ECF-200BP5-16-0026
Revision 0

Description of Flowpath Calculations for the 216-A-29 Ditch Completed During Calendar Year 2015

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

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

ECF-200BP5-16-0026
Revision 0

Description of Flowpath Calculations for the 216-A-29 Ditch Completed During Calendar Year 2015

Date Published
July 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julia Raymer at 1:59 pm, Aug 01, 2016

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: Completed by the Responsible Manager

Project:		**RELEASE/ISSUE** 0
Date:	04/29/2016	
Calculation Title & Description:	**Description of Flowpath Calculations for the 216-A-29 Ditch Completed During Calendar Year 2015**	

Section 2: Completed by Preparer

Calculation No.: ECF-200BP5-16-0026 **Revision No.: 000**

Revision History

Revision No.	Description	Date	Affected Pages
0	Initial Issue	04/29/2016	

Section 3: Completed by the Responsible Manager

Document Control:	
Is the document intended to be controlled within the Document Management Control System (DMCS)?	☒ Yes ☐ No
Does document contain scientific and technical information intended for public use?	☒ Yes ☐ No
Does document contain controlled-use information?	☐ Yes ☒ No

Section 4: Document Review & Approval

	Name /Position	Signature	Date
Preparer:	*Marinko Karanovic, Hydrogeologist, S.S. Papadopulos & Assoc., Inc.*		04/08/2016
Checker:	*M. Weber, INTERA Inc.*	M. Weber	03-May-16
Senior Reviewer:	*J Morshed, INTERA Inc.*	J. Morshed	03-May-16
Responsible Manager:	*William Faught, CHPRC*		7-26-16

Section 5: Applicable if calculation is a risk assessment or uses an environmental model

PRIOR TO INITIATING MODELING:

	Name /Position	Signature	Date
Required training for modelers completed:	HE NICHOLS		05-MAY-2016
Integration Lead			
Safety Software Approved:	HE NICHOLS		05-MAY-2016
Integration Lead			

CALCULATION APPROVED:

	Name /Position	Signature	Date
Risk/Modeling Integration Manager:	A. ALY		5/5/16

This page intentionally left blank.

Contents

1 Purpose **1**

2 Background **1**

3 Methodology **3**

3.1 Water Level Mapping 3

3.2 Groundwater Modeling 4

3.3 Particle Tracking 6

4 Assumptions and Inputs **6**

4.1 Assumptions 6

4.2 Input Data 7

5 Software Applications, Descriptions, Installation and Checkout, and Statements of Validity .. **9**

5.1 Approved Software 9

5.2 Descriptions 9

5.2.1 MODFLOW (Controlled Calculation Software) 9

5.3 Support Software 10

5.3.1 MODFLOW Suite Support Software 10

5.3.2 KT3D_H2O 10

5.3.3 Surfer 10

5.4 Software Installation and Checkout 10

5.4.1 Statement of Valid Software Application 10

6 Calculations **11**

6.1 Groundwater Flow Modeling 11

6.2 Water Level Mapping 11

6.3 Particle Tracking 11

7 Results **11**

8 References **13**

Appendices

A Software Installation and Checkout Forms ..... **A-i**

Figures

Figure 2.1. Location of Groundwater OUs within the Study Area 1

Figure 2.2. Location of Ditch 216-A-29 with Annotation from Water Quality Analysis (after DOE/RL-2008-58, 2015, Draft Rev. 1) 2

Figure 3.1. Approximate Groundwater Levels for May through December 2013 (after SGW-58828 Rev. 0)……..…..... 4
Figure 3.2. Groundwater Model Domain and Model Boundary Conditions 5
Figure 7.1. Particle Traces Generated using Simulated Water Levels..... 12
Figure 7.2. Particle Traces Generated using Interpolated Water Levels..... 13

Tables

Table 4.1. Monitoring water level data used to construct 2013 water level map..... 7

Terms

CHPRC	CH2M HILL Plateau Remediation Company
CPGWM	central plateau groundwater model
CY	calendar year
ECF	environmental calculation brief
OU	operable unit
DOE	U.S. Department of Energy

This page intentionally left blank.

1 Purpose

The calculations presented in this Environmental Calculation Brief (ECF) were completed to provide additional lines of evidence to those cited within this report in order to verify general directions of groundwater flow in the vicinity of the 216-A-29 ditch located in the 200-East area of the Hanford Site, Washington State.

2 Background

CH2M HILL Plateau Remediation Company (CHPRC) is in the process of evaluating the number and location of monitoring wells in the vicinity of the 216-A-29 ditch located within the southern area of the 200-BP-5 groundwater operable unit (OU) on the Hanford Site's Central Plateau, near Richland, Washington (Figure 2-1). Previous work completed by CHPRC that is documented in "Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch" (DOE/RL-2008-58, Draft Rev. 1) employed an evaluation of water quality data to infer groundwater flow and constituent migration directions in the vicinity of 216-A-29 (Figure 2-2). That analysis suggested that groundwater generally flows from northwest to southeast, passing across (beneath) the ditch. To assist in this evaluation, estimates of the general directions of groundwater flow in the vicinity of the ditch were made using two approaches that emphasize water level data and analyses, as detailed in this ECF.

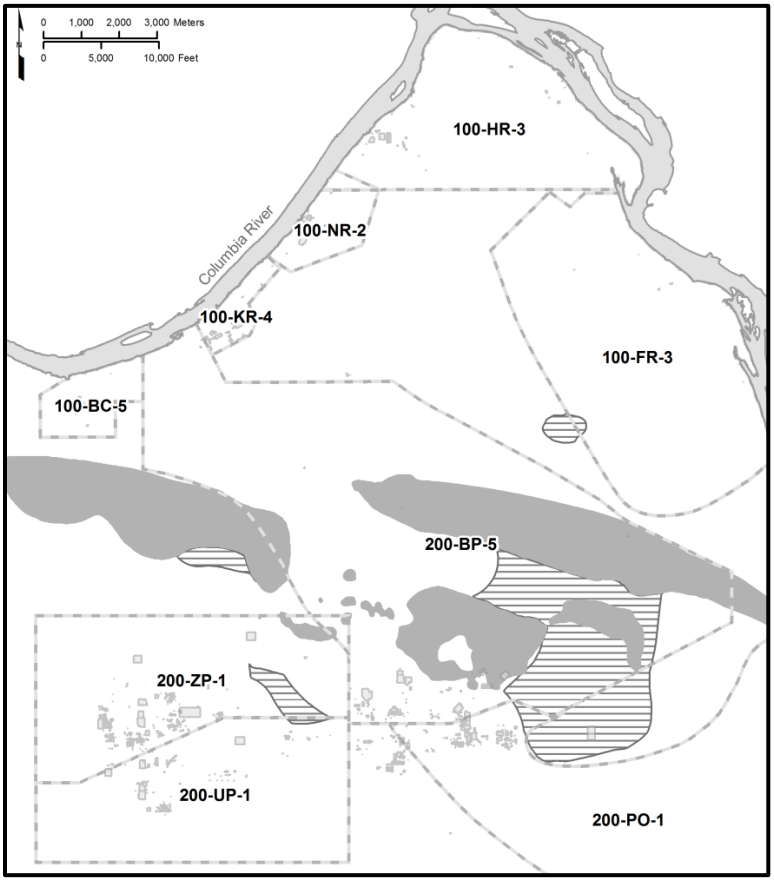

Figure 2.1. Location of Groundwater OUs within the Study Area

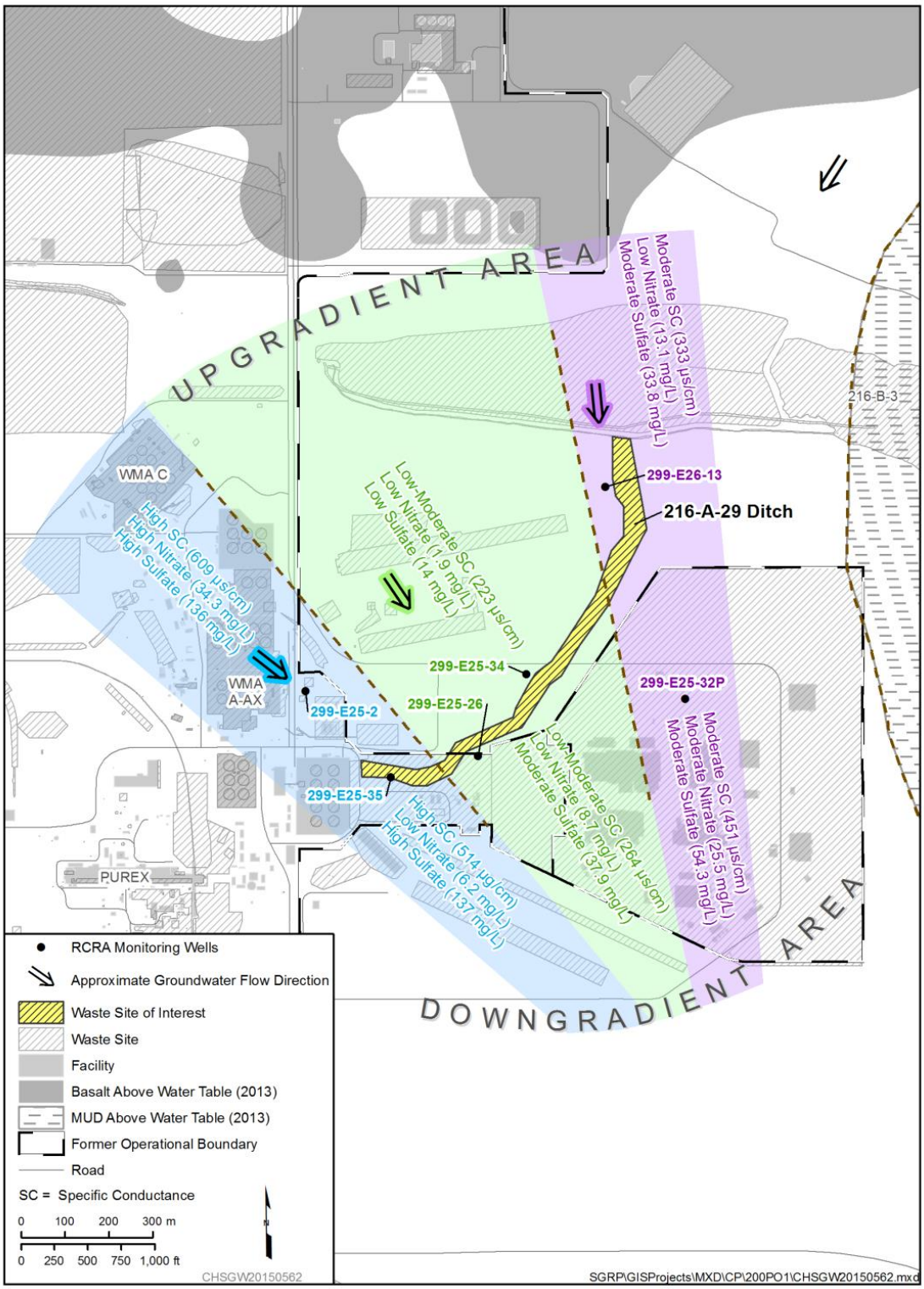

Figure 2.2. Location of Ditch 216-A-29 with Annotation from Water Quality Analysis (after DOE/RL-2008-58, 2015, Draft Rev. 1)

3 Methodology

Two methods were used to obtain approximate depictions of groundwater levels in the area of interest, to then use in pathline (particle tracking) analyses to evaluate general directions of groundwater flow:

1. Groundwater level mapping (with post-processing using particle tracking)
2. Groundwater modeling (with post-processing using particle tracking)

Each method used to obtain approximate groundwater levels is described in a subsection below, followed by a description of the method used to approximate the paths (i.e., groundwater flow directions) of groundwater and any dissolved constituents therein using those approximate water depictions.

3.1 Water Level Mapping

Maps of groundwater levels in the vicinity of the 216-A-29 ditch have been previously prepared and documented by CHPRC in the Soil and Groundwater report "Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014" (SGW-58828, 2015, Rev. 0). These maps were prepared using the Inverse Distance to a Power gridding method in Surfer™[1], resulting a piecewise-continuous "grid" of interpolated groundwater levels throughout the area of interest. This interpolated water level grid, as it is referred to herein, provided one estimate of the groundwater elevations – and accompanying hydraulic gradients – throughout the area of interest for use in subsequent particle tracking analyses. As such, an interpolated groundwater level map already exists for use in particle tracking calculations described in this ECF. The approximate groundwater levels mapped for the period May through December 2013, depicted in Figure 3-1 below (after SGW-58828, Rev. 0), were used as the basis for subsequent particle tracking in this ECF.

[1] Surfer is a trademark of Golden Software, Golden Co

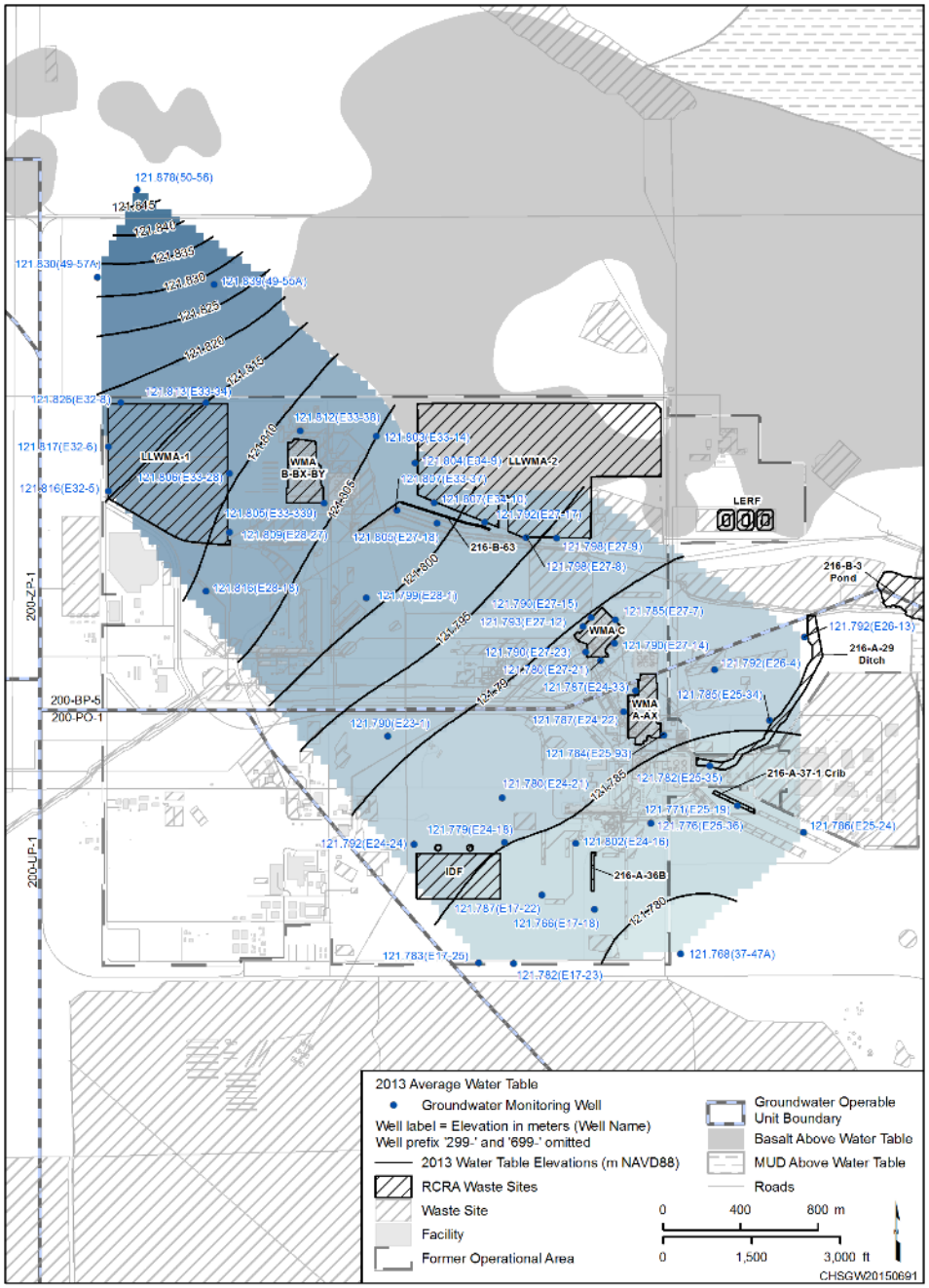

Figure 3.1. Approximate Groundwater Levels for May through December 2013 (after SGW-58828 Rev. 0)

3.2 Groundwater Modeling

The central plateau groundwater model (CPGWM), detailed in CP-47631, Model Package Report: Central Plateau Groundwater Model Version 3.3, Rev. 0 (CP-47631, 2011), is the principal computational tool used to design and evaluate the performance of the 200-ZP-1 and 200-UP-1 groundwater remedies. The model was constructed originally to support decisions in these groundwater OUs. However, the model was constructed to encompass portions of the 200-East groundwater OUs that lie within the Central Plateau, in order to be capable of providing preliminary assessments of groundwater conditions within those limited portions of these groundwater OUs. This is illustrated in Figure 3-2.

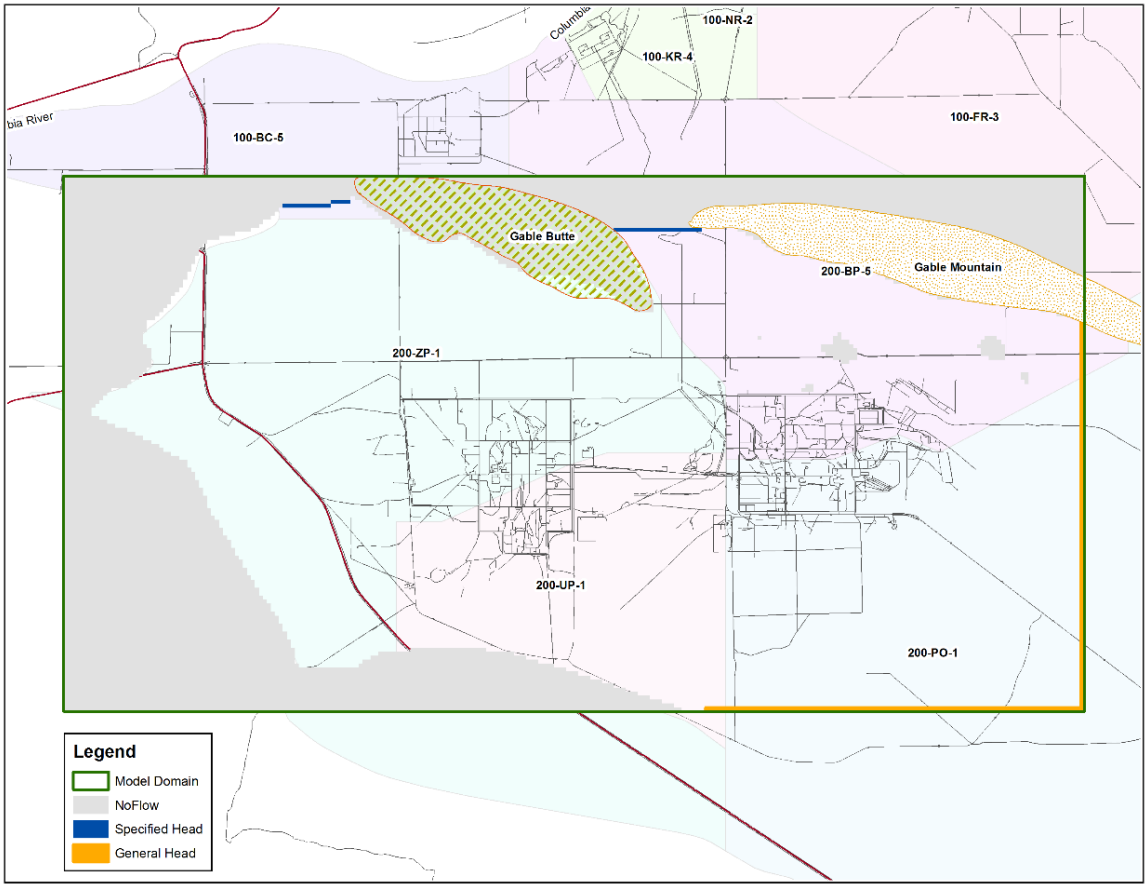

Figure 3.2. Groundwater Model Domain and Model Boundary Conditions

The CPGWM (v3.3) simulates groundwater flow using the U.S. Geological Survey (USGS) three-dimensional groundwater flow model, MODFLOW, which is discussed in the following documents:

- A Modular Three-Dimensional Finite-Difference Ground Water Flow Model (McDonald and Harbaugh, 1988)
- User's Documentation for MODFLOW 96, An Update to the U.S. Geological Survey Modular Finite-Difference Ground Water Flow Model (Harbaugh and McDonald, 1996)
- MODFLOW 2000, The U.S. Geological Survey Modular Ground Water Model – User's Guide to Modularization Concepts and the Ground Water Flow Process (Harbaugh et al., 2000)
- MODFLOW-2005, The U.S. Geological Survey Modular Ground Water Model – the Ground Water Flow Process (Harbaugh, 2005)

During calendar year 2015, the CPGWM was used in support of the report "Calendar Year 2014 Annual Summary Report for the 200-ZP-1 And 200-UP-1 Operable Unit Pump and Treat Operations" (DOE/RL-2015-06, Rev. 0). As part of the analyses completed in support of DOE/RL-2015-06, predictions of groundwater levels are generated by the CPGWM throughout the Central Plateau. As such, simulated groundwater level maps already exist for use in particle tracking calculations described in this ECF. The approximate groundwater levels simulated for the month February 2014 were used as the basis for subsequent particle tracking in this ECF.

3.3 Particle Tracking

In each case - i.e., to evaluate groundwater flow directions using the mapped water levels (after SGW-58828 Rev. 0) and the modeled water levels (after DOE/RL-2015-06) – sixteen (16) particles were released from locations approximately evenly distributed along the 216-A-26 ditch and tracked forward (i.e., in a downgradient direction) and backward (i.e., in an upgradient direction). For the case of the mapped water levels, there is no vertical aspect to the release location, since the surface is only 2D. When using the groundwater model – which is three-dimensional - particles were tracked upon the water table surface (i.e., upper-most "wet" layer at each row-column location) that was exported from MODFLOW. In each case, this approach most closely mimics the location where any release from a trench or ditch would occur – i.e., at the water table. For the limited purposes of this ECF – to provide a visual depiction of flow directions near 216-A-29 using typical groundwater flow directions – particle releases over time are not required, and the result is independent of the particle release time.

Particle tracking was accomplished using the KT3D-H2O software detailed in Section 5. The particle tracking program "Transient Tracker" that is included in the KT3D_H2O software is implemented using the fourth-order Runge-Kutta (RK4: Press et al. 1992) numerical integration (particle tracking) scheme, calculated upon hydraulic head surfaces that have been generated using any number of methods including analytical solutions, interpolation of observed values or a numerical simulation such as MODFLOW (McDonald and Harbaugh 1988). This particle tracking approach can be used to indicate the (relative) timing of the arrival of contaminants at potential receptors and/or points of calculation. This particle tracking approach is based upon that implemented in the MODFLOW-compatible particle tracking code Path3D (Zheng 1992), which has been demonstrated to provide very similar results to the USGS particle tracking program MODPATH (Pollock 1994).

4 Assumptions and Inputs

This section outlines the assumptions and the inputs that underlie the calculations. First described are the assumptions.

4.1 Assumptions

The CPGWM is a calibrated and flow-conserved numerical simulator of groundwater in the Central Plateau. Since previous efforts were completed to calibrate the flow model parameters, the flow model outputs (i.e., heads) in general correspond with measured water levels throughout the area. However, the accuracy of the simulated groundwater elevations (and of inferences from those elevations) are influenced by the structural accuracy of the CPGWM (i.e., how well the model represents actual physical conditions); the accuracy of the water level data used for calibration; the magnitude and distribution of validation-calibration residuals; and other factors. These and other potential sources of error in the simulated groundwater contours. As such, the simulated water level maps are interpreted as reasonable approximations that provide value when interpreting the likely directions and rates of groundwater movement.

Similarly, the groundwater elevation map prepared using interpolation of measured water levels with the Surfer™ software is considered a reasonable approximation of actual conditions. However, the accuracy of the interpolated groundwater elevations (and of inferences from those elevations) is affected by the interpolation algorithm used; the parameters selected for that algorithm; and the accuracy of the

underlying measured water level data. As such, the interpolated water level maps are interpreted as reasonable approximations that provide value when interpreting the likely directions and rates of groundwater movement.

4.2 Input Data

This section summarizes inputs that are specific to the calculations presented herein. Inputs to the CPGWM were unchanged from those used for the CY2014 pump and treat report as presented in DOE/RL-2015-06, Rev. 0: therefore, they are not detailed further herein.

The primary input to the groundwater level mapping conducted using Surfer™ is the measured groundwater elevation throughout a network of monitoring wells. This is documented in SGW-58828, (2015, Rev. 0) and re-tabulated below:

Table 4.1. Monitoring water level data used to construct 2013 water level map

Well Name	Easting (m)	Northing (m)	Hydraulic Head (m)	Residual greater than 2cm
299-E17-18	575112.433	135123.586	121.766	NO
299-E17-22	574841.09	135195.537	121.787	NO
299-E17-23	574694.483	134842.439	121.782	NO
299-E17-25	574515.185	134845.567	121.783	NO
299-E23-1	574043.396	136016.551	121.79	NO
299-E24-16	575017.622	135464.364	121.802	NO
299-E24-18	574647.088	135469.764	121.779	NO
299-E24-21	574635.761	135698.2	121.78	NO
299-E24-22	575262.68	136142.82	121.787	NO
299-E24-24	574179.77	135459.3	121.792	NO
299-E24-25	574598.56	136287.23	121.766	YES
299-E24-33	575325.4	136251.45	121.787	NO
299-E25-19	575852.333	135659.027	121.771	NO
299-E25-24	576193.873	135520.843	121.786	NO
299-E25-34	576019.038	136100.011	121.785	NO
299-E25-35	575708.338	135864.687	121.782	NO
299-E25-36	575403.611	135566.372	121.776	NO
299-E25-93	575471.51	136022.09	121.784	NO
299-E26-13	576199.3	136528.6	121.792	NO
299-E26-4	575733.962	136360.882	121.792	NO

Well Name	Easting (m)	Northing (m)	Hydraulic Head (m)	Residual greater than 2cm
299-E27-12	575054.135	136583.533	121.793	NO
299-E27-14	575217.341	136498.244	121.79	NO
299-E27-15	575095.256	136630.359	121.79	NO
299-E27-17	574547.31	137122.01	121.792	NO
299-E27-18	574299.61	137119.29	121.805	NO
299-E27-21	575145.03	136407.21	121.78	NO
299-E27-22	575185.1	136685.33	121.817	YES
299-E27-23	575069.46	136452.23	121.79	NO
299-E27-4	575032.02	136497.92	121.813	YES
299-E27-7	575220.59	136619.403	121.785	NO
299-E27-8	574759.08	137044.178	121.798	NO
299-E27-9	574917.649	137040.904	121.798	NO
299-E28-1	573933.394	136732.604	121.799	NO
299-E28-17	573461.2	136331.686	121.777	YES
299-E28-18	573104.076	136767.778	121.816	NO
299-E28-27	573226.784	137070.063	121.809	NO
299-E32-5	572599.697	137285.125	121.816	NO
299-E32-6	572600.4	137515.1	121.817	NO
299-E32-8	572663.39	137741.47	121.826	NO
299-E33-14	573985.612	137567.216	121.803	NO
299-E33-28	573226.365	137375.019	121.806	NO
299-E33-339	573716.86	137221.51	121.805	NO
299-E33-34	573104.458	137740.427	121.813	NO
299-E33-37	574091.477	137185.421	121.807	NO
299-E33-38	573591.158	137594.489	121.812	NO
299-E34-10	574284.4	137224.57	121.807	NO
299-E34-9	574186.02	137429.82	121.804	NO
699-37-47A	575556.97	134893.26	121.768	NO
699-49-55A	573146.301	138351.781	121.839	NO
699-49-57A	572544.276	138389.24	121.83	NO

Well Name	Easting (m)	Northing (m)	Hydraulic Head (m)	Residual greater than 2cm
699-50-56	572748.21	138841.55	121.878	NO

Note that if time-of-travel calculations were required, values for the hydraulic conductivity and mobile porosity can be provided for particle tracking using Transient Tracker within KT3D-H2O: however, for the limited purposes of this ECF, calculations are independent of values provided to KT3D-H2O and as a result they are not provided.

5 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.

5.1 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. 3, MODFLOW and Related Codes Software Management Plan.
- CHPRC-00259 Rev. 3, MODFLOW and Related Codes Software Test Plan.
- CHPRC-00260 Rev. 6, MODFLOW and Related Codes Acceptance Test Report.
- CHPRC-00261 Rev. 6, MODFLOW and Related Codes Requirements Traceability Matrix.
- CHPRC-00261 Rev. 8, MODFLOW and Related Codes Acceptance Test Report.

CHPRC-00258 Rev. 3 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.

5.2 Descriptions

5.2.1 MODFLOW (Controlled Calculation Software)

- Software Title: MODFLOW-2000 (Open File Report 00-92, MODFLOW-2000, the US. Geological Survey Modular Ground water model -- User Guide to Modularization Concepts and the Ground-Water Flow); solves transient groundwater flow equations using the finite-difference discretization technique.

- Software Version: Version 1.19.01 modified by S.S. Papadopulos and Associates, Inc. (SSP&A) to address dry cell issues and to use the Orthomin solver; approved as CH2M HILL Plateau Remediation Company (CHPRC) Build 7 using a version of the executable “mf2k-mst-chprc07dpv.exe” compiled to default double precision for real variables and optimized for speed.

- Hanford Information Systems Inventory (HISI) Identification Number: 2517 (Safety Software, graded Level C).

- Workstation type and property number (from which software is run):
  - S.S. Papadopulos and Assoc, Inc, FE449.

5.3 Support Software

The following programs are classified as Support Software.

5.3.1 MODFLOW Suite Support Software

- Groundwater Vistas™[2] : (Guide to Using Groundwater Vistas [Rumbaugh and Rumbaugh, 2007].) Provided graphical tools used for model quality assurance and model input/output review.
- ArcGIS™[3] : (The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships [Mitchell, 1999].) Provided visualization tool for assessing simulated plume distributions, identifying extraction/injection well coordinates and mapping auxiliary data.

5.3.2 KT3D_H2O

KT3D_H20 was used to perform particle tracking to compute particle traces using both the interpolated and simulated groundwater levels. This software's use at Hanford is managed under an integrated software management plan, CHPRC-02839, KT3D_H20 and MEUK Integrated Software Management Plan.

- Software Title: KT3D_H20 (User's Guide to KT3D-H2O, Version 2 [SSP&A, 2011])
- Software Version: CHPRC Build 2 (Version 3.5.1)
- HISI Identification Number: 2517 (Safety Software, graded Level C)
- Workstation type and property number (from which software is run):
  - S.S. Papadopulos and Assoc, Inc, FE449.

5.3.3 Surfer

- Surfer™ was used to generate the groundwater level grids from the measured water levels.

5.4 Software Installation and Checkout

Safety Software is checked out in accordance with procedures specified in CHPRC-00258. Executables are obtained from the CHPRC software owner who maintains the configuration managed copies in MKS Integrity, installation tests identified in CHPRC 00259 performed and successful installation confirmed, and Software Installation and Checkout Forms are required and must be approved for installations used to perform model runs. Approved Users are registered in HISI for safety software

5.4.1 Statement of Valid Software Application

- The software identified above was used consistent with intended use for CHPRC as identified in CHPRC-00257 and is a valid use of this software for the problem addressed in this application.

2 Groundwater Vistas is a trademark of Environmental Simulations Incorporated, Reinholds, PA.

3 ArcGIS is a trademark of ESRI, Redlands, CA.

- The software was used within its limitations as identified in CHPRC-00257.

6 Calculations

Details on the calculations performed in support of this document are provided below.

6.1 Groundwater Flow Modeling

The water table simulated by the CPGWM representing conditions in February 2015 was extracted from the existing simulation results (after DOE/RL-2015-06, Rev. 0) in a text (ASCII) grid format suitable for import into the KT3D-H2O software.

6.2 Water Level Mapping

The water table interpolated in Surfer™ representing typical conditions from May-December 2013 was exported from Surfer™ in a text (ASCII) grid format suitable for import into the KT3D-H2O software.

6.3 Particle Tracking

In each case - i.e., to evaluate groundwater flow directions using the mapped water levels (after SGW-58828 Rev. 0) and the modeled water levels (after DOE/RL-2015-06) – the corresponding ASCII grid was imported into KT3D-H2O; particles were released from the sixteen (16) pre-assigned starting locations and tracked forward (i.e., downgradient) and backward (i.e., upgradient) for sufficient time to prepare figures that depict the general patterns of groundwater flow in the vicinity of 216-A-29.

7 Results

Figure 7-1 depicts particle traces as calculated using KT3D-H2O upon the simulated water table for February 2014 obtained from the CPGWM by extracting heads from the highest active layer in each row-column locations. The pathlines converge and diverge in certain areas upgradient and downgradient of the ditch due, in part, to contrasts in hydraulic conductivity in those areas that are explicitly simulated within the CP Model.

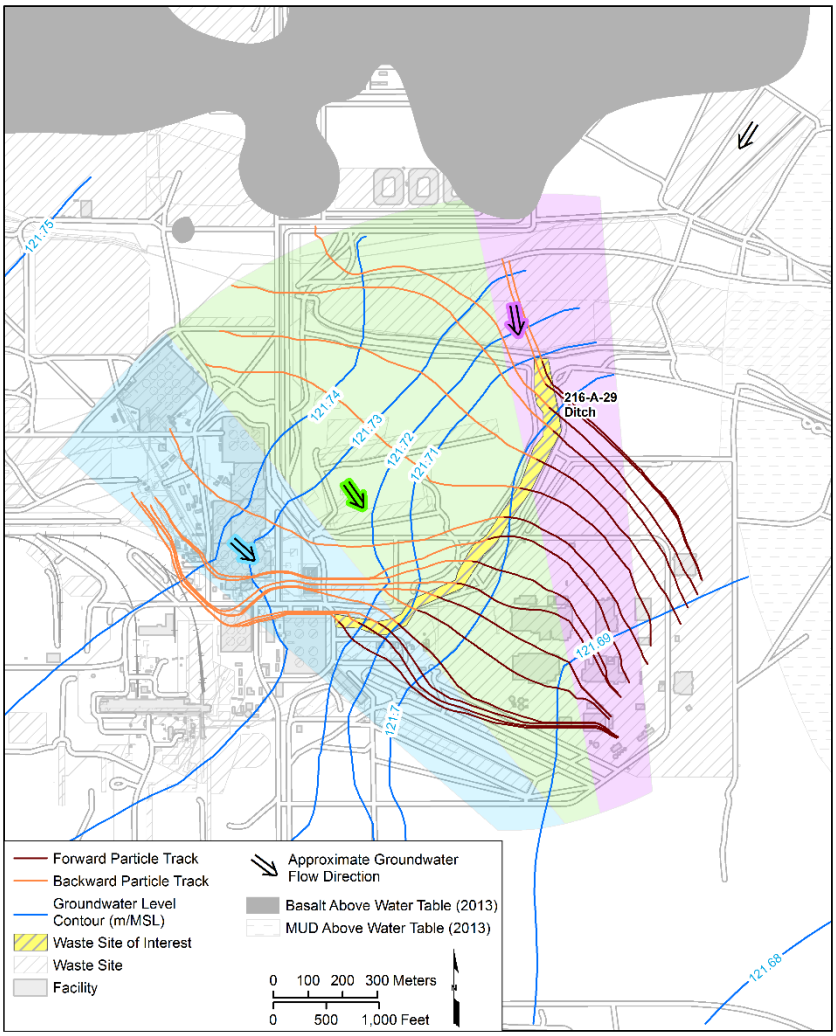

Figure 7.1. Particle Traces Generated using Simulated Water Levels

Figure 7-2 depicts particle traces as calculated using KT3D-H2O upon the mapped water table for obtained by interpolating measured groundwater level data. The pathlines converge downgradient of the ditch due, in part, to contrasts in hydraulic conductivity that are reflected in the measured groundwater elevations and the resulting hydraulic gradients.

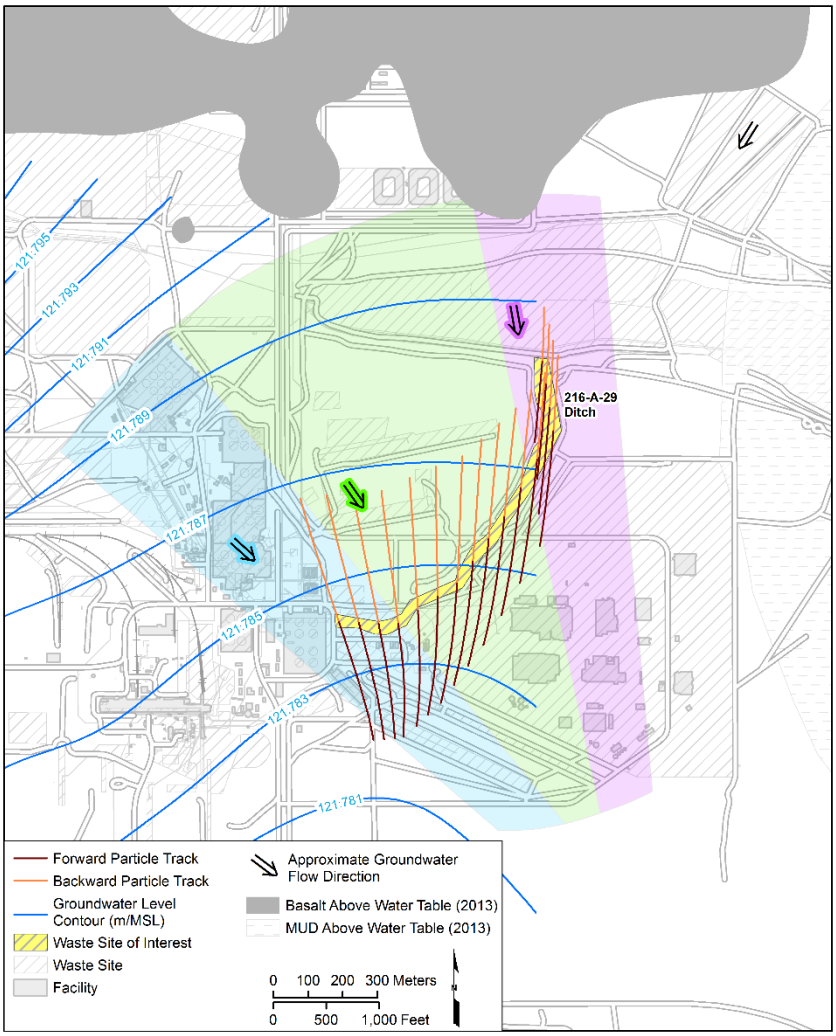

Figure 7.2. Particle Traces Generated using Interpolated Water Levels

Figures 7-1 and 7-2 also depict, for general reference purposes, the colored geochemical "zones" and general groundwater flow directions that were inferred independently from the geochemical analysis described in DOE/RL-2008-58 (2015, Draft Rev. 1). Both depictions, presented in Figure 7.1 and Figure 7.2, suggest that groundwater generally flows from north, northwest and/or west of the trench, across the trench, in a south, southeast and/or east direction. This general pattern is broadly consistent with the pattern inferred independently from analysis of water quality data as presented in Figure 2.2 and detailed in DOE/RL-2008-58 (2015, Draft Rev. 1).

8 References

CHPRC-00257, 2010, *MODFLOW and Related Codes Functional Requirements Document*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00258, 2015, *MODFLOW and Related Codes Software Management Plan*, Rev. 3, WE Nichols, CH2M Hill Plateau Remediation Company, Richland, Washington.

CHPRC-00259, 2014, *MODFLOW and Related Codes Software Test Plan*, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00260, 2015, *MODFLOW and Related Codes Acceptance Test Report*, Rev. 6, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00261, 2015, *MODFLOW and Related Codes Acceptance Test Repor*t, Rev. 6, CH2M HILL Plateau Remediation Company, Richland, Washington.

CHPRC-00261, 2015, *MODFLOW and Related Codes Acceptance Test Report*, Rev. 8, CH2M HILL Plateau Remediation Company, Richland, Washington

CHPRC-02839, 2016, *KT3D_H2O and MEUK Integrated Software Management Plan: KT3D_H2O Version 3.5.1 and MEUK Version 0.2.2*, Rev. 0, WE Nichols and MJ Tonkin, CH2M Hill Plateau Remediation Company, Richland, Washington

CP-47631, 2011, *Model Package Report: Central Plateau Groundwater Model Version 3.3*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075973H.

DOE/RL-2008-58, 2015, *Interim Status Groundwater Monitoring Plan for the 216-A-29 Ditch*, Draft Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079138.

DOE/RL-2015-06, 2015, *Calendar Year 2014 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080209H.

Harbaugh, A.W. and McDonald, M.G., 1996, *MODFLOW-2000, User's Documentation for MODFLOW-96, an update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model*, U.S. Geological Survey Open-File Report 96-485.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model - User guide to modularization concepts and the ground-water flow process:* U.S. Geological Survey Open-File Report 00-92, 121 p.

Harbaugh, A.W, 2005, *MODFLOW-2005, The U.S. Geological Survey Modular Ground-Water Model—the Ground-Water Flow Process*, U.S. Geological Survey Techniques and Methods 6–A16

McDonald, M.G, and Harbaugh, A.W, 1988, *A Modular Three-Dimensional Finite-Difference Ground Water Flow Model*, USGS Open File Report 83-875.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model - User guide to modularization concepts and the ground-water flow process*: U.S. Geological Survey Open-File Report 00-92, 121 p.

Pollock, D. W., 1994, *User's guide for MODPATH/MODPATH-PLOT*, Version 3: A particle tracking post-processing package for MODFLOW, the U. S. Geological Survey finite difference ground-water flow model, Open File Report 94-464,U.S.G.S.

PRC-PRO-IRM-309, "Controlled Software Management," CH2M HILL Plateau Remediation Company, Richland, Washington.

Press, W., B. Flannery, S. Teukolsky, and W. Vetterling, 1992, *Numerical Recipes in Fortran 77: The Art of Scientific Computing*, 2 ed., 992 pp., Cambridge University Press, Cambridge.

Rumbaugh J. and Rumbaugh D, 2011, *Guide to Using Groundwater Vistas*, Version 6.

SGW-42305, 2009, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1001210169.

S.S. Papadopulos & Associates, Inc. (SSP&A), 2011, User's Guide to KT3D-H2O Version 2.

SGW-58828, 2015, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*, Rev. 0. CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0079727H.

Zheng, C., 1992, *PATH3D: A Groundwater Path and Travel-Time Simulator*, S.S. Papadopulos and Associates Inc., 3 ed.

This page intentionally left blank.

Appendix A. Software Installation and Checkout Forms

This page intentionallly left blank.

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:

Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:

Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: KT3D_H20 & MEUK Package Software Version No.: Bld 2

EXECUTABLE INFORMATION:

2. Executable Name (include path):

3. Executable Size (bytes): 3,097,600; 2,304,512; 23,040

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):

   Compiled by SSPA

5. Operating System (include version number):

   Window

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

   FE449

7. Operating System (include version number):

   Windows 10

8. Open Problem Report? ◉ No ◯ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

10. Procedure(s):

    per CHPRC-02839 Rev 0 (KT3D H20 and MEUK Integrated Software Management Plan), Section 14

11. Libraries:

    N/A

12. Input Files:

    KT3D_H20: LineSink, PointSink, RealTest
    MEUK: LineSinkRun.R, PointSinkRun.R, RealWorldRun.R, MultiEvent.R

13. Output Files:

    Generated by codes

14. Test Cases:

    KT3D H20-1, -2, -3; MEUK-1, -2, -3, -4

15. Test Case Results:

    Match expected results as presented in CHPRC-02839

16. Test Performed By: Marinko Karanovic

17. Test Results: ◉ Satisfactory, Accepted for Use ◯ Unsatisfactory

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: KT3D_H2O & MEUK Package Software Version No.: Bld 2

18. Disposition (include HISI update):

Accepted; installation added to authorized user list

Prepared By: William E. Nichols

Digitally signed by William E. Nichols
DN: cn=William E. Nichols, o=CHPRC, ou=Risk & Modeling Integration, email=william_e_nichols@rl.gov, c=US
Date: 2016.05.19 07:12:09 -07'00'

19.		
Software Owner (Signature)	Print	Date
	WE Nichols	

20. Test Personnel:

Sign	Print	Date
	Marinko Karanovic	05/08/2016
Sign	Print	Date
Sign	Print	Date

Approved By:

21.		
Software SME (Signature)	Print	Date
	N/R per SMP	