Systematic Method for Evaluating Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Appendix A: ECF-Hanford-12-0085

Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment.....	A-i
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Terms

AWQC	ambient water quality criteria
CEM	capture efficiency map
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHPRC	CH2M Hill Plateau Remediation Company
CFM	capture frequency map
COC	contaminant of concern
CY	calendar year
DOE	Department of Energy
ECF	environmental calculation
EPA	Environmental Protection Agency
FRD	Functional Requirement Document
GPM	gallons per minute
GWM	groundwater model
ICFM	interpolated capture frequency map
IX	ion exchange
NPL	National Priority List
OU	operable unit
P&T	pump-and-treat
RAO	remedial action objective
RD/RAWP	Remedial Design / Remedial Action Work Plan
RI/FS	Remedial Investigation / Feasibility Study
RPO	Remedial Process Optimization
SCFM	simulated capture frequency map
TPA	Tri-Party Agreement

Note: The term Interpolated Capture Frequency Map (ICFM) is used in this document for the technique and resulting map that is referred to as a Capture Frequency Map (CFM) by Karanovic et al (2009) and in the Hanford reports DOE/RL-2011-25, DOE/RL-2012-02 and SGW-42305. The term Simulated Capture Frequency Map (SCFM) is used in this document for the technique and resulting map that is referred to as the Capture Efficiency Map (CEM) in the Hanford pump-and-treat (P&T) reports

DOE/RL-2011-25 and DOE/RL-2012-02. These terms are used henceforth to emphasize the similarity in the two approaches, and, in the case of the use of the term SCFM in place of the term CEM, to recognize that the method is fundamentally frequency-based.

1. Introduction

This document describes a systematic method to develop flow rate recommendations for Pump-and-Treat (P&T) extraction and injection wells in 100-KR-4 and 100-HR-3 Groundwater Operable Units (OU) of the Hanford Site. Flow rate recommendations are developed as part of ongoing performance monitoring and remedy optimization of the P&T interim actions to develop hydraulic containment of the dissolved chromium¹ plume in groundwater and protect the Columbia River from further discharges of groundwater from inland, consistent with the objectives detailed in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0) and based on the results of the assessments and calculations described in the associated Environmental Calculation briefs (ECF) that are developed based on that guidance document.

The *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0) details a systematic method to evaluate the length of the Columbia River shoreline adjacent to the 100 Area Groundwater OUs that is protected from further discharges from inland groundwater contaminated by dissolved chromium toward the achievement of the interim remedial action objectives (RAOs) defined in the *Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions* (EPA/ROD/R10-96/134). Based on the results of the approach described therein, this document details the methodology and data required to infer the influence of individual wells near the shoreline on hydraulic containment and river protection and develop flow rate recommendations to improve system performance and mitigate potential shortcomings of the system configuration in place.

2. Background

The development of flow rate recommendations is part of the systematic approach to evaluate and optimize remedy performance in the OUs where a P&T system is in place, currently in 100-KR-4 and 100-HR-3. This systematic approach consists of procedures and methods for acquisition and reduction of data reflecting system operations and aquifer response; data analysis; quantitative and qualitative evaluations of the results of those analyses; and recommendations for adjustments to system operations for performance improvement.

Five ion-exchange (IX) groundwater P&T systems are currently operating as part of ongoing efforts to remediate groundwater contaminated with chromium and other chemicals at the Hanford Site in the 100-KR-4 and 100-HR-3 OUs along the Columbia River (Figure 1-1):

- Three P&T systems operate within the 100-KR-4 Groundwater OU – these are the KR-4, KW, and KX P&T systems.
- Two P&T systems operate within the 100-HR-3 Groundwater OU – one system, the DX P&T, is located in the 100-D Area, and the other system, the HX P&T, is located west of the 100-H Area and includes the region designated as the Horn Area.

¹ Unless specified otherwise, “dissolved chromium” or simply “chromium” in this document refers to the combination of total chromium in filtered samples and hexavalent chromium in filtered or unfiltered samples.

Figure 1-1. Groundwater Interest Areas and Operable Units Along the Columbia River

These groundwater P&T remedial actions are part of the effort to achieve the following interim RAOs [Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions (EPA/ROD/R10-96/134)]:

- **RAO 1:** Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- **RAO 2:** Protect human health by preventing exposure to contaminants in the groundwater.
- **RAO 3:** Provide information that will lead to a final remedy.

In addition to these RAOs, several Tri-Party Agreement (TPA: Ecology et al., 1989) target milestones have been established to ensure that impacts to the Columbia River and to groundwater by hexavalent chromium and other contaminants are remediated in a timely manner. The following four milestones are directly applicable to the 100 Area OUs:

- **Milestone M-016-110-T01 (December 31, 2012):** DOE shall take actions necessary to contain or remediate hexavalent chromium groundwater plumes in each of the 100 Area NPL [National Priority List] Operable Units such that ambient water quality standards for hexavalent chromium are achieved in the hyporheic zone and river column water.
- **Milestone M-016-110-T02 (December 31, 2020):** DOE shall take actions necessary to remediate hexavalent chromium groundwater plumes such that hexavalent chromium will meet drinking water standards in each of the 100 Area NPL Operable Units.
- **Milestone M-016-110-T03 (December 31, 2016):** DOE shall take actions to contain the strontium-90 plume at 100-NR-2 Operable Unit such that the default ambient water quality standard (8 pCi/L) is achieved in the hyporheic zone and river water column.
- **Milestone M-016-110-T04 (December 31, 2016):** DOE shall implement remedial actions selected in all 100 Area Records of Decision for Groundwater Operable Units so that no contamination above drinking water standards enters the Columbia River unless otherwise specified in a CERCLA decision.

The systematic approach to evaluate and optimize remedy performance in the OUs focuses on the evaluation of progress toward, and the status of, the attainment of RAO 1, hereafter referred to as the River Protection Objective, and the recommendations developed to optimize system performance. The *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0) details the methods and analyses used to perform the evaluation of system performance with regard to the River Protection Objective and identify the areas where additional action may be necessary.

Upon completion of the above-mentioned evaluations, recommendations on system operations are required to ensure that necessary actions are taken to improve system performance toward the River Protection Objective. Currently, the interim remedies in 100-KR-4 and 100-HR-3 rely primarily on extraction and injection wells as part of conventional P&T configurations. Adjustments to extraction and injection well operations are essential to the improvement of system performance. This document describes and demonstrates the steps to be taken for a complete assessment of the historic well operations; the resulting hydraulic containment of the dissolved chromium plume; and the development of an updated configuration of extraction and injection rates to improve hydraulic containment toward the River Protection Objective.

2.1 Evaluation of System Performance

In the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0), methods of analysis are presented for evaluating whether groundwater conditions at 100-KR-4 and 100-HR-3 OUs meet the interim ROD remedial action objective of protecting the Columbia River from discharges of contaminants above applicable standards, i.e. the River Protection Objective. These methods comprise groundwater level and groundwater concentration analyses as part of an integrated assessment of the groundwater conditions that implements quantitative and qualitative evaluations of the River Protection Objective. The quantitative assessment rests upon computational processing of four of the work products from the foregoing analysis:

- The Simulated Capture Frequency Map (SCFM);
- The Interpolated Capture Frequency Map (ICFM);
- The Standard Test (comparison of sample values to the aquatic standard); and
- The Target Zone (plume map).

Following the quantitative assessment, a qualitative assessment is undertaken that considers and weighs additional factors that are difficult to incorporate directly into the quantitative assessment, including:

- Locations that exhibit increasing concentrations; stable concentrations; declining concentrations or for which a trend cannot be determined;
- Regions where the ICFM and/or the SCFM maps depict low capture frequencies, and/or where the frequencies depicted in the ICFM and SCFM maps differ;
- Proximity of P&T remedy extraction and injection wells; and,
- Hydraulic gradients in areas of limited monitoring well coverage.

Calculations are performed considering aquifer conditions and system performance during: (a) the entire calendar year, hereafter referred to as the annual-average conditions; and (b) low river stage conditions. The results of these integrated assessments are depicted in color-coded maps that illustrate regions paralleling the Columbia River shoreline that fall into each of the following three categories:

1. Groundwater is contaminated above standards but inland contamination is hydraulically contained, or groundwater exhibits concentrations below standards such that hydraulic containment is not required:

Interpretation: the required River Protection Objective is being met.

Color Code: **GREEN**

2. Groundwater is contaminated above standards and inland contamination is not hydraulically contained, however hydraulic gradients and concentration trends suggest there is limited net migration toward the Columbia River, such that the river is not threatened by discharges of inland contamination.

Interpretation: the required River Protection Objective is being met. However, although the Columbia River is not immediately threatened by contamination, action may be required to ensure that the River Protection Objective is met over the longer-term.

Color Code: **YELLOW**

3. Groundwater is contaminated above standards and inland contamination is not hydraulically contained, and hydraulic gradients and concentration trends suggest there is the potential for significant net migration toward the Columbia River, such that the river is potentially threatened by discharges of inland contamination.

Interpretation: the required River Protection Objective is not being met. If a remedy is in place to achieve the River Protection Objective, the remedy is likely underperforming; additional action is required to achieve the River Protection Objective.

Color Code: **RED**

This categorization of each region of the shoreline provides the basis for the selection of extraction and injection wells that are primary targets for flow rate adjustments. The methods and procedures to form these recommendations are described in following sections.

2.2 Data Requirements

The development of flow rate recommendations is based on the results of the systematic system performance evaluation and the historic performance of each P&T well. Implementation of this methodology requires the following information:

1. Well design rates and past operations: design rates and historical well operation data provide information on the feasible range of flow rates for each well, which in turn provides a basis to determine the range of flow rate adjustments that can be made to each well.
2. Well operating extraction and injection rates: daily extracted and injected water volumes and corresponding hours of operation for each extraction and injection well within each P&T system.
3. Well locations relative to hydraulic containment for river protection: flow rate modifications are made to wells based on their influence on achieving hydraulic containment and river protection consistent with the objectives detailed in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0).
4. Well location relative to dissolved chromium distribution: plume contours are depicted in annual Hanford Site Groundwater Monitoring reports. Dissolved chromium is the primary contaminant of concern (COC) in 100-KR-4 and 100-HR-3 and, therefore, adjustments to well flow rates target those wells that influence the hydraulic containment of the dissolved chromium plume.
5. Projected well operations: well realignment and/or other operational considerations during the evaluation period can further constrain the flow rate adjustments.

3. Methodology

Flow rate recommendations are developed at the beginning of the current calendar year, following the completion of the analysis described in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0). Recommendations are developed for each quarter of the current calendar year, focusing on the River Protection Objective and based on the evaluations of system performance under (a) annual-average aquifer conditions, and (b) low river stage conditions, for the previous calendar year.

The methodology for developing flow rate recommendations consists of the following steps:

1. Calculating historic flow rate statistics for each extraction and injection well;

2. Reviewing past and projected system operations;
3. Identifying the base period for past performance baseline to use in the analysis;
4. Combining the results of the systematic system performance evaluation with the historic well operations in maps and tables; and
5. Developing and assessing criteria and constraints for flow rate adjustments and assigning flow rates to each extraction and injection well.

In the following section the steps of this comprehensive methodology are described in detail.

3.1 Historic Flow Rates

Design rates and historic well operation data provide information on the feasible range of flow rates for each well, which in turn provides a basis to determine the range of flow rate adjustments that can be made to each well.

Generally, design rates for extraction and injection wells are developed as part of a Remedial Design/Remedial Action Work Plan (RD/RAWP) and are documented in associated Functional Design Criteria (FRD) documents. These rates reflect the operational blueprint for each well either upon installation of the particular well or when changes in equipment or functional range are made.

However, extraction and injection rates developed as part of Remedial Process Optimization (RPO) and/or Remedial Investigation and Feasibility Study (RI/FS) can be considered as design rates if they represent more up-to-date well operations that are not documented in FRDs formally yet, but could be essentially considered as design rates for the purposes of the current effort for hydraulic containment and river protection. The ECF documenting the relevant calculations should clearly identify the source and justification for the design rate assigned to each well.

Historic flow rates are calculated based on daily volumes of extracted or injected water at each well. For the purposes of the analyses presented herein, monthly-average flow rates are calculated for each well. Given the historic operation of each P&T system in 100-KR-4 and 100-HR-3, the timeframe for historic rate calculations is from January 1, 2006 to date.

Maximum achieved flow rates for each well are calculated for the entire historic timeframe defined above, to provide a preliminary comparison between the design and maximum actual flow rate that was achieved. In cases when revised design rates are defined, maximum historic flow rates could be higher than the recent design rates.

3.2 Review of Past and Projected System Operations

The historic operations of each P&T system and each individual well within the P&T system are compiled and reviewed. P&T system operations include timeseries of total volumes of water treated and any modifications to the system configuration, including treatment procedures and infrastructure characteristics. Examples of such modifications to the system operations are: (a) the system expansion in 100-HR-3 where additional system capacity was facilitated through the construction and operation of the DX and HX treatment systems in 2010 and 2011, respectively; (b) the reconfiguration of the KW treatment train to split train operation which resulted in increased capacity; and (c) elimination of premature resin loading problems by switching to SIR-700 resin, resulting in increased system throughput.

The historic operation of each individual well is the result of decisions made based on aquifer response; scheduled and/or unforeseen system shutdown; system modifications; and contaminant concentration considerations. Historic well operation data provide information on the feasible range of flow rates for each well, which in turn provides a basis to determine the range of flow rate adjustments that can be made to each well.

Projected system operations include well realignment plans associated with system modifications and/or other field activities that will impact the system configuration. For example, planned excavations in 100-HR-3 require abandoning a number of P&T wells: under draft realignment plans there is provision for installation of new extraction and injection wells both near the abandoned wells and at new locations strategically defined to enhance hydraulic containment of the plume and expedite mass recovery.

3.3 Base Period for Past Performance Baseline

Flow rate adjustments are developed on a quarterly basis, following closely the typical aquifer response patterns observed across the River Corridor and especially the conditions that characterize system performance in 100-HR-3. Aquifer response is controlled by the operation of P&T wells and river-stage fluctuations in Columbia River. Observed river-stage elevation patterns are the result of (a) seasonal variations and (b) diurnal changes due to releases from Priest Dam located upstream of the Hanford Site. High and low river stage conditions are observed during the second and fourth quarter of the year, with intermediate conditions in the other two quarters. During each one of those periods, the available saturated thickness in the aquifer varies accordingly, directly influencing the extraction and injection well operations. The feasible range of extraction and injection rates during each period are inherently impacted by the available saturated thickness and therefore, flow rate recommendations are developed for each period separately.

For developing flow rate recommendations for a particular quarter, i.e. the period of interest, a base period is identified to provide past system performance baseline conditions. The most recent period characterized by system operations and aquifer response similar to the period of interest is determined. Such a period is usually the same quarter during the previous calendar year. However, in cases when system configuration and operations have changed significantly over a longer period, the base period can be defined in terms of a timeframe that spans a calendar period that is longer than a quarter or a quarter that is different than the one representing the period of interest. For example, switching to resin SIR-700 altered the throughput capabilities for the P&T system in 100-KR-4, resulting in treated water volumes that were maximized during the end of the calendar year, contrary to expectations for such achievement to take place during high river-stage conditions.

3.4 System Performance Evaluation and Historic Well Operations

Extraction and injection well locations are mapped relative to the depictions of hydraulic containment (ICFM and SCFM), dissolved chromium plume and categorized regions of shoreline based on the results of the analysis presented in the ECF documenting the calculations consistent with the objectives and methodology detailed in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0). The categorized regions of shoreline used for the purposes of flow rate adjustments are based on the color-coded maps developed for (a) annual-average conditions, and (b) low river stage conditions presented in that ECF, reflecting the qualitative assessments of the River Protection Objective.

Mapped well locations are labeled with the design and maximum historic flow rate to facilitate a preliminary visual inspection of historic well performance relative to the areas where additional action

may be required to meet the River Protection Objective for both the annual-average conditions and low river stage conditions.

3.5 Criteria and Comprehensive Procedure for Flow Rate Adjustments

Based on the information described above, a comprehensive procedure is developed for flow rate adjustments that relies on the following criteria and calculations:

1. Well location: extraction and injection wells located along or near the shoreline are considered as primary candidates for flow rate adjustments as their operation controls the efficacy of the hydraulic containment efforts near the river.
2. Well influence on hydraulic containment: wells of interest are identified based on the influence on hydraulic containment as inferred qualitatively based on the well locations defined in (1) and the results of the integrated assessment of river protection.
3. The relative location of the well with respect to the dissolved chromium plume and the concentration level in the vicinity of the well is determined.
4. Calculation of maximum and mean flow rates for the base period.
5. For each extraction and/or injection well identified in (1) and (2) draft flow rates are determined on the basis of the corresponding base period, i.e. the calendar year quarter, and the associated results of the river protection assessment. Therefore, flow rate recommendations for the first and fourth quarter of the calendar year are based on the results of the qualitative assessments considering low river stage conditions; recommendations for the second and third quarter are based on the results of the qualitative assessments considering annual-average aquifer conditions. Draft flow rate are then determined as follows:
 - If River Protection Objective is met (green), then the flow rate:
 - Remains unchanged at high concentration plume locations; or
 - Is reduced at low concentration (near AWQC levels) portions of the plume if additional capacity is needed for other locations;
 - If River Protection Objective is not being met (red), flow rate of a particular well or cluster of wells is increased;
 - If River Protection Objective is met, but action may be required to ensure that the River Protection Objective is met over the longer-term (yellow), then flow rate adjustment is based on the following additional criteria:
 - If hydraulic containment in the vicinity of the well is low and the well lies within a high-concentration part of the plume, the flow rate is increased;
 - If hydraulic containment in the vicinity of the well is high, the flow rate is unchanged;
 - If hydraulic containment in the vicinity of the well is low and the well lies within a low-concentration part of the plume, the flow rate is increased or maintained, depending on the distance to the river. If the distance to the river is short, the flow rate is increased; if the well lies farther inland and near the plume boundary, the flow rate can remain unchanged.

The draft flow rates are adjusted to address:

- a. Limited capability for rate increase in cases where the well is already performing at the maximum rate of the range of flow rates identified in (4) above for that well. In such cases rate adjustments are made to neighboring wells, if possible.

- b. Balancing of the total extraction and injection water volumes within each P&T system. Rates are adjusted at inland wells and in particular those located within the plume and upgradient of the shoreline wells as identified in (3) above.
- c. Better-than-expected well performance: when historic flow rates are higher than the design rates, proposed flow rates are increased, if necessary, to a value higher than the design rate.

Once flow rates are developed, SCFM calculations are performed for the current calendar year using the 100 Area Groundwater Model (*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, SGW-46279, Rev.2) following the methodology described in *Calendar Year 2011 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation* (DOE/RL-2012-02, Rev. 0). The resulting SCFM will be compared to the SCFM and ICFM which will be developed as part of the Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation for the current CY. This comparison will provide necessary feedback on the actual system performance during the calendar year.

Implementation of the above procedure results in flow rate recommendations provided in tabulated form separately for the P&T systems in the 100-KR-4 and 100-HR-3 OUs, and accompanied by maps illustrating hydraulic containment, dissolved chromium plume depictions and ratios of proposed-to-design and proposed-to-historic-maximum flow rates. This information and the associated calculations are summarized in an ECF.

Given that flow rates are developed a priori for the entire calendar year, it is possible that extraction/injection well performance and/or aquifer response and plume migration may suggest that further adjustments are necessary. To ensure that the proposed flow rates do not compromise the effectiveness of remedy, the results of monthly, quarterly and semiannually system performance reviews will provide the basis for interim flow rate assessments. If those assessments suggest that further adjustments are necessary, revised flow rate recommendations will be developed on the basis of the recently acquired information, as described in the interim system performance reviews, and a revised ECF will be issued.

4. Calculation

Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment, (ECF-Hanford-12-0085, Rev.0) documents the implementation of the approach described in this document to develop flow rate recommendations in 100-HR-3 and 100-KR-4 OUs for the first quarter of CY2013, using data obtained within or prior to December of CY 2011. ECF-Hanford-12-0085 is included in the document as Appendix A to illustrate how the methods, calculations, graphical depictions and methods of interpretation described throughout this document are applied to a specific data set.

An example of a map showing well locations and ratios of proposed-to-design flow rates combined with the results of the performance evaluation for CY2011 in 100-KR-4 is provided in Figure 4-1 [*Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment*, (ECF-Hanford-12-0085, Rev.0)].

Figure 4-1. Ratio of Proposed-to-Design Flow Rates and CY 2011 ICFM for the P&T System in 100-KR-4.

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Appendix A

ECF-Hanford-12-0085, Rev 0

Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment

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Terms

AWQC	ambient water quality criteria
CEM	capture efficiency map
CFM	capture frequency map
CHPRC	CH2M Hill Plateau Remediation Company
COC	contaminant of concern
Cr(VI)	hexavalent chromium
CY	calendar year
ECF	environmental calculation
GPM	gallons per minute
ICFM	interpolated capture frequency map
OU	operable unit
P&T	pump-and-treat
RAO	remedial action objective
SCFM	simulated capture frequency map

Note: The term Interpolated Capture Frequency Map (ICFM) is used in this document for the technique and resulting map that is referred to as a Capture Frequency Map (CFM) by Karanovic et al (2009) and in the Hanford reports DOE/RL-2011-25, DOE/RL-2012-02 and SGW-42309. The term Simulated Capture Frequency Map (SCFM) is used in this document for the technique and resulting map that is referred to as the Capture Efficiency Map (CEM) in the Hanford pump-and-treat (P&T) reports DOE/RL-2011-25 and DOE/RL-2012-02. These terms are used henceforth to emphasize the similarity in the two approaches, and, in the case of the use of the term SCFM in place of the term CEM, to recognize that the method is fundamentally frequency-based.

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1. Purpose

The purpose of this environmental calculation brief (ECF) is to describe the methodology, input data and calculations used to develop flow rate recommendations for the Pump-and-Treat (P&T) extraction and injection wells in 100-KR-4 and 100-HR-3 Groundwater Operable Units (OU) of the Hanford Site. These rates are proposed as part of ongoing performance monitoring and remedy optimization of the P&T interim actions to develop hydraulic containment of the hexavalent chromium [Cr(VI)] plume in groundwater and protect the Columbia River from further discharges of groundwater from inland, consistent with the objectives detailed in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0) and based on the procedures and methodology detailed in the *Systematic Method for Evaluating Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment* (SGW-54400, Rev.0).

Flow rate recommendations are developed for adjusting flow rates of the P&T wells that influence the hydraulic containment of the Cr(VI) plumes in 100-KR-4 and 100-HR-3 OUs to improve system performance toward the achievement of the interim remedial action objectives (RAO) defined in the *Record of Decision for the USDOE Hanford 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions* (EPA/ROD/R10-96/134).

2. Methodology

Flow rate recommendations for the extraction and injection wells in 100-KR-4 and 100-HR-3 are developed following the methodology described in the *Systematic Method for Evaluating Extraction and Injection Flow Rates for 100-KR-4 and 100-HR-3 Groundwater Operable Unit Pump-and-Treat Interim Actions for Hydraulic Containment* (SGW-54400, Rev.0). Implementation of this methodology requires the following information:

1. Well design rates and past operations: design rates and historical well operation data provide information on the feasible range of flow rates for each well, which in turn provides a basis to determine the range of flow rate adjustments that can be made to each well.
2. Well locations relative to hydraulic containment for river protection: flow rate modifications are made to wells based on their influence on achieving hydraulic containment and river protection consistent with the objectives detailed in the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0) and based on the results of the analysis presented in the *Assessment of the River Protection Objective: Calculation for Calendar Year 2011 (CY 2011)* (ECF-Hanford-12-0078, Rev.0).
3. Well location relative to Cr(VI) distribution as depicted in the report *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, Rev. 0): Cr(VI) is the primary COC in 100-KR-4 and 100-HR-3 and, therefore, adjustments to well flow rates target those wells that influence the hydraulic containment of the Cr(VI) plume; however, additional considerations for system-wide adjustments to flow rates are implemented on the basis of Cr(VI) concentrations in the vicinity of each P&T wells.
4. Projected well operations: well realignment and/or other operational considerations for Calendar Year (CY) 2013 can further constrain the flow rate adjustments.

Well design rates considered are those defined in the *Modeling of RI/FS Design Alternatives for 100-KR-4* (ECF-100KR4-11-0113, Rev.3) and the *Modeling of RI/FS Design Alternatives for 100-HR-3* (ECF-100HR3-11-0114, Rev.4) for those wells that were operational during CY 2012. Well operational data for the period January 1, 2006 through December 11, 2012 were compiled and reviewed, and monthly-

average rates were calculated for each well. Wells that were inactive during CY 2012 were assumed to remain inactive during CY 2013. No flow rate recommendations are provided for those wells. Flow rate modifications are made so that balanced extraction-injection for each P&T system is maintained.

In the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0), methods of analysis are presented for evaluating whether groundwater conditions at 100-KR-4 and 100-HR-3 OUs meet the interim record of decision (ROD) remedial action objective of protecting the Columbia River from discharges of contaminants above applicable standards (River Protection Objective). These methods comprise groundwater level and groundwater concentration analyses as part of an integrated assessment of the groundwater conditions, the results of which are depicted color-coded maps that illustrate regions paralleling the Columbia River shoreline that fall into each of the following three categories:

1. Groundwater is contaminated above standards but inland contamination is hydraulically contained, or groundwater exhibits concentrations below standards such that hydraulic containment is not required:

Interpretation: the required River Protection Objective is being met.

Color Code: **GREEN**

2. Groundwater is contaminated above standards and inland contamination is not hydraulically contained, however hydraulic gradients and concentration trends suggest there is limited net migration toward the Columbia River, such that the river is not threatened by discharges of inland contamination.

Interpretation: the required River Protection Objective is being met. However, although the Columbia River is not immediately threatened by contamination, action may be required to ensure that the River Protection Objective is met over the longer-term.

Color Code: **YELLOW**

3. Groundwater is contaminated above standards and inland contamination is not hydraulically contained, and hydraulic gradients and concentration trends suggest there is the potential for significant net migration toward the Columbia River, such that the river is potentially threatened by discharges of inland contamination.

Interpretation: the required River Protection Objective is not being met. If a remedy is in place to achieve the River Protection Objective, the remedy is likely underperforming: additional action is required to achieve the River Protection Objective.

Color Code: **RED**

The results of the integrated assessment for river protection for the 100-KR-4 and 100-HR-3 OUs are presented in the *Assessment of the River Protection Objective: Calculation for Calendar Year 2011 (CY 2011)* (ECF-Hanford-12-0078, Rev.0), based on data available for CY 2011. These evaluations provide the foundation for the procedure to develop flow rate recommendations as described below.

1. Wells located along or near the shoreline are considered the primary candidates for flow rate adjustments as their operation controls the efficacy of the hydraulic containment efforts near the river. Flow rate recommendations for those wells are based on the following procedure:
 - a. The design rate is identified;
 - b. Maximum and mean flow rates are calculated for periods of interest;

- c. Selected periods of operation are identified to develop flow rate recommendations that are consistent with system operations during those periods. Such periods correspond to maximum or limited capacity conditions for a particular system, for example reflecting high or low river-stage conditions in 100-HR-3, respectively.
2. The influence of the well on the hydraulic containment is evaluated.
3. The relative location of the well with respect to the Cr(VI) plume and the concentration level in the vicinity of the well is determined.
4. Draft flow rates are determined in the following manner:
 - If River Protection Objective is met (green), then the flow rate:
 - Remains unchanged at high concentration plume locations; or
 - Is reduced at low concentration (near ambient water quality criteria [AWQC] levels) portions of the plume if additional capacity is needed for other locations;
 - If River Protection Objective is not being met (red), flow rate of a particular well or cluster of wells is increased;
 - If River Protection Objective is met, but action may be required to ensure that the River Protection Objective is met over the longer-term (yellow), then flow rate adjustment is based on the following additional criteria:
 - If hydraulic containment in the vicinity of the well is low and the well lies within a high-concentration part of the plume, the flow rate is increased;
 - If hydraulic containment in the vicinity of the well is high, the flow rate is unchanged;
 - If hydraulic containment in the vicinity of the well is low and the well lies within a low-concentration part of the plume, the flow rate is increased or maintained, depending on the distance to the river. If the distance to the river is short, the flow rate is increased; if the well lies farther inland and near the plume boundary, the flow rate can remain unchanged.
5. The draft flow rates are adjusted to address:
 - a. Limited capability for rate increase in cases where the well is already performing at the maximum rate of the range of flow rates identified earlier for that well. In such cases rate adjustments are made to neighboring wells, if possible.
 - b. Balancing of the total extraction and injection water volumes within each P&T system. Rates are adjusted at inland wells and in particular those located within the plume and upgradient of the shoreline wells.
 - c. Better-than-expected well performance: when historical flow rates are higher than the design rates, proposed flow rates are increased, if necessary, to a value higher than the design rate.
 - d. Flow rates are adjusted to reflect operations during selected periods of interest, for example low river-stage conditions in 100-HR-3.

Implementation of the above procedure results in flow rate recommendations provided in tabulated form separately for the P&T systems in the 100-KR-4 and 100-HR-3 OUs, and accompanied by maps illustrating hydraulic containment, Cr(VI) plume depictions and ratios of proposed-to-design and proposed-to-historic-maximum flow rates.

3. Calculation

Well operational data for the period January 1, 2006 to December 11, 2012 were compiled and reviewed. Well flow rate recommendations are developed based on the methodology described above and the following well design and performance information:

- a. Design rates, as defined in the Modeling of RI/FS Design Alternatives for 100-KR-4 (ECF-100KR4-11-0113, Rev.3) and the Modeling of RI/FS Design Alternatives for 100-HR-3 (ECF-100HR3-11-0114, Rev.4), for wells operational in CY 2012.
- b. Mean monthly flow rates during calendar year CY 2011.
- c. Mean monthly flow rates during CY 2012.
- d. Maximum historic flow rate during the period 2006-2012.

During CY 2012 maximum capacity in 100-KR-4 was increased compared to the capacity corresponding to well design rates as a result of recent changes in the configuration and operation of the treatment plants. As a result of this increase, flow rate adjustments were developed considering the following increased capacities: (a) KW: 275gpm; (b) KR: 300gpm; (c) KX: 600gpm, as recorded during December 2012.

In 100-HR-3, fully developed operation of the DX and HX systems resulted in high capacities during high river stage conditions. However, limited system capacity was observed during low river stage conditions, as the available saturated thickness was decreased during these periods. Two sets of flow rates were developed for:

- Maximum capacity, corresponding to the total design capacity for DX and HX; and
- Limited capacity, corresponding to operations during February 2012.

Ratios of proposed-to-design and proposed-to-historic-maximum flow rates were developed for each OU.

The following P&T system projected/scheduled operations are considered:

- KR: Operation of wells 199-K-198 and 199-K-199 in CY 2013 is not scheduled to date. Proposed flow rates are set to zero. Revised flow rates will be considered when the wells are connected to the network.
- KR: Well 199-K-129 was inactive in CY 2012.
- KW: Operation of well 199-K-196 in CY 2013 is not scheduled to date. Proposed flow rate is set to zero. Revised flow rate will be considered when the well is connected to the network.
- KX: Proposed flow rates for extraction wells 199-K-130, 199-K-141, and 199-K-163 are near the historic maximum flow rate observed for the wells which is above the design rate and maximum observed rate in CY 2012. If current conditions do not enable operating at the proposed flow rates, the wells should operate at the maximum possible flow rate and total injection in KX should be proportionally decreased at the injection wells so that balanced extraction/injection is maintained.
- Wells 199-K-127, 199-K-152, 199-K-173 and 199-K-182 had variable design rates, depending on the proposed designs as part of the RI/FS. For those wells no design rate was specified for the flow recommendation calculations.

- DX: Operation of wells 199-D8-53, 199-D8-54A, 199-D8-68 and 199-D8-72 are not connected to the P&T system to date. Proposed flow rates are set to zero. Revised flow rates will be considered when the wells are connected to the network.
- DX: Wells 199-D2-10, 199-D2-12 and 199-D8-93 operate at very low or zero flow rates and their operation is river-stage dependant due to their proximity to the river. No proposed rate is assigned to those wells; instead, a “maximum possible” flow rate is proposed for those wells. If/when these wells become fully operational at a higher flow rate, total injection in DX should be proportionally decreased at the remaining injection wells so that balanced extraction/injection is maintained.
- DX: Proposed flow rates for extraction wells 199-D8-69, 199-D8-89, 199-D8-90, 199-D8-91, 199-D8-95, 199-D8-96, 199-D6-2, 199-D8-55 are near the historic maximum flow rate observed for the wells which is above the design rate and maximum observed rate in CY 2012. If current conditions do not enable operating at the proposed flow rates, the wells should operate at the maximum possible flow rate and total injection in DX should be proportionally decreased at the injection wells so that balanced extraction/injection is maintained.
- HX: Wells 199-H1-3, 199-H1-4 and 199-H4-17 operate at very low or zero flow rates and their operation is dependent upon the available saturated thickness at those locations. No proposed rate is assigned to those wells; instead, a “maximum possible” flow rate is proposed for those wells. If/when these wells become fully operational at a higher flow rate, total extraction in HX should be proportionally decreased at the remaining extraction wells so that balanced extraction/injection is maintained.
- HX: Proposed flow rate for extraction well 199-H4-4 is near the historic maximum flow rate observed for the well which is above the design rate and maximum observed rate in CY 2012. If current conditions do not enable operating at the proposed flow rate, the well should operate at the maximum possible flow rate and total injection in HX should be proportionally decreased at the injection wells so that balanced extraction/injection is maintained.
- Well 199-D8-94 had variable design rates, depending on the proposed designs as part of the RI/FS. For this well no design rate was specified for the flow recommendation calculations.

Depictions of contaminant plume and hydraulic capture that were used to develop the recommendations presented herein are based on calculations for presented in the *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, Rev. 0) and the *Systematic Method for Evaluating the Length of the Hanford Reach of the Columbia River shoreline that is Protected from Further Discharges of Chromium from the 100 Area Operable Units (OUs)* (SGW-54209, Rev. 0). Hydraulic capture calculations are based on the following assumptions and limitations associated with the mapping and modeling approaches used for developing the ICFM and SCFM, as discussed in the *Calendar Year 2011 (CY2011) Evaluation of Hanford 100 Area Groundwater Pump-and-Treat (P&T) Remedy Hydraulic Containment* (ECF-Hanford-12-0073, Rev.0):

- The aquifer is homogeneous, isotropic, and of infinite areal extent.
- The aquifer is confined so transmissivity is uniform and unchanging. If the aquifer is unconfined, drawdowns are a reasonably small fraction of the aquifer saturated thickness.
- Vertical flow is negligible compared to horizontal flow.
- A CFM typically provides a reasonable estimate of remedy-wide capture within the footprint of the measured data, but distinguishing the capture zones of individual wells within a multi-well remedy can be prone to error.
- The groundwater modeling approach is based on the assumption that the Ringold Upper Mud Formation, where present, is considered a vertical no-flow boundary. However, sensitivity

analysis should be performed to examine the effects, if any, of possible flow across the bottom of the model on plume migration and on the effectiveness of the proposed remedies.

Based on the proposed flow rates, the total extraction and injection rates for each P&T system are summarized in Tables 3-1 and 3-2. Design flow rates correspond to pumping rates developed for the RI/FS; current rates refer to the period selected as the basis for the rate adjustments for each OU (that is, December 2012 for 100-KR-4; and February 2012 for 100-HR-3). The flow rate recommendations will be updated when river protection assessments are performed for CY 2012.

Table 3-1. Summary Total Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

	Type	KW	KR	KX
Design	Injection	170 ¹	255	455
	Extraction	170	255	455
Current (December 2012)	Injection	270	285	556
	Extraction	270	278	554
Proposed	Injection	270	290	596
	Extraction	270	290	596

¹ Flow rates are in gallons per minute.

Table 3-2. Summary Total Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

	Type	DX	HX
Design	Injection	511 ¹	530
	Extraction	510	584
Current (February 2012)	Injection	377	563
	Extraction	383	554
Proposed (Maximum Capacity)	Injection	597	798
	Extraction	597	798
Proposed (Limited Capacity)	Injection	363	586
	Extraction	363	586

¹ Flow rates are in gallons per minute.

Tables 3-3 and 3-4 list the proposed flow rates for the wells in 100-KR-4 and 100-HR-3, respectively. Calculated ratios of proposed-versus-design rates are also included in these Tables.

Figures 3-1 through 3-8 depict ratios of the proposed flow rates to design and historic maximum rates for the DX P&T system in 100-HR-3 overlaying the CY 2011 ICFM and SCFM. Figures 3-9 through 3-16 illustrate ratios of the proposed flow rates to design and historic maximum rates for the HX P&T system in 100-HR-3 overlaying the CY 2011 ICFM and SCFM. Figures 3-17 through 3-20 depict ratios of the proposed flow rates to design and historic maximum rates in 100-KR-4 overlaying the CY 2011 ICFM and SCFM.

The calculations described in the procedure to develop flow rate recommendations are tabulated in detail in Tables A-1 and A-2 of Appendix A for 100-KR-4 and 100-HR-3, respectively.

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Table 3-3. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	CY 2012 Max	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-113A	570098.1	148294.5	Extraction	KR	(15.0)	(23.6)		(13.0)	55%	87%
199-K-114A	570020.3	148280.6	Extraction	KR	(25.0)	(25.0)		(23.0)	58%	92%
199-K-115A	569940.0	148135.4	Extraction	KR	(25.0)	(25.5)		(25.0)	57%	100%
199-K-116A	569871.1	147960.5	Extraction	KR	(20.0)	(44.9)		(42.0)	94%	210%
199-K-120A	569399.6	147518.5	Extraction	KR	(20.0)	(25.0)		(23.0)	46%	115%
199-K-127	569539.2	147539.0	Extraction	KR	-	(20.0)		(19.0)	42%	_ ¹
199-K-129	570283.7	148503.1	Extraction	KR	(25.0)	-		_ ²	0%	0%
199-K-144	569163.3	147266.0	Extraction	KR	(25.0)	(50.0)		(47.0)	94%	188%
199-K-145	569284.6	147425.7	Extraction	KR	(25.0)	(59.9)		(56.0)	93%	224%
199-K-162	569340.0	147460.1	Extraction	KR	(25.0)	(44.9)		(42.0)	71%	168%
199-K-198	569305.7	147552.2	Extraction	KR	(25.0)	-		_ ²	-	-
199-K-199	569339.7	147584.4	Extraction	KR	(25.0)	-		_ ²	-	-
199-K-121A	570017.2	147418.3	Injection	KR	35.0	46.3		40.0	85%	114%
199-K-122A	569975.1	147172.9	Injection	KR	50.0	69.4		66.0	63%	132%
199-K-123A	569931.1	147090.2	Injection	KR	60.0	40.8		29.0	46%	48%
199-K-128	570009.5	147257.5	Injection	KR	50.0	88.3		85.0	87%	170%

Table 3-3. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	CY 2012 Max	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-179	569847.2	147481.8	Injection	KR	60.0	72.6		70.0	80%	117%
199-K-132	568495.1	146670.8	Extraction	KW	(25.0)	(25.0)		(25.0)	86%	100%
199-K-137	568653.4	146374.5	Extraction	KW	(15.0)	(25.0)		(18.0)	46%	120%
199-K-138	568395.2	146616.6	Extraction	KW	(25.0)	(33.6)		(30.0)	86%	120%
199-K-139	568551.4	146518.4	Extraction	KW	(10.0)	(23.9)		(19.0)	56%	190%
199-K-165	568675.0	146342.4	Extraction	KW	(30.0)	(60.0)		(53.0)	88%	177%
199-K-166	568594.6	146342.2	Extraction	KW	(15.0)	(45.0)		(30.0)	67%	200%
199-K-168	568544.4	146513.6	Extraction	KW	(15.0)	(40.0)		(35.0)	78%	233%
199-K-196	568433.4	146639.0	Extraction	KW	(35.0)	-		- ²	-	-
199-K-158	568627.5	146164.4	Injection	KW	50.0	115.8		85.0	73%	170%
199-K-174	568915.4	146222.5	Injection	KW	40.0	77.8		85.0	102%	213%
199-K-175	568882.7	146008.8	Injection	KW	80.0	82.6		100.0	121%	125%
199-K-130	570479.0	148661.2	Extraction	KX	(40.0)	(25.4)		(40.0)	80%	100%
199-K-131	570662.0	148903.9	Extraction	KX	(45.0)	(47.6)		(45.0)	85%	100%
199-K-141	569024.2	146818.5	Extraction	KX	(25.0)	(32.9)		(35.0)	95%	140%
199-K-146	570197.6	148379.8	Extraction	KX	(15.0)	(10.0)		(10.0)	100%	67%

Table 3-3. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	CY 2012 Max	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-147	570411.6	148558.2	Extraction	KX	(20.0)	(20.0)		(20.0)	100%	100%
199-K-148	570585.3	148767.9	Extraction	KX	(45.0)	(49.9)		(45.0)	90%	100%
199-K-152	570736.4	148585.8	Extraction	KX	-	(50.0)		(50.0)	100%	- ¹
199-K-153	570530.0	148210.0	Extraction	KX	(25.0)	(65.0)		(65.0)	92%	260%
199-K-154	570320.7	148027.7	Extraction	KX	(35.0)	(60.0)		(60.0)	92%	171%
199-K-161	570004.4	148202.1	Extraction	KX	(30.0)	(30.0)		(20.0)	67%	67%
199-K-163	570230.7	147947.9	Extraction	KX	(30.0)	(60.0)		(65.0)	100%	217%
199-K-171	570544.0	147187.0	Extraction	KX	(30.0)	(60.0)		(60.0)	100%	200%
199-K-178	568962.8	146954.6	Extraction	KX	(40.0)	(55.3)		(55.0)	79%	138%
199-K-143	570934.4	148088.3	Injection	KX	60.0	36.0		36.0	75%	60%
199-K-156	569674.1	147270.8	Injection	KX	60.0	85.6		79.0	92%	132%
199-K-159	570912.0	149159.9	Injection	KX	20.0	71.7		71.0	99%	355%
199-K-160	570919.6	149116.0	Injection	KX	20.0	72.1		72.0	100%	360%
199-K-164	571202.2	148903.7	Injection	KX	45.0	56.4		55.0	90%	122%
199-K-169	569988.7	147555.1	Injection	KX	60.0	76.8		68.0	89%	113%
199-K-170	570009.1	147491.8	Injection	KX	60.0	83.1		83.0	100%	138%

Table 3-3. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	CY 2012 Max	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-172	570871.2	147166.5	Injection	KX	70.0	81.7		80.0	98%	114%
199-K-180	571116.1	147449.1	Injection	KX	60.0	60.9		52.0	85%	87%
199-K-173	568674.1	146266.9	Extraction	KW	-	(60.0)		(60.0)	100%	- ¹
199-K-182	571185.3	148350.2	Extraction	KX	-	(26.2)		(26.0)	99%	- ¹

¹ Variable design rate. Proposed-to-Design ratio undefined.

² Inactive well.

Note: Color-coded cells in field "River Protection Concern Level" indicate primary hydraulic containment wells for the River Protection Objective. River Protection Concern Levels and corresponding colors are:

- (a) Green: Low – River Protection Successful
- (b) Yellow: Medium – River Protection Successful: although river is not threatened by inland plumes action may be required
- (c) Red: High – River Protection Not Successful: action required.

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D4-101	572800.1	151425.9	Extraction	DX	(12.8)	(8.4)	(6.8)		(8.0)	-	95%	0%	63%	0%
199-D4-38	572671.3	151537.9	Extraction	DX	(6.8)	(9.0)	(6.2)		(8.0)	-	89%	0%	118%	0%
199-D4-39	572747.5	151650.8	Extraction	DX	(13.6)	(18.0)	(15.9)		(16.0)	(14.0)	89%	78%	118%	103%
199-D4-83	572859.4	151723.4	Extraction	DX	(1.3)	(13.0)	-		(10.0)	-	77%	0%	769%	0%
199-D4-84	572568.0	151433.5	Extraction	DX	(10.6)	(13.0)	(9.4)		(10.0)	(8.0)	77%	62%	94%	75%
199-D4-85	572486.2	151324.2	Extraction	DX	(14.2)	(21.0)	(17.4)		(18.0)	(16.0)	86%	76%	127%	113%
199-D4-95	572613.0	151227.0	Extraction	DX	(11.5)	(14.0)	(13.0)		(12.0)	(12.0)	86%	86%	104%	104%
199-D4-96	572777.0	151520.0	Extraction	DX	(13.6)	(16.0)	(7.5)		(12.0)	(5.0)	75%	31%	88%	37%
199-D4-97	572906.5	151624.9	Extraction	DX	(11.5)	(14.0)	(12.6)		(12.0)	(12.0)	86%	86%	104%	104%
199-D4-98	572575.6	151483.3	Extraction	DX	(11.5)	(14.0)	(13.0)		(12.0)	(11.0)	86%	79%	104%	96%
199-D4-99	572526.5	151376.6	Extraction	DX	(17.0)	(21.0)	(18.9)		(18.0)	(16.0)	86%	76%	106%	94%
199-D5-101	572943.0	151521.5	Extraction	DX	(11.1)	(27.0)	(26.9)		(27.0)	(24.0)	100%	89%	243%	216%
199-D5-104	573265.5	151422.4	Extraction	DX	(10.2)	(25.1)	(25.0)		(25.0)	(23.0)	100%	92%	245%	225%
199-D5-127	572992.3	151428.3	Extraction	DX	(12.8)	(20.0)	(0.0)		(8.0)	-	40%	0%	63%	0%
199-D5-130	574039.2	151928.5	Extraction	DX	(13.6)	(16.0)	(14.2)		(11.0)	(11.0)	69%	69%	81%	81%
199-D5-131	573684.4	152006.8	Extraction	DX	(12.8)	(19.0)	(18.0)		(17.0)	(15.0)	89%	79%	133%	117%

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D5-20	573240.0	152030.2	Extraction	DX	(7.2)	(9.8)	(0.0)		(9.0)	-	92%	0%	125%	0%
199-D5-32	573372.0	151903.4	Extraction	DX	(17.0)	(32.0)	(18.0)		(18.0)	(16.0)	56%	50%	106%	94%
199-D5-39	573142.9	151428.4	Extraction	DX	(14.5)	(25.1)	(24.9)		(24.0)	(23.0)	96%	92%	166%	159%
199-D5-92	573131.9	152009.8	Extraction	DX	(17.0)	(33.0)	(29.0)		(31.0)	(22.0)	94%	67%	182%	129%
199-D7-3	574151.4	152363.4	Extraction	DX	(12.8)	(22.0)	(17.8)		(18.0)	(11.0)	82%	50%	141%	86%
199-D7-6	574429.2	152980.4	Extraction	DX	(15.0)	(19.0)	(15.7)		(17.0)	-	89%	0%	113%	0%
199-D8-53	573889.9	152452.3	Extraction	DX	(7.2)	(32.0)	-		- ²	-	-	-	-	-
199-D8-54A	573781.2	152408.0	Extraction	DX	(14.5)	(52.0)	-		- ²	-	-	-	-	-
199-D8-6	573434.7	152060.8	Extraction	DX	(13.6)	(17.0)	-		(14.0)	-	82%	0%	103%	0%
199-D8-68	573711.7	152427.1	Extraction	DX	(12.0)	(57.0)	-		- ²	-	-	-	-	-
199-D8-69	573843.6	152552.2	Extraction	DX	(17.0)	(22.0)	(20.6)		(22.0)	(11.0)	100%	50%	129%	65%
199-D8-72	573570.5	152211.8	Extraction	DX	(11.1)	(24.0)	-		- ²	-	-	-	-	-
199-D8-73	573388.7	152167.4	Extraction	DX	(3.4)	(5.4)	(2.9)		(5.0)	-	93%	0%	147%	0%
199-D8-88	573292.3	152141.3	Extraction	DX	(1.7)	(7.7)	(4.8)		(6.0)	(4.0)	77%	52%	353%	235%
199-D8-89	573479.5	152250.4	Extraction	DX	(11.1)	(19.0)	(11.1)		(14.0)	(10.0)	74%	53%	126%	90%
199-D8-90	573948.7	152646.2	Extraction	DX	(17.0)	(21.0)	(18.7)		(21.0)	(11.0)	100%	52%	124%	65%

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D8-91	574037.2	152741.3	Extraction	DX	(17.0)	(23.0)	(18.3)		(21.0)	(11.0)	91%	48%	124%	65%
199-D8-95	573612.0	152160.6	Extraction	DX	(15.0)	(19.0)	(17.8)		(19.0)	(11.0)	100%	58%	127%	73%
199-D8-96	573706.0	152152.2	Extraction	DX	(20.0)	(25.0)	(23.9)		(25.0)	(22.0)	100%	88%	125%	110%
199-D8-97	573859.6	152087.4	Extraction	DX	(14.0)	(22.0)	(18.4)		(19.0)	(12.0)	86%	55%	136%	86%
199-D8-98	574013.1	152123.0	Extraction	DX	(13.0)	(20.0)	(18.9)		(19.0)	(13.0)	95%	65%	146%	100%
199-H1-5	574850.7	153090.3	Extraction	DX	(12.8)	(22.0)	(15.7)		(18.0)	(4.0)	82%	18%	141%	31%
199-H4-80	575239.0	152568.2	Extraction	DX	(15.3)	(18.0)	(15.7)		(18.0)	(5.0)	100%	28%	118%	33%
199-H4-81	575236.9	153035.4	Extraction	DX	(13.6)	(17.0)	(15.1)		(17.0)	(5.0)	100%	29%	125%	37%
199-H4-82	574907.0	152677.7	Extraction	DX	(12.8)	(19.0)	(17.6)		(18.0)	(5.0)	95%	26%	141%	39%
199-D2-10	574470.7	153465.2	Injection	DX	-	5.4	5.4		-	-	0%	0%	- ¹	-
199-D2-12	574343.4	153300.8	Injection	DX	-	17.0	5.7		-	-	0%	0%	- ¹	-
199-D5-128	573622.0	151237.1	Injection	DX	80.8	92.0	81.7		90.0	60.0	98%	65%	111%	74%
199-D5-129	573733.3	151465.2	Injection	DX	68.0	99.0	87.8		94.0	65.0	95%	66%	138%	96%
199-D5-42	573479.8	151622.7	Injection	DX	32.3	44.0	24.4		26.0	18.0	59%	41%	80%	56%
199-D5-44	572993.6	151835.7	Injection	DX	42.5	99.0	44.3		26.0	35.0	26%	35%	61%	82%
199-D6-1	574129.9	151691.7	Injection	DX	38.3	52.0	51.0		45.0	30.0	87%	58%	117%	78%

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D6-2	574544.6	151970.2	Injection	DX	63.8	72.0	36.3		72.0	26.0	100%	36%	113%	41%
199-D7-4	574377.1	152369.6	Injection	DX	28.9	115.1	50.4		90.0	30.0	78%	26%	311%	104%
199-D7-5	574434.3	152678.7	Injection	DX	64.5	69.0	41.1		55.0	30.0	80%	43%	85%	47%
199-D8-55	573621.0	152364.3	Injection	DX	12.8	27.0	4.0		15.0	-	56%	0%	117%	0%
199-D8-93	574149.0	153085.8	Injection	DX	10.2	17.0	0.0		-	-	0%	0%	0%	0%
199-D8-94	574047.1	152949.4	Injection	DX	-	10.5	8.8		9.0	6.0	86%	57%	- ¹	-
199-D8-99	574006.8	152364.4	Injection	DX	68.0	90.9	86.7		75.0	63.0	82%	69%	110%	93%
199-H1-1	576702.3	153384.5	Extraction	HX	(25.5)	(30.6)	(30.1)		(30.0)	(30.0)	98%	98%	118%	118%
199-H1-2	576451.1	153378.3	Extraction	HX	(25.5)	(6.9)	(2.0)		(7.0)	-	100%	0%	27%	0%
199-H1-25	576279.6	154070.0	Extraction	HX	(25.5)	(29.1)	(28.4)		(29.0)	(28.0)	100%	96%	114%	110%
199-H1-27	576403.9	154024.2	Extraction	HX	(25.5)	(29.6)	(23.8)		(29.0)	(23.0)	98%	78%	114%	90%
199-H1-3	576163.0	153372.0	Extraction	HX	-	(0.0)	-		-	-	0%	0%	- ¹	-
199-H1-32	576767.1	153766.0	Extraction	HX	(13.4)	(19.7)	(1.7)		(20.0)	-	100%	0%	149%	0%
199-H1-33	576833.3	153716.2	Extraction	HX	(25.5)	(27.8)	(6.4)		(27.0)	(5.0)	97%	18%	106%	20%
199-H1-34	576883.1	153667.1	Extraction	HX	(25.5)	(28.0)	(15.1)		(28.0)	(15.0)	100%	54%	110%	59%
199-H1-35	576958.3	153628.1	Extraction	HX	(25.5)	(28.0)	(26.5)		(28.0)	(25.0)	100%	89%	110%	98%

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-H1-36	576885.6	153486.5	Extraction	HX	(25.5)	(9.0)	(6.1)		(9.0)	(5.0)	100%	56%	35%	20%
199-H1-37	577106.9	153641.6	Extraction	HX	(25.5)	(28.0)	(10.1)		(28.0)	(10.0)	100%	36%	110%	39%
199-H1-38	577161.0	153555.0	Extraction	HX	(25.5)	(25.0)	(6.3)		(25.0)	(5.0)	100%	20%	98%	20%
199-H1-39	577223.5	153533.4	Extraction	HX	(7.3)	(41.1)	(2.3)		(41.0)	(5.0)	100%	12%	562%	68%
199-H1-4	575826.5	153366.5	Extraction	HX	-	(1.9)	(0.0)		-	-	0%	0%	- ¹	-
199-H1-40	577279.3	153500.2	Extraction	HX	(7.7)	(29.2)	(4.1)		(29.0)	(4.0)	99%	14%	377%	52%
199-H1-42	577127.2	153391.7	Extraction	HX	(25.5)	(29.0)	(28.9)		(29.0)	(28.0)	100%	96%	114%	110%
199-H1-43	577213.7	153384.3	Extraction	HX	(25.5)	(30.0)	(29.0)		(30.0)	(28.0)	100%	93%	118%	110%
199-H1-45	577241.0	153062.4	Extraction	HX	(25.5)	(27.0)	(27.0)		(27.0)	(27.0)	100%	100%	106%	106%
199-H1-6	576037.8	153745.7	Extraction	HX	(3.3)	(11.7)	(2.2)		(11.0)	(2.0)	94%	17%	333%	61%
199-H3-2C	577632.1	152750.3	Extraction	HX	(28.9)	(50.0)	(48.0)		(50.0)	(48.0)	100%	96%	173%	166%
199-H3-4	577544.3	152293.2	Extraction	HX	(57.8)	(125.2)	(125.0)		(93.0)	(110.0)	74%	88%	161%	190%
199-H4-12C	578011.8	152919.8	Extraction	HX	(14.5)	(30.0)	(29.7)		(29.0)	(29.0)	97%	97%	200%	200%
199-H4-15A	577906.0	153052.0	Extraction	HX	-	(39.1)	(37.7)		(39.0)	(37.0)	100%	95%	- ¹	-
199-H4-4	578060.9	152854.0	Extraction	HX	-	(14.0)	(6.1)		(14.0)	(6.0)	100%	43%	- ¹	-
199-H4-63	578185.8	152665.5	Extraction	HX	-	(27.4)	(26.3)		(27.0)	(26.0)	99%	95%	- ¹	-

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-H4-64	577946.1	153010.6	Extraction	HX	-	(42.0)	(14.9)		(20.0)	(14.0)	48%	33%	1	-
199-H4-69	578014.1	152686.7	Extraction	HX	(14.5)	(28.0)	(26.3)		(28.0)	(25.0)	100%	89%	193%	172%
199-H4-70	578003.8	152646.5	Extraction	HX	(12.8)	(25.0)	(24.0)		(22.0)	(22.0)	88%	88%	172%	172%
199-H4-75	577212.4	152704.6	Extraction	HX	(12.8)	(20.0)	(20.0)		(19.0)	(20.0)	95%	100%	148%	156%
199-H4-76	576787.3	152976.9	Extraction	HX	(12.8)	(18.0)	(1.0)		(14.0)	-	78%	0%	109%	0%
199-H4-77	576487.8	152975.4	Extraction	HX	(12.5)	(16.5)	(9.7)		(16.0)	(9.0)	97%	55%	128%	72%
199-H1-20	575706.0	154183.6	Injection	HX	80.0	86.7	72.7		80.0	68.0	92%	78%	100%	85%
199-H1-21	575896.8	154163.8	Injection	HX	80.0	101.7	94.0		98.0	90.0	96%	89%	123%	113%
199-H3-25	577410.4	152978.5	Injection	HX	55.6	94.0	53.3		60.0	52.0	64%	55%	108%	94%
199-H3-26	577440.8	152846.5	Injection	HX	25.5	89.4	45.5		50.0	45.0	56%	50%	196%	176%
199-H3-27	577567.1	152811.1	Injection	HX	21.3	143.1	39.5		70.0	39.0	49%	27%	329%	183%
199-H4-14	577803.7	152752.4	Injection	HX	61.4	111.0	15.6		10.0	15.0	9%	14%	16%	24%
199-H4-17	577779.2	153037.6	Injection	HX	-	140.0	-		2	-	-	-	-	-
199-H4-18	578018.3	152756.5	Injection	HX	21.0	50.0	13.2		20.0	13.0	40%	26%	95%	62%
199-H4-71	578010.6	152581.5	Injection	HX	33.3	62.9	34.2		50.0	34.0	79%	54%	150%	102%
199-H4-72	578036.3	152500.1	Injection	HX	12.8	62.7	24.2		50.0	24.0	80%	38%	391%	188%

Table 3-4. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	Max Q1-CY 2012	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-H4-73	577940.6	152370.0	Injection	HX	14.5	57.7	25.6		50.0	25.0	87%	43%	345%	172%
199-H4-74	577239.1	152268.8	Injection	HX	25.5	75.7	36.1		65.0	36.0	86%	48%	255%	141%
199-H4-78	576168.2	152166.1	Injection	HX	62.5	122.2	56.2		95.0	56.0	78%	46%	152%	90%
199-H4-79	575659.1	151989.3	Injection	HX	65.0	70.1	70.1		50.0	70.0	71%	100%	77%	108%
199-H6-2	577886.5	152194.1	Injection	HX	25.5	56.2	20.5		50.0	19.0	89%	34%	196%	75%

¹ Variable design rate. Proposed-to-Design ratio undefined.

² Inactive well.

Note: Color-coded cells in field "River Protection Concern Level" indicate primary hydraulic containment wells for the River Protection Objective. River Protection Concern Levels and corresponding colors are:

- (a) Green: Low – River Protection Successful
- (b) Yellow: Medium – River Protection Successful: although river is not threatened by inland plumes action may be required
- (c) Red: High – River Protection Not Successful: action required.

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Figure 3-3. Ratio of Proposed-to-Historic-Maximum Flow Rates (Maximum Capacity) and CY 2011 ICFM for the DX P&T System in 100-HR-3.

Figure 3-4. Ratio of Proposed-to-Historic-Maximum Flow Rates (Maximum Capacity) and CY 2011 SCFM for the DX P&T System in 100-HR-3.

Figure 3-6. Ratio of Proposed-to-Design Flow Rates (Limited Capacity) and CY 2011 SCFM for the DX P&T System in 100-HR-3.

Figure 3-8. Ratio of Proposed-to-Historic-Maximum Flow Rates (Limited Capacity) and CY 2011 SCFM for the DX P&T System in 100-HR-3.

Figure 3-9. Ratio of Proposed-to-Design Flow Rates (Maximum Capacity) and CY 2011 ICFM for the HX P&T System in 100-HR-3.

Figure 3-10. Ratio of Proposed-to-Design Flow Rates (Maximum Capacity) and CY 2011 SCFM for the HX P&T System in 100-HR-3.

Figure 3-11. Ratio of Proposed-to-Historic-Maximum Flow Rates (Maximum Capacity) and CY 2011 ICFM for the HX P&T System in 100-HR-3.

Figure 3-12. Ratio of Proposed-to-Historic-Maximum Flow Rates (Maximum Capacity) and CY 2011 SCFM for the HX P&T System in 100-HR-3.

Figure 3-13. Ratio of Proposed-to-Design Flow Rates (Limited Capacity) and CY 2011 ICFM for the HX P&T System in 100-HR-3.

Figure 3-14. Ratio of Proposed-to-Design Flow Rates (Limited Capacity) and CY 2011 SCFM for the HX P&T System in 100-HR-3.

Figure 3-15. Ratio of Proposed-to-Historic-Maximum Flow Rates (Limited Capacity) and CY 2011 ICFM for the HX P&T System in 100-HR-3.

Figure 3-16. Ratio of Proposed-to-Historic-Maximum Flow Rates (Limited Capacity) and CY 2011 SCFM for the HX P&T System in 100-HR-3.

Figure 3-17. Ratio of Proposed-to-Design Flow Rates and CY 2011 ICFM for the P&T System in 100-KR-4.

Figure 3-18. Ratio of Proposed-to-Design Flow Rates and CY 2011 SCFM for the P&T System in 100-KR-4.

Figure 3-19. Ratio of Proposed-to-Historic-Maximum Flow Rates and CY 2011 ICFM for the P&T System in 100-KR-4.

Figure 3-20. Ratio of Proposed-to-Historic-Maximum Flow Rates and CY 2011 SCFM for the P&T System in 100-KR-4.

4. Software Applications, Descriptions, Installation and Checkout, and Statements of Validity

Software use for this calculation was in accordance with PRC-PRO-IRM-309, Controlled Software Management.

Calculations required for the Simulated Capture Frequency Map (SCFM), Interpolated Capture Frequency Map (ICFM), and plume depiction were completed for previous reports, as detailed in the corresponding subsections below. As such, the software descriptions, installation and checkout, together with the statement of valid software application, and the workstations type and property number on which the software was run, are provided in those documents as referenced in the subsections below.

4.1 Approved Software

The following software was used to perform calculations and was approved and compliant with PRC-PRO-IRM-309 (PRC-PRO-IRM-309, Controlled Software Management). These software are managed under the following documents consistent with PRC-PRO-IRM-309:

- CHPRC-00257 Rev. 1, MODFLOW and Related Codes Functional Requirements Document.
- CHPRC-00258 Rev. 2, MODFLOW and Related Codes Software Management Plan.
- CHPRC-00259 Rev. 2, MODFLOW and Related Codes Software Test Plan.
- CHPRC-00260 Rev. 3, MODFLOW and Related Codes Acceptance Test Report.
- CHPRC-00261 Rev. 3, MODFLOW and Related Codes Requirements Traceability Matrix.

CHPRC-00258 Rev. 2 distinguishes between safety software and support software based on whether the software managed calculates reportable results or provides run support, visualization, or other similar functions. Brief descriptions of the software are provided below.

4.2 MODFLOW

Calculations for the Simulated Capture Frequency Map (SCFM) that are presented in this ECF were completed in support of the annual groundwater P&T report DOE/RL-2012-02 (*“Calendar Year 2011 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation, Rev. 0”*). The calculations were completed using MODFLOW-2000 as modified by S.S. Papadopoulos and Associates, Inc. (SSP&A) to address dry cell issues and to use the Orthomnin solver, and approved by CH2M Hill Plateau Remediation Company (CHPRC). Full details of the software used are provided in ECF-Hanford-12-0073 (*“Calendar Year 2011 (CY2011) Evaluation of Hanford 100 Area Groundwater Pump-and-Treat (P&T) Remedy Performance Hydraulic Containment, Rev. 0”*).

4.3 KT3D_H2O

Calculations for the Interpolated Capture Frequency Map (ICFM) that are presented in this ECF were completed in support of the annual groundwater P&T report DOE/RL-2012-02 (*Calendar Year 2011 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation, Rev. 0*). The KT3D_H2O program (*User's Guide to KT3D-H2O, Version 2* [SSP&A, 2011]) was used to perform the spatial interpolation of groundwater level data and particle tracking to compute an Interpolated Capture Frequency Map (ICFM). Full details of the software used are provided in ECF-Hanford-12-0073 (*Calendar Year 2011 (CY2011) Evaluation of Hanford 100 Area Groundwater Pump-and-Treat (P&T) Remedy Performance Hydraulic Containment, Rev. 0*).

5. References

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**Appendix A: Extraction/Injection Flow Rates for 100-KR-4 and 100-HR-3 OU P&T
Interim Actions**

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Table A-1. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-113A	570098.1	148294.5	Extraction	KR	(15.0)	(23.6)	(10.3)	(23.6)	(12.8)	none	weak	weak		(13.0)	55%	87%
199-K-114A	570020.3	148280.6	Extraction	KR	(25.0)	(40.0)	(9.3)	(25.0)	(23.1)	none	weak	weak		(23.0)	58%	92%
199-K-115A	569940.0	148135.4	Extraction	KR	(25.0)	(44.0)	(23.8)	(25.5)	(21.0)	10	weak	weak		(25.0)	57%	100%
199-K-116A	569871.1	147960.5	Extraction	KR	(20.0)	(44.9)	(24.2)	(44.9)	(42.2)	10	weak	weak		(42.0)	94%	210%
199-K-120A	569399.6	147518.5	Extraction	KR	(20.0)	(50.0)	(11.2)	(25.0)	(23.3)	none	strong	weak		(23.0)	46%	115%
199-K-127	569539.2	147539.0	Extraction	KR	-	(45.0)	(10.7)	(20.0)	(18.6)	none	weak	weak		(19.0)	42%	_ ¹
199-K-129	570283.7	148503.1	Extraction	KR	(25.0)	(29.0)	-	-	-	none	weak	weak		_ ²	0%	0%
199-K-144	569163.3	147266.0	Extraction	KR	(25.0)	(50.0)	(46.8)	(50.0)	(46.6)	20	strong	weak		(47.0)	94%	188%
199-K-145	569284.6	147425.7	Extraction	KR	(25.0)	(60.0)	(56.1)	(59.9)	(56.0)	20	strong	weak		(56.0)	93%	224%
199-K-162	569340.0	147460.1	Extraction	KR	(25.0)	(59.0)	(14.8)	(44.9)	(42.0)	none	strong	strong		(42.0)	71%	168%
199-K-198	569305.7	147552.2	Extraction	KR	(25.0)	-	-	-	-	10	strong	weak		_ ²	-	-
199-K-199	569339.7	147584.4	Extraction	KR	(25.0)	-	-	-	-	20	weak	weak		_ ²	-	-
199-K-121A	570017.2	147418.3	Injection	KR	35.0	47.0	28.4	46.3	32.9	none	0	0		40.0	85%	114%
199-K-122A	569975.1	147172.9	Injection	KR	50.0	104.0	43.9	69.4	66.3	none	0	0		66.0	63%	132%
199-K-123A	569931.1	147090.2	Injection	KR	60.0	63.0	20.5	40.8	24.6	none	0	0		29.0	46%	48%
199-K-128	570009.5	147257.5	Injection	KR	50.0	98.0	33.3	88.3	84.8	none	0	0		85.0	87%	170%
199-K-179	569847.2	147481.8	Injection	KR	60.0	88.0	28.0	72.6	69.8	none	0	0		70.0	80%	117%
199-K-132	568495.1	146670.8	Extraction	KW	(25.0)	(29.0)	(13.1)	(25.0)	(18.6)	10	weak	weak		(25.0)	86%	100%
199-K-137	568653.4	146374.5	Extraction	KW	(15.0)	(39.0)	(26.8)	(25.0)	(18.0)	20	strong	strong		(18.0)	46%	120%
199-K-138	568395.2	146616.6	Extraction	KW	(25.0)	(35.0)	(13.2)	(33.6)	(30.0)	10	weak	weak		(30.0)	86%	120%
199-K-139	568551.4	146518.4	Extraction	KW	(10.0)	(34.0)	(19.9)	(23.9)	(19.0)	20	strong	strong		(19.0)	56%	190%
199-K-165	568675.0	146342.4	Extraction	KW	(30.0)	(60.0)	(56.3)	(60.0)	(60.0)	100	strong	strong		(53.0)	88%	177%
199-K-166	568594.6	146342.2	Extraction	KW	(15.0)	(45.0)	(27.1)	(45.0)	(30.0)	20	strong	strong		(30.0)	67%	200%
199-K-168	568544.4	146513.6	Extraction	KW	(15.0)	(45.0)	(33.6)	(40.0)	(35.0)	20	strong	strong		(35.0)	78%	233%

Table A-1. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-196	568433.4	146639.0	Extraction	KW	(35.0)	-	-	-	-	10	weak	weak		-	-	-
199-K-158	568627.5	146164.4	Injection	KW	50.0	115.8	83.5	115.8	115.8	none	0	0		85.0	73%	170%
199-K-174	568915.4	146222.5	Injection	KW	40.0	83.0	69.1	77.8	73.6	none	0	0		85.0	102%	213%
199-K-175	568882.7	146008.8	Injection	KW	80.0	82.6	35.7	82.6	80.8	none	0	0		100.0	121%	125%
199-K-130	570479.0	148661.2	Extraction	KX	(40.0)	(50.0)	(24.4)	(25.4)	(19.2)	20	weak	strong		(40.0)	80%	100%
199-K-131	570662.0	148903.9	Extraction	KX	(45.0)	(53.0)	(49.5)	(47.6)	(40.1)	10	strong	strong		(45.0)	85%	100%
199-K-141	569024.2	146818.5	Extraction	KX	(25.0)	(37.0)	(34.4)	(32.9)	(26.2)	20	strong	weak		(35.0)	95%	140%
199-K-146	570197.6	148379.8	Extraction	KX	(15.0)	(10.0)	(9.7)	(10.0)	(9.3)	10	weak	weak		(10.0)	100%	67%
199-K-147	570411.6	148558.2	Extraction	KX	(20.0)	(20.0)	(19.5)	(20.0)	(20.0)	20	strong	strong		(20.0)	100%	100%
199-K-148	570585.3	148767.9	Extraction	KX	(45.0)	(49.9)	(43.3)	(49.9)	(45.0)	20	strong	strong		(45.0)	90%	100%
199-K-152	570736.4	148585.8	Extraction	KX	-	(50.0)	(48.5)	(50.0)	(50.0)	20	strong	strong		(50.0)	100%	1 ¹
199-K-153	570530.0	148210.0	Extraction	KX	(25.0)	(71.0)	(41.5)	(65.0)	(65.0)	20	strong	strong		(65.0)	92%	260%
199-K-154	570320.7	148027.7	Extraction	KX	(35.0)	(65.0)	(58.1)	(60.0)	(60.0)	48	strong	strong		(60.0)	92%	171%
199-K-161	570004.4	148202.1	Extraction	KX	(30.0)	(30.0)	(11.9)	(30.0)	(19.8)	none	weak	weak		(20.0)	67%	67%
199-K-163	570230.7	147947.9	Extraction	KX	(30.0)	(65.0)	(55.1)	(60.0)	(60.0)	20	strong	strong		(65.0)	100%	217%
199-K-171	570544.0	147187.0	Extraction	KX	(30.0)	(60.0)	(57.2)	(60.0)	(60.0)	20	strong	strong		(60.0)	100%	200%
199-K-178	568962.8	146954.6	Extraction	KX	(40.0)	(70.0)	(41.8)	(55.3)	(55.3)	20	weak	weak		(55.0)	79%	138%
199-K-143	570934.4	148088.3	Injection	KX	60.0	48.0	29.2	36.0	36.0	none				36.0	75%	60%
199-K-156	569674.1	147270.8	Injection	KX	60.0	85.6	64.7	85.6	79.7	none				79.0	92%	132%
199-K-159	570912.0	149159.9	Injection	KX	20.0	71.7	58.4	71.7	71.7	none				71.0	99%	355%
199-K-160	570919.6	149116.0	Injection	KX	20.0	72.1	58.6	72.1	72.1	none				72.0	100%	360%
199-K-164	571202.2	148903.7	Injection	KX	45.0	61.0	48.3	56.4	30.2	none				55.0	90%	122%
199-K-169	569988.7	147555.1	Injection	KX	60.0	76.8	53.5	76.8	68.1	none				68.0	89%	113%
199-K-170	570009.1	147491.8	Injection	KX	60.0	83.1	48.6	83.1	83.1	none				83.0	100%	138%

Table A-1. Extraction/Injection Flow Rates for 100-KR-4 OU P&T Interim Actions

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate	Ratio Proposed – Historic Max	Ratio Proposed - Design
199-K-172	570871.2	147166.5	Injection	KX	70.0	81.7	63.7	81.7	81.7	none				80.0	98%	114%
199-K-180	571116.1	147449.1	Injection	KX	60.0	61.0	49.6	60.9	31.8	none				52.0	85%	87%
199-K-173	568674.1	146266.9	Extraction	KW	-	(60.0)	-	(60.0)	(59.7)	100				(60.0)	100%	. ¹
199-K-182	571185.3	148350.2	Extraction	KX	-	(26.2)	-	(26.2)	(26.2)	48				(26.0)	99%	. ¹

¹ Variable design rate. Proposed-to-Design ratio undefined.

² Inactive well.

Note: Color-coded cells in field “River Protection Concern Level” indicate primary hydraulic containment wells for the River Protection Objective. River Protection Concern Levels and corresponding colors are:

- (a) Green: Low – River Protection Successful
- (b) Yellow: Medium – River Protection Successful: although river is not threatened by inland plumes action may be required
- (c) Red: High – River Protection Not Successful: action required.

Table A-2. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	February 2012	Max Q1-CY 2012	June 2012	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D4-101	572800.1	151425.9	Extraction	DX	(12.8)	(8.4)	(7.0)	(8.4)	-	(6.8)	-	(8.0)	100	strong	strong		(8.0)	-	95%	0%	63%	0%
199-D4-38	572671.3	151537.9	Extraction	DX	(6.8)	(9.0)	(7.9)	(8.0)	-	(6.2)	(7.8)	(8.0)	20	strong	strong		(8.0)	-	89%	0%	118%	0%
199-D4-39	572747.5	151650.8	Extraction	DX	(13.6)	(18.0)	(15.9)	(16.0)	(14.1)	(15.9)	(12.8)	(14.5)	100	strong	strong		(16.0)	(14.0)	89%	78%	118%	103%
199-D4-83	572859.4	151723.4	Extraction	DX	(1.3)	(13.0)	(0.5)	(13.0)	-	-	(9.6)	(13.0)	no	weak	weak		(10.0)	-	77%	0%	769%	0%
199-D4-84	572568.0	151433.5	Extraction	DX	(10.6)	(13.0)	(10.8)	(13.0)	(8.4)	(9.4)	(10.7)	(8.5)	20	strong	strong		(10.0)	(8.0)	77%	62%	94%	75%
199-D4-85	572486.2	151324.2	Extraction	DX	(14.2)	(21.0)	(16.1)	(19.0)	(17.4)	(17.4)	(18.2)	(19.0)	no	strong	strong		(18.0)	(16.0)	86%	76%	127%	113%
199-D4-95	572613.0	151227.0	Extraction	DX	(11.5)	(14.0)	(12.2)	(13.0)	(12.2)	(13.0)	(11.7)	(13.0)	48	strong	strong		(12.0)	(12.0)	86%	86%	104%	104%
199-D4-96	572777.0	151520.0	Extraction	DX	(13.6)	(16.0)	(13.8)	(12.0)	(5.0)	(7.5)	(7.2)	(12.0)	100	strong	strong		(12.0)	(5.0)	75%	31%	88%	37%
199-D4-97	572906.5	151624.9	Extraction	DX	(11.5)	(14.0)	(12.1)	(13.0)	(12.2)	(12.6)	(11.9)	(13.0)	100	strong	weak		(12.0)	(12.0)	86%	86%	104%	104%
199-D4-98	572575.6	151483.3	Extraction	DX	(11.5)	(14.0)	(12.1)	(13.2)	(11.9)	(13.0)	(12.8)	(13.2)	20	strong	strong		(12.0)	(11.0)	86%	79%	104%	96%
199-D4-99	572526.5	151376.6	Extraction	DX	(17.0)	(21.0)	(15.7)	(19.4)	(16.5)	(18.9)	(18.6)	(19.4)	no	strong	strong		(18.0)	(16.0)	86%	76%	106%	94%
199-D5-101	572943.0	151521.5	Extraction	DX	(11.1)	(27.0)	(21.8)	(27.0)	(24.4)	(26.9)	(26.8)	(25.0)	100	strong	strong		(27.0)	(24.0)	100%	89%	243%	216%
199-D5-104	573265.5	151422.4	Extraction	DX	(10.2)	(25.1)	(24.7)	(25.1)	(23.5)	(25.0)	(24.7)	(24.0)	5000	strong	strong		(25.0)	(23.0)	100%	92%	245%	225%
199-D5-127	572992.3	151428.3	Extraction	DX	(12.8)	(20.0)	(13.7)	(8.0)	-	(0.0)	-	(8.0)	48	strong	strong		(8.0)	-	40%	0%	63%	0%
199-D5-130	574039.2	151928.5	Extraction	DX	(13.6)	(16.0)	(14.7)	(14.2)	(11.2)	(14.2)	(11.5)	(10.8)	100	strong	strong		(11.0)	(11.0)	69%	69%	81%	81%
199-D5-131	573684.4	152006.8	Extraction	DX	(12.8)	(19.0)	(15.9)	(18.0)	(16.8)	(18.0)	(17.3)	(13.6)	1000	strong	strong		(17.0)	(15.0)	89%	79%	133%	117%
199-D5-20	573240.0	152030.2	Extraction	DX	(7.2)	(9.8)	(6.6)	(9.8)	-	(0.0)	(9.4)	-	48	weak	strong		(9.0)	-	92%	0%	125%	0%
199-D5-32	573372.0	151903.4	Extraction	DX	(17.0)	(32.0)	(17.7)	(19.0)	(16.8)	(18.0)	(18.2)	(17.2)	100	strong	strong		(18.0)	(16.0)	56%	50%	106%	94%
199-D5-39	573142.9	151428.4	Extraction	DX	(14.5)	(25.1)	(19.0)	(25.1)	(23.2)	(24.9)	(23.8)	(25.0)	2000	strong	strong		(24.0)	(23.0)	96%	92%	166%	159%
199-D5-92	573131.9	152009.8	Extraction	DX	(17.0)	(33.0)	(16.7)	(33.0)	(22.6)	(29.0)	(31.3)	(17.8)	10	strong	strong		(31.0)	(22.0)	94%	67%	182%	129%
199-D7-3	574151.4	152363.4	Extraction	DX	(12.8)	(22.0)	(17.7)	(18.8)	(11.4)	(17.8)	(16.6)	(13.4)	48	weak	strong		(18.0)	(11.0)	82%	50%	141%	86%
199-D7-6	574429.2	152980.4	Extraction	DX	(15.0)	(19.0)	(14.9)	(18.2)	(4.1)	(15.7)	(17.5)	(10.3)	10	weak	weak		(17.0)	-	89%	0%	113%	0%
199-D8-53	573889.9	152452.3	Extraction	DX	(7.2)	(32.0)	(15.4)	-	-	-	-	-	20	strong	strong		- ²	-	-	-	-	-
199-D8-54A	573781.2	152408.0	Extraction	DX	(14.5)	(52.0)	(18.7)	-	-	-	-	-	20	weak	strong		- ²	-	-	-	-	-
199-D8-6	573434.7	152060.8	Extraction	DX	(13.6)	(17.0)	(14.0)	(6.9)	-	-	(2.0)	-	100	weak	strong		(14.0)	-	82%	0%	103%	0%
199-D8-68	573711.7	152427.1	Extraction	DX	(12.0)	(57.0)	(51.2)	-	-	-	-	-	no	weak	strong		- ²	-	-	-	-	-
199-D8-69	573843.6	152552.2	Extraction	DX	(17.0)	(22.0)	(18.0)	(21.0)	(11.4)	(20.6)	(20.3)	(19.2)	20	weak	strong		(22.0)	(11.0)	100%	50%	129%	65%

Table A-2. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	February 2012	Max Q1-CY 2012	June 2012	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D8-72	573570.5	152211.8	Extraction	DX	(11.1)	(24.0)	(7.5)	-	-	-	-	-	100	0	0		2	-	-	-	-	-
199-D8-73	573388.7	152167.4	Extraction	DX	(3.4)	(5.4)	(3.5)	(5.4)	(1.2)	(2.9)	(5.3)	-	100	weak	strong		(5.0)	-	93%	0%	147%	0%
199-D8-88	573292.3	152141.3	Extraction	DX	(1.7)	(7.7)	(2.8)	(7.7)	(4.0)	(4.8)	(6.4)	(5.7)	100	weak	strong		(6.0)	(4.0)	77%	52%	353%	235%
199-D8-89	573479.5	152250.4	Extraction	DX	(11.1)	(19.0)	(14.1)	(13.1)	(10.3)	(11.1)	(12.0)	(10.9)	48	strong	strong		(14.0)	(10.0)	74%	53%	126%	90%
199-D8-90	573948.7	152646.2	Extraction	DX	(17.0)	(21.0)	(17.1)	(19.0)	(11.3)	(18.7)	(18.2)	(12.9)	20	weak	strong		(21.0)	(11.0)	100%	52%	124%	65%
199-D8-91	574037.2	152741.3	Extraction	DX	(17.0)	(23.0)	(18.7)	(18.9)	(11.4)	(18.3)	(18.3)	(13.6)	20	weak	strong		(21.0)	(11.0)	91%	48%	124%	65%
199-D8-95	573612.0	152160.6	Extraction	DX	(15.0)	(19.0)	(16.2)	(18.3)	(11.5)	(17.8)	(17.6)	(13.6)	100	strong	strong		(19.0)	(11.0)	100%	58%	127%	73%
199-D8-96	573706.0	152152.2	Extraction	DX	(20.0)	(25.0)	(19.6)	(24.0)	(22.4)	(23.9)	(23.0)	(17.6)	500	strong	strong		(25.0)	(22.0)	100%	88%	125%	110%
199-D8-97	573859.6	152087.4	Extraction	DX	(14.0)	(22.0)	(18.8)	(18.9)	(12.3)	(18.4)	(18.3)	(13.6)	500	strong	strong		(19.0)	(12.0)	86%	55%	136%	86%
199-D8-98	574013.1	152123.0	Extraction	DX	(13.0)	(20.0)	(16.4)	(19.0)	(13.2)	(18.9)	(17.6)	(13.6)	48	strong	strong		(19.0)	(13.0)	95%	65%	146%	100%
199-H1-5	574850.7	153090.3	Extraction	DX	(12.8)	(22.0)	(16.4)	(18.9)	(4.1)	(15.7)	(17.5)	(10.3)	20	weak	weak		(18.0)	(4.0)	82%	18%	141%	31%
199-H4-80	575239.0	152568.2	Extraction	DX	(15.3)	(18.0)	(14.9)	(18.0)	(4.1)	(15.7)	(17.5)	(11.3)	20	strong	weak		(18.0)	(5.0)	100%	28%	118%	33%
199-H4-81	575236.9	153035.4	Extraction	DX	(13.6)	(17.0)	(14.7)	(17.0)	(4.4)	(15.1)	(16.6)	(11.6)	20	weak	weak		(17.0)	(5.0)	100%	29%	125%	37%
199-H4-82	574907.0	152677.7	Extraction	DX	(12.8)	(19.0)	(16.0)	(18.7)	(4.1)	(17.6)	(18.5)	(10.3)	10	weak	weak		(18.0)	(5.0)	95%	26%	141%	39%
199-D2-10	574470.7	153465.2	Injection	DX	-	5.4	1.3	5.4	5.4	5.4	-	1.4	no	0	0		-	-	0%	0%	1	-
199-D2-12	574343.4	153300.8	Injection	DX	-	17.0	5.4	5.7	3.7	5.7	-	2.2	20	0	0		-	-	0%	0%	1	-
199-D5-128	573622.0	151237.1	Injection	DX	80.8	92.0	78.3	91.3	62.1	81.7	90.5	76.0	no	0	0		90.0	60.0	98%	65%	111%	74%
199-D5-129	573733.3	151465.2	Injection	DX	68.0	99.0	84.3	99.0	66.8	87.8	98.8	82.2	no	0	0		94.0	65.0	95%	66%	138%	96%
199-D5-42	573479.8	151622.7	Injection	DX	32.3	44.0	21.4	26.7	18.2	24.4	23.3	21.7	48	0	0		26.0	18.0	59%	41%	80%	56%
199-D5-44	572993.6	151835.7	Injection	DX	42.5	99.0	53.8	44.3	37.7	44.3	26.6	22.6	no	0	0		26.0	35.0	26%	35%	61%	82%
199-D6-1	574129.9	151691.7	Injection	DX	38.3	52.0	34.1	51.0	29.1	51.0	42.2	28.5	48	0	0		45.0	30.0	87%	58%	117%	78%
199-D6-2	574544.6	151970.2	Injection	DX	63.8	72.0	57.4	36.3	26.6	36.3	26.7	18.9	no	0	0		72.0	26.0	100%	36%	113%	41%
199-D7-4	574377.1	152369.6	Injection	DX	28.9	115.1	30.5	115.1	31.7	50.4	106.5	98.4	48	0	0		90.0	30.0	78%	26%	311%	104%
199-D7-5	574434.3	152678.7	Injection	DX	64.5	69.0	50.7	58.8	30.4	41.1	54.0	51.5	20	0	0		55.0	30.0	80%	43%	85%	47%
199-D8-55	573621.0	152364.3	Injection	DX	12.8	27.0	8.1	4.0	2.4	4.0	1.7	2.7	48	0	0		15.0	-	56%	0%	117%	0%
199-D8-93	574149.0	153085.8	Injection	DX	10.2	17.0	12.5	0.0	-	0.0	-	-	no	0	0		-	-	0%	0%	0%	0%
199-D8-94	574047.1	152949.4	Injection	DX	-	10.5	3.7	10.5	5.4	8.8	-	9.5	no	0	0		9.0	6.0	86%	57%	1	-

Table A-2. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	February 2012	Max Q1-CY 2012	June 2012	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-D8-99	574006.8	152364.4	Injection	DX	68.0	90.9	46.1	90.9	63.0	86.7	78.7	56.6	100	0	0		75.0	63.0	82%	69%	110%	93%
199-H1-1	576702.3	153384.5	Extraction	HX	(25.5)	(30.6)	(29.8)	(30.6)	(29.4)	(30.1)	(26.7)	(28.5)	20	strong	strong		(30.0)	(30.0)	98%	98%	118%	118%
199-H1-2	576451.1	153378.3	Extraction	HX	(25.5)	(6.9)	(2.8)	(6.9)	(1.9)	(2.0)	(6.1)	(2.5)	20	strong	weak		(7.0)	-	100%	0%	27%	0%
199-H1-25	576279.6	154070.0	Extraction	HX	(25.5)	(29.1)	(24.8)	(29.1)	(26.6)	(28.4)	(26.3)	(26.3)	10	weak	weak		(29.0)	(28.0)	100%	96%	114%	110%
199-H1-27	576403.9	154024.2	Extraction	HX	(25.5)	(29.6)	(18.0)	(29.6)	(18.7)	(23.8)	(26.4)	(20.2)	20	weak	weak		(29.0)	(23.0)	98%	78%	114%	90%
199-H1-3	576163.0	153372.0	Extraction	HX	-	(0.0)	(0.1)	(0.0)	-	-	(0.0)	-	20	strong	weak		-	-	0%	0%	- ¹	-
199-H1-32	576767.1	153766.0	Extraction	HX	(13.4)	(19.7)	(2.2)	(19.7)	(0.3)	(1.7)	(19.7)	(3.8)	20	weak	weak		(20.0)	-	100%	0%	149%	0%
199-H1-33	576833.3	153716.2	Extraction	HX	(25.5)	(27.8)	(8.8)	(27.8)	(0.2)	(6.4)	(25.3)	(13.0)	20	weak	strong		(27.0)	(5.0)	97%	18%	106%	20%
199-H1-34	576883.1	153667.1	Extraction	HX	(25.5)	(28.0)	(13.8)	(28.0)	(11.0)	(15.1)	(27.6)	(13.6)	20	weak	strong		(28.0)	(15.0)	100%	54%	110%	59%
199-H1-35	576958.3	153628.1	Extraction	HX	(25.5)	(28.0)	(26.4)	(27.8)	(23.1)	(26.5)	(26.5)	(26.6)	20	strong	strong		(28.0)	(25.0)	100%	89%	110%	98%
199-H1-36	576885.6	153486.5	Extraction	HX	(25.5)	(9.0)	(7.7)	(9.0)	(5.3)	(6.1)	(8.9)	(7.0)	48	strong	strong		(9.0)	(5.0)	100%	56%	35%	20%
199-H1-37	577106.9	153641.6	Extraction	HX	(25.5)	(28.0)	(11.2)	(28.0)	(3.0)	(10.1)	(27.6)	(16.1)	20	weak	weak		(28.0)	(10.0)	100%	36%	110%	39%
199-H1-38	577161.0	153555.0	Extraction	HX	(25.5)	(25.0)	(5.9)	(25.0)	(4.3)	(6.3)	(24.5)	(8.4)	20	weak	weak		(25.0)	(5.0)	100%	20%	98%	20%
199-H1-39	577223.5	153533.4	Extraction	HX	(7.3)	(41.1)	(2.3)	(41.1)	(0.6)	(2.3)	(37.6)	(4.8)	20	weak	weak		(41.0)	(5.0)	100%	12%	562%	68%
199-H1-4	575826.5	153366.5	Extraction	HX	-	(1.9)	(1.1)	(1.9)	-	(0.0)	(0.0)	(1.2)	20	weak	weak		-	-	0%	0%	- ¹	-
199-H1-40	577279.3	153500.2	Extraction	HX	(7.7)	(29.2)	(4.2)	(29.2)	(2.5)	(4.1)	(29.2)	(7.0)	20	weak	weak		(29.0)	(4.0)	99%	14%	377%	52%
199-H1-42	577127.2	153391.7	Extraction	HX	(25.5)	(29.0)	(28.4)	(29.0)	(28.9)	(28.9)	(28.0)	(27.5)	20	strong	strong		(29.0)	(28.0)	100%	96%	114%	110%
199-H1-43	577213.7	153384.3	Extraction	HX	(25.5)	(30.0)	(29.0)	(30.0)	(24.6)	(29.0)	(29.6)	(28.5)	20	strong	strong		(30.0)	(28.0)	100%	93%	118%	110%
199-H1-45	577241.0	153062.4	Extraction	HX	(25.5)	(27.0)	(26.4)	(27.0)	(27.0)	(27.0)	(4.1)	(10.1)	20	strong	weak		(27.0)	(27.0)	100%	100%	106%	106%
199-H1-6	576037.8	153745.7	Extraction	HX	(3.3)	(11.7)	(2.4)	(11.7)	(1.0)	(2.2)	(8.5)	(1.8)	20	strong	weak		(11.0)	(2.0)	94%	17%	333%	61%
199-H3-2C	577632.1	152750.3	Extraction	HX	(28.9)	(50.0)	(44.2)	(50.0)	(48.0)	(48.0)	(49.4)	(45.8)	no	weak	weak		(50.0)	(48.0)	100%	96%	173%	166%
199-H3-4	577544.3	152293.2	Extraction	HX	(57.8)	(125.2)	(106.3)	(125.2)	(125.0)	(125.0)	(95.6)	(118.8)	20	strong	strong		(93.0)	(110.0)	74%	88%	161%	190%
199-H4-12C	578011.8	152919.8	Extraction	HX	(14.5)	(30.0)	(22.3)	(30.0)	(29.7)	(29.7)	(29.6)	(27.5)	no	weak	weak		(29.0)	(29.0)	97%	97%	200%	200%
199-H4-15A	577906.0	153052.0	Extraction	HX	-	(39.1)	(36.6)	(39.1)	(37.5)	(37.7)	(32.1)	(29.4)	20	strong	strong		(39.0)	(37.0)	100%	95%	- ¹	-
199-H4-4	578060.9	152854.0	Extraction	HX	-	(14.0)	(5.8)	(11.0)	(2.5)	(6.1)	(10.9)	(7.0)	no	weak	weak		(14.0)	(6.0)	100%	43%	- ¹	-
199-H4-63	578185.8	152665.5	Extraction	HX	-	(27.4)	(23.9)	(27.4)	(26.0)	(26.3)	(26.8)	(24.7)	no	strong	strong		(27.0)	(26.0)	99%	95%	- ¹	-
199-H4-64	577946.1	153010.6	Extraction	HX	-	(42.0)	(11.5)	(22.9)	(11.7)	(14.9)	(20.1)	(16.5)	no	strong	weak		(20.0)	(14.0)	48%	33%	- ¹	-

Table A-2. Extraction/Injection Flow Rates for 100-HR-3 OU P&T Interim

Well Name	Easting	Northing	Type	System	Design Rate	Historic Max (January 1, 2006 – December 12, 2012)	CY 2011 Avg Rate	CY 2012 Max	February 2012	Max Q1-CY 2012	June 2012	December 2012	In-Plume? (within contour [ug/l])	Capture CEM (Weak, Strong)	Capture CFM (Weak, Strong)	River Protection Concern Level	Proposed Rate (Maximum Capacity)	Proposed Rate (Limited Capacity)	Ratio Proposed – Historic Max (Maximum Capacity)	Ratio Proposed – Historic Max (Limited Capacity)	Ratio Proposed – Design (Maximum Capacity)	Ratio Proposed – Design (Limited Capacity)
199-H4-69	578014.1	152686.7	Extraction	HX	(14.5)	(28.0)	(26.6)	(28.0)	(21.3)	(26.3)	(27.7)	(25.8)	no	strong	strong		(28.0)	(25.0)	100%	89%	193%	172%
199-H4-70	578003.8	152646.5	Extraction	HX	(12.8)	(25.0)	(23.4)	(25.0)	(24.0)	(24.0)	(22.3)	(22.8)	no	strong	weak		(22.0)	(22.0)	88%	88%	172%	172%
199-H4-75	577212.4	152704.6	Extraction	HX	(12.8)	(20.0)	(19.6)	(20.0)	(20.0)	(20.0)	(19.1)	(18.0)	48	strong	strong		(19.0)	(20.0)	95%	100%	148%	156%
199-H4-76	576787.3	152976.9	Extraction	HX	(12.8)	(18.0)	(9.6)	(18.0)	-	(1.0)	(13.6)	(13.4)	48	strong	strong		(14.0)	-	78%	0%	109%	0%
199-H4-77	576487.8	152975.4	Extraction	HX	(12.5)	(16.5)	(11.7)	(16.5)	(9.1)	(9.7)	(9.3)	(12.5)	48	strong	strong		(16.0)	(9.0)	97%	55%	128%	72%
199-H1-20	575706.0	154183.6	Injection	HX	80.0	86.7	73.2	86.7	69.2	72.7	19.3	48.4	no	0	0		80.0	68.0	92%	78%	100%	85%
199-H1-21	575896.8	154163.8	Injection	HX	80.0	101.7	95.0	101.7	90.0	94.0	65.7	58.4	no	0	0		98.0	90.0	96%	89%	123%	113%
199-H3-25	577410.4	152978.5	Injection	HX	55.6	94.0	49.8	94.0	49.8	53.3	88.2	58.3	20	0	0		60.0	52.0	64%	55%	108%	94%
199-H3-26	577440.8	152846.5	Injection	HX	25.5	89.4	43.8	89.4	42.7	45.5	83.9	55.8	10	0	0		50.0	45.0	56%	50%	196%	176%
199-H3-27	577567.1	152811.1	Injection	HX	21.3	143.1	37.7	143.1	36.6	39.5	70.9	48.9	no	0	0		70.0	39.0	49%	27%	329%	183%
199-H4-14	577803.7	152752.4	Injection	HX	61.4	111.0	61.5	15.6	14.5	15.6	8.5	10.3	no	0	0		10.0	15.0	9%	14%	16%	24%
199-H4-17	577779.2	153037.6	Injection	HX	-	140.0	34.4	-	-	-	-	-	no	0	0		- ²	-	-	-	-	-
199-H4-18	578018.3	152756.5	Injection	HX	21.0	50.0	32.7	13.2	12.1	13.2	9.5	9.2	no	0	0		20.0	13.0	40%	26%	95%	62%
199-H4-71	578010.6	152581.5	Injection	HX	33.3	62.9	31.6	62.9	31.1	34.2	58.8	39.3	no	0	0		50.0	34.0	79%	54%	150%	102%
199-H4-72	578036.3	152500.1	Injection	HX	12.8	62.7	19.8	62.7	20.7	24.2	58.6	40.0	no	0	0		50.0	24.0	80%	38%	391%	188%
199-H4-73	577940.6	152370.0	Injection	HX	14.5	57.7	23.2	57.7	22.5	25.6	53.6	36.3	20	0	0		50.0	25.0	87%	43%	345%	172%
199-H4-74	577239.1	152268.8	Injection	HX	25.5	75.7	35.3	75.7	33.5	36.1	68.9	48.4	20	0	0		65.0	36.0	86%	48%	255%	141%
199-H4-78	576168.2	152166.1	Injection	HX	62.5	122.2	55.6	122.2	52.2	56.2	96.1	59.2	20	0	0		95.0	56.0	78%	46%	152%	90%
199-H4-79	575659.1	151989.3	Injection	HX	65.0	70.1	56.8	70.1	62.0	70.1	-	57.9	20	0	0		50.0	70.0	71%	100%	77%	108%
199-H6-2	577886.5	152194.1	Injection	HX	25.5	56.2	18.3	56.2	17.7	20.5	52.3	30.0	20	0	0		50.0	19.0	89%	34%	196%	75%

¹ Variable design rate. Proposed-to-Design ratio undefined.

² Inactive well.

Note: Color-coded cells in field "River Protection Concern Level" indicate primary hydraulic containment wells for the River Protection Objective. River Protection Concern Levels and corresponding colors are:

- (a) Green: Low – River Protection Successful
- (b) Yellow: Medium – River Protection Successful: although river is not threatened by inland plumes action may be required
- (c) Red: High – River Protection Not Successful: action required.

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