, temporary localized chromium plume bulging in the upper aquifer could occur. Alternative 4C-2 would have greater agricultural treatment extraction and irrigation (up to 3,167 gpm compared to 1,100 gpm) and ~~substantially~~ higher in-situ remediation injection flows (up to 431 gpm compared to 190 gpm) compared to existing conditions. ~~Thus, with increased injection and irrigation, there is a greater~~The inclusion of agricultural treatment extraction wells in the southern part of the plume near the IRZ injection areas may help to reduce the potential for plume bulging to occur in that location. However, with increased IRZ injection, there remains a potential for localized plume bulging to occur during implementation.

Mitigation measures to control these impacts include the following: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and alternative water supply (**Mitigation Measure WTR-MM-2**), as necessary. With these mitigation measures, this impact will be less than significant for domestic and agricultural wells. The impact to the aquifer within the plume bulging areas will remain temporarily significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels and mitigation measures can cease.

Freshwater injection for plume control would be similar to ~~increased~~existing conditions.

Alternative 4C-3: Spreading of Chromium Plume Due to Remedial Activities

With the implementation of increased agricultural treatment irrigation and in-situ remediation injection with Alternative 4C-3, compared to existing conditions, temporary localized chromium plume bulging in the upper aquifer could occur. Alternative 4C-3 would have greater agricultural treatment extraction and irrigation (up to 4,388 gpm compared to 1,100 gpm) and ~~substantially~~ higher in-situ remediation injection flows (up to 431 gpm compared to 190 gpm) compared to existing conditions. ~~Thus~~The inclusion of agricultural treatment extraction wells in the southern part of the plume near the IRZ injection areas may help to reduce the potential for plume bulging to occur in that location. However, with increased IRZ injection~~ and irrigation~~, there ~~is~~remains a greater potential for localized plume bulging to occur during implementation. The operation of two above-ground treatment facilities during winter time should provide better control of potential bulging in the Source Area and the Desert View Dairy through groundwater extraction.

Mitigation measures to control these impacts include: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and alternative water supply (**Mitigation Measure WTR-MM-2),** as necessary. With these mitigation measures, this impact will be less than significant for domestic and agricultural wells. The impact to the aquifer within the plume bulging areas will remain temporarily significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels.

Freshwater injection for plume control would be similar to ~~increased~~existing conditions.

Alternative 4C-4: Spreading of Chromium Plume Due to Remedial Activities

Alternative 4C-4 would have similar effects as Alternative 4C-3 because it would have similar levels of groundwater extraction and ~~irrigation and in-situ remediation injection flows~~in-situ remediation injection flows. However, the increased number of agricultural units to accommodate winter-time groundwater pumping not going to above-ground treatment facilities may result in plume bulging. Agricultural extraction in the southern part of the plume may help to control potential plume bulging in that location.

Mitigation measures to control these impacts include: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and alternative water supply (**Mitigation Measure WTR-MM-2**), as necessary. With these mitigation measures, this impact will be less than significant for domestic and agricultural wells. The impact to the aquifer within the plume bulging areas will remain temporarily significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels and mitigation measures can cease.

Freshwater injection for plume control would be similar to existing conditions.

Alternative 4C-5: Spreading of Chromium Plume Due to Remedial Activities

With the implementation of increased agricultural treatment irrigation and in-situ remediation injection with Alternative 4C-5, compared to existing conditions, spreading the chromium plume in the upper aquifer could occur. Alternative 4C-5 would have greater agricultural treatment extraction and irrigation (up to 3,167 gpm compared to 1,100 gpm) and somewhat higher in-situ remediation injection flows (up to 244 gpm compared to 190 gpm) compared to existing conditions. Because Alternative 4C-5 would use ex-situ treatment for the high concentration source area, it would have lower carbon-amended injection flows in the source area than all other action alternatives and would have less potential for plume bulging in the southern part of the plume. Thus, even though Alternative 4C-5 would have less in-situ injection then other alternatives, compared to existing conditions, the increased injection would still result in the potential for localized plume bulging in the Central Area. The year-round operation of an above-ground treatment facility, however, should prevent potential bulging in the Source Area through groundwater extraction.

Mitigation measures to control these impacts include: enhancement and maintenance of hydraulic control and plume water balance (**Mitigation Measure WTR-MM-3**) and alternative water supply (**Mitigation Measure WTR-MM-2**), as necessary. With these mitigation measures, this impact will be less than significant for domestic and agricultural wells. The impact to the aquifer within the plume bulging areas will remain temporarily significant and unavoidable until final cleanup of the chromium has returned the entire aquifer to background levels and mitigation measures can cease.

Freshwater injection for plume control would be similar to ~~increased~~existing conditions.

Impact WTR-2e: Increase in Total Dissolved Solids, Uranium, and Other Radionuclides due to Agricultural Treatment (Temporarily Significant and Unavoidable for Aquifer and Less than Significant with Mitigation for Water Supply Wells)

Methodology

The use of agricultural treatment could result in increased concentrations of certain elements in groundwater, such as TDS, uranium, and other radionuclides in groundwater (nitrate is discussed separately under Impact WTR-2f). Potential impacts related to TDS were analyzed by reviewing the remedial history at the PG&E Hinkley site in terms of the effect of prior agricultural treatment and the concentrations of TDS in the aquifer at present. Potential impacts related to uranium and other radionuclides were analyzed by review of the ~~limited~~ data available at Hinkley, studies of agricultural irrigation and uranium levels in the San Joaquin Valley, and consideration of groundwater chemistry.

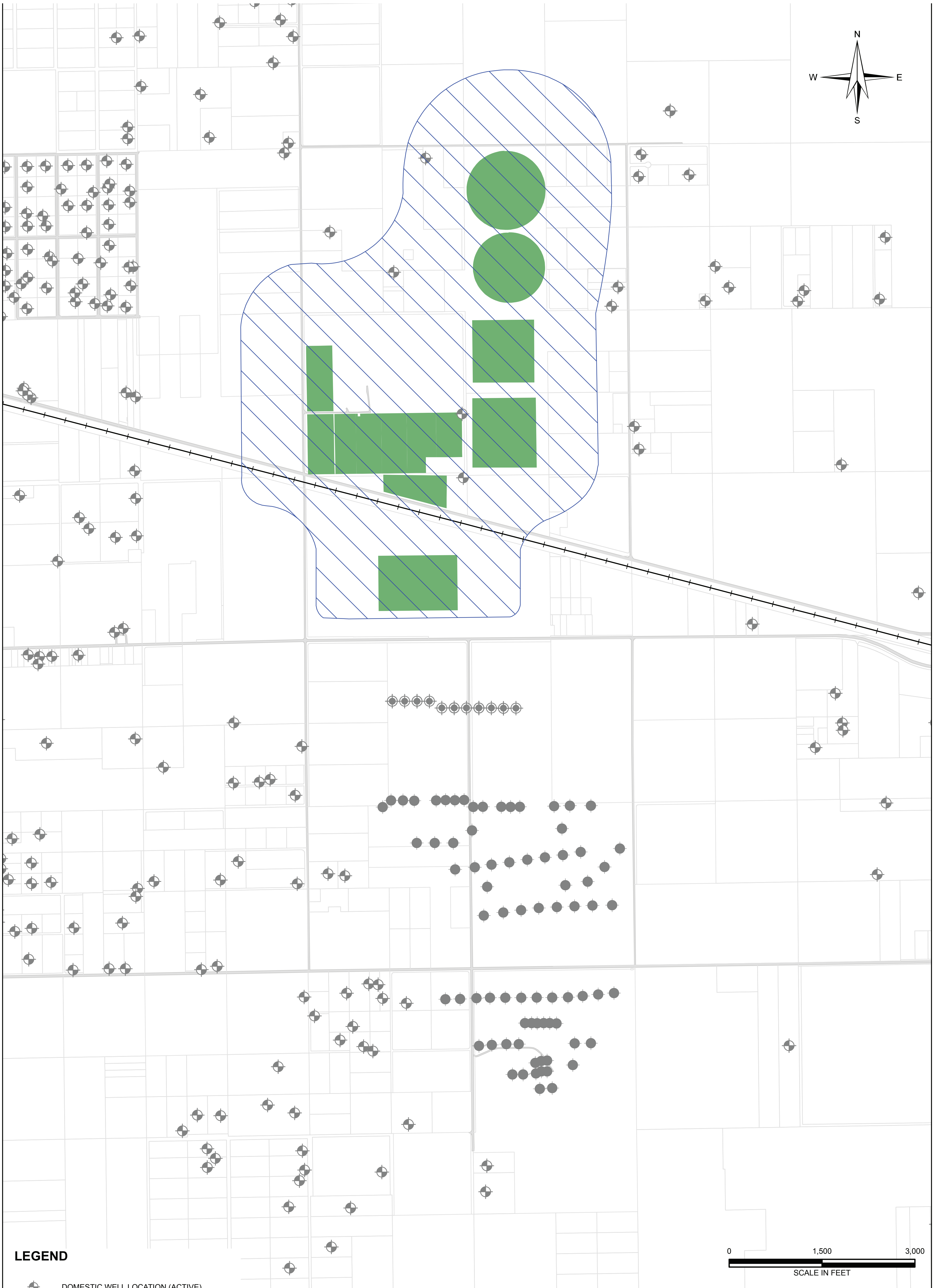
Where existing levels of TDS, uranium or other radionuclides are less than the primary or secondary Maximum Contaminant Level and remedial activities result in concentrations that exceed a primary or secondary Maximum Contaminant Level, this is considered a significant impact. Where existing levels of TDS in groundwater in the study area already exceed the secondary Maximum Contaminant Levels (both federal and state), an increase of more than 20% above existing levels is considered significant unless it is proven otherwise. Where existing levels of uranium and gross alpha already exceed the primary Maximum Contaminant Level (presently known to occur in wells near the Gorman agricultural treatment unit) a 10% increase in uranium and gross alpha concentrations above current levels is considered significant unless it is proven otherwise. In areas where TDS, uranium or other radionuclide levels do not exceed the Maximum Contaminant Levels, this impact is considered significant if levels increase by 20%. Finally, where any of the above conditions are found in a water supply well or monitoring well within one-half mile upgradient or one-quarter mile cross gradient of another water supply well, this is also considered a significant impact.

Impact Overview

Total Dissolved Solids

Agricultural treatment of chromium in groundwater would likely result in increased TDS in the water that infiltrates back to the aquifer below the irrigated land as a result of increased concentrations of TDS in the root zone due to evaporation. This process occurs d~~D~~uring periods where more irrigation water is applied ~~that~~than is taken up by evapotranspiration, causing the solids in the root zone ~~are~~to be flushed down to the water table. Such irrigation periods typically occur when seeds and plants are starting to germinate in spring time and the weather is on the cool side.

In some of the proposed areas for increased agricultural treatment, TDS levels already exceed 1,500 ppm (up to nearly 6,000 ppm near Thompson Road), ~~but~~ while some of the easternmost and westernmost areas where agricultural treatment is proposed have current levels of less than 1,000 ppm. Levels greater than 1,000 ppm ~~would~~, the upper drinking water standard, compromise the



LEGEND

DOMESTIC WELL LOCATION (ACTIVE)

MONITORING WELL LOCATION (500 SERIES)

INJECTION WELL LOCATION

AREA OF POTENTIAL IMPACT - AU BYPRODUCT

AGRICULTURAL UNITS, INCLUDING DVD LTU

NOTES

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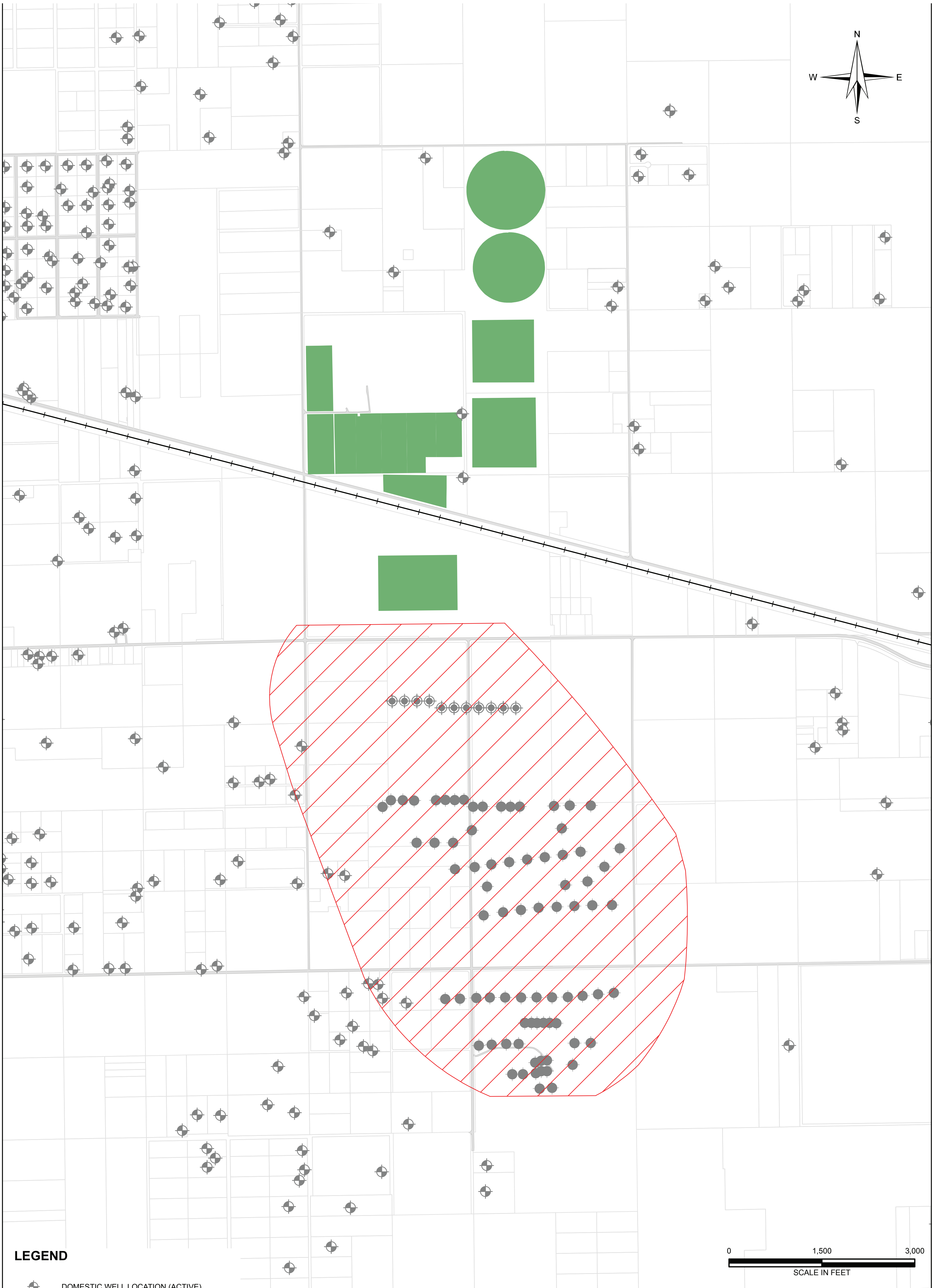
Figure 3.1-19a
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4B



LEGEND

- DOMESTIC WELL LOCATION (ACTIVE)
- MONITORING WELL LOCATION (500 SERIES)
- INJECTION WELL LOCATION
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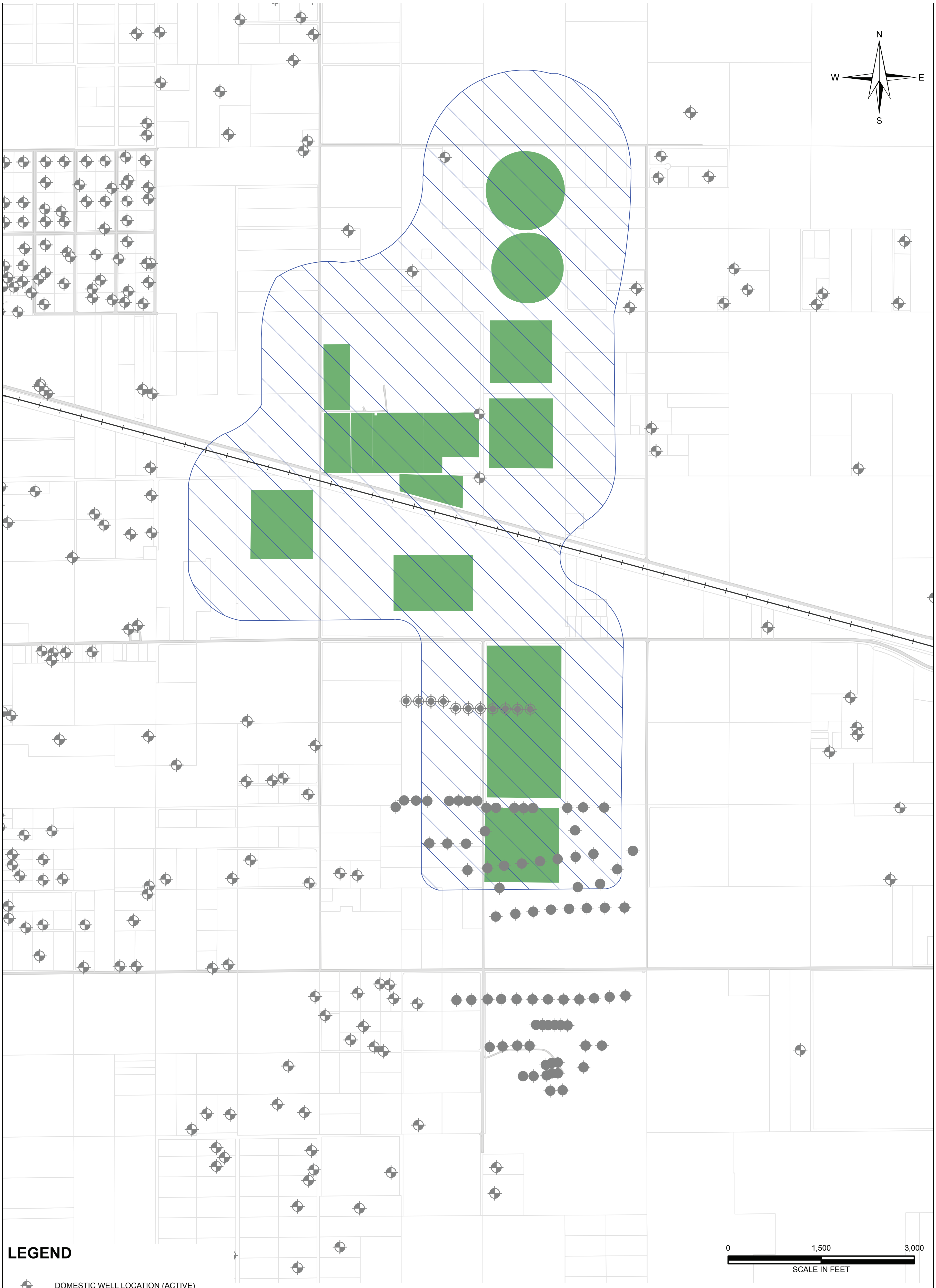
Figure 3.1-19b
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4B



LEGEND

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Figure 3.1-20a
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-2

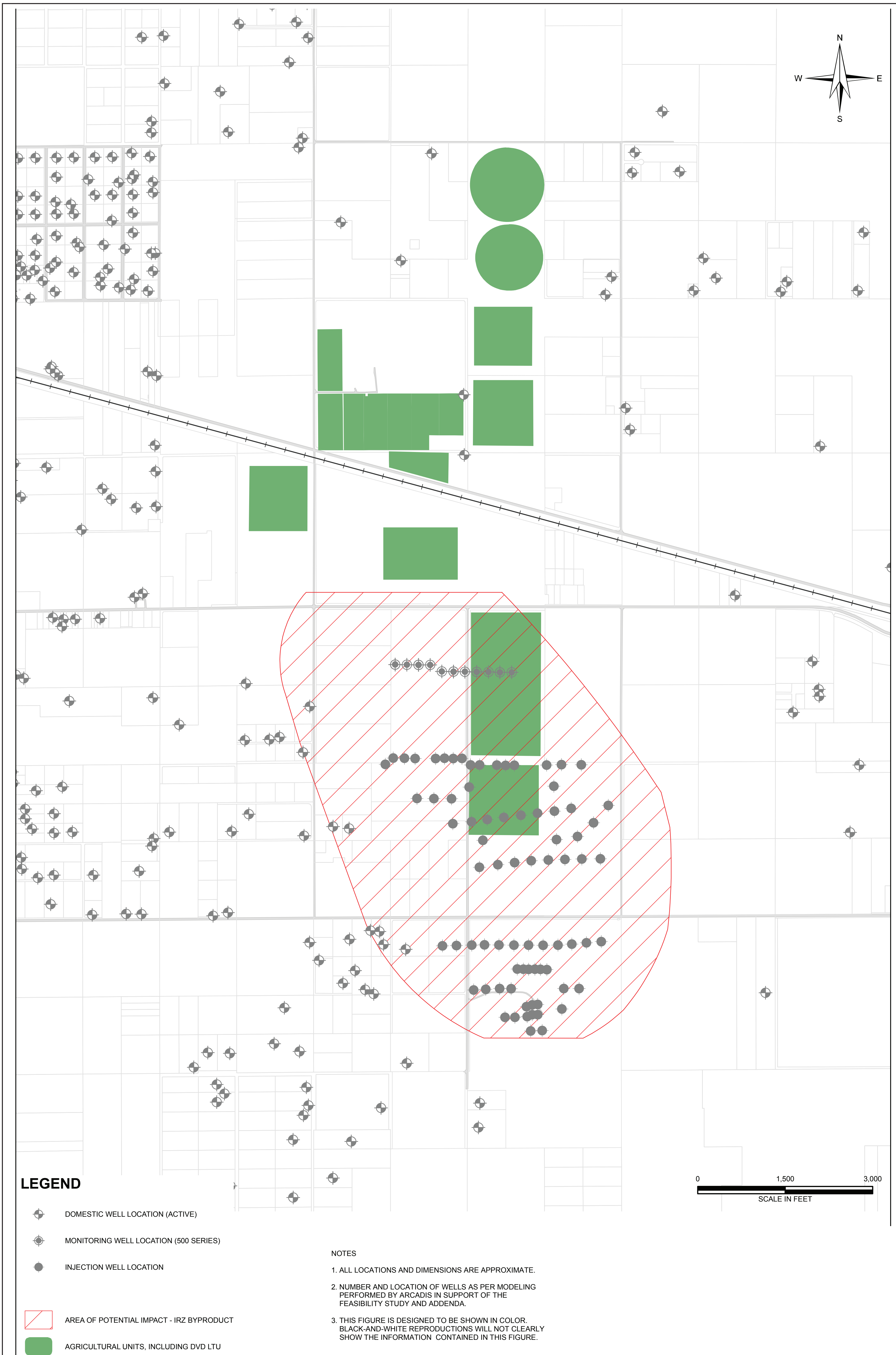

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Figure 3.1-20b
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-2

drinkability of water from domestic supply wells. Crop sensitivity varies. Some crops can experience decreased yields when TDS levels are in excess of 1,000 ppm, whereas more salt-tolerant crops (such as alfalfa) will only experience substantial decreases in yields at much higher concentrations.

There is a potential for remedial actions to cause an increase of TDS levels above levels that would compromise domestic supply wells (or increase levels substantially that are already above secondary Maximum Contaminant Levels). In addition, given that existing levels between SR 58 and Thompson Road are already highly elevated, in large part due to prior and ongoing dairy operations, the project could contribute over time to TDS increases that may compromise agricultural uses. This is considered to impair the beneficial use of the aquifer for other users in the Hinkley Valley. As a result, this impact of agricultural treatment would be significant.

Mitigation of increased TDS concentrations in the aquifer as a whole is generally feasible~~ but challenging~~. TDS can be removed from the water by reverse osmosis or boiling ~~but is~~in above-ground treatment facilities that are expensive and energy-intensive. These methods separate out TDS which would then ~~need~~require the waste product to be disposed of outside of the area. PG&E has successfully implemented one such above ground treatment plant involving reverse osmosis at the Topock Compressor Station on the Colorado River. This facility, which began operating in 2005, treated contaminated groundwater up to 135 gallons per minute and successfully removed chromium, other metals, and TDS. ~~The~~In addition to chromium removal, the added benefit from this system was the offsite disposal of treatment brine that resulted in improved water quality to the aquifer.

Another option to reduce this impact to the aquifer (to less than 1,000 ppm TDS) would be to move some of the irrigated agricultural treatment to locations above the chromium plume where TDS concentrations are relatively low (less than 750 ppm), or by using extracted groundwater from the chromium plume with relatively low TDS concentrations for agricultural treatment. However, some of the existing chromium plume has TDS concentrations greater than 1,000 ppm. Such methods do not remove or reduce the overall TDS contribution to the aquifer, but rather just spread it over a wider area causing the average concentration to increase everywhere.

If agricultural treatment were discontinued or limited to only using water with low TDS concentrations, this would reduce remedial options available to PG&E to completely clean up the chromium plume. Because agricultural treatment is one of the ~~major~~principle methods being proposed by PG&E for successful chromium remediation, the impact of all alternatives of increasing TDS concentrations in the aquifer is considered significant and would need to be mitigated to protect the other beneficial users of the aquifer.

For drinking water supply wells, mitigation of increased TDS concentrations is feasible. Either the impact to drinking water wells could be avoided or treated after the fact. In the ~~past~~latter scenario, PG&E implemented agricultural land treatment by purchasing land from willing sellers and also acquired drinking water wells that were removed from potable uses. For drinking water wells ~~previously~~ contaminated from dairy operation, the Water Board has required the provision of alternate water supply or well head treatment to remove TDS prior to potable use. Alternative water supplies could be provided through provision of an alternative water supply (through tanks and water trucking, or alternative wells and piping) or possibly through drilling of deeper wells if the deeper aquifer can be shown to meet standards for TDS.

Because prior dairy activities have resulted in elevated TDS levels in the project area, it is important to determine separately the effect of new agricultural treatment activities on TDS levels. **Mitigation**

Measure WTR-MM-5 requires investigation and monitoring of TDS levels to identify pre-remedial reference conditions and where and when remedial actions result in significant impacts ~~in order to determine~~for determining when replacement water and/or aquifer restoration are warranted. **Mitigation Measure WTR-MM-2** requires alternative water supplies for all affected or potentially wells and control of byproduct plumes where feasible. While replacement water can address water supply wells effects, there would remain the potential for long-term impairment of beneficial uses of the aquifer, even after completion of remediation of the chromium plume. **Mitigation Measure WTR-MM-4** requires restoration of the drinking water aquifer from all substantial water quality impairments ~~resultant~~resulting from remedial activity ~~within~~in a timely manner (to be determined by the Water Board).

With implementation of these mitigation measures, the impacts from all alternatives to water supply wells and the long-term beneficial uses of the aquifer would be reduced to less than significant. However, where full avoidance of significant byproduct increases are not feasible, there could be a temporary significant and unavoidable impact on the aquifer as TDS levels could increase in order to implement chromium plume remediation activities.

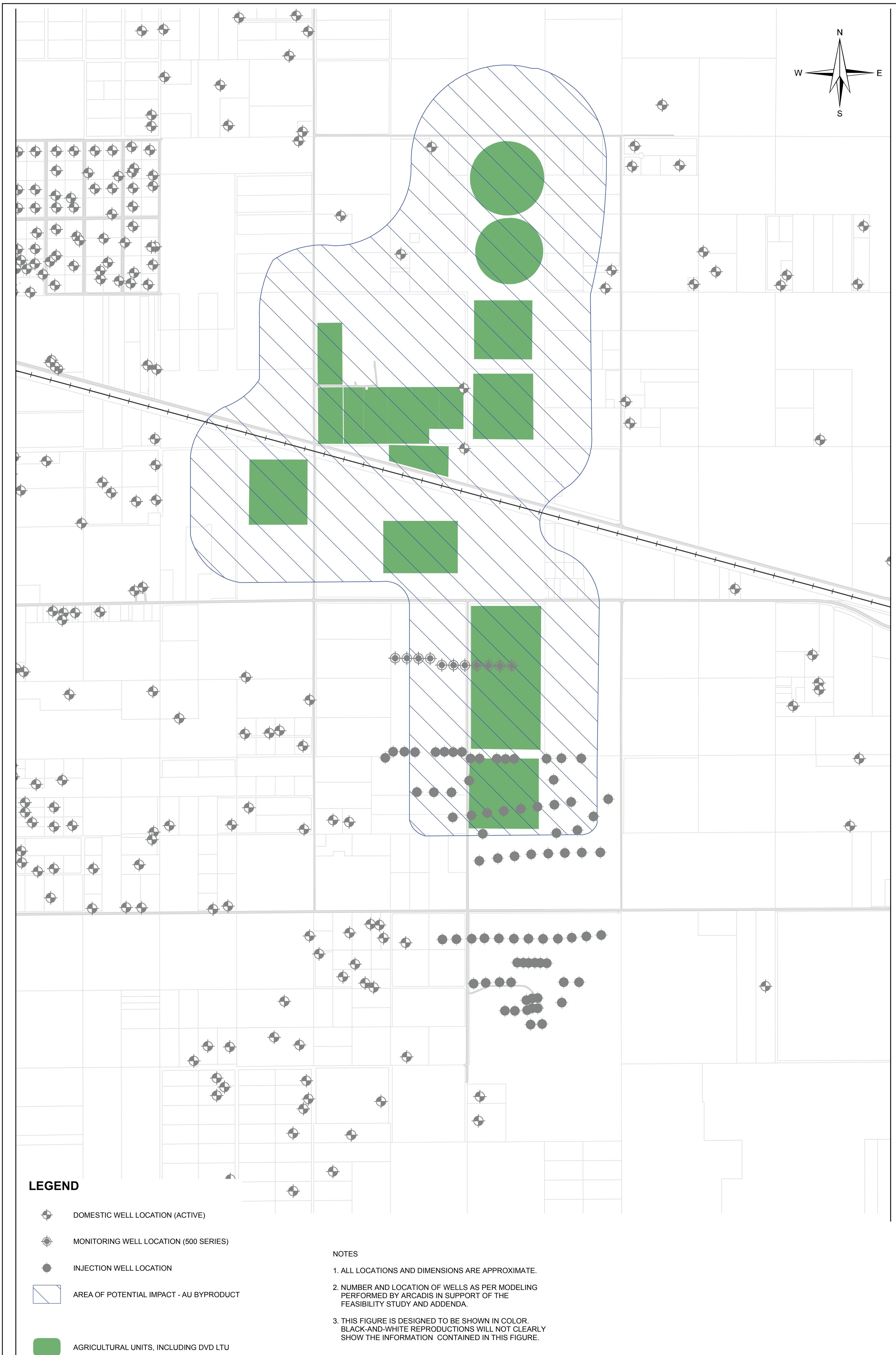
Uranium and Other Radionuclides

Uranium and other radionuclides are naturally occurring in Mojave Desert soils and rocks. The potential impact identified in this EIR is that PG&E's agricultural pumping for remediation could transport or mobilize background uranium and other radionuclides concentrations.

In-Situ ~~Remediation~~remediation is not likely to result in increases in uranium or other ~~constituents.~~radionuclides. As described above, in-situ remediation using carbon amendments creates chemically reducing conditions, resulting in the conversion of Cr[VI] to Cr[III]. Uranium chemistry is similar to that of chromium~~,~~ in ~~that the U[VI]~~ which the oxidized form is much more mobile than the reduced ~~Ur[III]~~ form. In this case, dissolved U[VI] in groundwater reduces to the U[IV]form, which tends to bind to soils. Like Cr[VI], U[VI] can be changed to U[~~III~~IV] by microbial action in low oxygen, reducing conditions. This process has been studied by the U.S. Department of Energy, most notably at Hanford, Oak Ridge and Old Rifle sites which all have uranium contamination in groundwater (Seyrig 2010; DOE 2012 ~~at http://ifchanford.pnnl.gov~~/; NRC 2008). The tendency of uranium to bind to soils is also influenced by soil grain size (tends to adhere to more fine grain soils), and pH/carbonate effects (DOE 2012). In-situ remediation with carbon amendment has been used successfully at several sites with man-made uranium groundwater contamination (DOE 2012). At the Hinkley site, because reducing conditions created by in-situ remediation for addressing the chromium plume also support reduction of U[VI] to the less mobile U[~~III~~IV], U[VI] concentrations should ~~not increase~~decrease in groundwater~~ due~~. Due to ~~in-situ remediation and~~this added benefit, this impact is not considered further in this analysis.

As described above for in-situ remediation, uranium in groundwater can be reduced to a less mobile form under reducing conditions. Agricultural treatment for chromium plume remediation works by exposing chromium-contaminated irrigation water to subsurface root zone conditions that contain a reducing environment that converts soluble Cr[VI] to relatively immobile Cr[III]. Thus, ~~naturally-occurring~~ background uranium in agricultural treatment water should also be immobilized by the reducing environment, and remain bound to soil particles. Monitoring for uranium in soil and plants will determine whether this is the case.

However, other geochemical conditions and pumping could also affect uranium and other radionuclide conditions. One study in the San Joaquin Valley suggested that the combination of



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Source: PG&E 2012m, and modified by ICF

Figure 3.1-21a
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-3

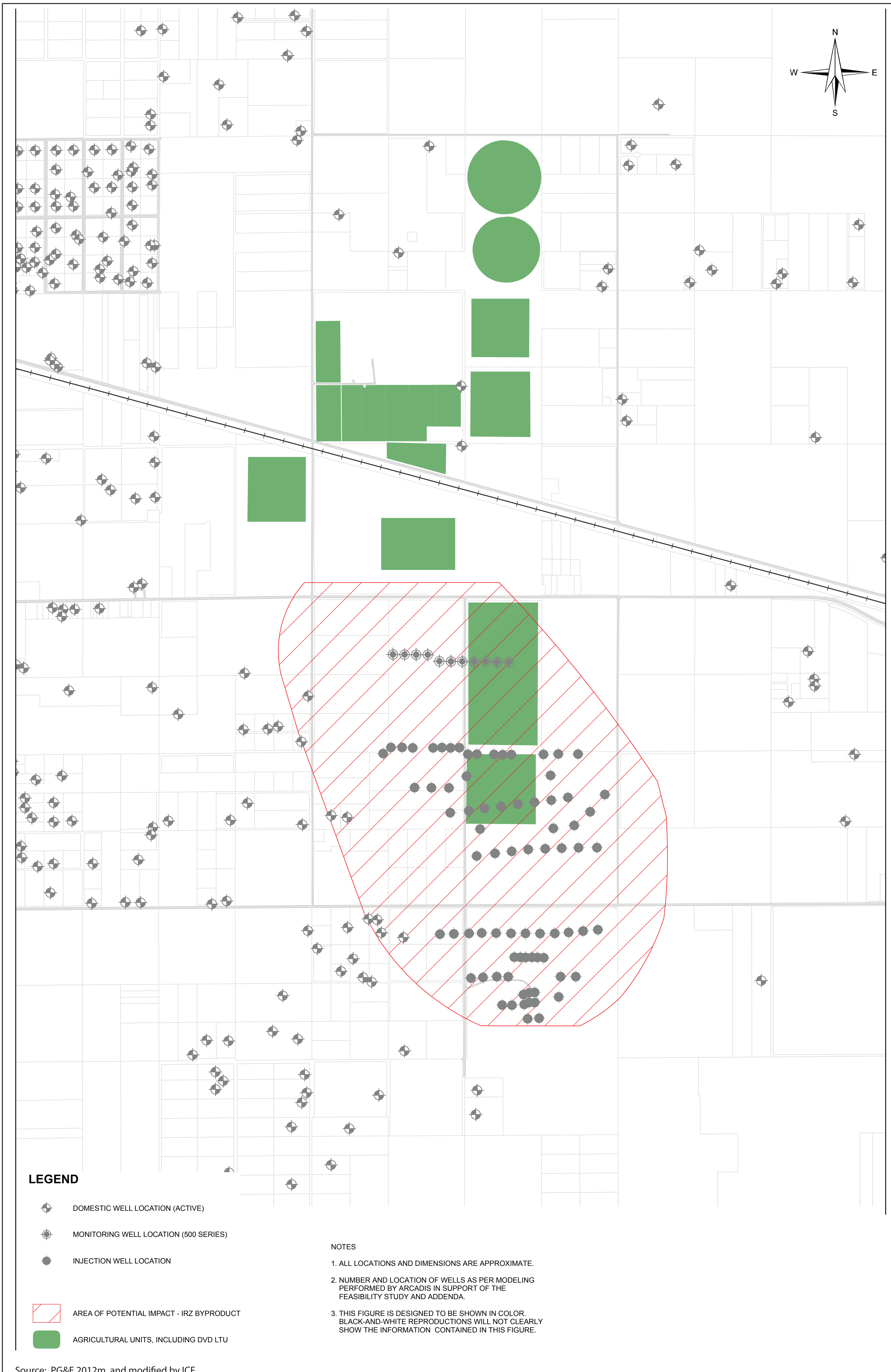

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Figure 3.1-21b
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-3

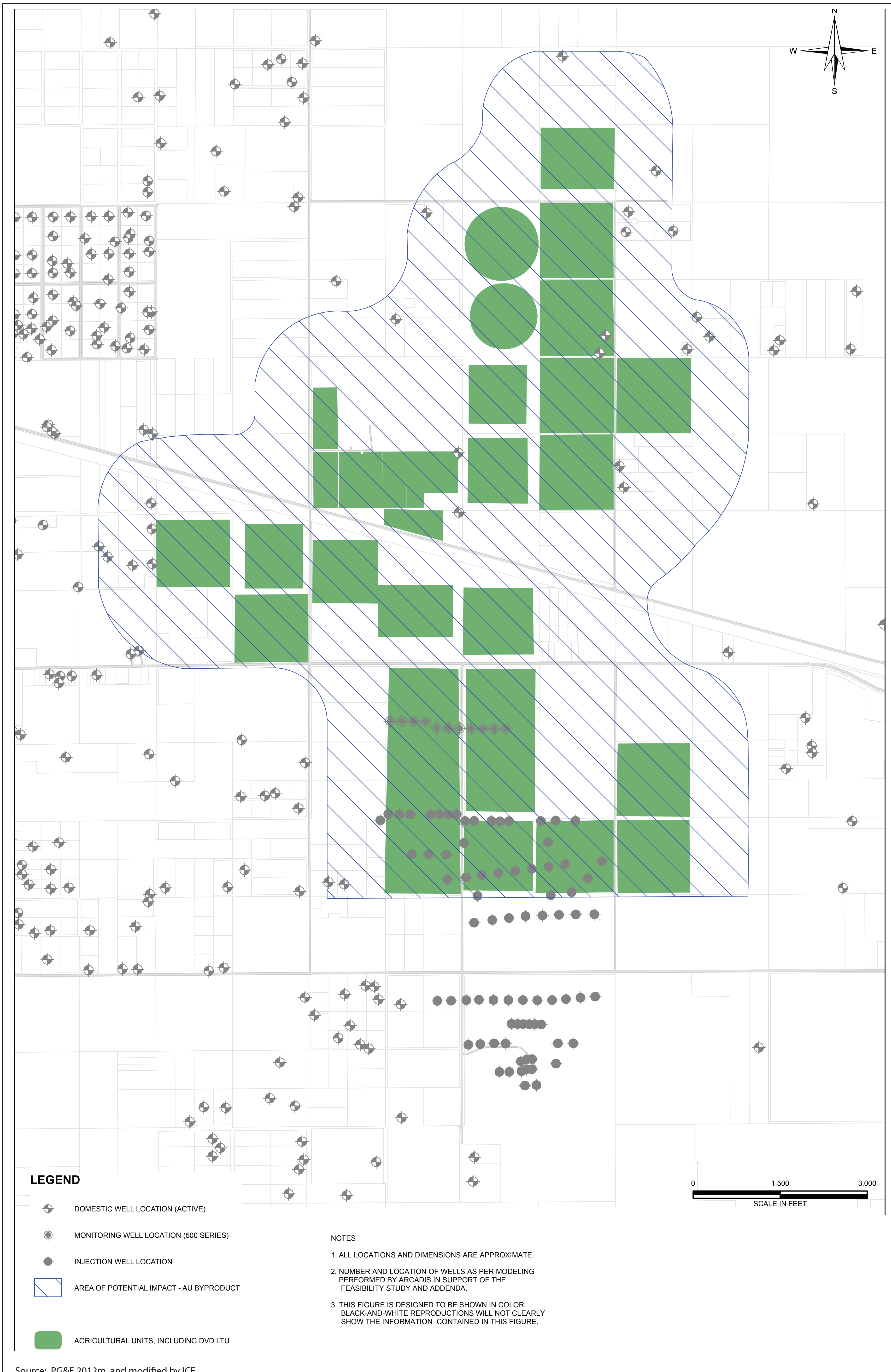
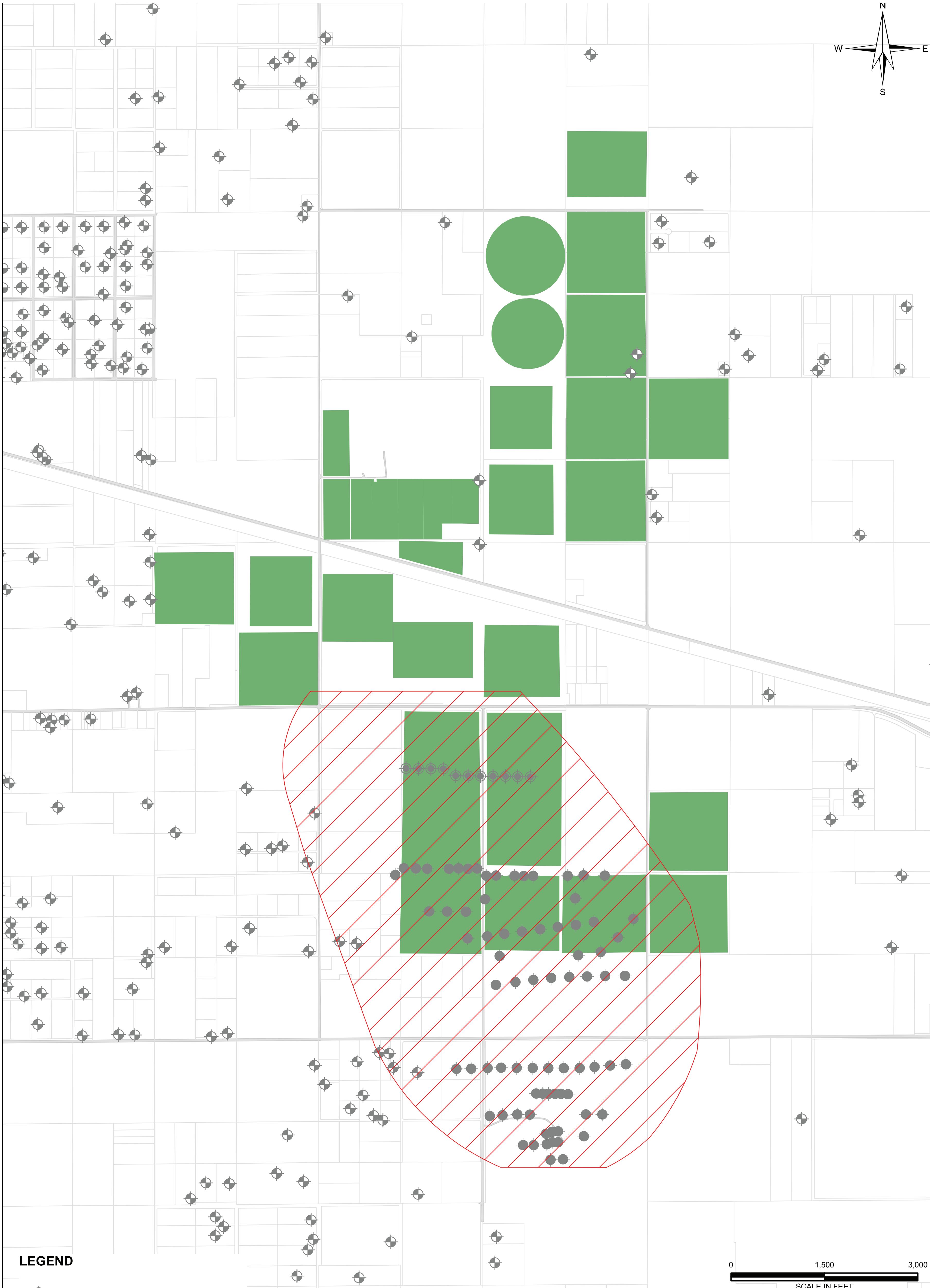


Figure 3.1-22a
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-4



LEGEND

- DOMESTIC WELL LOCATION (ACTIVE)
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- INJECTION WELL LOCATION
- AREA OF POTENTIAL IMPACT - IRZ BYPRODUCT
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Figure 3.1-22b
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-4

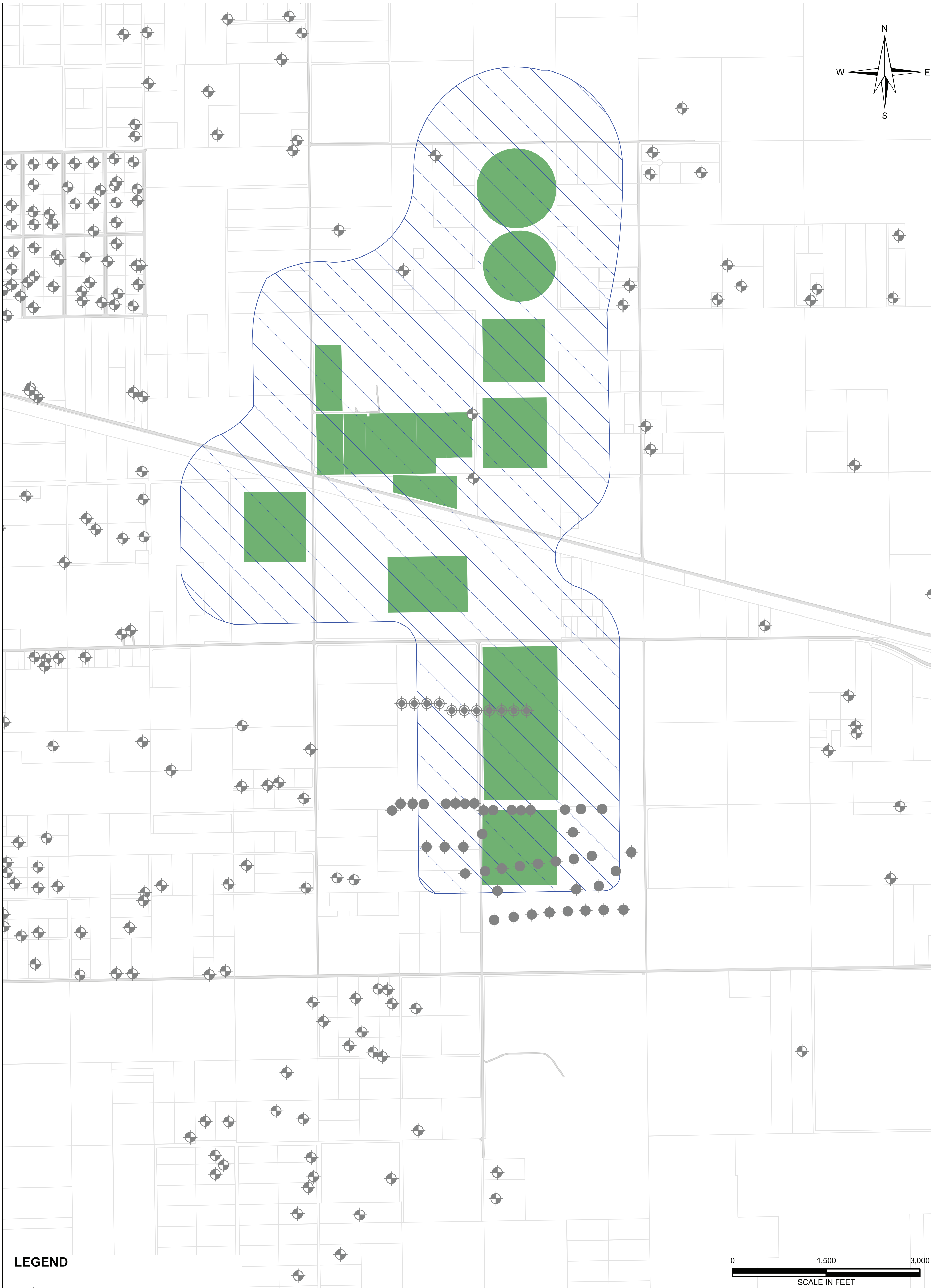

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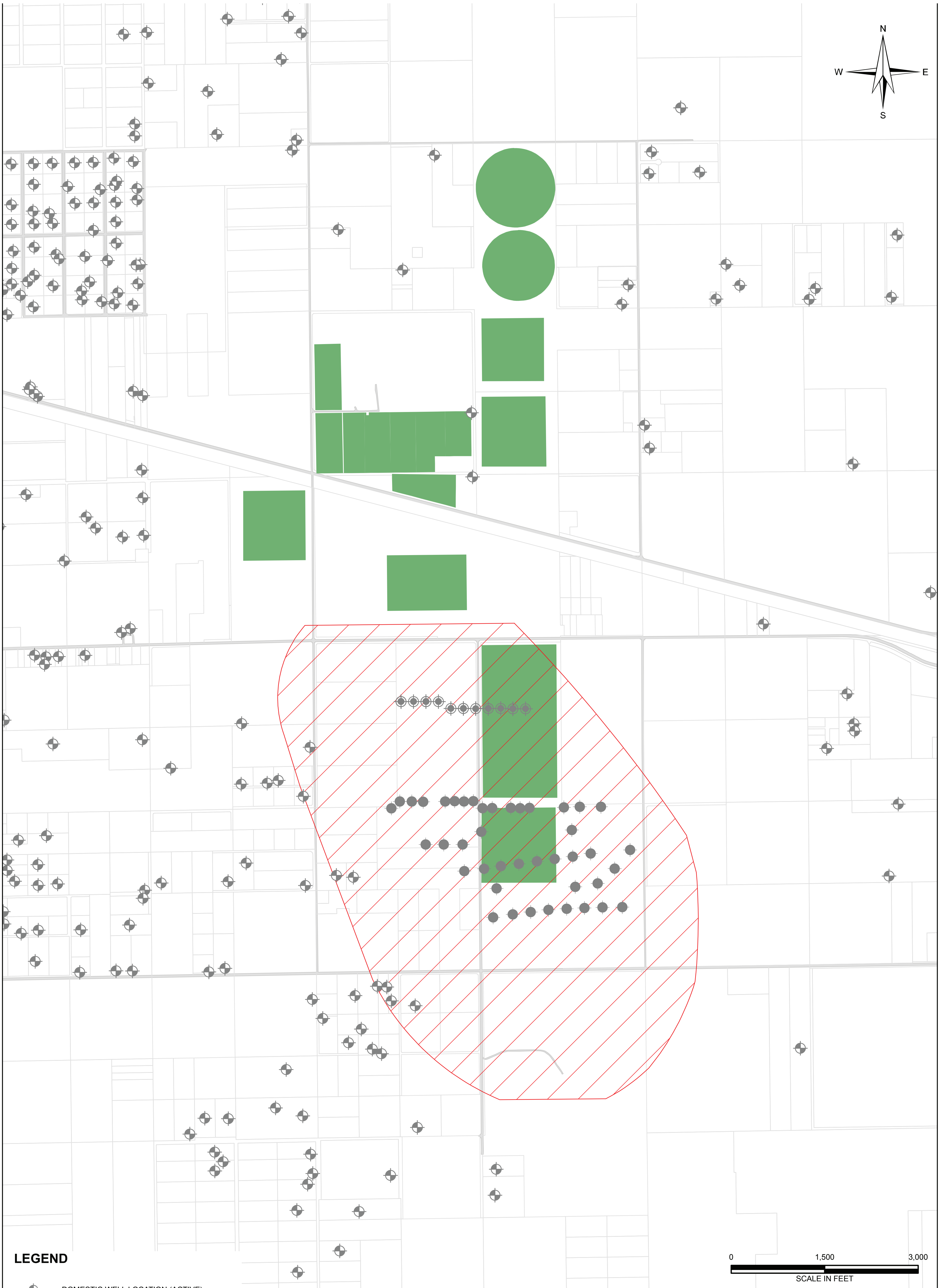
Figure 3.1-23a
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-5



DOMESTIC WELL LOCATION (ACTIVE)

MONITORING WELL LOCATION (500 SERIES)

INJECTION WELL LOCATION

AREA OF POTENTIAL IMPACT - IRZ BYPRODUCT

AGRICULTURAL UNITS, INCLUDING DVD LTU

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Figure 3.1-23b
Potential Areas Affected by Remedial Byproduct Plumes, Alternative 4C-5

increased bicarbonate concentrations in the soil zone and increases in the rate of downward groundwater flow due to groundwater pumping for agricultural use could increase the mobilization of uranium and cause it to migrate to deeper parts of the aquifer (Jurgens, B.C. et al 2009). However, there are only limited data to date on uranium levels in the agricultural treatment areas so the actual potential for agricultural treatment to affect ~~naturally occurring~~ uranium levels is currently unknown. In addition, it is unknown if carbonate conditions may be present in a similar way in the local aquifer as described in the San Joaquin Valley study.

In addition, uranium and radionuclide levels are generally found to be higher in groundwater closer to bedrock strata since they originate in bedrock. As a result, when groundwater pumping results in a lowering of the water table, it can draw ~~more preferentially~~ from deeper levels which can have higher concentrations of these constituents. Further, as part of implementing Mitigation Measure WTR-MM-2, deeper wells may be provided in order to supply replacement water which may result in further draw on deeper aquifer waters.

Since data is limited on uranium and radionuclide conditions in the project area and the net effect of agricultural treatment and other pumping, this EIR conservatively considers this impact to be potentially significant and requires further evaluation. This impact is considered ~~potentially significant and~~ unavoidable for the aquifer but ~~can be mitigated for~~ the impact to potentially affected water supply wells can be mitigated through requirement for replacement water. Investigation, monitoring and contingency actions will be required in the event that agricultural treatment ~~is found to~~ have the potential to increase ~~naturally-occurring~~background uranium or other radionuclides in groundwater per **Mitigation Measure WTR-MM-5** ~~and if necessary~~. For affected or potentially affected water supply wells, alternative water supplies will be required to be provided ~~to affected wells~~ per **Mitigation Measure WTR-MM-2**. **Mitigation Measure WTR-MM-4** would require restoration of the drinking water aquifer from all substantial water quality impairments resultant from remedial activity within a timely manner (to be determined by the Water Board).

No Project: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Although there will be no increase in irrigation for the agricultural treatment activities above existing conditions as part of the No Project Alternative, continued operations will likely temporarily increase TDS concentrations depending on the applied concentrations and crop uptake.

Measures included in prior WDRs to keep TDS concentrations within these levels include monitoring and adjustment of groundwater extraction and discharge and groundwater treatment and other methods. WDR R6V-2008-0014 specifies that TDS shall not increase more than 25 percent above current conditions. With implementation of the prior WDR requirements, the effects of agricultural treatment on TDS would likely be less than significant for this alternative.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment has affected ~~naturally occurring~~ uranium or other radionuclide levels. Given that the existing CAOs and WDRs do not address this potential effect, should the No Project Alternative be selected, then **Mitigation Measures WTR-MM-2, WTR-MM3 and WTR-MM-5** would be required to reduce this impact for affected wells to a less than significant level.

Alternative 4B: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Alternative 4B would have greater agricultural treatment extraction and irrigation (up to 2,395 gpm) compared to existing conditions and the No Project Alternative (1,100 gpm) and thus will have increased impacts on TDS. Larger areas of the chromium plume compared to existing conditions will be affected by increased TDS concentrations during remediation. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-19. With implementation of **Mitigation Measures WTR-2, WTR-MM-4, and WTR-MM-5**, impacts to drinking water supplies related to TDS can be reduced to less than significant. Where complete avoidance of significant TDS increase is not feasible during remediation, there would be temporary degradation of the aquifer during remediation which would be significant and unavoidable~~, but~~. **Mitigation Measure WTR-MM-4**, however, would require ultimate remediation of any significant TDS increases due to remedial actions ~~in~~at the end of the project.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment have affected ~~naturally-occurring~~background uranium and other radionuclide levels. If existing agricultural treatment has increased levels of these constituents, then Alternative 4B would increase them further due to the increase in agricultural treatment. Potential impacts to water supply wells and permanent impacts to the aquifer can be mitigated to a less than significant level through investigation, monitoring, alternative water supply, and aquifer restoration per **Mitigation Measures WTR-MM- 2, WTR-MM-4, and WTR-MM-5**. However, temporary impacts to the aquifer may be significant and unavoidable if increases in uranium or other radionuclides cannot be avoided during remediation without substantially impeding chromium remediation progress.

Alternative 4C-2: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Alternative 4C-2 would have greater agricultural treatment extraction and irrigation (up to 3,167 gpm) compared to existing conditions and the No Project Alternative (1,100 gpm) and thus will have greater impacts on TDS. Larger areas of the plume than existing conditions will be affected by increased TDS concentrations during remediation. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-20. With implementation of **Mitigation Measures WTR-2, WTR-MM-4, and WTR-MM-5**, impacts to the drinking water aquifer and wells related to TDS can ~~reduce impacts~~be reduced to less than significant. Where complete avoidance of significant TDS increase is not feasible, there would be temporary degradation of the aquifer during remediation which would be significant and unavoidable, but **Mitigation Measure WTR-MM-4** would require ultimate remediation of any significant TDS increases due to remedial actions ~~in~~at the end of the project.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment have affected ~~naturally-occurring~~background uranium and other radionuclide levels. If existing agricultural treatment has increased levels of these constituents, then Alternative 4C-2 would increase them further due to the increase in agricultural treatment. Potential impacts to water supply wells and permanent impacts to the aquifer can be mitigated to a less than significant level through investigation, monitoring, alternative water supply, and aquifer restoration per **Mitigation Measures WTR-MM- 2, WTR-MM-4, and WTR-MM-5**. However, temporary impacts to the aquifer may be significant and unavoidable if increases in uranium or other radionuclides cannot be avoided during remediation without substantially impeding chromium remediation progress.

Alternative 4C-3: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Alternative 4C-3 would have greater agricultural treatment extraction and irrigation (up to 4,388 gpm) compared to existing conditions and the No Project Alternative (1,100 gpm) and thus will have greater impacts on TDS. Larger areas of the plume than existing conditions will be affected by increased TDS concentrations during remediation. During winter, this alternative would employ some above-ground treatment for hexavalent chromium removal and reduced agricultural treatment compared to Alternative 4C-2. Above-ground treatment would not result in increased concentration of TDS because it would avoid evaporation that occurs with irrigation. Since treatment wastes would be transported offsite for disposal, this alternative would have the added benefit of permanently removing TDS, chromium, other metals, and radionuclides from the environment. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-21. With implementation of **Mitigation Measures WTR-2, WTR-MM-4, and WTR-MM-5**, impacts to the aquifer in wells related to TDS can be reduced to less than significant. Where complete avoidance of significant TDS increases is not feasible, there would be temporary degradation of the aquifer during remediation which would be significant and unavoidable, but **Mitigation Measure WTR-MM-4** would require ultimate remediation of any significant TDS increases due to remedial actions ~~in~~at the end of the project.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment have affected ~~naturally-occurring~~background uranium or other radionuclide levels. If existing agricultural treatment has increased levels of these constituents, then Alternative 4C-3 would also increase levels further due to the increase in agricultural treatment. Potential impacts to water supply wells and permanent impacts to the aquifer can be mitigated to a less than significant level through investigation, monitoring, alternative water supply, and aquifer restoration per **Mitigation Measures WTR-MM- 2, WTR-MM-4, and WTR-MM-5**. However, temporary impacts to the aquifer may be significant and unavoidable if increases in uranium or other radionuclides cannot be avoided during remediation without substantially impeding chromium remediation progress.

Alternative 4C-4: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Alternative 4C-4 would have the greatest agricultural treatment extraction and irrigation (up to 4,388 gpm) compared to existing conditions and the No Project Alternative (1,100 gpm) and thus will have far greater impacts on TDS. Larger areas of the plume and overall aquifer than existing conditions will be affected by increased TDS concentrations during remediation. While Alternative 4C-4 has the same maximum extraction flows for agricultural treatment as Alternative 4C-3, it would have a higher impact on TDS in groundwater due to continuous, year-round agricultural treatment occurring at more locations. In comparison, Alternative 4C-3 would use above-ground treatment to treat only the winter excess water the AUs could not use and agricultural treatment the rest of the year. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-22. With implementation of **Mitigation Measures WTR-2, WTR-MM-4, and WTR-MM-5**, impacts to the aquifer and drinking water wells related to TDS can ~~reduce impacts~~be reduced to less than significant. Where complete avoidance of significant TDS increases is not feasible, there would be temporary degradation of the aquifer during remediation which would be significant and unavoidable, but **Mitigation Measure WTR-MM-4** would require ultimate remediation of any significant TDS increases due to remedial actions ~~in~~at the end of the project.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment have affected ~~naturally occurring~~ uranium or other radionuclide levels. If existing agricultural treatment has increased levels of these constituents, then Alternative 4C-4 would also increase them further due to the increase in agricultural treatment. Potential impacts to water supply wells and permanent impacts to the aquifer can be mitigated to a less than significant level through investigation, monitoring, alternative water supply, and aquifer restoration per **Mitigation Measures WTR-MM- 2, WTR-MM-4, and WTR-MM-5**. However, temporary impacts to the aquifer may be significant and unavoidable if increases in uranium or other radionuclides cannot be avoided during remediation without substantially impeding chromium remediation progress.

Alternative 4C-5: Increase in Total Dissolved Solids, Uranium and Other Radionuclides due to Agricultural Treatment

Although this alternative would use above-ground treatment for remediation of hexavalent chromium in the ~~source area~~Source Area where concentrations are greatest instead of in-situ remediation, it would still utilize agricultural treatment for remediation of the lower concentration part of the plume. Therefore, impacts from implementing Alternative 4C-5 would be similar to other alternatives in regards to TDS. Alternative 4C-5 would have greater agricultural treatment extraction and irrigation (up to 3,167 gpm) compared to existing conditions and the No Project Alternative (1,100 gpm) and thus will have greater impacts on TDS. Larger areas of the plume than existing conditions will be affected by increased TDS concentrations during remediation. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-23. With implementation of **Mitigation Measures WTR-2, WTR-MM-4, and WTR-MM-5** impacts to drinking water aquifer and wells related to TDS can ~~reduce impacts~~be reduced to less than significant. Where complete avoidance of significant TDS increase is not feasible, there would be temporary degradation of the aquifer during remediation which would be significant and unavoidable, but **Mitigation Measure WTR-MM-4** would require ultimate remediation of any significant TDS increases due to remedial actions ~~in~~at the end of the project.

As described above, there is currently a lack of data to determine whether or not existing agricultural treatment have affected ~~naturally occurring~~ uranium and other radionuclide levels. If existing agricultural treatment has increased levels of these constituents, implementing Alternative 4C-5 would also increase them due to the increase in agricultural treatment. Potential impacts to water supply wells and permanent impacts to the aquifer can be mitigated to a less than significant level through investigation, monitoring, alternative water supply, and aquifer restoration per **Mitigation Measures WTR-MM- 2, WTR-MM-4, and WTR-MM-5**. However, temporary impacts to the aquifer may be significant and unavoidable if increases in uranium or other radionuclides cannot be avoided during remediation without substantially impeding chromium remediation progress.

Impact WTR-2f: Changes in Nitrate Levels due to Agricultural Treatment (Less than Significant, No Project Alternative; Beneficial for the Aquifer Overall and Less than Significant with Mitigation for Water Supply Wells, All Action Alternatives)

Methodology

The overall long-term effect of agricultural treatment will be removal of nitrate from groundwater due to crop uptake, which will be a beneficial effect for the aquifer as a whole. However, if groundwater were extracted from an area of higher nitrate concentrations and then treated in agricultural units in an area with lower nitrate concentrations, it is theoretically possible that nitrate concentrations could increase locally in the latter areas if plant uptake was not complete or extensive percolation occurs to groundwater such as in cooler times of the growing season.

This potential localized impact was analyzed by examining the possibility for different alternatives to extract groundwater from locations with relatively higher nitrate concentrations and discharge to areas of lower nitrate concentrations.

This impact is considered significant if remedial activities would increase nitrate concentrations in groundwater or water supply wells to levels above Maximum Contaminant Levels (if current concentrations are less than the standard) or would increase nitrate concentration by more than 10% (if current concentrations exceed the standard) or would increase nitrate concentration by more than 20% (if current concentrations do not exceed the standard) unless proven to not be significant. Finally, where any of the above conditions are found in a water supply well or a monitoring well within one-half mile upgradient or one-quarter mile cross gradient of a water supply well, this is also considered a significant impact

Impact Overview

All alternatives discussed in this document would not add nitrates as part of remedial actions and thus would not increase the amount of nitrate in the aquifer overall beyond that which already exists. However, since all alternatives involve agricultural treatment of the chromium plume, they all could change concentrations of nitrate in the aquifer locally as extracted water may have different levels of nitrate than present in the aquifer beneath irrigated land. If the extracted water has higher levels of nitrate than present in the aquifer beneath irrigated land, irrigation could result in increased of nitrate concentrations in the local part of the aquifer and potentially in water supply wells.

Agricultural treatment has the potential to reduce the nitrate concentration in the aquifer when the applied nitrate water is ~~used~~taken up by crops as nutrients. Agricultural treatment units located in the same area as groundwater extraction will reduce nitrate concentration in that area over time. As described above under Existing Setting, nitrate concentrations in extracted groundwater applied to existing agricultural treatment units have been shown to be reduced by up to 90%. The overall effect of agricultural treatment will be removal of nitrate from groundwater, which will be a beneficial effect for the aquifer as a whole.

There is, however, potential for localized nitrate increases to still occur due to movement of water during remediation. The project areas with known highest nitrate concentrations (40 ppm as N or higher) are in the central part of the project area between Acacia Road and Thompson Road (See Figure 3.1-8). As shown on Figure 3.1-8, south of Acacia Road, most of the nitrate concentrations are less than 20 ppm N with some areas, such as west of Summerset Road, having concentrations less than 10 ppm N. If groundwater were extracted from an area of higher nitrate concentrations and then discharged in an area with lower nitrate concentrations, it is theoretically possible that nitrate concentrations could increase in those areas due to percolation. Adversely changing the water quality of the aquifer may be a significant impact if the time of impact was long term or if there is a significant increase or potentially significant increase in nitrate concentrations in a water supply well.

However, this potential impact can be addressed with the implementation of mitigation measures that involve monitoring nitrate levels and managing agricultural treatment to avoid increases in nitrate concentration above 10 ppm (as N) by more than significance criteria compared to existing conditions (per **Mitigation Measure WTR-MM-6~~7~~**). This may be done by monitoring nitrate levels at agricultural treatment units, managing extraction source water, and or providing alternative water supplies (for affected wells) if necessary. Implementation of this mitigation measure would reduce nitrate impacts to a less than significant level.

No Project: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

As described above, prior agricultural treatment activities as part of remediation of the chromium plume has resulted in reduction of nitrate levels overall in groundwater beneath the Desert View Dairy. The No Project Alternative does not propose to change agricultural treatment compared to existing conditions.

WDR R6V-2008-0014 specifies that nitrate levels shall not exceed water quality standards or increase more than 25 percent above current conditions. Current monitoring and management of nitrate levels during remediation activities will continue as required by current Water Board orders. Therefore nitrate concentrations are unlikely to increase as part of the No Project Alternative compared to existing conditions and this impact would be less than significant.

Alternative 4B: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

Alternative 4B involves increased groundwater pumping for agricultural treatment of the chromium plume compared to existing conditions, which could change concentrations of nitrate in the aquifer below the irrigated land. Overall, Alternative 4B would over time result in reduction of nitrate levels through agricultural treatment.

Alternative 4B would include a new pivot (the Yang pivot) directly south of the Cottrell agricultural treatment unit, in an area where existing nitrate concentrations are mostly of 10 ppm or less. Depending on where groundwater is extracted from, it may contain nitrate concentrations greater than 10 ppm. In addition, additional agricultural treatment units will be required for this alternative to address the expanded plume and they may also be located in areas with nitrate concentration less than 10 ppm, such as along Summerset Road. Where agricultural treatment uses water extracted from areas with higher nitrate concentrations than that in the groundwater beneath the agricultural treatment unit, nitrate concentrations could increase.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-19.

This potential impact to local parts of the aquifer can be addressed with the implementation of mitigation measures that involve monitoring nitrate levels and managing agricultural treatment to avoid significant increases in nitrate concentrations (per **Mitigation Measure WTR-MM-6~~7~~**). This may be done by only applying water with nitrate concentrations less than 10 ppm and/or through demonstrated pilot studies showing that application of water with higher concentrations is not resulting in any significant increase in nitrate levels (more than 20%). Where necessary, alternative water supplies will be required for affected or potentially affected water supply wells. Implementation of this mitigation measure would reduce this impact to a less than significant level.

Alternative 4C-2: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

Alternative 4C-2 involves increased groundwater pumping for agricultural treatment of the chromium plume compared to existing conditions, which could change concentrations of nitrate in the water that infiltrates back to the aquifer below the irrigated land. Overall, Alternative 4C-2 would over time result in reduction of nitrate levels through agricultural treatment.

Alternative 4C-2 would include new pivots (the Yang, Bell South and North, and West pivots) in areas with existing nitrate concentrations mostly of 20 ppm or less. Depending on where groundwater is extracted from, it may contain nitrate concentrations greater than 20 ppm. In addition, additional agricultural treatment units will be required for this alternative to address the expanded plume and they may also be located in areas with nitrate concentration less than 10 ppm, such as along Summerset Road. Where agricultural treatment uses water extracted from areas with higher nitrate concentrations than that in the groundwater beneath the agricultural treatment unit, nitrate concentrations could increase.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-20.

This potential impact to local parts of the aquifer can be addressed with the implementation of mitigation measures that involve monitoring nitrate levels and managing agricultural treatment to avoid significant increases in nitrate concentrations (per **Mitigation Measure WTR-MM-6~~7~~**). This may be done by only applying water with nitrate concentrations less than 10 ppm and/or through demonstrated pilot studies showing that application of water with higher concentrations is not resulting in any significant increase in nitrate levels (more than 20%). Where necessary, alternative water supplies will be required for affected or potentially affected water supply wells. Implementation of this mitigation measure would reduce this impact to a less than significant level.

Alternative 4C-3: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

This impact would be similar to that previously described for Alternative 4C-2. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-21. Impacts to the aquifer from agricultural treatment would be overall beneficial by reducing nitrate levels over time.

Although pumping for agricultural treatment would be greater for this alternative compared to Alternative 4C-2, the agricultural treatment unit acreages would be the same. As described for Alternative 4C-2, potential impacts to local parts of the aquifer would be addressed with implementation of **Mitigation Measure WTR-MM-~~7~~6** (monitoring and management of nitrate levels). Where necessary, alternative water supplies will be required for affected or potentially affected water supply wells. Implementation of this mitigation measure would reduce this impact to a less than significant level.

Alternative 4C-4: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

Alternative 4C-4 involves increased groundwater pumping for agricultural treatment of the chromium plume compared to existing conditions, which could change concentrations of nitrate in the water that infiltrates back to the aquifer below the irrigated land. The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-22. Overall, Alternative 4C-4 would over time result in reduction of nitrate levels in the aquifer through agricultural treatment.

Alternative 4C-4 would include new pivots, some in areas with existing nitrate concentrations mostly of 20 ppm or less and some such as along Summerset Road, with nitrate concentrations of 10 ppm or less. Depending on where groundwater is extracted from it may contain nitrate concentrations greater than 20 ppm or 10 ppm. Where agricultural treatment uses water extracted from areas with higher nitrate concentrations than that in the groundwater beneath the agricultural treatment unit, nitrate concentrations could increase locally.

This potential impact to local parts of the aquifer can be addressed with the implementation of mitigation measures that involve monitoring nitrate levels and managing agricultural treatment to avoid significant increases in nitrate concentrations (per **Mitigation Measure WTR-MM-~~7~~6**). This may be done by only applying water with nitrate concentrations less than 10 ppm and/or through demonstrated pilot studies showing that application of water with higher concentrations is not resulting in any significant increase in nitrate levels (more than 20%). Where necessary, alternative water supplies will be required for affected or potentially affected water supply wells. Implementation of this mitigation measure would reduce this impact to a less than significant level.

Alternative 4C-5: Changes in Nitrate Levels in the Hinkley Valley Aquifer due to Agricultural Treatment

This impact would be similar to that previously described for Alternative 4C-2 due to a similar level of agricultural treatment. Impacts to the aquifer from agricultural treatment would be overall beneficial by reducing nitrate levels over time.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-23. Potential impacts to local parts of the aquifer from agricultural treatment would be addressed through implementation of **Mitigation Measure WTR-MM-~~7~~6** (monitoring and management of nitrate levels). Where necessary, alternative water supplies will be required for affected or potentially affected water supply wells. Implementation of this mitigation measure would reduce this impact to a less than significant level.

Impact WTR-2g: Increase in Other Secondary Byproducts (Dissolved Arsenic, Iron and Manganese) due to In-Situ Remediation (Less than Significant, No Project Alternative; Temporarily Potentially Significant and Unavoidable for Aquifer and Less than Significant with Mitigation for Water Supply Wells, All Action Alternatives)

Methodology

In-situ remediation may result in temporary mobilization of byproduct metals (arsenic, manganese, and iron) naturally present in aquifer soils as a result of anaerobic (oxygen-poor, also called "reducing") groundwater conditions caused by injecting carbon into the aquifer for remediation of the chromium plume. Localized m~~M~~obilization of these metals can result in ~~an~~a short-term increase in the concentration of dissolved arsenic, manganese, and iron in groundwater.

This impact was evaluated by examining monitoring data to date from pilot testing of in-situ remediation using carbon amendment ~~to date in terms of~~for the generation of byproducts and the use of in-situ remediation by the different alternatives.

This impact is considered significant if in-situ remediation results in an increase of concentrations above primary or secondary Maximum Contaminant Levels~~,~~. This impact is also considered significant if in-situ remediation results in an increase of 10% or more of arsenic if current levels are more than the primary Maximum Contaminant levels, an increase of 20% of more of iron or manganese if current levels are more than secondary Maximum Contaminant Level, or an increase of 20% or more if current levels of the by-products are less than the primary or secondary Maximum Contaminant Levels[16]. Finally, where any of the above conditions are found in a water supply well or a monitoring well within one-half mile upgradient or one-quarter mile cross gradient of a water supply well, this is also considered a significant impact.

Impact Overview[17]

All action alternatives would increase the amount of in-situ remediation compared to existing conditions. Temporary and localized degradation of the aquifer near carbon amendment injection points is unavoidable if in-situ remediation is to be employed. As previously described, elevated byproduct concentrations in groundwater have been detected at distances estimated greater than 1,600 feet downgradient of injection points. If carbon amendment injection rates are increased and/or groundwater movement is locally faster than in the IRZs implemented to date, then the zone of influence could be greater than 1,600 feet experienced previously.

~~As well as~~In addition to measures already being performed to reduce potential impacts, proposed mitigation measures can help further reduce impacts or potential impacts to domestic water supplies.

If iron, manganese, or arsenic levels in a domestic water supply well are increased above the primary or secondary Maximum Contaminant Levels, PG&E will be required to provide alternative water supply (per Mitigation Measure WTR-MM-2). In addition, PG&E will be required to construct and operate additional extraction wells downgradient of or between the IRZ treatment area to intercept carbon amendments and secondary by product to prevent effects or potential effects to domestic water supply wells (per Mitigation Measure WTR-MM-7) and other receptors. Implementation of these mitigation measures would reduce this impact to a less than significant level for domestic, community, and agricultural wells.

While this impact can be mitigated, ~~control of the byproduct plumes by~~ limiting the byproduct plume extent through extraction wells~~,~~ or ~~limiting~~ the rate of carbon injections to the aquifer, could compromise the pace of chromium plume remediation. Should the Water Board allow temporary aquifer degradation due to byproduct plume generation to achieve more rapid or complete

[16] As noted in the significance criteria, the discharger may submit evidence if it believes the increase in a specific instanced is not statistically significant.

[17] Aboveground ex-situ treatment (Alternatives 4C-3 and 4C-5 only) would include filtering of any precipitated metals prior to reinjection into the aquifer, thus managing potential increases in arsenic, iron, manganese or other metals and their effect on the aquifer. As described in Chapter 2, *Project Description*, filter precipitates may contain hazardous waste levels of chromium or other elements and will be disposed of in offsite facilities approved to receive such material. There would be less than significant impacts on byproduct concentrations due to aboveground treatment and this impact is not analyzed further under this impact.

chromium plume remediation, then the aquifer would be temporarily and locally degraded and this would be a significant and unavoidable impact.

Prior experience with in-situ remediation has shown that concentrations of remedial byproducts return to ~~background~~pre injection levels as the injected carbon is consumed by microbial processes and is diluted with downgradient migration. This has occurred within a matter of months with prior pilot studies and prior remediation efforts. Thus, concentrations of iron, manganese, and arsenic are expected to return to pre-injection ~~background~~ levels within several months up to ~~several~~two years following the end of carbon injection based on experience with in-situ remediation to date. However, in case any residual effect were to be present near the end of chromium plume remediation activities, PG&E would be required to restore aquifer water quality conditions to the pre-project ~~(pre-remedial)~~ condition ~~in order~~. This action is necessary to restore beneficial uses of the aquifer to what they were before implementation of the remedial actions included in the proposed project, as described in **Mitigation Measure WTR-MM-4**.

No Project: Increase in Other Byproducts Due to In-Situ Remediation

As part of the No Project Alternative, in-situ remediation will not be increased above existing conditions. As described above, in-situ remediation has resulted in an increase in byproduct (arsenic, iron, manganese) generation in areas downgradient from injection points ~~and these increases can exceed~~ at concentrations exceeding primary and/or secondary Maximum Contaminant Levels, but the increases due in-situ remediation is limited to within the 3.1 ppb chromium plume.

WDR R6V-2008-0014 specifies that groundwater concentrations of byproducts outside the chromium plume area shall not exceed water quality standards due to remedial operations.[18] Degradation of water quality in domestic supply wells can be avoided through the existing IRZ Contingency Plan ~~which~~. The Plan includes specific measures to be performed if ~~threshold~~pre-remedial reference concentrations of byproducts ~~specified~~listed in the General Permit for IRZ treatment (Lahontan Regional Water Quality Control Board 2009) are exceeded at designated monitoring wells within the project area. ~~This plan~~The Plan also includes adaptive measures, such as reduced carbon amendment concentrations or additional extraction wells near the plume boundary to avoid byproduct increases compromising domestic water supply well water quality.

The IRZ Contingency Plan (Pacific Gas and Electric 2011c, *Appendix H—Contingency Plan for Hydraulic Capture and Treatment*) requires avoidance of the following ~~in~~conditions affecting domestic water supply wells:

- increases in arsenic concentrations above current conditions;
- increase in iron concentrations above the secondary drinking water Maximum Contaminant Level of 300 ppb (or increases in iron if already above the Maximum Contaminant Level); and

[18] R6V-2008-0014 requires ~~groundwater~~ concentrations of remedial byproducts in groundwater outside the plume area to ~~meet all~~not exceed primary and secondary Maximum Contaminant Levels due to remedial operations, except for Total Dissolved Solids and nitrate which already exceed standard levels. See discussion of existing TDS and Nitrate levels in Section 3.1.4.3 above and Figures 3.1-7 and 3.1-8.

- increases in manganese concentrations above the secondary drinking water Maximum Contaminant Level of 50 ppb (or increases in manganese if already above the Maximum Contaminant Level).

Mobilization of these metals would be controlled by decreasing injected carbon concentrations in the injection wells. This would minimize the size and magnitude (i.e., redox potential) of the reduction zone and would allow the carbon to be depleted more quickly from the groundwater. If byproducts plumes will not be controlled by reducing carbon injections, then more active remedial measures will be required, such as extraction wells to intercept these plumes.

This impact would be less than significant with PG&E's continued implementation of previously required requirements such as the IRZ Contingency Plan (Lahontan Regional Water Quality Control Board 2009) and the latest Manganese Mitigation Plan (Pacific Gas and Electric 2011h). With the implementation of these previously required mitigation measures, this impact would be less than significant for the No Project Alternative.

Alternative 4B: Increase in Other Byproducts Due to In-Situ Remediation

The implementation of increased in-situ remediation as part of Alternative 4B could result in increased levels of byproducts, such as dissolved arsenic, iron, and manganese in the groundwater compared to existing conditions. Alternative 4B would increase carbon-amended injection rates from 190 gpm (at present) up to 431 gpm. Mobilization of byproduct metals can be controlled by reducing injected carbon concentrations and/or reducing injection flows, as described in the existing IRZ Contingency Plan. However, decreasing carbon injections could interfere with achieving project cleanup goals, and maintaining higher injection rates may be desired to maintain cleanup speed. In managing the tradeoff between faster cleanup and greater byproduct creation, faster cleanup may be desirable in the long run.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-19.

Where byproduct concentrations are increased above the significance criteria described above, this is considered a significant impact to the aquifer. Byproduct concentrations could also be exceeded at designated monitoring wells, and if unmitigated could affect domestic wells and this impact would be significant. Implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes) would reduce this impact to less than significant for domestic and agricultural wells.

However, temporary impacts to the aquifer (not to water supply wells) during remediation may be significant and unavoidable in the event that the Water Board allows temporary and localized degradation to occur in favor of accelerated chromium plume remediation.

Alternative 4C-2: Increase in Other Byproducts Due to In-Situ Remediation

The implementation of increased in-situ remediation as part of Alternative 4C-2 would have the same impacts as Alternative 4B as it would have the same level of in-situ remediation.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-20.

Where byproduct concentrations are increased above the significance criteria, this is considered a significant impact to the aquifer. Impacts to domestic supply wells due to in-situ remediation byproducts would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

However, temporary impacts to the aquifer (not to water supply wells) during remediation may be significant and unavoidable in the event that the Water Board allows temporary and localized degradation to occur in favor of accelerated chromium plume remediation.

Alternative 4C-3: Increase in Other Byproducts Due to In-Situ Remediation

The implementation of increased in-situ remediation as part of Alternative 4C-3 would have the same impacts as Alternatives 4B and 4C-2 as it would have the same level of in-situ remediation.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-21.

Where byproduct concentrations are increased above the significance criteria this is considered a significant impact to the aquifer. Impacts to domestic supply wells due to in-situ remediation byproducts would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

However, temporary impacts to the aquifer (not to water supply wells) during remediation may be significant and unavoidable in the event that the Water Board allows temporary and localized degradation to occur in favor of accelerated chromium plume remediation.

Alternative 4C-4: Increase in Other Byproducts Due to In-Situ Remediation

The implementation of increased in-situ remediation as part of Alternative 4C-4 would have the same impacts as Alternative 4B, 4C-2, and 4C-3 as it would have the same level of in-situ remediation.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-22.

Where byproduct concentrations are increased above the significance criteria, this is considered a significant impact to the aquifer. Impacts to domestic supply wells due to in-situ remediation byproducts would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

However, temporary impacts to the aquifer (not to water supply wells) during remediation may be significant and unavoidable in the event that the Water Board allows temporary and localized degradation to occur in favor of accelerated chromium plume remediation.

Alternative 4C-5: Increase in Other Byproducts Due to In-Situ Remediation

This impact would be similar to that previously described for other action alternatives. However, Alternative 4C-5 does not include in-situ remediation in the Source Area IRZ; it includes only the Central Area IRZ and the South Central Reinjection Area, and as such, the overall in-situ treatment and thus the magnitude of this impact under this alternative would be less than for other action alternatives.

The area of likely effect for remedial byproducts for this alternative is shown in Figure 3.1-23.

Where byproduct concentrations are increased above the significance criteria, this is considered a significant impact to the aquifer. Impacts to domestic supply wells due to in-situ remediation byproducts would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

However, temporary impacts to the aquifer (not to water supply wells) during remediation may be significant and unavoidable in the event that the Water Board allows temporary and localized degradation to occur in favor of accelerated chromium plume remediation.

Impact WTR-2h: Potential Degradation of Water Quality due to Freshwater Injection (Less than Significant with Mitigation, All Alternatives)

Freshwater is extracted from three supply wells (PGE-14, FW-01, and FW-02) located south of the Compressor Station property and injected into five wells along Serra Road, at the western plume boundary. This action wouldis done to prevent chromium plume migration towards the west by deflecting the migration instead to the northeast. The injection of freshwater into wells along Serra Road is proposed to continue unchanged under all alternatives.

One of the current supply wells used by PG&E at its Compressor Station for freshwater injection has concentrations of arsenic up to 60 ppb, which far exceeds the Maximum Contaminant Level of 10 ppb. Prior to injection of this water into the injection well field, the water is filtered through an ion exchange system to remove naturally-occurring arsenic to concentrations below the Maximum Contaminant Level (Pacific Gas and Electric 2010a). As described in Chapter 2, *Project Description*, all alternatives will include filtration or pretreatment of water for arsenic to ensure that naturally-occurring arsenic is not introduced into the injection areainjected water meets drinking water quality.

As shown in Figures 3.1-7 (TDS), Figure 3.1-8 (Nitrate), Figure 3.1-10 (TDS), and Figure 3.1-11 (Manganese), the location of the currentwater supply well containing arsenic is in an area with relatively low levels of these constituents compared to other parts of the Hinkley Valley Aquifer. Use of water from the current source would not degrade water quality for these constituents at the injection point.

In response to Order No. R6V-2012 – 0057, PG&E submitted a Radionuclide Data Summary Report on November 30, 2012. PG&E data on freshwater supply wells (PGE-14, FW-01, and FW-02) located upgradient (south) of the chromium plume and of the IRZ and agricultural treatment areas had total uranium levels up to 4.1 pCi/L, up to 8.5 pCi/L for gross alpha, and up to 23.3 pCi/L for gross beta (PG&E 2012j). These concentrations are less than the corresponding MCLs. Data on uranium or other radionuclide levels for the current water supply wells used for freshwater water injection was not located and is limited in general for the Hinkley Valley. Thus, it is possible thatcurrent uranium or other radionuclide levels in the existinga water supply well used for freshwater injection could be higher that the location of injection.do not appear to be a water quality concern.

However, gGiven the decades-long duration of remedial activities, it is also possible that future water supply wells may be located in other locations and/or the water quality of the current source water could change due to external factors. In order to ensure that freshwater injection does not result in significant degradation of water quality, **Mitigation Measure WTR-MM-8** will require water used for freshwater injection to meet applicable water quality standards or, if injection point.

If, however, injected water quality does not meet water quality standards, ~~injection water~~ it must have water quality equal to or better than that at the injection point.

With this mitigation, freshwater injection would not result in a significant impact on water quality.

Impact WTR-2i: Taste and Odor Impacts due to Remedial Activities (Less than Significant, No Project Alternative; Less than Significant with Mitigation, All Action Alternatives)

Methodology

Agricultural treatment could increase TDS concentrations in groundwater, which could result in exceedance of taste and odor standards for drinking water. Increased ~~in the introduction~~use of carbon amendments or other treatment byproducts to the groundwater due to in-situ remediation could also affect taste and odor characteristics of the groundwater used for drinking water supplies.

~~This impact was~~These impacts were analyzed by considering the potential for remedial activities to impair taste and/or odor characteristics of groundwater. Since potential taste and odor issues are related to TDS and other remedial byproducts (such as iron and manganese), this impact is considered significant if remedial activities result in exceedance of the significance criteria described above for Impact WTR-2g for remedial byproducts.

Impact Overview

Implementation of all action alternatives would involve more intense application of the in-situ treatment compared to existing conditions~~, which~~. This action would increase the ~~introduction~~amount of carbon amendments and/or other treatment byproducts to the groundwater that could affect temporarily taste and/or odor. In most cases, carbon amendments should dissipate by anaerobic or aerobic microorganisms before reaching domestic water supply wells unless such wells are close to the injection point (experience to date indicates substantially elevated total organic carbon concentrations 400 to 800 feet downgradient of injection wells). ~~Similarly, byproducts may~~The dissipation of added carbon to the groundwater will be monitored in wells surrounding the IRZ areas. In the unlikely event that byproducts migrate from the treatment zone, but it is expected that the concentrations of these compounds would ~~usually~~ dissipate before reaching domestic wells, unless such wells are relatively close to the injection point. Taste and odor impacts or potential impacts to domestic supply wells due to in-situ remediation reagent injection would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply), **Mitigation Measure WTR-MM-4** (remediation of byproduct plumes) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

All alternatives, other than the No Project Alternative, would also include more agricultural treatment than existing conditions~~, which~~. This action could increase TDS as discussed above under Impact WTR-2e which could result in significant taste and odor impacts to domestic water supply wells. Taste and odor impacts or potential impacts to domestic supply wells due to agricultural treatment would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply) and/or **Mitigation Measure WTR-MM-4** (remediation of byproduct plumes).

No Project: Taste and Odor Impacts Due to Remedial Activities

Implementation of the No Project Alternative would not involve additional extraction and injection wells for in-situ treatment compared to existing conditions which would not increase the potential for taste and odor impacts (agricultural treatment would be the same as existing conditions).

WDR R6V-2008-0014 requires that groundwater outside the proposed project boundaries not contain taste or odor-producing substances that cause nuisance or adversely affect beneficial uses. For groundwater designated as municipal or domestic supply, at a minimum, concentrations shall not exceed the secondary Maximum Contaminant Levels.

The IRZ Contingency Plan includes specific measures to be performed if ~~threshold~~reference concentrations of Total Organic Carbon and/or secondary byproducts are exceeded at designated monitoring wells within the project area (Lahontan Regional Water Quality Control Board 2009). This ~~plan~~Plan requires adaptive measures (reduced carbon amendment concentrations) to eliminate any taste and odor concerns outside of the chromium plume boundary.

With the implementation of previously required mitigation measures, impacts of this alternative on taste and odor objectives would be less than significant.

All Action Alternatives: Taste and Odor Impacts Due to Remedial Activities

The implementation of both increased agricultural treatment and in-situ remediation as part of Alternatives 4B, 4C-2, 4C-3, 4C-4, and 4C-5 could degrade taste and odor characteristics of groundwater used for drinking water compared to existing conditions. Agricultural treatment impacts would result in increased TDS in groundwater~~ which would increase with the amount of agricultural treatment and~~. ~~T~~Tthus, increased TDS concentrations would be highest with Alternative 4C-4, roughly similar for Alternatives 4C-2, 4C-3, and 4C-5, and relatively the smallest with Alternative 4B. In-situ remediation impacts would be the same for Alternatives 4B, 4C-2, 4C-3, and 4C-4 due to similar levels of carbon-amended flows~~ and~~. In-situ remediation impacts however would be somewhat less~~ impacts~~ with Alternative 4C-5 due to less use of carbon-amended flows.

Taste and odor potential impacts to domestic supply wells would be less than significant with implementation of **Mitigation Measure WTR-MM-2** (alternative water supply), **Mitigation Measure WTR-MM-4** (remediation of byproduct plumes) and/or **Mitigation Measure WTR-MM-7** (use of extraction wells to intercept byproduct plumes).

3.1.8.3 Drainage Impacts

This section discusses drainage impacts. Flooding impacts are discussed separately in Section 3.1.8.4.

Impact WTR-3: Impacts Related to Drainage Patterns and Runoff (Less than Significant, All Alternatives)

The areas where project remedial activities would occur are located in geographically flat areas where most of the drainage will likely accumulate as localized pools and ultimately evaporate or infiltrate into surface soils, rather than being transported as sheet flow.

Implementation of project alternatives would not result in an alteration of drainage patterns such that potentially significant erosion, siltation, or flooding will result on or off the project site. The project area has no surface drainage features other than surface irrigation drainage ditches (from historical flood irrigation) and small floodwater channels and washes. The nearest substantial surface water body to the project site is the Mojave River, located approximately 1 mile south of the Hinkley Compressor Station. There is also a sizable desert wash that runs parallel to Coon Canyon Road that drains ~~much~~the eastern portion of the Hinkley Valley toward Harper Lake.

The project alternatives would not exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of runoff. There would be an increase in impervious area due to new road segments, parking lots, and structures associated with the construction and operation of above-ground treatment plants (Alternatives 4C-3 and 4C-5 only). Implementation of project alternatives will create minor impervious surfaces for supporting infrastructure, such as treatment system equipment pads, wellhead protection pads, etc. However, these impacts would be minimal compared to the overall project area, as it would cover a small area compared to 21,093 acre project area, most of which consists of pervious land. Therefore, project alternatives would have less than significant impacts on drainage patterns and runoff.

3.1.8.4 Flooding Impacts

This section discusses physical impacts related to flooding.

Impact WTR-4: Impacts Related to Flooding (Less than Significant, All Alternatives)

Based on Federal Emergency Management Agency (FEMA) flood zone designation maps, the majority of the project area is not located within the 100-year floodplain and would not be subject to flood-related hazards. However, as shown in Figure 3.1-2, a small portion of the southeastern edge of the project area lies within a FEMA Special Flood Hazard Area (SFHA) Zone A, which is defined as area subject to inundation by the 1-percent-annual-chance flood event.

The portion of the project area that lies within an area of flood risk (near the Mojave River) is located in an area where no structures are expected to be placed, with the exception of potential installation of new monitoring wells, which would not impede or increase flood flows. Housing is not part of the project and therefore it will not involve placing housing within a 100-year flood hazard area. In addition, this project would likely not place structures within a 100-year flood hazard area that would impede or redirect flood flows or result in an increased risk in loss, injury or death due to flooding.

The majority of infrastructure associated with new wells lies underground, and surface well pads typically cover a small area (i.e., 10 square feet and 1 ft. in height) compared to the surrounding area and would not significantly impede flood flows.

This project would not expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam. As previously described, the flood hazard zone is located in a small area in the southeastern portion of the project area where minimal to no remedial activity is anticipated. There will be no significant alteration in drainages or large structures that would cause flooding in a non-flood hazard zone within the project area. Because the Mojave River is located outside of the area where remedial actions would take place and there are no levees located immediately upstream of the Mojave River in relation to the project area, there would be no associated flood risk with the failure of a levee.

There is a dam approximately 45 miles upstream from Hinkley on the Mojave River south of Hesperia (the Mojave River Dam also called Mojave River Forks Dam) which is used for flood control. In the unlikely event of breach of this dam, dam inundation maps indicate that the Mojave River could overflow into the Hinkley Valley. Were this to occur, underground remedial infrastructure would likely be unaffected, but surficial features such as roads, well pads, irrigation equipment, and above-ground treatment plants could be damaged. Should these features be damaged by this low-probability event, they could be rebuilt. Given the remote nature of this potential impact, and the fact that the project does not include residential use, this is considered a less than significant impact.

The project area is not subject to risk from a seiche, tsunami, or mudflow because there are no water bodies, such as a large lake or ocean, located nearby that would pose a risk of a seiche or tsunami. There are no known areas where landslides or mudflows have occurred in the project area.

For these reasons, the project alternatives are all considered to have a less than significant impact relative to flooding.

3.1.9 Mitigation Measures

Mitigation Measure WTR-MM-1: Purchase of Water Rights to Comply with Basin Adjudication

Regional groundwater drawdown from the project may reduce the availability of regional and state water supplies in the Centro Subarea.

The Water Board will include requirements in the new CAO and/or associated WDRs issued for the remediation as follows:

- By ~~December~~January 31 of every year, PG&E will document its total water rights and its Free Production Allowance for groundwater pumping relative to the remedial project to the Water Board.
- By December 31 of every year, PG&E will document the expected total amount of net agricultural treatment water use for the following year.
- At all times, PG&E will possess adequate water rights and Free Production Allowance that meet or exceed the current expected agricultural treatment water use.
- If PG&E fails to acquire adequate water rights and FPA to support proposed agricultural treatment, PG&E will be required to implement above-ground treatment ~~adequate to~~or modify existing remedial activities to adequately compensate for any loss in planned agricultural treatment.

Mitigation Measure WTR-MM-2: Mitigation Program for Water Supply Wells Affected by Remedial Activities, including Impacts Due to Chromium Plume Expansion, Remediation Byproducts and Groundwater Drawdown

PGE& will implement a comprehensive program to determine residences and agricultural land owners whose wells may be adversely affected by remedial actions in relation to chromium plume expansion, remediation byproducts, or groundwater drawdown.

Implementation of the program described below is designed to provide advance warning before water supply well impairment occurs ~~and is~~. Such a program will be designed to either expedite remediation before a water supply well becomes affected, or provide reliable water supply for the entire duration of well impairment due to remedial activities. For the purposes of the project and this EIR, water supply wells are those that provide water for agricultural, domestic, or industrial uses, and include those that are used for water supply for freshwater injections. Water supply wells do not include IRZ injection wells or monitoring wells.

The Mitigation Program will determine all "actually affected" and all "potentially affected" wells (defined for each sub-mitigation measure, WTR-MM-2a through 2c, below).

If a water supply well is determined to be an "actually affected" well, then PG&E will provide alternative water supply meeting the requirements described below.

If a water supply well is determined to be "potentially affected" well, then PG&E will either 1) expedite remediation of the conditions causing the well to be potentially affected such that actual impacts do not occur; or 2) provide alternative water supply. If PG&E chooses to remediate the triggering condition, it will provide a feasibility study and plan to the Water Board demonstrating feasible means to avoid actually affecting any domestic or agricultural well.

If expedited remediation is not feasible, PG&E will provide alternative water supply to all "potentially affected" wells prior to the wells being actually affected by chromium plume expansion, remedial byproducts or substantial groundwater drawdown. Because the definition of a "potentially affected" well includes any well that is projected to be affected in the next year, this provides adequate advanced warning to feasibly provide the alternative water supply before impacts to ~~affected~~supply wells occur.

Water Quality Requirements for Alternative Water Supply

- Domestic Wells - For domestic wells affected by remedial activities, the alternative water supply will meet the following water quality requirements for interior household uses:
    - For chromium, alternative water supply shall be equal to or less than Water Board established maximum background levels.
    - Alternative water supply will meet all primary and secondary Maximum Contaminant Levels for any constituent, other than chromium, that is affected by remedial activities as defined in this mitigation.
    - For constituents not affected by remedial activities, the alternative water supply will be consistent with pre-project water quality.
    - California and federal requirements for public water systems will apply if the replacement water supply is defined as a public water system. Where the requirements in the three prior bullets are e stricter than public water system requirements, then the more restrictive requirement shall apply.[19]

[19] The federal Safe Drinking Water Act and derivative legislation define public water system as an entity that provides "water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year.

- Domestic Wells - For domestic wells affected by remedial activities, PG&E will provide replacement water for outside non-potable household uses in an amount and quality sufficient to support existing outdoor non-potable water uses. Such outside non-potable uses include, but are not limited to, the following: irrigation for landscaping, gardening, provision of water for pets and livestock, and washing.
- Agricultural Wells - PG&E will provide replacement water suitable for agricultural use (including livestock) to all potentially affected agricultural wells, as defined below, in an amount and quality sufficient to support existing agricultural use.

Water Supply Options

In advance of implementing the project PG&E will provide a feasibility study and plan to provide alternative water supplies. Provision of alternative water supplies may be through one or more of the following methods:

- Deeper Well Option—PG&E may opt to drill supply wells deeper if the deeper well is shown to have sufficient water supply yield and to meet the water quality requirements (defined above) or be treatable to such levels through on-site treatment provided by PG&E. The Water Board will not allow the use of deeper wells if there is a potential to spread chromium from the upper aquifer to the lower aquifer. Although PG&E has indicated that it is no longer offering the deeper well option as part of the current whole house water replacement program due to the inability to meet the Water Board order's standard for Cr[VI] of 0.06 ppb, the EIR mitigation standard for Cr[VI] is the maximum background level of Cr[VI] (currently 3.1 ppb), thus the deeper well option remains a feasible option for EIR mitigation.
- Storage Tank and Hauled Water Option—PG&E may opt to provide water storage tanks and haul water to the affected location provided water meets the water quality requirements (defined above) or be treatable to such levels through on-site treatment provided by PG&E. If a homeowner rejects this option for their residence, PG&E must offer them an alternative.
- Well Head Treatment Option—PG&E may opt to provide treatment systems at the well head to provide water that meets the water quality requirements.
- Well Modification—For wells only affected by groundwater drawdown due to remediation, existing wells may be modified to provide water, such as by lowering the well pump, provided that the modification provides adequate water supply and water quality to support domestic or agricultural use, as appropriate.
- Alternative Supply Option—PG&E may opt to provide an alternative water supply that draws water from a source of water that is not affected by the chromium plume, such as a community water system,. This option can only be provided such that the water source is not projected to be affected by plume expansion, remedial byproducts, or groundwater drawdown for the lifetime of remediation and can meet the water quality requirements. There are several different options for a water supply system as follows:
  - Use of wells upgradient or otherwise unaffected by the chromium plume or remediation, combined with a system of pipelines to water recipients. For example, wells near the Mojave River are upgradient of the chromium plume, are consistently productive, and could be potential candidates for a well source. Based on experience with freshwater injection using PG&E's wells south of the Compressor Station, there may be naturally-

occurring constituents, such as arsenic, that might require pre-treatment before providing as a drinking water system.

  - Use of a connection to Golden State Water Company which could involve an estimated 12-mile pipeline to tie in to the existing water treatment system.
  - Use of a connection to the MWA recharge pipeline located along Community Blvd. The MWA recharge pipeline derives water from the California aqueduct and MWA would have to acquire adequate rights to water to provide it as local water supply. If this water is unable to meet drinking water standards in its original state, it may require treatment before distribution as a water source.
  - As described below under Mitigation Measure WTR-MM-5, as the specifics of proposed water systems are developed, additional project-level CEQA analysis may be necessary.

- Bottled Water Option – If requested by the homeowner, PG&E may provide bottled water for consumptive uses. However, the provision of bottled water does not meet the full intent of this mitigation because full well water replacement would not be provided for all indoor and outside water uses. Therefore, bottled water would need to be supplemented with one of the other options described above to provide full well water replacement. If the homeowner only wants bottled water and not full well water replacement by the proposed methods, then PG&E shall document this to the Water Board.

Regarding a community water system, while technically feasible, there may be challenges to implementing such a system in Hinkley.

- According to the EPA, very small systems (those serving 25 to 500 people) have the largest number of violations (mostly monitoring/reporting violations), and they experience one maximum Contaminant Level Violation for every 80 people serve, which is the highest ratio of all system service population categories. By comparison, large urban systems (serving more than 100,000 people) experience one Maximum Contaminant Level violation for every 200,000 people service (EPA ~~2012~~2012b)[20].
- The California Department of Public Health (CDPH) has regulatory authority over community water systems. Under the provisions of Section 116330 of the California Health and Safety Code, CDPH has delegated approval of small water systems with less than 200 connections to local primary agencies, which in this case would be the San Bernardino County Public Health Department, Division of Environmental Health Services. A permit application for a community water system would require comprehensive technical, managerial, and financial assessments to gain CDPH (if more than 200 connections) or San Bernardino County (if less than 200 connections) approval. In order to be approved, ~~Small~~small water systems must demonstrate that they can be sustainable for the long term.
- An additional concern is the long lead time to implement a community water system, given the approval and review process, and more extensive construction activities than other options, which could take as long as 5 years.
- Hinkley is dominated by rural residences, many of which are highly dispersed, which increases the amount of piping, pumping, and associated cost and construction.

[20] See http://www.epa.gov/nrmrl/wswrd/dw/smallsystems/regulations.html.

- Some individuals in Hinkley may prefer a community water system, but other individuals may prefer the independence of their own well, which may complicate the implementation of this option.

Monitoring

Water Quality Monitoring and Groundwater Modeling

- PG&E will monitor water quality and model groundwater conditions as required by Mitigation Measures WTR-MM-2a, -2b, and -2c below.

Reporting

- PG&E will incorporate reporting on water supply program implementation into annual reporting to the Water Board. Reporting will include descriptions of all completed and planned expedited remediation actions and alternative water supplies for the following year.

Mitigation Measure WTR-MM-2a: Mitigation Program for Water Supply Wells Affected by the Chromium Plume Expansion due to Remedial Activities

Defining Actually and Potentially Affected Domestic Supply Wells

"Actually affected domestic wells" will be defined as any domestic water supply well with chromium (hexavalent or total) concentrations that exceed any of the following criteria due to remedial actions:

- Maximum background levels (if the well previously had concentrations below maximum background levels); or
- concentrations increase by 10% or more (if the well previously had concentrations that exceed maximum background levels).

"Potentially affected domestic wells" will be defined as domestic supply wells that have an increase in chromium concentrations due to remedial actions and which:

- are located within one-mile of the defined chromium plume; or
- are predicted to have any of the above conditions for an "actually affected domestic well" within one year as indicated by groundwater modeling.

Monitoring

Water Quality Monitoring

- PG&E will monitor Cr[VI] and Cr[T] in domestic wells ~~where levels~~ (wherever allowed by well owners) within one mile down gradient or cross gradient of the previously defined chromium plume, on a quarterly basis.
- Monitoring requirements may be adjusted by the Water Board's Executive Officer based on contaminant concentration trends, plume geometry changes, or other factors.

Water Quality and Groundwater Modeling

- PG&E will annually model the movement of the chromium plume and will provide maps and descriptions of estimated plume movement for the following three years. The modeling effort will be provided to the Water Board by ~~December~~January 31 of each year.

- The results of the modeling will include predictions for wells that may become affected within the following year and such predictions will be used to plan for either changing remediation activities and/or the provision of alternative water supplies in advance of effects on domestic and agricultural wells.
- The report will also define the down gradient and cross gradient monitoring program areas under this section for the following year. Monitoring areas may be modified over the course of the year as described in the water quality monitoring section above.

Mitigation Measure WTR-MM-2b: Water Supply Program for Water Supply Wells Affected by Remedial Activity Byproducts

Defining Actually Affected and Potentially Affected Wells

"Actually affected domestic wells" will be defined as any domestic water supply well with remediation byproduct concentrations that exceed any of the following criteria due to remedial actions:

- concentrations above a California primary or secondary Maximum Contaminant Levels if the well currently contains concentrations that are less than California primary or secondary Maximum Contaminant Level or water quality objective; or
- a 10% increase above current levels if the well has concentrations that currently exceed a California primary Maximum Contaminant Level (unless it can be demonstrated that an increase is statistically significant at a different level) [21]; or
- a 20% increase above current levels if the well has concentrations that currently exceed a California secondary Maximum Contaminant Level or water quality objective (unless it can be demonstrated that an increase is statistically significant at a different level)[22]; or
- a 20% increase above current levels if the well has concentrations that currently are less a California primary or secondary Maximum Contaminant Level or water quality objective (unless it can be demonstrated that an increase is statistically significant at a different level)..[23]

"Potentially affected domestic wells" will be defined as wells that meet any of the following criteria:

- All wells located within one-half mile downgradient or one-quarter mile cross gradient of an "actually affected domestic well" or an affected monitoring well (when no domestic well exists within these intervals).
- All wells predicted to be within one-half mile downgradient or one-quarter mile cross gradient of an "actually affected domestic well" or an affected monitoring well (when no domestic well exists within these intervals) in the next year by water qualitygroundwater flow and transport modeling.

[21] As noted in the significance criteria, the discharger may submit evidence if it believes the increase in a specific instance is not statistically significant.

[22] Ibid.

[23] Ibid.

"Actually affected monitoring wells" will be defined using the criteria above for "actually affected domestic wells".

"Actually affected agricultural wells" will be defined as an agricultural well where the following has occurred:

- remedial action has caused an increase in TDS or otherwise affected water quality such that (1) agricultural yields are predicted to be reduced by at least 25% or (2)agricultural product is predicted to ~~be substantially reduced~~have substantial or likely reduction in quality or quantity. Examples of substantial changes in quality include changes in palatability, appearance, or other factors that would impede the ability to sell crops at prevailing crop prices.

"Potentially affected agricultural wells" will be defined as wells that meet any of the following criteria:

- Agricultural wells within one-half mile downgradient or one-quarter mile cross gradient of an "actually affected agricultural well" or an affected monitoring well (when no agricultural well exist within these intervals);
- All wells where any of the above conditions is predicted to occur through ~~water quality~~groundwater flow and transport modeling within one year.

Monitoring

Water Quality Monitoring

- PG&E will conduct an initial monitoring of domestic and agricultural wells within one-mile downgradient or cross-gradient of any proposed in-situ remediation or agricultural treatment unit commencing~~ immediately~~ upon approval of a new order allowing expanded remediation. Where possible without delaying planned remediation efforts, initial monitoring will be done before operation of new in-situ remediation areas and agricultural treatment units for a minimum of one~~-~~ year on a quarterly basis. Where initial monitoring cannot be done for ~~a full~~one year prior to operations without delaying planned remediation efforts, then initial monitoring can be done concurrently with commencement of operations of new in-situ remediation areas and agricultural treatment units. Groundwater elevations and constituents analyzed will include all potential remedial activity byproducts to ensure that pre-remediation ~~baseline~~ water quality is defined, and that definition is approved by the Water Board, for all domestic and agricultural wells for which well owners provide permission for sampling.
- PG&E will monitor for remedial activity byproducts in domestic and agricultural wells (wherever ~~allowed by well owners~~the Water Board deems appropriate) within one-half mile down gradient and one-quarter-mile cross gradient of any in-situ or agricultural treatment unit, on a twice-yearly (semi-annual) basis.
- If any domestic or agricultural wells are found to be ~~impacted~~actually affected by remedial byproducts (as described ~~below~~above), PG&E will increase monitoring of the ~~impacted~~affected well to once~~-a-~~ per month until alternate water supply is provided to the satisfaction of the ~~well owner~~Water Board, after which monitoring can be reduced to twice-yearly if nearby monitoring wells exist.

- In addition, if any domestic or agricultural wells are found to be actually affected by remedial byproducts (as described above), PG&E will further monitor for that byproduct in all domestic and agricultural wells (wherever ~~allowed by well owners~~the Water Board deems appropriate) within one-half mile downgradient/one-quarter mile cross gradient of that impacted well for the following two years on a ~~semi-annual~~quarterly basis. This program is intended to expand the area of monitoring in advance of any potential byproduct plume, and to expand and contract the monitoring area in response to the observed byproducts and remedial progress.
- In-situ treatment byproduct monitoring will consist of iron, manganese, arsenic and total organic carbon.
- Agricultural treatment unit byproduct monitoring will consist of TDS, ~~nitrate, and any chemicals applied to fields as fertilizers, pesticides, etc.~~nitrates, uranium, and radionuclides. If the investigation required by Mitigation Measure WTR-MM-5 identifies that agricultural treatment would significantly affect or have the potential to affect uranium or gross-alpha levels in groundwater, then agricultural treatment unit byproduct monitoring will also include uranium, gross-alpha, and any other applicable radionuclide, such as radium, in addition to soil and plant samples. Additional monitoring for agricultural inputs may be required by the Water Board, if the Water board determines it is warranted.
- Monitoring requirements may be adjusted by the Water Board's Executive Officer based on contaminant concentration trends, byproduct plume geometry, or other factors.

~~Water Quality and~~ Groundwater Flow and Transport Modeling

- PG&E will annually model the movement of any byproduct plumes and will provide maps and descriptions of estimated plume movement and groundwater level changes for the following three years. The modeling effort will be provided to the Water Board by ~~December~~January 31 of each year.
- The results of the modeling will include predictions for water supply wells that may be impacted within the following year and such predictions will be used to plan for either changing remediation activities and/or the provision of alternative water supplies in advance of effects on domestic and agricultural wells.
- The report will also define and confirm the down gradient and cross gradient monitoring program areas under this section for the following year. If there are insufficient wells within the monitoring areas, as determined by the Water Board in its review of the yearly reporting, then quarterly monitoring of areas of insufficiency will be required.

Mitigation Measure WTR-MM-2c: Water Supply Program for Wells Affected by Groundwater Drawdown due to Remedial Activities

Defining Actually and Potentially Affected Wells

"Actually affected domestic wells" will be defined as follows:

- All wells where groundwater drawdown of more than 25% of the potentially affected ~~well~~ wetted screen depth within the saturated zone has occurred due to remedial pumping compared to the ~~2011 water~~pre-remedial reference levels, unless it can be demonstrated that the well remains capable of providing an adequate flow rate for domestic supply and the well owner concurs that the flow rate is adequate for their use.

- All wells where groundwater drawdown of at least 10 feet occurs and water quality sampling shows at least a 10% increase over ~~baseline~~pre-remedial reference conditions of arsenic, manganese, uranium, or gross alpha.[24]

"Potentially affected domestic wells" will be defined as follows:

- All wells where any of the above conditions is predicted to occur through groundwater modeling within one year.

"Actually affected agricultural wells" will be defined as follows:

- Agricultural wells where groundwater drawdown of more than 25% of the potentially affected wetted well screen depth has occurred due to remedial pumping.

"Potentially affected agricultural wells" will be defined as follows:

- All wells where any of the above conditions is predicted to occur through groundwater modeling within one year.

Monitoring

Groundwater Drawdown Monitoring

- PG&E will conduct an initial monitoring of groundwater levels and water quality in all domestic and agricultural wells (wherever allowed by well owners) within one-half mile downgradient or cross-gradient of any existing or proposed groundwater extraction well ~~commencing immediately~~ upon approval of a new order allowing expanded remediation. Initial monitoring will be for a minimum of one~~-~~ year, will be done quarterly, and will include monitoring in March and October, if possible. Initial monitoring will be done ~~for one year~~ prior to operation of groundwater extraction wells, where feasible, without unreasonably delaying planned remediation. Where initial monitoring cannot be done for a full year without delaying planned remediation, then monitoring may be done concurrently with extraction commencement.
- PG&E will monitor the groundwater levels in all domestic and agricultural wells (wherever allowed by well owners) within one-quarter mile of any groundwater extraction point for the duration of remedial pumping until groundwater levels have stabilized for a minimum of two years following commencement of groundwater extraction. If groundwater levels cannot be measured in domestic or agricultural wells, then monitoring wells located between water supply wells and the area of remedial action can be substituted.
- In addition, if any domestic or agricultural wells are found to be ~~impacted~~affected or potentially ~~impacted~~affected by excessive drawdown as described below, PG&E will (1) conduct byproduct monitoring (for arsenic, manganese, uranium and gross alpha) and (2) measure the groundwater levels in or adjacent to domestic and agricultural wells (wherever allowed by well owners) within one-quarter mile of that well until groundwater levels have stabilized for a minimum of two years. This program is intended to expand the area of

[24] Ibid.

monitoring in advance of any excessive drawdown, and to expand and contract the monitoring area in response to the observed drawdown.

- PG&E will monitor groundwater levels semi-annually in October (after peak irrigation months) and March (after winter rains and before peak irrigation months).
- Monitoring requirements may be adjusted by the Water Board's Executive Officer based on groundwater level conditions or other factors.

Groundwater Modeling

- PG&E will annually model predicted groundwater levels based upon the month with the greatest well water use and will provide maps and descriptions of estimated groundwater level changes for the following three years. The modeling effort will be provided to the Water Board by ~~December~~January 31 of each year.
- The results of the modeling will include predictions for wells that will be impacted within the following year and ~~such predictions will be used to plan~~plans for the provision of alternative water supplies in advance of effects on domestic and agricultural wells.
- The report will also define the monitoring program area under this section for the following year.

Mitigation Measure WTR-MM-3: ~~Boundary Control Monitoring, Enhancement and Maintenance of Hydraulic Control and Plume Water Balance~~Incorporate Measures to Prevent ~~or~~, Reduce and Control Potential Temporary Localized Chromium Plume Bulging Into Overall Plume Control and Monitoring

The Water Board ~~will~~shall include requirements in the new CAO and associated WDRs ~~issued~~to address potential chromium plume bulging due to remedial activities. These requirements shall be incorporated into the overall plume boundary monitoring and hydraulic capture requirements. These requirements will be flexible to allow for ~~the remediation~~expansion and contraction of the plume (only as ~~follows:~~

~~PG&E will develop a Boundary Monitoring Plan to identify~~ authorized by the Water Board) over time as the entirety of the ~~chromium plume over time.~~plume is addressed and remediated. The following minimum requirements shall be incorporated into the overall plume boundary monitoring and hydraulic capture requirements:

- ~~During remedial pumping and injection activities, PG&E will~~ Monitoring of plume boundaries in areas with new remedial injections or withdrawals for the potential for bulging.
- Measures to limit chromium plume bulges during operations. This can be achieved by maintaining hydraulic control ~~with adjustments to pumping rates where necessary, and~~ and inward gradients ~~will be maintained as long as necessary to prevent Cr[VI] migration. Hydraulic control can be obtained by capturing the plume at~~by pumping of extraction wells. ~~Although the~~The plume can be allowed to move toward these extraction wells~~, the extraction wells will be designed to stop the spread of the plume~~ but not beyond the wells.
- Until the Water Board determines otherwise, PG&E will operate and maintain the existing groundwater extraction system to achieve and maintain hydraulic capture within targeted areas on a year-round basis consistent with CAO R6V-2008-0002A3, (Lahontan Regional Water Quality Control Board 2012). ~~PG&E will expand plume containment and monitoring~~

~~to include the entirety of the chromium plume over time and develop a contingency plan in case containment is not met~~The Water Board may periodically modify hydraulic capture requirements as appropriate to address remedial priorities over time.

- Agricultural treatment units and/or treated water from above-ground treatment facilities can be used~~ for water treatment as appropriate~~ to assist with inward hydraulic gradients, plume water balance, and water quality restoration of the aquifer.
- PG&E will implement the Contingency Plan for AU Operations as described in the Feasibility Study Addendum No. 3 (Pacific Gas and Electric Company 2011c).

If the Water Board determines that alternative measures are more effective at control of plume bulging, the Water Board may modify the requirements mentioned above.

Mitigation Measure WTR-MM-4: Mitigation Program for Restoring the Hinkley Aquifer Affected by Remedial Activities for Beneficial Uses

This requirement holds PG&E responsible for restoring the Hinkley aquifer back to ~~baseline conditions~~ pre-remedial reference conditions (defined as conditions prior to the initiation of remedial actions included in the project defined in this EIR).

As described in Mitigation Measure WTR-MM-5 and WTR-MM-6, PG&E may implement two different approaches to meet this requirement:

- aquifer restoration through direct treatment of water; and/or
- basin-wide approaches to managing agricultural treatment remedial TDS and nitrate byproducts that may avoid the need for post-chromium remediation activities to address these remedial byproducts.

No later than ~~5~~10 years prior to the conclusion of the proposed chromium remediation project, PG&E ~~will~~shall conduct an assessment to evaluate adverse impacts or potential adverse impacts to the Hinkley aquifer from its remedial actions.

- If the assessment finds that the aquifer contains constituents~~,~~ exceeding ~~drinking water standards or water quality objectives and are in excess baseline~~pre-remedial reference conditions and are due to remedial action, and that these constituents are likely to be present upon the conclusion of remedial actions, PG&E will propose cleanup actions to restore the aquifer for beneficial uses as soon as possible, as approved by the Water Board. Aquifer water quality restoration to ~~baseline~~pre-remedial reference conditions will occur ~~no longer than 10 years~~ as soon as possible after completion of chromium remediation. The recommended timeframe for restoration is within 10 years of completion of chromium remediation but the Water Board will retain authority to determine the required duration for completion.
- If the assessment finds that the aquifer includes groundwater drawdown due to remedial actions such that domestic or agricultural wells were still experiencing water supply shortages and require alternative water supplies, and these excess levels are likely to exist upon the conclusion of remedial actions, PG&E will propose actions (which could include contributing to MWA's groundwater recharge program; temporary purchase of water allocations to help accelerate water level recovery, or other measures) to restore the aquifer for beneficial uses as soon as possible, as approved by the Water Board or Mojave Water

Agency. These actions will likely require future environmental analyses as the details of the action are defined. Groundwater levels will be restored to ~~baseline~~pre-remedial reference conditions ~~no longer than 20 years~~ as soon as possible after the completion of chromium remediation. The recommended timeframe for restoration of groundwater levels is within 10 years of chromium remediation, but Water Board will retain authority to determine the required duration for completion.

- ~~Every year afterwards~~Every year following preparation of the assessment and approval of restoration timeframes, PG&E must submit a status report of actions to restore the aquifer for beneficial uses. The status report will describe all actions taken over the course of the year and list proposed actions for implementation during the following year. An updated schedule will be provided predicting fulfillment of aquifer restoration.

The assessment described above can include analysis of the potential for natural attenuation to return pre-remedial reference conditions within an acceptable timeframe, as determined by the Water Board. This measure is limited to addressing the effects of PG&E remedial actions that cause changes above pre-remedial reference conditions. It is possible that water quality or groundwater baseline levels may be affected by non-PG&E actions (such as other agricultural or dairy activity not controlled by PG&E) during chromium remediation. PG&E will only be responsible to remediate the effects that it causes, not those that are due to the actions of other third-parties.

- Several options exist for treatment of agricultural treatment byproducts (TDS, nitrate, uranium and other radionuclides) if necessary:
  - *Aboveground Treatment*: Treatment technologies, including reverse osmosis, electrochemical treatment (such as electrocoagulation), ion exchange and possibly other methods can be used to remove TDS, nitrate and uranium from water.
  - *In-Situ Remediation*: In-situ remediation using carbon amendment, like that proposed in the high concentration portion of the chromium plume, has been used to remediate elevated uranium levels in groundwater.
  - *Basin-Wide Approach to TDS and Nitrate*: A basin-wide approach to reducing TDS and nitrate could involve fallowing of, or changes in farming practices at other agricultural fields within the basin that are not used for agricultural unit treatment and at area dairies. Since the project will increase agricultural fields and production of animal feed, a basin-wide approach may include an option to implement a "farm swap" to allow fallowing of other local agricultural fields to reduce TDS levels in the groundwater basin. There may also be options to improve irrigation techniques by using drag-drip irrigation instead of broadcast irrigation techniques (thus lowering irrigation amounts and TDS loading), and crop rotation (which may lower water demand). There may also be options to work with local Hinkley dairies to lower TDS and nitrate inputs through better site management practices of manure and runoff. Participation by owners/operators of other agricultural land and dairies would be voluntary and would be subject to private negotiation between PG&E and willing participants. While these approaches could lower overall loading of TDS and nitrate into the Hinkley groundwater aquifer, long-term use of agricultural treatment units for chromium treatment may still result in localized increases of TDS and nitrate. If a basin-wide approach is proposed by PG&E, the Water Board shall require the following:

- A basin-wide approach must show a net benefit to the Hinkley Valley aquifer that equals or exceeds the impairment caused by remedial activities compared to pre-remedial reference conditions. For example, the basin-wide approach must avoid or remove an equal amount of TDS as the increased TDS loading resultant from agricultural treatment units. Potential ways of measuring the benefit and impairment can be in terms of thein the number of impaired wells due to TDS and/or nitrate, the area of aquifer impairment due to TDS and/or nitrate, and the overall annual TDS and/or nitrate loading. The discharger may proposed the means of measuring for Water Board review and approval.;

- If the basin-wide net benefit above is demonstrated to be equal to or greater than the remedial impairment, then the Water Board will require maintenance of the basin-widenet actions for the benefit for the Hinkley aquifer until all areas significantly impaired by TDS and/or nitrate due to remedial actions return to pre-remedial reference conditions.

- If the basin-widenet benefit above is demonstrated to be equal to or greater than the remedial impairment, then the Water Board may decide to not require PG&E to specifically remediate localized TDS and/or nitrate increases due to remedial actions provided that all affected domestic and agricultural wells are provided replacement water (per Mitigation Measure WTR-MM-2) until pre-remedial reference conditions return.

- The implementation of a basin-wide approach is limited to the project study area for this EIR at this time. If in the future, PG&E proposes basin-wide approaches involving farms outside the project study area, the Water Board will need to comply with CEQA and may need supplemental CEQA evaluation prior to inclusion of additional actions outside the current project study area.

- Several options also exist for treatment of IRZ byproducts (manganese, iron and arsenic) if necessary:
  - As necessary, manganese mitigation may be through the methods proposed in the manganese mitigation plan, such as extraction and capture of manganese-affected groundwater, aboveground aeration, and/or infiltration galleries or other measures determined to be effective by the Water Board. These methods can also be used for mitigation of iron levels, if necessary.
  - As necessary, arsenic mitigation may be through aboveground treatment using precipitation/coprecipitation, ion-exchange units, membrane filtration, electrochemical methods (such as electrocoagulation) or other means determined to be effective by the Water Board.

Mitigation Measure WTR-MM-5: Investigate and Monitor Total Dissolved Solids, Uranium, and Other Radionuclide Levels in relation to Agricultural Treatment and Take Contingency Actions

The Water Board will include requirements in the new CAO and/or associated WDRs issued for the remediation as follows:

- PG&E will submit an investigation plan to the Water Board concerning TDS, uranium, and other radionuclides levels in relation to existing agricultural treatment by sampling water used for agricultural treatment and in groundwater upgradient, beneath and downgradient of agricultural treatment units. PG&E will submit the investigation plan within three months of Water Board approval of WDRs allowing new agricultural treatment units.

- After approval of the investigation plan by the Water Board, PG&E will conduct the investigation and provide the results to the Water Board along with an analysis of whether agricultural treatment is affecting ~~naturally occurring uranium levels~~uranium levels. The investigation shall be completed within one year of Water Board approval of WDRs allowing new agricultural treatment units.

- PG&E will monitor all new agricultural treatment units by establishing ~~a baseline of~~pre-remedial reference levels for TDS, uranium, and other radionuclides levels at the outset agricultural treatment and during operation. Monitoring data will be conducted for one year prior to establishment of new agricultural treatment units wherever feasible (if not feasible without undue remediation delay, monitoring will be done concurrently with startup of agricultural treatment units).

- If TDS, uranium, and other radionuclides levels are determined to increase ~~measurably by a statistically significant amount~~ due to agricultural treatment associated with remedial actions, then PG&E will monitor these levels in and adjacent to all agricultural treatment units for the duration of operation and propose remedial methods for Water Board approval to restore the aquifer to ~~baseline~~pre-remedial reference conditions.

- If the ~~study~~monitoring of agricultural units indicates that TDS, uranium, and other radionuclide concentrations increase ~~in association with~~ due to agricultural ~~operations and boundary monitoring confirms an increase in these levels,~~ treatment associated with remedial actions then corrective actions (which could include aboveground treatment, carbon amendment, or other methods) ~~and /or alternative water supplies will be provided per~~ ~~**Mitigation Measure WTR-MM-2** and~~ per **Mitigation Measure WTR-MM-4** will be implemented ~~toward the end of chromium plume remediation~~ to restore aquifer beneficial uses~~.~~ after remediation is complete. Alternative water supplies will be provided per **Mitigation Measure WTR-MM-2** for any significantly affected water wells until beneficial uses are restored.

Mitigation Measure WTR-MM-6: Monitor Nitrate Levels and Manage Agricultural Treatment to Avoid Significant Increases in Nitrate Levels and Provide Alternative Water Supplies As Needed

Agricultural treatment will likely reduce nitrate levels in the groundwater aquifer overall. However, if groundwater is extracted from an area of higher nitrate concentrations and then treated in an area with much lower nitrate concentrations, it is possible that nitrate concentrations could increase in those localized areas.

The Water Board will include requirements in the new CAO and/or associated WDRs issued for the remediation as follows:

- Given that prior agricultural treatment at the Desert View Dairy has been shown to reduce nitrate levels substantially, it is possible that use of irrigation water with higher nitrate levels may not result in increased nitrate levels in groundwater beneath new agricultural treatment locations. In order to confirm if this is occurring, PG&E will monitor nitrate levels for one year before creating new agricultural treatment units (as feasible without delaying remediation), monitor at the start of new agricultural treatment, and continue monitoring nitrate levels during implementation of all new agricultural treatment units. If nitrate levels do not: 1) increase above 10 ppm (as N), or 2) by more than 10% compared to existing levels (if current levels are already above 10 ppm as N), or 3) by more than 20% compared to existing levels (if current levels are less than 10 ppm as N) then no further action, other than monitoring, will be required.

- If monitoring indicates that nitrate levels are approachingexceed 10 ppm (as N) or increasing by more than the criteria noted above, then PG&E will implement a contingency plan for managing nitrate levels which may include some combination of the following:
    - Extraction source water will be shifted from application where it would raise concentrations substantially to locations with existing higher concentrations of nitrate, provided it would not cause an exceedance of nitrate levels at any domestic well.
    - Extraction source water will be blended before application to agricultural treatment units so as to avoid exceedance of 10 ppm as N and avoid increases in existing levels that exceed the criteria noted above.
    - Above-ground treatment may be used as necessary to meet the concentration levels described above.
    - If control of nitrate cannot meet these requirements, PG&E may request permission from the Water Board to allow temporary increases in nitrate conditions at certain agricultural treatment units, if and only if, the following can be demonstrated:
        - no domestic wells will contain nitrate concentrations above 10 ppm or an increase in nitrate levels exceeding the criteria above; or
        - PG&E will provide whole housereplacement water for any affected domestic well until such a time as nitrate concentrations return to existing concentrations at the affected well, and
        - PG&E will be held accountable for implementing remedial methods to restore the aquifer to baselinepre-remedial reference conditions after remediation is complete.
    - PG&E will estimate the duration of nitrate impairment of water quality due to remedial activities and will identify how long before affected groundwater nitrate levels will return to backgroundpre-remedial reference conditions prior to the timeframe for remediation of the chromium plume to the established cleanup levels. The duration of nitrate impairment due to remedial activities may possibly extend beyond the time necessary to remediate the chromium plume; the goal of remedial operation in the later stages of the cleanup should be to minimize the duration of all impacts.
    - The Water Board will retain the authority to approve or deny temporary impairment of the aquifer due to nitrate contamination and will make determinations on a case by case basis taking into account information on remedial progress, the affected wells and community, the certainty of returning affected groundwater to backgroundpre-remedial reference water quality conditions over time and any other relevant considerations.

Alternatively this mitigation measure may be met through basin-wide approaches described in Mitigation Measure WTR-MM-4.

Mitigation Measure WTR-MM-7: Construction and Operation of Additional Extraction Wells to Control Carbon Amendment In-situ Byproduct Plumes

Increased in-situ remediation could result in increased levels of byproducts, such as dissolved arsenic, iron, and manganese in the groundwater compared to current levels.

The Water Board will include requirements in the new CAO and/or associated WDRs issued for the remediation as follows:

- PG&E will monitor secondary byproducts in groundwater as required by Mitigation Measure WTR-MM-2.
- PG&E shall complete an investigation of manganese and arsenic in the area west of the defined chromium plume (as of Q4/2012) and demonstrate to the satisfaction of the Water Board that the detection of these constituents in domestic wells is not related to IRZ operations. This demonstration shall occur before the Water Board will allow further expansion of IRZ operations.
- If arsenic ~~levels are increased~~, iron, or manganese concentrations at designated monitoring wells ~~or iron or manganese are increased~~increase to more than 20 percent above ~~their respective secondary Maximum Contaminant Levels, or reagent levels exceed taste or odor criteria~~the maximum pre-remedial reference monitoring well concentration, PG&E will construct and operate additional extraction wells or implement an equally effective mitigation measure along or upgradient of the IRZ treatment boundary to intercept or reduce reagent concentrations and secondary byproducts to prevent effects to domestic water supply wells.
    - Extraction wells may be used to intercept elevated concentrations of byproducts and prevent downgradient migration.
    - As necessary, manganese mitigation may be through the methods proposed in the current manganese mitigation plan, such as extraction and capture of manganese-affected groundwater, aboveground aeration, and/or infiltration galleries or other measures determined to be effective by the Water Board. These methods can also be used for mitigation of iron levels, if necessary.
    - As necessary, arsenic mitigation may be through aboveground treatment using precipitation/coprecipitation, ion-exchange units, membrane filtration, electrochemical methods (such as electrocoagulation) or other means determined to be effective by the Water Board.
- If control of byproduct plumes cannot be achieved without compromising the pace of cleanup such that domestic wells may be affected by byproduct plumes, then PG&E will request permission from the Water Board to allow byproduct plume migration provided the following are implemented:
    - PG&E will provide fate and transport modeling of byproduct plume migration, in absence of complete boundary control, including identification of all affected domestic and agricultural wells.
    - PG&E will demonstrate the duration of byproduct plume impairment of water quality and will identify how/when affected groundwater will return back to ~~background~~pre-remedial reference conditions. The duration of byproduct plume impairment may

possibly extend beyond the time necessary to remediate the chromium plume. The goal of remedial operation in the later stages of the cleanup should be to minimize the duration of all impacts.

- PG&E will provide alternative water supplies to all wells proposed to be affected, per Mitigation Measure WTR-2.
- The Water Board will retain the authority to approve or deny temporary impairment of the aquifer due to byproduct generation and will make determinations on a case by case basis taking into account information on remedial progress, the affected wells and community, the certainty of returning affected groundwater to ~~background~~pre-remedial reference water quality over time and any other relevant considerations.

Mitigation Measure WTR-MM-8: Ensure Freshwater Injection Water Does Not Degrade Water Quality

The Water Board will include requirements in the new CAO and/or associated WDRs issued for the remediation as follows:

- PG&E will sample all water sources proposed for use in freshwater injection for all basic water quality parameters and will specifically ~~include~~monitor for chromium (total and hexavalent chromium), TDS, uranium, other radionuclides (including gross alpha), nitrate, arsenic, manganese, iron and sulfate. Data will be provided to the Water Board for review.
- Concentrations of all constituents in freshwater injected for plume control must either be 1) less than the applicable primary or secondary Maximum Contaminant Level or 2) if the concentrations of certain constituents at the injection point already exceed a Maximum Contaminant Level~~ already~~, then the injection water must have concentrations of the constituent equal to or less than that in the ambient groundwater at the injection point.
- PG&E will identify to the Water Board the filtration or pretreatment necessary to meet the water quality levels described above~~ to the Water Board~~. After approval of the water source for use for freshwater injection, PG&E will sample the treated water on ~~an~~ a semi-annual basis (twice per year) at a minimum to demonstrate that the water source is still acceptable for use for freshwater injection. If it is found that the water source is not acceptable for use for freshwater injection, freshwater may need to draw from different area where water quality levels are met.

3.1.10 Secondary Impacts of Water ~~Supply Replacement~~Resource and Water Quality Mitigation Measures

Impact WTR-5: Secondary Impacts of Water Supply and Water Quality Mitigation Measures

The following sections address potential secondary impacts of water supply and water quality mitigation measures as well as methods to address the impacts. CEQA allows for a lesser level of detail of analysis of the secondary impacts of mitigation measures. ~~Physical~~ The impacts of water supply and water quality mitigation described in this section are addressed as follows:

- Mitigation Measure WTR-1: Purchase of Water Rights (see Impact WTR-5a below)

- Mitigation Measure WTR-2: Water Supply Mitigation (see Impact WTR-5b below)
- Mitigation Measure WTR-3: Boundary and Hydraulic Controls (see Impact WTR-5c below)
- Mitigation Measure WTR-4, 5, and 6: Agricultural Unit Byproduct Mitigation (see Impact WTR-5d below)
- Mitigation Measure WTR-4 and 7: IRZ Byproduct Mitigation (see Impact WTR-5e below)
- Mitigation measure WTR-8: Freshwater Injection Water Quality Control (see Impact WTR-5f below)

Impact WTR-5a: Secondary Impacts of Water Right Purchase Mitigation (Less than Significant with Mitigation)

Mitigation Measure WTR-MM-1 requires purchase of new water rights to comply with the MWA basin adjudication requirements. As discussed above, if PG&E acquires unused allowances through outright purchase or yearly transfer, then this would not result in any displacement of other land uses in the Centro subarea. However, if PG&E were to acquire allowances in use, such as for current agricultural use, then the acquisition could result in abandonment or displacement of the current supported land use. This potential land use impact is discussed in Section 3.2, *Land Use, Agriculture, Population and Housing*. **Mitigation Measure LU-MM-2** would require PG&E to either avoid acquiring water rights from existing agricultural users or would require PG&E to acquire and record an agricultural easement over any important farmland (prime, unique, statewide importance) from which it acquires water rights for remedial purposes, so that the land can be returned to agricultural use at the point that the water allowance is no longer used for remedial purposes. With this mitigation measure, the project would not result in a long-term indirect loss of important farmland, and the impact would be reduced to a less than-significant level.

Impact WTR-5b: Secondary Impacts of Water Supply Replacement Mitigation (Less than Significant with Mitigation)

Mitigation Measure WTR-MM-2 requires provision of alternative water supplies where remedial activities significantly affect domestic and agricultural water supply wells. This may include drilling of deeper wells, wellhead treatment systems, storage tanks and trucking of water, and/or creation of a water supply system with wells and pipelines. The construction of alternative water supplies could have physical effects on the environment and result in impacts related to land use, hazards and hazardous materials, geology and soils, air quality/greenhouse gas emissions, noise, biological resources, cultural resources, utilities, traffic, and aesthetics.

~~Project-level CEQA compliance may be necessary for alternative water supply systems, once the methods of providing alternative water supplies is more specifically defined.~~

Facilities and actions that may be needed to provide alternative water supplies ~~would~~could include the following:

- Drilling of deeper wells: This approach would require temporary drilling equipment activity at or adjacent to existing water supply locations. In many cases, these locations will be previously disturbed.

- Wellhead treatment systems: This approach would require ~~of~~ treatment systems and possible storage tanks at affected locations. In many cases, these locations will also be previously disturbed.

- Storage Tanks and Trucking of Water: This approach would require placement of storage tanks at affected locations, addition of piping from the tanks to the water supply location, and periodic trucking of water to the storage tanks, including associated traffic. It should be noted that CDPH, which regulates water supply systems, has taken the position that hauling water is not a long-term water supply strategy.

- New Water Supply System: ~~The most likely~~<u>One possible</u> configuration of this approach would be use of wells near the Mojave River (upgradient of the chromium plume), pumps, and pipelines from the supply location to the supply points. It is possible that the source well could be located elsewhere.<u> Other options could include connections to Golden State Water in Barstow (which would require a 12-mile pipeline easement to the project area) or a connection to the MWA Mojave River pipeline, which runs along Community Blvd. east of the PG&E Compressor Station within OU3.</u>

- <u>Provision of Bottled Water: As noted above, bottled may be combined with other methods to provide well replacement water. Although delivery of bottled water requires vehicle travel, which would result in air quality emissions, these emissions are limited in character. No other secondary impacts would be associated with bottled water provision.</u>

At this time, the exact extent and location of new facilities that would be needed to provide <u>additional</u> alternative water supplies is not known, although most facilities are expected to be located within OU1, OU2, and OU3. However, if sources or connections are made outside of these areas~~,~~<u> (OU1, OU2 or OU3),</u> construction could affect additional parts of the project area. If <u>replacement </u>water<u> is</u> to be provided through a connection to another water system, this could affect areas outside the project study area<u>, and may require additional CEQA analysis</u>.

The section below summarizes potential secondary physical impacts of water supply replacement. As noted below, all relevant project mitigation measures<u> identified in this EIR</u> would also apply to alternative water supply efforts.

- **Water Quality<u> and Water Resources</u>**: Construction of new water supply facilities may result in minor erosion which has the potential for sedimentation of downstream water bodies. However, compliance with San Bernardino County erosion control requirements and state/federal SWPPP requirements would keep this impact to a less than significant level. Disposal of any treatment by~~-~~<u>-</u>products, such as brine, would need to comply with all applicable<u> state</u> disposal requirements.

  <u>Use of wells near the Mojave River to replace local well water would not change groundwater drawdown as the wells would draw from the same groundwater sub-basin. Golden State Water in Barstow uses groundwater from the Mojave River Basin-Centro Sub-basin which is the same regional basin as the Hinkley aquifer. The MWA Mojave River Pipeline uses water from the State Water Project which is derived from the San Francisco-San Joaquin Delta (the Delta). As the Delta is not in the Hinkley aquifer, a MWA pipeline option would not affect local groundwater levels. If water replacement mitigation were to utilize one of the Mojave River basin sources, there would need to be an assessment of the impact of the additional demand from servicing Hinkley wells. At present, Golden State Water has sufficient water to serve projected new demands (in Barstow) through 2025 without exceeding its adjudicated limit (Golden State</u>

Water 2011) and thus likely has sufficient water rights to serve new customers in Hinkley (PG&E 2012k). MWA projects that it has adequate water supplies to meet its demand through 2035 at least (MWA 2011) and thus likely has sufficient capacity to provide water to Hinkley, although the Mojave River Pipeline has only been used for recharge purposes to date and has not been used to deliver water to retail customers and would likely require treatment before use.

- **Land Use:** The provision of new water supply facilities at affected domestic and agricultural locations would not introduce incompatible uses or displace existing land uses. The construction of a new water supply system may require centralized treatment facilities, which would be a light industrial use that would be ~~highly~~ very similar to the above-ground treatment facilities included in Alternatives 4C-3 and 4C-5, but on a much smaller scale. With compliance with local land use regulations and requirements, it is expected that any such treatment facility would not result in significant land use impacts. Construction of pipelines may temporarily disrupt land uses, but similar to pipelines for remedial actions, this temporary disturbance is not considered significant. Relevant mitigation measures from Section 3.2, *Land Use, Agriculture, and Population, and Housing,* would also apply to construction of water supply mitigation facilities and would be able to reduce impacts to a less than significant level.
- **Hazards and Hazardous Materials:** Construction of water supply facilities would include handling of petroleum and other materials. Treatment facilities may also handle certain treatment chemicals and would generate wastes (such as brine if reverse osmosis is used and other wastes for other treatment methods) requiring disposal. Application of all local, state, and federal regulations for handling and transport of hazardous materials will control the potential for exposure to hazardous materials and thus construction should result less than significant impacts. Relevant mitigation measures from Section 3.3, *Hazards and Hazardous Materials,* would also apply to construction of water supply mitigation facilities and would be able to reduce impacts to a less than significant level.
- **Geology and Soils:** Construction of new water supply facilities may result in minor erosion. However, compliance with San Bernardino County erosion control requirements and state/federal SWPPP requirements would keep this impact to a less than significant level. Construction or operation of new water supply facilities are not expected to result in any other significant geology or soils impacts.
- **Air Quality/Greenhouse Gas Emissions:** Construction of new water supply facilities will result in construction emissions of criteria pollutants and greenhouse gases. During operations, where pipelines are used, pumping will also result in electricity emissions. Where trucking of water is done for alternative water supplies, trucking will result in gasoline and/or diesel emissions. Relevant mitigation measures from Section 3.5, *Air Quality and Climate Change,* would also apply to construction and operations of water supply mitigation facilities and would be able to reduce impacts to a less than significant level.
- **Noise:** Construction of new water supply facilities will generate noise from equipment and vehicles similar to construction of remedial facilities. Operations of alternative water supply systems will have limited noise generation and would result in less than significant impacts. Relevant mitigation measures from Section 3.6, *Noise*, would also apply to construction of water supply mitigation facilities and would be able to reduce impacts to a less than significant level.
- **Biological Resources:** Construction of new water supply facilities could disturb habitats and individual special status species, sensitive vegetation communities as follows:

  - Drilling of deeper wells: In ~~many~~most cases, these locations will be previously disturbed and thus the potential for significant impacts to biological resources would be limited from this activity.
  - Wellhead treatment systems: In ~~many~~most cases, these locations will also be previously disturbed and thus the potential for significant impacts to biological resources would be limited from this activity.
  - Storage Tanks and Trucking of Water: In ~~many~~most cases, these locations will also be previously disturbed and thus the potential for significant impacts to biological resources would be limited from this activity.
  - New Water Supply System: Of the water supply options, this approach has the greatest potential to disturb biological resources, in particular due to the need for construction of new water pipelines from water supply sources to end users and the need to construct new treatment facilities. In addition, the creation of new source wells may also have the potential to disturb biological resources.

  Relevant mitigation measures from Section 3.7, *Biological Resources*, would also apply to construction of water supply mitigation facilities and would likely be able to reduce impacts to a less than significant level.

- **Cultural Resources:** Construction of new water supply facilities could disturb cultural and paleontological resource. Operations of alternative water supply systems ~~should~~would not disturb cultural resources, unless new ground disturbance is necessary for system maintenance and, if so, would result in less than significant impacts. Relevant mitigation measures from Section 3.8, *Cultural Resources*, would also apply to water supply mitigation facilities and would ~~likely~~ be able to reduce impacts to a less than significant level.
- **Utilities:** For the most part, construction of new water supply facilities will not disrupt existing utilities; however in some cases, in particular for construction of new pipelines, there could be disturbance of existing utilities. However, local and state regulations require planning for, and avoidance of, disruption to existing utilities, and thus construction impacts will be less than significant. Extension of electrical power lines ~~will~~may be needed for new pumping and water treatment facilities for new water supply systems. Operations of alternative water supply systems should not disrupt existing utilities or create need for additional public services.
- **Traffic:** Construction of new water supply facilities will generate traffic similar to construction of remedial facilities. It is possible that construction might affect traffic safety or emergency access, but application of mitigation from Section 3.10, *Transportation and Traffic*, would reduce impacts to a less than significant level. Operations of deeper wells or wellhead treatment systems will generate minimal new traffic due to the need for maintenance. Operations of alternative water supply systems will generate routine traffic for the tank/truck option and the new water supply system operation. However, given the uncongested conditions on local roadways, such traffic is not considered to result in any significant traffic conditions.
- **Aesthetics.** Construction of new water supply facilities will temporarily disturb local aesthetic conditions due to construction noise, dust, and presence of equipment and vehicles, but these impacts would be limited in scale and extent at any one location and thus would be considered less than significant on the environment. Deeper wells or wellhead treatment systems will have less than significant effects on aesthetics due to limited apparent facilities that would be located at existing residences and structures. The tank/truck water supply option would require new

water storage tanks to be placed adjacent to existing residences. However, this is not an uncommon site in rural residential areas, which often have existing storage tanks for water and propane and would not substantially degrade visual character of the local area. A new water supply system ~~would~~could require a treatment facility to treat source water and provide pumps to deliver water to end users. This facility would have similar aesthetic effects as the above-ground treatment facilities included in Alternative 4C-3 and 4C-5. Relevant mitigation measures from Section 3.11, *Aesthetics*, would also apply to any new water supply centralized treatment facilities and would ~~likely~~ be able to reduce impacts to a less than significant level.

- **Physical Effects of Socioeconomic Changes.** Construction of new water supply facilities would not be expected to require acquisition of property containing existing residents or other structures and thus would not have the potential for the creation of blighted conditions due to abandoned structures.

As PG&E develops and defines plans for alternative water supplies, the Water Board will be required to ~~evaluate the specific environmental~~determine whether impacts from proposed replacement water methods require further evaluation. The mitigation above will be applied as appropriate. In most cases~~, it is considered possible that~~ the identified mitigation will reduce secondary physical impacts to a less than significant level.

As described throughout this document, the EIR has followed a conservative scaling approach to disclose potential worst-case effects of the remedial actions overall. It is ~~distinctly~~ possible that this approach may overstate the actual environmental effects that will occur in implementing the project. Given that the alternative water supply method has not been fully defined at this time, additional CEQA analysis of the specific impacts may be necessary at the time that the method is defined and designed.

Impact WTR-5c: Secondary Impacts of Plume Boundary and Hydraulic Control Mitigation (No Additional Impacts Beyond that Disclosed for Remedial Alternatives in the EIR)

Mitigation Measure WTR-MM-3 requires plume boundary and hydraulic controls to prevent or reduce chromium plume bulging including adjustment to pumping rates to maintain inward gradients and use of agricultural treatment and /or aboveground treatment as necessary to assist with hydraulic gradient and plume water balance. **WTR-MM-3** also includes implementation of the AU Contingency Plan described in Feasibility Study Addendum No. 3 (described in Chapter 2, Project Description) which includes reduction of agricultural flow rates, bringing additional agricultural units on line, use of infiltration galleries and/or ex-situ treatment.

The impacts of adjustment to pumping rates on groundwater are disclosed in this EIR in the analysis of proposed pumping rates associated with remedial alternatives. Pumping rates are limited by the amounts disclosed in this EIR and thus changes in pumping rates would not result in additional secondary impacts. The impacts of agricultural treatment units are also discussed throughout the EIR and the amounts of overall unit acreage and extraction are limited by the amounts disclosed in this EIR and thus the addition of additional agricultural treatment units would not result in additional secondary impacts. Given that the amount of land required (200 acres to maintain flow rates of 1,200 gpm) for infiltration galleries is much smaller than the amount of land required for agricultural units for a given flow and that the nature of impacts (such as ground disturbance) are very similar to agricultural units, the impacts of infiltration galleries are addressed through the analysis of agricultural unit impacts. Footprint acreages overall are limited by the amounts disclosed in this EIR and thus the addition of infiltration galleries would not result in additional secondary impacts. The impacts of ex-situ (aboveground) treatment are disclosed in this EIR in the analysis of the aboveground treatment elements in Alternatives 4C-3 and 4C-5.

The mitigation identified in this EIR would also apply to impacts of implementing Mitigation Measure WTR-MM-3 as appropriate and applicable.

Impact WTR-5d: Secondary Impacts of Agricultural Treatment Byproduct Mitigation (Less than Significant with Mitigation)

Mitigation Measures WTR-MM-4, WTR-MM-5 and WTR-MM-6 require PG&E to address the water quality effects of agricultural treatment byproducts (TDS, nitrate, and potentially uranium and other radionuclides) through either specific water treatment technologies or basin-wide approaches. Mitigation of these byproducts could include:

- Remedial Flow Management: **Mitigation Measure WTR-MM-6** allows for management of extraction water by application location and blending to avoid localized increases in nitrate concentrations above 10 ppm (as N). Selectivity in the location of applied water and blending would not result in additional impacts of agricultural treatment beyond that disclosed elsewhere in this EIR and thus is not discussed further in the impact analysis below.
- Water Treatment: **Mitigation Measures WTR-MM-4, 5, and 6** allow for the use of direct water treatment of byproducts through use of aboveground treatment (reverse osmosis, ion-exchange, electrocoagulation, etc.) or in-situ remediation (carbon amendment) as necessary to address byproducts. These impacts of these treatment methods are similar to that discussed elsewhere in this EIR, but they are discussed further in the impact analysis below. Potential impacts of electrocoagulation are also provided in Appendix A.2.
- Basin-Wide Approaches: **Mitigation Measures WTR-MM-4, 5 and 6** allow for use of basin-wide approaches to TDS and nitrate instead of direct water treatment including the following.
  - "Farm Swap Method": This method involves fallowing of other agricultural fields within the basin that are not used for agricultural unit treatment. Since the Project will increase the number of agricultural fields and production of animal feed, the basin-wide approach may include an option to implement a "farm swap" to allow fallowing of other local agricultural fields to reduce TDS levels in localized areas. Participation by owners of other agricultural land would be voluntary and would be subject to private negotiation between PG&E and willing participants.
  - Change in farm management practices: This method involves working with local farmers and dairies to lower TDS and nitrate inputs through better site management and techniques. For example, changes in irrigation techniques to the use of drag drip irrigation instead of broadcast irrigation techniques and crop ration could lower irrigation amounts and thus lower TDS loading. Changes in manure management and runoff at dairies could lower both TDS and nitrate loadings.

The section below summarizes potential secondary physical impacts of byproduct mitigation involving direct water treatment and/or basin-wide approaches. All relevant project mitigation measures would also apply to these actions.

- **Water Quality and Hydrology**:
  - Aboveground treatment technologies do not have secondary effects on water quality in the aquifer being treated but often result in waste generation in the form of brine (reverse osmosis), sludge and other treatment remains. Brine disposal requires special attention to avoid impacts on water quality at the disposal site and sludge can often require special handling. In-situ approaches using carbon amendment, as discussed in this EIR can require management of byproducts.
  - While basin-wide approaches could lower overall loading of TDS and nitrate into the Hinkley groundwater aquifer, long-term use of agricultural treatment units for chromium treatment may still result in localized increases in TDS and nitrate. If basin-wide approaches are utilized, the Water Board will have to balance potential basin-wide improvements against localized impairments in deciding on WDR and CAO requirements. Fallowed agricultural land would also result in less groundwater pumping, which would likely increase overall groundwater levels in the aquifer as well as reduce TDS loading. Improved dairy management could lower both TDS and nitrate loading into the local aquifer. On a basin-wide scale, these methods could have an overall beneficial impact on the water quality and hydrology of the Hinkley aquifer.
  - Relevant mitigation measures from this section would also apply to remediation of agricultural unit byproducts and would usually reduce impacts to less than significant. However in-situ remediation may result in an unavoidable temporary impact in other constituents in the aquifer. Additional mitigation may be required for brine disposal depending on the disposal method.
- **Land Use:**
  - Aboveground treatment requires facility compounds to be installed that can require special permitting. However, similar to the discussion of aboveground treatment for Alternatives 4C-3 and 4C-5, such facilities can usually be permitted, even if land use amendments are required. In-situ approaches have a much more limited footprint and thus have few if any conflicts with other land uses.
  - The "farm swap" method could involve retiring existing agricultural fields. This could result in the conversion of agricultural land to non-agricultural use (including FMMP-Designated and Williamson Act Lands). Mitigation Measure LU-MM-2 (as modified in this final EIR) would require that PG&E place agricultural conservation easements over important farmland involved in a "farm swap" in the Mojave River basin to prevent the net loss of important farmland in the basin overall. Alternatively, PG&E could place an easement on local agricultural land in the project study area that could be removed after the land is no longer required to be fallowed to implement a basin-wide approach to remediating TDS or Nitrate.
  - Relevant mitigation measures from Section, 3.2, *Land Use, Agriculture, Population and Housing* would also apply to remediation of agricultural unit byproducts and would reduce impacts to less than significant.
- **Hazards and Hazardous Materials:**
  - Aboveground treatment technologies can require handling of treatment chemicals as well as disposal of sludge and other treatment remains that may require special attention. In-situ approaches require use of ethanol or other carbon materials, some of which require special

handling as well, but in-situ approaches do not result in generation of wastes that must be disposed. Relevant mitigation measures from Section, 3.3, *Hazards and Hazardous Materials* would also apply to remediation of agricultural unit byproducts and would reduce impacts to less than significant.

- Basin-wide approaches may require the fallowing of fields and installation of new irrigation techniques, but no major hazardous materials are expected to be part of the implementation of these programs. Therefore, this impact is considered to be less than significant for the basin-wide approaches.

- **Geology and Soils:**
  - Aboveground treatment facilities would require grading and excavation for new facilities and connecting pipelines, but erosion concerns can be handled through standard project level mitigation for erosion control. Existing regulations control the potential for seismic risk of upset. In-situ treatment facilities are more limited than aboveground treatment facilities. Relevant mitigation measures from Section 3.4, *Geology and Soils*, would also apply to construction and operation of byproduct treatment facilities and would reduce impacts to a less than significant level.
  - Fallowing of agricultural fields, introduction of new irrigation techniques, crop rotation or improved dairy manure management are not expected to result in significant geology or soil impacts.
- **Air Quality/Greenhouse Gas Emissions:**
  - Construction of aboveground treatment or in-situ treatment facilities requires land disturbance (generating dust) and equipment activity (resulting in air pollution and GHG emissions) but these emissions are temporary and readily mitigated through standard project controls. Operation of aboveground treatment facilities can result in substantial energy consumption, especially for reverse osmosis plants which are particularly energy-intensive, which can result in indirect electricity emissions of air pollutants and greenhouse gas emissions. Operation of in-situ treatment requires more limited energy demands associated with pumping and injection. Relevant mitigation measures from Section 3.5, *Air Quality and Climate Change*, would also apply to the construction and operation of treatment facilities and would reduce impacts to a less than significant level.
  - Fallowing of fields and changes in farm or dairy practices are unlikely to result in increased air pollution or greenhouse gas emissions. Depending on methods used, improved manure management may actually reduce methane emissions (which is a greenhouse gas). Overall impacts relative to air quality and greenhouse gas emissions are expected to be less than significant.
- **Noise:**
  - Construction of aboveground treatment or in-situ treatment facilities requires equipment activity resulted in temporary noise generation. Operation of treatment facilities can include pumping noise and traffic noise, but in general have very limited noise impacts. Relevant construction mitigation measures from Section 3.6, *Noise*, would also apply to construction of new treatment facilities and would reduce impacts to a less than significant level.

- Fallowing of fields and changes in farm practices may involve the use of heavy farm machinery, which would result in limited noise generation similar to existing conditions and thus would result in less than significant impacts.

- **Biological Resources:**
  - Construction of aboveground treatment or in-situ treatment facilities requires land disturbance that can result in temporary or permanent loss of habitat valuable for rare or common species. Aboveground treatment facilities usually require larger footprints than in-situ facilities.
  - Fallowing of agricultural land could increase its value for rare and common biological species during the period of fallowing. With the "farm swap" method, PG&E could have an opportunity to work with the California Department of Fish and Wildlife to restore fallowed farm land to biological species habitat, such as desert tortoise, which would result in a permanent beneficial impact on biological resources. However, dedication of any restrictive covenants on the retired land for the exclusive protection of species habitat could prevent the resumption of agricultural activities after completion of TDS/nitrate basin remediation. This could result in the loss of important farmland which could conflict with the implementation of Mitigation Measure LU-MM-2 (see discussion above). In order to manage this potential conflict, Mitigation Measure LU-MM-2 has been modified to allow PG&E to place an agricultural conservation easement on important farmland in other locations outside the project study area but within the Mojave River basin to ensure no net loss of important farmland within the basin overall.
  - Changes in farming or dairy practices should have limited to no adverse effects on biological resources.
  - Relevant mitigation measures from Section 3.7, *Biological Resources*, would also apply to AU byproduct remediation and would reduce impacts to a less than significant level.
- **Cultural Resources:**
  - Construction of aboveground treatment or in-situ treatment facilities requires land disturbance that could disturb archaeological resources. In most cases, such facilities would not result in disturbance of architectural resources. Relevant mitigation measures from Section 3.8, *Cultural Resources*, would also apply to treatment facility construction and would reduce impacts to a less than significant level.
  - Land retirement or changes in existing agricultural practices should not disturb cultural resources as current agriculture lands have been previously disturbed
- **Utilities and Public Services:**
  - Construction of aboveground treatment or in-situ treatment facilities can be done without disruption to existing utilities or public services provided normal construction utility coordination is performed. These facilities require limited workers and thus would not generate significant new demands for public services. For aboveground treatment, utility extensions would need to be made to provide power, which could require additional land disturbance.
  - Land retirement or changes in existing agricultural practices will not disrupt existing utilities or create need for additional public services.

- **Traffic:**
  - Construction of aboveground treatment or in-situ treatment facilities would have temporary traffic impacts that can be controlled through a standard traffic plan. Operational traffic is limited overall although aboveground treatment facilities will generate higher traffic requirements than in-situ treatment due to worker commutes, material deliveries, and waste disposal. Relevant mitigation measures for construction from Section 3.10, *Transportation and Traffic*, would also apply to treatment facility construction and would reduce impacts to a less than significant level.
  - Fallowing existing agricultural land would lower traffic levels. Changes in farm practice change would likely not change existing traffic levels. However, given the uncongested conditions on local roadways, such traffic is not considered to result in any significant traffic conditions. This impact would be less than significant.
- **Aesthetics:**
  - New aboveground treatment facilities could be anomalous in the rural context of Hinkley and thus would require aesthetic treatments to reduce their impact. In-situ facilities are more limited in extent and scale and usually have less than significant aesthetic impacts. Relevant mitigation measures from Section 3.11, *Aesthetics*, would also apply new treatment facilities and would reduce impacts to a less than significant level.
  - Fallowed lands may result in revegetation and restoration of habitat for biological species which would result in a change from an agricultural to a more native land condition. Hinkley is a mix of agricultural and undeveloped land so this would not result in a visual aesthetic inconsistent with the general local character, especially in light of continued agricultural landscapes with the agricultural treatment units and in continuing other agriculture unaffected by retiring. Changes in farm or dairy practices would not result in changes to visual aesthetics.
- **Physical Effects of Socioeconomic Changes:**
  - Construction of aboveground treatment or in-situ treatment facilities would not usually require acquisition of land or other actions that might contribute to socioeconomic changes than might contribute to physical blight.
  - The "farm swap" method could allow fallowing of other local agricultural fields without lowering the amount of locally available feed for local dairies, which are a key source of local jobs and economic activity. While fallowing some land would lower employment at that location with the addition of agricultural units, there would be an offset of agricultural employment. Working with dairies to change management practices may also help improve their regulatory compliance which could enhance their long-term viability and reduce their compliance costs as some of the local dairies are presently under regulatory review by the Water Board. As a result, the farm swap method should not have an adverse impact on socioeconomics that might contribute to physical blight.

Impact WTR-5e: Secondary Impacts of IRZ Remediation Byproduct Mitigation (Less than Significant with Mitigation)

Mitigation Measures WTR-MM-4 and **WTR-MM-7** include remediation of IRZ byproducts (dissolved arsenic, iron, and manganese) as necessary to restore aquifer beneficial uses. Byproduct remediation could include manganese remediation actions (such as such as extraction and capture of manganese-affected groundwater, aboveground aeration, and/or infiltration galleries, which can also be used to treat iron levels in groundwater) as well as potential arsenic remediation actions (aboveground treatment using precipitation/coprecipitation, ion-exchange units, membrane filtration, or other means determined to be effective by the Water Board).

Table 3.1-12. Secondary Impacts of IRZ Byproduct Mitigation

Byproduct Constituent	Potential Treatment Methods	Potential Impacts	
		Construction	Operation
Manganese	Extraction and capture, aeration, percolation/filtration back into aquifer via dry wells or infiltration galleries, and monitoring	Drilling, excavation and land disturbance for extraction wells, monitoring wells, trenching/piping, dry wells, and infiltration galleries	Energy use, increased pumping rates, percolation back into aquifer
Iron	Same as for manganese	Same as for manganese	Same as for manganese
Arsenic	Extraction and capture, above ground treatment, injection back into the aquifer via injection wells or filtration back into aquifer via dry wells or infiltration galleries, and monitoring	Well drilling, installation of wellhead treatment systems, trenching/piping, installation of injection wells/ dry wells/infiltration galleries	Energy use, increased pumping rates, injection or percolation back into aquifer

Manganese and Iron Treatment Methods

According to the manganese mitigation plan, treatment of manganese and iron may involve the installation and operation of a groundwater extraction well (or wells) to capture groundwater with concentrations of dissolved manganese that exceed the reference concentration. The extraction rate will be adjusted to optimize capture during operations. The extracted water will be piped back to a previously disturbed area (the Central Area Pilot Test area is proposed presently but this could be to other areas in the future) and aerated by bubbling air into the water. A reaction basin can be provided after the aeration to allow the oxidation to proceed to completion. The aeration of the extracted groundwater has been designed to oxidize the dissolved manganese (Mn[II]), converting it into solid manganese (Mn[III/IV]), thus removing it from groundwater. After the groundwater is aerated and the manganese has been removed, the water must be filtered to remove the precipitated material and it would be percolated through the vadose zone using dry wells or an infiltration gallery. An infiltration gallery would consist of the following elements: fourteen perforated lateral distribution pipes constructed of polyethylene pipe placed within 4-foot wide trenches containing an aggregate bed (crushed rock or gravel) to a depth approximately 5 feet below ground surface. The gallery footprint would cover a 150 foot by 85 foot area (12,750 square feet or 0.3 acre).

The construction and operation of all of these facilities could have physical effects on the environment and result in impacts as described below.

In-situ methods are not considered as they could likely interfere with IRZ operations to treat chromium. Since manganese and iron are concern due to IRZ operations, another alternative is natural attenuation with reduction of carbon amendment as manganese and iron levels have been shown to drop within months to a year or two after carbon amendment levels drop. Natural attenuation would not have any secondary physical impacts and is not discussed further.

Arsenic Treatment Methods

Methods used to treat arsenic in groundwater could include precipitation/coprecipitation, electrochemical treatment (such as electrocoagulation) ion exchange, membrane filtration, and other methods. In-situ methods are not considered as they could likely interfere with IRZ operations to treat chromium.

Since arsenic is a concern due to IRZ operations, another alternative is natural attenuation with reduction of carbon amendment as arsenic levels have been shown to drop within months to a year or two after carbon amendment levels drop. Natural attenuation would not have any secondary physical impacts and is not discussed further.

Impact Analysis

The section below summarizes potential secondary physical impacts of byproduct mitigation for IRZ remediation. As noted below, all relevant project mitigation measures would also apply to byproduct remediation.

- **Water Quality**: Construction of new wells, piping and treatment facilities may result in minor erosion which has the potential for sedimentation of downstream water bodies. However, compliance with San Bernardino County erosion control requirements and state/federal SWPPP requirements would keep this impact to a less than significant level. Disposal of any treatment by products would need to comply with all applicable disposal requirements. Relevant mitigation measures for construction and operation of wells, piping, and treatment facilities as described in this section above would be able to reduce impacts to less than significant level.
- **Land Use:** The construction of byproduct treatment facilities would be constructed on existing domestic, agricultural, or remedial lands, and not introduce incompatible uses or displace existing land uses due to the small area of these facilities relative to the surrounding area. With compliance with local land use regulations and requirements, it is expected that any such treatment facility would not result in significant land use impacts. Construction of wells and pipelines may temporarily disrupt land uses, but similar to wells and pipelines for remedial actions, this temporary disturbance is not considered significant. Relevant mitigation measures from Section 3.2, *Land Use, Agriculture, and Population, and Housing*, would also apply to construction of byproduct treatment facilities and would reduce impacts to a less than significant level.
- **Hazards and Hazardous Materials:** Construction of byproduct treatment facilities would include handling of slurry, bentonite and cement grout, backfill, PVC, silica sand, ion exchange resins, and other materials. Treatment facilities may also handle certain treatment chemicals and would generate wastes (such as ion exchange resin-adsorbed contaminants or sludge accumulation in aeration reaction basins) requiring disposal (such as regeneration water and spent resin containing high levels of arsenic or aeration reaction basin sludge removal). Application of all local, state, and federal regulations for handling and transport of hazardous materials will control the potential for exposure to hazardous materials and thus construction should result less than significant impacts. Relevant mitigation measures from Section 3.3, *Hazards and Hazardous Materials*, would also apply to construction of remediation facilities and would reduce impacts to a less than significant level.

- **Geology and Soils:** Ground-disturbing activities, such as well, lysimeter, piping, wellhead treatment, aboveground treatment facility and infiltration gallery installations have the potential to result in increased soil erosion or loss of topsoil. However, compliance with San Bernardino County erosion control requirements and state/federal SWPPP requirements would keep this impact to a less than significant level. However, these areas would be minimal compared to the surrounding area and soils would be replaced and re-stabilized post-construction. Relevant mitigation measures from Section 3.4, *Geology and Soils*, would also apply to construction and operation of byproduct treatment facilities and would reduce impacts to a less than significant level.

- **Air Quality/Greenhouse Gas Emissions:** Construction of new byproduct treatment facilities will result in construction emissions of criteria pollutants and greenhouse gases. During operations, pumping and aboveground treatment facilities will also result in electricity emissions. Where trucking of materials or generated wastes for disposal is required, trucking will result in gasoline and/or diesel emissions. Relevant mitigation measures from Section 3.5, *Air Quality and Climate Change*, would also apply to construction and operations of remediation facilities and would reduce impacts to a less than significant level.

- **Noise:** Construction of new byproduct treatment facilities will generate noise from equipment and vehicles similar to construction of remedial facilities. Operations of these facilities will have limited noise generation and would result in less than significant impacts. Relevant mitigation measures from Section 3.6, *Noise*, would also apply to construction of byproduct treatment facilities and would be able to reduce impacts to a less than significant level.

- **Biological Resources:** Construction of new byproduct treatment facilities could disturb habitats and individual special status species, sensitive vegetation communities, however the footprint of potential facilities will likely be limited to several acres. Aboveground treatment facilities will likely have a footprint of 1 acre or less and infiltration galleries for manganese and iron mitigation will likely have a footprint under 0.5 acre. Efforts will be made to locate the facilities in previously disturbed areas facilities will be designed to be constructed and operated without resulting in the temporary or permanent loss of threatened and endangered species habitat and the associated need for incidental take permits. However, biological resources surveys would be conducted in proposed areas prior to construction activities. If the construction of treatment facilities were found to result in the permanent and temporary destruction of habitat for species, such as desert tortoise and Mohave ground squirrel. Appropriate "incidental take" permits would be obtained from the California Department of Fish and Wildlife and United States Fish and Wildlife Service. Relevant mitigation measures from Section 3.7, *Biological Resources*, would also apply to construction of remediation facilities and would reduce impacts to a less than significant level.

- **Cultural Resources:** Construction of new byproduct treatment facilities could disturb cultural and paleontological resource. Operations of byproduct treatment facilities should not disturb cultural resources unless new ground disturbance is necessary for system maintenance and would result in less than significant impacts. Relevant mitigation measures from Section 3.8, *Cultural Resources*, would also apply to byproduct treatment facilities and would reduce impacts to a less than significant level.

- **Utilities:** For the most part, construction of new byproduct treatment facilities will not disrupt existing utilities; however in some cases, in particular for construction of new pipelines, there could be disturbance of existing utilities. However, local and state regulations require planning for and avoidance of disruption to existing utilities and thus construction impacts will be less than significant. Operations of byproduct treatment facilities should not disrupt existing utilities or create need for additional public services.

- **Traffic:** Construction of new byproduct treatment facilities will generate traffic similar to construction of chromium remedial facilities. It is possible that construction might affect traffic safety or emergency access, but application of mitigation from Section 3.10, *Transportation and Traffic*, would reduce impacts to a less than significant level. Operations of wells, monitoring or byproduct treatment systems (including waste disposal) will generate minimal new traffic due to the need for maintenance. However, given the uncongested conditions on local roadways, such traffic is not considered to result in any significant traffic conditions.

- **Aesthetics.** Construction of new byproduct treatment facilities will temporarily disturb local aesthetic conditions due to construction noise, dust, and presence of equipment and vehicles, but these impacts would be limited in scale and extent at any one location and thus less than significant. New aboveground treatment facilities could be anomalous in the rural context of Hinkley and thus would require aesthetic treatments to reduce their impact. Relevant mitigation measures from Section 3.11, *Aesthetics*, would also apply new treatment facilities and would reduce impacts to a less than significant level.

- **Physical Effects of Socioeconomic Changes.** Construction of new byproduct treatment facilities would not be expected to require acquisition of property containing existing residents or other structures and thus would not have the potential for the creation of blighted conditions due to abandoned structures.

Impact WTR-5f: Secondary Impacts of Freshwater Injection Water Quality Control (Less than Significant)

Mitigation Measure WTR-MM-8 requires that if the current freshwater source is not acceptable for injection, water may be sourced from a different area where water quality levels are met, which could require additional wells and pipelines to be built. Impacts associated with additional wells and pipelines that might be necessary are the same as those included in the analysis of chromium remediation alternatives. Application of relevant mitigation discussed in the EIR would reduce potential impacts to less than significant.