# Appendix K

# Cost Estimate

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# Contents

## Environmental Calculations

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# ENVIRONMENTAL COST ESTIMATE

# ECE-100FR111-00010

# Environmental Cost Estimate for 100 F/IU Vadose Zone and Groundwater RI/FS

**Revision 2**

**Date: December 10, 2012**

**Project: CH2M HILL Plateau Remediation Company**

**Topic: Cost Analysis**

**Lead Estimator: K. Klink**

**Senior Review: S. Ferries**

# Administrative Use

# CHPRC ENVIRONMENTAL COST ESTIMATE COVER PAGE

**Part 1**: **To be completed by the ER&QA Lead Cost Estimator**

| | |
|---|---|
| **Project:** 100-F/IU Areas RI/FS | **Date:** 12/10/2012 |
| **Calculation Title & Description:** Environmental Cost Estimate for 100 FIU Vadose Zone and Groundwater RI/FS | |
| K. Klink<br>**Project Cost Estimator(s)** | **Basis of Qualification:**<br>Chemical Engineer with 31 years of experience; including 20 years of hazardous and radioactive waste site characterization and remediation and cost estimating, including development and application leading parametric models, CORA, RACER, and private corporate models. |
| B. Ostapkowicz<br>**Cost Estimate Checker** | **Basis of Qualification:**<br>Civil Engineer with 8 years experience in hazardous waste site characterization/remediation and process design. |
| S. Ferries<br>**ER & QA Lead Cost Estimator** | **Basis of Qualification:**<br>Geologist with 27 years of experience in environmental remediation, 15 years in cost estimating, and 13 years of RACER experience. |

**Part 2**: **To be completed by Project Cost Estimator**

**Calculation No.**: ECE-100FR111-00010 **Revision No.**: 2

**Revision History:**

| Revision No. | Description | Date | Affected Pages |
|---|---|---|---|
| 0 | Environmental Cost Estimate for 100 FIU Vadose Zone and Groundwater RI/FS | 08/23/11 | all |
| 1 | ECE for 100 F/IU Vadose Zone and GW RI/FS | 09/26/12 | all |
| 2 | Entire document | 12/10/2012 | all |
| | | | |

**Part 3:** **Document Review & Approval**

| | | |
|---|---|---|
| **Project Cost Estimator:** | K. Klink/Chemical Engineer<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/11/12<br>DATE |
| **Cost Estimate Checker:** | B. Ostapkowicz/Engineer<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/11/12<br>DATE |
| **ER & QA Lead Cost Estimator:** | S. Ferries/Sr. Cost Estimator<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/10/2012<br>DATE |
| **Project Manager:** | P. Burke/Document Lead<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/12/12<br>DATE |

*CST10_Environmental_Cost_Estimate_Cover_Page* Page 1 of 2 A-6005-863 (REV 0)

| CHPRC ENVIRONMENTAL COST ESTIMATE COVER PAGE | | |
|---|---|---|
| **Responsible Manager:** | R. Brunke/Manager Environmental Integration<br>NAME/POSITION | |
| | SIGNATURE | 12/11/2012<br>DATE |

# Terms

| | |
|---|---|
| AACE | Association for the Advancement of Cost Engineering International |
| CHPRC | CH2M HILL Plateau Remediation Company |
| COC | Contaminant of Concern |
| DOE | U.S. Department of Energy |
| ECE | Environmental Cost Estimate |
| ECF | Environmental Calculation File |
| EPA | U.S. Environmental Protection Agency |
| ERDF | Environmental Restoration Disposal Facility |
| FICA | *Federal Insurance Contributions Act* |
| FP | Fixed-price |
| G&A | General and administrative |
| HSSA | Hanford Site Stabilization Agreement |
| MS Excel™ | Microsoft Excel |
| O&M | Operation and Maintenance |
| OMB | Office of Management and Budget |
| PRC | Plateau Remediation Company |
| PW | Present Worth |
| RACER™ | Remedial Action Cost Engineering and Requirements System (Cost Estimating Software) |
| RCTs | Radiological Control Technicians |
| RTD | Remove, Treat, Dispose |
| TRACE | Tool for Response Action Cost Estimating, version 3.0, 2012 |

# Table of Contents

**Figures**



**Tables**



**Appendix**

# Introduction

CHPRC has prepared this Environmental Cost Estimate (ECE) to support the evaluation of remedial action alternatives to be documented in the Remedial Investigation/ Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units, DOE/RL-2010-98.

The cost estimates for each waste site and groundwater area summarized in this ECE have been prepared for comparative response action evaluation(s) from the information available at the time of preparation. The cost estimates reflect specific response action approaches, and scope assumptions and exclusions as well as cost estimating methodologies. The response action cost estimates have expected ranges of accuracy described in the "Estimate Classification" section (Section 11). The final costs of the selected response action will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, and other factors.

# 1 Purpose of Estimate

This ECE and backup material supports the response action alternatives analysis for the 100-F/IU Feasibility Study project (Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units). It provides an overview of response action-specific cost inputs, methodology, and results. It also provides documentation of references that provide more detailed scope and cost estimate information used to prepare these estimates.

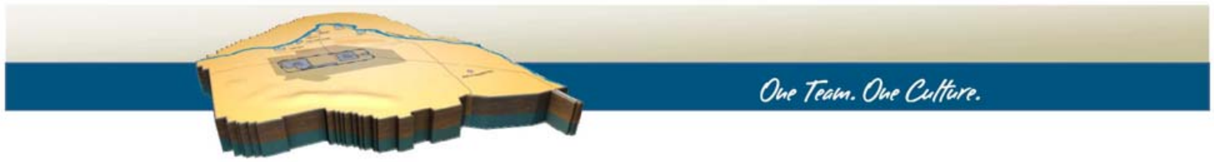
The purpose of this ECE is to:

- Describe the methodology applied in performing the cost estimates.
- Describe the general and response action-specific assumptions and cost inputs applied to the subject cost estimates.
- Summarize the response action alternative cost estimates.

This ECE also documents the references that provide additional scope and cost estimate information used to prepare these estimates.

# 2 General Project Description

In 1989, representatives from Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and U.S. Department of Energy (DOE) signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al., 1989a]). The agreement created a cohesive regulatory framework, schedule, and adjudication process to administer environmental remediation activities at the Hanford Site for both *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) response action and *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action activities.




For the purpose of remediation, the River Corridor was divided into different geographic areas: 100-BC, 100-K, 100-D, 100-H (managed as 100-D/H), 100-N, 100-F, 100-IU-2, 100-IU-6 (managed as 100-F/IU-2/IU-6), and the 300 Area (see Figure below). These geographic areas include groundwater OUs, source OUs, and facilities that encompass the 100 Area National Priorities List sites.

The 100 Area sites and the groundwater (shown in Figure 1) are contaminated from releases and spills of radiological and/or chemical constituents, and historical solid waste disposal practices, and encompass the 100 Area sites that are on the National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan (NCP).")

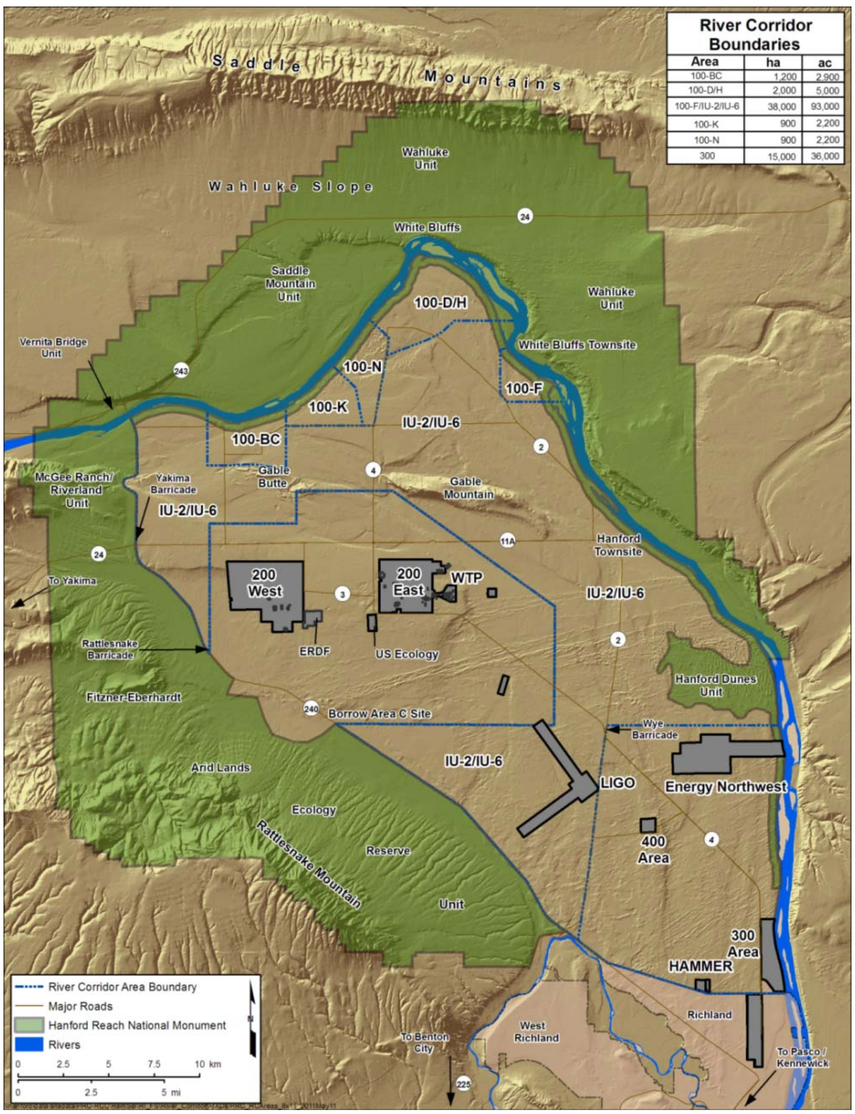



*Figure 1-River Corridor Area at Hanford*

The 100-F Area (100-FR-1 and 100-FR-2) is located downstream of the 100-H Area and upstream of the 300 Area and contains the F Reactor and associated infrastructure. The 100-IU-2 and 100-IU-6 OUs were not part of reactor operations, including the Hanford and White Bluffs Town sites, and consist of large expanses of open land between and outside the various production areas. 100-FR-3 is the groundwater OU associated with 100-FR-1 and 100-FR-2 OUs. Groundwater contamination in the areas underlying the 100-IU-2 and 100-IU-6 OUs is from past disposal practices in the 100 and 200 Areas. For cleanup purposes, groundwater OUs are linked to the source of the contaminant plume, not to the plume's physical location. There is no groundwater contaminant source from within the 100-IU-2 and 100-IU-6 OUs. Groundwater contamination underlying the 100-IU-2 and 100-IU-6 OUs will be addressed by river corridor and central plateau groundwater OUs.

This cost estimate encompasses the cost of one alternative for waste sites and four groundwater alternatives evaluated in the 100-F/IU Feasibility Study. The FS alternatives focus on the following sites within the 100 F area, shown in Table 1.

*Table 1-List of Sites and Groundwater Plumes in CHPRC 100-F/IU Estimate*

| **Waste Sites – No Dig ICs** | |
|---|---|
| 100-F-19:1 (includes sub sites: 100-F-19:3, 100-F-34, and 116-F-12) | 116-F-9 |
| 100-F-19:2 (includes sub sites: 100-F-29, 116-F-11, and UPR-100-F-1) | 118-F-6 |
| 116-F-2 | 118-F-8:3 |
| 116-F-4 | 118-F-8:4 |
| 116-F-6 | 116-F-14 |
| **Groundwater Plumes** | |
| Cr(VI) | Sr-90 |
| TCE | Nitrate |

# 3 Scope of Work

The cost estimate for the 100-F/IU Feasibility Study project was developed in accordance with EPA/540/R-00/002, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, OSWER 9355.0-75 (EPA, 2000), and PRC-PRO-EP-40282 Cost Estimating Procedure for Response Action Decision-Making (PRC,2010).

Quantities used in this estimate were based on the information provided by the technical project manager in the Environmental Calculation File (ECF) document, ECF-100FR3-11-0148, Rev 1, December 2012.

Remedial action alternatives were developed for sixteen waste sites and four groundwater contaminant plumes. The waste sites listed in table 1 have site specific institutional controls as an alternative. Washington Closure Hanford (WCH) provided costs for the “Sites Remaining for Remedial Action” of which there are 36 sites. The alternative for these interim action sites is Remove, Treatment, and Disposal (RTD) and will be addressed on a post-ROD basis. RTD cost estimates were provided by WCH and shown in appendix Table A-6. The waste site alternatives are described further in Section 3.1.

The four groundwater contaminant plumes include a 56 acre plume of hexavalent chromium, 25 acre plume of Sr-90, two TCE plumes of 4.4 acres and 168 acres, and a nitrate plume of 3,160 acres and are described further in Section 3.2.

## 3.1 Waste Site Alternatives:

### 3.1.1 Alternative S-1—No Action.

The National Contingency Plan (NCP) (40 CFR 300.430(e)(6)) requires consideration of a No Action Alternative. The No Action Alternative, which serves as a baseline for evaluating other remediation action alternatives, is retained throughout the FS process. No action means that no remediation would be implemented to alter the existing conditions. For this alternative, it was assumed that all site remedial activities and interim actions (with the possible exception of backfilling any open excavations for safety purposes) would be discontinued. No conceptual designs or cost estimates are prepared for Alternative S-1 because no actions are proposed.

### 3.1.2 Alternative S-2— RTD.

Alternative S-2 uses RTD at waste sites. Contaminated soil and debris are excavated using shallow and deep excavation technology, treated as necessary to meet disposal criteria, and transported and disposed of at ERDF. The site will be backfilled, re contoured, followed by planting and establishment of native vegetation. There is no O&M post remediation. The estimated time for remedy implementation is 3 to 5 years.

## 3.2 Groundwater

### 3.2.1 Alternative GW-1 – No Action.

This alternative is required by the NCP (“Remedial Investigation/Feasibility Study and Selection of Remedy” [40 CFR 300.430(e)(6)]). The No Action Alternative, which serves as a baseline for evaluating other remediation action alternatives, is retained throughout the FS process. No action means that no remediation would be implemented to address the groundwater contaminant plumes. All existing groundwater monitoring and data evaluation and reporting would be discontinued, and existing ICs lifted. No conceptual designs or cost estimates are prepared for Alternative GW-1 because no actions are proposed.

### 3.2.2 Alternative GW-2 —ICs and MNA

This alternative uses ICs to prevent exposure to contaminated groundwater until MNA processes reduce COC concentrations to preliminary remediation goals (PRGs). The estimated time frame to achieve PRGs based on the 90th percentile (C90) concentration is 25 years for Cr(VI), 45 years for trichloroethene, 30 years for nitrate, and 90 years for strontium-90. In lieu of the C90 concentration, the maximum projected (Cmax) concentration was used for the trichloroethene plume because the C90 concentration is projected to be below the PRG at time zero. The estimated timeframe for the trichloroethene plume to achieve its PRG based on Cmax is 45 years. Groundwater sampling and analysis, and data evaluation and reporting are also an important component of this alternative to confirm that natural attenuation processes are reducing COC concentrations in accordance with expectations, and to provide a basis for determining when remedial action is complete and ICs can be removed.

### 3.2.3 Alternative GW-3 — Pump-and-Treat Optimized with Other Technologies.

This alternative utilizes pump-and-treat for Cr(VI), trichloroethene, strontium-90 and nitrate for cleanup of the remedial action target area. Substrate injection will be performed at upgradient nitrate and Cr(VI) injection wells to promote in-situ reduction of nitrate to nitrogen gas and reduction of Cr(VI) to Cr(III). Incidental reductive dechlorination of trichloroethene to cis 1,2-dichloroethene is also expected to occur although such was not simulated under this alternative. MNA, following pump-and-treat operations, will also contribute to achieving cleanup levels for strontium-90 and the southern portion of the nitrate plume. The estimated remedial action timeframes based on the C90 concentration are: 5 years for Cr(VI), 10 years for trichloroethene, 10 years for the concentrated-northern portion of the nitrate plume and 60 years for the southern low-concentration plume area, and 85 years for strontium-90. The 10 year timeframe to achieve the PRG for trichloroethene is based on the Cmax concentration.

### 3.2.4 Alternative GW-4 – Enhanced Pump-and-Treat

This alternative uses pump-and-treat with ex situ treatment technology for Cr(VI), strontium-90, trichloroethene, and nitrate-contaminated groundwater. This alternative uses more aggressive pumping and treatment technology employed for many of the 100 Area groundwater interim actions to achieve groundwater protection PRGs within a shorter timeframe relative to the other groundwater remedial action alternatives. The estimate remedial action timeframes under this alternative based on the C90 concentration are: 5 years for Cr(VI), 10 years for nitrate, and 85 years for strontium-90. The estimated timeframe to achieve the PRG for trichloroethene, based on Cmax, is 10 years.

## 4 Overall Costs

Table 2 presents site specific capital, annual, periodic, total non-discounted, and total discounted (present value) costs for the waste sites. Table 3 presents site specific capital, annual, periodic, total non-discounted, and total discounted (present value) costs for each alternative for each of the four 100-F/IU groundwater alternatives.

*Table 2-Summary of Total Costs (Vadose Zone)*

| | *Alternative S-2 |
|---|---|
| Total Capital (Non-discounted) | $ 9,630,000 |
| Total Annual (Non-discounted) | $26,711,000 |
| Total Periodic (Non-discounted) | $ 1,173,000 |
| Total Non-discounted Cost | $37,514,000 |
| **Total Discounted (Discounted)** | $**20,637,000** |
| *Note: Range of accuracy is expected to be +50%/-30%* | |

* RTD costs for Sites Remaining for Remedial Action" are included in the total and were provided by WCH. CHPRC estimated the site specific institutional controls for 10 sites.

*Table 3 – Summary of Total Costs (Groundwater)*

| | Alternative GW-2 | Alternative GW-3 | Alternative GW-4 |
|---|---|---|---|
| Total Capital (Non-discounted) | $4,930,000 | $83,083,000 | $98,365,000 |
| Total Annual (Non-discounted) | $30,495,000 | $94,826,000 | $87,883,000 |
| Total Periodic (Non-discounted) | $19,615,000 | $42,177,000 | $41,667,000 |
| Total Non-discounted Cost | $55,039,000 | $220,086,000 | $227,915,000 |
| **Total Discounted (Discounted)** | $33,514,000 | $181,917,000 | $199,500,000 |
| *Note: Range of accuracy is expected to be +50%/-30%* | | | |

Additional tables for the wastes sites and groundwater plumes can be found in Appendix A and are listed below:

Table A-1: Waste Sites – Total Cost
Table A-2: Waste Sites – Individual Site Costs
Table A-3: Waste Sites – Important Input Quantities to Cost Estimate
Table A-4: Groundwater – Total Cost
Table A-5: Groundwater – Important Input Quantities to Cost Estimate
Table A-6: Waste Sites Remaining for Remedial Action (WCH)

# 5 Major Assumptions

There are two different types of assumptions and inputs for cost estimation; general and response activity specific.

## 5.1 General Assumptions and Inputs

General assumptions apply to all response action cost estimates. The general assumptions discussed in the sections below include direct and indirect cost assumptions and other general pricing assumptions.

### 5.1.1 General Direct Cost Assumptions

Direct costs include all costs that can be directly attributed to a particular construction activity or item of work required to accomplish the project. Typical direct cost items include: labor, material, equipment and subcontract items. Direct cost assumptions for this estimate include:

- Scope and Bid Contingencies, see Section 8
- Project management, remedial design, and construction management capital costs, see Section 9.
- Construction labor are discussed in Section 15
- Material such as: backfill soil, grout, worker health and safety protective items, anionic ion exchange resin, vapor phase granular activated carbon, HDPE pipe, and bio-substrate are included in the estimates. Material costs were based on operating Hanford systems costs, RACER 2011 unit costs.
- Site preparation costs such as site access enhancements and controls, utility connections, site clearing and leveling, were included as allowances based on estimator judgment.
- Cost impacts for performing work under specific levels of worker health safety protection:
    - Work assumed to be performed under worker health and safety level D was assumed to be at the standard TRACE V3 unit cost rates

### 5.1.2 General Indirect Cost Assumptions

Indirect costs are costs not directly attributable to the completion of an activity. Indirect costs are typically allocated or spread across all activities on a predetermined basis. Indirect costs items can include the following job-related overhead items: taxes; project-specific insurance; bonds; permits and licenses; general supervision; temporary office personnel; schedules; preparatory work and testing services; temporary project facilities; temporary utilities; operations and maintenance of temporary project-site facilities; project vehicles; personal protective equipment and OSHA requirements; quality controls; mobilization and demobilization; and site security.

General indirect cost assumptions for this estimate include:

- Markups are included for profit and G&A, see Section 7

- Mobilization/demobilization and bonding/insurance – a standard TRACE V3 percentage allowance was used based on project size and using the high percentage value from the low, medium, and high percentages presented by TRACE V3 for the project size.

### 5.1.3 Other general cost Assumptions

Remedial action assumptions and cost inputs used in this cost estimate were provided by the technical team in the Environmental Calculation File, (ECF-100FR3-11-0148,Rev0)100-F/IU Cost Estimate Inputs for Remedial Investigation/Feasibility Study Alternatives for 100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6 and 100-FR-3 Operable Units. Any changes from the original quantities and any additional cost estimate basis assumptions are documented below in this section.

Institutional Controls

The estimated costs for providing the sitewide or programmatic ICs including site access, personnel badging, real estate and deeds, warning signs along the Columbia River bank and other access points, maintaining a current site wide institutional controls plan, controls for excavating soil, accessing and using groundwater, and irrigation restrictions are also included in the costs developed for each alternative:

- These costs were assembled and where appropriate a 50% adjustment was made to represent CERCLA cleanup as a portion of the current Hanford Site mission. The TPA currently identifies 22 CERCLA Records of Decision, so each ROD would be allocated an equal portion of the CERCLA programmatic ICs costs. The programmatic ICs costs are projected for the next 150 years. In 2068 ICs costs are reduced by 50% to reflect removal of the 100 area reactors, as the more active programmatic controls, like site access, would be likewise reduced.
- The total non-discounted cost for the ICs for 150 years is estimated to be $563,000,000 for the Hanford site (about $26,000,000 per ROD). The total discounted cost for the ICs at Hanford are estimated at $221,000,000 (about $10,000,000 per ROD).
- The total non-discounted cost for the 5-Year Reviews for 150 years is estimated to be $14,000,000 (about $630,000 per ROD). The total discounted cost for the 5-Year Reviews for 150 years is estimated to be $4,000,000 (about $190,000 per ROD).

## 5.2 Response Activity-Specific Assumptions and Inputs

Assumptions specific to the proposed remedial activities for this cost estimate are described below. Quantity inputs used in the TRACE V3 cost estimating workbook are summarized in for the vadose zone and groundwater estimates in Tables A-3 and A-5, respectively.

### 5.2.1 Groundwater Flow Rates

The groundwater flow rates were provided by the technical team for the following time ranges:

- Alternative GW-2 – not applicable

- Alternative GW-3
  - Cr(VI) plume: 2014 to 2018 (bio-injection through 2023)
  - Sr-90 plume: 2014 to 2025
  - TCE plume: 2014 to 2023
  - Nitrate plume: 2014 to 2023
- Alternative GW-4
  - Cr(VI) plume: 2014 to 2018
  - Sr-90 plume: 2014 to 2023
  - TCE plume: 2014 to 2023
  - Nitrate plume: 2014 to 2023

### 5.2.2 Summary of cost by site:

The costs for the 100 F/IU remedial action alternatives were calculated both individually and combined as a total cost, with itemized vadose zone site costs and itemized groundwater remediation costs for each alternative. Costs for each of the ten waste sites and four groundwater plumes were calculated and summarized separately from the alternative total costs by:

- Breaking out and summing each of the site-specific costs for each site
- Allocating a portion of the overall mobilization/demobilization/bonding/insurance, site preparation, and alternative markup costs to each specific site based on the site subtotal cost of the overall alternative cost

### 5.2.3 Modified standard TRACE V3 unit costs

The following unit costs were used in the cost estimate and were added to the original TRACE V3 default costs. The source of the unit cost is listed beside the item in the list below.

From the groundwater cost estimate:

- Air stripper system with granular activate carbon (GAC) and complete elec/mech/I&C – Estimator Allowance
- Bionode System – Estimator Allowance
- Sr-90 Treatment Process Development – Estimator Allowance
- Tanks, pumps, miscellaneous process equipment not in system – Alt 3 – Estimator Allowance
- Tanks, pumps, miscellaneious process equipment not in system – Alt 4 – Estimator Allowance
- Maintain GWT systems readiness during 5 year compliance check – Estimator Allowance
- Annual O&M for air stripper with granular activated carbon – Estimator Allowance
- Annual O&M for Nitrate IX – Same as Cr(IV) O&M cost
- Final decommissioning/removal of above ground systems-Cr(VI) Alt 3 – 33% of capital cost
- Final decommissioning/removal of treatment systems-Sr-90 Alt 3 – 33% of capital cost

- Final decommissioning/removal of treatment systems-TCE Alt 3 – 33% of capital cost
- Final decommissioning/removal of treatment systems -NO3 Alt 3 – 33% of capital cost
- Final decommissioning/removal of treatment systems-Cr(VI) Alt4 – 33% of capital cost
- Final decommissioning/removal of treatment systems-Sr-90 Alt 4 – 33% of capital cost
- Final decommissioning/removal of treatment systems-TCE Alt 4 – 33% of capital cost
- Final decommissioning/removal of treatment systems -NO3 Alt 4 – 33% of capital cost

### 5.2.4 Specific assumptions

The following specific assumptions were included in the cost estimates:

- Monitoring well replacement – every 30 years
- Monitoring Well Pump Replacement – every 5 years

- Extraction well replacement – every 20 years
- Extraction well rehabilitations – every 10 years
- Extraction well pump replacement – every 5 years

- Injection well replacement – every 10 years
- Injection well rehabilitations – every 2 years

- Site preparation – estimator's judgment at $100,000 to $500,000 for groundwater plume specific, alternative specific estimates.

- A single mobilization/demobilization for the groundwater remediation.

## 5.3 Alternative Specific Assumptions Used in Estimate

### 5.3.1 Waste Site Remedial Action Alternatives

The following assumptions for the VZ alternatives are based on data for the 100-F/IU operable units, as presented in Chapter 9 of DOE/RL-2010-98

**Alternative S-1- No Action**

- There are no alternative development cost estimate assumptions associated with this alternative.

**Alternative S-2: ICs and Monitored Natural Attenuation (MNA)**

The following ten sites have site specific ICs associated with them. This table provides the site name along with the site specific duration.

*Table 4 – Waste Sites with Site Specific ICs*

| Site | IC Duration |
|---|---|
| 100-F-19:1 (includes sub sites: 100-F-19:3, 100-F-34, and 116-F-12) | 76 years |
| 100-F-19:2 (includes sub sites: 100-F-29, 116-F-11, and UPR-100-F-1) | 15 years |
| 116-F-2 | 89 years |
| 116-F-4 | 90 years |
| 116-F-6 | 101 years |
| 116-F-9 | 50 years |
| 118-F-6 | 20 years |
| 118-F-8:3 | 175 years |
| 118-F-8:4 | 13 years |
| 116-F-14 | 64 years |

RTD costs for “Sites Remaining for Remedial Action” were provided by WCH for the following Post ROD sites: 600-20; 600-279; 600-293; 600-294; 600-301; 600-329; 600-331; 600-332; 600-334:2; 600-349; 600-358; 600-368; 600-369:1; 600-369:2; 600-369:3; 600-369:4; 600-369:5; 600-369:6; 600-369:7; 600-369:8; 300-370; 600-371; 600-372:1; 600-372:2; 600-373; 600-374; 600-375:1; 600-375:2; 600-375:3; 600-375:4; 600-375:5; 600-376:1; 600-376:2; 600-377; 600-378; and 600-379

### 5.3.2 Site: 100-F/ IU (100-FR-3 Groundwater OU)

The following assumptions for the GW alternatives are based on data for the 100-F/IU operable units, as presented in Chapter 9 of DOE/RL-2010-8.

**Alternative GW-1- No Action Alternative**

- There are no cost estimate development assumptions associated with this alternative

**Alternative GW-2- ICs and MNA**

The alternative development assumptions are based on Chapter 9 of DOE/RL-2010-98. Cost elements are segregated for all COC plumes and are shown below:

- Monitored Natural Attenuation

- Monitor Wells
- Groundwater Monitoring
- Well Abandonment
- Site Closeout

**Alternative GW-3 – Pump-and-Treat Optimized with Other Technologies**

The alternative development assumptions are based on Chapter 9 of DOE/RL-2010-98. Cost elements are segregated for all COC plumes (except as noted in paranthesis) and are shown below:

- Monitored Natural Attenuation
- Monitor Wells
- Extraction Wells
- Injection Wells (Cr(VI), TCE and nitrate plumes only)
- Ion Exchange (Cr(VI), nitrate and Sr-90 plumes only)
- Air Stripping (TCE plume only)
- In Situ Biodegredation (Cr(VI), TCE and nitrate plumes only)
- Well Abandonment
- Site Closeout

**Alternative GW-4 – Enhanced Pump-and-Treat**

The alternative development assumptions are based on Chapter 9 of DOE/RL-2010-98. Cost elements are segregated for all COC plumes (except as noted in parenthesis) and are noted below:

- Monitor Wells
- Extraction Wells
- Injection Wells (Cr(VI), nitrate, and TCE plumes only)
- Ion Exchange (Cr(VI), nitrate and Sr-90 plumes only)
- Air Stripping (TCE plume only)
- Well Abandonment
- Site Closeout

# 6 Exclusions

This section identifies costs that have not been included in the estimate. The following items have been excluded from the estimate:

- Escalation – Separate escalation has not been included in these calculations. The costs are all based on fiscal year 2012 costs distributed into years that the activities and associated costs would occur, and a present value (PV) analysis is performed to convert all costs back to fiscal year 2012 basis using the alternative-specific stated OMB real discount rate.

- Costs for remediating the sites individually under separate contracts. The costs in this estimate assume that the sites are remediated under one contract corresponding to the specific alternative, or at most one vadose zone and one groundwater contract. If sites are remediated separately, the individual site costs would be expected to be higher than shown for the individual sites in Table A-2, since certain fixed costs would not be spread over a group of sites and certain activity economies of scale would not be present.

# 7 Markups

The following markups have been included in the Cost Estimate:

- Subcontractor Profit at 8 percent.
- Prime Contractor Profit at 10 percent.
- PRC general and administrative (G&A) costs have been applied at a rate of 30.24[1] percent to all PRC labor, material, and equipment. G&A is also applied to the FP contractor costs. This markup includes a number of job-related overhead items:
  - Taxes
  - Project-specific insurance
  - Bonds
  - Permits and licenses
  - General supervision
  - Temporary office personnel
  - Schedules
  - Preparatory work and testing services
  - Temporary project facilities and O&M of these facilities
  - Temporary utilities (e.g. phone, electrical)
  - Project vehicles
  - Personal protective equipment and Occupational Health and Safety requirements
  - Quality controls
  - Mobilization and demobilization
  - Site security

[1] G&A rate is obtained from CH2M Hill Plateau Remediation Company FY 2012 - – (provisional approval granted) http://prc.rl.gov/rapidweb/finance/index.cfm?pagenum=11

# 8 Contingencies

Contingency is factored into a cost estimate to cover unknowns, unforeseen circumstances, or unanticipated conditions that are not possible to evaluate from the available data at the time the estimate is prepared. It is used to reduce the risk of possible cost overruns.

The two main types of contingency are scope and bid. Scope contingency covers unknown costs due to scope changes that may occur during design. Bid contingency covers unknown costs associated with constructing and implementing a given project scope. The range for bid contingency is typically from 10 to 20 percent.

- Scope Contingency. Contingency rates have been applied to the capital costs at 35 percent as per EPA/540/R-00/002, Section 5.4 for soil excavation. The scope contingency for this estimate has been set at 0% for the waste site alternative 2 estimate; 35% for alternative 2 and 25% for alternatives 3 and 4 for the groundwater estimates.
- Bid Contingency. The range for bid contingency is typically from 10 to 20 percent. The bid contingency for this estimate has been set at 10% for the waste site alternative 2 estimate; 20% for the groundwater estimates.
- O&M Contingency. The O&M contingency has been estimated to be 20% for the waste site alternative 2 estimate; 30% for alternative 2 and 20% for alternatives 3 and 4 for the groundwater estimates.

# 9 Project Management, Remedial Design, and Construction Management Costs

Project management, remedial design, and construction management capital costs are estimated using factors based on EPA/540/R-00/002, Exhibit 5-8.

- For projects with construction costs less than $100,000 – remedial design is planned at 20 percent, project management is planned at 10 percent, and construction management is planned at 15 percent of the construction cost.
- For projects with construction costs from $100,000 to $500,000 – remedial design is planned at 15 percent, project management is planned at 8 percent, and construction management is planned at 10 percent of the construction cost.
- For projects with construction costs from $500,000 to $2 million – remedial design is planned at 12 percent, project management is planned at 6 percent, and construction management is planned at 8 percent of the construction cost.
- For projects with construction costs from $2 million to $10 million – remedial design is planned at 8 percent, project management is planned at 5 percent, and construction management is planned at 6 percent of the construction cost.
    - Alternative GW-2

- For projects with construction costs greater than $10 million – remedial design is planned at 6 percent, project management is planned at 5 percent, and construction management is planned at 6 percent of the construction cost.
    - Alternative GW-3and GW-4

## 10 Present Worth

As per EPA Guidance, EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study***,** OSWER 9355.0-75 (EPA, 2000) the estimate includes present worth calculations for work performed in out years.

The costs are presented as present worth values. The present worth value method establishes a common baseline for evaluating costs that occur during different time periods, thus allowing for direct cost comparisons between different alternatives. The present worth value represents the dollars that would need to be set aside today, at the defined real discount rate, to ensure that funds would be available in the future as they are needed to perform the response action alternative.

Present worth costs were estimated using the real discount rate published in Appendix C of the Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, effective October 2012* (OMB, 2012). Based on this guidance and durations of 97 yrs for groundwater alternative 2 and 92 years for groundwater alternatives 3 and 4, real discount rate of 2.0 percent was used in the cost estimate present value calculations for these alternatives.

## 11 Estimate Classification

This estimate was prepared in accordance with the guidelines of "*A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, EPA 540-R-00-002, OSWER 9355.0-75, July 2000. It's important to remember that at the FS stage, the design for the response action project is still conceptual, not detailed, and the cost estimate is considered to be "order-of-magnitude." The expected accuracy range of the cost estimate at this stage is approximately plus 50 percent, minus 30 percent.

The expected accuracy range is an indication of the degree to which the final cost outcome for a given project could vary from the estimated cost. Accuracy is traditionally expressed as a +/- percentage range around the point estimate after application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range (+/- measures are a useful simplification, given that actual cost outcomes have different frequency distributions for different types of projects). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.

The accuracy range of an estimate is dependent upon a number of characteristics of the estimate input information and the estimating process. The extent and the maturity of the input information as measured by percentage completion (and related to level of project definition) is an important determinant of accuracy. However, there are factors besides the available input information that also greatly affect estimate accuracy measures. Primary among these are the state of technology in the project and the quality of reference cost estimating data.

The accuracy of any given estimate is not fixed or determined by its classification category. Significant variations in accuracy from estimate to estimate are possible if any of the determinants of accuracy, such as technology, quality of reference cost data, quality of the estimating process, and skill and knowledge of the estimator vary. Accuracy is also not necessarily determined by the methodology used or the effort expended. Estimate accuracy must be evaluated on an estimate-by estimate basis, usually in conjunction with some form of risk analysis process.

## 12 Cost Resources

The following is a list of the cost resources used in the development of the cost estimate.

- TRACE V3 (ECF-Hanford-11-0098 through 0107)
- RACER™ 2011
- RS Means
- Hanford historical actual costs
- Estimator Judgment

## 13 Estimate Methodology

The cost estimate for the 100-F/IU project was developed in accordance with EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75 (EPA, 2000), and PRC-PRO-EP-40282 *Cost Estimating Procedure for Response Action Decision-Making* (PRC, 2010). The TRACE V3 cost estimating workbook in conjunction with the RACER™ Cost Estimator software were used to develop the cost estimate for each of the removal action alternatives.

This cost estimate has been prepared for guidance in project evaluation from the information available at the time of the estimate. The final cost of the project will depend on final design, selected scope of work, actual labor and material costs, competitive market conditions, implementation schedule and other variable factors. As a result, the final project costs will vary from the estimate presented here. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

## 14 Sensitivity Analysis

Sensitivity analysis for this cost estimate was not performed. The following factors might cause the estimate to significantly change.

- Levels of contamination
- Depth and extent of contamination encountered during RTD of vadose Zone sites
- Rate(s) of groundwater extraction and injection

- Duration of extraction and injection systems
- Duration and actual operations and maintenance requirements for groundwater treatment systems
- Less favorable working conditions and/or increased monitoring requirements that would significantly increase the impact of working in health and safety protection and/or increase the health and safety protection requirements.

Because of these factors:

1. The remedy selection process must consider differences in response action cost uncertainties/cost risks in addition to response action-specific cost estimates and ranges.
2. Funding needs must be carefully reviewed before making specific financial decisions or establishing final budgets.

# 15 Labor Costs

Fixed-price (FP) construction craft labor rates are those listed in Appendix A of the Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site (commonly known as the Hanford Site Stabilization Agreement [HSSA]). The HSSA rates include base wage, fringe benefits, and other compensation as negotiated between CH2M HILL Plateau Remediation Company (CHPRC) and the National Building and Construction Trades Department American Federation of Labor-Congress of Industrial Organizations (AFL-CIO). Other factors that account for additional costs (Workman’s Compensation, Federal Insurance Contributions Act (FICA), and state and Federal unemployment insurance) to develop a fully burdened rate by craft, have been incorporated. The labor rates used are for 2012.

Plateau Remediation Contractor (PRC) labor rates for management, engineering, safety oversight, and technical support are based on the PRC-approved planning rates for fiscal year 2012.

# 16 Sales Tax

Washington State sales tax has been applied to all materials and equipment purchases at 8.3 percent and is included in the PRC general and administrative (G&A) percentage discussed in section 5.

# 17 References

EPA 540-R-00-002, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

PRC-PRO-EP-40282, 2010, *Cost Estimating Procedure for Response Action Decision-Making*, Rev. 0, Chg. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

Means, R. S., 2001, ECHOS *Environmental Remediation Cost Date Unit Price*, Robert S. Means Company, Kingston, Massachusetts.

Means, R. S., 2010a, *Building Construction Cost Book,* 68th annual ed., Robert S. Means Company, Kingston, Massachusetts.

Means, R. S., 2010b, *Heavy Construction Cost Data,* 24th annual ed., Robert S. Means Company, Kingston, Massachusetts.

OMB Circular No. A-94, 2011, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" (memorandum for Heads of Executive Departments and Establishments), Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," as revised, Office of Management and Budget, Washington, D.C.

*Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site*, 1984, as amended, commonly known as the Hanford Site Stabilization Agreement (HSSA)(original title, *Site Stabilization Agreement, Hanford Site, between J.A. Jones Construction Services Company and Morrison-Knudsen Company, Inc., and the Building and Construction Trades Department of the AFL-CIO and its affiliated international unions, and the International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America.*

ECF-Hanford-11-0164, Environmental Calculation File TRACEV3 – Site Cost Distribution

ECF-Hanford-11-0098, Environmental Calculation File for TRACE_V3-Overview, (Rev1)

ECF-Hanford-11-0099, Environmental Calculation File for TRACE_V3-Actual Costs, (Rev1)

ECF-Hanford-11-0100, Environmental Calculation File for TRACE_V3- RACER Costs, (Rev1)

ECF-Hanford-11-0101, Environmental Calculation File for TRACE_V3-Calculations, (Rev1)

ECF-Hanford-11-0102 Environmental Calculation File for TRACE_V3-Unit Costs, (Rev1)

ECF-Hanford-11-0103, Environmental Calculation File for TRACE_V3-Capital Cost, (Rev1)

ECF-Hanford-11-0104, Environmental Calculation File for TRACE_V3-O&M Cost, (Rev1)

ECF-Hanford-11-0105, Environmental Calculation File for TRACE_V3-O&M Distribution, (Rev1)

ECF-Hanford-11-0106, Environmental Calculation File for TRACE_V3-Present Value, (Rev1)

ECF-Hanford-11-0107, Environmental Calculation File for TRACE_V3-Totals, (Rev1)

ECF-Hanford-11-0037, Environmental Calculation File for Excavation Template_V1

DOE/RL-2001-41, Revision 5, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions,* June 2012

The Hanford Sitewide Institutional Control Plan, DOE/RL-2001-41, Rev. 5

EPA/ROD/R10-00/121, Record of Decision for the USDOE Hanford 100-Area, Benton County, Washington

EPA, 2001, USDOE Hanford Site, First Five-Year Review Report

EPA/ROD/R10-01/119, Record of Decision for the USDOE Hanford 300 Area, Benton County, Washington

DOE/EIS-0222-F, Final Hanford Comprehensive Land-Use Plan Environmental Impact Statements

DOE/EIS-0019F, NEPA Environmental Impact Statement, Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington, December 1992.

Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Appendix C of the Office of Management and Budget (OMB), Washington D.C., *20*

ECF-Hanford-12-0067, Institutional Controls Costs Apportioned by ROD Groups

# Appendix

# Table A-1: Waste Sites - Total Cost

Table A-1

## COMPARISON OF TOTAL COST OF RESPONSE ACTION ALTERNATIVES*

| | | | |
|---|---|---|---|
| **Site:** | 100-F/IU | **Base Year:** | 2012 |
| **Location:** | Hanford, WA | **Date:** | November-12 |
| **Phase:** | FS | **Rev:** | 0 |

| | **Alternative S-2** | | |
|---|---|---|---|
| | **No-dig ICs** | | |
| Total Duration (years) | *** | | |
| **Cost Summary** | | | |
| Capital Cost | $9,630,000 | | |
| Total Annual Cost | $26,711,000 | | |
| Total Periodic Cost | $1,173,000 | | |
| **Non-Discounted** ** | **$37,514,000** | | |
| **Real Discount Rate** | **2.0%** | | |
| **Total Present Value of Alternative (Discounted)** | **$20,637,000** | | |
| **Expected Accuracy Range for total present value is +50%/-30%** | | | |
| **-30%** | **$14,446,000** | | |
| **50%** | **$30,956,000** | | |

*Notes:
Range of accuracy is expected to be +50%/-30%
** RTD costs for sites remaining for remedial action are included in the total

# Table A-2: Waste Sites- Individual Site Costs

| *Duration of the ICs = 76 Years* | No-dig ICs | | | |
|---|---|---|---|---|
| **Site name** | **100-F-19:1** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 122,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 177,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 76,000 | $ - | $ - | $ - |

| *Duration of the ICs = 15 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **100-F-19:2** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 24,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 79,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 62,000 | $ - | $ - | $ - |

| *Duration of the ICs = 89 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **116-F-2** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 143,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 198,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 77,000 | $ - | $ - | $ - |

| *Duration of the ICs = 90 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **116-F-4** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 144,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 199,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 77,000 | $ - | $ - | $ - |

| *Duration of the ICs = 101 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **116-F-6** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 162,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 217,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 78,000 | $ - | $ - | $ - |

| *Duration of the ICs = 50 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **116-F-9** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 80,000 | $ - | $ - | $ - |
| **Periodic** | $ 55,000 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 135,000 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 72,000 | $ - | $ - | $ - |

| *Duration of the ICs = 20 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **118-F-6** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 32,000 | $ - | $ - | $ - |
| **Periodic** | $ 54,400 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 86,400 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 62,772 | $ - | $ - | $ - |

| *Duration of the ICs = 175 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **118-F-8:3** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 280,000 | $ - | $ - | $ - |
| **Periodic** | $ 54,400 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 334,400 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 79,200 | $ - | $ - | $ - |

| *Duration of the ICs = 13 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **118-F-8:4** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 20,800 | $ - | $ - | $ - |
| **Periodic** | $ 54,400 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 75,200 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 60,210 | $ - | $ - | $ - |

| *Duration of the ICs = 64 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **116-F-14** | | | |
| **Capital Cost** | $ - | $ - | $ - | $ - |
| **Annual** | $ 102,400 | $ - | $ - | $ - |
| **Periodic** | $ 54,400 | $ - | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 156,800 | $ - | $ - | $ - |
| **Discounted (PV)** | $ 72,792 | $ - | $ - | $ - |
| ***Subtotal Discounted Waste Sites*** | *$ 716,974* | | | |

| *Duration of the ICs = 150 Years* | | | | |
|---|---|---|---|---|
| **Site name** | **Programmatic Institutional Controls** | | | |
| **Capital Cost** | | | | |
| **Annual (Programmatic ICs (100-F/IU) 150 Yrs)** | $ 25,600,000 | | $ - | $ - |
| **Periodic (5-Year Review (100-F/IU) 150 Yrs)** | $ 625,000 | | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 26,225,000 | | $ - | $ - |
| **Discounted (PV)** | $ 10,290,000 | | $ - | $ - |

| | | | | |
|---|---|---|---|---|
| **Site name** | **Sites Remaining for Remedial Action** | | | |
| ***Capital Cost** | $ 9,630,000 | | $ - | $ - |
| **Annual** | $ - | | $ - | $ - |
| **Periodic** | $ - | | $ - | $ - |
| **Individual Site (Non Discounted)** | $ 9,630,000 | | $ - | $ - |
| **Discounted (PV)** | $ 9,630,000 | | $ - | $ - |
| | | | | |
| **Total Capital (Non-discounted)** | **$ 9,630,000** | **$ -** | **$ -** | **$ -** |
| **Total Annual (Non-discounted)** | **$ 26,711,000** | **$ -** | **$ -** | **$ -** |
| **Total Periodic (Non-discounted)** | **$ 1,173,000** | **$ -** | **$ -** | **$ -** |
| **Total Non Discounted** | **$ 37,514,000** | **$ -** | **$ -** | **$ -** |
| **Total Discounted (Discounted)** | **$ 20,637,000** | **$ -** | **$ -** | **$ -** |

**Institutional Controls Costs**
**from the ECF for the Institutional Controls, 2012 (ECF-HANFORD-12-0067, Rev 0)**
*The total non-discounted cost for the ICs for 150 years is estimated to be $562,781,000 for the Hanford site (about **$25,600,000 per ROD**). The total discounted cost for the ICs at Hanford are estimated at $221,299,000 (about **$10,100,000 per ROD**).*

*The total non-discounted cost for the 5-Year Reviews for 150 years is estimated to be $13,740,000 (about **$625,000 per ROD**). The total discounted cost for the 5-Year Reviews for 150 years is estimated to be $4,175,000 (about **$190,000 per ROD**).*

** Capital Cost is only provided due to expected completion timeframe of remediation, approximately 2013 to 2014.*

# Table A-3: Waste Sites - Important Input Quantities to Cost Estimate

# TRACE V3 Setup

| SCOPE PARAMETER | ALTERNATIVE S-2 |
|---|---|
| **Site specific ICs** | |
| **100-F-19:1** | **x** |
| Start Date | 2012 |
| End Date | 2088 |
| Site Visit per year | 1 |
| **100-F-19:2** | **x** |
| Start Date | 2012 |
| End Date | 2027 |
| Site Visit per year | 1 |
| **116-F-2** | **x** |
| Start Date | 2012 |
| End Date | 2101 |
| Site Visit per year | 1 |
| **116-F-4** | **x** |
| Start Date | 2012 |
| End Date | 2102 |
| Site Visit per year | 1 |
| **116-F-6** | **x** |
| Start Date | 2012 |
| End Date | 2113 |
| Site Visit per year | 1 |
| **116-F-9** | **x** |
| Start Date | 2012 |
| End Date | 2062 |
| Site Visit per year | 1 |
| **118-F-6** | **x** |
| Start Date | 2012 |
| End Date | 2032 |
| Site Visit per year | 1 |
| **118-F-8:3** | **x** |
| Start Date | 2012 |
| End Date | 2187 |
| Site Visit per year | 1 |
| **118-F-8:4** | **x** |
| Start Date | 2012 |
| End Date | 2025 |
| Site Visit per year | 1 |
| **116-F-14** | **x** |
| Start Date | 2012 |
| End Date | 2076 |
| Site Visit per year | 1 |

# Table A-4: Groundwater - Total Cost

## COMPARISON OF TOTAL COST OF RESPONSE ACTION ALTERNATIVES*

| | | | |
|---|---|---|---|
| **Site:** | 100 F and IU-2/6 | **Base Year:** | 2013 |
| **Location:** | Hanford, WA | **Date:** | Dec-11-2012 |
| **Phase:** | FS | **Rev:** | 1 |

| | **Alternative 2** | **Alternative 3** | **Alternative 4** |
|---|---|---|---|
| | **GW-2- ICs and MNA** | **Pump & Treat Optimized with Other Technologies** | **Enhanced Pump-and-Treat** |
| Total Duration (years) | **97** | **92** | **92** |
| **Cost Summary** | | | |
| Capital Cost | $4,930,000 | $83,083,000 | $98,365,000 |
| % of Total Non-discounted cost | 8.96% | 37.75% | 43.16% |
| Total Annual Cost | $30,495,000 | $94,826,000 | $87,883,000 |
| % of Total Non-discounted cost | 55.41% | 43.09% | 38.56% |
| Total Periodic Cost | $19,615,000 | $42,177,000 | $41,667,000 |
| % of Total Non-discounted cost | 36% | 19% | 18% |
| **Non-Discounted** | **$55,039,000** | **$220,086,000** | **$227,915,000** |
| **Real Discount Rate** | **2.0%** | **2.0%** | **2.0%** |
| **Total Present Value of Alternative (Discounted)** | **$33,514,000** | **$181,917,000** | **$199,500,000** |
| **Expected Accuracy Range for total present value is +50%/-30%** | | | |
| **-30%** | **$23,460,000** | **$127,342,000** | **$139,650,000** |
| **50%** | **$50,271,000** | **$272,876,000** | **$299,250,000** |

*Notes:

Range of accuracy is expected to be +50%/-30%

# Table A-5: Groundwater – Important Input Quantities to Cost Estimate

## TRACE V3 Setup

| SCOPE PARAMETER | ALTERNATIVE 2 | ALTERNATIVE 3 | ALTERNATIVE 4 |
|---|---|---|---|
| **GW Monitoring** | | | |
| Monitoring Duration - Cr(VI) (years) | 25 | 5 | 5 |
| Total Number of Samples - Year 1 | 40 | 40 | 40 |
| Total Number of Samples/yr - Years 2&3 | 34 | 34 | 34 |
| Total Number of Samples/yr - Years 4 to 10 | 34 | 10 | 10 |
| Total Number of Samples - Years 11 to End (biennial) | 238 | 0 | 0 |
| Total Number of Samples per biennial yr - Years 11 to End | 32 | 0 | 0 |
| Compliance Monitoring Samples - End + 5yrs | 170 | 170 | 170 |
| Monitoring Duration - Sr-90 (years) | 90 | 85 | 85 |
| Total Number of Samples - Year 1 | 20 | 20 | 20 |
| Total Number of Samples/yr - Years 2&3 | 17 | 17 | 17 |
| Total Number of Samples/yr - Years 4 to 10 | 17 | 17 | 17 |
| Total Number of Samples - Years 11 to End (biennial) | 680 | 638 | 638 |
| Total Number of Samples per biennial yr - Years 11 to End | 17 | 17 | 17 |
| Compliance Monitoring Samples - End + 5yrs | 85 | 85 | 85 |
| Monitoring Duration - TCE (years) | 45 | 10 | 10 |
| Total Number of Samples - Year 1 | 30 | 30 | 30 |
| Total Number of Samples/yr - Years 2&3 | 24 | 24 | 24 |
| Total Number of Samples/yr - Years 4 to 10 | 24 | 24 | 24 |
| Total Number of Samples - Years 11 to End (biennial) | 420 | 0 | 0 |
| Total Number of Samples per biennial yr - Years 11 to End | 24 | 0 | 0 |
| Compliance Monitoring Samples - End + 5yrs | 120 | 120 | 120 |
| Monitoring Duration - Nitrate-N (years) | 30 | 10 | 10 |
| Monitoring Duration - Nitrate-S (years) | same as N | 60 | same as N |
| Total Number of Samples - Year 1 | 65 | 65 | 65 |
| Total Number of Samples/yr - Years 2&3 | 35 | 35 | 35 |
| Total Number of Samples/yr (N) - Years 4 to 10 | 35 | 25 | 35 |
| Total Number of Samples/yr (S) - Years 4 to 10 | (incl. in N) | 10 | (incl. in N) |
| Total Number of Samples (N) - Years 11 to End (biennial) | 350 | 0 | 0 |
| Total Number of Samples (S) - Years 11 to End (biennial) | (incl. in N) | 125 | (incl. in N) |
| Total Number of Samples per biennial yr (N) - Years 11 to End | 35 | 0 | 0 |
| Total Number of Samples per biennial yr (S) - Years 11 to End | (incl. in N) | 5 | (incl. in N) |
| Compliance Monitoring Samples - End + 5yrs | 175 | 175 | 175 |
| **Monitoring Wells** | | | |
| Wells & Aquifer Tubes to be used - Cr(VI) | 34 | 34 | 34 |
| New Wells | 2 | 2 | 2 |
| Well Depth, Ft | 65 | 65 | 65 |
| Well Casing Dia, In | 6 | 6 | 6 |
| Wells & Aquifer Tubes to be used - Sr-90 | 17 | 17 | 17 |
| New Wells | 1 | 1 | 1 |
| Well Depth, Ft | 65 | 65 | 65 |
| Well Casing Dia, In | NA | NA | NA |
| Wells & Aquifer Tubes to be used - TCE | 24 | 24 | 24 |
| New Wells | 2 | 2 | 2 |
| Well Depth, Ft | 65 | 65 | 65 |
| Well Casing Dia, In | NA | NA | NA |
| Wells & Aquifer Tubes to be used - Nitrate | 35 | 35 | 35 |
| New Wells | 10 | 10 | 10 |
| Well Depth, Ft | 65 | 65 | 65 |
| Well Casing Dia, In | 6 | 6 | 6 |
| MW pump type - all plumes | NA | NA | NA |
| MW pump replacement, yrs | 5 | 5 | 5 |
| MW replacement, yrs | 30 | 30 | 30 |
| MW Rehab | NA | NA | NA |
| **Extraction Wells** | | | |
| # EW - Cr(VI) | NA | 4 | 4 |
| Flow rate per well, gpm | NA | 45 | 45 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 4", 56-95 gpm, 101'< Head <=220', 5 hp, w/ controls | 6", 56-95 gpm, 221'< Head <=300', 7 1/2 hp, w/ controls |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 11000 | 11000 |
| 6" HDPE Transfer Piping, ft | NA | NA | NA |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | 1 | 1 |
| Tank Capacity Each, gal | NA | 20000 | 20000 |

| | | | |
|---|---|---|---|
| # EW - Sr90 | NA | 1 | 1 |
| Flow rate per well, gpm | NA | 40 | 40 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 6", 56-95 gpm, 221'< Head <=300', 7 1/2 hp, w/ controls | 6", 56-95 gpm, 221'< Head <=300', 7 1/2 hp, w/ controls |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 1980 | 1980 |
| 6" HDPE Transfer Piping, ft | NA | NA | NA |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | NA | 1 |
| Tank Capacity Each, gal | NA | NA | 3000 |
| # EW - TCE | NA | 2 | 2 |
| Flow rate per well, gpm | NA | 40 | 40 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 6", 56-95 gpm, 221'< Head <=300', 7 1/2 hp, w/ controls | 6", 56-95 gpm, 301'< Head <=400', 10 hp, w/ controls |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 3190 | 3190 |
| 3" HDPE Transfer Piping, ft | NA | 6930 | 6930 |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | 1 | 1 |
| Tank Capacity Each, gal | NA | 10000 | 10000 |
| # EW - Nitrate | NA | 11 | 17 |
| Flow rate per well, gpm | NA | 41 | 41 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | NA | 20 |
| Type of Submersible Pump | NA | 6", 56-95 gpm, 301'< Head <=400', 10 hp, w/ controls | 6", 56-95 gpm, 301'< Head <=400', 10 hp, w/ controls |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 26840 | 41360 |
| 4" HDPE Transfer Piping, ft | NA | 8030 | 23100 |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| | NA | 1 | 1 |
| Tank Capacity Each, gal | NA | 15000 | 15000 |
| Important Quantity 126 | NA | NA | NA |
| EW- Rehab | NA | 10 | 10 |
| EW - Pump replacement | NA | 5 | 5 |
| EW- Well replacement | NA | 20 | 20 |
| Important Quantity 130 | NA | NA | NA |
| **Injection Wells** | | | |
| # IW - Cr(VI) | NA | 4 | 4 |
| Flow rate per well, gpm | NA | 55 | 55 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 0 | 0 |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 8580 | 8580 |
| 6" HDPE Transfer Piping, ft | NA | NA | NA |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | 0 | 0 |
| Tank Capacity Each, gal | NA | NA | NA |

| | | | |
|---|---|---|---|
| # IW - Sr90 | NA | 0 | 0 |
| Flow rate per well, gpm | NA | 0 | 0 |
| Assumed well depth | NA | 0 | 0 |
| Expected Safety Level | NA | NA | 0 |
| Type of Submersible Pump | NA | NA | 0 |
| Well Casing Diameter, in | NA | 0 | 0 |
| 2" HDPE Transfer Piping, ft | NA | 0 | 0 |
| 6" HDPE Transfer Piping, ft | NA | NA | NA |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | NA | NA |
| Tank Capacity Each, gal | NA | NA | NA |
| # IW - TCE | NA | 1 | 1 |
| Flow rate per well, gpm | NA | 40 | 40 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 0 | 0 |
| Well Casing Diameter, in | NA | 8 | 8 |
| 2" HDPE Transfer Piping, ft | NA | 4290 | 4290 |
| 6" HDPE Transfer Piping, ft | NA | NA | NA |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | NA | NA |
| Tank Capacity Each, gal | NA | NA | NA |
| # IW - Nitrate | NA | 13 | 21 |
| Flow rate per well, gpm | NA | 37 | 37 |
| Assumed well depth | NA | 65 | 65 |
| Expected Safety Level | NA | D | D |
| Type of Submersible Pump | NA | 0 | 0 |
| Well Casing Diameter, in | NA | 0 | 0 |
| 2" HDPE Transfer Piping, ft | NA | 55000 | 102850 |
| 4" HDPE Transfer Piping, ft | NA | 8030 | 23100 |
| Influent Pumping Stations (New) | NA | NA | NA |
| Influent Pumping Station Flow, ea | NA | NA | NA |
| Influent collection tanks | NA | 0 | 0 |
| Tank Capacity Each, gal | NA | NA | NA |
| Important Quantity 126 | NA | NA | NA |
| IW- Rehab | NA | 2 | 2 |
| IW - Pump replacement | NA | 5 | 5 |
| IW- Well replacement | NA | 10 | 10 |
| Important Quantity 130 | NA | NA | NA |
| Important Quantity 199 | NA | NA | NA |
| Important Quantity 200 | NA | NA | NA |
| Important Quantity 201 | s | NA | NA |
| **Treatment** | | | |
| Cr(VI) design flow, gpm (to IX) | NA | 180 | 180 |
| Bio-amended Injection for Cr, gpm | | 110 | 0 |
| System % online time | NA | 1 | 1 |
| Sr-90 flow, gpm (to IX) | NA | 40 | 40 |
| System % online time | NA | 1 | 1 |
| TCE flow, gpm (to Air Stripper) | NA | 80 | 80 |
| Bio-amended Injection for TCE, gpm | | 40 | 0 |
| System % online time | NA | 1 | 1 |
| NO3 flow, gpm (to IX) | NA | 455 | 695 |
| NO3 flow, gpm (to IX) - PHASE II | NA | 335 | 575 |
| NO3 flow, gpm (to IX) - PHASE III | NA | 0 | 0 |
| Bio-amended Injection for nitrate, gpm | NA | 240 | 0 |
| Bio-amended Injection for nitrate, gpm - PHASE II | NA | 240 | 0 |
| Bio-amended Injection for nitrate, gpm - PHASE III | NA | 0 | 0 |
| System % online time | NA | 1 | 1 |
| Total Treatment System Flow (initial), gpm | NA | 755 | 995 |
| Total Bio-amended injection flow (initial), gpm | | 280 | 0 |

# Table A-6: Waste Sites Remaining for Remedial Action (WCH)

| 100-IU Sites Remaining for Remedial Action | | |
|---|---|---|
| **Site** | **RTD Estimate** | **Estimate Basis** |
| 600-20 | $230,000 | Analogy to the RTD cost estimated for the similar 600-280 site in the 2009 Explanation of Significant Difference to the Remaining Sites ROD. |
| 600-279 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-293 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-294 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-301 | $2,000,000 | Analogy to the RTD cost for the 1607-D2 septic system in the 2009 Explanation of Significant Difference to the Remaining Sites ROD. |
| 600-329 | $400,000 | Analogy to the RTD cost for the 100-F-43 spillway in the 2009 Explanation of Significant Difference to the Remaining Sites ROD. |
| 600-331 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-332 | $520,000 | Analogy to the RTD cost for the 100-D-14 septic system in the 2009 Explanation of Significant Difference to the Remaining Sites ROD. |
| 600-334:2 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-349 | $2,400,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. Estimated cost scaled up by a factor of 20 based on large site footprint area and 600-149 remediation experience. |
| 600-358 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-368 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:1 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:2 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:3 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:4 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:5 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:6 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:7 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-369:8 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 300-370 | $1,200,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. Estimated cost scaled up by a factor of 10 based on large site footprint area. |
| 600-371 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-372:1 | $120,000 | Estiamted total cost for both small subsites based on analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-372:2 | | |
| 600-373 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-374 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |

| 100-IU Sites Remaining for Remedial Action | | |
|---|---|---|
| **Site** | **RTD Estimate** | **Estimate Basis** |
| 600-375:1<br>600-375:2<br>600-375:3<br>600-375:4<br>600-375:5 | $120,000 | Estiamted total cost for all subsites based on analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-376:1<br>600-376:2 | $120,000 | Estiamted total cost for both small subsites based on analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-377 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-378 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| 600-379 | $120,000 | Analogy to the RTD cost estimated for many small 100-IU-2&6 sites in the 2009 Explanation of Significant Difference and 2010 Fact Sheet for the Remaining Sites ROD. |
| **Total** | **$9,630,000** | |

ECF-100FR1-11-0148, REV. 1

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Plateau Remediation Company

# Environmental Calculation Cover Page

**Part 1: Completed by the Responsible Manager**

**Calculation Title & Description: Cost Estimate Inputs for *Remedial Investigation/Feasibility Study Groundwater Alternatives for 100-FR-3Operable Unit.***

| | |
|---|---|
| Preparer: S. McKinley | Basis of Qualification: Education and Experience |
| Checker: T. Dye | Basis of Qualification: Education and Experience |
| Senior Reviewer: K. Klink | Basis of Qualification: Education and Experience |

**Part 2: Completed by Preparer**

**Calculation No.: ECF-100FR3-11-0148** **Revision No.:** 1

**Revision History:**

| Revision No. | Description | Date | Affected Pages |
|---|---|---|---|
| 0 | Initial Issue | 9-24-2011 | All |
| 1 | Revision 1 | 12-10-12 | All |

**Part 3: Document Review & Approval:**

| | | |
|---|---|---|
| Preparer: | S. McKinley, PE/ Senior Project Hydrogeologist<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12-10-12<br>DATE |
| Checker: | T. Dye, PE / Environmental Engineer<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12-10-12<br>DATE |
| Senior Reviewer: | Kevin Klink/Senior Reviewer<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/11/12<br>DATE |
| Responsible Manager: | Phil Burke / Project Manager<br>NAME/POSITION<br>[signature]<br>SIGNATURE | 12/11/12<br>DATE |

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# Contents



# Appendices

# Terms

| | |
|---|---|
| ARAR | Applicable, Relevant, and Appropriate Requirement |
| CERCLA | Comprehensive Environmental Compensation and Liability Act of 1980. |
| Cr(VI) | hexavalent chromium |
| COC | Contaminant of Concern |
| ERDF | Environmental Restoration Disposal Facility |
| FS | Feasibility Study |
| GPM | gallons per minute |
| GW | groundwater |
| IC | Institutional Controls |
| ISS | Interim safe storage |
| MNA | Monitored Natural Attenuation |
| NCP | National Contingency Plan |
| OU | Operable Unit |
| O&M | operation and maintenance |
| PRG | preliminary remediation goal |
| RAO | Remedial action objective |
| RBSL | Risk based screening level |
| RTD | Remove, Treatment and Disposal |

# 1 Purpose

The purpose of this calculation is to document and describe cost estimate inputs and key assumptions that support the *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6, and 100-FR-3 Operable Units* (DOE/RL-2010-98). This document documents assumptions and calculations supporting development and cost estimation for the 100-FR-3 Operable Unit (OU). The feasibility study (FS) cost inputs are derived from site features, physical parameters, and characteristics of the 100-FR-3 groundwater OU. The FS cost estimates are prepared to an expected accuracy of +50%/-30%, and used as part of the detailed and comparative analysis of remedial alternatives under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, (CERCLA). This analysis ultimately leads to recommendation of a preferred alternative in the proposed plan.

# 2 Background

A range of 100-FR-3 groundwater alternatives was developed for the FS that achieve remedial action objectives (RAOs) within progressively shorter timeframes. Table 1 lists the key characteristics of each groundwater contaminant of concern (COC) plume.

Table 1. 100-FR-3 Groundwater COC Plume Information

| | **Groundwater COC Plumes** | | | |
|---|---|---|---|---|
| **Parameter** | Cr(VI) | Strontium-90 | Trichlorethene | Nitrate |
| Plume Size (acres) | 56 | 25 | 172 | 3160 |
| Plume Volume (gallons) | 46,000,000 | 21,000,000 | 140,000,000 | 2,600,000,000 |
| COC Mass[a] (kg or Ci) | 16.5 | 2.1 | 8 | 1,200,000 |
| Preliminary Remediation Goal (PRG) | 10 µg/L Surface Water Protection<br>48 µg/L Groundwater Protection | 8 pCi/L | 4.9 µg/L | 45,000 µg/L |

[a] COC mass estimate represents the mass enclosed with the 0.1 * PRG concentration isopach.

Four groundwater remedial alternatives were developed for the 100-FR-3 OU. The groundwater remedial action alternative descriptions presented below present a range of estimated timeframes for each alternative to achieve their respective preliminary remediation goal (PRG). The lower end of the remediation timeframe range is defined by the time required for 90$^{th}$ percentile (C90) concentration to decline to the PRG while the upper end of the range is defined by the time required for the Cmax concentration to decline to the PRG. Table 2 provides a summary of the estimated time necessary for the C90 and Cmax concentrationto reach their respective PRG under the different alternatives. The model simulations presented in ECF-100FR3-11-0116 Rev. 2, *Modeling of RI/FS Design Alternatives for 100-FR-3,* portray the COC plumes based on Cmax concentrations.

The C90 concentration, which corresponds to the lower end of the remediation timeframe, provides a reasonable estimate for the cleanup timeframe that could be achieved with rigorous monitoring and remedial process optimization. The operation and maintenance (O&M) portion of the remedial action alternative cost estimates is based on the C90 timeframe. The Cmax concentration, which corresponds to upper end of the

Table 2. Comparison of Remedial Action Timeframe Estimates[a] (years)

| COC | PRG | GW-1: No Action | | GW-2: ICs and MNA | | GW-3: Pump-and-Treat Optimized with Other Technologies | | GW-4: Enhanced Pump-and-Treat | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cmax | C90 | Cmax | C90 | Cmax | C90 | Cmax | C90 |
| Cr(VI) | 10 µg/L | 35 | 25 | 35 | 25 | 5 | 5 | 10 | 5 |
| Cr(VI) | 48 µg/L | 20 | 10 | 20 | 10 | 5 | 5 | 5 | 5 |
| Nitrate<br>- North<br>- South | 45,000 µg/L | 80 | 30 | 80 | 30 | 15<br>75 | 10<br>60 | 25 | 10 |
| Trichloroethene | 4.9 µg/L | 45 | --[b] | 45 | --[b] | 10 | --[b] | 10 | --[b] |
| Strontium-90 | 8 pCi/L | 150 | 90 | 150 | 90 | 150 | 85 | 150 | 85 |

Notes:

[a] The estimated C90 durations presented in ECF-100FR3-11-0116 Rev. 2, *Modeling of RI/FS Design Alternatives for 100-FR-3* were rounded up to the nearest five year increment to reflect uncertainties in actual versus simulated alternative performance.

[b] The Cmax remedial action timeframe was used in lieu of C90 because the model estimates that the C90 concentration is less than the PRG at time zero for all four remedial alternatives.

remediation timeframe, provides the worst-case estimate corresponding to isolated point-concentrations that might occur.

A C90 remediation timeframe for the trichlorethene plume was not calculated for the groundwater remedial action alternatives, therefore only the Cmax timeframe is presented. The model simulations for each of the TCE plume remedial action alternatives indicate that the C90 concentration, as calculated from the model results, is always less than the PRG. Because a C90 timeframe of 0 years does not provide a basis for estimating remedial action O&M costs, the timeframe to complete remediation of the TCE plume was estimated using the Cmax timeframe only.

Modeling of RI/FS Design Alternatives for 100-FR-3 (ECF-100FR3-11-0116, Rev. 2), presented in Appendix F, presents the calculations and modeling results used for developing remedial action alternatives and estimating remedial action alternative completion timeframes. These timeframes are estimates based on current information. The actual timeframes may vary depending on the final configuration of the selected alternative, as determined during remedial design, the aquifer's response to the remedy, and the scope and effectiveness of remedial process optimization.

The groundwater alternatives are:

- **Alternative GW-1: No Action.** This alternative is required by the NCP ("Remedial Investigation/Feasibility Study and Selection of Remedy" [40 CFR 300.430(e)(6)]). The No Action Alternative, which serves as a baseline for evaluating other remediation action alternatives, is retained throughout the FS process. No action means that no remediation would be implemented to address the groundwater contaminant plumes. All existing groundwater monitoring and data evaluation and reporting would be discontinued, and existing ICs lifted. No conceptual designs or cost estimates are prepared for Alternative GW-1 because no actions are proposed.

- **Alternative GW-2: ICs and Monitored Natural Attenuation (MNA).** This alternative uses ICs to prevent exposure to contaminated groundwater until MNA processes reduce COC concentrations to preliminary remediation goals (PRGs). The estimated time frame to achieve PRGs based on the 90$^{th}$ percentile (C90) concentration is 25 years for Cr(VI), 30 years for nitrate, and 90 years for strontium-90. In lieu of the C90 concentration, the maximum projected (Cmax) concentration was used for the trichloroethene plume because the C90 concentration is projected to be below the PRG at time zero. The estimated timeframe for the trichloroethene plume to achieve its PRG based on Cmax is 45 years. Groundwater sampling and analysis, and data evaluation and reporting are also an important component of this alternative to confirm that natural attenuation processes are reducing COC concentrations in accordance with expectations, and to provide a basis for determining when remedial action is complete and ICs can be removed.

- **Alternative GW-3: Pump-and-Treat Optimized with Other Technologies.** This alternative utilizes pump-and-treat for Cr(VI), trichloroethene, strontium-90 and nitrate for cleanup of the remedial action target area. Substrate injection will be performed at upgradient nitrate and Cr(VI) injection wells to promote in-situ reduction of nitrate to nitrogen gas and reduction of Cr(VI) to Cr(III). Incidental reductive dechlorination of trichloroethene to cis 1,2-dichloroethene is also expected to occur although such was not simulated under this alternative. MNA, following pump-and-treat operations, will also contribute to achieving cleanup levels for strontium-90 and the southern portion of the nitrate plume. The estimated remedial action timeframes based on the C90 concentration are: 5 years for Cr(VI), 10 years for the concentrated-northern portion of the nitrate plume, and 60 years for the southern low-concentration plume area, and 85 years for strontium-90. The estimated timeframe to achieve the PRG for trichloroethene is 10 years based on the Cmax concentration.

  **Alternative GW-4: Enhanced Pump-and-Treat.** This alternative uses pump-and-treat with ex situ treatment technology for Cr(VI), strontium-90, trichloroethene, and nitrate-contaminated groundwater. This alternative uses more aggressive pumping and treatment technology employed for many of the 100 Area groundwater interim actions to achieve groundwater protection PRGs within a shorter timeframe relative to the other groundwater remedial action alternatives. The estimate remedial action timeframes under this alternative based on the C90 concentration are: 5 years for Cr(VI), 10 years for nitrate, and 85 years for strontium-90. The estimated timeframe to achieve the PRG for trichloroethene, based on Cmax, is 10 years.

# 3 Methodology

Development of the cost inputs for the 100-F/IU OU alternatives requires simple calculations performed in Microsoft Excel (MS Excel)™ spreadsheets. Due to the basic nature of these calculations, development of a detailed methodology for each calculation was not conducted. Section 4 provides the key inputs and assumptions that support each calculation and Section 6 provides a summary of the spreadsheet calculations.

# 4 Assumptions and Input

This section describes the overall assumptions applicable to the 100-F/IU groundwater alternatives. The information used in this form was obtained from ECF-100FR3-11-0116 Rev. 2, *Modeling of RI/FS*

™ Microsoft Excel (MS Excel) is a trademark of Microsoft Corporation.

*Design Alternatives for 100-FR*-3, and Chapters 8, 9, 10 and Appendix J of DOE/RL-2010-98. Tables 3 to 6 provide the input parameters for the groundwater plumes. Table 6 presents how costs associated with ICs will be handled for the 100-F/IU FS cost estimate.

Figures 1 and 2 illustrate the extraction and injection well layout for groundwater alternatives GW-3 and GW-4 while Figures 3 and 4 show conceptual treatment system schematics. Appendix A provides supporting information for the groundwater alternatives.

| Table 3. Groundwater Remedial Action Alternatives Cost Estimate Parameter Assumptions and Inputs | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cr(VI) | | | Strontium-90 | | | Trichlorethene | | | Nitrate | | |
| | Alternative | | | Alternative | | | Alternative | | | Alternative | | |
| Parameter | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |
| Average depth to static water table (ft) [from Figure 3-12 in DOE/RL-2010-98] | 20 | 20 | 20 | 20 | 20 | 20 | 30 | 30 | 30 | 30 | 30 | 30 |
| Average depth to base of aquifer (ft) [from Figure 3-12 in DOE/RL-2010-98] | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 60 | 60 | 60 |
| Expected Safety Level | D | | | | | | | | | | | |
| **Extraction Wells** | | | | | | | | | | | | |
| No. of New Extraction Wells | 0 | 4 | 4 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 11 | 17 |
| Average Instantaneous Flow rate per well (gpm) [a] | 0 | 45 | 45 | 0 | 40 | 40 | 0 | 40 | 40 | 0 | 41 | 41 |
| Total Pumping Rate (gpm) | | | | | | | | | | | | |
| - Year 0-3 | 0 | 180 | 180 | 0 | 40 | 40 | 0 | 80 | 80 | 0 | 455 | 695 |
| - Year 3-5 | 0 | 180 | 180 | 0 | 40 | 40 | 0 | 80 | 80 | 0 | 455 | 695 |
| - Year 6-7 | 0 | 0 | 0 | 0 | 40 | 40 | 0 | 80 | 80 | 0 | 455 | 695 |
| - Year 8-10 | 0 | 0 | 0 | 0 | 40 | 40 | 0 | 80 | 80 | 0 | 335 | 575 |
| - Year 11-12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Year 13-15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Year 16-18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Submersible pump (hp) [see Table 6] | -- | 3 | 3 | -- | 3 | 3 | -- | 3 | 3 | -- | 3 | 3 |
| Well casing dia (inches) | -- | 8 | 8 | -- | 8 | 8 | -- | 8 | 8 | -- | 8 | 8 |
| Type of enclosure | -- | Std | Std | -- | Std | Std | -- | Std | Std | -- | Std | Std |

| Table 3. Groundwater Remedial Action Alternatives Cost Estimate Parameter Assumptions and Inputs | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cr(VI)** | | | **Strontium-90** | | | **Trichlorethene** | | | **Nitrate** | | |
| | **Alternative** | | | **Alternative** | | | **Alternative** | | | **Alternative** | | |
| **Parameter** | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |
| Screen length/length (ft) | -- | 25 | 25 | -- | 25 | 25 | -- | 25 | 25 | -- | 25 | 25 |
| Riser Casing Type/Length (ft) | -- | 40 | 40 | -- | 40 | 40 | -- | 40 | 40 | -- | 40 | 40 |
| Well Conveyance Piping dia (inches) | -- | 2 | 2 | -- | 2 | 2 | -- | 2 | 2 | -- | 2 | 2 |
| Well Conveyance Piping Length (ft) | -- | 11,000 | 11,000 | -- | 1,980 | 1,980 | -- | 3,190 | 3,190 | -- | 26,840 | 41,360 |
| No. of Existing Extraction Wells | -- | 0 | 0 | -- | 0 | 0 | -- | 0 | 0 | -- | 0 | 0 |
| **Injection Wells** | | | | | | | | | | | | |
| No. of New Injection Wells | -- | 4 | 4 | -- | 0 | 0 | -- | 1 | 1 | -- | 13 | 21 |
| Injection rate (gpm) | -- | 0 | 0 | -- | 0 | 0 | -- | 0 | 0 | -- | 42 | 38 |
| - Year 0-3 | 0 | 220 | 220 | 0 | 0 | 0 | 0 | 40 | 40 | 0 | 495 | 735 |
| - Year 4-7 | 0 | 220 | 220 | 0 | 0 | 0 | 0 | 40 | 40 | 0 | 495 | 735 |
| - Year 7–10 | 0 | 220 | 220 | 0 | 0 | 0 | 0 | 40 | 40 | 0 | 375 | 615 |
| - Year 10-12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Year 13-15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| - Year 16-18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Well casing dia (inches) | -- | 8 | 8 | -- | 0 | 0 | -- | 8 | 8 | -- | 8 | 8 |
| Type of enclosure | -- | Std | Std | -- | -- | -- | -- | Std | Std | -- | Std | Std |
| Screen length (ft) | -- | 40 | 40 | -- | -- | -- | -- | 40 | 40 | -- | 40 | 40 |
| Riser Casing Type/Length (ft) | -- | 25 | 25 | -- | -- | -- | -- | 25 | 25 | -- | 25 | 25 |
| Well Conveyance Piping dia (inches) | -- | 2 | 2 | -- | -- | -- | -- | 2 | 2 | -- | 2 | 2 |

**Table 3. Groundwater Remedial Action Alternatives Cost Estimate Parameter Assumptions and Inputs**

| | Cr(VI) | | | Strontium-90 | | | Trichlorethene | | | Nitrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alternative | | | Alternative | | | Alternative | | | Alternative | | |
| **Parameter** | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |
| Well Conveyance Piping Length (ft) | -- | 8,580 | 8,580 | -- | 0 | 0 | | 4,290 | 4,290 | | 55,000 | 102,850 |
| No. of Existing Injection Wells | -- | 0 | 0 | -- | -- | -- | -- | 0 | 0 | -- | 0 | 0 |
| No. of Injection Wells with Substrate Injection | -- | 2 | -- | -- | 0 | -- | -- | 1 | -- | -- | 6 | 0 |
| Substrate Injection Conc (mg/L) | -- | 500 | -- | -- | -- | -- | -- | 500 | -- | -- | 500 | -- |
| Substrate Mass (kg) | | | | | | | | | | | | |
| Per year | -- | 109,500 | -- | -- | -- | -- | -- | 39,800 | -- | -- | 238,900 | -- |
| -Year 0-3 (3 yrs) | -- | 328,500 | -- | -- | -- | -- | -- | 119,400 | -- | -- | 716,700 | -- |
| -Year 4-7 (4 yrs) | -- | 438,000 | -- | -- | -- | -- | -- | 159,200 | -- | -- | 955,600 | -- |
| - Year 8-10 (3 yrs) | -- | 328,500 | -- | -- | -- | -- | -- | 199,000 | -- | -- | 716,700 | -- |
| -Year 10-12 (5 yrs) | -- | 0 | -- | -- | -- | -- | -- | 0 | -- | -- | 0 | -- |
| -Year 13-15 (3 yrs) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -Year 16-18 (3 yrs) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Total | | 1,095,000 | | | | | | 398,000 | | | 2,389,000 | |
| **Monitoring Wells** | | | | | | | | | | | | |
| No. of New Monitor Wells | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 10 | 10 | 10 |
| Well casing dia (inches) | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Type of enclosure | Std | Std | Std | Std | Std | Std | Std | Std | Std | Std | Std | Std |
| Screen length/length (ft) | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Riser Casing Type/Length (ft) | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |

**Table 3. Groundwater Remedial Action Alternatives Cost Estimate Parameter Assumptions and Inputs**

| | Cr(VI) | | | Strontium-90 | | | Trichlorethene | | | Nitrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alternative | | | Alternative | | | Alternative | | | Alternative | | |
| **Parameter** | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |

Notes:

a. Nominal flow rates presented in ECF-100FR3-11-0116 Rev. 2 have been increased by 10 percent to account for a 90 percent uptime factor.

**Table 4. Pump Sizing Calculation**

Below are calculations for the minimum pump size and maximum projected head loss. The given conditions and assumptions are listed.

**Conditions**

- 30 ft (average) to static water level
- 35 ft (average) aquifer thickness
- 40 gpm pumping rate
- Groundwater containing Cr(VI), strontium-90, trichloroethene, and nitrate

**Assumptions**

- 10 ft of static head to transfer station temporary storage tank
- 500 ft of total head (static head, friction head, minor losses, head to tank) used for pump sizing
- Water temperature is 15° C

**Calculations**

Minimum Horse Power:

$$Hp = \frac{\text{GPM * Total Head* Specific Gravity}}{\text{3960 * Pump Efficiency}}$$

GPM = 40 gpm

Total Head = 75 ft static head + 25 ft friction loss + other = 100 ft

Specific Gravity = 1.0

Pump Efficiency = 80%

Hp = 2.4. Assume 3 Hp per Grundfos website recommendation

Friction Loss Check:

Hazen-Williams: hf = [0.002083* L * (100/C)^1.85 *(Q)^1.85]/d^4.8655)

C= roughness constant = 140 for ethylene pipe

L = Length = Average Pipe Run from Well to Transfer Tank = 500 ft

d = Hydraulic diameter = 3 inch (3 inch nominal HDPE pipe)

Hf = 2.5 ft

Minor losses estimated to be 22.5 feet, assuming 1 gate valve, 1 check valve, 1 flow meter, and 8 elbows.

| Table 5. Groundwater Treatment System Cost Estimate Parameter Assumptions and Inputs | | | |
|---|---|---|---|
| **Transfer Station** | | | |
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Number - Distribution | -- | 1 – TCE<br>1 – Nitrate Extraction<br>1 – Nitrate Injection | 1 – TCE<br>2 – Nitrate Extraction<br>2 – Nitrate Injection |
| Transfer Piping – 3” dia (ft) | -- | 6,930 | 6,930 |
| Transfer Piping – 4” dia (ft) | -- | 16,060 | 46,200 |
| Installation type | -- | Modeled after 100-KX | Modeled after 100-KX |
| **Cr(VI) IX System** | | | |
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Flowrate, gpm (avg) | 0 | 180 | 180 |
| Initial Concentration (mg/L) Based on C90 | Not applicable | 0.02 | 0.02 |
| Installation type | Not applicable | Modeled after 100-KX | Modeled after 100-KX |
| **Strontium-90 IX System** | | | |
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Flowrate, gpm (avg) | 0 | 40 | 40 |
| Initial Concentration (pCi/L) Based on C90 | Not applicable | 3.3 | 3.3 |
| Installation type | Not applicable | Modeled after 100-KX | Modeled after 100-KX |
| **Nitrate IX System** | | | |
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Flowrate, gpm (avg) | 0 | 455 | 695 |
| Initial Concentration (mg/L) Based on C90 | Not applicable | 110 | 110 |
| Installation type | Not applicable | Modeled after 100-KX | Modeled after 100-KX |
| **Trichloroethene Air Stripping System** | | | |

| Table 5. Groundwater Treatment System Cost Estimate Parameter Assumptions and Inputs | | | |
|---|---|---|---|
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Flowrate, gpm (avg) | 0 | 80 | 80 |
| Initial Concentration (mg/L) Based on C-90 | Not applicable | 0.011 | 0.011 |
| Installation type | Not applicable | Modeled after 100-KX Pretreatment System | Modeled after 100-KX Pretreatment System |
| **Nitrate, Cr(VI) and Trichlorethene Substrate Injection System** | | | |
| **Parameter** | **Alternative GW-2** | **Alternative GW-3** | **Alternative GW-4** |
| Transfer Piping Diameter (HDPE, in) | Not applicable | Included above | Not applicable |
| 20,000 Gallon HDPE Tank (1 month volume) | Not applicable | 1 | Not applicable |
| 0.1-1 gpm chemical metering pump, valves, piping | Not applicable | 1 | Not applicable |
| Ethanol, dairy whey, yeast or other local agricultural processing facility substrate. Assume 500 mg/L substrate concentration. Actual amount of substrate injected and amount of nitrate treated will vary and be determined during remedial design testing. | Not applicable | 3,882,000 kg<br>(8,540,400 lbs) – total | Not applicable |
| Substrate Injection Period | Not applicable | Years 1-7 (Cr(VI) and TCE Plumes)<br>Years 1-10 (Nitrate Plume) | Not applicable |
| Electrical Service to node | Not applicable | Yes | Not applicable |

| Table 6. Groundwater Monitoring | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cr(VI)** | | | **Strontium-90** | | | **Trichlorethene** | | | **Nitrate** | | |
| **Parameter** | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |
| Expected Safety Level | D | | | | | | | | | | | |
| GW, avg sample depth, ft | 25 | | | 25 | | | 25 | | | 25 | | |
| GW, # of events/year (1st year), New Monitor Wells Only | 4 | | | 4 | | | 4 | | | 4 | | |
| GW, # of events/year (Year 2-10) | 1 | | | 1 | | | 1 | | | 1 | | |
| GW, # of events/year (Year 11-end) | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | | |
| Monitoring Duration (yrs) – estimated O&M duration | 25 | 5 | 5 | 90 | 85 | 85 | 45 | 10 | 10 | 30 | 10 – N<br>60 - S | 10 |
| Compliance Monitoring Period-Years | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total Number of New Wells to be Sampled | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 10 | 5 – N<br>5 - S | 10 |
| Total Number of Existing Wells and Aquifer Tubes to be Sampled | 32 | 32 | 32 | 16 | 16 | 16 | 22 | 22 | 22 | 25 | 20 – N<br>5 – S | 25 |
| Total Number of Wells and Aquifer Tubes to be Sampled | 34 | 34 | 34 | 17 | 17 | 17 | 24 | 24 | 24 | 35 | 35 | 35 |
| Total Number of Samples – Year 1 | 40 | 40 | 40 | 20 | 20 | 20 | 30 | 30 | 30 | 65 | 65 | 65 |
| Total Number of Samples – Years 2 + 3 (annual) | 68 | 68 | 68 | 34 | 34 | 34 | 48 | 48 | 48 | 70 | 70 | 70 |
| Total Number of Samples – Years 4+5+6+7+8+9+10 (annual) | 238 | 68 | 68 | 119 | 119 | 119 | 168 | 168 | 168 | 245 | 175 – N<br>70 – S | 245 |
| Total Number of Samples – Years 11 to End (biennial) | 238 | 0 | 0 | 680 | 638 | 638 | 420 | 0 | 0 | 350 | 0 – N<br>125 - S | 0 |
| Total Number of Samples – Compliance Monitoring (annual) | 170 | 170 | 170 | 85 | 85 | 85 | 120 | 120 | 120 | 175 | 175 | 175 |
| Notes: | | | | | | | | | | | | |

| Table 6. Groundwater Monitoring | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cr(VI)** | | | **Strontium-90** | | | **Trichlorethene** | | | **Nitrate** | | |
| **Parameter** | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 | GW-2 | GW-3 | GW-4 |
| DOE/RL-2010-987, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6, and 100-FR-4 Operable Units* | | | | | | | | | | | | |
| ECF-100FR3-11-0116, Rev 2, Modeling of RI/FS Design Alternatives for 100-FR-3 | | | | | | | | | | | | |

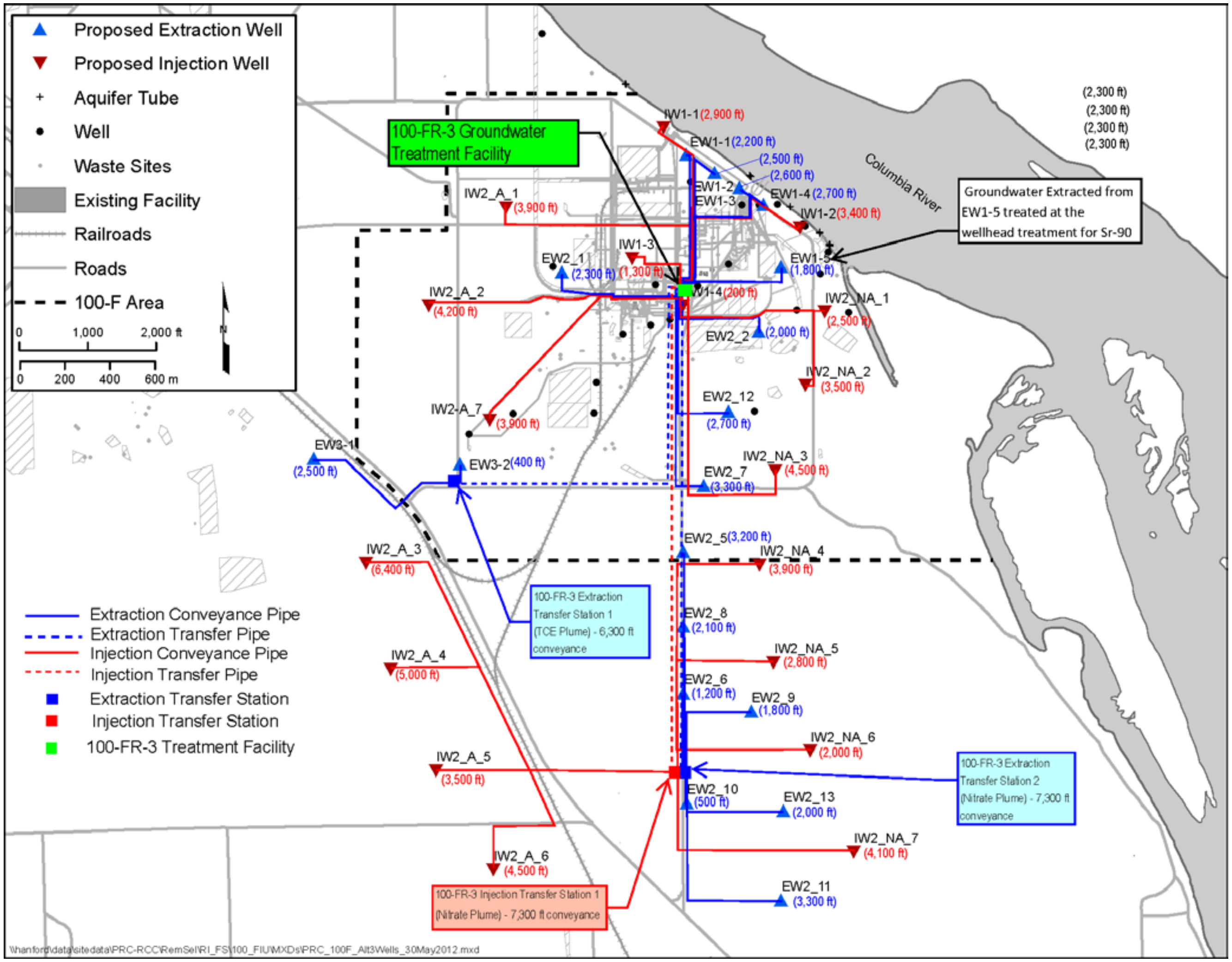


**Figure 1. Alternative GW-3. Wellfield and Conveyance Piping Layout[1]**

[1] This figure depicts measured pipe lengths. Cost estimate inputs assume 10% increase from measured length to account for field routing of piping to account for terrain and other routing constraints. See Appendix B for assumed pipe lengths.

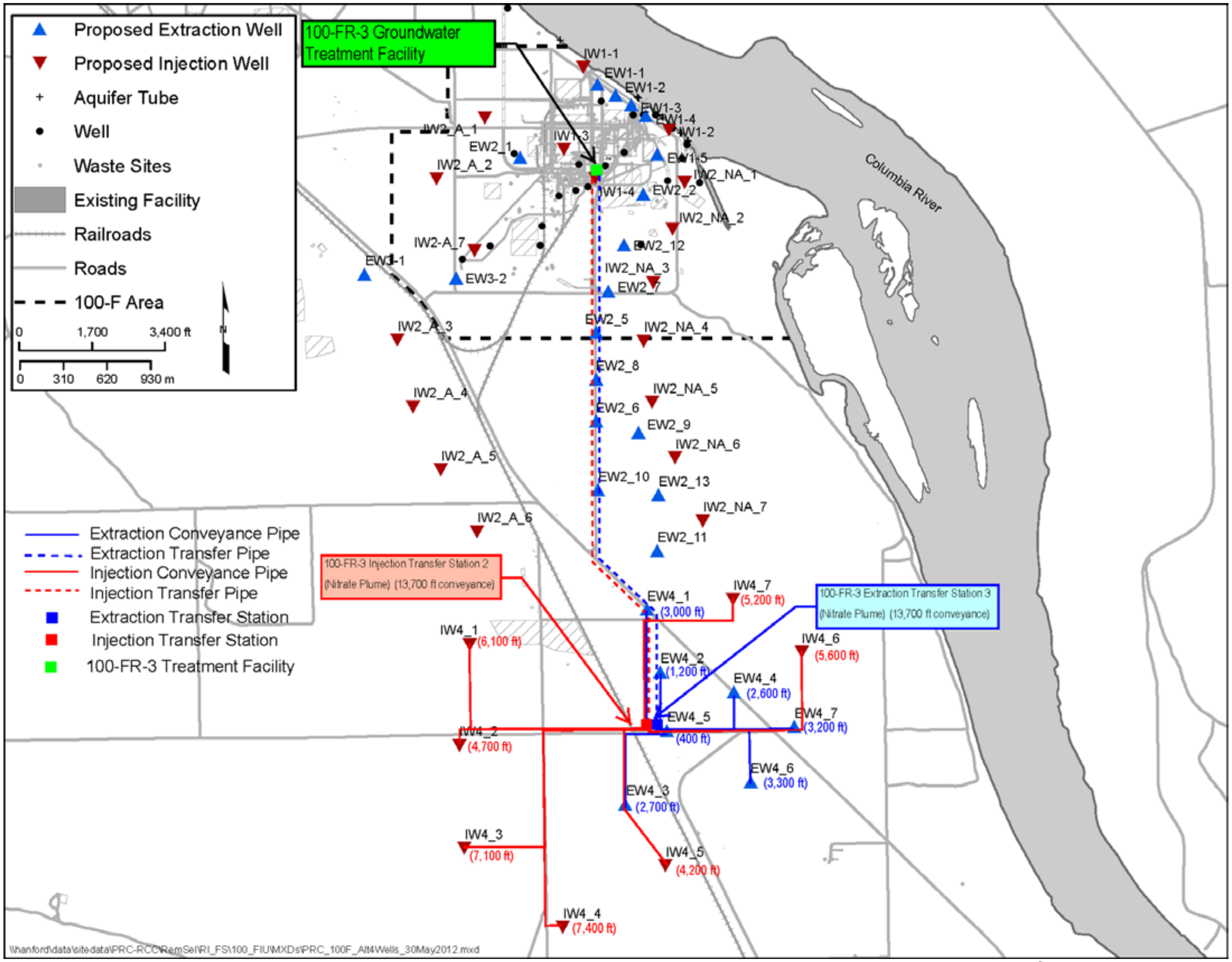


**Figure 2. Alternative GW-4. Additional Wellfield and Conveyance Piping Components[2]**

[2] This figure depicts additional pump stations and piping in addition to what is required for Alt.GW-3. Cost estimate inputs assume 10% increase from measured length (shown on this figure) to account for field routing of piping to account for terrain and other routing constraints. See Appendix B for assumed pipe lengths.

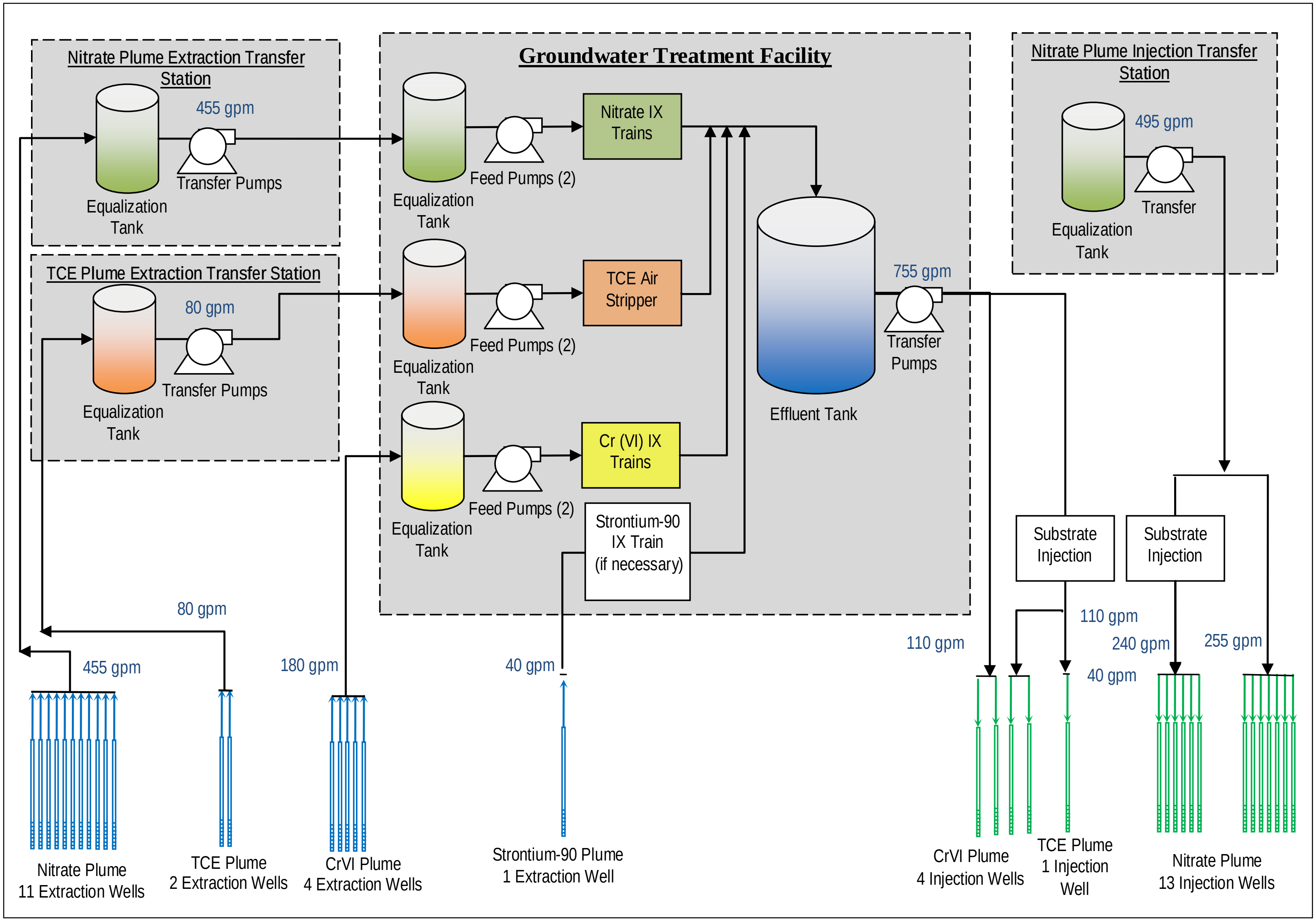


**Figure 3. Conceptual Process Flow Diagram for Alternative GW-3: Pump-and-Treat Optimized with Other Technologies**

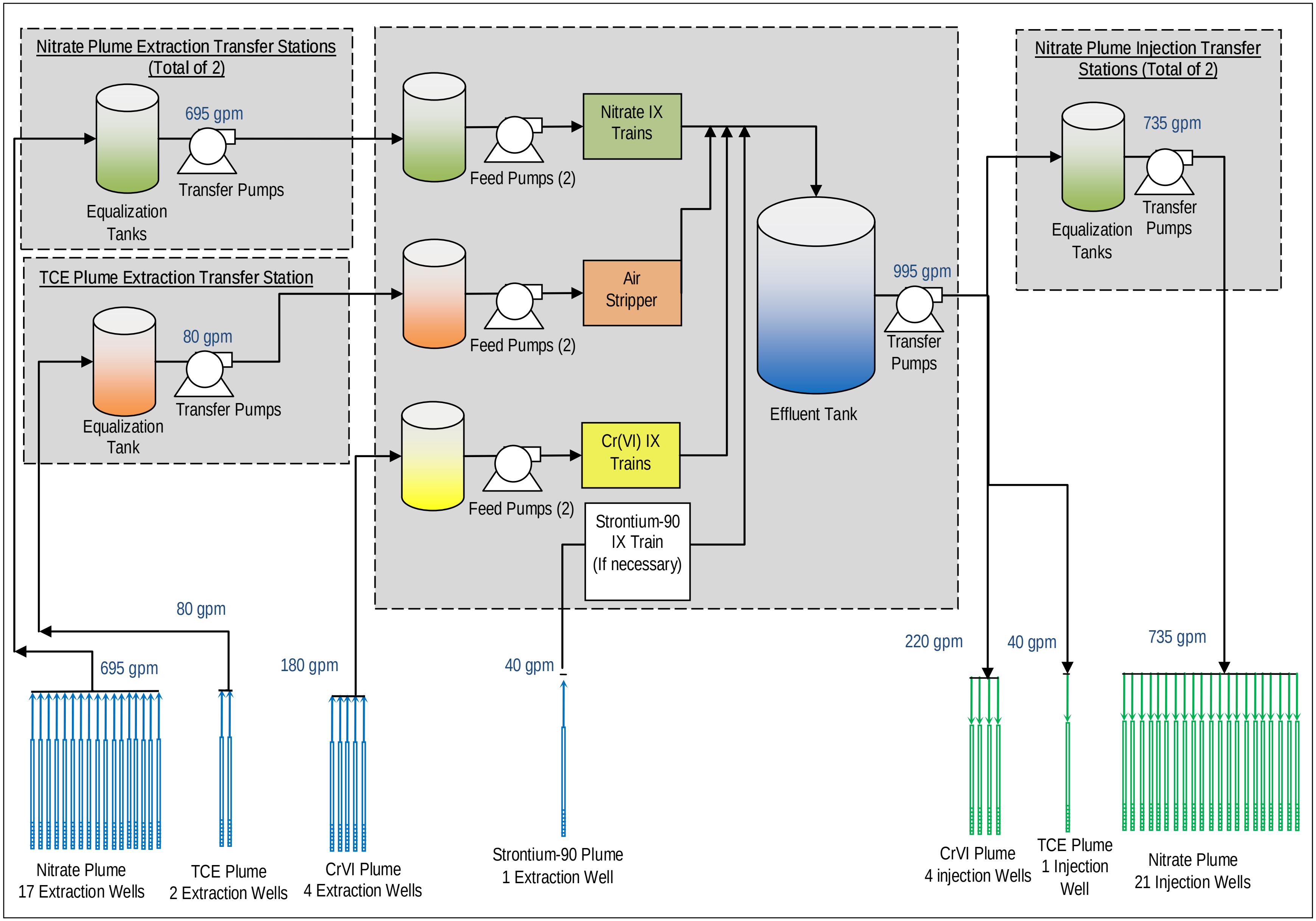


**Figure 4. Conceptual Process Flow Diagram for Alternative GW-4: Enhanced Pump-and-Treat**

# 5 Software Applications

Microsoft Office Excel 2007 was used to perform the calculations. Excel is a “Site Licensed Client Software” and is exempt from formal control requirements of PRC-PRO-IRM-309, Controlled Software Management.

# 6 Calculation

This section provides calculations for cost estimate inputs for each alternative. The cost estimate calculations are broken down into the following calculation categories:

- Groundwater Sampling
- Groundwater Extraction, Injection and Treatment Flow Rates

Each of these categories is discussed in the following subsections.

## 6.1 Groundwater Sampling

The following calculations were performed in support of cost estimating for groundwater sampling:

1. Average Sample depth (groundwater): lower range of unconfined aquifer thickness + upper range of unconfined aquifer thickness ÷ 2
2. Total number of samples:
    a. Year 1 (new wells): No. of New Wells * 4
    b. Year 1 (existing wells): No. of Existing Wells * 1
    c. Year 2 – 10: No. of Wells * 1
    d. Year 11 to End: No. of Wells * 0.5 (biennial frequency)
    e. Compliance Monitoring: No. of Wells * 5 (annual frequency)

## 6.2 Groundwater Extraction, Injection and Treatment System Flow Rates

Groundwater alternatives GW-3, and GW-4 require calculation of groundwater extraction, injection, and treatment system flow rates. Assumptions were made based on modeling information from ECF-100FR3-11-0116, Rev 2, Modeling of RI/FS Design Alternatives for 100-FR-3. To facilitate cost estimating, the following calculations were made:

- Nominal Flow Rate for Extraction wells = Sum of nominal gallons per minute (GPM) for all wells ÷ total number of wells.
- The Total Annual Flow Volume (Gallons/Year) is based on system operational uptime of 90%, which is used for operating and maintenance (O&M) cost calculations. = nominal flow rate in GPM x 0.9 x minutes per year.
    - Average Nominal Flow (GPM) = sum of individual well nominal flow rates (GPM) ÷ number of wells

- Total Nominal Flow (Gallons/Year) = Average Nominal flow rate (GPM) × 525948.766 minutes per year[3]
- Total Annual Flow (Gallons) for System running 90% of the time = Total Nominal Volume (Gallons) × 0.9

# 7 Results/Conclusions

The cost inputs, assumptions, and calculations presented in the previous sections were used to develop detailed descriptions for each alternative, and document cost estimate assumptions in standard estimating forms to be used by the estimator. Appendix A presents all assumptions, inputs, and calculations that are carried forward into the final cost estimate.

# 8 References

DOE/RL-2010-98, Decisional Draft, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6, and 100-FR-3 Operable Units*, CH2M Hill Plateau Remediation Company, Richland, Washington

ECF-100FR3-11-0116, Rev. 2, *Modeling of RI/FS Design Alternatives for 100-FR-3*, CH2M Hill Plateau Remediation Company, Richland, Washington

[3] This calculation assume 525948.769 minutes per year, which represents the number of minutes in an average Julian calendar year including standard and leap Julian years.

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# Appendix A

# Groundwater Alternative Cost Input Backup Calculations for 100-FR-3

# 100-FR-3 Groundwater Alternative Cost Estimate Input Calculations
# Appendix A

### Table A-1: Alternative GW-3 Individual Well Pumping Rates

| COC | Well Name | Bio-remediation | Pumping Rate | |
|---|---|---|---|---|
| | | | Avg | Instantaneous |
| CR | EW1-1 | NA | -40.5 | -45 |
| | EW1-2 | NA | -40.5 | -45 |
| | EW1-3 | NA | -40.5 | -45 |
| | EW1-4 | NA | -40.5 | -45 |
| SR-90 | EW1-5 | NA | -36 | -40 |
| CR | IW1-1 | NA | 49.5 | 55 |
| | IW1-2 | NA | 49.5 | 55 |
| | IW1-3 | Amended | 49.5 | 55 |
| | IW1-4 | Amended | 49.5 | 55 |
| TCE | EW3-1 | NA | -36 | -40 |
| | EW3-2 | NA | -36 | -40 |
| | IW2-A_7 | Amended | 36 | 40 |
| Nirtrate | IW2_NA_1 | NA | 36 | 40 |
| | IW2_NA_2 | NA | 36 | 40 |
| | IW2_NA_3 | NA | 31.5 | 35 |
| | IW2_NA_4 | NA | 31.5 | 35 |
| | IW2_NA_5 | NA | 31.5 | 35 |
| | IW2_NA_6 | NA | 31.5 | 35 |
| | IW2_NA_7 | NA | 31.5 | 35 |
| | IW2_A_1 | Amended | 36 | 40 |
| | IW2_A_2 | Amended | 36 | 40 |
| | IW2_A_3 | Amended | 36 | 40 |
| | IW2_A_4 | Amended | 36 | 40 |
| | IW2_A_5 | Amended | 36 | 40 |
| | IW2_A_6 | Amended | 36 | 40 |
| | EW2_1 | NA | -36 | -40 |
| | EW2_2 | NA | -36 | -40 |
| | EW2_5 | NA | -36 | -40 |
| | EW2_6 | NA | -36 | -40 |
| | EW2_7 | NA | -40.5 | -45 |
| | EW2_8 | NA | -36 | -40 |
| | EW2_9 | NA | -36 | -40 |
| | EW2_10 | NA | -36 | -40 |
| | EW2_11 | NA | -36 | -40 |
| | EW2_12 | NA | -40.5 | -45 |
| | EW2_13 | NA | -40.5 | -45 |

Notes:

[1] Pumping rates in gallons per minute (gpm)

[2] Negative values indicate extraction

**Table A-2: Alternative GW-3 Design Pumping Rate Totals by Plume**

| COC | Pumping Rate | | | |
|---|---|---|---|---|
| | Extraction Rate (gpm) | | Injection Rate (gpm) | |
| | AVG | Instantaneous | AVG | Instantaneous |
| CrVI | -162 | -180 | 198 | 220 |
| Sr-90 | -36 | -40 | 0 | 0 |
| TCE | -72 | -80 | 36 | 40 |
| Nitrate | -410 | -455 | 446 | 495 |
| **Totals** | **-680** | **-755** | **680** | **755** |

1. Average pumping rate is the pumping rate used to calculate O&M Costs.
2. Instantaneous pumping rate is the pumping rate used to size pumps and piping.

**100-FR-3 Groundwater Alternative Cost Estimate Input Calculations**
**Appendix A**

**Table A-3: Alternative GW-4 Individual Well Pumping Rates**

| COC | Well Name | Pumping Rate | |
|---|---|---|---|
| | | Avg | Instantaneous |
| CR | EW1-1 | -40.5 | -45 |
| | EW1-2 | -40.5 | -45 |
| | EW1-3 | -40.5 | -45 |
| | EW1-4 | -40.5 | -45 |
| SR-90 | EW1-5 | -36 | -40 |
| CR | IW1-1 | 49.5 | 55 |
| | IW1-2 | 49.5 | 55 |
| | IW1-3 | 49.5 | 55 |
| | IW1-4 | 49.5 | 55 |
| TCE | EW3-1 | -36 | -40 |
| | EW3-2 | -36 | -40 |
| | IW2-A_7 | 36 | 40 |
| Nirtrate | IW2_NA_1 | 36 | 40 |
| | IW2_NA_2 | 36 | 40 |
| | IW2_NA_3 | 31.5 | 35 |
| | IW2_NA_4 | 31.5 | 35 |
| | IW2_NA_5 | 31.5 | 35 |
| | IW2_NA_6 | 31.5 | 35 |
| | IW2_NA_7 | 31.5 | 35 |
| | IW2_A_1 | 36 | 40 |
| | IW2_A_2 | 36 | 40 |
| | IW2_A_3 | 36 | 40 |
| | IW2_A_4 | 36 | 40 |
| | IW2_A_5 | 36 | 40 |
| | IW2_A_6 | 36 | 40 |
| | EW2_1 | -36 | -40 |
| | EW2_2 | -36 | -40 |
| | EW2_5 | -36 | -40 |
| | EW2_6 | -36 | -40 |
| | EW2_7 | -40.5 | -45 |
| | EW2_8 | -36 | -40 |
| | EW2_9 | -36 | -40 |
| | EW2_10 | -36 | -40 |
| | EW2_11 | -36 | -40 |
| | EW2_12 | -40.5 | -45 |
| | EW2_13 | -40.5 | -45 |
| | IW4_1 | 27 | 30 |
| | IW4_2 | 27 | 30 |
| | IW4_3 | 27 | 30 |
| | IW4_4 | 27 | 30 |
| | IW4_5 | 27 | 30 |
| | IW4_6 | 27 | 30 |
| | IW4_7 | 27 | 30 |
| | EW4_1 | -36 | -40 |
| | EW4_2 | -36 | -40 |
| | EW4_3 | -36 | -40 |
| | EW4_4 | -36 | -40 |
| | EW4_5 | -36 | -40 |
| | IW4_8 | 27 | 30 |
| | EW4_6 | -36 | -40 |

Notes:

[1] Pumping rates in gallons per minute (gpm)

[2] Negative values indicate extraction

**Table A-4: Alternative GW-4 Design Pumping Rate Totals by Plume**

| COC | Total Pumping Rate | | | |
|---|---|---|---|---|
| | Extraction Rate (gpm) | | Injection Rate (gpm) | |
| | Avg | Instantaneous | Avg | Instantaneous |
| CrVI | -162 | -180 | 198 | 220 |
| Sr-90 | -36 | -40 | 0 | 0 |
| TCE | -72 | -80 | 36 | 40 |
| Nitrate | -626 | -695 | 662 | 735 |
| **Totals** | **-896** | **-995** | **896** | **995** |

Notes:

1. Average pumping rate is the pumping rate used to calculate O&M Costs.
2. Instantaneous pumping rate is the pumping rate used to size pumps and piping.

**100-FR-3 Groundwater Alternative Cost Estimate Input Calculations**
**Appendix A**
**Table A-5. Conveyance Piping Quantity Summary by COC Plume**

| COC Plume | Description | Alternative 3 | | | | Alternative 4 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Measured Length | | Adjusted Length | | Measured Length | | Adjusted Length | |
| | | feet | meters | feet | meters | feet | meters | feet | meters |
| Cr (VI) Plume | 2" Dia HDPE Extraction Piping | 10000 | 3050 | 11000 | 3350 | 10000 | 3050 | 11000 | 3350 |
| | 2" Dia HDPE Injection Piping | 7800 | 2380 | 8580 | 2620 | 7800 | 2380 | 8580 | 2620 |
| Sr-90 Plume | 2" Dia HDPE Extraction Piping | 1800 | 550 | 1980 | 600 | 1800 | 550 | 1980 | 600 |
| TCE Plume | 2" Dia HDPE Extraction Piping | 2900 | 880 | 3190 | 970 | 2900 | 880 | 3190 | 970 |
| | 2" Dia HDPE Injection Piping | 3900 | 1190 | 4290 | 1310 | 3900 | 1190 | 4290 | 1310 |
| | 3" Dia HDPE Extraction Transfer Piping | 6300 | 1920 | 6930 | 2110 | 6300 | 1920 | 6930 | 2110 |
| Nitrate Plume | 2" Dia HDPE Extraction Piping | 24400 | 7440 | 26840 | 8180 | 37600 | 11460 | 41360 | 12610 |
| | 2" Dia HDPE Injection Piping | 50000 | 15240 | 55000 | 16770 | 93500 | 28510 | 102850 | 31360 |
| | 4" Dia HDPE Extraction Transfer Piping | 7300 | 2230 | 8030 | 2450 | 21000 | 6400 | 23100 | 7040 |
| | 4" Dia HDPE Injection Transfer Piping | 7300 | 2230 | 8030 | 2450 | 21000 | 6400 | 23100 | 7040 |
| Totals | 2" Piping - Extraction | | | 43,010 | 13,110 | | | 57,530 | 17,540 |
| | 2" Piping - Injection | | | 67,870 | 20,690 | | | 115,720 | 35,280 |
| | 3" Transfer Piping | | | 6,930 | 2,110 | | | 6,930 | 2,110 |
| | 4" Transfer Piping | | | 16,060 | 4,900 | | | 46,200 | 14,090 |
| 3D Pipe Routing Adjustement Factor = | 10% | | | | | | | | |