Chapter 2
Project Description

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2.1 Introduction

This chapter describes the project location, defines the project area, establishes the existing conditions, identifies project goals and objectives, discusses the context for how the project alternatives were developed, and describes the alternatives evaluated in the EIR.

Pursuant to existing Water Board orders, PG&E has implemented remediation activities to clean the groundwater impacted by historical chromium discharges from PG&E's Hinkley Compressor Station (refer to Section 1.1, *Overview*, in Chapter 1). The proposed project consists of expanded remediation activities. This EIR evaluates six alternatives with different combinations of several types and intensities~~combinations~~ of ~~additional~~ remediation activities, including plume containment, in-situ treatment, land treatment, and above-ground treatment. Refer to Section 2.8, *Project Alternatives*, below for a detailed description of each.

Rather than selecting one alternative as the proposed project and providing a less detailed evaluation of the other alternatives (as CEQA allows), the Water Board has elected to not list a preferred alternative but to evaluate each alternative with an equal level of detail to provide more detailed information and disclosure of impacts.

2.2 Project Location

The proposed project is located in San Bernardino County ~~in~~ near the ~~town~~ community of Hinkley, California. The PG&E Hinkley Compressor Station is located in the Mojave Desert approximately 6 miles west of the city of Barstow, California, and about 1 mile north of the Mojave River. Figure 2-1 shows the project location and vicinity. All Chapter 2 figures are included at the end of this chapter.

2.3 Project Area

At the initiation of this CEQA process in late 2010, the project area was delineated as the hexavalent chromium Cr[VI] groundwater contamination (or plume) area containing more than 3.1 parts per billion (ppb) of Cr[VI], including immediately adjacent areas. Since late 2010, the defined plume area containing more than 3.1 ppb of Cr[VI] has been determined to be substantially larger, likely due to some combination of the following: movement of the chromium with groundwater (also called plume *migration*), more comprehensive sampling of additional areas surrounding the prior plume boundaries, ~~and~~ improved understanding of where the chromium occurs in different layers of the aquifer, and improved sampling~~how to sample~~ to obtain maximum concentrations. In addition, groundwater modeling analysis of project alternatives has indicated that remediation activities may result in potential groundwater drawdown in areas far outside of the defined chromium plume area. The project area, therefore, had to be expanded in order~~to be able~~ to analyze these potential impacts of the remediation activities.

Consequently, the current project area for the EIR analysis encompasses the plume area as of the fourth quarter of 2012~~2011~~ (Q4 2012~~2011~~). The current project area also adds~~,~~ adjacent areas to the north, east and west where the plume may be defined in the future (due to migration and additional investigation) and where monitoring activities may occur, as well as areas of potential effects due to groundwater pumping from the remediation alternatives. This project study area that could be directly or indirectly affected by the project is approximately 50 ~~33~~ square miles (32,159 ~~21,093~~ acres) in size and extends approximately 9 ~~6~~ miles north and 3 miles south of State Route 58 (SR 58) at its longest point. It is approximately 6 miles east to west at its widest point, and generally bounded by Valley Wells ~~Hinkley~~ Road on the west, Mount General on the northeast, and areas just south of the Mojave River on the southeast. The northern boundary of the study area has been set approximately 1 mile north of the northernmost detection of Cr[VI] above 3.1 ppb in monitoring reports to date.

For the purposes of EIR analysis, the project area is also discussed in terms of sub-areas, which include the following:

- Plume area, which is the geographical limits of known groundwater contamination as of Q4 2012~~2011~~;
- Areas in which groundwater contamination may migrate or be detected as a result of expanding the monitoring well network;
- Operable units (OUs), which are areas where specific remedial activities would continue or be expanded under the project; and
- Potential areas of direct and indirect effects from the remedial activities, such as, but not limited to, groundwater drawdown, impairment of water quality, reduction in domestic water supplies, visual effects, increased noise and traffic, socioeconomic effects, loss or disturbance of endangered species habitat; monitoring activities, construction of supporting infrastructure to implement remediation (such as piping, treatment buildings, other treatment facilities, ~~ethanol,~~ and equipment and material storage), and construction of new wells to provide water supplies (for freshwater injection, replacement water, and extraction and injection for cleanup).

The project area is also generally discussed as having south, central, and north sections relative to the geographic portions of the chromium plume in groundwater. The south area extends from Riverview Avenue north to Community Boulevard and contains the PG&E Hinkley Compressor Station; the central area extends from Community Boulevard north to SR 58; and the north area extends from SR 58 north to the northern limit of the project area.

The EIR project area, including the sub–areas, is shown in Figure 2-2a. Detailed descriptions of the plume area and OUs are provided below.

2.3.1 Plume Area

As described in Chapter 1, *Introduction*, the Water Board requires PG&E to monitor and report on the concentrations of total chromium (Cr[T]) and Cr[VI] detected ~~present~~ to establish the extent of waste chromium in groundwater. PG&E has sampled for Cr[T] and Cr[VI] contamination levels for many years by installing monitoring wells throughout the project area. Monitoring activities consist of sampling of groundwater and soils (i.e., collection of groundwater and soils for testing) and water level readings. Data collected during sampling is used to determine the geographical variance in contamination levels that is then used to develop boundaries to represent the presence of Cr[T] and

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Figure 2-1
Project Location and Vicinity

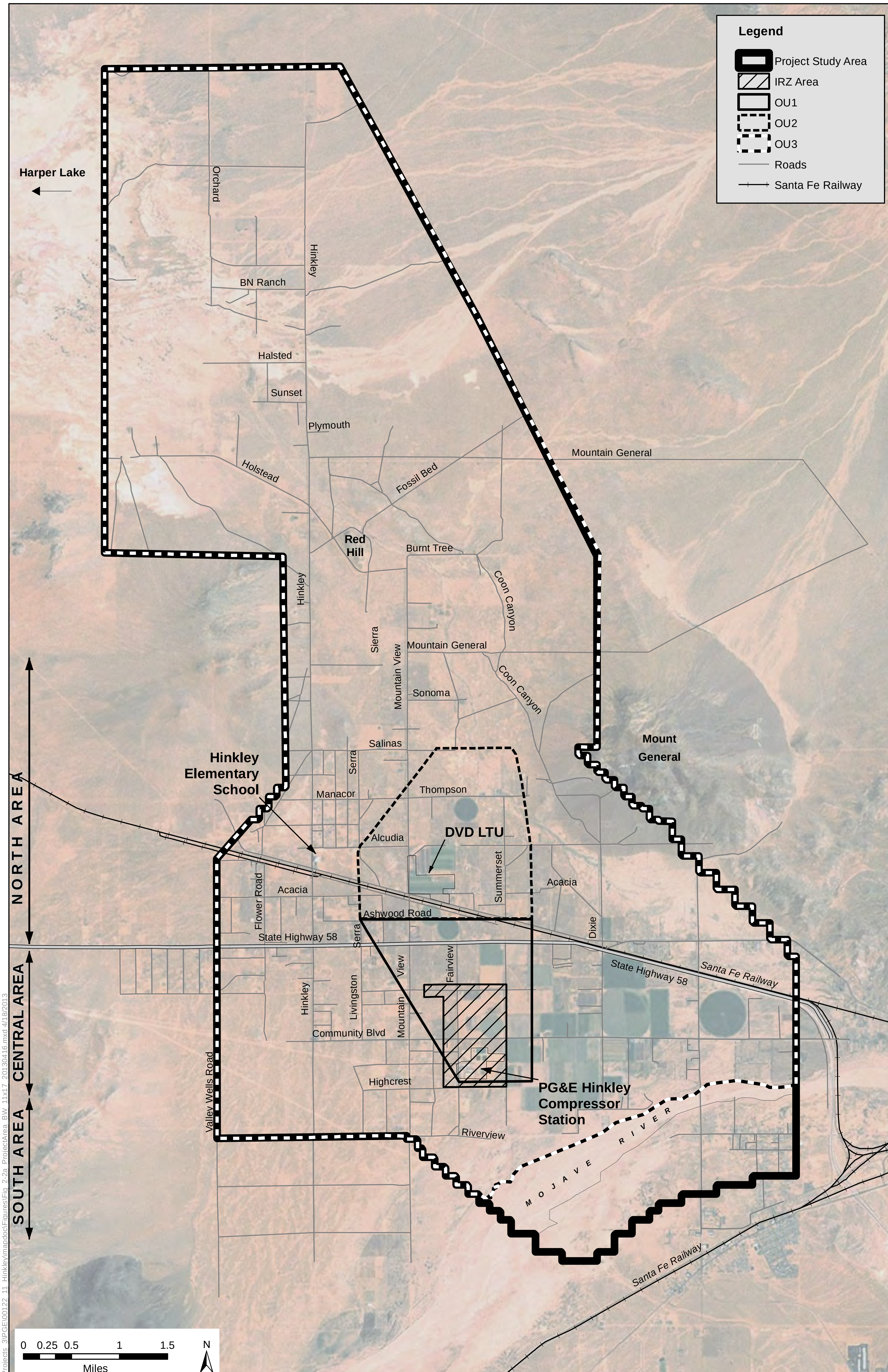


Figure 2-2a
Project Area

Source: Based on information from PG&E 2011c.

Cr[VI] contamination. The maximum extent of these boundaries is characterized as the plume area ~~and the groundwater~~ in chromium concentration contours for different levels of contamination ~~are~~ depicted on plume maps. At present, the plume maps depict contours representing Cr[VI] concentrations of 3.1 parts per billion (ppb, essentially equivalent to micrograms per liter) (Figure 2-2b), 10 ppb (Figure 2-2c), and 50 ppb (Figure 2-2d). These concentrations were mapped for the following reasons:

- **3.1 ppb for Cr[VI]** – This contour traces the outer boundary of what is defined as the chromium plume in groundwater as of the Fourth Quarter 2012~~1~~. The 3.1 ppb value for Cr[VI] was determined based on a 2007 Background Study Report ~~conducted~~ by PG&E that evaluated background levels of Cr[T] and Cr[VI] in areas that were then outside the recognized plume area. The results of that study estimated that maximum background levels were 3.1 ppb for Cr[VI] and 3.2 ppb for Cr[T] and the average background levels were 1.2 ppb for Cr[VI] and 1.5 ppb for Cr[T] (Pacific Gas and Electric 2007). The Water Board will use these values as cleanup targets for the remediation unless and until new evidence is developed that background levels are different than these cleanup targets[1] or PG&E demonstrates that background levels of water quality cannot be restored.~~,~~ If this occurs,~~at which time~~ the Water Board will identify the best water quality achievable, consistent with the procedures set forth in State Water Resources Control Board Resolution 92-49 (described in detail in Section 2.5 below).
- **10 ppb for Cr[VI]** – This contour defines the portion of the plume where ~~medium-level~~ 10 ppb concentrations Cr[VI] occur. The 10 ppb level is not tied to a regulatory level or a background level, but is used to compare~~d~~ maps in previous monitoring reports.
- **50 ppb for Cr[T] or Cr[VI]** – This contour defines the portion of the plume where~~in~~ Cr[T] or Cr[VI] concentrations are at or above the California Maximum Contaminant Level (MCL) of 50 ppb for Cr[T], which includes Cr[VI]. The MCL is the current drinking water standard and is only specified for total chromium, not hexavalent chromium.

Since initiating monitoring activities, PG&E has prepared quarterly groundwater monitoring reports ~~(GMP)~~ in accordance with Water Board orders that have been used to track the area of contamination. Groundwater monitoring reports ~~GMPs~~ are also used as a means to determine effectiveness of remediation activities being implemented as well as their ability to meet interim remedial targets. In sampling from monitoring wells conducted between 2006 through the second quarter of 2010 (Q2 2010), a level of 4.0 parts per billion (ppb) was used to delineate the extent of the plume area. Subsequently, the 3.1 ppb Cr[VI] and 3.2 ppb Cr[T] levels have been used to delineate the extent of the plume area.

Figures 2-2b through 2-2d illustrate the progression of the plume area boundaries from 2008 through the end of 2012~~1~~.

2.3.2 Operable Units

Three OUs (OU1, OU2, and OU3) were defined to generally represent areas in which different types of remedial activities, which have been implemented and will likely~~would~~ be implemented in the

[1] As described in Sections 1.2.1 and 3.1, *Water Resources and Water Quality*, the Water Board initiated a peer review in 2011 of the 2007 Background Study Report and is evaluating the potential reevaluation of the 2007 data and/or conducting a new background study. These efforts may result in identification of different background levels than the 2007 study.

future, would be located. The OUs are defined in relation to the various groundwater contamination levels represented by the plume area (see Figures 2-2a to 2-2d). The OU locations and their boundaries are described below. A detailed description of the types of remedial activities to be implemented within each OU is provided in Section 2.9, *Construction, Operation, and Maintenance*.

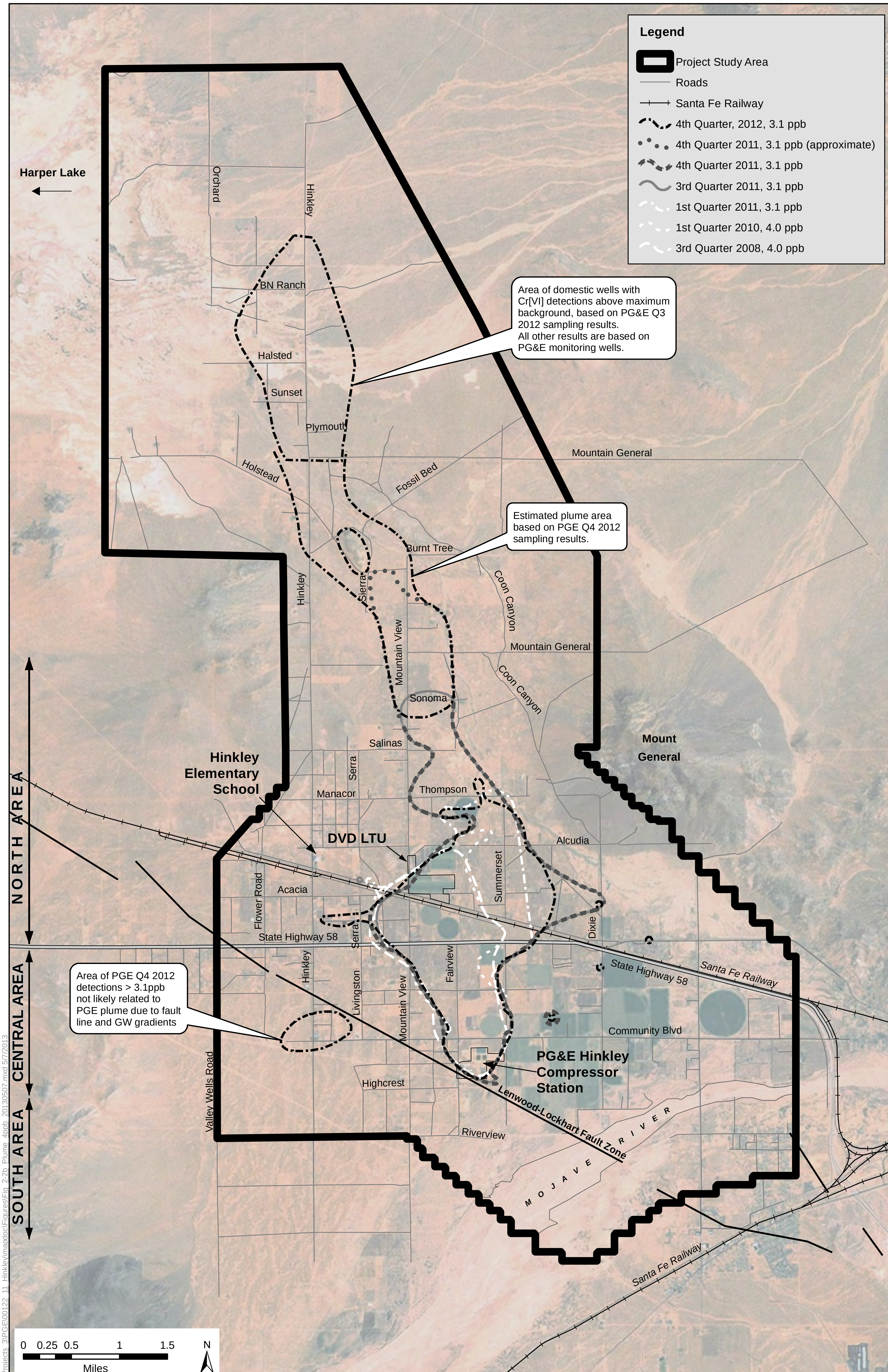
- OU1 extends from the Source Area located in the south on PG&E's Hinkley Compressor Station property to the approximate northern extent of the 50 ppb groundwater contour of the plume~~,~~ at approximately Ashwood Road. The OU1 area encompasses approximately 1,378 acres and is the area with the highest levels of chromium contamination. Remedial activities (in-situ, land treatment, and above-ground ex-situ treatment) aimed at treating the highest concentration portions of the plume would likely be located within OU1. Existing in-situ remediation zones (IRZs) are located within OU1.
- OU2 extends from the northern boundary of OU1 north to Salinas Road and contains most of the 10 ppb groundwater contour of the plume area (that is outside the 50 ppb contour). The OU2 area encompasses approximately 1,715 acres. This area contains the existing agricultural/land treatment units[2], including the Desert View Dairy land treatment unit, the former Gorman and Cottrell property agricultural units, and the Ranch agricultural unit.
- OU3 encompasses the portion of the project area that is outside of and adjacent to OU1 and OU2. This includes areas where the plume may migrate, and future remedial actions, monitoring activities and direct and indirect effects of remedial actions (such as those as described above) may occur. It is possible that the maximum extent of the plume area may change compared to the late 2012~~1~~ plume area and that remedial actions may ultimately be necessary beyond the OU3 boundary and possibly outside of the overall EIR project area as shown in Figure 2-2a. The current OU3 area encompasses approximately 30,174 ~~16,765~~ acres.

For the purposes of this analysis, remedial actions are assumed to potentially occur within any portion of OU3. However, there are practical constraints within certain areas included in OU3 that may influence where remedial actions are most likely to occur. For example, OU3 contains some areas of steeply sloping ground to the west and east of the Hinkley Valley. It is unlikely that above-ground ex-situ treatment facilities or agricultural units would be placed in such areas. Similarly, OU3 contains residential areas north of the Hinkley School where monitoring wells might be placed, but it would not be feasible or desirable to place agricultural units in these residential areas. The most likely areas of remedial action in OU3 are within the boundaries of the plume as known in late 2012~~1~~, depicted in Figure 2-2a.

2.4 Existing Conditions

As discussed in Chapter 1, *Introduction*, the Water Board previously issued CAOs requiring PG&E to conduct actions to prevent plume migration and ~~actions~~ to clean up the affected groundwater. The Water Board prepared CEQA documentation for all WDRs issued to implement remedial activities, such as in-situ remediation, agricultural land treatment, and freshwater injection. If the Water Board

[2] Land treatment is performed by irrigating land with chromium-laden water resulting in transformation of dissolved Cr[VI] to solid Cr[III] through microbial action and chemical reactions in soil. Land treatment units involve dispersing water on soil with or without crops, whereas agricultural units include growing crops. There are more agricultural units than land treatment units at present and in the alternatives considered in this EIR; the term "agricultural unit" is sometimes used to refer to both.



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Source: Plume contours based on PG&E quarterly monitoring reports

Figure 2-2b
Expansion of 3.1/4.0 ppb Maximum Background Plume Area Contours

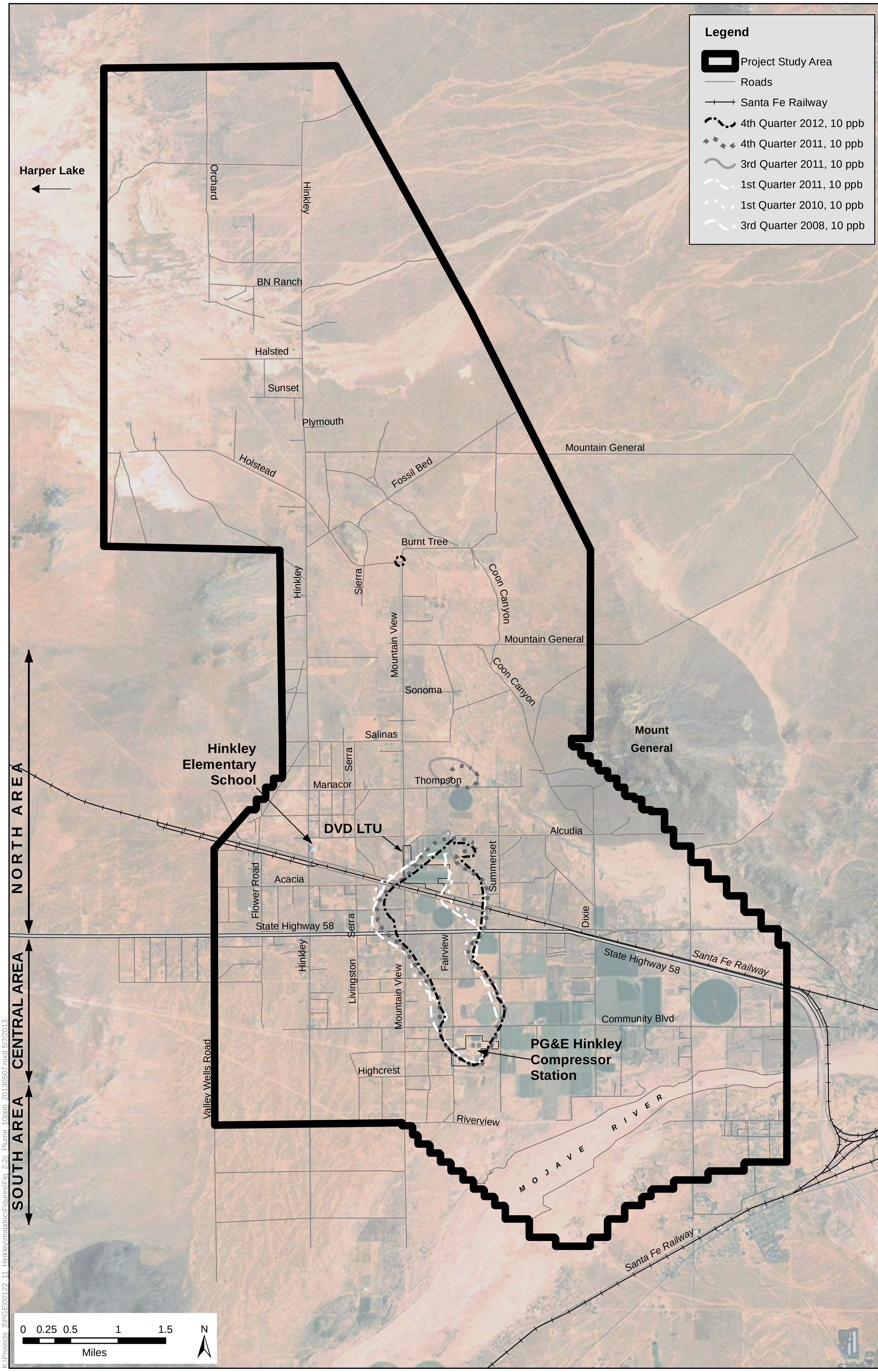

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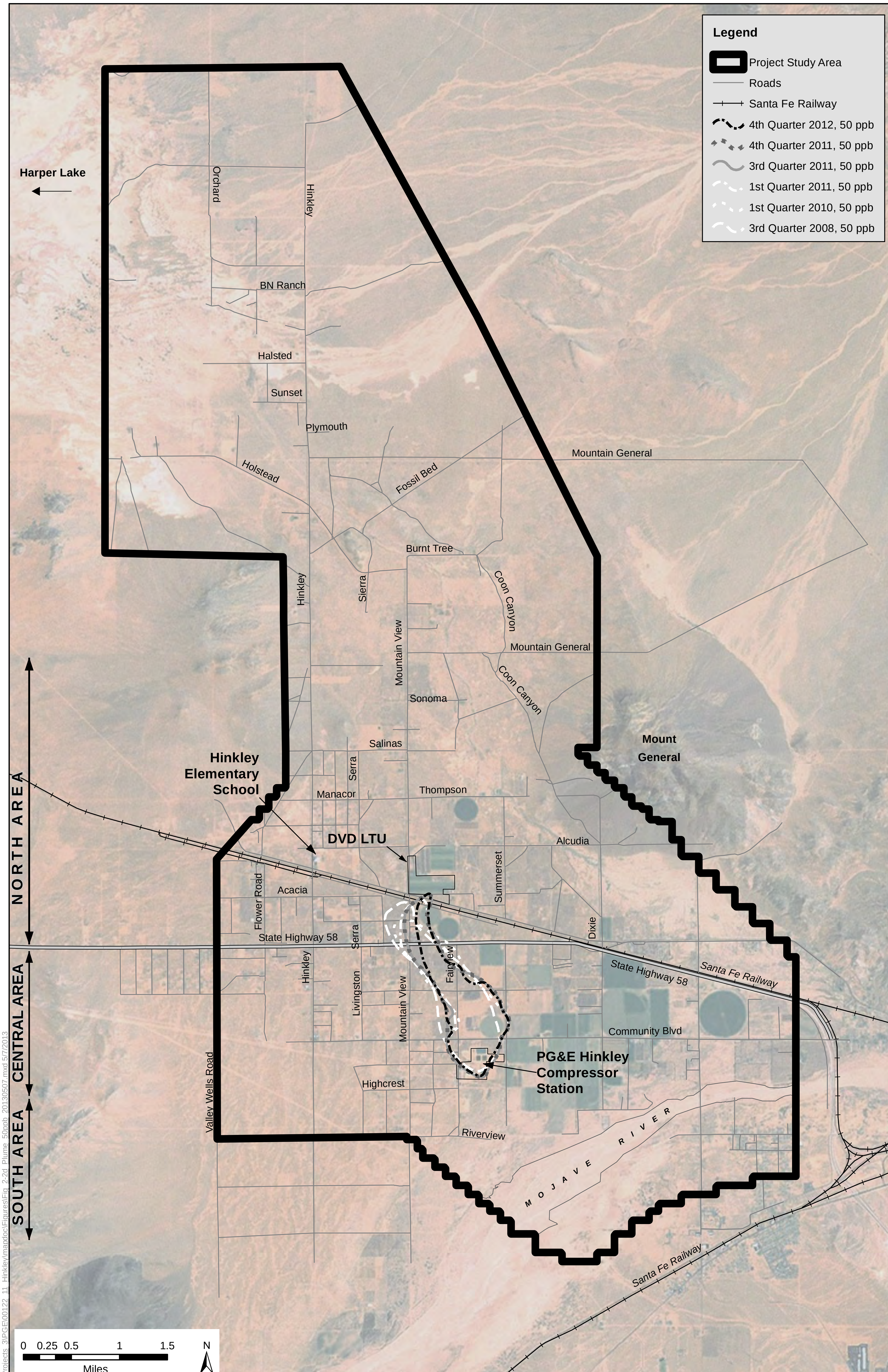
Figure 2-2c
Expansion of 10 ppb Maximum Background Plume Area Contours

Source: Plume contours based on PG&E quarterly monitoring reports



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Source: Plume contours based on PG&E quarterly monitoring reports

Figure 2-2d
Expansion of 50 ppb Maximum Background Plume Area Contours

takes no further action on the cleanup, PG&E will still be obligated to fulfill the prior CAO requirements and can implement remedial activities currently allowed under existing WDRs whose potential environmental impacts were previously evaluated under CEQA. These CEQA documents, all of which are mitigated negative declarations (MNDs), encompass the area from the Compressor Station to 1,000 ft north of the Desert View Dairy on Mountain View Road, which is about 3 miles in length.

Since the Notice of Preparation (NOP) of the EIR was published in late 2010, the project area and the amount of existing remedial actions have both expanded. These changes need to be accounted for when describing the existing conditions against which potential environmental impacts will be analyzed. Therefore, for the purposes of this EIR analysis, the existing conditions are defined as the physical conditions on the ground as of late 2012~~2011~~. In order to fully disclose project-related impacts, impacts of all project alternatives will be compared to the existing conditions (late 2012~~2011~~) instead of physical conditions that were present when the NOP was published in late 2010.

Table 2-1 summarizes and Figure 2-2e shows the characteristics of existing remediation activities and the remediation infrastructure currently in place and operating in the project area. Remediation activities for chromium contamination are currently being implemented where past and ongoing remediation pilot testing and experience has shown treatment to be effective. The current treatment approaches and technologies being implemented within the project area include:

- *In-situ treatment of the higher-concentration plume* in the IRZ areas within the south and central sections of OU1. The IRZ areas are generally divided into the Source Area IRZ (SAIRZ), the South Central Reinjection Area IRZ (SCRIA), and the Central Area IRZ (CAIRZ). Groundwater extracted within these areas is carbon-amended (primarily~~e.g.,~~ ethanol~~ or lactate~~ at present) and injected in either a recirculation loop configuration or as spot injections (also referred to as dosed-injection in Table 2-1 below). Refer to Figure 3.1-13 for a diagram of this treatment.

- *Plume containment and land treatment using water extracted from the low-concentration northern and fringe portions of the plume.* Five agricultural units are currently being operated (2 Gorman, 1 Cottrell, 1 Ranch, and the Desert View Dairy land treatment unit) in OU2. Extraction wells are operated to ~~augment~~ contain~~ment~~ migration at the downgradient end of the plume. P~~p~~umped~~ing~~ ~~and for application of~~ water is piped and applied to the agricultural units by either a subsurface drip system or an above-ground drag drip system ~~through a conveyance system of piping~~. Refer to Figure 3.1-12 for a diagram of this treatment.

- *Plume containment (or hydraulic control) using freshwater* injection to five wells located in the north area, directly adjacent to the western boundaries of OU1 and OU2. Freshwater is extracted from three supply wells (PGE-14, FW-01, and FW-02) located south of the Compressor Station property. The water from well PGE-14 is filtered for arsenic and combined with the water from the other two wells, which have low arsenic concentrations; and that water is conveyed through a pipeline to the northern freshwater reinjection wells. The resulting groundwater mound creates a hydraulic barrier and helps to prevent~~s~~ further plume migration to the west. A small "finger" of detections just above the maximum background level of chromium was identified in 4th Quarter of 2012, west of the line of injection wells. This new area is presently being investigated to determine the migration pathway for chromium.

- *Monitoring.* In addition to the containment, land treatment, and in-situ activities, PG&E oversees an extensive network of monitoring wells, which are located throughout the project area.

Monitoring wells are constructed with screens across various depths of the upper aquifer and in the lower aquifer. Monitoring activities include groundwater sampling and water level readings. Groundwater sampling frequency ranges from quarterly to semi-annually or annually, although PG&E may sometimes sample more frequently when a new monitoring well is installed. Water level readings are conducted concurrent with the groundwater sampling activities.

The majority of access roads to wells and the agricultural units are from secondary dirt roads or, where feasible, from public streets. Existing public streets are also used as the main point of access to dirt roads.

Table 2-1. Summary of Remedial Components under Existing Conditions

Agricultural Land Application	
Agricultural Units	182 ac[a]
Agricultural Unit Extraction Wells	29
Trenches (may contain multiple pipelines)	24,499 linear feet (lf)
Agricultural Unit Extraction flow[b, c]	1,100 gpm
In-Situ Remediation (IRZ)	
Extraction Wells	12
Injection Wells	58
Pipelines	14,985 lf
Carbon-amended IRZ flow (South Central Area IRZ, Source Area IRZ)[c]	190 gpm[d]
IRZ recirculation flow (Central Area IRZ, Source Area IRZ)[c]	83 gpm[d]
Northwest Freshwater Reinjection	
Extraction Wells	3
Injection Wells	5
Pipelines	31,886 lf
Freshwater injection flow[c]	80 gpm[d]
Monitoring Wells and Other Infrastructure	
Monitoring Wells	434
Wells and Supporting infrastructure[e]~~[d]~~	36 acres
Access roads	1 acre

Notes:

[a] Agricultural Units include the Desert View Dairy + 4 pivots [Gorman (2), Cottrell, Ranch])

[b] Flows (gpm) for Desert View Dairy land treatment unit are included in agricultural unit treatment flows for all alternatives.

[c] All flows are average annual pumping rates.

[d] Permitted, allowable flow; actual flow rate may be less.

[e]~~[d]~~ Includes area for agricultural units, IRZ, and northwest reinjection wells as well as monitoring wells.

2.5 Whole-House Replacement Water

As described in Section 1.2.1, *Timeline of Activities*, in Chapter 1, *Introduction*, PG&E is required to provide interim and whole house replacement water service to those served by domestic or community wells that are within one mile ~~the affected area~~ of the chromium plume and whose wells

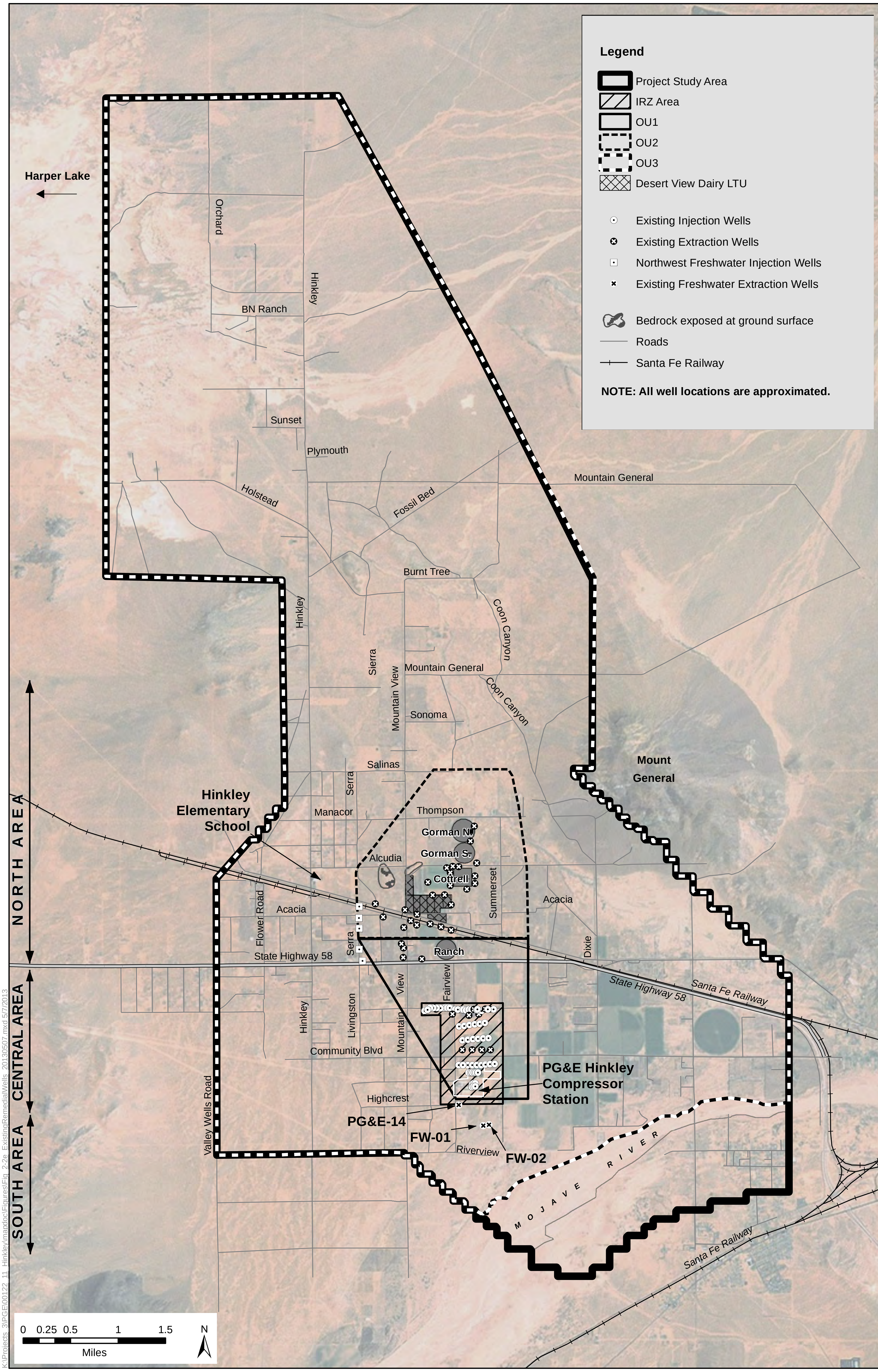

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Figure 2-2e
Existing Remedial Activities

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

have detectable levels of chromium. The whole house replacement water must be provided ~~determined to be impacted by the PG&E chromium discharge~~ for all consumptive indoor uses~~, including drinking, cooking, bathing, and hygiene~~ (CAO No. R6V-2011-0005A1~~, and~~ R6V-2011-0005A2, R6V-2011-0005A3, R6V-2011-0005A4). ~~This order applies to all domestic supply wells affected by PG&E's waste discharge of chromium within 1 mile downgradient or cross gradient from the most recent plume boundary, defined by the maximum background chromium concentrations, currently 3.1 ppb Cr[VI]/3.2 ppb Cr[T].~~ This requirement is described in greater detail in Section 3.1, *Water Resources and Water Quality* (3.1.3.2 *State Regulations*).

2.5.1 Affected Wells Eligible for Replacement Water

California Water Code section 13304(a) allows the Water Board to require replacement water for wells "affected" by a discharge of waste. "Affected wells" are those that do not meet federal, state and local drinking water standards. Where no federal, state, or local standard yet exists, as is the situation for hexavalent chromium, the State Water Board Water has concluded that "it is appropriate to use goals developed by agencies with expertise for public health determinations in deciding whether replacement drinking water is necessary" (Water Quality Order 2005-007, the "Olin Order").

Because the current California MCL of 50 ppb was set in 1977 for total chromium only and does not account for more recent evidence of Cr[VI] health risks particularly due to an oral route of exposure, and because no specific MCL for hexavalent chromium has been set, the Water Board is relying on the Public Health Goal of 0.02 ppb hexavalent chromium to determine "affected wells" requiring replacement water pursuant to CAO R6V-2011-0005A2~~0005A4~~. Due to the current limitations of laboratories to detect hexavalent chromium down to the Public Health Goal of 0.02 ppb, affected wells are those that contain any hexavalent chromium above the current laboratory ~~detection~~ reporting limit, ~~which is~~of 0.06 ppb (using a modified version of USEPA Method 218.6).

2.5.2 Replacement Water Provision before an MCL is Adopted

CAO R6V-2011-0005A2 addresses impacts to water supply wells from the existing chromium plume, which are not considered impacts of the project under CEQA because they were not caused by the implementation of the project (remedial activities). The chromium plume in groundwater is part of the CEQA baseline (~~or~~ existing conditions) of the project area, caused by past actions of PG&E when waste chromium was discharged to groundwater in the 1950s and 1960s. That discharge of waste is subject to regulatory and enforcement actions by the Water Board, such as CAO R6V-2011-0005A2, but is not an impact of the project under CEQA because it is not caused by the project (where, as here, the project here is to clean up the plume).

The replacement water supply program required by R6V-2011-0005A2 will continue, at a minimum, until a final MCL (or drinking water standard) for hexavalent chromium is adopted by the California Department of Public Health (CDPH).

As discussed in Section 3.1, *Water Resources and Water Quality*, if remedial activities significantly affect water quantity or quality conditions for water supply wells, replacement water will also be required as mitigation for remedial impacts.

2.5.3 Replacement Water Provisions after an MCL is Adopted

After CDPH adopts an MCL for hexavalent chromium, requirements pertaining to providing whole-house replacement water to affected wells will only apply to locations with wells containing hexavalent chromium at levels above the MCL level established by CDPH. At that time, PG&E's obligation under CAO R6V-2011-0005A2 to provide whole house replacement water ceases for those locations with four consecutive quarters of hexavalent chromium detections that~~which~~ do not exceed the MCL.

As discussed in Section 3.1, *Water Resources and Water Quality*, if remedial activities significantly affect water quality conditions for water supply wells, as defined by the significance criteria in Section 3.1, replacement water will also be required as mitigation for remedial impacts.

2.6 Project Goal and Objectives

The following provides a brief context for the discussion of the project goal and objectives.

The 2008 CAO No. R6V-2008-0002 required PG&E to submit a F~~f~~easibility S~~s~~tudy by September 1, 2010 (the 2010 Feasibility Study is described in more detail in Section 2.6 below) that assesses~~d~~ remediation strategies for chromium and proposes~~d~~ a final groundwater remediation proposal to achieve compliance with State Water Resources Control Board (SWRCB) Resolution 92-49, "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" (Resolution 92-49).

Resolution 92-49 requires a discharger to:

- Develop a cleanup plan that evaluates multiple remedies and weighs them against numerous factors such as:
  - Ability to achieve background levels;[3]
  - Time frame to achieve background levels; and
  - Potentially significant impacts.
- Propose a cleanup plan that either targets groundwater cleanup to background levels or provides the appropriate justification for a higher standard; and
- Consider what is reasonable when evaluating a cleanup goal, taking into account the technical and economic feasibility of attaining background conditions, the projected time frame to achieve background conditions, and the maximum beneficial use of the resource being protected.

2.6.1 Project Goal

The goal of the project is to restore groundwater quality to background levels of chromium for beneficial uses of the aquifer, in the minimum amount of time practicable, while limiting or mitigating environmental impacts associated with the cleanup activities.

[3] The term "background level" refers to the water quality that existed before the PG&E discharge.

The Water Board has the authority to require cleanup of any groundwater affected by chromium discharged from PG&E's Hinkley Compressor Station. Groundwater is considered to be affected by PG&E's discharge if the levels of chromium are above ~~naturally occurring~~ background levels as a result of Compressor Station operations.

For this EIR, the analysis looks at cleanup to the chromium background levels set in CAO No. R6V-2008-002A1 because, in part, PG&E's F~~f~~easibility S~~s~~tudy and addenda have considered cleanup to those levels and that analysis has generally shown that it is possible to meet those levels. In the future, the Water Board may identify a different background level and may set cleanup levels to meet that new background level. If PG&E is able to show that it is not feasible to restore water quality to background levels, the Water Board may require cleanup to the best water quality reasonably achievable, after considering a number of factors identified in State Water Resources Control Board Resolution 92-49, subsection G. ~~As long as the remedial activities that would be necessary to meet any new cleanup objectives are similar to those analyzed in this EIR and any associated environmental impacts do not exceed what had been analyzed in this EIR, t~~The Water Board's consideration of the revised cleanup objectives (and approval of new or amended WDRs) can rely upon ~~for CEQA compliance~~ the evaluation in this document for its CEQA compliance, as long as the remedial activities necessary to meet revised cleanup objectives are similar to those analyzed in this EIR, and the associated environmental impacts do not exceed those identified in this EIR.

2.6.2 Project Objectives

The specific project objectives are to:

- Contain the contaminated groundwater plume ~~horizontally and vertically~~ from migrating immediately and continuously from~~in~~ the area described in the amended CAO No R6V-2008-0002A3.
- Contain the contaminated groundwater plume overall.
- Reduce maximum groundwater concentrations to 3.2 ppb Cr[T] and 3.1 ppb Cr[VI] as described in CAO No. R6V-2008-0002A1.
- Reduce average groundwater concentrations to 1.2 ppb Cr[VI] and 1.5 ppb Cr[T], as described in CAO No. R6V-2008-0002A1.
- Restore beneficial uses of the groundwater by achieving the cleanup levels noted above in the minimum time feasible.
- Limit or mitigate environmental impacts associated with the cleanup activities.

Overall, these objectives are intended to reduce chromium concentrations in groundwater to the cleanup targets and contain the groundwater plume.[4] Development of these objectives takes into consideration the available technologies, recovery of beneficial uses, short-term effectiveness, long-

[4] Minor expansion of the chromium plume incidental to the remediation, such as limited "bulging" due to injection of water associated with remediation activities, would be consistent with these objectives, similar to the minor expansion (up to 1,000 feet) allowed by Amended CAO No. R6V-2008-0002A2, provided that chromium will be captured by the groundwater extraction system in the down gradient flow direction.

term effectiveness, and community concerns. Together, these objectives are intended to restore beneficial uses[5] to the groundwater aquifer.

2.7 Development of Project Alternatives

Development of the project alternatives by the Water Board was primarily based on the Water Board's independent review of information contained in the 2010 Feasibility Study[6] and its ~~Addendum~~ Addenda 1, 2 and ~~2~~3, the input and suggestions of the public (as described in Chapter 1, *Introduction*), independent review of the F~~f~~easibility S~~s~~tudy and addenda by the U.S. Environmental Protection Agency and the California Department of Toxic Substances Control, as well as information based on previous and existing PG&E remedial pilot projects in Hinkley. The F~~f~~easibility S~~s~~tudy and its addenda provide extensive detail regarding the potential technologies, their effectiveness at meeting cleanup objectives, and logistical, technological, and economic feasibility.

The 2010 Feasibility Study initially screened 36 chromium cleanup technologies/approaches (also referred to as remediation options or treatment approaches) with potential to be feasible and effective for containment and cleanup of the plume (Pacific Gas and Electric 2010). These 36 technologies can generally be categorized into the following remedial approaches:

- **Plume Containment through Groundwater Extraction:** Extracting contaminated groundwater at the outer edge of the plume to prevent further spreading of the plume.
- **Plume Containment through Clean Water Injection:** Injecting clean (non-contaminated water) at the outer edge of the plume to create a hydraulic barrier to prevent further spreading of the plume.
- **Groundwater Extraction and Land Treatment (with Agricultural Reuse):** Extracting contaminated groundwater and applying it to land where soil microbial action will reduce[7] dissolved Cr[VI] to solid Cr[III].
- **Plume-wide In-Situ Treatment:** Throughout the plume, injecting biological and chemical reductants (food-grade carbon sources such as ethanol or lactate) directly into the contaminated groundwater to promote microbial reduction of Cr[VI] to Cr[III] within the aquifer. Cr[III] has very low toxicity and is an essential dietary nutrient. It is typically immobilized in soils and tends not to dissolve easily in groundwater.

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[5] Designated beneficial uses for the Hinkley aquifer in the Basin Plan (see discussion in Section 3.1) include: municipal and domestic supply, agricultural supply, industrial service supply, freshwater replenishment, and aquaculture.

[6] A prior feasibility study was completed in 2002 and was also considered by Water Board staff, but the 2010 feasibility study (and its addenda) is a more comprehensive evaluation of potential remedial approaches from 2002 through 2010 and is the primary source of information used to help define project alternatives. The 2002 feasibility study is available from the Water Board upon request.

[7] "Reduce" in this context refers to a chemical reaction that adds electrons to a chemical species. Chromium has 24 protons and 24 electrons in its neutral state. Cr[VI] has 24 protons, but only 18 electrons and an oxidation state of +6. Cr[III] has 24 protons and 21 electrons and an oxidation state of +3. In this case, reduction of Cr[VI] to Cr[III] means that the chemical reaction adds 3 electrons to each Cr[VI] molecule which reduces its oxidation state from +6 to +3, thereby converting hexavalent chromium to trivalent chromium.

- **Plume-core[8] Only In-Situ Treatment:** Only in the Source Area (i.e., OU1), injecting biological and chemical reductants directly into the contaminated groundwater to promote microbial reduction of Cr[VI] to Cr[III] within the aquifer.
- **Ex-Situ Treatment (i.e., above-ground) and Discharge to Land:** Extracting contaminated groundwater and physically separating Cr[VI] from the water, disposing of the precipitated Cr[VI] off site, and discharging the treated water to land. Alternatively, ex-situ treatment could use biological and chemical reductants to reduce Cr[VI] to Cr[III] in contaminated water and then discharge the treated water to land.
- **Ex-Situ Treatment and Injection to Groundwater:** Extracting contaminated groundwater and physically separating Cr[VI] from the water, disposing of the precipitated Cr[VI] off site, and injecting the treated water directly into the aquifer. Alternatively, ex-situ treatment could use biological and chemical reductants to reduce Cr[VI] to Cr[III] in contaminated water and then inject the treated water directly into the aquifer.

Many of the technologies studied in the F~~f~~easibility S~~s~~tudy and addenda were included in one or more of the alternatives evaluated in the F~~f~~easibility S~~s~~tudy and/or included in the project alternatives evaluated in this EIR. Some of the approaches were not advanced further and are not considered in detail in this EIR. Section 2.10 below discusses the reasons why certain technologies/approaches were not studied further.

2.7.1 2010 Feasibility Study (September 2010)

In the 2010 Feasibility Study, the selected technologies were combined to form five alternatives to address the chromium cleanup goals specified in the project objectives. These five alternatives were as follows:

- **Feasibility Study Alternative 1.** No future pumping or groundwater treatment; cleanup achieved through natural attenuation. *Estimated time to cleanup to 3.1 ppb Cr[VI]: >1,000 years*
- **Feasibility Study Alternative 2.** Containment by injecting fresh water at the toe of the plume and land treatment. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 260 years*
- **Feasibility Study Alternative 3.** Plume-wide in-situ treatment using existing and new proposed injection wells. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 110 years*
- **Feasibility Study Alternative 4.** In-situ treatment in OU1 and land treatment using one existing and one new agricultural unit. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 150 years*
- **Feasibility Study Alternative 5.** Plume-wide pump and treat ex-situ, using existing and new injection and extraction wells and new above-ground treatment facilities. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 140 years*

Based on the Water Board staff's independent review of the 2010 Feasibility Study, it was determined that none of the five primary alternatives described above met the project goal and objectives for the following reasons: the proposed timeframes for cleanup and beneficial uses restoration ~~achieved by the five original alternatives~~ were too slow; the alternatives did not appear to clean up contamination in the minimum time feasible; and due to a larger plume area in late

[8] The term "plume-core" is only used to refer to the technologies consistent with the terminology used in the feasibility study.

2011/early 2012 than in 2010, ~~none of the five original~~ the alternatives were not specifically designed to contain the larger plume.

The Water Board staff requested PG&E to develop additional alternatives that included plume containment, ex-situ treatment, in-situ treatment, and land treatment that could achieve cleanup faster and control plume migration better than the five 2010 Feasibility Study alternatives.

2.7.2 2010 Feasibility Study Addendum 1 and Addendum 2 (January/March 2011)

Based on Water Board direction, PG&E developed two additional alternatives to accelerate groundwater cleanup and to provide more comprehensive plume containment, which were the basis of Feasibility Study Addendum 1 (Pacific Gas and Electric 2011a).

- **Alternative 4A:** Hydraulic containment of the chromium plume through groundwater extraction and injection, in-situ treatment using IRZ chromium conversion from Cr[VI] to Cr[III], and treatment of a portion of the extracted groundwater in agricultural fields. Alternative 4A is enlarged in scale over the 2010 Feasibility Study Alternative 4 by an increase in the Central Area IRZ, expansion of agricultural units, increased IRZ operations by 15 years, and increased volumes of groundwater extraction for application to expanded agricultural units. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 75 years*
- **Combined Alternative:** Hydraulic containment of the chromium plume through groundwater extraction and injection, core in-situ treatment, above-ground treatment of the high concentration portion of the plume, groundwater extraction and land treatment of the low concentration portion of the plume through expanded agricultural units to achieve the project objectives. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 90 years*

Upon review of the effectiveness of these alternatives, the Water Board requested that PG&E investigate options to use technologies employed in Alternative 4A to further reduce the time necessary to meet the project objectives and to provide for more comprehensive plume control. As a result, PG&E issued a Feasibility Study Addendum 2 (Pacific Gas and Electric 2011b) that described Alternative 4B.

- **Alternative 4B**. This alternative uses the same approach as Alternative 4A, but it includes additional extraction wells for agricultural land treatment and other facilities that more effectively remove the Cr[VI] contamination than Alternative 4A and significantly accelerates cleanup times. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 40 years*

2.7.3 2010 Feasibility Study Addendum 3 (September 2011)

Following review of Feasibility Study Addendum 2, the Water Board solicited input from the California Department of Toxic Substances Control (DTSC) and the U.S. EPA on the 2010 Feasibility Study, Feasibility Study Addendum 1, and Feasibility Study Addendum 2. Based on this input and review, the Water Board requested PG&E to develop further options to implement a program that maintained maximum year-round pumping and plume containment, evaluated the need for and effectiveness of varying pumping schedules, further evaluated the potential for additional cleanup time-frame reduction from that estimated under Alternative 4B, developed milestones for cleanup of different parts (or “operable units”) of the plume, developed optimization periods to facilitate adaptive management of the remedial activities, and established a contingency plan to maintain year-round plume capture. Optimization refers to changes that would be made in the remediation system configuration (e.g., change extraction well locations) to maximize remediation as plume cleanup progresses and the plume shape changes.

In response to the Water Board's request, PG&E developed four additional alternatives as part of Feasibility Study Addendum 3 (Pacific Gas and Electric 2011c) that used the same general remediation technologies as those previously studied in Alternative 4B, with the addition of extraction/treatment features and increases to extraction flow rates, continuous year-round pumping for enhanced year-round hydraulic control, winter-crop agricultural unit operation, and the consideration of winter water treatment by an ex-situ (above-ground) treatment plant. The purpose of the ex-situ treatment approach is to maintain fixed rate, year-round extraction rates since the agricultural units have a reduced capacity to treat water on a per-acre basis during winter months when less water can be absorbed. The additional alternatives were:

- **Alternative 4C-1.** In-situ and enhanced agricultural treatment, including additional extraction wells and agricultural units and associated infrastructure with higher extraction rates. Only one crop would be used for each agricultural treatment unit, resulting in seasonal fluctuations in flow rates. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 40 years*
- **Alternative 4C-2.** Same in-situ and enhanced agricultural treatment as Alternative 4C-1, except a winter crop would be added to increase extraction rates in winter relative to Alternative 4C-2. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 39 years*
- **Alternative 4C-3.** Same in-situ and enhanced agricultural treatment as Alternative 4C-2 with operations during summer and winter and the addition of ex-situ treatment with additional injection wells to accommodate the excess flow from the agricultural units in the winter in order to maintain a continuous extraction flow year-round. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 36 years*
- **Alternative 4C-4.** Same in-situ as Alternative 4C-2 with substantially expanded agriculture operations occurring during summer and winter, with addition of new agricultural units for winter-only operations in lieu of ex-situ treatment in order to maintain continuous extraction flow year-round. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 29 years*

After review of Feasibility Study Addendum 3, the Water Board recommended development of a more aggressive combined alternative that approximately matched the cleanup timeframe of Alternatives 4C-1 through 4C-4 while providing for removal of chromium from the aquifer in the high concentration portion of the plume. PG&E developed a new "Alternative 4C-5" in March 2012 to respond to the Water Board's recommendation.

- **Alternative 4C-5.** This alternative combines the in-situ and land treatment approaches proposed under Alternative 4C-2 with ex-situ approaches proposed under the previous Combined Alternative to remove chromium from the overall site from the high concentration portion of the plume. *Estimated time to cleanup to 3.1 ppb Cr[VI]: 50 years*

2.8 Scaling Approach to Address Recent Plume Changes

The F~~f~~easibility S~~s~~tudy ~~evaluations~~ (and addenda) was~~ere~~ based on the contaminated plume as it was defined at the time of the evaluation. The current chromium plume (> 3.1 ppb Cr[VI]) as ~~of~~ mapped in the PG&E Q4 2012 Monitoring Report ~~Q4 2011~~ is approximately 3,122 ~~2,949~~ acres. The plume area shown in the Q4 2012 Monitoring Report does not include an additional area of approximately 1,245 acres north of Mount General Road that includes an area in the Harper Lake Valley basin with domestic well detections greater than 3.1 ppb in the Q3 2012 Monitoring Report. PG&E has questioned whether the chromium background level in the Harper Lake Valley (defined as north and west of Red Hill including the areas around the lake, see Figure 2-2a), may be different than in the Hinkley groundwater basin. However, for the purposes of this EIR, the area north of Mount General is considered part of the project area. When including this northernmost area, the total plume area would be approximately 4,367 acres.

In either case (3,122 acres or 4,367 acres), the plume as defined by late 2012 ~~, which~~ is much larger than the plume that was studied in the F~~f~~easibility S~~s~~tudy as described below:

- **Alternative 4B.** Feasibility Study Addendum 2 used the Q1 2010 plume as its base condition for study for Alternative 4B. The Q1 2010 plume (defined by the 3.1 ppb Cr[VI] contour) was approximately 1,225 acres in size.
- **Alternative 4C-1 to Alternative 4C-5.** As noted above, Feasibility Study Addendum 3 studied both the Q1 2010 plume and the Q1 2011 plume. Addendum 3 (and subsequent data provided by PG&E) ~~presented an~~ identified~~cation of~~ infrastructure needed to address the Q1 2011 plume. The Q1 2011 plume (defined by the 3.1 ppb Cr[VI] contour) was approximately 1,788 acres in size.

The full extent of the plume area cannot be defined at this time because the plume boundary may be larger than the Q4 2012~~2011~~ delineated boundary as a result of further investigation and/or plume migration. Therefore, for this EIR, it has been assumed that the contaminated plume subject to remedial activities may be larger by up to 15% from the Q4 2011 plume, which would result in a total "study plume" area of 3,391 acres. This hypothetical "study plume" area is approximately 190% larger than the Q1 2011 plume and 277% larger than the Q1 2010 plume. This "study plume" is for the purposes of estimating remedial activity only; the actual plume area will be defined by the Water Board based on quarterly monitoring and background levels.

To provide an estimate of the potential expanded amount of remedial activity that may be necessary to address a future plume that is substantially larger than that used as the base condition for identification of remedial activities proposed in the F~~f~~easibility S~~s~~tudy (and addenda), the F~~f~~easibility S~~s~~tudy estimates of remedial activity were scaled as follows:

- **No Project Alternative.** The No Project Alternative was not scaled up as it is presumed that remedial activity will be limited to the area of the plume as identified between 2008 and 2010.

- **Agricultural Land Treatment.** Agricultural unit acreages, piping, wells, and extraction flows were scaled up by increasing the F~~f~~easibility S~~s~~tudy amounts to include additional agricultural unit acreage, infrastructure, and flows to treat the revised plume area.[9]

- **In-Situ Remediation.** In-situ remediation is primarily proposed to address the high concentration part of the plume (> 50 ppb) and some of the medium concentration part of the plume (> 10 ppb). The 50 ppb plume boundary has been mostly stable in recent years due to remedial actions. The 10 ppb plume boundary has expanded but not to the same degree as the 3.1 ppb plume boundary. As a result, scaling for in-situ remediation wells, piping, and flows utilized a 25% factor instead of scaling based on overall plume size.

- **Ex-Situ Remediation.** Ex-situ remediation is proposed in Alternative 4C-3 to maintain year-round pumping rates and winter hydraulic control and treatment, and thus ex-situ remediation activity for Alternative 4C-3 was scaled up based on PG&E estimated of additional activity needed to address additional agricultural units~~using the same methods as for agricultural land treatment.~~ Ex-situ treatment is also proposed in Alternative 4C-5 for treatment of the high concentration plume (>50 ppb) area. Since the high concentration plume area has been more or less stable due to current remedial actions, no scaling was applied for ex-situ treatment in Alternative 4C-5, but a scaling factor of 25% was included for the purposes of EIR analysis in the event that higher pumping/treatment rates may be needed to support remedial goals.

- **Freshwater Injection.** To date, freshwater injection on the northwest side of the plume has been mostly effective at controlling further westward migration of the plume and deflecting its movement northward.[10] Thus, it was assumed that a similar amount of freshwater injection would be used in all alternatives in the future. A scaling factor of 15% was used in order to cover potential expansion, should it be needed, to the existing amounts for EIR analysis.

- **Monitoring Wells.** As the plume has expanded, the number of monitoring wells has also expanded. PG&E originally included an additional 12 monitoring wells above existing wells. In order to cover potential monitoring wells needed~~s~~ to address an expanding plume, a scaling factor of 25% was added to the existing and projected number of monitoring wells for the EIR analysis.

In the alternative descriptions below, reference to agricultural acreages, wells, piping lengths, and flows are to the scaled totals, not the ~~original~~ 2010 F~~f~~easibility S~~s~~tudy totals. Tables that summarize the 2010~~original~~ F~~f~~easibility S~~s~~tudy totals for each alternative and show the specific scaling adjustments ~~to~~ accounting for the expanded plume are presented in Appendix B.

2.9 Project Alternatives

Based on the review of the F~~f~~easibility S~~s~~tudy (and addenda), input from EPA and DTSC, public comment and review of remediation experiences of prior pilot tests and remediation activities at the site to date, the Water Board selected the most promising five project alternatives to analyze in this

[9] The agricultural unit scaling was not done by a single increase factor. ICF, through the Water Board, worked with PG&E to identify potential additional AU acreages. Depending on the alternative, the amount of AUs included in the scaled up estimates are 55% to 100% larger than that included in the feasibility study and addendum.

[10] As noted above, 4th Quarter 2012 monitoring detected a “finger” of area with chromium detections slightly above maximum background levels that is westward of two of the injection wells, which may indicate some permeability in the hydraulic barrier. This is presently being investigated.

EIR, in addition to the CEQA required analysis of the No Project Alternative. Table 2-2 identifies the key features of the analyzed alternatives. Each alternative is further described below.

The description of remedial actions under each alternative is identified by phases, including the year that an action would be initiated and the period of time it would be implemented until cleanup is achieved. For all alternatives, the overall phases are:

- *Initial Buildout (0–5 years)*
- *Years 5 to 10*
- *Years 10 to 20*
- *Beyond Year 20*

2.9.1 No Project Alternative

Under the No Project Alternative, no additional or expanded remedial actions would be implemented. ~~the Water Board would not adopt a new CAO (and associated site-wide WDRs) and the p~~Prior authorizations would continue to be used for cleanup activities and the Water Board would not adopt a new CAO (and associated site-wide WDRs). The current remediation activities that would continue to be implemented under the No Project Alternative are described below. Table 2-3 summarizes the remedial actions for the No Project Alternative, and Figure 2-3 shows the locations of where remediation activities would be implemented.

- **Plume Containment.** Plume containment would continue via freshwater reinjection and northern land treatment. Freshwater would be pumped from the three existing PG&E supply wells located south of the Compressor Station and piped to the five reinjection wells located northwest of the plume at the currently authorized volumes and rates (80 gpm). Land treatment via the Desert View Dairy and four agricultural units (described below) would continue as under existing conditions.
- **Land Treatment at the Desert View Dairy and Four Adjacent Parcels.** Extraction of low concentration Cr[VI] groundwater and land application at the Desert View Dairy and the four agricultural units (on the Gorman [north and south], Cottrell, and Ranch properties) within OU1/OU2 would continue at the current volumes and rates (1,100 gpm).
- **In-Situ Treatment.** In-situ treatment within the Source, Central, and South Central IRZ areas using injection of reductants into the contaminated aquifer to convert dissolved Cr[VI] to solid Cr[III] would continue. In-situ operations would continue via pumping groundwater from extraction wells, mixing groundwater and reagents in mixing tanks, and injection of the mixture into injection wells. Biological (i.e., carbon-amended) and chemical reductants are injected by manual or semi-automated recirculation systems, or manually using ~~temporary well points on~~ direct injection methods. There are currently two IRZ compounds that include equipment, tanks, utilities, and wells, with footprint of no more than 100 by 200 feet in area and 20 feet in height surrounded by fences up to 12 feet high. Additionally, there are almost 30 smaller above-ground compounds (with approximately 20 by 20 feet footprint) for extraction wells, and 5 similar small compounds for injection wells dealing with the western bulge. All compounds have approximately 12-foot high fences with brown-colored slats. Also included are conveyance pipelines for in-situ treatment.

Table 2-2. PG&E Hinkley Groundwater Remediation Alternatives Analyzed in the EIR

Alternatives	No Project[a]	4B	4C-2	4C-3	4C-4	4C-5
Source of Information	FS Addendum 3	FS Addendum 2	FS Addendum 3	FS Addendum 3	FS Addendum 3	FS Addendum 4
Plume FS analysis based on	Q1/2011	Q1/2010	Q1/2011	Q1/2011	Q1/2011	Q1/2011
OU1–Remedial Method for High Concentration Plume	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ	Above-ground/ In-situ
Time to 50 ppb	6[b]	6	6	4	3	20
Time to 80% Cr[VI] Mass Conversion to Cr[III] or Removal	13[b]	10	7	6	6	15
OU 1/2/3–Remedial method for low concentration plume	IRZ/ AUs[c]	IRZ for 20 years AUs for 95 years	IRZ for 20 years AUs for 90 years	IRZ for 20 years AUs for 85 years	IRZ for 20 years AUs for 75 years	IRZ for 32 years AUs for 95 years
Time to 3.1 ppb cleanup	NA[c]	40	39	36	29	50
Time to 1.2 ppb cleanup	NA[c]	95	90	85	75	95
Fate of Cr3+ in the soil	Leaves	Leaves	Leaves	Leaves	Leaves	Removes from high concentration area
AU Pumping Rates[c]	1,100 gpm (FS)	1,270 gpm (FS) 2,395 gpm (total)	2,042 gpm (FS) 3,167 gpm (total)	2,829 gpm (FS) 4,388 gpm (total)	2,829 gpm (FS) 4,388 gpm (total)	2,042 gpm (FS) 3,167 gpm (total)
AUs[d, e]	182 acres	222 acres (FS)/ 446 acres (total)	351 acres (FS)/ 575 acres (total)	351 acres (FS)/ 575 acres (total)	895 acres (FS)/ 1,394 acres (total)	351 acres (FS)/ 575 acres (total)
FS Estimated Costs (NPV)[f]	N/A	$84.9M	$118M	$276M	$173M	$171M
Key Feature	Required by CEQA	Less groundwater pumping, AU acreage and lower cost.	Year round pumping for plume control (winter Crop).	Year round pumping for plume control (winter above-ground treatment).	Year round pumping for plume control. Fastest cleanup of all alternative.	Removal of chromium from the high concentration plume area.

Notes:

[a] No Project Alternative defined based on the No Project details provided for Alternative 4C-2 in FS Addendum No. 3.

[b] Based on FS Alternative No. 4 cleanup times because FS Addendum No. 3 did not identify cleanup times for No Project conditions.

[c] No Project Alternative limited to addressing the 2008–2010 plume. Thus, no duration for cleanup of entire plume is identified.

[d] Two pumping rates shown for action alternatives. First is highest pumping rate in the FS/Addenda marked with a (FS). Second is scaled up to account for expanded plume beyond that at the time of the FS/Addenda.

[e] Two acreages shown for agricultural units for action alternatives. First is from the FS/Addenda marked with a (FS). Second is scaled up to account for expanded plume beyond that at the time of the FS/Addenda.

[f] Costs are based on FS/Addenda costs to remediate to 1.2 ppb Cr[VI] level and only include the infrastructure described in the FS/Addenda and do not account for the additional cost for the infrastructure and activities to address the expanded plume.

AU = Agricultural Units
FS = Feasibility Study
gpm = gallons per minute
IRZ = In-Situ Remediation
NPV = Net present value
ppb = parts per billion

Table 2-3. Summary of Components under No Project Alternative[a]

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)	182 acres[b]			
AU Extraction Wells	29			
Pipelines	24,499 lf			
AU Extraction Flow[c]	1,100 gpm			
In-Situ Remediation Zone (IRZ)				
Extraction Wells	17	17	20	20
Injection Wells	86	86	89	89
Pipelines	31,392 lf	31,992 lf	33,892 lf	33,892 lf
Carbon amended IRZ flow (SCRIA, SAIRZ)[c, d]	190 gpm (110 gpm – SCRIA; 80 gpm – SAIRZ)			
IRZ Recirculation flow (CAIRZ)[c, d]	83 gpm			
Northwest Area Freshwater Injection				
Extraction Wells	3~~5~~			
Injection Wells	5~~3~~			
Pipelines	31,886 lf			
Northwest Freshwater Reinjection Flow[c]	80 gpm			
Monitoring Wells				
Monitoring Wells	446			
Wells and Supporting infrastructure acreage[e]	39	39	39	39
Access roads	1	1	1	1

Notes:

[a] All totals include existing infrastructure (see Table 2-1)

[b] Agricultural Units = DVD, Gorman, Cottrell, and Ranch (all existing).

[c] All flows are based on average annual rates.

[d] SCRIA refers to the South Central Reinjection Area.
SAIRZ refers to the Source Area In-Situ Remediation Zone.
CAIRZ refers to the Central Area In-Situ Remediation Zone.

[e] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs. For injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

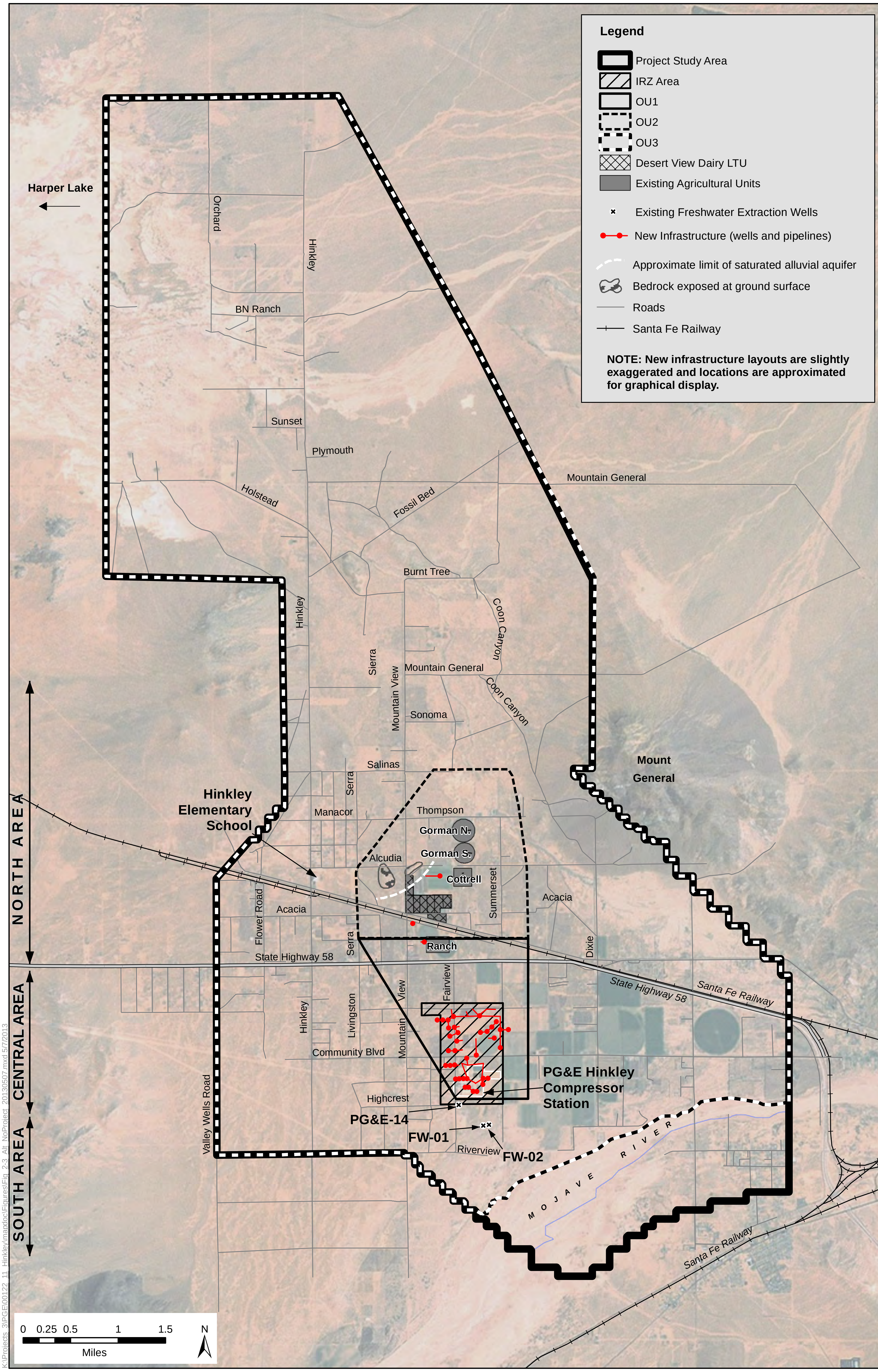

Figure 2-3
No Project Alternative Conceptual Layout (Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

Authorized chemical reductants used for in-situ treatment and groundwater injection for above-ground treatment include calcium polysulfide, ferrous chloride, ferrous sulfate, sodium dithionite, and zero-valent iron. Biological reductants include emulsified vegetable oil, ethanol, lactate, whey, molasses, corn syrup, acetate, glucose, and methanol. Only some of these biological reductants have been used to date. Authorized operation and maintenance (O&M) activities include discharges of tracer compounds, well-rehabilitation compounds, process chemicals, and nutrients into groundwater. Tracers are injected into groundwater to characterize flow conditions within the treatment areas. Tracers may include bromide, fluorescein, eosine, and additional fluorescent tracers. Well rehabilitation compounds are used to remove microbial or geochemical fouling that may have developed in the well. Well rehabilitation compounds authorized for use are acetic acid, citric acid, hydrochloric acid, hydrogen peroxide, and sodium hydroxide. Additionally, the Water Board has approved the use of several commercial well rehabilitation compounds that are certified under the California Waterworks Standards for commonly used rehabilitation of drinking water wells (Liquid Acid Descaler, Aqua-Clear AE, Aqua-Clear MGA, BETZMPH500, NuWell 120 Liquid Acid, NuWell 310 Bioacid Dispersant, and NuWell 400 Non-Ionic Surfactant). Process chemicals authorized for remediation activities include aluminum sulfate, anti-sealants, calcium hydroxide, calcium oxide, hydrochloric acid, phosphoric acid, polymeric flocculants, sodium hydroxide, and sulfuric acid. Potential discharges of nutrients during operation include ammonium, nitrate, phosphate, vitamins, and yeast extract. Existing WDRs require that all chemicals listed above do not migrate with groundwater to areas outside the IRZ.

- **Monitoring Activities.** Monitoring wells and sampling of chromium and by-product concentrations would continue to occur as under existing conditions; these activities would not be limited to a specific OU area and could be implemented throughout the project area.

The phased implementation of the remedial actions under the No Project Alternative would occur as follows:

- **Initial Buildout:** Install new extraction wells in the OU1 IRZ areas and adjacent to the Cottrell pivot[11] and the Desert View Dairy land treatment unit in OU2. Install new injection wells in the OU1 IRZ areas. Construct associated additional pipeline connections. Additional monitoring wells would be installed throughout the project area. Continue land treatment and IRZ treatment, including IRZ by-product management.
- **Year 5 to 10:** Construct an additional 600 linear feet (lf) of trenching for pipelines to accommodate agricultural unit well operations. All other operations would continue as in the previous phase.
- **Year 10 to 20:** Install three new extraction wells (in OU2 for pumping to IRZ area) and three new injection wells (in Source Area IRZ and South Central Area IRZ) for IRZ treatment of highest remaining Cr[VI]. All other operations would continue as in the previous phases.

All extraction and injection flow rates would be maintained throughout each phase as currently being operated under existing conditions.

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[11] Center "pivot" irrigation is a form of irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) joined together and supported by trusses, mounted on wheeled towers with sprinklers or drip lines positioned along its length. The system moves in a circular pattern and is fed with water from the pivot point at the center of the arc. Drip lines would be used to eliminate the potential for airborne mists containing Cr[VI].

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows[12]:

- *Estimated time to 50 ppb: 6 years*
- *Estimated time to achieve conversion of 80% of Cr[VI] mass to Cr[III] in high concentration area: 10 to 13 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/3.2 ppb Cr[T]: 75 to 150 years (but only for the Q1 2010 plume)*
- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 130 to 220 years (but only for the Q1 2010 plume)*

As described above, the No Project Alternative does not include remedial actions to address the expanded plume and thus would not actively remediate all of the existing (or potential future expanded) plume. As a result, the time to remediate chromium contamination within the entire plume would be closer to 1,000 years for areas outside the Q1 2010 plume (similar to F~~f~~easibility S~~s~~tudy Alternative 1). The No Project Alternative also does not include a contingency plan in the event that agricultural units cannot be operated due to crop disease, extended storms, or other events.

2.9.2 Alternative 4B

2.9.2.1 Overview

Alternative 4B expands the area, intensity, and duration of remediation activities over existing authorized and operating activities proposed under the No Project Alternative. The proposed treatment approach under this alternative would be similar to the general approach that PG&E is currently operating in the project area but on a greater scale.

Treatment methods for this alternative include in-situ treatment by extraction, carbon amendment of groundwater and reinjection in the IRZ areas in OU1 (as described in the description of the No Project Alternative), agricultural application within and adjacent to the northern diffuse portion of the plume in OU2, and freshwater injection in the northwest area of the plume adjacent to the western boundaries of OU1 and OU2. There would be more in-situ carbon injection/extraction wells and thus more above-ground IRZ well compounds (approximately 20 by 20 feet footprint) compared to the No Project Alternative. This alternative also includes expansion of agricultural land treatment and groundwater pumping as necessary to address the revised plume area, including into OU3. For example, this alternative could include up to 446 acres of agricultural units and up to 2,395 gpm of extraction for land treatment (compared to 182 acres of agricultural units and 1,100 gpm of extraction pumping for land treatment with the No Project Alternative).

Implementation of this alternative is likely to require the acquisition of properties and/or easements within the project area for installation and maintenance of supporting infrastructure for implementing remediation activities. This alternative also would require acquisition of water rights because it includes agricultural water use that would exceed PG&E's current water allocation.

[12] Timeframes for the No Project Alternative were estimated as between that of the original Alternative 4 and Alternative 4A because the No Project Alternative is similar to those alternatives.

Table 2-4 summarizes the main components of Alternative 4B, and Figure 2-4 shows the proposed remediation activities that would be implemented. The phased implementation of the remedial actions under Alternative 4B would occur as follows[13]:

- **Initial Buildout:** Agricultural units and associated wells and pipelines would be installed in OU2 for expanded land treatment (and in OU3 as necessary); flow rates would be increased over existing conditions for plume containment, land application, and IRZ treatment. IRZ treatment would be continuously operated. Additional monitoring wells also would be installed within the project area.
- **Year 5:** Several South Central Area injection wells in the IRZ areas would be turned off and northern area extraction flows would be redirected to the remaining South Central Area and Source Area injection wells for shared dosed injection; there would be a reduction in the South Central Area/Source Area flow rate. Southern Source Area extraction wells would be turned off and converted to injection wells; all other operations would continue as in the previous phases.
- **Year 10:** New extraction wells and pipelines for agricultural unit treatment would be installed in the northwest and northern areas in OU2 (and in other areas as necessary); IRZ flow rates in the Source Area and South Central Area would be increased. All other operations would continue as in previous phases.
- **Year 20:** IRZ flow rates in the Source Area/South Central Area would be reduced and eastern South Central Area wells would be turned off. The Central Area flows would be shutdown. IRZ treatment in South Central Area would be modified from continuous operation to long-term intermittent carbon amended treatment of low concentration areas in select South Central Area/Source Area injection wells that may need to operate beyond 20 years. Carbon dosage in the Source Area would be reduced. All other operations would continue as in previous phases.

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows:

- *Estimated time to 50 ppb: 6 years*
- *Estimated time to achieve conversion of 80% of Cr[VI] mass to Cr[III] in high concentration area: 10 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/3.2 ppb Cr[T]: 40 years*
- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 95 years*

Overall, in comparison to the other project alternatives, Alternative 4B would:

- Have a smaller land treatment operation than Alternatives 4C-2, 4C-3, 4C-4, and 4C-5;
- Have no winter agricultural operations/extraction;
- Have similar cleanup timeframes as other project alternatives;
- Have the same freshwater injection operations to maintain hydraulic control of the plume as all project alternatives; and
- Cost less than all other project alternatives.

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[13] Buildout phases for each alternative are provided to give the reader an idea how the construction and operation of the alternative might proceed, and are not intended to be a specific timeframe for implementation of any of the remedial technologies.

2.9.2.2 Implementation Details

Plume Containment and Land Treatment

Under Alternative 4B, a new agricultural unit would be installed in the OU2 area referred to as the Yang pivot and additional agricultural units would be installed as necessary to address the expanded plume. The Yang pivot is located adjacent to the eastern area of the Desert View Dairy land treatment unit. The specific location of additional agricultural units have not yet been identified but are likely to be in the northern or eastern portions of OU2 or in OU3 based on the current configuration of the chromium plume. Agricultural application would involve extraction of water from extraction wells constructed to support land treatment. The water would be piped to existing or new agricultural units for application by flood or drip irrigation (drag-drip or subsurface). Operation of the Desert View Dairy land treatment unit would continue as it does under existing conditions. Land treatment would operate at a much lower rate ~~be seasonal and would not occur~~ during winter months. Containment of the chromium plume would also be achieved as currently operated through freshwater extraction from freshwater wells in the southern IRZ area and injection to wells located at the northwestern boundary of the plume adjacent to OU1 and OU2. Freshwater extraction and injection is estimated to be up to approximately 92 gpm (including 15% contingency over current levels).

In-Situ Treatment

IRZ treatment would occur throughout OU1. The injections within OU1 would target the highest Cr[VI] concentrations within the plume. Groundwater recirculation in the area of the Central Area IRZ and Source Area IRZ and injection in the South Central Area IRZ would provide additional treatment to the Source Area in OU1.

In-situ treatment would include:

- Continuous South Central Area IRZ/Source Area IRZ operations up to 431 gpm during initial buildout.
- Continuous Source Area IRZ operations up to 188 gpm during initial buildout.
- Continuous Central Area IRZ recirculation operation for 20 years at up to 175~~279~~ gpm.
- During the second phase (5–10 years), select South Central Area wells would be turned off with flows redistributed to both South Central Area and Source Area injection wells for shared flow for dosed-injection (operated at up to 244 gpm between year 5 and 10 and then up to 319 gpm for years 10 through 20).
- After 20 years, eastern South Central Area wells would be turned off and continuous, intermittent low-dosage carbon amendment would be applied to select South Central Area/Source Area injection wells after 20 years (up to 213 gpm) with reduction in dosage from 125 mg/L to 25 mg/L. Central Area IRZ flows would be turned off.

Monitoring Activities

Monitoring activities would be the same as those being implemented for existing operations throughout the project area (described under Section 2.4 above).

Table 2-4. Summary of Components under Alternative 4B[a]

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)[b]	446 acres			
AU Extraction Wells	65	65	90	90
AU Pipeline	59,049 lf	59,049 lf	78,419 lf	78,419 lf
AU Extraction Flow[c]	2,395 gpm			
In-Situ Remediation Zone (IRZ)				
Extraction Wells	21	21	~~21~~25	25
Injection Wells	108	108	111	111
Pipelines	39,240 lf	39,990 lf	42,365 lf	42,365 lf
Carbon-amended IRZ flow (SCRIA/SAIRZ)[c, d]	431 gpm	244 gpm	319 gpm	213 gpm
IRZ Recirculation flow (CAIRZ)[c, d]	~~279~~ 175 gpm	175 gpm	175 gpm	175 gpm
Northwest Area Freshwater Injection				
Extraction Wells	~~5~~3			
Injection Wells	~~4~~6			
Pipelines	36,669 lf			
Northwest Freshwater Reinjection Flow[c]	92 gpm			
Monitoring Wells/Supporting Infrastructure				
Monitoring Wells	558			
Wells and Supporting Infrastructure (acres)[e]	51	51	53	53
Access roads (acres)	3	3	5	5

Notes:

[a] All totals include existing infrastructure. Well estimates include the number of wells to be constructed; not all may be operating at the same time. All estimates have been scaled up from the data from the Feasibility Study and Addenda to account for a larger plume than used in the feasibility study. See discussion in text.

[b] Desert View Dairy, Gorman, Cottrell, Ranch, plus additional Agricultural Units.

[c] All flows are based on average annual rates.

[d] SCRIA refers to the South Central Reinjection Area; SAIRZ refers to the Source Area In-Situ Remediation Zone; CAIRZ refers to the Central Area In-Situ Remediation Zone.

[e] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs. For injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

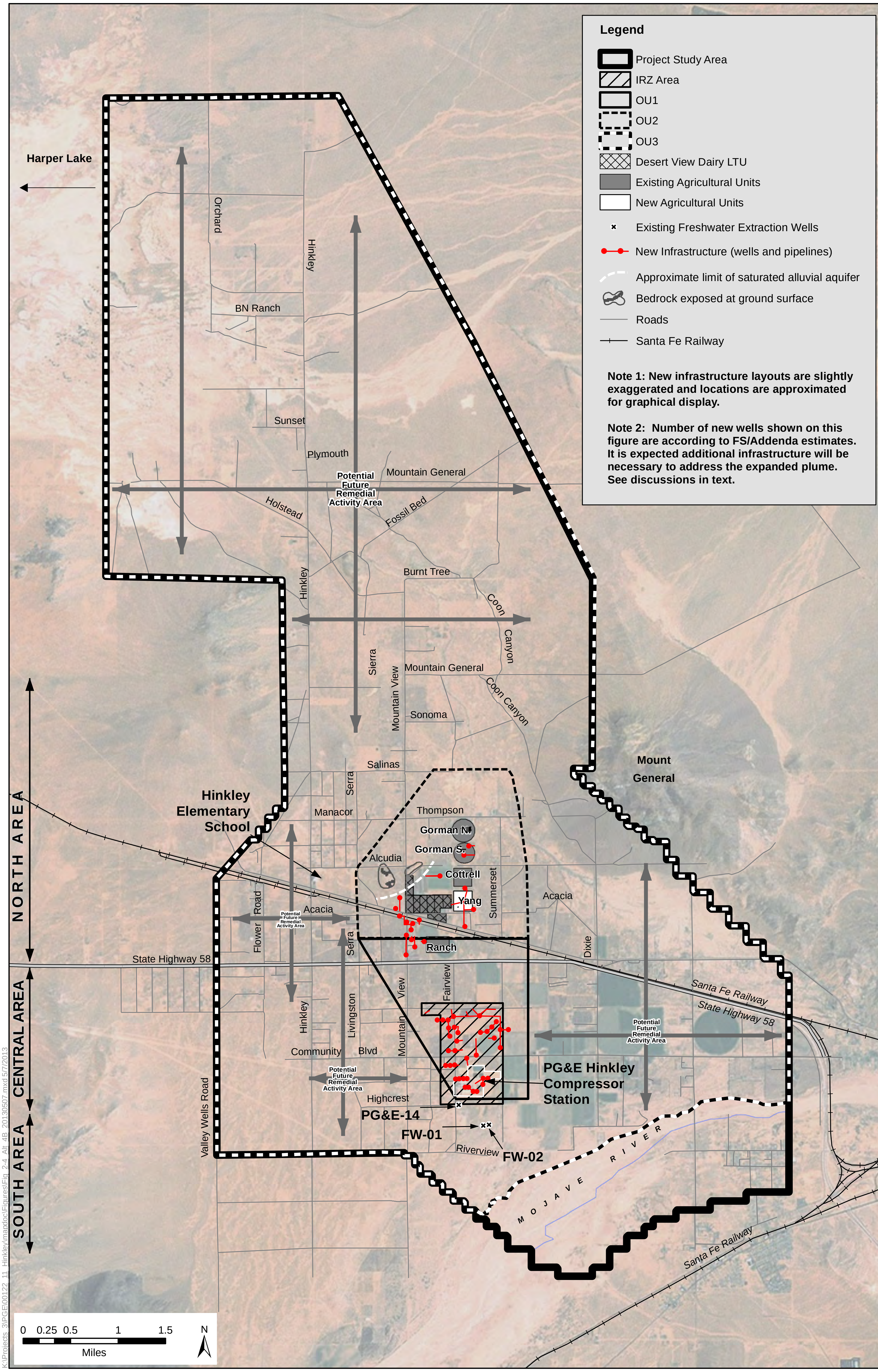

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Figure 2-4
Alternative 4B Conceptual Layout
(Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

Contingency Plan for Agricultural Unit Operations

Alternative 4B includes a contingency plan in the event that agricultural/land treatment cannot be implemented due to severe and extended storm activity that would preclude infiltration, crop disease, or other unforeseen events that would preclude agricultural unit operations for any substantial duration of time.[14] Based on a review of storm records and including a 200 percent contingency, the potential duration of a significant storm event would be 18 days. This gap in agricultural unit extraction pumping is not expected to result in any meaningful plume movement or loss of capture ~~and even a 90-day gap is not expected to result in full reversal of hydraulic gradients~~ (Pacific Gas and Electric 2011c). T~~hus, t~~he likelihood of having to implement the contingency plan due to inclement weather is low. However, there may be other unforeseen events that could result in a prolonged impairment of agricultural unit operations that impairs plume control and treatment; in such a case the contingency plan would be put into effect.

The contingency plan is described in the September 2011 Feasibility Study Addendum 3 and includes the following phases:

- Routine Agricultural Unit Operations – Flow rates included in this alternative would be maintained by adjusting the number of agricultural units being operated.
- Tier I Contingency Agricultural Unit Operation – In the event of severe weather or other impediments to temporary agricultural unit operations, agricultural unit flow rates can be temporarily reduced for a short period of time without hampering plume hydraulic control. However, if the impairment is lengthy~~ier~~, then PG&E would bring additional agricultural units on line by constructing additional agricultural units or restarting idle agricultural units. Flow rates would be reduced to up to 90 days (as necessary) while additional agricultural units were brought on line.
- Tier II Contingency Alternative Operations – If additional agricultural units are not feasible, then alternative control and treatment methods will need to be employed. The contingency plan identifies potential use of infiltration galleries and/or ex-situ treatment[15]. 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, infiltration galleries are not separately analyzed in this EIR. The impacts of ex-situ treatment are as described below for the ex-situ elements included in Alternatives 4C-3 and 4C-5.

2.9.3 Alternative 4C-2

2.9.3.1 Overview

Alternative 4C-2 uses much of the same general infrastructure and optimization as that proposed under Alternative 4B in relation to plume containment and IRZ treatment. Alternative 4C-2 differs from Alternative 4B by including more intensive groundwater extraction for land treatment with the addition of winter crops (winter rye or a similar crop) at select agricultural units. This expansion is

[14] Alternatives 4C-2, 4C-3, and 4C-4 also include contingency measures as described below.

[15] An infiltration gallery is an underground structure with perforated pipes where extracted groundwater is treated and recharged to the vadose zone and water table. Water treatment is accomplished through the addition of amendments to reduce Cr[VI] to Cr[III] similar to the IRZ process.

proposed to increase winter pumping rates for achievinge~~e~~ and maintaining year-round extraction/hydraulic control of the plume movement to foster faster cleanup periods compared to Alternative 4B.

This alternative also includes expansion of agricultural land treatment and groundwater pumping as necessary to address the revised plume area, including into OU3; for example this alternative could include up to 575 acres of agricultural units and up to 3,167 gpm of extraction for land treatment (compared to 182 acres of agricultural units and 1,100 gpm of extraction pumping for land treatment with the No Project Alternative).

Implementation of this alternative is likely to require the acquisition of properties and/or easements within the project area for installation and maintenance of supporting infrastructure to implement remediation activities. This alternative also would require acquisition of water rights because it includes agricultural water use that would exceed PG&E's current water allocation.

Table 2-5 summarizes the main components of Alternative 4C-2, and Figure 2-5 shows the proposed remediation activities that would be implemented. The phased implementation of the remedial actions under Alternative 4C-2 would occur as follows:

- **Initial Buildout:** Agricultural unit pivots and associated extraction wells and pipelines would be constructed in OU1 and OU2 areas; all flow rates for containment, land application, and IRZ treatment would increase from existing conditions. Additional pivots necessary to address plume expansion would be located in OU2 and OU3. IRZ treatment would be continuous. Additional monitoring wells also would be installed within the project area.
- **Year 5:** Several South Central Area injection wells in the IRZ areas would be turned off and northern area extraction flows would be redirected to remaining South Central Area and Source Area injection wells for shared dosed injection; there would be a reduction in the South Central Area/Source Area flow rate. Southern Source Area extraction wells would be turned off and converted to injection wells; all other operations would continue as in the previous phases.
- **Year 10:** Additional extraction wells and pipelines would be constructed in the northwest and northern areas in OU2 to expand agricultural unit treatment; IRZ flow rates in the Source Area and South Central Area would be increased. All other operations would continue as in previous phases.
- **Year 20:** Several agricultural pivots may be turned off (depending on remedial progress at the time) and flows from northern agricultural unit extraction wells installed in Year 10 could be shifted to IRZ treatment; Central Area IRZ recirculation flows would ~~be turned off~~continue. Eastern South Central Area wells would be turned off; IRZ treatment in South Central Area would be modified from continuous operation to long-term intermittent carbon amended treatment of low concentration areas in select South Central Area/Source Area injection wells beyond 20 years. Carbon dosage in the Source Area would be reduced.

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows:

- *Estimated time to 50 ppb: 6 years*
- *Estimated time to achieve conversion of 80% of Cr[VI] mass to Cr[III] in high concentration area: 7 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/ 3.2 ppb Cr[T]: 39 years*

Table 2-5. Summary of Components under Alternative 4C-2[a]

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)[b]	575 acres			
AU Extraction Wells	80	80	102	102
AU Pipeline	68,489 lf	68,489 lf	83,374 lf	83,374 lf
AU Extraction Flow[c]	3,167 gpm			
In-Situ Remediation Zone (IRZ)				
Extraction Wells	21	21	25	25
Injection Wells	108	108	111	111
Pipelines	39,240 lf	39,990 lf	42,365 lf	42,365 lf
Carbon-amended IRZ flow (SCRIA/SAIRZ)[c, d]	431 gpm	244 gpm	319 gpm	213 gpm
IRZ Recirculation flow (CAIRZ)[c, d]	175~~279~~ gpm	175 gpm	175 gpm	0 gpm
Northwest Area Freshwater Injection				
Extraction Wells	3~~5~~			
Injection Wells	6~~4~~			
Pipelines	36,669 lf			
Northwest Freshwater Reinjection Flow[c]	92 gpm			
Monitoring Wells/Supporting Infrastructure				
Monitoring Wells	558			
Wells and Supporting Infrastructure Acreage[e]	52	52	54	54
Access roads (acres)	4	4	5	5

Notes:

[a] All totals include existing infrastructure. Well estimates include the number of wells to be constructed; not all may be operating at the same time. All estimates have been scaled up from the data from the Feasibility Study and Addenda to account for a larger plume than used in the feasibility study. See discussion in text.

[b] Desert View Dairy, Gorman, Cottrell, Ranch, plus additional Agricultural Units.

[c] All flows are based on average annual rates.

[d] SCRIA refers to the South Central Reinjection Area.
SAIRZ refers to the Source Area In-Situ Remediation Zone.
CAIRZ refers to the Central Area In-Situ Remediation Zone.

[e] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs. For injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

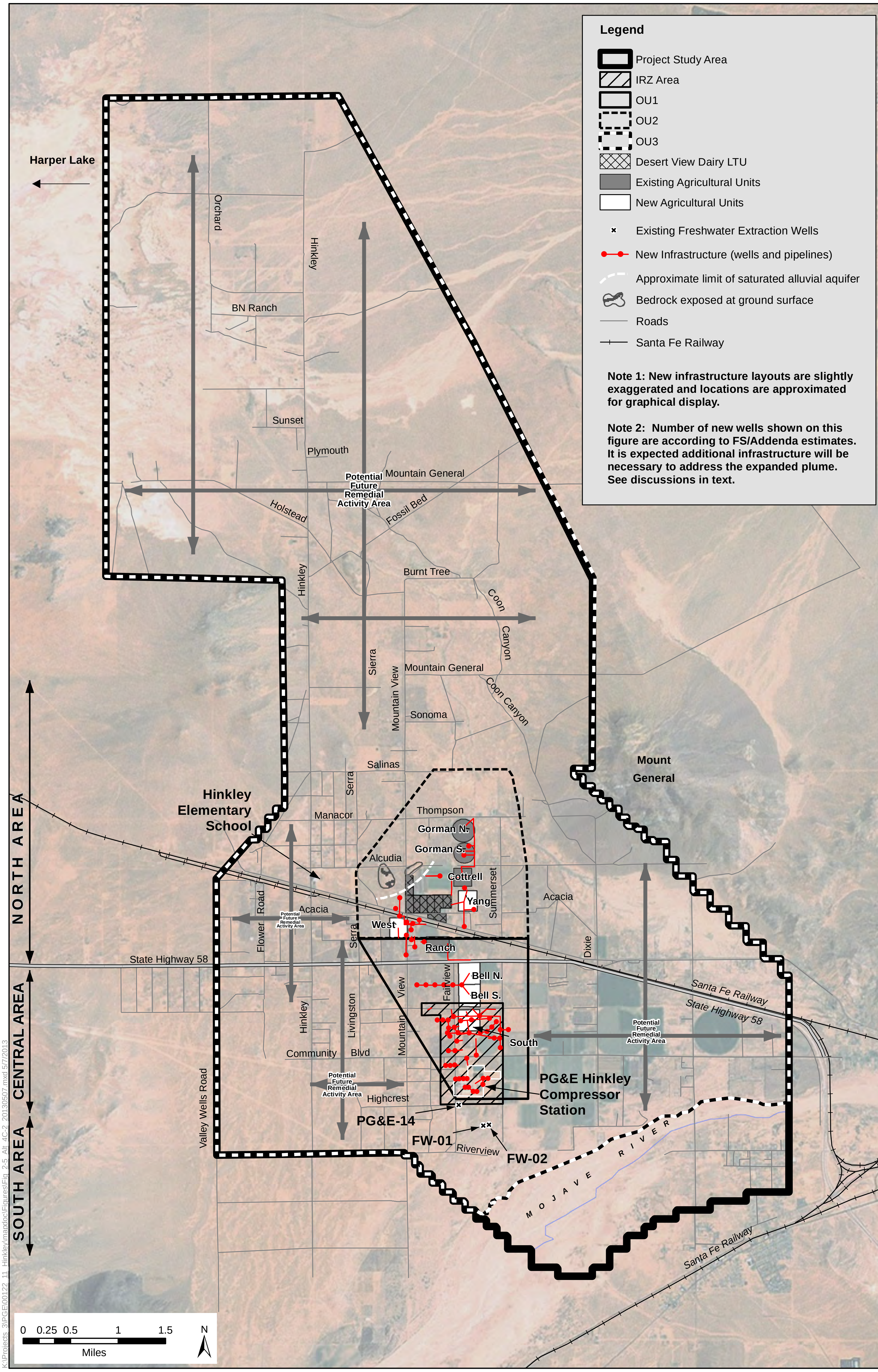

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Figure 2-5
Alternative 4C-2 Conceptual Layout (Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 90 years*

Overall, in comparison to the other project alternatives, Alternative 4C-2 would:

- Have a more extensive land treatment approach (including winter operations) than the No Project Alternative and Alternative 4B;
- Have the same freshwater injection operations to maintain hydraulic control as all project alternatives; and
- Have a shorter period for achieving cleanup to average and maximum Cr[T] and Cr[VI] interim cleanup levels over the No Project Alternative and Alternative 4B only.

2.9.3.2 Implementation Details

Plume Containment and Land Treatment

This alternative supports more agricultural treatment than Alternative 4B to accommodate additional agricultural extraction. The additional agricultural units would include:

- One pivot located just south of the Desert View Dairy land treatment unit;
- One pivot located east of the Desert View Dairy;
- Two pivots located in the central area of the plume on or near the former Bell property;
- One pivot located in the southern portion of the South Central Area, southeast of the Bell pivots and north of the Source Area within OU1; and
- Additional pivots necessary to address the expanded plume area to the east and the north (in future locations as yet undetermined).

Under Alternative 4C-2 the maximum flow rates for extraction of groundwater from northern low-concentration areas would be increased and used for year-round continuous operation of agricultural treatment on select agricultural units to support winter crops. Agricultural unit flows may be decreased at Year 20 depending on the treatment achievements at that time. Freshwater injection would remain the same, with estimated flows of up to 92 gpm (15% contingency over existing levels) for the duration of treatment. Other than these changes, all other activities would be similar to Alternative 4B.

In-Situ Treatment

In-situ treatment under Alternative 4C-2 would be the same as in-situ treatment described under Alternative 4B.

Monitoring Activities

Monitoring activities would be the same as those being implemented for existing operations throughout the project area (as described under Section 2.4 above).

Contingency Plan for Agricultural Unit Operations

Alternative 4C-2 would include a contingency plan as described for Alternative 4B above.

2.9.4 Alternative 4C-3

2.9.4.1 Overview

Alternative 4C-3 uses much of the same general infrastructure and optimization as that proposed under Alternatives 4B and 4C-2 in relation to plume containment, land treatment via agricultural treatment, and IRZ treatment. Alternative 4C-3 adds ex-situ treatment plants to provide year-round continuous pumping to treat excess winter water that cannot be treated by proposed agricultural units in winter. The proposed ex-situ technology is extraction, treatment through chemical reduction/precipitation, and reinjection of treated water into the groundwater. This technology was selected based on similar operations that have been implemented by PG&E at its Topock site where the technology has been effective in the cleanup of water contaminated by Cr[VI]. There would be up to a total of two above-ground treatment facilities that together would total approximately 81,060 square feet (approximately five times the size of the existing above-ground treatment plant at Topock). One treatment facility would be located generally near the Compressor Station adjacent to the southern boundary of the Source Area IRZ in OU1.~~, and one~~ The other treatment facility would be located generally near the Desert View Dairy adjacent to the northwestern boundary of OU2.

This alternative also includes additional agricultural land treatment and groundwater pumping as necessary to address the revised plume area including into OU3~~;~~. ~~f~~For example this alternative could include up to 575 acres of agricultural units and up to 4,388 gpm of extraction (annual average) for land treatment (compared to 182 acres of agricultural units and 1,100 gpm of extraction pumping for land treatment with the No Project Alternative).

Implementation of ~~this a~~Alternative 4C-3 is likely to require the acquisition of properties and/or easements within the project area for the installation and maintenance of infrastructure that supports the implementation of remediation activities. This alternative also would require acquisition of water rights because it includes agricultural water use that would exceed PG&E's current water allocation.

Table 2-6 summarizes the main components of Alternative 4C-3, and Figure 2-6 shows the proposed remediation activities that would be implemented. The phased implementation of the remedial actions under Alternative 4C-3 would occur as follows:

- **Initial Buildout:** New agricultural unit pivots and associated extraction wells and pipelines would be constructed in OU1 and OU2 areas; all flow rates for containment, land application and IRZ treatment would increase. Additional pivots necessary to address plume expansion would be located in OU2 and OU3. North and south ex-situ treatment plants, including supporting facilities, would be constructed; new ex-situ injection wells associated with each treatment plant would be installed, with additional conveyance piping and supporting infrastructure; operation of ex-situ treatment would be initiated. Additional monitoring wells would also be installed within the project area.
- **Year 5:** Several South Central Area injection wells in the IRZ areas would be turned off and northern area extraction flows would be redirected to remaining South Central Area and Source Area injection wells for shared dosed injection; there would be a reduction in the South Central Area/Source Area flow rate. Southern Source Area extraction wells would be turned off and converted to injection wells.

Table 2-6. Summary of Components under Alternative 4C-3

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)[a]	575 acres			
AU Extraction Wells	80	80	102	102~~103~~
AU Pipeline	72,751 lf	72,751 lf	83,374 lf	83,374 lf
AU Extraction Flow	4,388 gpm	4,388 gpm	4,388 gpm	3,606 gpm
In-Situ Remediation Zone (IRZ)				
Extraction Wells	~~22~~21	~~22~~21	25	25
Injection Wells	108	108	111	111
Pipelines	39,240 lf	39,990 lf	42,365 lf	42,365 lf
Carbon-amended IRZ flow (SCRIA/SAIRZ)[b, c]	431 gpm	244 gpm	319 gpm	213 gpm
IRZ Recirculation flow (CAIRZ)[b, c]	175~~279~~ gpm	175 gpm	175 gpm	0 gpm
Ex-Situ Treatment				
~~Extraction~~ Injection Wells	31			
Pipelines	41,816 lf			
~~Extraction~~ System Flow (~~annual~~annualized average)	1,222 gpm			
Northwest Area Freshwater Injection				
Extraction/Injection Wells	~~5/4~~3/6			
Pipelines	36,669 lf			
Northwest Freshwater Reinjection Flow[b]	92 gpm			
Monitoring Wells/Supporting Infrastructure				
Monitoring Wells	558			
Wells and Supporting Infrastructure acreage[d]	54	54	56	56
Access roads (acres)	7	9	12	15

Notes: All totals include existing infrastructure. Well estimates include the number of wells to be constructed; not all may be operating at the same time. All estimates have been scaled up from the data from the Feasibility Study and Addenda to account for a larger plume than used in the feasibility study. See discussion in text.

[a] Desert View Dairy, Gorman, Cottrell, Ranch, plus additional Agricultural Units.

[b] All flows are based on average annual rates.

[c] SCRIA refers to the South Central Reinjection Area.
SAIRZ refers to the Source Area In-Situ Remediation Zone.
CAIRZ refers to the Central Area In-Situ Remediation Zone.

[d] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs and for ex-situ extraction. For freshwater injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

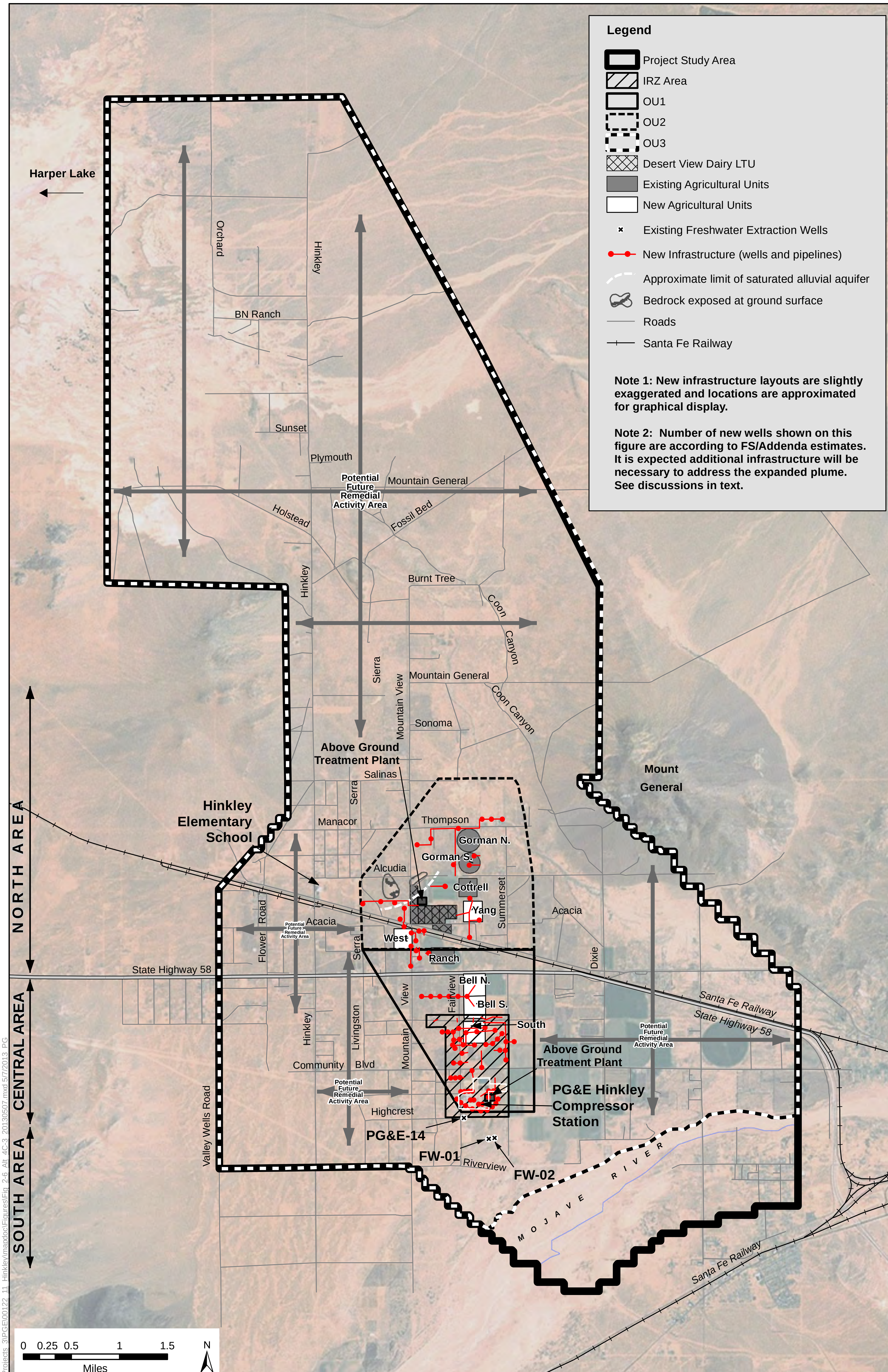

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Figure 2-6
Alternative 4C-3 Conceptual Layout
(Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

- **Year 10:** Additional extraction wells and pipelines would be constructed in the northwest and northern areas in OU2 to expand agricultural unit treatment; IRZ flow rates in the Source Area and South Central Area would be increased. All other operations would continue as in previous phases.
- **Year 20:** Several agricultural unit pivots may be turned off (depending on cleanup achievements by year 20) and flows from northern agricultural unit extraction wells installed in Year 10 would be shifted to IRZ treatment. Central Area IRZ recirculation flows would be turned off. Eastern South Central Area wells would be turned off; IRZ treatment in South Central Area would be modified from continuous operation to long-term intermittent carbon amended treatment of low concentration areas in select South Central Area/Source Area injection wells beyond 20 years. Carbon dosage in the Source Area IRZ would be reduced.

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows:

- *Estimated time to 50 ppb: 4 years*
- *Estimated time to achieve conversion of 80% of Cr[VI] mass to Cr[III] in high concentration area: 6 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/3.2 ppb Cr[T]: 36 years*
- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 85 years*

Overall, in comparison to the other project alternatives, Alternative 4C-3 would:

- Have a shorter time period to achieve cleanup to average and maximum Cr[T] and Cr[VI] interim cleanup levels than all other alternatives except Alternative 4C-4;
- Remove chromium mass from the aquifer due to the use of winter ex-situ treatment[16],~~;~~ resulting in the second most removal of chromium mass of all alternatives;
- Require more expansive construction associated with the ex-situ treatment plants and supporting infrastructure;
- Have a greater amount of truck traffic as required by the operation of the ex-situ treatment plants;
- Have the same freshwater injection operations to maintain hydraulic control as all project alternatives; and
- Have the highest cost for implementation of all alternatives.

2.9.4.2 Implementation Details

Plume Containment and Land Treatment

This alternative would support a similar level of agricultural land treatment and units as Alternative 4C-2. Under Alternative 4C-3, the maximum flow rates for extraction of groundwater from northern low-concentration areas for agricultural land treatment would be the highest of all project

[16] Alternatives 4B, 4C-2, and 4C-4 would not remove chromium from the aquifer but instead convert the more~~highly~~ toxic Cr[VI] in groundwater to low toxicity solid Cr[III]. Alternatives 4C-3 and 4C-5 would remove chromium in the source area using ex-situ above-ground treatment.

alternatives, except for Alternative 4C-4, which would have the same flow rate. Agricultural unit flows would be decreased at Year 20, depending on the effectiveness of remediation in reducing contamination levels by that time. Freshwater injection would remain the same with estimated flows of up to 92 gpm (15% more than existing) for the duration of treatment. Other than these changes, all other activities would be the same as those described for Alternative 4C-2.

In-Situ Treatment

In-situ treatment under Alternative 4C-3 would be the same as treatment described under Alternatives 4B and 4C-2.

Ex-Situ Treatment

As described above, under Alternative 4C-3, up to a total of two ex-situ treatment plants would be constructed to treat excess winter flows that would not be supported by the agricultural unit operations. As shown in the conceptual layout (Figure 2-6), a south plant and associated injection wells would be located near the Source Area at the Compressor Station in OU1 and a north plant would be located adjacent to the Desert View Dairy in OU2. ~~Two~~ The northern treatment plant~~s are assumed under this alternative, one with~~ would have a treatment capacity of approximately 1,200 gpm from flows north of SR 58, which would generally treat contamination in OU2.~~, and a second~~ The southern plant ~~with~~ would have a treatment capacity of approximately 450 gpm south of SR 58, which would generally treat contamination in OU1. Ex-situ treatment average annual flows would be 1,222 gpm. Ex-situ treatment includes extraction of chromium contaminated groundwater from particularly the highest concentration areas, but also from the ~~and~~ lower~~-~~concentration areas, treating it at the nearby above-ground facility using chemical precipitation and filtration processes, and reinjecting the ~~clean~~ treated water into associated injection wells. The solid ~~by-product~~ chromium residue generated during treatment would be managed and disposed of at Class I landfill disposal facilities, such as the Waste Management Kettleman Hills Facility, that are permitted to accept hazardous wastes as authorized under Title 27 of the California Code of Regulations.

Monitoring Activities

Monitoring activities would be the same as those being implemented under existing operations throughout the project area (as described under Section 2.4).

Contingency Plan for Agricultural Unit Operations

Alternative 4C-3 would include a contingency plan as described for Alternative 4B above, except that the two above-ground treatment plants included in this alternative already provide contingency options in the event that agricultural unit treatment is impaired for a short period of time. The above-ground treatment plants are being designed with more capacity than needed for expected average flows, which creates some built-in contingency. Also, since Alternative 4C-3 already relies on above-ground treatment in winter, it has a built-in contingency in the event of impairment of agricultural units due to winter storms.

2.9.5 Alternative 4C-4

2.9.5.1 Overview

Alternative 4C-4 uses much of the same infrastructure and optimization as proposed under Alternatives 4B, 4C-2, and 4C-3 but significantly expands the number of agricultural units for land treatment via operation of winter agricultural unit pivots using continuous pumping in lieu of an ex-situ treatment plant as proposed under Alternative 4C-3.

This alternative also expands agricultural land treatment and groundwater pumping as necessary to address the revised plume area, including into OU3; for example this alternative could include up to 1,394 acres of agricultural units and an annual extraction rate of up to 4,388 gpm for land treatment (compared to 182 acres of agricultural units and 1,100 gpm of extraction pumping for land treatment with the No Project Alternative).

Implementation of this alternative is likely to require the acquisition of properties and/or easements within the project area for installation and maintenance of supporting infrastructure for implementing remediation activities. This alternative also would require acquisition of water rights because it includes agricultural water use that would exceed PG&E's current water allocation.

Table 2-7 summarizes the main components of Alternative 4C-4, and Figure 2-7 shows the proposed remediation technologies that would be implemented. The phased implementation of the remedial actions under Alternative 4C-4 would occur as follows:

- **Initial Buildout:** At least sixteen new agricultural unit pivots and associated extraction wells and pipelines would be constructed in OU1 and OU2 areas; all flow rates for containment, land application, and IRZ treatment would increase. Additional agricultural unit pivots would be necessary to address the expanded plume and would likely be located in OU2 and OU3. Additional monitoring wells also would be installed within the project area.
- **Year 5:** Several South Central Area injection wells in the IRZ areas would be turned off and northern area extraction flows would be redirected to remaining South Central Area and Source Area injection wells for shared dosed injection; there would be a reduction in the South Central Area/Source Area flow rate. Southern Source Area extraction wells would be turned off and converted to injection wells.
- **Year 10:** Additional extraction wells and pipelines would be constructed in the northwest and northern areas in OU2 to expand agricultural unit treatment; IRZ flow rates in the Source Area and South Central Area would be increased. All other operations would continue as in previous phases.
- **Year 20:** Several agricultural unit pivots may be turned off (depending on effectiveness of remediation by Year 20) and flows from northern agricultural unit extraction wells installed in Year 10 would be shifted to IRZ treatment; Central Area IRZ recirculation flows would continue~~ld be turned off~~; Eastern South Central Area wells would be turned off; IRZ treatment in South Central Area would be modified from continuous operation to long-term intermittent carbon amended treatment of low concentration areas in select South Central Area/Source Area injection wells beyond 20 years. Carbon dosage in the Source Area would be reduced. All other operations would continue as in previous phases.

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows:

- *Estimated time to 50 ppb: 3 years*
- *Estimated time to achieve conversion of 80% of Cr[VI] mass to Cr[III] in high concentration area: 6 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/ 3.2 ppb Cr[T]: 29 years*
- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 75 years*

Overall, in comparison to the other project alternatives, Alternative 4C-4 would:

- Have the fastest timeframes to achieve average and maximum Cr[T] and Cr[VI] interim cleanup levels over all project alternatives;
- Require construction of the largest area of agricultural units and associated pipeline conveyance systems of all project alternatives; and have the same freshwater injection operations to maintain hydraulic control as all alternatives; and
- Have the second highest cost of all alternatives.

2.9.5.2 Implementation Details

Containment and Land Treatment

This alternative includes a large increase in agricultural pivots over the existing condition. The increase in agricultural pivots for this alternative is greater than all other alternatives, with additional agricultural units to be added for winter-only operations. Under Alternative 4C-4, the maximum flow rates for extraction of groundwater from northern low-concentration areas for agricultural land treatment would be the highest of all alternatives, except for Alternative 4C-3, which would have the same flow rates. Agricultural unit flows may be decreased at Year 20 depending on effectiveness of remediation by that time. The overall land treatment flow rates are higher than Alternatives 4B and 4C-2 because the treatment approach is more aggressive. Freshwater injection would remain the same with estimated flows of up to 92 gpm (existing flow level plus 15% contingency) for the duration of treatment.

In-Situ Treatment

In-situ treatment under Alternative 4C-4 would be the same as in-situ treatment proposed under the other described alternatives.

Monitoring Activities

Monitoring activities would be the same as those proposed under the other described alternatives.

Contingency Plan for Agricultural Unit Operations

Alternative 4C-4 would include a contingency plan as described for Alternative 4B above.

Table 2-7. Summary of Components under Alternative 4C-4

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)[a]	1,394 acres			
AU Extraction Wells	149	149	190	190
AU Pipeline	132,875 lf	132,875 lf	147,374 lf	147,374 lf
AU Extraction Flow	4,388 gpm			
In-Situ Remediation Zone (IRZ)				
Extraction Wells	~~22~~21	~~22~~21	25	25
Injection Wells	108	108	111	111
Pipelines	39,240 lf	39,990 lf	42,365 lf	42,365 lf
Carbon-amended IRZ flow (SCRIA/SAIRZ)[b, c]	431 gpm	244 gpm	319 gpm	213 gpm
IRZ Recirculation flow (CAIRZ)[b, c]	~~279~~ 175 gpm	175 gpm	175 gpm	175 gpm
Northwest Area Freshwater Injection				
Extraction Wells	~~5~~3			
Injection Wells	~~4~~6			
Pipelines	36,669 lf			
Northwest Freshwater Reinjection Flow[b]	92 gpm			
Monitoring Wells/Supporting Infrastructure				
Monitoring Wells	558			
Wells and Supporting Infrastructure acreage[d]	56	56	59	59
Access roads (acres)	8	8	9	9

Notes: All totals include existing infrastructure. Well estimates include the number of wells to be constructed; not all may be operating at the same time. All estimates have been scaled up from the data from the Feasibility Study and Addenda to account for a larger plume than used in the feasibility study. See discussion in text.

[a] Desert View Dairy, Gorman, Cottrell, Ranch, plus additional Agricultural Units.

[b] All flows are based average annual rates.

[c] SCRIA refers to the South Central Reinjection Area.
SAIRZ refers to the Source Area In-Situ Remediation Zone.
CAIRZ refers to the Central Area In-Situ Remediation Zone.

[d] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs. For freshwater injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

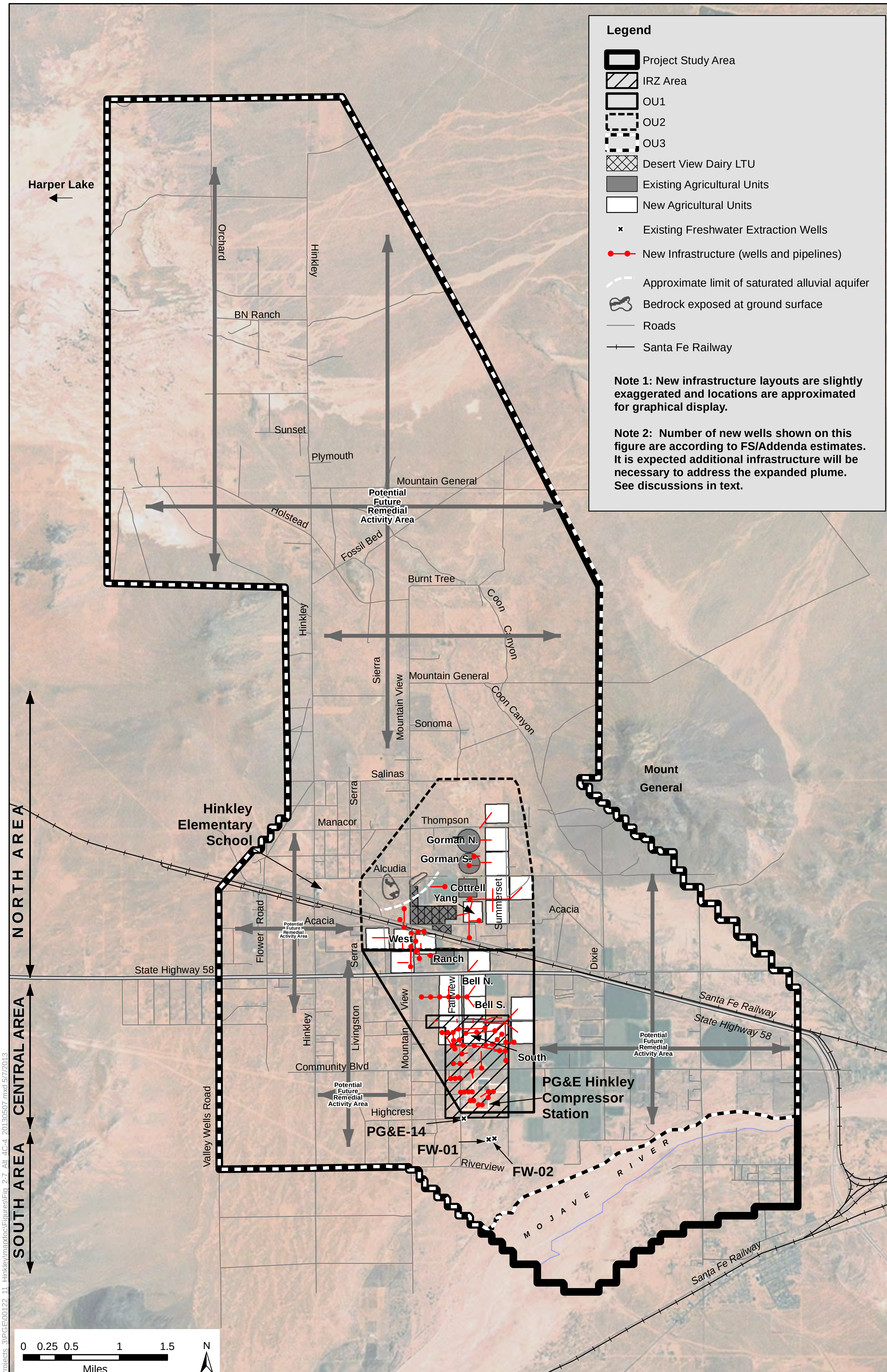

Figure 2-7
Alternative 4C-4 Conceptual Layout (Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

2.9.6 Alternative 4C-5

2.9.6.1 Overview

Alternative 4C-5 is a combination of three remedial strategies: agricultural land treatment, in-situ remediation, and chemical treatment in an ex-situ (above-ground)~~ chemical treatment~~ plant. Like the other action alternatives, implementation of this alternative is likely to require the acquisition of properties and/or easements within the project area for installation and maintenance of supporting infrastructure for implementing remediation activities. This alternative also would require acquisition of water rights because it includes agricultural water use that would exceed PG&E's current water allocation.

Table 2-8 summarizes the main components of Alternative 4C-5, and Figure 2-8 shows the proposed remediation activities that would be implemented.

The primary difference in the configurations of Alternative 4C-5 and Alternative 4C-2 is that Alternative 4C-5 focuses in-situ treatment in the South Central Area and Central Area and includes above-ground treatment in the Source Area instead of the in-situ treatment proposed for the Source Area under Alternative 4C-2. Therefore, compared to ~~the No Project Alternative and~~ the other action alternatives, there would be fewer in-situ carbon injection/extraction wells and thus less above-ground IRZ well compounds (approximately 20 by 20 feet footprint). The primary difference between the configurations of Alternative 4C-5 and Alternative 4C-3 is that Alternative 4C-5 uses only one above-ground treatment plant for year-round ex-situ treatment of the high concentration plume, whereas Alternative 4C-3 uses two above-ground treatment plants for winter plume control only. The above-ground treatment plant would be located generally near the Compressor Station adjacent to the southern boundary of the Source Area IRZ in OU1 for removing the highest concentrations of chromium from the aquifer. This alternative also expands agricultural land treatment and groundwater pumping as necessary to address the revised plume area, including into OU3; for example, this alternative could include up to 575 acres of agricultural units and up to 3,167 gpm (annual average) of extraction for land treatment (compared to 182 acres of agricultural units and 1,100 gpm of extraction pumping for land treatment with the No Project Alternative).

Implementation of this alternative is likely to require the acquisition of properties and/or easements within the project area. These acquisitions would be for installation and maintenance of supporting infrastructure for implementing remediation activities.

The phased implementation of the remedial actions under Alternative 4C-5 would occur as follows:

- **Initial Buildout:** New agricultural unit pivots and associated extraction wells and pipelines would be constructed in OU1 and OU2 areas; all flow rates for containment, land application and IRZ treatment would increase. The ex-situ treatment plant and associated supporting infrastructure would be constructed. New ex-situ injection wells would be installed in the Source Area with associated pipelines.
- **Year 5:** Several South Central Area injection wells in the IRZ areas would be turned off and northern area extraction flows would be redirected to remaining South Central Area; there would be a reduction in the South Central Area flow rate. All other operations would continue as in previous phases.
- **Year 10:** Additional extraction wells and pipelines would be constructed in the northwest and northern areas in OU2 to expand agricultural unit treatment; IRZ flow rates in the Source Area

and South Central Area would be increased. All other operations would continue as in previous phases.

- **Year 15:** Source Area ex-situ treated water injection would be shifted north; additional injection wells installed and conveyance piping and supporting infrastructure would be constructed; several extraction wells would be turned off.
- **Year 20:** Several agricultural unit pivots would be turned off (depending on effectiveness of remediation by that time) and flows from northern agricultural unit extraction wells installed in Year 10 would be shifted to IRZ treatment; Central Area IRZ recirculation flows would be turned off; IRZ treatment in South Central Area would be modified from continuous operation to long-term intermittent carbon amended treatment of low concentration areas in select South Central Area injection wells beyond 20 years. Carbon dosage in the Source Area would be reduced. All other operations would continue as in previous phases.
- **Year 32:** Source Area extraction wells would be converted to carbon-amended injection wells supplied by South Central Area extraction flows.

As noted in Table 2-2, the estimated time periods for cleanup for this alternative are expected to be as follows:

- *Estimated time to 50 ppb: 20 years*
- *Estimated time to achieve removal of 80% of Cr[VI] mass in high concentration area: 15 years*
- *Estimated time to interim maximum cleanup level of 3.1 ppb Cr[VI]/ 3.2 ppb Cr[T]: 50 years*
- *Estimated time to interim average cleanup levels of 1.2 ppb Cr[VI]/1.5 ppb Cr[T]: 95 years*

Overall, in comparison to the other project alternatives, Alternative 4C-5 would:

- Take longer to achieve interim cleanup levels to meet the drinking water MCL for Cr[T] (below 50 ppb) than the other described alternatives;
- Take longer to achieve average and maximum Cr[T] and Cr[VI] interim cleanup levels compared to other alternatives;
- Use above-ground pump and treat in the Source Area IRZ instead of in-situ treatment, resulting in removal of chromium ~~from the~~ from the overall site instead of conversion from Cr[VI] to Cr[III], thus resulting in the largest removal of chromium mass of all alternatives; ~~and~~
- Have lesser amounts of reagents injected to the aquifer for in-situ treatment, thus create lesser amounts of byproducts of all alternatives; and
- Have the same freshwater injection operations to maintain hydraulic control as all other described alternatives.

2.9.6.2 Implementation Details

Containment and Land Treatment

This component of Alternative 4C-5 would be the same as that described for Alternative 4C-2; however the total maximum groundwater extraction flows for land treatment would be slightly higher.

Table 2-8. Summary of Components under Alternative 4C-5

Optimization Period	Initial Buildout (0–5 years)	Year 5 (5–10 years)	Year 10 (10–20 years)	Year 20 (20+ years)
Agricultural Land Application				
Agricultural Units (AUs)[a]	575 acres			
AU Extraction Wells	80	80	102	102
AU Pipeline	68,489 lf	68,489 lf	83,374 lf	83,374 lf
AU Extraction Flow[b]	3,167 gpm	3,167 gpm	3,167 gpm	2,618 gpm
In-Situ Remediation Zone (IRZ)				
Extraction Wells	~~19~~21	~~19~~21	23	23
Injection Wells	90	90	91	91
Pipelines	33,940 lf	34,690 lf	36,340 lf	36,340 lf
Carbon-amended IRZ flow (SCRIA~~/SAIRZ~~)[b, c]	244 gpm	244 gpm	319 gpm	213 gpm
IRZ Recirculation flow (CAIRZ)[b, c]	~~279~~ 175 gpm	175 gpm	175 gpm	0 gpm
Ex-Situ Treatment				
Extraction Wells	~~20~~6	~~20~~6	~~24~~6	~~24~~6
Injection Wells	10	10	13 (year 15)	13
Pipelines	7,719 lf	7,719 lf	8,594 lf	8,589 lf
~~Extraction~~ System Flow (~~annual~~annualized anverage)	250 gpm	250 gpm	250 gpm	~~0~~ 250 gpm
Northwest Area Freshwater Injection				
Extraction/Injection Wells	5/4			
Pipelines	36,669 lf			
Northwest Freshwater Reinjection Flow[b]	92 gpm			
Monitoring Wells/Supporting Infrastructure				
Monitoring Wells	558			
Wells and Supporting Infrastructure (acres)[d]	52	52	54	54
Access roads (acres)	4	4	5	5

Notes: All totals include existing infrastructure. Well estimates include the number of wells to be constructed; not all may be operating at the same time. All estimates have been scaled up from the data from the Feasibility Study and Addenda to account for a larger plume than used in the feasibility study. See discussion in text.

[a] Desert View Dairy, Gorman, Cottrell, Ranch, plus additional Agricultural Units.

[b] All flows are based on average annual rates.

[c] SCRIA refers to the South Central Reinjection Area.
~~SAIRZ refers to the Source Area In-Situ Remediation Zone.~~
CAIRZ refers to the Central Area In-Situ Remediation Zone.

[d] Includes acreage for all wells, including Agricultural Units, In-Situ Remediation, Northwest Freshwater Reinjection, and monitoring wells.

lf = linear feet of trenching for AUs and IRZs and for ex-situ extraction. For freshwater injection pipelines, these are existing lf of pipelines.

gpm = gallons per minute

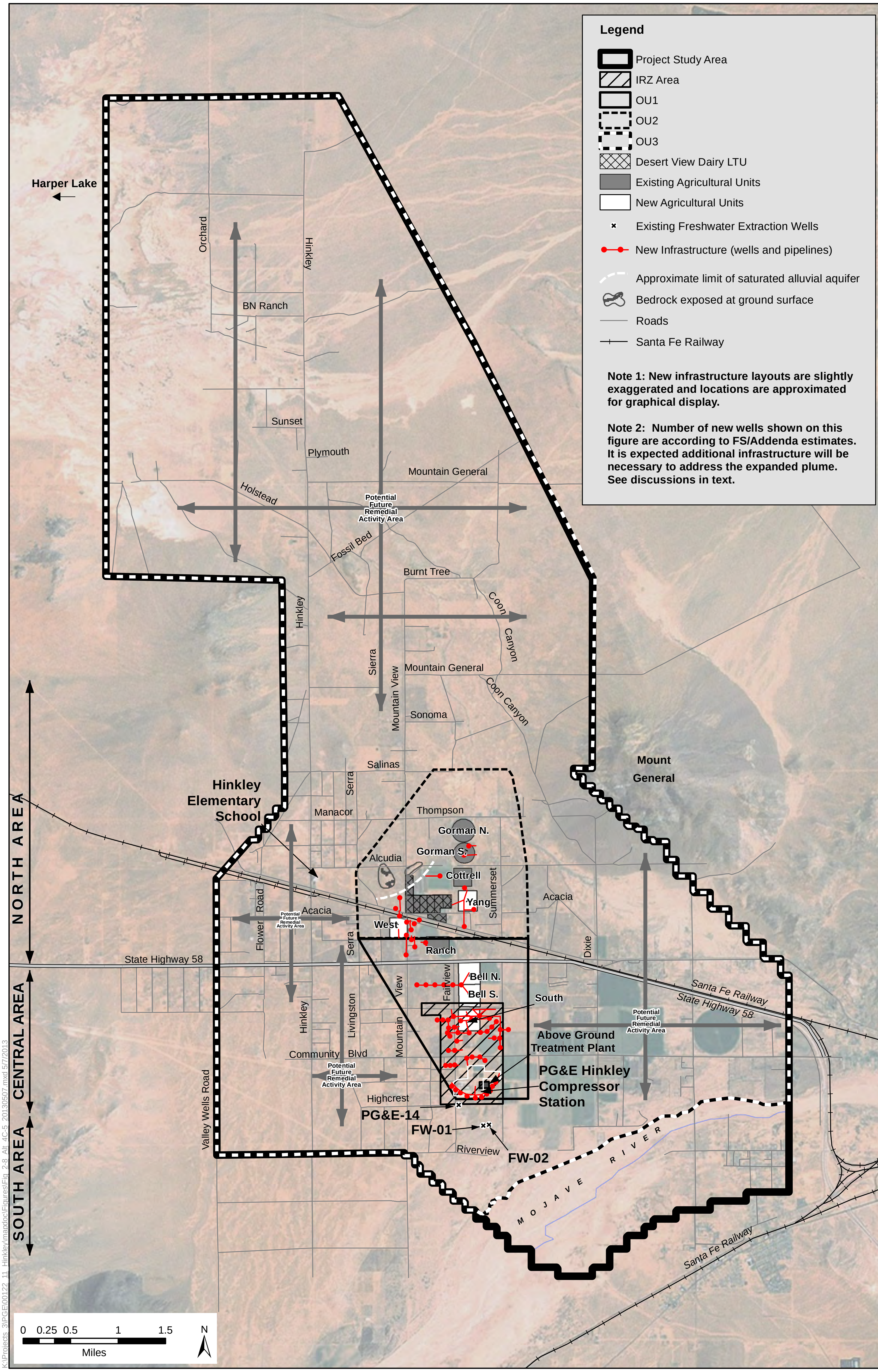

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Figure 2-8
Alternative 4C-5 Conceptual Layout (Initial Buildout to Year 20)

Source: Based on information from PG&E 2011c and subsequent updated information from PG&E.

In-Situ Treatment

In-situ treatment under Alternative 4C-5 would be similar to in-situ treatment described for Alternative 4C-2. However, Alternative 4C-5 does not include in-situ treatment in the Source Area IRZ; as a result, the overall in-situ treatment implemented under Alternative 4C-5 would be less than that of the other described alternatives.

Ex-Situ Treatment

As shown in Figure 2-8, the conceptual approach for ex-situ treatment activities under Alternative 4C-5 includes extracting approximately 200 gpm of chromium contaminated groundwater from the highest concentration areas in the Source Area IRZ, treating it at the nearby above-ground facility using chemical precipitation and filtration processes, and re-injecting the ~~clean~~ treated water into the south end of the Source Area IRZ. The solid ~~by-product~~chromium residue would be managed and disposed off site in the same manner as that described under Alternative 4C-3.

Monitoring Activities

Monitoring activities would be the same as those being implemented under existing operations throughout the project area (as described under Section 2.4 above).

Contingency Plan for Agricultural Unit Operations

Alternative 4C-5 would include a contingency plan as described for Alternative 4B above.

2.10 Construction, Operation, and Maintenance

2.10.1 Description of Remediation Activities in Operable Units

As part of Feasibility Study Addendum 3, PG&E delineated three OUs (Figure 2-2a). The OU delineation was generally based on areas that contain different plume characteristics and therefore different remedial emphasis. The specific activities that would occur within each OU are generally as follows:

- **OU1.** The remediation emphasis in OU1 is treatment of the high chromium concentration plume through either in-situ ~~chromium~~ reduction from Cr[VI] to Cr[III] (all alternatives except 4C-5) or removal through ex-situ treatment (Alternative 4C-5). In-situ treatment (Alternatives 4B, 4C-2, -3, and -4) in OU1 will use IRZ technology (i.e., treatment by biological or chemical reductants) ~~and will focus on accomplishing the MCL for drinking water (50 ppb)~~ focused on the high-concentration part of the plume ~~at the boundary of OU1 and OU2~~. In-situ reduction byproducts (e.g., manganese, iron, arsenic) will be generated through the IRZ process and primarily managed within OU1. Due to the aggressive nature of treatment proposed in OU1, the fringes of the 3.1 ppb plume could temporarily fluctuate over time in response to injection and extraction activities. To minimize these effects, hydraulic control and inward gradients (i.e., plume containment) will be maintained as long as necessary to prevent Cr[VI] and byproduct (e.g., manganese) migration. The agricultural units within OU1 will be used for water treatment as appropriate to assist with inward hydraulic gradients and plume water balance. Alternative 4C-

5 would add ex-situ treatment in OU1 to remove Cr[VI] from the aquifer instead of reducing it to Cr[III].

- **OU2.** OU2 is a lower chromium concentration area where agricultural treatment would be focused in all alternatives. The remediation emphasis will be on groundwater extraction and treatment via agricultural units. Chromium plume containment is accomplished through the maintenance of seasonal or year-round inward hydraulic gradients produced by numerous groundwater extraction wells and limited freshwater injection. Water supply pumping in the lower aquifer[17] will be minimized to mitigate further Cr[VI] impacts on the lower aquifer. Aggressive pumping in the upper aquifer[18] over the lower aquifer combined with minimizing lower aquifer pumping is also planned to neutralize or reverse downward gradients and mitigate Cr[VI] impacts occurring via downward migration. Limited remedial pumping in the lower aquifer may also be considered in the future to address the limited area of contamination in the lower aquifer at present. In-situ remediation, as described above, may be applied to OU2 to address ~~higher~~ recalcitrant concentrations of the plume if and/or where it is present in OU2. An above-ground treatment plant would be included in OU2 in Alternative 4C-3 to provide for winter groundwater extraction and treatment.

- **OU3.** As of December 2012~~2011~~, the expanded plume ~~included over 900 acres~~ in OU3 included extensive areas north of Thompson Road, as well as small areas on the east side of the plume near Mulinax Road and the Q4 2012 "finger" west of Serra Road. As such, agricultural land treatment may be applied to remediate~~treat~~ the plume in OU3, similar to that described above for OU2. Groundwater monitoring and assessment activities are currently ongoing in the northern section of OU3 in coordination with the Water Board. It is possible that the OU3 area (and subsequently the plume area boundary) could change in the event monitoring and assessment activities identify additional areas ~~show continued migration~~ of chromium contamination ~~levels~~. Monitoring and remedial pumping and conveyance (to agricultural unit treatment units) are the primary activities anticipated for this area. Elevated total dissolved solids (TDS) and nitrate concentrations are observed in some of the northern portions of OU3 as a result of historical agricultural operations. Although no remediation is currently shown for OU3 in the F~~f~~easibility S~~s~~tudy and addenda, it is expected that new agricultural unit units may be placed in OU3 starting in the areas north of Thompson Road with groundwater extraction and~~with~~ localized agricultural unit treatment. Ex-situ treatment (as proposed in Alternative 4C-3) could also be implemented in OU3 in combination with above-ground treatment, if required. Adjustment of the ~~final~~ OU3 boundary may be necessary to address any migration of the chromium contamination levels.

2.10.2 Construction Equipment

Construction equipment will be needed for the installation of wells and supporting infrastructure, to develop agricultural units, and construct conveyance pipelines and new facilities associated with above-ground treatment plants. This equipment would be similar for all alternatives. The construction equipment and anticipated duration of construction activities are summarized by each alternative in Tables 2-9 and 2-10 below. Construction activities are expected to occur between the

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[17] The lower aquifer is the portion of the aquifer located below the clay confining layer (i.e., the blue clay) which separates the upper and lower aquifer.

[18] The upper aquifer is the portion of the aquifer located above the blue clay which separates the upper and lower aquifer.

hours of 7 a.m. and 7 p.m., in accordance with San Bernardino County ordinances. Upon completion of construction, all construction equipment will be removed and sites will be returned to pre-project conditions to the extent possible.

Table 2-9. Required Construction Equipment and Infrastructure.

Alternative	Construction Activity	Equipment	
All Alternatives	Pipeline installation	Excavator Backhoe Front-end loader Motor grader Water truck Utility potholing machine Utility/support/welding truck	Jumping jack compactor (around vaults) Vibratory plate compactor Trench roller compactor Generator Compressor HDPE welding machine
	Well installation and development	Drill rig Auxiliary compressor Concrete well vault 480-volt power drop and motor control panel HDPE groundwater conveyance piping SS submersible groundwater extraction pump 120-volt power conduit	Support truck Forklift PVC and SS well casing 120-volt control panel with radio communications Steel well head piping Security fencing Actuated valves and switches
Alternatives 4C-3 and 4C-5 only	Above-Ground Treatment Facility		
	Grading/ excavation	Motor grader Backhoe Utility/support/welding truck	Rubber tired dozer Front end loader Water truck
	Paving/concrete	Cement/mortar maker Roller Motor grader Chop saw for steel reinforcement Vibratory plate compactor Utility/support/welding truck	Paver Front-end loader with forks Water truck Concrete saw Generators
	Building construction	Crane Tractor/loader/backhoe Cutoff saw or demolition saw Vibratory plate compactor Utility/support/welding truck	Forklift Front-end loader with forks Concrete saw

Source: Pacific Gas and Electric 2011d, 2012

Notes: HDPE = High-density polyethylene, PVC = Polyvinyl chloride, SS = Stainless steel

Table 2-10. Typical Timeframes by Alternative

Alternative	Pipeline[a] Installation	Well Installation and Development[a]	Treatment Facility—Grading and Excavation	Treatment Facility—Paving and Concrete	Treatment Facility—Building Construction[a]
No Project	5 months	16 months	n/a	n/a	n/a
Alternative 4B	3 months	6 months	n/a	n/a	n/a
Alternative 4C-2	4 months	11 months	n/a	n/a	n/a
Alternative 4C-3	6 months	16 months	1 month	2 months	12 months
Alternative 4C-4	7 months	11 months	n/a	n/a	n/a
Alternative 4C-5	4 months	11 months	1 month	2 months	12 months

[a] The duration assumes full buildout as defined in the Feasibility Study and Addenda. Durations for actions relative to the larger plume are assumed to be the same as described in Feasibility Study and Addenda indicating higher intensity of activity with higher infrastructure construction.

2.10.3 Construction Activities

2.10.3.1 Wells and Agricultural Units

Construction of new wells would involve a minimal amount of land clearing, well drilling and well casing placement, installation of well pads and mounts, installation of supporting equipment (e.g., pumps) and mixing tanks (for wells used in in-situ treatment), installation of conveyance piping, and installation of~~ing~~ exclusionary fencing around the well operational area.

Construction of new agricultural units would involve land clearing, planting of crops, installation of irrigation systems, and installation of conveyance piping to carry water pumped from extraction wells for land application. New access roads may be required to reach wells and agricultural units with their associated supporting infrastructure in areas that were previously undisturbed. These access roads would primarily be unpaved and consist of land cleared to accommodate the largest piece of equipment (about a 10-foot wide lane). It is estimated that approximately 3–6 workers per day would be required for installation and development of a well, and approximately 15 workers per day would be required for pipeline installation (refer to Table 2-10).

2.10.3.2 Ex-Situ Treatment Facilities

Construction of the ex-situ (above-ground) facilities would involve site preparation through grading and excavation, paving and concrete pouring for building foundations, and construction of the treatment facility building and other structures, such as above ground storage tanks. New utilities including power connections (including backup diesel generators), septic systems (for non-process and non-lab wastewater), and telecommunications connections also would be installed. A new paved road would be constructed to provide access to the treatment facility from the nearest street. There would be approximately 5–19 workers on site per day during construction activities (refer to Table 2-10). Once construction of the treatment facility is complete~~Upon completion of construction~~, all construction equipment would be removed and sites would be returned to pre-project conditions to the extent possible. The size of the above-ground facility is described under *Ex-Situ Treatment Facilities* below.

2.10.4 Operations and Maintenance Activities

Operations and maintenance (O&M) activities would be similar to current, ongoing activities and would be similar across all alternatives for each type of treatment being implemented. The scale of activity would increase from existing levels and would vary in scale for different project alternatives.

2.10.4.1 Wells

Operating characteristics for future extraction, ~~and~~ injection, and monitoring wells would be similar to the operating characteristics of existing wells. Extraction wells supplying water to agricultural units would operate mostly at night, and the level of pumping activity could vary over the course of the year. (Operations and maintenance activities associated with agricultural units are described below.) IRZ extraction and injection wells would likely operate continuously, and flow could vary based on the relative optimization year. Outside the IRZ well compounds, all IRZ operations occur below grade. Source Area IRZ wells and the freshwater supply well PG&E #14 are connected to the Hinkley Compressor Station's electrical supply. It is expected that power to new IRZ wells (not within the Source Area IRZ) would come from tie-ins to the existing infrastructure and would be powered by the electric grid. It is expected that 2 to 4 additional workers would be needed to operate and maintain new well and associated facilities.

The main operations and maintenance activities at IRZ wells would include:

- Daily system checks (e.g., onsite system inspections);
- Collection of operating data at well and other facility sites (e.g., water-level measurements, tank readings);
- Adjustment of pump operations;
- Completing Central Area, Source Area, and South Central Area injections;
- Periodic cleaning, including handling of backwash water;
- Periodic troubleshooting, repairs, and replacement of components;
- Collection of water quality samples for laboratory analysis;
- Periodic cleaning or maintenance of pipelines, tanks, and appurtenances;
- Removal and cleaning or maintenance of downhole equipment such as pumps, pipes, and valves; ~~and~~
- Delivery of carbon reagent and other chemicals to IRZ compounds; and
- As-needed manual carbon substrate addition.

Freshwater supply wells would continue to be operated as under existing conditions. The same general O&M activities would occur at these wells as under the IRZ wells. In addition, O&M activities at these wells would require adjustment of flow rates in extraction wells and in individual freshwater injection wells to optimize hydraulic mounding.

Monitoring wells also would continue to be operated as under existing conditions. The wells would be used for groundwater samplings and water level readings, with samples being taken quarterly, semi-annually, annually or less frequently, depending on the well. PG&E sometimes may sample more frequently at a new well. Monitoring wells may be established throughout the project area. Access to the wells is generally from existing secondary roads or public streets where feasible.

2.10.4.2 Desert View Dairy Land Treatment Unit

Operations and maintenance activities associated with the Desert View Dairy land treatment unit would continue as existing conditions and include:

- Performing daily system checks for leaks, potential trouble shooting and repair, and general maintenance needs;
- Collecting system flow, pressure, and totalizer readings in extraction wells and booster pump and performing visual inspection of instrumentation and equipment;
- Adjusting flow rates in individual extraction wells to optimize irrigation rates and/or hydraulic capture;
- Collecting water depth measurements at extraction wells and samples from lysimeters and monitoring wells for laboratory analyses;
- Planting, coordinating harvest scheduling, and evaluating crop health;

- Periodic troubleshooting, maintenance, and repair of pumps and other systems;
- Periodic well rehabilitation and redevelopment;
- Periodic cleaning or maintenance of pipelines and appurtenances via surging or chemical injection;
- Removal and cleaning or maintenance of downhole equipment such as pumps, pipes, and valves; and
- Replacement of equipment over the course of operations.

2.10.4.3 Agricultural Units

Operations and maintenance activities associated with land treatment via agricultural units would be similar to existing agricultural unit operations, which are also similar to the Desert View Dairy land treatment unit operations. O&M activities at new agricultural units would include:

- Checking water application rates to evaluate groundwater extraction for hydraulic control;
- Routine inspection and monitoring of extraction well performance;
- Routine inspection, repair, and maintenance of filters and system parts;
- Planting, coordinating harvest scheduling, and evaluating crop health;
- Periodic well rehabilitation and redevelopment;
- Periodic cleaning or maintenance of pipelines and appurtenances;
- Periodic pump troubleshooting and repair;
- Removal and cleaning or maintenance of downhole equipment – pumps, pipes, and valves; and
- Replacement of equipment over the course of operations.

It is expected that 1 to 3 additional workers would be needed to operate and maintain ~~the~~ each new agricultural unit~~s~~.

2.10.4.4 Ex-Situ Treatment Facilities

As described above, there would be two ex-situ (above-ground) treatment facilities under Alternative 4C-3 and one treatment facility under Alternative 4C-5. Figures 2-6 and 2-8, respectively, show the approximate locations of the ex-situ treatment facilities. Each of the proposed above-ground treatment facilities would be located in a compound approximately 40,500 square feet in size.[19] For Alternative 4C-3, one facility would treat water from mostly north of SR 58 and one would treat water from mostly south of SR 58. For Alternative 4C-5, the facility would only treat water in the Source Area south of SR 58. Each treatment facility would include treatment wells, conveyance system operations, a 35-foot tall process building and an office/laboratory, and 12-foot high security fencing with brown slats. The process buildings would house pumps, pipes, reactors[20], filters, and other equipment to treat the contaminated water. The office/laboratories would include office spaces, a control room, restrooms, and a laboratory. The area within the compound would be paved, would include a concrete loading dock for outgoing waste and incoming materials, and would

[19] The precise size of the treatment facility depends on the alternative.

[20] This is a vat (i.e., vat reactor) where the contaminated water is placed to react with substances.

include exterior floodlighting. Water tanks and other appurtenant structures may be housed in the compound areas. Operations of new facilities would be powered by the existing electric grid. Waste residue from ex-situ water treatment would be transported and disposed off-site at the Waste Management Kettleman Hills Facility or a similar Class I landfill permitted to accept hazardous wastes as authorized under Title 27 of the California Code of Regulations. Operations and maintenance activities associated with ex-situ treatment facilities would primarily include:

- Monitoring and maintenance of ex-situ treatment wells (extraction and injection) and conveyance system operations;
- Collecting and analyzing mid-treatment samples at the on-site lab;
- Measuring, tracking, and changing operational and process parameters as needed;
- Scheduling trash and lab waste pickup and transportation to a landfill;
- Scheduling materials delivery;
- Mechanical maintenance of all equipment; and
- Inspection and maintenance of all supporting structures.

One to three workers would be present at all times (24-hours a day) at each treatment facility that may be constructed, working in 2–3 shifts per day to conduct all O&M activities.

2.10.4.5 Hazardous Materials

Under all alternatives, the project would require storage, use, and transport of chemicals and hazardous materials (e.g., ethanol, petroleum, cleaning fluids, etc.) during operations and maintenance and thus be subject to existing hazardous materials laws, regulations and programs. This includes the requirements of the San Bernardino Count-y Fire Code, Articles 79 and 80, which require a Business Emergency/Contingency Plan or equivalent. Ethanol storage tanks would comply with requirements for curbed containment areas in case of spills. Remediation workers would comply with OSHA standards when handling chemicals, and agricultural treatment would be in compliance with state and federal regulations regarding application of chemicals. Additionally, for the above-ground treatment facilities proposed as part of Alternatives 4C-3 and 4C-5, hazardous waste byproducts would be handled in accordance with permit requirements from the San Bernardino County Fire Department to comply with federal and state hazardous materials requirements, and the Cr[VI]-contaminated waste residue would be transported and disposed of at a Class I landfill permitted to accept hazardous wastes as authorized under Title 27 of the California Code of Regulations (such as the Waste Management Kettleman Hills Facility).

2.11 Other Alternatives Considered but Dismissed from Further Analysis

CEQA requires that the lead agency consider alternatives that would avoid or reduce one or more of the significant impacts identified for the project in an EIR. The CEQA Guidelines (Title 14 of the California Code of Regulations) state that the range of alternatives required to be evaluated in an EIR is governed by the “rule of reason”; the EIR needs to describe and evaluate only those alternatives necessary to allow a reasonable choice and to foster informed decision-making and informed public participation (CEQA Guidelines section 15126.6[a][f]). Detailed consideration of alternatives focuses on those that can either eliminate significant adverse environmental impacts or reduce them to less-than-significant levels; alternatives considered in this context may include those that are more costly and those that could impede to some degree the attainment of all the project objectives (CEQA Guidelines section 15126.6[b][f]).CEQA does not require the alternatives to be evaluated in the same level of detail as the proposed project.

As part of the alternatives development process, a range of reasonable chromium cleanup alternatives was evaluated in the 2002 and 2010 feasibility studies and the three addenda to the 2010 Feasibility Study. These alternatives included suggestions by members of the public during the EIR scoping process.

Out of these alternatives, five project alternatives (4B, 4C-2, 4C-3, 4C-4, and 4C-5, as described above) were selected for detailed analysis in this EIR.

The other alternatives, all described below, either do not meet the project goal and most of the objectives, or have feasibility or effectiveness concerns that precluded them from further consideration. The alternatives are described briefly below, and the reasons they were dismissed from further consideration are identified.

2.11.1 2010 Feasibility Study Alternative 1—Natural Attenuation

This alternative assumes no future pumping or groundwater treatment.~~;~~ ~~thus,~~C~~c~~urrent containment pumping, agricultural water treatment, and in-situ chromium treatment operations would be discontinued. This alternative would take more than 1,000 years to reduce Cr[VI] concentrations to 3.1 ppb. This alternative does not meet the fundamental project objectives because it does not clean up chromium in the groundwater within a meaningful period of time.

2.11.2 2010 Feasibility Study Alternative 2—Containment Only

The main operational features of this alternative include plume containment/hydraulic control through groundwater extraction followed by treatment of Cr[VI] in the soil and use of extracted groundwater for agricultural application. All operations would occur north of SR 58. This alternative would take approximately 120 years to reduce Cr[VI] concentrations throughout the plume to 50 ppb, 260 years to reduce Cr[VI] concentrations to 3.1 ppb, and 320 years to reduce Cr[VI] concentrations to 1.2 ppb. ~~This a~~Alternative 2 does not meet the fundamental project objectives because it does not clean up the groundwater within a meaningful period of time.

2.11.3 2010 Feasibility Study Alternative 3—Plume-Wide In-Situ Treatment

The conceptual approach for Alternative 3 is to utilize extraction wells at the point of the plume farthest away from the source to provide hydraulic containment, add carbon amendment to the extracted water, and inject the carbon-amended water into wells to create IRZs. This alternative would take approximately 8 years to reduce Cr[VI] concentrations throughout the plume to 50 ppb, approximately 110 years to reduce Cr[VI] levels to 3.1 ppb, and 180 years to reduce Cr[VI] concentrations to 1.2 ppb. ~~This a~~Alternative 3 does not meet the fundamental project objectives because it does not clean up chromium in groundwater within a meaningful period of time.

2.11.4 2010 Feasibility Study Alternative 4—In-Situ Remediation and Land Treatment

This alternative would be similar to the general combined treatment approach presently operating in the project area (in-situ remediation and agricultural land treatment) and that proposed in Alternatives 4B and 4C-2. As originally proposed in the 2010 Feasibility Study, this alternative was only designed to address the extent of the chromium plume that was known as of February 2010, which is far smaller than the plume now known to exist as of late 2012~~1~~ and would have agricultural units and pumping similar to what is already occurring, but would have increased IRZ treatment. This alternative would take approximately 6 years to reduce Cr[VI] concentrations throughout the plume to 50 ppb, approximately 150 years to reduce Cr[VI] concentrations to 3.1 ppb, and 220 years to reduce Cr[VI] concentrations to 1.2 ppb. ~~This a~~Alternative 4 does not meet the fundamental project objectives because it does not clean up chromium in groundwater within a meaningful period of time.

2.11.5 2010 Feasibility Study Alternative 5—Plume-Wide Pump and Treat

This alternative would focus on plume containment and ex-situ treatment to reduce Cr[VI] contaminant mass while providing supplemental containment through recharging the treated groundwater to the periphery of the plume. This alternative provides a level of hydraulic containment similar to Alternative 2, although with a different groundwater withdrawal configuration. This alternative would take approximately 50 years to reduce Cr[VI] concentrations throughout the plume to 50 ppb, approximately 140 years to reduce Cr[VI] concentrations to 3.1 ppb, and 210 years to reduce Cr[VI] concentrations to 1.2 ppb. ~~This a~~Alternative 5 does not meet the fundamental project objectives because it does not clean up chromium in groundwater within a meaningful period of time.

2.11.6 2010 Feasibility Study (Addendum 1) Alternative 4A—Aggressive In-Situ Treatment with ~~Beneficial~~ Agricultural Use

Alternative 4A was developed to further accelerate clean-up periods to meet the project objective of timely cleanup. Alternative 4A was enlarged in scale over F~~f~~easibility S~~s~~tudy Alternative 4 by an increase in size of the Central Area IRZ, expansion of agricultural units, increasing IRZ operations by 15 years, and increasing the volume of groundwater extraction for application to expanded agricultural units. Alternative 4A would clean up Cr[VI] contamination to the maximum interim cleanup target level of 3.1 ppb in 75 years and to the average interim cleanup target level of 1.2 ppb in 130 years. These time periods would not adequately meet the objectives of the project.

2.11.7 2010 Feasibility Study (Addendum 1)—Combined Alternative

The Combined Alternative was developed as an alternative method for accelerating removal of Cr[VI] from the high concentration area of the plume through addition of ex-situ treatment at an above-ground facility. The Combined Alternative included agricultural treatment, in-situ treatment and ex-situ treatment. The Combined Alternative would clean up Cr[VI] contamination to the maximum interim cleanup target level of 3.1 ppb in 90 years and to the average interim cleanup target level of 1.2 ppb in 130 years.

This alternative would be slower than Alternative 4B, any of the alternatives developed under Addendum 3, and Alternative 4C-5, which includes above-ground treatment (included in the detailed analysis in the EIR). This alternative does not achieve the project objective of timely cleanup and, therefore, does not meaningfully expand the range of alternatives for analysis.

2.11.8 2010 Feasibility Study (Addendum 3) Alternative 4C-1—In-Situ and Enhanced Agricultural Treatment (1 crop)

Alternative 4C-1 was developed to further expand on the in-situ remediation and agricultural treatment approaches developed under Alternative 4B. The main goals of developing this alternative were to ~~optimize and~~ increase extraction related to plume capture, mitigate plume migration to the east, reduce the incidence of the untreated areas in the IRZ, reduce formation of manganese as a by-product of in-situ reduction, and attempt to further reduce the overall remediation timeframe. This alternative does not accelerate cleanup time periods or provide additional benefit beyond that provided by Alternatives 4B, 4C-2, 4C-3, 4C-4, or 4C-5, and thus does not meaningfully expand the range of alternatives for analysis.

2.11.9 Other Alternative Technologies Considered in the 2010 Feasibility Study

The following list describes the range of other alternative technologies for chromium cleanup considered in the 2010 Feasibility Study that were dismissed from more detailed analysis or consideration in the EIR. These alternatives were screened out because either (1) they do not meet the project goal and most of the objectives or (2) feasibility or effectiveness concerns precluded them from further consideration. These alternatives are briefly described below, and the reasons they were dismissed from further consideration are identified.

- **Alternative Water Supply:** Develop a plan to supply alternative water supply to local residents and a monitoring program to limit use of currently affected domestic groundwater wells. This would require a groundwater piping infrastructure from the new well(s). This alternative alone would not result in remediation of the contaminated aquifer and would not return it to beneficial use. As described above, pursuant to the 2011 CAO (No. RV6-2011-0005, as amended), ~~requires~~ PG&E is ~~to~~ providing~~e~~ interim and whole house replacement water service to those served by domestic or community wells that are within one-mile of the plume and have a detection of hexavalent chromium in their well ~~the affected area and determined to be impacted by its discharge. The Order defined impacted wells as all domestic or community wells in the affected area that are above 3.1 ppb hexavalent chromium or 3.2 ppb total chromium~~

~~plume boundaries, based upon monitoring well data drawn in the most current quarterly site-wide groundwater monitoring report submitted by PG&E. The Order also defined impacted wells as those domestic or community wells in the affected area that contain hexavalent chromium in concentrations greater than 0.02 ppb that were the result of PG&E's discharge at the Facility.~~ As a result, this remedial action is already required and need not be considered as an alternative to groundwater cleanup.

- **Containment—Capping:** Cover affected areas with an impermeable cap (i.e., engineered, native soils, or imported soil caps) to mitigate infiltration and aid in groundwater transport retardation. This alternative was not retained because it is considered not to be effective due to limited rainfall in the region, influences of area agricultural pumping, and the depth of contaminated groundwater. This alternative would not cease groundwater input by the Mojave River (the principal supply to the Hinkley Valley) and thus ~~also~~ would not contain the plume or restore beneficial uses to the aquifer.

- **Containment—Physical Barriers:** Install a vertical or horizontal physical barrier that limits the migration of the affected groundwater. This likely would be incorporated in conjunction with a groundwater extraction system. This alternative is effective in localized areas, but it was not retained because the extent (5.4 miles by 2.4 miles at the time of 2010 Feasibility Study development) and mobility of the chromium plume along with the required depths (> 100 feet) would make it infeasible to effectively control the plume using this method in OU1 and OU2.

- **In-Situ Biological Treatment—Aerobic Bioremediation:** Add an oxidative substrate to the subsurface to aerobically degrade Cr[VI]. This alternative was not retained because it is not applicable to Cr[VI] as this material is already in an oxidized state and needs to be reduced rather than oxidized.

- **In-Situ Biological Treatment—Phytoremediation:** Use plants and their associated rhizospheric microorganisms to remove, degrade, or contain contaminants in groundwater. This alternative was not retained because the extent of groundwater contamination is too deep (approximately 80 feet) for this direct application to be effective. However, the agricultural land treatment included in all project alternatives operates on the same principals as this alternative, but uses agricultural crops and their microorganisms. Therefore this alternative is incorporated in its general approach into the project alternatives.

- **In-Situ Physical/Chemical Treatment—Air Sparging:** Inject air into the subsurface to volatilize the contaminant and enhance aerobic conditions to accelerate aerobic biological remediation of plume. This alternative was not retained because air sparging is not applicable for Cr[VI], which is not volatile and already exists in an oxidized state.

- **In-Situ Physical/Chemical Treatment—Electrokinetic Treatment:** Create electrical fields by application of low-voltage power to subsurface electrodes to alter redox state and to immobilize certain constituents in-situ. Although this alternative is effective, it was not retained because it is cost-prohibitive due to the large size of the plume. In addition, this technology is only effective in areas of high contaminant concentrations, but not for relatively low Cr[VI] concentrations and high aquifer permeability characteristic of the plume.

- **In-Situ Physical/Chemical Treatment—Dual Phase Extraction:** Apply a high-powered vacuum system to simultaneously remove soil vapors, groundwater, and other liquid (i.e., nonaqueous-phase liquid) from low-permeability or heterogeneous subsurface environments.

This alternative was not retained because Cr[VI] is not volatile, and this technology has not been proven to reduce Cr[VI] concentrations.

- **In-Situ Physical/Chemical Treatment—Permeable Reactive Barriers (PRBs):** Install permeable treatment walls (i.e., zero-valent iron PRBs) using trenches, fracturing, boreholes, or other means to create a barrier wall across the flow path of a contaminant plume. As groundwater moves through the treatment wall, contaminants are passively removed in the treatment zones by physical and/or chemical processes. Although this alternative is effective, it was not retained because it is not feasible due to the depth of contamination in OU1 and OU2~~, which is at the high end of traditional trench application technology limits~~.
- **In-Situ Physical/Chemical Treatment—In-Situ Air Stripping:** Inject air into the subsurface (through circulating cells, vacuum vapor extraction, etc.) at a high rate to strip Cr[VI] out of the groundwater; the process also oxidizes the treatment area. This alternative was not retained because air stripping is not applicable treatment for Cr[VI], which is not volatile and already exists in an oxidized state.
- **In-Situ Physical/Chemical Treatment—In-Situ Chemical Oxidation:** Inject an oxidant such as hydrogen peroxide or potassium permanganate to oxidize the affected areas. This alternative was not retained because chemical oxidation has not been proven to reduce Cr[VI] concentrations because Cr[VI] already exists in an oxidized state.
- **In-Situ Thermal Treatment—Steam Injection, 6-Phase Heating, Electrical Resistance:** Use heat to volatilize, oxidize, or mobilize Cr[VI]. This alternative was not retained because it is not applicable treatment for reducing Cr[VI] concentrations because~~as~~ Cr[VI] already exists in an oxidized state, is not volatile, and needs to be reduced.
- **Ex-Situ Biological Treatment—Aerobic Bioremediation:** Add an oxidative substrate to a bioreactor to aerobically degrade Cr[VI]. This alternative was not retained because it is not applicable for reducing Cr[VI] concentrations because~~as~~ Cr[VI] already exists in an oxidated state and needs to be reduced.
- **Ex-Situ Physical/Chemical Treatment—Chemical Oxidation:** Extract groundwater from the subsurface and add an oxidant such as hydrogen peroxide or potassium permanganate to the flow to oxidize the affected groundwater. This alternative was not retained because it is not applicable for reducing Cr[VI] concentrations because~~as~~ Cr[VI] is already in an oxidated state and needs to be reduced.
- **Ex-Situ Physical/Chemical Treatment—Air Stripping:** Extract water and pass it through an air stripper to strip Cr[VI] from the groundwater to the air. This alternative was not retained because it would not be effective because~~as~~ Cr[VI] is not volatile and therefore will not strip out of water; in addition the technology has not been proven to work for removing Cr[VI] from water.
- **Ex-Situ Physical/Chemical Treatment—Electrocoagulation Process:** Use electricity passed through iron plates to generate ferrous iron to reduce the chromium and precipitate it from solution. The resulting sludge is settled in a clarifier and then disposed. This alternative can be effective but was not retained because it is not feasible at the site due to high capital and O&M costs, and because the size of the existing diffuse plume and treatment flows. The electrocoagulation technology is discussed in depth in Master Response 6 (Volume I, Chapter 3) and Appendix A (Volume II), as comments were submitted on the Draft EIR supporting the use of this technology for remediation of the chromium plume in Hinkley. As described in Master

Response 6, electrocoagulation has not been used for a full-scale environmental remediation project to date and has not been pilot tested at Hinkley. Thus, the assertion that electrocoagulation could be a faster and cheaper method of groundwater remediation (particularly as a replacement for aboveground treatment using chemical filtration/precipitation in Alternatives 4C-3 and 4C-5 but also possibly as an alternative to IRZ treatment) have not been substantiated with the necessary site-specific feasibility assessment. The technology could be considered in the future to address high chromium concentrations in the Source Area.

- **Ex-Situ Physical/Chemical Treatment—Liquid-Phase Carbon Adsorption:** Pump groundwater through a series of canisters or columns containing activated carbon to which dissolved organic contaminants are adsorbed. Periodic replacement or regeneration of saturated carbon is required. This alternative was not retained because it is generally not applicable to Cr[VI] treatment, and because Cr[VI] does not absorb to carbon media as organic carbon contaminants do (e.g., petroleum).
- **Discharge/Injection—Off-Site Management at Permitted Facility:** Pump groundwater from the plume and pipe or ship it to an off-site treatment facility. This alternative was not retained because the project area is located in a remote area and no treatment facility is located within a suitable distance for this option, especially in light of the amount of contaminated water that would have to be piped or shipped considering the plume extent and extraction flows. In addition to the potential negative environmental impacts of extensive shipping, offsite disposal would reduce groundwater available to surrounding agricultural operations.
- **Discharge/Injection—Discharge to Surface Water:** Treat groundwater using ex-situ remediation by an approved treatment method in an above-ground facility and then discharge treated water to surface receiving streams. Although this alternative is effective, it was not retained because the preference is to keep water within project boundaries and return it to the aquifer if possible, for beneficial use ~~and there also are no receiving surface water streams with active flow in the area~~.
- **Discharge/Injection—Discharge to Evaporation Ponds:** Use surface impoundments to contain treated or untreated groundwater until it evaporates. Evaporation ponds for temporary storage of extracted water were evaluated as a contingency to injection or agricultural application. Evaporation ponds would be designed with impermeable liners to prevent infiltration of stored water, a leak detection system, and access controls to prevent access to the ponds by unauthorized personnel or wildlife. The ponds would possibly require classification as permitted Waste Management Units based on the quality of the stored water. Ponds would require large surface areas to completely evaporate stored water in a reasonable time. A minimum of approximately 330 acres of storage ponds would be required to evaporate extracted water within one year. The concentration of dissolved constituents would increase as stored water evaporates, possibly requiring ~~further treatment or~~ periodic off-site disposal of remaining concentrated water or sludge. ~~Evaporated water would not be put to beneficial uses, such as for agriculture, or injected to enhance plume control. It is more feasible to treat, irrigate, or otherwise actively manage extracted water at the time of extraction rather than to store it on-site because on-site storage would require so much land and also may require further on-site of off-site treatment.~~ This alternative was not retained because of its space requirements, potential environmental impacts (~~e.g., the conversion of agricultural~~ from converting land to ponds), and

reduced groundwater availability in the aquifer that would result from implementation ~~for agriculture render the alternative unattractive~~.

The following list describes other alternatives considered for chromium cleanup in the 2010 Feasibility Study that initially were retained during the alternatives screening and were pilot-tested or researched for application at the site. Although these alternatives were initially retained, they ultimately were not included as core elements of the remedial alternatives because there are other technologies included in the five action alternatives analyzed in this EIR (agricultural land treatment, in-situ remediation, and ex-situ remediation) that have been found to be more suited for use based on past site experience, cost, or other considerations. These technology alternatives may play a role in the future as substitutes for the core elements (for example, an ion exchange system could be substituted for a chemical reduction/precipitation system for use in an ex-situ treatment plant). These alternatives are briefly described below and the reasons they were not selected as the current primary technology at this time are identified.

- **Direct-Push Technology (DPT):** Directly inject reducing agents at various groundwater depths in each of the DPT injection points. Tracer study results indicated DPT is not effective for full-scale implementation because the distribution of injected amendment in target areas was unpredictable and would require very close injection spacing (Pacific Gas and Electric Company 2010).
- **Infiltration Galleries for In-Situ Cr[VI] Reduction in the Vadose Zone:** Divert contaminated groundwater through a subsurface infiltration gallery (gravel) and amend the infiltrated water with ethanol and the tracer dye eosine. Pilot Study results indicated infiltration galleries can be effective, but they could generate by-products such as iron, manganese, and arsenic (similar to IRZ operations), ~~they do not provide for any beneficial use of groundwater (e.g., for crop production),~~ and full-scale infiltration galleries have not been tested or proven at the site.
- **Ex-Situ Treatment Using Ion Exchange Units:** Remove Cr[VI] in extracted groundwater using ion exchange technology in an above-ground facility. Although this technology was not recommended for use in the ex-situ treatment plants presented in the F~~f~~easibility S~~s~~tudy, the technology may be beneficial in specific circumstances that arise as the project evolves. Given the similarities of environmental impacts expected for ion exchange to chemical reduction/precipitation, the analyses in this EIR for ex-situ chemical reduction would be applicable to ion-exchange as well. In the ion exchange process, the Cr[VI] is removed by exchange with another inert ion. Ion-exchange can be done through either a Strong-Base Anion (SBA) Exchange or a Weak-Base Anion (WBA) Exchange. Both were reviewed for potential application at Hinkley as discussed below.
    - The SBA exchange process is greatly influenced by sulfate concentrations. The SBA resins have a higher selectivity for sulfate compared to other anions. Hinkley groundwater has high concentrations of sulfate (relative to comingled Cr[VI] concentrations) that severely affect the performance and feasibility of SBA exchange processes. The Lawrence Livermore National Laboratory (LLNL) evaluated the use of SBA resins to remove Cr[VI] from groundwater. At the LLNL Site, the average Cr[VI] and sulfate concentrations were respectively 34 ppb and 38 ppm (LLNL 1997). For the LLNL study, the breakthrough for Cr[VI] occurred at less than 6,000 bed volumes, which translate to approximately 10 days of run time at 2.5 minutes contact time. The City of Glendale evaluated several SBA resins for treating groundwater with Cr[VI] and sulfate concentrations of 100 ppb and 87 ppm, respectively (WRF Report 2007). The number of bed volumes for breakthrough was 400 to

1,700, which translate to approximately 1 to 3 days of run time. At the Hinkley Site, Cr[VI] concentrations in the diffuse downgradient area of the plume can range as low as approximately 2.5 to 4.5 ppb with sulfate concentrations in the range of 186 to 700 ppm. Sulfate concentrations are several orders of magnitude higher than Cr[VI] concentrations throughout the diffuse downgradient plume. Under these groundwater conditions, anticipated run time before breakthrough for SBA resins is less than one day. Rigorous pilot testing and continuous monitoring and operation of SBA vessels in series would be necessary to avoid substandard performance due to "chromatographic peaking," which is a phenomena in which less preferentially absorbed ions appear in the effluent at higher concentrations than they appear in the influent as they are released from ion exchange resin when more strongly held ions are adsorbed. Due to interference from high levels of sulfate in some areas and expected short time to breakthrough, the SBA exchange process is not recommended for further consideration for large-scale remediation at Hinkley[21] (Pacific Gas and Electric 2011c).

- The WBA exchange process is less sensitive to co-occurring ions. However, the potential feasibility of WBA exchange process for Cr[VI] removal from Hinkley groundwater has not been evaluated at bench or pilot-scale level. Before WBA exchange can be considered as an alternative, extensive pilot testing of the WBA exchange process would need to occur to evaluate technical effectiveness and the implementability factors described below (Pacific Gas and Electric 2011c).
    - The performance of the WBA resins is strongly influenced by factors such as the influent water pH. Recent studies indicate the optimum pH for Cr[VI] removal is approximately 5.5 to 6.0. Testing is necessary to confirm and optimize the pH range for Hinkley groundwater.
    - In the WBA exchange process, the Cr[VI] can be removed by two mechanisms: ion exchange process and reduction to trivalent chromium (Cr[III]). The mechanism of removal for the Hinkley groundwater will need to be determined to design a treatment system that can reliably lower the Cr[VI] concentrations to the required target concentrations.
    - Recent studies on WBA resins by the City of Glendale indicated potential leaching of harmful byproducts such as formaldehyde and N-nitrosodimethylamine (NDMA) or nitrosamines. The EPA is planning to regulate NDMA in drinking water in the near future.
    - The WBA resins could also accumulate other ions such as radionuclides (uranium was recently detected at one of the existing agricultural units), which would require special handling and disposal of the spent resin.
    - Rigorous pilot testing that addresses the technical issues of WBA resins would need to be conducted prior to full-scale implementation. Pending pilot test results that provide data required to fully evaluate the technical effectiveness and ability to implement, WBA

[21] Ion exchange with SBA is being considered as one approach for providing whole-house water for affected residences. However, the use for an individual house is on a very small scale by comparison with the effort to clean the entire contaminated plume. The operational concerns noted above for large-scale application are not the same for a single residence-scale treatment system.

exchange may be feasible for the Contingency Plan due to the simplicity of implementation and also may be considered at a future date.

- **Membrane Biofilm Reactors (MBfRs):** Reduce Cr[VI] and nitrate in extracted groundwater with a membrane-based biological treatment in an above-ground facility. Bench-scale test results indicate that MBfR technology can treat groundwater with Cr[VI] concentrations in the range of 50 μg/L, but it is ineffective for treating groundwater with the high Cr[VI] concentrations present in the plume core and has not been demonstrated for treatment to the interim cleanup levels for this project. The following is a summary of reasons why this alternative was dismissed from further consideration at this time (Pacific Gas and Electric 2011c).
  - As described in the F~~f~~easibility S~~s~~tudy, MBfR is a potentially viable technology for treating relatively low (i.e., ≤50 ppb) Cr[VI] concentrations in groundwater. MBfR was retained as an ex-situ treatment process option during the initial technology screening in the F~~f~~easibility S~~s~~tudy, but was not selected as the preferred process option for remediation alternatives that would include ex-situ treatment.
  - Bench-scale testing conducted by PG&E in 2009 showed proof-of-concept of the process's technical effectiveness for removing Cr[VI] in groundwater. However, MBfR has not yet been fully implemented at a remediation site to treat Cr[VI]. As of the last review of the technology, MBfR was being pilot tested for removal of dissolved perchlorate and nitrate in groundwater only. The technology is currently commercially available only as a nitrate removal process in the wastewater treatment industry. As a result, the technology cannot be fully evaluated for technical effectiveness. At a minimum, the following factors would need to be better understood before it could be adopted as a remedial option.
    - Treatment to discharge limits: MBfR has not been proven to remove Cr[VI] to meet project objectives of Cr[VI] levels of 3.1 ppb maximum and 1.2 ppb average at full scale.
    - Reliability: This technology has not been implemented at a scale similar to the scale needed in Hinkley. It is not known whether this process could operate reliably for the extended period of time needed.
    - Hydrogen storage and management: MBfR uses diffused hydrogen gas as the electron donor. Hydrogen would have to be delivered and stored or generated on-site. As MBfR has never been implemented at the scale required at the Hinkley Site, it is currently infeasible to fully evaluate the implementability constraints of effectively and safely delivering, storing, or generating the required quantity of hydrogen gas.
    - Post-MBfR secondary treatment for injection: MBfR generates biomass as part of the process. This excess biomass is usually sloughed into the water stream. As treated water would be returned to groundwater via injection wells, the suspended biomass would likely have to be removed to prevent biofouling in injection wells. Without extensive pilot testing, biomass generation cannot be estimated and the appropriate secondary treatment process required to mitigate biomass generation cannot be evaluated.
  - The technology requires extensive pilot testing to evaluate technical effectiveness and implementability factors described above. Without this information, MBfR is not recommended as a preferred ex-situ treatment process (for Alternative 4C-3 or Alternative 4C-5) relative to other processes.

- **In-Situ Chemical Reductants:** Use several different chemical reductants for in-situ remediation instead of organic compounds. The following is a summary of the reasons chemical reductants were not included in the action alternatives as part of in-situ remediation approaches (Pacific Gas and Electric 2011c). Although these reagents are not recommended for general use in the in-situ recirculation systems presented in the F~~f~~easibility ~~s~~Study, they may be beneficial in specific circumstances that arise as the project evolves.
    - This alternative was considered in the bench testing phase of the project in 2003, prior to pilot study implementation and F~~f~~easibility S~~s~~tudy preparation. Calcium polysulfide was screened out prior to bench scale testing due to potential problems with precipitation in-well, uncertainty of nitrate treatment, and potential increased sulfur content of the aquifer. Zero-valent iron (ZVI) was screened out due to cost and in-situ delivery challenges. The bench testing results indicate that the organic carbon substrates (e.g., emulsified vegetable oil, lactate, and ethanol) and sodium dithionite are effective reagents for the treatment of Cr[VI] in groundwater. The organic carbon substrates were retained for pilot testing over sodium dithionite based on safety, ease of handling, material properties, ability to deliver to the aquifer, permitting, and nitrate removal considerations.
    - One of the most challenging aspects of in-situ treatment is reagent delivery within the aquifer, particularly at the spatial scales of the in-situ areas for this project. Reagents which are very reactive will be consumed more quickly in the subsurface and are more difficult to distribute than less reactive reagents that are more slowly consumed. Chemical reductants, including calcium polysulfide, sodium dithionite, and ferrous iron, are very reactive in the subsurface. For example, dithionite consumption is on the timescale of minutes compared to organic carbon consumption rates which are on the timescale of days. The slower consumption rates of the organic carbon substrates allow them to persist in the subsurface and be distributed to greater distances from injection locations. A second consideration for reagent distribution is the potential for clogging the aquifer formation, which limits the ability to inject and distribute reductants. Sulfide- and ferrous iron-based reagents may oxidize to elemental sulfur and ferric iron precipitates, which can limit injectability much more rapidly than the gradual build-up of fouling materials with organic carbon substrates. Nanoscale zero valent iron (nZVI) distribution is limited by the agglomeration of nZVI particles and incorporation into aquifer solids; this makes it difficult to distribute nZVI via injections for in-situ treatment.
    - Treatment Effectiveness. Organic carbon substrates are just as effective and aggressive as chemical reductants in treating high Cr[VI] concentrations in source areas. For example, in the Source Area, Cr[VI] concentrations were reduced from greater than 1,000 ppb to less than 0.2 ppb at one location within approximately one month of the startup of in-situ injections of sodium lactate in one source area (see discussion in Section 3.1, *Water Resources and Water Quality*). Similarly, in a pilot test conducted at the PG&E Topock Compressor Station in Needles, California, Cr[VI] concentrations of up to 8,000 ppb were rapidly treated to less than 0.2 ppb in a pilot test using ethanol. Organic carbon substrates are also as effective as chemical reductants for treatment of Cr[VI] that may be present in immobile pore space in source areas.
    - Generation of By-products. For both organic carbon substrates and soluble chemical reductants, reduction of aquifer minerals and associated dissolution of iron, manganese, and arsenic will occur with in-situ treatment implementation. Due to the highly reactive nature of chemical reductants, concentrations of metals generated may be comparable to or greater

with chemical reductants than with the use of organic carbon substrates, as indicated in EPA comments on the Ffeasibility Sstudy. For example, injection of sodium dithionite is sometimes followed by an extraction phase where several times the injected volume of reagent is extracted due to the production of elevated concentrations of by-products as well as reagent reaction by-products. In addition to dissolution of metals, some chemical reductants may also increase concentrations of other constituents that contribute to total dissolved solids. The reaction products of sodium dithionite include sulfite, thiosulfate, and sulfate. Ferrous iron is often provided as ferrous sulfate, thereby increasing the concentration of sulfate through injections.

- **Monitored Natural Attenuation:** Dilute, diffuse, and/or reduce Cr[VI] to Cr[III] under the geochemical conditions that exist in groundwater in the northern diffuse portion of the plume. Results of an 8-week Pilot Study indicated that portions of the upper aquifer have some reductive capacity, which can reduce low levels of Cr[VI] in groundwater, but the magnitude of this reductive capacity is not sufficient for use as a primary component of a plume-wide remedy, and the cleanup timeframe would be too extensive.

2.11.10 Other Alternatives Considered in the 2002 Feasibility Study

The following list describes the range of other alternatives considered in the 2002 Feasibility Study that were dismissed from further consideration. These alternatives were screened out because they do not meet the project goal and most of the objectives, or have feasibility or effectiveness concerns that precluded them from further consideration. These alternatives are briefly described below, and the reasons they were dismissed from further consideration are identified. Alternatives that were considered in the 2002 Feasibility Study and previously listed as considerations in the 2010 Feasibility Study, such as monitored natural attenuation, ex-situ treatment—ion exchange, ex-situ treatment—coagulation, and microfiltration were discussed above under the discussion of the 2010 Feasibility Study and are not discussed further here.

- **Ex-Situ Treatment—Electrochemical Precipitation:** Use electrical current and reactive electrodes to reduce Cr[VI] and precipitate chromium as Cr[III]. This alternative was not retained because of uncertainty of effectiveness and very high O&M costs from the production of waste requiring transport and disposal.

- **Ex-Situ Treatment—Reverse Osmosis:** Use membranes to remove Cr[VI] from water. This alternative was not retained because of very high O&M costs from the production of waste requiring transport and disposal.

- **Ex-Situ Treatment—Biological Reduction/Precipitation:** Biologically reduce Cr[VI] to less soluble Cr[III] in a bioreactor. Although this alternative can be effective, it was not retained because it requires continual operator oversight, which makes it difficult to implement.

- **Water Reuse/Disposal—Flood Irrigation:** Use overland flow (flood irrigation) to distribute water. Although this alternative is considered to be potentially effective as a reuse option, its effectiveness depends on specific soil conditions at proposed locations (i.e., infiltration ability), the method requires additional operational controls to contain all overland flow from entering adjacent areas, and the method requires fencing to preclude human entry into the irrigated area to avoid exposure. Further, this approach would result in much higher evaporation than drip irrigation included in the project alternatives and therefore ~~lacks the greater beneficial use of~~

~~treated water that results from drip irrigation~~would result in far higher water losses than the drip irrigation included for agricultural units in the studied alternatives.

- **Water Reuse/Disposal—Reuse at Compressor Station:** Reuse treated water at the plant for various purposes, such as process and cooling water. This alternative was not retained because it is effective only if the Compressor Station can use all the water and thus it may be incompatible with Compressor Station operations. Additionally, it is not feasible because of pipeline lengths and extensive permitting and approval required for railway/roadway crossings, and would not meet the fundamental objective of remediating the contaminated groundwater within a meaningful period of time.

- **Water Reuse/Disposal—Reinjection:** Inject treated groundwater into subsurface using wells, infiltration galleries, or recharge basins. This alternative is effective, as was shown during use at the Topock facility, and could be considered in the future at Hinkley. However, this alternative would have to be combined with other technologies in order to actually remediate chromium contamination and thus is not a stand-alone remedial alternative ~~if a subsurface aquifer can accommodate water quantities and thus it is retained only as a backup to drip irrigation systems included in agricultural treatment approaches included in the five project alternatives~~.