PIVOX Corporation
Construction and Remediation

Appendix E

Final Design Cost Estimate: Topock Groundwater Remedy

This memo provides a construction, operations, and management cost estimate based on the Final (100%) Design for the PG&E Topock Groundwater Remedy, in support of the Construction/Remedial Action Work Plan (C/RAWP), PG&E Topock Final Groundwater Remedy (CH2M HILL, Inc., 2015). This summarizes the results of the cost estimate effort, and includes discussion of the estimate's high-level technical basis, assumptions, approach, and exemptions.

Purpose of Estimate

PIVOX Corporation has prepared this construction cost estimate for the Final Design of the PG&E Topock Compressor Station (the Site) final groundwater remedy (the Remedy). The estimate is intended to represent the budgetary cost of the Remedy at the 100% Design stage, and to support PG&E's financial assurance certification for the Project as required by California Code of Regulations Title 22, Sections 66264 and 22.66265, and to address the requirements of Section XIII, Performance Guarantee, of the Remedial Design/Remedial Action Consent Decree, Civil No. 5:13-cv-00074-BRO-OP.

Project Overview

Groundwater activities at the Site are being performed in conformance with the requirements of the Resource Conservation and Recovery Act (RCRA) Corrective Action pursuant to a Corrective Action Consent Agreement (CACA) entered into by PG&E and the California Department of Toxic Substances Control (DTSC) in 1996. In addition, work is governed by the Remedial Design/Remedial Action Consent Decree (CD), executed by PG&E and the Department of the Interior (DOI), under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 2012, which was approved by the U.S. District Court for the Central District of California in November 2013.This memo is packaged with the PG&E Topock Final Groundwater Remedy Final Basis of Design Submittal. Remedy technical design information used to develop this estimate is provided in the Final Remedy BOD Report (CH2M HILL, Inc., 2015) and will not be detailed in herein.

Technical/Scope Basis for Estimate

The Remedy construction estimate used design information, comprised of 100% drawings and specifications provided by the project design teams. As described further in this memo, estimates for Remedy operation, including O&M and Monitoring were developed by PIVOX in collaboration with the design teams.

Refer to the Remedy BOD Report for the technical description of the Remedy.

Project and Cost Estimate Organization

The Final Design cost estimate effort includes the following project components:

1. Construction of the Remedy as specified in the final design documents provided by the design team.

2. Decommissioning of the IM-3 Treatment System as described in the November 2015 IM3 Decommissioning Work Plan (CH2M HILL, Inc., 2015).
3. Operations and Maintenance (O&M) of the Remedy over a 30-year operational period. The first two years of O&M assume a greater operational level of effort and greater annual O&M costs.
4. Groundwater monitoring, surface water monitoring, remedy process monitoring and reporting over a 50-year monitoring period. The 50-year monitoring period encompasses an initial baseline monitoring event, 30 years of Remedy operation, 10 subsequent years of post-Remedy operation, and 10 subsequent years of monitoring related to fresh water injection.
5. MMRPs, Oversight, and Institutional Controls, which include estimates for regulatory oversight, implementation of biological, cultural, and other mitigation measures prescribed in the EIR Mitigation Monitoring and Reporting Program (MMRP), the Cultural and Historic Properties Management Plan (CHPMP), the Programmatic Biological Assessment (PBA), and implementation of institutional controls.
6. Post-Remedy decommissioning and restoration, including decommissioning/removal of Remedy facilities, pipelines, and remediation wells at the end of Remedy operation, and destruction of all Remedy monitoring wells at the end of their monitoring periods.

The work breakdown structure (WBS) developed to organize the Project's component tasks and associated tasks is illustrated in Figure 1. This WBS differs from the project structure described in other design or construction documentation, and was developed specifically for this effort to organize the cost estimate. As shown on Figure 1, Remedy construction is broken into the following Level 1 tasks:

1.1 Construction Management, Project Management, Quality, Compliance, and Administration: Includes project-wide construction and project management, engineering support during construction, health and safety management, implementation of the project quality assurance/quality control program, programmatic compliance, and site operations support. Subcontractor project management costs associated with their completion of discrete construction tasks are included in those construction task line items. This task is subject to change based on PG&E's project management and engineering support contracting strategy.

1.2 Preconstruction and Mobilization: Includes premobilization planning and coordination, any remaining construction permitting, project procurement, and mobilization.

1.3 Park Moabi Road Facilities: Includes construction of the Remedy construction headquarters and soil processing area. A portion of the construction headquarters area is assumed to remain in place after completion of Remedy construction. The soil processing plant is assumed to be used for storage of clean soil after completion of Remedy construction.

1.4 Access Roads: Construction of new site access roads that used to access areas of the site during Remedy construction and operations that currently are not accessible.

1.5 Remedy Well System: Includes pilot borehole drilling and data collection, Remedy remediation and monitoring well construction and development, remediation well testing, and mechanical build-out, including installation of well head and metering vaults. This WBS task includes well site development and civil and mechanical build-out for the freshwater supply well HNWR-1A. This cost estimate includes construction costs for future provisional wells.

1.6 National Trails Highway (NTH) Insitu Remediation Zone (IRZ) & Remedy Pipeline System: Includes trenching and installation of pipelines, electrical conduits, and their associated support infrastructure, including pipeline support bridges and service roads. This task also includes general construction support activities, including hauling of construction water, dust control, and stockpile management. The pipeline construction estimate was broken out as follows (pipeline letter designations are adopted from the Remedy design drawings):

1.6.1. Upland Area Pipelines A and H

1.6.2. NTH IRZ Pipeline C

1.6.3. Riverbank extraction Pipeline G

1.6.4. Transwestern Bench (TWB) associated Pipelines E, F, and J (including associated integrated retaining wall for Pipeline F)

1.6.5. Topock Compressor Station (TCS) injection well and process Pipelines I, K, L, D M, P, T

1.6.6. Freshwater Supply Pipeline B. Pipeline connection or buildout of the contingency expansion to Site B and Topock-2/3 wells is not included.

1.7 Remedy Facilities: MW-20 Bench (MW20B) Facilities: Includes architectural, structural, civil, mechanical, electrical, and process equipment installation for facilities located at the MW-20 Bench and Transwestern Bench. The MW-20 Bench facility estimate includes a new carbon amendment building and carbon substrate storage tank. The Transwestern Bench facility estimate includes a new Operations Building.

1.8 TCS Facilities: Includes architectural, structural, civil, mechanical, electrical, and process equipment installation for facilities located at the TCS, including:

1.8.1. Site process piping and civil work associated with piping connections between facilities that were not given a separate pipeline designation

1.8.2. The Remedy Produced Water Conditioning (RPWC) Plant, including necessary earthwork, retaining walls, and the decontamination pad/foundation for the adjacent provisional fresh water pre-injection treatment system

1.8.3. The influent water tank farm

1.8.4. The conditioned water storage tank

1.8.5. The conditioned water tank farm, including earthwork

1.8.6. Improvements to the TCS evaporation ponds

1.9 Electrical: Includes all Remedy 12-kV, 480-V, and low-voltage electrical power distribution, and electrical connections to all Remedy well sites and facilities, including the fresh water supply well site in Arizona.

1.10 Controls & Communications: Includes all control hardware, powered instrumentation, wired and wireless communications and telemetry installation at wells sites and facilities, and installation and programming of the site wide controls and SCADA system.

1.11 Contingent Fresh water Pre-Injection Treatment System: Includes civil, mechanical, process, and electrical installation. Per PG&E direction, this system is included in the work breakdown structure for completeness, but was not estimated, as it is a contingent scope of work with currently no direction to implement.

1.12 System Functional Testing and Shakedown: Includes all integrated system testing prior to Remedy system startup operation. Note that this does not include individual component installation testing, which is covered in the individual component installation cost estimates.

1.13 Project Closeout: Includes site demobilization and cleanup, preparation of Remedy construction completion documentation and reporting (including project record drawings), and installation of construction mitigation vegetation as described in Appendix X of the Topock Groundwater Remedy Final Construction / Remedial Action Work Plan (CH2M HILL, Inc., 2015).

1.14 TCS Power Supply: Includes installation of the sufficient additional power within the Topock Compressor Station facility to provide adequate power for all remedy systems.

Previous Project Cost Estimates

Previous cost estimates for the Project were completed as part of the Corrective Measures Study/Feasibility Study (CH2M HILL, Inc., 2009), the Project's 30% Design Submittal (CH2M HILL, Inc., 2011), the Project 60% Design Submittal (Haley and Aldrich, Inc.), the Pre-Final (90%) Basis of Design Submittal (CH2M HILL, Inc., 2014), and Supplemental Pre-Final 90% Design Submittal (CH2M HILL, 2015).

The Final Remedy estimate carried forth cost estimate components from the Supplemental Pre-Final estimate where the Final Design project specifications were unchanged from the Supplemental Pre-Final Design. Estimate components carried forth from the Supplemental Pre-Final Design are noted. Otherwise, the Final Remedy construction estimate is the result of new bottom-up estimates based on the Final Design drawings and specifications.

Pre-Final (90%) Design Estimate Response to Comments (RTC)

The Final Design cost estimate includes changes to address agency and stakeholder comments received during review of the Pre-Final (90%) Design cost estimate. Pre-Final (90%) RTC information, including a compilation of comments, PG&E response, and final adjudication are provided in the 90% Final RTC Table (CH2M HILL, Inc., 2015). Revisions to the cost estimate report text in accordance with the RTC

process are identified in this report. Several other RTC revisions resulted in material change to the cost estimate, and are summarized in Table 1. Refer to the 90% Final RTC Table for a full description of the RTC summarized below. Note that although Table 1 describes cost estimate changes specific to the 90% RTC process, these are not the only changes in the project cost estimate.

Table 1: Summary of 90% RTC Cost Changes

RTC #	90% DESIGN COMMENT SUMMARY	SUMMARY OF ADJUDICATED RESPONSE	100% DESIGN COST IMPACT ESTIMATE
DOI-227, DTSC-116	Cost estimate for regulatory oversight appears inadequate.	Task estimate revised based on review of recent regulatory oversight costs and estimate of fraction of total regulatory oversight costs that is associated with Remedy construction	Increase of $2.9MM to Regulatory Oversight task estimate
DTSC-114	Contingency (5%) too low, DTSC guidance is to apply a contingency between 10-20%	Contingency will be increased to 15%	Increase of $13.8MM to Remedy construction cost estimate (compared using a 5% contingency, which was used in the 90% Design estimate)
DTSC-115	Cost estimate should include installation of future provisional wells.	Future provisional well installation has been added to the remedy well construction estimate	Increase of $19MM to the Remedy well construction task estimate (only due to added wells, not including contingency change).
DTSC-117	Revise present value discount factor to 1.4%	Final (100%) Design present value evaluations will use a discount rate of 1.4%	Increase of $35MM to the present value estimate of the GW Remedy lifecycle (from

			construction through decommissioning)
DTSC-118	Include estimate for DTSC reporting in the Post-Remedy estimate	A line item for DTSC Report submittal/review was added to the Post-Remedy task estimate	Increase of $250k to the Post-Remedy task estimate

Estimate Classification

The Association for Advancement of Cost Engineering (AACE) provides a guideline on classifying construction cost estimates to aid in review or evaluation of the estimate. This estimate has been classified using AACE Practice 18R-97 (AACE International, 2011), which provides framework specific to process-oriented engineering-procurement-construction projects. The AACE 18R-97 estimate classification definition is excerpted from the guidance in Table 2.

Estimate classifications for different components of the Project are described on Table 3. Due to the very wide scope of the estimate, and the varying degrees of scope detail for the different components of the Project, this estimate provides different classifications for the different major Project components, including the major Remedy construction and operations categories. The Final Design cost estimate has classified various components of the Remedy estimate as Class 2, Class 3, or Class 4.

Table 2: AACE 18R-97 Estimate Classification Definitions

	PRIMARY CHARACTERISTIC	***SECONDARY CHARACTERISTIC***		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges[(a)]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%

Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

A Class 2 estimate is defined as one used to form a detailed baseline cost for the project. Class 2 estimates generally involve a high degree of deterministic estimating methods. For scope items that are not fully defined, a Class 2 estimate will develop a detailed takeoff, but may use an assumed approach, estimated quantities, or assumed unit rates.

A Class 3 estimate is defined as one used to form the basis of a project budget authorization against which actual costs can be monitored. A Class 3 estimate would generally utilize unit cost line items, but with less precision than a Class 2 estimate (e.g., developing unit costs for assemblies instead of individual components). A Class 3 estimate may use cost factors or other stochastic methods when lack of scope definition or detail requires less deterministic methods.

A Class 4 estimate is defined as one used when detailed technical information or scope definition is not available, and is used for long-term planning, feasibility evaluation, and budget development or approval.

Table 3: Remedy Estimate Classification Summary

Final Design Estimate Component	AACE Classification	Intended Accuracy Range	Comments
Remedy Construction: Management, Site Support, General Conditions	Class 3	-20% to +30%	Construction management, engineering support during construction, and project management organizational charts described in the C/RAWP, and subject to change. Full site support personnel requirements to be determined during detailed construction planning.
Remedy Construction: Remediation Well Construction	Class 3	-20% to +30%	Materials (stainless steel casing) are fungible and thus

Final Design Estimate Component	AACE Classification	Intended Accuracy Range	Comments
			highly variable. Estimate includes future provisional wells that may not be required.
Remedy Construction: Monitoring Well Construction	Class 2	-10% to +20%	Materials (stainless steel casing) are fungible and thus highly variable.
Remedy Construction: Pipeline and Conveyance	Class 2	-10% to +20%	Includes IRZ, Fresh water extraction, Plume extraction, Fresh water injection, and IRL pipelines not located at TCS
Remedy Construction: TCS Pipelines and Connections	Class 2	-10% to +20%	Scope uncertainty associated with unknown underground utilities within pipeline alignments
Remedy Construction: MW20B Facilities	Class 2	-10% to +20%	
Remedy Construction: TWB Facilities	Class 2	-10% to +20%	
Remedy Construction: TWB Site Civil and Grading	Class 2	-10% to +20%	
Remedy Construction: TCS RPWC Plant and Water Storage Facilities	Class 2	-10% to +20%	
Remedy Construction: TCS Site Civil and Grading	Class 3	-20% to +30%	Scope uncertainty associated with level of effort associated with rock excavation at TCS
Remedy Construction: TCS Evaporation Pond Improvements	Class 2	-10% to +20%	Scope uncertainty due to equipment spec level of detail
Remedy Construction: Electrical Distribution	Class 3	-20% to +30%	Materials (power cable) are fungible and thus highly variable.
Remedy Construction: Controls & Communications	Class 2	-10% to +20%	
Remedy Construction: Functional Testing	Class 2	-10% to +20%	

Final Design Estimate Component	AACE Classification	Intended Accuracy Range	Comments
Remedy Construction: TCS Power Supply	Class 2	-10% to +20%	Design and estimated by PG&E as an integrated TCS facility
IM-3 Decommissioning	Class 3	-20% to +30%	Decommissioning work plan provides approach, but not a detailed specification. Required use of assumed unit rates.
Remedy Operations: System O&M	Class 2	-10% to +20%	Scope developed with design team using remedy process operational experience and technical judgment
Remedy Operations: Groundwater Monitoring and Reporting	Class 2	-10% to +20%	Uncertainty in sample quantities and required analyses through duration of monitoring period
Remedy Construction: Mitigation Measures and Institutional Controls	Class 3	-20% to +30%	Mitigation monitoring estimates are forced-detailed unit cost estimates. Full site support regulatory compliance personnel requirements to be determined during detailed construction planning.
Post-Remedy: Site Restoration	Class 4	-30% to +50%	Costs to be incurred 30-50 years in the future, no detailed specifications.
Post-Remedy: Well Decommissioning	Class 4	-30% to +50%	Costs to be incurred 30-50 years in the future.

As shown on Table 3, most Remedy construction tasks were able to be given a Class 2 estimate, as at present there is not a bid package that describes contract general or special conditions, underground utility locations have not been physically confirmed (e.g, potential unknown underground utilities at the TCS), , and construction procurement is not expected to begin until 2017. The remediation well and electrical construction tasks were assigned as Class 3 estimates; primarily due to variable materials prices that are not expected to be procured until the construction project is underway. The TCS site civil

construction task was assigned as a Class 3 estimate due to the lack of geotechnical data to evaluate the effort necessary to perform rock excavation for TCS facility construction.

The estimate for IM-3 decommissioning was defined as a Class 3 estimate due to forced assumptions on waste characterization of decontamination liquids, the level of decontamination required for equipment removal, and the volume of wastes generated during decontamination. IM-3 decommissioning will also take place after Remedy startup is complete, and IM-3 pipeline removal will have to work around the newly-built Remedy pipelines.

Post Remedy task estimates were defined as Class 4 estimates. These tasks have not undergone detailed scoping specification, and occur 30 to 50 years in the future.

Estimate Contingencies and Markups

The Remedy construction estimate has applied a 15% bottom-line contingency to the cost estimate.

The IM3 decommissioning and Remedy operations and monitoring cost estimate carried a 15% bottom-line contingency. Task-specific contingencies were not applied. The IM3 decommissioning estimate contingency used a 15% contingency due to lack of detailed specifications and limited waste characterization information for decontamination wastes. Although the scope for Remedy operations work is well defined, the long period of performance for these tasks (30 years for O&M and 50 years for Monitoring) require a larger contingency to account unforeseen changes to the project's scope, regulatory requirements, technical challenges, and other project uncertainties that cannot be predicted.

The Post Remedy restoration estimate carried a 25% bottom-line contingency, due to the relatively undefined scope of work for this task, and the fact that this work would be taking place 30 to 50 years in the future.

The following markups, which are conservative but realistic, pending development of project contractual conditions, were applied to the Remedy construction estimate:

- Labor: 10%, to account for all project labor costs, to account for top-level contractor labor general and administrative expense and profit.
- Materials: 10%, to account for vendor/procurement markups
- Subcontracts: 10% to account for subcontract markup
- Other Direct Costs (e.g., per diem, travel): 2% to account for administrative costs associated with carrying these costs

Remedy Estimate

The Final Design cost estimate for Remedy construction is included as Table 3, attached. Table 3 includes Supplemental Pre-final (90%) Design estimate values for each high-level task breakdown to aid in comparison.

Note that the work breakdown structure shown in Table 3 does not follow the work breakdown structure shown in Table 3 of the Pre-Final and Supplemental Pre-Final (90%) Remedy BOD Reports. The work breakdown structure was revised for the 100% estimate to better match the expected construction contract structure for the project. PIVOX redistributed construction task estimates from the Pre-Final and Supplemental Pre-Final estimates to be able to appropriately compare estimate line items between the Final (100%) and Pre-Final/Supplemental Pre-Final (90%) estimates.

Estimates for non-capital components of the Final Design estimate, including O&M and groundwater monitoring, are summarized in Table 4, which follows the format used in previous estimates to aid in comparison.

Estimate Components and Methodology

Remedy Construction

Construction of remedy pipelines, groundwater extraction, conveyance, and injection civil and mechanical infrastructure were estimated, to the extent possible, by PIVOX as if PIVOX was bidding to perform the work. A true "bid" estimate would not be possible without bid-level scope definition and contract conditions.

Construction management, project management, project quality program implementation, site operational support, and engineering support during construction were estimated by applying a percentage factor to the construction cost estimate.

Electrical and controls installation, site civil development, remediation well construction and testing, monitoring well construction, trenchless pipeline installation, and process facility construction, were estimated by appropriate and qualified contractors in collaboration with PIVOX.

For remediation and monitoring well construction, PIVOX solicited detailed cost estimates from a pre-selected drilling firm, and estimated well drilling, development, testing, and waste management tasks as described in the C/RAWP (CH2M HILL, Inc., 2015).

PIVOX solicited cost estimate development support from the following contractors for the major (with significant cost impact) specialty construction work:

1. Construction headquarters construction: Redmond Construction, Mohave Valley, Arizona, Colorado River Plumbing, Needles, California, and Robinson Electric Co., Inc., Laughlin, Nevada
2. Process facility vertical construction: Redmond Construction, Mohave Valley, Arizona, and Apex Building Construction, Gardena, California (specialty subs not listed)
3. Process facility mechanical and process equipment installation: Corey Delta Constructors, Benicia, California

4. Remediation well pilot borehole drilling and data collection (associated with both remediation and monitoring wells), and monitoring well drilling and development: Cascade Drilling, L.P., Peoria, Arizona
5. Remediation well drilling, development, and testing: Cascade Drilling, L.P., Peoria, Arizona
6. Building/facility code electrical construction: Robinson Electric Co., Inc., Laughlin, Nevada
7. Remedy process electrical and controls/communications systems construction: Presidio Systems Incorporated, Livermore, California
8. Trenchless construction, including jack-and-bore: Pacific Boring, Caruthers, California
9. Colorado River bridge pipe crossing: ARB, Inc., Lake Forest, California
10. IM-3 treatment plant decommissioning and deconstruction: PSC, Inc., San Ramon, California

All major materials and equipment were estimated by soliciting actual purchase estimates from appropriate and qualified vendors, using actual equipment makes/models specified in the design. Where specific makes/models were not specified in the design, PIVOX used technical judgment and experience with similar projects to develop equipment prices estimates. Equipment estimates include allowances for sales tax and freight for delivery to the Site.

The Remedy construction estimate is summarized in Table 3.

IM-3 Decommissioning

IM-3 Decommissioning work was estimated using the Final IM-3 Decommissioning Work Plan (CH2M HILL, Inc., 2015). The Work Plan did not provide detailed specifications, but did provide a description of the approach for decommissioning the IM-3 treatment plant and its associated infrastructure. This estimate assumes that both above- and underground pipelines will be fully removed (instead of abandoned in-place), which was not specified in the Work Plan.

The estimate also included cleaning and decontamination of all IM-3 mechanical, electrical, and process equipment, and deconstruction of the plant, including the plant's foundation, office/laboratory trailer, utility connections, and shade structure. At the MW-20 Bench location, the estimate included removal of the IM-3 conveyance manifold valve structure. The estimate does not include salvage value; any equipment designated in the Work Plan for potential salvage is assumed to be secured on-site for PG&E salvage. As IM-3 decommissioning will take place after Remedy construction is complete, construction management, dedicated project management, and engineering support allowances were added to this estimate.

The IM-3 decommissioning estimate is summarized in Table 3.

Remedy O&M

The O&M estimate was developed in collaboration with the design team. The design team developed the scope of work, level of effort, and labor designations for O&M of the Remedy through 30 years of operation.

The Remedy O&M estimate includes the following:

1. O&M of the NTH IRZ, including operations of the NTH IRZ remediation wells, and carbon amendment and support facilities at the MW20B
2. O&M of the RPWC Plant, fresh water extraction well, riverbank extraction wells, east ravine extraction wells, TCS injection wells, TWB extraction wells, fresh water injection wells, and Inner Recirculation Loop injection wells
3. Operation of the remedy pipeline Clean-In-Place system and periodic remedy pipeline cleanout
4. Maintenance and rehabilitation of the NTH IRZ wells, extraction wells, and injection wells
5. Maintenance of the long term remedy support and clean soil storage areas

The O&M estimate includes system operations using local operators, non-local engineering support and project management, system consumables, and a stipend for equipment replacement. NTH IRZ O&M assumed a two year operational cycle consisting of a 6-month active operation followed by an 18-month inactive period.

To account for the extra effort required during initial operations, the O&M estimate assumed a higher level of effort for the first 2 years of operation, which includes the designated Remedy startup period.

The O&M estimate is summarized in Table 4.

Remedy Well Replacement

Remedy IRZ, extraction, and injection wells can be expected to require replacement over the 30-year operating life of the Remedy. Well replacement was estimated as an annual cost using 2% of the total remediation well installation capital cost estimate, not including future provisional wells.

The Remedy well replacement estimate is summarized in Table 4.

Groundwater, Surface Water, and Process Monitoring and Reporting

Groundwater, surface water, and process monitoring and reporting was estimated by ARCADIS US, Inc., the firm that is currently contracted to implement the site groundwater monitoring program. ARCADIS estimated sample collection, sample analysis, well transducer data collection, and reporting for a 50-year reporting period (30 years of monitoring during active remediation and 20 years of long term monitoring). The estimate includes sampling, analysis, data management, and reporting for the fresh water supply well, and analytical, data management, and reporting costs associated with process monitoring at the for in-situ systems and RPWC, as described in the sampling and monitoring program

set forth in the O&M Manual Volume 2 (Sampling and Monitoring Plan), included in the Final BOD submittal.

The Groundwater, Surface Water, and Process Monitoring estimate is summarized in Table 4 and detailed in Attachment A. The annual averages provided in Table 4 include an average for the 30 years of Remedy operation, and an average for the following 20 years of post-Remedy monitoring. The expected evolution of the monitoring program during and after Remedy operation is detailed in Attachment A.

MMRPs, Oversight, and Institutional Controls

Implementation of specific biological, cultural, and environmental controls during construction of the remedy is required by the Project EIR, the MMRP, the PA (Bureau of Land Management, 2010), the CHPMP (Bureau of Land Management, 2012), and the PBA (CH2M HILL, Inc., 2014). The estimate for this task includes costs associated with the formation and continued operation of the Technical Review Committee. The mitigation measure, regulatory oversight, reporting, stakeholder oversight, and biological and cultural oversight estimates were reviewed and calibrated to, where possible, against actual recent PG&E expenditures for equivalent tasks underway during ongoing implementation of the Topock remediation program. Line item estimates for mitigation measures that were completed after the Pre-Final Design cost estimate were removed.

As these tasks are required to maintain project compliance during Remedy construction, this estimate is shown as a capital cost line item on Table 3. A detailed breakdown of this estimate is provided in Table 5.

Post Remedy Decommissioning and Restoration

These tasks include site restoration, decommissioning of monitoring wells, and decommissioning of remediation and monitoring wells after completion of the remedy (30-50 years after startup), including preparation and submittal of the necessary Remedy closeout reports for DTSC review. These costs cannot currently be estimated with a high degree of confidence, as post-remedy work will not commence until at least 30 years from the start of remedy operation.

Well Decommissioning/Destruction

Well decommissioning was estimated using decommissioning procedures described in the project Standard Operating Procedures (SOPs) (PG&E, 2014). The estimate includes destruction of 233 monitoring wells and 47 remediation wells. Where a remediation well consists of multiple borings, the estimate includes destruction of all borings associated with that well. The estimate includes full removal and disposal of all surface infrastructure, down-well equipment, and wastes generated during the work.

This estimate is unchanged from the 90% estimate, as specification for well decommissioning/ destruction did not change during Final design development.

Pipeline and Access Road Removal

This estimate is unchanged from the 90% estimate, as specification for pipeline and access road removal did not change during Final design development. The 90% estimate added full removal of Remedy pipelines during post-Remedy restoration, as opposed to abandoning in place. The 90% estimate also reflects removal of the additional quantity of access roads included in the 90% design, but uses the same removal unit rate as the 60% design estimate.

Facility Deconstruction and Area-Wide Restoration

Deconstruction of Remedy facilities were estimated by using the 90% estimate for IM3 decommissioning to develop unit rates for deconstruction of Remedy facilities. The deconstruction estimate includes decontamination of facility process equipment and waste disposal. This estimate is unchanged from the 90% estimate, as specification for facility deconstruction and site restoration did not change during Final design development.

Post remedy restoration costs are shown as a line item in Table 3.

Estimate Assumptions & Exemptions

1. Topock Compressor Station improvement projects not specifically required for remedy operation (i.e., Compressor Station Integration Projects) were not included. Work not included:
    a. Upgrades to TCS to reduce waste water generation
    b. IT infrastructure upgrades
    c. Fence realignment
2. The estimate does not include construction or operation of the contingent fresh water supply well and pipeline, or the fresh water pre-injection treatment system.
3. Estimates are in current dollars, and do not factor in cost escalation due market conditions, inflation, or related factors.
4. The estimate was developed as if PIVOX will self-perform underground pipeline construction work.
5. Construction management costs have been estimated on the assumption that one prime general contractor will be retained by PG&E for the project, and will subcontract construction tasks as shown on Table 3. “Labor” indicates general contractor labor. A different management/contracting approach may change this estimate. Further efficiencies from the contracting process or contractor value engineering/optimization not factored in this estimate. Subsequent value engineering or contract strategy savings to be developed at the appropriate time.

6. PG&E diversity spend goals were factored into the estimate. This included searching for and using diversity subcontractors where feasible.
7. No prevailing wages for work off the TCS. Construction labor at the TCS assumes prevailing wages. This may require separate contractors working at these different locations, and this approach has not yet been confirmed.
8. Non-Prevailing wage pipeline and earthwork construction labor and equipment rates were based on PIVOX experience at PG&E remediation projects, including Hinkley. Hinkley is located in San Bernardino County in the high Mojave Desert, and can be expected to have similar wage rates as the Topock area. Pricing will be based on the PIVOX wage scale for tasks assumed to be self-performed and on subcontractors' actual wage scales for the subcontractors utilized to compile the estimate.
9. Equipment rates were developed based on current PG&E Chromium Program contracted equipment rates. Equipment rates generally use a weekly rate basis.
10. The MMRP mitigation measure estimate did not include costs for a Disturbance Coordinator, as it is assumed that the Coordinator will be a PG&E employee.
11. No perimeter or worker air sampling is required. Air monitoring will be restricted to handheld dust meters and PID to be utilized by site H&S personnel as needed. Air monitoring may be required during work at designated Areas of Concern, however this cannot be estimated without additional soil characterization data and a worker/public exposure hazard evaluation, which was not performed.
12. Level D personal protective equipment to be employed throughout the project.
13. Standard 5-day working schedule, except for limited long-duration well installation tasks. No night work or work during public holidays for estimating purposes. A different schedule may ultimately be utilized in an effort to expedite schedule, lower labor costs, or minimize health and safety risks associated with working in the Topock summer season.
14. All soil generated during remedy construction will either be reused or stored on-site (at soil handling area) pending establishment of site-specific soil cleanup concentrations and additional characterization, as appropriate. No soil will be sent off-site as (RCRA or California) hazardous or non-hazardous waste.
15. Wastewater generated during drilling, development and well testing will be managed by processing at the IM-3 plant, disposal at the TCS evaporation ponds, or reinjection during injection well testing (well testing water only). Transfer to occur by using remedy pipelines to the extent possible, temporary pipelines, or water trucks and portable tanks, to as needed.

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Table 3: Remedy Construction Cost Estimate
Final Design, Final Groundwater Remedy
PG & E Topock Compressor Station

December 4, 2015

							100% Design Cost Estimate Task Totals						90% Supplemental Design Cost Estimate Task Totals	Comparison	
WBS #	Description	Labor	Materials	Equipment	Subcontracts	Other Direct Cost	100% Design Total Cost w/o Contingency or Markup	Contingency	Allocated Contingency (%)	Total w/ Contingency	Markup	Estimated Cost w/ Contingency & Markup	90% Supplemental Design Total Cost w/o Contingency or Markup	100% vs 90% Supplemental w/o Contingency or Markup	
														Delta Cost	%
1	**Remedy Construction**														
1.1	**Construction Management, Quality, Compliance, Administration**	$18,765,050	-	-	-	-	$18,765,050	$2,814,757	15.0%	$21,579,807	$1,876,505	$23,456,312	$14,625,274	$4,139,776	28%
1.2	**Preconstruction and Mobilization**	$394,208	$234,363	$118,673	$109,857	$23,891	$880,992	$132,149	15.0%	$1,013,141	$86,188	$1,099,329	$1,059,745	($178,753)	-17%
1.3	**Park Moabi Rd. Facilities**	-	-	-	$4,023,905	-	$4,023,905	$603,586	15.0%	$4,627,491	$402,391	$5,029,882	$3,934,689	$89,216	2%
1.4	**Access Roads**	$80,868	$257,284	$53,654	$239,512	$21,045	$652,364	$97,855	15.0%	$750,218	$63,553	$813,771	$950,670	($298,306)	-31%
1.5	**Remedy Well System**	$5,286,092	$4,277,009	$291,564	$29,549,679	$1,737,421	$41,141,765	$6,171,265	15.0%	$47,313,029	$3,975,183	$51,288,212	$29,607,446	$11,534,319	39%
1.6	**Remedy Pipeline System**	$6,779,350	$5,058,573	$3,526,169	$2,911,316	$1,417,299	$19,692,707	$2,953,906	15.0%	$22,646,613	$1,855,887	$24,502,500	$21,316,815	($1,624,108)	-7.6%
1.7	**Remedy Facilities**	-	$555,651	-	$3,429,514	-	$3,985,165	$597,775	15.0%	$4,582,940	$398,517	$4,981,457	$4,332,561	($347,396)	-8.0%
1.8	**Topock Compressor Station (TCS) Facilities**	-	$1,434,060	-	$4,849,601	-	$6,283,662	$942,549	15.0%	$7,226,211	$628,366	$7,854,577	$6,554,491	($270,830)	-4%
1.9	**Electrical**	-	-	-	$5,940,316	-	$5,940,316	$891,047	15.0%	$6,831,363	$594,032	$7,425,395	$5,345,215	$595,101	11%
1.10	**Controls and Communications Systems**	-	-	-	$2,605,417	-	$2,605,417	$390,813	15.0%	$2,996,230	$260,542	$3,256,771	$2,350,583	$254,834	11%
1.11	**TCS Contingent FWPTS**	-	-	-	-	-	-	-		-	-	-	-	-	
1.12	**System Functional Testing & Shakedown**	$818,700	-	-	-	$151,680	$970,380	$145,557	15.0%	$1,115,937	$84,904	$1,200,841	$970,380	$0	0%
1.13	**Project Closeout**	$411,452	$72,995	$66,832	$10,588	$143,745	$705,612	$105,842		$811,453	$59,062	$870,515	$239,104	$466,508	195%
1.14	**TCS Generator**	-	-	-	$12,274,746	-	$12,274,746	-	-	$12,274,746	-	$12,274,746	$12,274,746	$0	0%
2	**IM-3 System Decommissioning**	$407,875	$22,500	$149,625	$852,043	$70,950	$1,502,993	$225,449	15.0%	$1,728,442	$144,623	$1,873,066	$1,502,993	$0	0%
5	**MMRPs, Oversight, and Institutional Controls**	-	-	-	-	$9,680,000	$9,680,000	$1,452,000	15.0%	$11,132,000	$193,600	$11,325,600	$5,580,000	$4,100,000	73%
	Total Cost Without Contingency	$51,708,644	$11,912,436	$4,206,517	$66,796,495	$13,246,032	**$129,105,074**						$110,644,713	$18,460,361	
	Contingency on Total Cost							$17,524,549							
	Total Cost Including Contingency									$146,629,623					
	Total Markup										$10,623,350				
	Total Cost Including Contingency & Markup											**$157,252,974**	$124,866,458	$32,386,516	
	Bonding and Insurance											$3,145,059	$2,497,329	$647,730	
	Total Cost Including Contingency, Markup, Bonding & Insurance											**$160,398,033**	$127,363,787	$33,034,246	
	Post-Remedy Completion											$20,228,825	$19,978,825	$250,000	
	Total Cost Including Contingency, Markup, Bonding, Insurance & Post-Remedy Work											**$180,626,858**	$147,342,612	$33,284,246	23%

Notes:
Estimate task contingencies changed to 15% from 5% per RTC DTSC-114
Provisional wells are now included in remediation well estimate per RTC DTSC-115
MMRP estimate revised per DOI-227, DTSC-116
Post Remedy Completion estimate revised per DTSC-118

Table 4: Remedy Operational Cost Summary
Final Design, Final Groundwater Remedy
PG & E Topock Final Groundwater Remedy

December 4, 2015

	Pre-Final (90%) Design Updated Cost			Final (100%) Design Updated Cost		
Description	**Annual O&M**	**Annual Long Term Monitoring**	**Comments**	**Annual O&M**	**Annual Long Term Monitoring**	**Comments**
Duration	**30 years**	**20 years**		**30 years**	**20 years**	
Ex-Situ Treatment Plant O&M	$620,000	$0	Includes O&M of Remedy Produced Water Conditioning Plant (RPWC), freshwater supply well, freshwater injection wells, and O&M labor for IRL and TCS recirculation loops. Assumes local operators with remote office-based engineering support. Includes coagulant and solids disposal. Uses 3% of initial equipment installation material and labor costs to estimate annual equipment replacement costs. Assumes greater O&M level of effort (15% increase) during Year 1-2 startup period. Includes periodic use of Aqua Gard (TM) on extraction and injection wells assuming a Code Yellow frequency as described in O&M Manual.	$610,000	$0	Basis of estimate unchanged from 90% Design estimate. Revisions include updated consumables cost from new vendor quotes and from current IM3 operational data. Revised equipment replacement estimate based on elimination of TWB CA system and updated mechanical equipment/labor costs..
Freshwater well maintenance & pumping	$82,000	$0	FW supply well maintenance already included in Ex-Situ Plant O&M estimate. Cost is for electrical power for operation of FW supply well, assuming 24-hour operation. Supply well maintenance is estimate in Maintenance of Wells estimate.	$82,000	$0	Unchanged from 90% design estimate.
IRZ	$490,000	$0	Includes O&M of IRZ wells and supporting facilities. Assumes local operators with remote office-based engineering support. Uses 3% of initial equipment installation material and labor costs to estimate annual equipment replacement costs. Assumes greater O&M level of effort (15% increase) during Year 1-2 startup period. Includes CIP operations and periodic pipeline cleanout, although actual magnitude of these activities not yet well understood.	$470,000	$0	Basis of estimate unchanged from 90% Design estimate. Revisions include updating equipment replacement estimate based on 100% design IRZ construction estimate. Pipeline G (Riverbank extraction pipeline) was added to the pipeline CIP operational cost estimate.
Remedy Well Replacement	$360,000	$0	Based on replacing 47 total remediation well borings, using of 2% of total well installation costs (including well civil and mechanical buildout) from the 90% remedy well estimate.	$400,000	$0	Used of 2% of total well installation costs for all remediation wells (including well civil and mechanical buildout) from the 100% remedy well estimate. Well construction totals used to estimate replacement does not include provisional wells. Estimate revised based on updated well construction cost estimate.
Rehabilitation of Wells	$1,200,000	$0	IRZ well rehabilitated twice per year, injection wells rehabilitated once per year, and injection wells rehabilitated every year, extraction wells rehabilitated every 4 years, and upper screen of riverbank wells rehabilitated every 8 years. Rehabilitation with Nu-Well 120 and Nu-Well 310. Level of effort based on similar rehab at Hinkley site wells.	$1,100,000	$0	Basis of estimate unchanged from 90% estimate. Revised based on revised remediation well design, and updated chemical costs.
Groundwater/Surface Water Monitoring	$654,279	$53,739	Includes groundwater monitoring, remedy system process sample analytical costs, transducer network operation, data management, QAQC, and combined reporting. Long term monitoring through Year 50. Higher level of effort in Year 1 and 2 due to higher frequency remedy process monitoring during startup years. Assumes predominantly low-flow sampling for compliance and grab sampling for process monitoring.	$830,329	$149,304	Added initial baseline sampling from GW monitoring network prior to first annual sampling event. Revised estimate to reflect 100% design groundwater monitoring program monitoring wells, analytes, sampling frequency, data collection program, and reporting requirements. Otherwise basis of estimate is unchanged from 90% estimate.
Reporting - Site-wide groundwater monitoring	$0	$0	See above	$0	$0	See above
Reporting - Performance	$0	$0	See above	$0	$0	See above
Other facilities - road maintenance and construction HQ.	$68,000	$0	Assume $5/linear feet for road maintenance, with a total service road length of 6800 linear feet (increased from 800 linear feet in 60% estimate). 90% estimate also includes maintenance of Park Moabi constructrion headquarters and soil bin area through Year 30.	$109,000	$0	Basis of estimate unchanged from 90% Design estimate. Revised based on updated Construction HQ construction estimate.
Other O&M Costs						
Project Management	$115,000	$115,000	No change from 60% design. Site wide management, PM for O&M and Groundwater Monitoring programs included in line items above.	$115,000	$115,000	No change from 60% design.
Permit Compliance	$360,000	$72,000	No change from 60% design.	$360,000	$72,000	No change from 60% design.
Groundwater ICs	$20,000	$20,000	No change from 60% design.	$20,000	$20,000	No change from 60% design.
Biological Surveys	$100,000	$20,000	No change from 60% design.	$100,000	$20,000	No change from 60% design.
Cultural Surveys	$16,667	$10,000	No change from 60% design.	$100,000	$20,000	Revised estimate such that cultural survey estimated annual cost is equal to the biological survey estimate, which more accurately reflects the expected level of effort for cultural surveys during Remedy operation.
Reg/stakeholder oversight	$100,000	$20,000	No change from 60% design.	$100,000	$20,000	No change from 60% design.
Water Rights	$630	$0	No change from 60% design.	$630	$0	No change from 60% design.
5-year reviews	$15,000	$15,000	No change from 60% design.	$15,000	$15,000	No change from 60% design.
Power Supply O&M	$10,000	$0	No change from 60% design.	$10,000	$0	No change from 60% design.
Arsenic and Fluoride Treatment Plant	$0	$0	No contingent system O&M costs included in 90% estimate.	$0	$0	No contingent system O&M costs included in 90% estimate.
SUBTOTAL	$4,211,576	$325,739		$4,421,959	$431,304	
Contingency	$631,736	$48,861	15% contingency	$663,294	$64,696	15% contingency
TOTAL	**$4,843,312**	**$374,599**		**$5,085,253**	**$496,000**	

Assumptions:
Task descriptions, 90% estimate values, and 90% estimate task notes are copied directly from 90% BOD.
All remedy produced water is reused or disposed of on-site.
No additional mitigation measures are included in these estimates.
30 years of active remediation followed by 20 years of post-remediation long term monitoring.
See backup calculations for Ex-Situ, IRZ, and well rehabilitation O&M estimates.
See Arcadis 2015 Topock Final Groundwater Remedy Final (100%) Design, GW Monitoring Estimate Basis, for groundwater monitoring estimate details.

Table 5: Cost Estimate; MMRPs, Oversight, and Institutional Controls December 4, 2015
Final Design, Final Groundwater Remedy
PG & E Topock Compressor Station

Category	Mitigation Measure ID	Deliverable / Explanation	Estimated Cost - Final (100%) Design	Changes to Final (100%) Design Estimate	Estimated Cost - Pre-Final (90%) Design
Mitigation Measures					
Cultural	CUL-1a-2	Access Plan	**$0**	Access Plan completed and submitted to Agencies, no future expenditure expected.	$5,000
Cultural	CUL-1a-3 (c)	Retain cultural resource consultant to implement MMRPs and conduct inspections. Retain tribal monitors during construction as designated by tribal leadership. This estimate was prepared during the 60% design, and is carried over to 90% as this requirement remains.	**$330,000**	No change.	$330,000
Cultural	CUL-1a-3 (c)	Park Moabi outreach effort, including installation and staffing of informational kiosk.	**$60,000**	No change.	$60,000
Cultural	CUL-1a-3 (b)	Site Security Plan: Additional nominal costs for submittal and response to comments.	**$0**	Site Security Plan completed and submitted to Agencies, no future expenditure expected.	$5,000
Cultural	CUL-1a-3 (d)	Posting signage to delineate off-road access.	**$25,000**	No change.	$25,000
Cultural	CUL-1a-4	Convene and retain Technical Review Panel through duration of construction field activities. Assumed durations is 14 quarters, per Section 3.2 of Construction/Remedial Action Work Plan	**$2,920,000**	Estimate revised based on review of actual TRC expenditures, extended through a 4-year construction period.	$2,520,000
Cultural	CUL-1a-5	Plant survey to identify plants listed in EIR Appendix PLA and three repeat visits. Mapping of protected plants, and developing plan to monitor and manage protected species propagrules.	**$250,000**	No change.	$250,000
Cultural	CUL-1a-11	Grant for tribal cultural resource specialist during construction field activities. Assumed duration is 14 quarters, per Section 3.2 of Construction/Remedial Action Work Plan	**$1,320,000**	Estimate revised based on review of actual cultural resource specialist expenditures, extended through a 4-year construction period.	$525,000
Cultural	CUL-1a-13	Educational Plan: Additional nominal costs for submittal and response to comments.	**$5,000**	No change.	$5,000
Cultural	CUL-1b/c-2	Resources Study: Additional nominal costs for submittal and response to comments.	**$0**	Geo-arch Resources Study completed and submitted to Agencies, no future expenditure is expected.	$10,000
Cultural	CUL-1b/c-3	Treatment Plan: Additional nominal costs for submittal and response to comments.	**$10,000**	No change.	$10,000
Noise	NOISE-1.1	Vibration Receptor Study	**$0**	Completed during Final Design effort, no future expenditure expected.	$25,000
Noise	NOISE-1.2	Provide Disturbance Coordinator during construction, O&M, and decommissioning.	**$0**	No change.	$0
Noise	NOISE-2.3	Noise Monitoring during construction field activities. Includes background study, downloads, and data compilation.	**$180,000**	No change.	$180,000
Waste	HAZ-1a.3	Hazard Materials Business Plan that provides project-specific chemical standard operating procedure protocols and contingency plans to ensure that proper response procedures are implemented in the event of spills or releases.	**$50,000**	Added new estimate to update project Hazard Materials Business Plan for submittal to San Bernardino County when required during construction.	$0
Monitoring and Regulatory Costs					
Institutional Controls and Administrative Approvals		From 90% Estimate, scope for this line item has not changed during 100% development.	**$1,000,000**	No change.	$1,000,000
Biological Monitoring		From 90% Estimate, scope for this line item has not changed during 100% development.	**$330,000**	No change.	$330,000
Regulatory Oversight		$800K annual cost, spent over 4 years for construction planning oversight.	**$3,200,000**	Revised per RTC DOI-227 and DTSC-116 based on review of actual regulatory oversight costs.	$300,000
		Total Oversight and Mitigation Measure Capital Estimate:	***$9,680,000***		*$5,580,000*

Notes
1. Costs compiled from June 2014 EIR Mitigation cost estimates (with exception of Noise 2.3), completed by CH2M HILL and ARCADIS. Reviewed during Final (100%) Design effort to capture project mitigation/oversight planning progress since Pre-Final Design effort.
2. Disturbance coordinator is internal PG&E position, not a separate cost line item.
3. Oversight and mitigation measure costs above are to be completed over construction duration, and are accordingly considered capital costs to be included with the remedy construction cost esimate.

- Topock Groundwater Remedy
  - 1. Remedy Construction
    - 1.1 Construction Management, Quality, Compliance, Administration
      - 1.1.1 PM, CM, Site Ops
      - 1.1.2 Engineering & QC
      - 1.1.3 QA & MMRP Compliance
    - 1.2 Preconstruction and Mobilization
      - 1.2.1 Submittals & Work Plans
      - 1.2.2 Permitting
      - 1.2.3 Procurement
      - 1.2.4 Mobilization
    - 1.3 Park Moabi Rd.Support Facilities(Code 15)
      - 1.3.1 Construction HQ
      - 1.3.2 Soil Processing Area Improvements
    - 1.4 Access Roads
      - 1.4.1 Bat Cave Wash Access Road
      - 1.4.2 IRZ/Riverbank Service Road
      - 1.4.3 TW Bench Lower Access Road
    - 1.5 Remedy Well System
      - 1.5.1 Category 1 Monitoring Wells
      - 1.5.2 Uplands
        - 1.5.2.1 Monitoring Wells
        - 1.5.2.2 Remediation Wells
      - 1.5.3 Bat Cave Wash
        - 1.5.3.1 Monitoring Wells
      - 1.5.4 IRZ-South / Flood Plain
        - 1.5.4.1 Monitoring Wells
        - 1.5.4.2 Remediation Wells
      - 1.5.5 IRZ-North
        - 1.5.5.1 Monitoring Wells
        - 1.5.5.2 Remediation Wells
      - 1.5.6 River Bank Extraction
        - 1.5.6.1 Monitoring Wells
        - 1.5.6.2 Remediation Wells
      - 1.5.7 MW-20 Bench
        - 1.5.7.1 Monitoring Wells
      - 1.5.8 TCS
        - 1.5.8.1 Monitoring Wells
        - 1.5.8.2 Remediation Wells
      - 1.5.9 East Ravine
        - 1.5.9.1 Monitoring Wells
        - 1.5.9.2 Remediation Wells
      - 1.5.10 Arizona River Bank
        - 1.5.10.1 Monitoring Wells
      - 1.5.11 Transwestern Bench
        - 1.5.11.1 Monitoring Wells
        - 1.5.11.2 Remediation Wells
      - 1.5.12 Arizona FW Supply
        - 1.5.12.1 HNWR-01
    - 1.6 Remedy Pipeline System (FC 07)
      - 1.6.1 Upland Remedy Pipelines A-H
        - 1.6.1.1 Pipeline A
        - 1.6.1.2 Pipeline H
      - 1.6.2 NTH IRZ Pipelines (Line C)
        - 1.6.2.1 Pipeline C1-C4 and C6(North IRZ)
        - 1.6.2.2 Pipeline C5, C7-C11(South IRZ)
        - 1.6.2.3 PipelineC13-C18(Central IRZ and connections)
      - 1.6.3 River Bank Pipeline(Line G)
        - 1.6.3.1 Pipeline G
      - 1.6.4 Pipelines E, F, J
        - 1.6.4.1 Pipe Line E
        - 1.6.4.2 Pipeline F
        - 1.6.4.3 Pipeline J
      - 1.6.5 TCS Pipeline
        - 1.6.5.1 TCS Pipelines I,K,L,D
        - 1.6.5.2 TCS Pipelines M,N
        - 1.6.5.3 TCS Pipeline T, P
      - 1.6.6 Freshwater Supply System
        - 1.6.6.1 Freshwater Supply Pipeline B
        - 1.6.6.2 Colorado River Bridge Crossing
        - 1.6.6.3 Extension to Well Site & Development (Contingent)
    - 1.7 Remedy Facilities
      - 1.7.1 MW-20 Bench Facilities (FC 6)
        - 1.7.1.1 MW-20 Bench Carbon Amendment Building
        - 1.7.1.2 MW-20 Bench Carbon Amendment Storage Tank
        - 1.7.1.3 MW-20 Bench Site Civil Improvements
        - 1.7.1.4 MW-20 Bench Yard Piping
      - 1.7.2 Transwestern (TW) Bench Facilities(FC 08)
        - 1.7.2.1 Transwestern Bench Site Civil Improvements
        - 1.7.2.2 Transwestern Bench Operations Building
    - 1.8 Topock Compressor Station (TCS) Facilities
      - 1.8.1 TCS Site Piping Civil Work
      - 1.8.2 Remedy Produced Water Conditioning Plant
      - 1.8.3 Influent Water Tank Farm Site
      - 1.8.4 Conditioned Water Storage Tank
      - 1.8.5 Conditioned Water Tank Farm Site
      - 1.8.6 TCS Ponds
    - 1.9 Electrical
      - 1.9.1 12KV power distribution
      - 1.9.2 480 V power distribution
      - 1.9.3 Well Site HNWR Electrical
      - 1.9.4 TCS Facilities Electrical
      - 1.9.5 Transwestern Bench Electrical
      - 1.9.6 Mw-20 Bench Facility Electrical
      - 1.9.7 Distribution Node Structures
      - 1.9.8 Electrical Power-Up and Testing
    - 1.10 Communications & Controls Systems
      - 1.10.1 Node 01 TW Bench Fiber Optic Network
      - 1.10.2 Node 002 Mw-20 Bench Fiber Optic Network
      - 1.10.3 Node 003 North NTH Fiber Optic Network
      - 1.10.4 Node 004 South NTH Fiber Optic Network
      - 1.10.5 Node 005 Inner Recirculation Loop Fiber Optic Network
      - 1.10.6 TW Bench Control System SCADA
      - 1.10.7 Controls Testing/Troubleshooting
      - 1.10.8 Remedy Well Control System
      - 1.10.9 MW-20 Bench Carbon Amendment Facility
      - 1.10.10 TCS Facilities Controls
      - 1.10.11 Monitoring Well Data Collection Systems
    - 1.11 TCS Contingent FWPTS
    - 1.12 System Functional Testing & Shakedown
      - 1.12.1 NTH IRZ Startup
      - 1.12.2 Freshwater System Startup
      - 1.12.3 Riverbank/IRL/TCS/ER System Startup
    - 1.13 Closeout
      - 1.13.1 Demobilization and Site Cleanup
      - 1.13.2 Post Construction Documentation
      - 1.13.3 Post-Construction Mitigation Vegetation
  - 2. Im-3 System Decommissioning
  - 3. Remedy O&M
    - 3.1 Initial (Years 1-2)
      - 3.1.1 NTH IRZ
      - 3.1.2 RPWC, Extraction Wells, Freshwater System
      - 3.1.3 Well Rehabilitation
    - 3.2 Operations (Years 3-30)
      - 3.2.1 NTH IRZ
      - 3.2.2 RPWC, Extraction Wells, Freshwater System
      - 3.2.3 Well Rehabilitation
  - 4. Groundwater Monitoring
  - 5. MMRPs, Oversight, and Institutional Controls
  - 6. Post-Remedy Completion
    - 6.1 Well Decommissioning
    - 6.2 Site Restoration

Figure 1
Work Breakdown Structure

Final Design Cost Estimate
Final Groundwater Remedy
PG&E Topock

Attachment A

Basis of Estimate: Remedy Monitoring, Final Design, Final Groundwater Remedy

Final Groundwater Remedy – Final (100%) Design – Remedy Monitoring (Revised November 2015)

PREPARED FOR:	Pacific Gas & Electric Company
PREPARED BY:	Arcadis U.S., Inc.
DATE:	November 2015
PROJECT NUMBER:	RC000753.0028

This memorandum presents the updated remedy monitoring cost estimate for the Pacific Gas & Electric Company, Topock Compressor Station (TCS), Final Groundwater Remedy Project. The site is located in San Bernardino County, California near Needles. This memorandum is appended to the Basis of Design Report/Final (100%) Design Submittal for the Final Groundwater Remedy (Final BOD Report) that was issued for the project. For a more detailed description of the project, see the Final BOD Report.

This memorandum is a supporting document to the Basis of Estimate document for the construction cost. The estimate presented in this memorandum is a Class 2 estimate that may have a range of uncertainty from +20% to -15%, due to the uncertainty of monitoring scope (frequency and analytical suite) over the remedy duration.

Specific assumptions related to the groundwater and surface water monitoring cost estimate are explained below.

Final Remedy Groundwater and Surface Water Monitoring

Groundwater remedy monitoring costs are based on the following tables from the Sampling and Monitoring Plan (Appendix L, Volume 2 of the Final BOD Report): Table 2.1-2 “Monitoring Program Wells and Surface Water Sampling Points”; Table 4.2-1 “Process Control Monitoring Program Analytes and Sampling Frequencies”; Table 5.2-4 “Analytical Suite for Freshwater Supply Well (HNWR-1A) and Extracted River Bank Water Samples”; Table 5.2-5 “Analytical Suite for MW-55 Cluster Samples”; Table 5.3-1 “Analytical Suite for Process Control Monitoring – Remedy-produced Water Management”; and Table 5.4-1 “Analytical Suite for Domestic/Private Wells Samples”. In addition, Table 3.6-1 of the Final BOD Report was used for new monitoring well screen quantities.

The primary objectives of the remedy monitoring program are:

1. Compliance monitoring at monitoring wells located inside and outside of the chromium plume and at surface water sampling locations;
2. Process control monitoring of the final remedy elements, i.e., the National Trails Highway (NTH) In-Situ Reactive Zone (IRZ); the Inner Recirculation Loop; the TCS Recirculation Loop; and freshwater injection.
3. Post-remedy monitoring years 31-50, including an arsenic monitoring program over years 41-50 to monitor for effects from the in-situ reduction and freshwater injection components of the groundwater remedy.

Cost Estimating Approach

The tables used as scope references assigned sampling frequencies for each of the listed analytes to the existing and proposed monitoring locations. For the first year of the remedy monthly sampling was specified for many locations, becoming quarterly or semi-annual in the second and continuing years of remedy operation. Several specific assumptions were made for cost estimating purposes:

- The frequency for wells identified in the table with “as needed” sampling was assumed to be one sample in the first year, 0.5 samples in the second year, and 0.25 samples per year for years 3-10, with no as needed sampling in later years.

- The sampling frequency for monitoring of the NTH IRZ component of the remedy is assumed to reduce over time as follows after years 1 and 2. For years 3-5, a 30% reduction; for years 6-20, a 50% reduction; for years 21-30, a 75% reduction; with no remedy monitoring after year 30.
- The sampling frequency for monitoring of the Inner Recirculation Loop component of the remedy is assumed to remain constant at year 2 sampling rates through year 30; with no remedy monitoring after year 30.
- The sampling frequency for monitoring of the TCS Recirculation Loop component of the remedy is assumed to reduce over time as follows after years 1 and 2. For years 3-10, a 40% reduction; for years 11-20, a 75% reduction; and monitoring of the Transwestern Bench (TW) portion of the TCS Recirculation Loop stops after 20 years. For years 21-30, monitoring only at the East Ravine (ER) portion of the TCS area is assumed, and no remedy monitoring after year 30.
- The sampling frequency for wells that are used only for compliance monitoring is assumed to remain constant at year 2 sampling rates through year 30; with a 50% reduction for post-remedy monitoring years 31-40.
- For years 41-50, the only monitoring scope is assumed to consist of annual sampling for hexavalent chromium (Cr[VI]), chromium, and arsenic at 30 wells, with annual reporting.
- No contingency costs are included.
- Mark-up of 4% is shown where called out in the cost summary, second table below.
- A 10% added scope for QC samples (duplicates, various field blanks, etc.) is included with the analytical costs.

Sampling Frequency and Analytical Costs

Current groundwater and surface water sampling and reporting for the site is being conducted utilizing fixed unit rates negotiated by the Program Management Office for the PG&E Chromium Program. The annual number of units for the remedy compliance and process control monitoring programs were totaled and are presented below.

The current negotiated discount laboratory unit costs were used for each analyte, which include electronic data delivery (EDD) at no added cost. These unit costs, and the ratio of sampling for analytes other than Cr(VI), were used to calculate an average per sample laboratory cost for years 1-50 per sample for the remedy compliance and process control monitoring.

Remedy Compliance and Process Control Monitoring Units Summary

	Quantity	Quantity	Annual Quantity	Annual Quantity	Annual Quantity	Annual Quantity	Annual Quantity	Annual Quantity
Well Depth, if applicable	**Year 1**	**Year 2**	**Years 3-5**	**Years 6-10**	**Years 11-20**	**Years 21-30**	**Years 31-40**	**Years 41-50**
Remedy Compliance Monitoring – Well Sampling								
0-100'	5	5	5	5	5	5	3	0
101-200'	25	25	25	25	25	25	12	0
201-300'	21	21	21	21	21	21	11	0
>300'	9	9	9	9	9	9	5	0
Remedy Process Control Monitoring – Well Sampling								
0-100'	407	300	209	161	144	82	0	0
101-200'	397	278	197	167	135	84	0	0
201-300'	137	123	92	83	67	50	0	0

Remedy Compliance and Process Control Monitoring Units Summary

Well Depth, if applicable	Quantity Year 1	Quantity Year 2	Annual Quantity Years 3-5	Annual Quantity Years 6-10	Annual Quantity Years 11-20	Annual Quantity Years 21-30	Annual Quantity Years 31-40	Annual Quantity Years 41-50
>300'	54	46	38	32	32	25	0	0
Surface Water Sampling								
	64	64	64	64	64	64	64	0
Average per sample cost (all analytes)	$151	$138	$132	$132	$126	$126	$68	$56

There are five monitoring programs that are not reflected in the summary table above but are included in the cost estimate. The following cost estimate table gives costs for these programs in the line “other sampling”. The five programs and references for their cost estimates are described below:

- Monitoring of the NTH IRZ, Inner Recirculation Loop, and TCS Recirculation Loop extracted groundwater streams (Table 4.2-1 of the Sampling and Monitoring Plan) is not shown on the above table. This program includes sample collection from three sampling ports located prior to carbon amendment, and is assumed to continue through year 30. The analytical, data management and reporting cost estimate is included in the cost table below.
- Monitoring of the NTH IRZ force mains and injection vaults, after carbon amendment, for remedy operations is not shown on the above table. This program is assumed to include quarterly sampling from two sampling ports at the Carbon Amendment Building and 45 sampling ports at the injection vaults for total organic carbon in year 1, followed by semi-annual sampling in year 2, and as needed sampling (0.25 samples per year) in subsequent years. This program is assumed to continue through year 30. The analytical, data management and reporting cost estimate is included in the cost table below.
- Monitoring of the freshwater supply and injected water quality (Tables 5.2-4 and 5.2-5 of the Sampling and Monitoring Plan) is not shown on the above table. This program is assumed to continue through year 30. The analytical, data management and reporting cost estimate is included in the cost table below.
- Monitoring of the remedy-produced water conditioning process (Table 5.3-1 of the Sampling and Monitoring Plan) is not shown on the above table. Quarterly sample collection from four sampling locations is assumed for years 1 and 2, followed by semi-annual sampling. This program is assumed to continue through year 30. The analytical, data management and reporting cost estimate is included in the cost table below.
- Domestic well sampling from eight private wells (Table 5.4-1 of the Sampling and Monitoring Plan) will be performed at biennial frequency. This program is assumed to continue through year 30. The analytical, data management and reporting cost estimate is included in the cost table below.

In addition, costs for baseline monitoring (as described in Section 3.2.1.6 of the Construction/Remedial Action Work Plan [C/RAWP] for the Final Groundwater Remedy) are included separately in year 0 assuming two samples collected from each new extraction, injection, and monitoring well to be analyzed for a suite of parameters as listed in Exhibit 3.2-4 of the C/RAWP.

Groundwater Elevation Data Collection

The cost for groundwater elevation data collection and management are estimated separately from groundwater, surface water, and system sampling. These costs assume that water level elevations will be monitored to verify hydraulic gradient and groundwater flow during the final remedy operations. Key assumptions are summarized as follows:

- 128 monitoring wells will be instrumented with in-well pressure transducers, and transducer data will be downloaded manually on an approximately quarterly basis.
- Transducer initial equipment costs are included in year 1, and 10% of the initial cost is included in years 2-30 to cover equipment maintenance/replacement.
- The following reductions in the extent of the transducer monitoring network are assumed in the cost estimate:
  - Years 3-5, 25% reduction vs. years 1-2
  - Years 6-10, 40% reduction vs. years 1-2
  - Years 11-20, 50% reduction vs. years 1-2
  - Years 21-30, 60% reduction vs. years 1-2
  - No transducer data collection after year 30.

Summary of Cost Estimate

The summary of all costs for data collection, data validation, data management, and reporting is shown below. No year to year cost escalations are included.

Year 0 Analytical Cost	$128,409
Year 0 Sampling, Data Management, and Project Management Cost	$185,986
YEAR 0 TOTAL	**$314,395**
Year 1 Analytical Cost	$225,082
Year 1 Sampling, Data Management, and Project Management Cost	$641,015
Year 1 Reporting Cost	$73,412
Year 1 Transducer Cost	$355,164
Year 1 Other Sampling	$129,567
YEAR 1 TOTAL	**$1,424,239**
Year 2 Analytical Cost	$150,015
Year 2 Sampling, Data Management, and Project Management Cost	$509,040
Year 2 Reporting Cost	$73,412
Year 2 Transducer Cost	$280,284
Year 2 Other Sampling	$70,095
YEAR 2 TOTAL	**$1,082,845**
Years 3-5 Analytical Cost	$123,953
Years 3-5 Sampling, Data Management, and Project Management Cost	$487,150
Years 3-5 Reporting Cost	$73,412
Years 3-5 Transducer Cost	$210,213
Years 3-5 Other Sampling	$22,172
YEARS 3-5 ANNUAL TOTAL	**$916,900**
YEARS 3-5 GRAND TOTAL	**$2,750,700**
Years 6-10 Analytical Cost	$115,072
Years 6-10 Sampling, Data Management, and Project Management Cost	$478,108
Years 6-10 Reporting Cost	$73,412
Years 6-10 Transducer Cost	$168,170
Years 6-10 Other Sampling	$22,172
YEARS 6-10 ANNUAL TOTAL	**$852,643**
YEARS 6-10 GRAND TOTAL	**$4,284,669**
Years 11-20 Analytical Cost	$105,598
Years 11-20 Sampling, Data Management, and Project Management Cost	$470,822
Years 11-20 Reporting Cost	$36,706
Years 11-20 Transducer Cost	$140,142

Years 11-20 Other Sampling	$22,172
YEARS 11-20 ANNUAL TOTAL	**$775,440**
YEARS 11-20 GRAND TOTAL	**$7,754,401**
Years 21-30 Analytical Cost	$97,518
Years 21-30 Sampling, Data Management, and Project Management Cost	$461,353
Years 21-30 Reporting Cost	$36,706
Years 21-30 Transducer Cost	$112,114
Years 21-30 Other Sampling	$22,172
YEARS 21-30 ANNUAL TOTAL	**$729,863**
YEARS 21-30 GRAND TOTAL	**$7,298,627**
Years 31-40 Analytical Cost	$30,555
Years 31-40 Sampling, Data Management, and Project Management Cost	$202,740
Years 31-40 Reporting Cost	$18,353
Years 31-40 Transducer Cost	$0
YEARS 31-40 ANNUAL TOTAL	**$251,648**
YEARS 31-40 GRAND TOTAL	**$2,516,478**
Years 41-50 Analytical Cost	$1,848
Years 41-50 Sampling, Data Management, and Project Management Cost	$15,275
Years 41-50 Reporting Cost	$18,353
Years 41-50 Transducer Cost	$0
YEARS 41-50 ANNUAL TOTAL	**$35,476**
YEARS 41-50 GRAND TOTAL	**$354,760**
Average Annual Cost Years 1-30 with 4% markup	**$852,643**
Average Annual Cost Years 31-50 with 4% markup	**$149,304**
TOTAL MONITORING COST YEARS 0-50 with 4% markup	**$28,892,359**