ECF-100BC5-16-0058
Revision 0

Calculation and Depiction of Groundwater Contamination for the Period 2010-2014 in 100-BC-5

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;
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1. Purpose

The purpose of this environmental calculation brief is to present updated calculations and depictions of groundwater contamination in 100-BC-5 for the period 2010-2014, prepared for the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)) *Remedial Investigation/Feasibility Study for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units* (DOE/RL-2010-96), undertaken for the 100-BC-5 portion of the Hanford Site that will support final remedy selection and provide the basis for a final Record of Decision (ROD) for 100-BC-5.

2. Background

Updated maps of the extent of contamination in 100-BC-5 for hexavalent chromium [Cr(VI)], strontium-90 and tritium were developed for selected years within the period 2010-2014, to reflect the revised conceptual model of plume migration in the shallow aquifer, as developed based on the findings and analyses presented DOE/RL-2010-96.

Updated plume maps were developed for:

- Cr(VI) in 2010-2011, 2012, 2013 and 2014;
- Strontium-90 in 2010-2011 and 2012;
- Tritium in 2010-2011 and 2012.

3. Methodology

Maps of the extent of contamination, referred to as contaminant plume maps, were developed by interpolating point sample data obtained from wells, and aquifer tubes to a grid using Ordinary Kriging (OK) in two dimensions (2-D). A systematic approach to develop contaminant plume maps using an integrated numerical interpolation methodology was first applied for the *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, Rev. 0). The methodology was applied again for the *Hanford Site Groundwater Monitoring for 2012* (DOE/RL-2013-22, Rev. 0); for the *Hanford Site Groundwater Monitoring for 2013* (DOE/RL-2014-32, Rev. 0); for the *Hanford Site Groundwater Monitoring for 2014* (DOE/RL-2015-07, Rev. 0); and for the *Hanford Site Groundwater Monitoring for 2015* (DOE/RL-2016-09, Rev. 0), with additional capabilities and revisions to the interpolation algorithm.

For the period 2010-2011 a single plume depiction was developed for each contaminant of concern (COC) using a composite interpolation dataset which was compiled based on the following steps:

- Mean concentration values were calculated from samples collected during the period from September 2010 to February 2011, to account for the long monitoring period at the end of 2010 and beginning of 2011, and ensure that (a) sampling data from the majority of monitoring wells and aquifer tubes in 100-BC-5 were compiled and (b) datasets representative of contaminant distribution in the aquifer during that period were developed;
- Datasets were supplemented with sampling data from 2009 for monitoring wells and/or aquifer tubes with no sampling data available during the period from September 2010 to February 2011;
- Maximum values of characterization data during drilling in the upper part of the aquifer were calculated for wells that are screened in the deeper part of the aquifer;
- Interpolation was performed, with kriging parameters used in the mapping of the calendar year (CY) 2015 for the corresponding COC in 100-BC-5. A detailed discussion of the plume mapping procedure for CY2015 is provided in the *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2015 (CY2015) Hanford Site Groundwater Monitoring Report* (ECF-Hanford-16-0061, Rev.0).

For the period 2012-2014, interpolation datasets were developed based on:

- Data selection and mapping procedures for the following annual reports, as documented in the corresponding environmental calculation briefs (ECFs):
    - *Hanford Site Groundwater Monitoring for 2012* (DOE/RL-2013-22, Rev. 0);
    - *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2012 (CY2012) Hanford Site Groundwater Monitoring Report* (ECF-Hanford-13-0012, Rev.0);
    - *Hanford Site Groundwater Monitoring for 2013* (DOE/RL-2014-32, Rev. 0);
    - *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2013 (CY2013) Hanford Site Groundwater Monitoring Report* (ECF-Hanford-14-0034, Rev.0);
    - *Hanford Site Groundwater Monitoring for 2014* (DOE/RL-2015-07, Rev. 0);
    - *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2014 (CY2014) Hanford Site Groundwater Monitoring Report* (ECF-Hanford-15-0003, Rev.0);
- Addition and/or removal of selected data points to reflect the revised conceptual model of plume migration in the shallow aquifer.

A general discussion on data types for mapping in 100-BC-5 is provided in Section 3.1. The additional data selection rules applied for developing the updated plume depictions for 2010-2014 are discussed in Section 3.2.

3.1 Data Types

Mapping in 100-BC-5 is based primarily on data collected at each measurement location during the year of interest. Where data are unavailable during the year of interest, the dataset is expanded to include all data collected during the two-year period leading to the year of interest, always selecting the most recent available sample to the year of interest.

In cases where such recent direct measurements were unavailable, additional data points were included to represent known conditions at the site. These points are categorized by type as discussed below.

Type 1: Point values which are based on COC concentration measurements but were not determined based on the data selection rules described in detail in Section 3.2. For example, a historical measurement outside the three-year timeframe may be used where more recent data are not available.

Type 2: Points determined by geologic constraints. For example, a COC concentration value of zero (0.0) is included in areas where basalt outcrop is thought to provide a barrier to COC migration.

Type 3: Points determined based on knowledge of plume sources, previous remediation activities, historical plume configuration, etc., including migrated and interpolated data. No new calculations for migrated data were performed as part of developing the maps in this ECF.

3.2 Additional Data Selection Rules

The composite dataset for 2010-2011 and the datasets previously developed for plume mapping purposes for the Hanford Site Groundwater Monitoring Reports for the period 2012-2014, were edited for developing the updated plume depictions considering the following additional data selection rules:

- Grab sample data collected in 2010 from selected boreholes, not completed as monitoring wells, were added to the strontium-90 and tritium datasets.
- Cr(VI) data from selected monitoring wells were excluded from all data sets because of their screened interval and measured Cr(VI) concentrations not comparable to nearby wells.

4. Assumptions and Inputs

4.1 Assumptions and limitations

Assumptions and limitations of the sample and supporting data that are used to form the inputs to the contaminant plume mapping are summarized below:

- The data set used as input to the mapping procedure is representative of the extent of contamination in the aquifer for the corresponding COC. Other points were incorporated in the form of either (a) previous sampling results or (b) values that are considered as representative given the scale of the contaminant plume(s).

Assumptions and limitations of the contaminant plume interpolation approaches that are used to prepare the plume maps are summarized below:

- With regard to the depicted lateral extents of contamination, the distribution of contaminants in groundwater is reasonably well represented by the qualified data used as inputs.
- In the absence of replicates (i.e., multiple values at one location) or small-scale variance - such as measurement errors - represented using a nugget, ordinary kriging honors the sample data values at the sampled locations. However:
    - When interpolating to a grid for mapping purposes, this is not guaranteed.
    - Because the interpolation data set can include data over a period of up to three years the resulting map does not necessarily represent an actual “instantaneous” condition within the aquifer, but rather provides a representative composite depiction.
- Studies by other investigators (e.g., Reed et al. 2004) suggest that use of ordinary kriging together with data transformations - such as quantile kriging - produces robust interpolation results, which mitigate bias due to highly skewed data and/or variations in the spacing of measured data (i.e., data support). However, each of the logarithmic, uniform-score and indicator transforms generally lead to median-unbiased estimators that may, depending on the true distribution of the data, under-estimate the contaminant mass.
- Interpolation for different COC within the same OU may be conducted using different variogram parameters. As mentioned earlier, no experimental variograms were developed during that process. Instead, variogram models were developed in collaboration with the project scientists to ensure that plume depictions comport with the conceptual model of historical plume migration. The interpolation procedure guarantees that development of plume depictions is traceable and repeatable, provided that input data and parameters remain unchanged.

4.2 Inputs

The updated interpolation datasets were developed based on the methodology described in Section 3. Input files for kriging interpolation are tabulated in Section 6 for each COC and period of interest.

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

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

5.1 QUANTILE

The QUANTILE program (*User's Guide for Interpolation using QUANTILE, Version 1.2* [SSP&A, 2014]) was used to perform the spatial interpolation of sampled contaminant concentration data that is detailed in this calculation. QUANTILE is a FORTRAN program based upon the United States Geological Survey (USGS) kriging routines of Skrivan and Karlinger (1980). QUANTILE incorporates routines to conduct the logarithmic, quantile and categorical data transforms, undertake OK of the transformed values, and complete the necessary back-transformations. Quantile also supports Simple Kriging (SK) of untransformed data values. QUANTILE is a program for spatial interpolation in two dimensions programmed in Fortran 90/95 using a modular program structure. It has been developed to be independent of any specific model platform, requiring simple ASCII input files and producing ASCII output files.

QUANTILE is identified in CHPRC-02087, *QUANTILE Software Management Plan*, as level D developed software, with the assigned Hanford Information Systems Inventory (HISI) Identification Number: 3500. Acceptance tests for this software are provided in CHPRC-02088, *QUANTILE Acceptance Test Report*.

The workstation type and property number from which software is run is S.S. Papadopulos and Assoc, Inc, FE407.

5.2 Statement of Valid Software Application

QUANTILE was used in a manner consistent with their intended use and are valid uses of these software for the problems addressed in this calculation.

6. Calculation

Calculations were performed following the procedures described in Section 3. Interpolation datasets for each COC and period of interest were developed implementing the procedure described in Section 3 and, in particular, the following additional data selection rules:

- Grab sample data collected in 2010 from boreholes C7842, C7844, C7845, C7849 and C8239, which were not completed as monitoring wells, were added to the strontium-90 and tritium datasets.
- Cr(VI) data from monitoring well 199-B4-4 were excluded from all data sets as this well has a longer screened interval and measured Cr(VI) concentrations are not comparable to nearby wells.
- Cr(VI) data from monitoring well 199-B2-16 were excluded as the well is screened in the lower unconfined aquifer.

Tables 6-1 through 6-8 list the interpolation datasets used for developing each plume depiction.

Table 6-1. Interpolation Dataset for Cr(VI) in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
01-M	562697.66	146033.08	2	2009	AQUIFER TUBE	R
03-D	564077.43	145469.25	2.666667	2009	AQUIFER TUBE	R
04-D	564612.18	145283.28	8.3	2009	AQUIFER TUBE	R
05-S	564908.31	145332.29	31.66667	2009	AQUIFER TUBE	R
06-M	565293.93	145412.05	46.1375	2009	AQUIFER TUBE	R
199-B2-13	564086.52	145264.56	7.125	2010	GROUNDWATER WELL	R
199-B2-14	565095.99	145232.26	27.08571	2011	GROUNDWATER WELL	R
199-B3-1	565561.46	145342.08	23.86667	2011	GROUNDWATER WELL	R
199-B3-46	565899.57	145369.04	14.97143	2011	GROUNDWATER WELL	R
199-B3-47	565388.66	145368.95	51.98333	2011	GROUNDWATER WELL	R
199-B3-50	566028.90	145058.21	14.575	2010	GROUNDWATER WELL	R
199-B3-52	565391.00	145115.03	32.8	2011	GROUNDWATER WELL	C
199-B4-1	565289.81	144791.53	37.3	2011	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	19.1	2010	GROUNDWATER WELL	C
199-B4-15	565439.68	144551.98	23.2	2011	GROUNDWATER WELL	C
199-B4-7	565398.86	144382.85	21.43333	2011	GROUNDWATER WELL	R
199-B4-8	565578.45	144653.79	20.925	2010	GROUNDWATER WELL	R
199-B5-1	564878.15	144764.90	25.2	2011	GROUNDWATER WELL	R
199-B5-2	565405.43	144939.70	26.36667	2011	GROUNDWATER WELL	R
199-B5-5	564721.99	144955.49	24	2009	GROUNDWATER WELL	C
199-B5-8	566014.00	143587.69	5.43	2011	GROUNDWATER WELL	C
199-B8-6	564498.83	144157.79	6.91	2011	GROUNDWATER WELL	R
199-B8-7	564760.86	144045.17	11.2	2010	GROUNDWATER WELL	R
199-B8-8	565006.14	144001.01	13.3	2010	GROUNDWATER WELL	R
199-B8-9	565276.43	144054.45	12.93333	2011	GROUNDWATER WELL	R
199-B9-2	565534.79	144078.08	11.85	2010	GROUNDWATER WELL	R
199-B9-3	565667.36	144046.72	13.87	2011	GROUNDWATER WELL	R
699-65-83	564590.47	143249.09	9.41	2010	GROUNDWATER WELL	R
699-67-86	563661.65	143873.05	6.075	2010	GROUNDWATER WELL	R
699-71-77	566401.95	145098.61	9.486	2011	GROUNDWATER WELL	R
AT-B-1-M	564308.89	145379.94	2	2011	AQUIFER TUBE	R

Table 6-1. Interpolation Dataset for Cr(VI) in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
AT-B-2-D	564513.95	145329.14	5.566667	2009	AQUIFER TUBE	R
AT-B-3-D	565130.48	145397.27	21.72	2009	AQUIFER TUBE	R
AT-B-5-D	566438.06	145746.81	5.85	2009	AQUIFER TUBE	R
AT-B-7-M	566143.32	145680.05	8.26	2009	AQUIFER TUBE	R
C6227	564749.63	145303.59	8.033333	2009	AQUIFER TUBE	R
C6231	565426.02	145460.44	37.1	2009	AQUIFER TUBE	R
C6235	565563.42	145495.24	17.83333	2009	AQUIFER TUBE	R
C7719	564994.21	145388.39	23.95	2010	AQUIFER TUBE	R
C7725	565187.51	145406.64	34.8	2010	AQUIFER TUBE	R
C7782	565752.63	145558.52	11.36667	2010	AQUIFER TUBE	R

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

Table 6-2. Interpolation Dataset for Cr(VI) in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
03-D	564077.44	145469.25	0	2012	AQUIFER TUBE	R
04-D	564612.19	145283.28	6.1	2012	AQUIFER TUBE	R
05-M	564908.31	145332.30	23.1	2012	AQUIFER TUBE	R
06-M	565293.94	145412.05	44	2012	AQUIFER TUBE	R
199-B2-13	564086.50	145264.56	9	2012	GROUNDWATER WELL	R
199-B2-14	565096.00	145232.27	30.5	2012	GROUNDWATER WELL	R
199-B3-1	565561.44	145342.08	28.65	2012	GROUNDWATER WELL	R
199-B3-46	565899.56	145369.05	15.4	2012	GROUNDWATER WELL	R
199-B3-47	565388.69	145368.95	50.625	2012	GROUNDWATER WELL	R
199-B3-50	566028.88	145058.20	13.9	2012	GROUNDWATER WELL	R
199-B4-1	565289.81	144791.53	39.2	2012	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	68.83636364	2012	GROUNDWATER WELL	R
199-B4-7	565398.88	144382.84	49	2012	GROUNDWATER WELL	R
199-B4-8	565578.44	144653.80	33.3	2012	GROUNDWATER WELL	R
199-B5-1	564878.13	144764.91	7.133333333	2012	GROUNDWATER WELL	R
199-B5-2	565405.44	144939.69	31.5	2012	GROUNDWATER WELL	R
199-B5-8	566014.00	143587.69	10.98	2012	GROUNDWATER WELL	R
199-B8-6	564498.81	144157.80	2.8	2012	GROUNDWATER WELL	R
199-B8-7	564760.88	144045.17	50		Type 3	
199-B8-8	565006.13	144001.02	50		Type 3	
199-B8-9	565276.44	144054.45	41.575	2012	GROUNDWATER WELL	R
199-B9-2	565534.81	144078.08	11.7	2012	GROUNDWATER WELL	R
199-B9-3	565667.38	144046.72	9.75	2011	GROUNDWATER WELL	R
699-65-83	564590.44	143249.09	8.345	2012	GROUNDWATER WELL	R
699-67-86	563661.63	143873.05	4.468333333	2010	GROUNDWATER WELL	R
699-71-77	566401.94	145098.61	0	2011	GROUNDWATER WELL	R
AT-B-1-M	564308.88	145379.94	5.1	2012	AQUIFER TUBE	R
AT-B-2-D	564513.94	145329.14	5.8	2012	AQUIFER TUBE	R
AT-B-3-D	565130.50	145397.27	26	2012	AQUIFER TUBE	R
AT-B-5-D	566438.06	145746.81	7.9	2012	AQUIFER TUBE	R
AT-B-7-M	566143.31	145680.05	9.8	2012	AQUIFER TUBE	R

Table 6-2. Interpolation Dataset for Cr(VI) in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
C6227	564779.13	145298.41	14.1	2012	AQUIFER TUBE	R
C6230	565430.13	145453.80	39.1	2012	AQUIFER TUBE	R
C7719	564994.19	145388.39	24.6	2012	AQUIFER TUBE	R
C7726	565188.88	145406.81	27.6	2012	AQUIFER TUBE	R
C7782	565752.63	145558.53	16.9	2012	AQUIFER TUBE	R
CP41	563781.00	142732.00	0		Type 2	
CP42	565715.00	142355.00	0		Type 2	

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

Table 6-3. Interpolation Dataset for Cr(VI) in 2013

Name	Easting	Northing	Value	Period	Location Type	Collection Purpose
01-M	562697.66	146033.08	2	_LOW	AQUIFER TUBE	R-X
03-D	564077.43	145469.25	2	_LOW	AQUIFER TUBE	R-X
04-D	564612.18	145283.28	6.25	_LOW	AQUIFER TUBE	R-X
05-M	564908.31	145332.29	24.3	_LOW	AQUIFER TUBE	R-X
06-M	565293.93	145412.05	39.65	_LOW	AQUIFER TUBE	R-X
199-B2-13	564086.52	145264.56	8.716667	_LOW	GROUNDWATER WELL	R-X
199-B2-14	565095.99	145232.26	23.23333	_LOW	GROUNDWATER WELL	R-X
199-B3-1	565561.46	145342.08	31.9	_LOW	GROUNDWATER WELL	R-X
199-B3-46	565899.57	145369.04	20.86667	_LOW	GROUNDWATER WELL	R-X
199-B3-47	565388.66	145368.95	59.45	_LOW	GROUNDWATER WELL	R-X
199-B3-50	566028.90	145058.21	23.53333	_LOW	GROUNDWATER WELL	R-X
199-B4-1	565289.81	144791.53	41.8	_LOW	GROUNDWATER WELL	R-X
199-B4-14	564969.25	144313.98	31.25833	_LOW	GROUNDWATER WELL	R-X
199-B4-16	566132.00	144480.00	9.5	_2013	GROUNDWATER WELL	NA
199-B4-7	565398.86	144382.85	55.74286	_LOW	GROUNDWATER WELL	R-X
199-B4-8	565578.45	144653.79	60.63333	_LOW	GROUNDWATER WELL	R-X
199-B5-1	564878.15	144764.90	6.25	_LOW	GROUNDWATER WELL	R-X
199-B5-11	565188.34	144240.98	36.5	_2013	GROUNDWATER WELL	NA
199-B5-13	564893.41	144764.86	4.7	_2013	GROUNDWATER WELL	NA
199-B5-14	564170.23	144520.06	2.8	_2013	GROUNDWATER WELL	NA
199-B5-2	565405.43	144939.70	43.55714	_LOW	GROUNDWATER WELL	R-X
199-B5-8	566014.00	143587.69	10.85667	_LOW	GROUNDWATER WELL	R-X
199-B5-9	564821.98	144250.05	12.1	_2013	GROUNDWATER WELL	NA
199-B8-6	564498.83	144157.79	3.936667	_LOW	GROUNDWATER WELL	R-X
199-B8-9	565276.43	144054.45	11.98333	_LOW	GROUNDWATER WELL	R-X
199-B9-2	565534.79	144078.08	13.36667	_LOW	GROUNDWATER WELL	R-X
199-B9-3	565667.36	144046.72	13.76667	_LOW	GROUNDWATER WELL	R-X
699-63-90	562367.22	142612.35	5	_LOW	GROUNDWATER WELL	R-X
699-65-83	564590.47	143249.09	8.336667	_LOW	GROUNDWATER WELL	R-X
699-68-105	557803.35	144206.12	5	_2013	GROUNDWATER WELL	R-X
699-71-77	566401.95	145098.61	7.7	_2013	GROUNDWATER WELL	R-X

Table 6-3. Interpolation Dataset for Cr(VI) in 2013

Name	Easting	Northing	Value	Period	Location Type	Collection Purpose
699-72-92	561839.42	145359.75	7.2	_2013	INDEPENDENT PIEZOMETER	R-X
AT-B-1-M	564308.89	145379.94	5.8	_LOW	AQUIFER TUBE	R-X
AT-B-2-D	564513.95	145329.14	5.5	_LOW	AQUIFER TUBE	R-X
AT-B-3-M	565128.63	145397.70	28.7	_LOW	AQUIFER TUBE	R-X
AT-B-5-D	566438.06	145746.81	6.3	_LOW	AQUIFER TUBE	R-X
AT-B-7-M	566143.32	145680.05	10.3	_LOW	AQUIFER TUBE	R-X
C6228	564746.34	145303.78	6.9	_LOW	AQUIFER TUBE	R-X
C6230	565423.77	145459.99	23.05	_LOW	AQUIFER TUBE	R-X
C6234	565560.41	145495.82	22.2	_LOW	AQUIFER TUBE	R-X
C7719	564994.21	145388.39	19.4	_LOW	AQUIFER TUBE	R-X
C7725	565187.51	145406.64	33.9	_LOW	AQUIFER TUBE	R-X
C7781	565750.81	145555.14	19.4	_LOW	AQUIFER TUBE	R-X
C8840	563551.00	145732.00	6.736667	_LOW	AQUIFER TUBE	R-X
C8841	564087.00	145547.00	1.61	_LOW	AQUIFER TUBE	R-X
C8842	564600.70	145341.10	2.183333	_LOW	AQUIFER TUBE	R-X
C8843	564753.80	145307.70	8.460667	_LOW	AQUIFER TUBE	R-X
C8844	564904.00	145380.00	17.88039	_LOW	AQUIFER TUBE	R-X
C8847	565008.60	145402.00	19.78143	_LOW	AQUIFER TUBE	R-X
C8848	565127.00	145425.00	25.73654	_LOW	AQUIFER TUBE	R-X
C8851	565202.20	145415.00	27.744	_LOW	AQUIFER TUBE	R-X
C8853	565295.00	145443.00	13.85	_LOW	AQUIFER TUBE	R-X
C8855	565441.80	145469.00	21.26667	_LOW	AQUIFER TUBE	R-X
C8859	565746.00	145563.00	20.5	_LOW	AQUIFER TUBE	R-X
C8860	565848.20	145598.00	17.3	_LOW	AQUIFER TUBE	R-X
C8861	566151.80	145686.00	17.9	_LOW	AQUIFER TUBE	R-X
CP41	563781.00	142732.00	0		Type 2	
CP42	565715.00	142355.00	0		Type 2	

Notes:
_LOW = Sampling data representing low river stage conditions
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R - X = Routine data collected after well completion
NA = Value represents mean annual concentration from multiple sampling data

Table 6-3. Interpolation Dataset for Cr(VI) in 2013

Name	Easting	Northing	Value	Period	Location Type	Collection Purpose

Table 6-4. Interpolation Dataset for Cr(VI) in 2014

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
01-M	562697.66	146033.08	8	_LOW	AQUIFER TUBE	R-X
03-D	564077.43	145469.25	12	_LOW	AQUIFER TUBE	R-X
04-D	564612.18	145283.28	6.28	_LOW	AQUIFER TUBE	R-X
05-D	564908.31	145332.29	29	_LOW	AQUIFER TUBE	R-X
06-M	565293.93	145412.05	46.25	_LOW	AQUIFER TUBE	R-X
12-D	567231.72	146055.17	10	_LOW	AQUIFER TUBE	R-X
199-B2-13	564086.52	145264.56	11.53333	_LOW	GROUNDWATER WELL	R-X
199-B2-14	565095.99	145232.26	25.85	_LOW	GROUNDWATER WELL	R-X
199-B3-1	565561.46	145342.08	48.6	_LOW	GROUNDWATER WELL	R-X
199-B3-46	565899.57	145369.04	26.1	_LOW	GROUNDWATER WELL	R-X
199-B3-47	565388.66	145368.95	53.43333	_LOW	GROUNDWATER WELL	R-X
199-B3-50	566028.90	145058.21	24.86667	_LOW	GROUNDWATER WELL	R-X
199-B4-1	565289.81	144791.53	40.56667	_LOW	GROUNDWATER WELL	R-X
199-B4-14	564969.25	144313.98	19.3	_LOW	GROUNDWATER WELL	R-X
199-B4-16	566132.00	144480.00	17.06667	_LOW	GROUNDWATER WELL	R-X
199-B4-7	565398.86	144382.85	46.13333	_LOW	GROUNDWATER WELL	R-X
199-B4-8	565578.45	144653.79	46.53333	_LOW	GROUNDWATER WELL	R-X
199-B5-1	564878.15	144764.90	5.3	_LOW	GROUNDWATER WELL	R-X
199-B5-10	564812.00	144250.00	8.95	_LOW	GROUNDWATER WELL	R-X
199-B5-12	565178.94	144240.89	46.33333	_LOW	GROUNDWATER WELL	R-X
199-B5-14	564170.23	144520.06	2.42	_LOW	GROUNDWATER WELL	R-X
199-B5-2	565405.43	144939.70	50.86667	_LOW	GROUNDWATER WELL	R-X
199-B5-8	566014.00	143587.69	12.4	_LOW	GROUNDWATER WELL	R-X
199-B8-6	564498.83	144157.79	4.57	_LOW	GROUNDWATER WELL	R-X
199-B8-9	565276.43	144054.45	10.4	_LOW	GROUNDWATER WELL	R-X
199-B9-2	565534.79	144078.08	13.46667	_LOW	GROUNDWATER WELL	R-X
199-B9-3	565667.36	144046.72	13.8	_LOW	GROUNDWATER WELL	R-X
699-63-90	562367.22	142612.35	5	_2013	GROUNDWATER WELL	R-X

Table 6-3. Interpolation Dataset for Cr(VI) in 2013

Name	Easting	Northing	Value	Period	Location Type	Collection Purpose
699-65-83	564590.47	143249.09	8.395	_LOW	GROUNDWATER WELL	R-X
699-68-105	557803.35	144206.12	1	_LOW	GROUNDWATER WELL	R-X
699-71-77	566401.95	145098.61	10.8	_LOW	GROUNDWATER WELL	R-X
699-72-73	567551.54	145418.78	9.4	_LOW	GROUNDWATER WELL	R-X
699-72-92	561839.42	145359.75	3.52	_LOW	INDEPENDENT PIEZOMETER	R-X
AT-B-1-M	564308.89	145379.94	8	_LOW	AQUIFER TUBE	R-X
AT-B-2-D	564513.95	145329.14	23	_LOW	AQUIFER TUBE	R-X
AT-B-3-M	565128.63	145397.70	33	_LOW	AQUIFER TUBE	R-X
AT-B-5-D	566438.06	145746.81	11	_LOW	AQUIFER TUBE	R-X
AT-B-7-M	566143.32	145680.05	15	_LOW	AQUIFER TUBE	R-X
C6227	564749.63	145303.59	8	_LOW	AQUIFER TUBE	R-X
C6230	565423.77	145459.99	35	_LOW	AQUIFER TUBE	R-X
C6234	565560.41	145495.82	33	_LOW	AQUIFER TUBE	R-X
C7719	564994.21	145388.39	23	_LOW	AQUIFER TUBE	R-X
C7724	565186.27	145406.79	39	_LOW	AQUIFER TUBE	R-X
C7781	565750.81	145555.14	29	_LOW	AQUIFER TUBE	R-X
CP41	563781.00	142732.00	0		Type 2	
CP42	565715.00	142355.00	0		Type 2	

Notes:
_LOW = Sampling data representing low river stage conditions
R - X = Routine data collected after well completion

Table 6-5. Interpolation Dataset for Strontium-90 in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
05-M	564908.31	145332.29	6.5	2009	AQUIFER TUBE	R
06-M	565293.93	145412.05	10.7	2009	AQUIFER TUBE	R
199-B2-13	564086.52	145264.56	1.85	2010	GROUNDWATER WELL	R
199-B2-14	565095.99	145232.26	2.35	2011	GROUNDWATER WELL	R
199-B2-16	564915.00	145190.68	4.35	2010	GROUNDWATER WELL	C
199-B3-1	565561.46	145342.08	30.5	2011	GROUNDWATER WELL	R
199-B3-46	565899.57	145369.04	40.5	2011	GROUNDWATER WELL	R
199-B3-47	565388.66	145368.95	15.5	2011	GROUNDWATER WELL	R
199-B3-50	566028.90	145058.21	1.6	2010	GROUNDWATER WELL	R
199-B3-52	565391.00	145115.03	54.1	2011	GROUNDWATER WELL	C
199-B4-1	565289.81	144791.53	4.4	2011	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	2.4	2010	GROUNDWATER WELL	C
199-B4-15	565439.68	144551.98	8.61	2011	GROUNDWATER WELL	C
199-B4-4	565377.08	144479.71	6.7	2010	GROUNDWATER WELL	R
199-B4-7	565398.86	144382.85	3.2	2011	GROUNDWATER WELL	R
199-B4-8	565578.45	144653.79	1.8	2010	GROUNDWATER WELL	R
199-B5-1	564878.15	144764.90	1.6	2010	GROUNDWATER WELL	R
199-B5-2	565405.43	144939.70	14	2011	GROUNDWATER WELL	R
199-B5-5	564721.99	144955.49	3	2009	GROUNDWATER WELL	C
199-B5-8	566014.00	143587.69	1.8	2011	GROUNDWATER WELL	C
199-B8-6	564498.83	144157.79	1.9	2011	GROUNDWATER WELL	R
199-B8-9	565276.43	144054.45	1.5	2011	GROUNDWATER WELL	R
199-B9-3	565667.36	144046.72	1.8	2010	GROUNDWATER WELL	R
699-65-83	564590.47	143249.09	1.9	2010	GROUNDWATER WELL	R
699-67-86	563661.65	143873.05	1.8	2010	GROUNDWATER WELL	R
699-71-77	566401.95	145098.61	1.7	2010	GROUNDWATER WELL	R
AT-B-3-S	565127.53	145397.21	7.1	2009	AQUIFER TUBE	R
C6228	564746.34	145303.78	5.65	2009	AQUIFER TUBE	R
C6230	565423.77	145459.99	19.5	2009	AQUIFER TUBE	R
C6233	565561.41	145496.48	5.35	2009	AQUIFER TUBE	R
C7720	564995.09	145388.79	2.4	2010	AQUIFER TUBE	R

Table 6-5. Interpolation Dataset for Strontium-90 in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
C7725	565187.51	145406.64	18	2010	AQUIFER TUBE	R
C7782	565752.63	145558.52	5.3	2010	AQUIFER TUBE	R
C7842	565391.93	145327.43	13.3	2010	BORING	C
C7844	565290.19	144761.31	21.6	2010	BORING	C
C7845	565355.92	144638.85	72.9	2010	BORING	C
C7849	565397.34	144026.97	0.745	2010	BORING	C
C8239	565331.70	144527.57	41.4	2010	BORING	C

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

Table 6-6. Interpolation Dataset for Strontium-90 in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
05-M	564908.31	145332.30	7.7	2012	AQUIFER TUBE	R
06-M	565293.94	145412.05	15	2012	AQUIFER TUBE	R
199-B2-13	564086.50	145264.56	0	2012	GROUNDWATER WELL	R
199-B2-14	565096.00	145232.27	6.2	2012	GROUNDWATER WELL	R
199-B3-1	565561.44	145342.08	33	2012	GROUNDWATER WELL	R
199-B3-46	565899.56	145369.05	39	2012	GROUNDWATER WELL	R
199-B3-47	565388.69	145368.95	21.33333	2012	GROUNDWATER WELL	R
199-B3-50	566028.88	145058.20	0	2012	GROUNDWATER WELL	R
199-B4-1	565289.81	144791.53	21	2012	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	0	2011	GROUNDWATER WELL	R
199-B4-4	565377.06	144479.70	15	2012	GROUNDWATER WELL	R
199-B4-7	565398.88	144382.84	3.2	2011	GROUNDWATER WELL	R
199-B4-8	565578.44	144653.80	1.5	2012	GROUNDWATER WELL	R
199-B5-1	564878.13	144764.91	0	2012	GROUNDWATER WELL	R
199-B5-2	565405.44	144939.69	12.5		Type 1	
199-B5-8	566014.00	143587.69	0	2011	GROUNDWATER WELL	R
199-B8-6	564498.81	144157.80	0	2011	GROUNDWATER WELL	R
199-B8-9	565276.44	144054.45	0	2011	GROUNDWATER WELL	R
199-B9-3	565667.38	144046.72	0	2010	GROUNDWATER WELL	R
699-65-83	564590.44	143249.09	0	2010	GROUNDWATER WELL	R
699-67-86	563661.63	143873.05	0	2010	GROUNDWATER WELL	R
699-71-77	566401.94	145098.61	0	2010	GROUNDWATER WELL	R
AT-B-3-S	565127.50	145397.22	8	2012	AQUIFER TUBE	R
AT-B-7-M	566143.31	145680.05	0		Type 1	
C6227	564779.13	145298.41	2	2012	AQUIFER TUBE	R
C6230	565430.13	145453.80	49	2012	AQUIFER TUBE	R
C6233	565566.13	145495.70	0	??	AQUIFER TUBE	NN
C7718	564993.13	145388.06	0	2012	AQUIFER TUBE	R
C7725	565187.50	145406.64	14	2012	AQUIFER TUBE	R
C7782	565752.63	145558.53	5.3	2010	AQUIFER TUBE	NN
C7842	565391.94	145327.44	13.3	2010	BORING	C

Table 6-6. Interpolation Dataset for Strontium-90 in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
C7844	565290.19	144761.31	21.6	2010	BORING	C
C7845	565355.94	144638.84	72.9	2010	BORING	C
C7849	565397.31	144026.97	0	2010	BORING	C
C8239	565331.69	144527.56	41.4	2010	BORING	C

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

Table 6-7. Interpolation Dataset for Tritium in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
01-M	562697.66	146033.08	230	2009	AQUIFER TUBE	R
03-D	564077.43	145469.25	1250	2009	AQUIFER TUBE	R
04-D	564612.18	145283.28	2400	2009	AQUIFER TUBE	R
05-M	564908.31	145332.29	4550	2009	AQUIFER TUBE	R
06-M	565293.93	145412.05	27000	2009	AQUIFER TUBE	R
199-B2-13	564086.52	145264.56	1200	2010	GROUNDWATER WELL	R
199-B2-14	565095.99	145232.26	7800	2011	GROUNDWATER WELL	R
199-B2-16	564915.00	145190.68	4800	2010	GROUNDWATER WELL	C
199-B3-1	565561.46	145342.08	4000	2011	GROUNDWATER WELL	R
199-B3-46	565899.57	145369.04	1650	2011	GROUNDWATER WELL	R
199-B3-47	565388.66	145368.95	29000	2011	GROUNDWATER WELL	R
199-B3-50	566028.90	145058.21	1300	2010	GROUNDWATER WELL	R
199-B3-52	565391.00	145115.03	13400	2011	GROUNDWATER WELL	C
199-B4-1	565289.81	144791.53	24000	2011	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	19000	2010	GROUNDWATER WELL	C
199-B4-15	565439.68	144551.98	13100	2011	GROUNDWATER WELL	C
199-B4-4	565377.08	144479.71	11000	2010	GROUNDWATER WELL	R
199-B4-7	565398.86	144382.85	13000	2011	GROUNDWATER WELL	R
199-B4-8	565578.45	144653.79	10000	2010	GROUNDWATER WELL	R
199-B5-1	564878.15	144764.90	12000	2011	GROUNDWATER WELL	R
199-B5-2	565405.43	144939.70	42000	2011	GROUNDWATER WELL	R
199-B5-5	564721.99	144955.49	5900	2009	GROUNDWATER WELL	C
199-B5-8	566014.00	143587.69	540	2011	GROUNDWATER WELL	C
199-B8-6	564498.83	144157.79	10300	2011	GROUNDWATER WELL	R
199-B8-7	564760.86	144045.17	28000	2010	GROUNDWATER WELL	R
199-B8-8	565006.14	144001.01	28000	2010	GROUNDWATER WELL	R
199-B8-9	565276.43	144054.45	9500	2011	GROUNDWATER WELL	R
199-B9-2	565534.79	144078.08	1300	2010	GROUNDWATER WELL	R
199-B9-3	565667.36	144046.72	863.3333	2011	GROUNDWATER WELL	R
699-65-83	564590.47	143249.09	210	2010	GROUNDWATER WELL	R
699-67-86	563661.65	143873.05	200	2010	GROUNDWATER WELL	R

Table 6-7. Interpolation Dataset for Tritium in 2010-2011

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
699-71-77	566401.95	145098.61	545	2011	GROUNDWATER WELL	R
AT-B-1-M	564308.89	145379.94	2000	2009	AQUIFER TUBE	R
AT-B-2-D	564513.95	145329.14	1650	2009	AQUIFER TUBE	R
AT-B-3-D	565130.48	145397.27	5600	2009	AQUIFER TUBE	R
AT-B-5-D	566438.06	145746.81	10000	2009	AQUIFER TUBE	R
AT-B-7-M	566143.32	145680.05	5766.667	2009	AQUIFER TUBE	R
C6229	564748.32	145303.79	2150	2009	AQUIFER TUBE	R
C6232	565426.35	145453.67	15000	2009	AQUIFER TUBE	R
C6235	565563.42	145495.24	6400	2009	AQUIFER TUBE	R
C7720	564995.09	145388.79	4500	2010	AQUIFER TUBE	R
C7726	565188.85	145406.81	8700	2010	AQUIFER TUBE	R
C7781	565750.81	145555.14	1700	2011	AQUIFER TUBE	R
C7842	565391.93	145327.43	28800	2010	BORING	C
C7844	565290.19	144761.31	18000	2010	BORING	C
C7845	565355.92	144638.85	19900	2010	BORING	C
C7849	565397.34	144026.97	1740	2010	BORING	C
C7883	564812.40	144161.10	21700	2010	BORING	C
C7884	564734.50	144158.10	19900	2010	BORING	C
C8239	565331.70	144527.57	17400	2010	BORING	C

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

Table 6-8. Interpolation Dataset for Tritium in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
03-D	564077.44	145469.25	660	2012	AQUIFER TUBE	R
04-D	564612.19	145283.28	850	2012	AQUIFER TUBE	R
05-M	564908.31	145332.30	5100	2012	AQUIFER TUBE	R
06-M	565293.94	145412.05	22000	2012	AQUIFER TUBE	R
199-B2-13	564086.50	145264.56	520	2012	GROUNDWATER WELL	R
199-B2-14	565096.00	145232.27	8200	2012	GROUNDWATER WELL	R
199-B3-1	565561.44	145342.08	4100	2012	GROUNDWATER WELL	R
199-B3-46	565899.56	145369.05	1900	2012	GROUNDWATER WELL	R
199-B3-47	565388.69	145368.95	21000	2012	GROUNDWATER WELL	R
199-B3-50	566028.88	145058.20	2800	2012	GROUNDWATER WELL	R
199-B4-1	565289.81	144791.53	13000	2012	GROUNDWATER WELL	R
199-B4-14	564969.25	144313.98	6330	2012	GROUNDWATER WELL	R
199-B4-4	565377.06	144479.70	12000	2012	GROUNDWATER WELL	R
199-B4-7	565398.88	144382.84	14000	2012	GROUNDWATER WELL	R
199-B4-8	565578.44	144653.80	14000	2012	GROUNDWATER WELL	R
199-B5-1	564878.13	144764.91	3100	2012	GROUNDWATER WELL	R
199-B5-2	565405.44	144939.69	19000	2012	GROUNDWATER WELL	R
199-B5-8	566014.00	143587.69	676.6667	2012	GROUNDWATER WELL	R
199-B8-6	564498.81	144157.80	10000	2012	GROUNDWATER WELL	R
199-B8-7	564760.88	144045.17	28000	2010	GROUNDWATER WELL	R
199-B8-8	565006.13	144001.02	28000	2010	GROUNDWATER WELL	R
199-B8-9	565276.44	144054.45	19750	2012	GROUNDWATER WELL	R
199-B9-2	565534.81	144078.08	5700	2012	GROUNDWATER WELL	R
199-B9-3	565667.38	144046.72	935	2011	GROUNDWATER WELL	R
699-65-83	564590.44	143249.09	0	2012	GROUNDWATER WELL	R
699-67-86	563661.63	143873.05	0	2011	GROUNDWATER WELL	R
699-71-77	566401.94	145098.61	0	2011	GROUNDWATER WELL	R
AT-B-1-M	564308.88	145379.94	910	2012	AQUIFER TUBE	R
AT-B-2-D	564513.94	145329.14	2700	2012	AQUIFER TUBE	R
AT-B-3-D	565130.50	145397.27	5900	2012	AQUIFER TUBE	R
AT-B-5-D	566438.06	145746.81	6700	2012	AQUIFER TUBE	R

Table 6-8. Interpolation Dataset for Tritium in 2012

Name	Easting	Northing	Value	Year	Location Type	Collection Purpose
AT-B-7-M	566143.31	145680.05	4600	2012	AQUIFER TUBE	R
C6229	564779.13	145298.41	1400	2012	AQUIFER TUBE	R
C6232	565430.13	145453.80	8600	2012	AQUIFER TUBE	R
C7720	564995.13	145388.80	0	2012	AQUIFER TUBE	R
C7726	565188.88	145406.81	8600	2012	AQUIFER TUBE	R
C7781	565750.81	145555.14	1900	2012	AQUIFER TUBE	R
C7842	565391.94	145327.44	28800	2010	BORING	C
C7844	565290.19	144761.31	18000	2010	BORING	C
C7845	565355.94	144638.84	19900	2010	BORING	C
C7849	565397.31	144026.97	1740	2010	BORING	C
C7883	564812.38	144161.09	21700	2010	BORING	C
C7884	564734.50	144158.09	19900	2010	BORING	C
C8239	565331.69	144527.56	17400	2010	BORING	C
199-B8-7 MIG	564879.00	144185.00	23693		Type 3	
199-B8-8 MIG	565124.00	144140.00	23693		Type 3	

Notes:
C = Characterization data collected during drilling (subset representing upper part of unconfined aquifer)
R = Routine data collected after well completion

7. Results

Plume depictions for the COCs and periods of interest are presented in the following figures:

1. Figure 7-1: Cr(VI) in 2010-2011
2. Figure 7-2: Cr(VI) in 2012
3. Figure 7-3: Cr(VI) in 2013
4. Figure 7-4: Cr(VI) in 2014
5. Figure 7-5: strontium-90 in 2010-2011
6. Figure 7-6: strontium-90 in 2012
7. Figure 7-7: tritium in 2010-2011
8. Figure 7-8: tritium in 2012

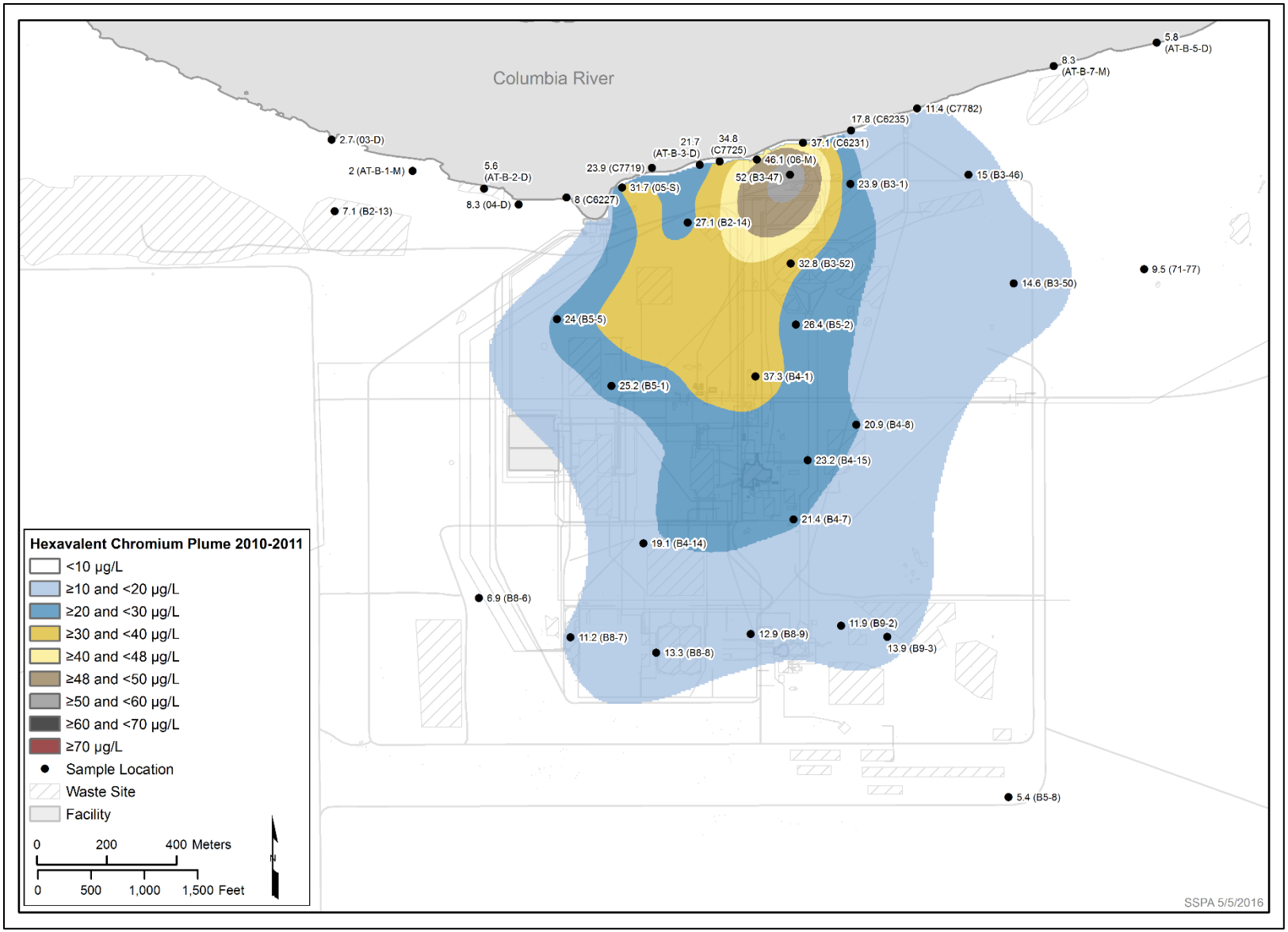

Figure 7-1. Cr(VI) Distribution in the Shallow Aquifer in 100-BC-5 in 2010-2011.

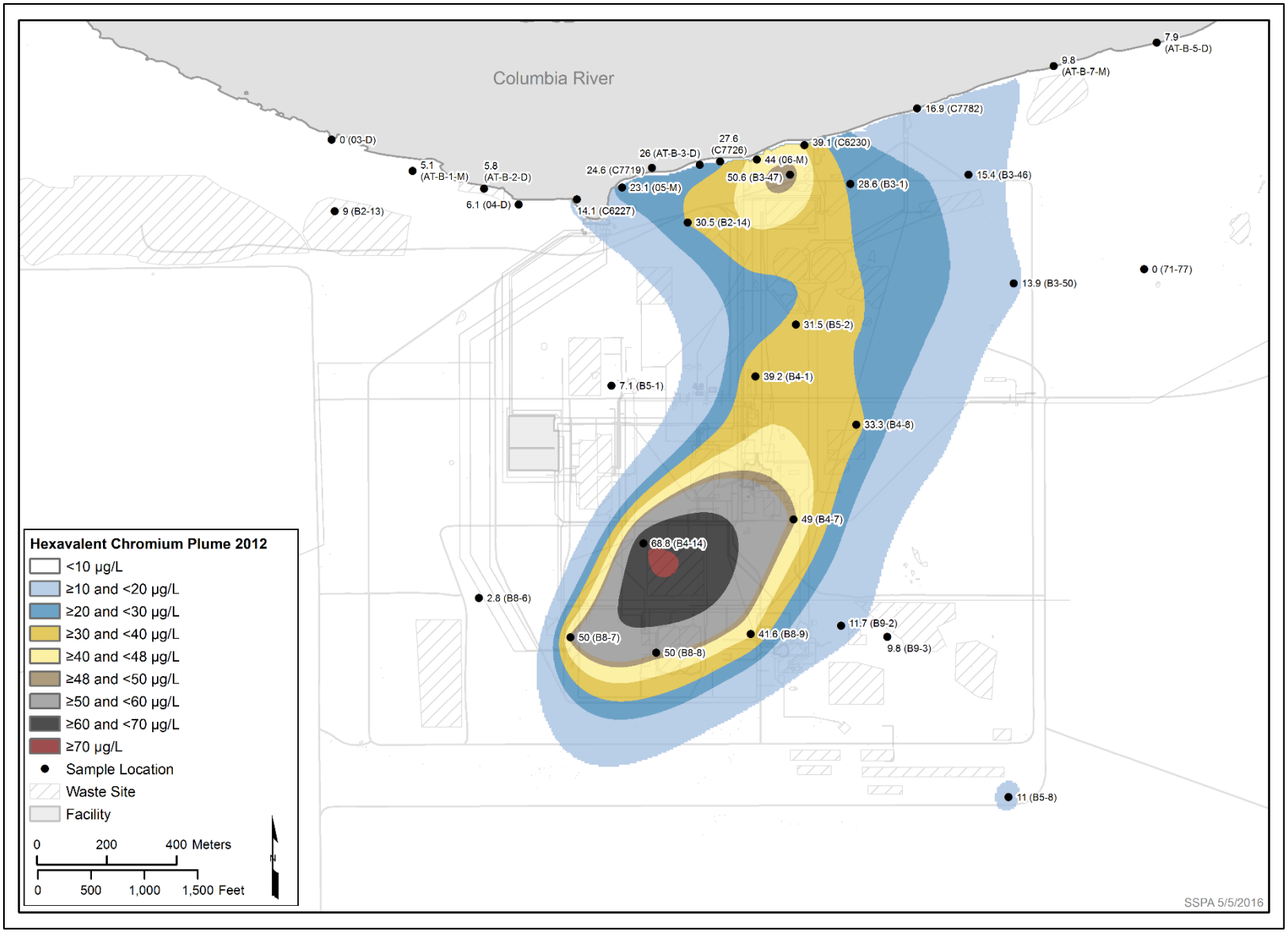

Figure 7-2. Cr(VI) Distribution in the Shallow Aquifer in 100-BC-5 in 2012.

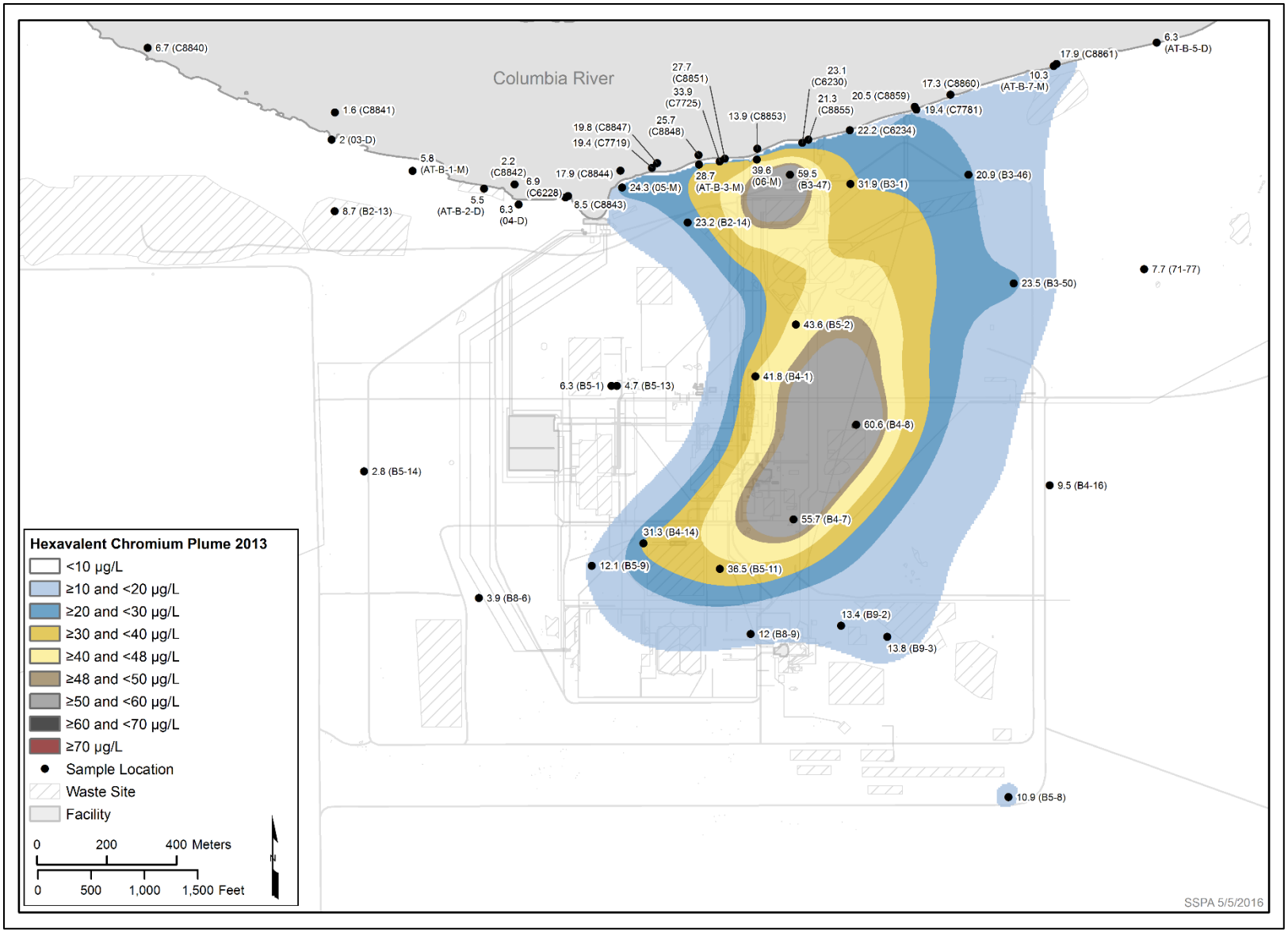

Figure 7-3. Cr(VI) Distribution in the Shallow Aquifer in 100-BC-5 in 2013.

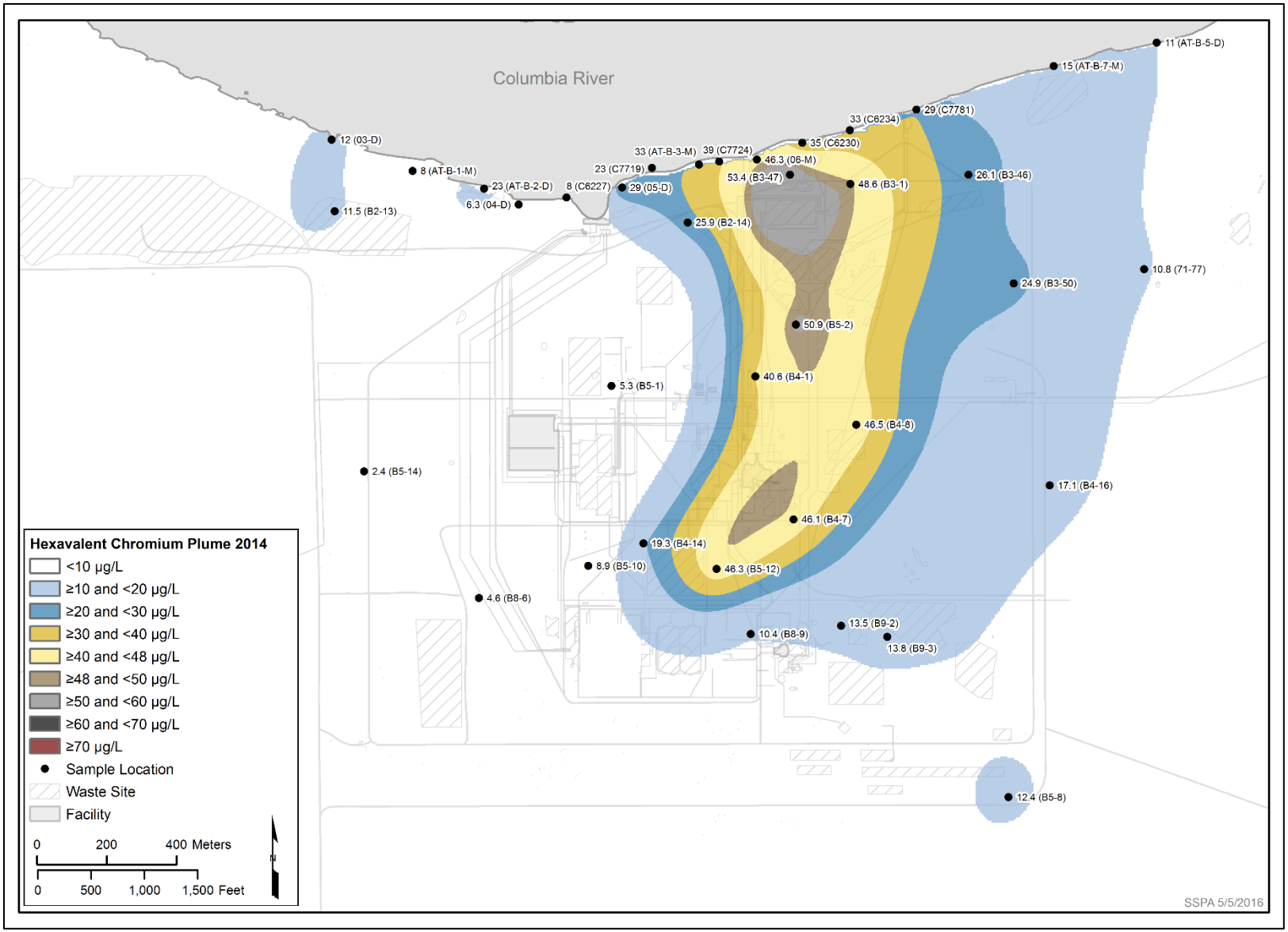

Figure 7-4. Cr(VI) Distribution in the Shallow Aquifer in 100-BC-5 in 2014.

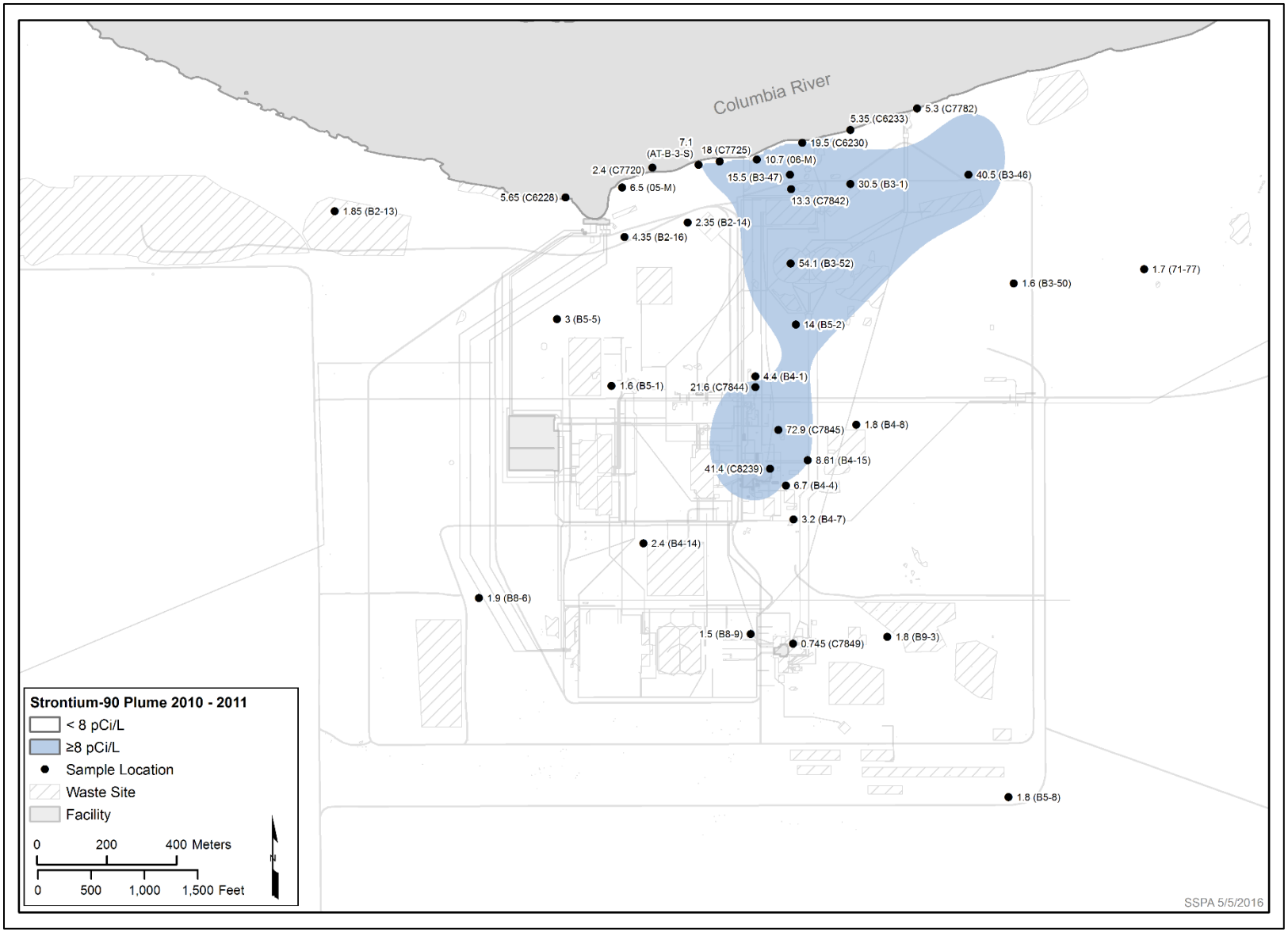

Figure 7-5. Strontium-90 Distribution in the Shallow Aquifer in 100-BC-5 in 2010-2011.

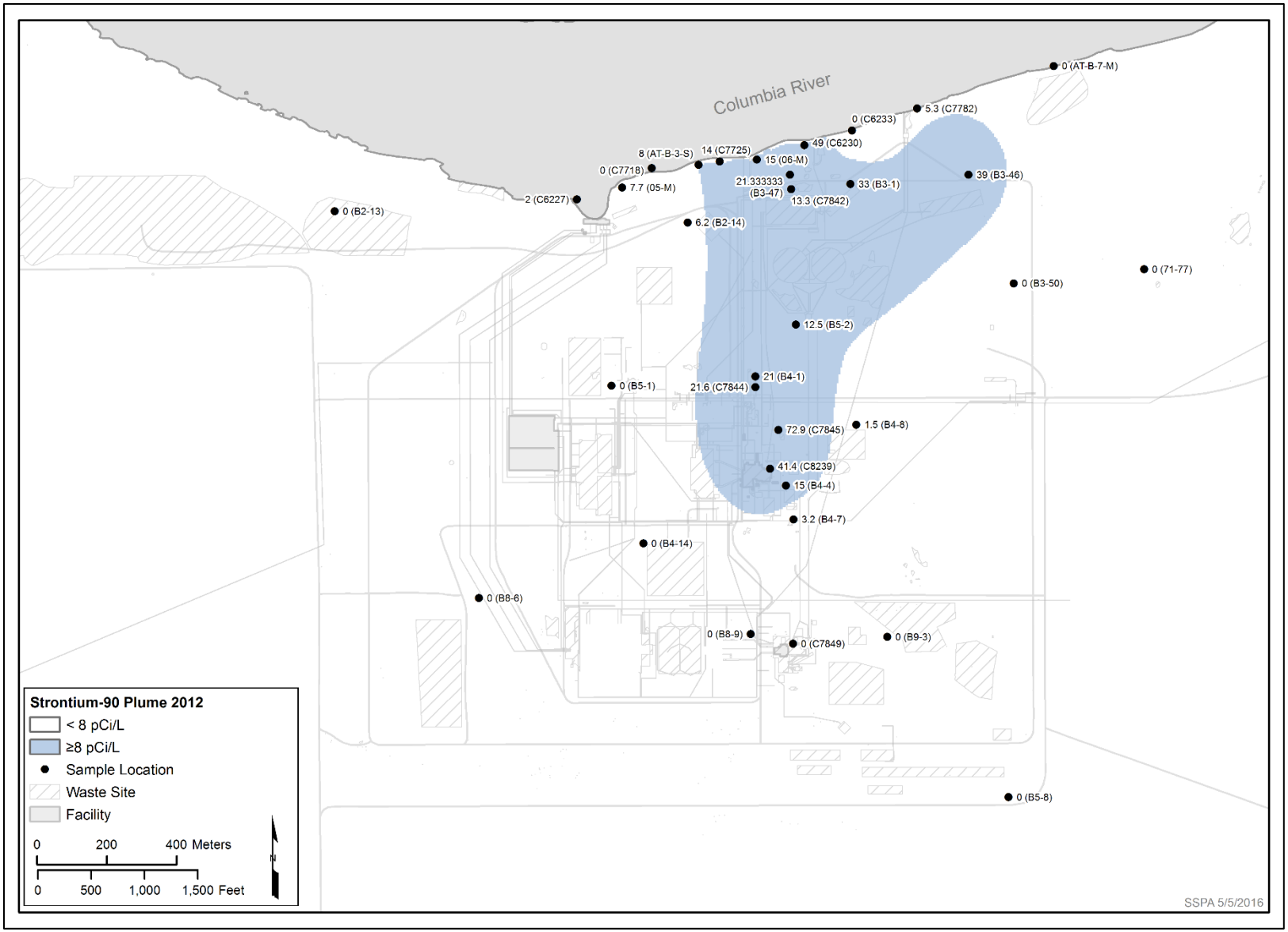

Figure 7-6. Strontium-90 Distribution in the Shallow Aquifer in 100-BC-5 in 2012.

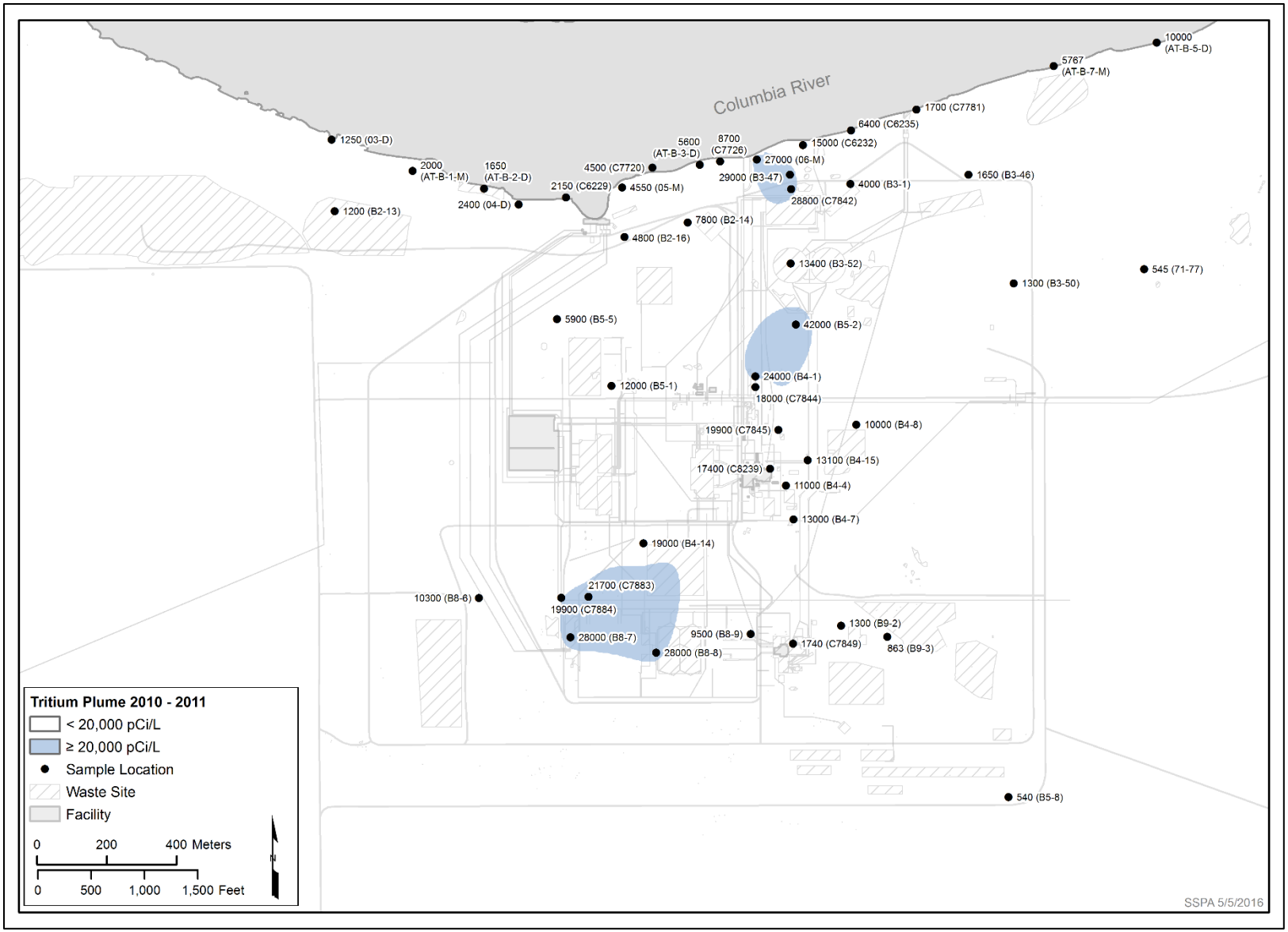

Figure 7-7. Tritium Distribution in the Shallow Aquifer in 100-BC-5 in 2010-2011.

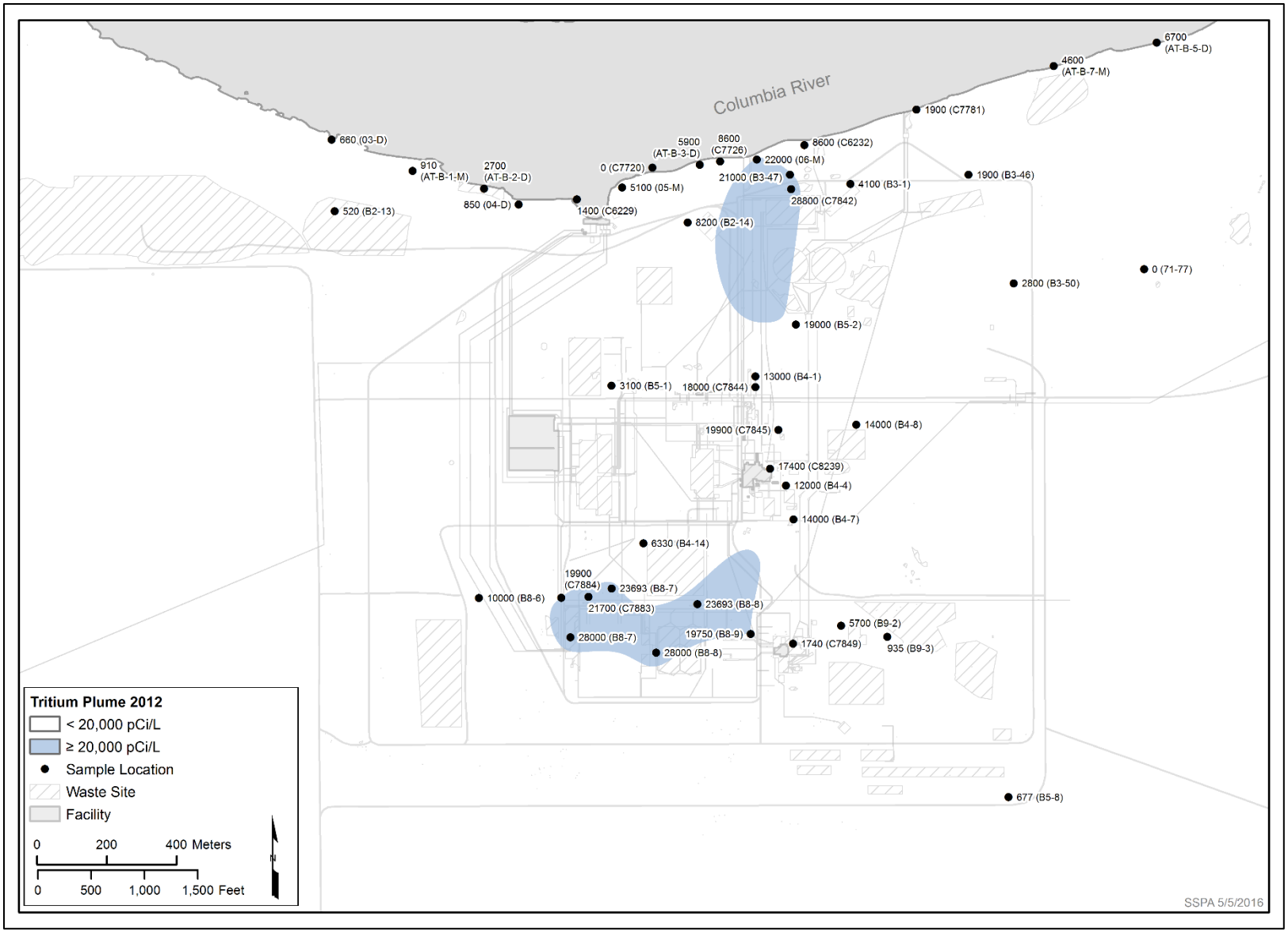

Figure 7-8. Tritium Distribution in the Shallow Aquifer in 100-BC-5 in 2012.

8. References

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