ECF-HANFORD-18-0023
Revision 0

Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives

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

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

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Document Type: ENV Program/Project: EP&SP

J. B. Fullerton
INTERA, Inc.

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Release Approval Date

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ENVIRONMENTAL CALCULATION COVER PAGE

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Project: 200-East Remedial Investigations

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	Name /Position	Signature	Date
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Senior Reviewer:	TJ Budge/Sr Hydrogeologist	TJ Budge	7/16/18
Responsible Manager:	AH Aly/Risk & Modeling Integr. Mngr WE NICHOLS, ACTING		26 JUL 2018

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Safety Software Approved:

	Name /Position	Signature	Date
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Groundwater Modeler

MS, Civil Engineering, Brigham Young University, 2017

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Licenses: Engineer in Training (EIT)

Jacob Fullerton's experience encompasses civil and environmental engineering, and is focused on the development and application of groundwater models using codes and platforms such as GMS, ArcMap, and GSSHA. He also brings expertise with coding web applications in multiple programming languages, including Javascript, HTML, JQuery, and Python. He has incorporated an analytic element groundwater model called TimML into a web app capable of performing general groundwater modeling tasks. Additionally, he has created an educational groundwater dewatering web app that simulates aquifer dewatering using wells and slurry trenches.

Checker: Helalur Rashid

Hydrologist

MS, Civil Engineering, Washington State University, 2010

BS, Civil Engineering, Bangladesh University of Engineering & Technology, 2007

License: Professional Engineer (Washington)

Helalur Rashid's professional experience encompasses numerical modeling of groundwater in the saturated and unsaturated zones, model calibration, groundwater management, geostatistics analysis, sediment transport, and hydraulic characterization of watersheds. He has applied a wide variety of modeling codes and geographic information system software including MODFLOW, MODFLOW-SURFACT, MT3DMS, MODPATH, PEST, Parallel PEST, STOMP, SWAT, HEC-HMS, ArcGIS, Leapfrog Hydro, Groundwater Vistas, RETC, and TecPlot. Helal has worked primarily on environmental restoration projects for the federal government. He is also skilled in using various laboratory and field instruments such as acoustic Doppler velocimeters, laser distance meters, and viscometers.

Senior Reviewer: Trevor Budge

Senior Hydrogeologist

PhD, Geological Sciences, The University of Texas at Austin, 2008

MS, Civil and Environmental Engineering, Brigham Young University, 2000

BS, Civil and Environmental Engineering, Brigham Young University, 1999

Trevor Budge's experience encompasses characterizing and modeling hydrologic and hydrogeologic systems in support of a wide range of water resources, environmental, and waste isolation projects. His work has included analyzing and optimizing remediation well configuration and operation, investigating long-term remediation costs, characterizing complex geological settings with the use of geophysical and remote sensing data, designing slurry walls and hydraulic barrier walls near sensitive water bodies, emergency planning-based modeling of catastrophic dam failures and large storm events, and developing geographic information system tools to efficiently process data and modeling results. These tasks have been completed using a wide range of numerical, analytical, and geostatistical tools. His knowledge of computer hardware and software, including GIS and programming languages, allows him to solve problems that arise specific to each project that cannot be resolved using standard out-of-the-box software and hardware. Trevor has completed projects for organizations ranging from small municipalities and local water authorities to state and federal government agencies, and he has authored and developed software applications used by the US Environmental Protection Agency and the US Department of Defense.

Environmental Calculation File

Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives

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Terms

BCM	B-Complex
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DST	distal
ECF	environmental calculation file
F&T	fate-and-transport
FS	feasibility study
G2E	Greater 200 East
GGP	Gable Gap
P&T	pump-and-treat
P2R	Plateau to River (model)
REC	remediation evaluation case
RI	remedial investigation
TEDF	Treated Effluent Disposal Facility
WMC	waste management complex

1 Purpose

The calculation described in this environmental calculation file (ECF) is part of the combined Feasibility Study (FS) of groundwater remedial alternatives for the 200-BP-5 and 200-PO-1 Operable Units (collectively referred to herein as 200 East). The purpose of the FS is to provide a comparison of potential remedial actions for cleanup of groundwater in 200 East area of the U.S. Department of Energy's (DOE's) Hanford Site. The remedial actions evaluated in the FS are limited to pump and treat (P&T) alternatives. The method of evaluation is fate and transport (F&T) modeling. The outcome of the FS will be to determine if P&T is a viable remedial alternative and to provide a description of a feasible range of extraction and injection well configurations (including well locations and rates) that can be used as the basis for the design of such a system.

The objective of this modeling calculation is to provide a description of current and expected future groundwater contaminant concentrations with and without the effects of various P&T scenarios developed as part of the RI/FS process. The model was used to calculate the fate and transport of eight contaminants of potential concern (COPCs). These include:

- For the 200-PO-1 FS: cyanide, tritium, strontium-90, iodine-129, technetium-99, nitrate, and uranium
- For the 200-BP-5 FS: tritium, strontium-90, iodine-129, technetium-99, nitrate, chromium, cyanide, and uranium

The P&T scenarios developed for assessing an effective cleanup strategy focused on technetium-99, uranium, and nitrate as the key drivers of risk. Given that multiple factors may impact COPC fate and transport, sensitivities of the calculation to initial contaminant distribution, potential for continuing vadose zone sources of COPCs, and the potential influence of future liquid discharge at the Treated Effluent Disposal Facility (TEDF) were modeled for the range of P&T configurations.

2 Background

The F&T model used to perform simulations supporting the 200-East RI/FS is the Plateau-to-River (P2R) Model. This is the same model applied for evaluation of baseline future groundwater conditions in the Remedial Investigation (RI) reports for the 200-BP-5 and 200-PO-1 Operable Units (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit,* and DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, respectively). The P2R Model is documented in CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model (Version 7.1),* and in ECF-HANFORD-13-0031, *Fate and Transport Modeling for Baseline Conditions for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*. Detailed information concerning the model construction, calibration, and application for baseline conditions are found in those reports.

The scenarios presented in this ECF are based on simulations using the P2RGWM reported in ECF-HANFORD-13-0031. It must be noted that some wells in the 200 West area were not located correctly in those model files. The following table lists those wells and shows their updated location information.

Table 2-1. P2R Model Well Locations

Well Name	ECF-HANFORD-13-0031[a] Simulated Locations		Updated Locations	
	Row	Column	Row	Column
IW-3-I	40	Column	41	33
IW-2-Cr	41	19	53	30
IW-2-I	41	20	43	33
IW-1-I	43	33	45	33
EW-2-Cr	43	15	48	40
IW-1-Cr	45	33	49	28
EW-1-Cr	45	15	50	35
EW-1-Tc	45	16	43	15
EW-2-Tc	48	33	45	15
EW-3-Tc	49	40	45	16
EW-2-U	50	28	41	20
EW-1-U	53	35	40	19

a. ECF-HANFORD-13-0031, *Fate and Transport Modeling for Baseline Conditions for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Unit.*

To maintain configuration management and consistency with this ECF, those well locations are not updated in this ECF. These wells are well outside the area of interest for the alternatives evaluations presented in this ECF, and the updated locations do not impact the relative performance of these alternatives. It is recognized that future evaluations in support of the 200-BP-5 and 200-PO-1 RD/RA WP will utilize updated models, including updated initial conditions, pumping rates, and well locations.

3 Methodology

Developing a set of simulations to evaluate possible remedial strategies for 200-East included was completed in several steps. These include, 1) development of a set of goals to guide the evaluation process; 2) determining the metric used to rank the effectiveness of the scenarios at achieving the remedial goals; 3) completing individual simulations for comparing P&T scenarios; and 4) establishing the remedial evaluation case or the parameters and inputs that will reflect the expected behavior of the plume for comparison to the various P&T scenarios. Each of these steps is discussed in the following sections.

3.1 P&T Scenario Analysis Goals

A set of goals was developed in order to guide the development of the P&T analysis and comparison. These goals were established in order ensure that the simulated scenarios provided the information necessary to make a reasonable comparison. These included:

- Simulate at least a 50-year duration to match the total remedy duration identified as part of the FS process.
- Present a range of P&T scenarios that show a progression of aggressiveness toward reaching remedial goals
- Limit P&T duration to 25 years and vary the number and extraction/injection rate of wells to achieve cleanup within this time frame.

These guidelines were used to develop the individual MODFLOW/MT3D simulations used to compare the effectiveness of P&T scenarios.

3.2 Ranking Metrics

MT3D-MST results provide an estimate of concentration for each computational cell at each time for the entire model domain. In order to assimilate all of this information into a useful narrative it is often useful to develop summary statistics for the entire model and for separate regions of the model. These statistical measures can be used to compare between separate P&T scenarios. They can also be used as metrics for establishing the rank of effectiveness for the P&T scenarios at remediating portions of and/or the entire model. This section describes the methods used to calculate the metrics used to compare the various P&T scenarios.

3.2.1 Model Regions

At times it is useful to evaluate the model as a whole and/or based on sub regions of the model. This provides a method to compare the P&T scenarios effectiveness on the local scale and on the model scale. For the scenario analysis a set of sub regions was developed based on both the plume geometry and the location of infrastructure at 200-East in order to compare simulation results. Figure 3.1 shows the 6 sub regions developed for evaluating the model results. These include the B-complex, B-plant, WMA C, Gable Gap, Gable Mountain Pond, and Distal Plume sub regions. When summary statistics are calculated for the entire model all computational cells in the model domain are used for the calculation. When the statistics are calculated for the sub region, only those computational cells within the boundary of the sub region are used for the calculation.

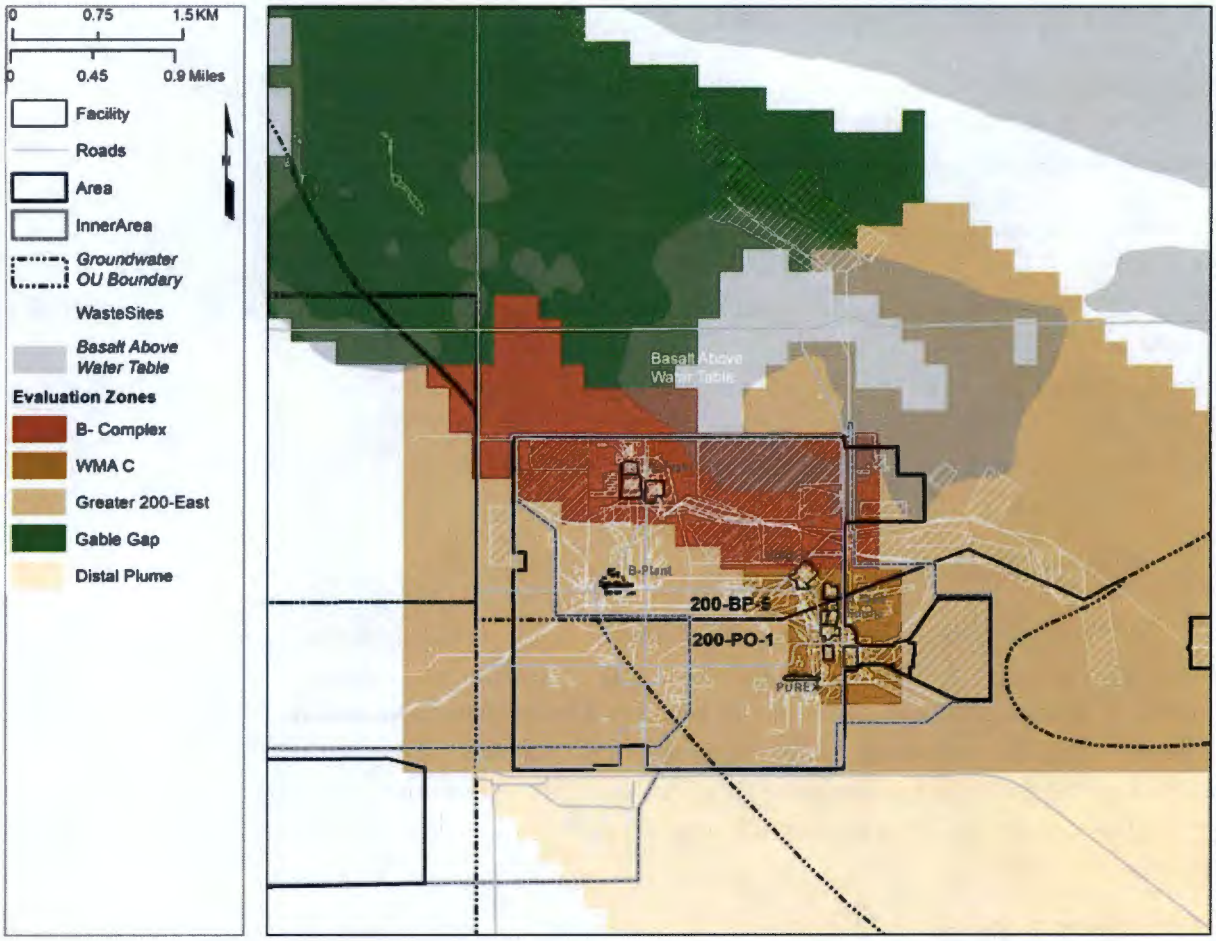

Figure 3.1 – Locations of model domain sub regions used to evaluate simulation results.

3.2.2 Summary Statistics

The primary statistics used to analyze the results of F&T modeling for the COCs were the peak, the 90th percentile, and the arithmetic mean concentration. The 90th percentile rank is calculated for the simulated results for comparison with regulatory standards to assess cleanup times. For all calculations of summary statistics, when the estimated concentration at any computational cell location falls below half of the cleanup level (DWS) the cell was not included in the calculation of the summary statistics. The calculation of each summary statistic is described further in the following sections.

3.2.2.1 Peak

The peak concentration refers to the highest magnitude concentration at any computational cell within its corresponding region.

3.2.2.2 90th Percentile

The 90th percentile calculation is carried out non-parametrically using a Weibull ranking scheme. The values for all cells are tabulated, sorted based on concentration value, and a rank is applied to the sorted data based on Equation 3.1. The concentration whose plotting position has the exact value of 0.9 is selected as the 90th percentile concentration. However, in most cases no concentration will have an exact

rank of 0.9. Therefore, in these cases, the two values with ranks closest to 0.90, above and below, are selected and the 90th percentile concentration is selected by linearly interpolating between these values using the rank as the weighting factor.

$$P = r/(n+1) \qquad \text{Equation 3.1}$$

where, P = Weibull plotting position
r = rank of data point
n = number of samples

3.2.2.3 *Mean*

The arithmetic mean is calculated by summing the estimated concentration value for each cell within the region and dividing by the number of cells within the region. Only those cells above half the cleanup level are considered a part of the calculation.

3.3 Developing Individual Simulations

Individual simulations were developed based on the guidelines above and through an iterative process of running simulations, reviewing the results, and developing new P&T scenarios based on the analysis goals and the information obtained from the previous simulations. A total of 3 P&T scenarios were developed as part of the analysis in addition to a no action scenario (4 modeling scenarios). These simulations are summarized in Table 3.1. The steps used in developing these simulations included the following steps:

- Identifying the location and rates of wells
- Modifying the model inputs and executing the simulation
- Post-processing and evaluating the results

Each of these steps is discussed in the following sections.

3.3.1 Identify Well Location and Rate

The locations of all wells used at some point in the scenario analysis are shown in Figure 3.2. These locations were initially selected based on previously constructed extraction wells (299-E33-268 and 299-E33-36) and on areas where plume concentrations were of the greatest magnitude. Once the initial simulations were completed the locations were adjusted based on the resulting F&T of the contaminant plumes over the duration of the simulation. The extraction/injection rates ranged from a total of 250/0 gallons per minute (gpm) to 425/100 gpm in the simulations. These were also adjusted in an iterative manner based on the simulation results. Table 3.1 illustrates how changes progressed through the iterative process. All wells were simulated as fully penetrating wells with the exception of wells targeting the B-Plant plume. These wells were simulated in order to focus remediation within the deeper portions of the unconfined aquifer.

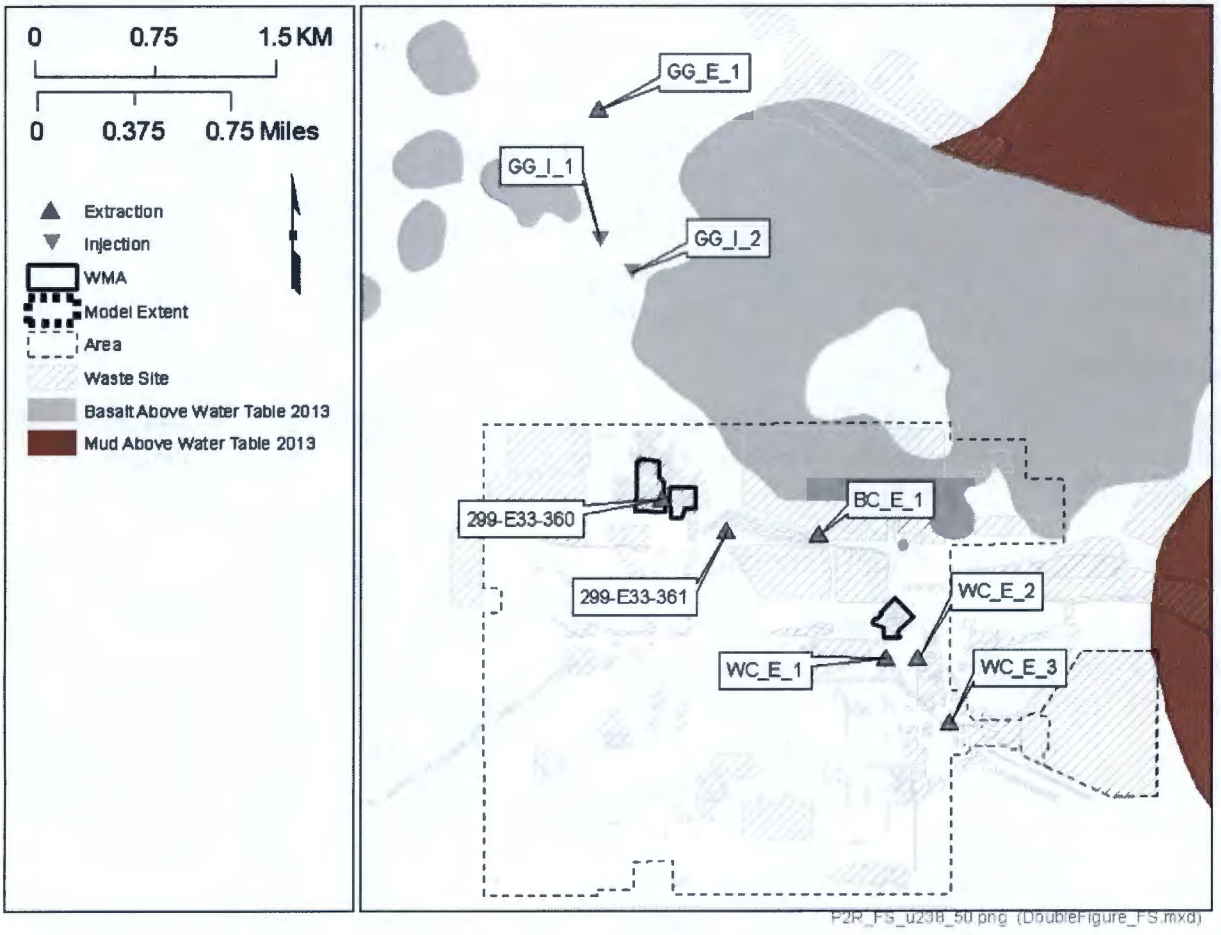

Figure 3.2 – Location of wells used as part of the scenario analysis in support of the 200-East FS.

3.3.2 Modify Simulation Inputs and Executing Simulations

The MODFLOW discretization and the multi-node well (MNW2) package for the P2R model were altered as part of the simulations involved in the P&T scenario analysis. The discretization package was altered to reflect a shortened time frame of evaluation. All simulations were carried out for a 50-year period. The MNW2 package was altered for each simulation to reflect the extraction/injection rates, duration, and locations listed in Table 3-1. The WEL package was unaltered from the P2R model.

The MODFLOW and MT3DMS software programs were used to simulate groundwater flow and contaminant transport, respectively. MODFLOW solves the groundwater flow equation to calculate hydraulic heads and groundwater flow velocities. MT3DMS uses the resultant groundwater flow velocities, along with transport properties of the aquifer and contaminants, to solve the groundwater advection-dispersion equation, yielding concentrations in time and space. These resultant concentration estimates were used to evaluate the future conditions of plumes based on the simulated P&T scenarios.

3.3.3 Post Processing Results

After completion of the MODFLOW/MT3D simulations the estimated concentrations were post-processed to provide summary statistics tables and charts and plume concentration contour maps for the

200-East area. These products were utilized to compare results between P&T scenarios and make adjustments for subsequent scenario simulations. Post-processing was completed using several applications designated as support software for the MODFLOW/MT3D. These include PEST, ArcGIS®[1], Tecplot®[2] and R software package were used to process these results. PEST utilities were used to provide the summary statistic estimates presented in 3.2.2, Tecplot and ArcGIS were used to prepare the plume concentration contour maps, and the R software package was used to tabulate the time to cleanup and create chart summary statistics over time.

3.4 Remedial Evaluation Case

The remedial evaluation case provides a baseline set of simulation results that can be used to compare subsequent simulations in order to assess P&T effectiveness. Key features of the remedial evaluation case for the 200-East FS include:

- Initial distribution of contaminant concentration is based on the averaging concentrations from the annual report plumes within the boundary of each computational cell.
- No continuing source is considered for any contaminant plumes.
- Discharge from TEDF is assumed to occur.

While this case provides a baseline for assessing the effectiveness of the P&T scenarios, the value of simulating other conditions than those listed above provides an assessment of the uncertainty in the numerical model. Therefore, other conditions than those provided above were simulated to address the uncertainty that exists in the assumptions used to rank the P&T scenarios. The model inputs affecting the remedial evaluation case are discussed in detail in Section 4 of this ECF.

[1] ArcGIS® is a registered trademark, or service mark, of ESRI in the United States, the European Community, or certain other jurisdictions.

[2] TecPlot is a registered trademark of Tecplot, Inc., Bellevue, Washington.

Table 3.1 – Location and rates of injection and extraction wells for all simulation sets developed for the evaluation scenarios to support the 200-East FS.

Well Name	X	Y	Scenario			
			1	2	3	4
C8923 (299-E33-360)	573772.1	137386.9	0	-75	-75	-75
C8924 (299-E33-361)	574069.3	137122.3	0	-75	-75	-75
BC_E_1	574900	137100	0	0	0	-75
WC_E_1	575100	136300	0	-33.3	-33.3	-33.3
WC_E_2	575300	136300	0	-33.3	-33.3	-33.3
WC_E_3	575500	135900	0	-33.3	-33.3	-33.3
GG_E_1	573300	139700	0	0	-100	-100
GG_I_1	573300	138900	0	0	50	50
GG_I_2	573500	138700	0	0	50	50
B Complex	Total EXT		0	-150	-150	-225
	Total INJ		0	0	0	0
WMA C	Total EXT		0	-100	-100	-100
	Total INJ		0	0	0	0
Gable Gap	Total EXT		0	0	-100	-100
	Total INJ		0	0	100	100
Total Extraction			0	-250	-350	-425
Total Injection			0	0	100	100

4 Assumptions and Inputs

All model properties, initial conditions and boundary conditions are drawn from the P2R Model. A full description of the P2R Model provided in CP-57037 (Appendix F), and its application to simulate contaminant F&T for the scenarios is detailed in ECF-HANFORD-13-0031. The inputs and assumptions presented in the previous reports documenting the P2R model are inherited by the use of the model for this application. Only those assumptions and inputs unique to this application of the P2R model will be presented in this ECF. In this section the development of the extraction well network, the initial contaminant plumes, and the continuing source terms used in the modeling will be discussed.

4.1 Extraction and Injection Wells

The extraction and injection wells associated with the P&T systems evaluated are modeled using the Modified Multi-Node Well Package (MNW2) available as part of MODFLOW. The locations of all wells evaluated as part of the analysis are shown in Figure 3.2. Pump-and-treat remediation schemes have been developed at the Hanford site to aid in the cleanup effort. The process of selecting well locations was discussed in Section 3.

As part of the RI simulation development, documented in ECF-HANFORD-13-0031, several features of the predicted fate and transport of the contaminant plumes were documented that affected the placement of the extraction/injection wells. These included the development of stagnation zones where contamination remained present for a longer than expected duration based on the behavior of the adjacent plume. Figure 4.1 shows the nitrate concentration at simulations times 0, 20, and 50 years. While much of the plume disperses from 0 to 20 years, near Gable Mountain Pond and B-plant portions of the plume remain until past the 50 years.

The locations in the model where the plumes persist correspond to the locations of low transmissivity within the aquifer. Figure 4.2 shows the transmissivity map developed based on the calibrated groundwater flow model. Each of the locations showing persistent contamination past 50 years is associated with a location within the model domain that is estimated to have a relatively lower transmissivity than the surrounding aquifer. Placement of the extraction/injection wells was conducted with consideration for the total transmissivity of the aquifer in order to minimize the stagnation zones that appeared within the simulated model domain. In some cases, placement of extraction wells decreased transmissivity causing stagnation in locations where it had they had not previously occurred. Also, in some instances injection wells were placed in locations to increase the transmissivity in order to promote movement out of stagnation zones towards extraction wells. Developing the final set of scenarios was based on an iterative process of executing simulations and interpreting simulation results.

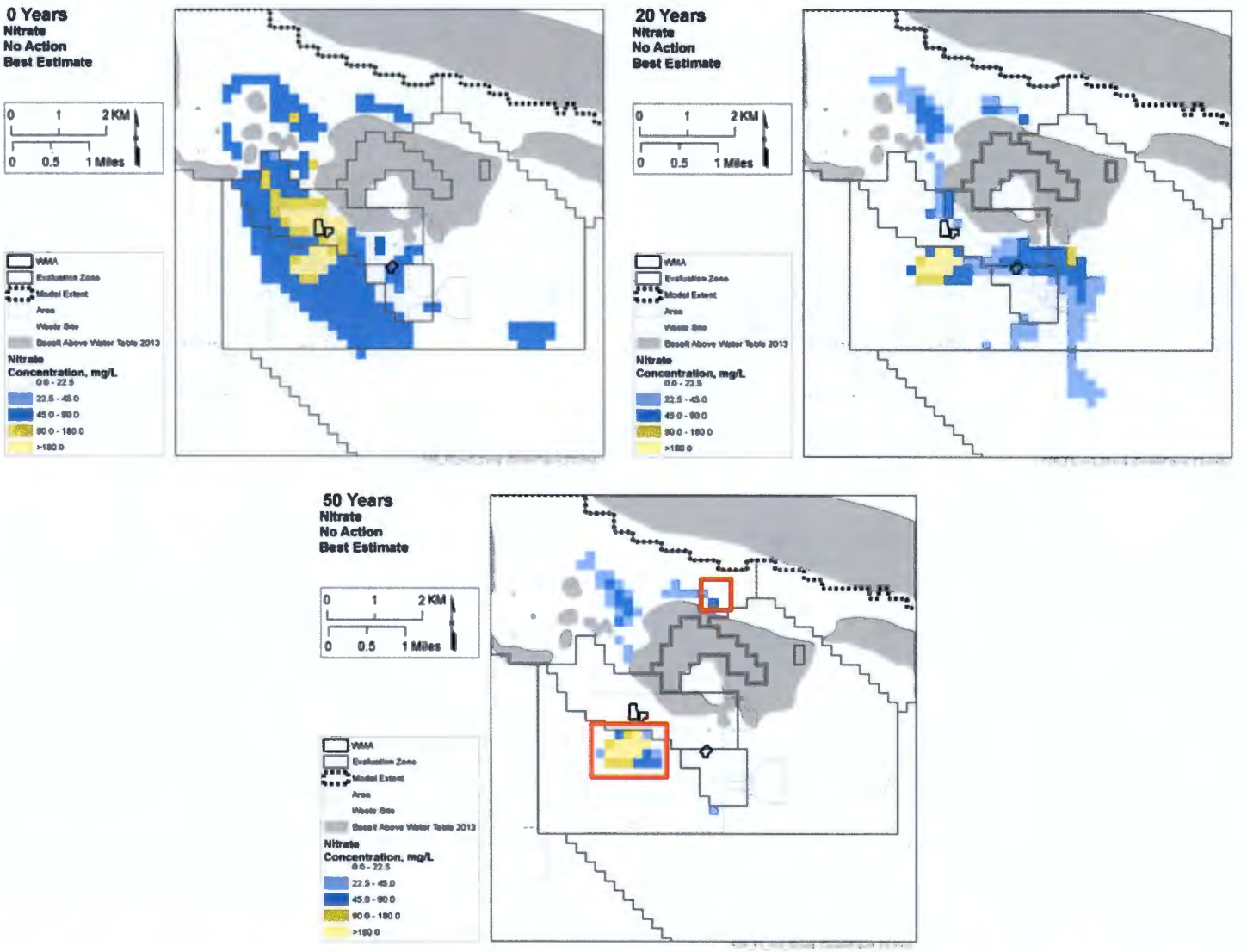

Figure 4.1 – Simulated nitrate concentration over time illustrating the tendency of contamination to stagnate in low transmissivity areas of the model (highlighted in red).

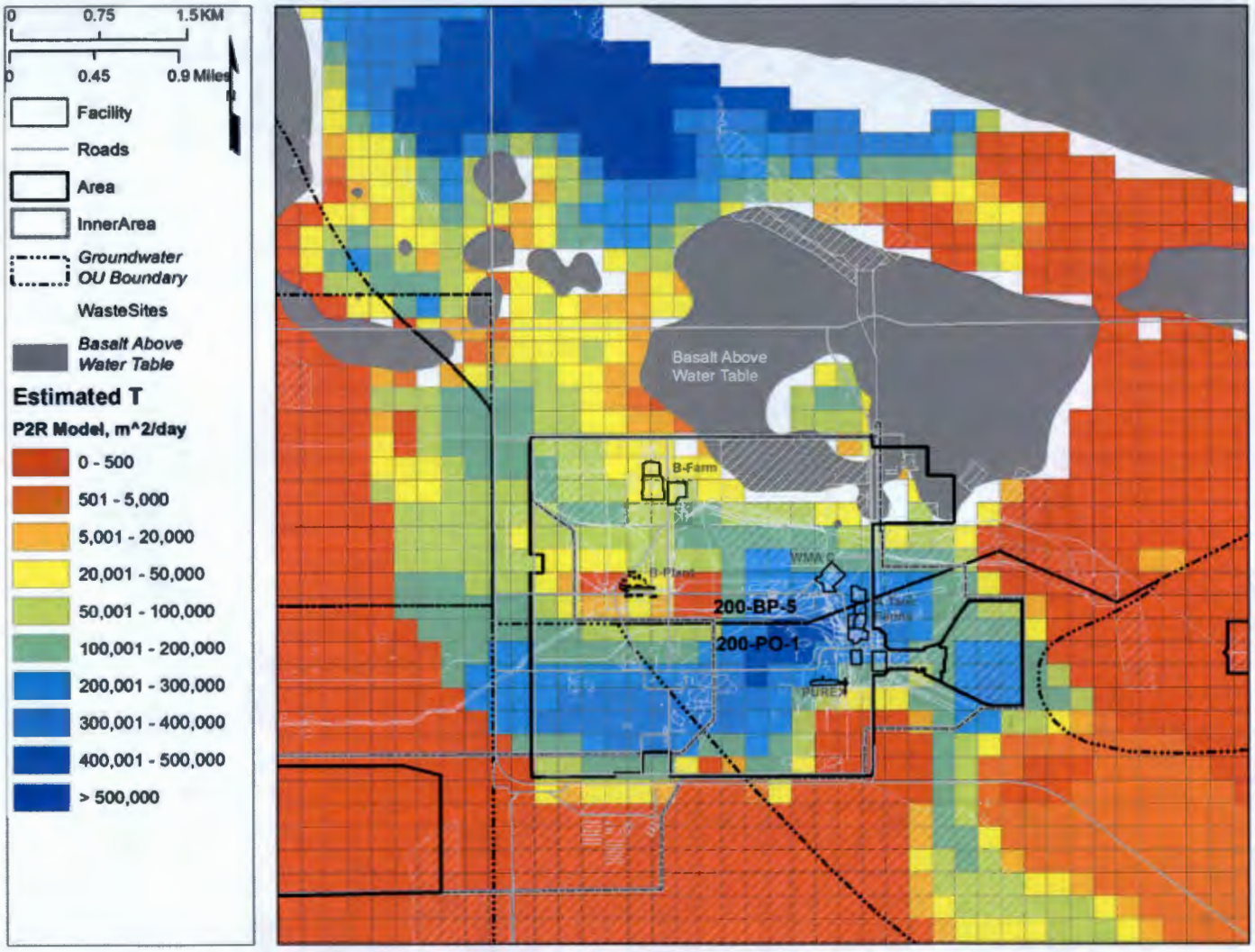

Figure 4.2 – Estimated transmissivity map for 200-East based on the simulated transmissivity field in the P2R model.

4.2 Initial Conditions

4.2.1 Contaminant Concentration

The initial groundwater contaminant distributions of the eight COPCs identified in Section 1 were based on ECF-HANFORD-13-0030, *Initial Groundwater Plume Development to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*. The approach documented there is summarized in the following sections.

Contaminant plumes were created to represent average and maximum concentration initial conditions. Figure 4-3 shows a visual representation of how this was determined. The original estimate (presented in the 2013 annual Hanford Site groundwater monitoring report; DOE/RL-2014-32) was produced using a 10 m × 10 m raster estimate of concentrations in the unconfined aquifer. The initial estimate was upscaled to the P2R Model grid based on the on the arithmetic average concentration within each 200 m × 200 m cell for the average initial concentration conditions.

Based on information presented in ECF-HANFORD-13-0037, two areas have been identified within the 200 East Area where continuing sources of contaminant release from the vadose zone into the 200-BP-5 OU are likely to persist over the foreseeable future: WMA C (C Tank Farm area) and the B-Complex (B-BX-BY Tank Farms and BY cribs area). Note that the vadose zone sources described in this section are not associated with TEDF nor are they part of the 200-BP-5 OU. The primary contaminants of concern that are likely to provide continuing source from the vadose zone are technetium-99, uranium, and nitrate. The recommended mass and activity from the ECF are presented in Table 4.2. These values were included in the Continuing Source simulations using the source/sink mixing package of MT3DMS.

Table 4.2 - Vadose Zone COPC Continuing Sources

Area	Contaminant	Units	Rate	Duration (years)
WMAC	Technetium-99	Ci/yr	0.1	60
BYCRIB	Technetium-99	Ci/yr	0.22	90
BYCRIB	Nitrate	kg/yr	8,212.5	90
BBXB7	Technetium-99	Ci/yr	0.008	300
BBXB7	Uranium	kg/yr	3.8	300

Source: ECF-HANFORD-13-0037, *Development of Source Terms for Inclusion in Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*.

5 Software Applications

MODFLOW-2000-MST, MT3D-MST, Excel®[3], PEST, ArcGIS®, and Groundwater Vistas™[4] software programs were used for this calculation. These are CH2M Hill Plateau Remediation Company (CHPRC) approved software, managed and used in compliance with the requirements of controlled software management procedure that implements the requirements of DOE O 414.1d, *Quality Assurance*. MODFLOW-2000-MST and MT3D-MST are approved calculation software and Excel®, PEST, ArcGIS, and Groundwater Vistas are approved support software (CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*).

MODFLOW-2000-MST, MT3D-MST, and PEST were executed on the Tellus Linux®[5] Cluster. The details regarding the cluster are presented below. A copy of the *Software Installation and Checkout Form* for the MODFLOW-2000 and MT3D-MST installation used for this calculation is provided in Attachment A to this ECF.

The Tellus Linux cluster that is owned by CHPRC and operated by Mission Support Alliance. The Tellus cluster consists of 16 Dell®[6] PowerEdge® M610 blade servers. Each with 2x Intel®[7] Xeon® X5670 CPU's (6 cores/CPU, 2.93 GHz), 96GB of RAM, and 10Gbps Ethernet cards. The management node is a Dell®[8] PowerEdge® M710 blade server with 2x Intel® Xeon® X5550 CPU's (4 cores/CPU, 2.7 GHz, 96 GB of RAM. As given by the command "uname –a", the operating system details are:

```
Linux tellusmgmt.rl.gov 2.6.18-308.4.1.el5 #1 SMP Tue Apr 17
17:08:00 EDT 2012 x86_64 x86_64 x86_64 GNU/Linux
```

Microsoft Excel®[9] is site-licensed software used as "flat file" spreadsheets that are wholly incorporated into this calculation and verified during the technical review of this report and is therefore rated as exempt software. Excel® spreadsheets were used to tabulate average monthly and long-term hydraulic head and river stage data for model input, and chart modeling results produced by MODFLOW-2000 and MT3DMS-MST.

5.1 Approved Software

MODFLOW-2000-MST and MT3D-MST are approved calculation software (CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*). PEST, ArcGIS, TecPlot, and Groundwater Vistas are approved support software per CHPRC-00258.

5.1.1 MODFLOW-2000-MST

- Software Title: MODFLOW-2000-MST

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[3] Excel is a registered trademark of Microsoft Corporation, Redmond, Washington.

[4] Groundwater Vistas™ is a trademark of Environmental Simulations, Inc.

[5] Linux is a registered trademark of Linux Torvalds.

[6] Dell and PowerEdge are trademarks of Dell, Inc., Round Rock, Texas.

[7] Intel and Xeon are registered trademarks of Intel Corporation.

[8] Dell and PowerEdge are registered trademarks of Dell Corporation.

[9] Excel is a registered trademark of Microsoft Corporation in the United States and other countries.

- Software Version: CHPRC Build 6 (executable "mf2k-mst-chprc06dp.x"), double precision compilation
- Hanford Information System Inventory (HISI) Identification Number: 2517 (Safety Software, Level C)
- Authorized Workstation type and property number: Linux® Cluster, HLAN Property Tag (Front End Node) WD56054
- Authorized User: J. Fullerton
- Software Vendor Documents:
    - Harbaugh et al. (2000), *MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process*
    - SSPA (2012a), *Documentation for: MODFLOW-2000-SSPA Build 006 Modifications and options added to MODFLOW-2000*
- CHPRC Software Control Documents:
    - CHPRC-00257, *MODFLOW and Related Codes Functional Requirements Document*
    - CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*
    - CHPRC-00259, *MODFLOW and Related Codes Software Test Plan*
    - CHPRC-00260, *MODFLOW and Related Codes Requirements Traceability Matrix: CHPRC Build 6*
    - CHPRC-00261, *MODFLOW and Related Codes Acceptance Test Report: CHPRC Build 6*

5.1.2 MT3DMS-MST

- Software Title: MT3DMS-MST
- Software Version: CHPRC Build 6 (executable name "mt3d-mst-chprc06dp.x"), double precision compilation
- HISI Identification Number: 2518 [Support Software; CHPRC-00258]
- Authorized Workstation type and property number: Linux® Cluster, HLAN Property Tag (Front End Node) WD56054
- Authorized User: J. Fullerton
- Software Vendor Documents:
    - Zheng and Wang (1999), *MT3DMS, A Modular Three-Dimensional Multi-Species Transport Model for Simulation of Advection, Dispersion and Chemical Reactions Of Contaminants in Groundwater Systems; Documentation and User's Guide*

- SSPA (2012b), *Documentation for: MT3DMS-SSPA Build 006 Modifications and options added to MT3DMS*

- CHPRC Software Control Documents:
  - CHPRC-00257, *MODFLOW and Related Codes Functional Requirements Document*
  - CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*
  - CHPRC-00259, *MODFLOW and Related Codes Software Test Plan*
  - CHPRC-00260, *MODFLOW and Related Codes Requirements Traceability Matrix: CHPRC Build 6*
  - CHPRC-00261, *MODFLOW and Related Codes Acceptance Test Report: CHPRC Build 6*

5.1.3 MODFLOW & Related Codes Support Software

CHPRC-00257 distinguishes calculational software from supporting software because these two groups of software are classified and graded differently. The basis for the difference is that calculational software, including MODFLOW-2000-MST and MT3DMS-MST, calculate results that will be used to support decision-making and as such, constitute safety software graded to level C. In contrast, supporting software includes graphical interfaces, visualization, and input preparation support but not calculation of results that directly support decision-making, and are therefore not rated as safety software. The support software items identified in CHPRC-00258 and used in this calculation were:

- **Groundwater Vistas:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used graphical tools for model input/output review. Groundwater Vistas™ was used in pre-processing some input files.
- **PEST:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used pest utilities for changing formats of inputs and output files for ease of manipulation in creating figures for the report.
- **ArcGIS®:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used graphical tools for model input/output review. ArcGIS was used in pre-processing some input files and creating output graphics for the report.
- **TecPlot:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used to create graphics of the simulated output from MODFLOW-MST and MT3D-MST in order to develop figures for the report.

5.2 Software Installation and Checkout

Safety Software (MODFLOW-2000-MST and MT3DMS-MST) was checked out and installed in accordance with procedures specified in CHPRC-00259. Executable files were obtained from the Software Owner, installation tests identified in CHPRC-00259 were performed and confirmed, and Software Installation and Checkout Forms were completed and approved for installations used to perform model runs reported in this calculation. A copy of the Software Installation and Checkout Forms for the

authorized users and authorized workstations for software used that requires this documentation are provided in Attachment A to this ECF.

5.3 Statement of Valid Software Application

The preparers of this calculation attest that the software identified above, and used for the calculations described in this calculation, is appropriate for the application and used within the range of intended uses for which it was tested and accepted by CHPRC. Because MODFLOW-2000-MST and MT3DMS-MST are graded as Level C software, use of this software is logged in the HISI under the corresponding entries (Identification Numbers 2517 and 2518). These software items were used within the limitations identified in CHPRC-00257. Installations of the software are operating correctly, as demonstrated by installation testing performed on the Tellus Subsurface Modeling Platform and documented in the Software Installation and Checkout Form (Attachment A).

6 Calculation

Following the methodology detailed in Section 3, 4 sets of simulations were conducted to support the feasibility study of the 200 East. Each set of simulations included simulations for each of the eight COCs for the average initial condition, and simulations with continuing source terms for nitrate, technetium-99, and uranium. Thus, one set of simulations included 11 individual MT3D simulations. Simulations are assumed to start at the commencement of the P&T remediation. All scenarios were completed for a simulated duration of 50 years. The results of these simulations are discussed in Section 7.

6.1 Assessing Plume Migration for Existing Plumes

The simulation outputs from each of the simulations mentioned previously were processed to create a set of figures to illustrate the fate and transport of the simulated contaminants. The figures created include plan view contour maps at simulation time of 0, 1, 2, 5, 10, 15, 20, 25, 30, and 50 years and summary charts for the mean, 90th percentile, and maximum concentration for full domain of the model. An example of the figures shows results for the nitrate simulation for average concentration initial conditions in Figure 6.1 and 6.2. The following sections describe the information that can be obtained from these figures. The figures for the selected simulation sets conducted for this ECF are included in Attachment B.

6.1.1 Plan View Contours

Figure 6.1 shows plan view contour plots for the technetium-99 plume after 20 years of simulation. Several aspects of the figure help identify the simulations. There is a title in the upper right-hand corner that describes the scenario simulated and the time of year. In this case the simulation time is at 20 years. The title indicates that this simulation was for average initial concentration conditions, where no remediation action is considered for either BP-5 or PO-1 (e.g., No Action). The color ramp for the contours is designed that the first colored contour interval (light blue) represents concentrations between 0.5 and 1.0 times the cleanup level of 900 pCi/L for techneitium-99 and the second interval (darker blue) represents concentrations above the cleanup level. The concentrations shown are the maximum for any given location regardless of depth.

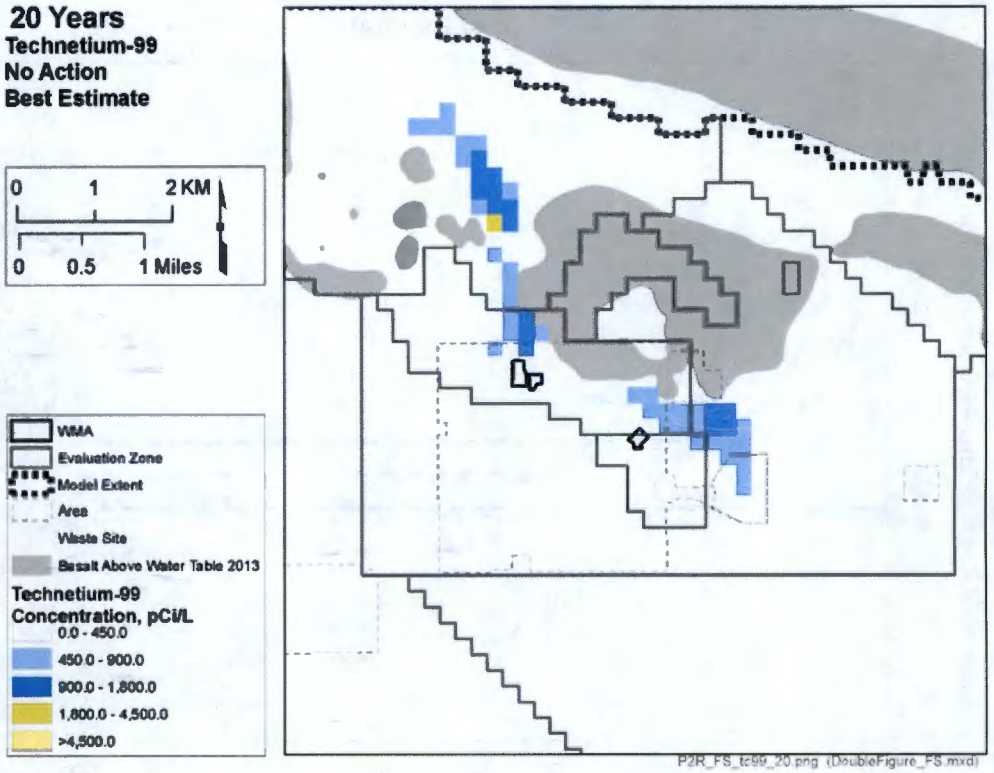

Figure 6.1 – Plan view contours of the nitrate plume at simulation time 20 years based on average concentration initial conditions.

6.1.2 Statistical Summary Chart

The charts shown in Figure 6.2 provide a statistical summary of the plume migration over the domain of the model. The charts indicate the contaminant concentration on the ordinate axis and simulation time in years on the abscissa. Figure 6.2 shows the mean, 90th percentile, peak concentration within the boundaries of the modeling area, and also shows the total area whose concentration exceeds the drinking water standard. The mean value represents an arithmetic mean concentration for all cells within the specified subregion or the entire model domain. The 90th percentile is estimated by tabulating all estimated concentration values, sorting the values, assigning a Weibull plotting position to determine rank, and selecting the concentration value corresponding to the 90th percentile value. The peak concentration is the concentration with the highest magnitude from any estimated concentration. In figures simulating a departure from the remedial evaluation case, the simulated results for the remedial evaluation case is shown in faint grey behind in order to provide a comparison to the no action scenario.

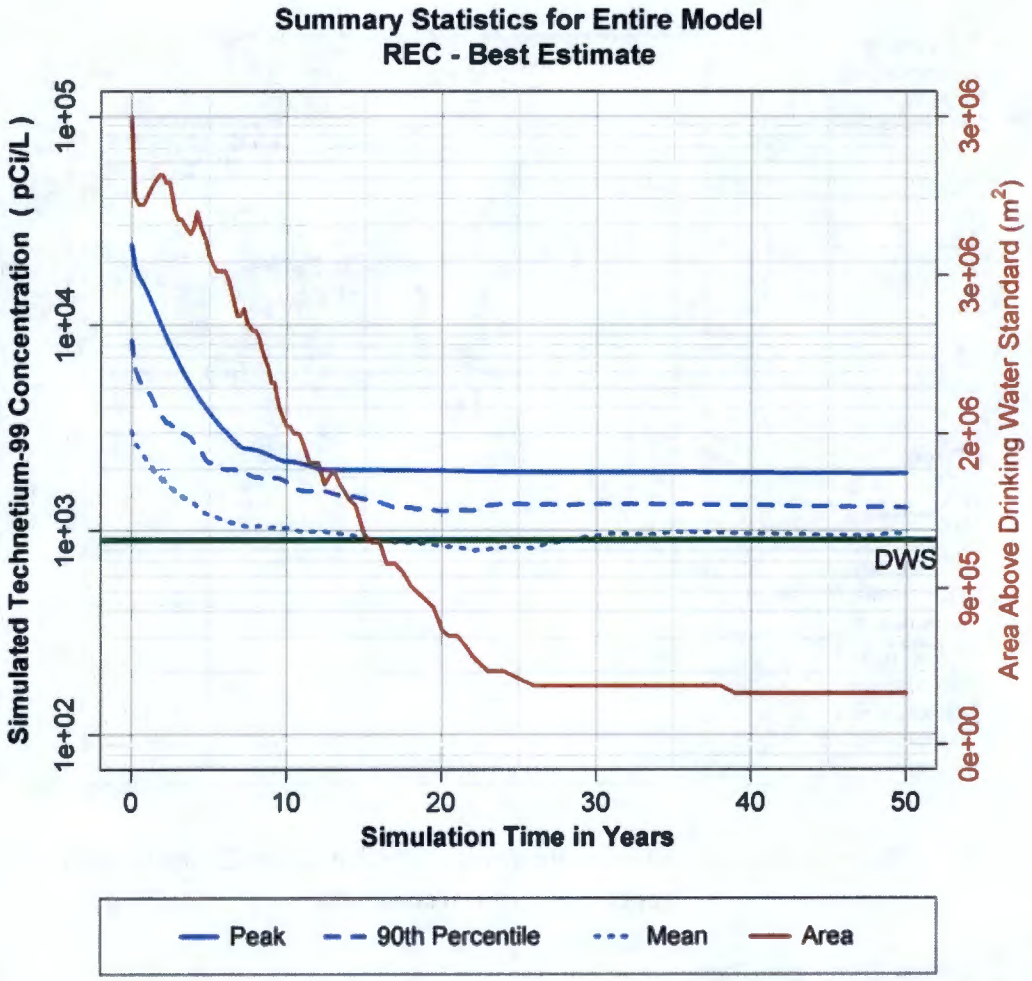

Figure 6.2 – Statistical summary of simulated concentration within subregions of the model domain for the cyanide plume for average concentration initial conditions.

7 Results

Four sets of simulations were conducted as part of the scenario analysis. The total number of F&T simulations for these simulation sets is 4. Plume maps and statistics plots are provided for technetium-99 and uranium. Extraction summaries are provided for all simulated constituents. Results from these simulations are documented in the figures and charts discussed in Attachment B.

Tables 7-1 through 7-4 were developed to provide a summary of the relative differences in time to clean up in years for the various scenarios executed as part of this ECF. Tables 7-1 through 7-4 show the time to cleanup based on 90th percentile concentration within their respective domains for the selected scenarios for the average concentration conditions without continuing sources. The domains for Tables 7-1 through 7-4 are as follows: B Complex Area, Waste Management Area C, B Plant (also refers to the Greater 200 East Area), and Gable Gap Area, respectively. These time to cleanup numbers were used to develop the FS for 200-BP-5 and 200-PO-1.

Table 7.1 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Complex Area.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	25	50*	25	32	1	50*	1	1
2	-250/0	23	31	27	32	1	32	1	1
3	-350/100	22	30	23	29	1	30	1	1
4	-425/100	7	26	16	25	1	9	1	1

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as "50*")

Table 7.2 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Waste Management Area C.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	5	19	23	50*	0	24	0	14
2	-250/0	6	18	1	50*	0	1	0	14
3	-350/100	6	18	17	50*	0	1	0	14
4	-425/100	7	18	1	50*	0	1	0	13

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as "50*")

Table 7.3 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Plant Area (including the Greater 200 East Area).

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	22	50*	50*	50*	50*	34	0	29
2	-250/0	5	33	50*	50*	50*	35	0	28
3	-350/100	5	35	50*	50*	50*	34	0	28
4	-425/100	5	37	50*	50*	50*	0	0	28

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as "50*")

Table 7.4 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Gable Gap Area.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	50*	0	50*	50*	50*	50*	0	0
2	-250/0	50*	0	50*	50*	50*	50*	0	0
3	-350/100	15	0	50*	50*	50*	9	0	0
4	-425/100	18	0	13	50*	50*	9	0	0

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as "50*")

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. 4, 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.

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CHPRC-00261, 2012, *MODFLOW and Related Codes Acceptance Test Report: CHPRC Build 6*, Rev. 5, CH2M Hill Plateau Remediation Company, Richland, Washington.

CP-57037, 2015, *Model Package Report: Plateau to River Groundwater Transport Model (Version 7.1)*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080149H.

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ECF-HANFORD-13-0037, 2014, *Development of Source Terms for Inclusion in Fate and transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080139H.

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. Available at: http://pubs.er.usgs.gov/usgspubs/ofr/ofr200092.

Mitchell, 1999, The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships.

Rumbaugh, James O. and Douglas B. Rumbaugh, 2007, *Guide to Using Groundwater Vistas, Version 5*, Environmental Simulations, Inc.

SSPA, 2012a, *Documentation for: MODFLOW-2000-SSPA Build 006 Modifications and options added to MODFLOW-2000*, S.S. Papadopulos and Associates, Inc. Bethesda, Maryland.

SSPA, 2012b, *Documentation for: MT3DMS-SSPA Build 006 Modifications and options added to MT3DMS*, S.S. Papadopulos and Associates, Inc. Bethesda, Maryland.

Zheng, C. and P. P. Wang, 1999, *MT3DMS, A Modular Three-Dimensional Multi-Species Transport Model for Simulation of Advection, Dispersion and Chemical Reactions Of Contaminants in Groundwater Systems; Documentation and User's Guide*, U.S. Army Engineer Research and Development Center Contract Report SERDP-99-1, Vicksburg, MS, 202 p. Available at: https://hydro.geo.ua.edu/mt3d/mt3dmanual.pdf.

Attachment A

Software and Installation Checkout Form

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: MODFLOW & Related Codes Software Version No.: Bld 6

EXECUTABLE INFORMATION:

2. Executable Name (include path):

MD5 sums of executable files tested:

```
c2d687beee9d58dc615995ce8220d9ea [redacted]/bin/mf2k-chprc06sp.x
e396d1c03769a966f529b2480bd17c26 [redacted]/bin/mf2k-chprc06dp.x
ae88adlee47b2a368716d9c12294b73a [redacted]/bin/mf2k-mst-chprc06sp.x
80429a2d296461a6b69425b0f9e25077 [redacted]/bin/mf2k-mst-chprc06dp.x
69cc646caea7dba83b2eb44a9fafed8d [redacted]/bin/mt3d-mst-chprc06sp.x
4795224002dba418ebe47aa507fcac42 [redacted]/bin/mt3d-mst-chprc06dp.x
```

3. Executable Size (bytes): Uniquely identified by MD5 signatures listed above.

COMPILATION INFORMATION:

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

WD56054 (PNNL Property System); RANSAC Linux Cluster

5. Operating System (include version number):

Red Hat Enterprise Linux WS 3 (Taroon Update 7)

INSTALLATION AND CHECKOUT INFORMATION:

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

Tellus Modeling Platform

7. Operating System (include version number):

Linux
2.6.18-308.4.1.el5 #1 SMP Tue Apr 17 17:08:00 EDT 2012 x86_64 x86_64 x86_64 GNU/Linux

8. Open Problem Report? (●) No ( ) Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]bin

10. Procedure(s):

CHPRC-00259 Rev 2, MODFLOW and Related Codes Software Test Plan

11. Libraries:

N/A (static linking)

12. Input Files:

Test suite per CHPRC-00259 Rev. 2 installed in [redacted]/test/modflow/build-6/

13. Output Files:

Test results in [redacted]/test/modflow/build-6;
Results summarized in log file run-install-tests-all-nodes.log

14. Test Cases:

MF-ITC-1 (both standard and MST versions of MODFLOW); single & double precision versions
MT-ITC-1 run single & double precision versions

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: MODFLOW and Related Codes — Software Version No.: Bld 6

14. Test Cases:

MF-ITC-1 (both standard and MST versions of MODFLOW); run both single & double precision
MT-ITC-1 run for single and double precision, multiple solvers

15. Test Case Results:

Exact match for MF2K and MF2K-MST executable files and single-precision MT3DMS-MST single-precision executable file. A minor text difference was detected in MT3DMS-MST double-precision output was evaluated and found insignificant. All tests are rated PASS.

16. Test Performed By: WE Nichols

17. Test Results: (●) Satisfactory, Accepted for Use ( ) Unsatisfactory

18. Disposition (include HISI update):

This supercedes prior installation test of CHPRC Build 6 of these executables performed to revalidate this installation following OS upgrade (configuation change).

Prepared By:

19.	[redacted]	WE Nichols	
	Sign	Print	Date

20. Test Personnel:

Sign	WE Nichols Print	Date
Sign	Print	Date
Sign	Print	Date

Approved By:

21.	N/R (CHPRC-00258 Rev. 2)	
Software SME (Signature)	Print	Date

A-6005-149 (REV 0)

Attachment B

Simulation results from Selected P&T Scenarios

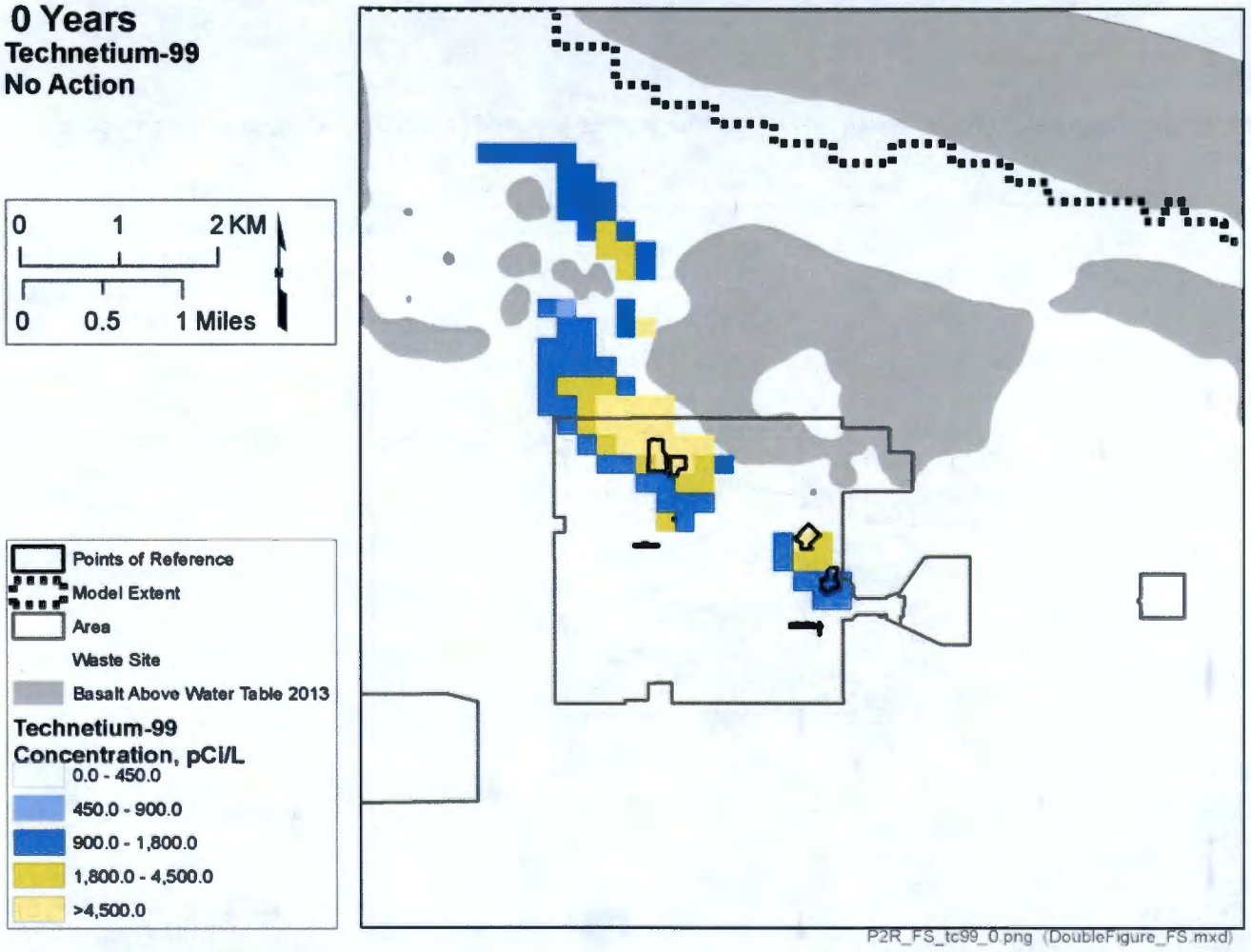

Figure B-1 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the remedial evaluation case simulation.

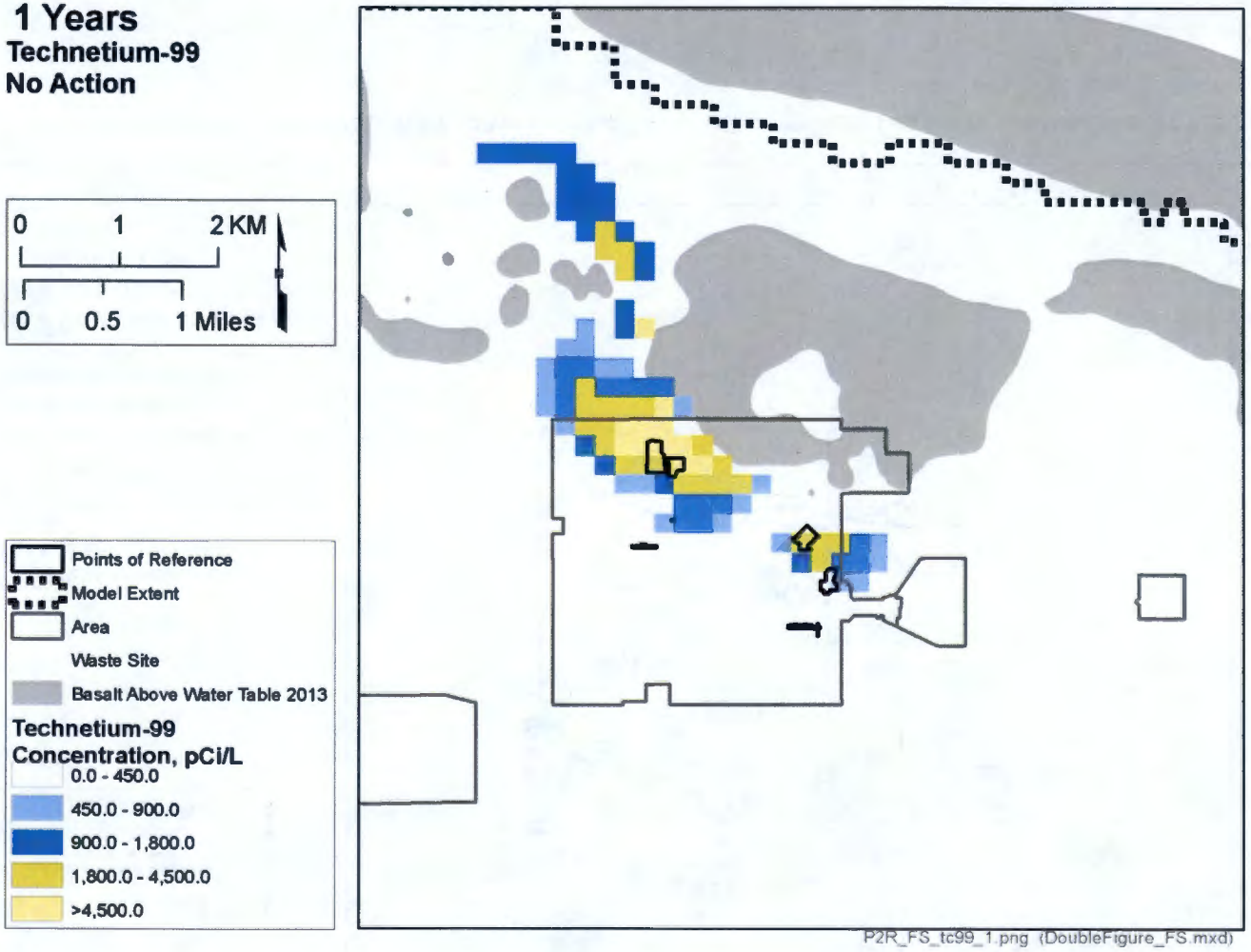

Figure B-2 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the remedial evaluation case simulation.

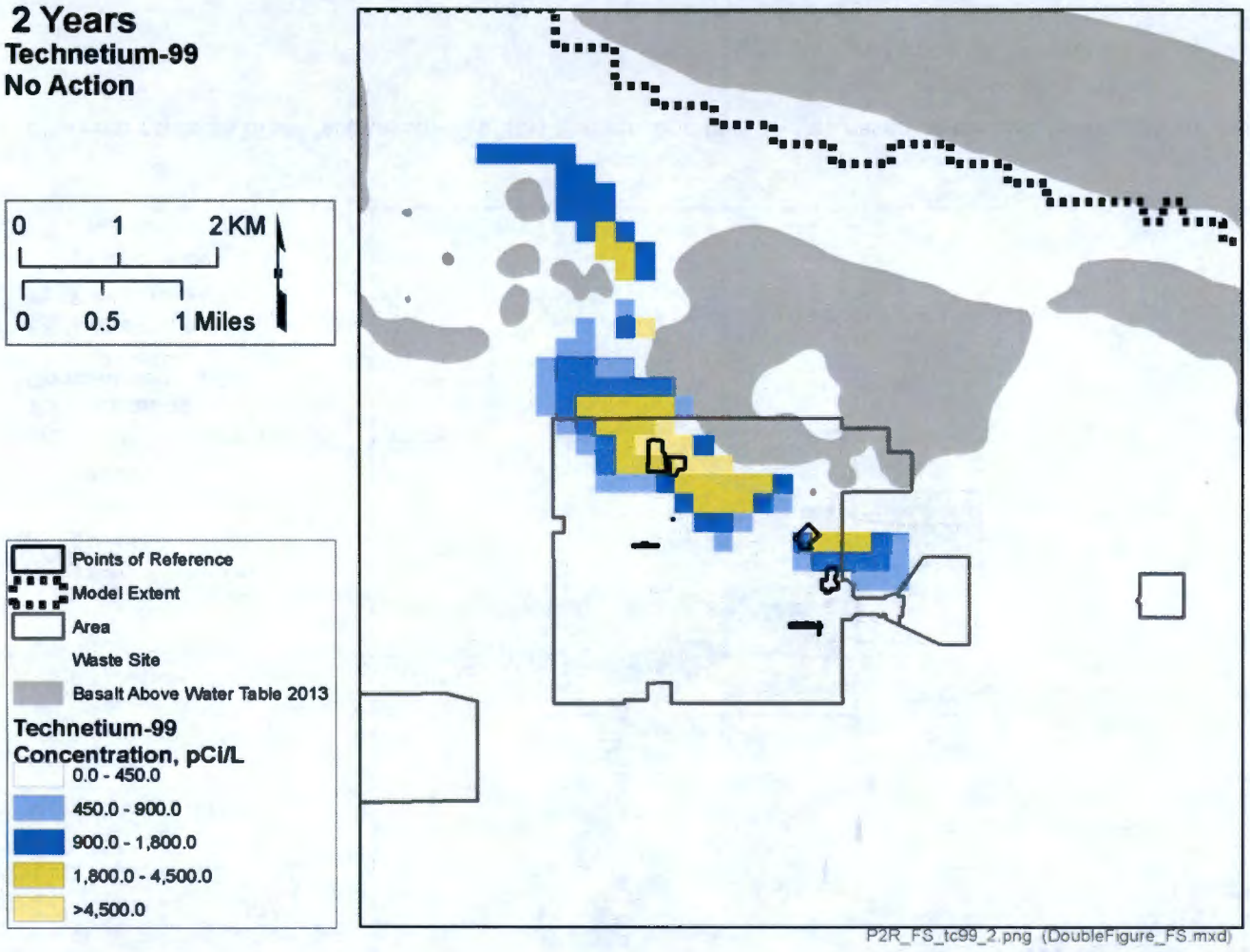

Figure B-3 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the remedial evaluation case simulation.

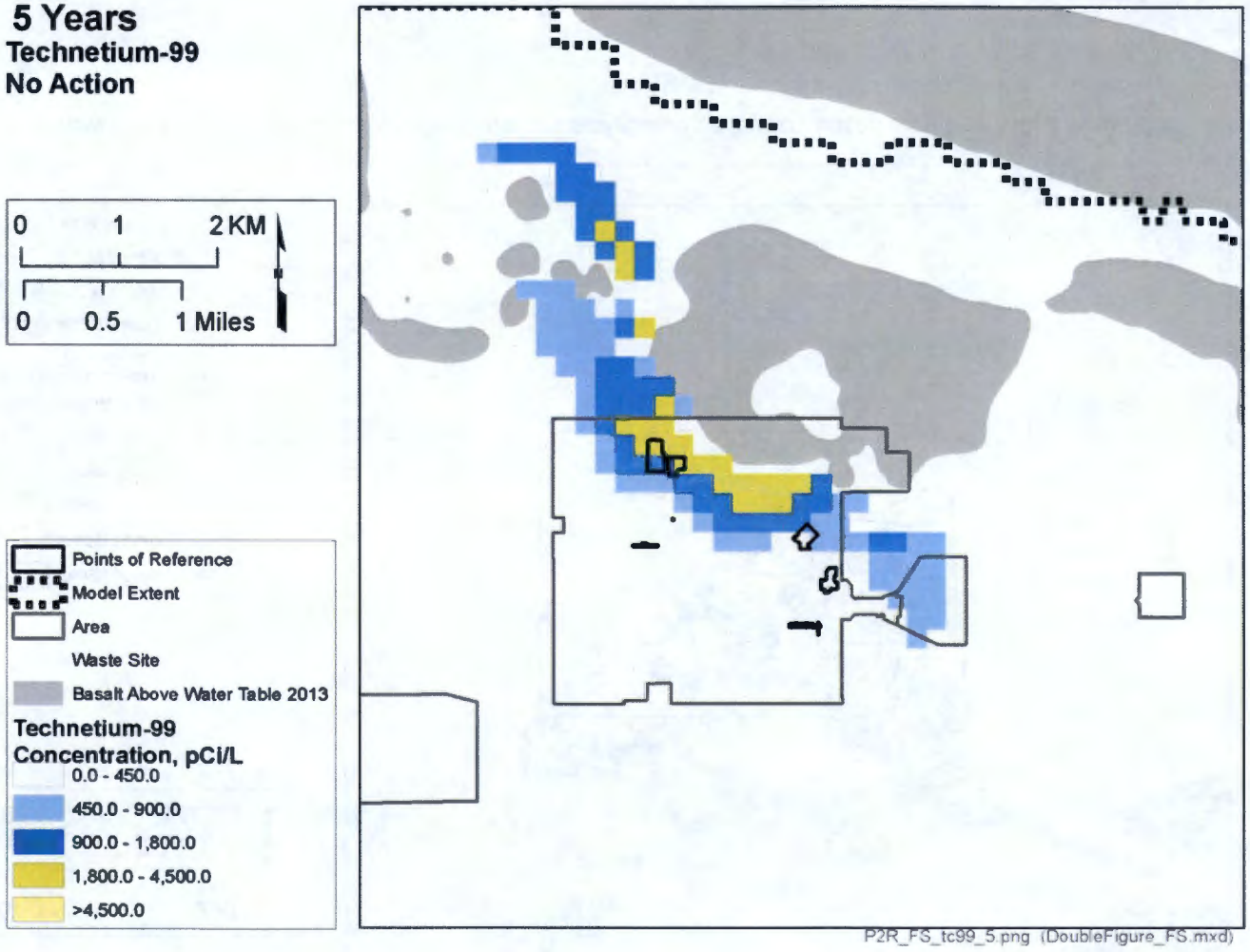

Figure B-4 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the remedial evaluation case simulation.

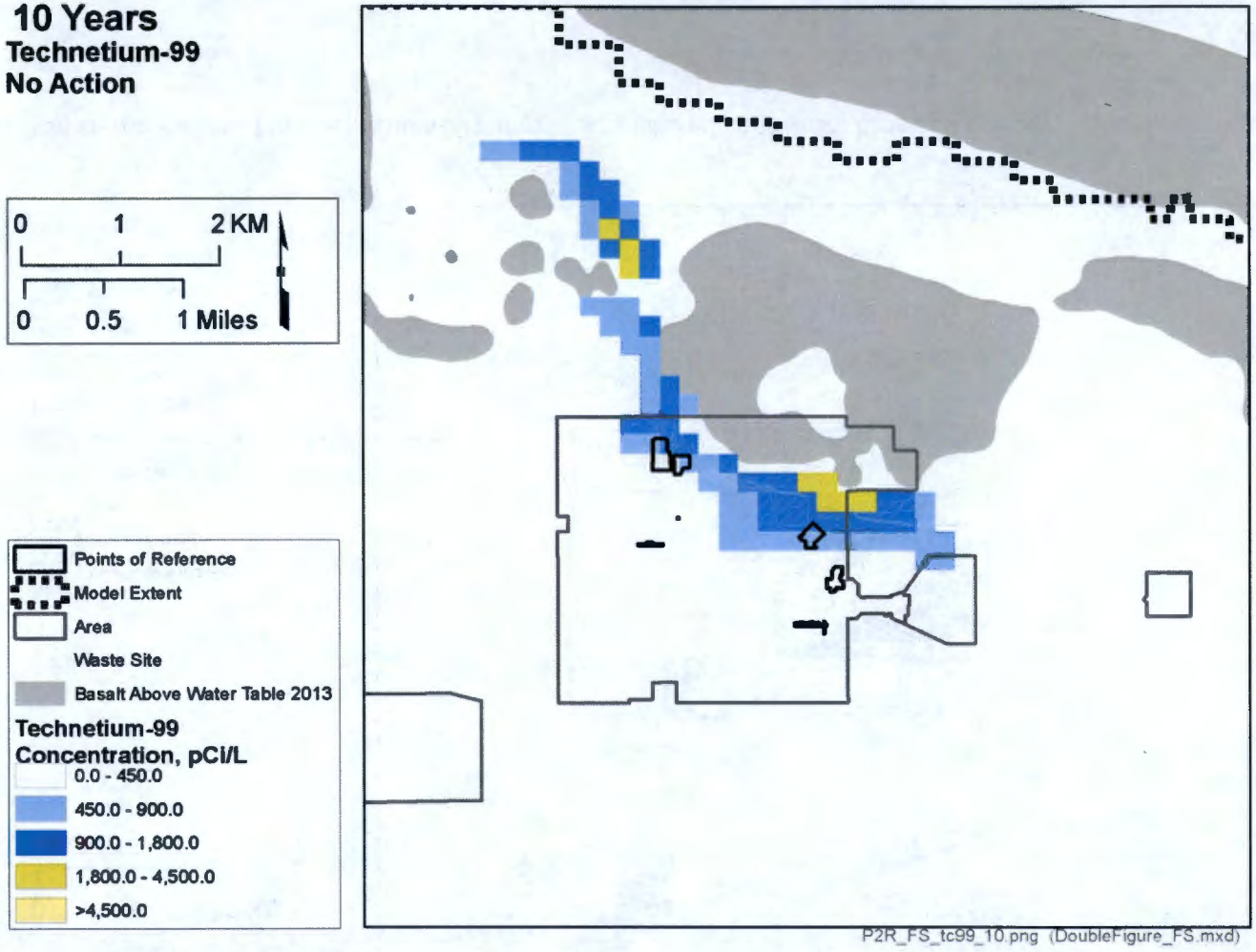

Figure B-5 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the remedial evaluation case simulation.

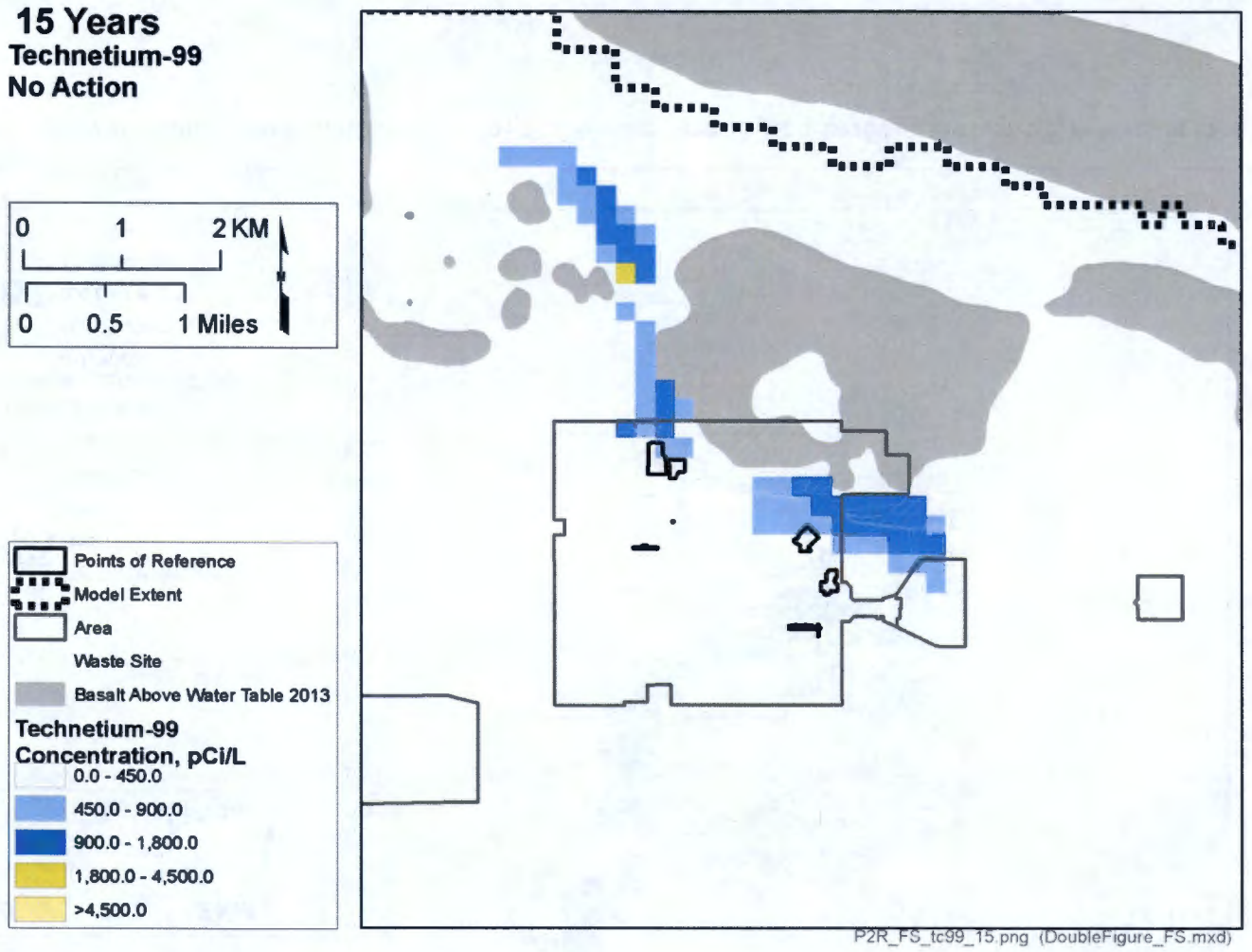

Figure B-6 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the remedial evaluation case simulation.

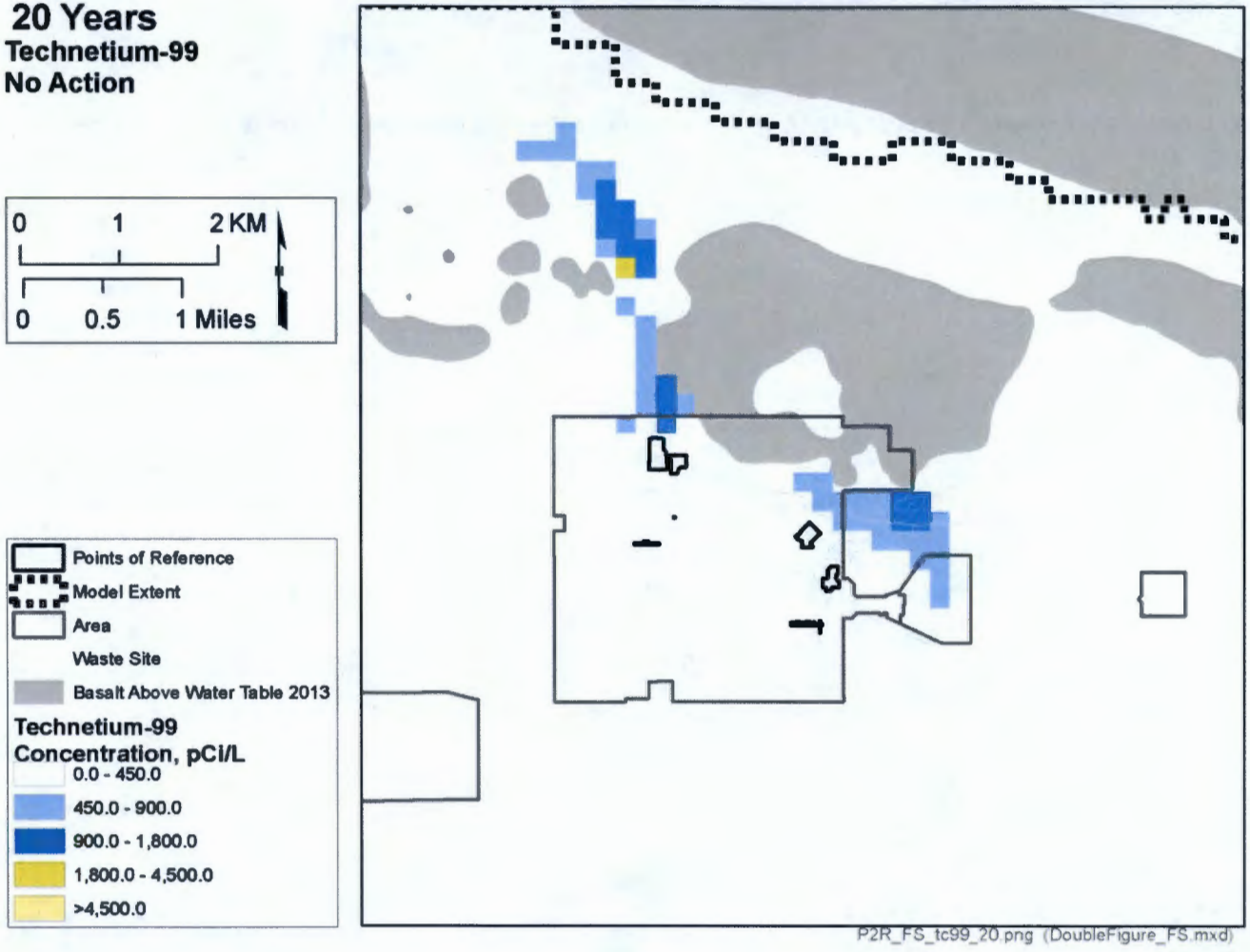

Figure B-7 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the remedial evaluation case simulation.

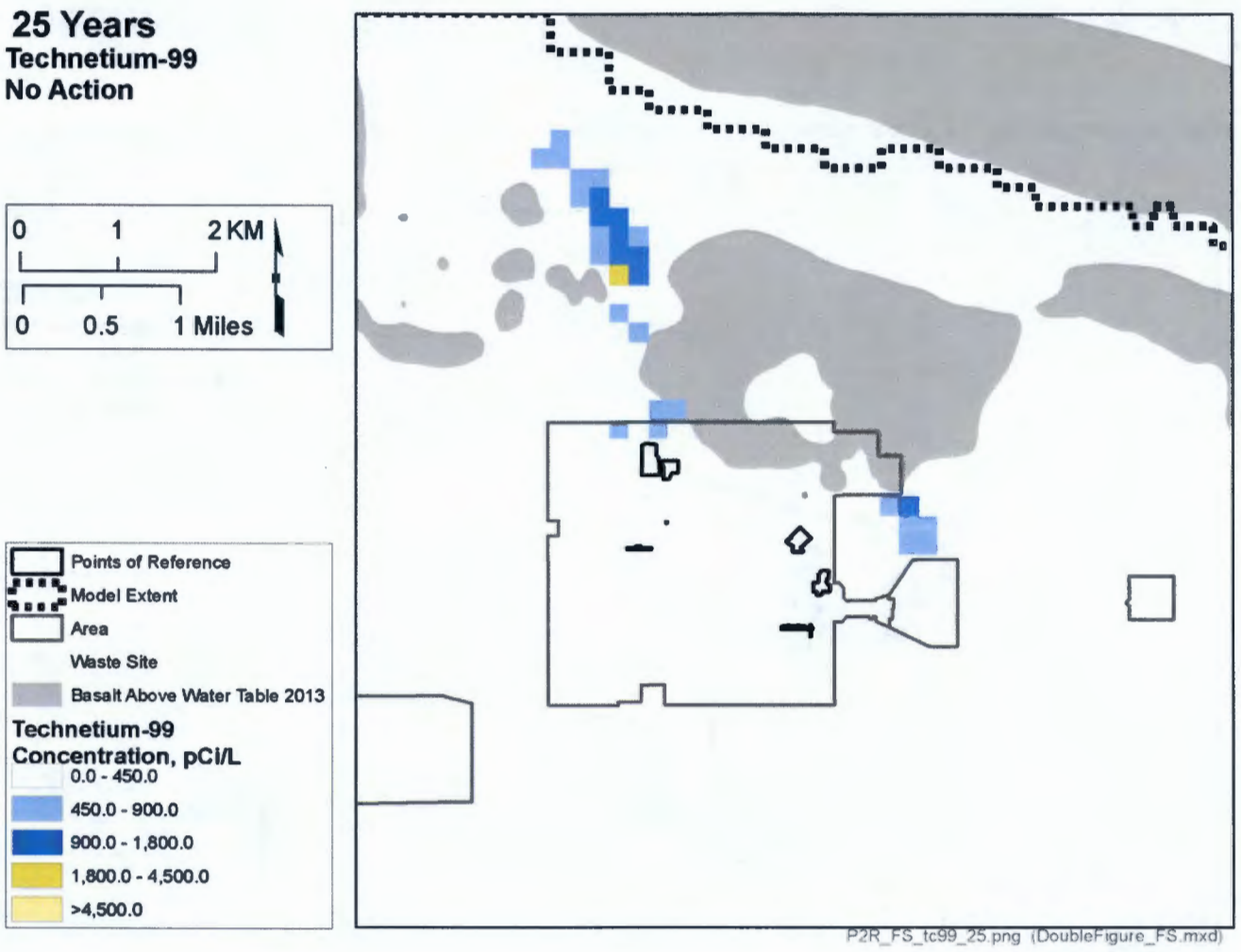

Figure B-8 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the remedial evaluation case simulation.

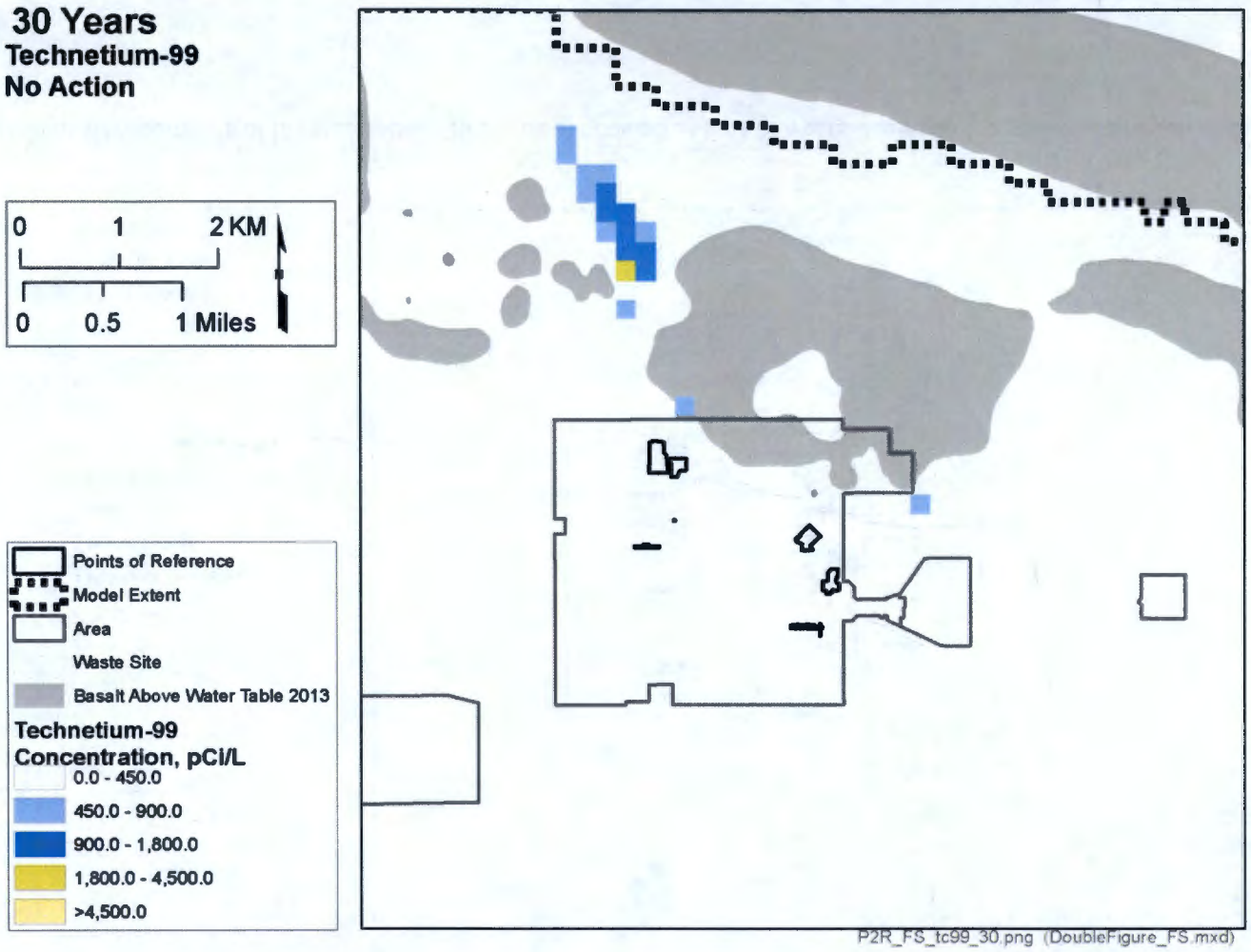

Figure B-9 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the remedial evaluation case simulation.

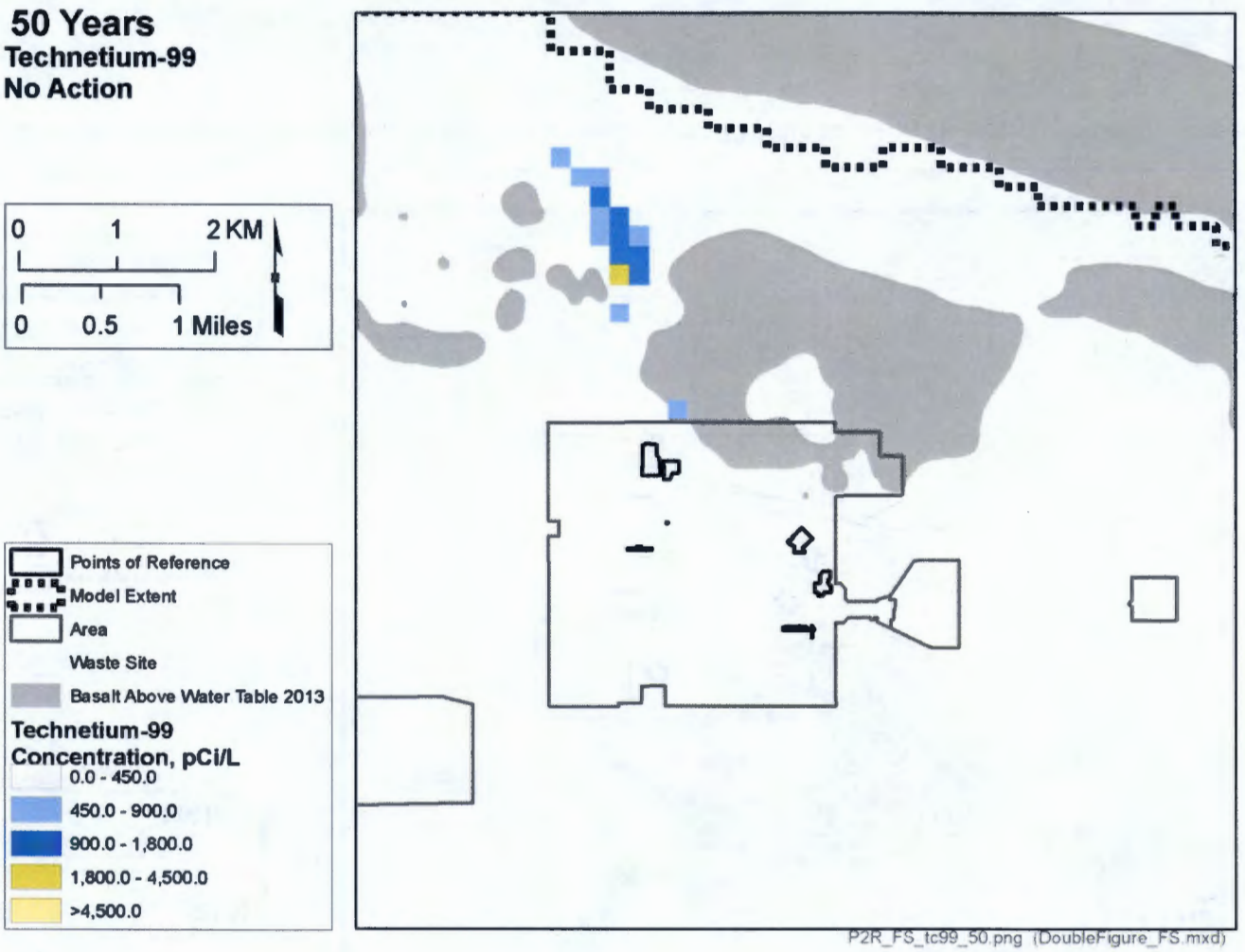

Figure B-10 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the remedial evaluation case simulation.

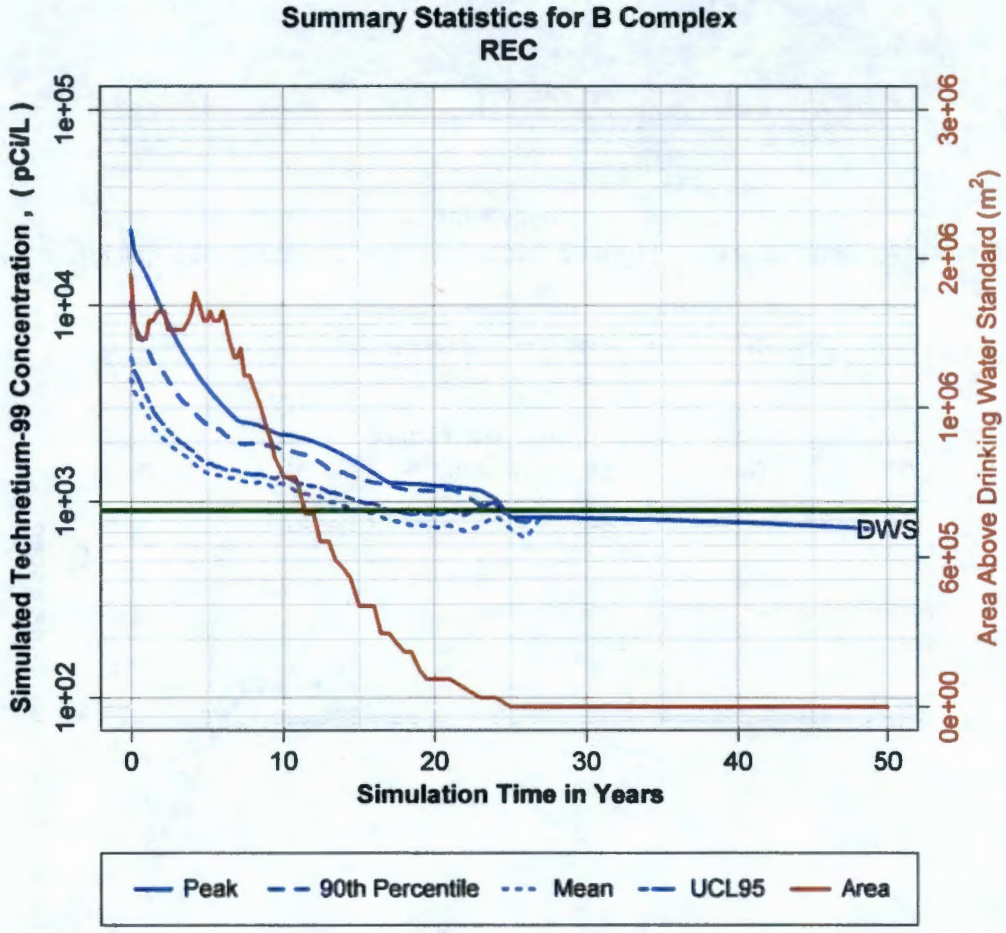

Figure B-11 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

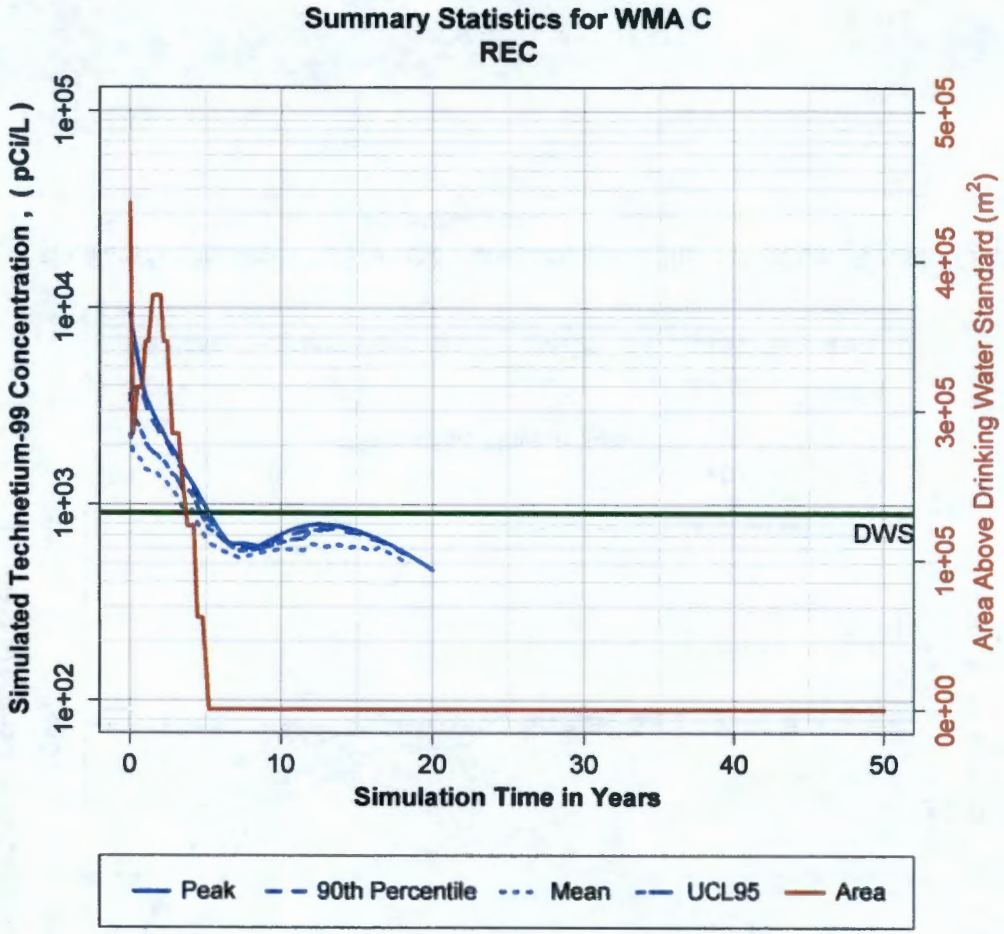

Figure B-12 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

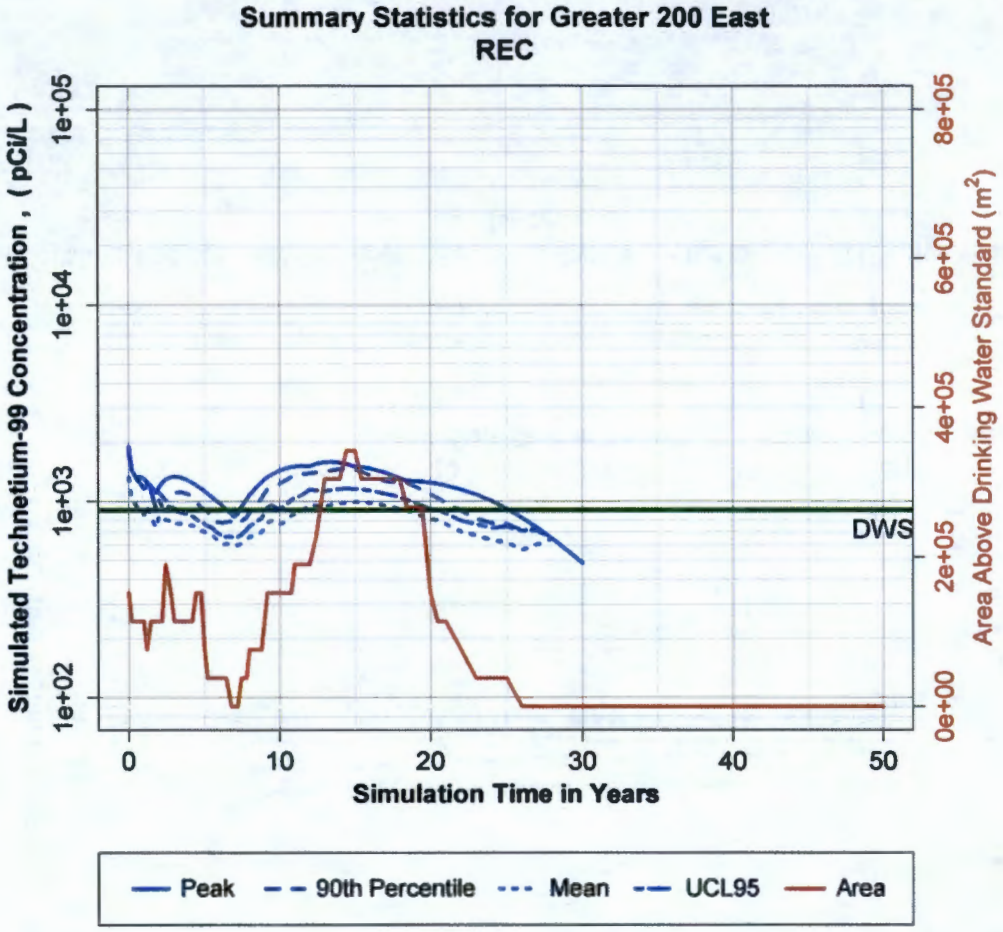

Figure B-13 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

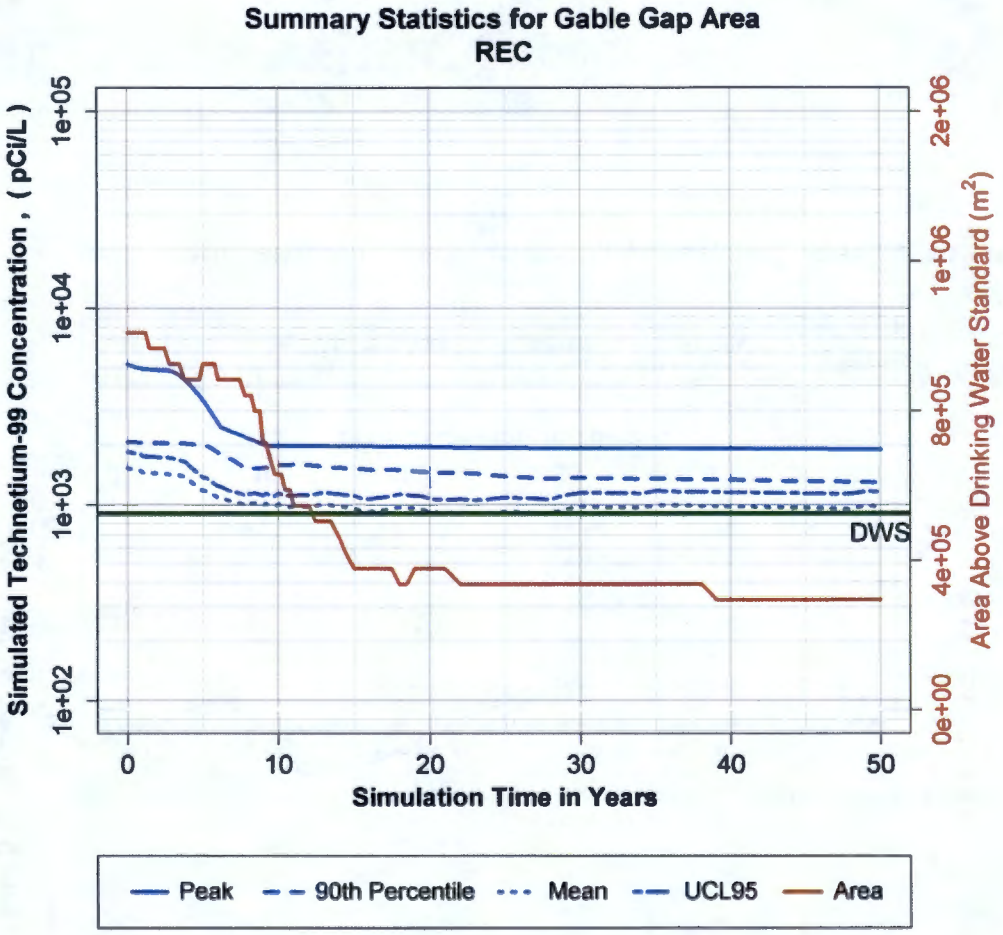

Figure B-14 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

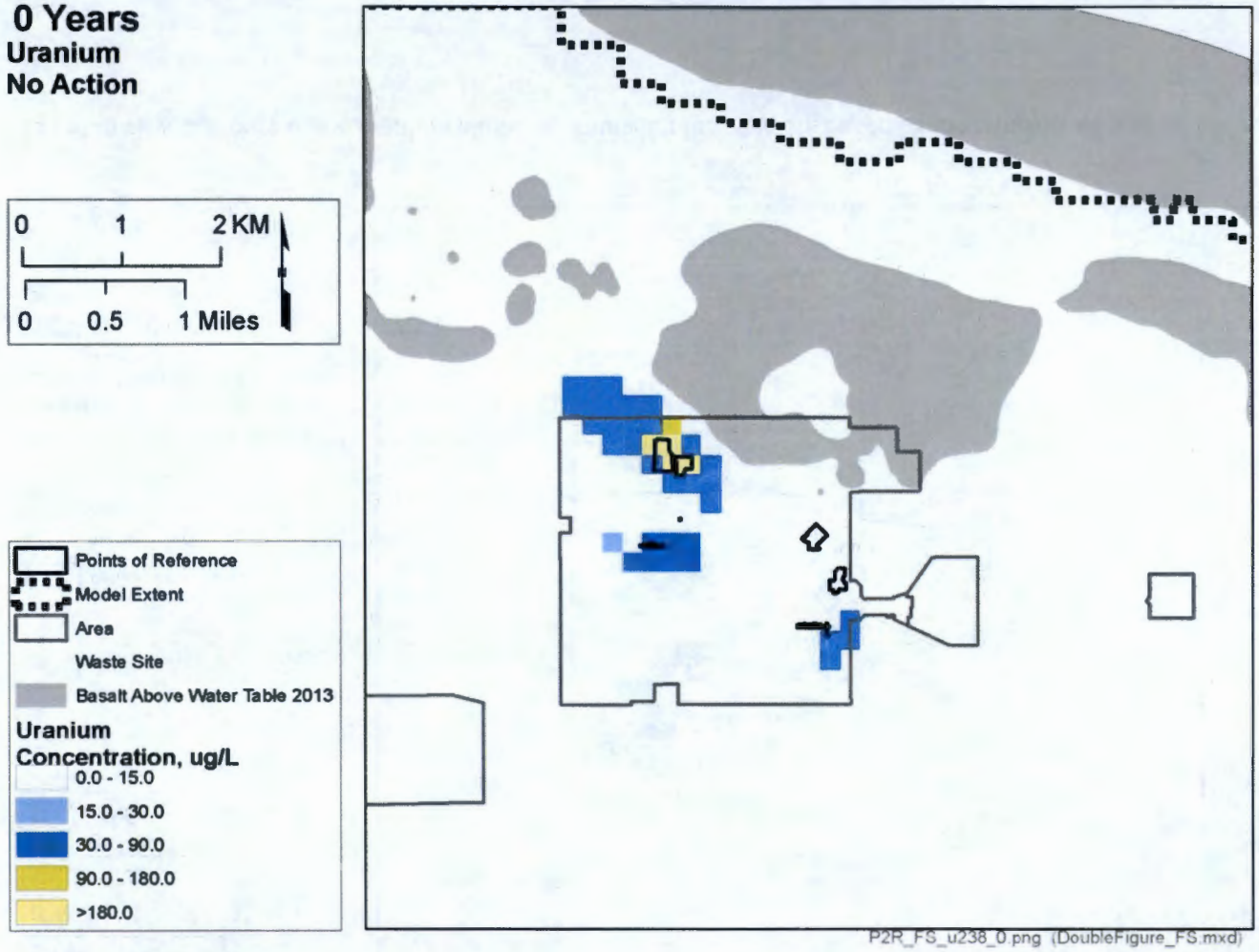

Figure B-15 - Plan view contours of the uranium plume at simulation time 0 years based on the remedial evaluation case simulation.

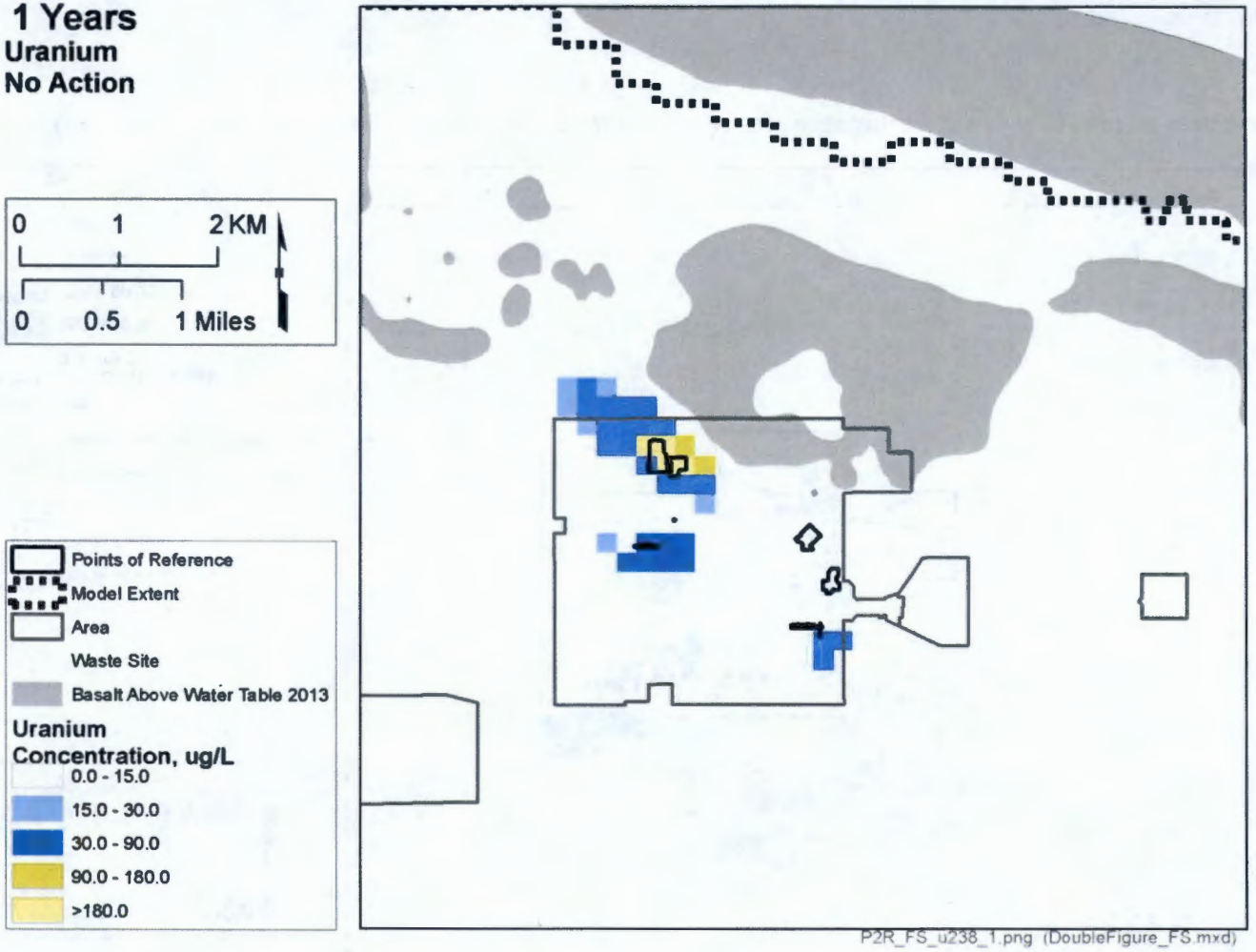

Figure B-16 - Plan view contours of the uranium plume at simulation time 1 years based on the remedial evaluation case simulation.

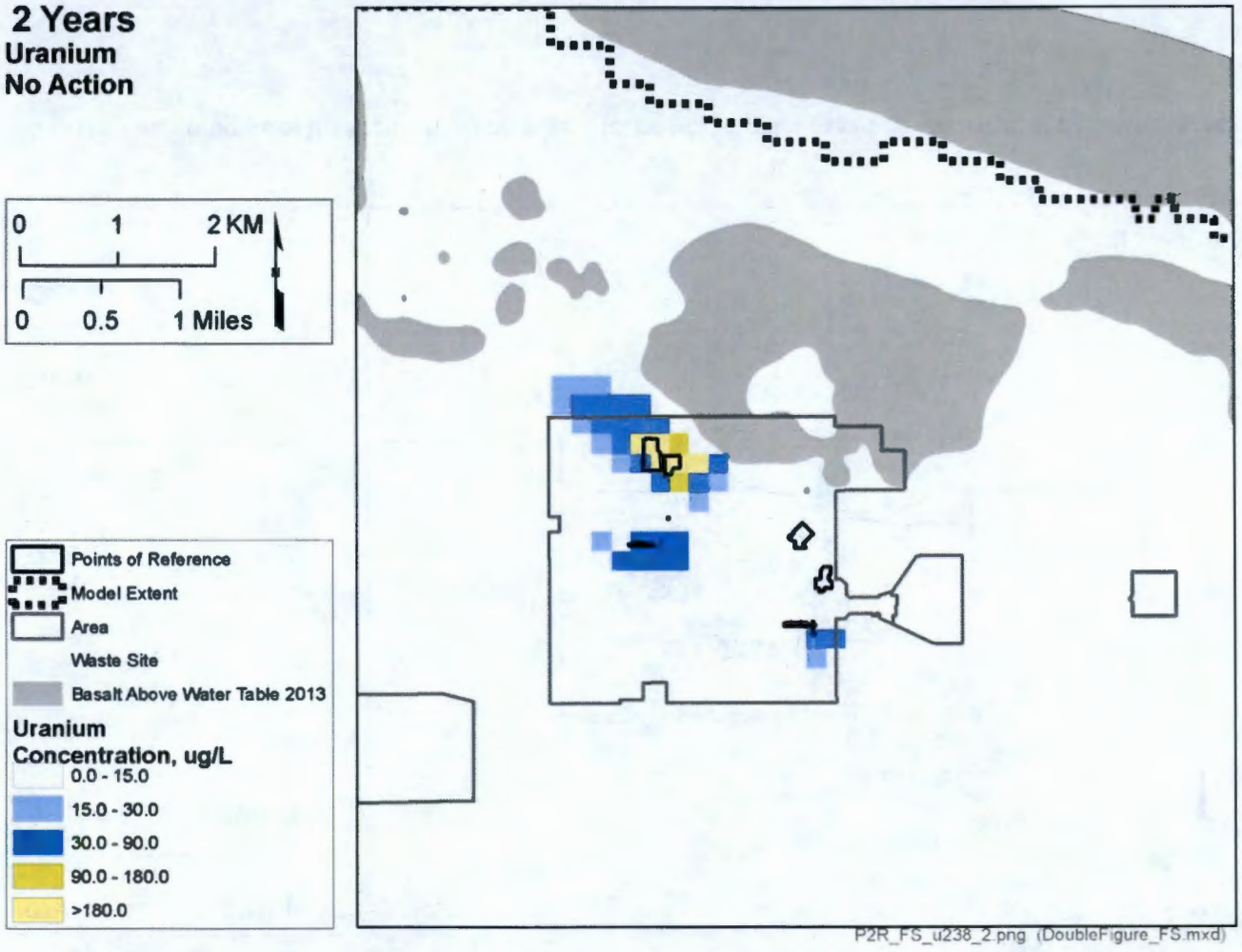

Figure B-17 - Plan view contours of the uranium plume at simulation time 2 years based on the remedial evaluation case simulation.

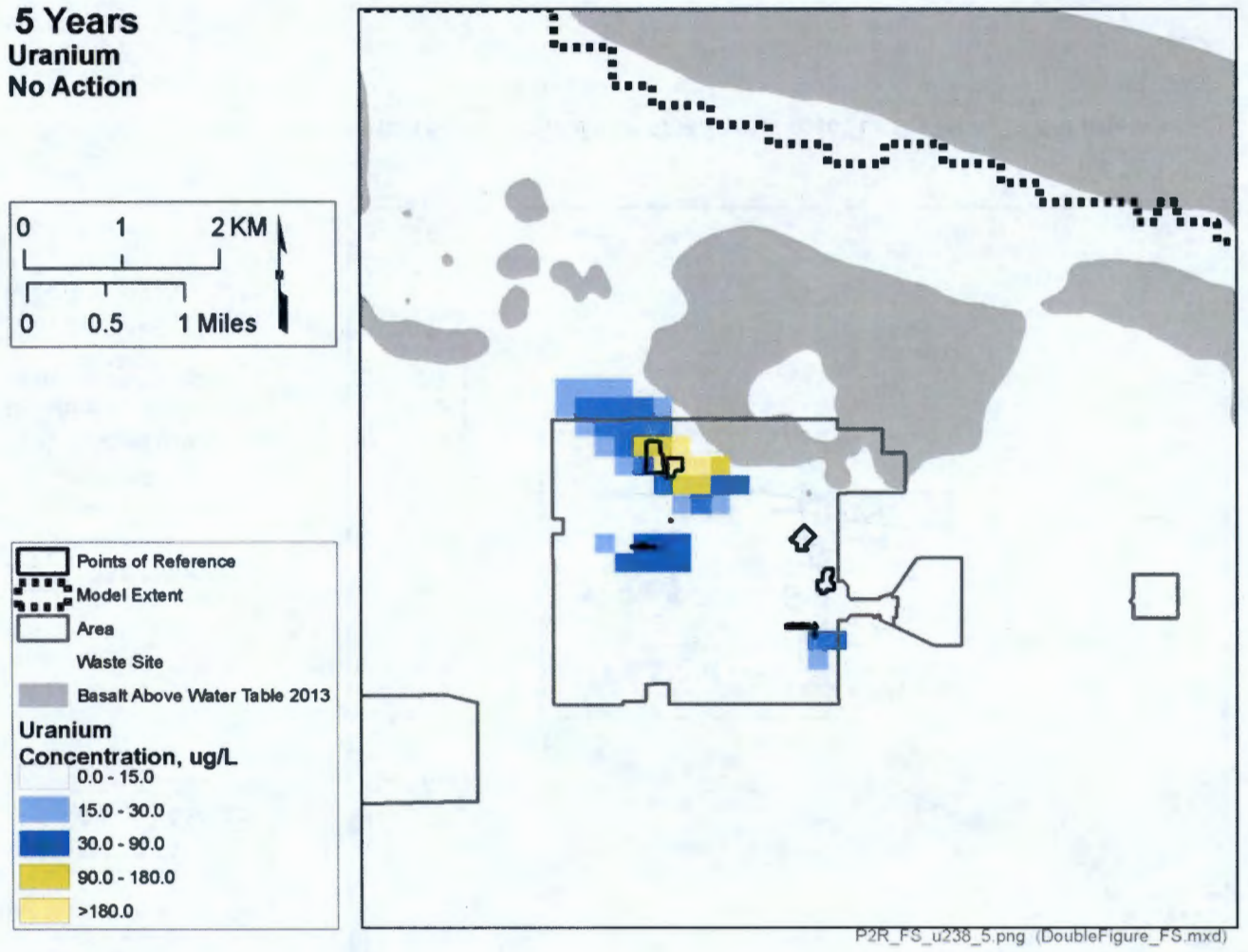

Figure B-18 - Plan view contours of the uranium plume at simulation time 5 years based on the remedial evaluation case simulation.

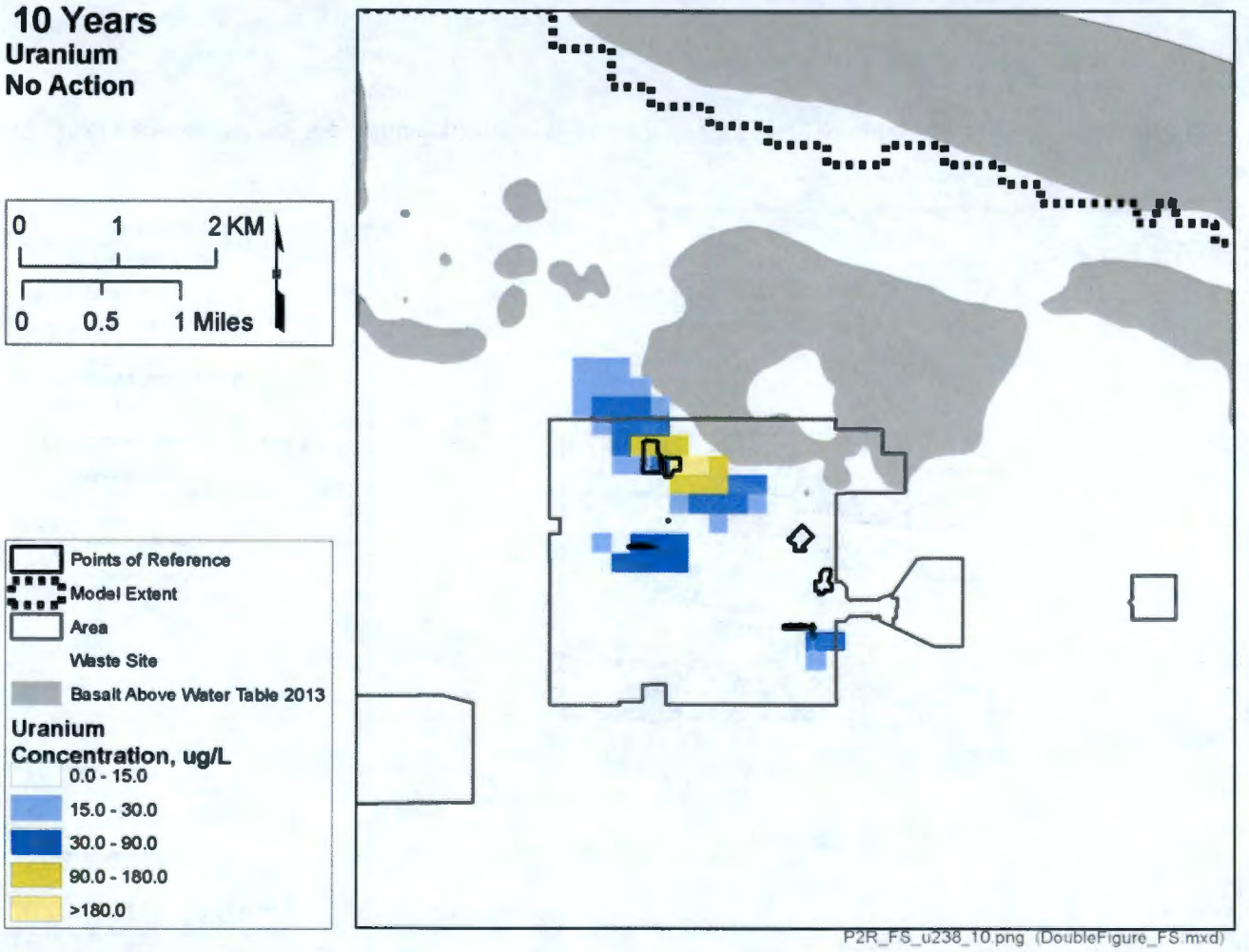

Figure B-19 - Plan view contours of the uranium plume at simulation time 10 years based on the remedial evaluation case simulation.

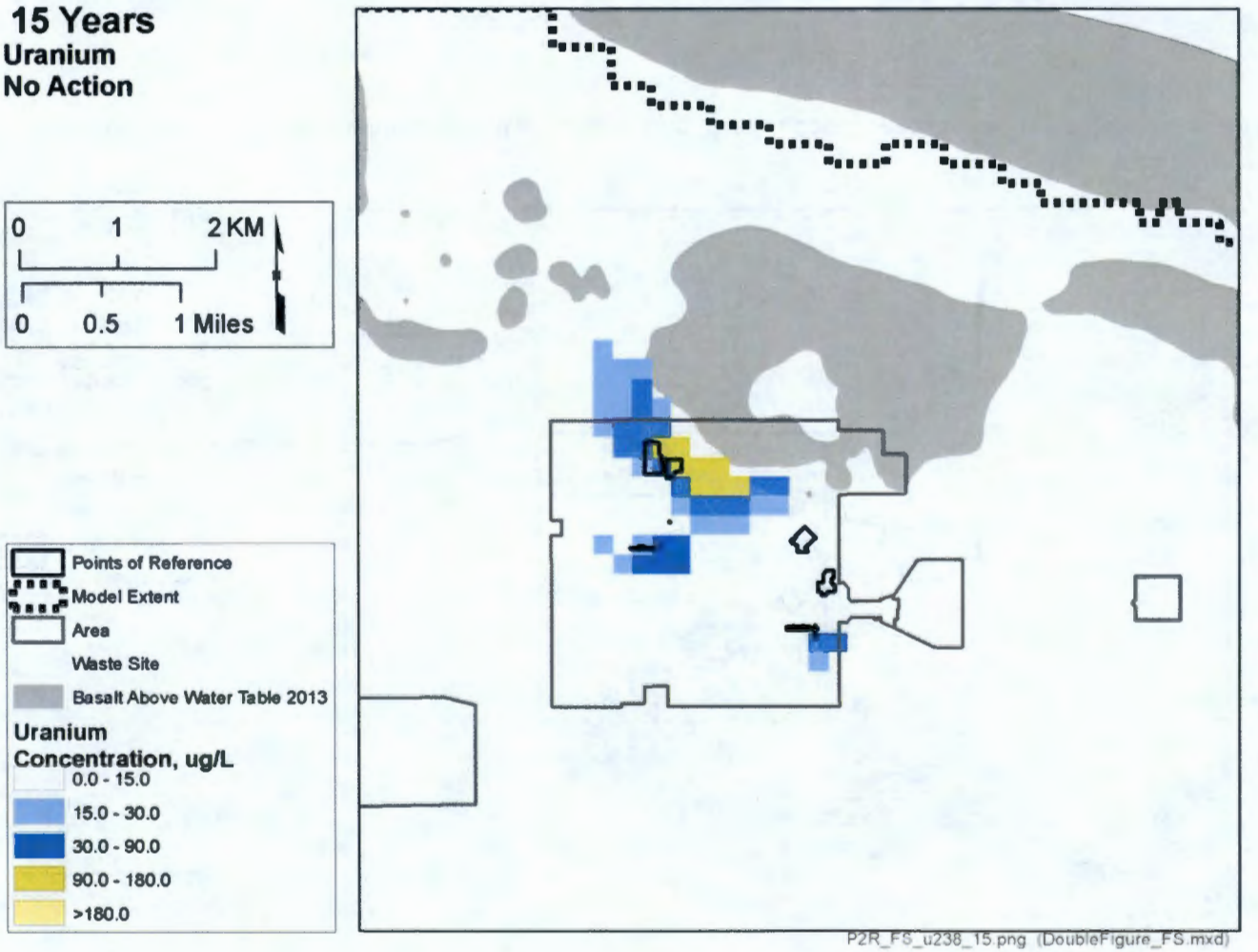

Figure B-20 - Plan view contours of the uranium plume at simulation time 15 years based on the remedial evaluation case simulation.

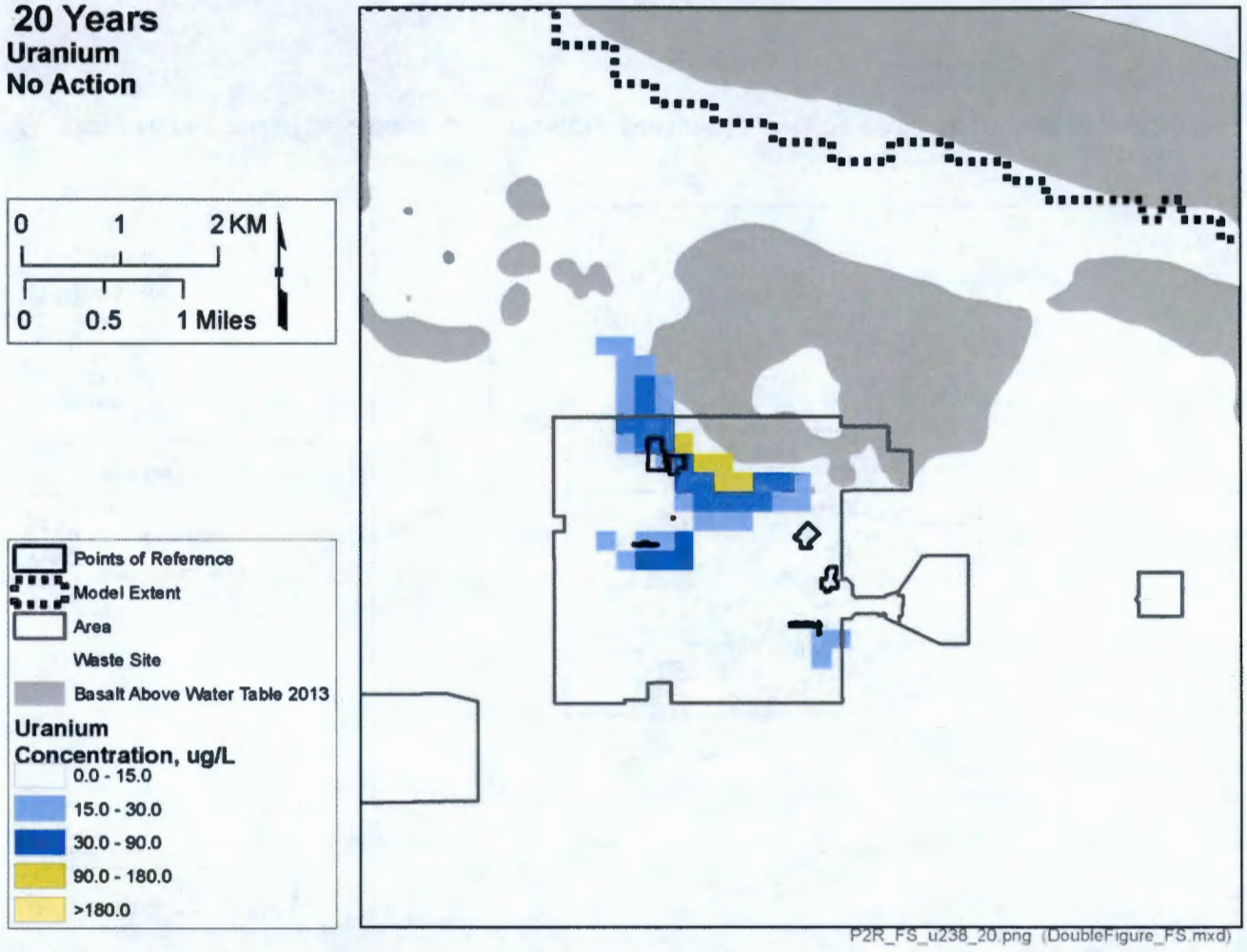

Figure B-21 - Plan view contours of the uranium plume at simulation time 20 years based on the remedial evaluation case simulation.

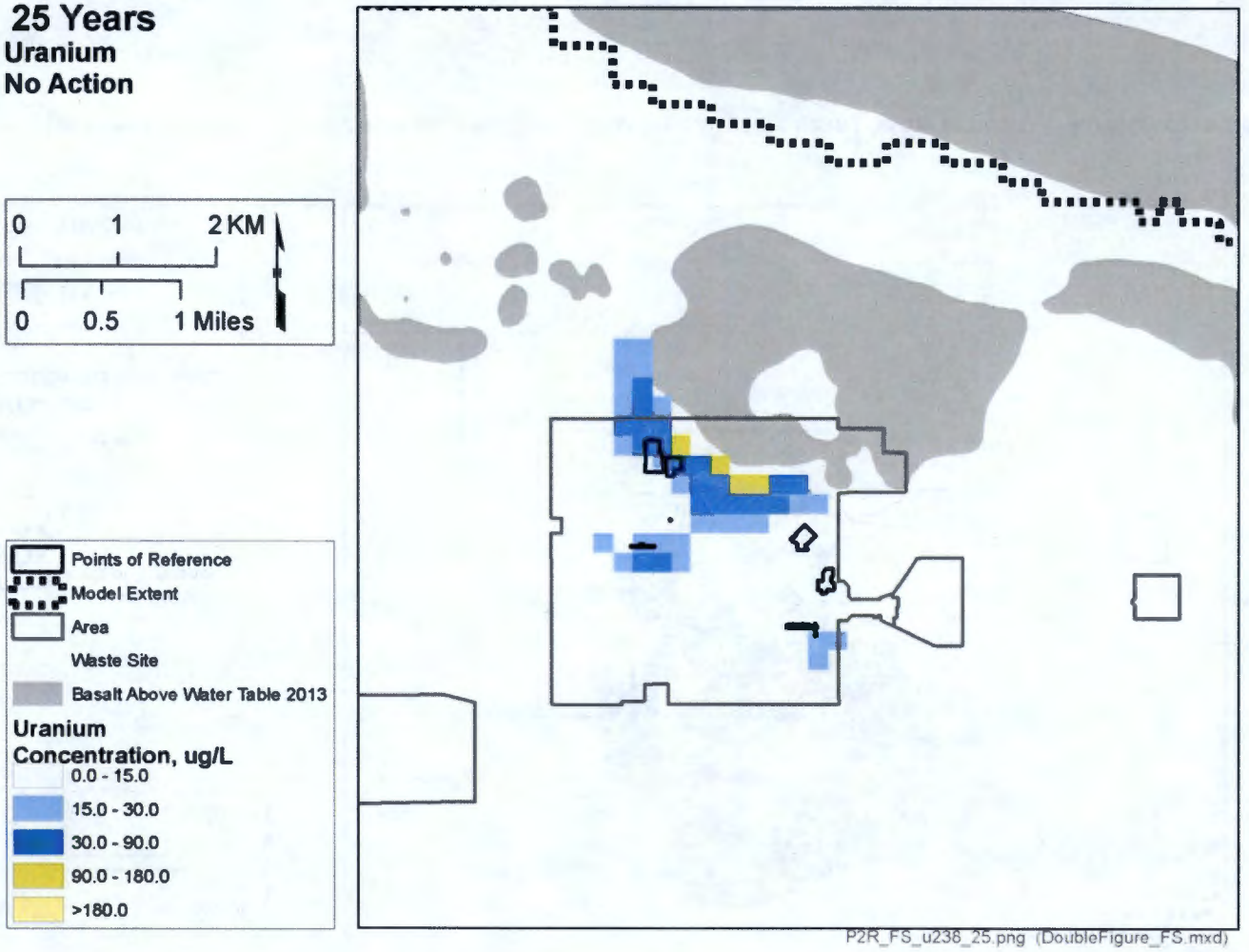

Figure B-22 - Plan view contours of the uranium plume at simulation time 25 years based on the remedial evaluation case simulation.

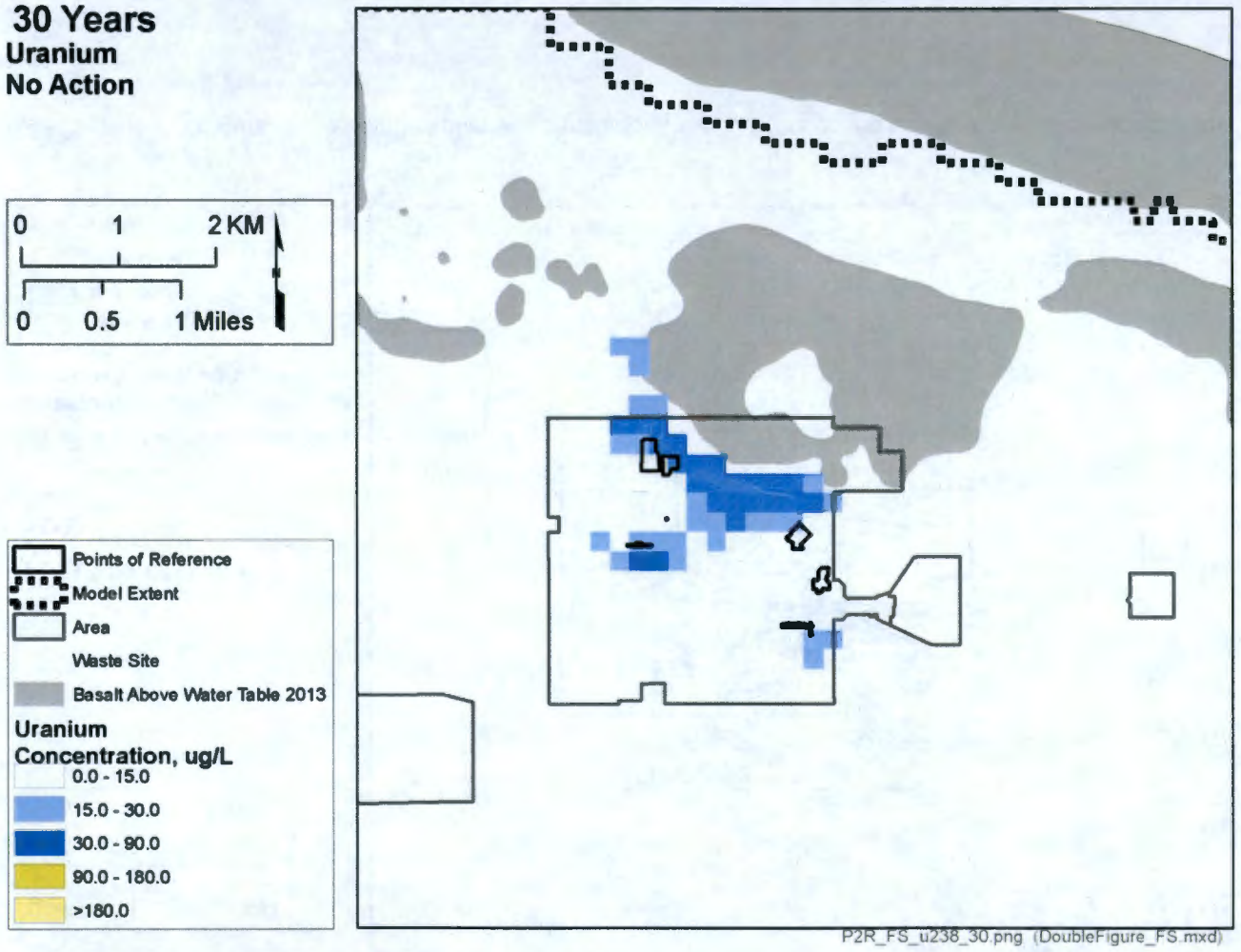

Figure B-23 - Plan view contours of the uranium plume at simulation time 30 years based on the remedial evaluation case simulation.

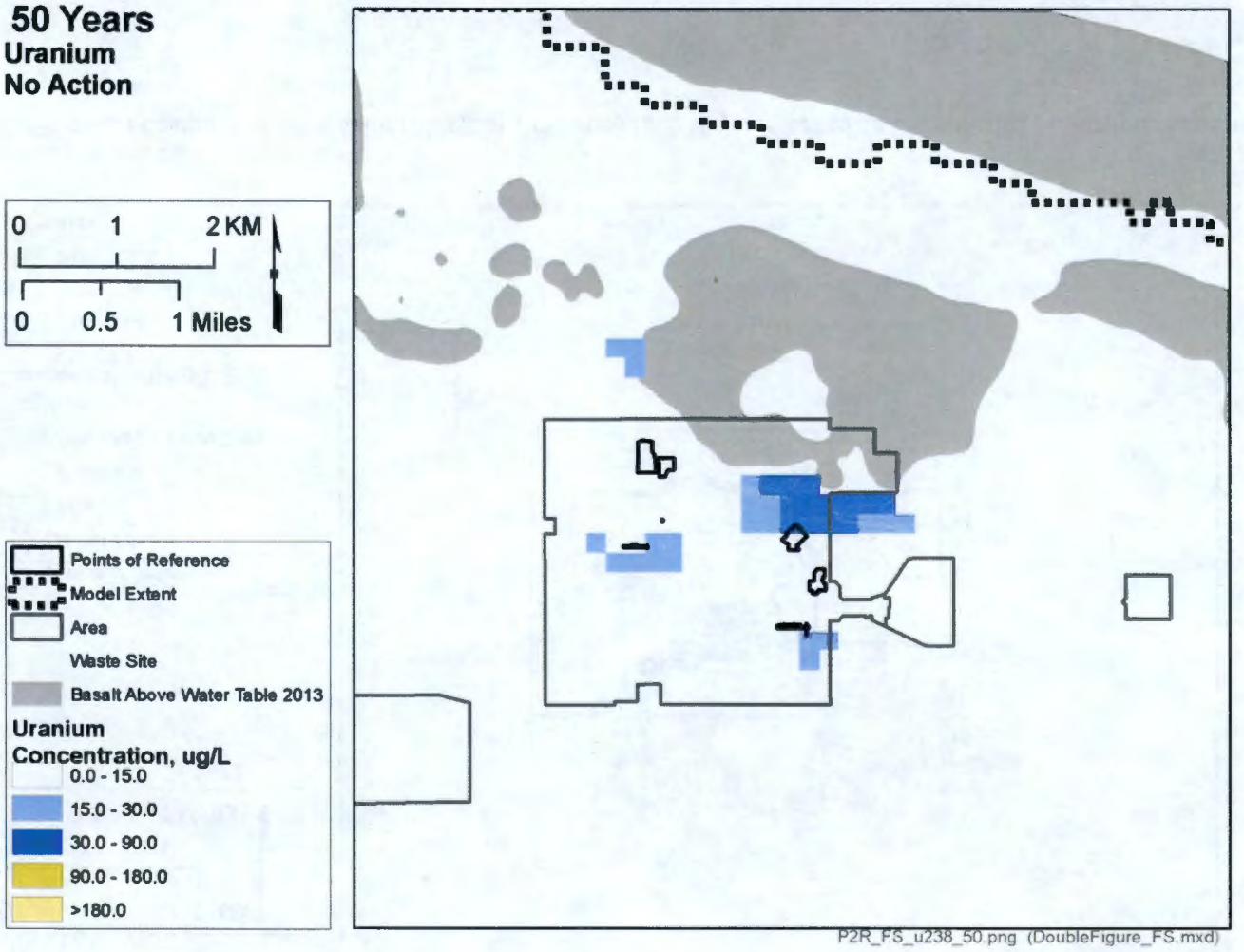

Figure B-24 - Plan view contours of the uranium plume at simulation time 50 years based on the remedial evaluation case simulation.

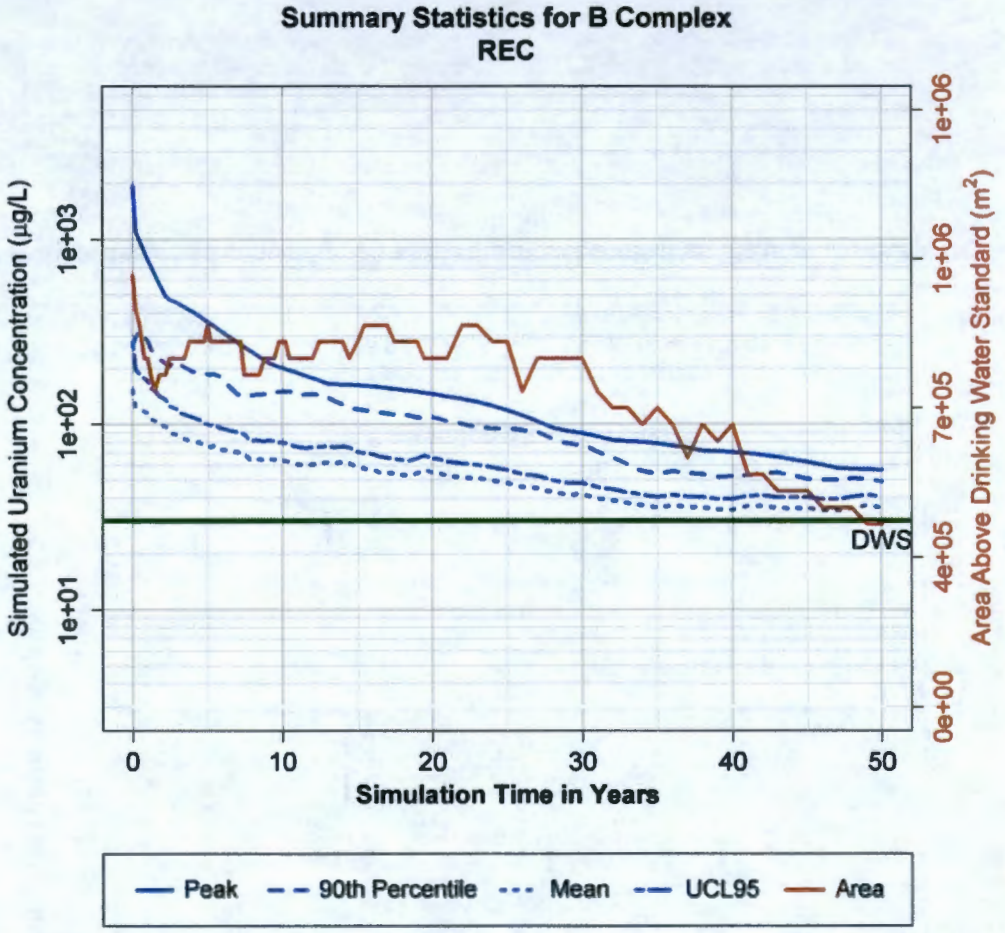

Figure B-25 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

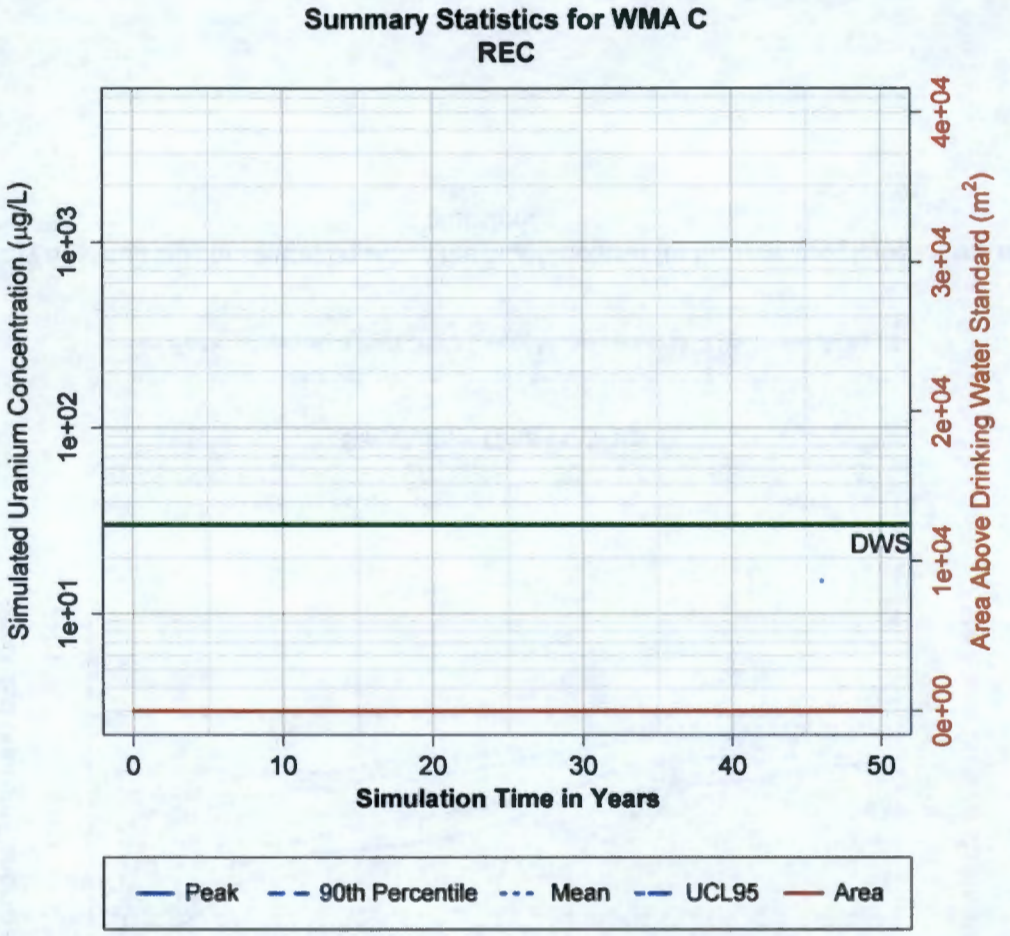

Figure B-26 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

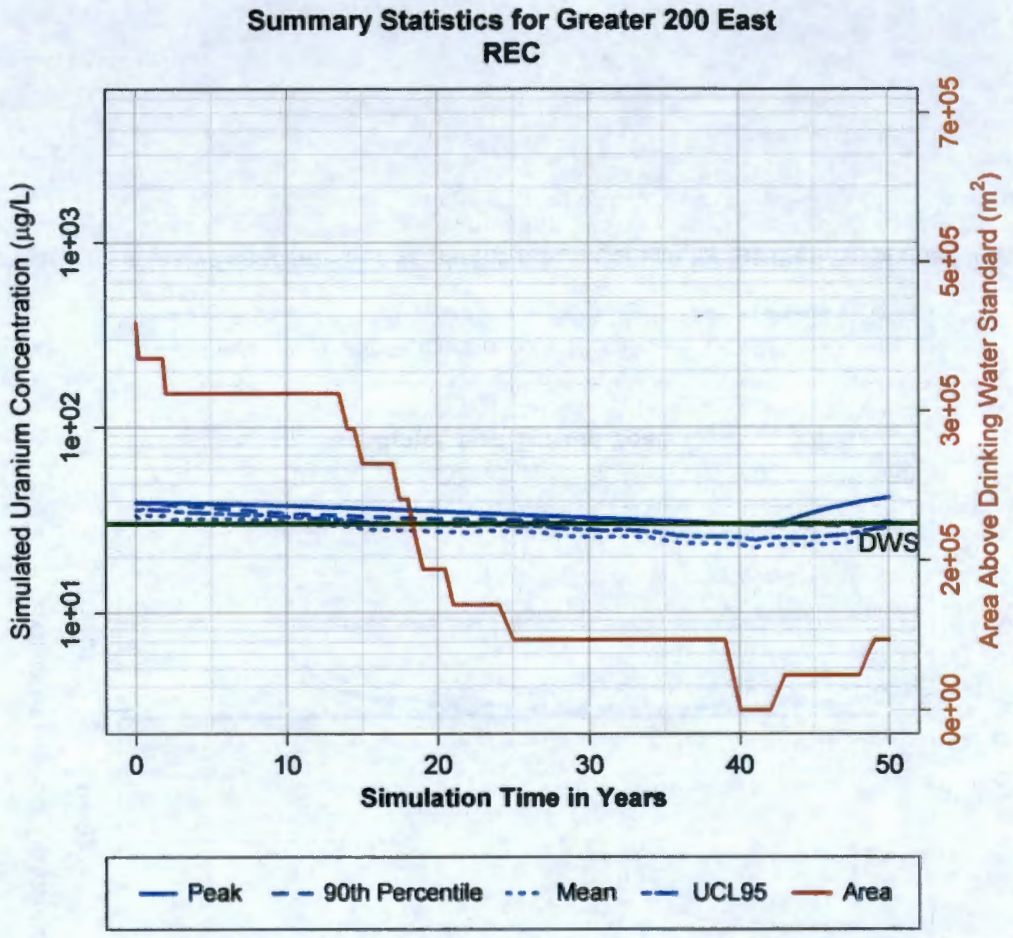

Figure B-27 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

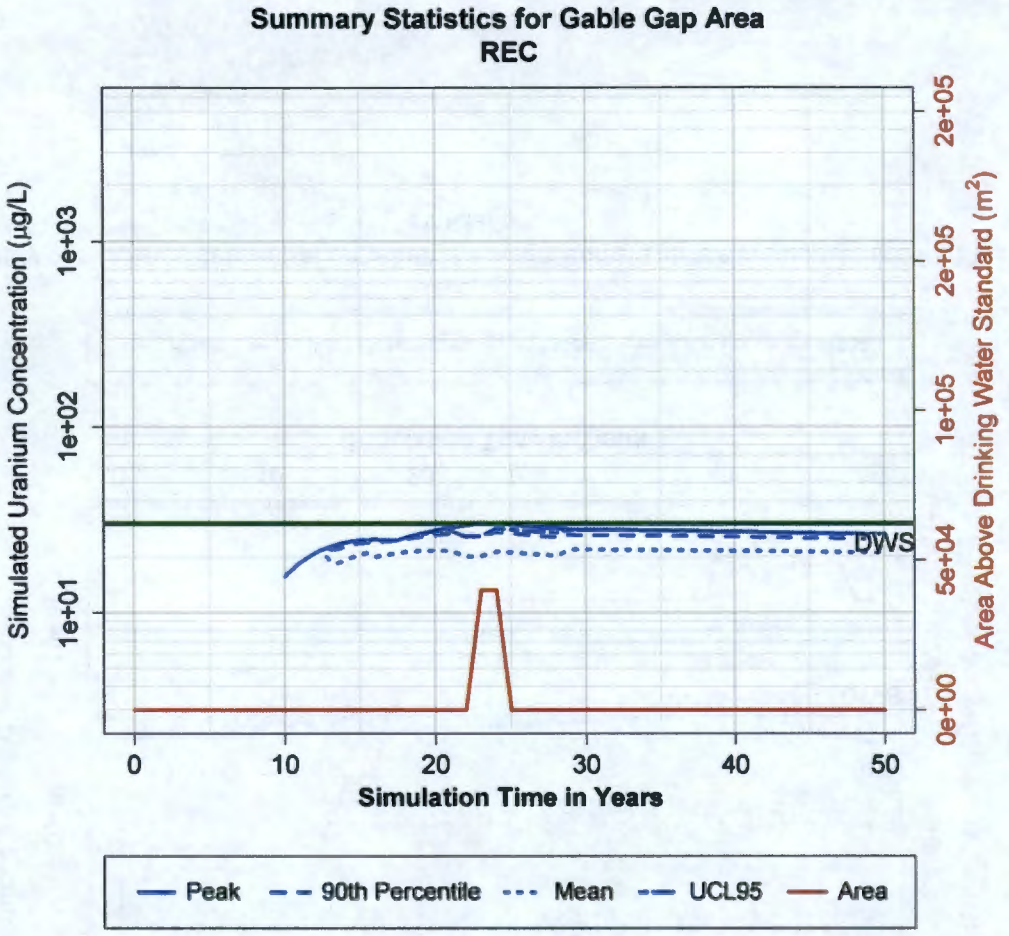

Figure B-28 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

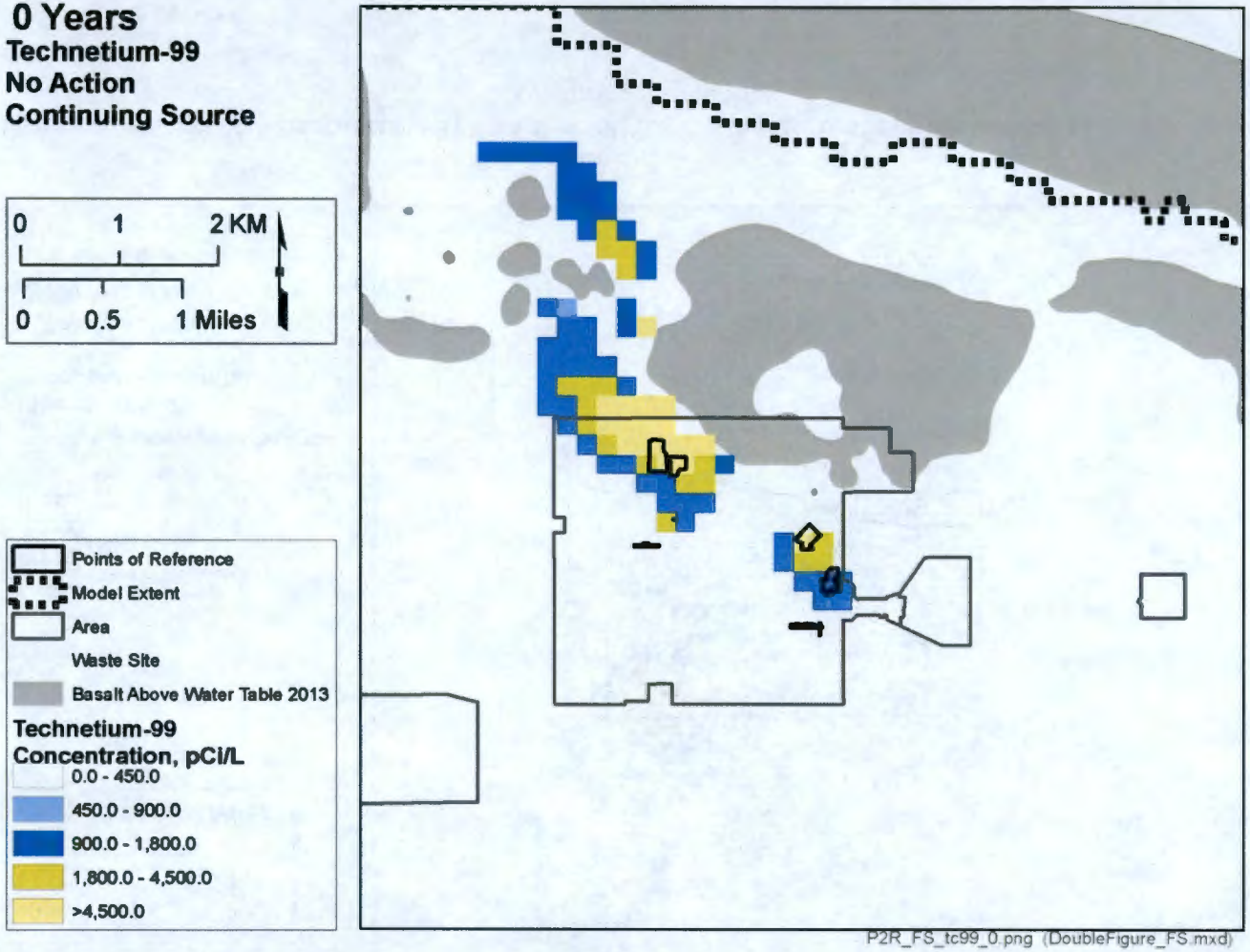

Figure B-29 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the remedial evaluation case simulation with a continuing source term.

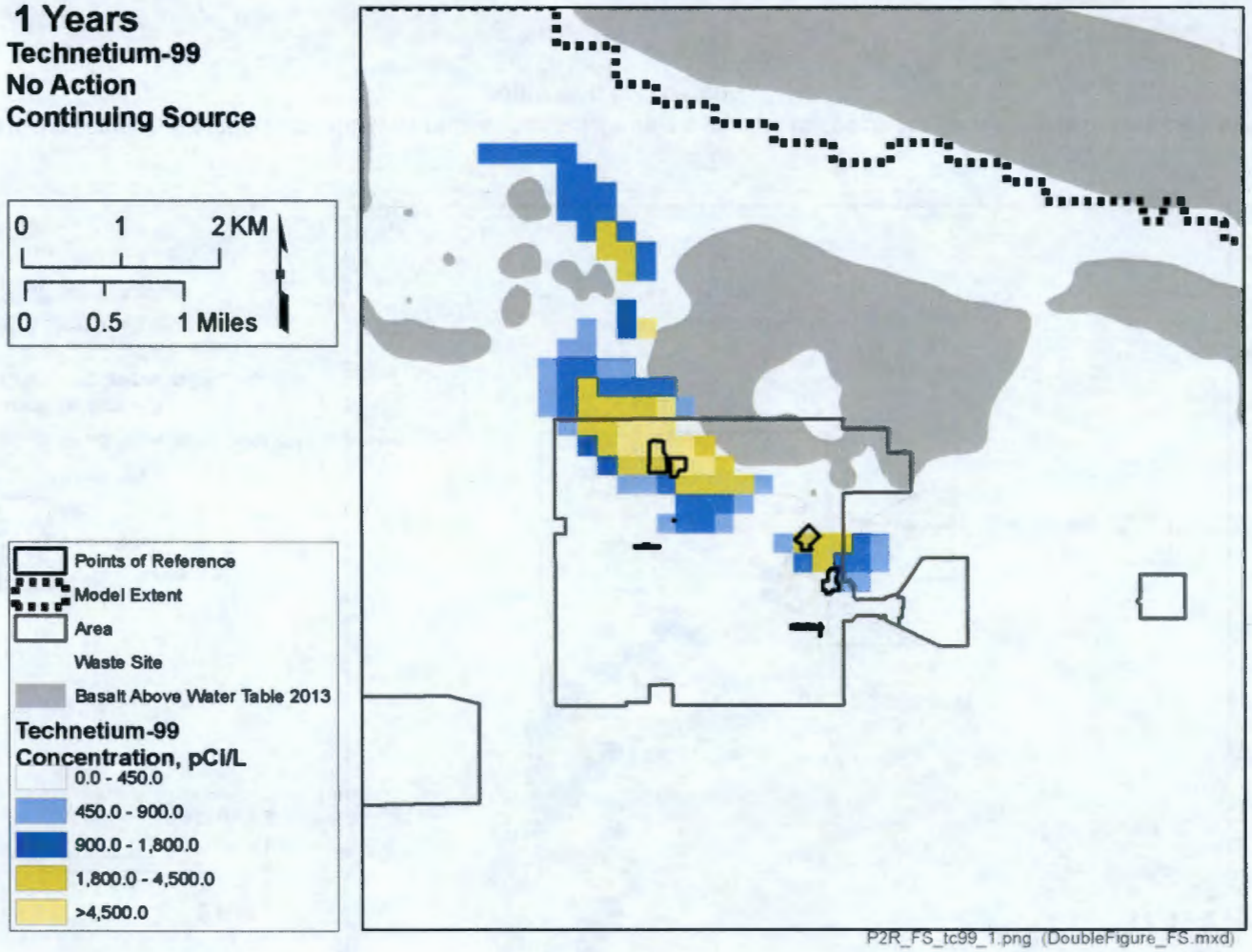

Figure B-30 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the remedial evaluation case simulation with a continuing source term.

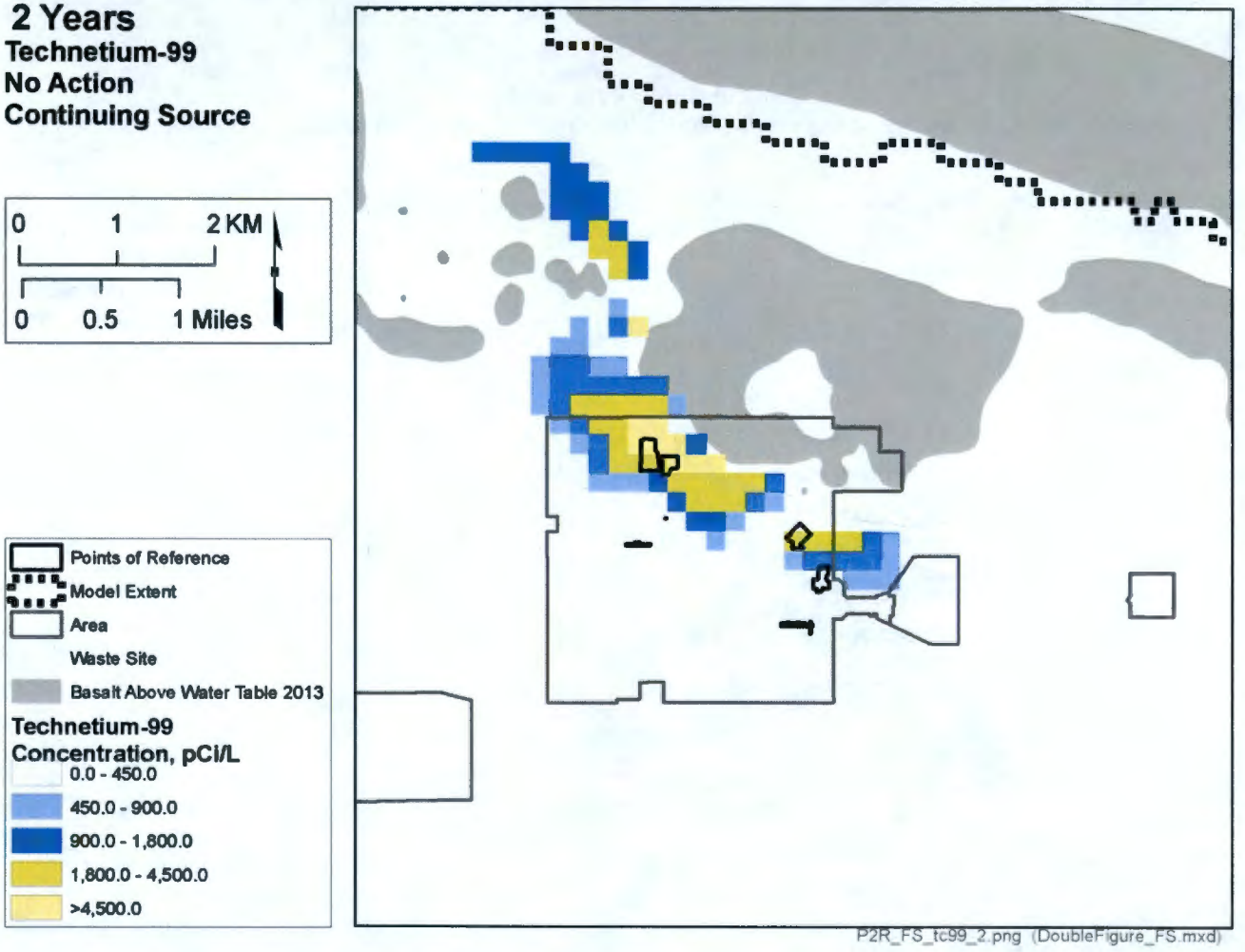

Figure B-31 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the remedial evaluation case simulation with a continuing source term.

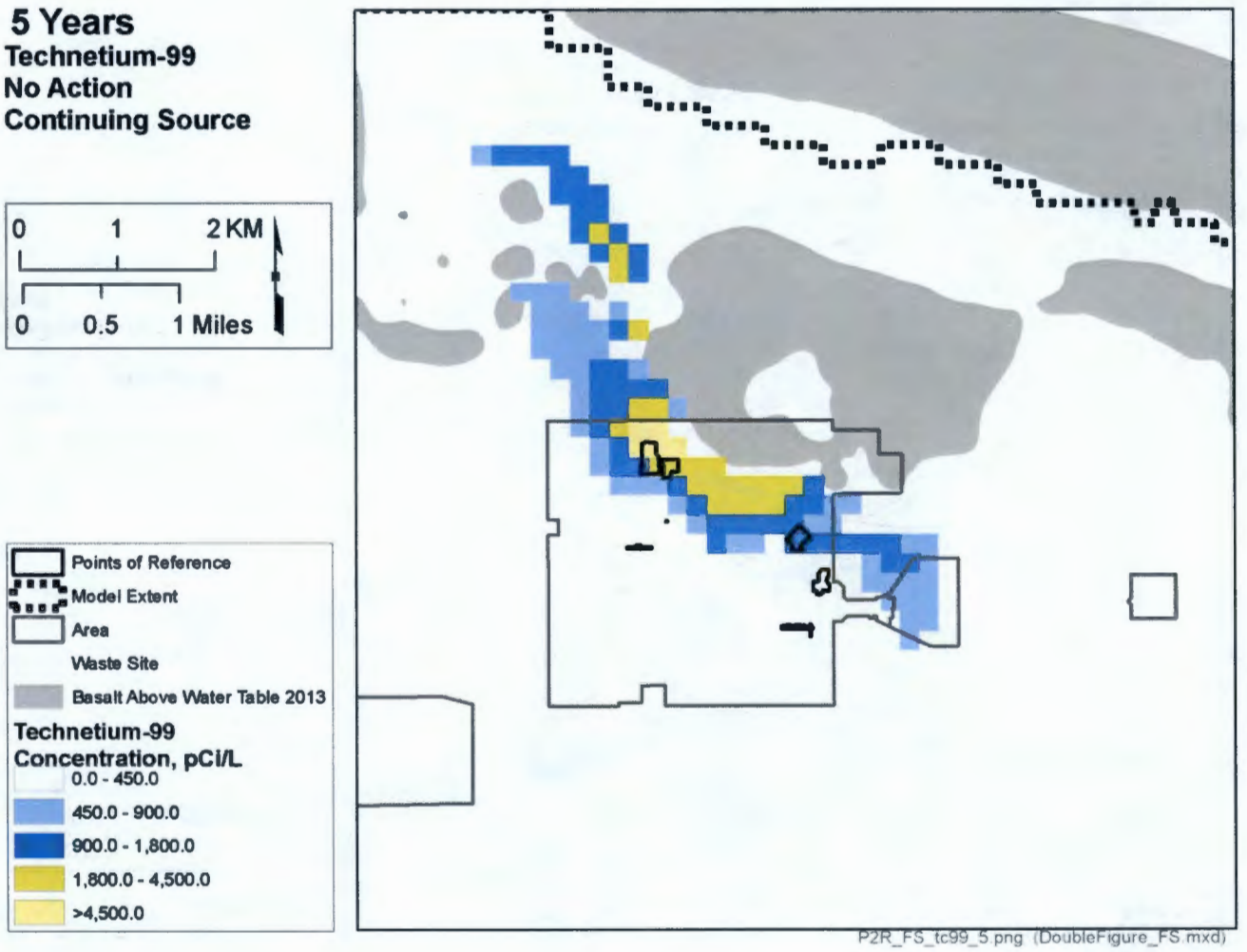

Figure B-32 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the remedial evaluation case simulation with a continuing source term.

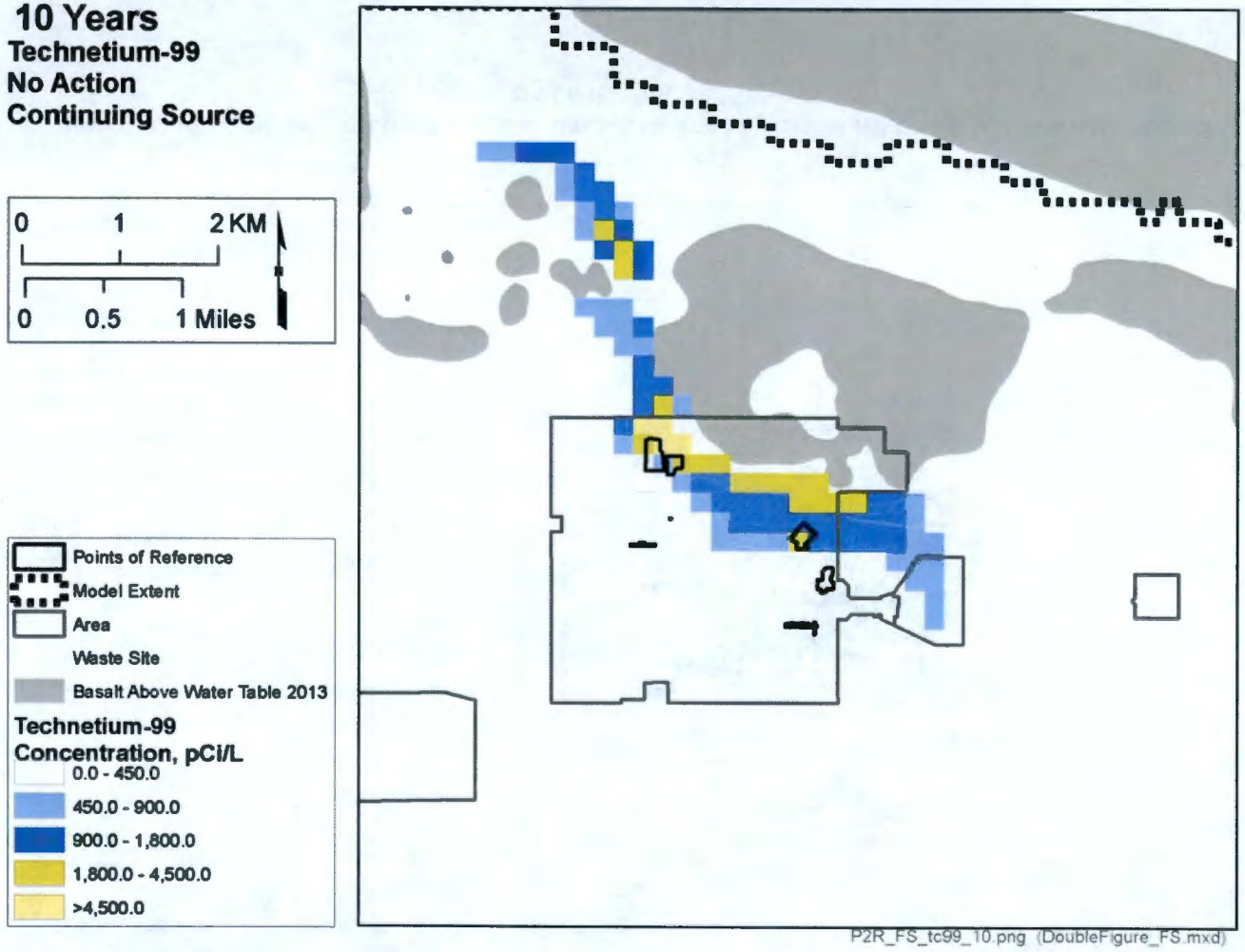

Figure B-33 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the remedial evaluation case simulation with a continuing source term.

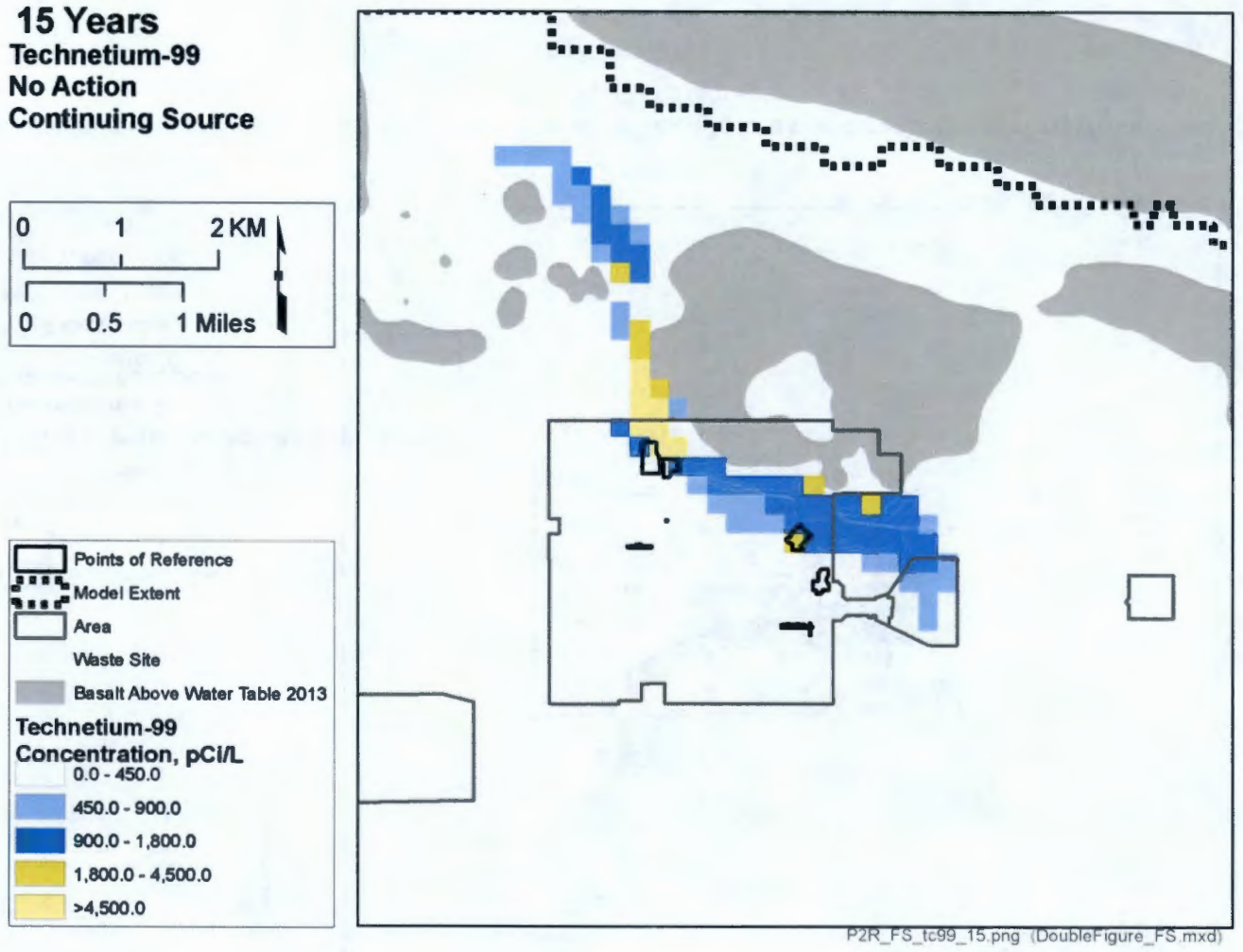

Figure B-34 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the remedial evaluation case simulation with a continuing source term.

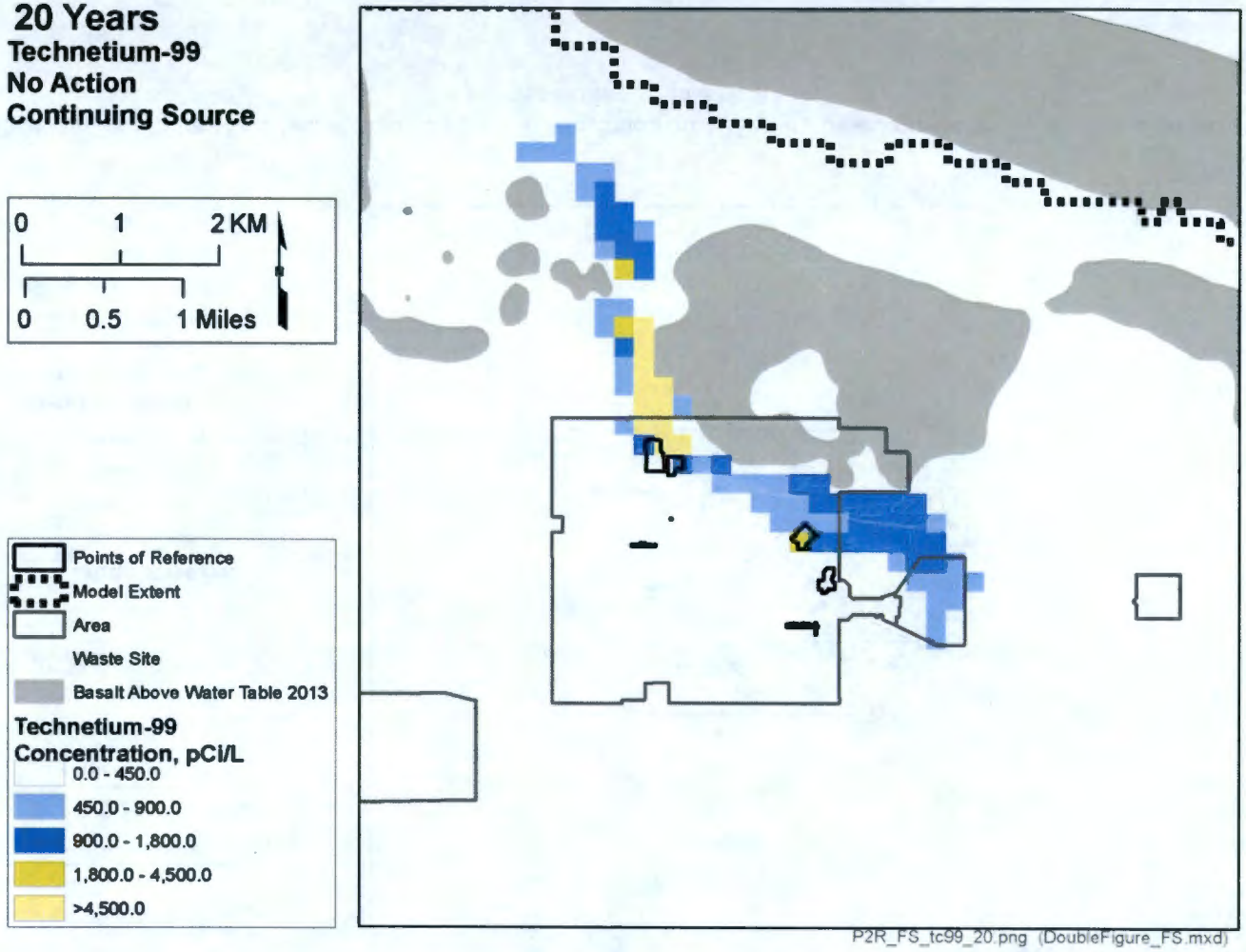

Figure B-35 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the remedial evaluation case simulation with a continuing source term.

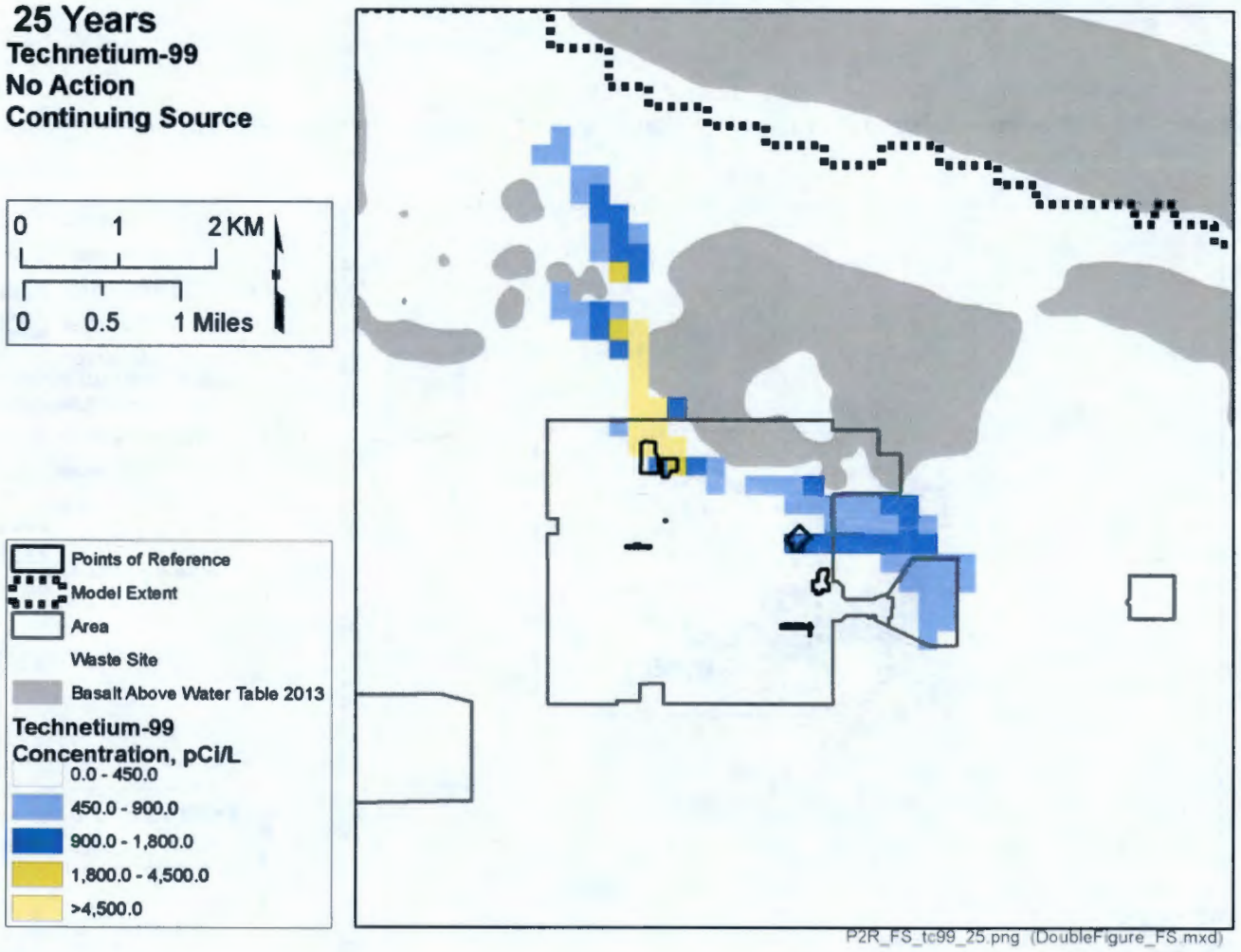

Figure B-36 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the remedial evaluation case simulation with a continuing source term.

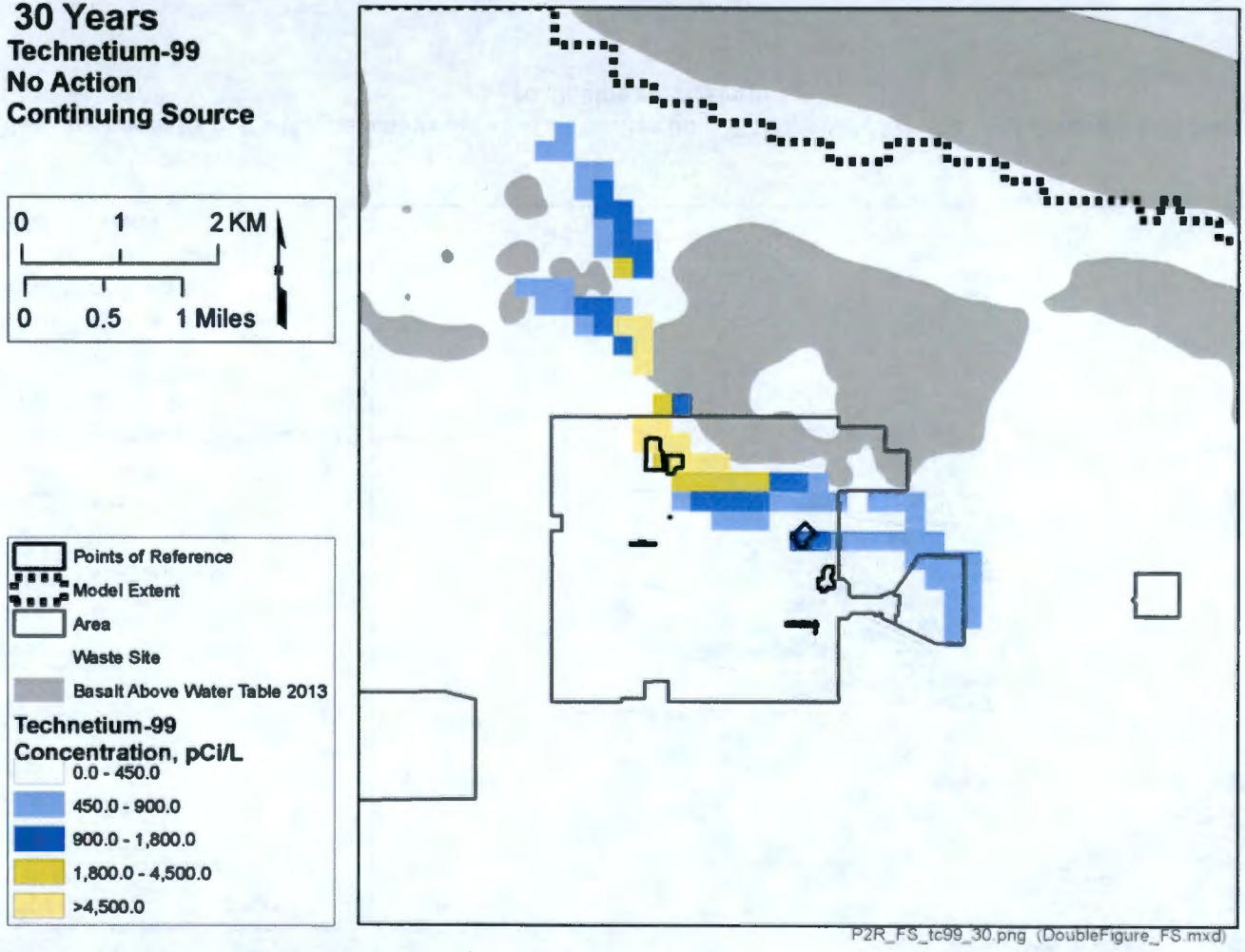

Figure B-37 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the remedial evaluation case simulation with a continuing source term.

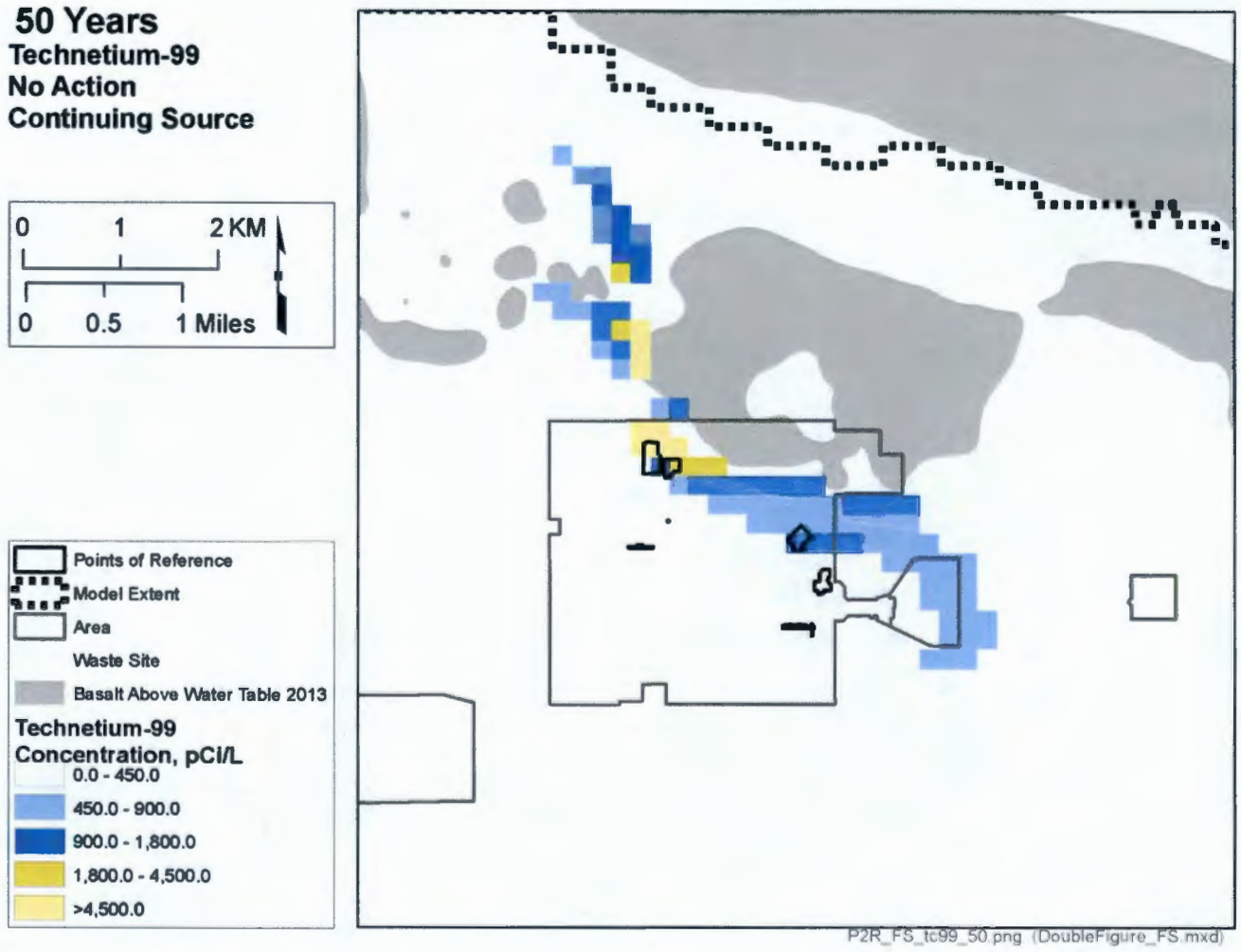

Figure B-38 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the remedial evaluation case simulation with a continuing source term.

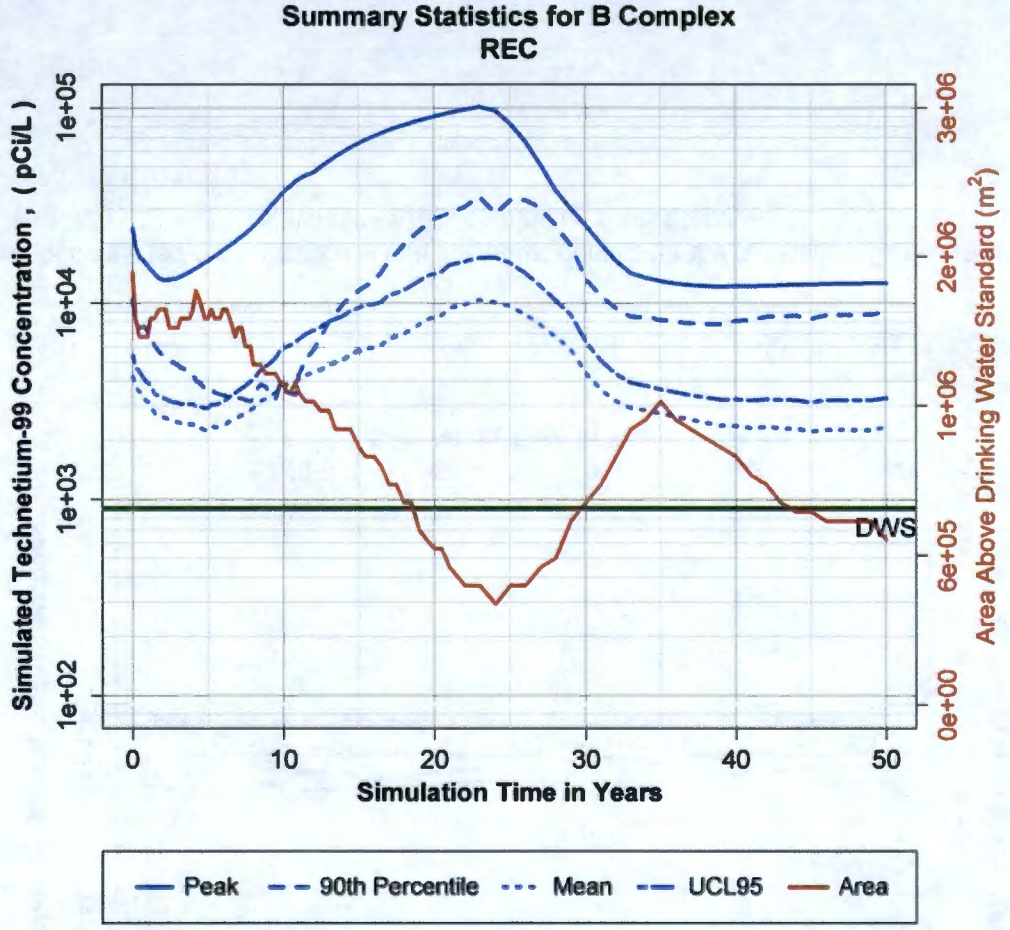

Figure B-39 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

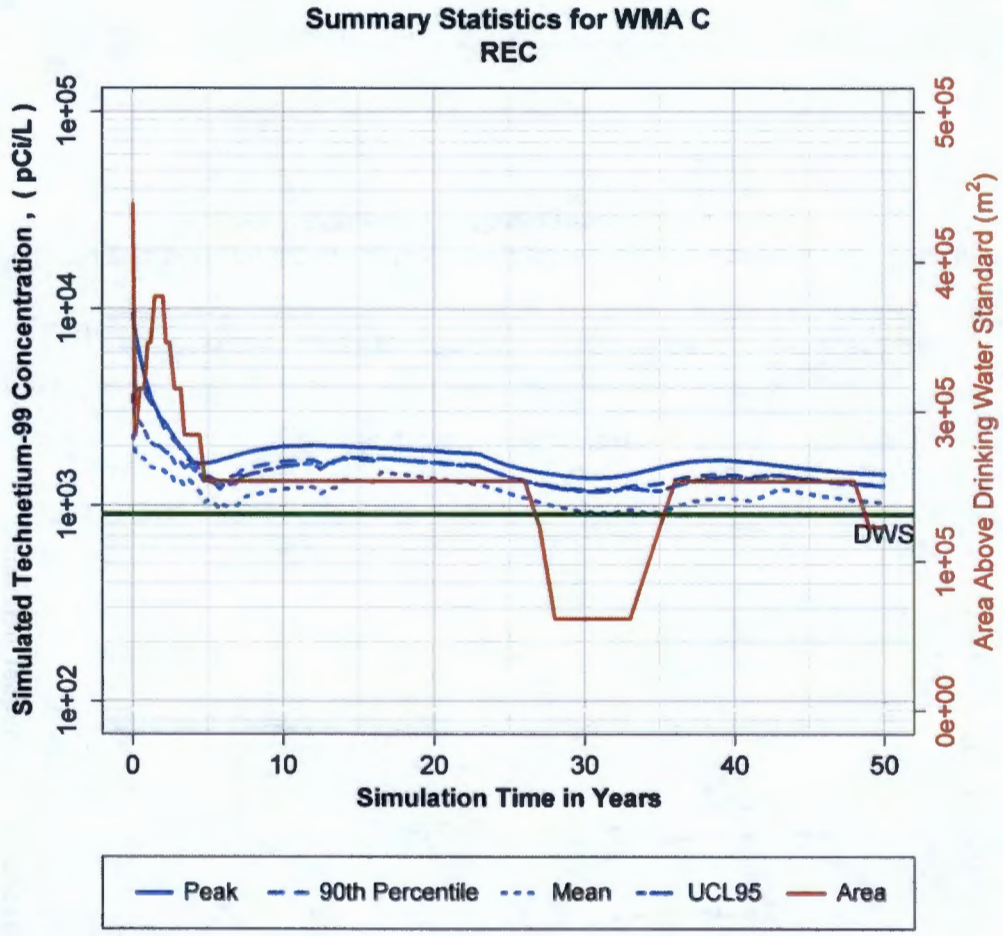

Figure B-40 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

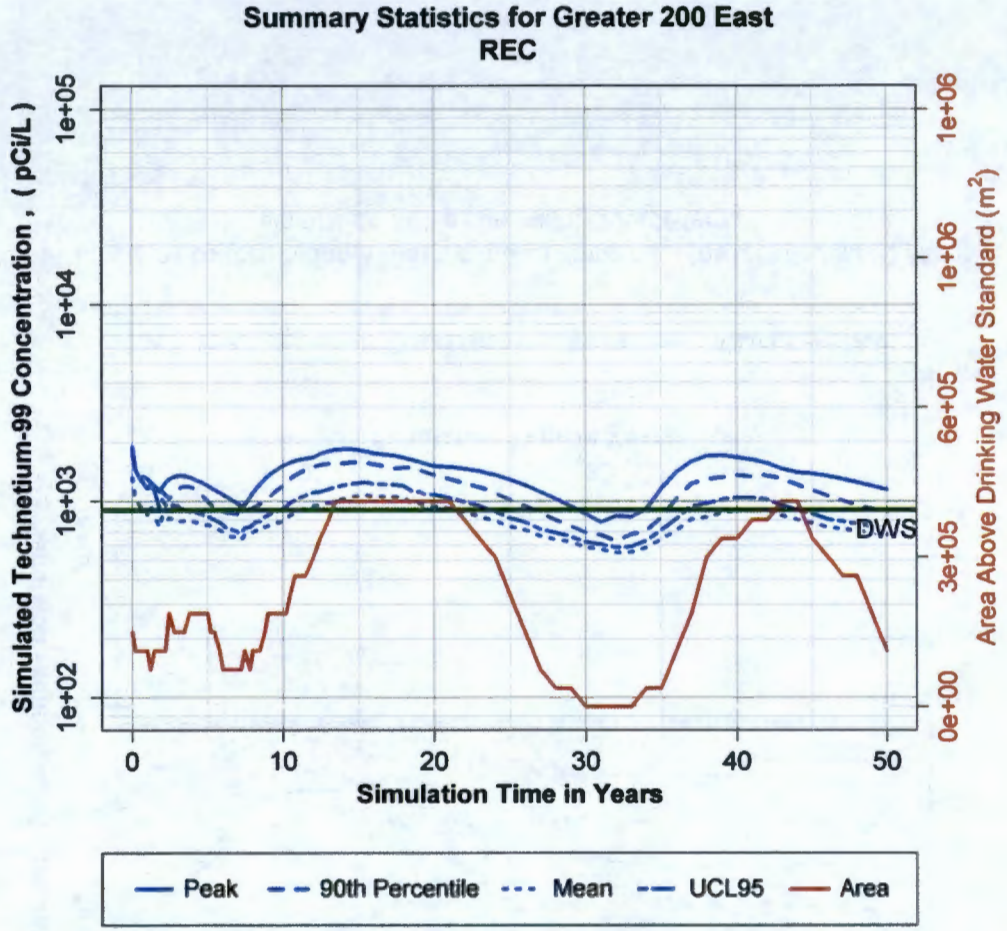

Figure B-41 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

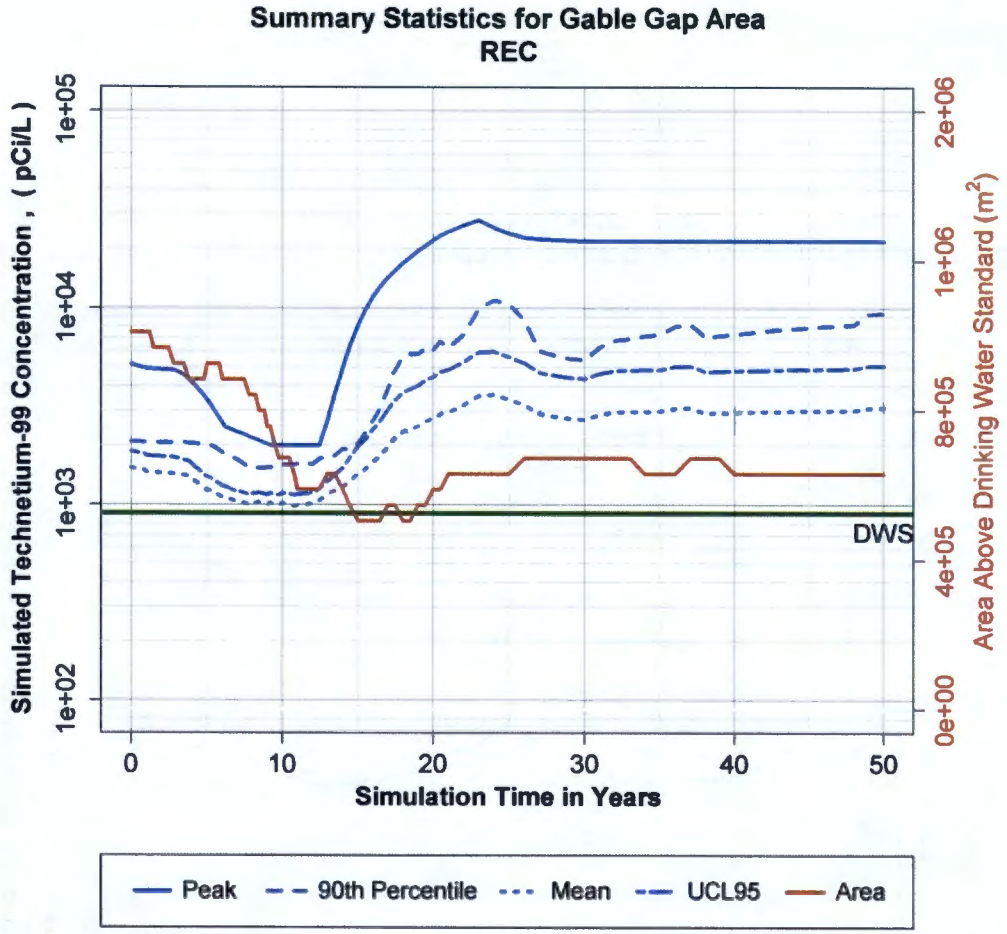

Figure B-42 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

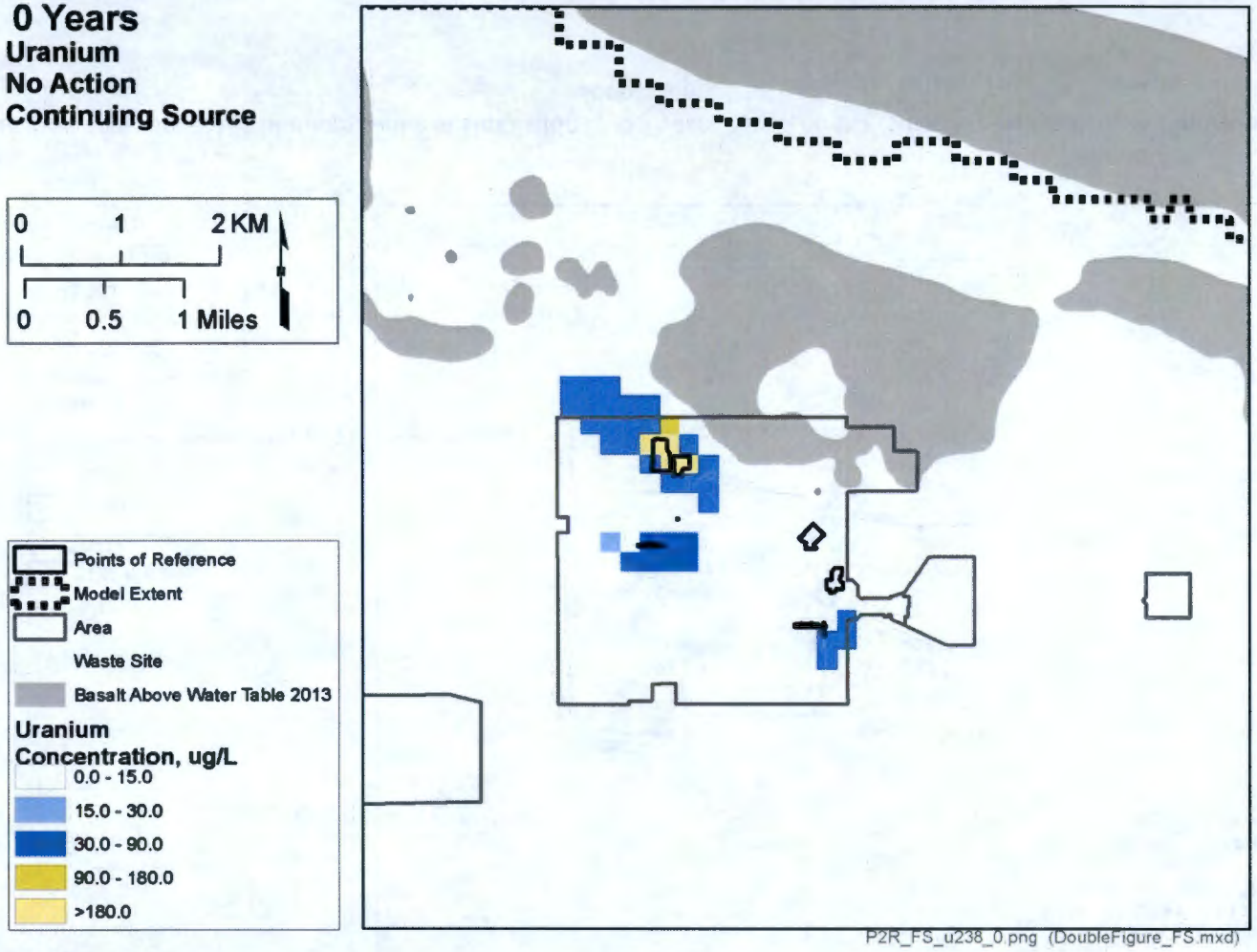

Figure B-43 - Plan view contours of the uranium plume at simulation time 0 years based on the remedial evaluation case simulation with a continuing source term.

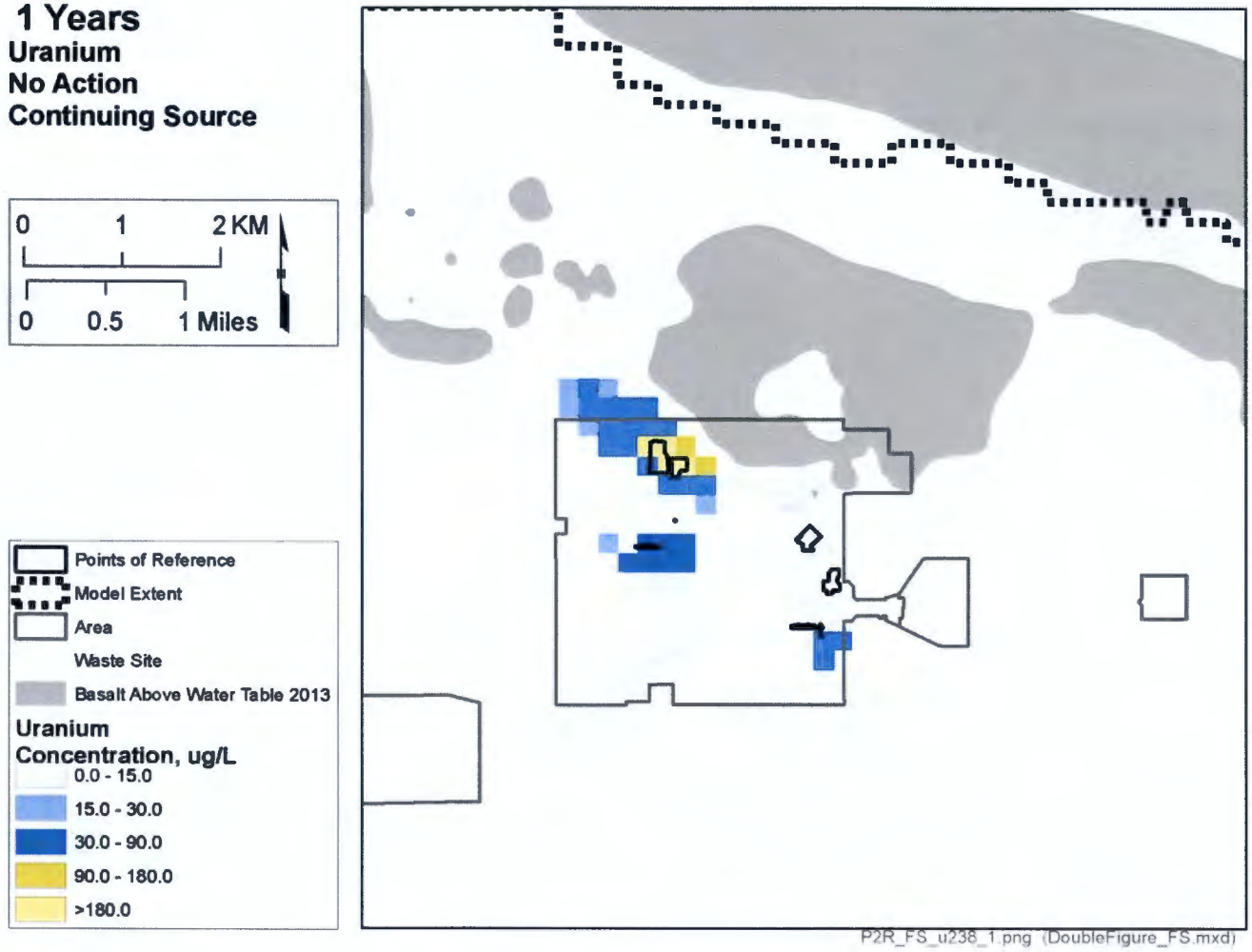

Figure B-44 - Plan view contours of the uranium plume at simulation time 1 years based on the remedial evaluation case simulation with a continuing source term.

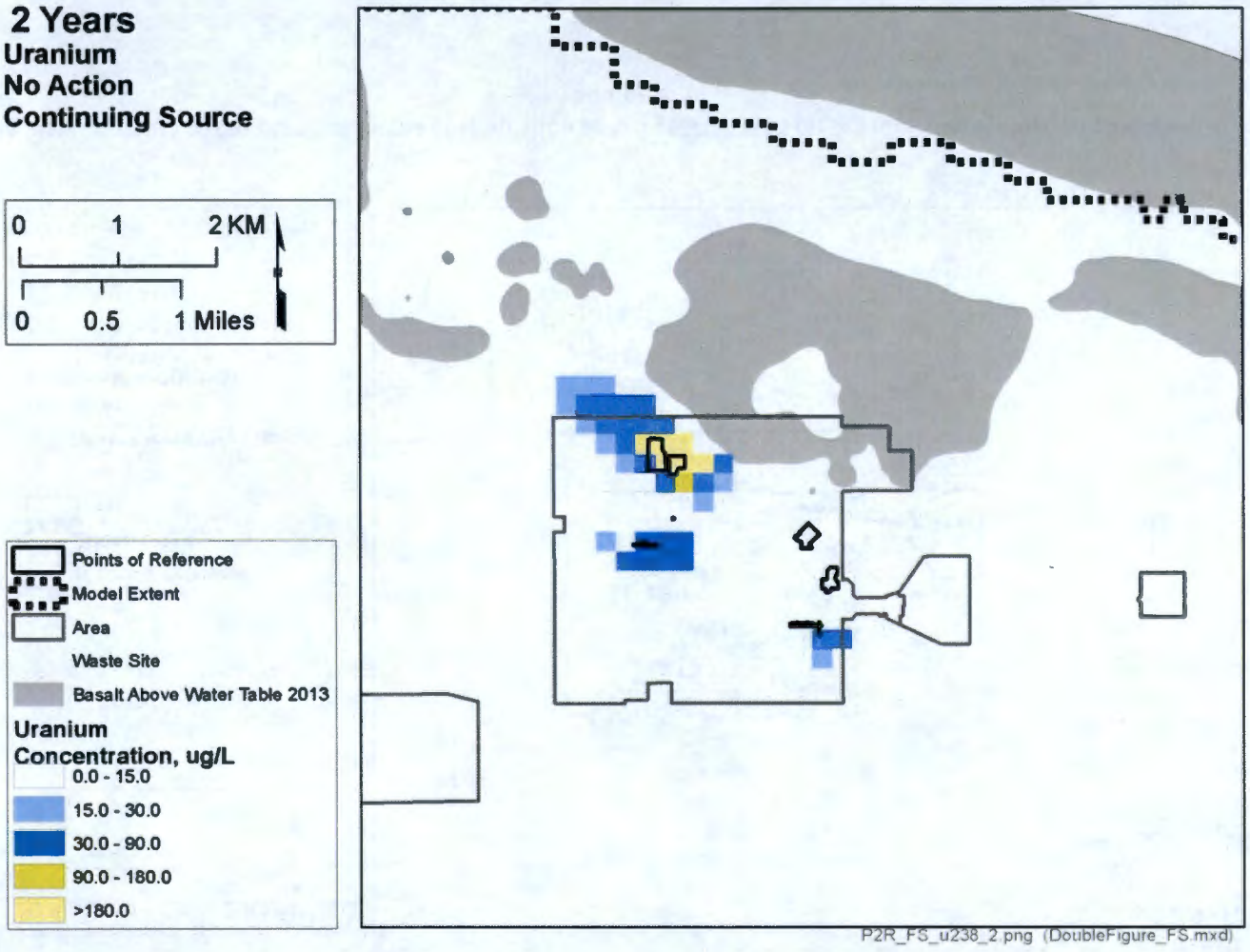

Figure B-45 - Plan view contours of the uranium plume at simulation time 2 years based on the remedial evaluation case simulation with a continuing source term.

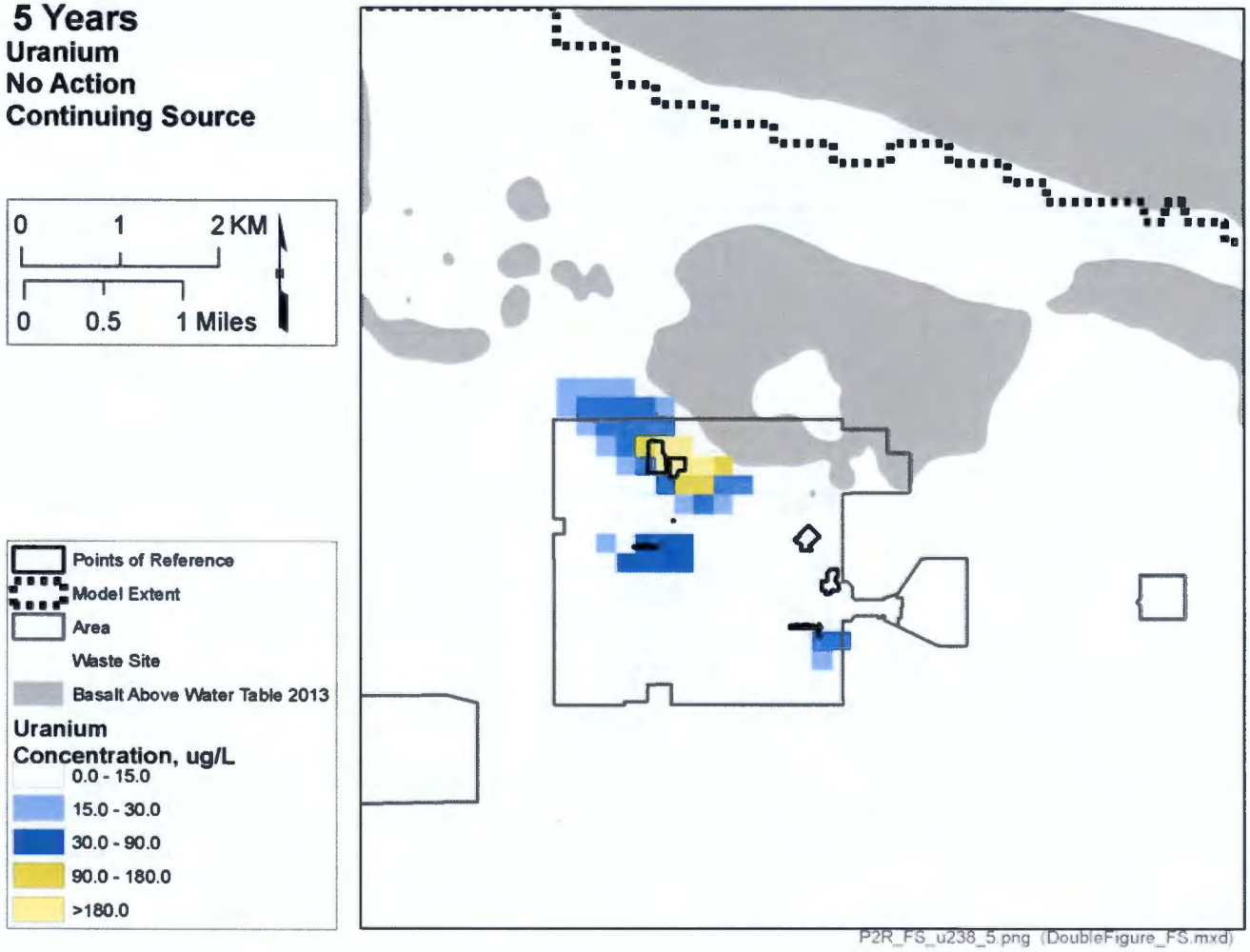

Figure B-46 - Plan view contours of the uranium plume at simulation time 5 years based on the remedial evaluation case simulation with a continuing source term.

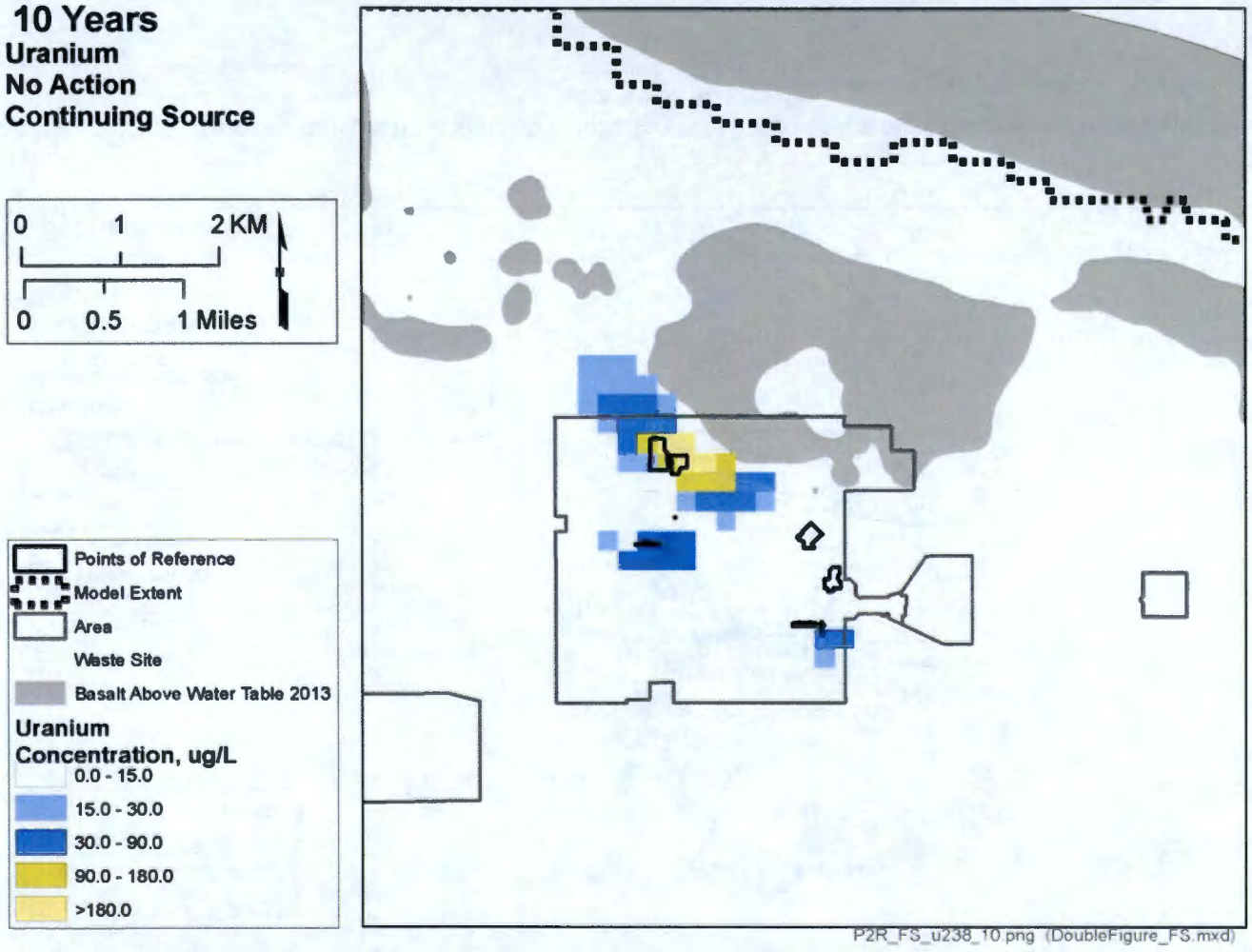

Figure B-47 - Plan view contours of the uranium plume at simulation time 10 years based on the remedial evaluation case simulation with a continuing source term.

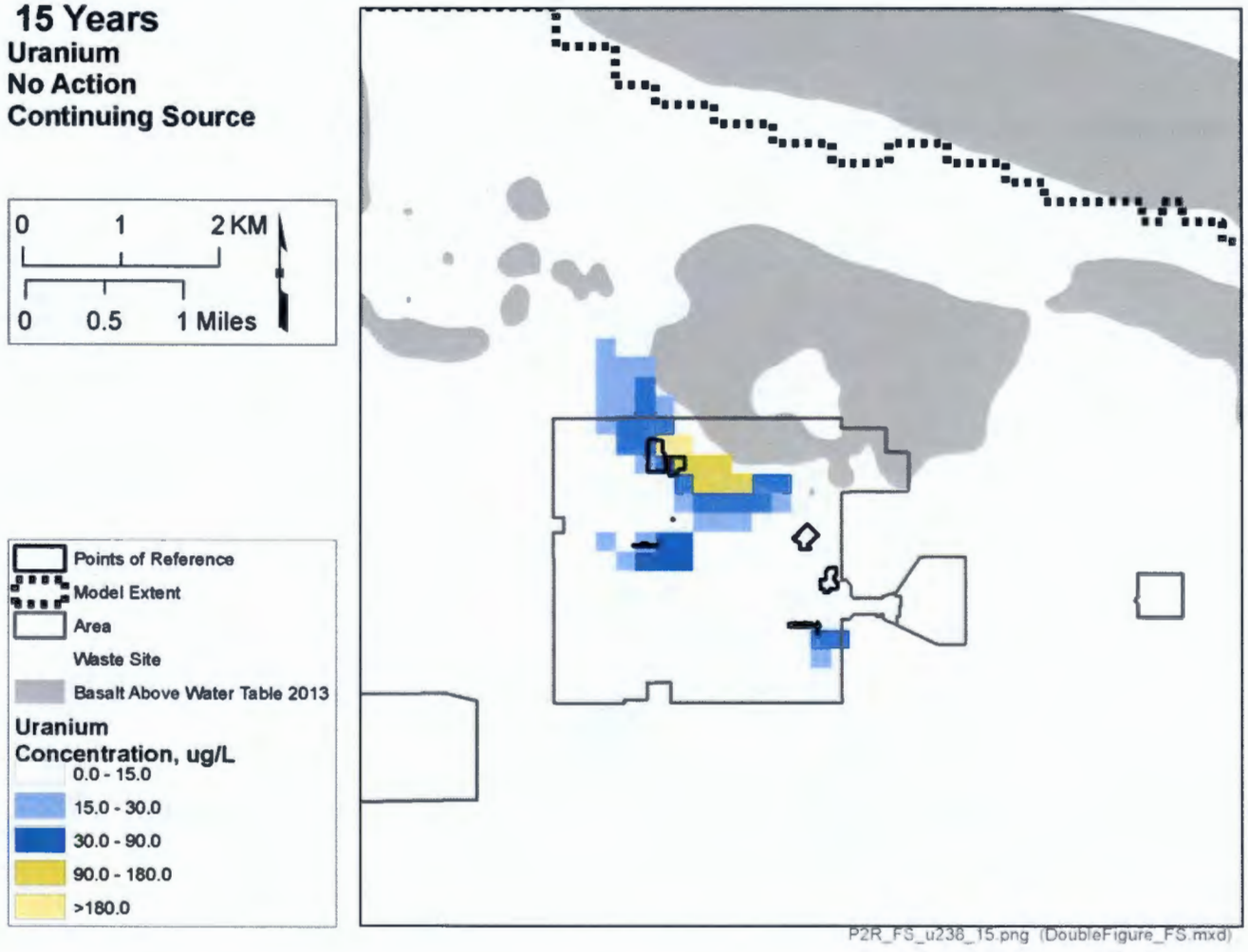

Figure B-48 - Plan view contours of the uranium plume at simulation time 15 years based on the remedial evaluation case simulation with a continuing source term.

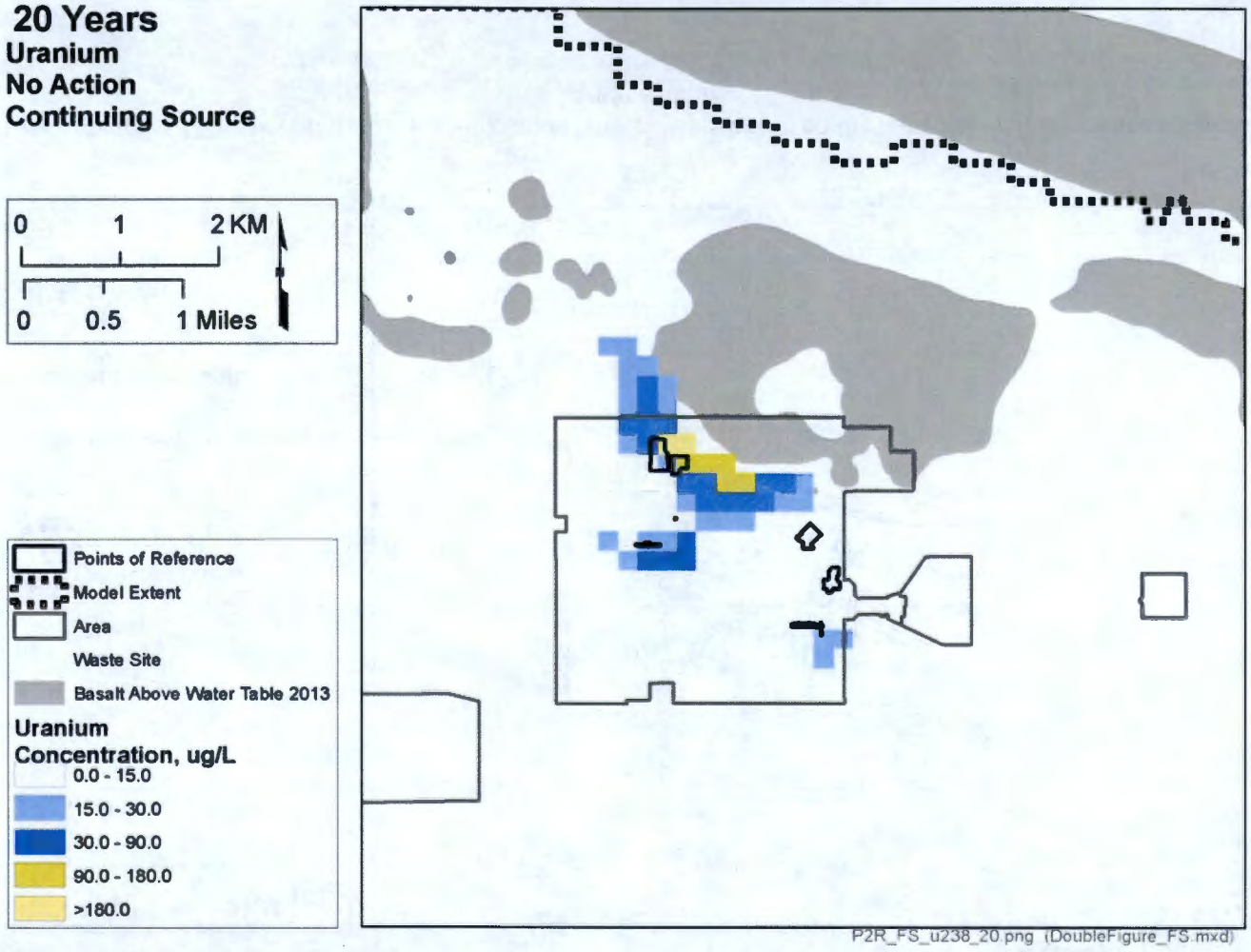

Figure B-49 - Plan view contours of the uranium plume at simulation time 20 years based on the remedial evaluation case simulation with a continuing source term.

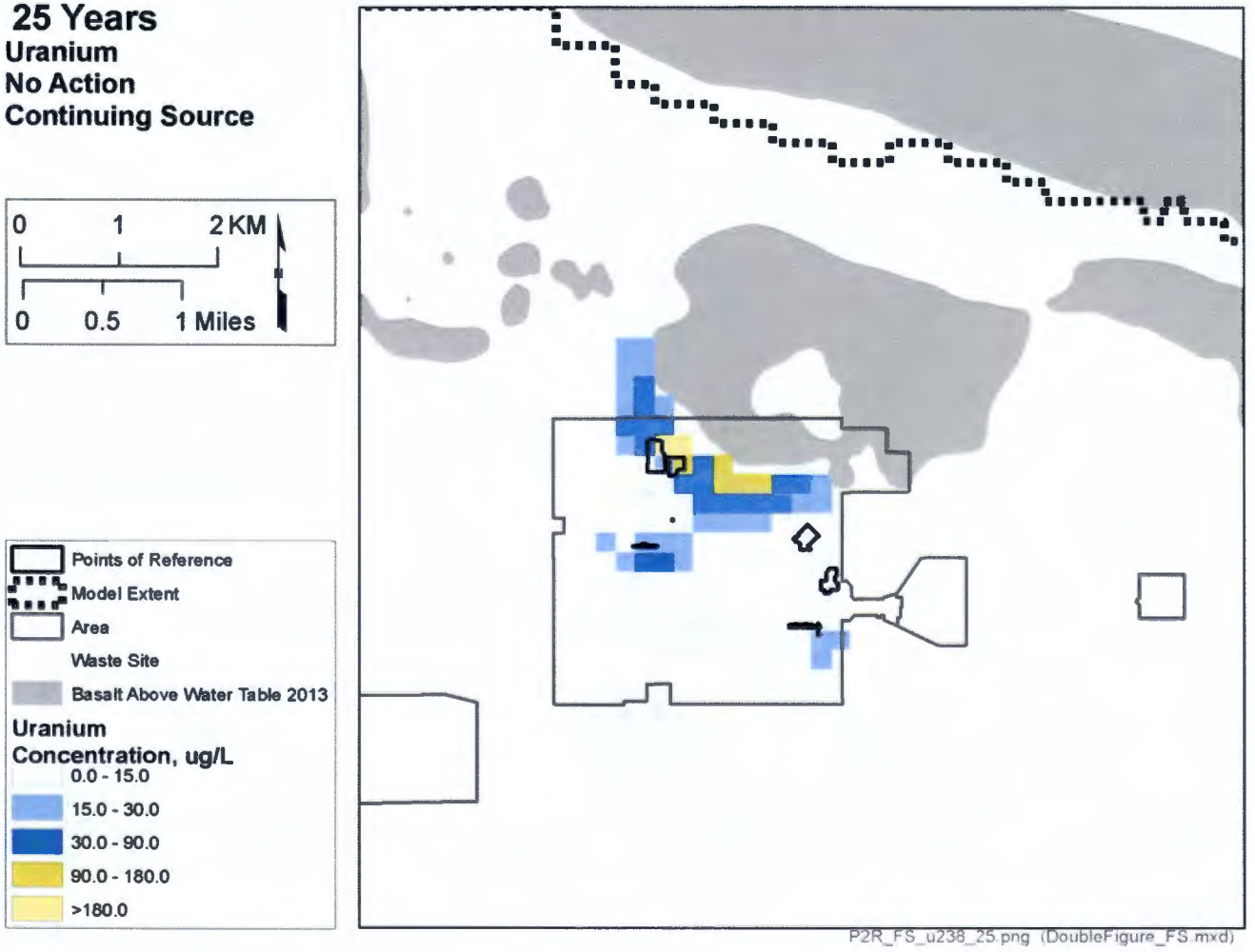

Figure B-50 - Plan view contours of the uranium plume at simulation time 25 years based on the remedial evaluation case simulation with a continuing source term.

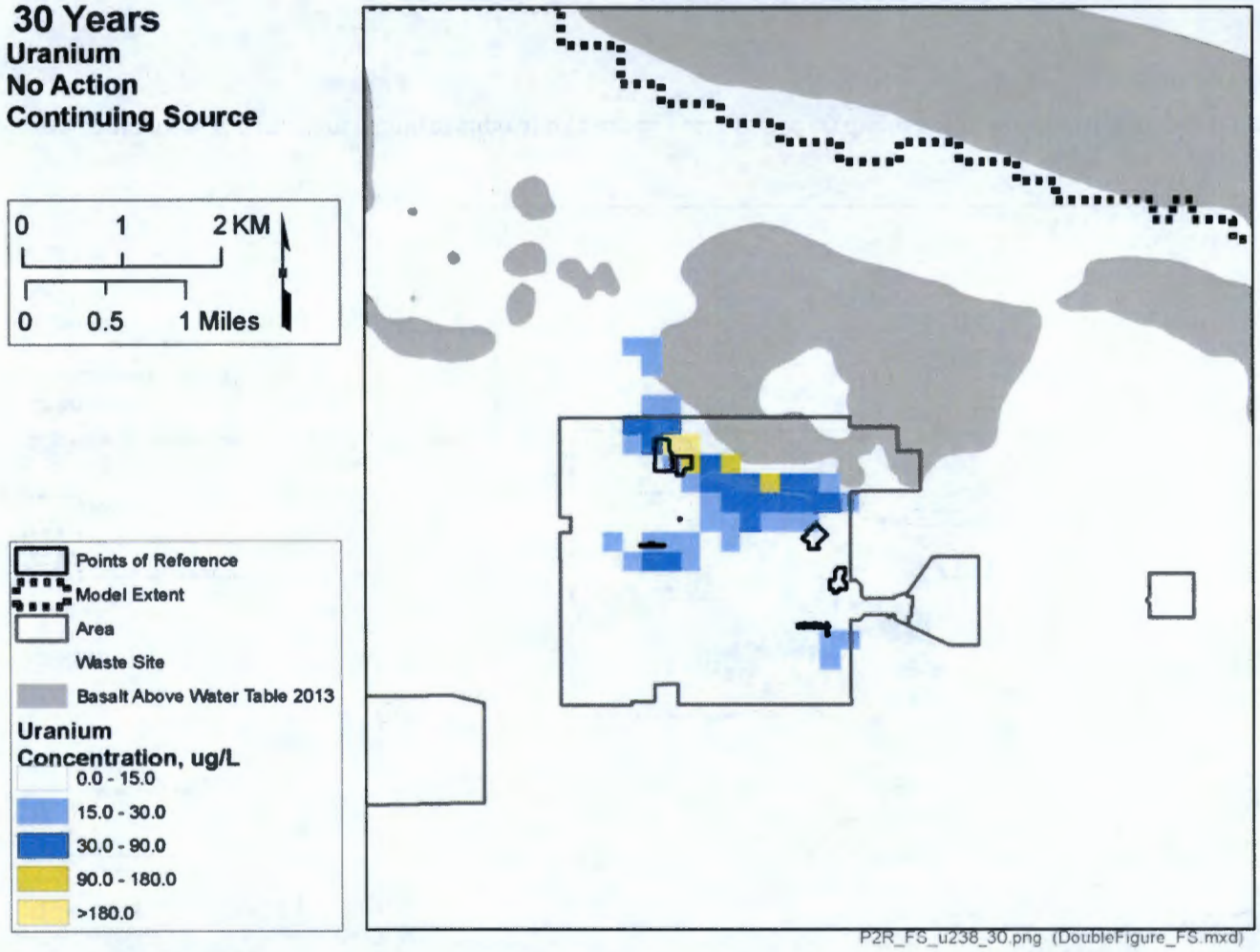

Figure B-51 - Plan view contours of the uranium plume at simulation time 30 years based on the remedial evaluation case simulation with a continuing source term.

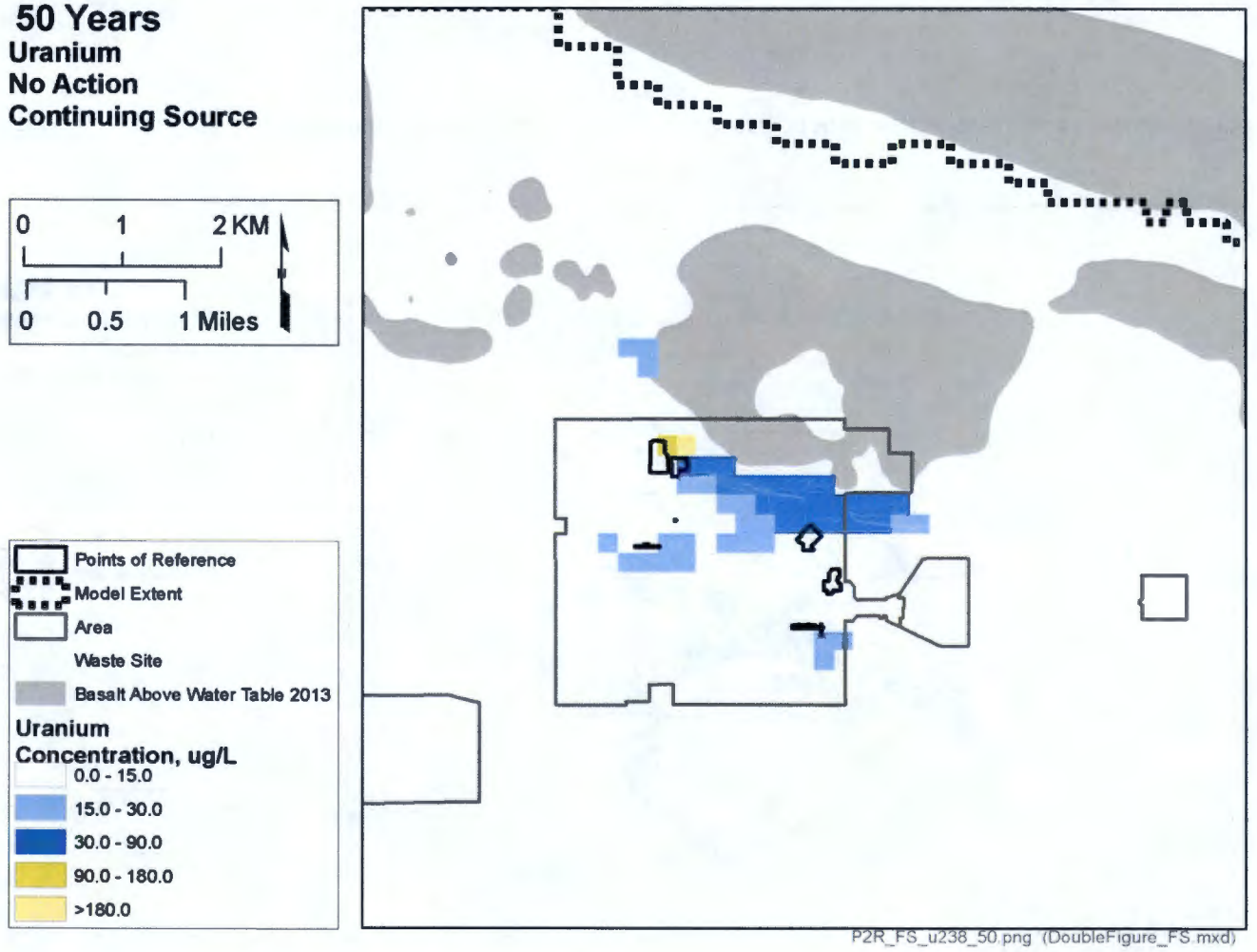

Figure B-52 - Plan view contours of the uranium plume at simulation time 50 years based on the remedial evaluation case simulation with a continuing source term.

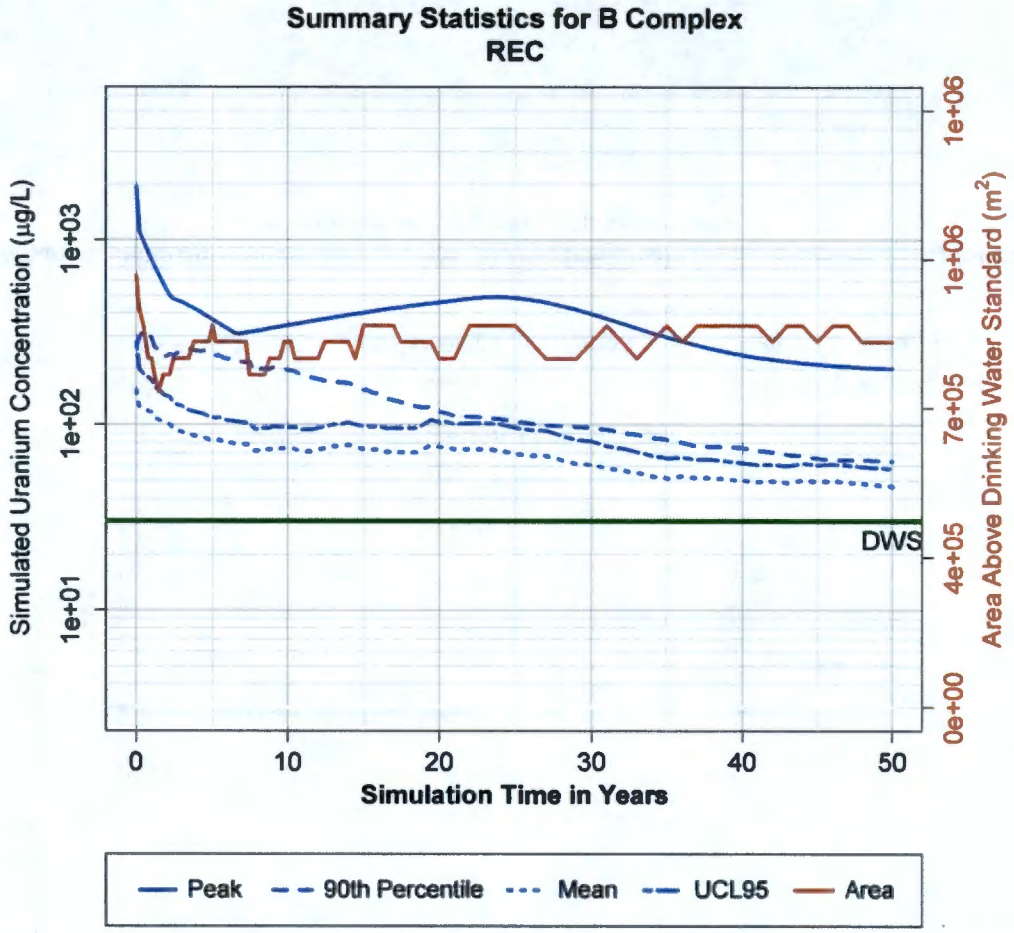

Figure B-53 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

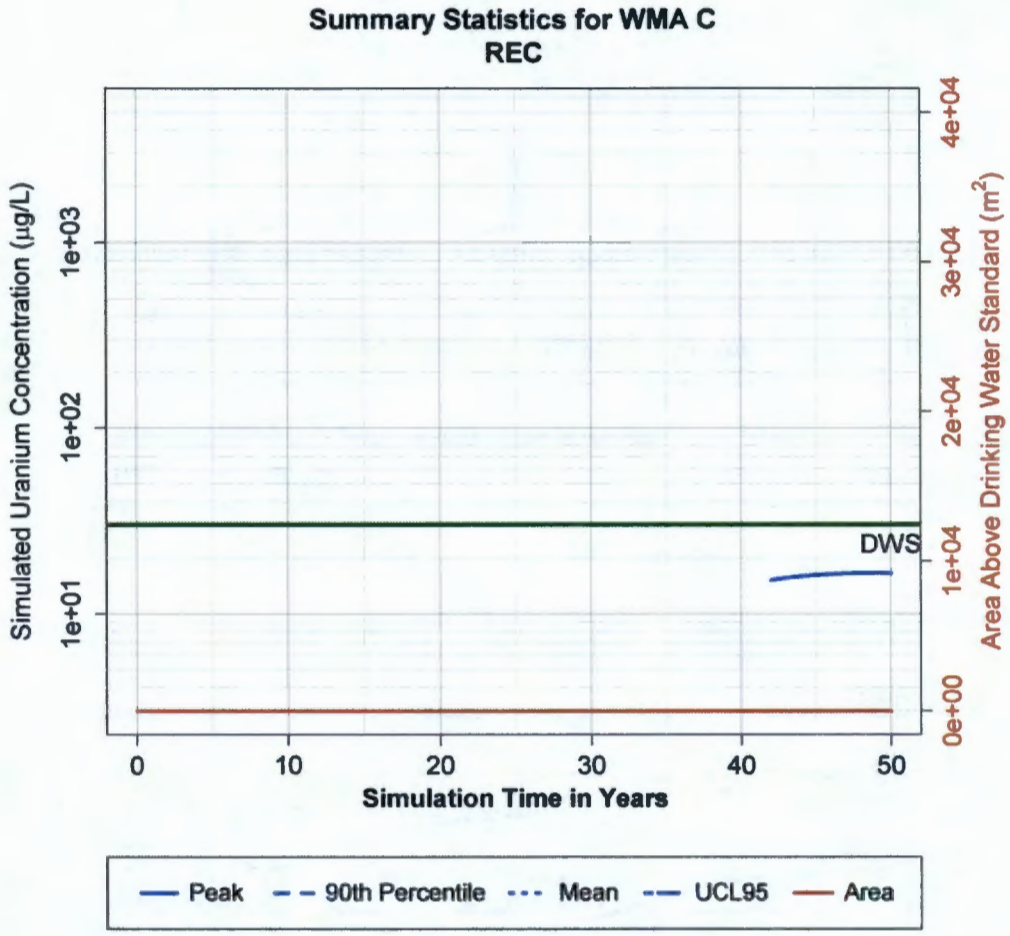

Figure B-54 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

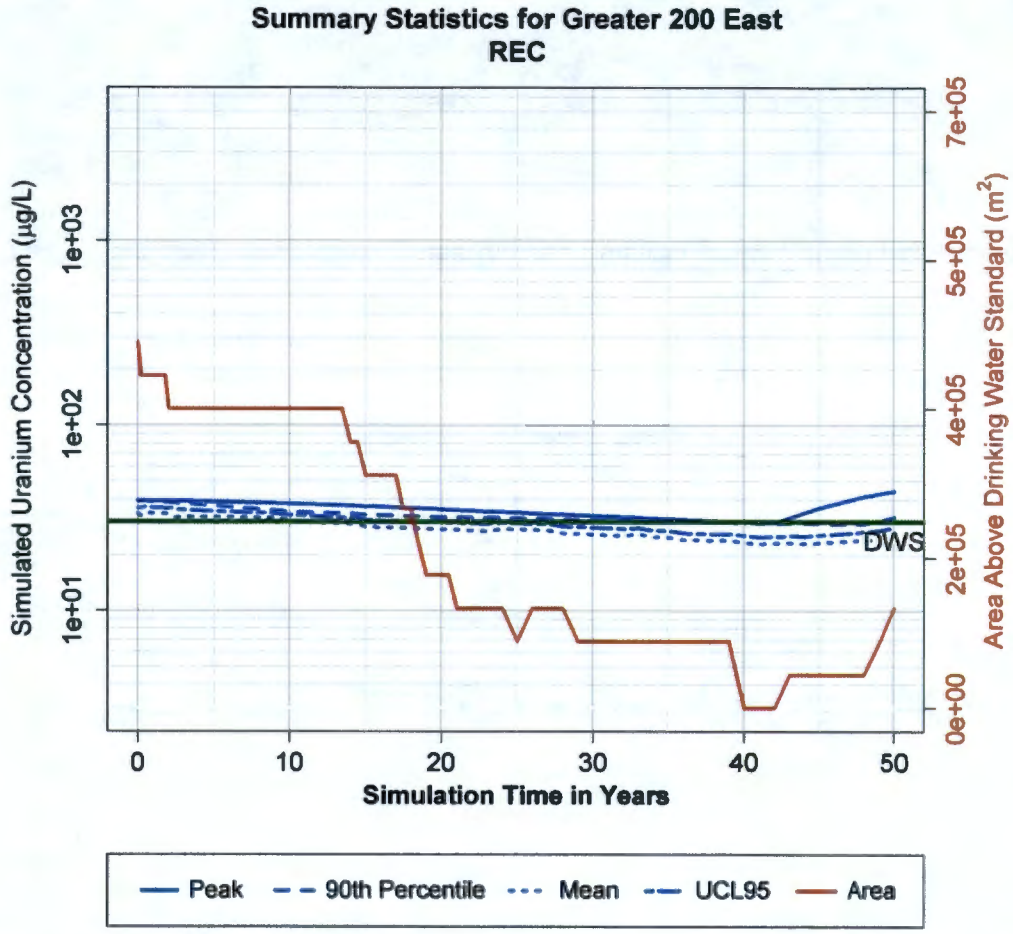

Figure B-55 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

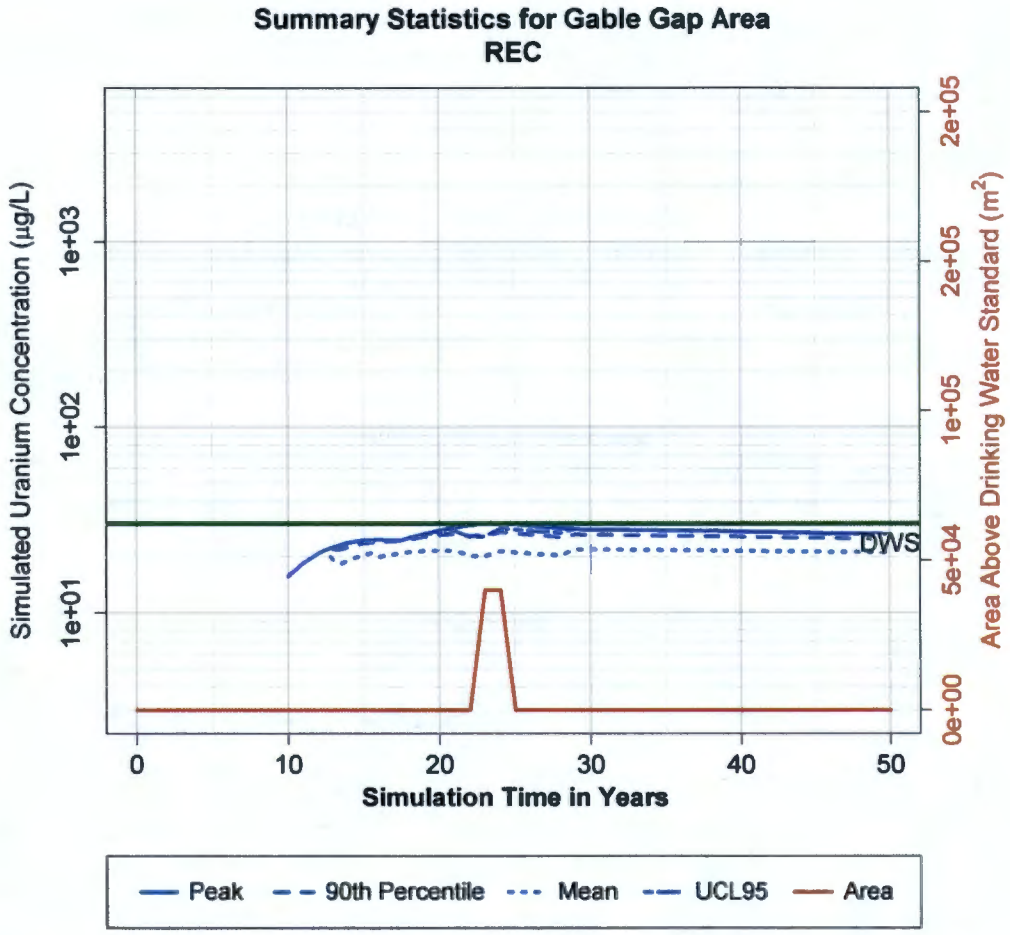

Figure B-56 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

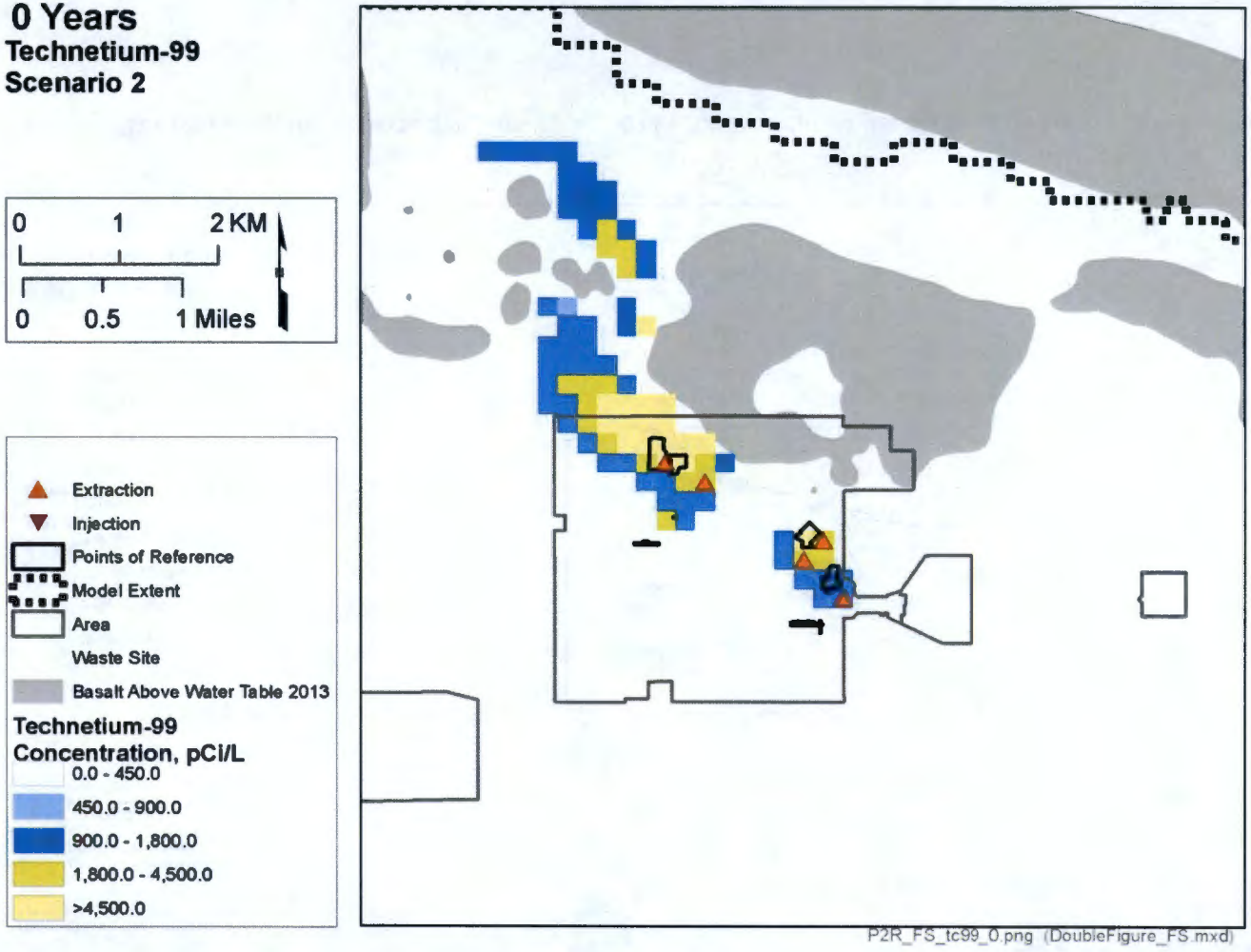

Figure B-57 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 2 simulation.

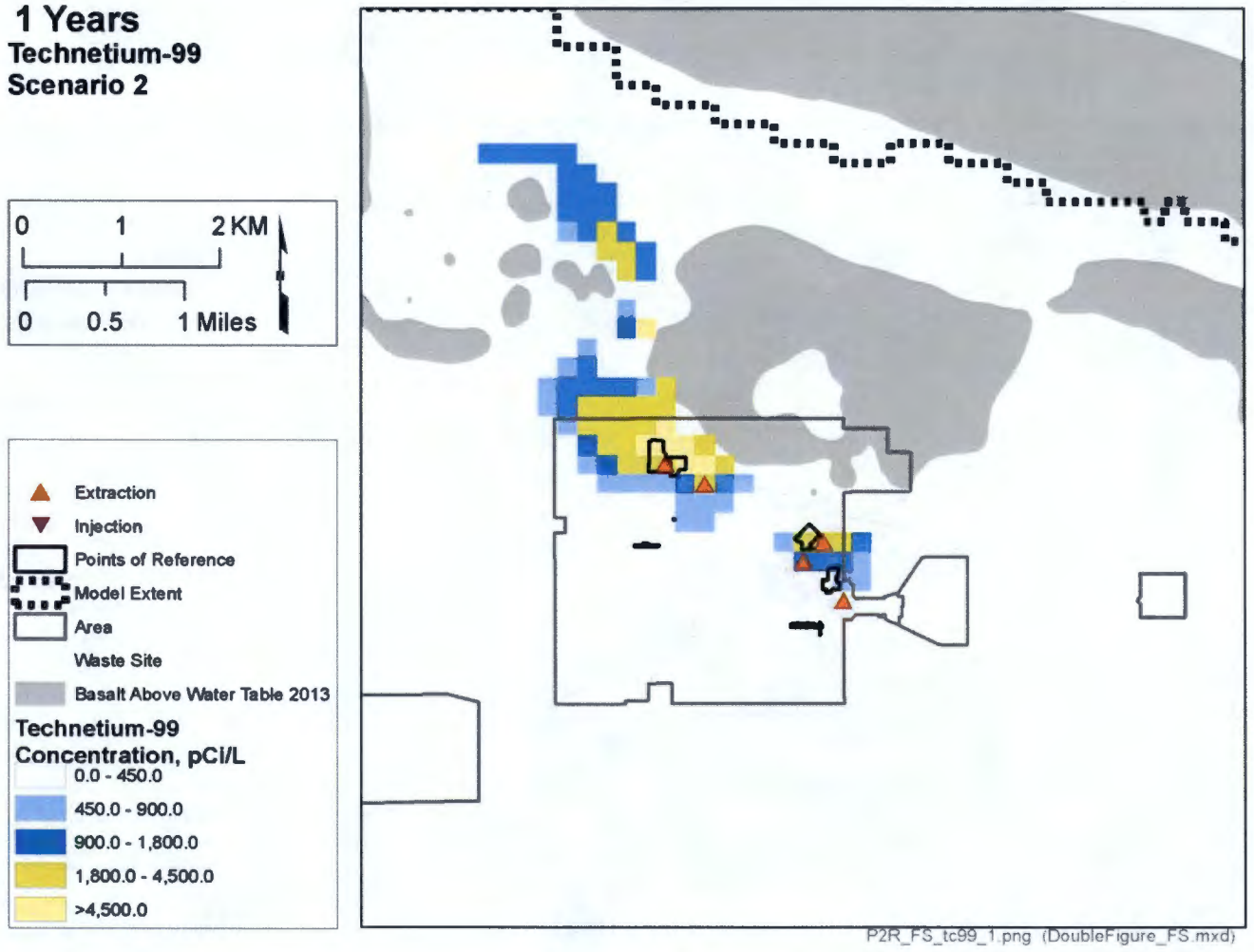

Figure B-58 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 2 simulation.

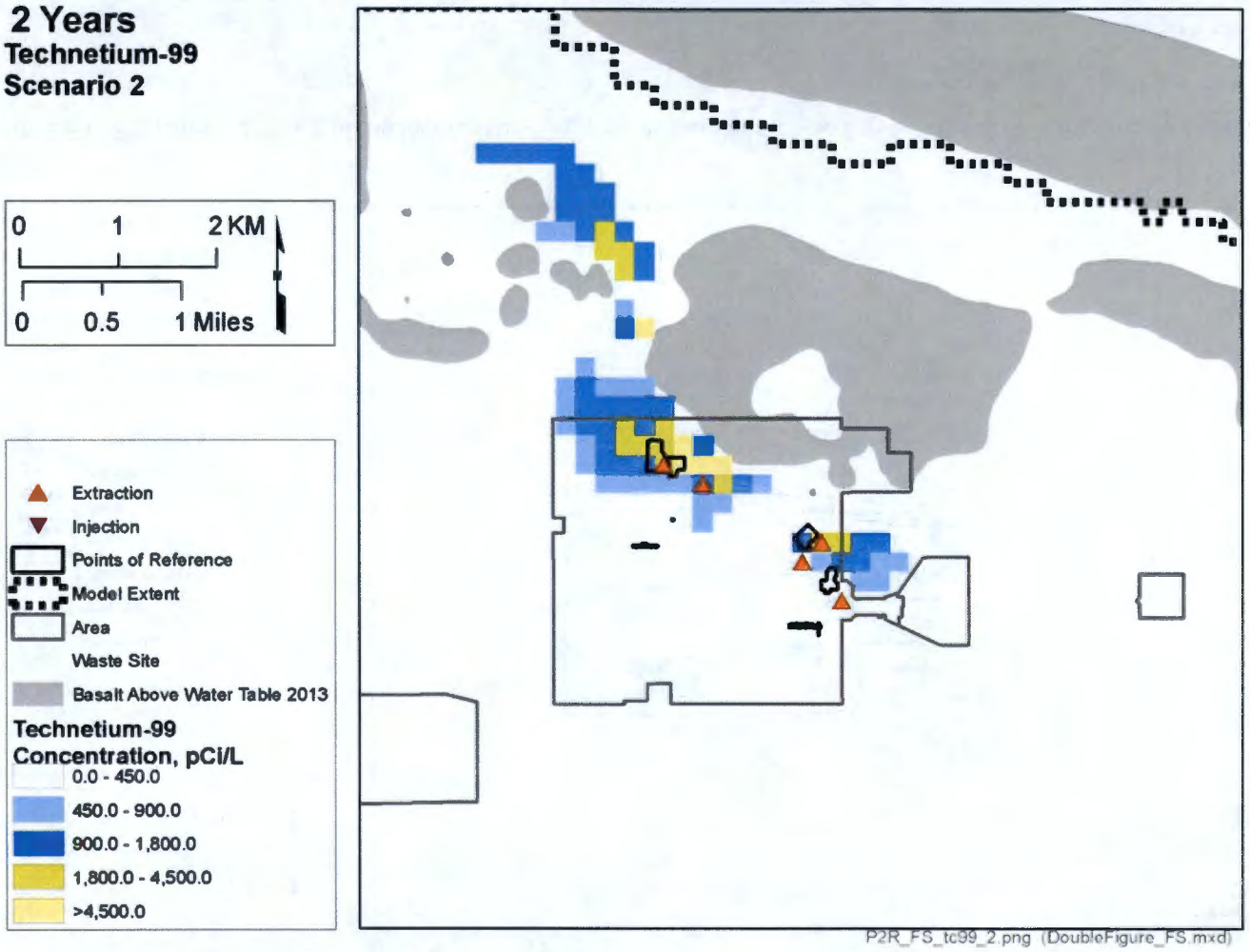

Figure B-59 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 2 simulation.

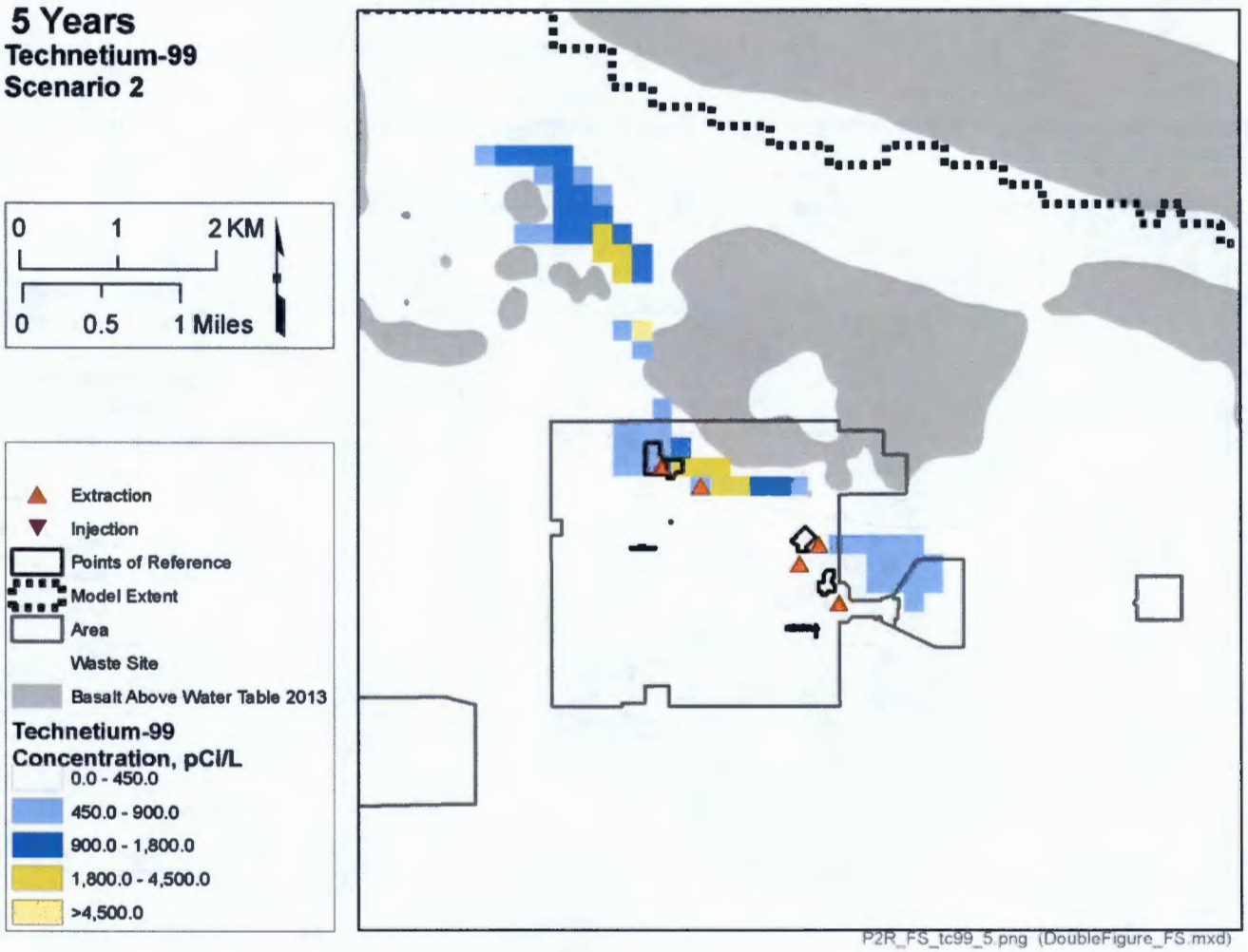

Figure B-60 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 2 simulation.

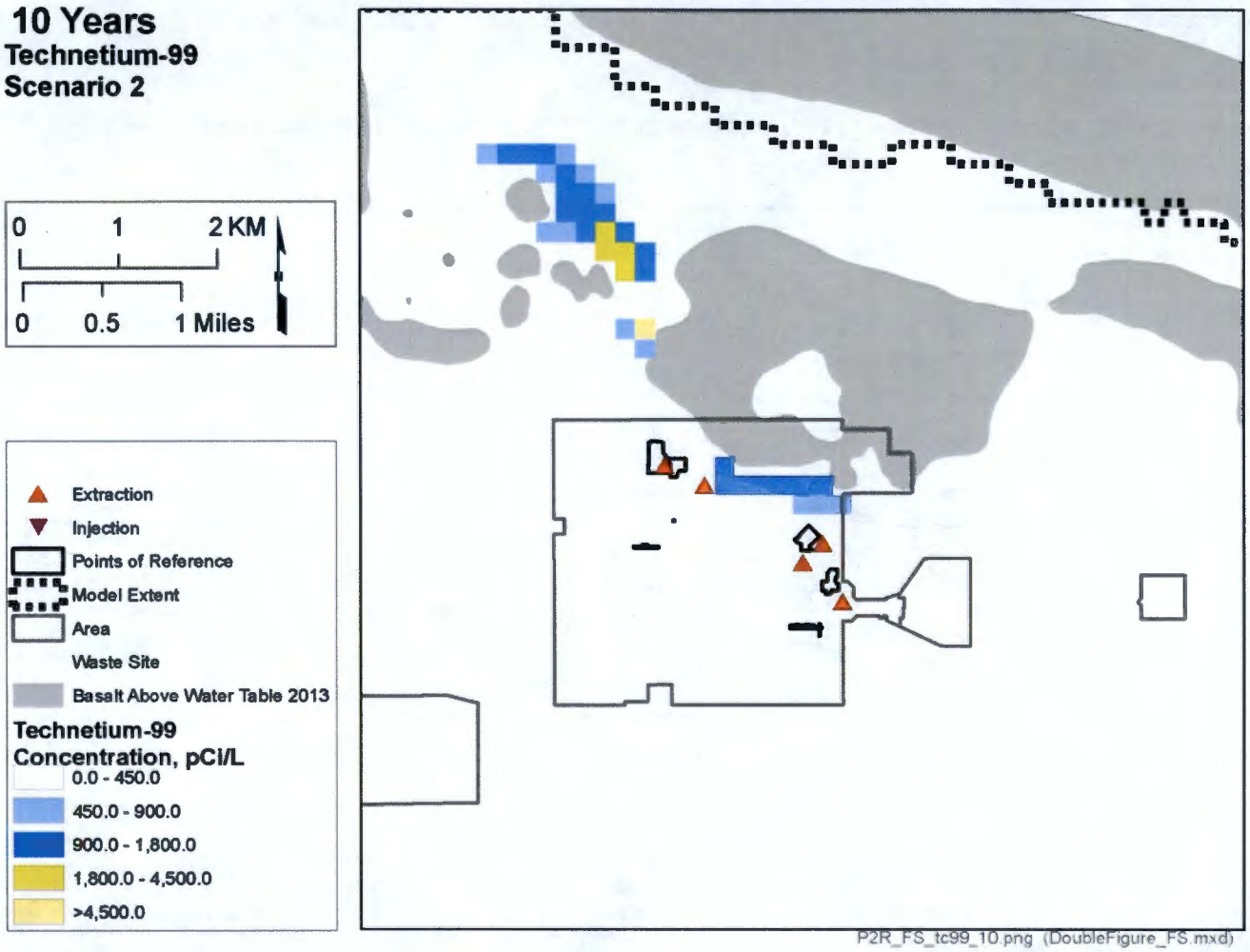

Figure B-61 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 2 simulation.

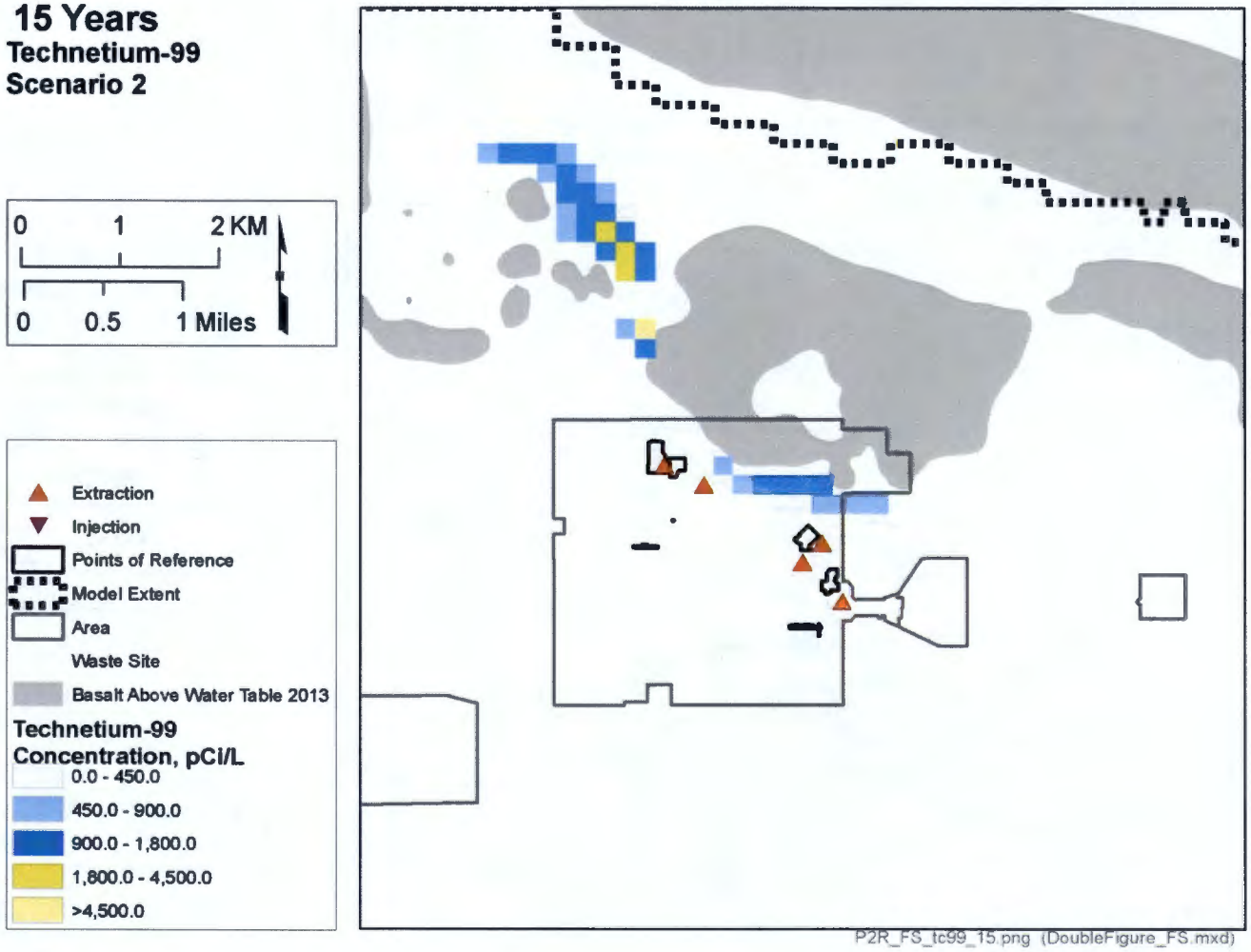

Figure B-62 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 2 simulation.

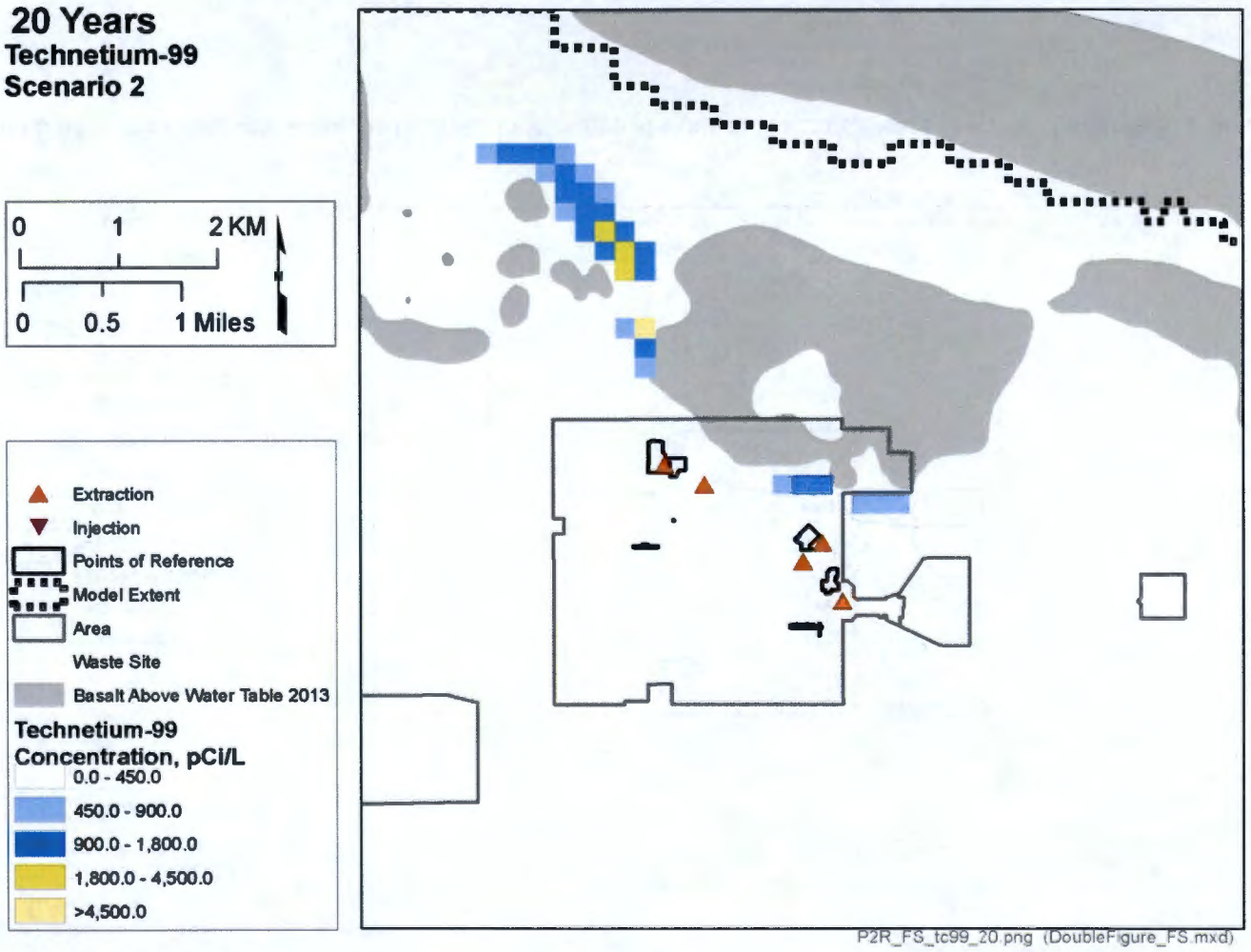

Figure B-63 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 2 simulation.

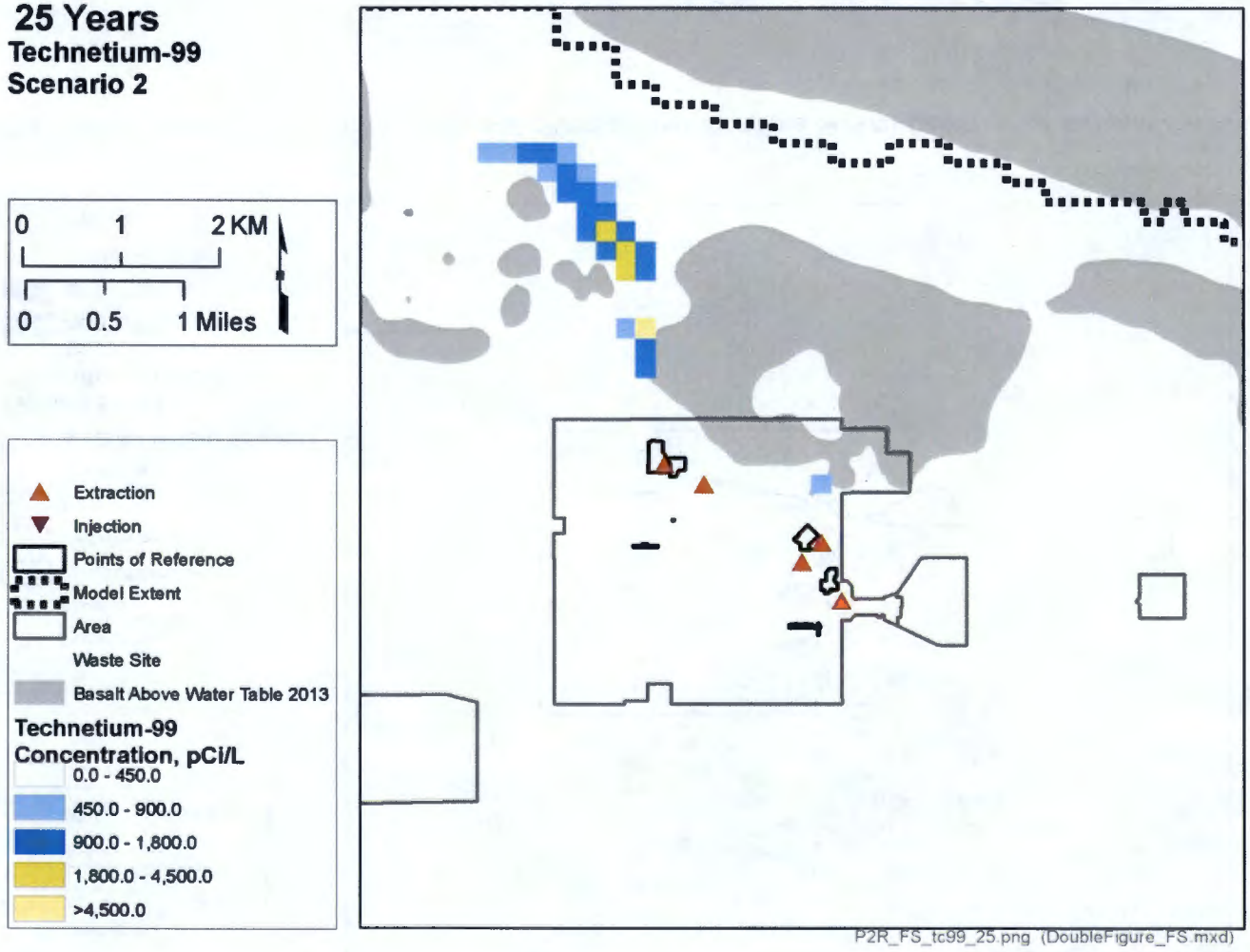

Figure B-64 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 2 simulation.

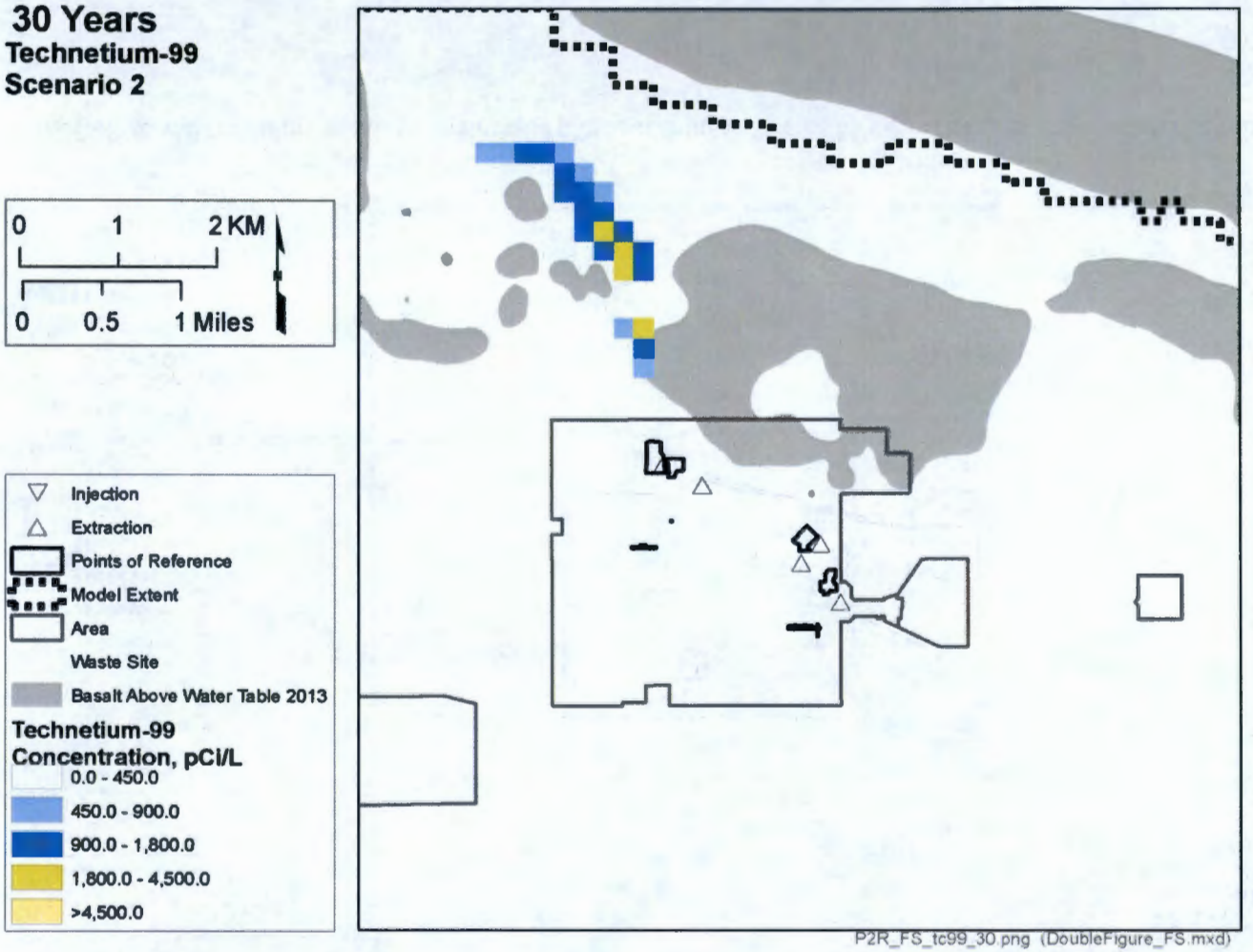

Figure B-65 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 2 simulation.

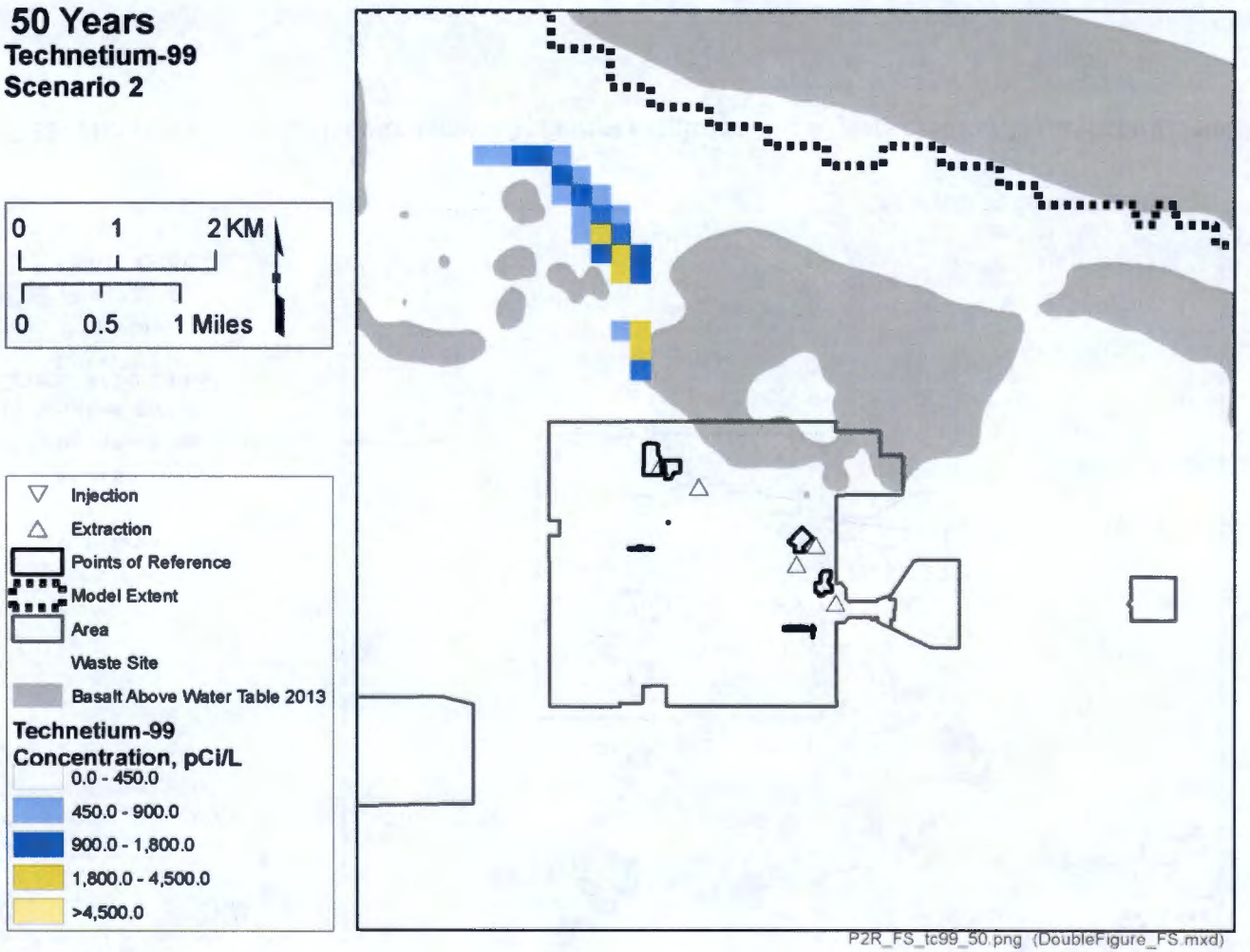

Figure B-66 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 2 simulation.

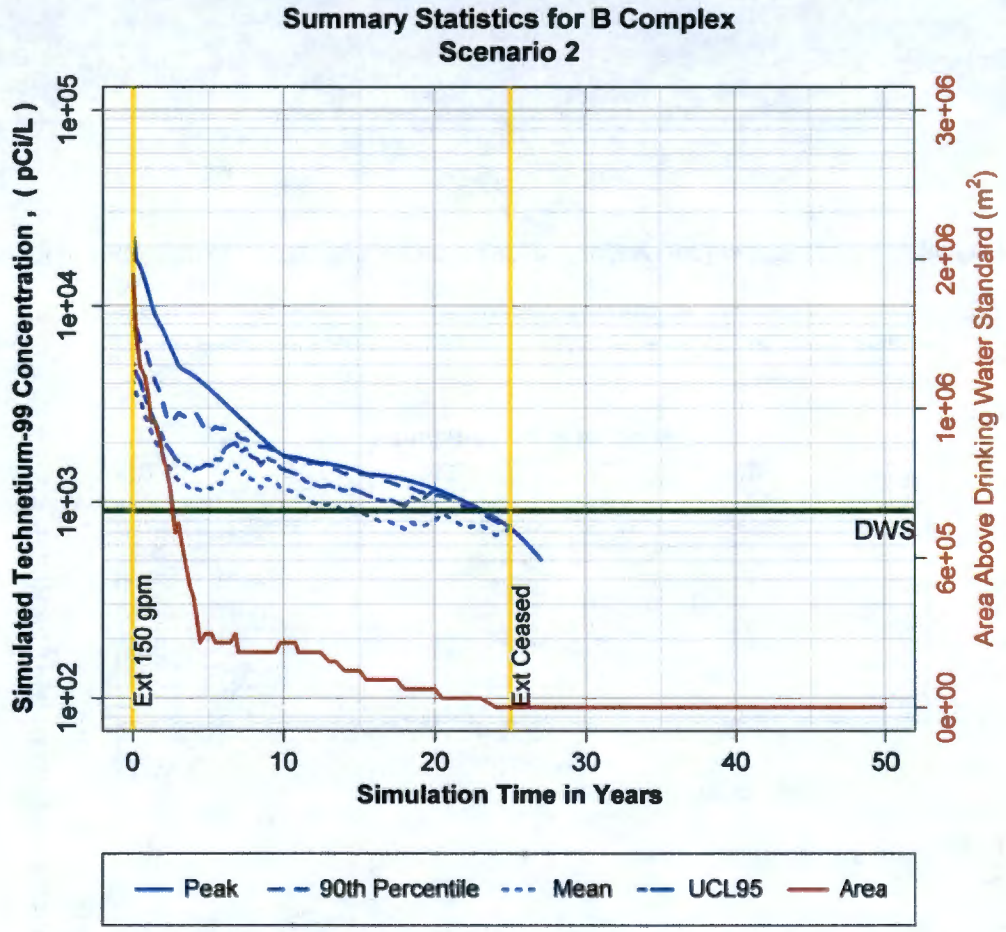

Figure B-67 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

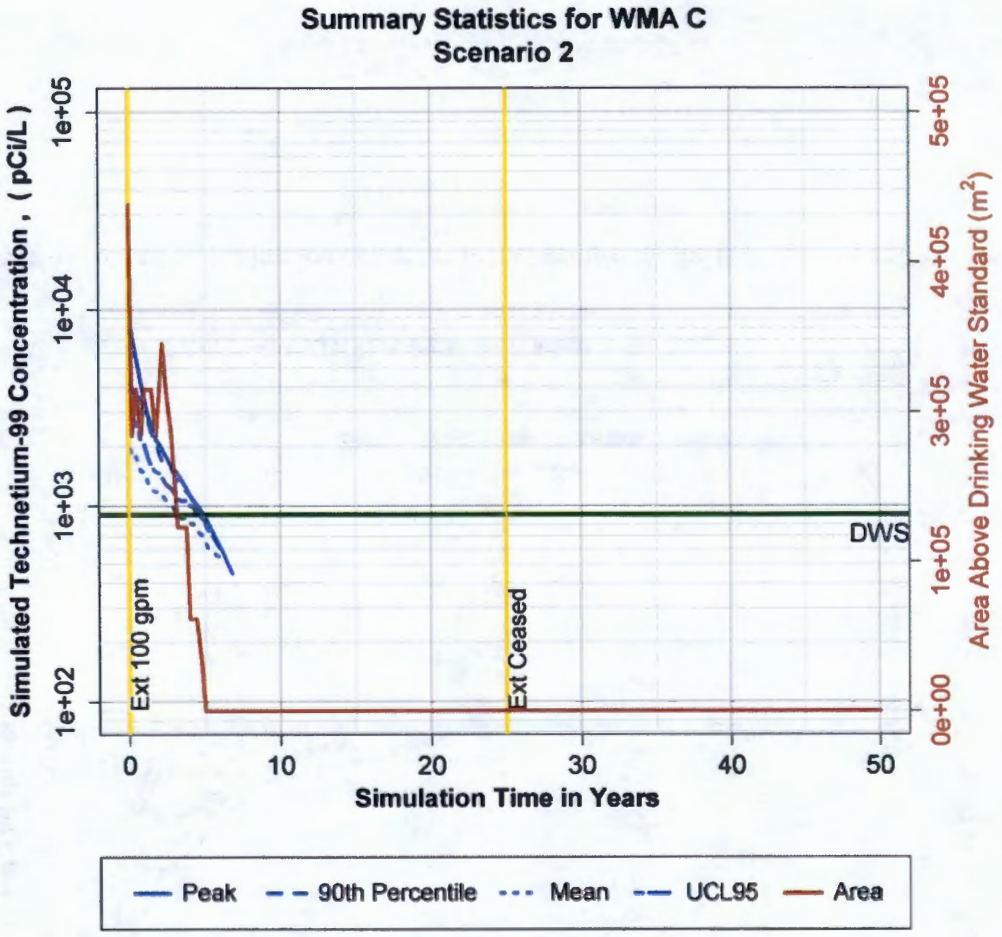

Figure B-68 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

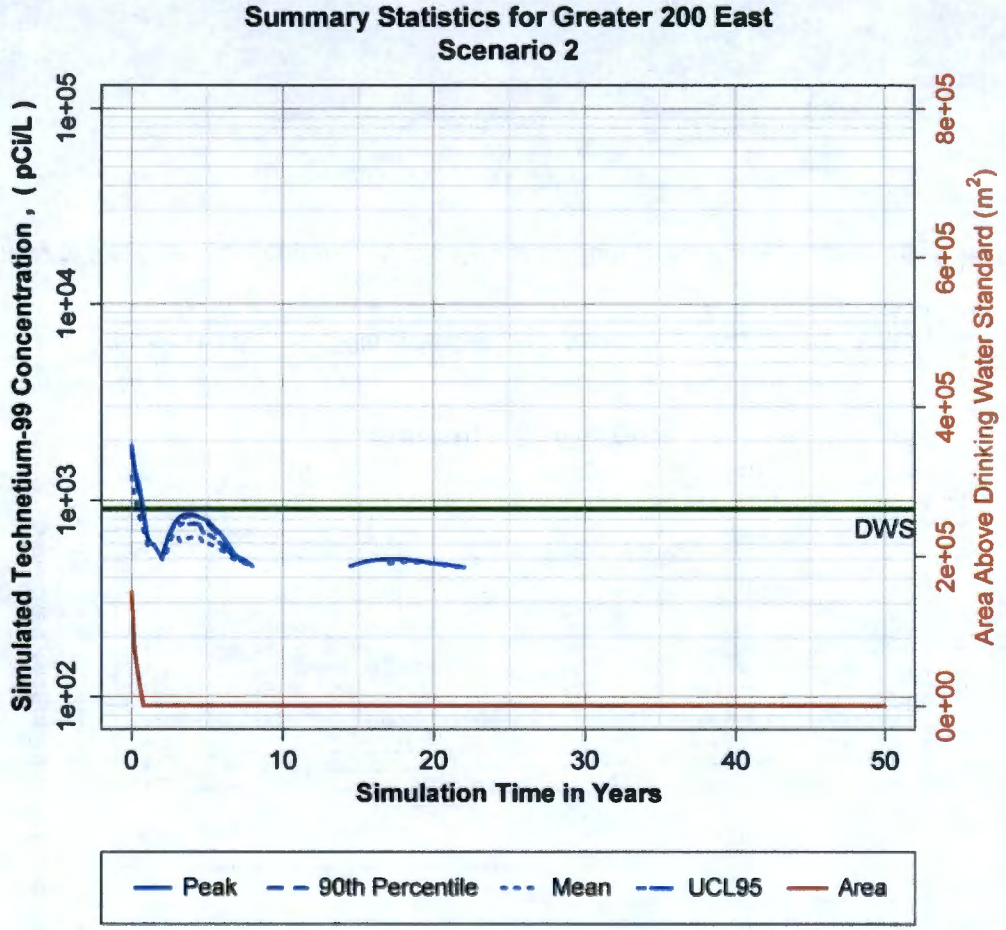

Figure B-69 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

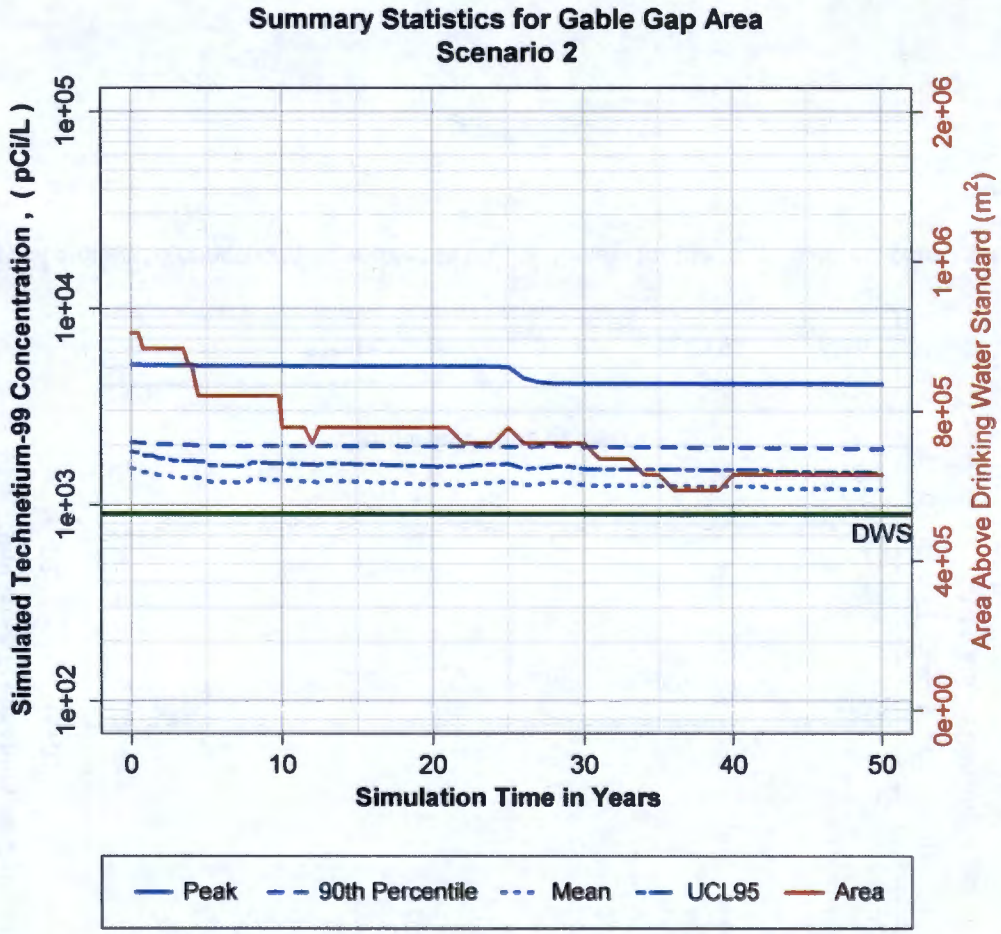

Figure B-70 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

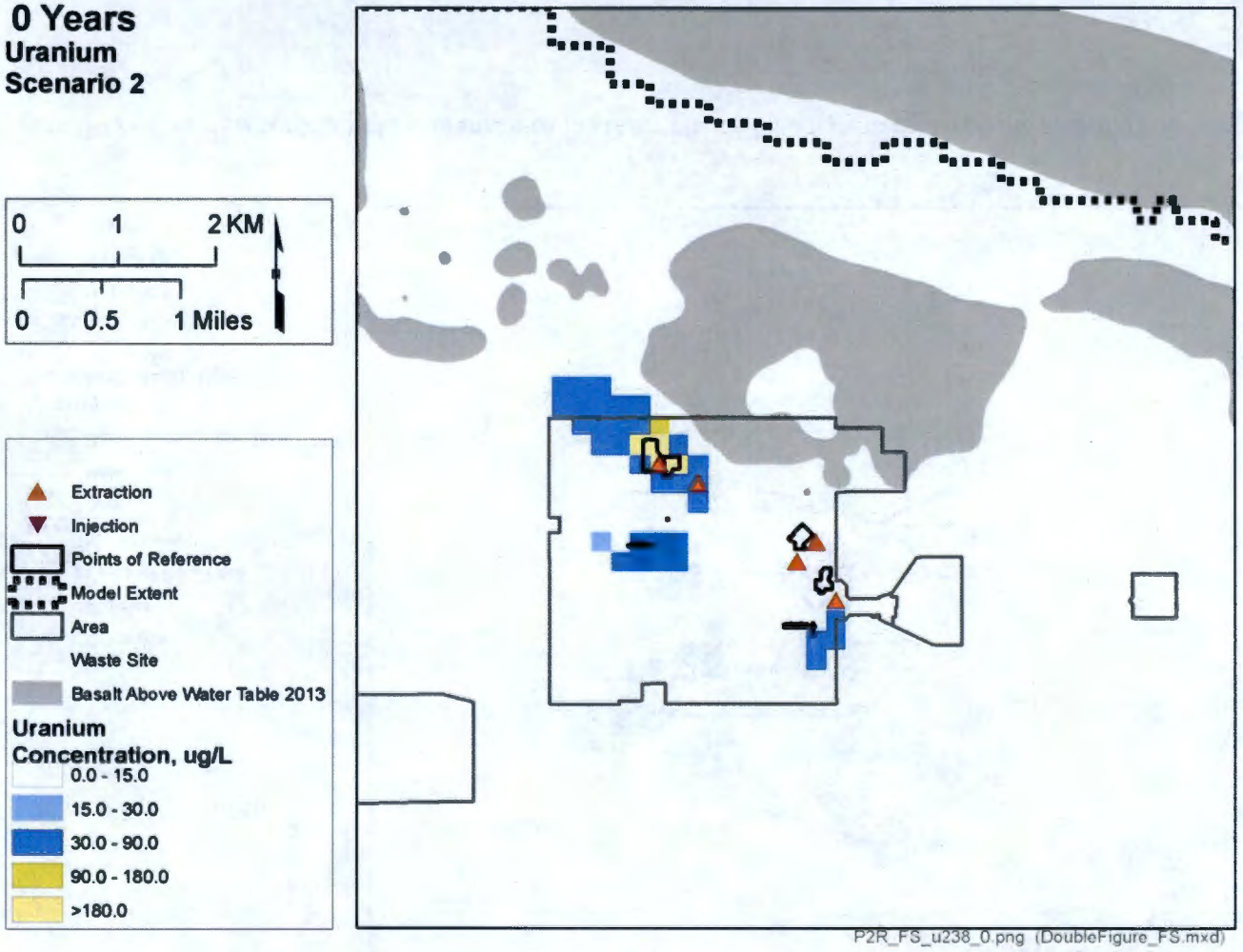

Figure B-71 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 2 simulation.

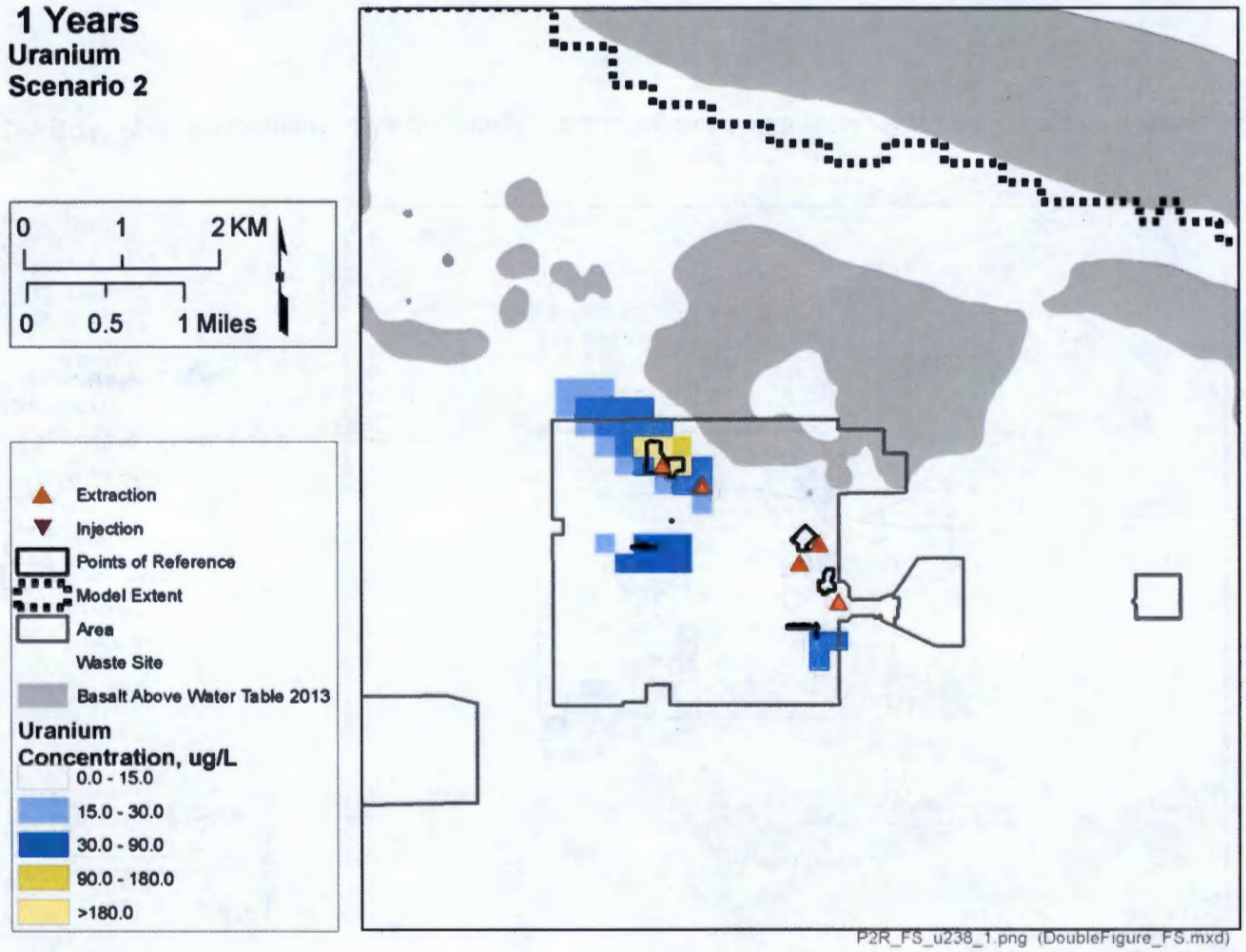

Figure B-72 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 2 simulation.

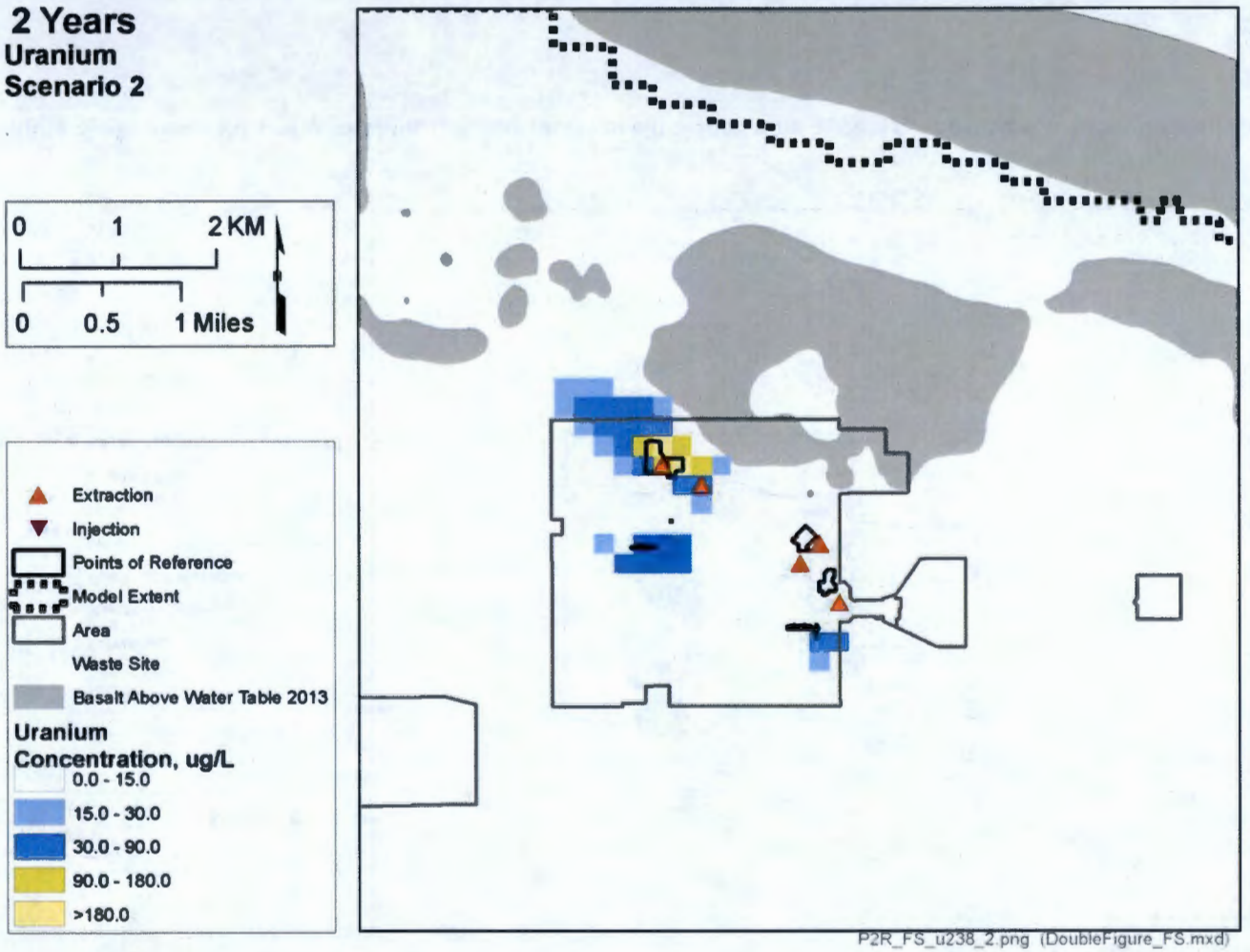

Figure B-73 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 2 simulation.

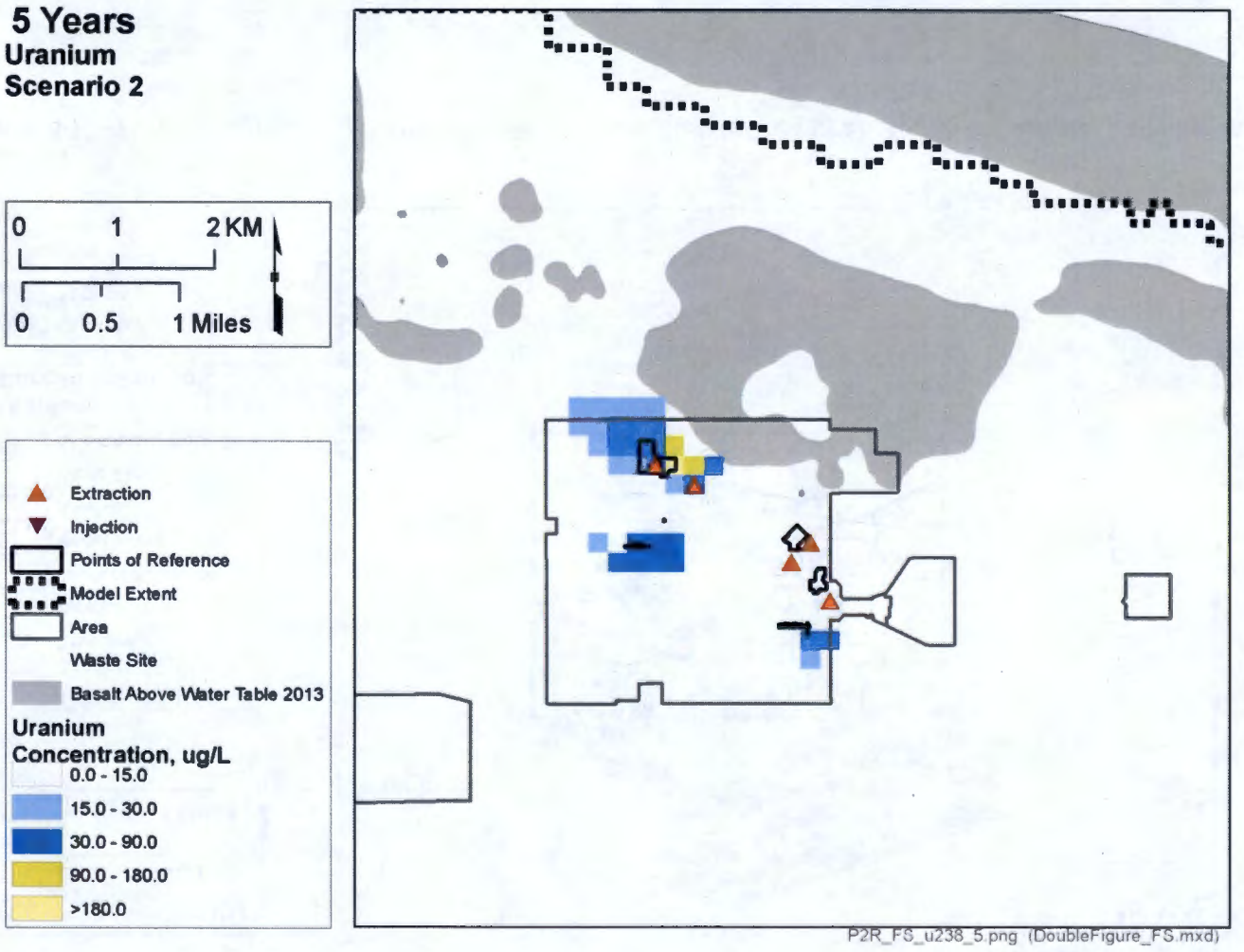

Figure B-74 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 2 simulation.

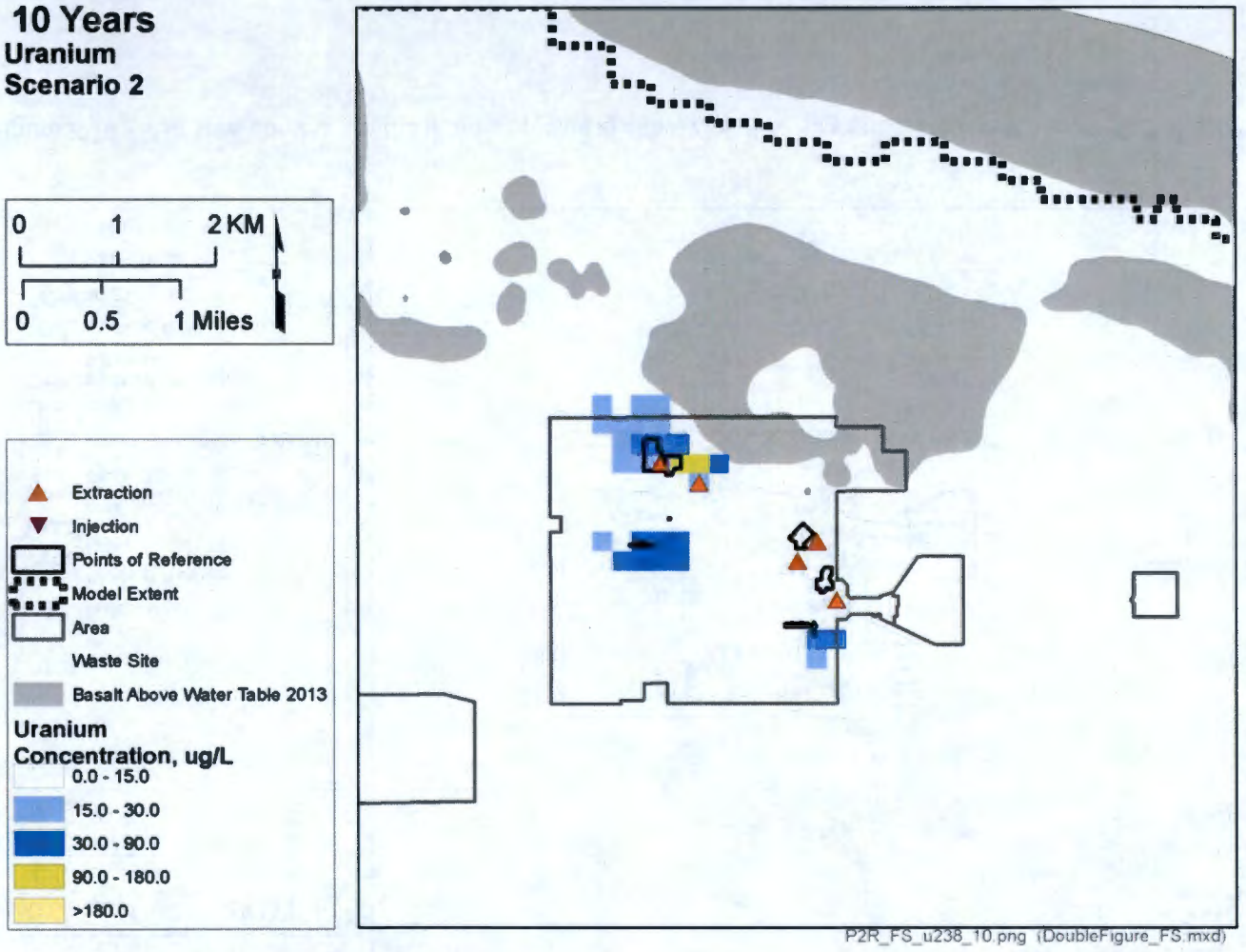

Figure B-75 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 2 simulation.

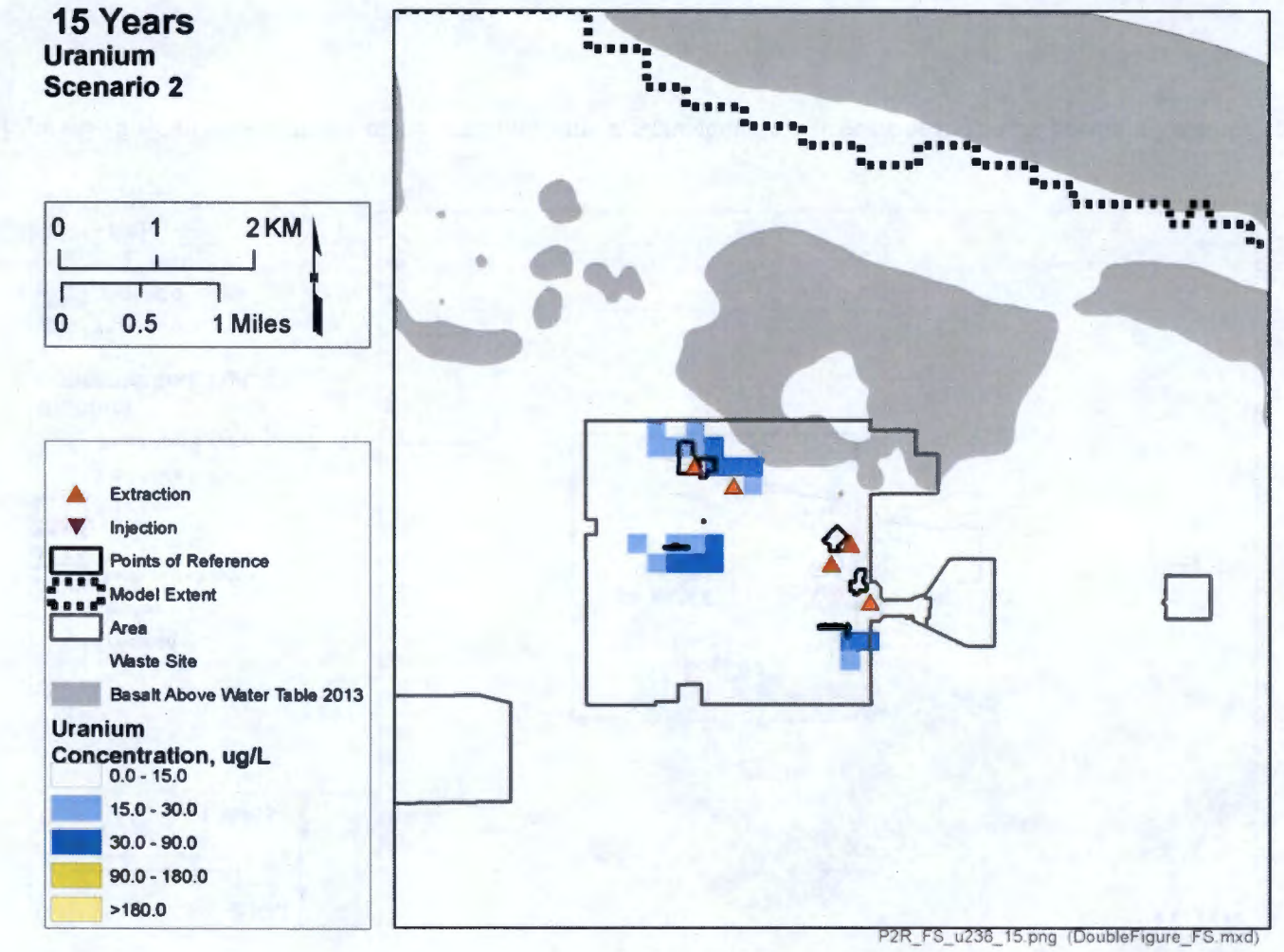

Figure B-76 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 2 simulation.

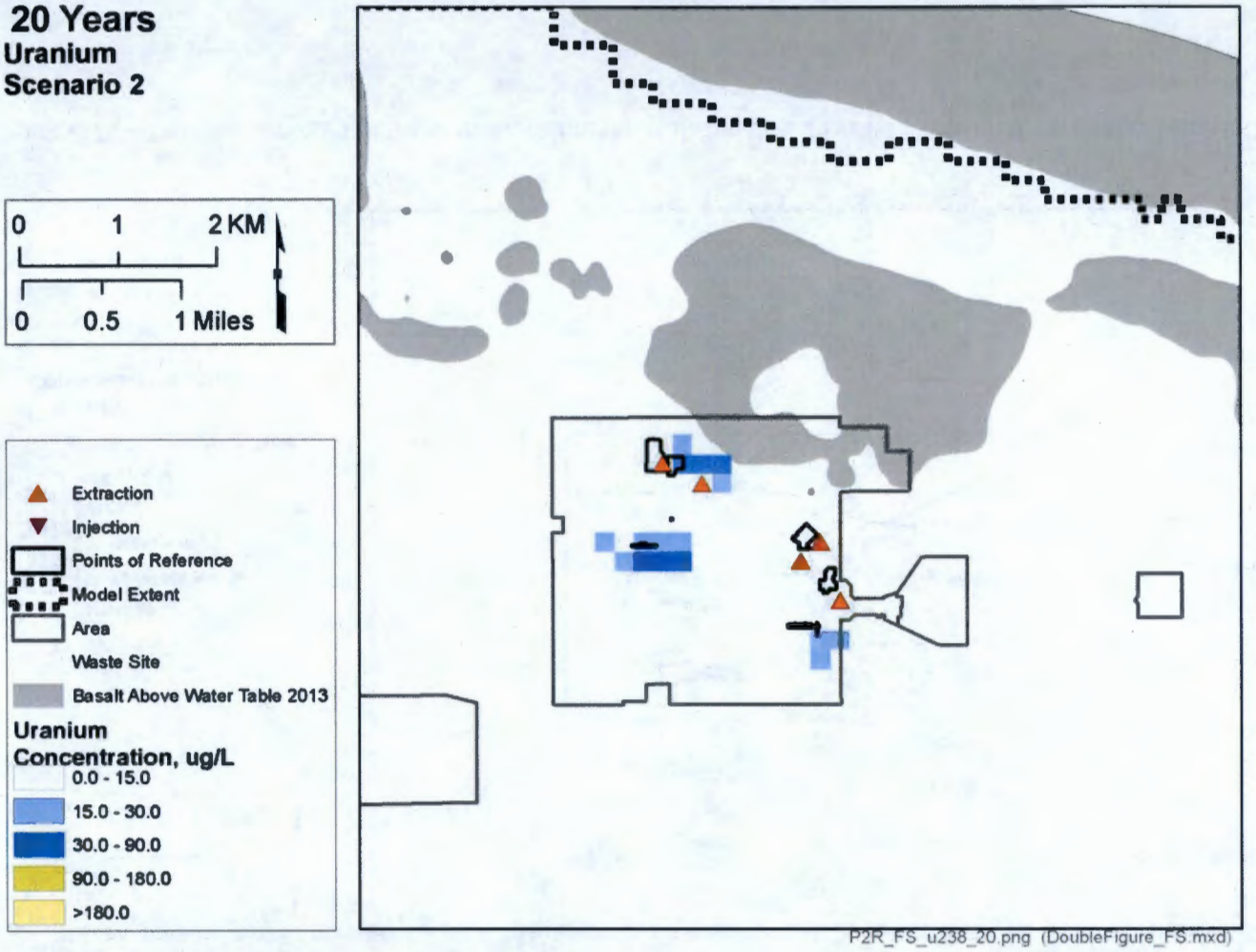

Figure B-77 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 2 simulation.

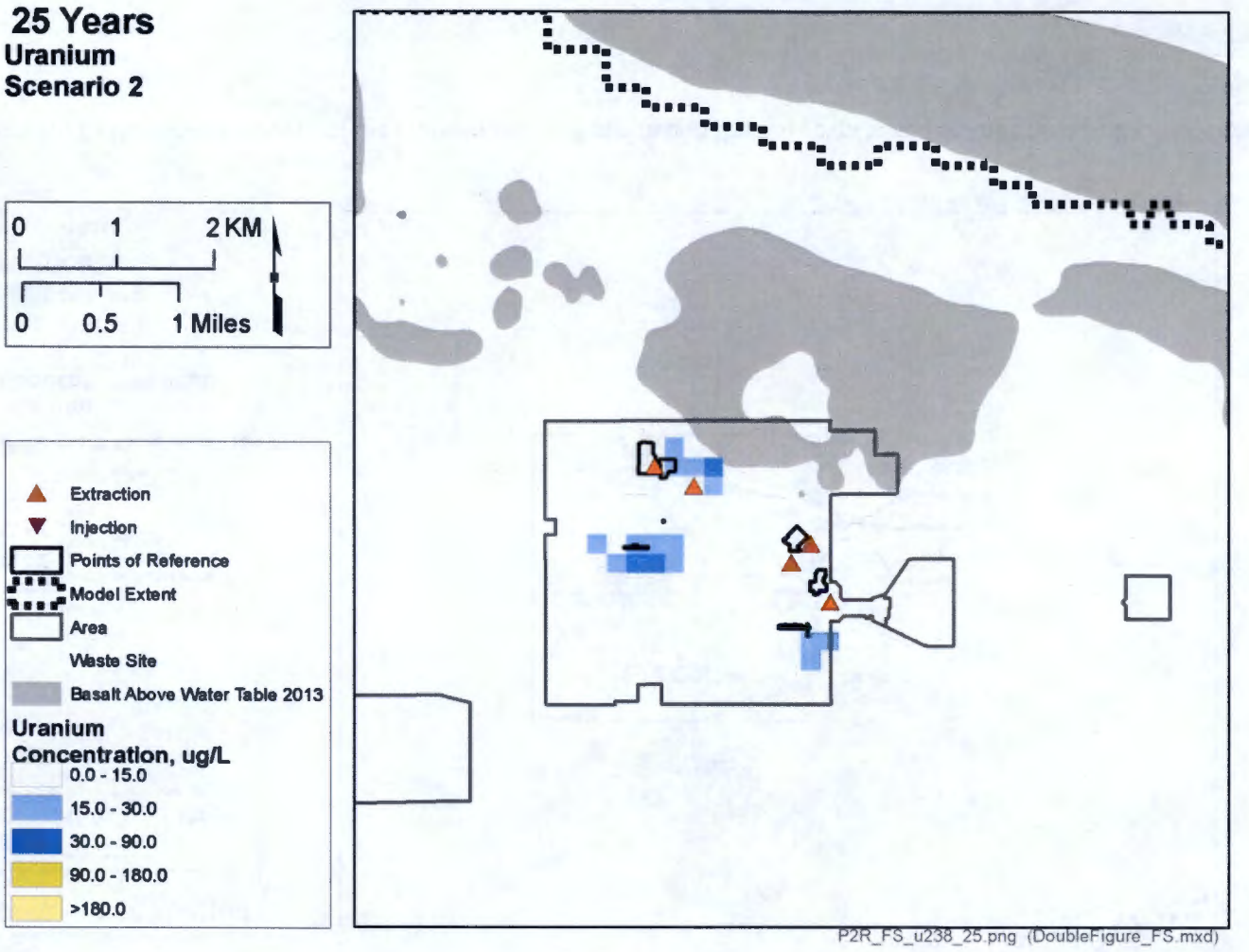

Figure B-78 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 2 simulation.

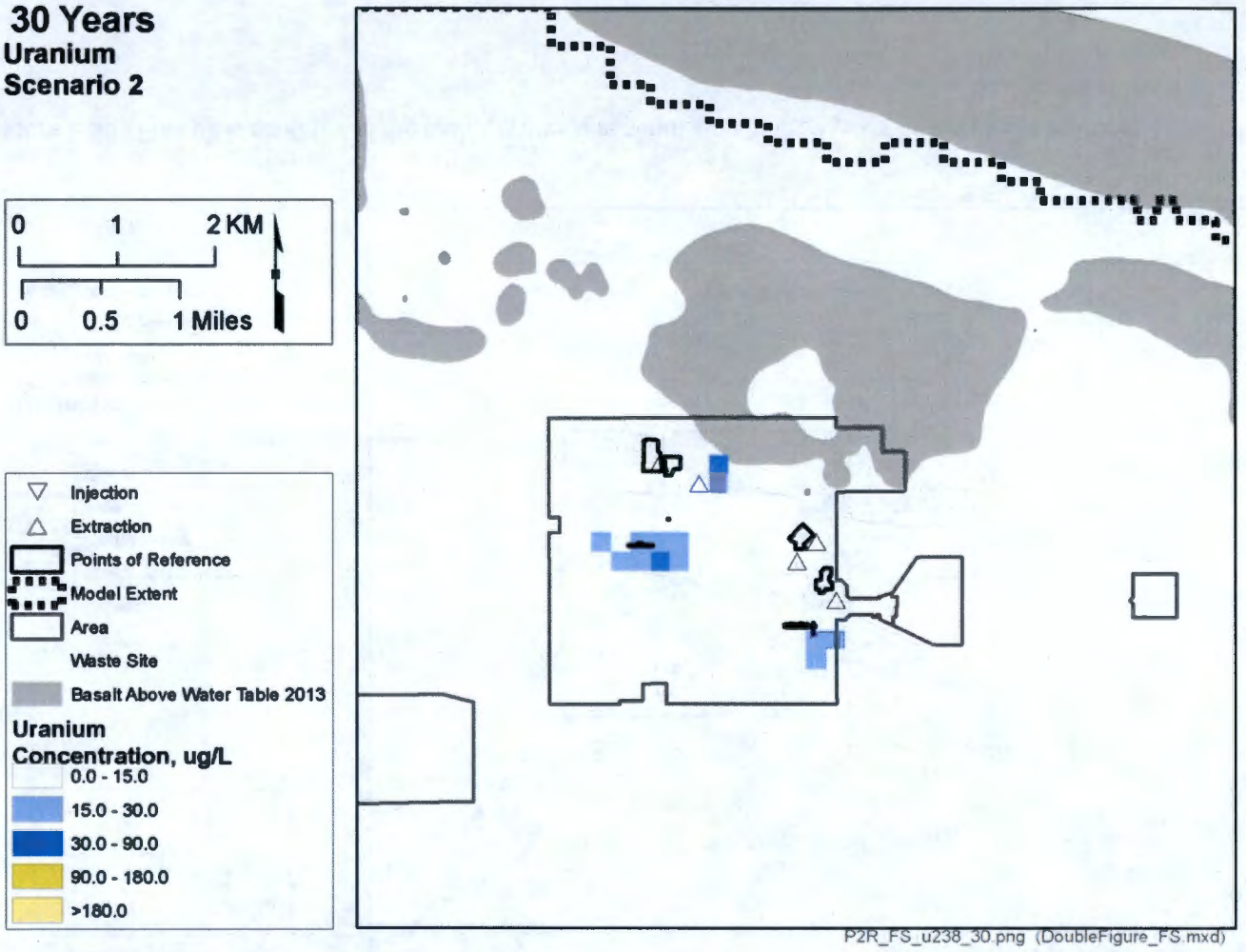

Figure B-79 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 2 simulation.

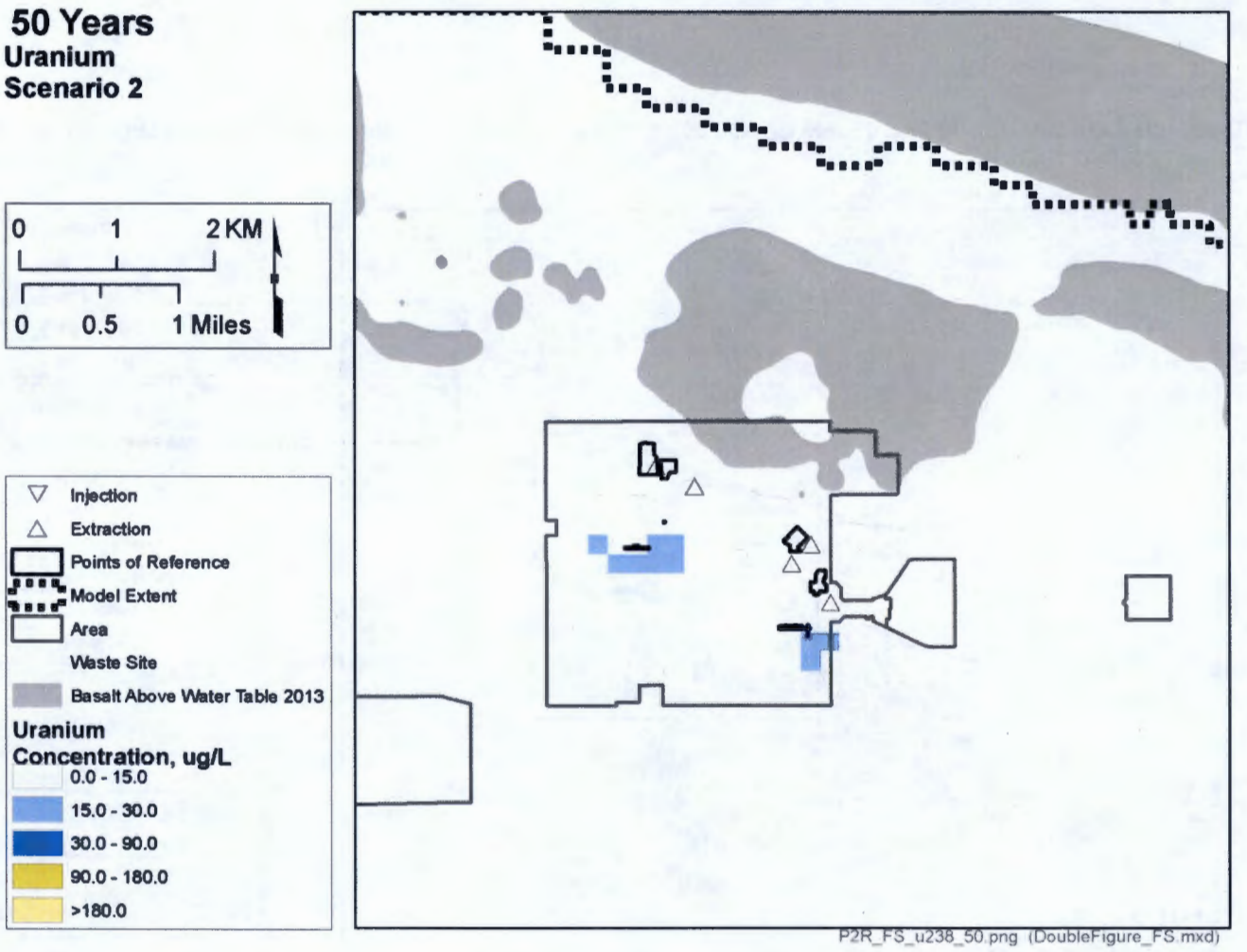

Figure B-80 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 2 simulation.

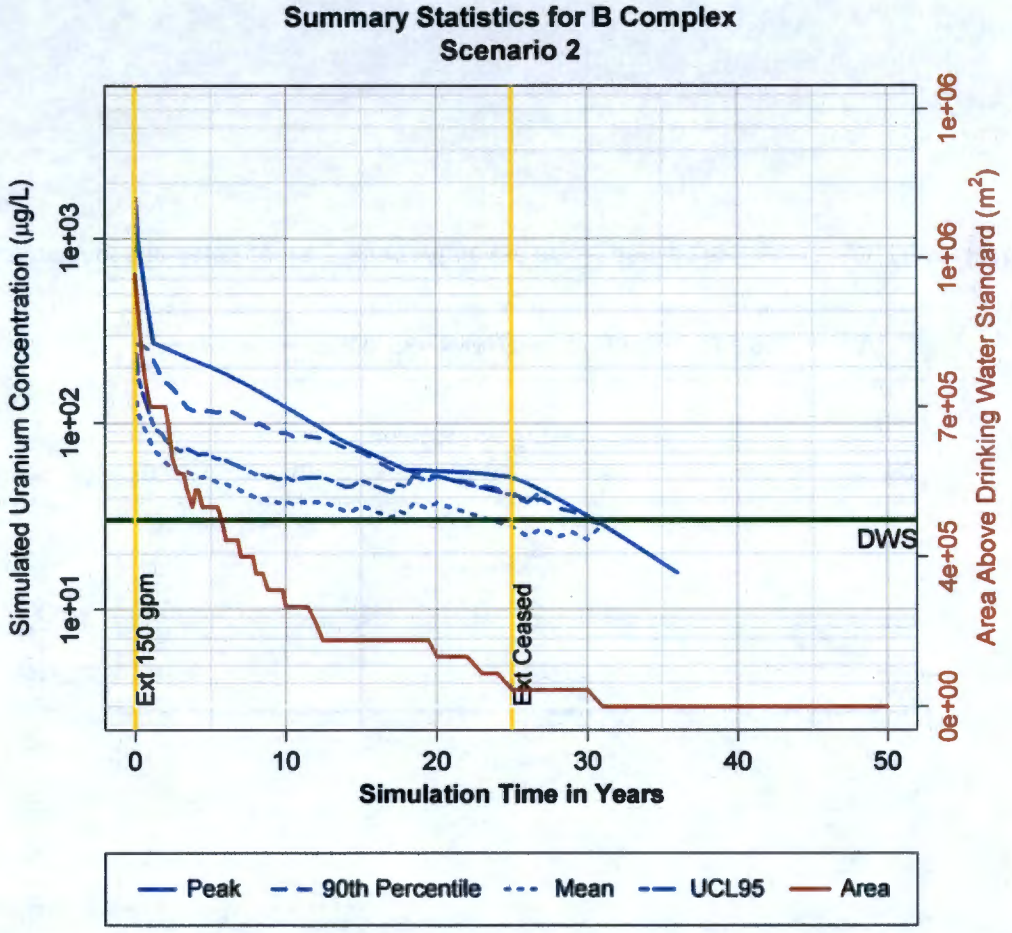

Figure B-81 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

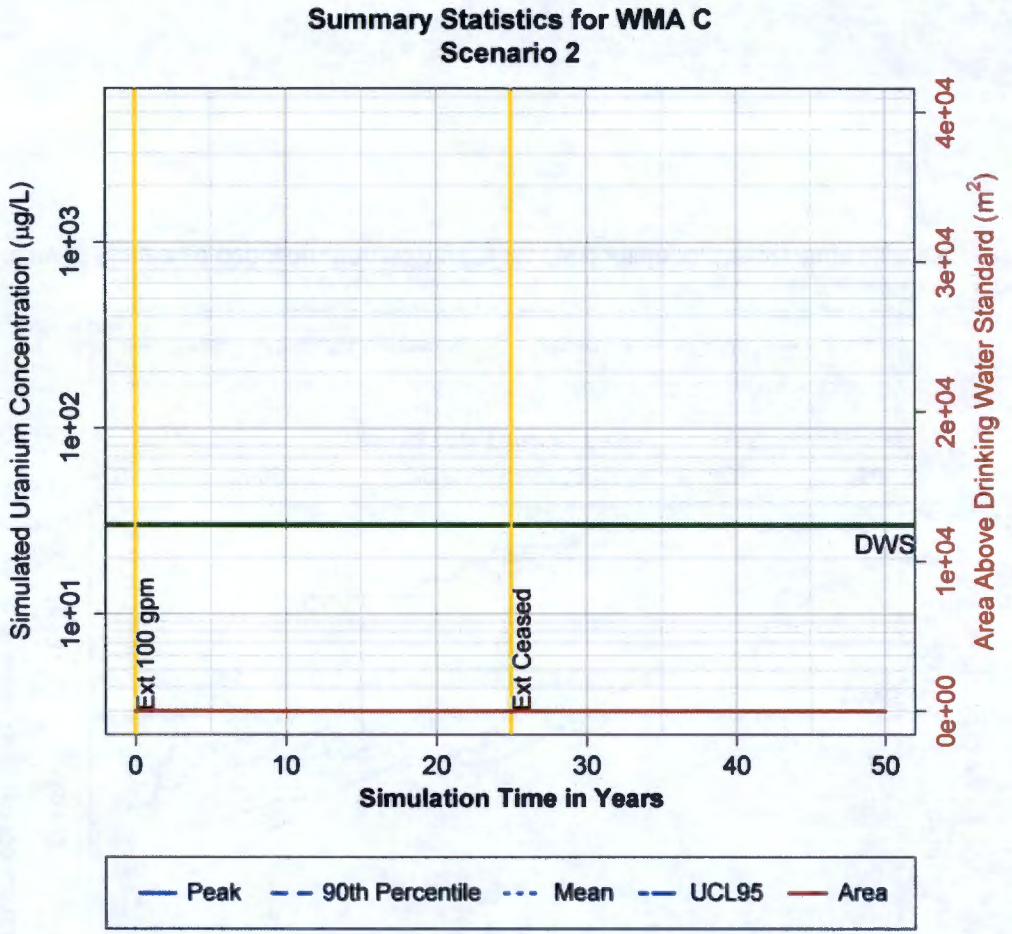

Figure B-82 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

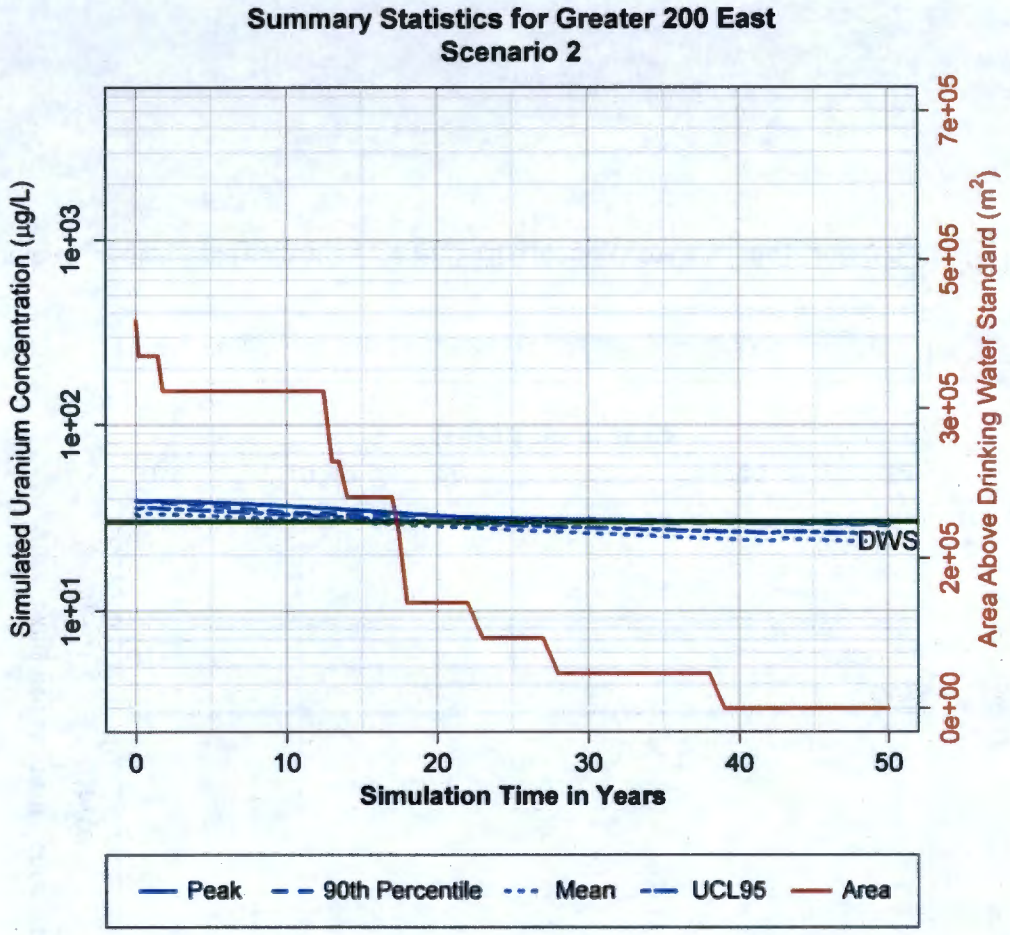

Figure B-83 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

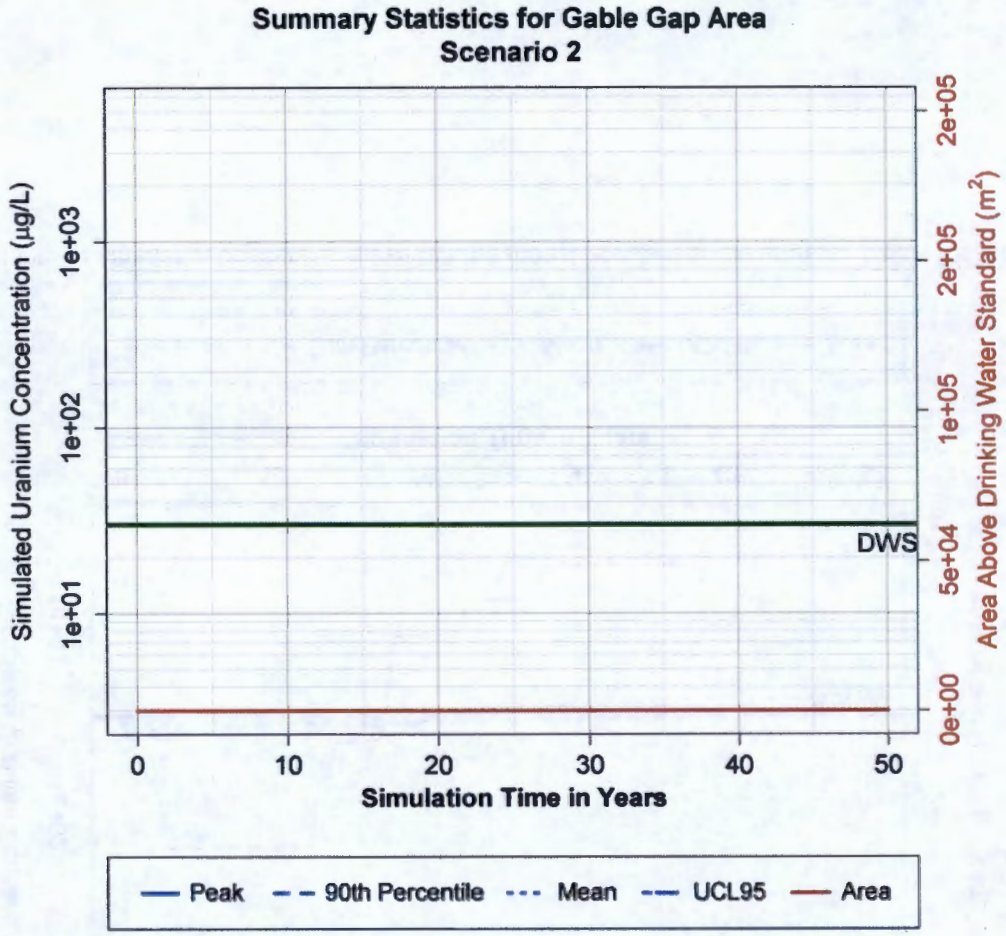

Figure B-84 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

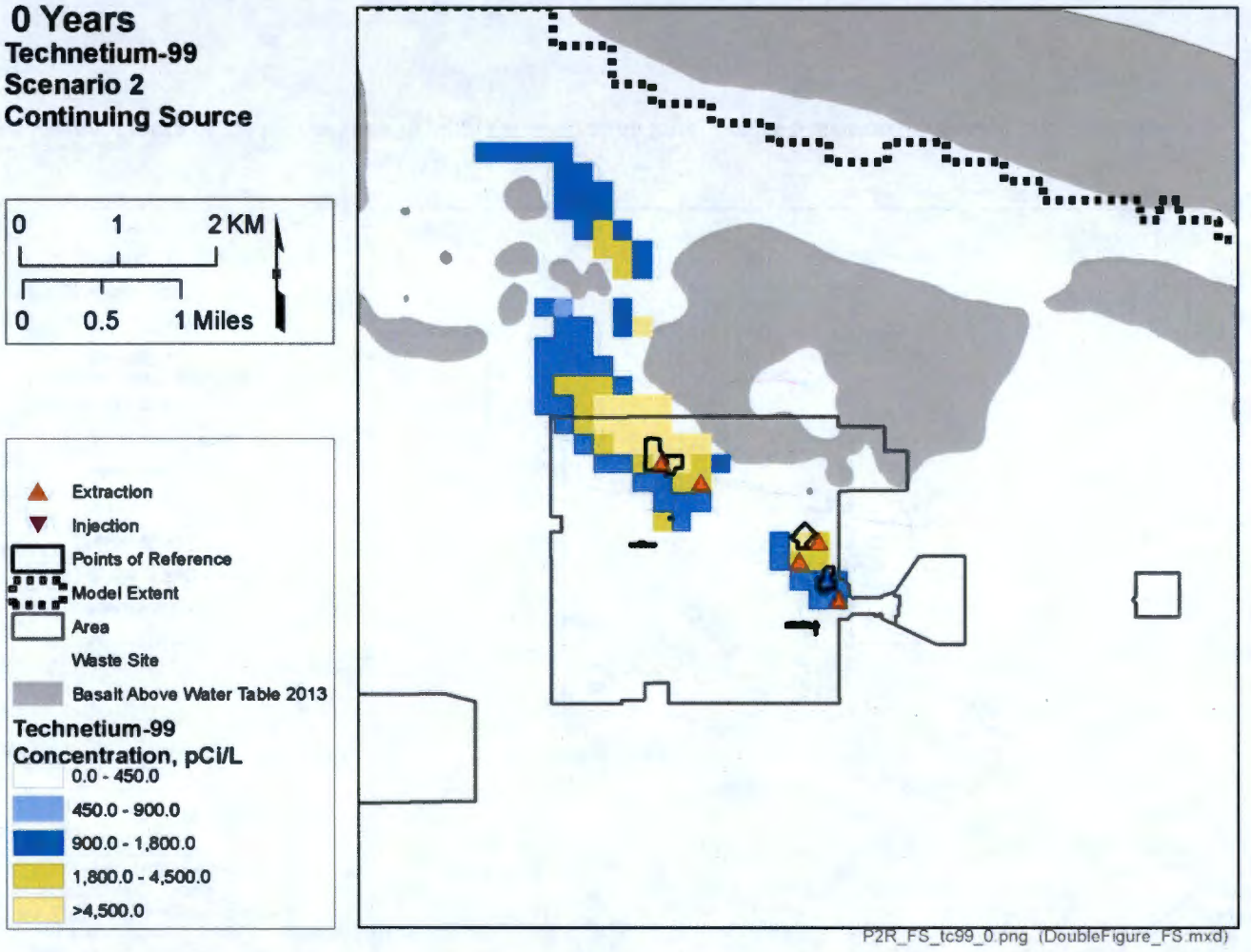

Figure B-85 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 2 simulation with a continuing source term.

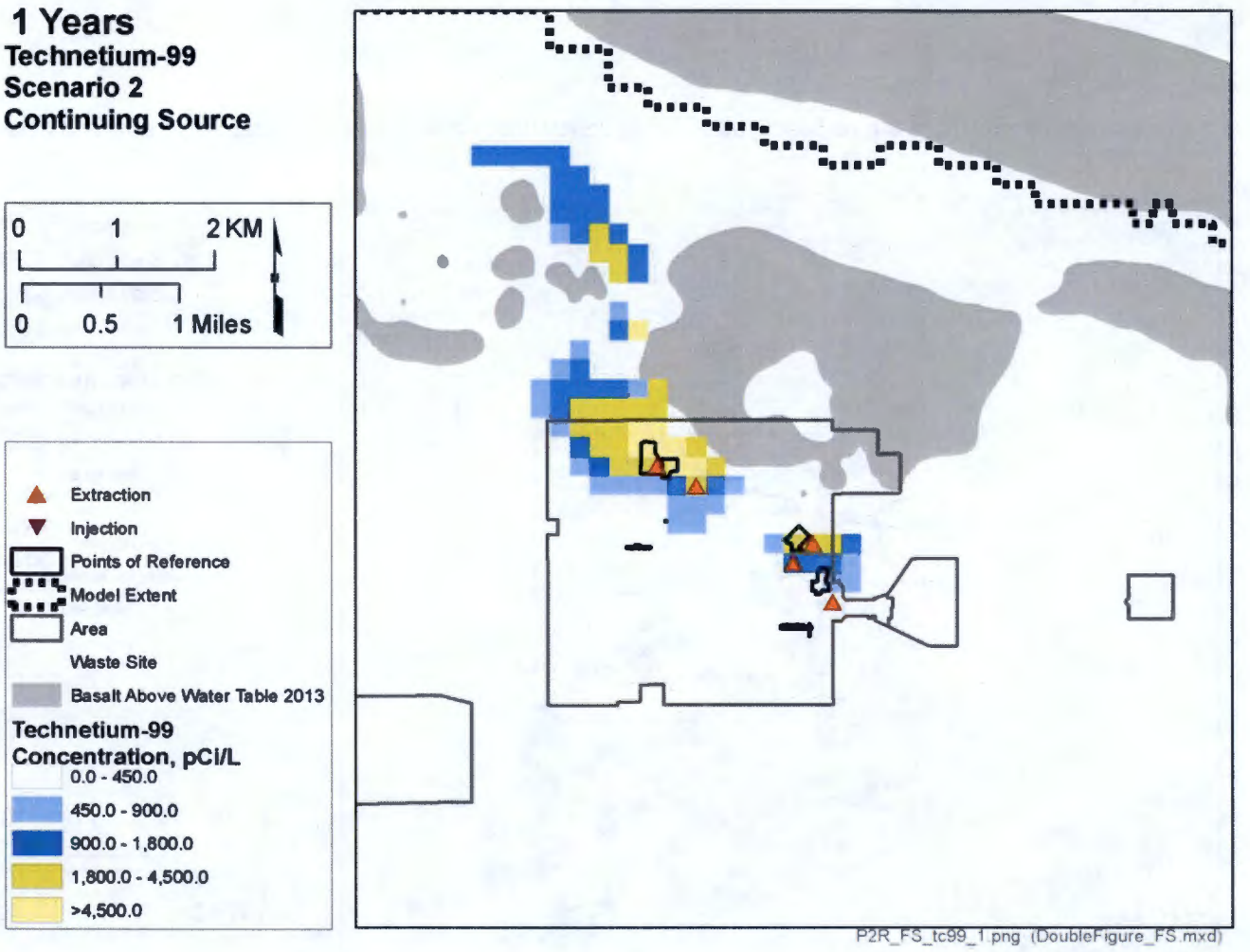

Figure B-86 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 2 simulation with a continuing source term.

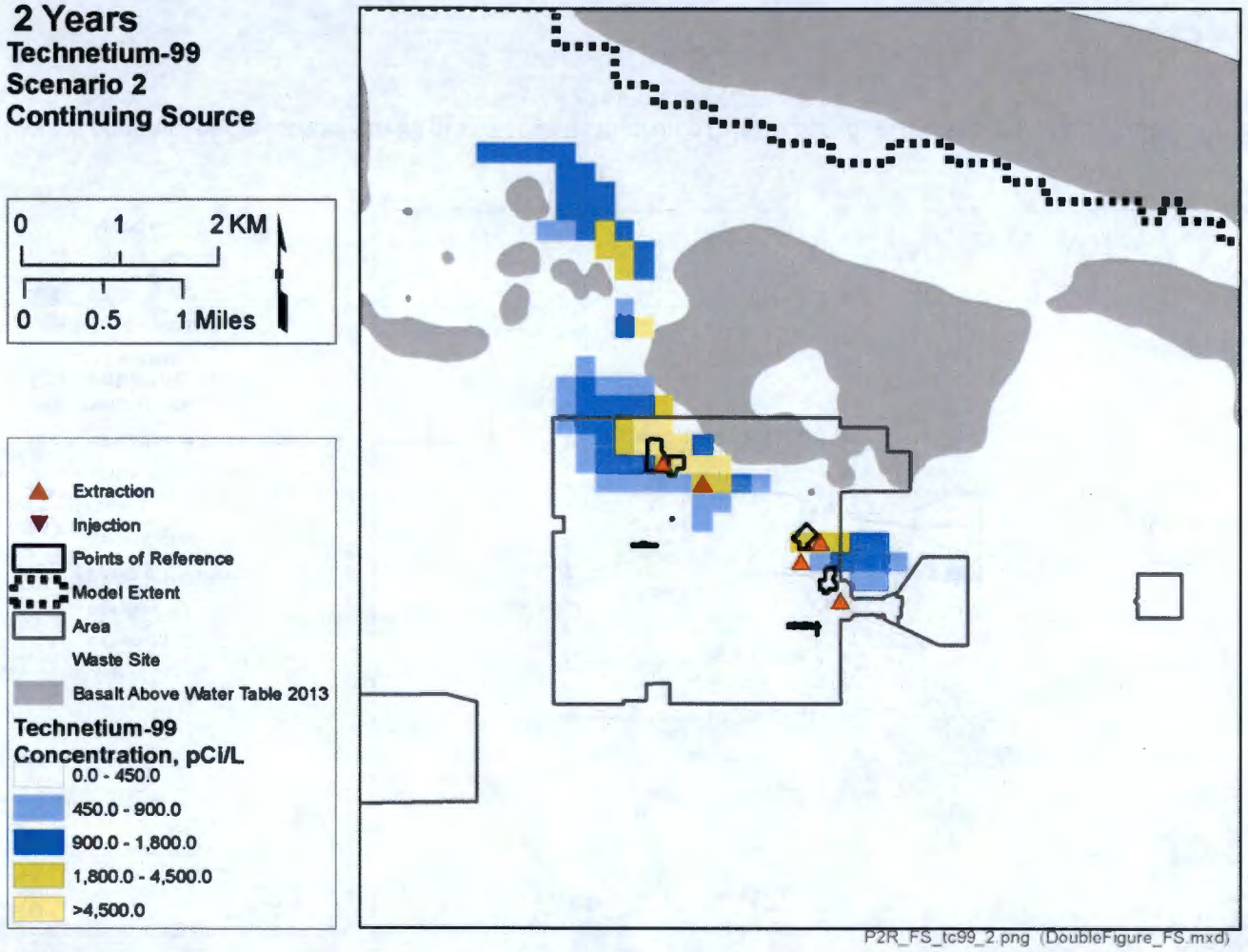

Figure B-87 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 2 simulation with a continuing source term.

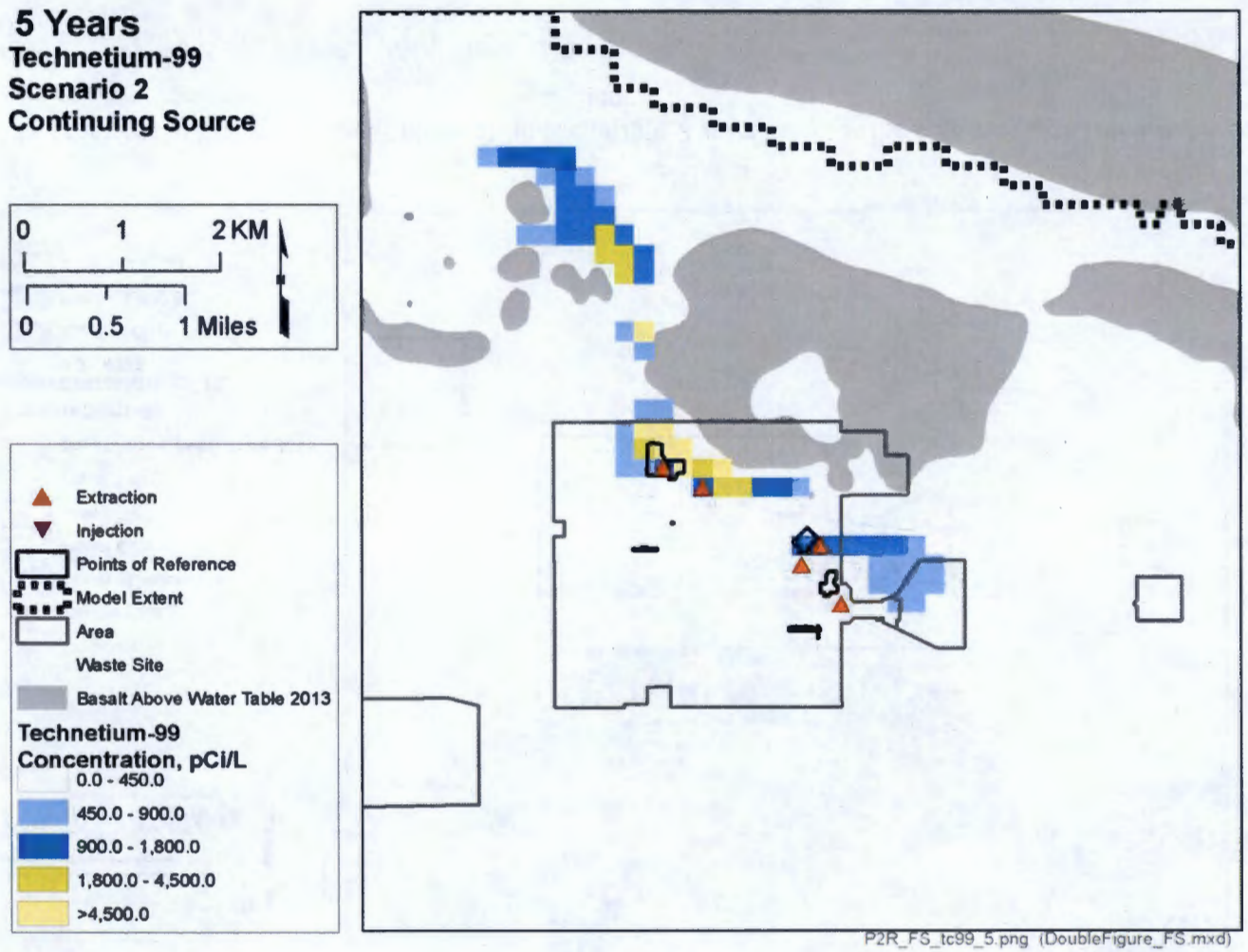

Figure B-88 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 2 simulation with a continuing source term.

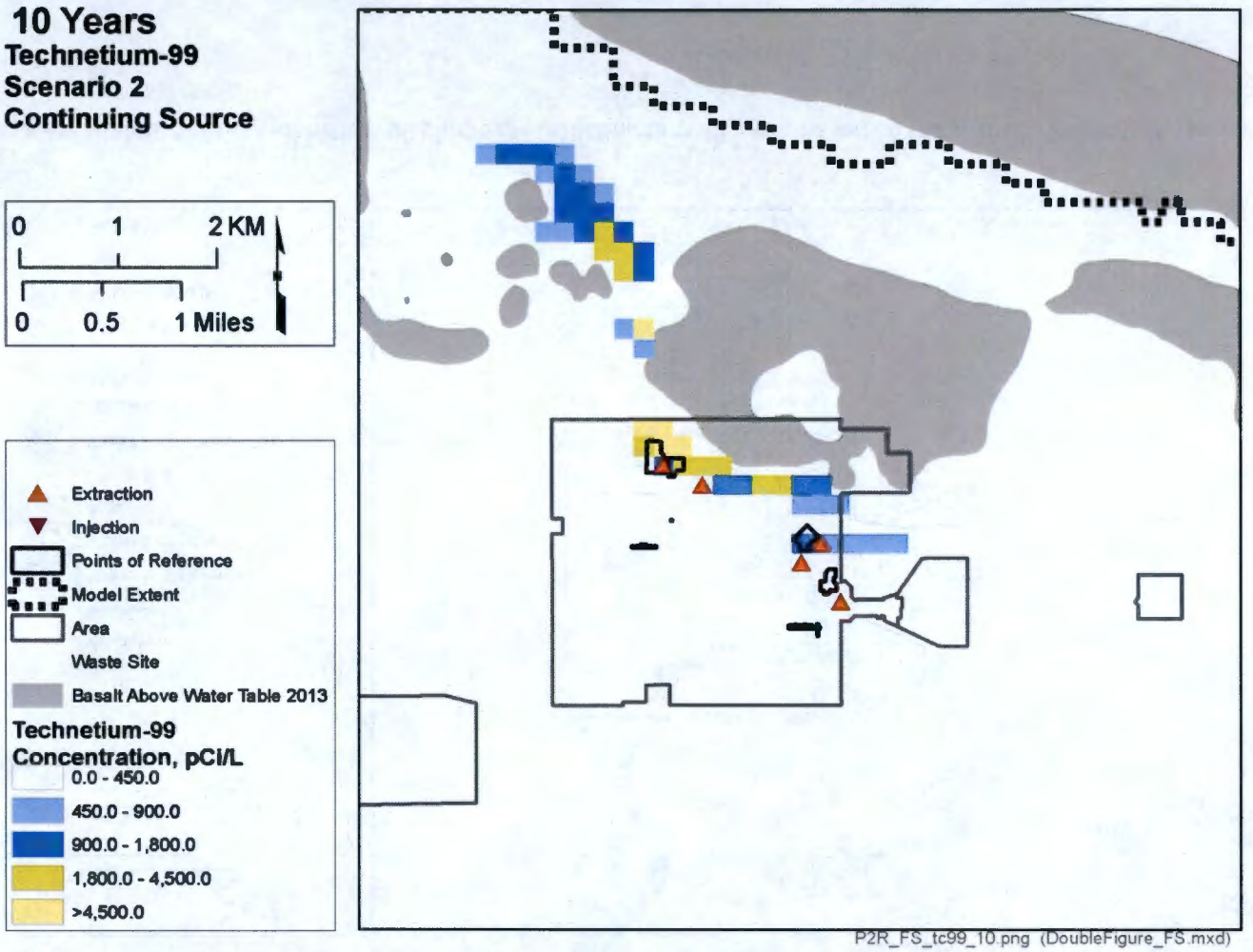

Figure B-89 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 2 simulation with a continuing source term.

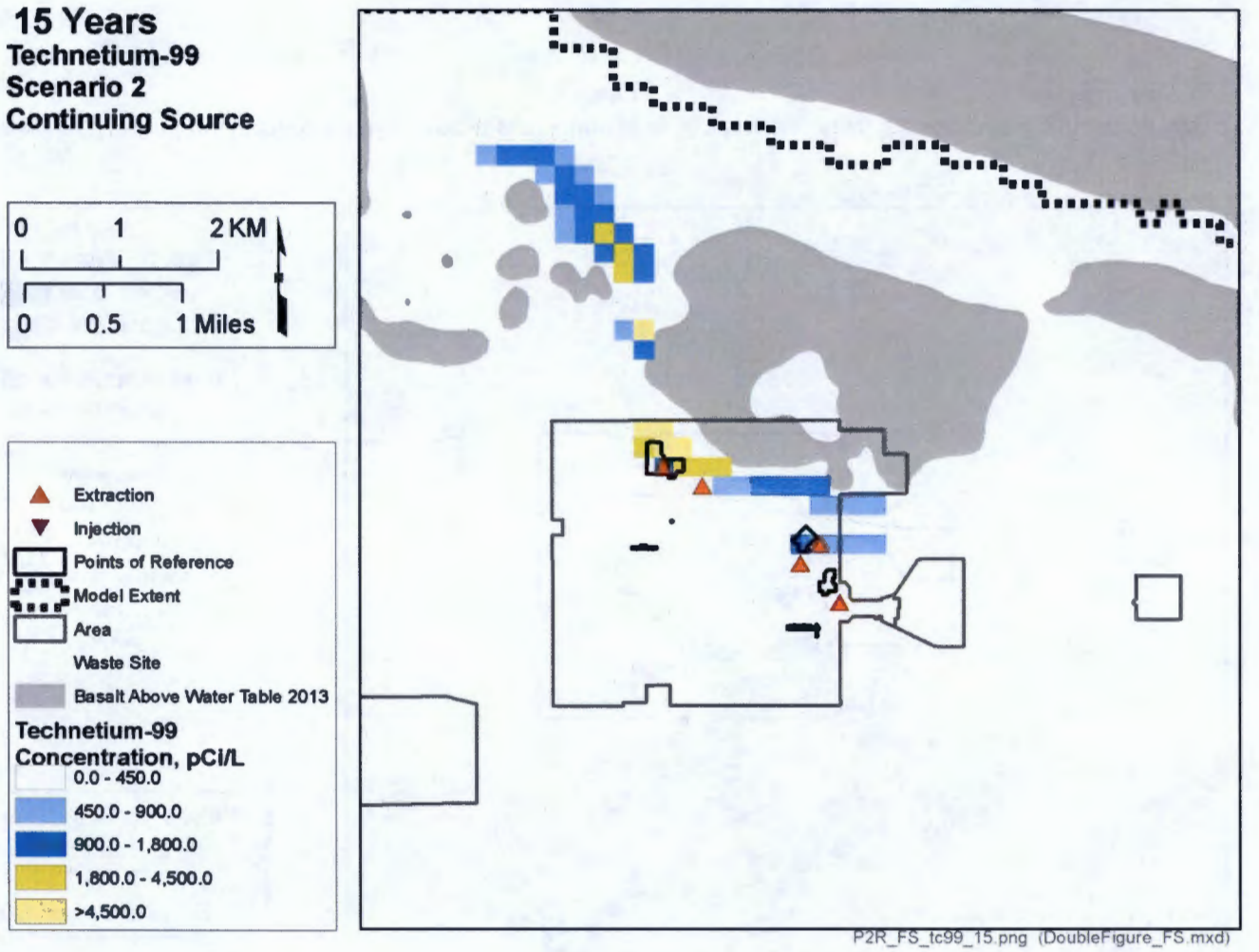

Figure B-90 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 2 simulation with a continuing source term.

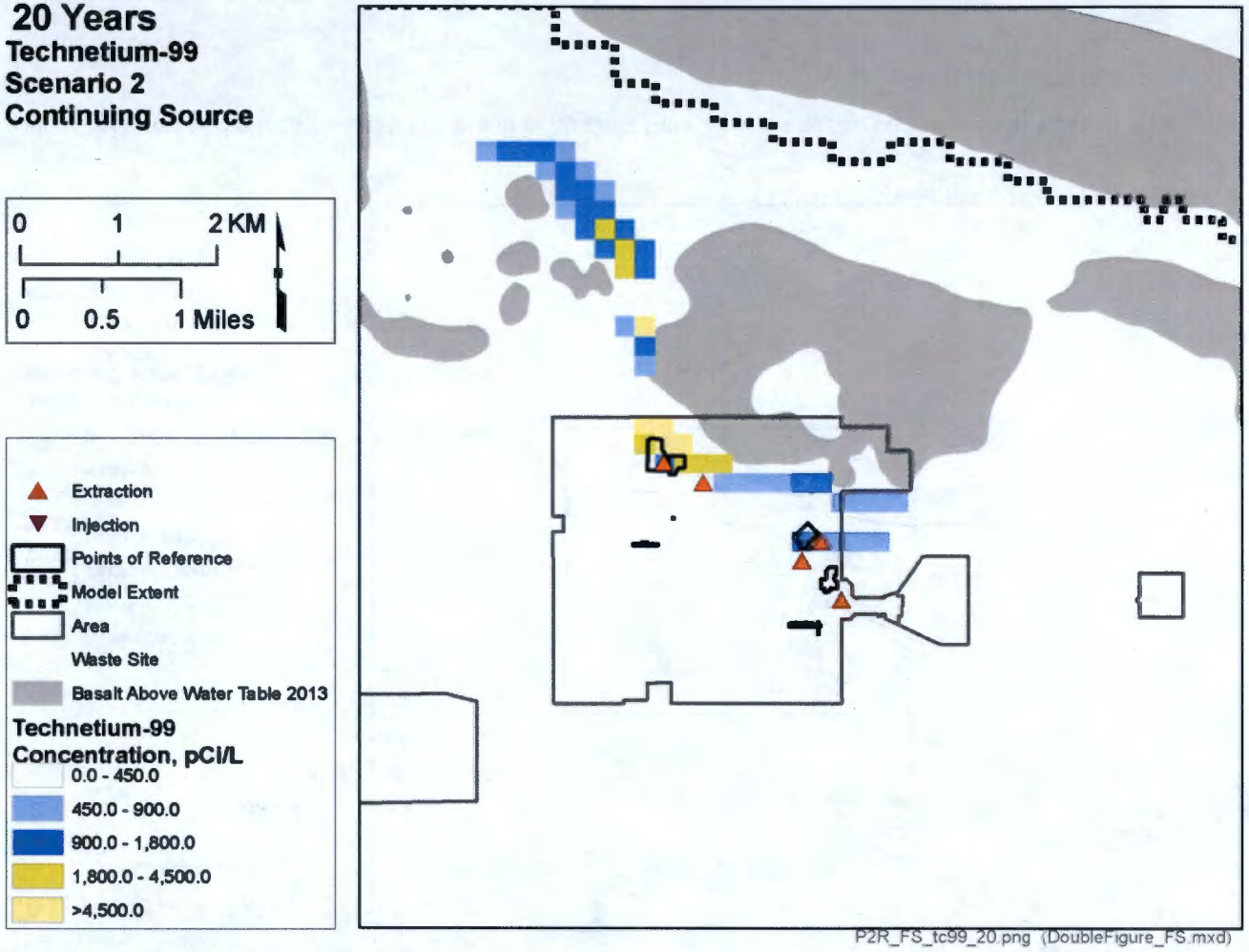

Figure B-91 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 2 simulation with a continuing source term.

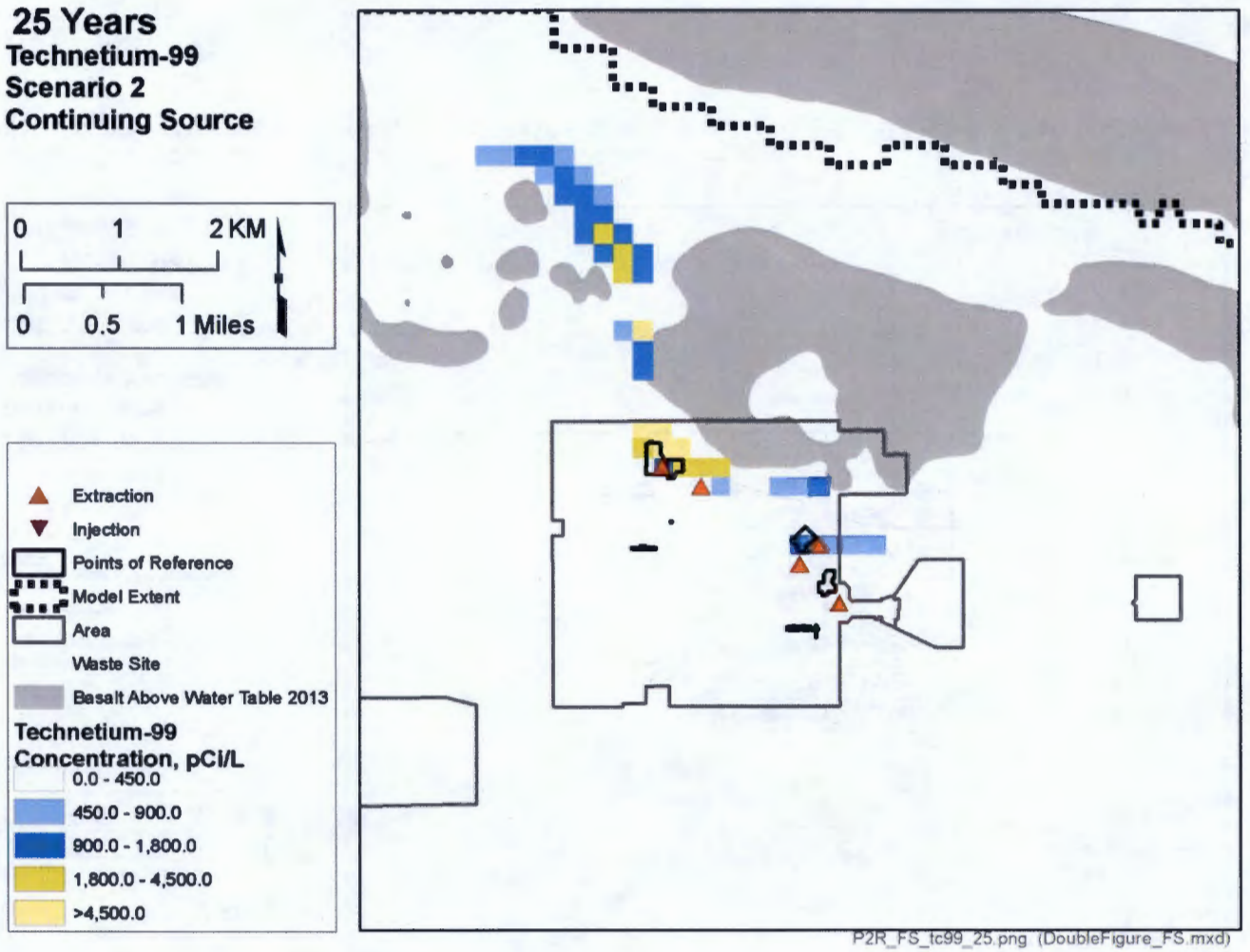

Figure B-92 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 2 simulation with a continuing source term.

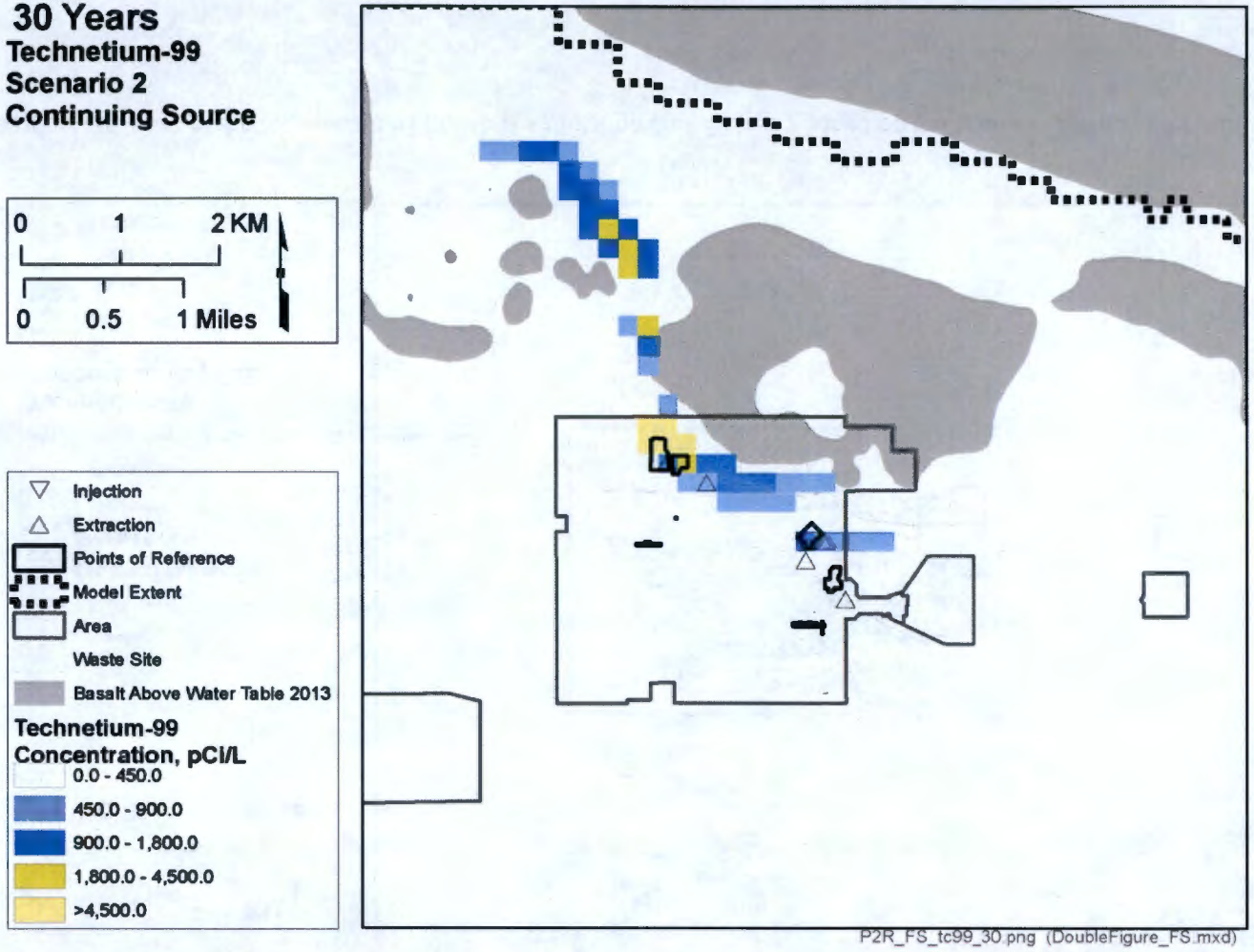

Figure B-93 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 2 simulation with a continuing source term.

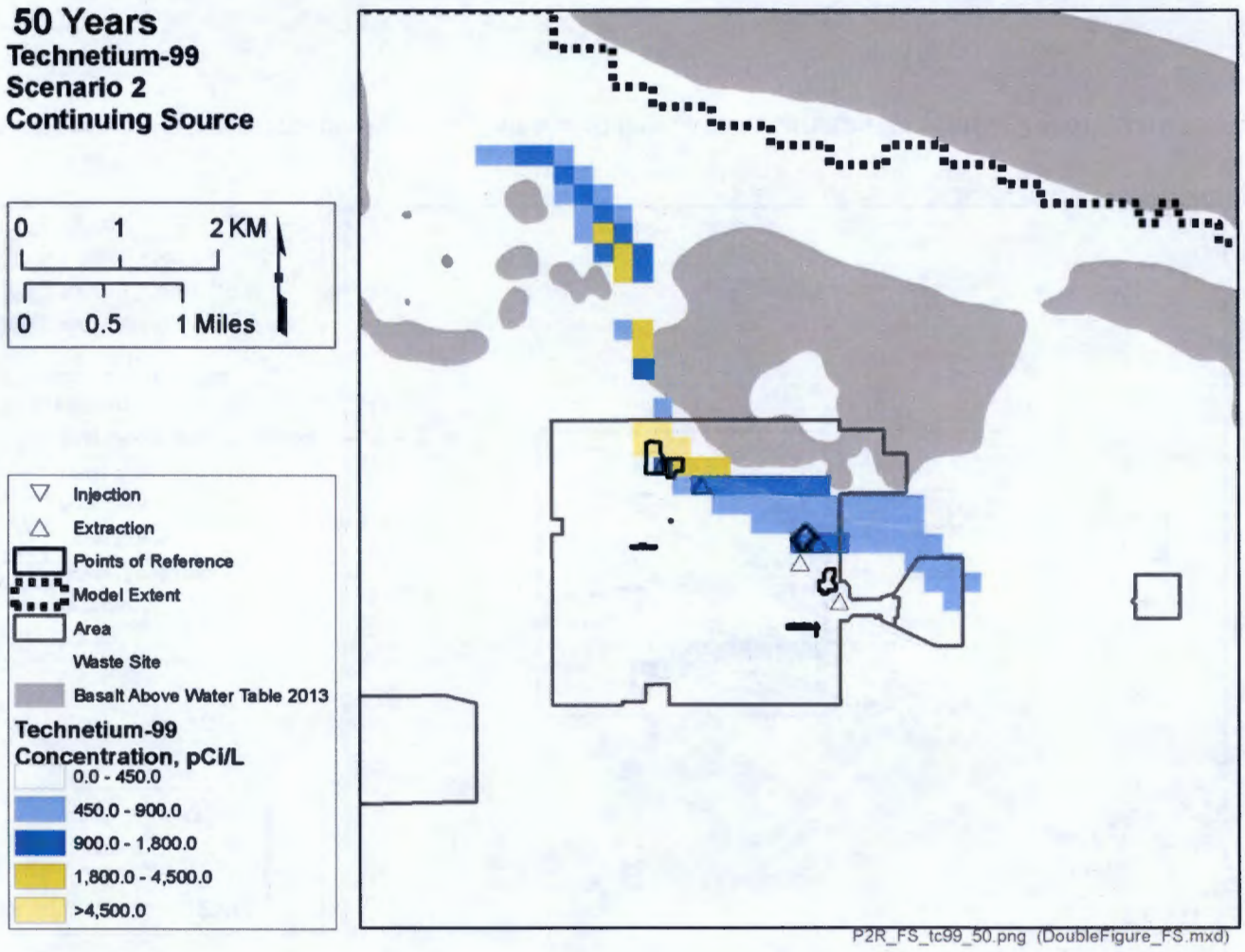

Figure B-94 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 2 simulation with a continuing source term.

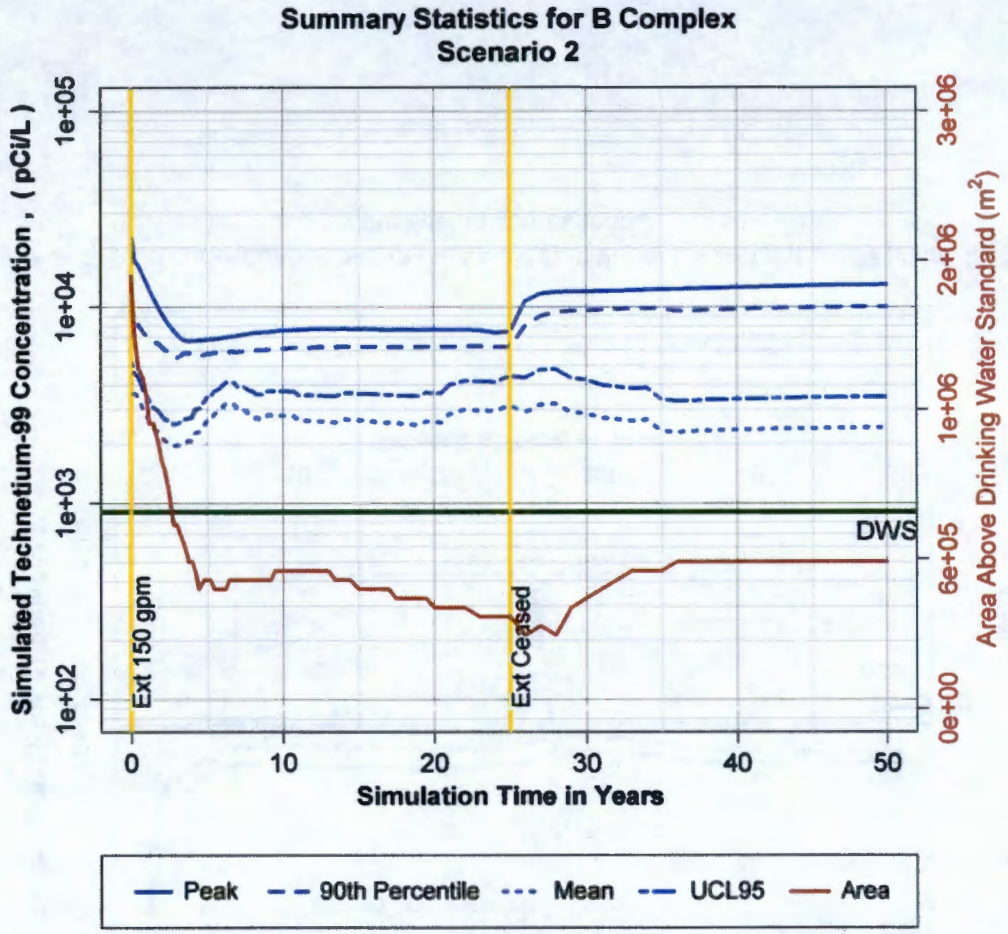

Figure B-95 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

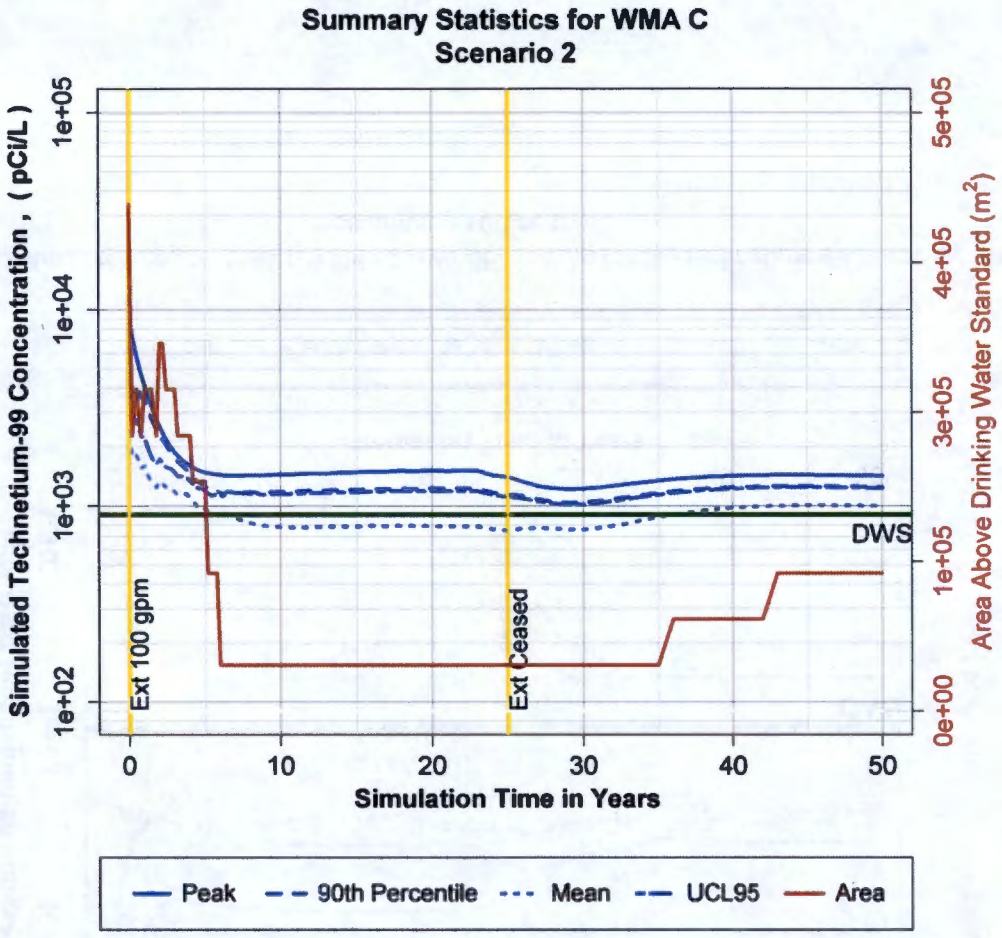

Figure B-96 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

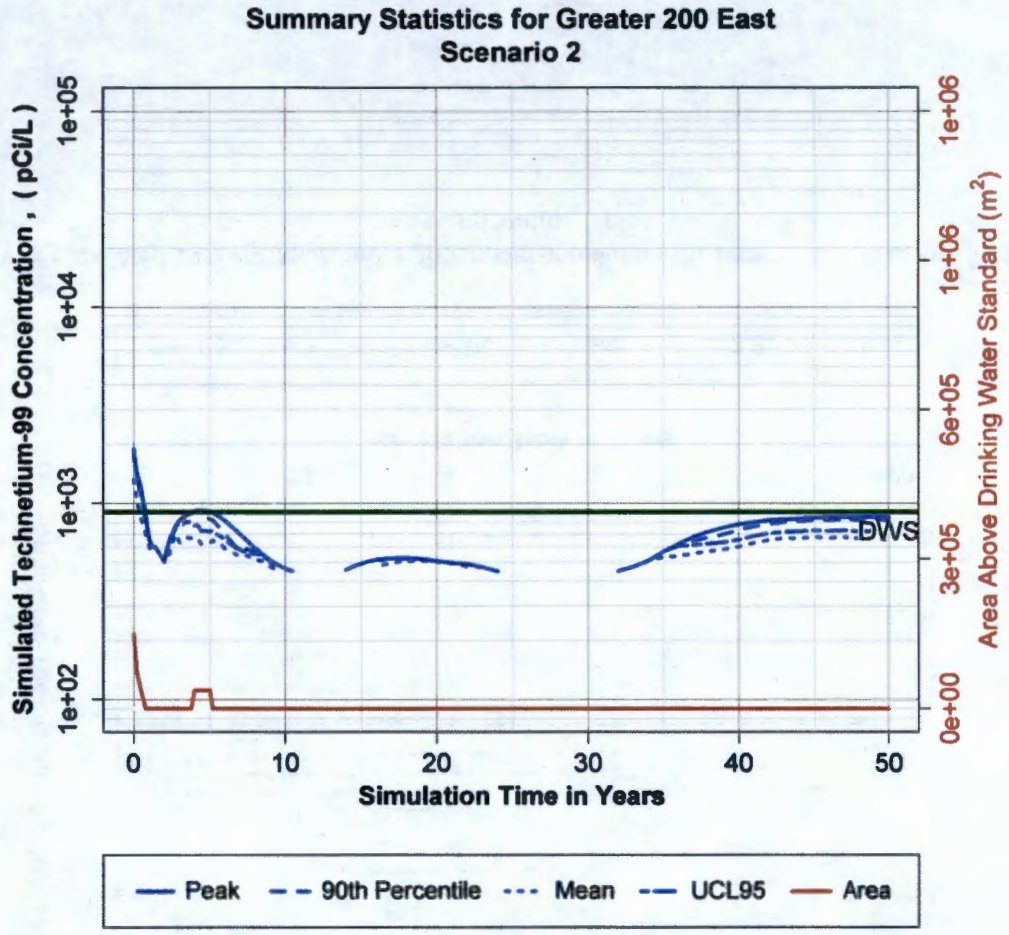

Figure B-97 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

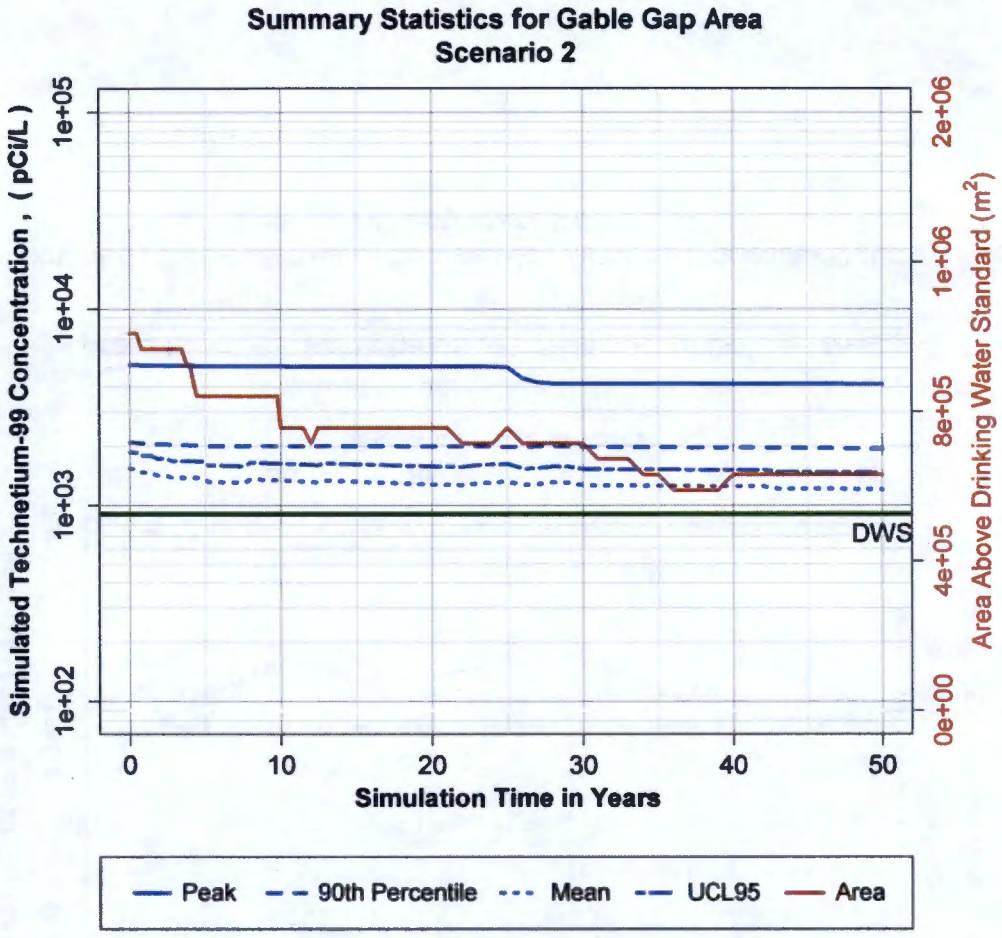

Figure B-98 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

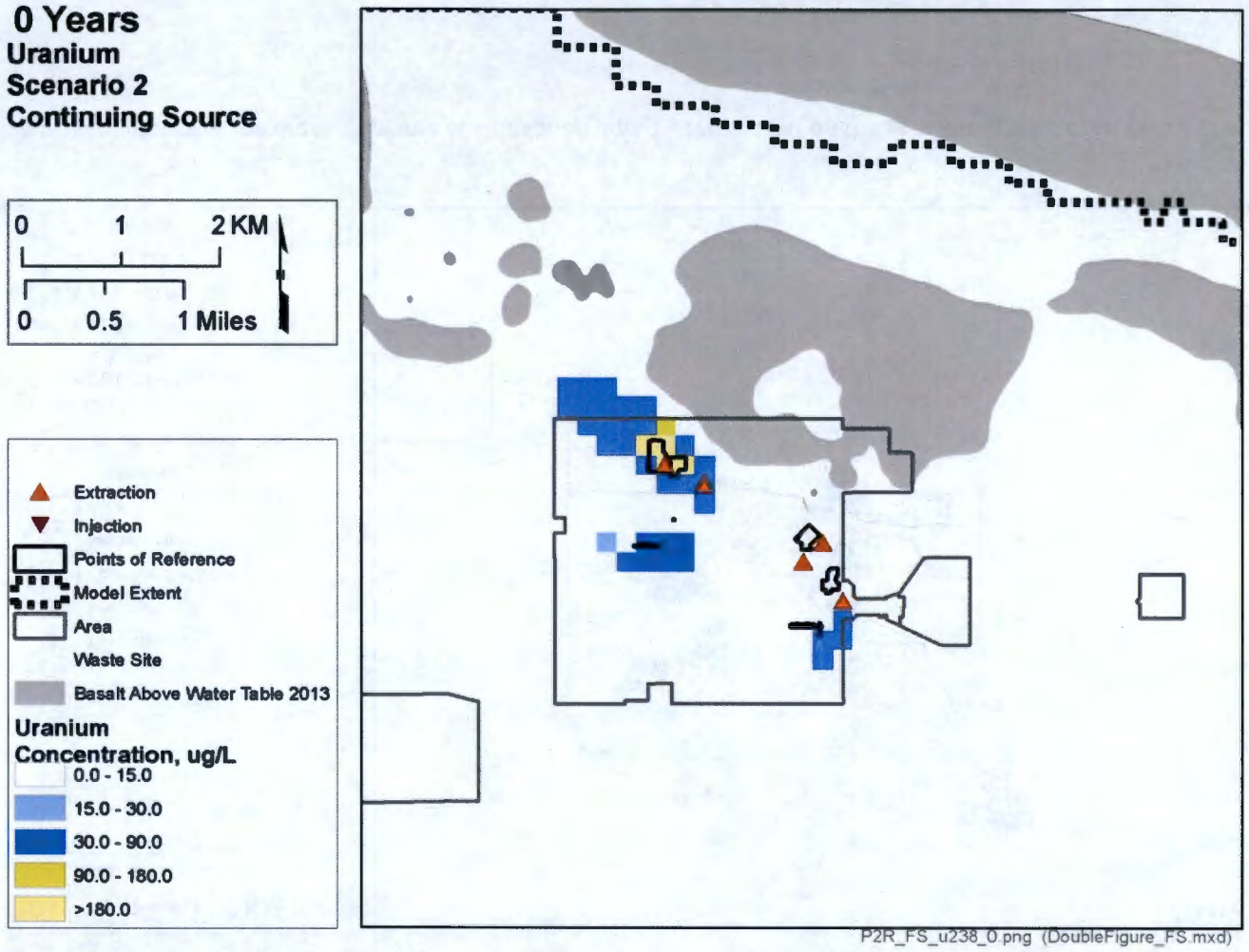

Figure B-99 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 2 simulation with a continuing source term.

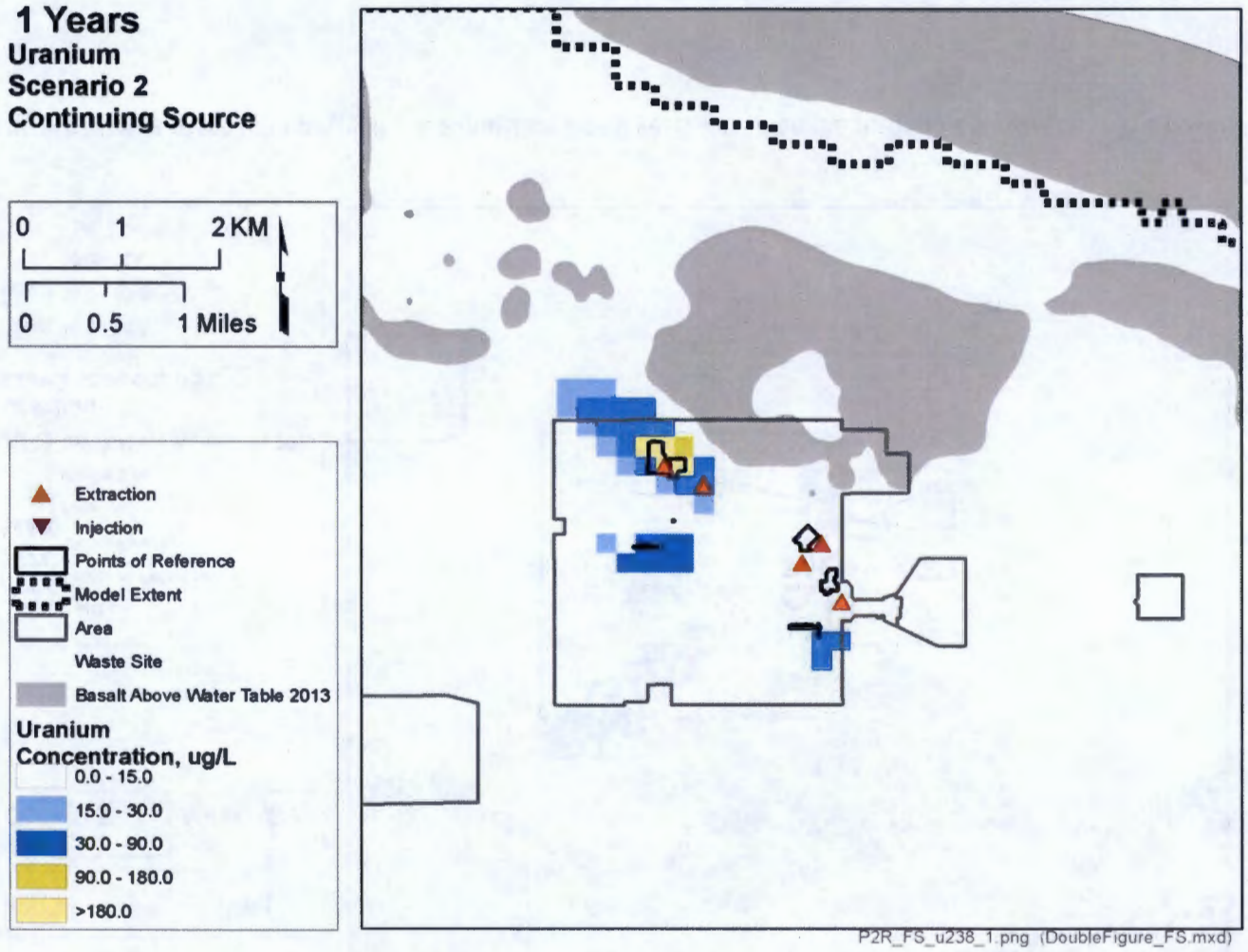

Figure B-100 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 2 simulation with a continuing source term.

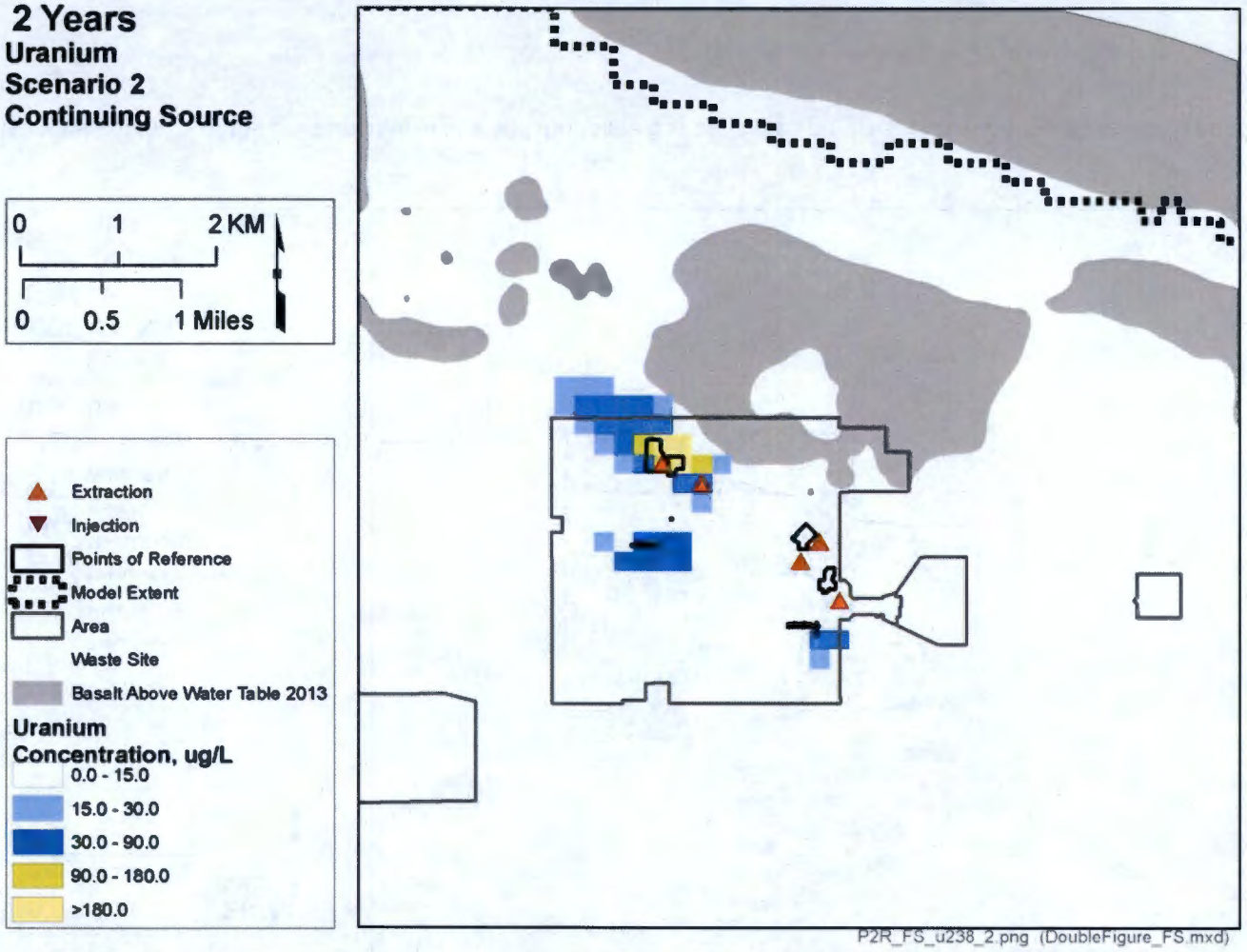

Figure B-101 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 2 simulation with a continuing source term.

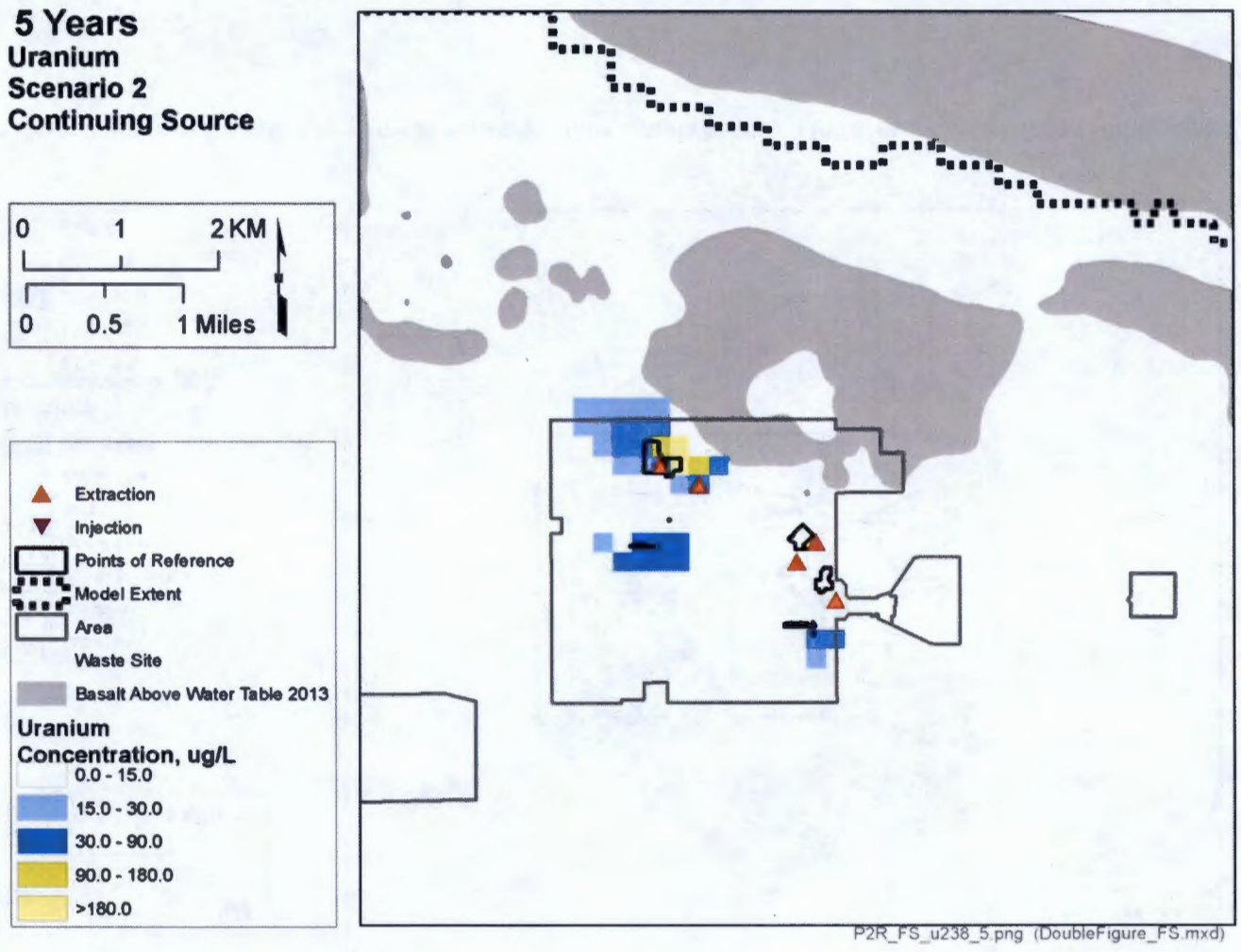

Figure B-102 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 2 simulation with a continuing source term.

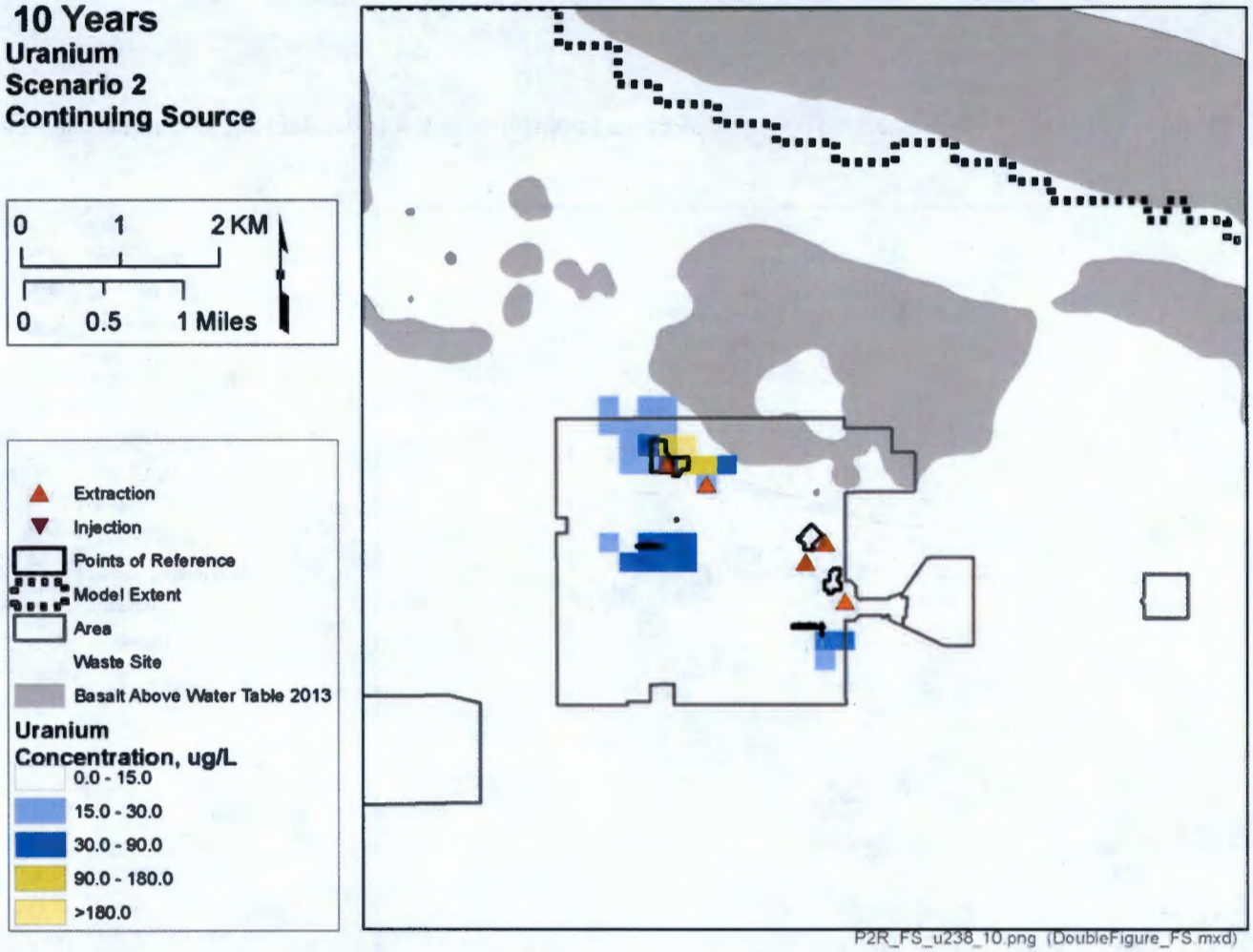

Figure B-103 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 2 simulation with a continuing source term.

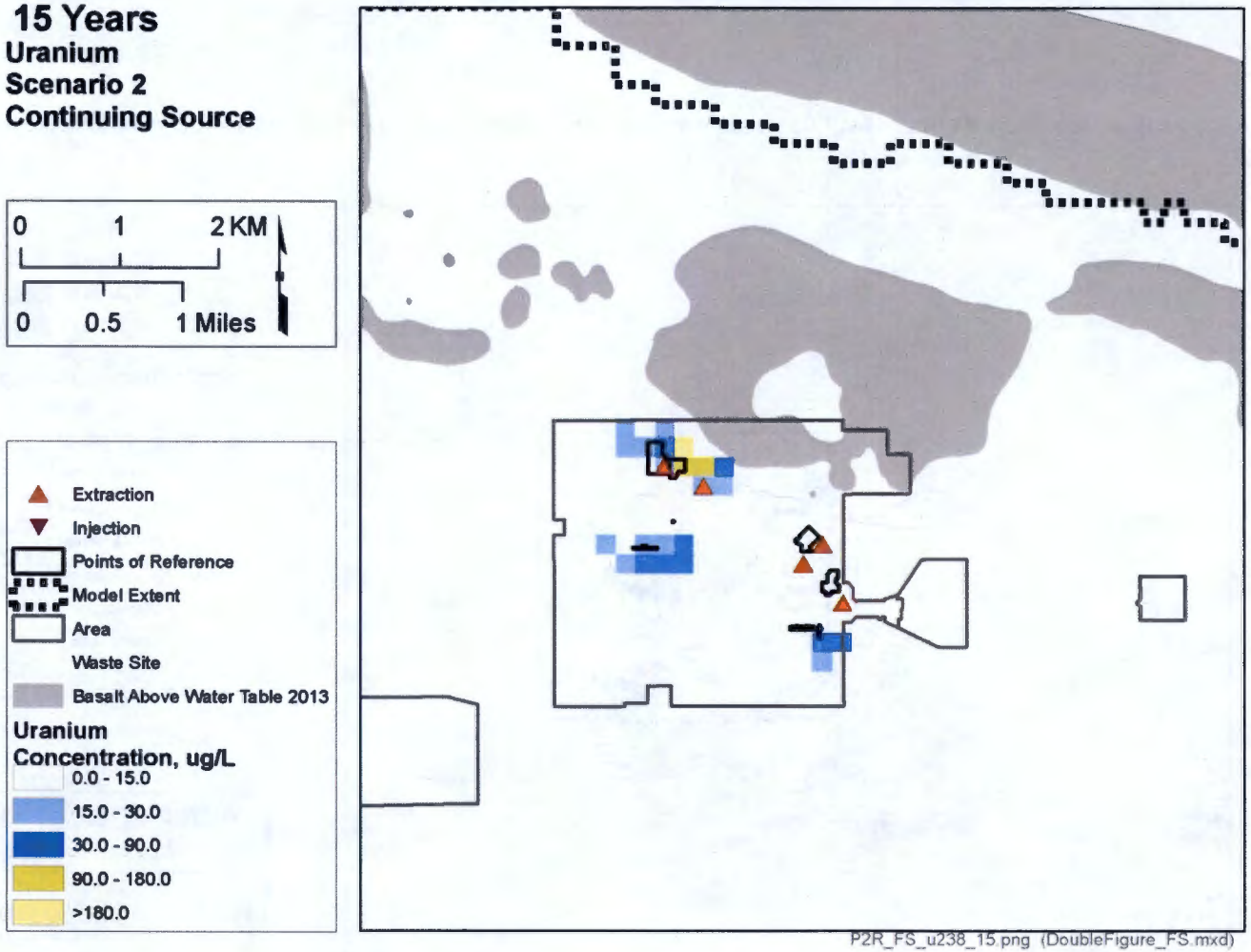

Figure B-104 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 2 simulation with a continuing source term.

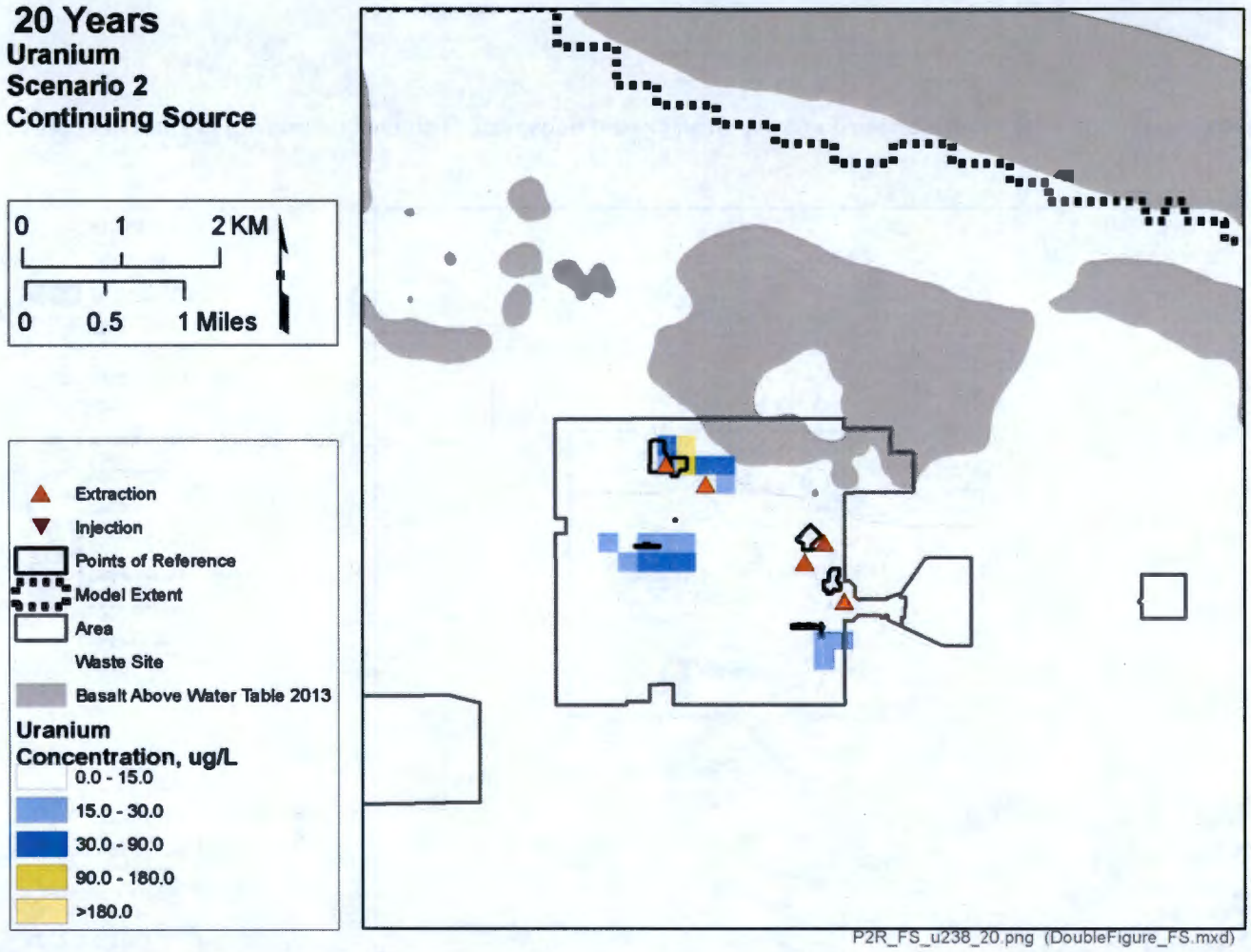

Figure B-105 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 2 simulation with a continuing source term.

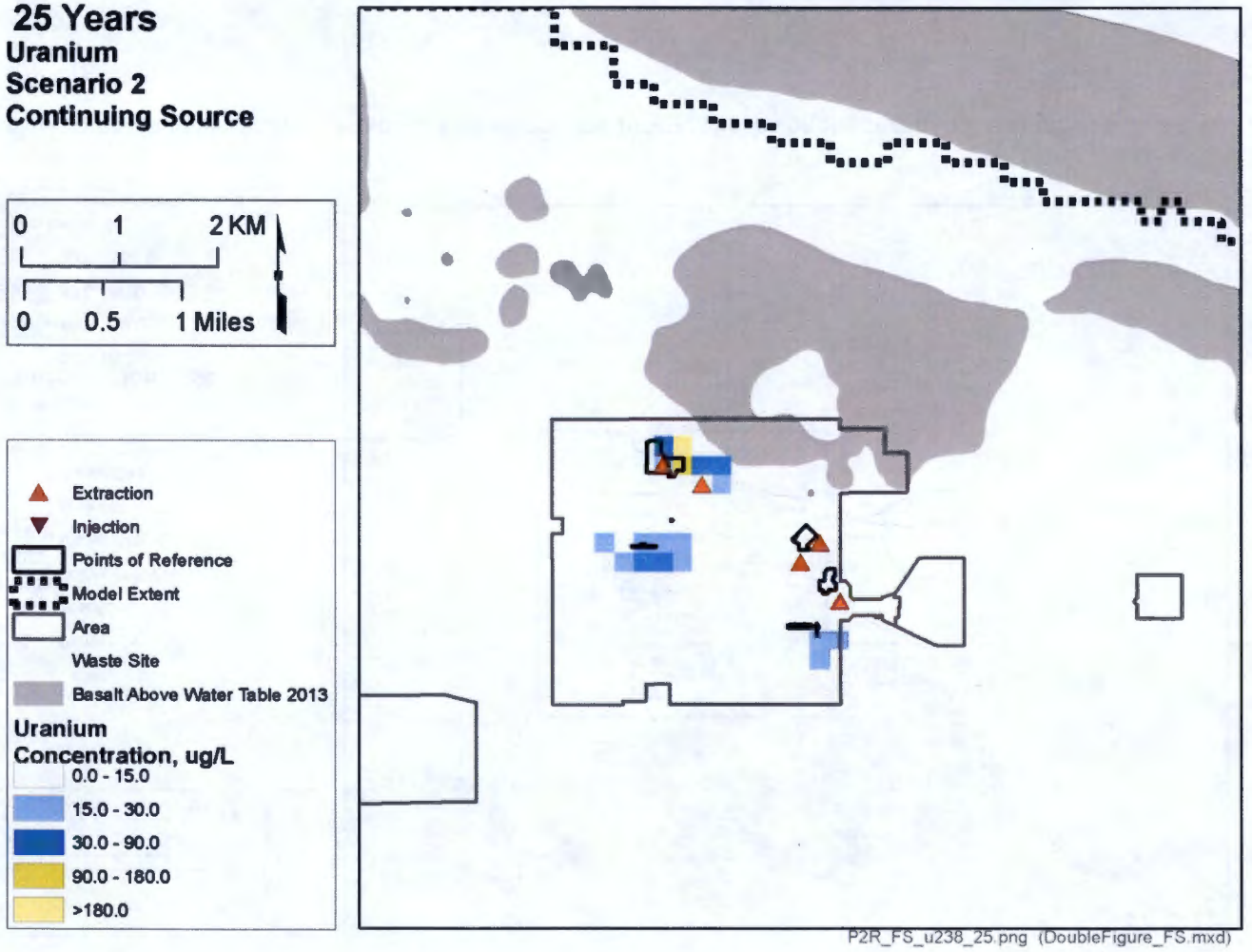

Figure B-106 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 2 simulation with a continuing source term.

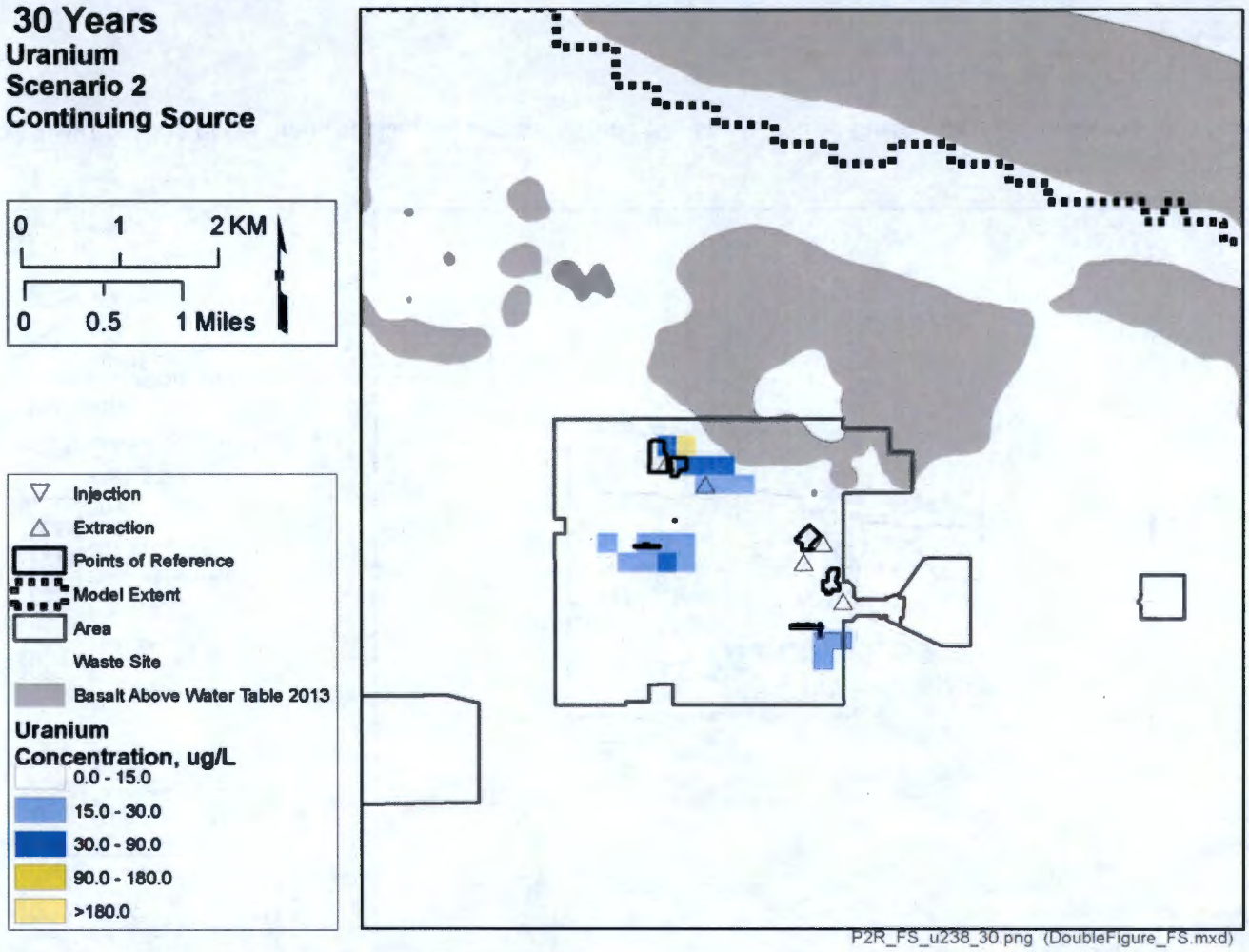

Figure B-107 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 2 simulation with a continuing source term.

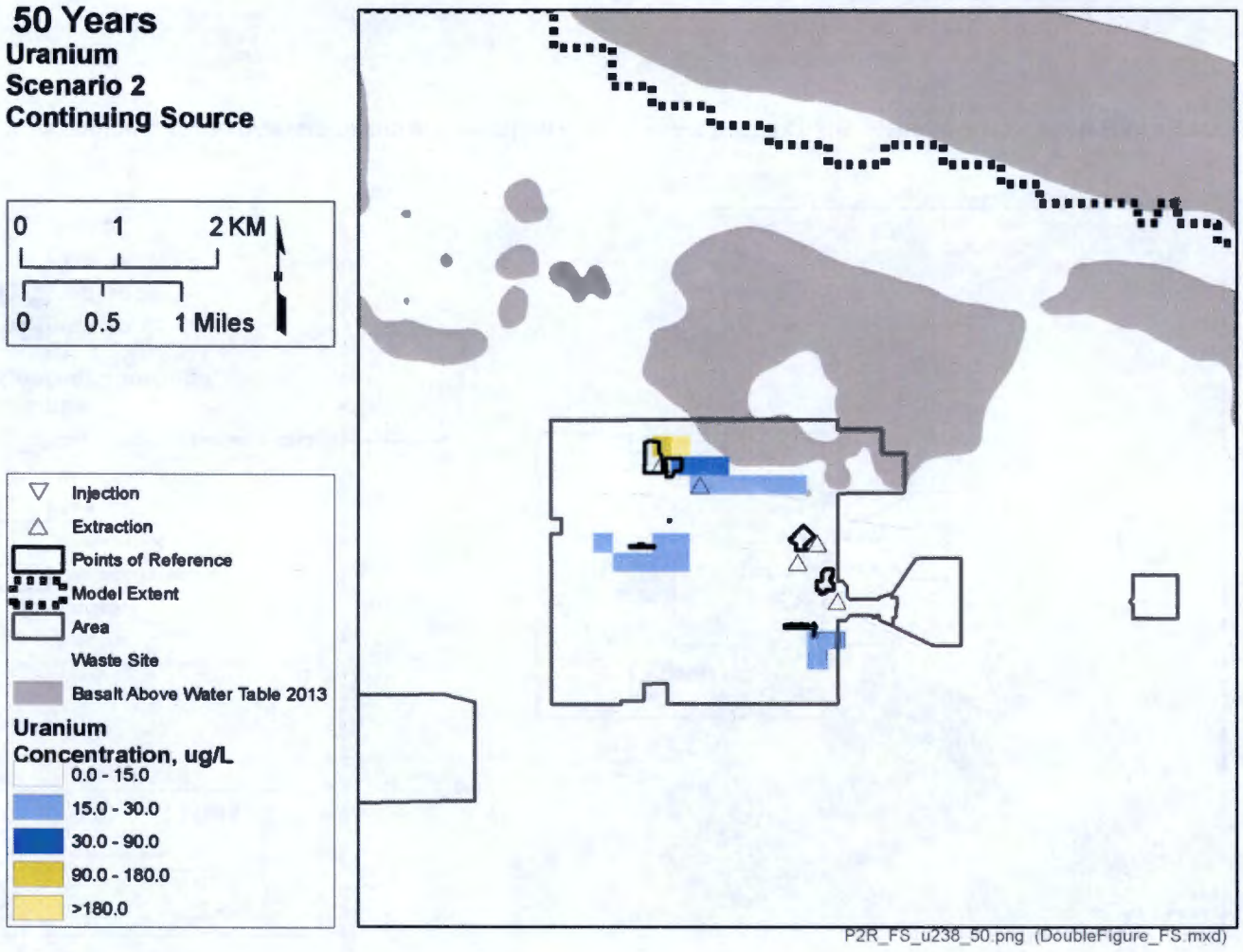

Figure B-108 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 2 simulation with a continuing source term.

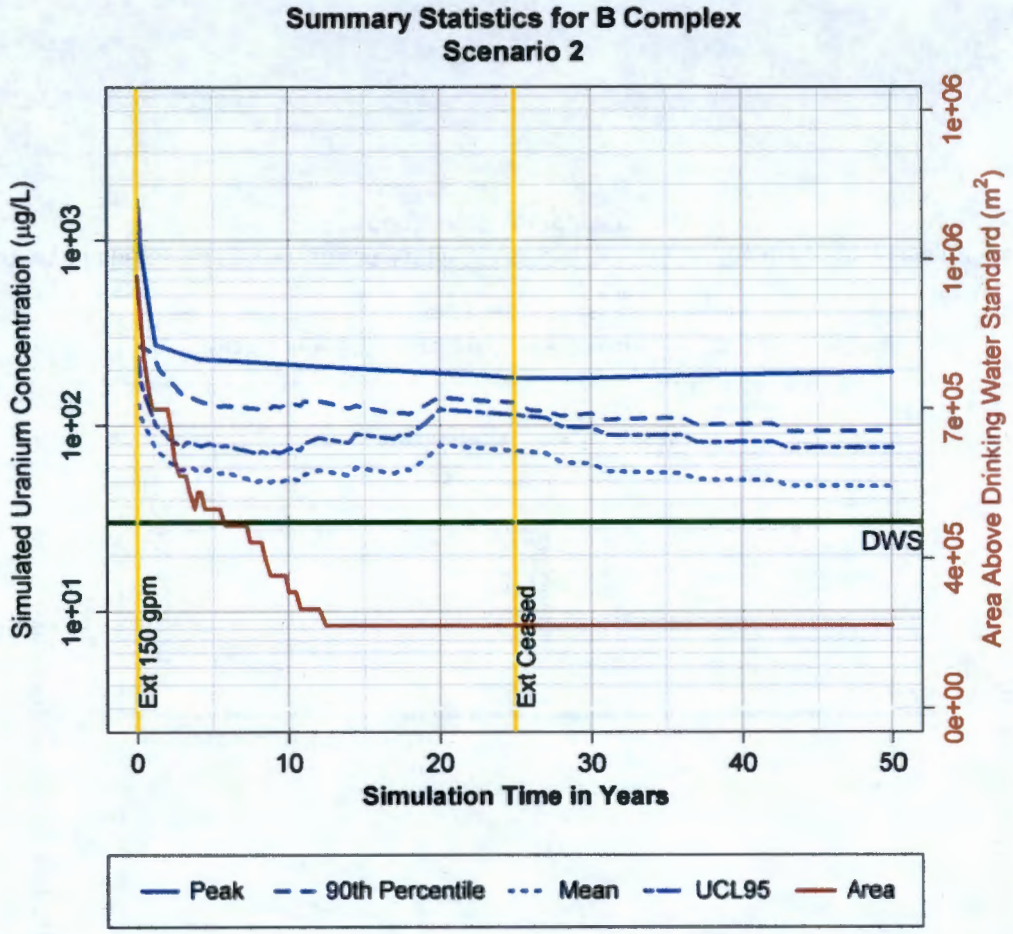

Figure B-109 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

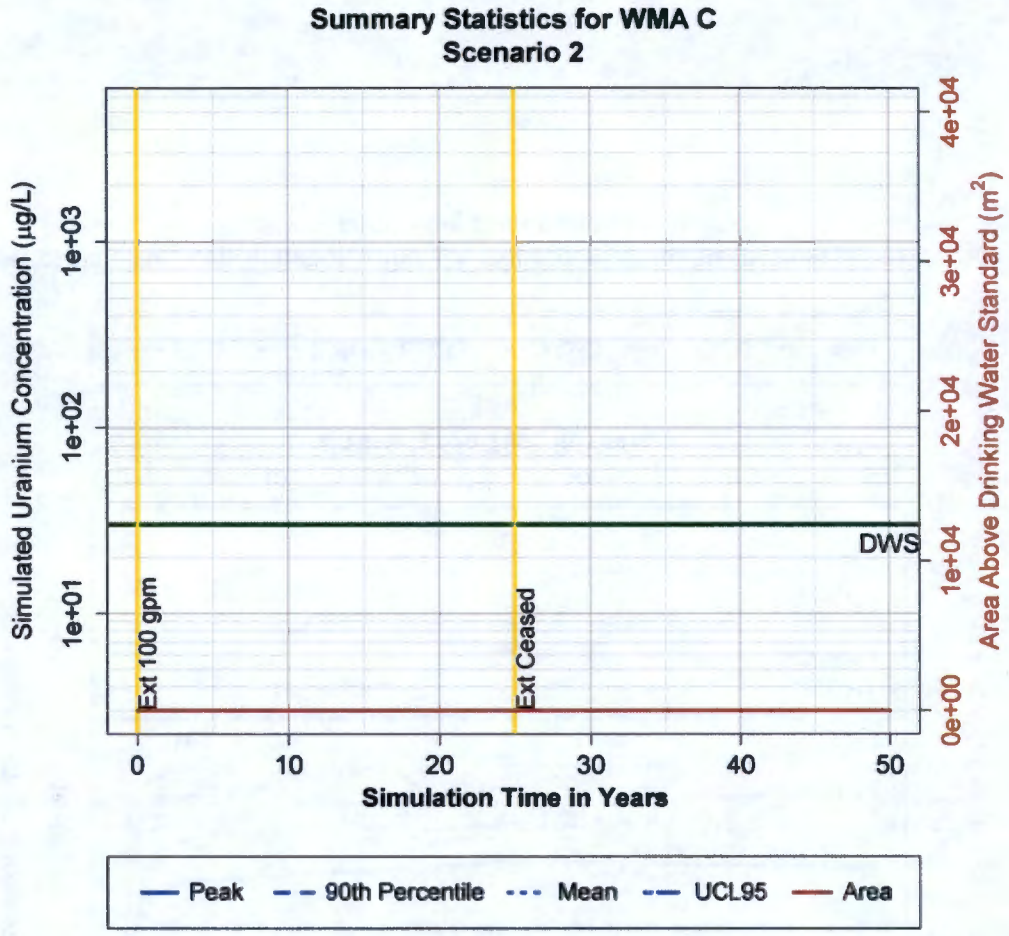

Figure B-110 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

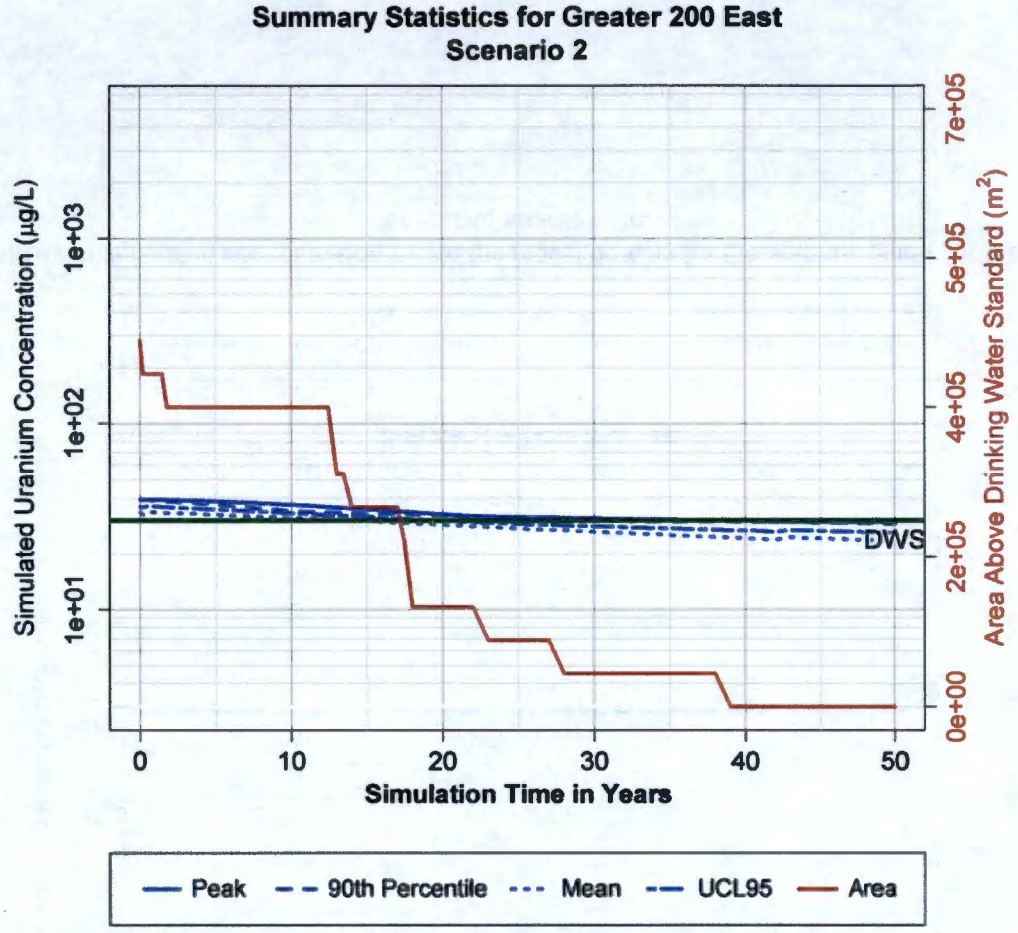

Figure B-111 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

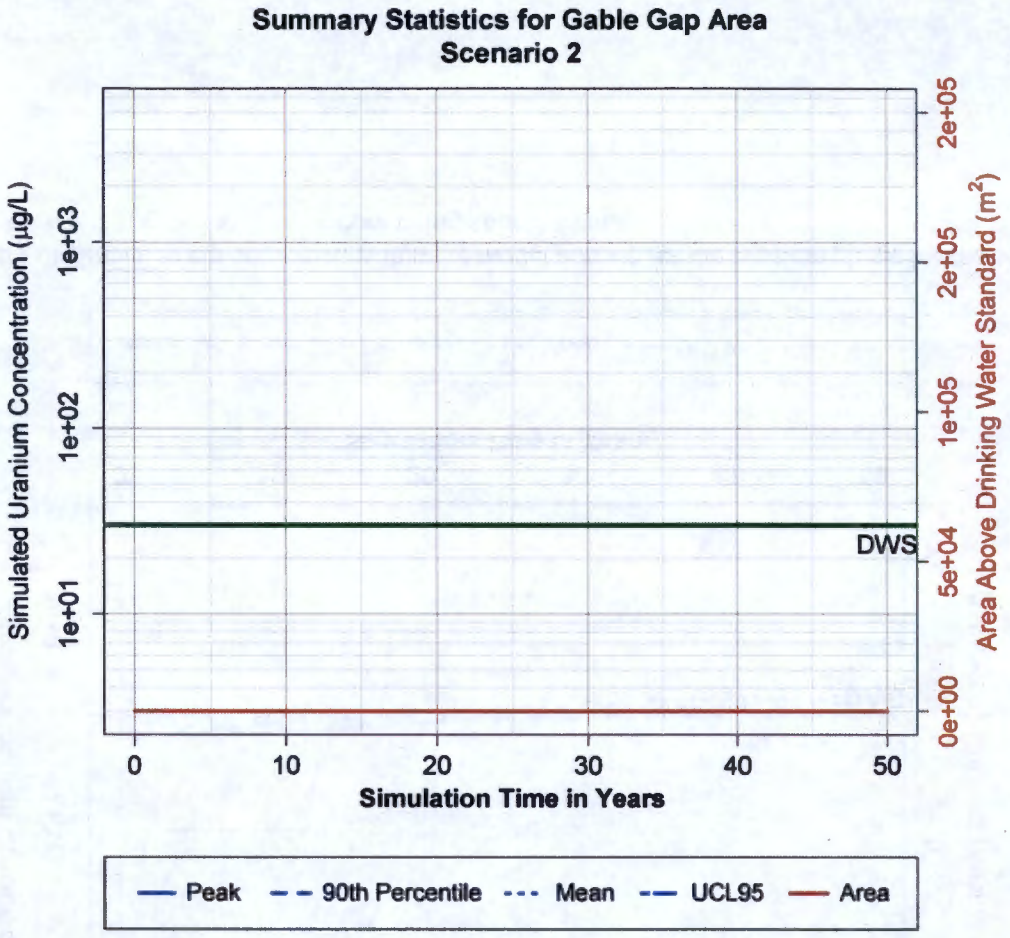

Figure B-112 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

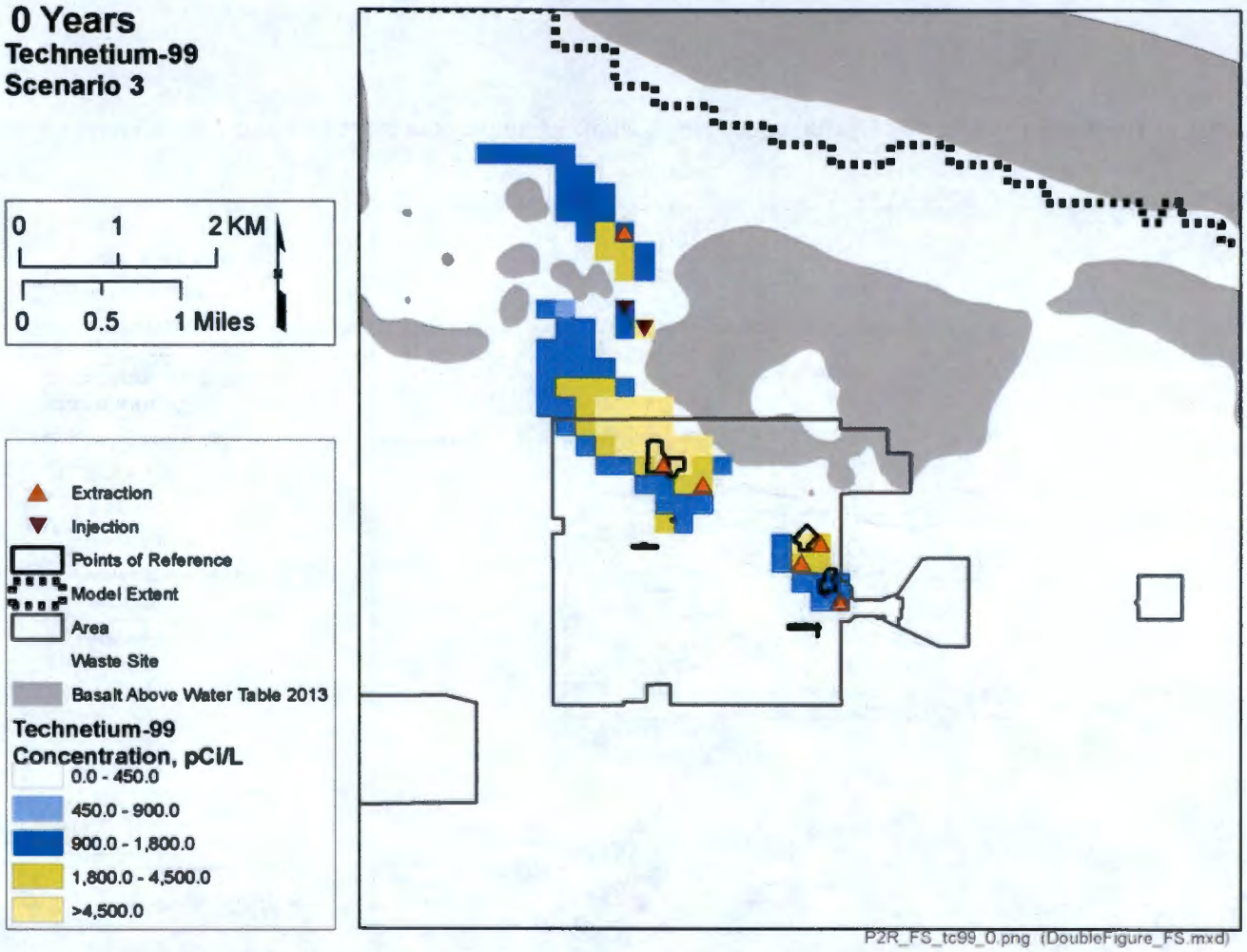

Figure B-113 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 3 simulation.

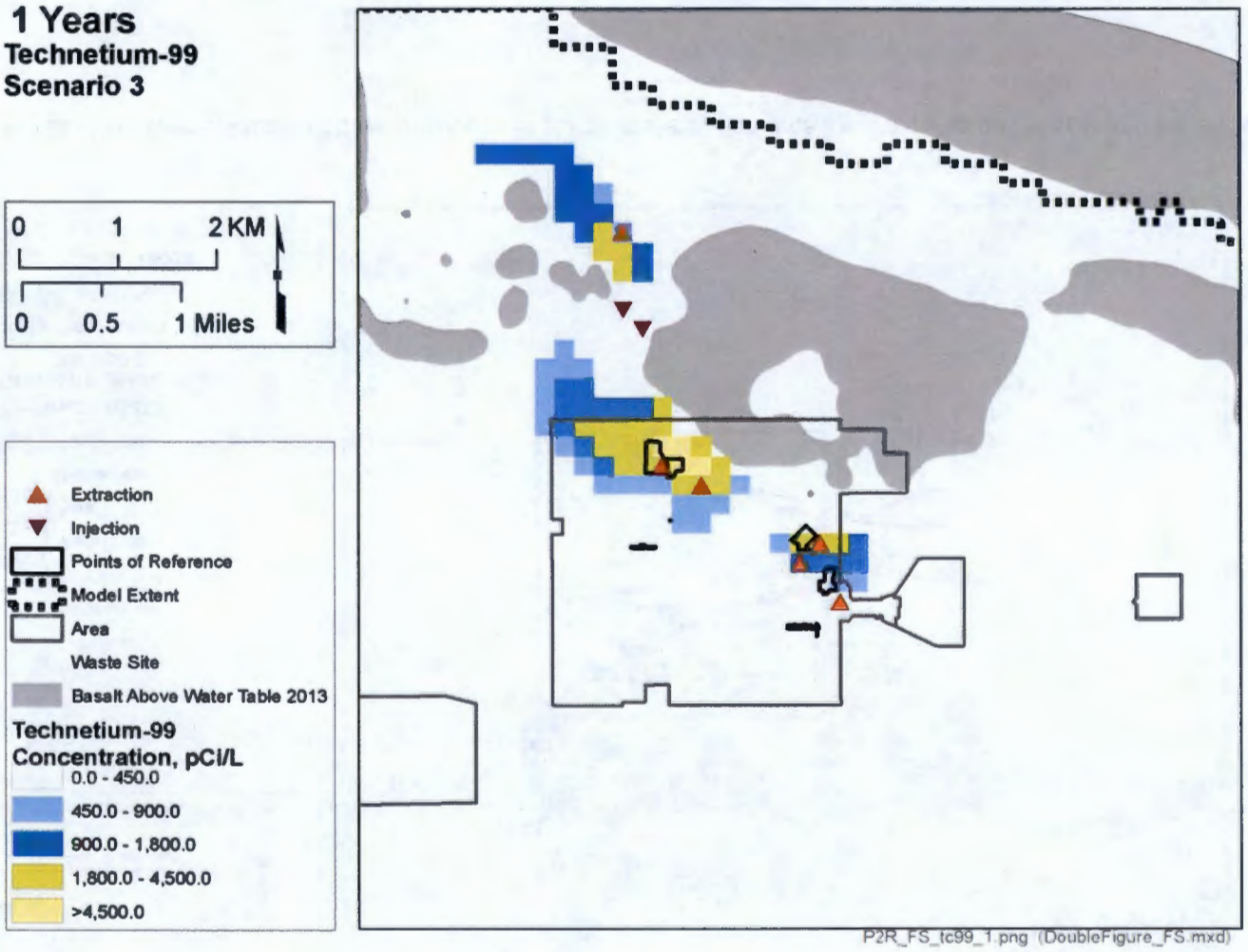

Figure B-114 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 3 simulation.

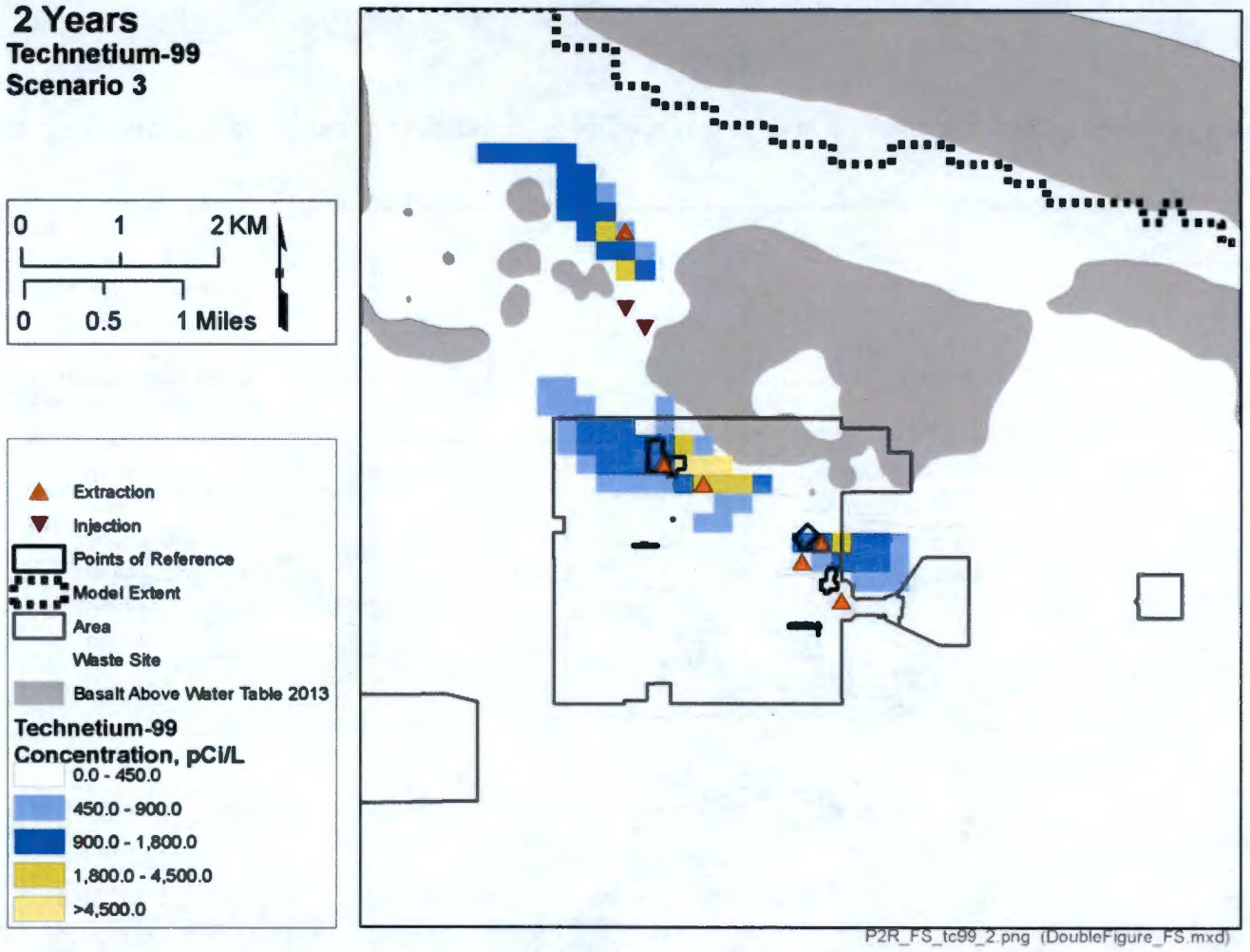

Figure B-115 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 3 simulation.

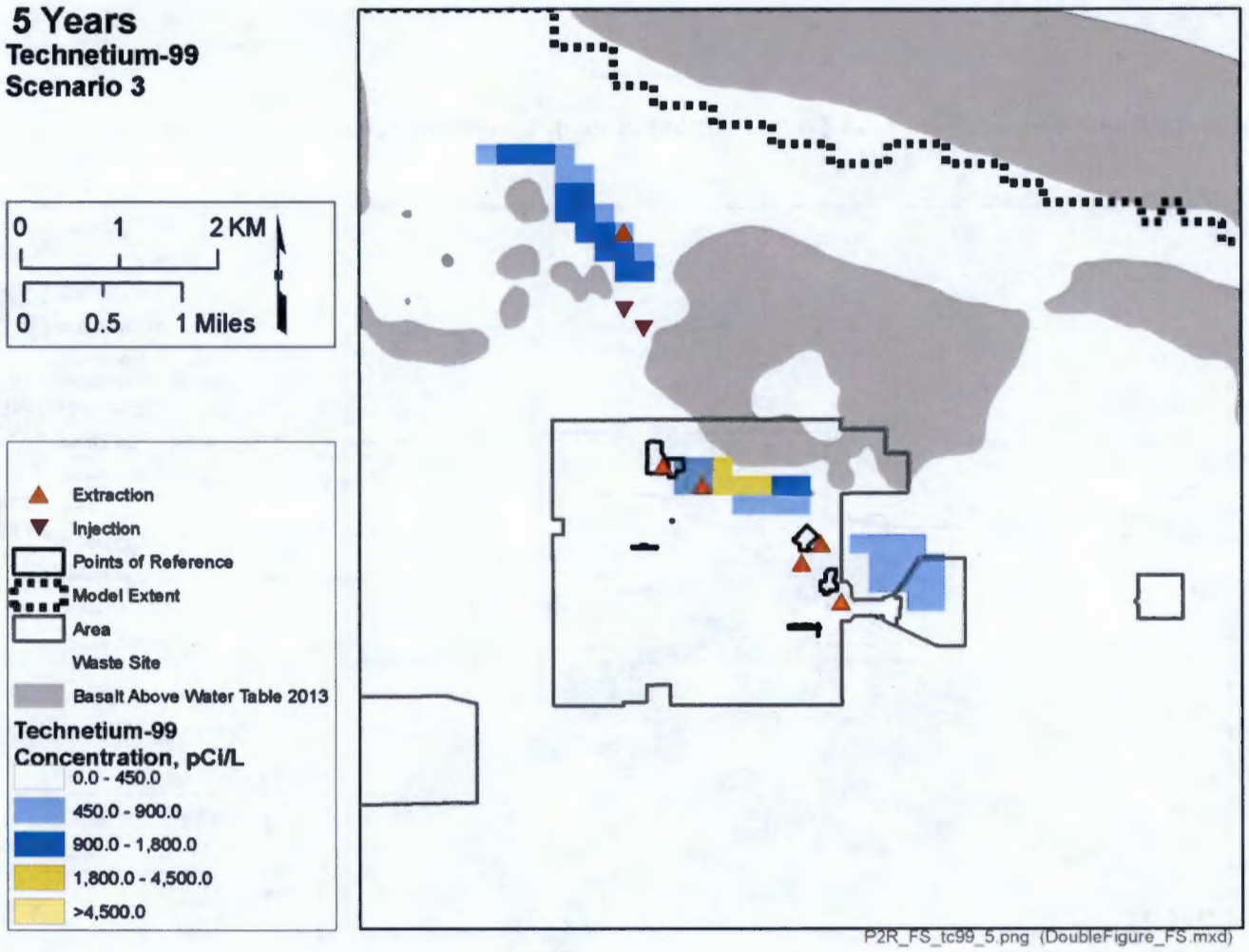

Figure B-116 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 3 simulation.

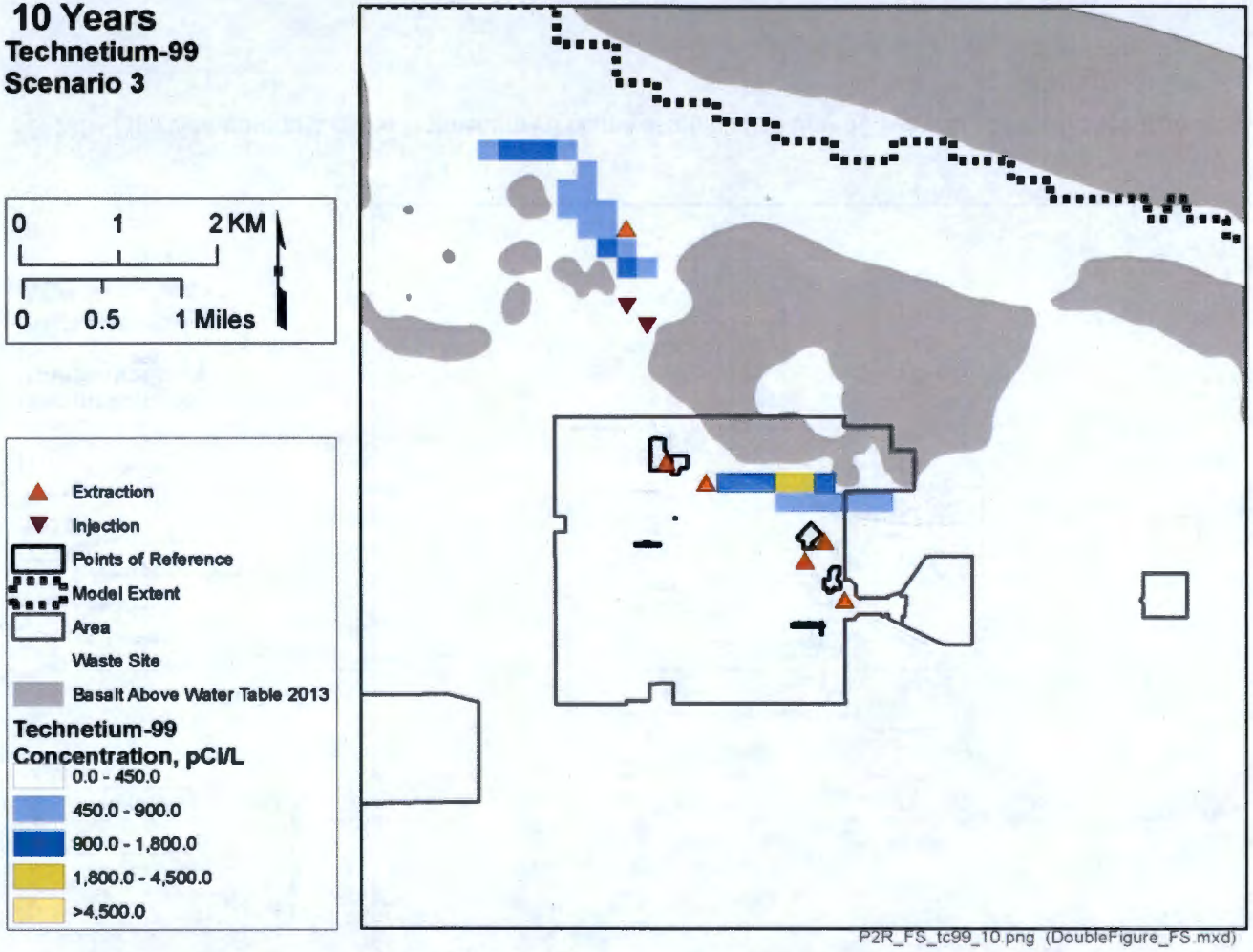

Figure B-117 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 3 simulation.

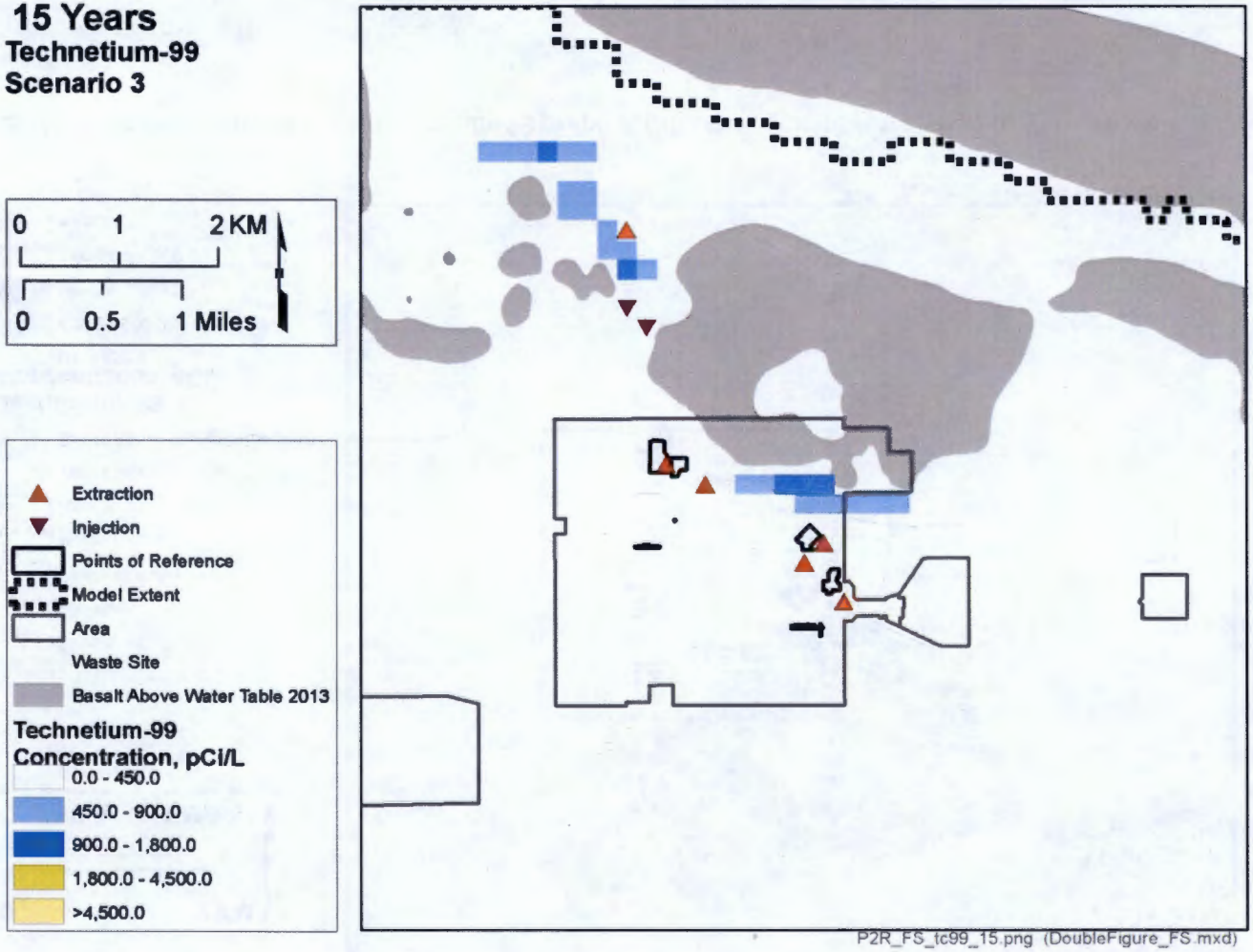

Figure B-118 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 3 simulation.

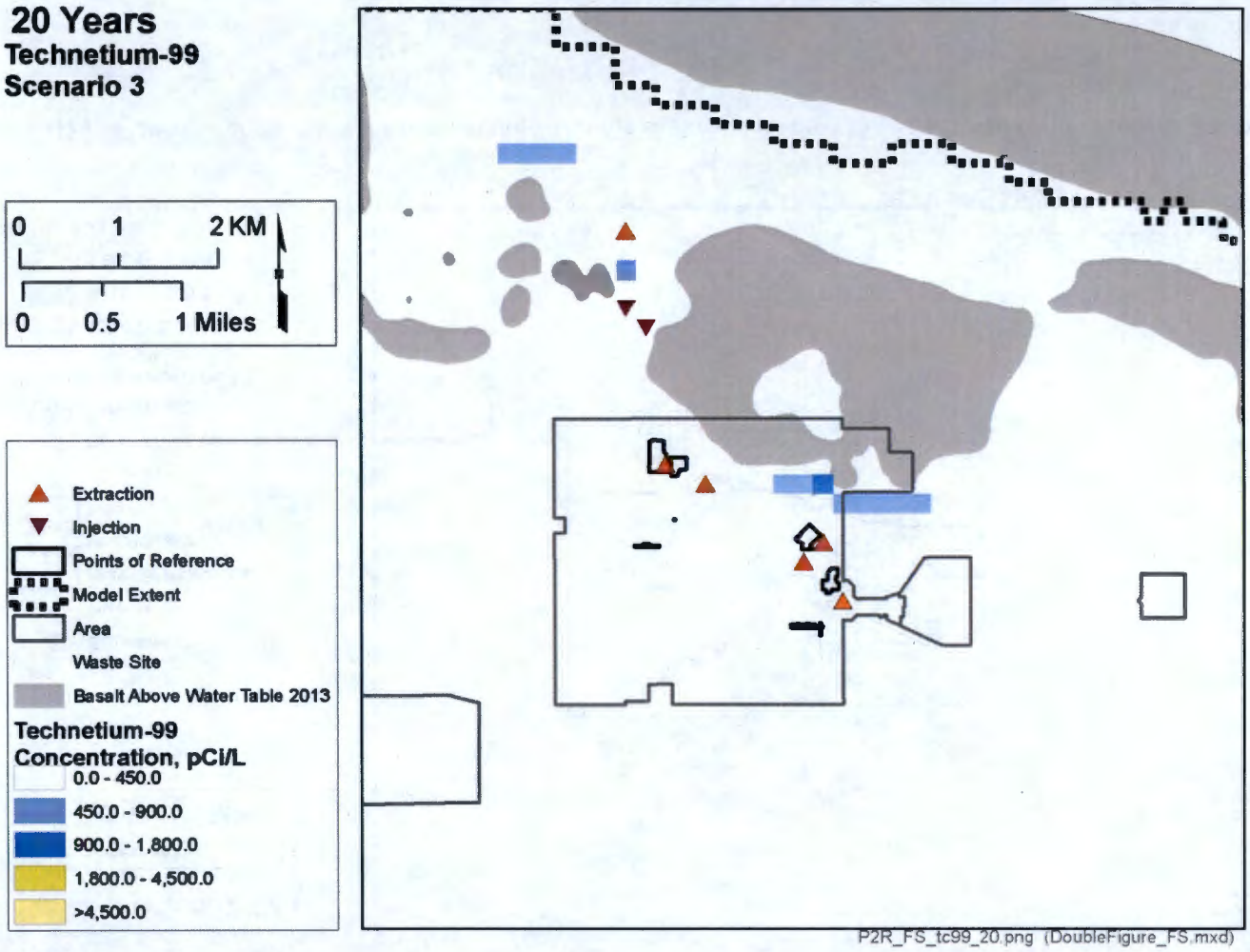

Figure B-119 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 3 simulation.

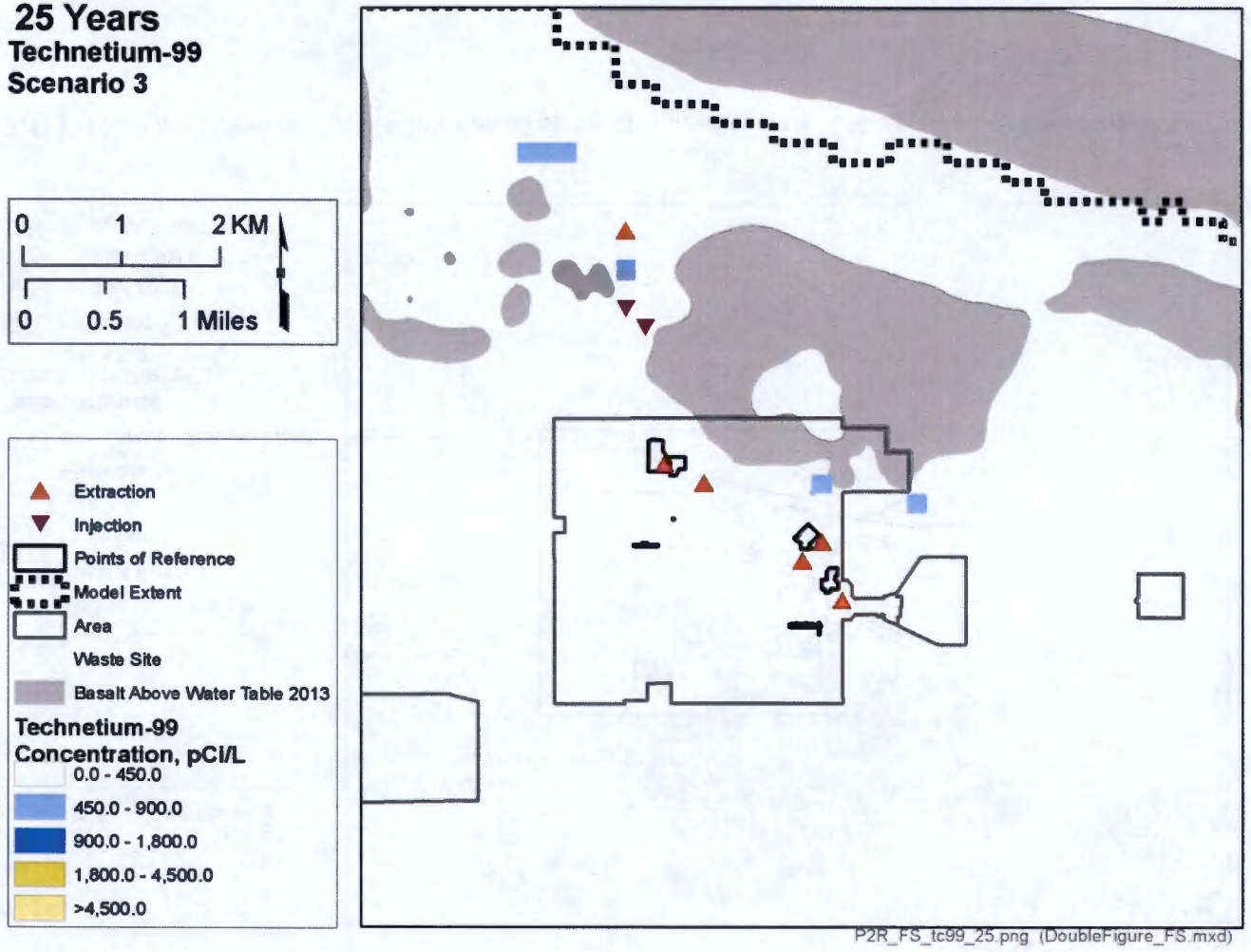

Figure B-120 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 3 simulation.

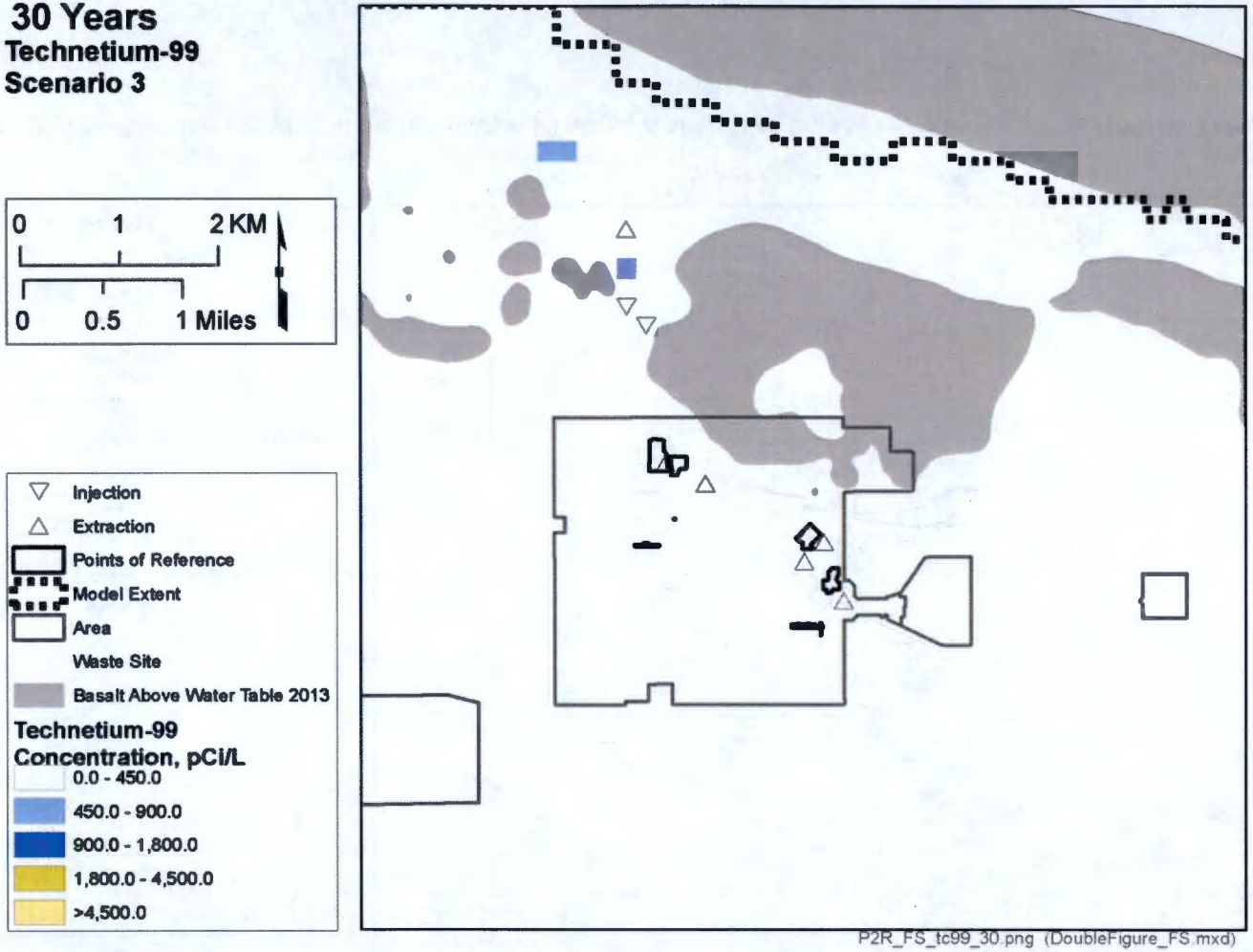

Figure B-121 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 3 simulation.

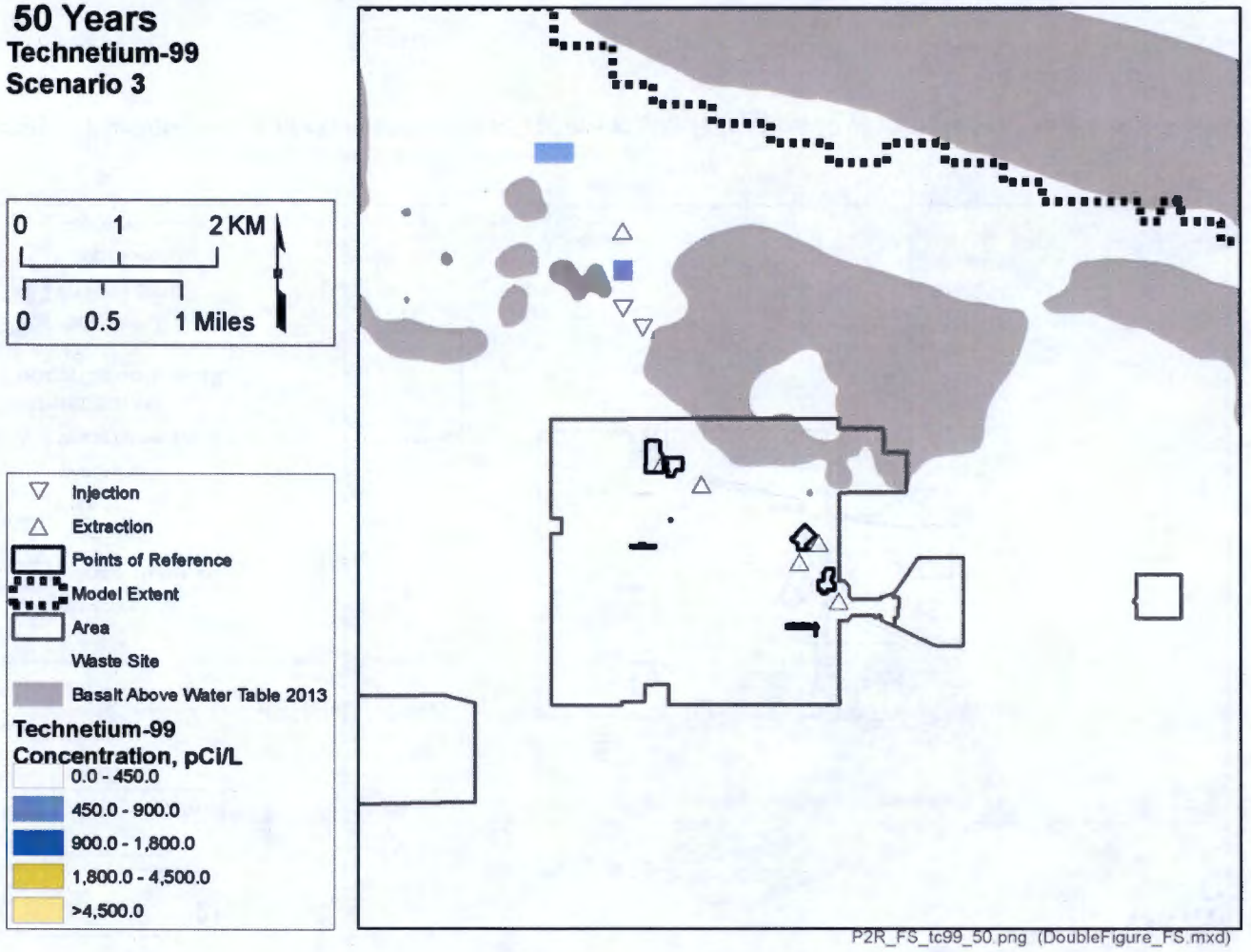

Figure B-122 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 3 simulation.

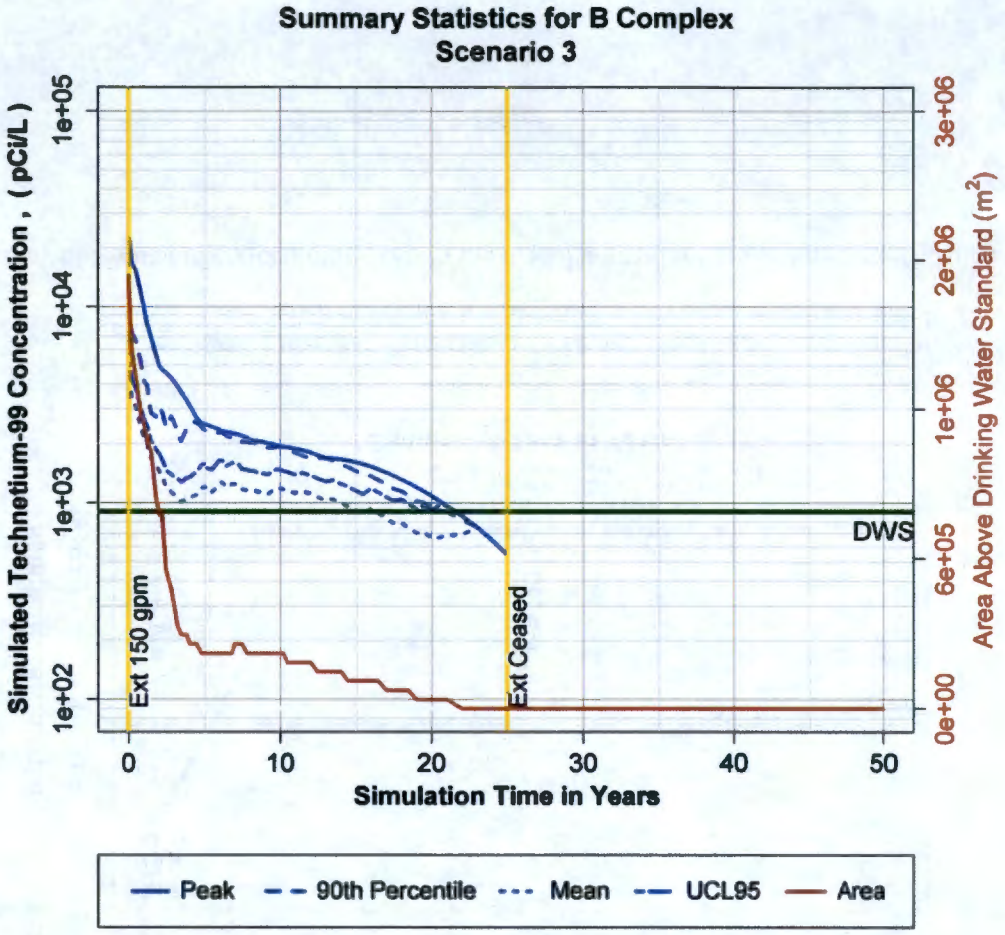

Figure B-123 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

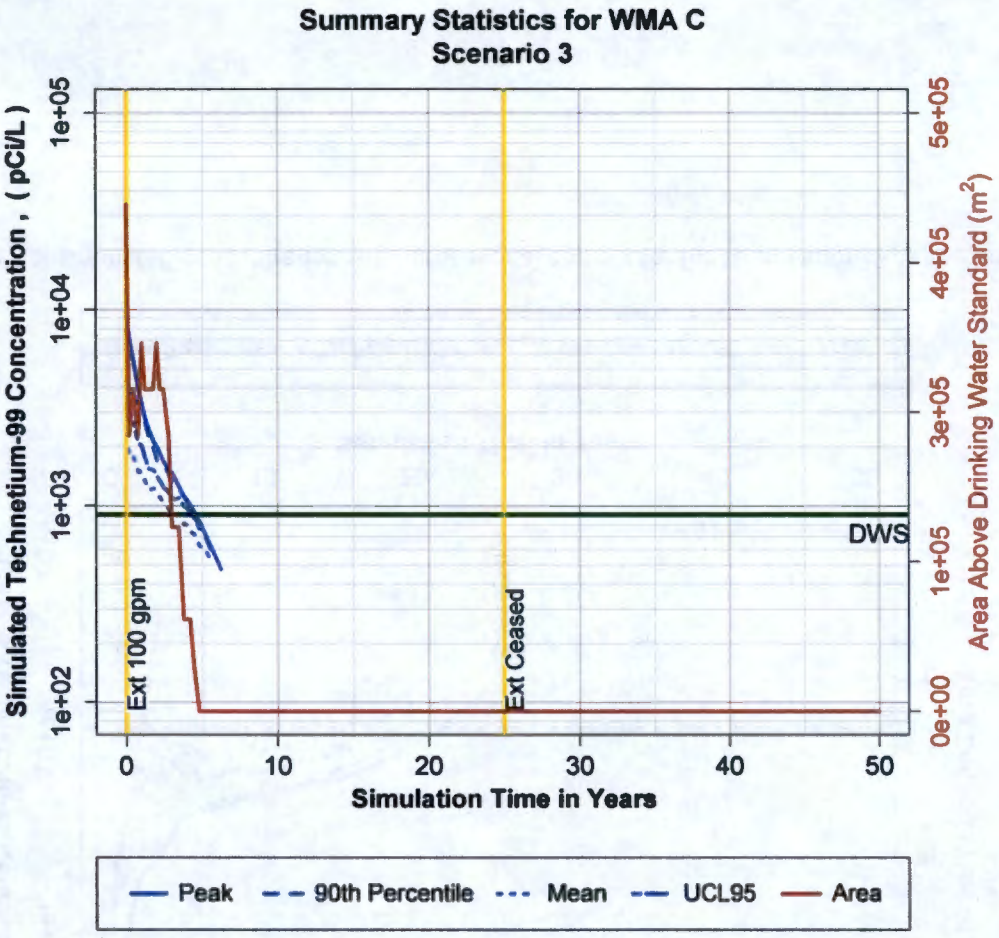

Figure B-124 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

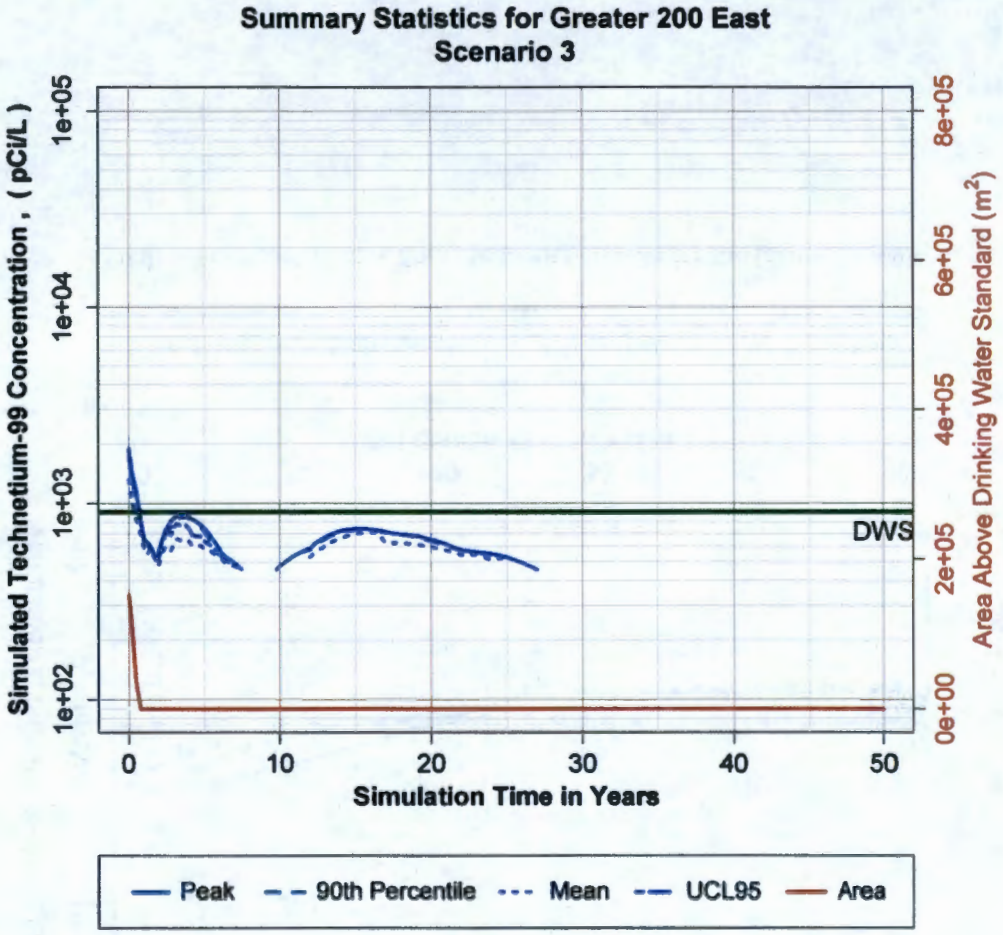

Figure B-125 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

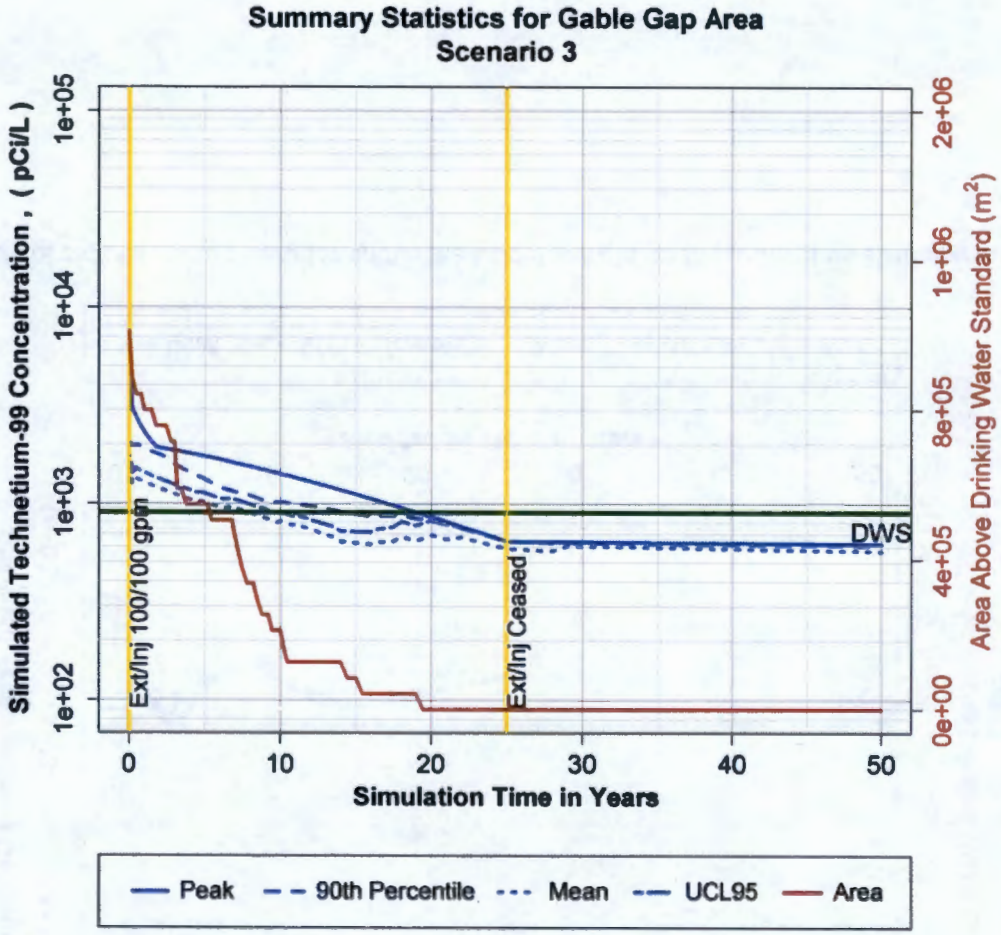

Figure B-126 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

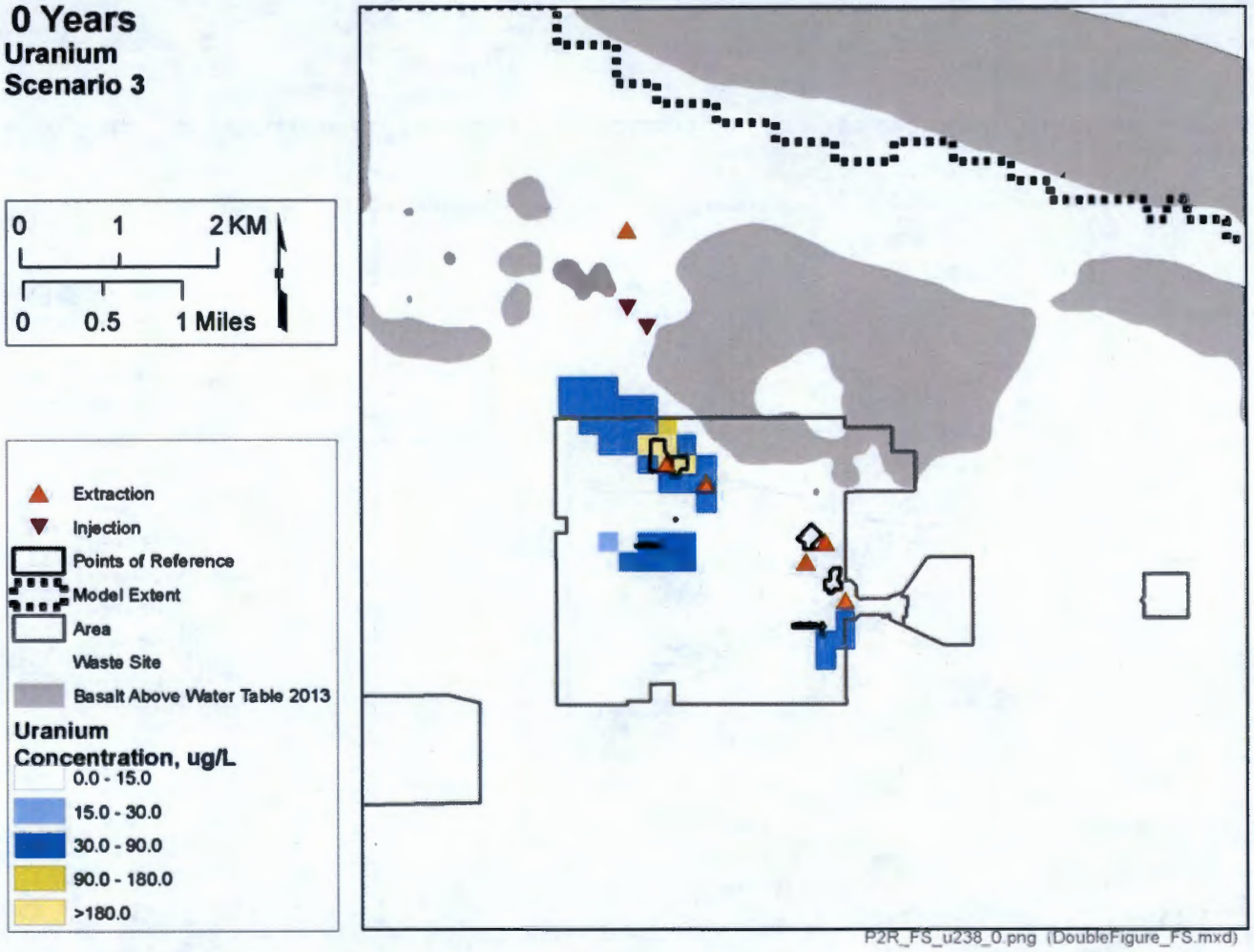

Figure B-127 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 3 simulation.

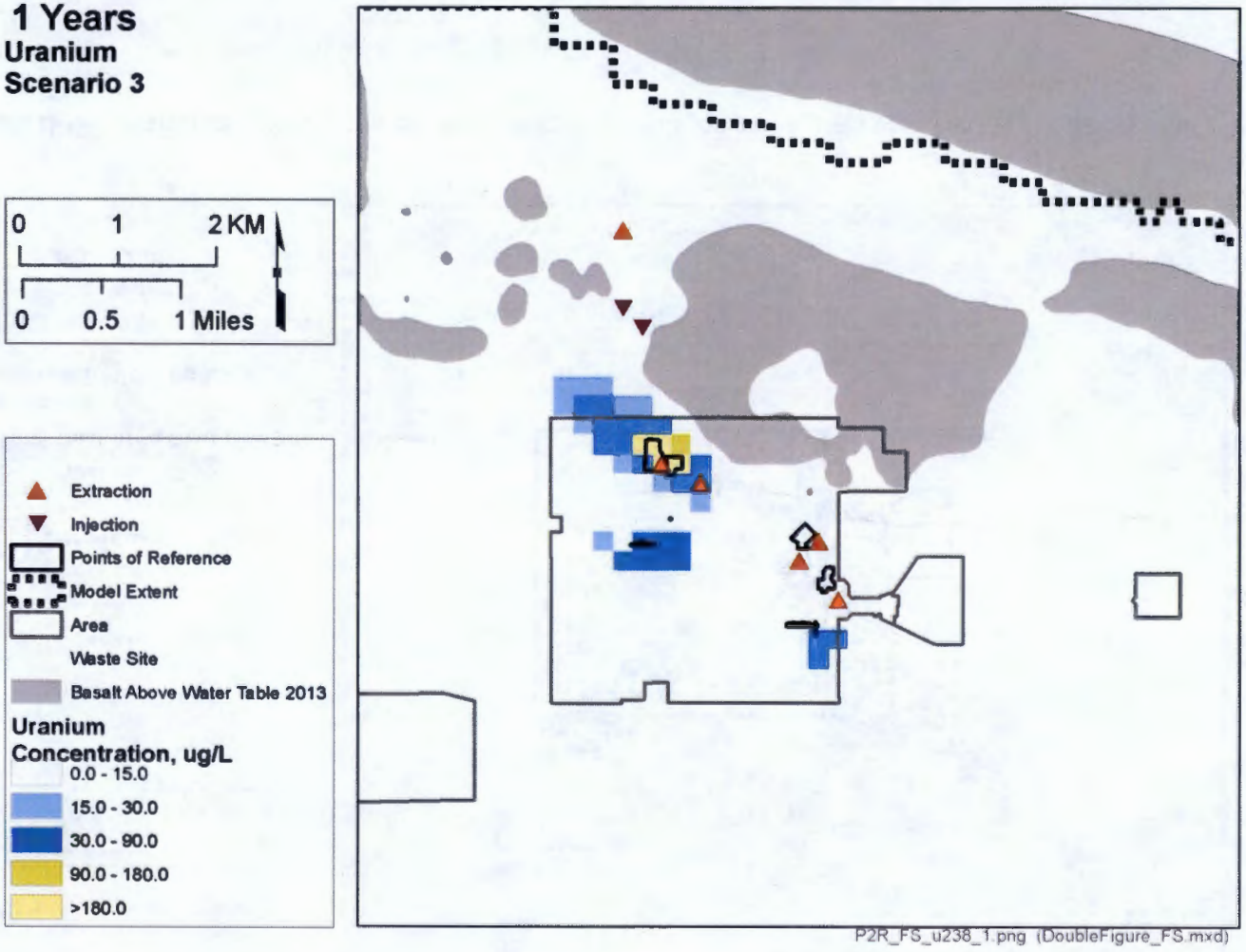

Figure B-128 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 3 simulation.

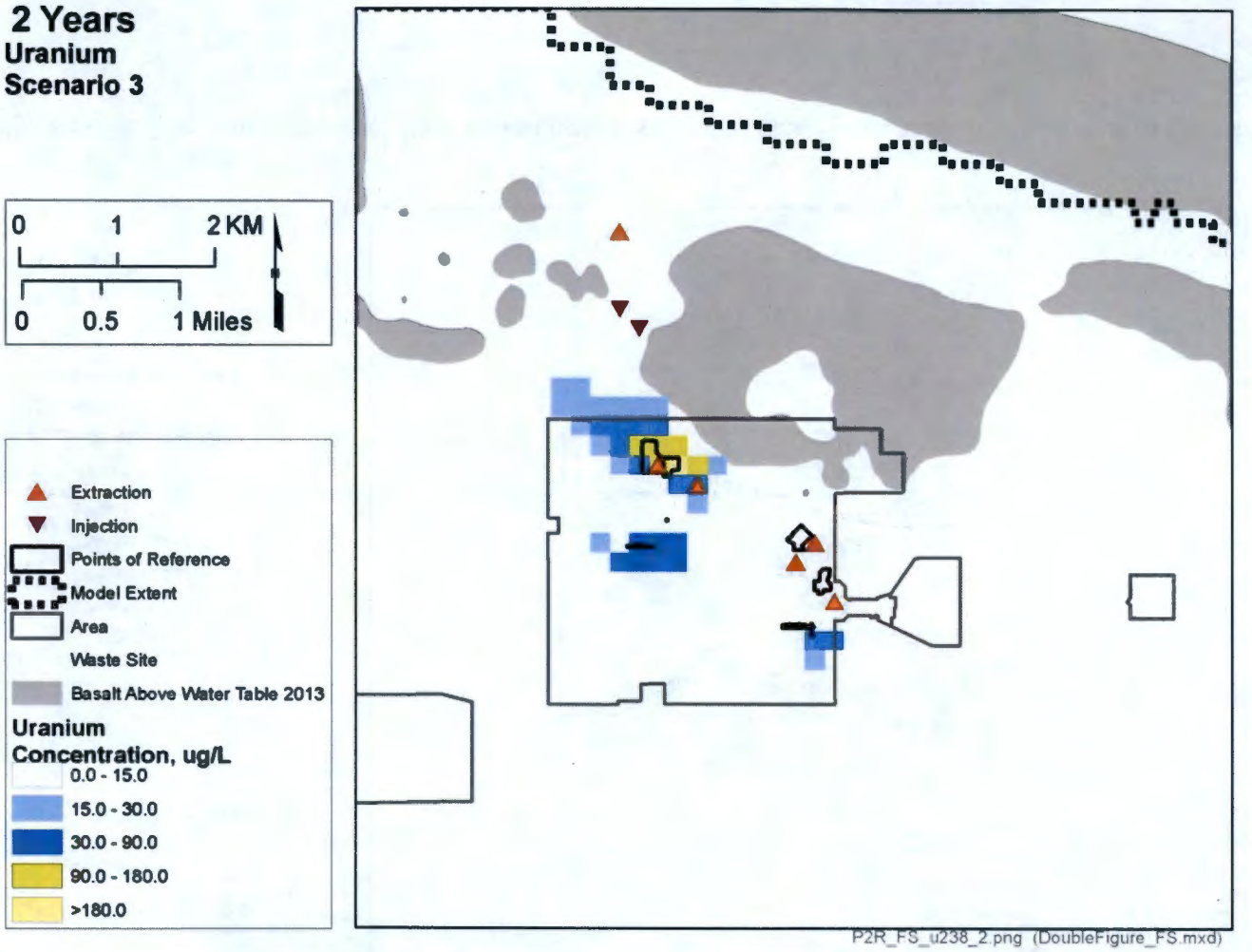

Figure B-129 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 3 simulation.

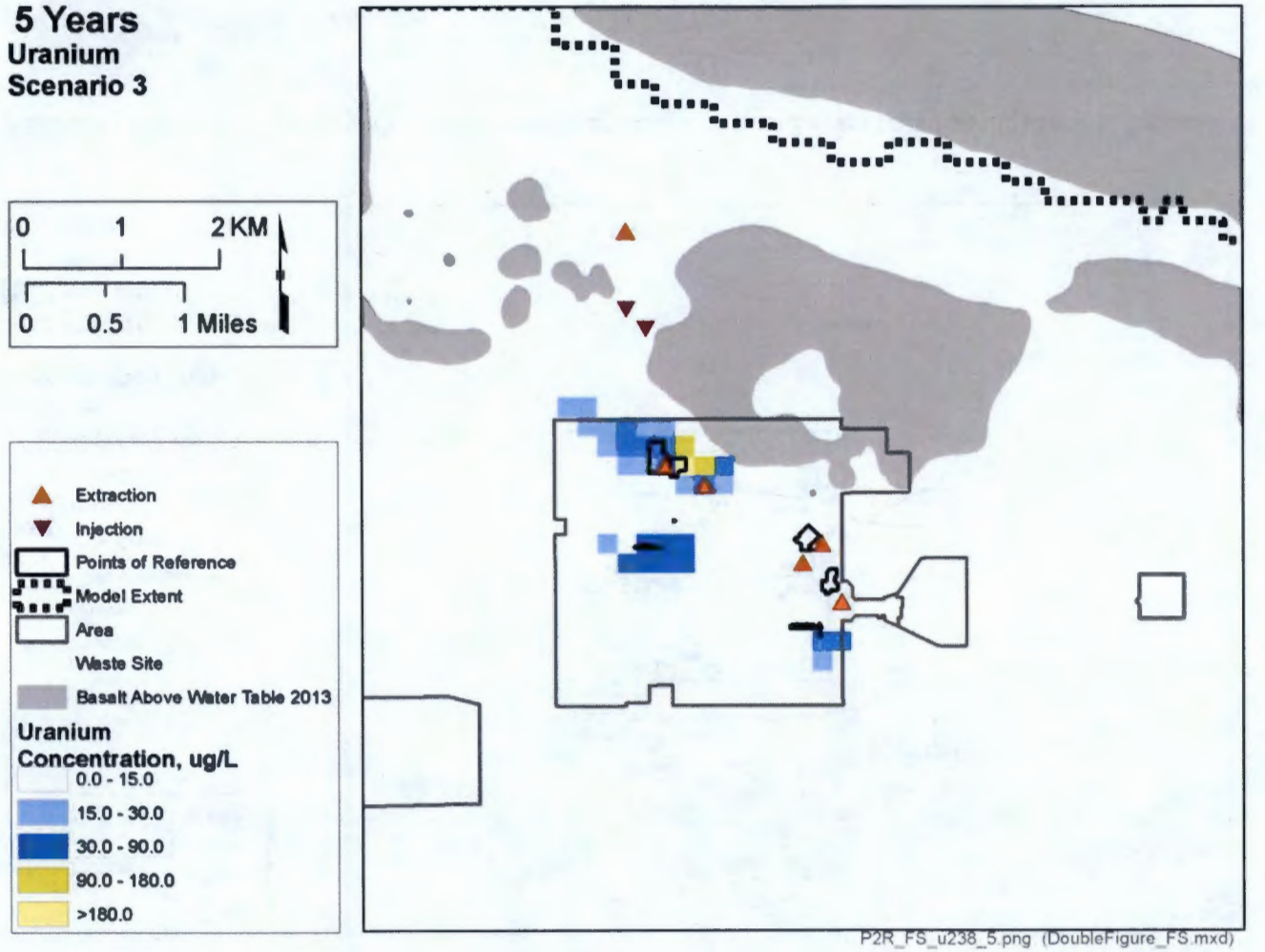

Figure B-130 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 3 simulation.

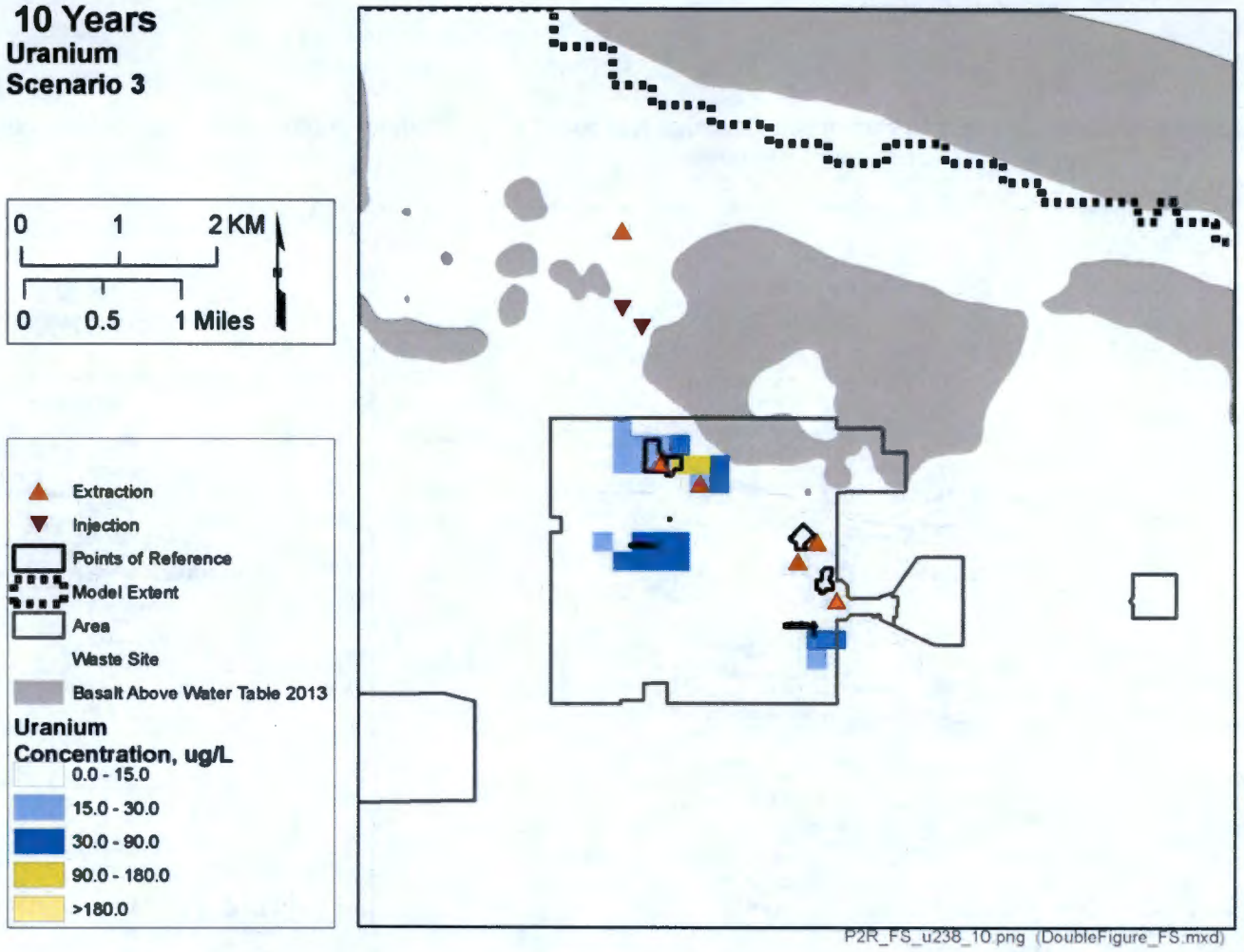

Figure B-131 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 3 simulation.

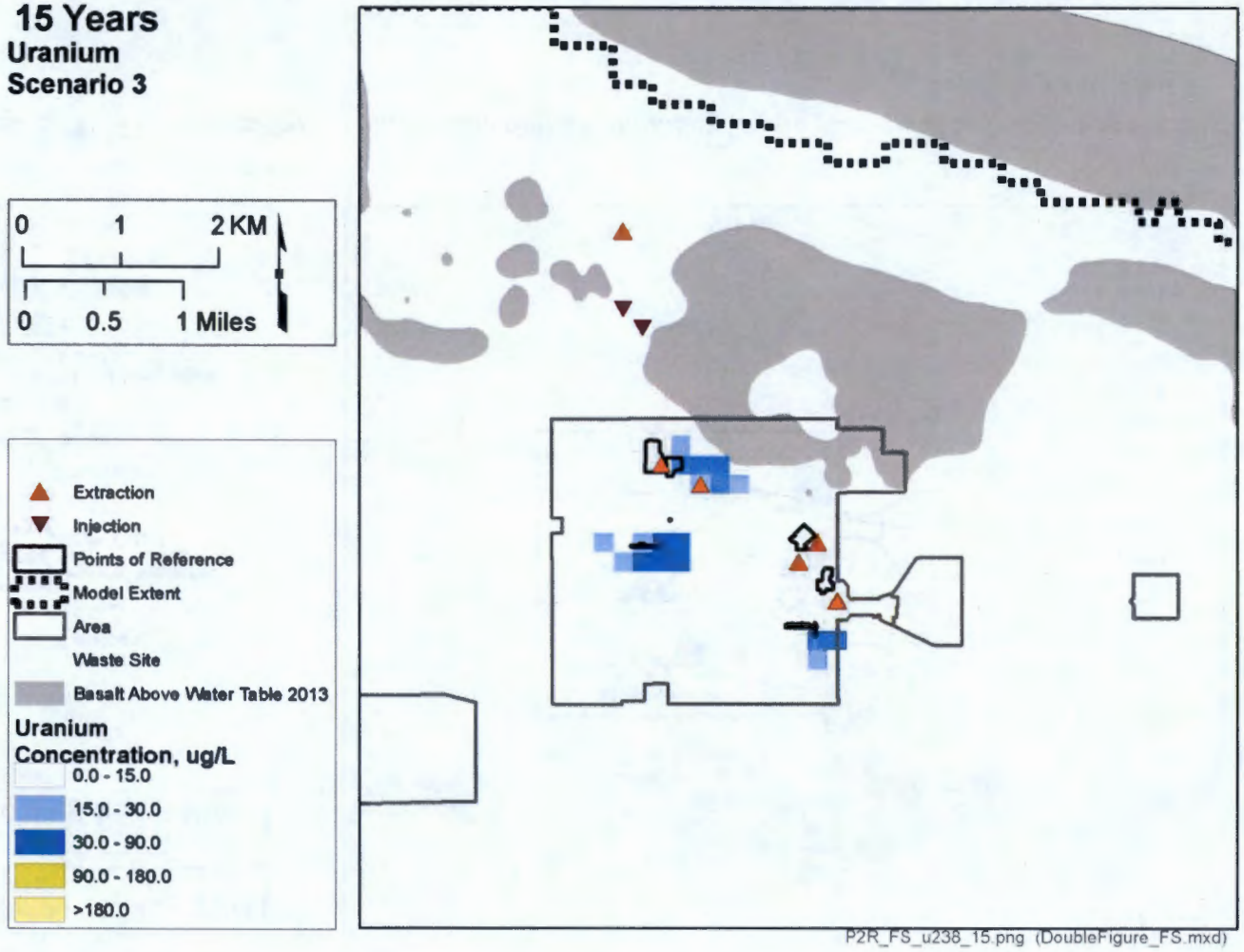

Figure B-132 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 3 simulation.

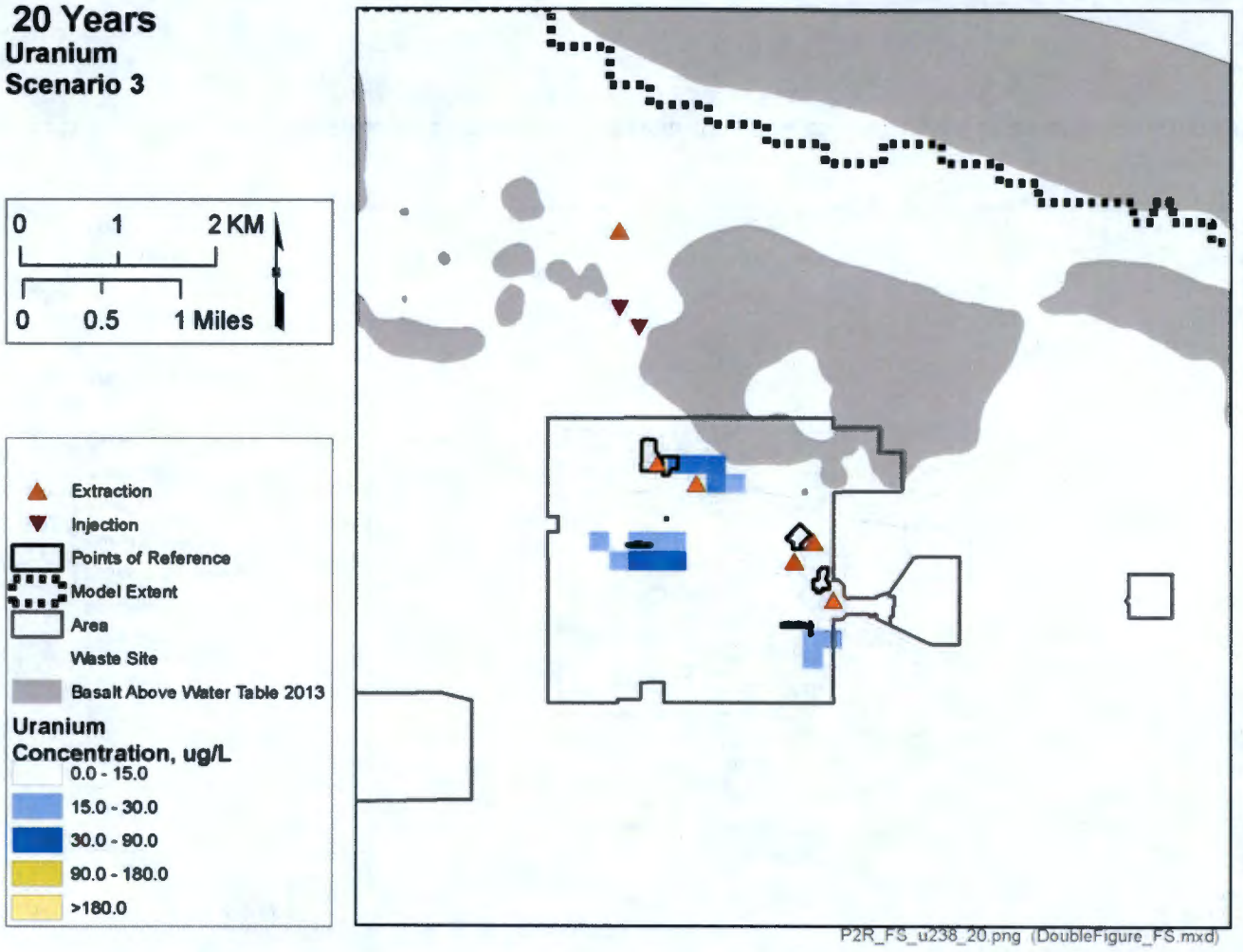

Figure B-133 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 3 simulation.

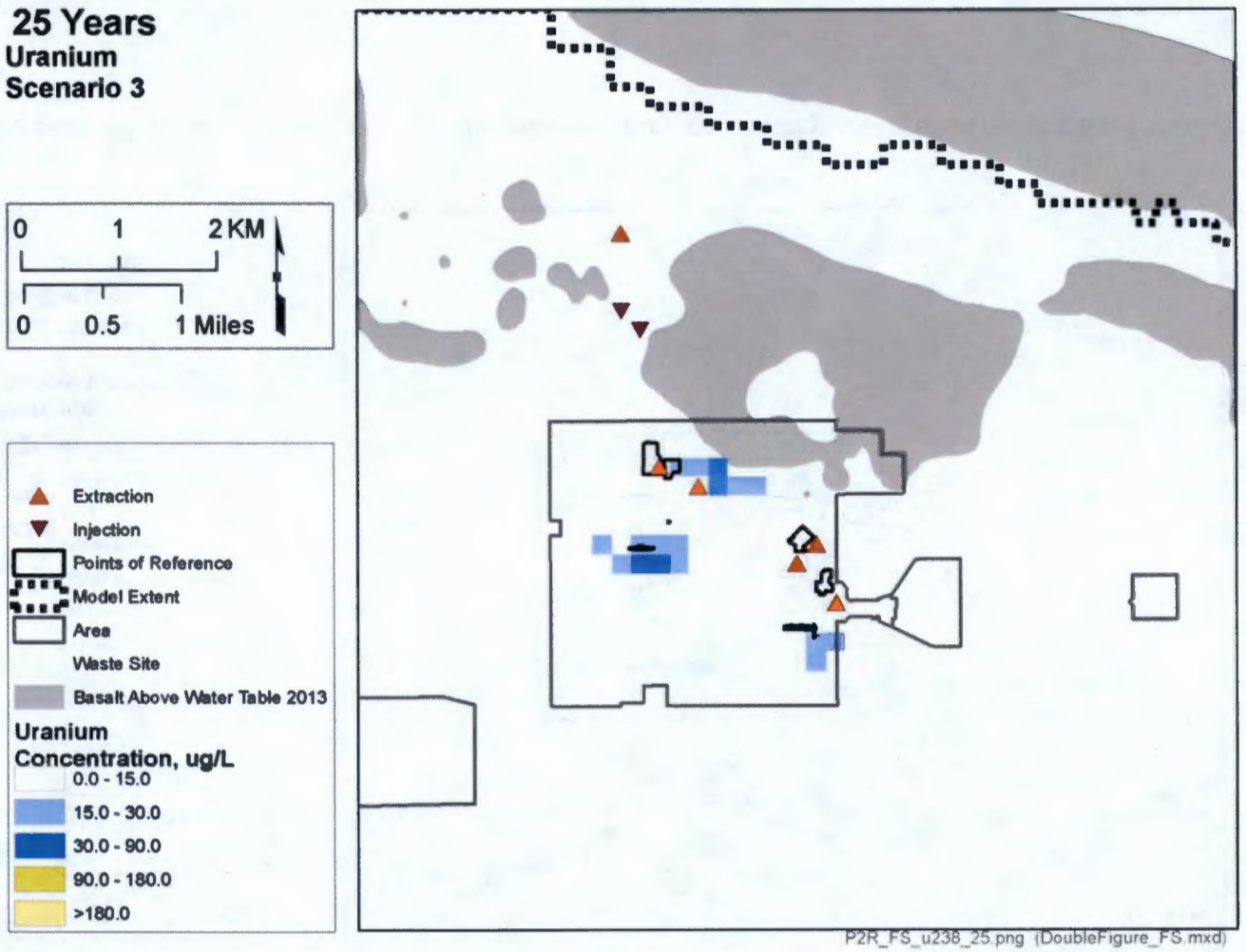

Figure B-134 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 3 simulation.

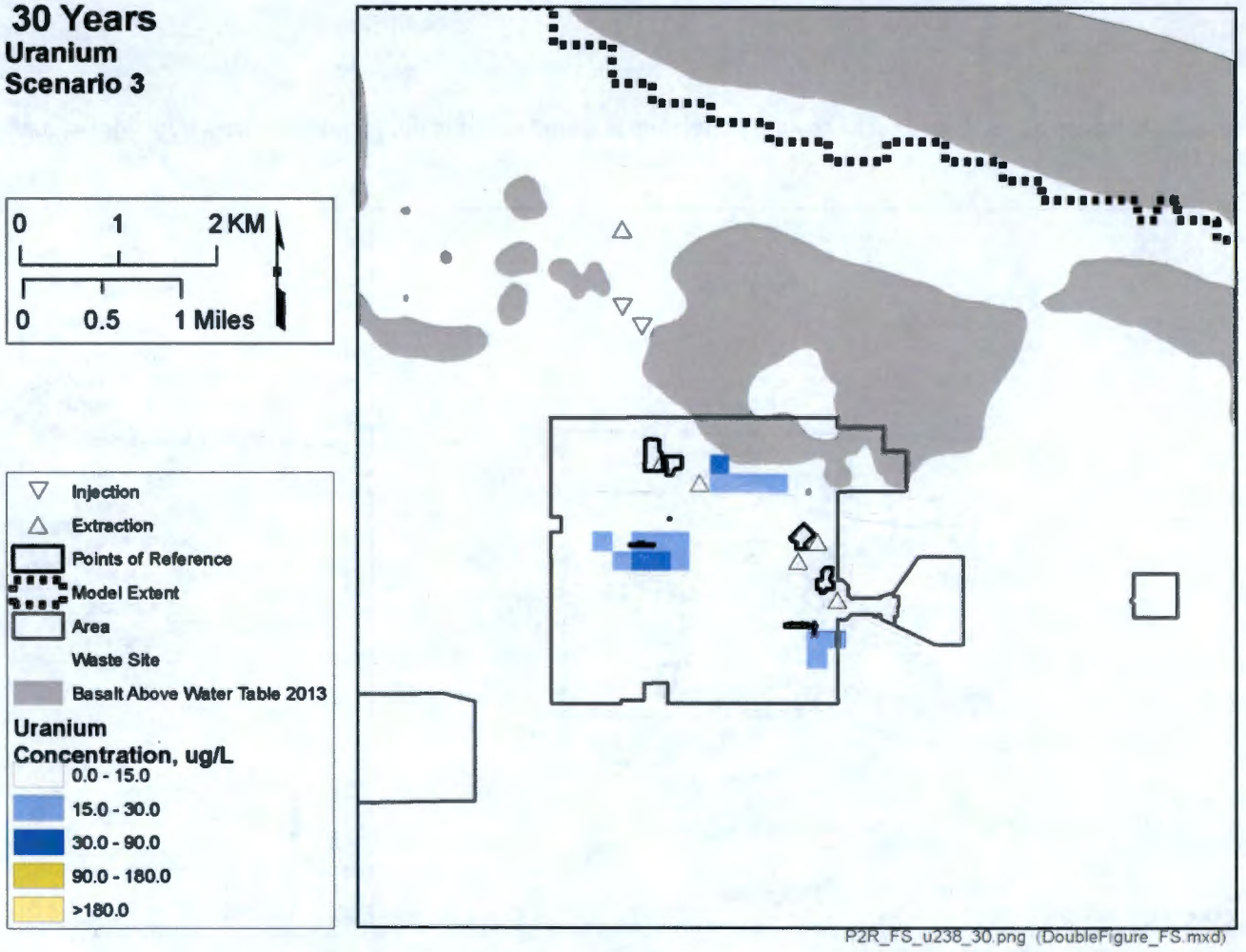

Figure B-135 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 3 simulation.

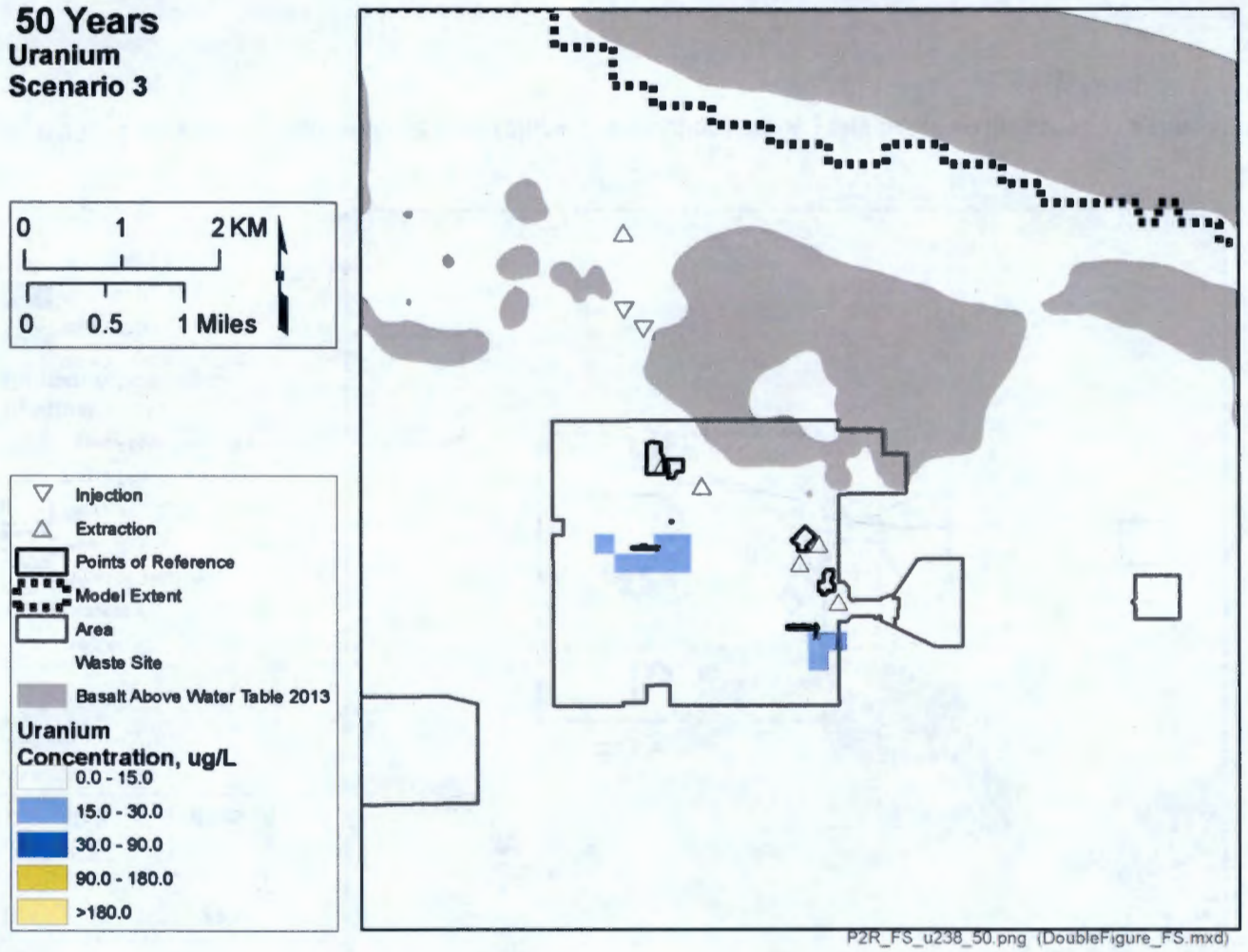

Figure B-136 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 3 simulation.

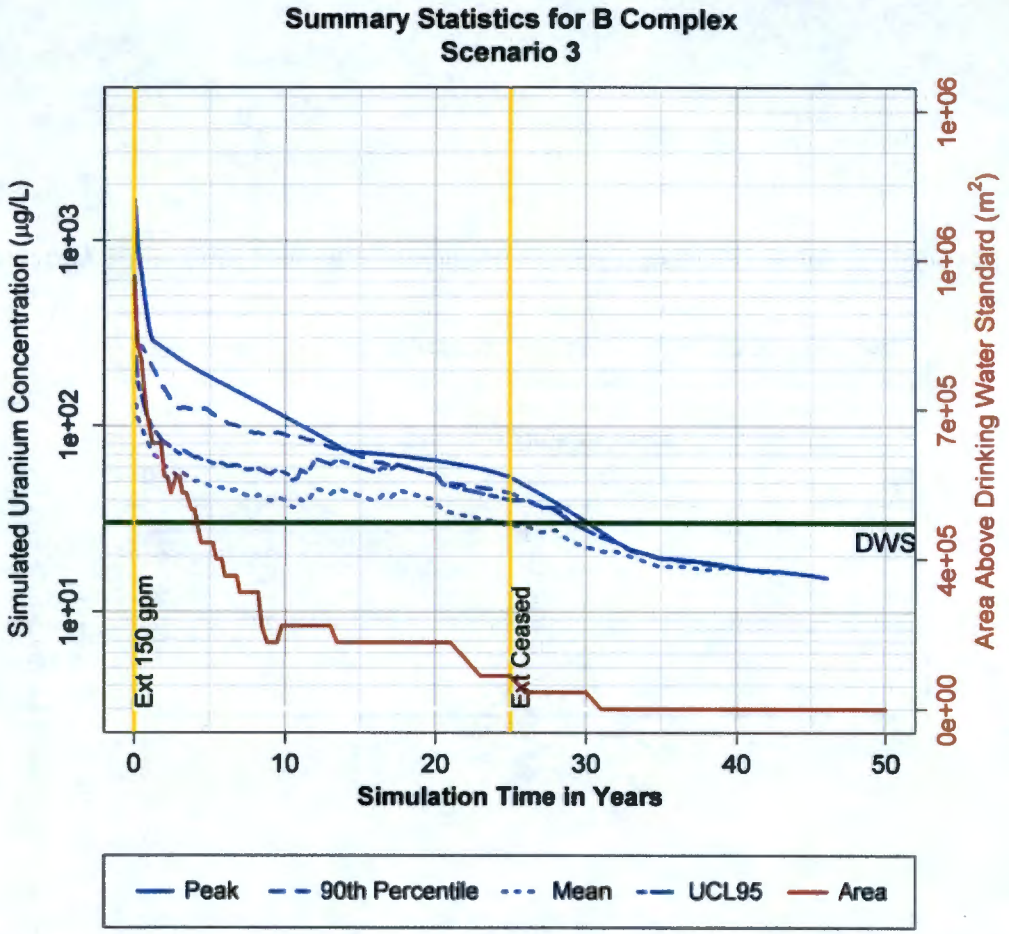

Figure B-137 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

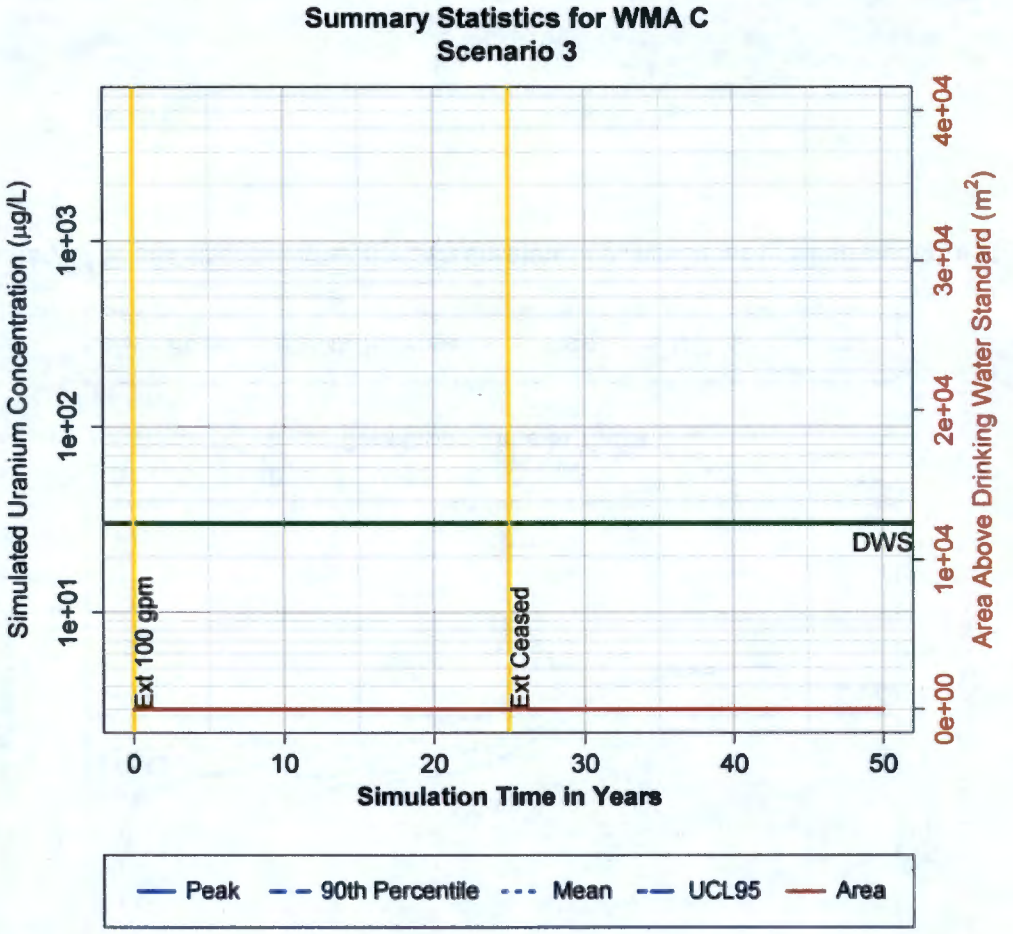

Figure B-138 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

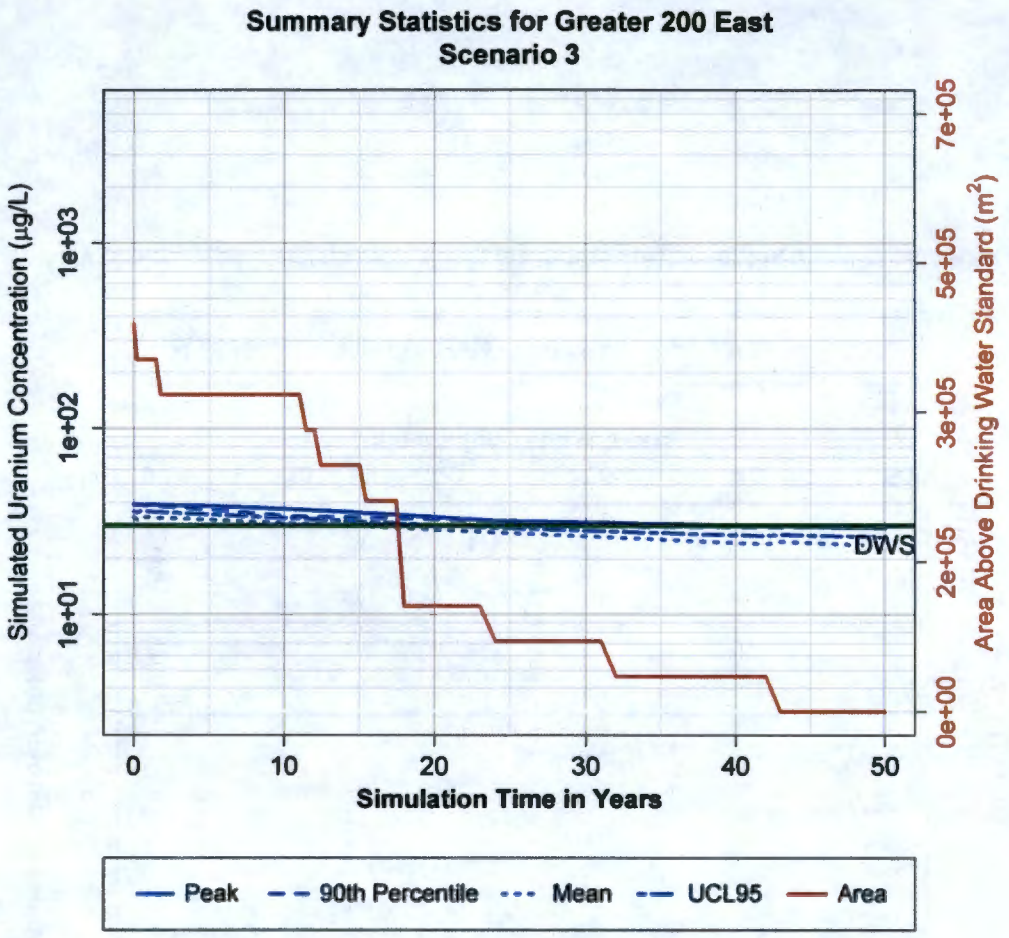

Figure B-139 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

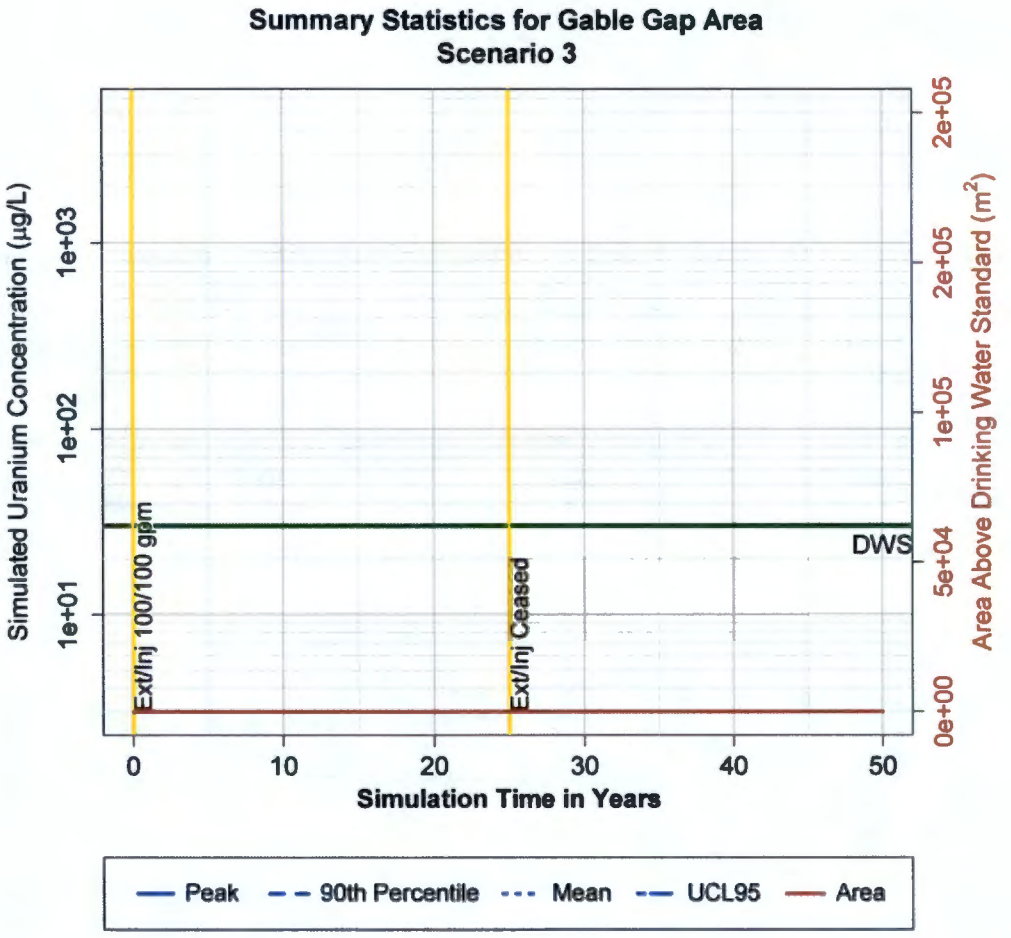

Figure B-140 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

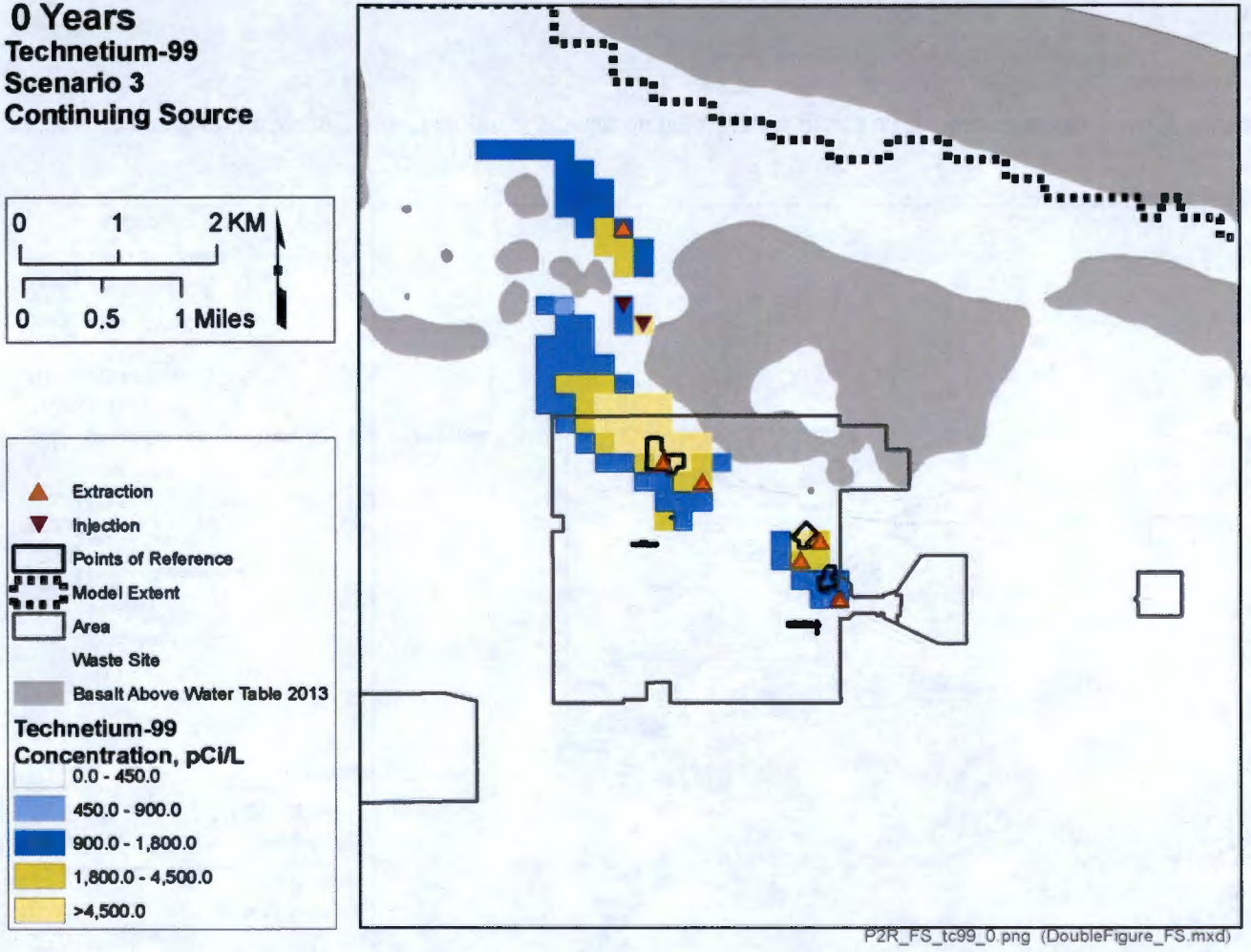

Figure B-141 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 3 simulation with a continuing source term.

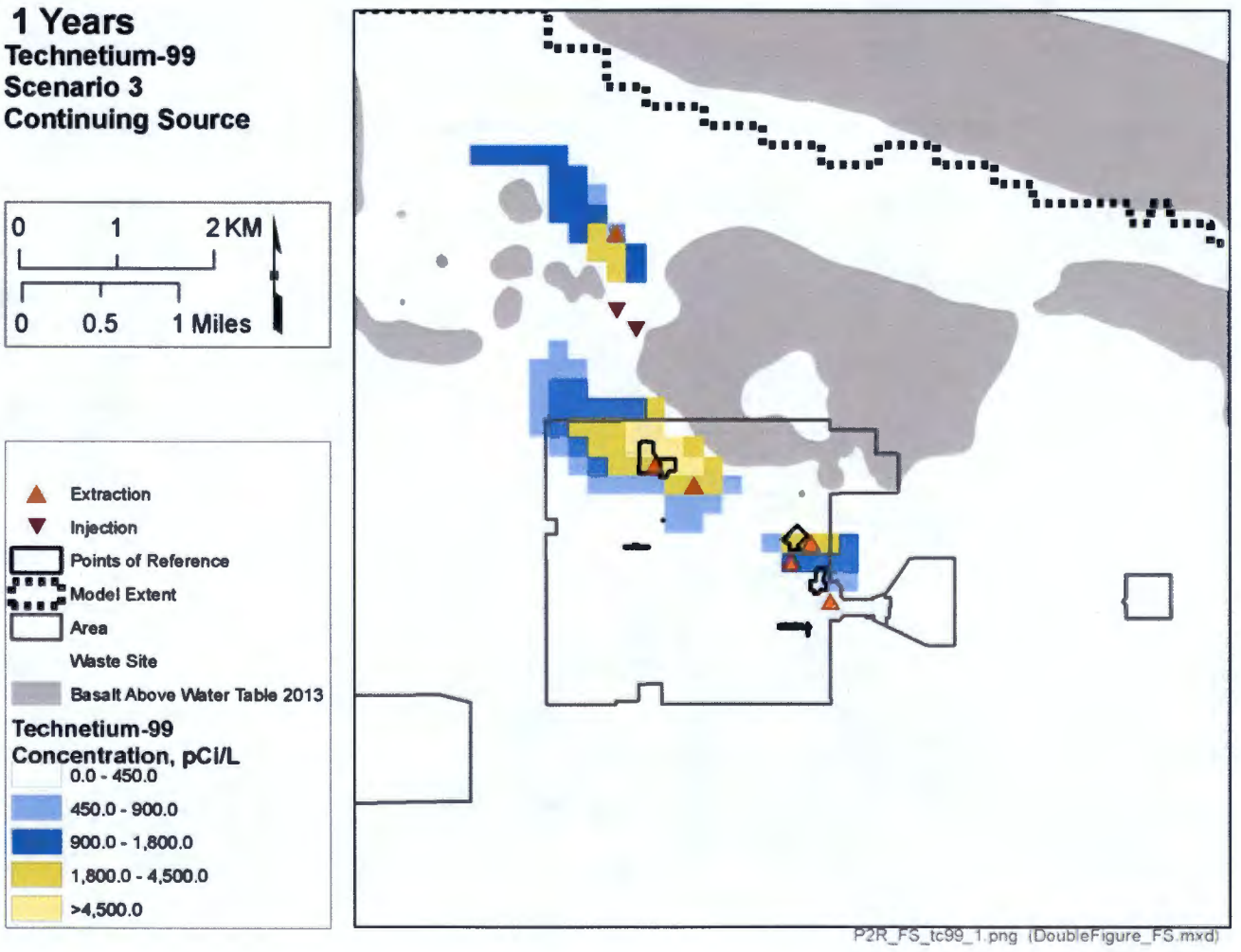

Figure B-142 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 3 simulation with a continuing source term.

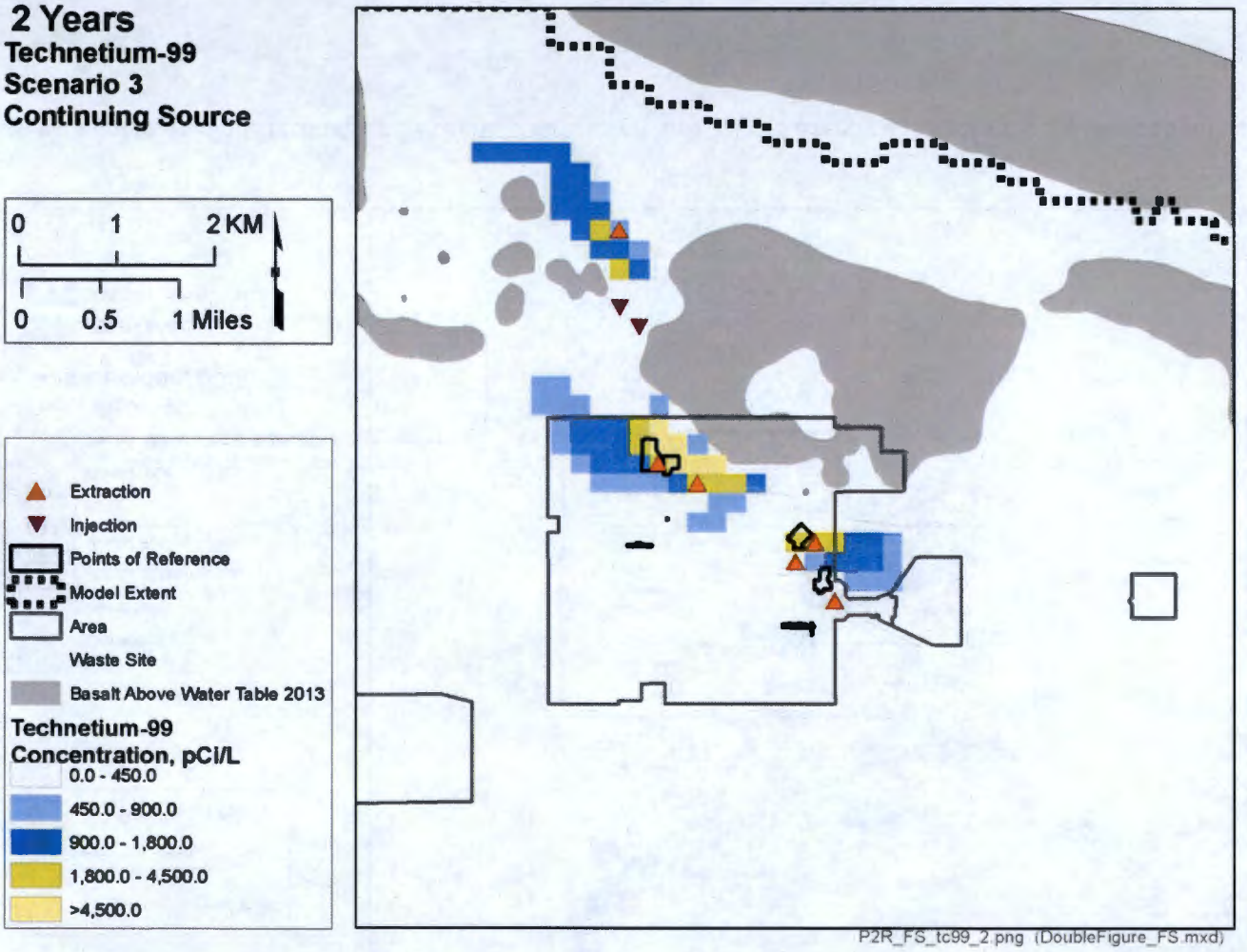

Figure B-143 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 3 simulation with a continuing source term.

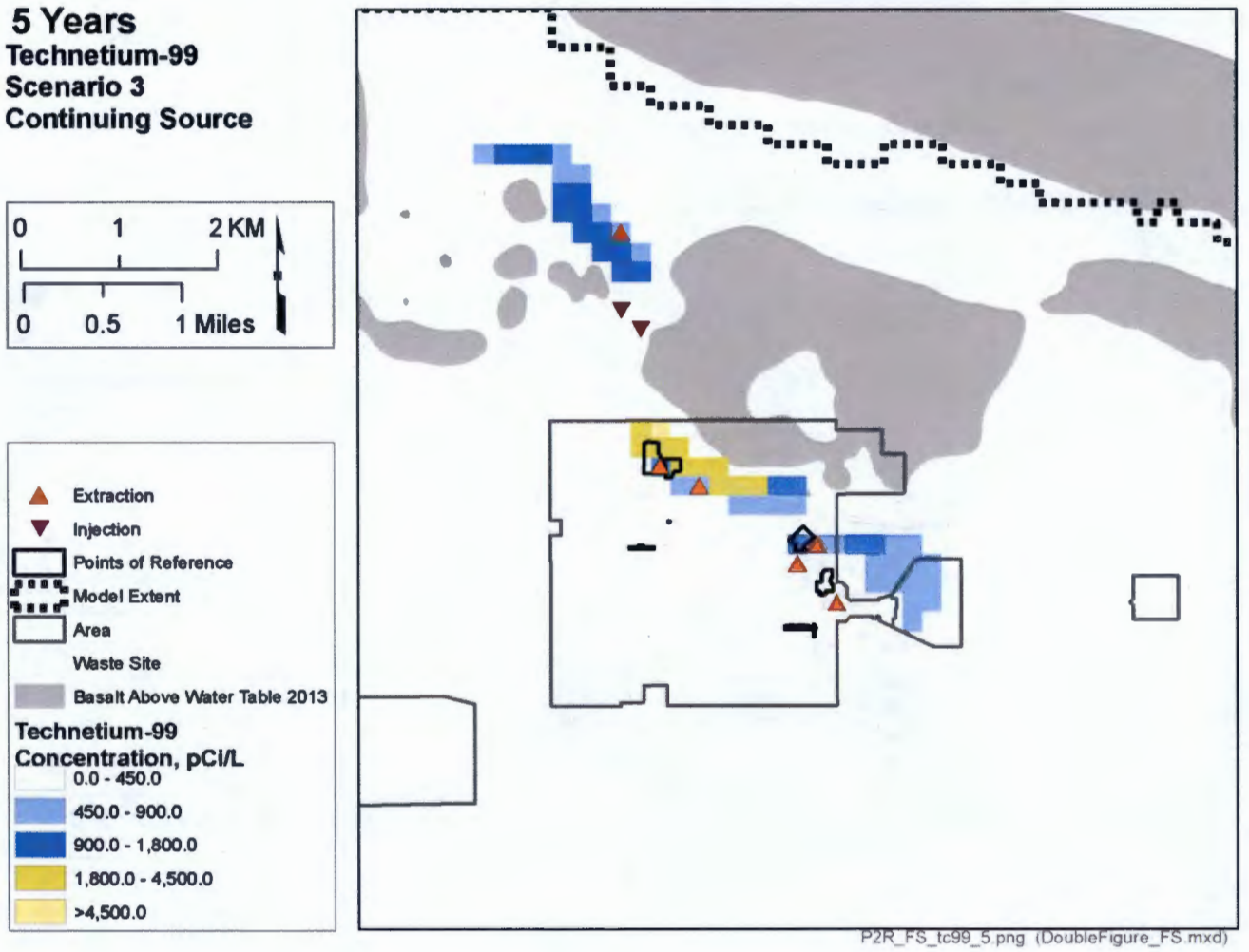

Figure B-144 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 3 simulation with a continuing source term.

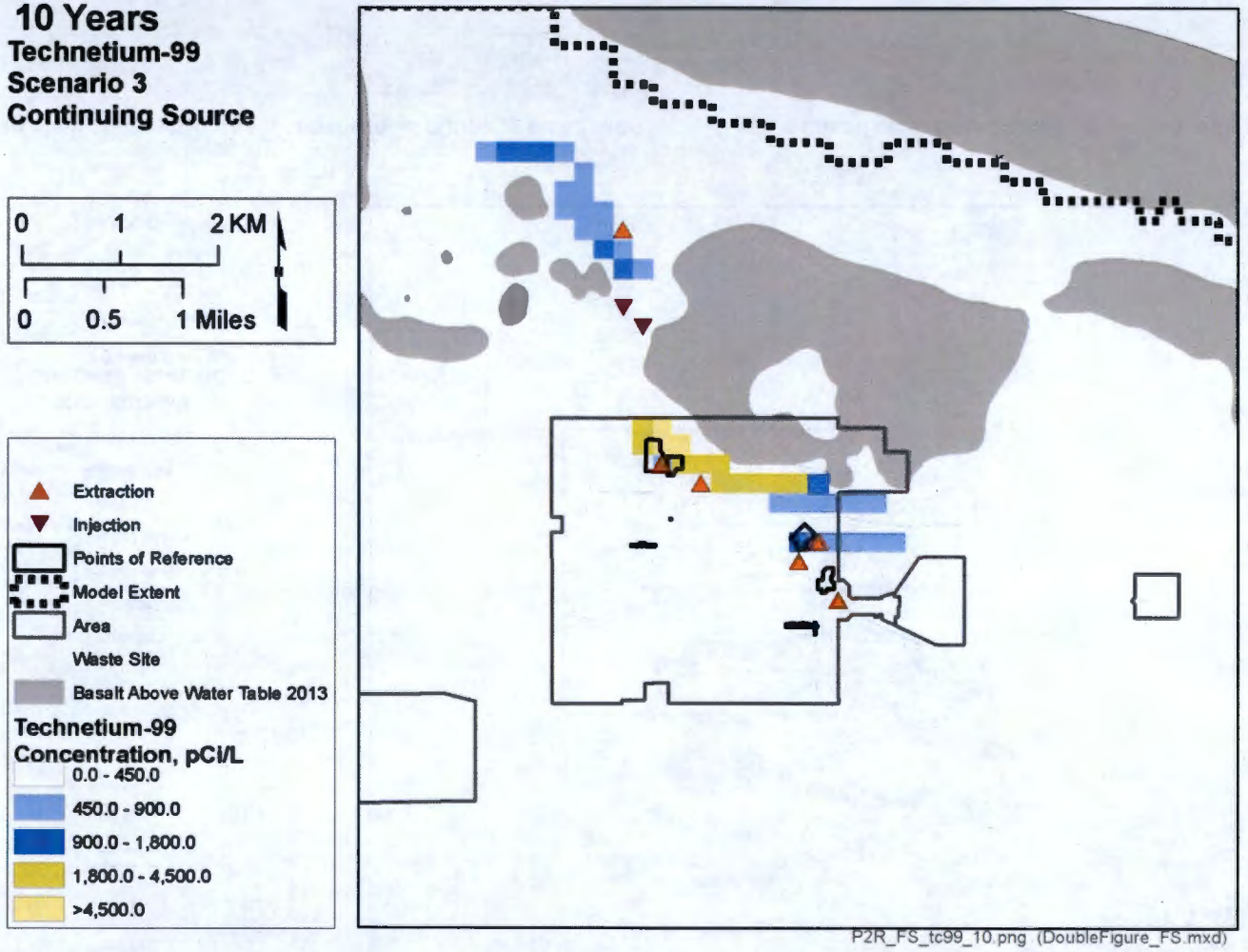

Figure B-145 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 3 simulation with a continuing source term.

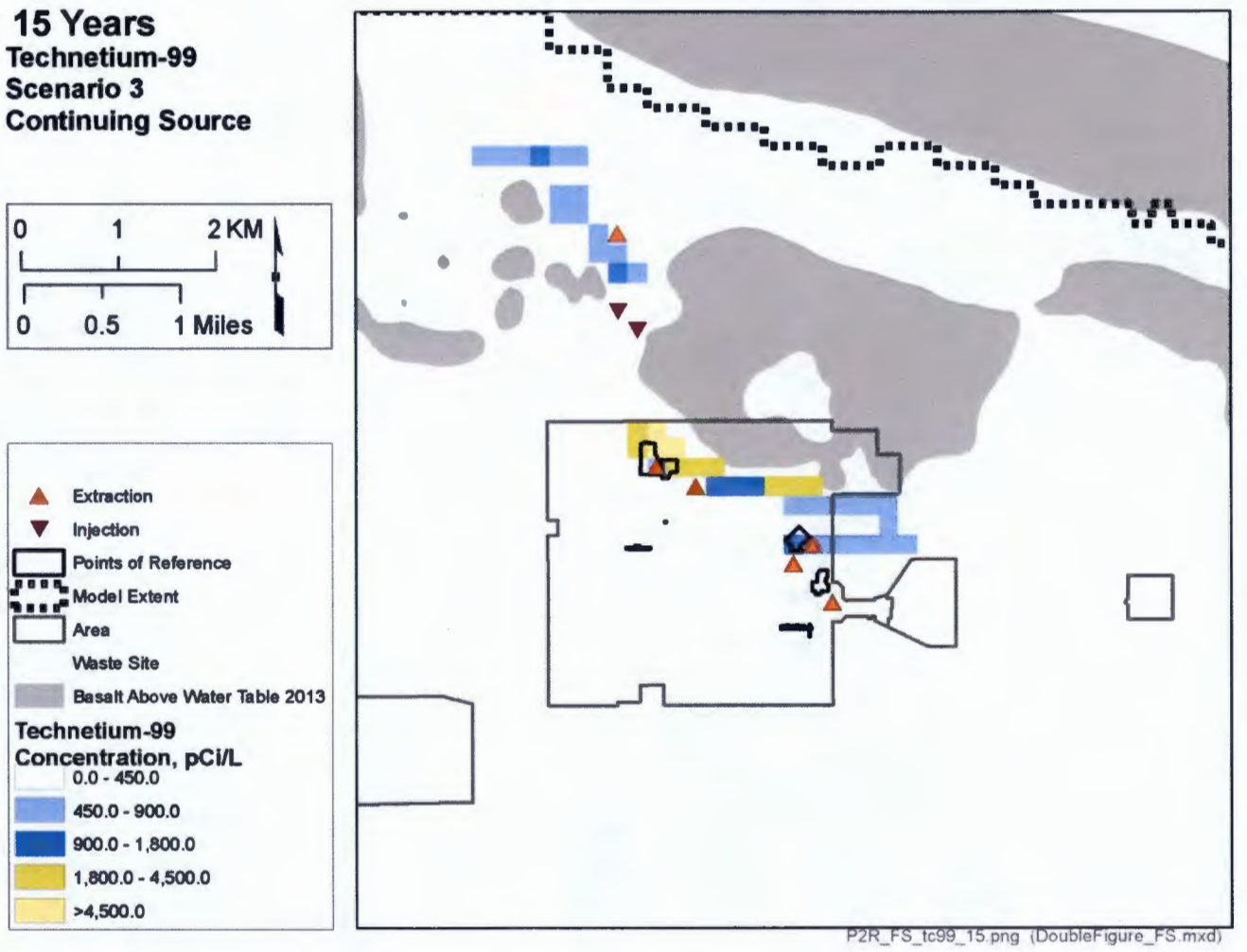

Figure B-146 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 3 simulation with a continuing source term.

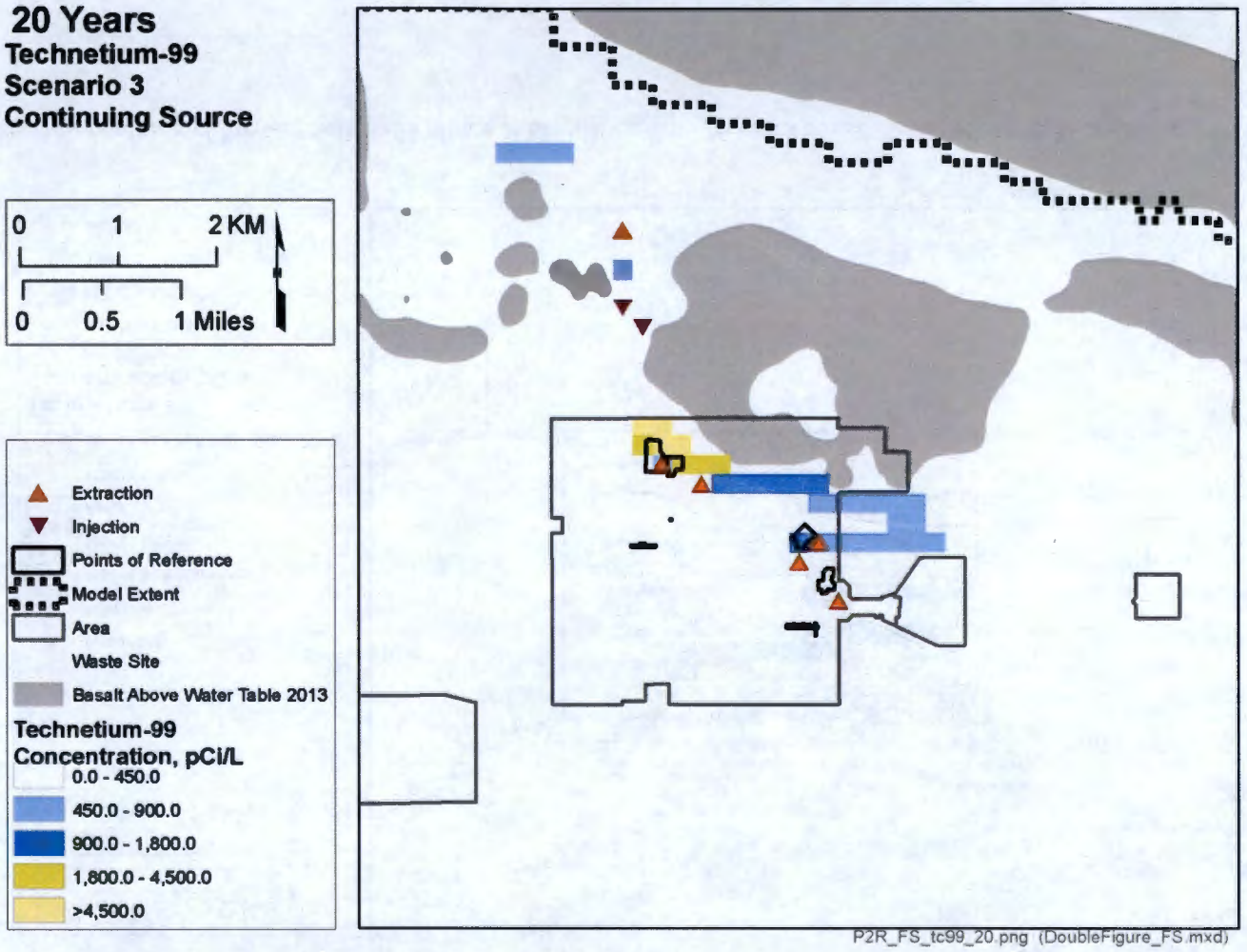

Figure B-147 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 3 simulation with a continuing source term.

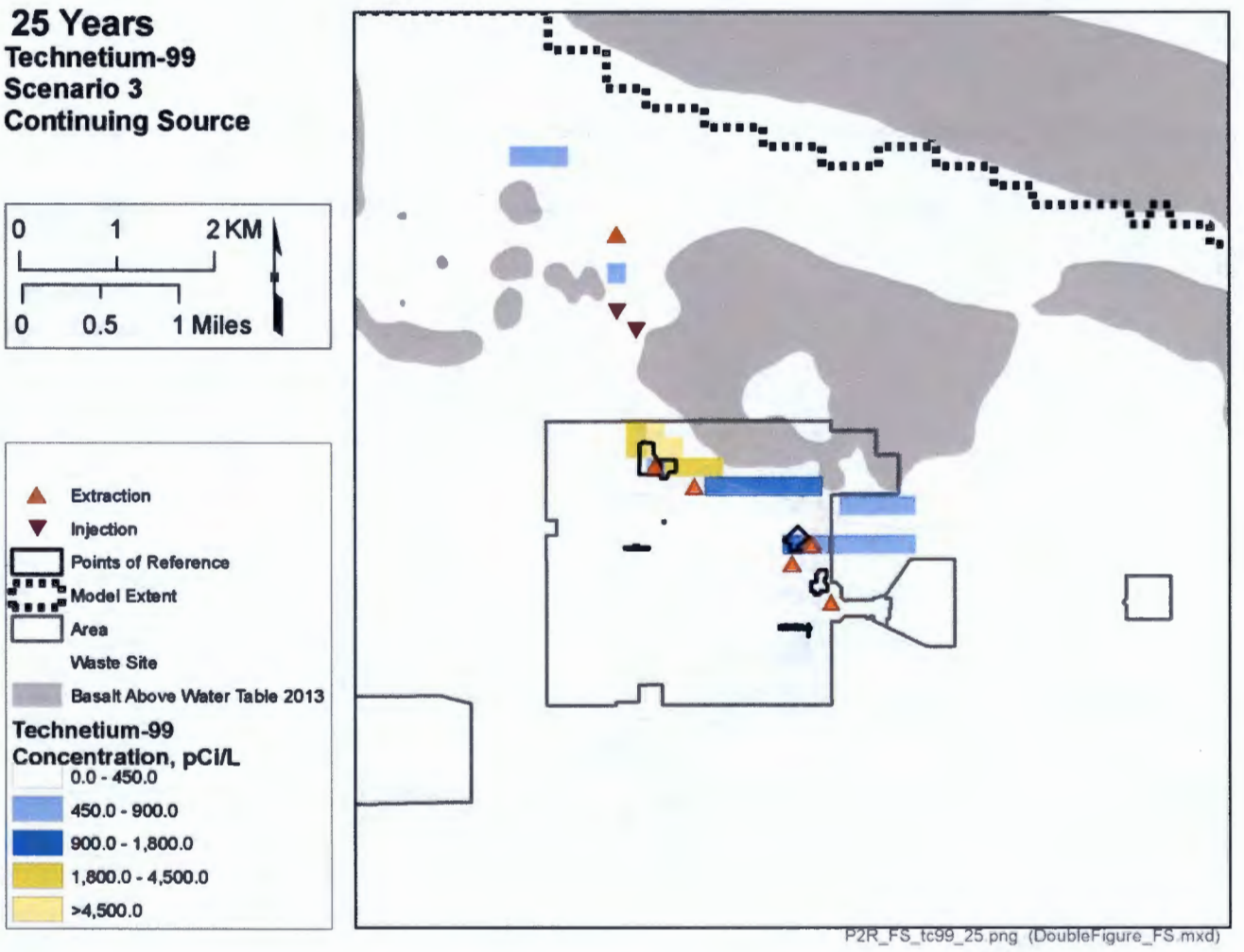

Figure B-148 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 3 simulation with a continuing source term.

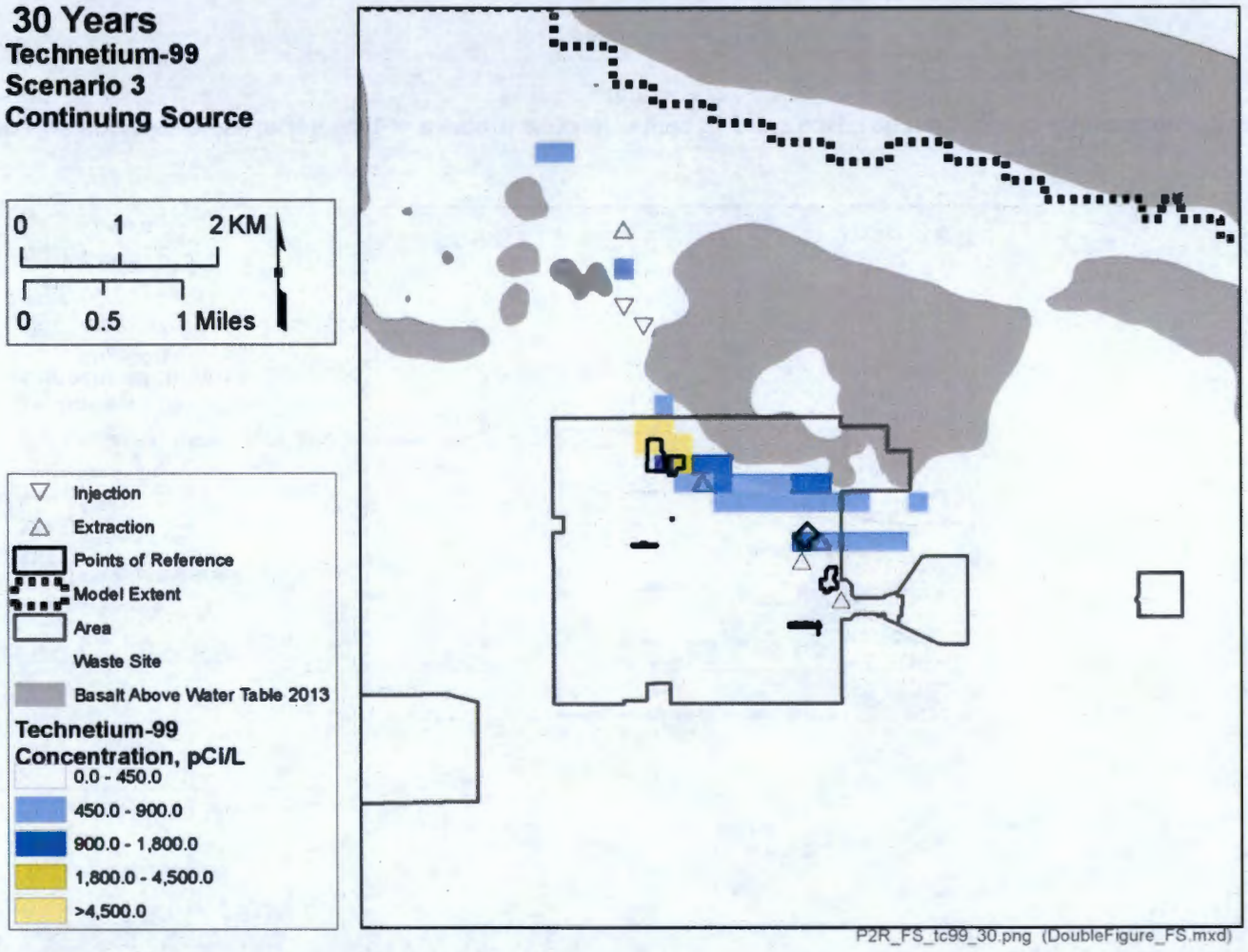

Figure B-149 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 3 simulation with a continuing source term.

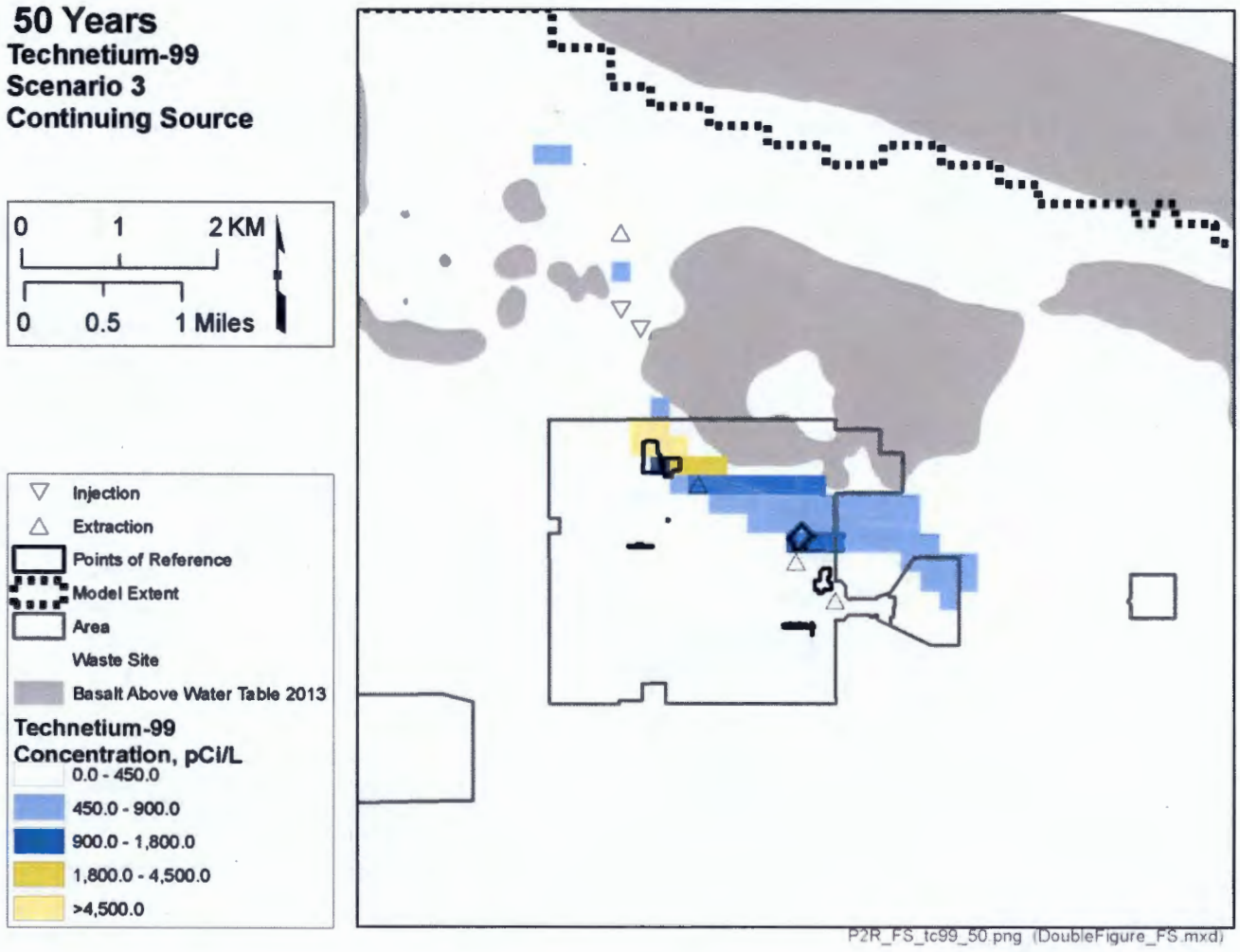

Figure B-150 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 3 simulation with a continuing source term.

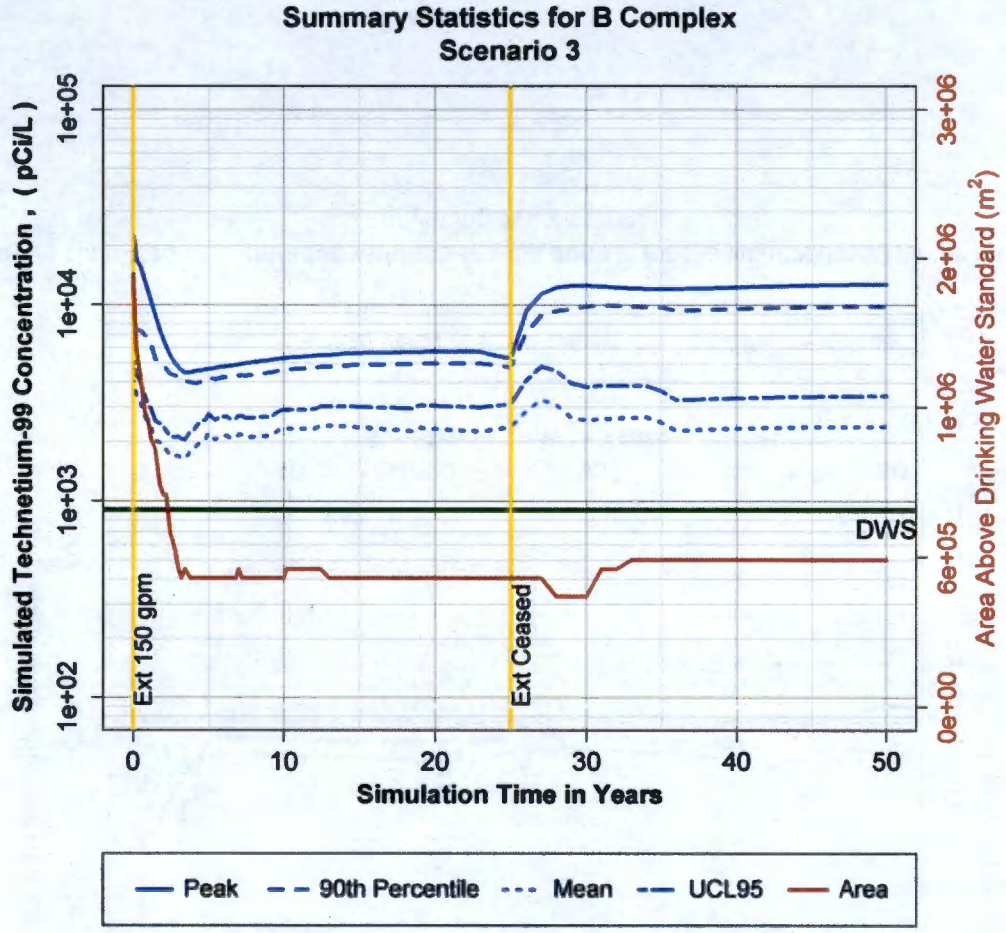

Figure B-151 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

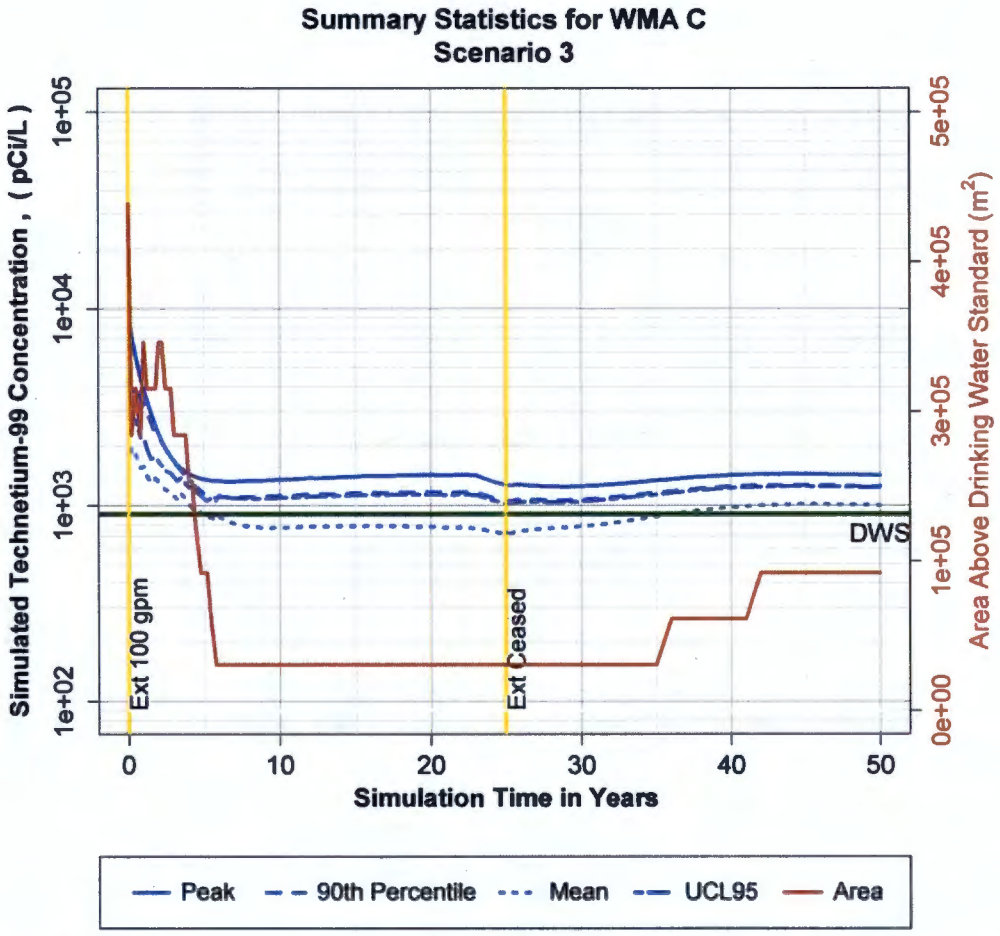

Figure B-152 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

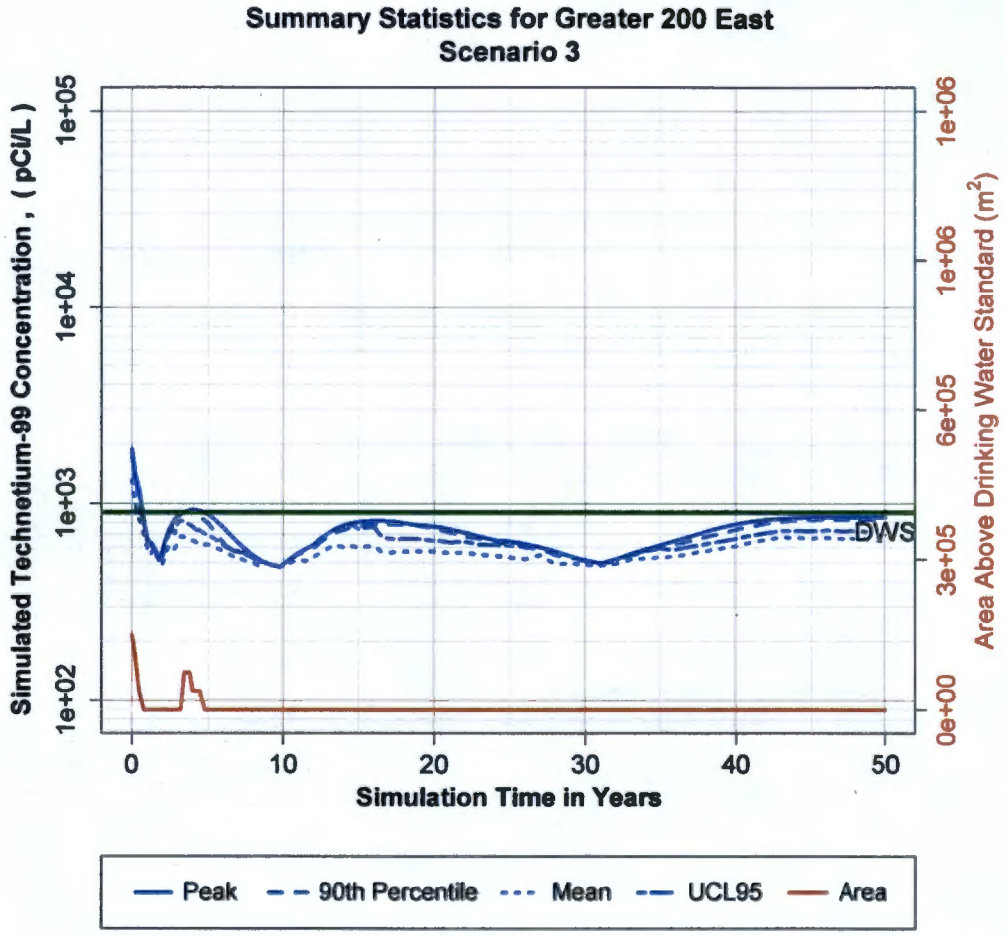

Figure B-153 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

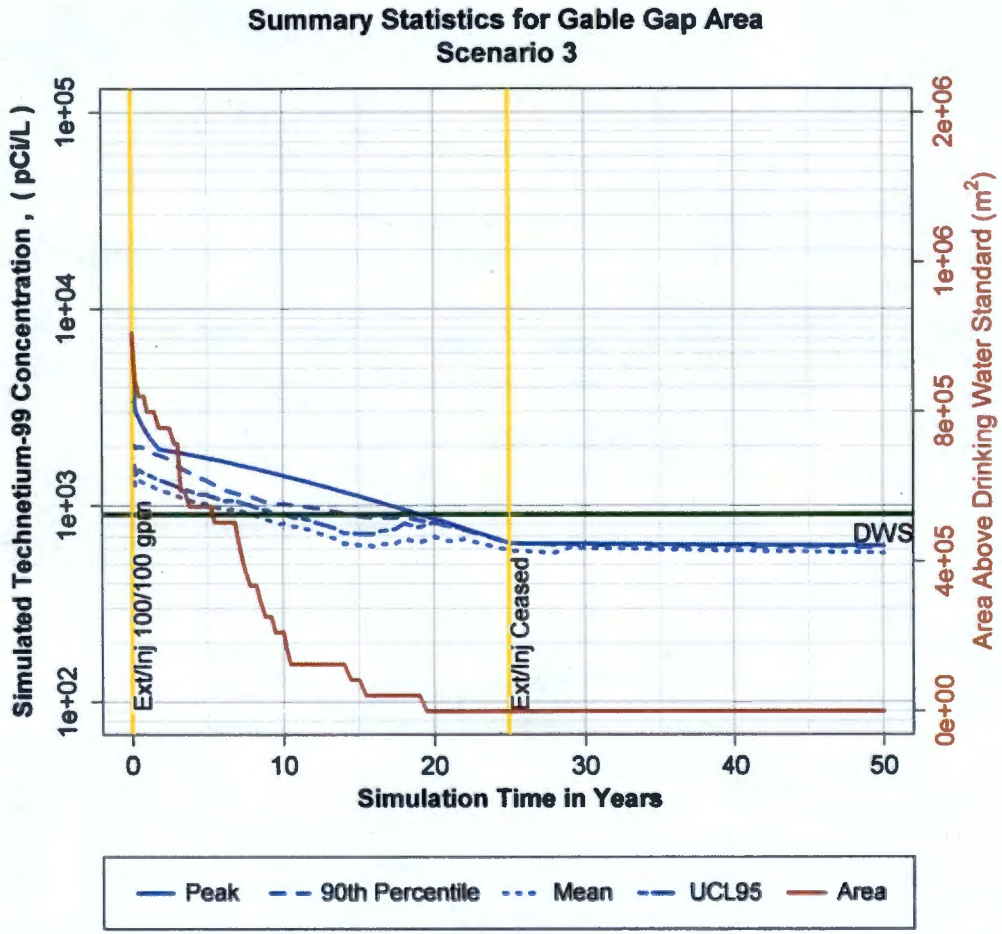

Figure B-154 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

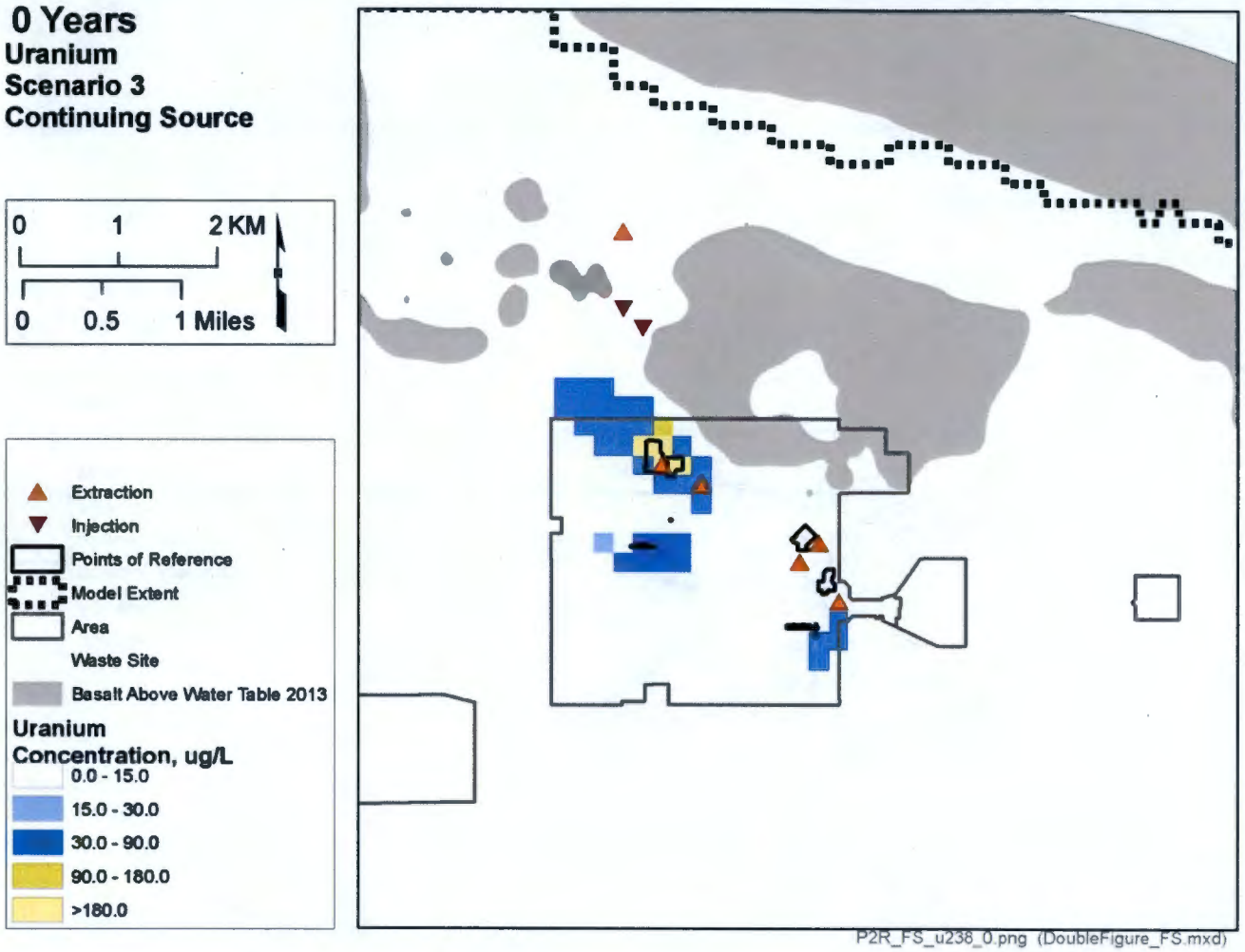

Figure B-155 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 3 simulation with a continuing source term.

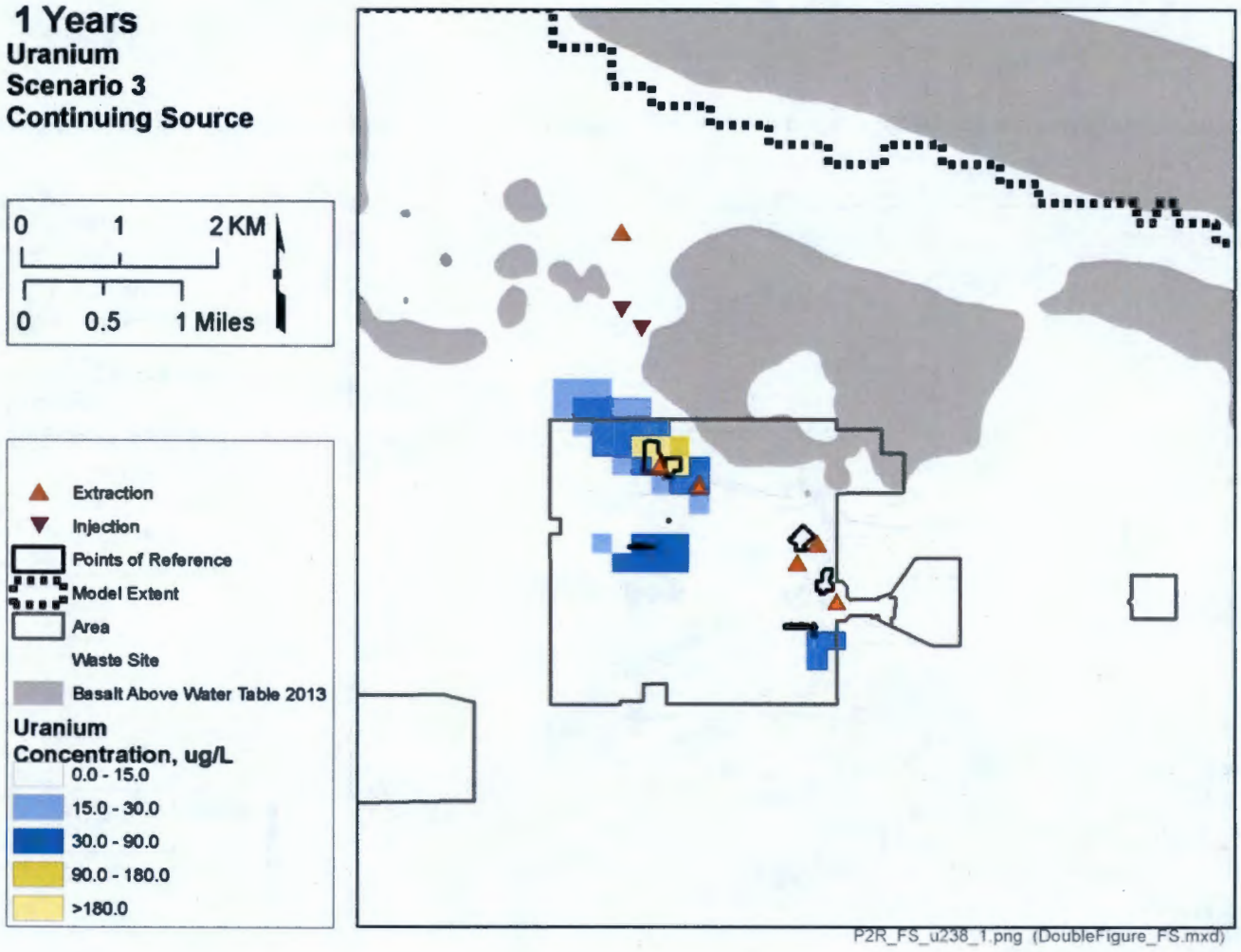

Figure B-156 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 3 simulation with a continuing source term.

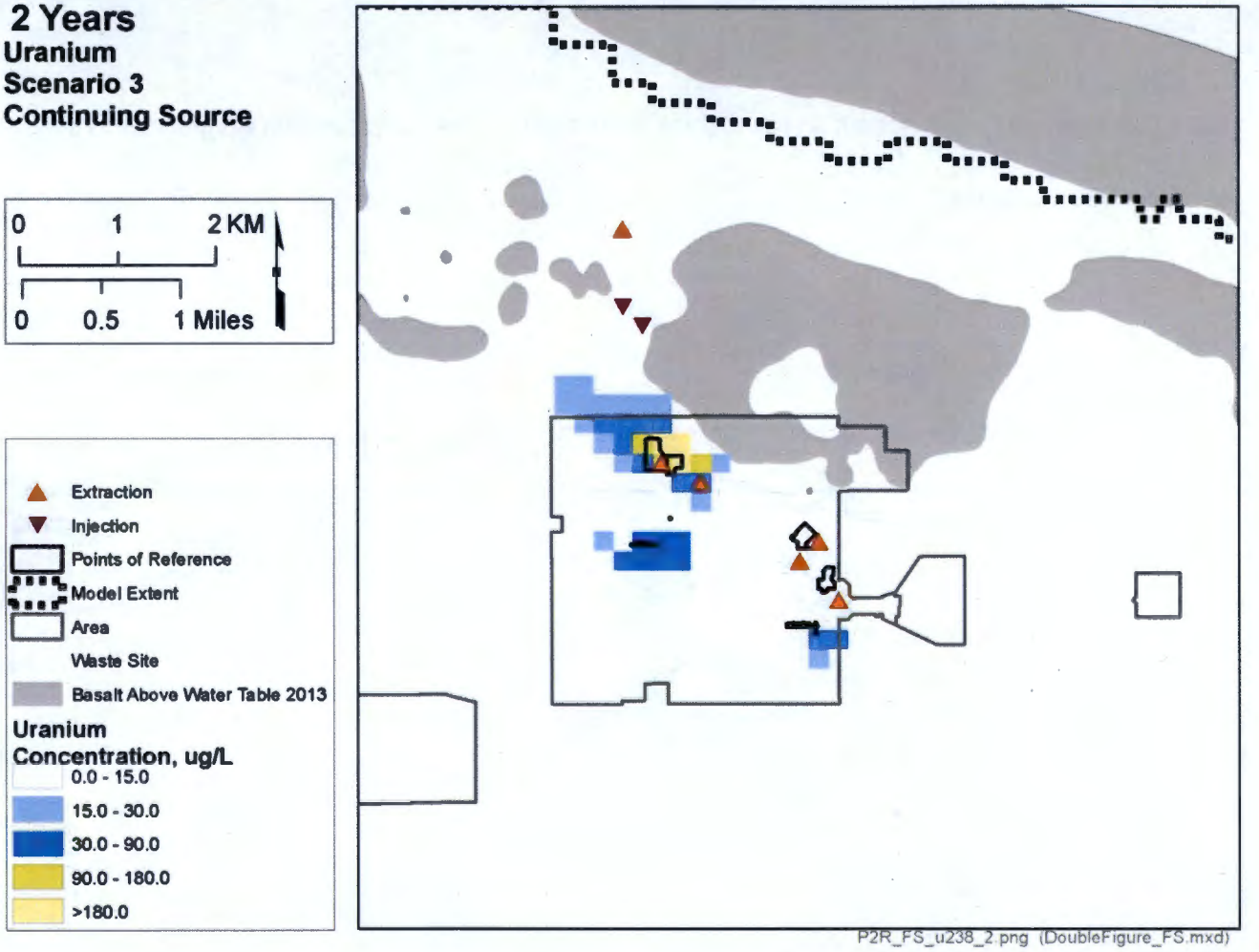

Figure B-157 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 3 simulation with a continuing source term.

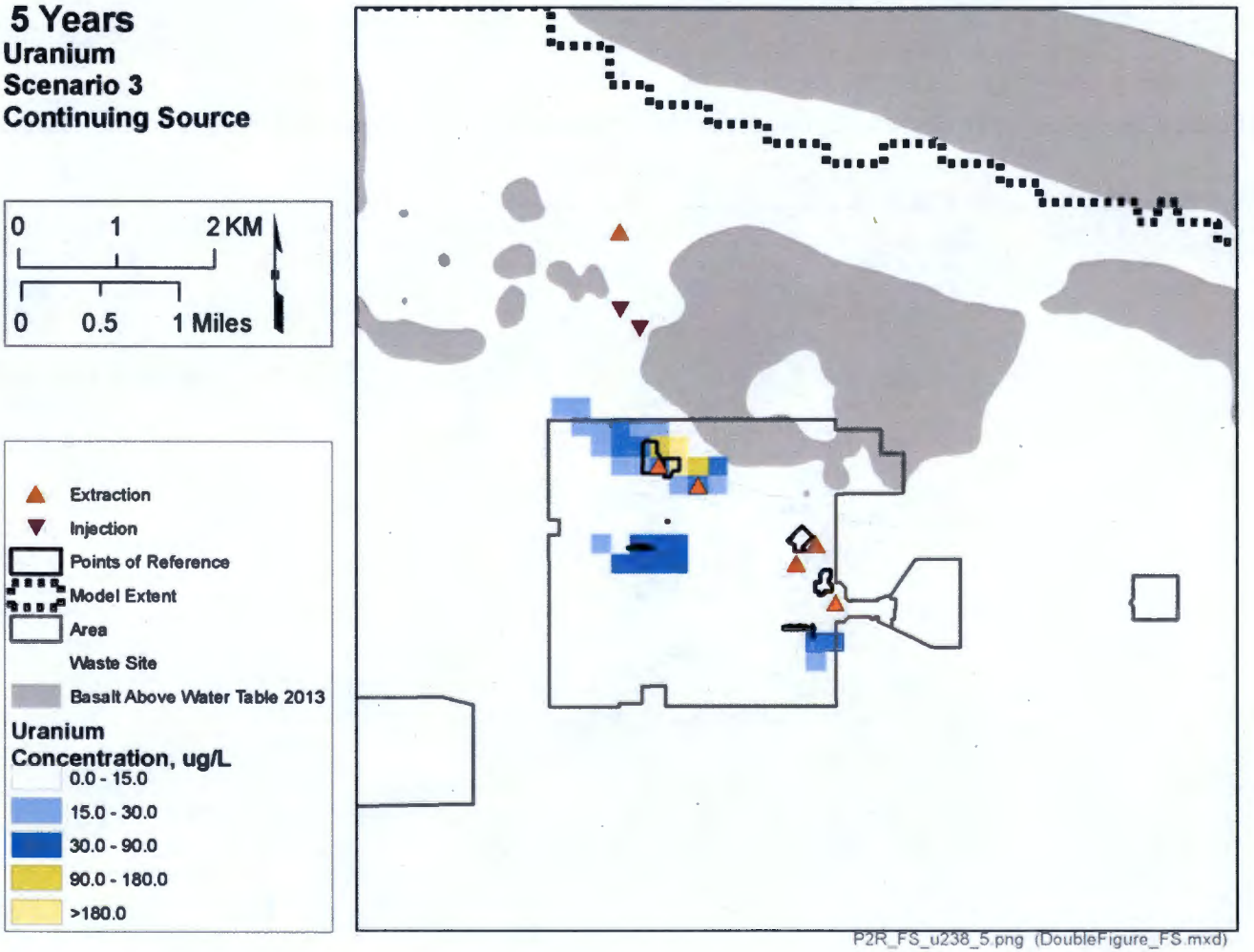

Figure B-158 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 3 simulation with a continuing source term.

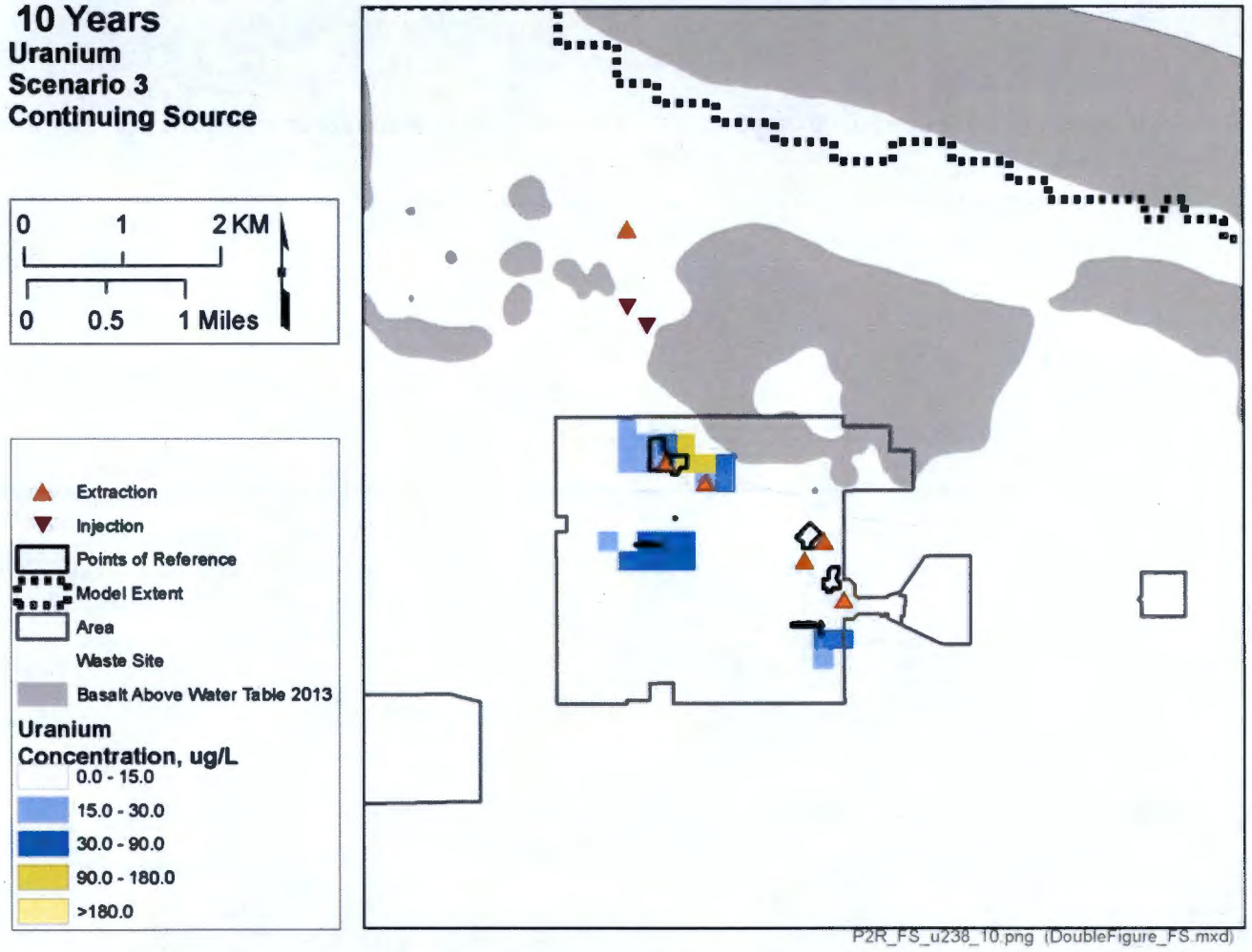

Figure B-159 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 3 simulation with a continuing source term.

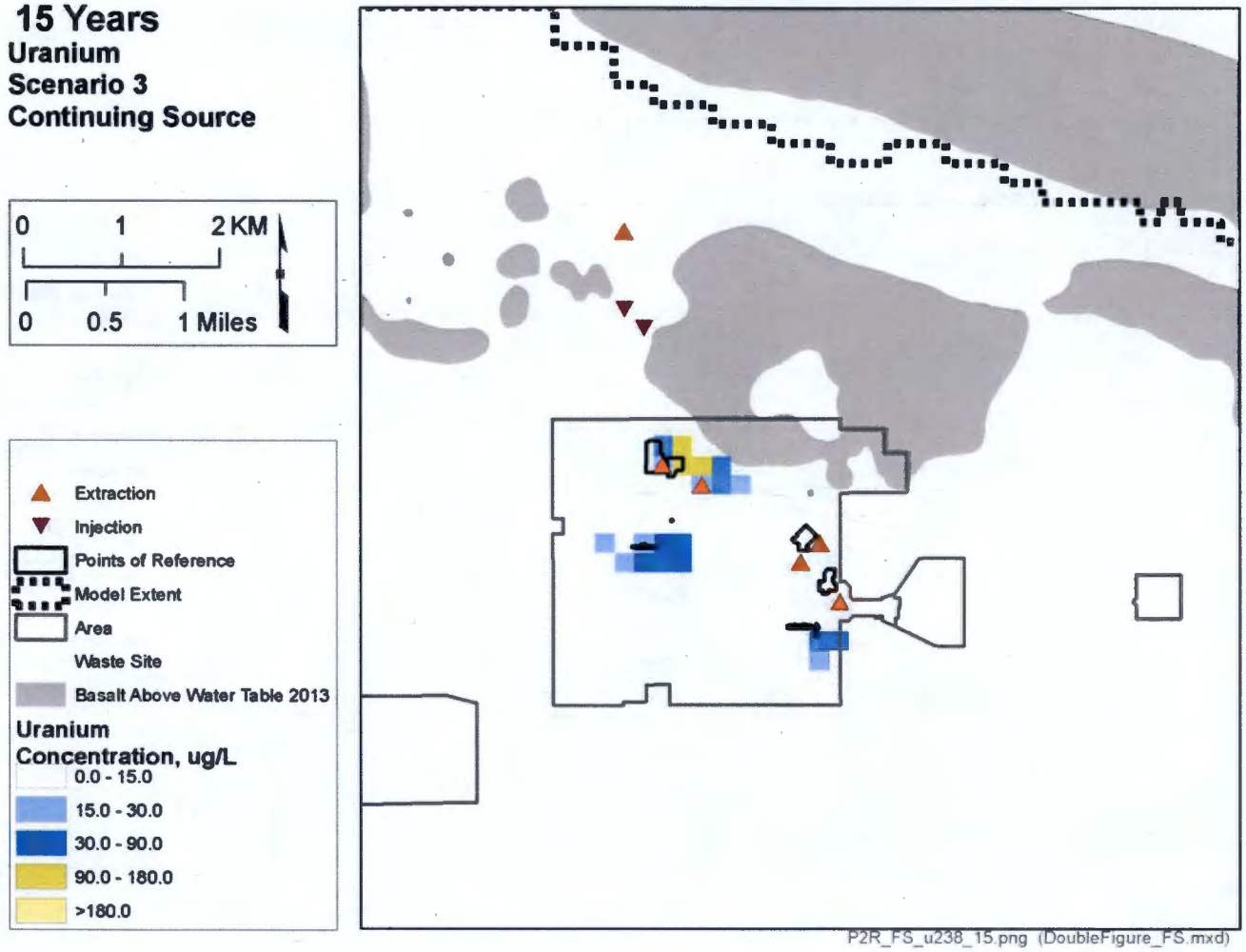

Figure B-160 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 3 simulation with a continuing source term.

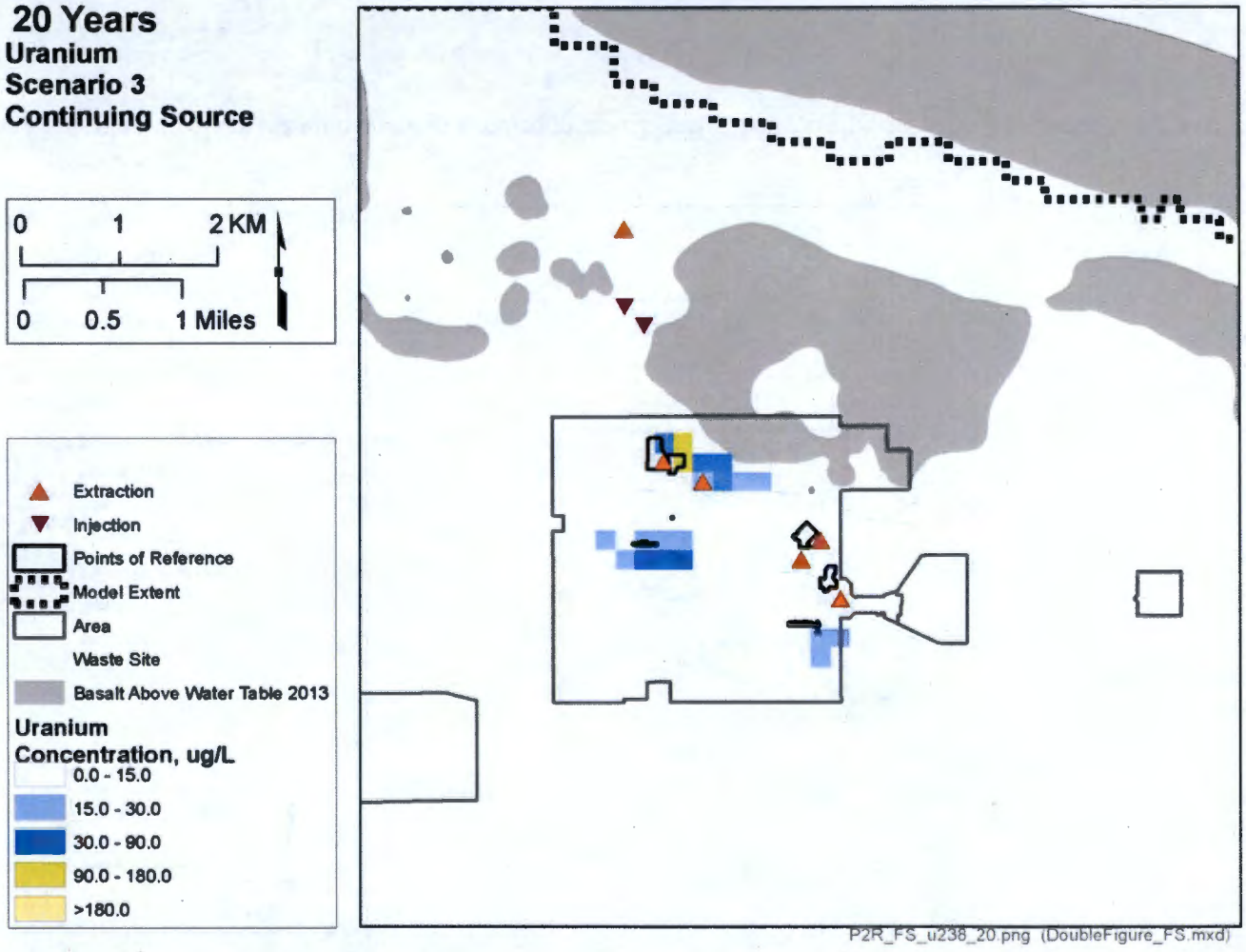

Figure B-161 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 3 simulation with a continuing source term.

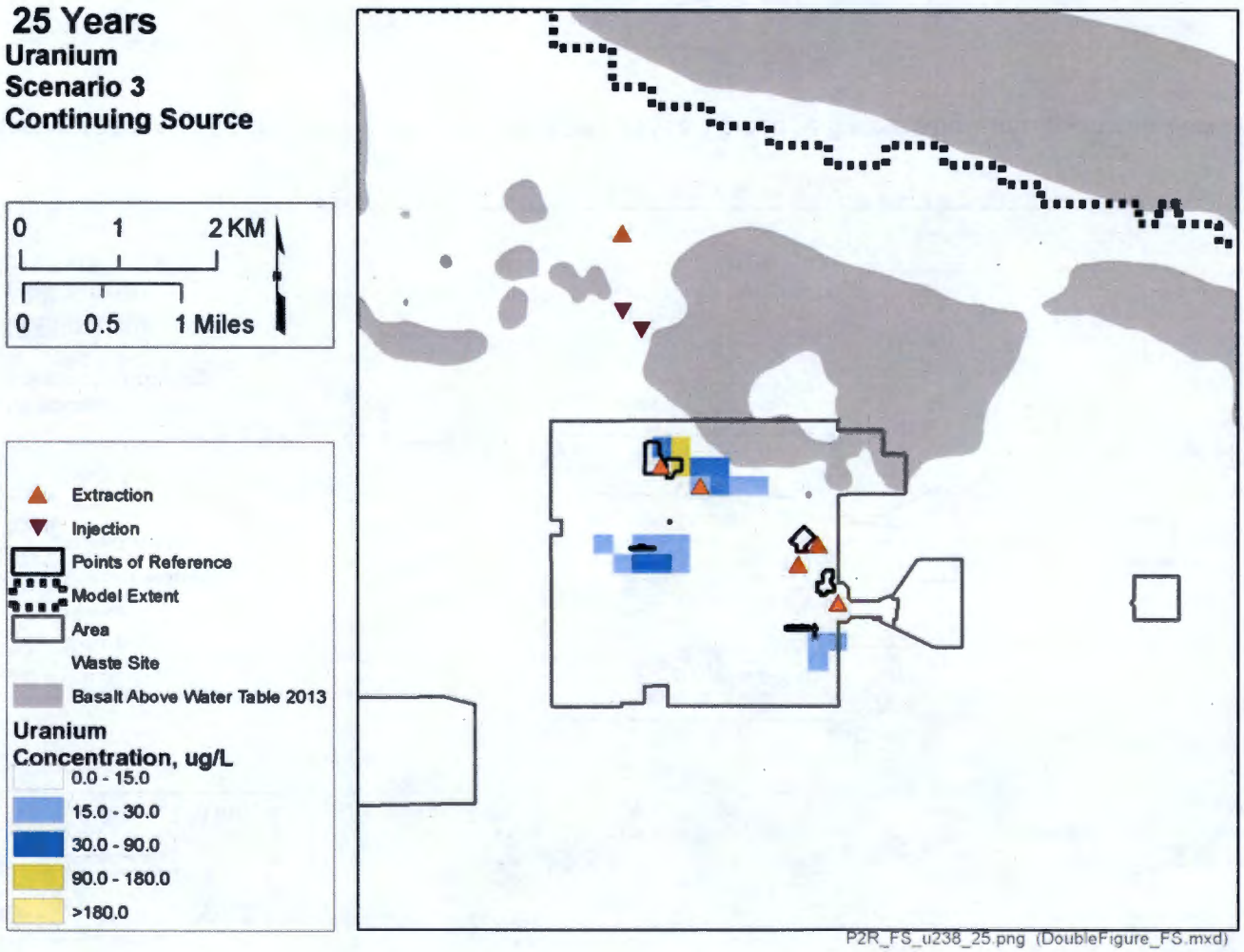

Figure B-162 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 3 simulation with a continuing source term.

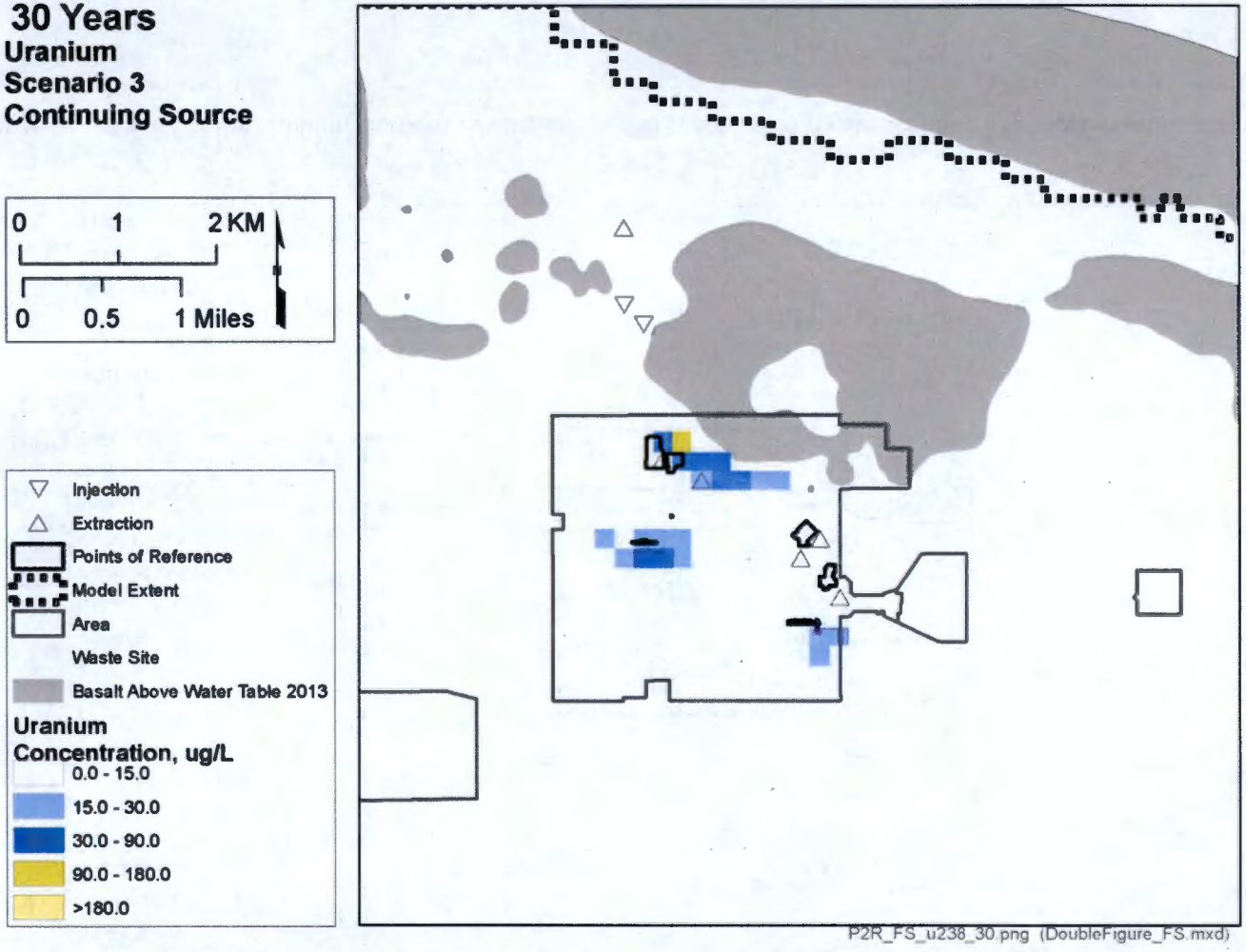

Figure B-163 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 3 simulation with a continuing source term.

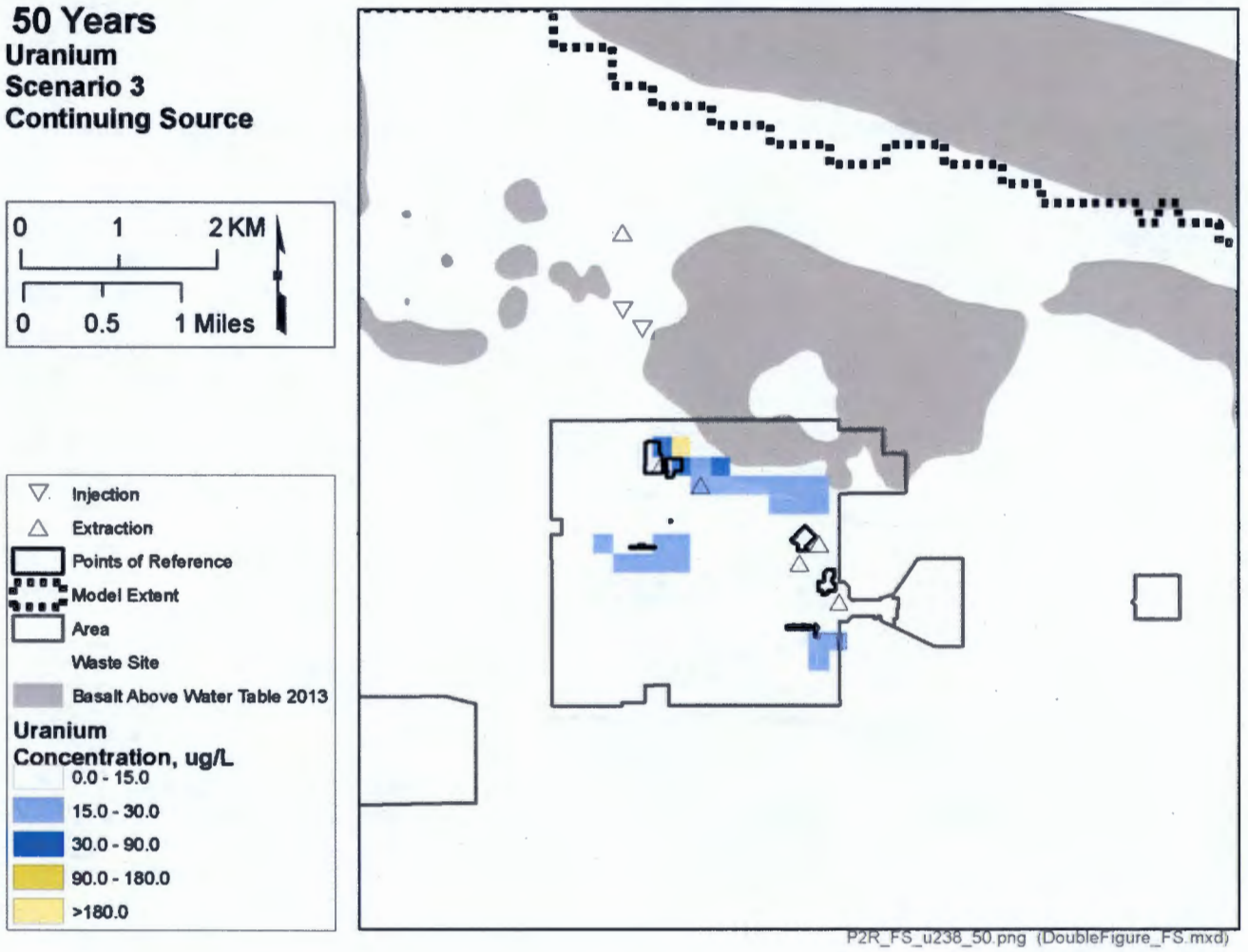

Figure B-164 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 3 simulation with a continuing source term.

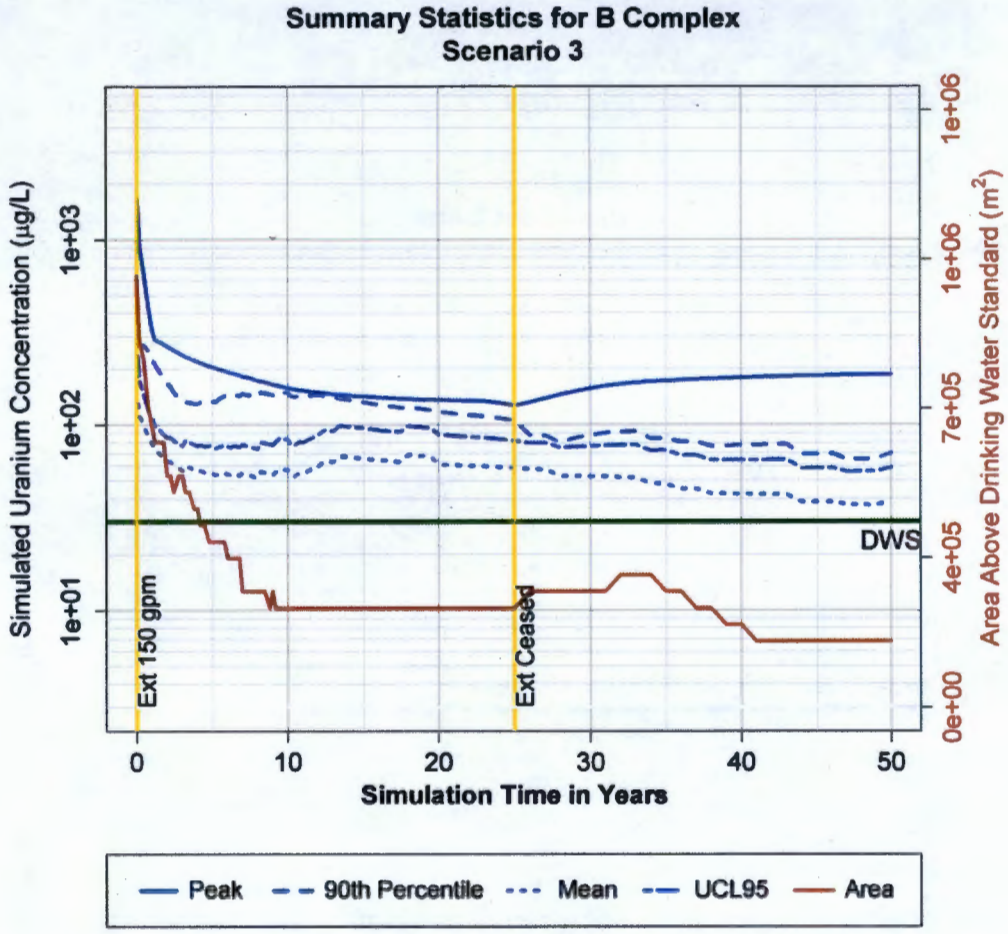

Figure B-165 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

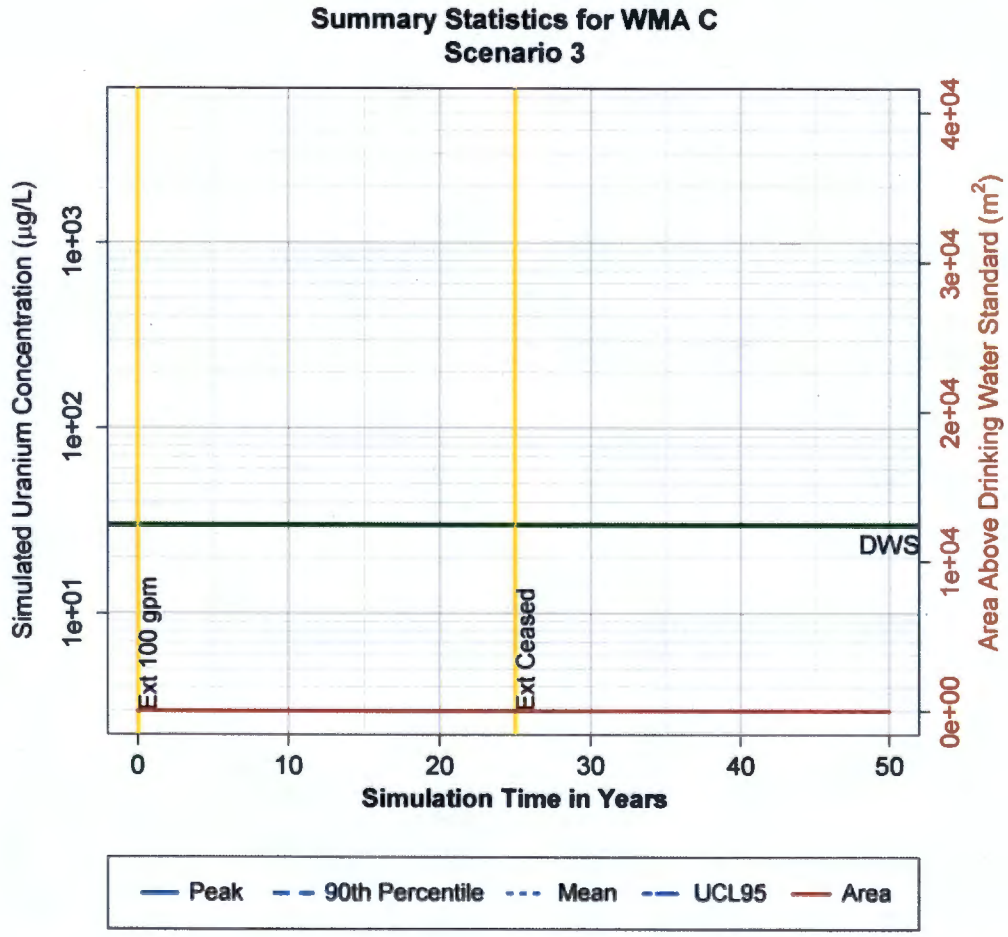

Figure B-166 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

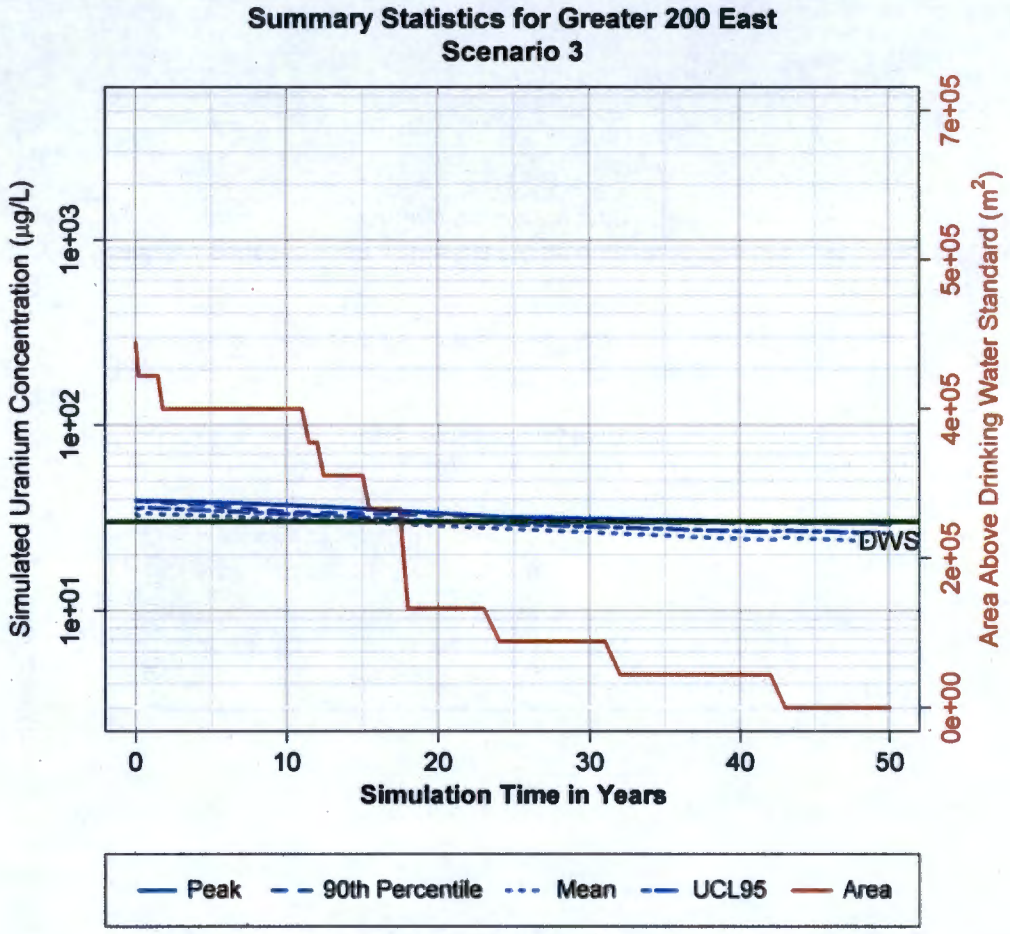

Figure B-167 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

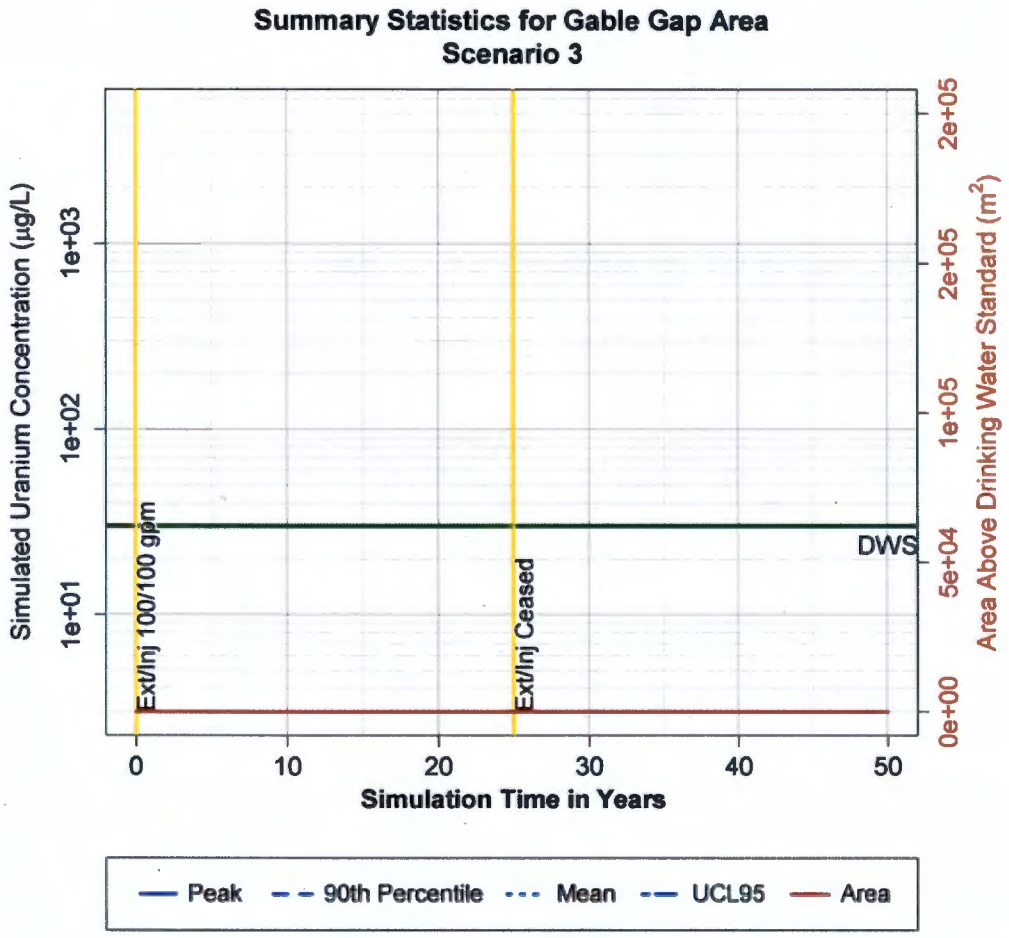

Figure B-168 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

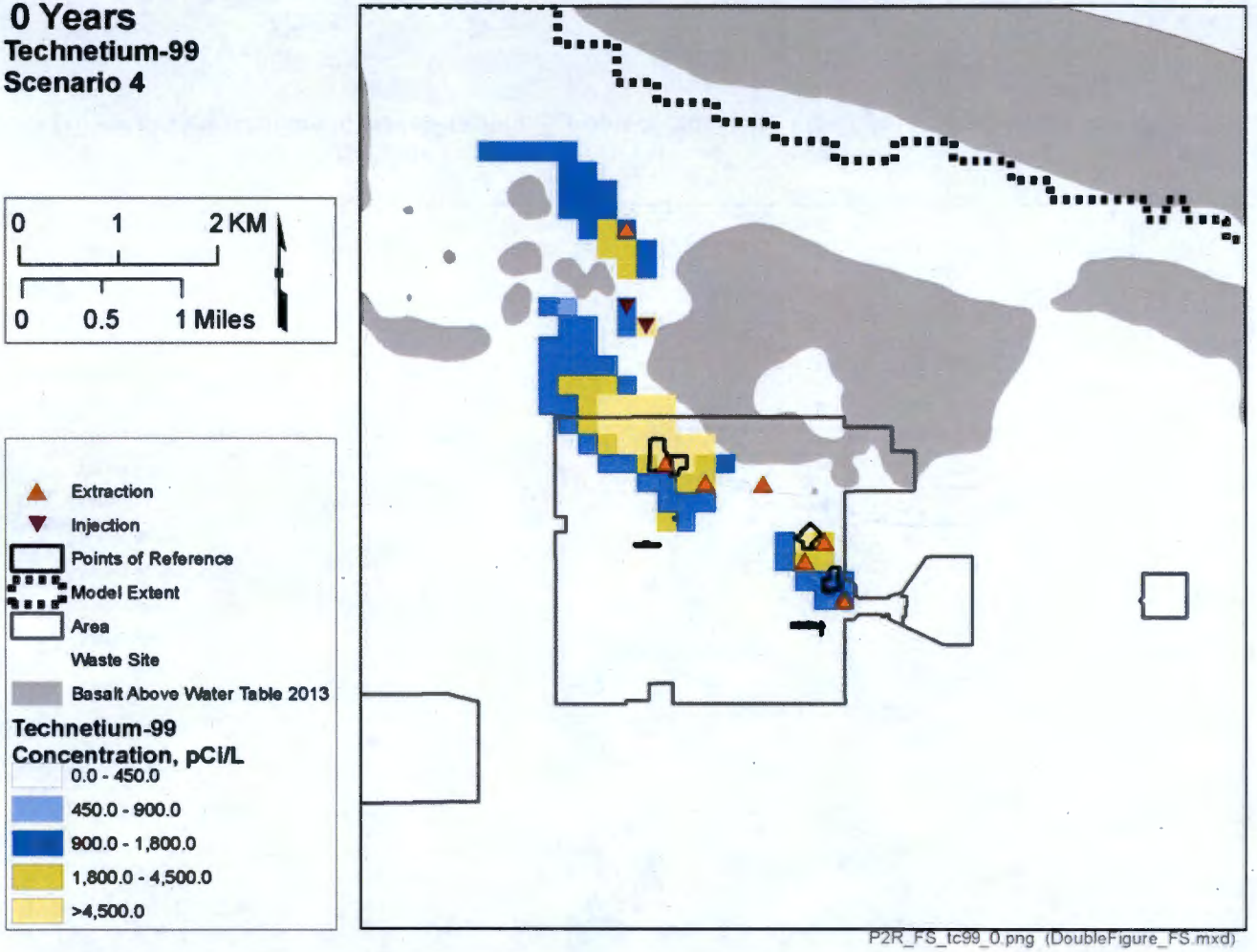

Figure B-169 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 4 simulation.

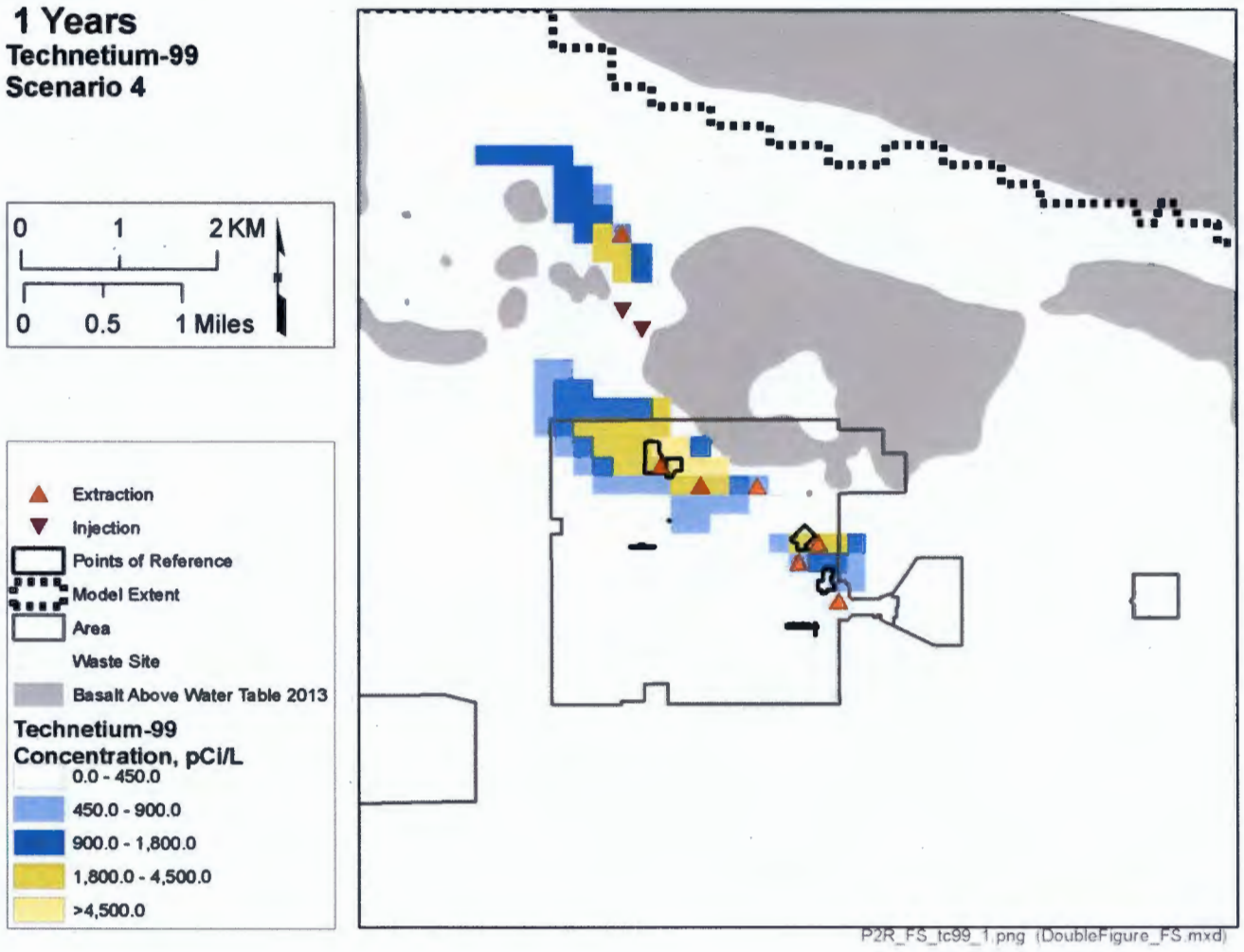

Figure B-170 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 4 simulation.

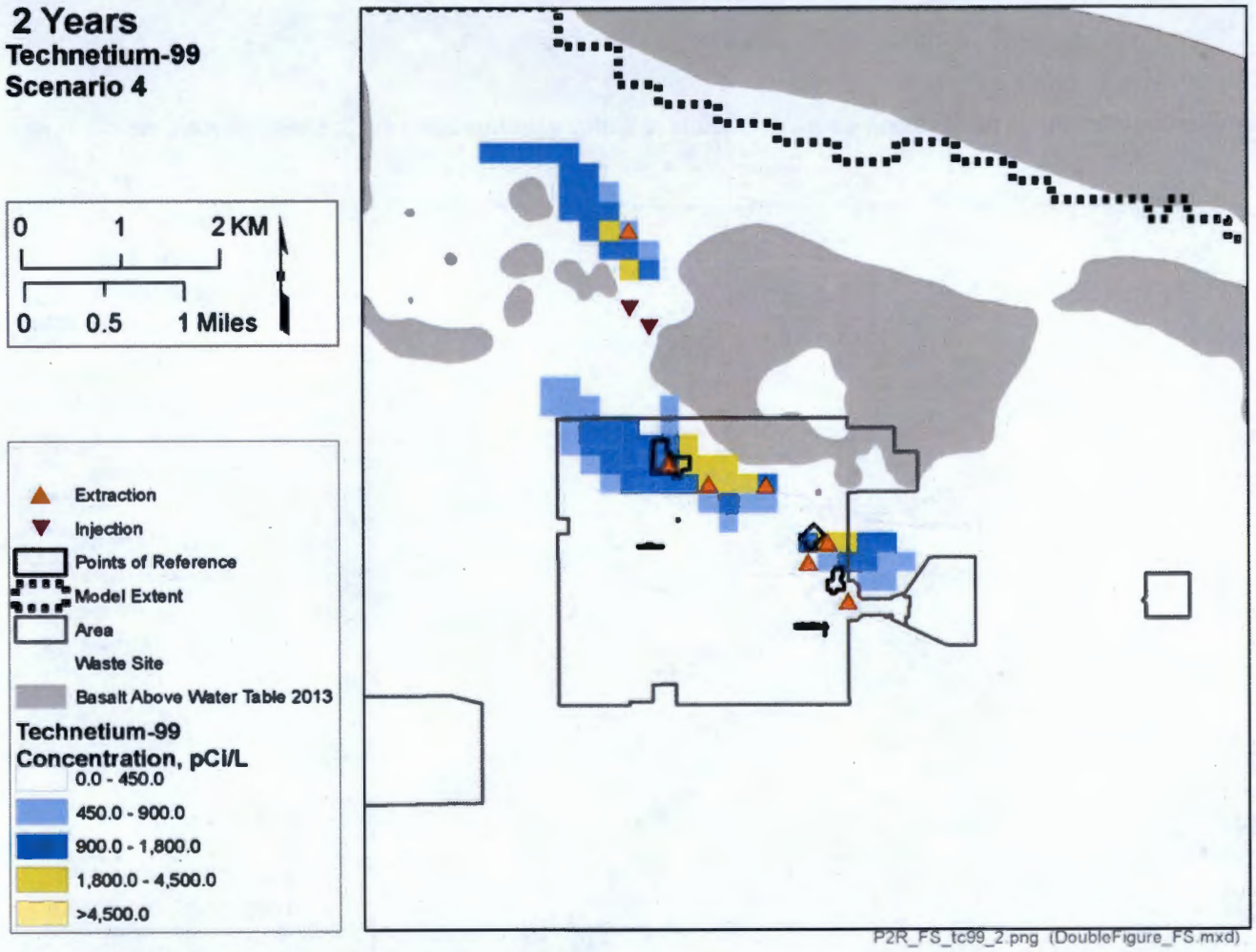

Figure B-171 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 4 simulation.

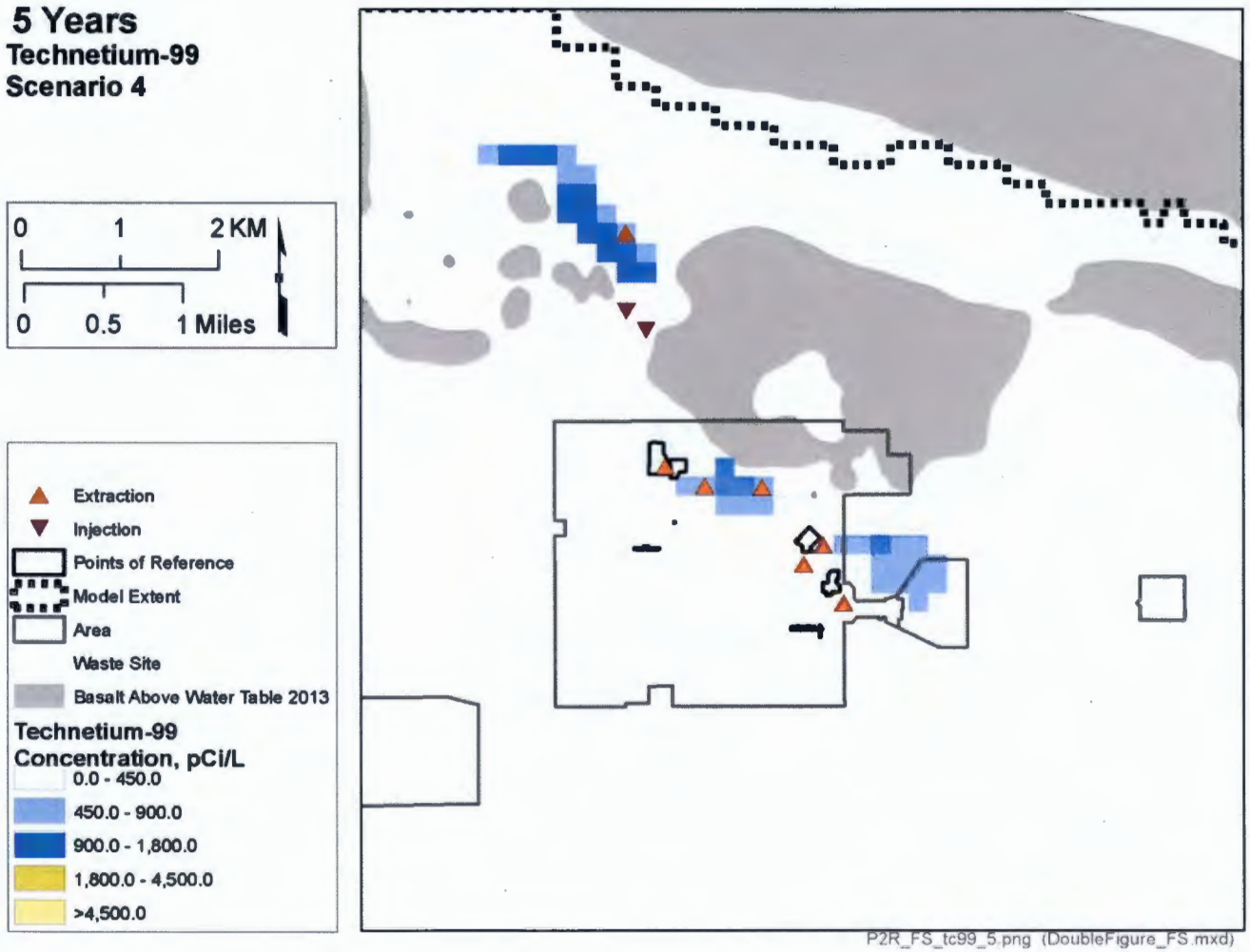

Figure B-172 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 4 simulation.

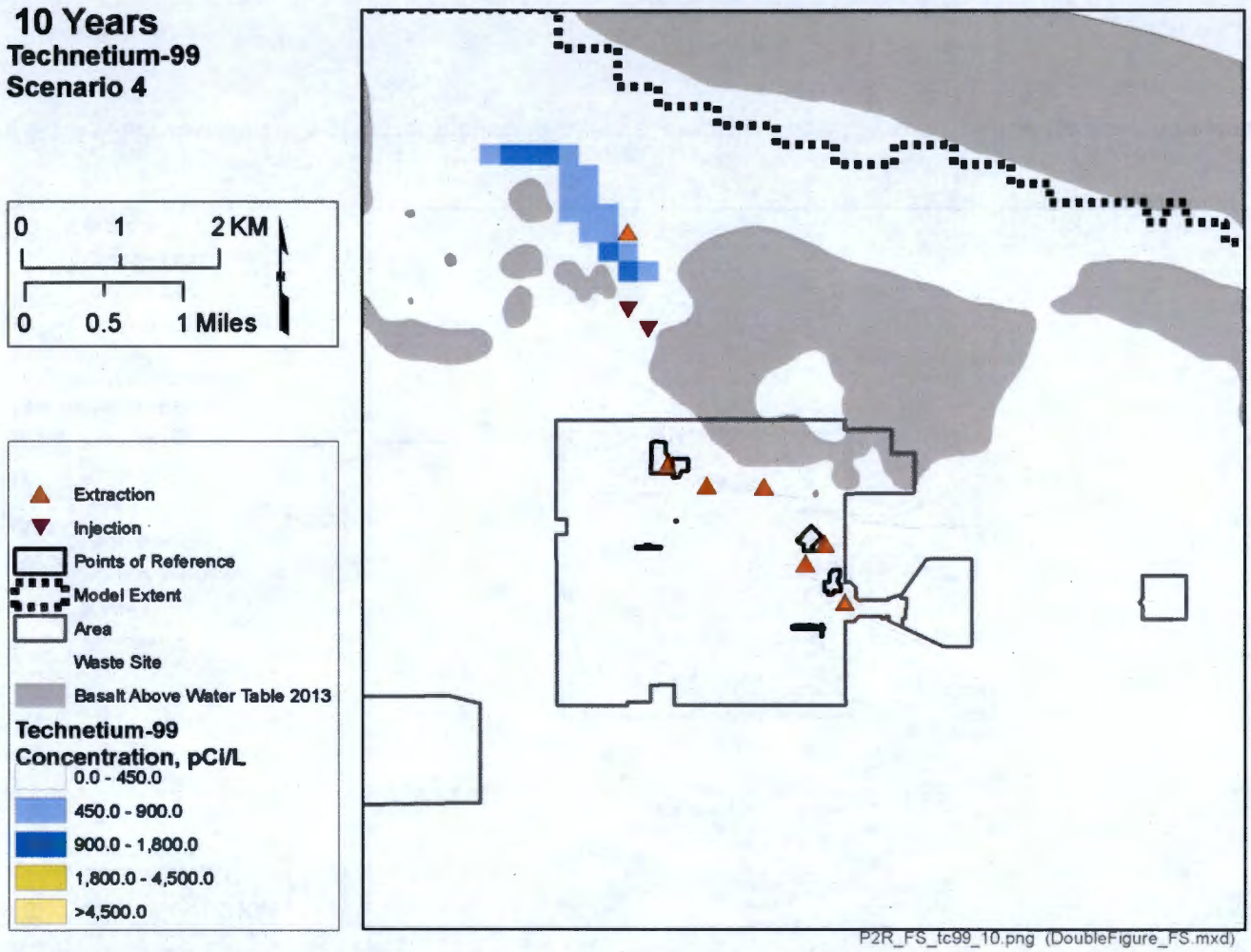

Figure B-173 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 4 simulation.

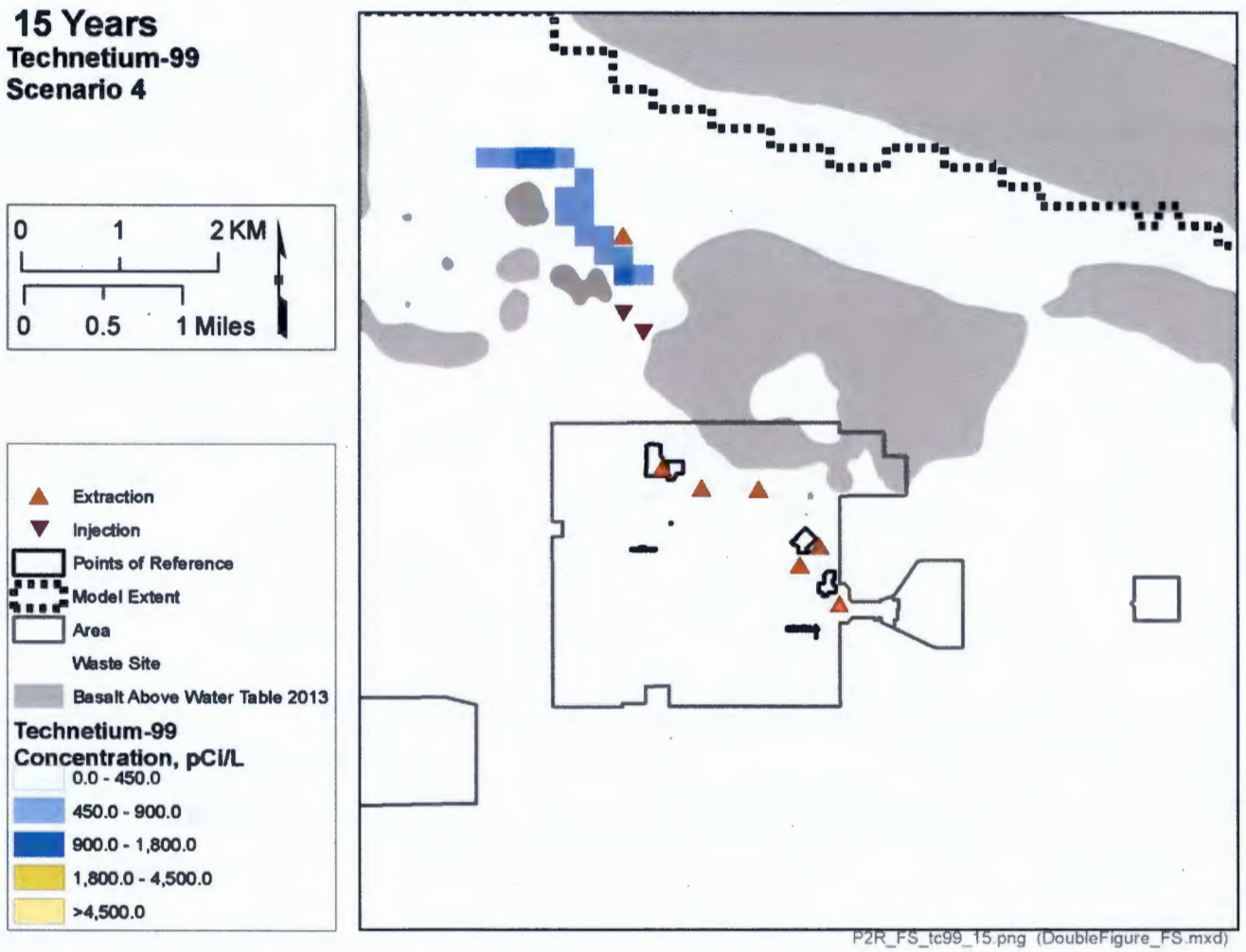

Figure B-174 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 4 simulation.

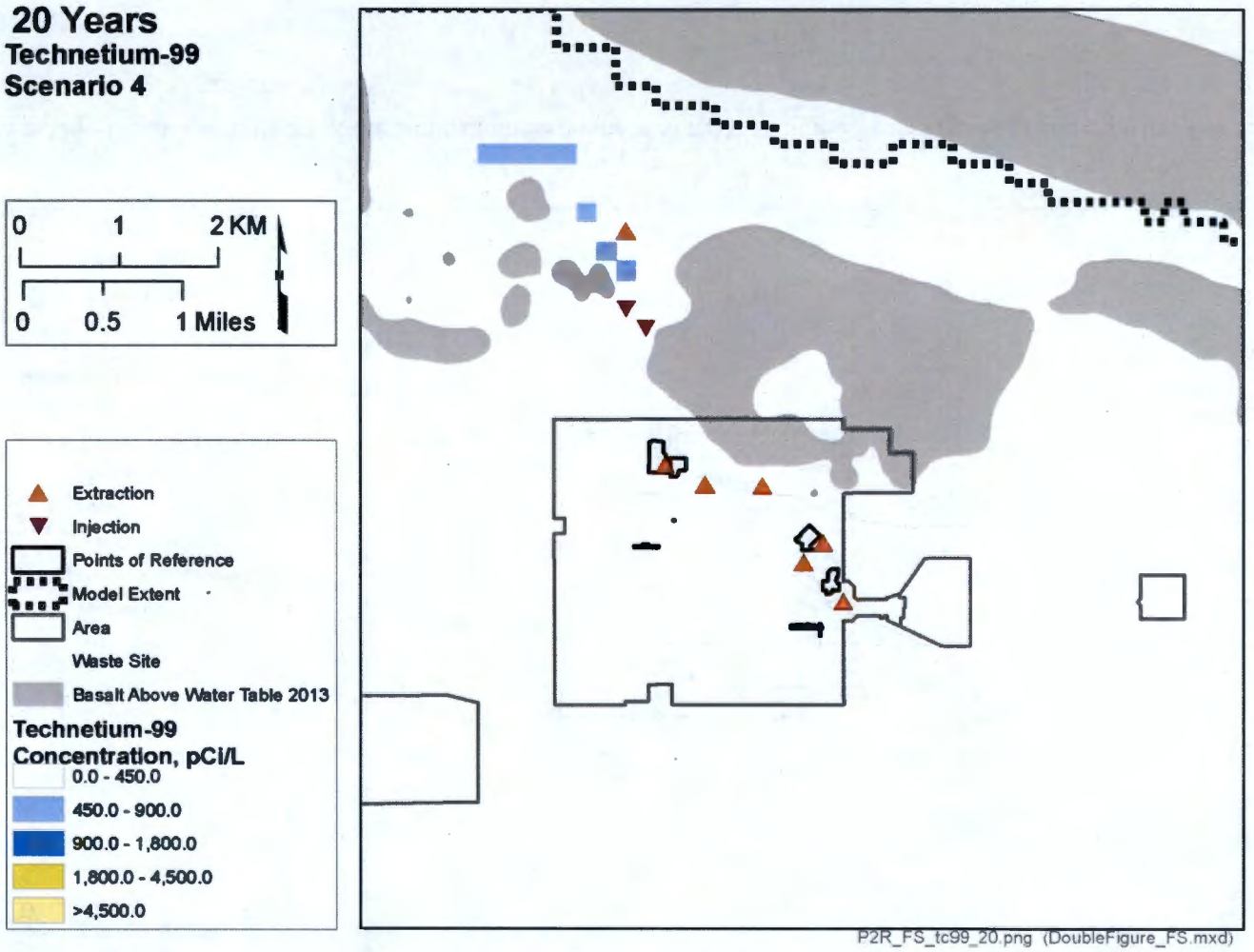

Figure B-175 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 4 simulation.

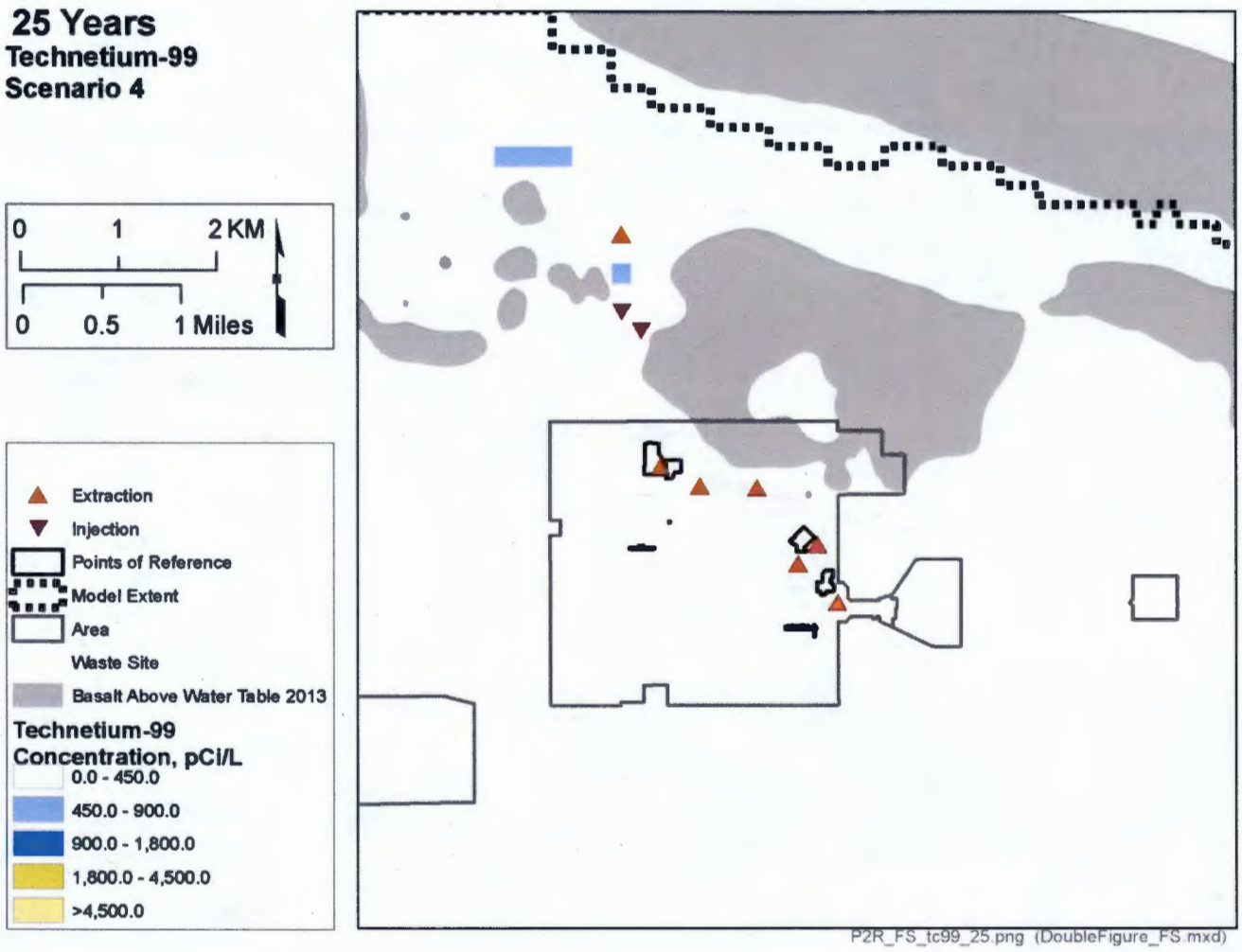

Figure B-176 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 4 simulation.

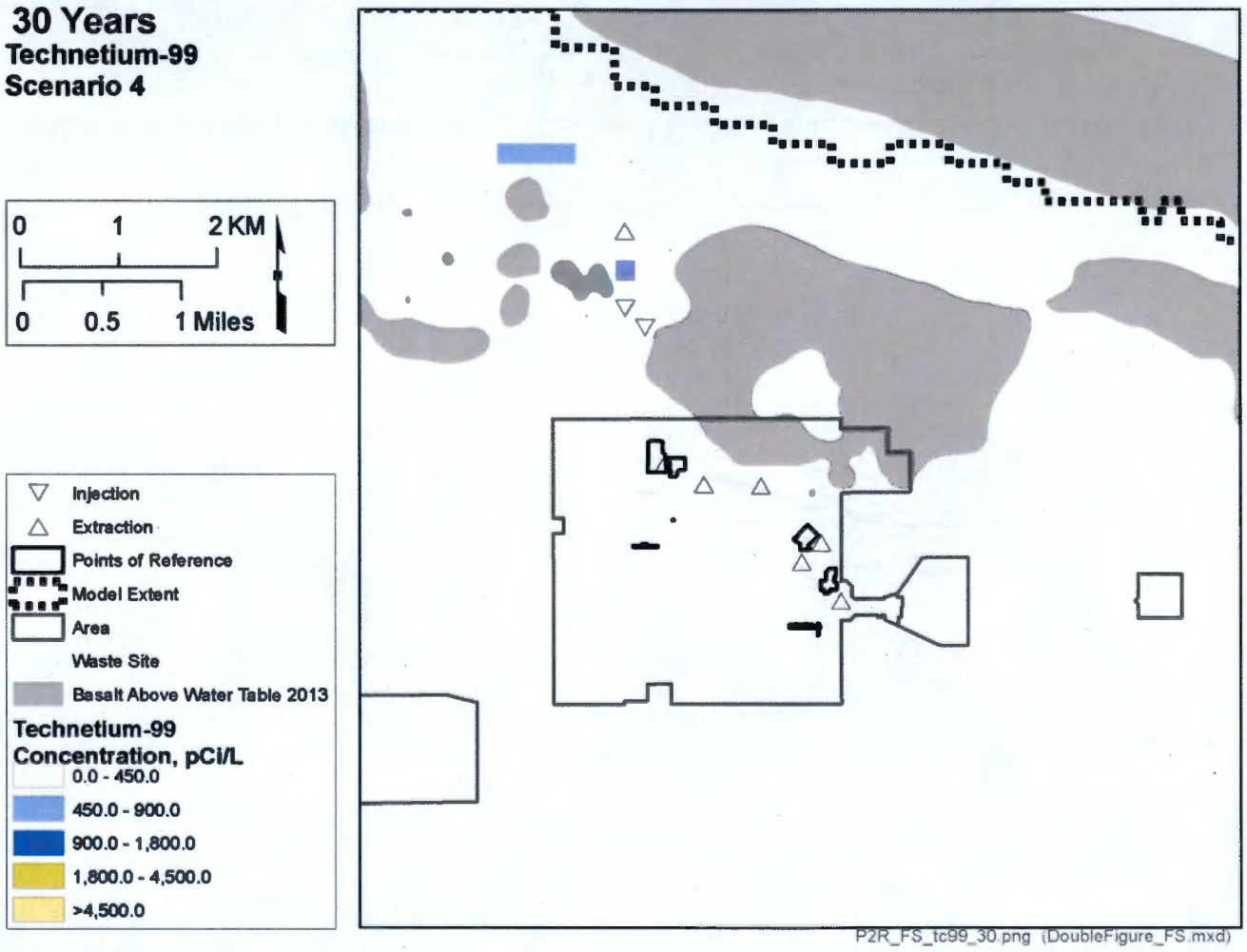

Figure B-177 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 4 simulation.

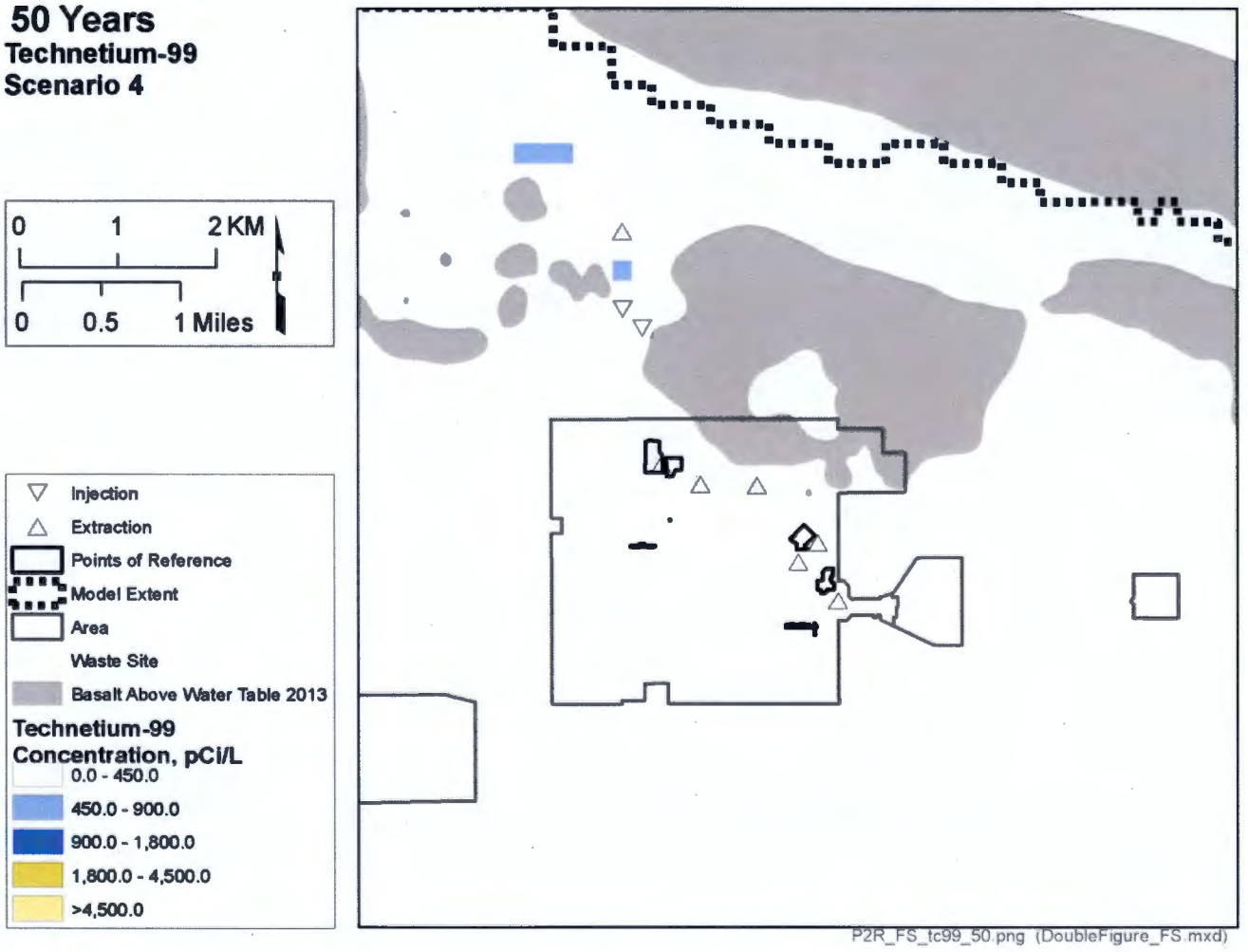

Figure B-178 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 4 simulation.

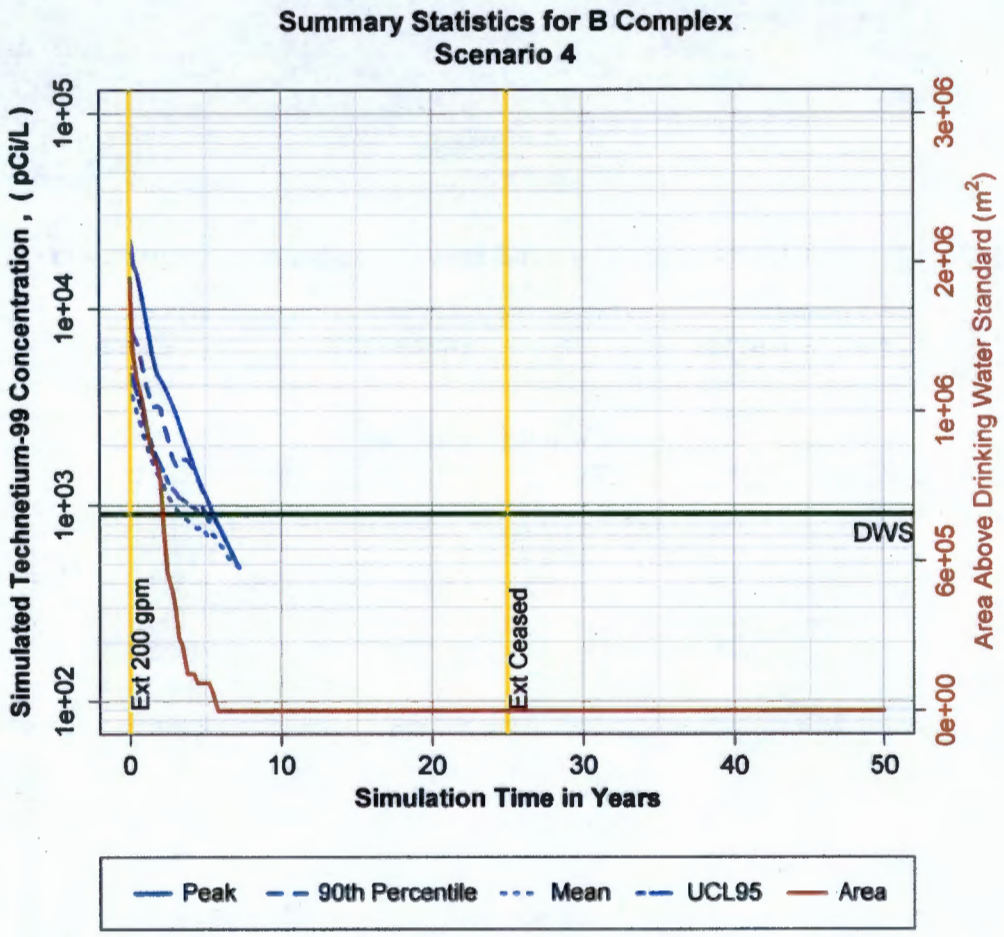

Figure B-179 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

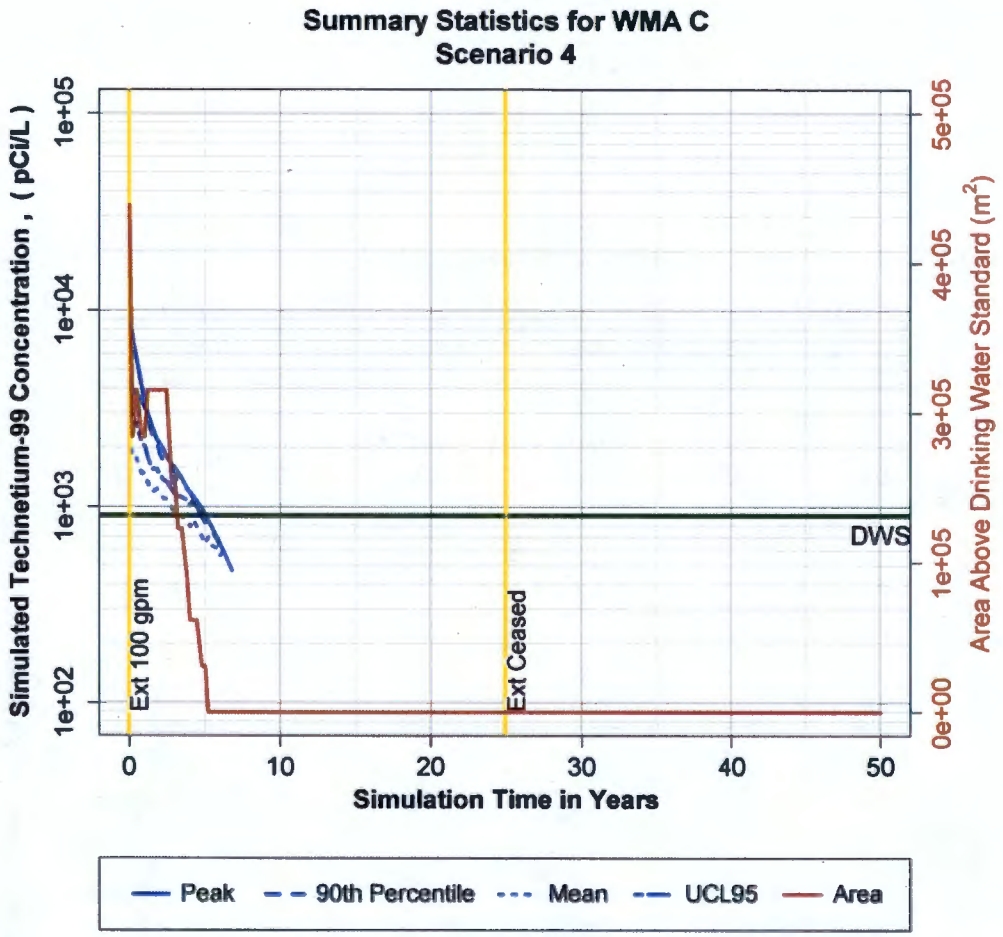

Figure B-180 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

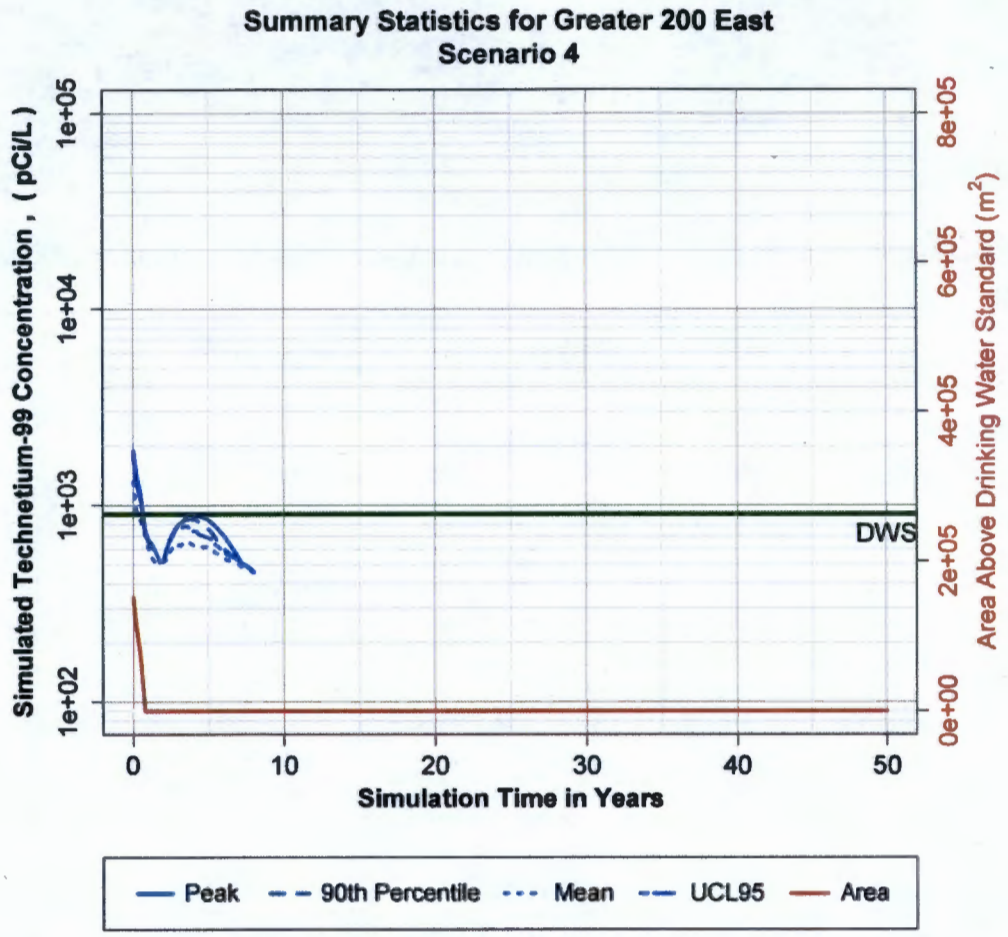

Figure B-181 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

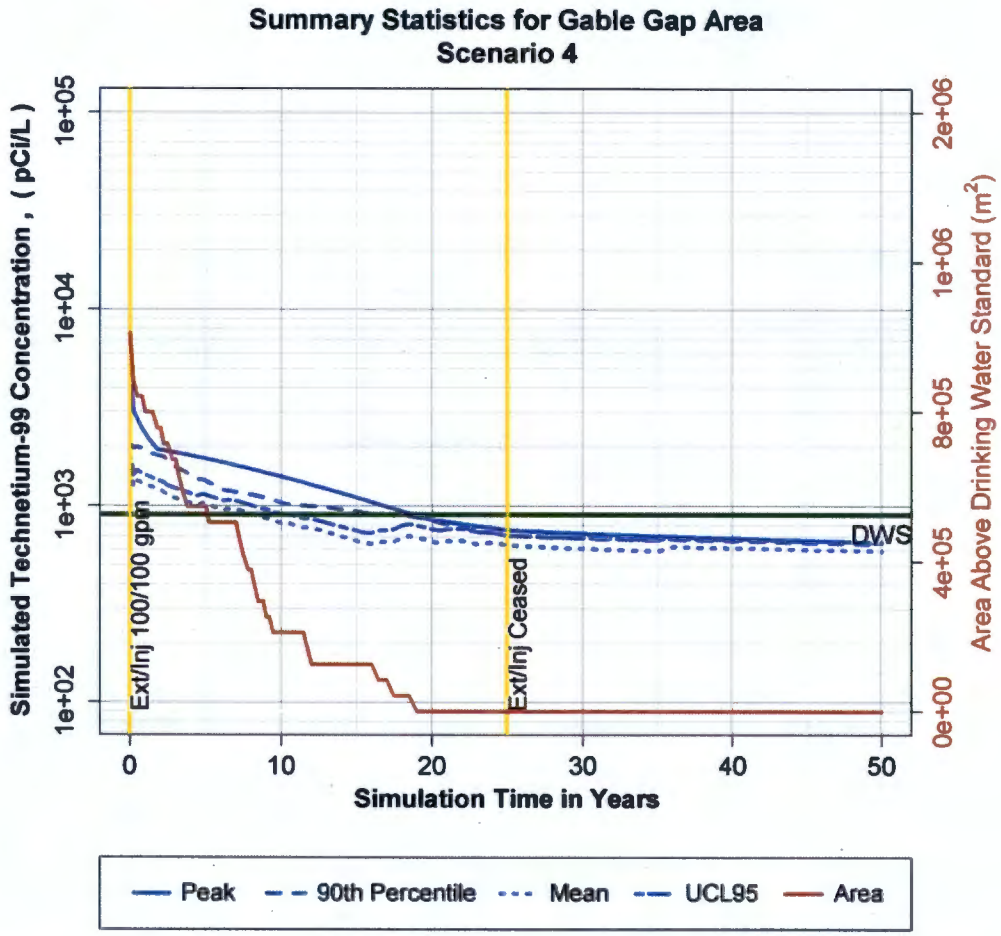

Figure B-182 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

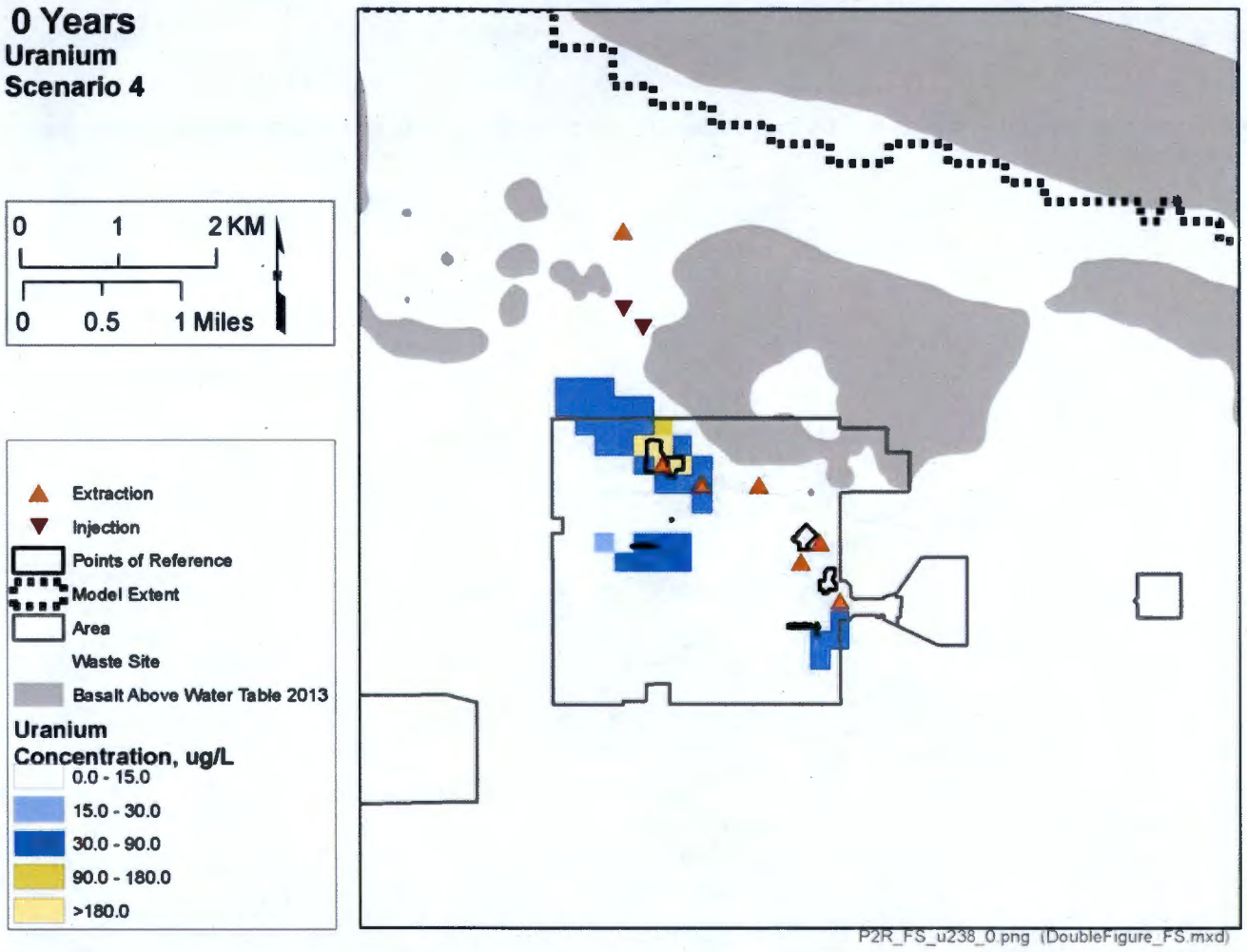

Figure B-183 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 4 simulation.

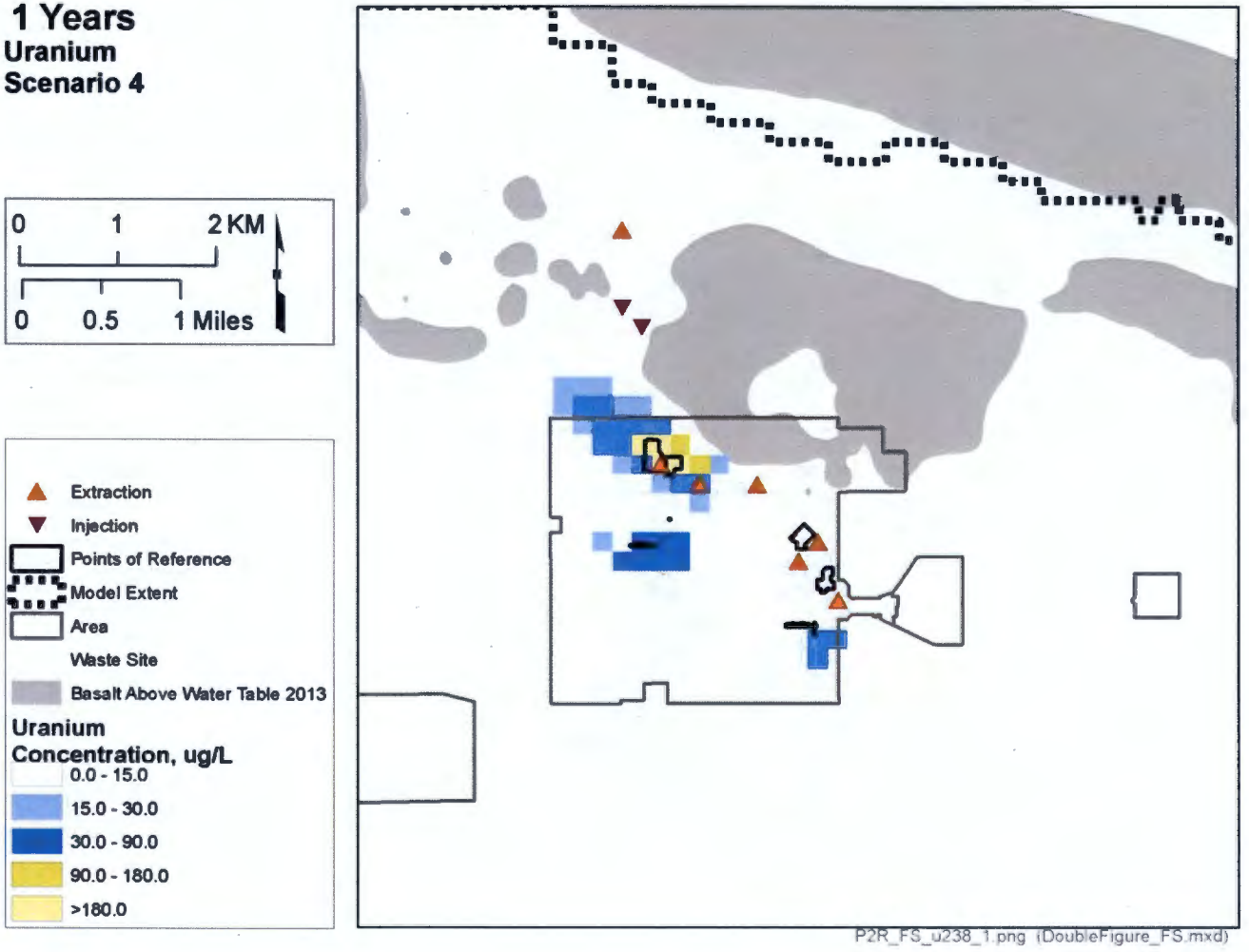

Figure B-184 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 4 simulation.

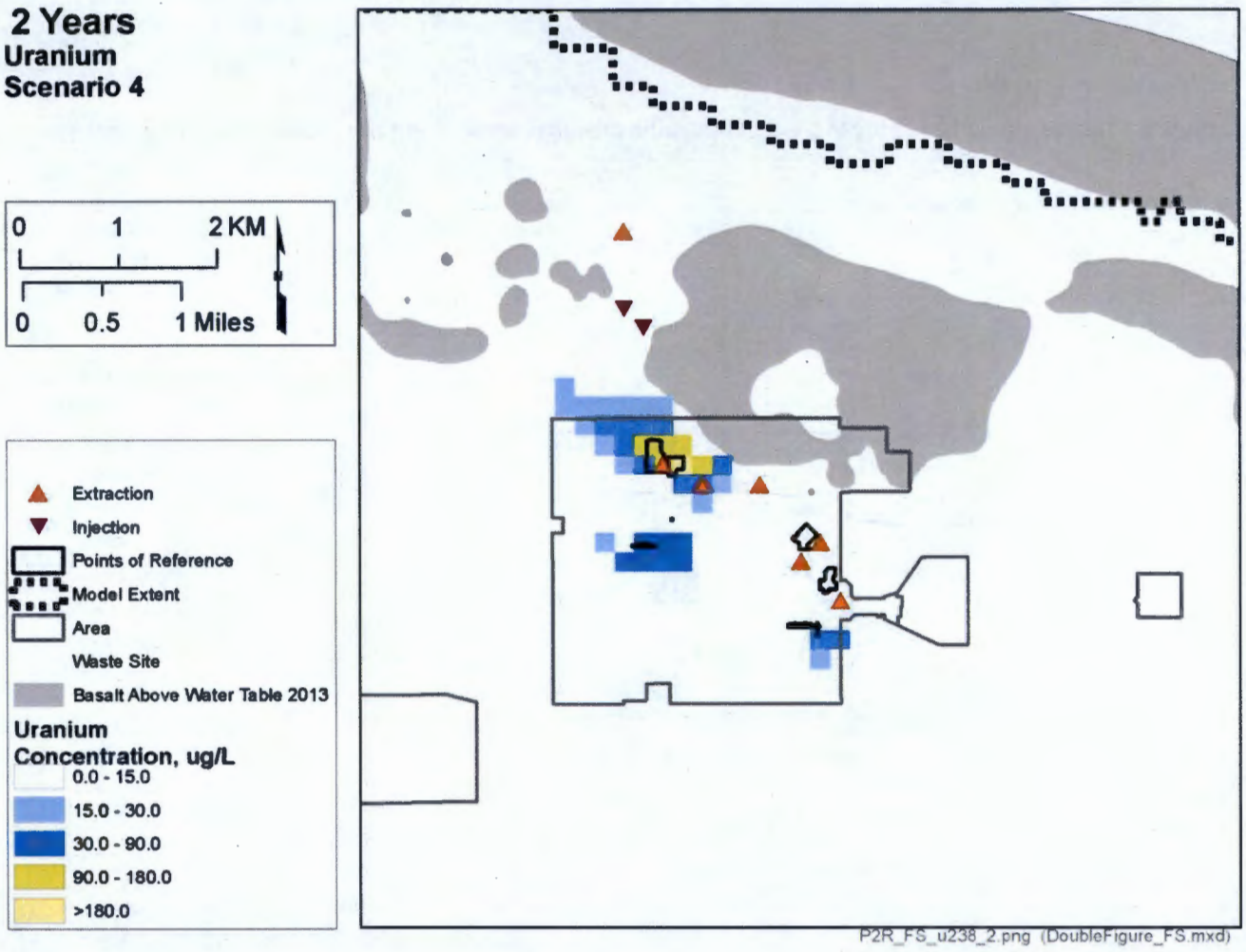

Figure B-185 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 4 simulation.

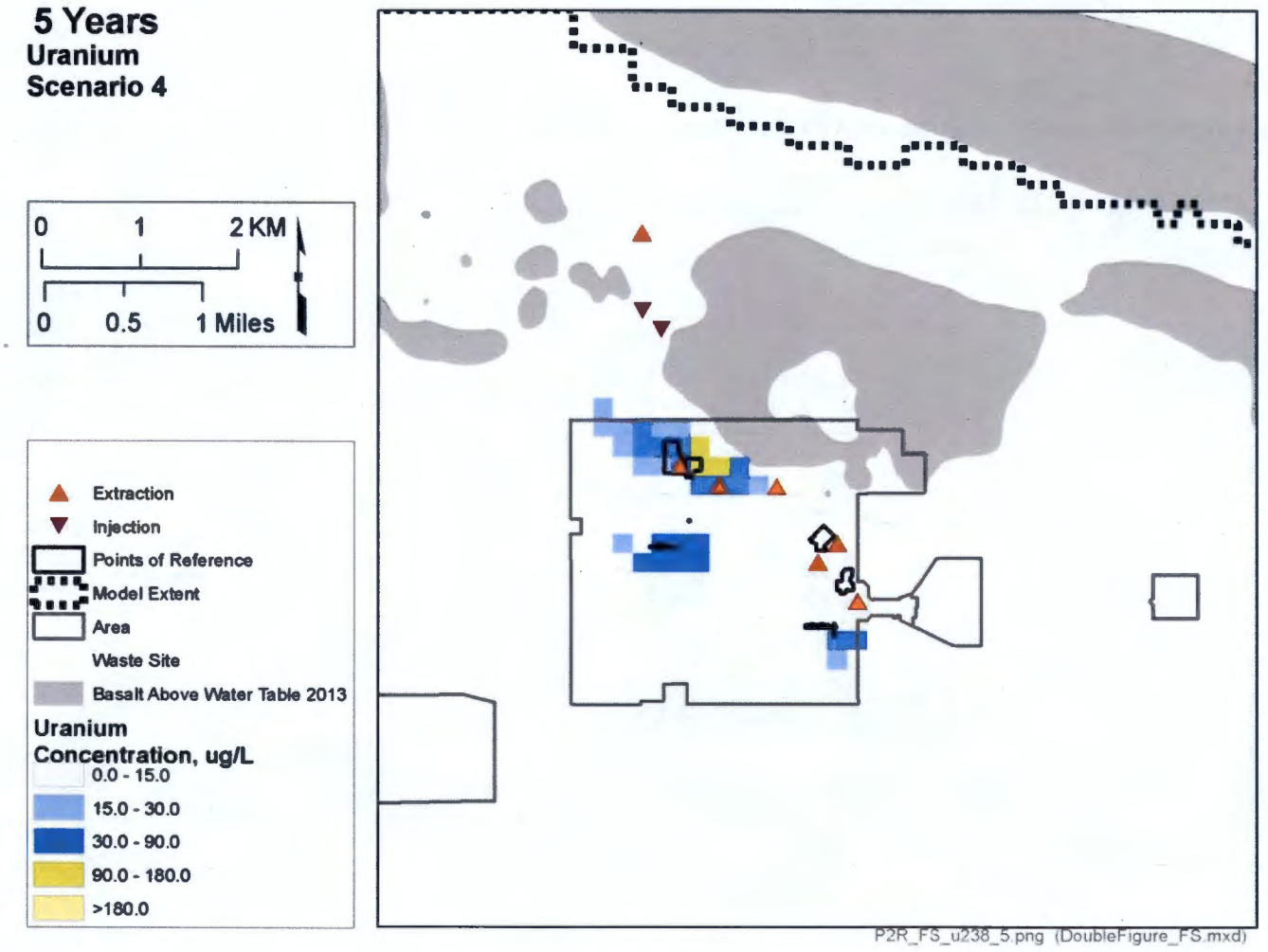

Figure B-186 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 4 simulation.

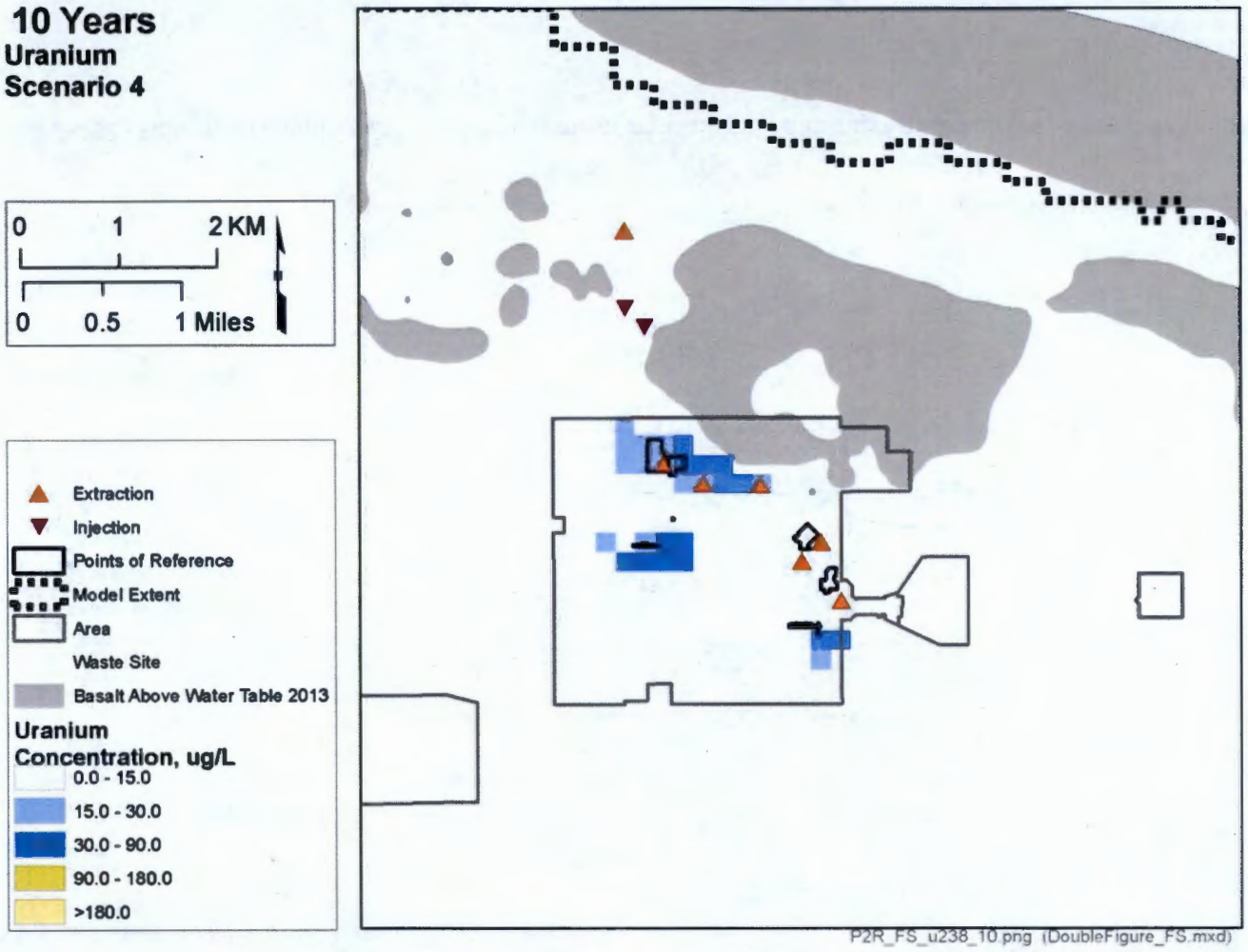

Figure B-187 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 4 simulation.

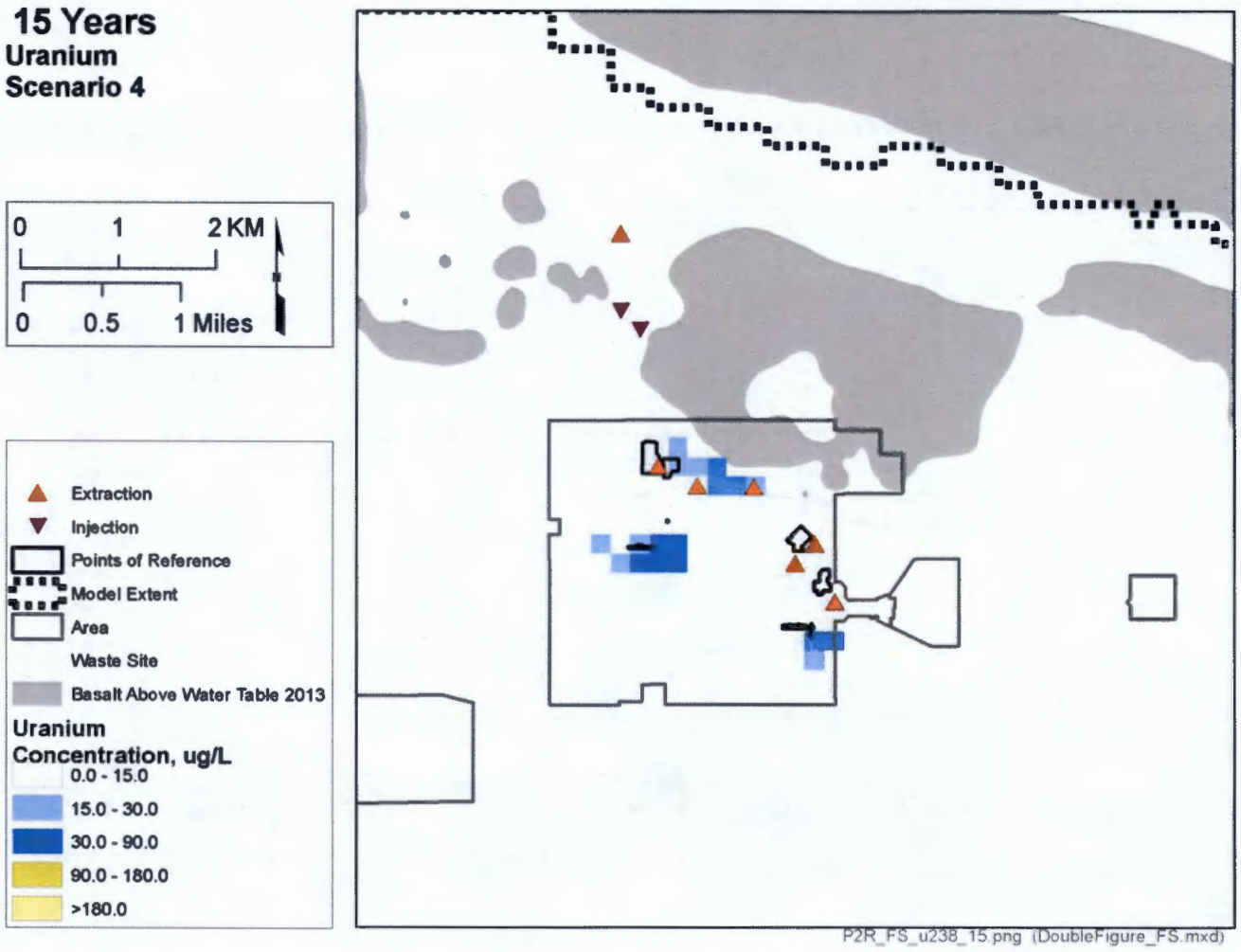

Figure B-188 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 4 simulation.

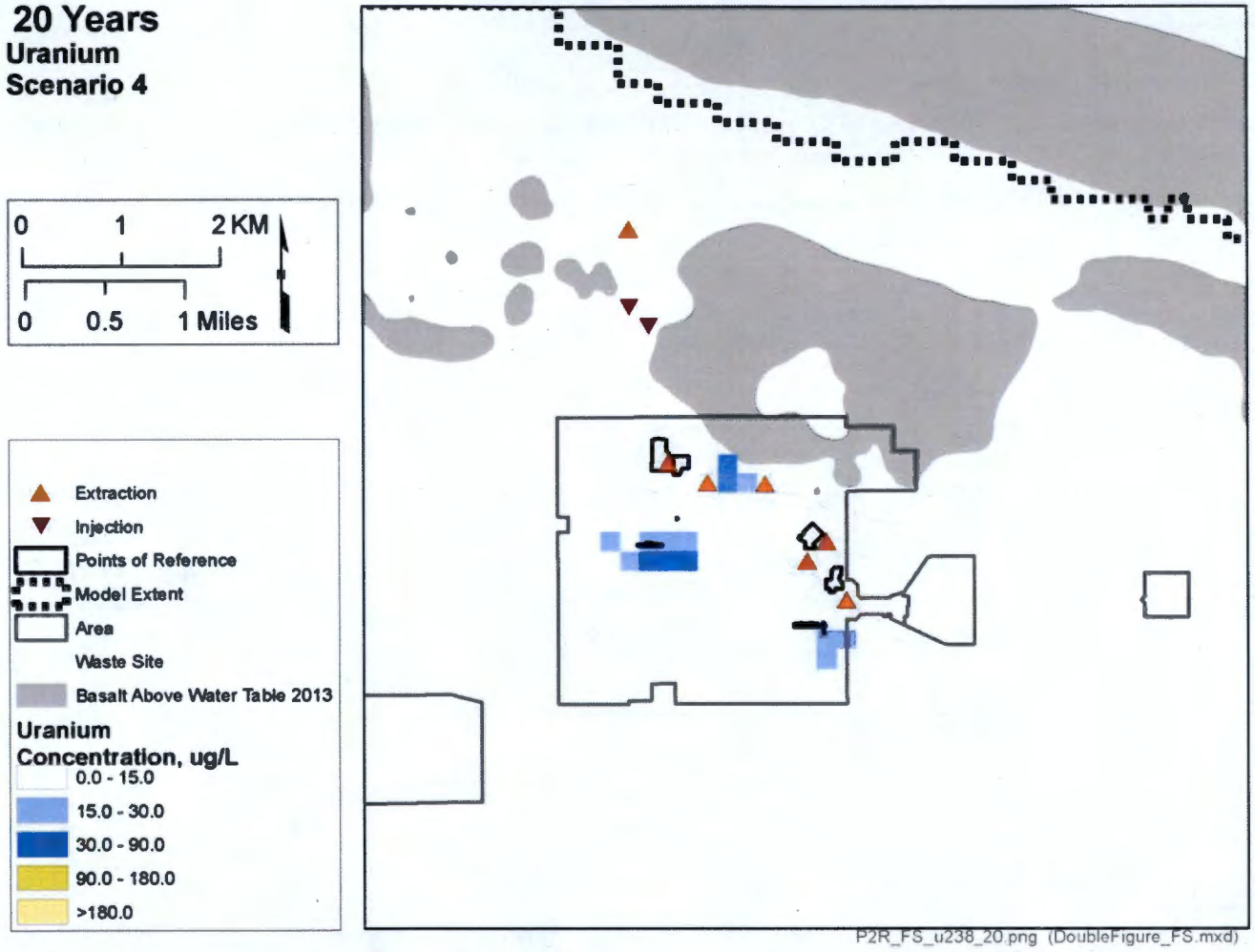

Figure B-189 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 4 simulation.

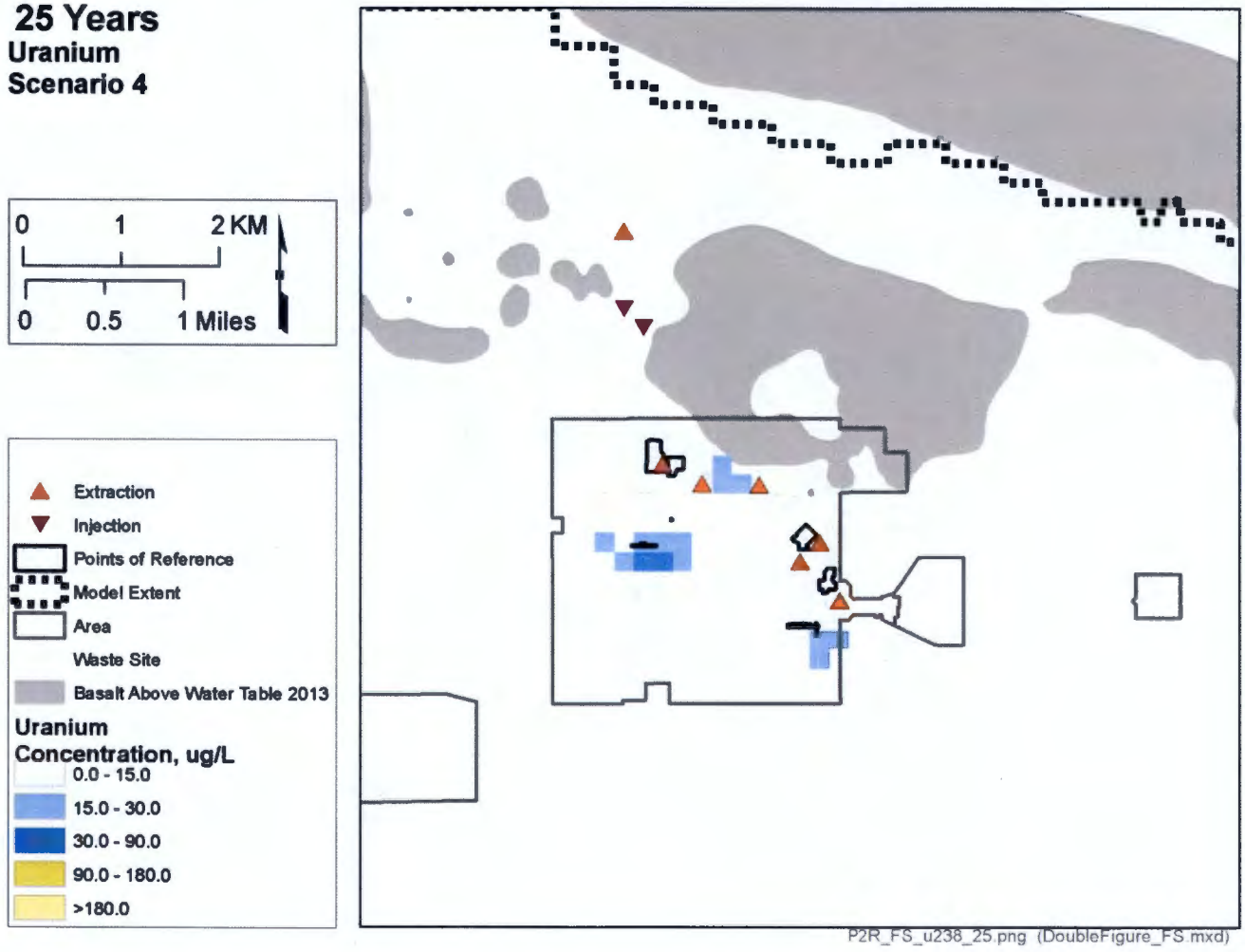

Figure B-190 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 4 simulation.

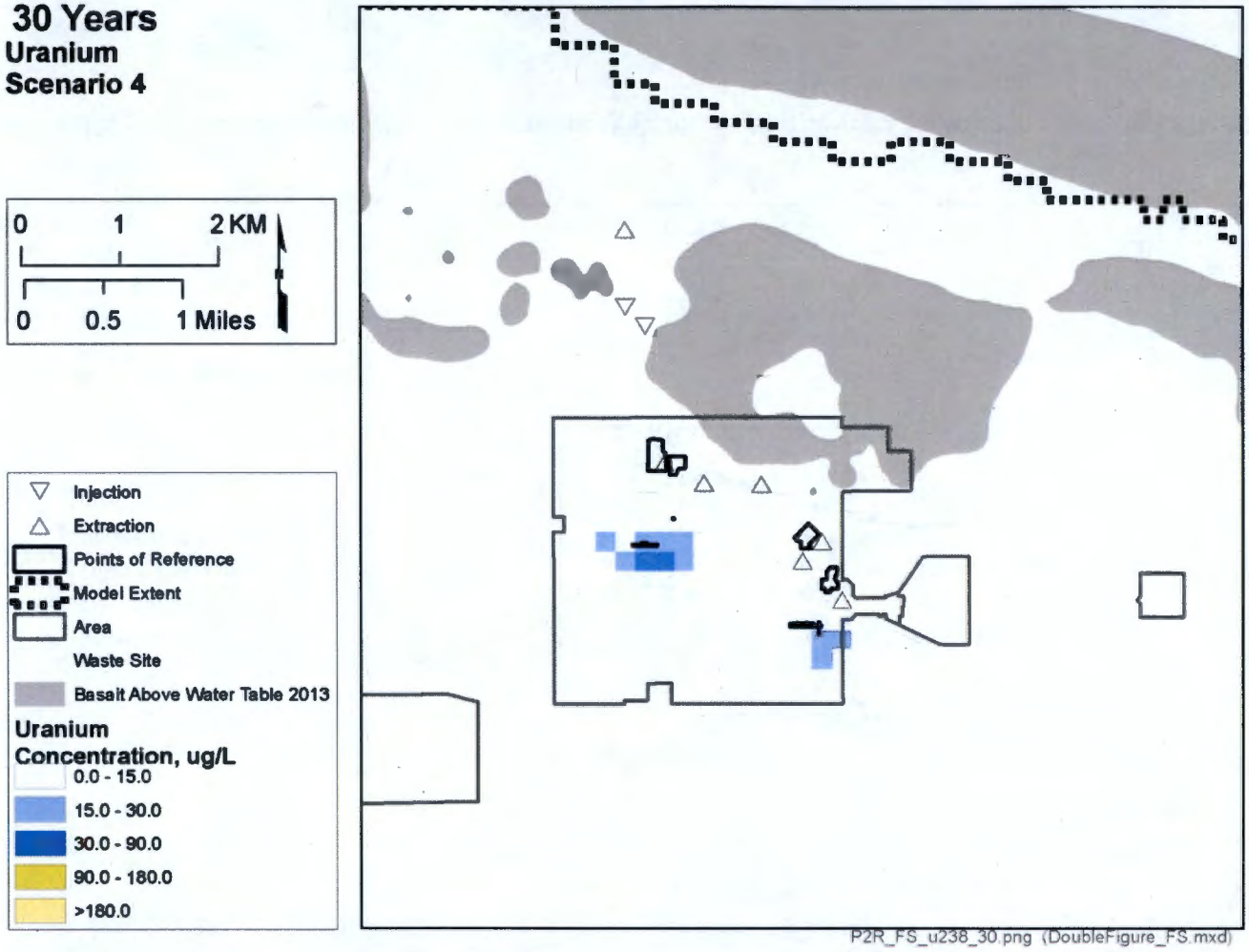

Figure B-191 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 4 simulation.

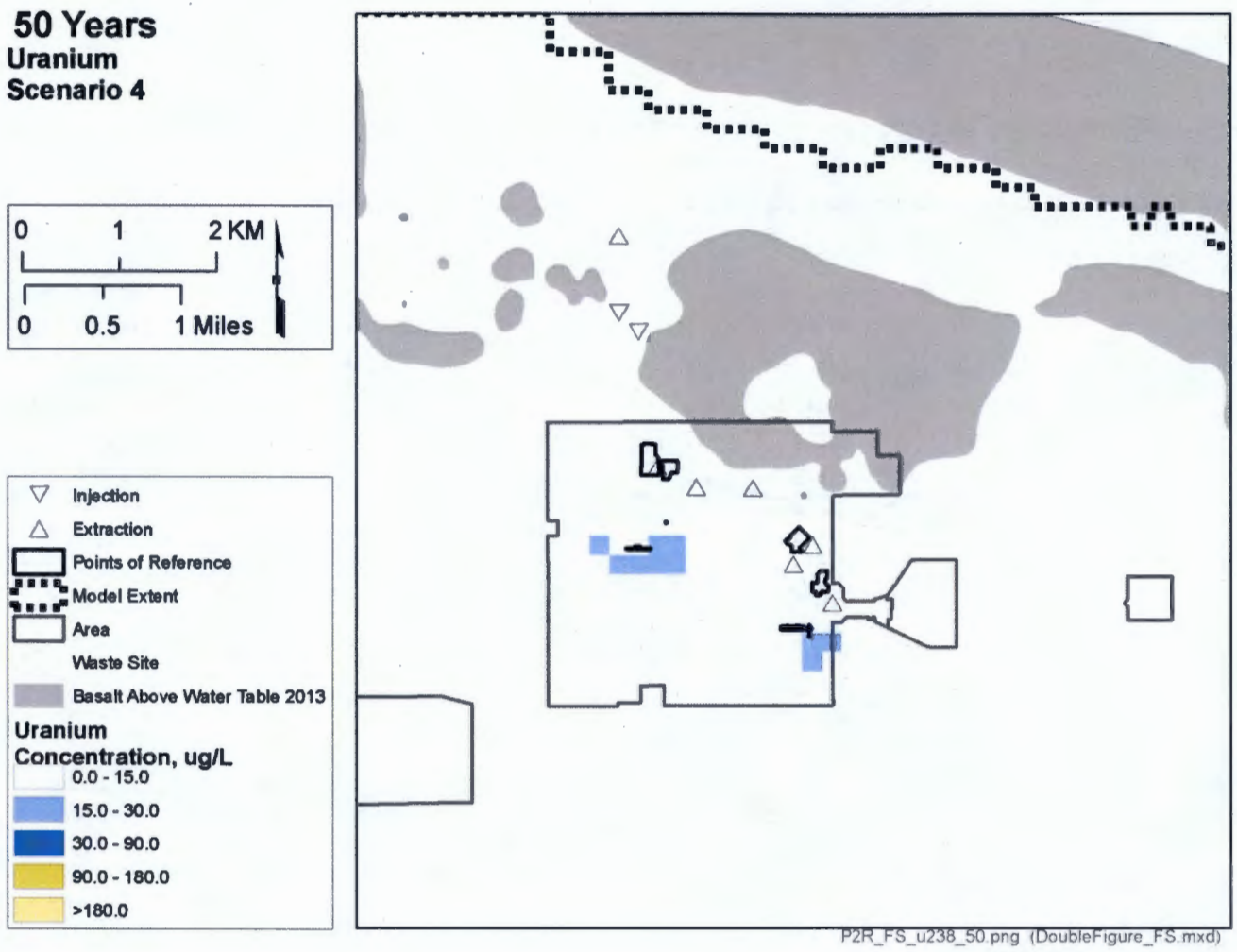

Figure B-192 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 4 simulation.

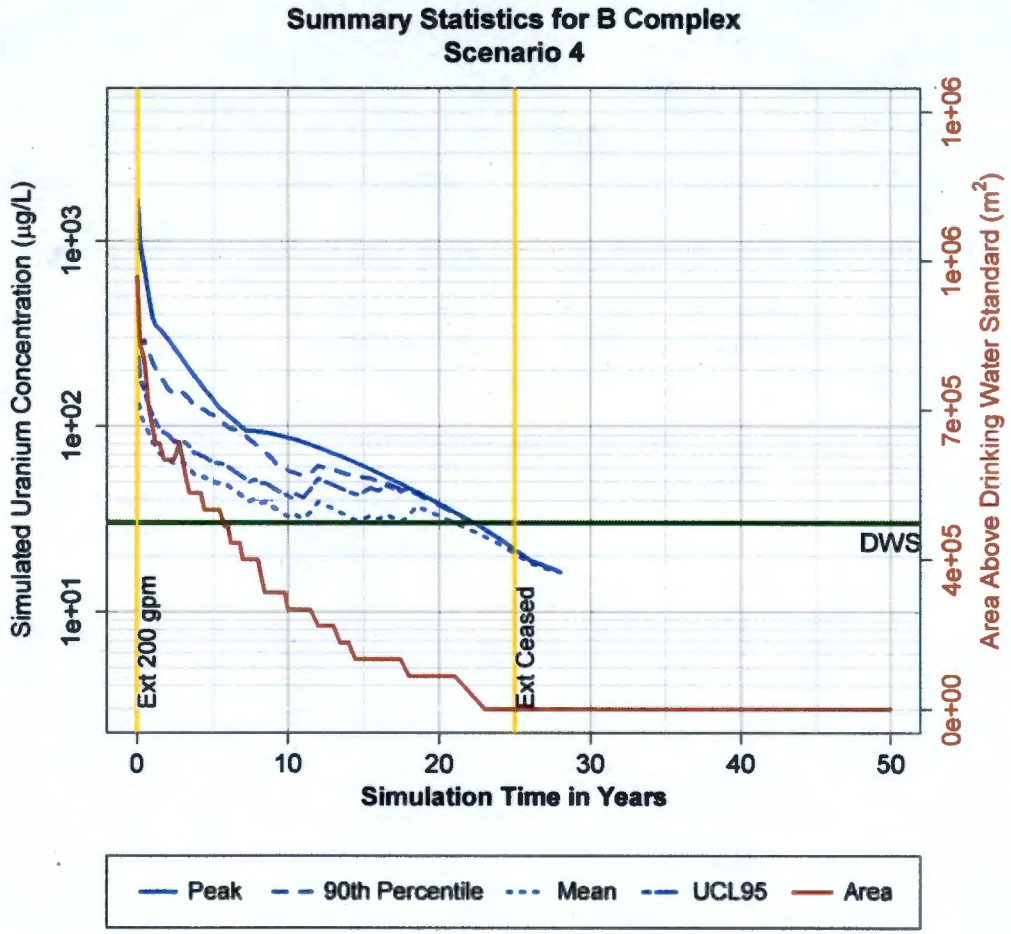

Figure B-193 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

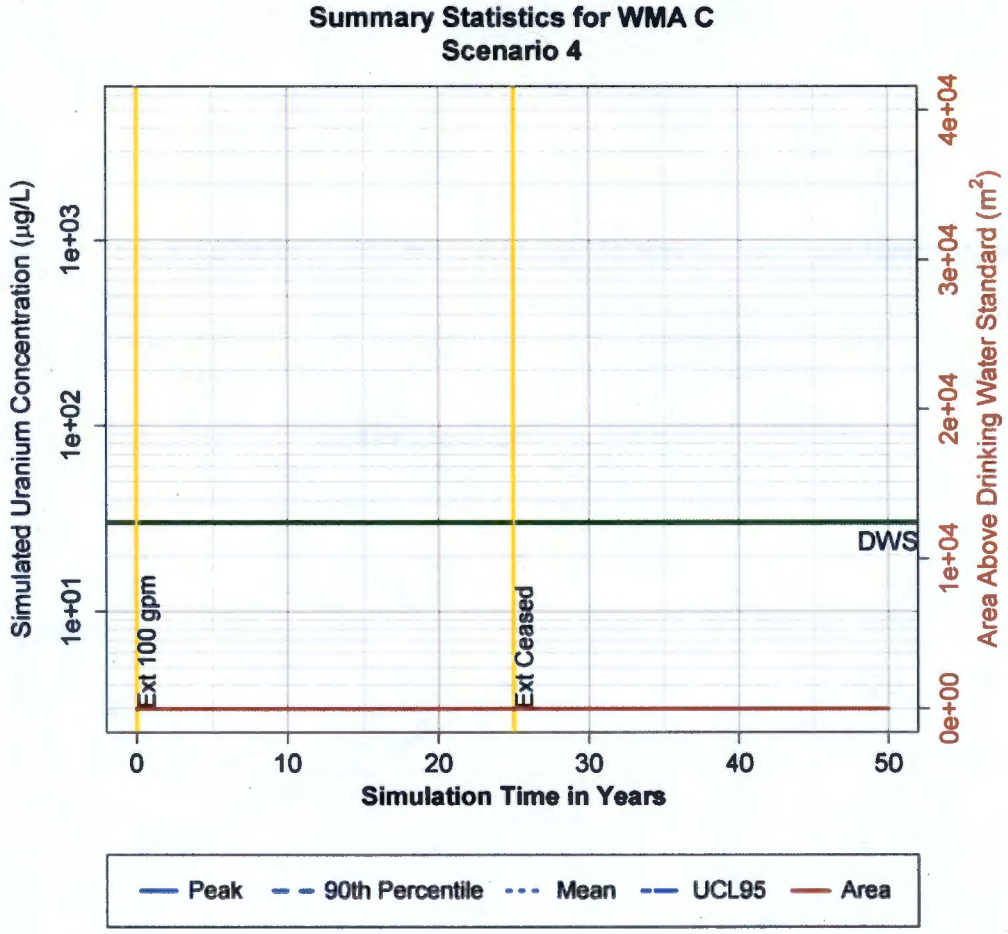

Figure B-194 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

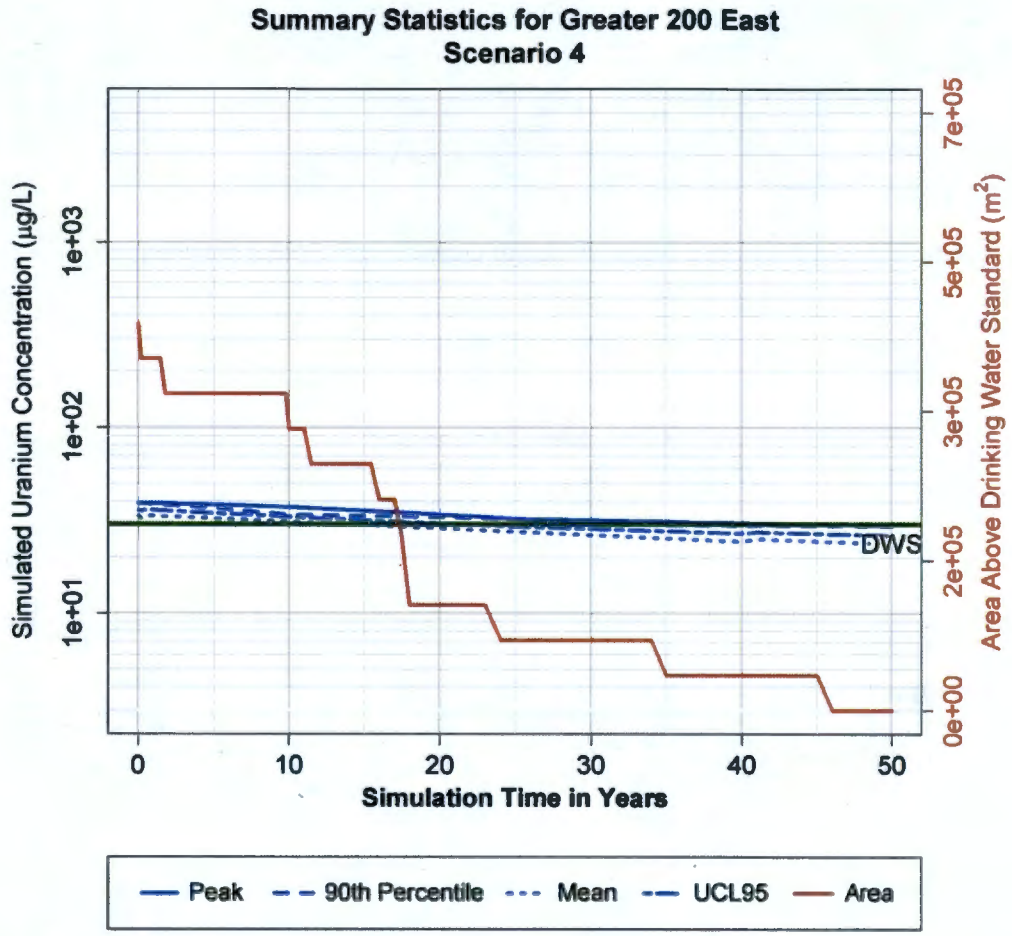

Figure B-195 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

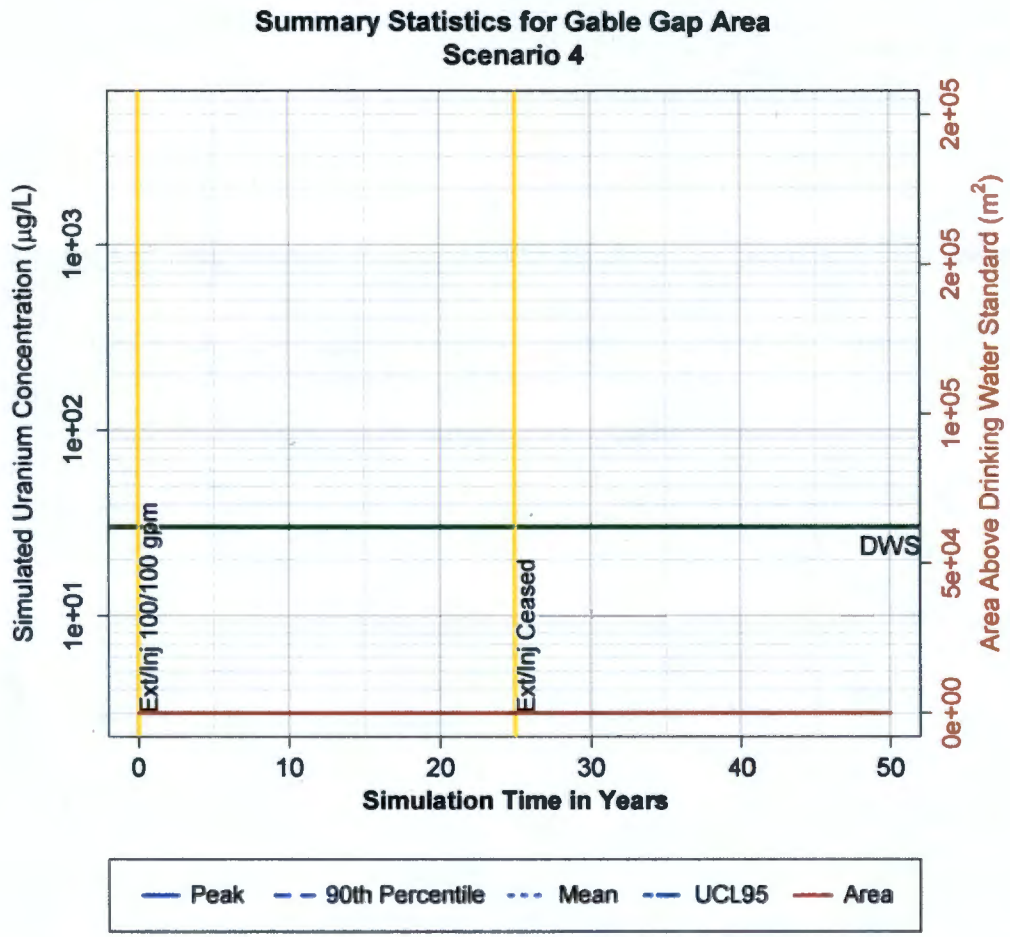

Figure B-196 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

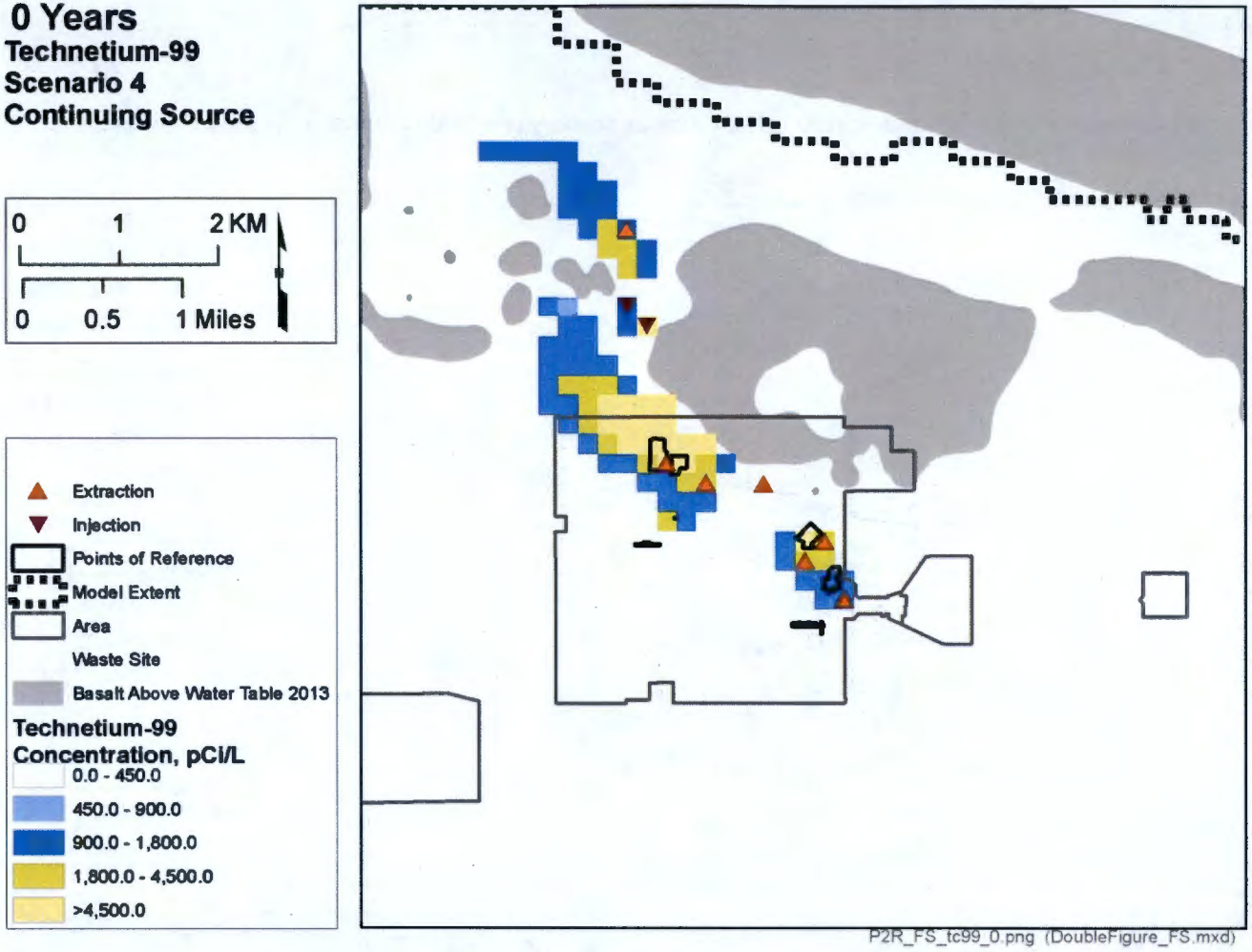

Figure B-197 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 4 simulation with a continuing source term.

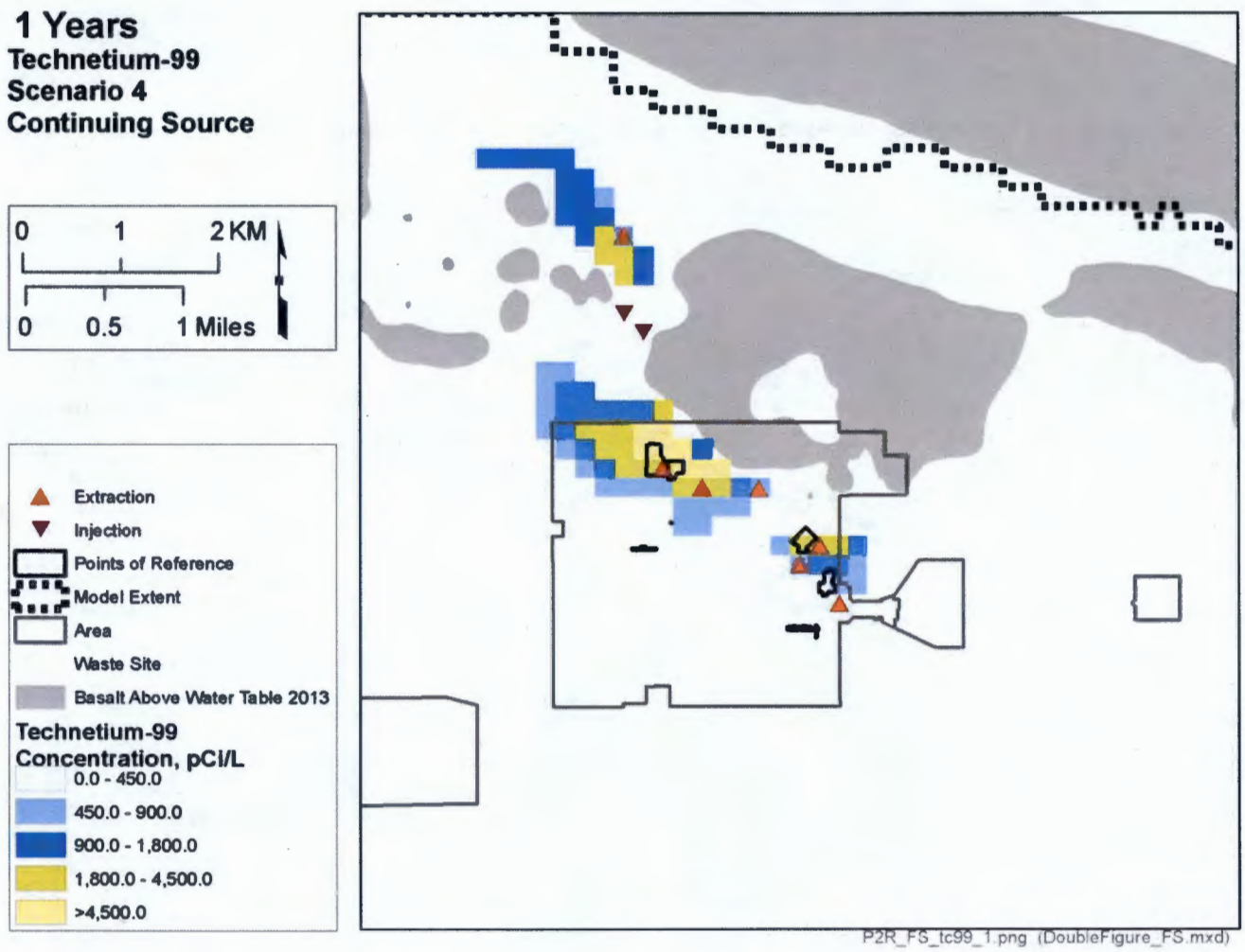

Figure B-198 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 4 simulation with a continuing source term.

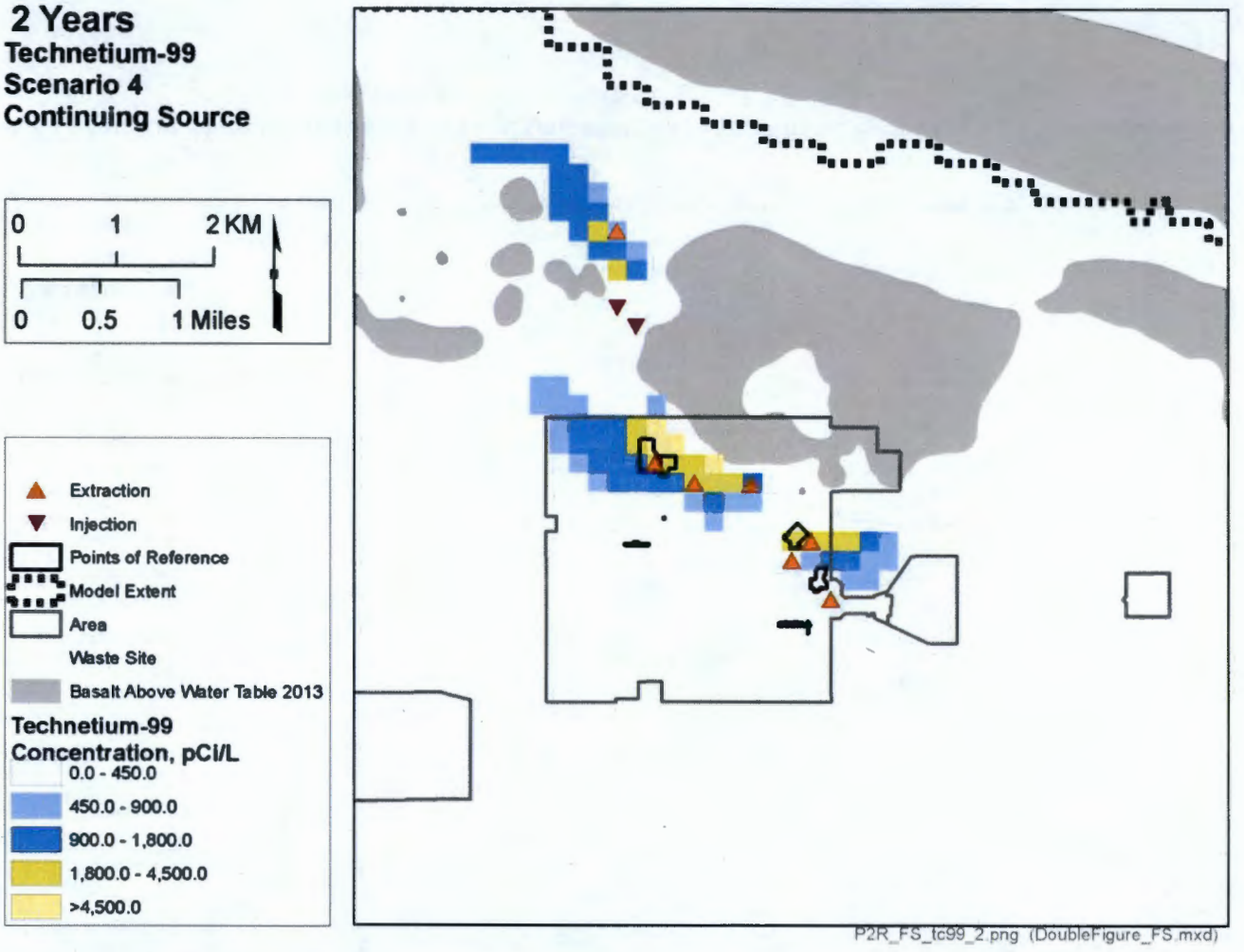

Figure B-199 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 4 simulation with a continuing source term.

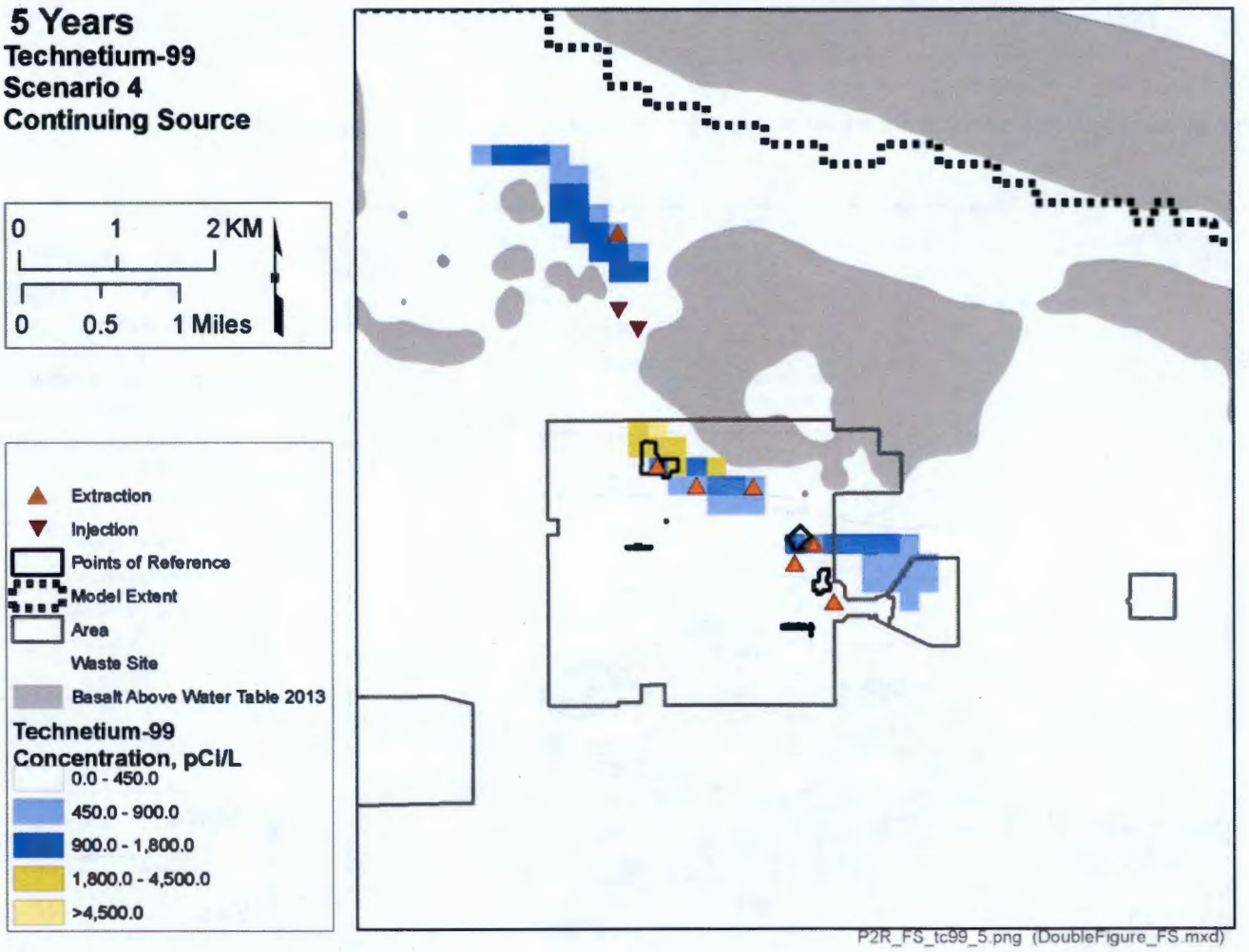

Figure B-200 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 4 simulation with a continuing source term.

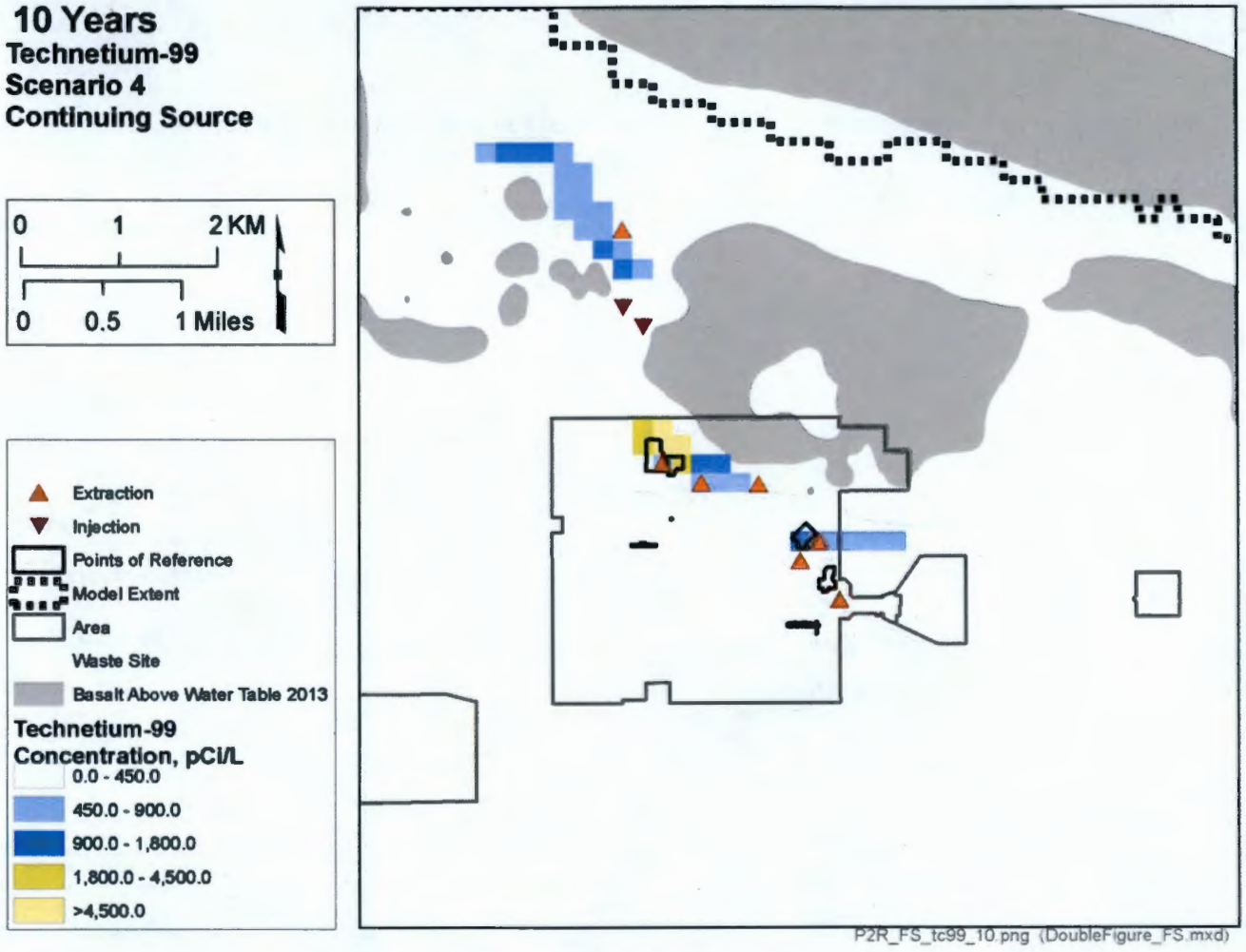

Figure B-201 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 4 simulation with a continuing source term.

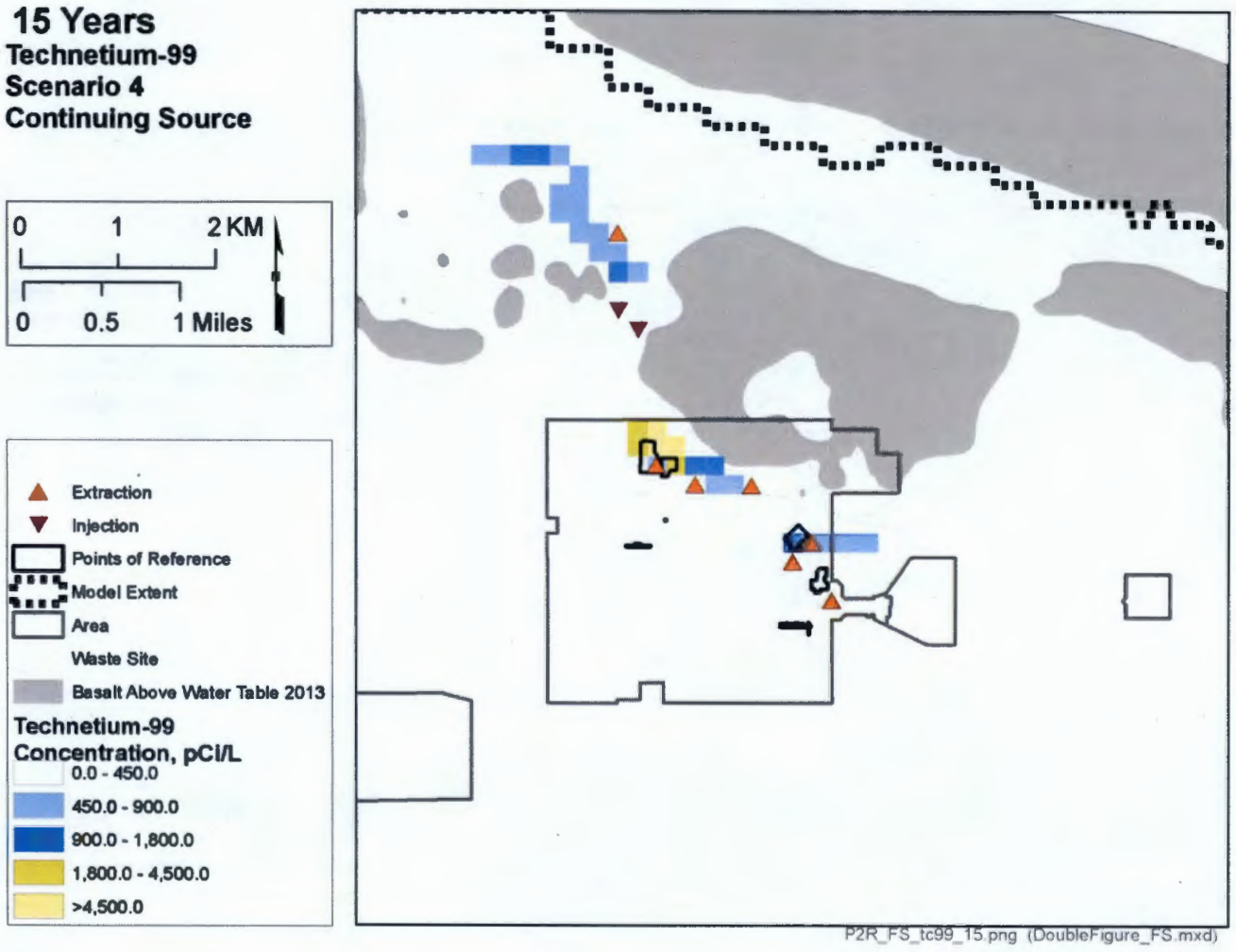

Figure B-202 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 4 simulation with a continuing source term.

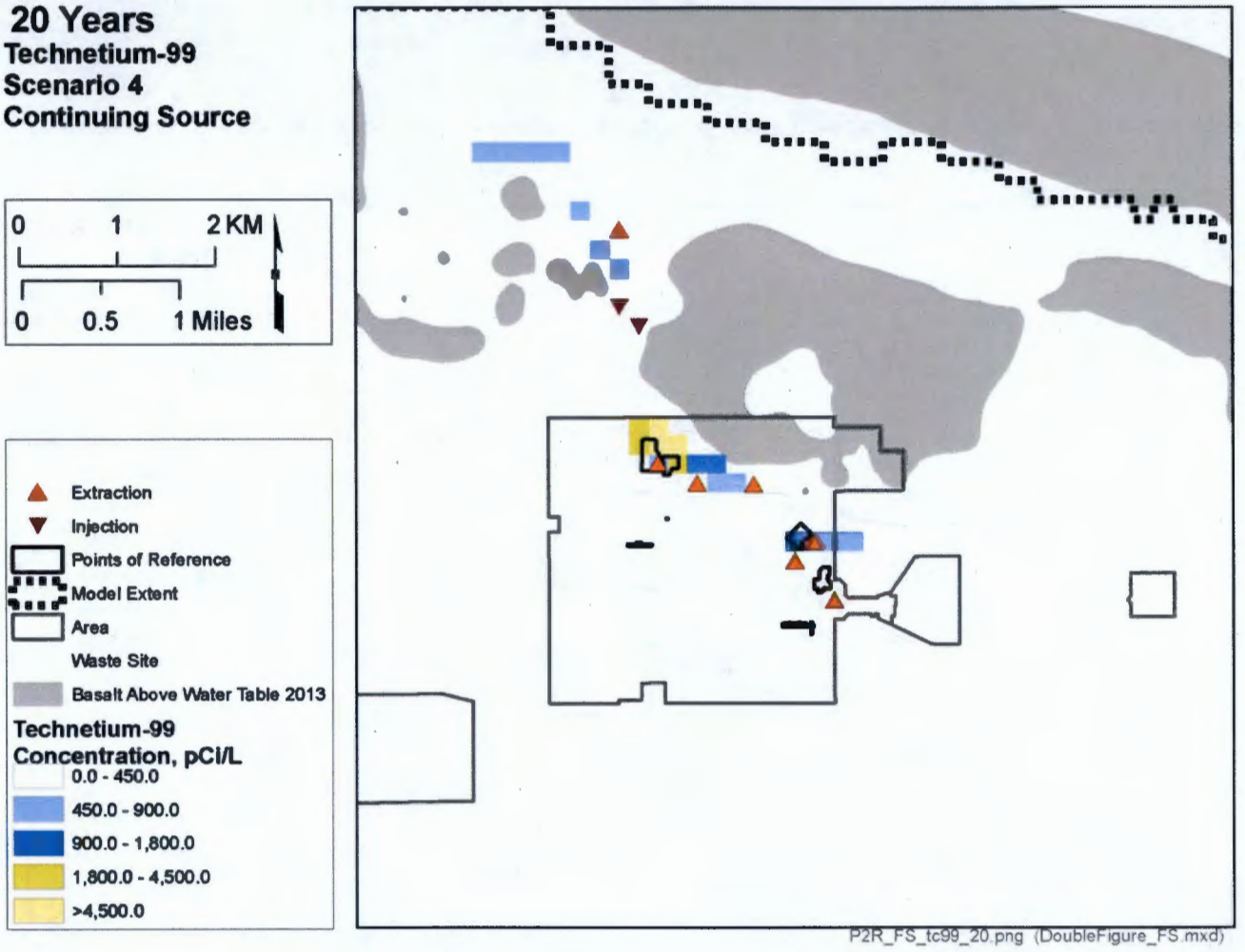

Figure B-203 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 4 simulation with a continuing source term.

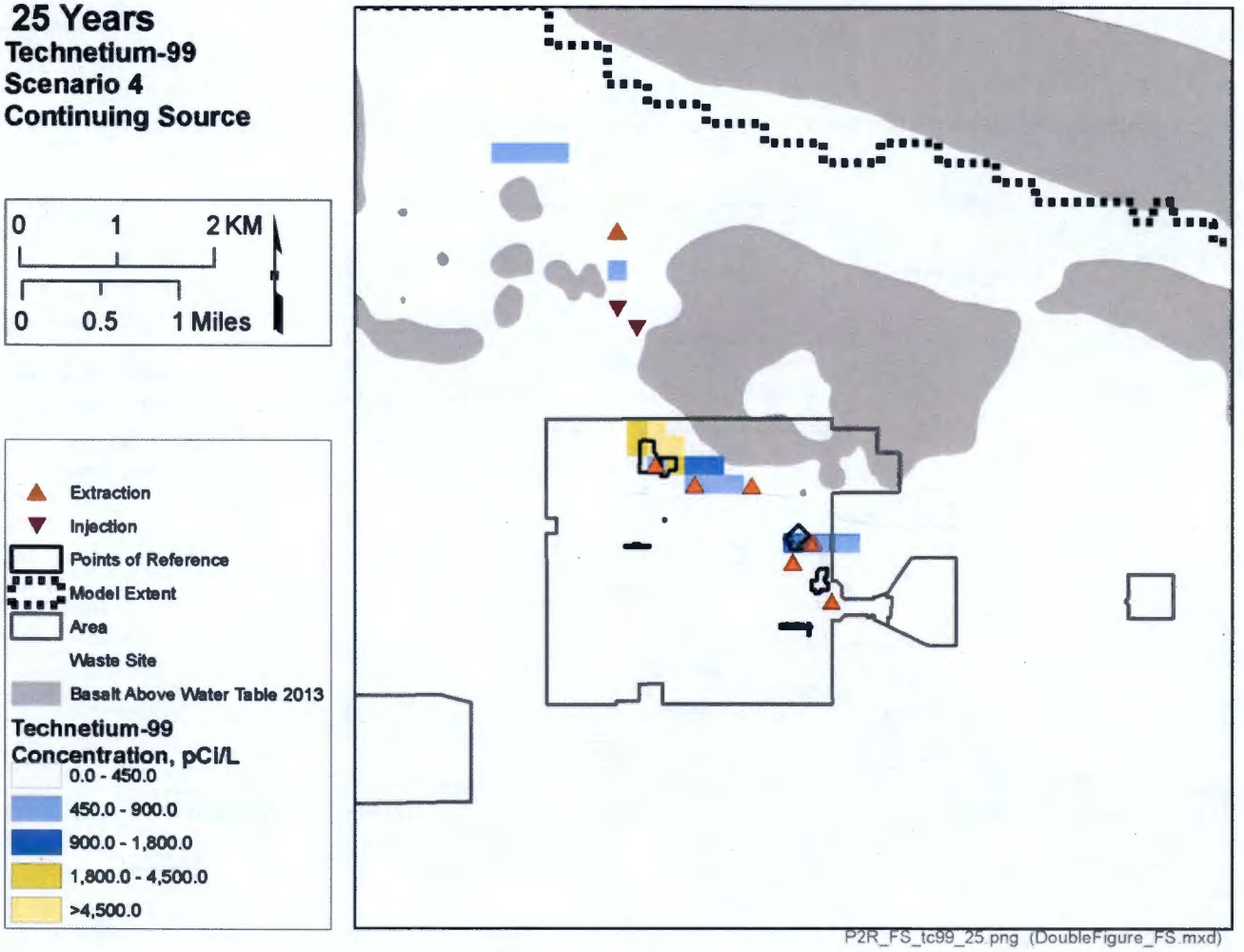

Figure B-204 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 4 simulation with a continuing source term.

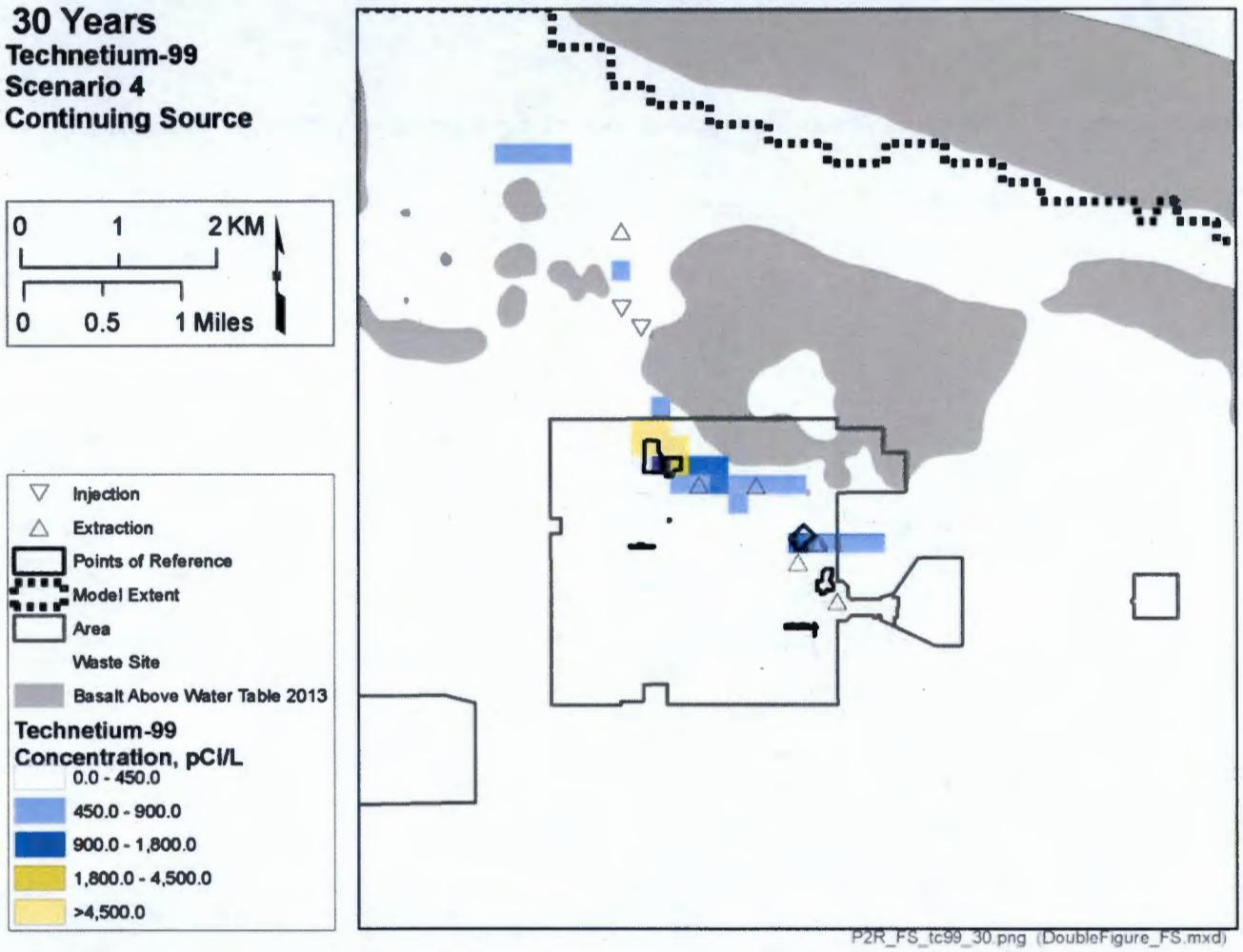

Figure B-205 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 4 simulation with a continuing source term.

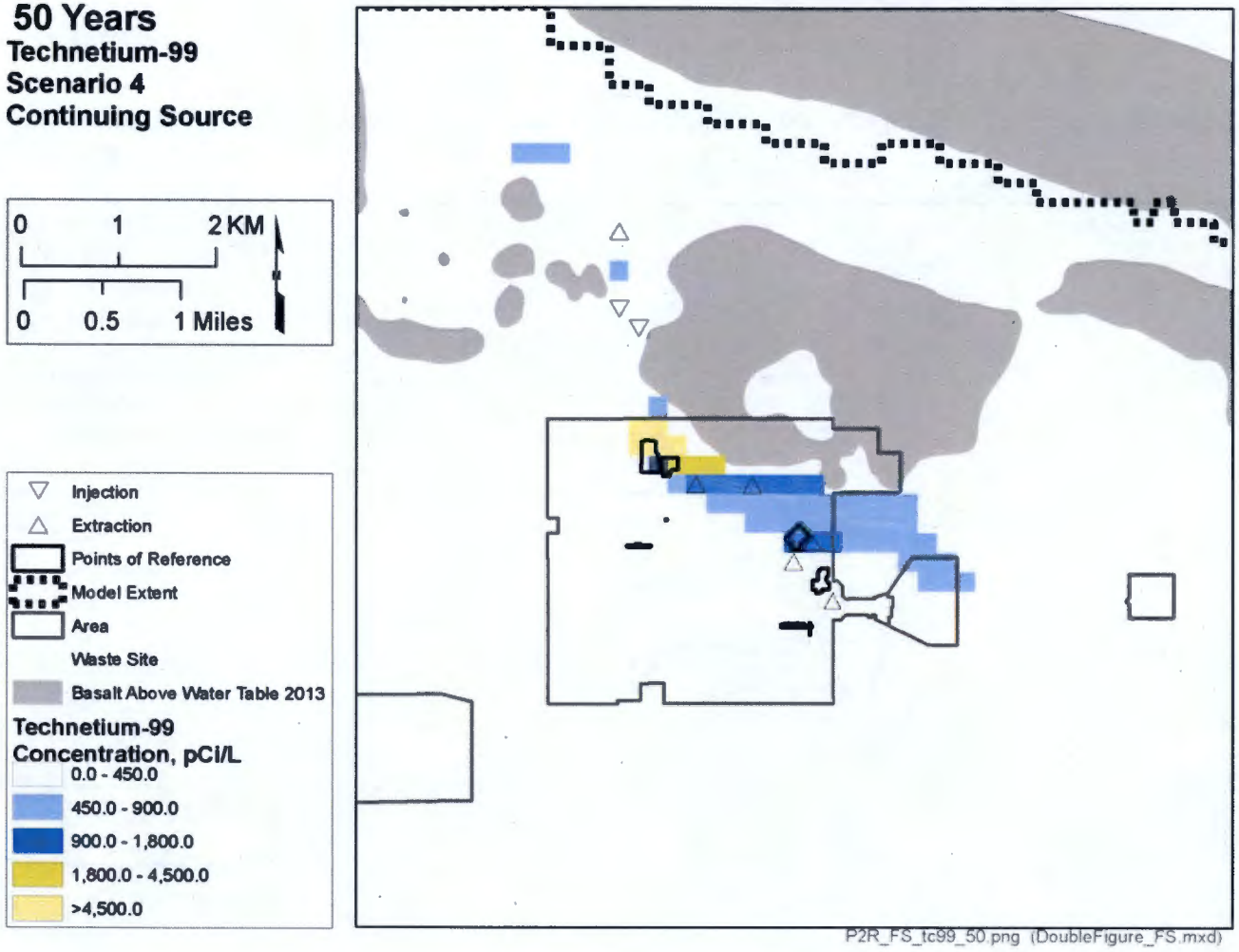

Figure B-206 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 4 simulation with a continuing source term.

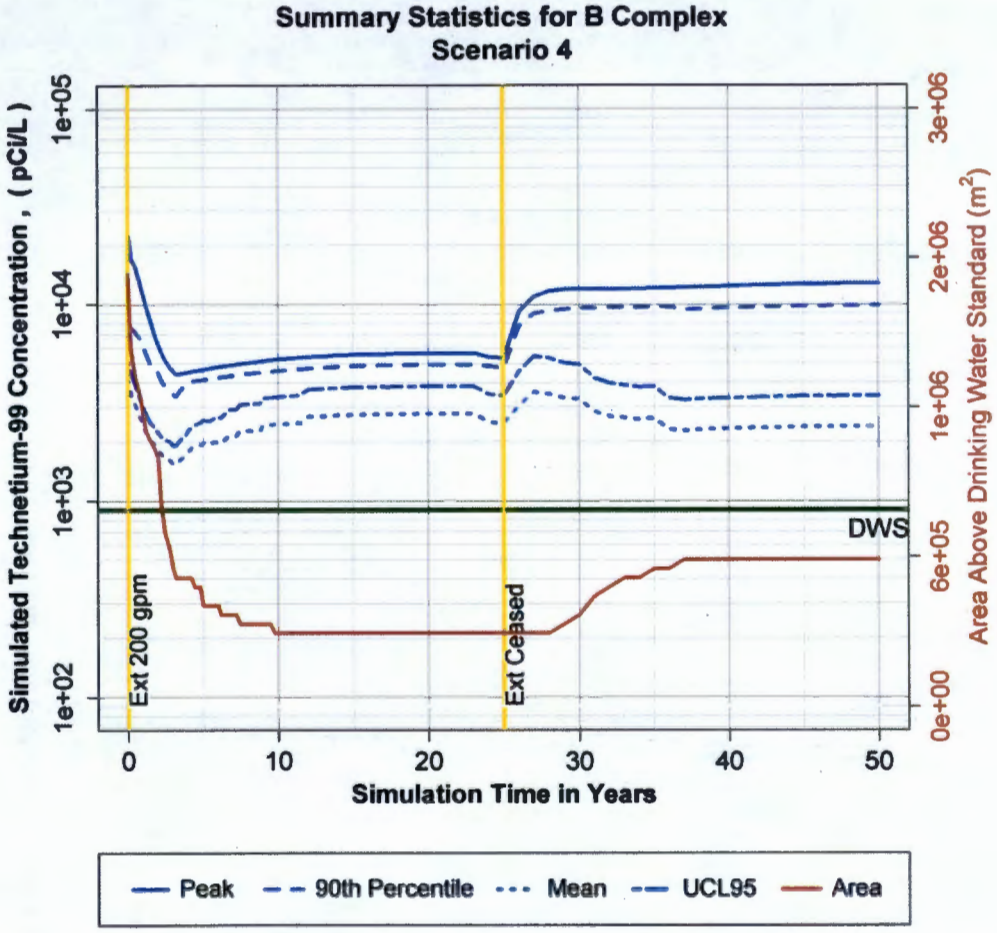

Figure B-207 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

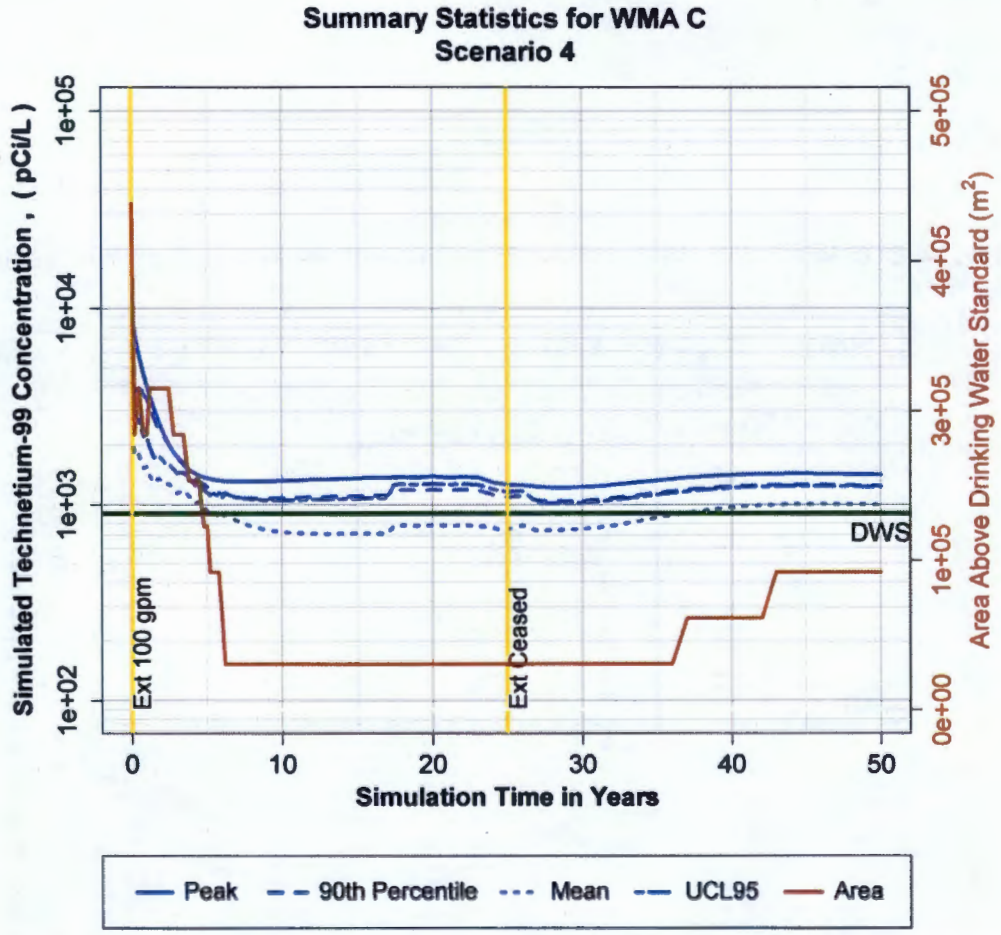

Figure B-208 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

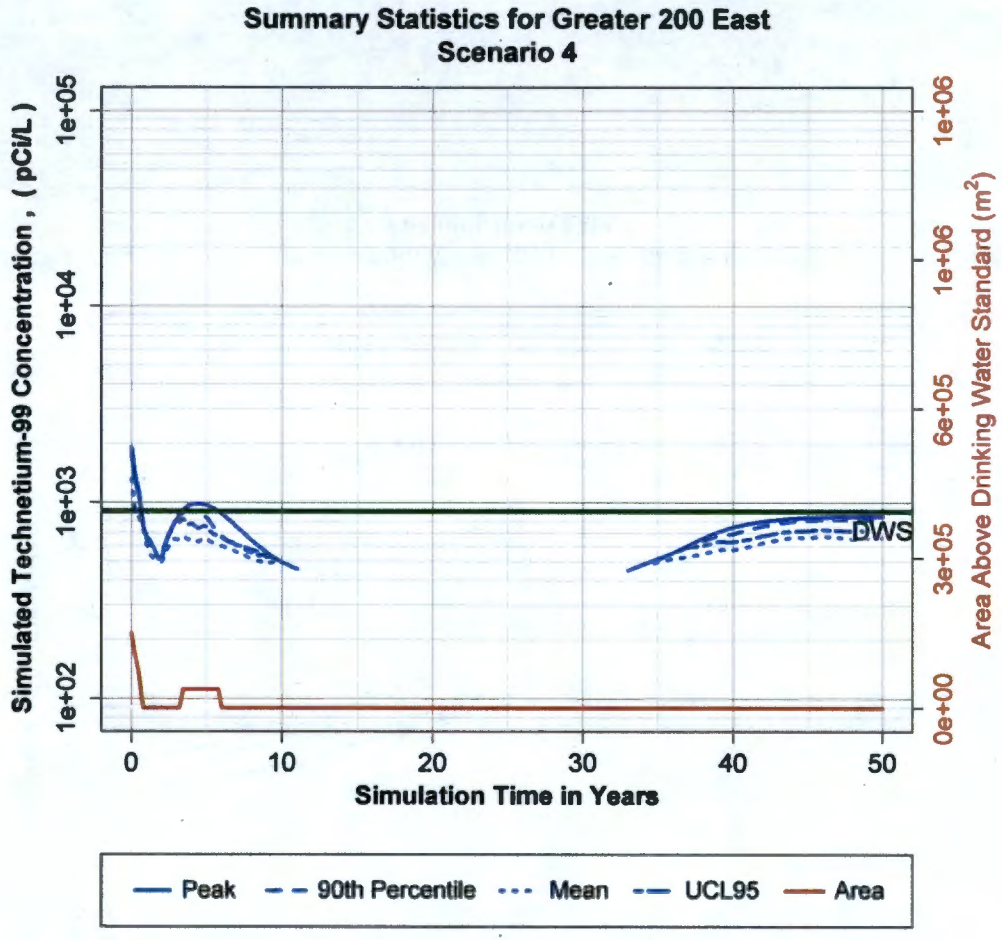

Figure B-209 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

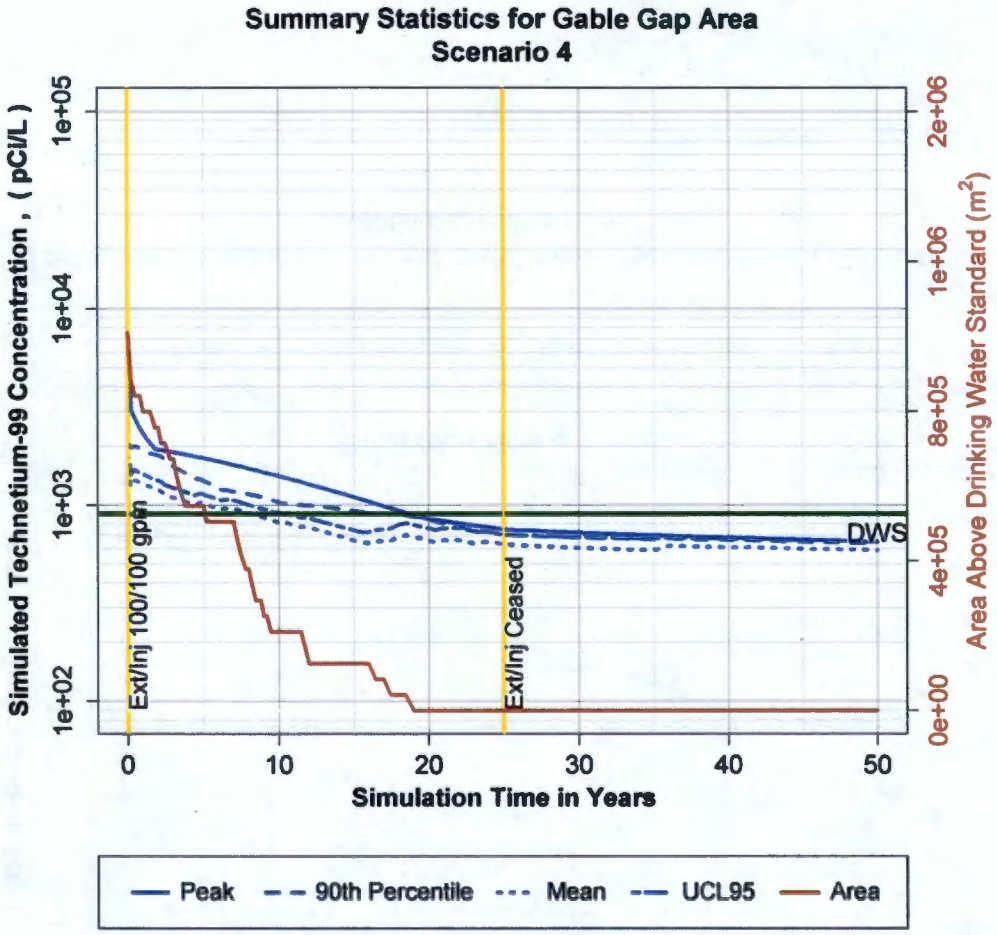

Figure B-210 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

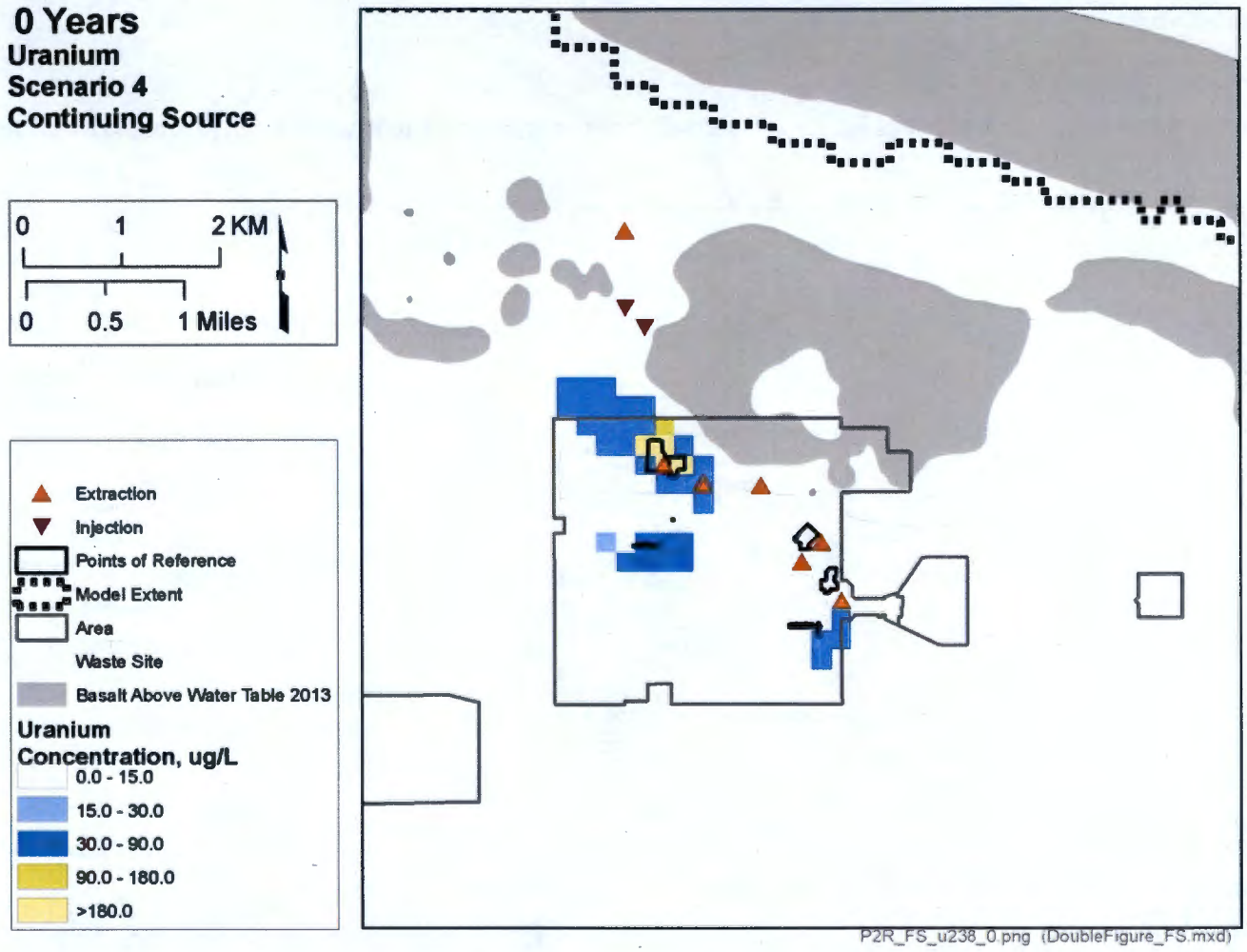

Figure B-211 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 4 simulation with a continuing source term.

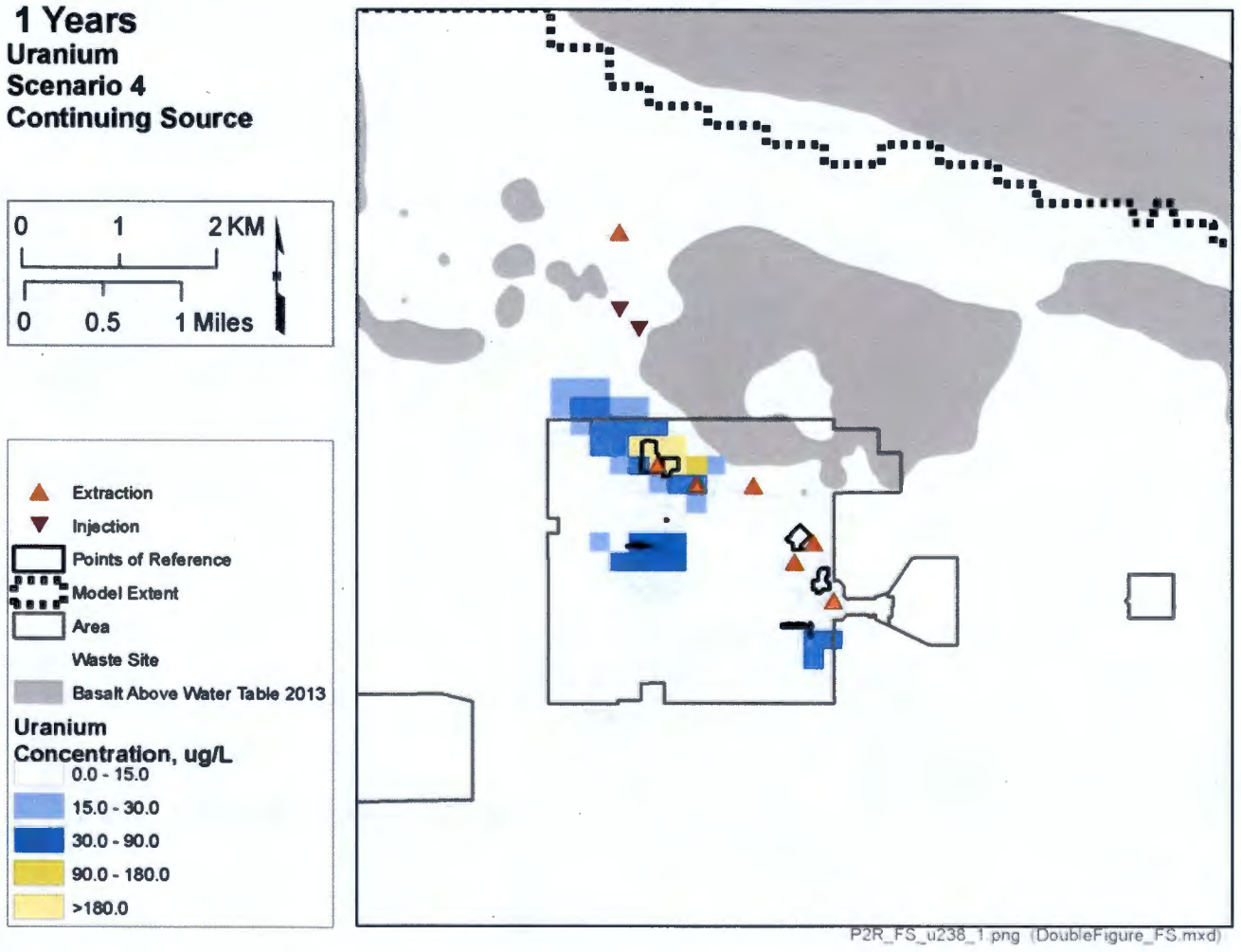

Figure B-212 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 4 simulation with a continuing source term.

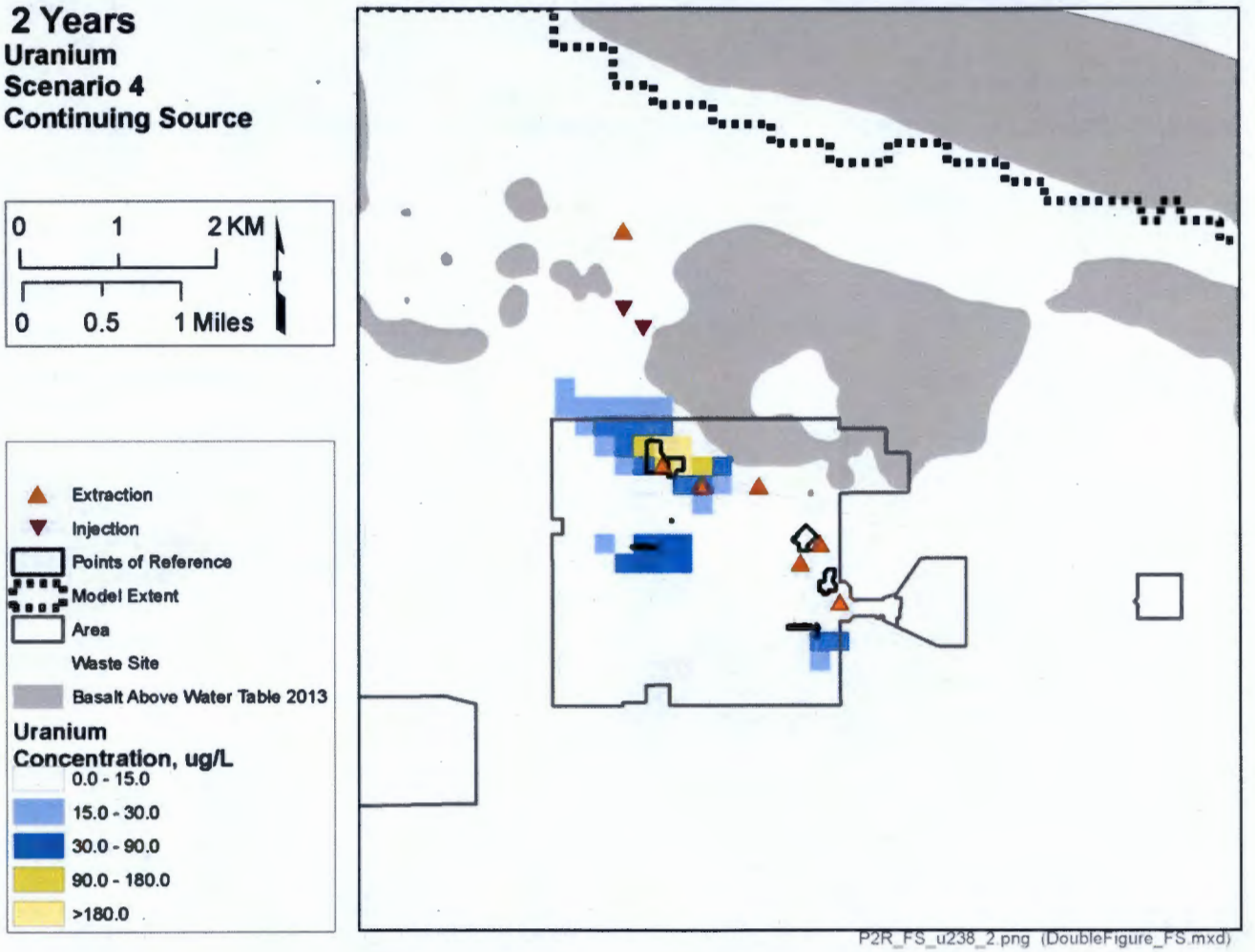

Figure B-213 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 4 simulation with a continuing source term.

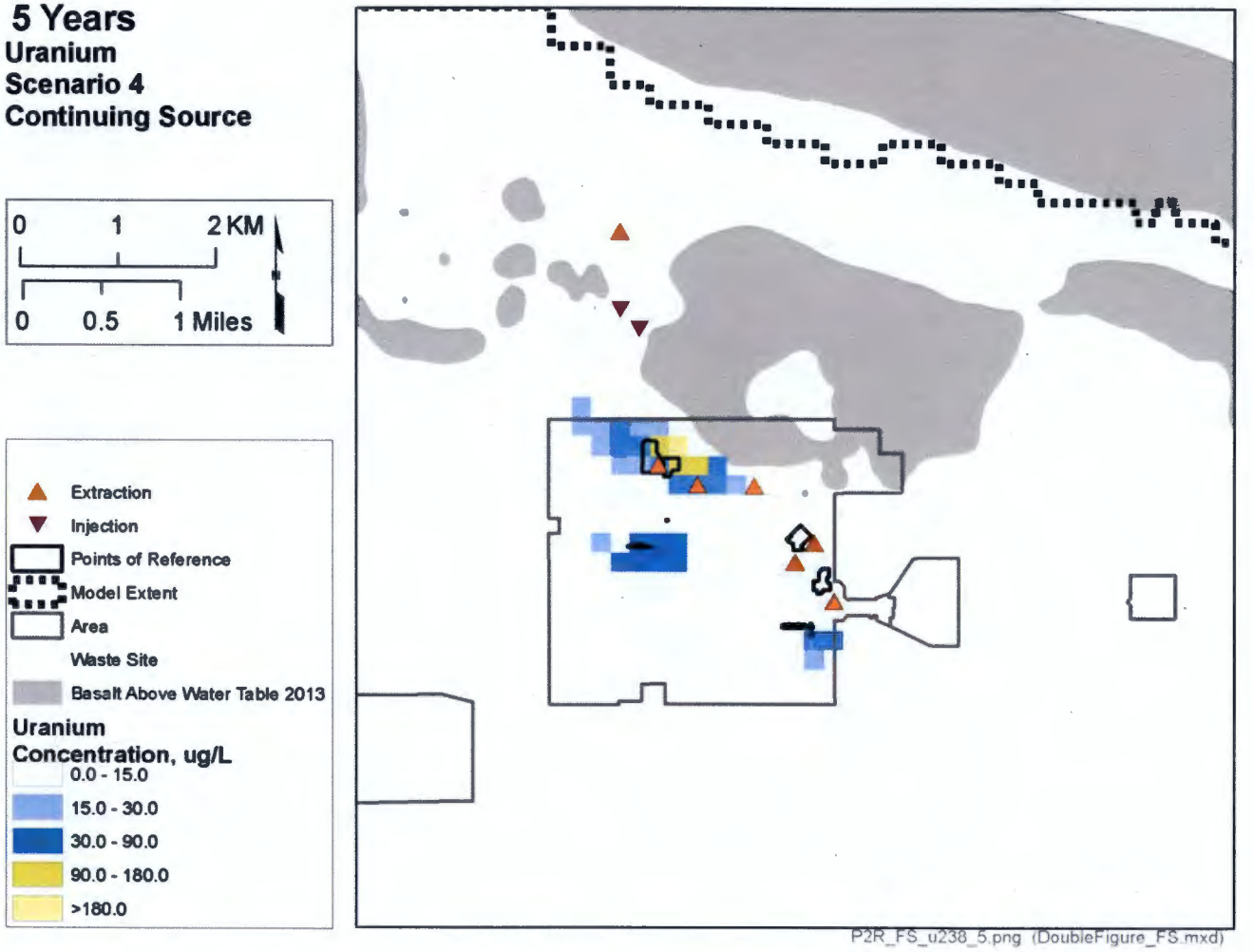

Figure B-214 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 4 simulation with a continuing source term.

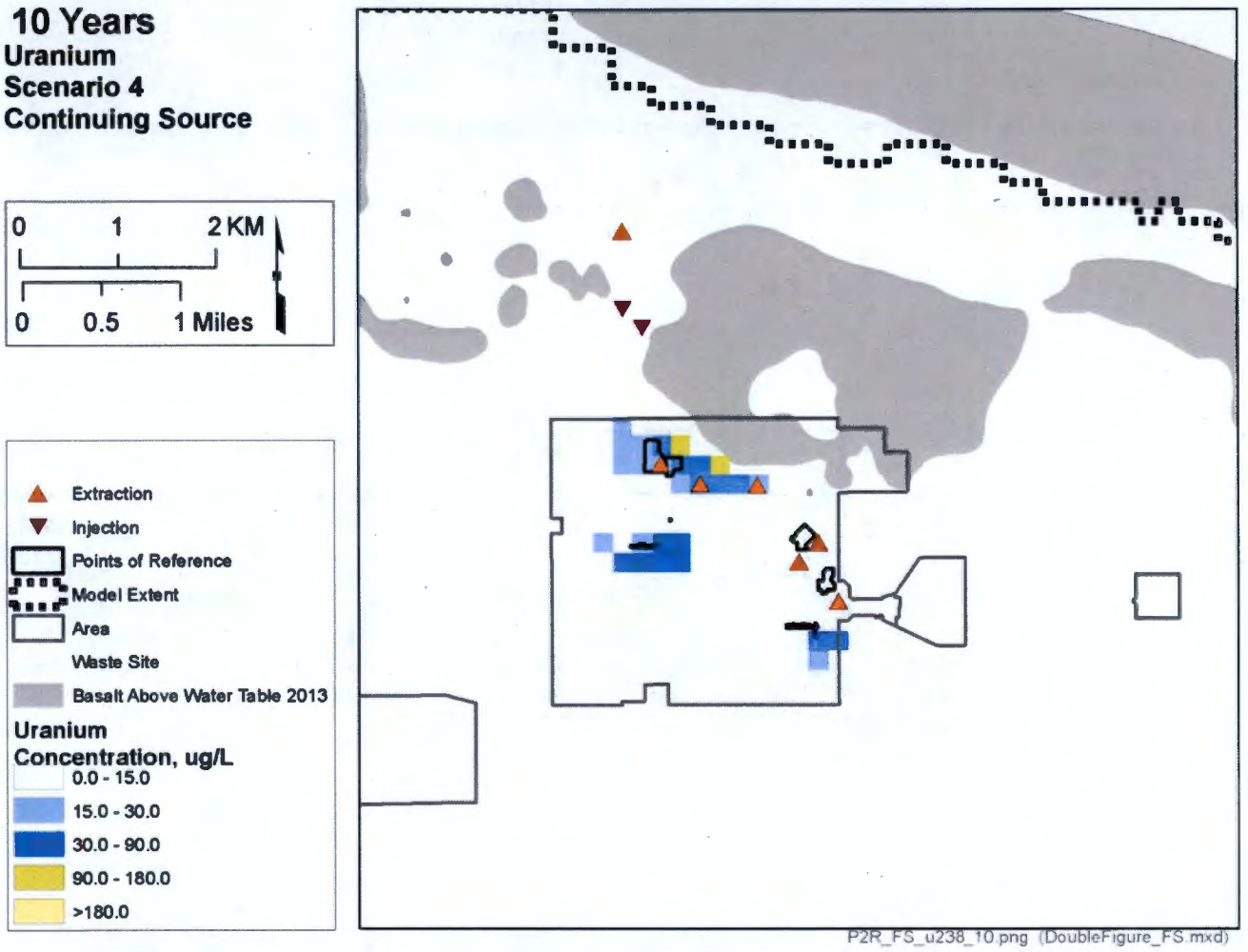

Figure B-215 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 4 simulation with a continuing source term.

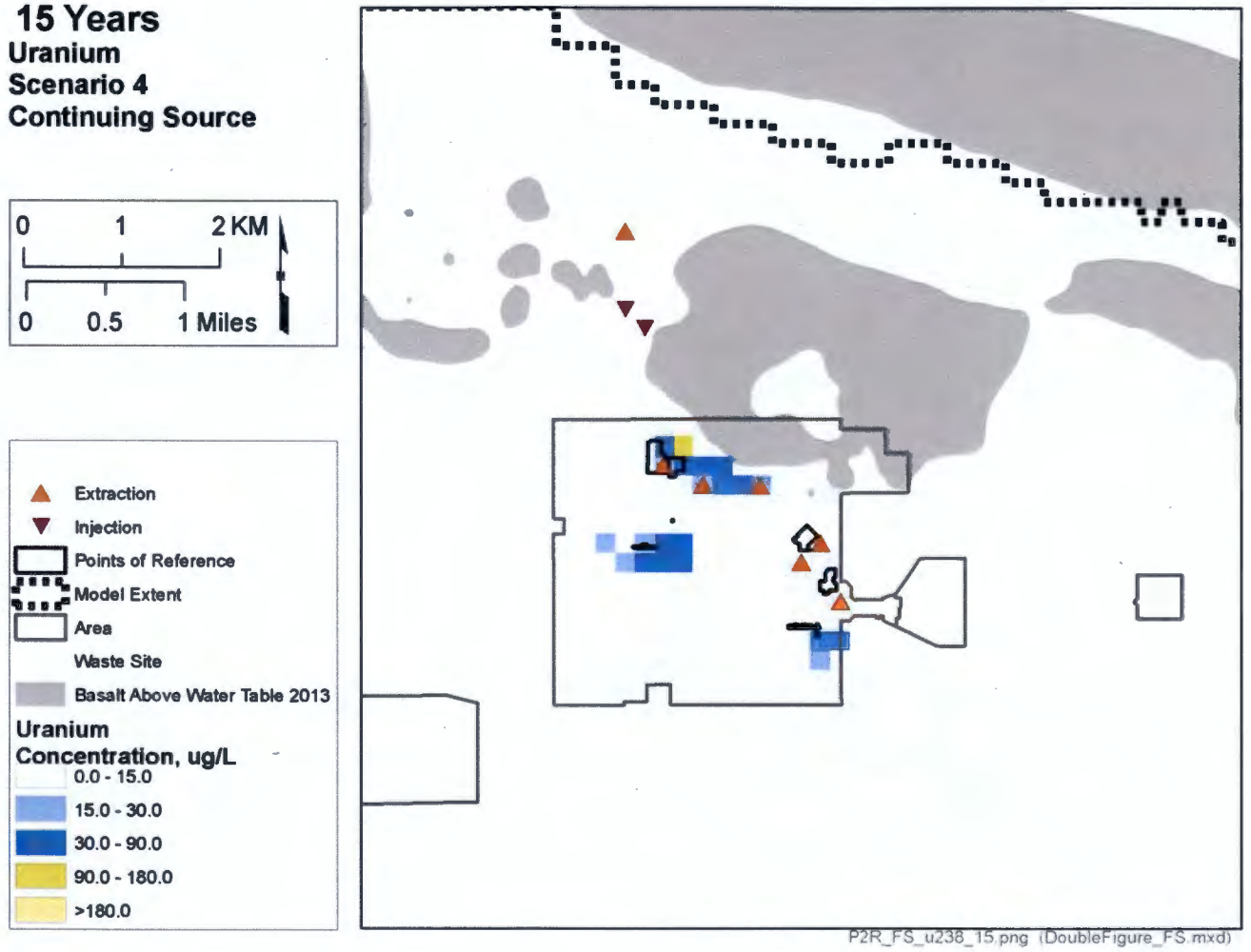

Figure B-216 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 4 simulation with a continuing source term.

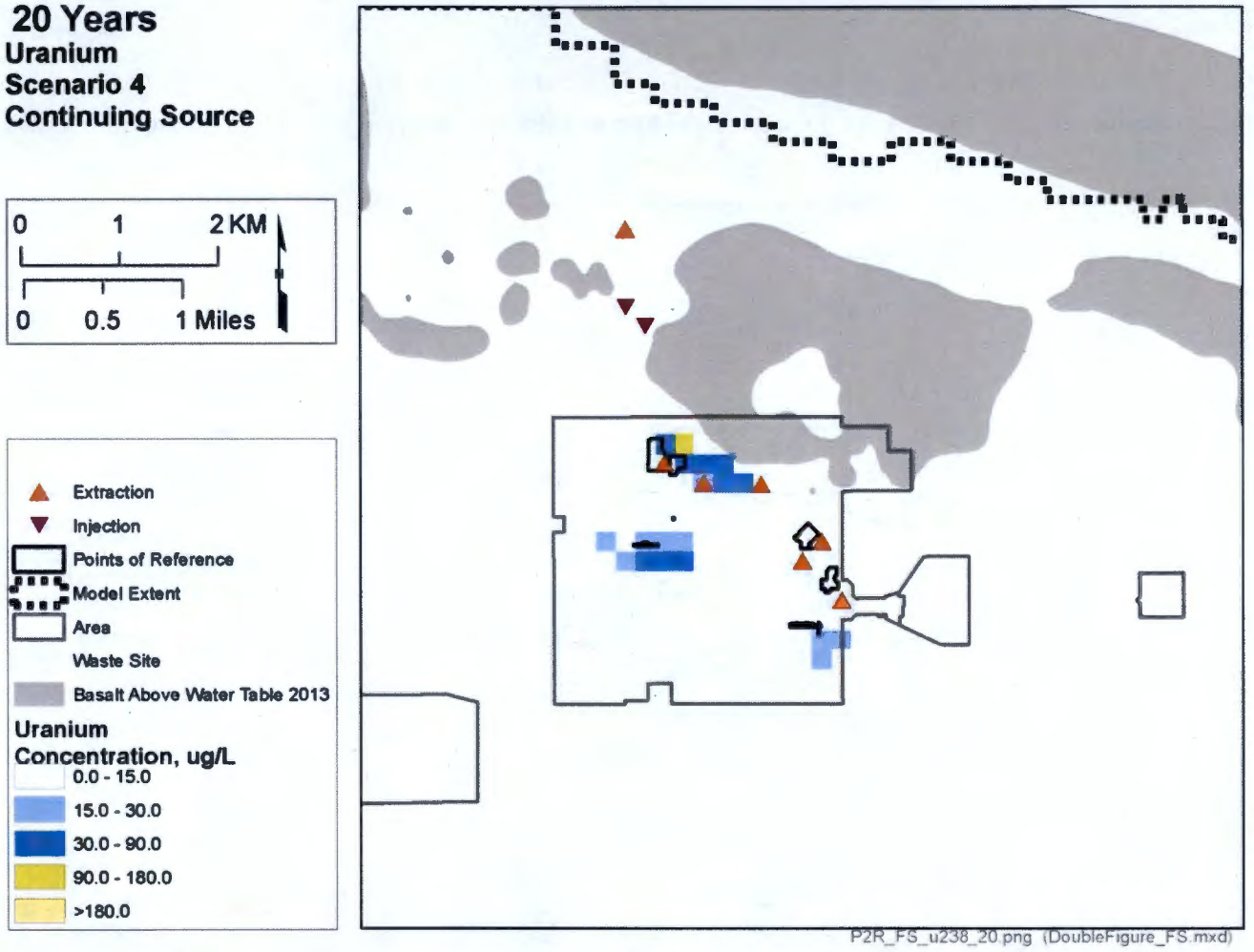

Figure B-217 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 4 simulation with a continuing source term.

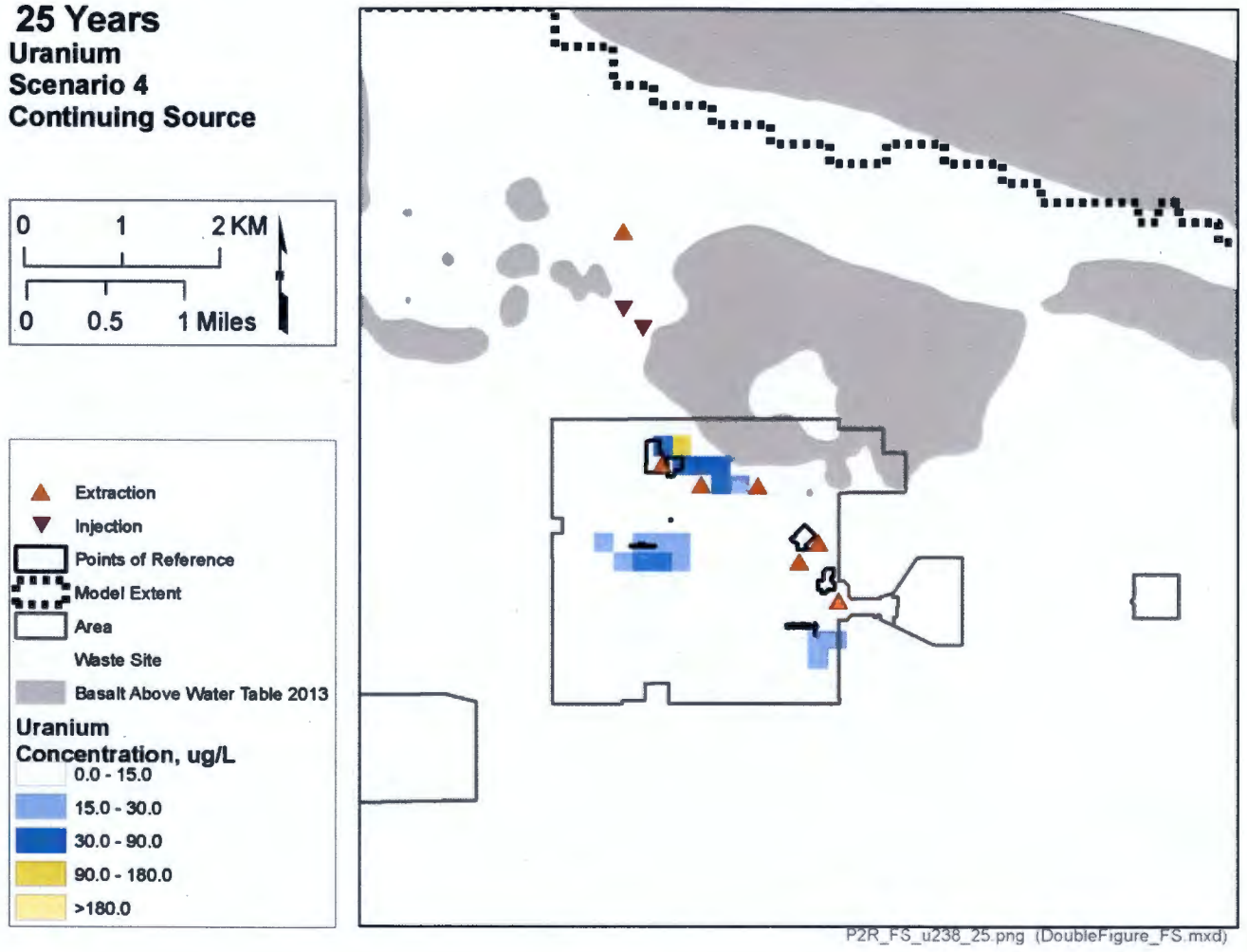

Figure B-218 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 4 simulation with a continuing source term.

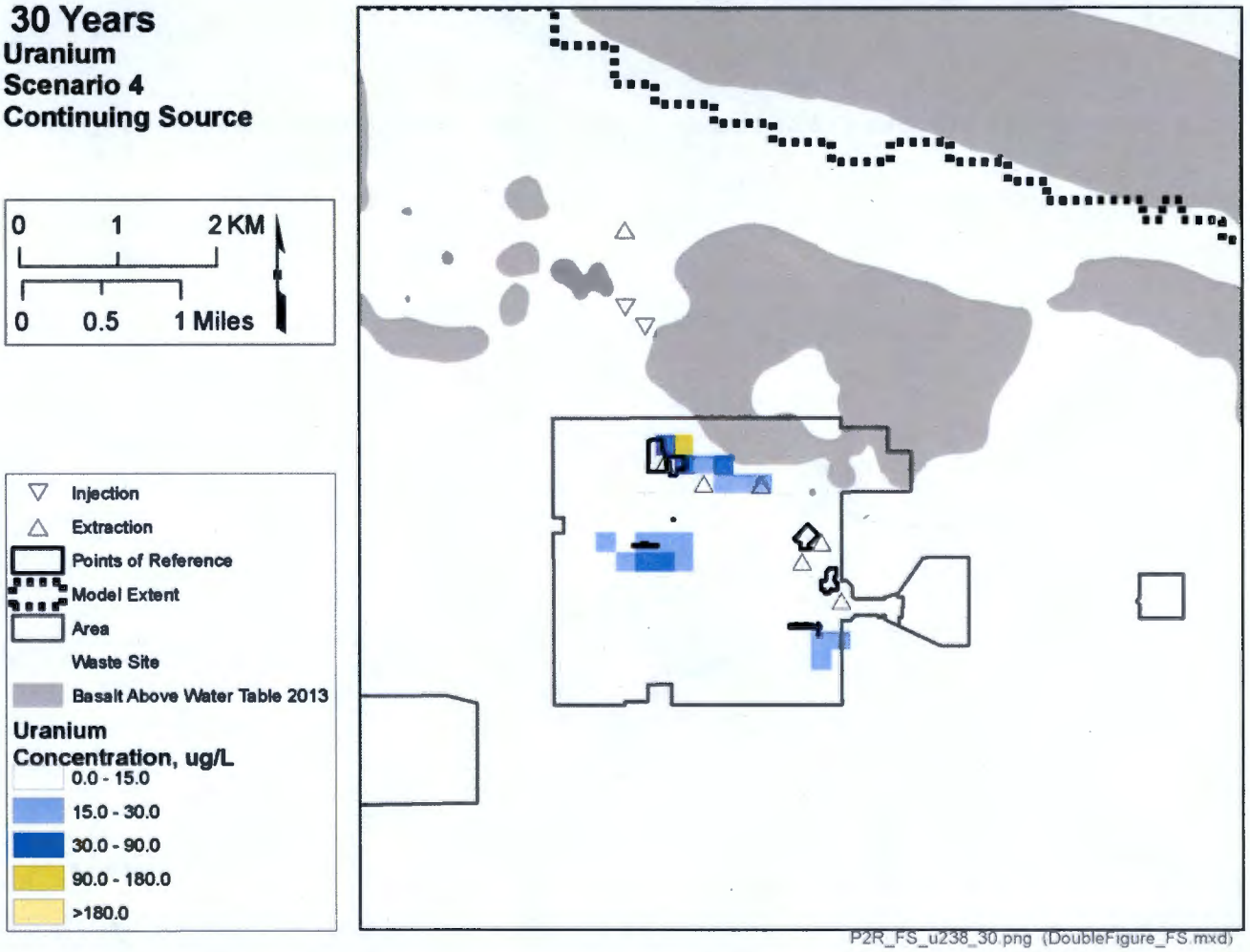

Figure B-219 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 4 simulation with a continuing source term.

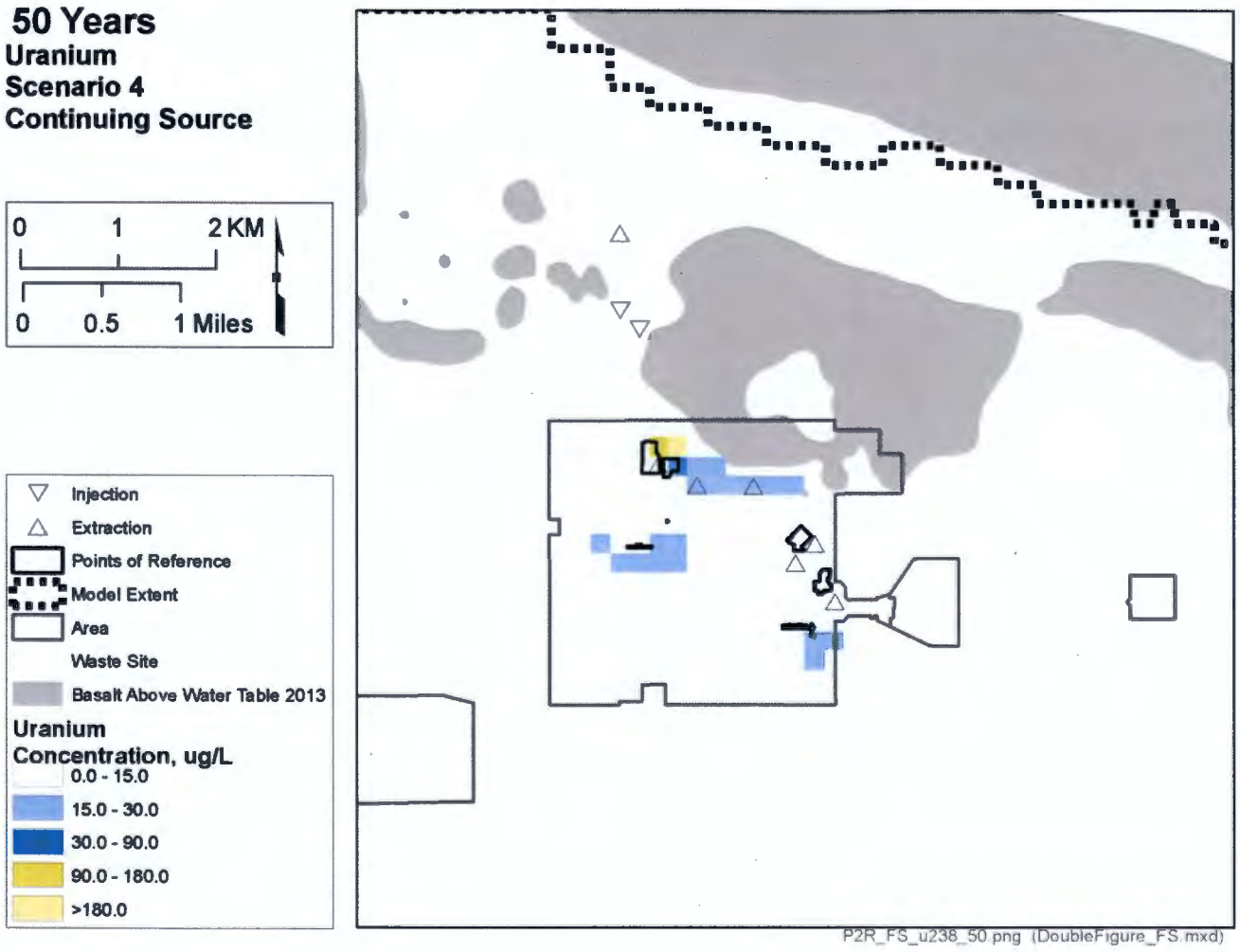

Figure B-220 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 4 simulation with a continuing source term.

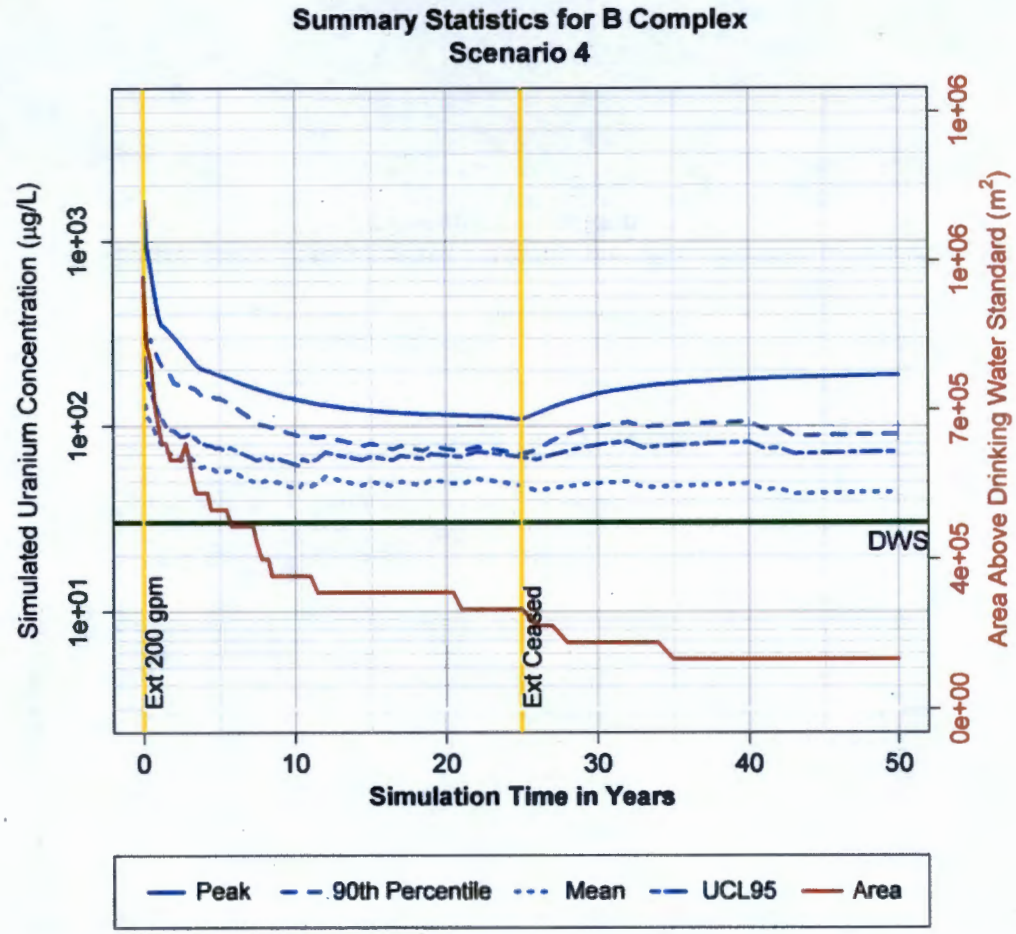

Figure B-221 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

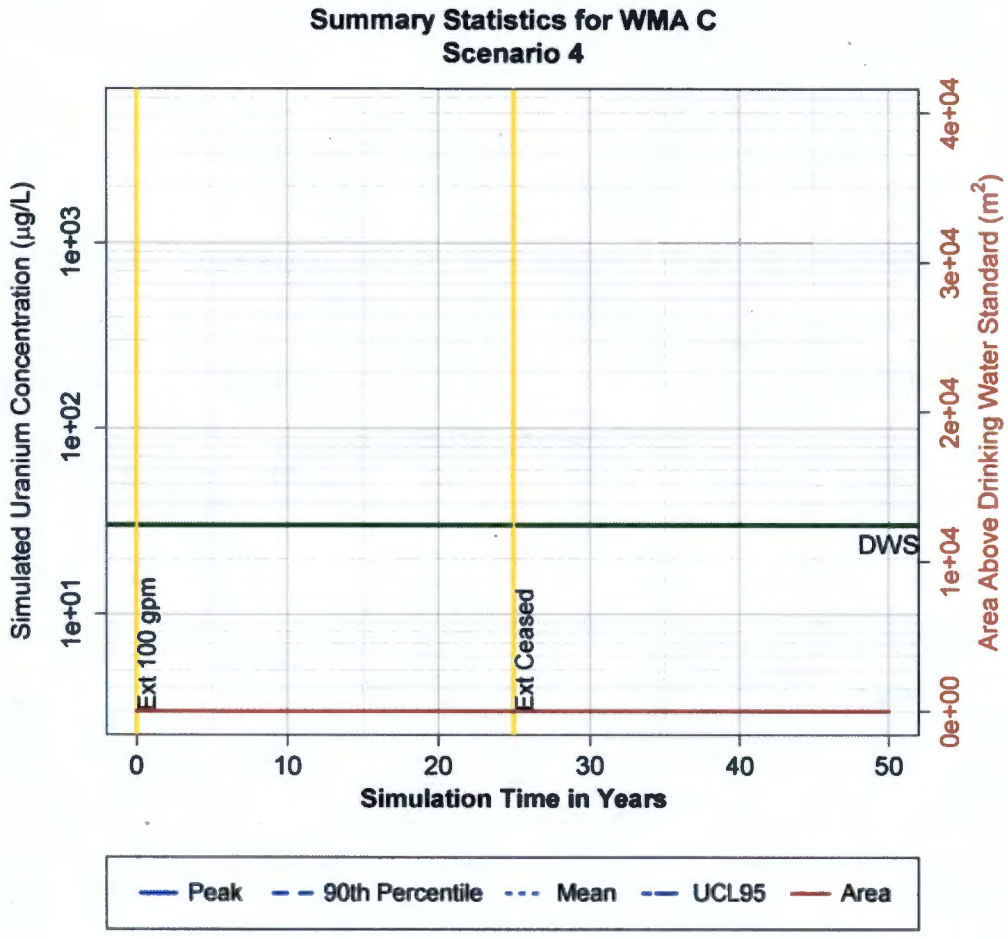

Figure B-222 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

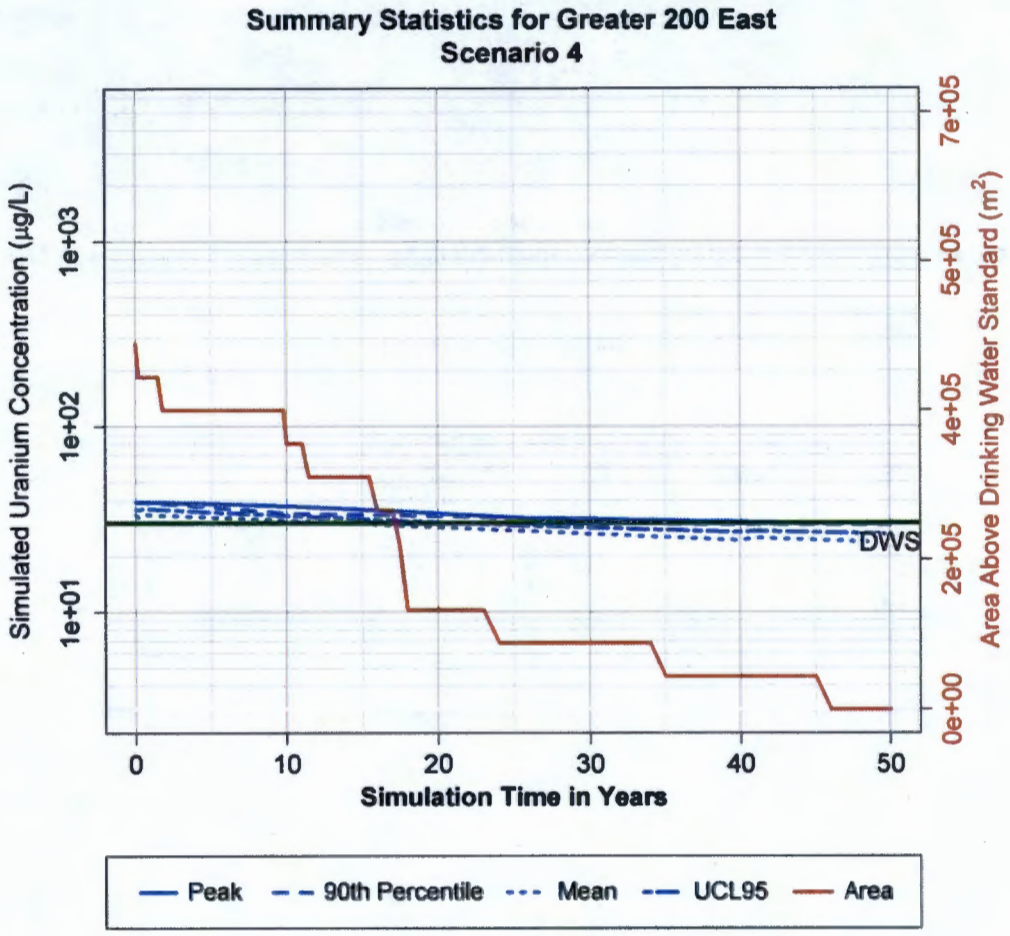

Figure B-223 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

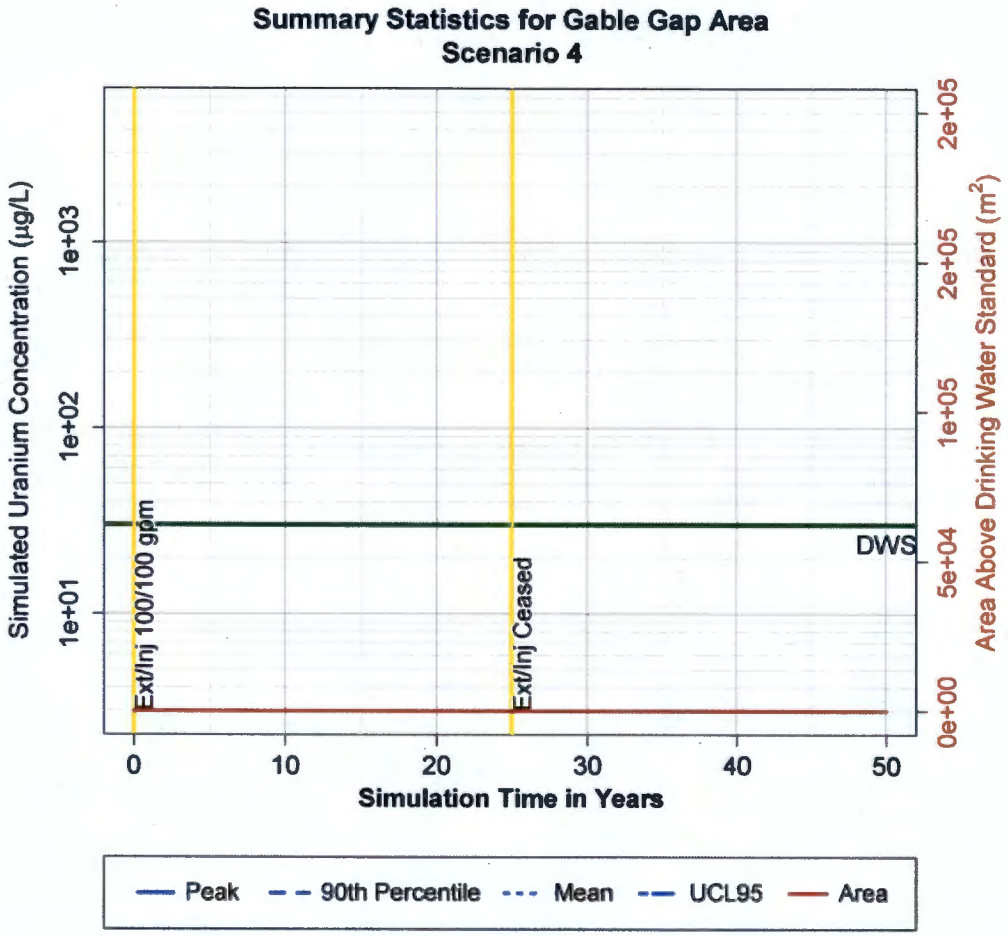

Figure B-224 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

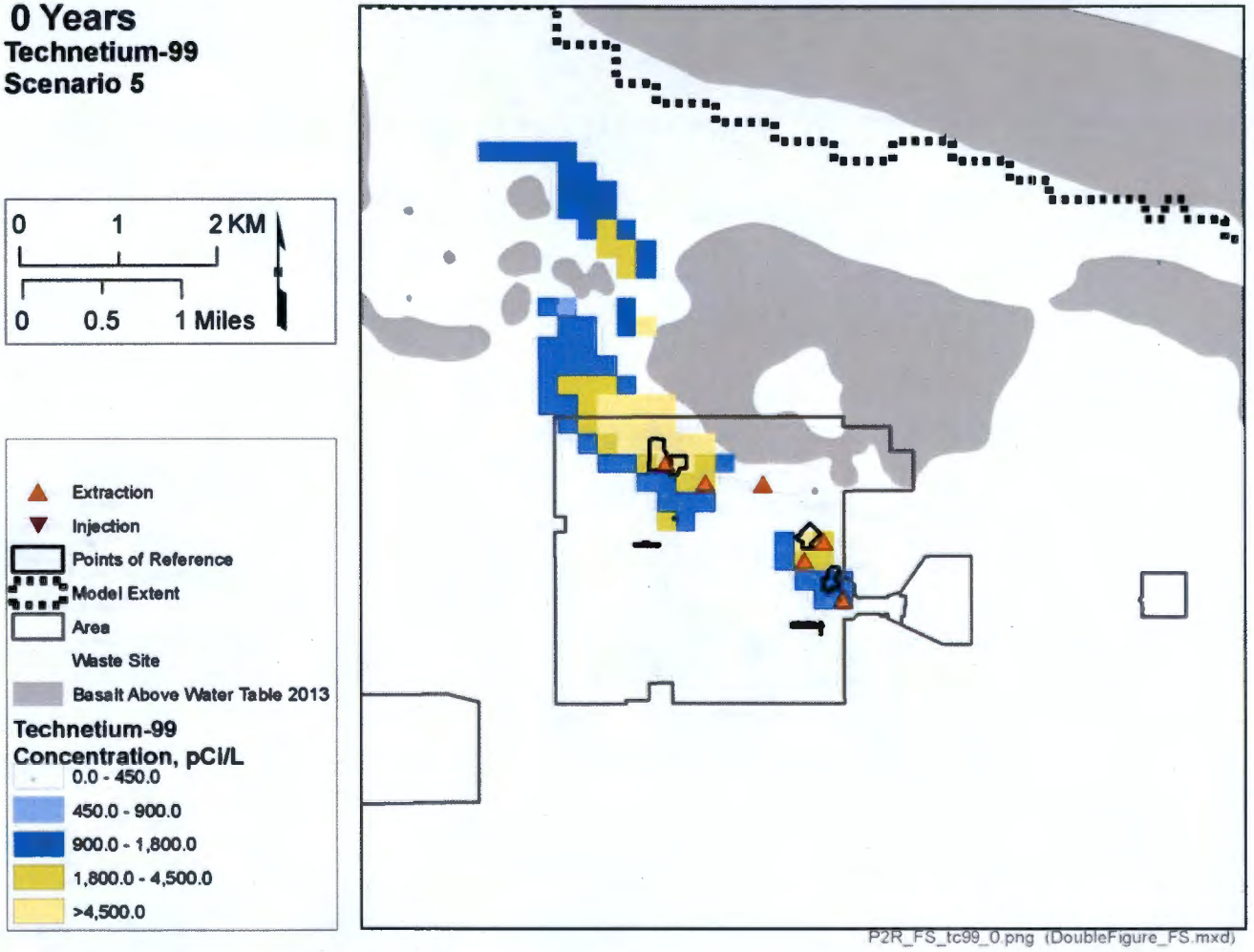

Figure B-225 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 5 simulation.

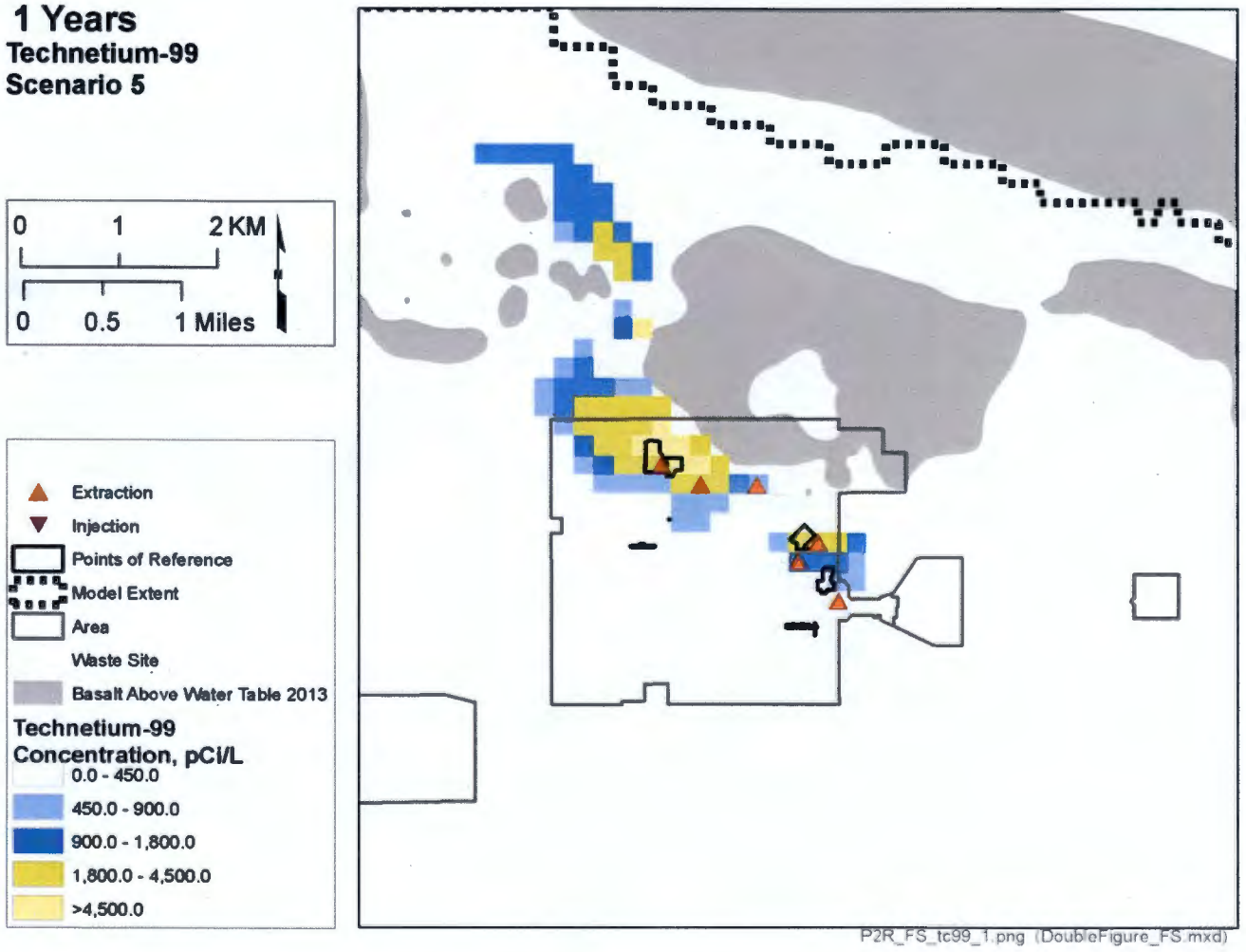

Figure B-226 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 5 simulation.

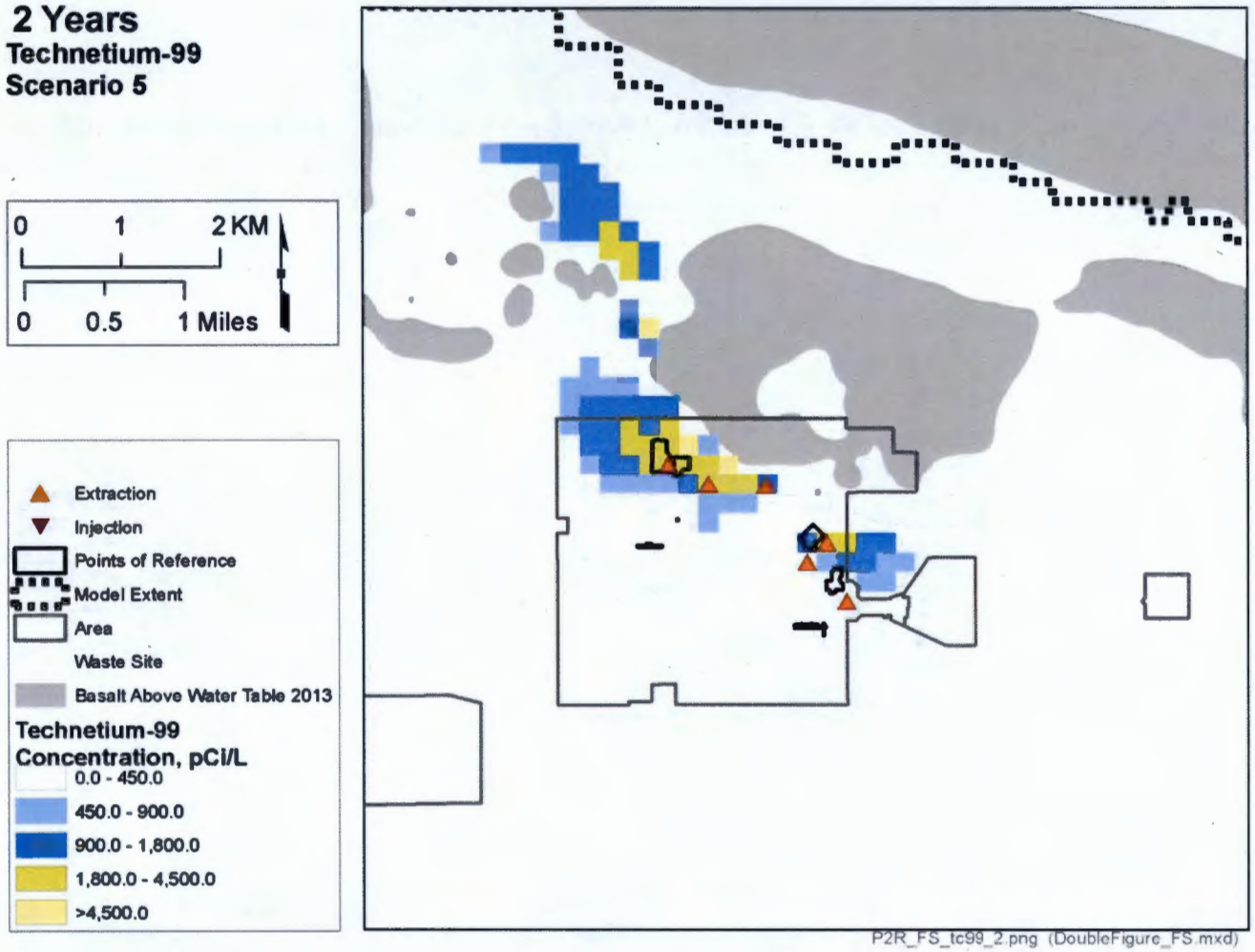

Figure B-227 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 5 simulation.

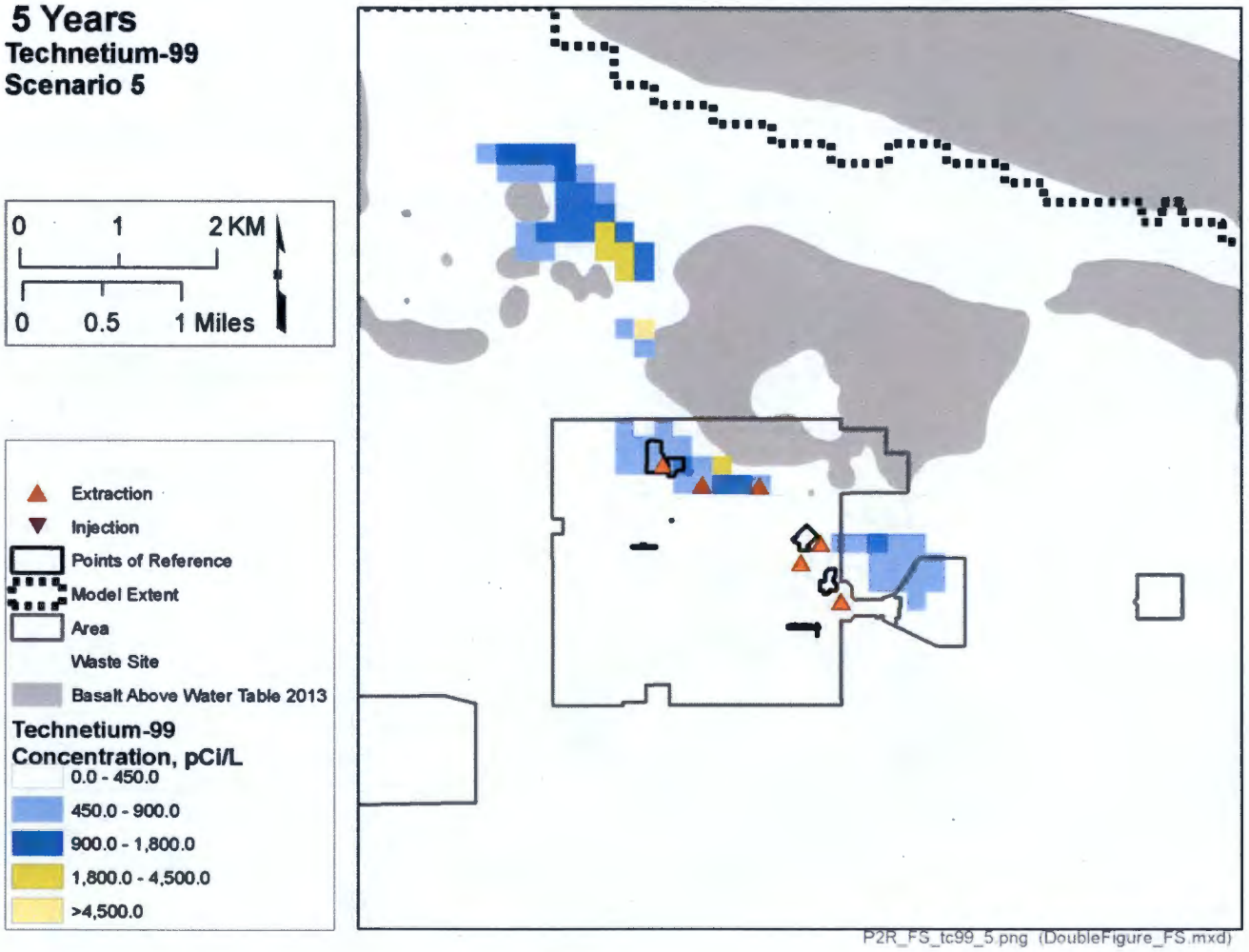

Figure B-228 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 5 simulation.

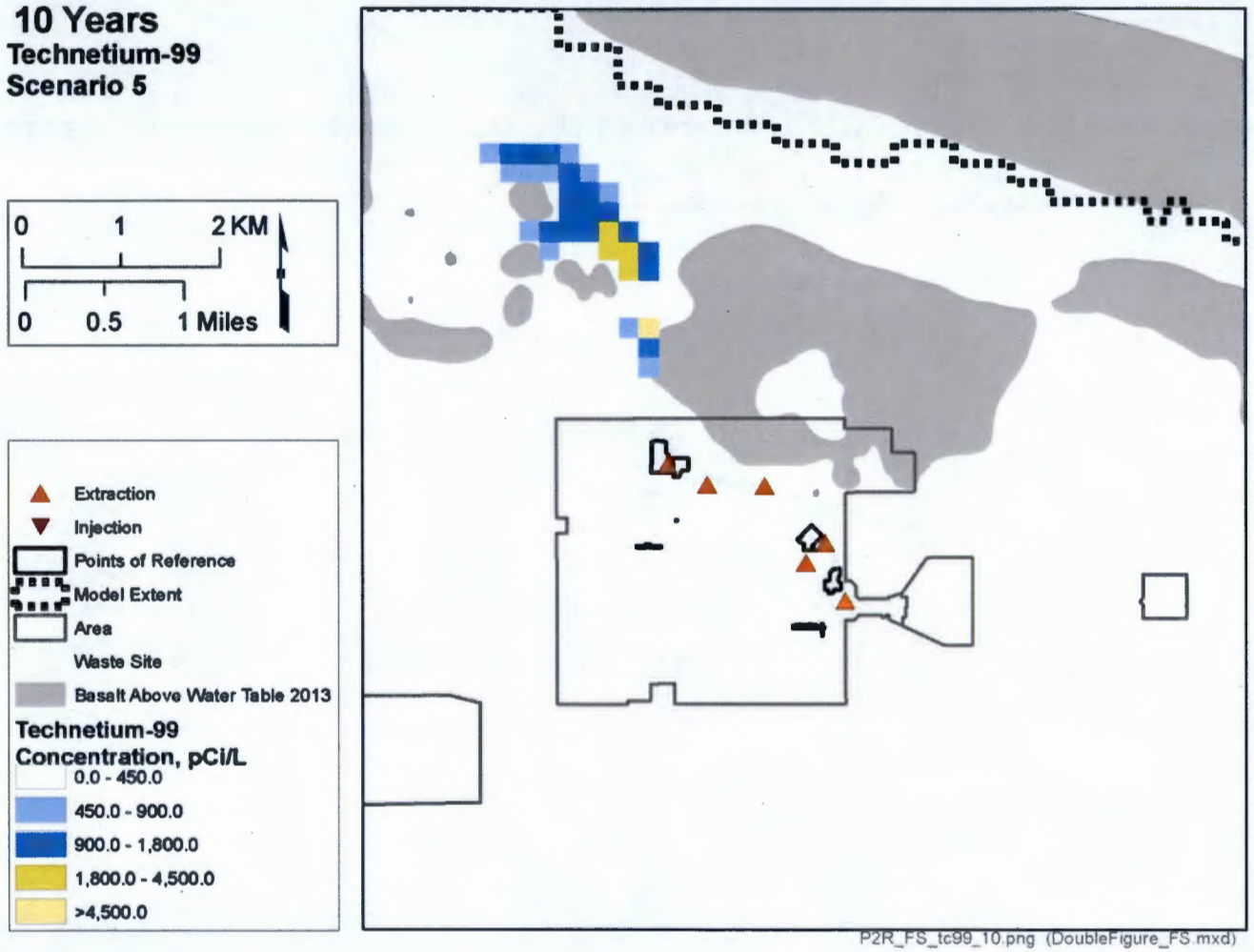

Figure B-229 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 5 simulation.

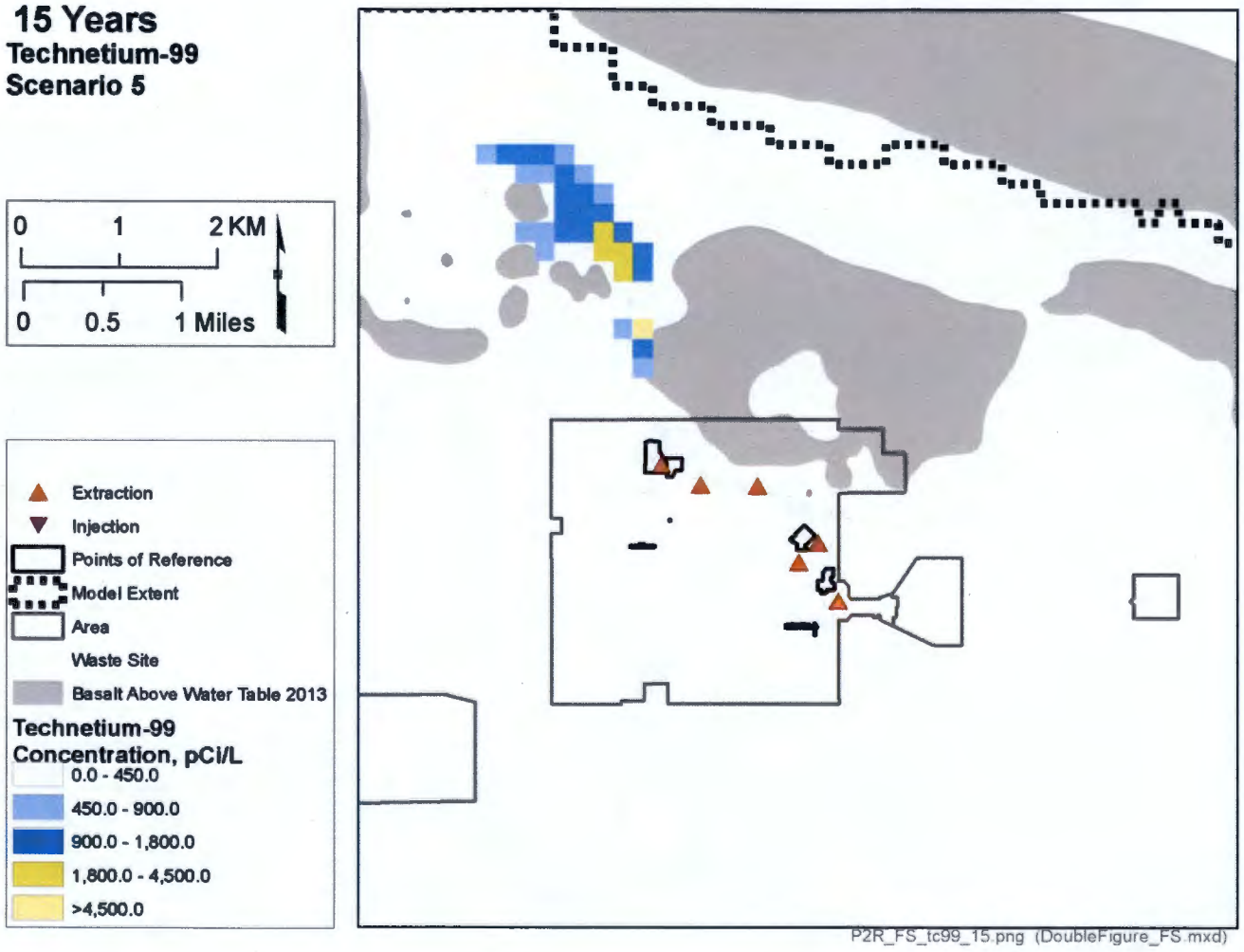

Figure B-230 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 5 simulation.

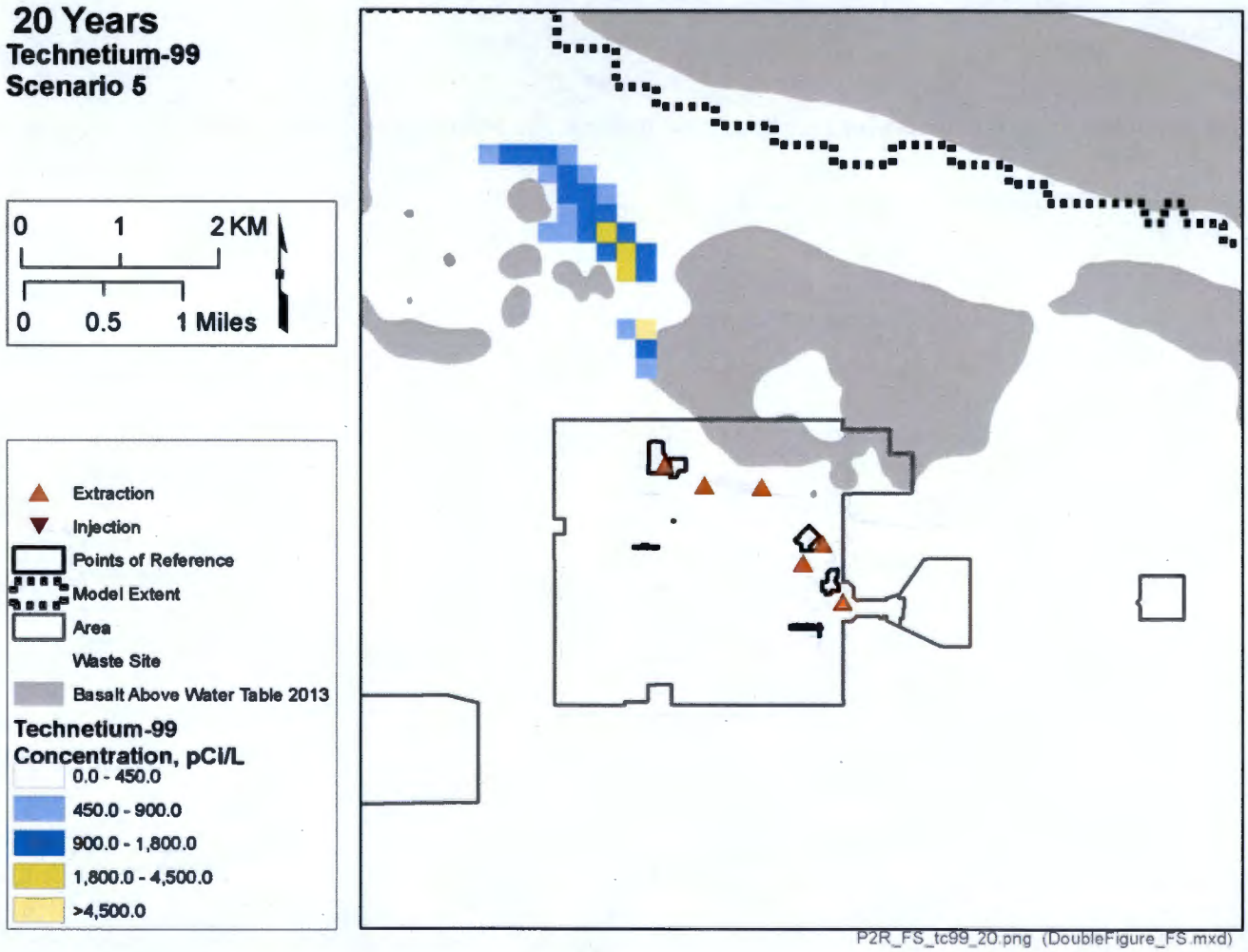

Figure B-231 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 5 simulation.

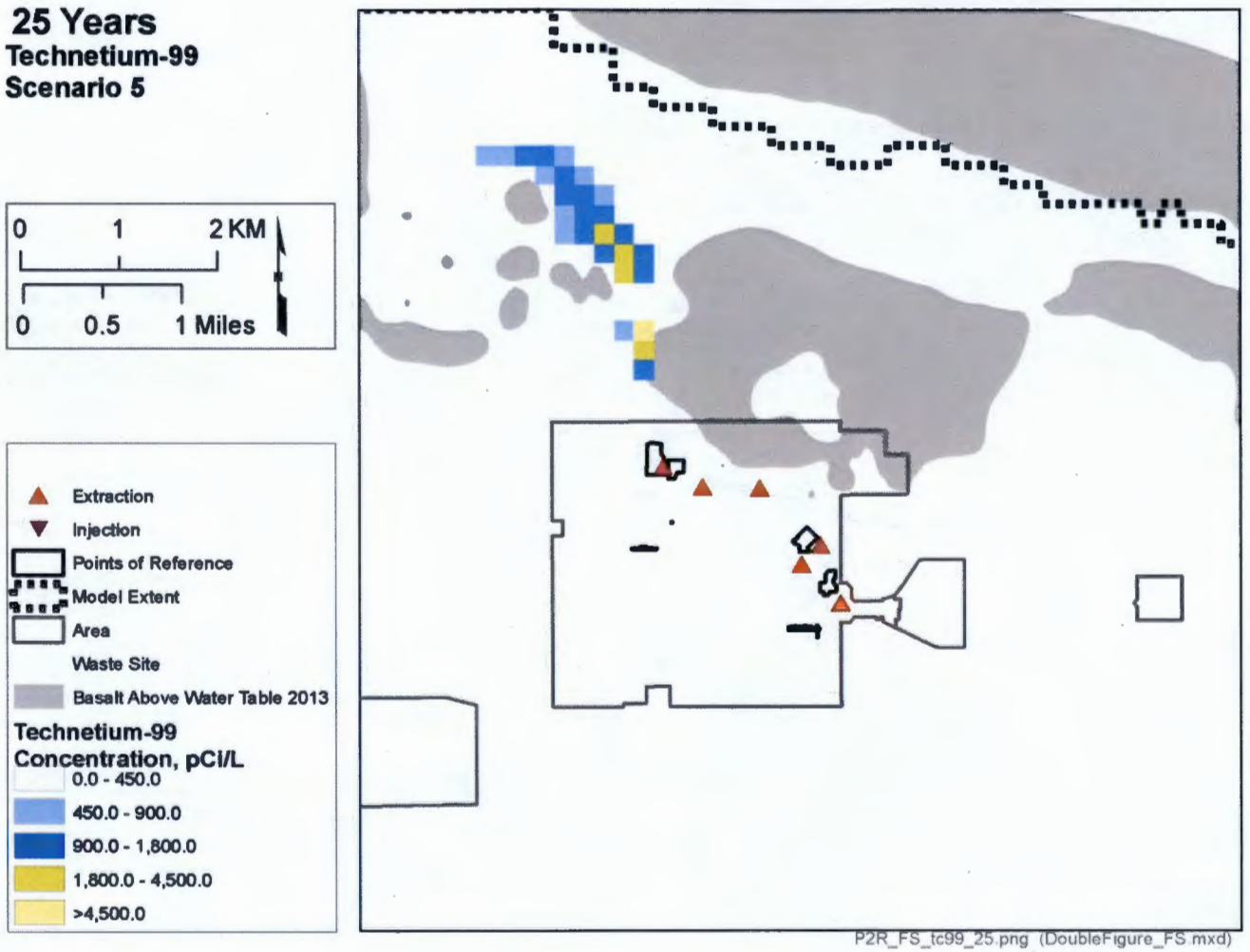

Figure B-232 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 5 simulation.

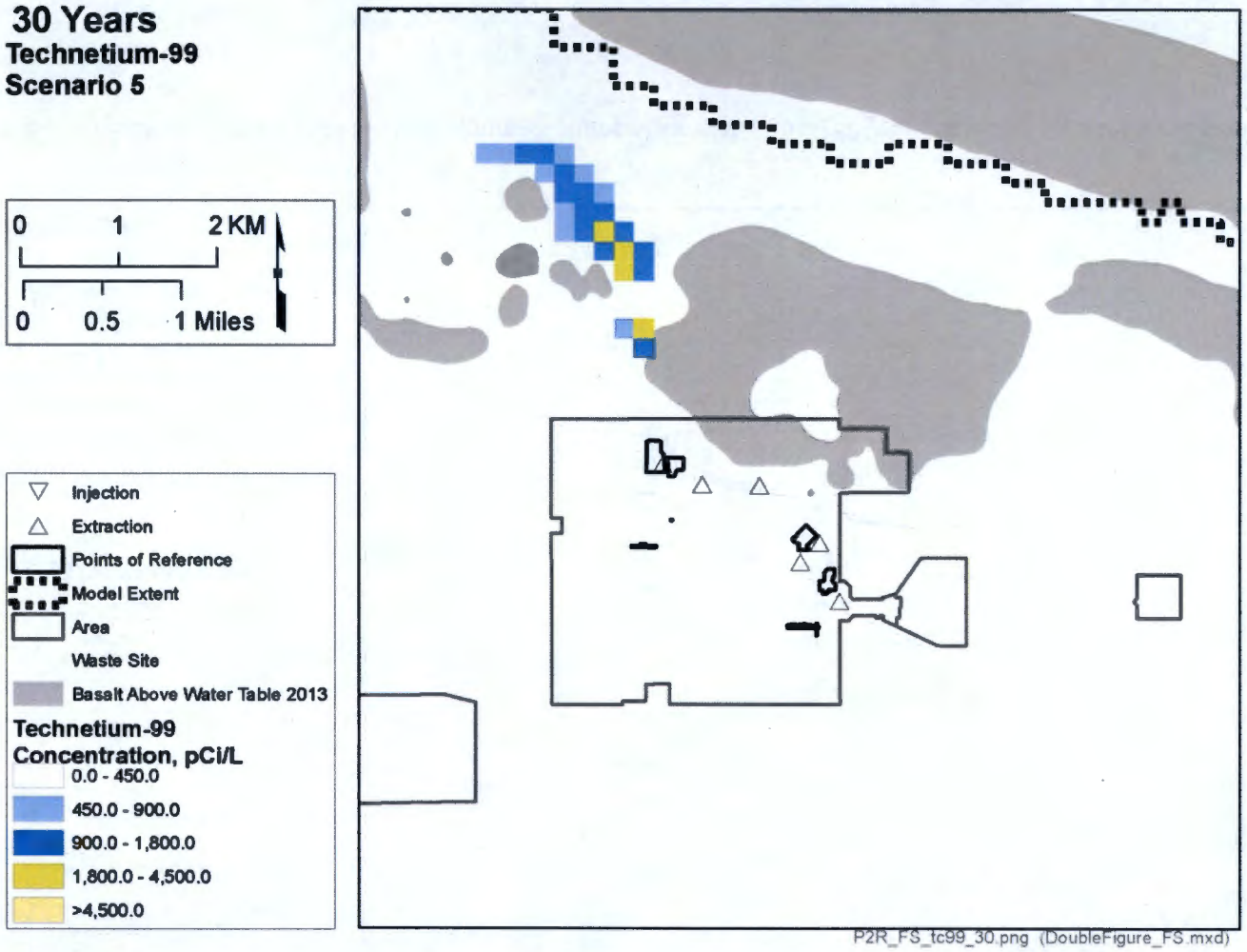

Figure B-233 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 5 simulation.

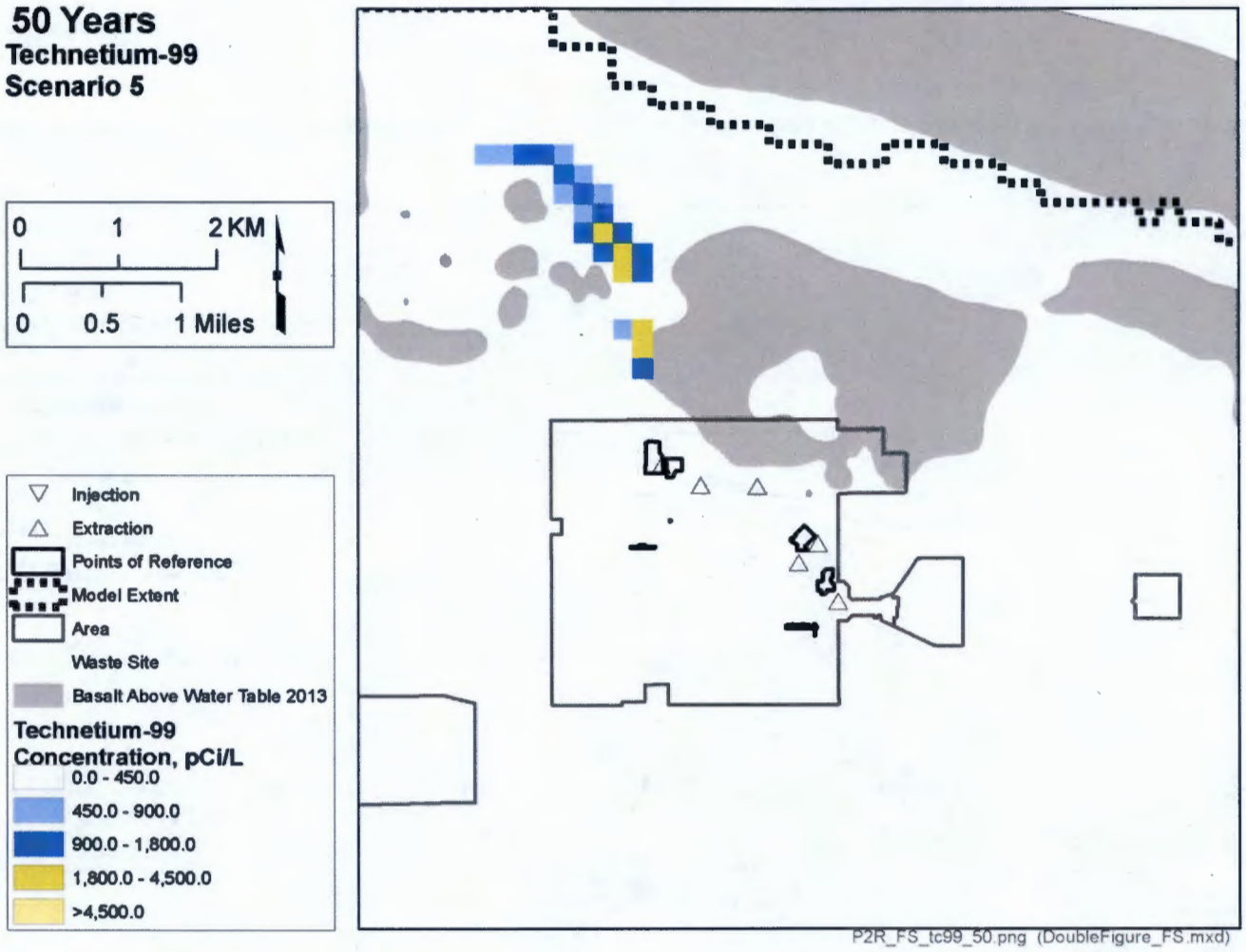

Figure B-234 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 5 simulation.

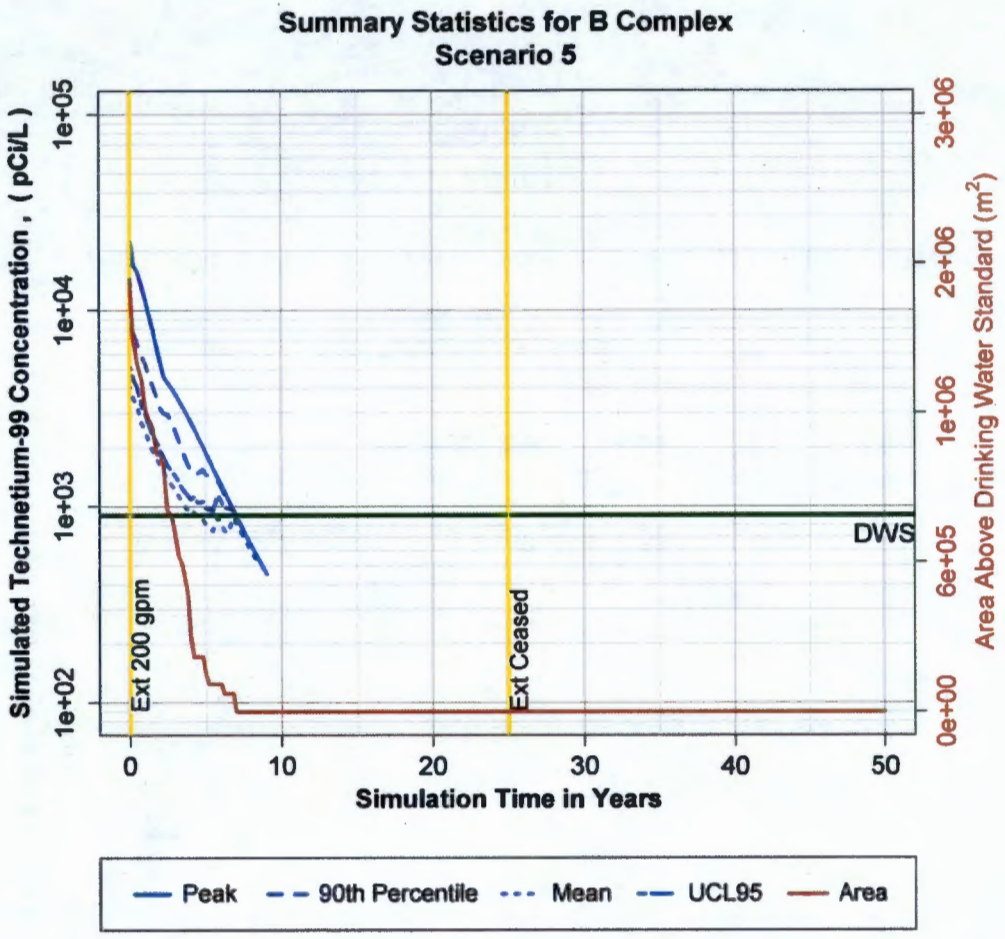

Figure B-235 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

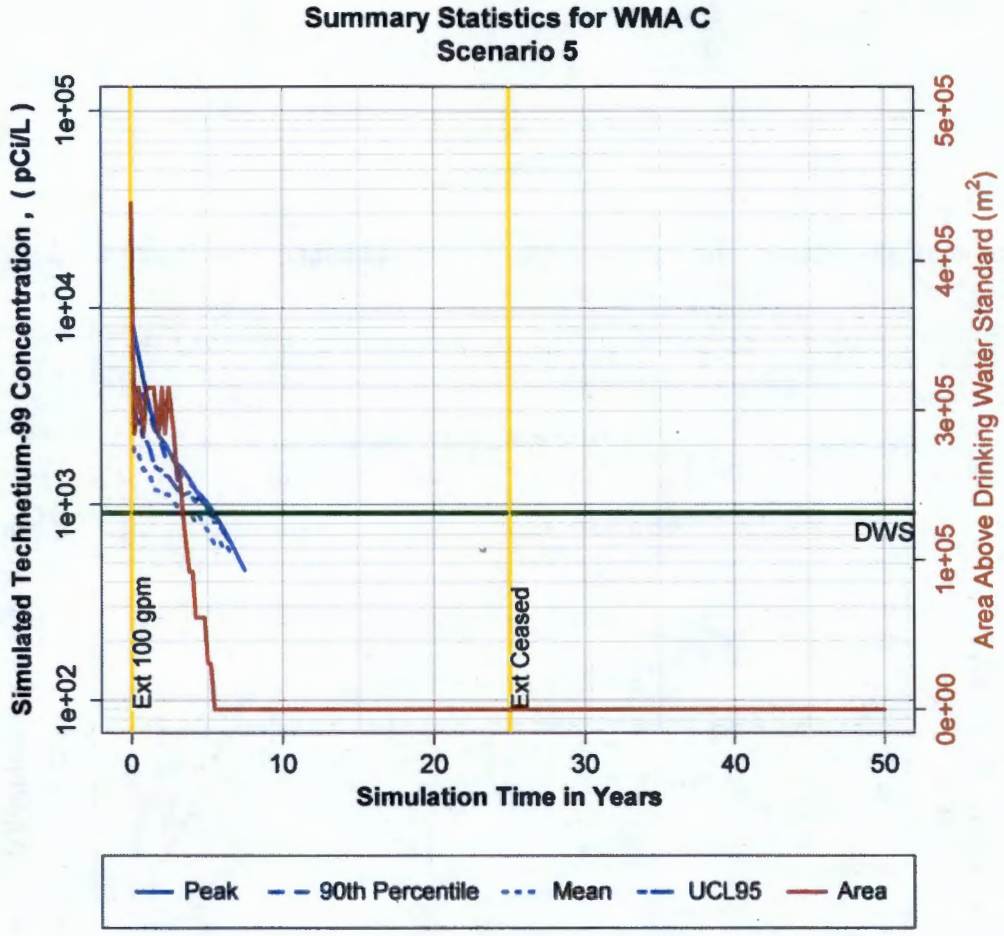

Figure B-236 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

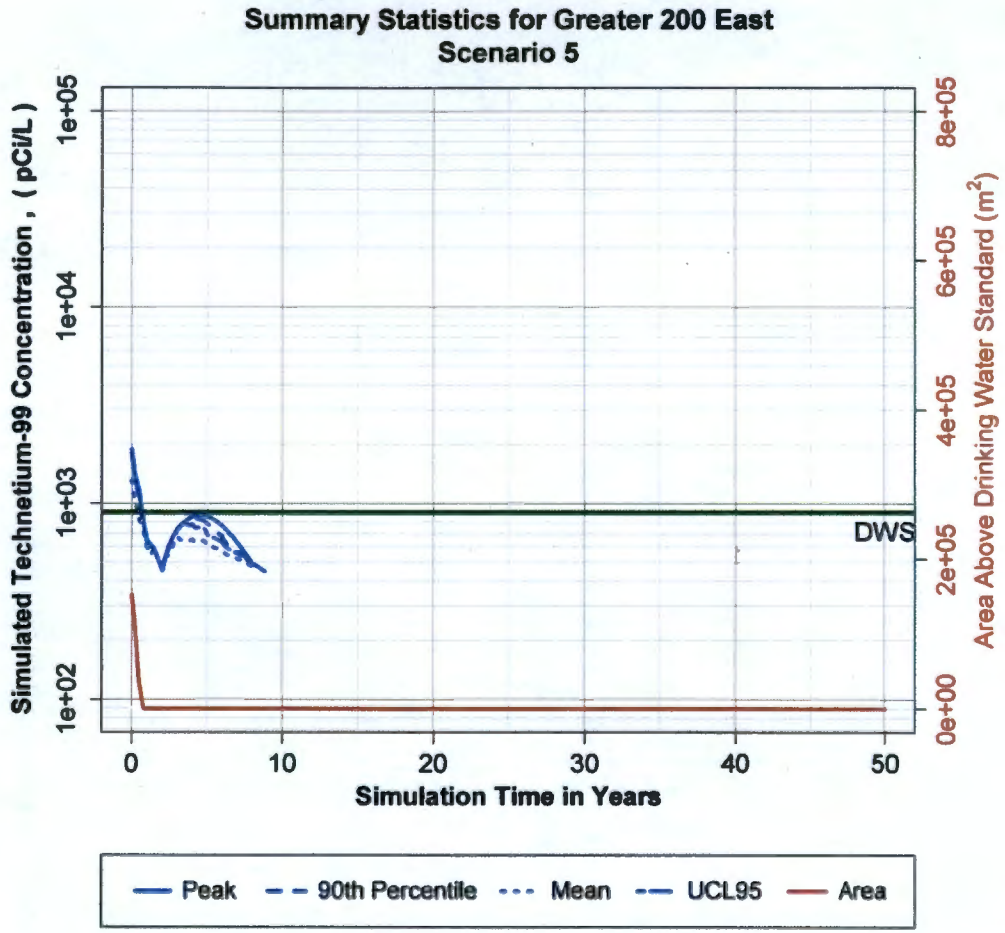

Figure B-237 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

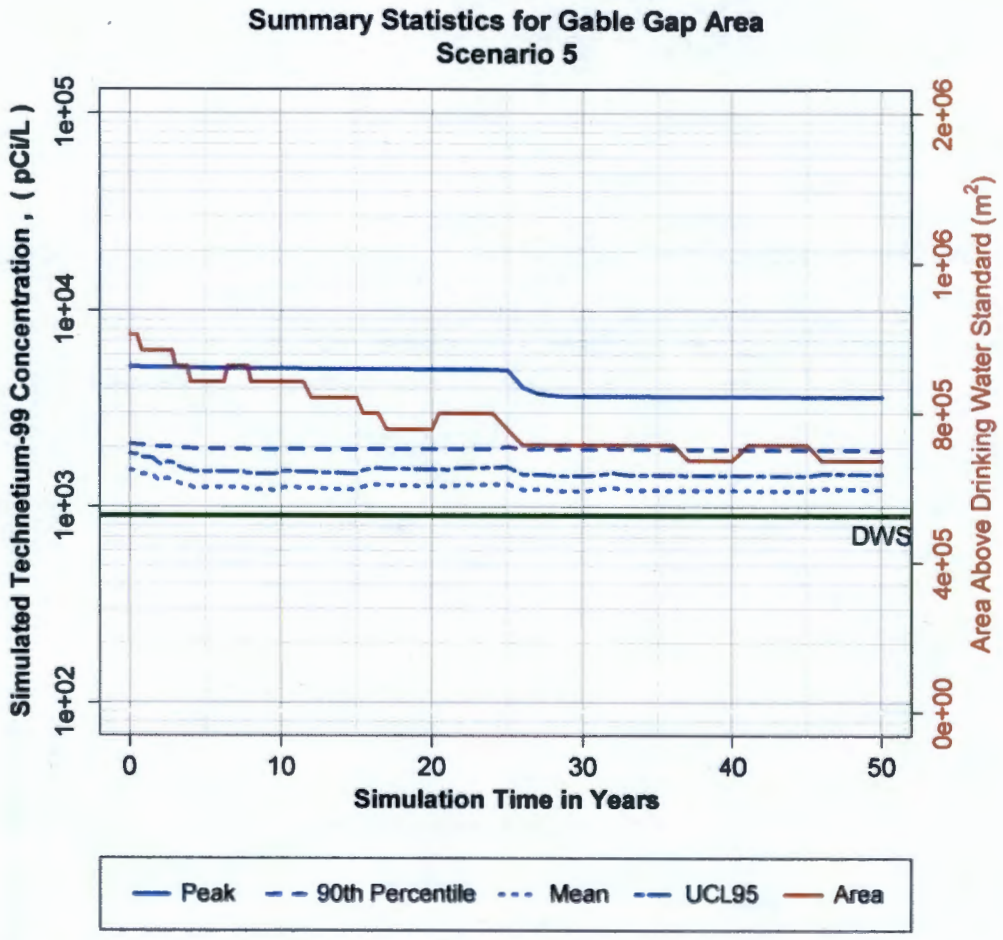

Figure B-238 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

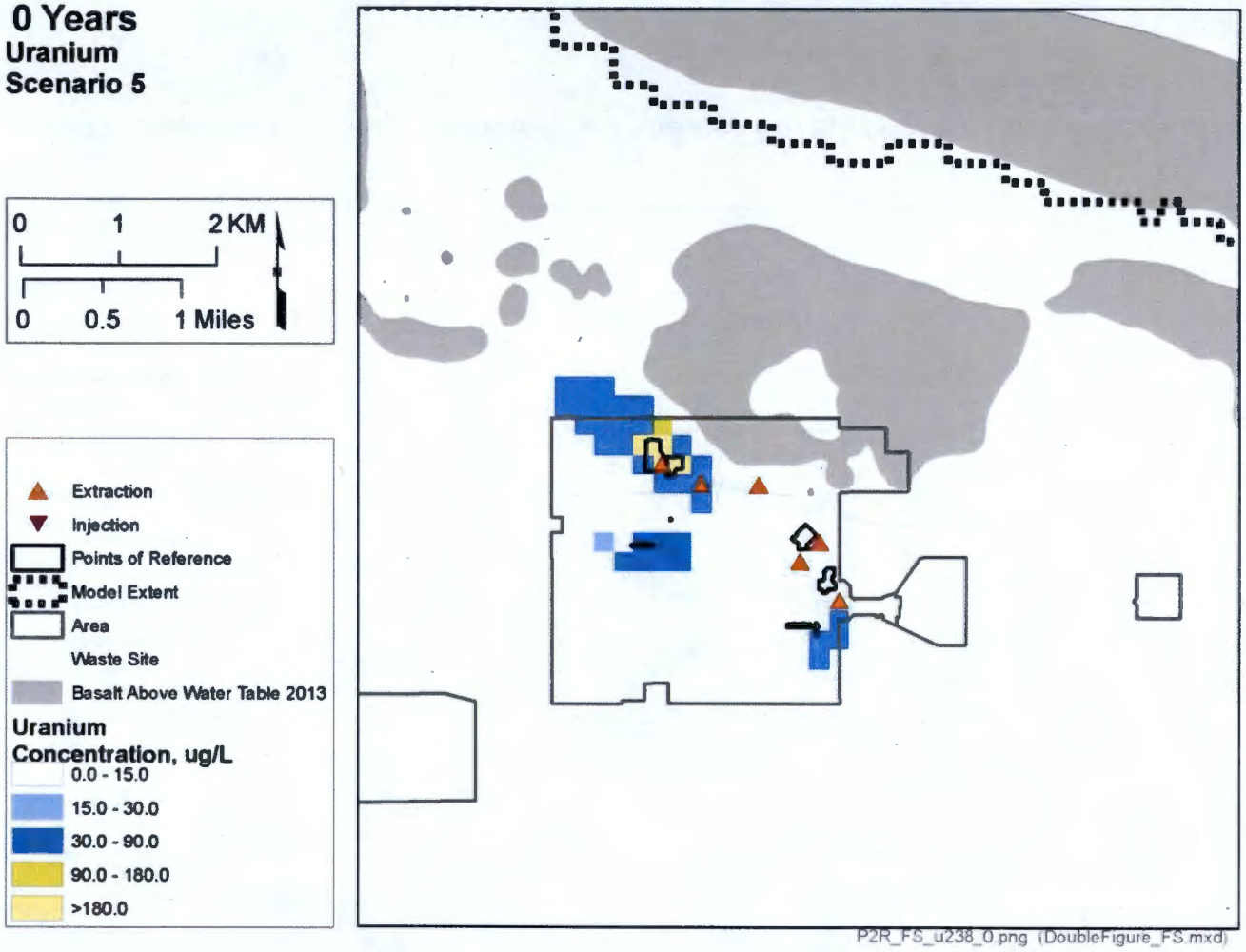

Figure B-239 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 5 simulation.

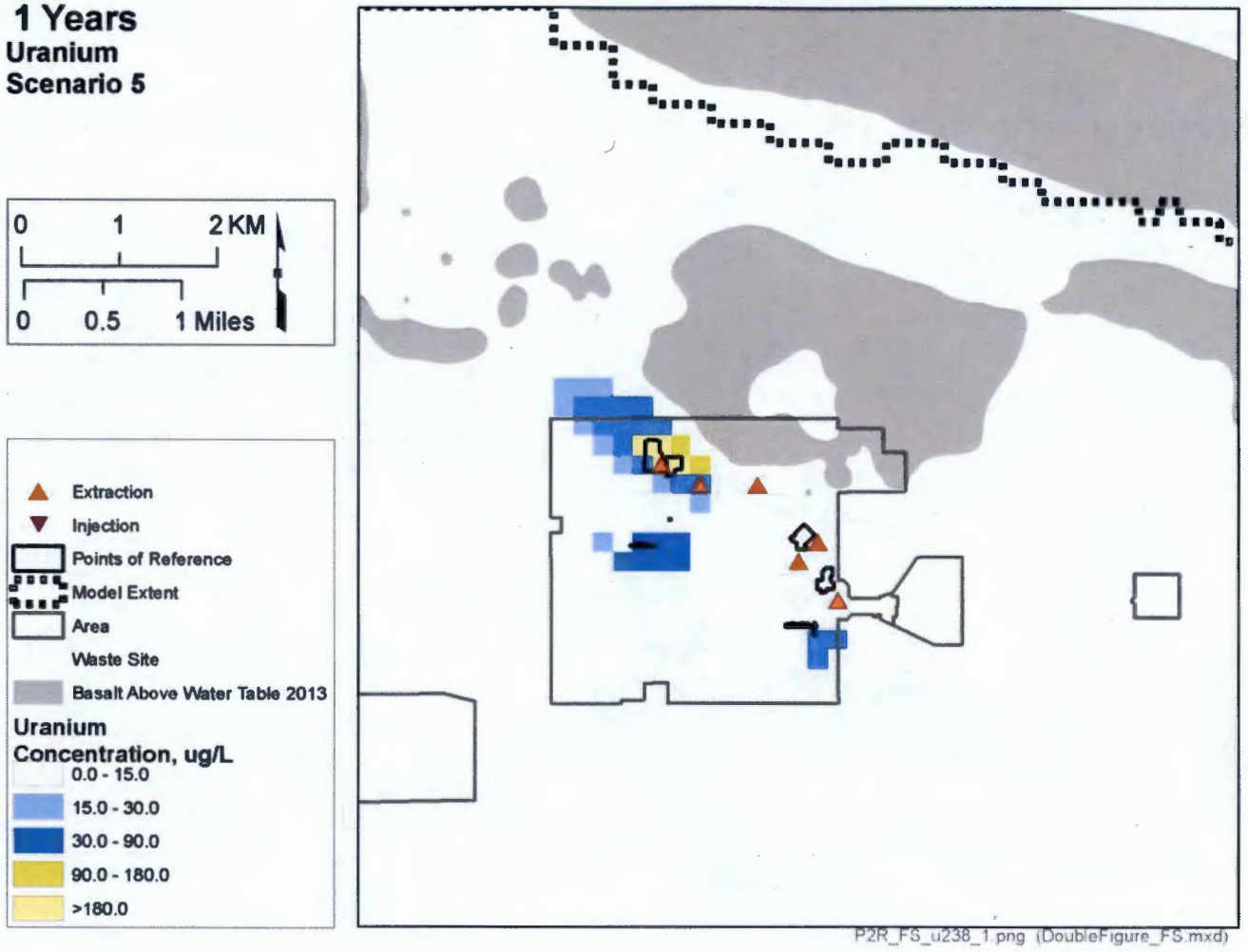

Figure B-240 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 5 simulation.

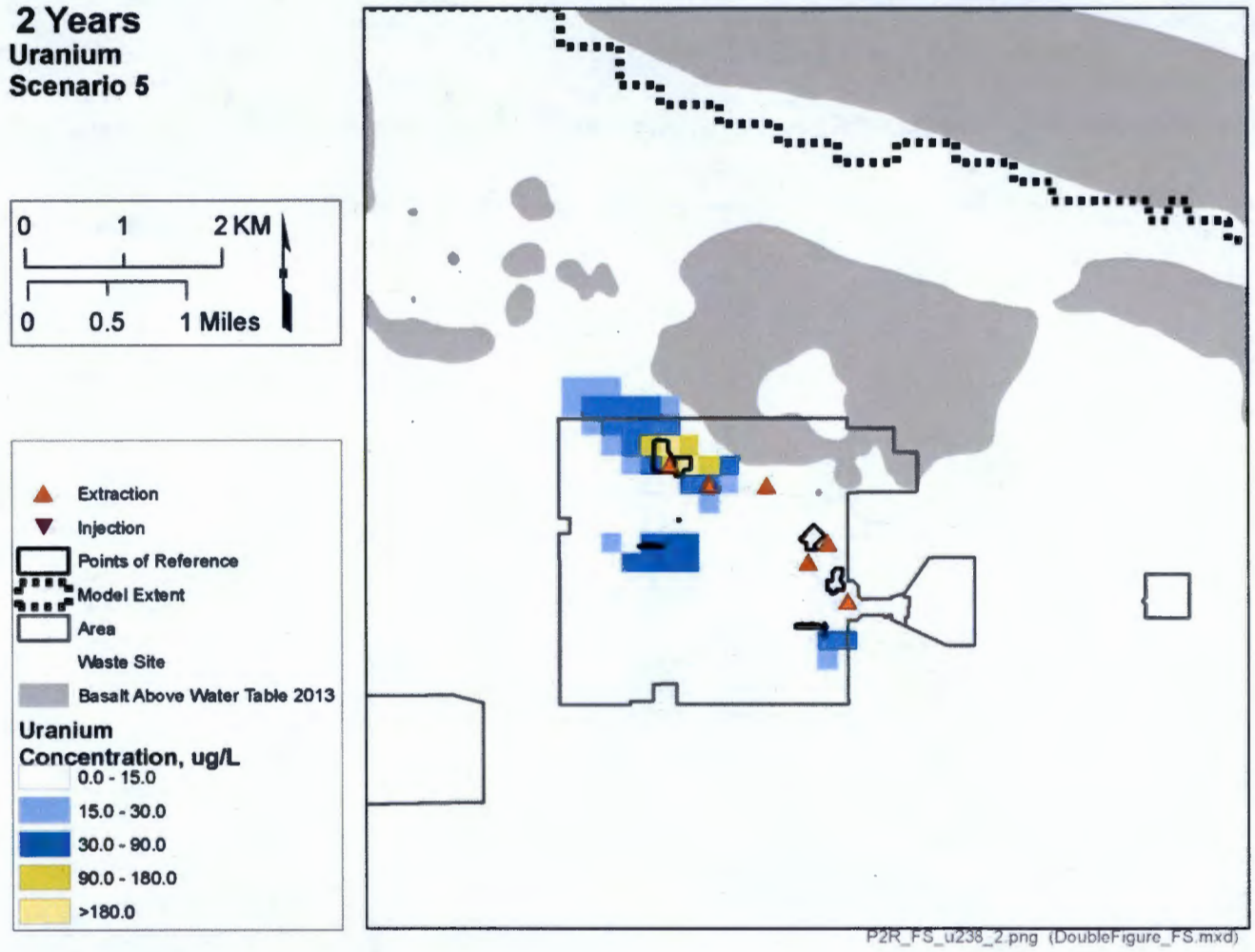

Figure B-241 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 5 simulation.

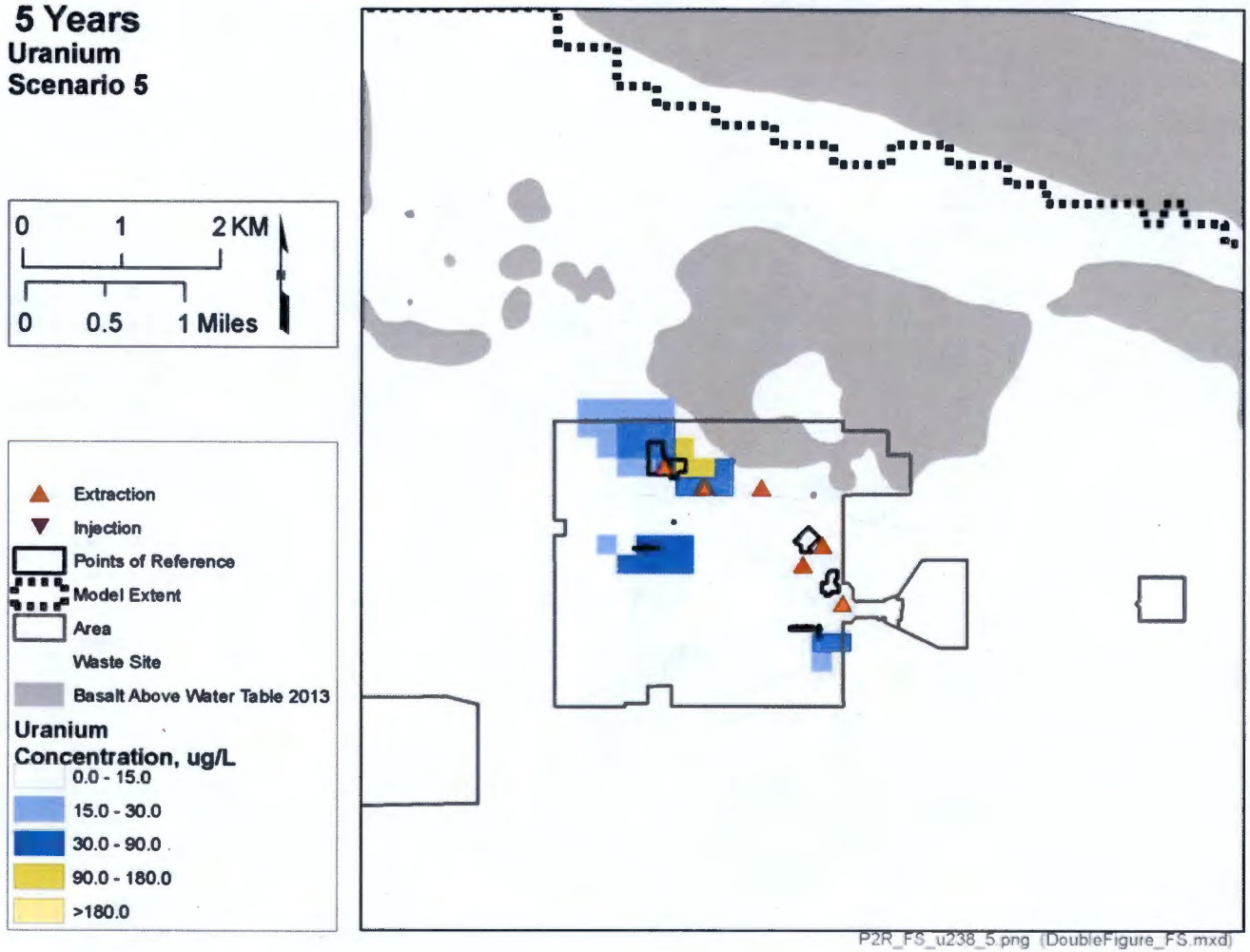

Figure B-242 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 5 simulation.

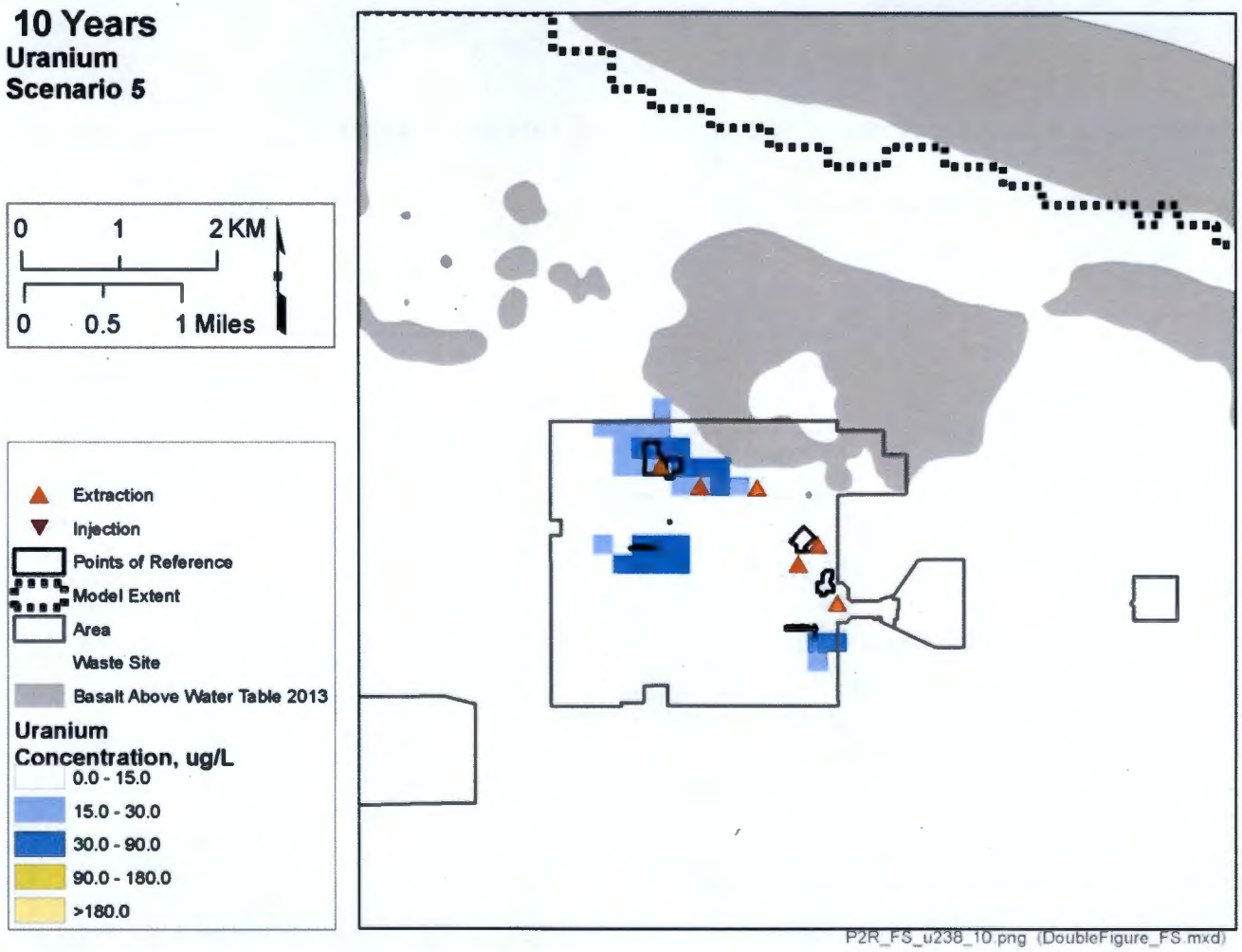

Figure B-243 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 5 simulation.

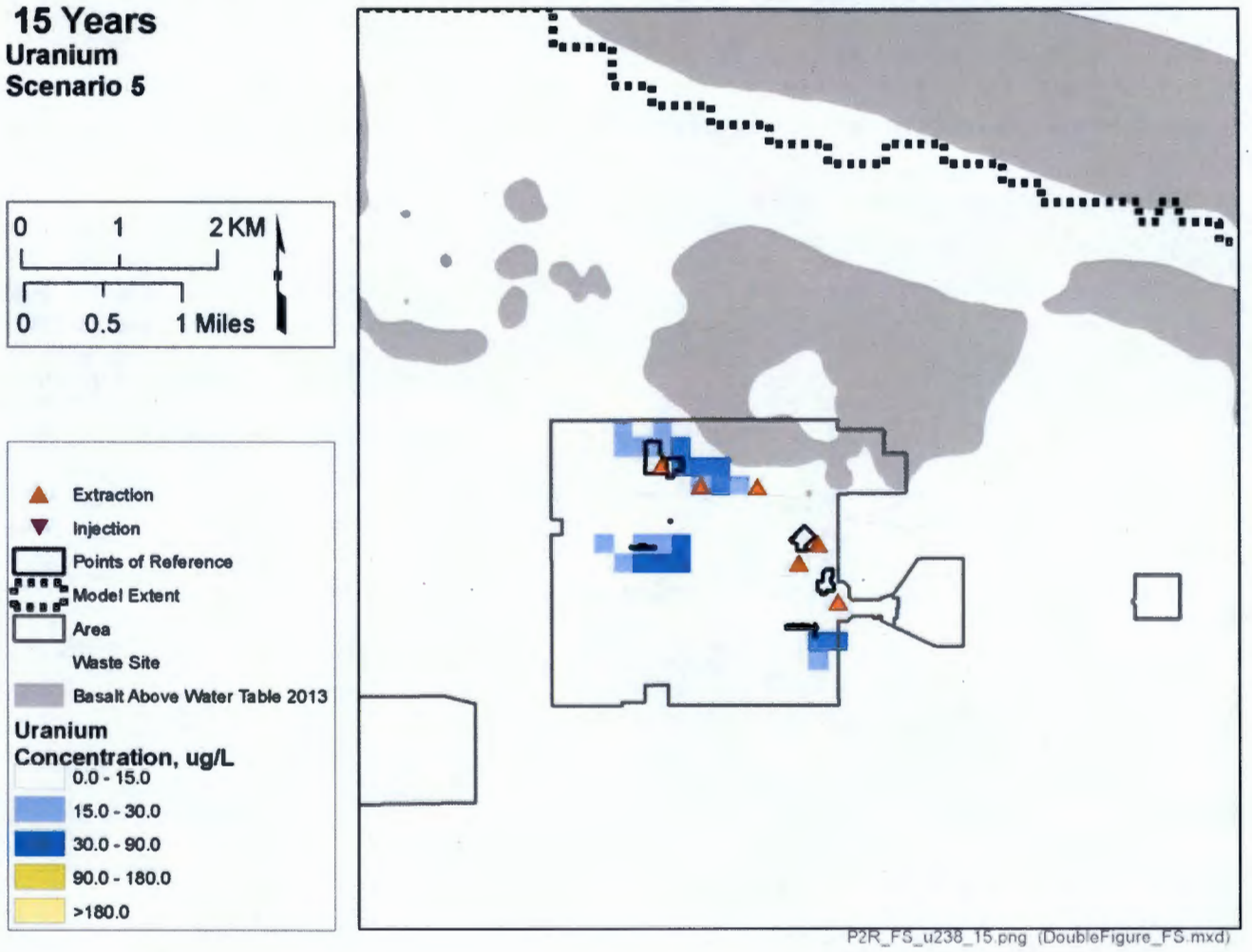

Figure B-244 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 5 simulation.

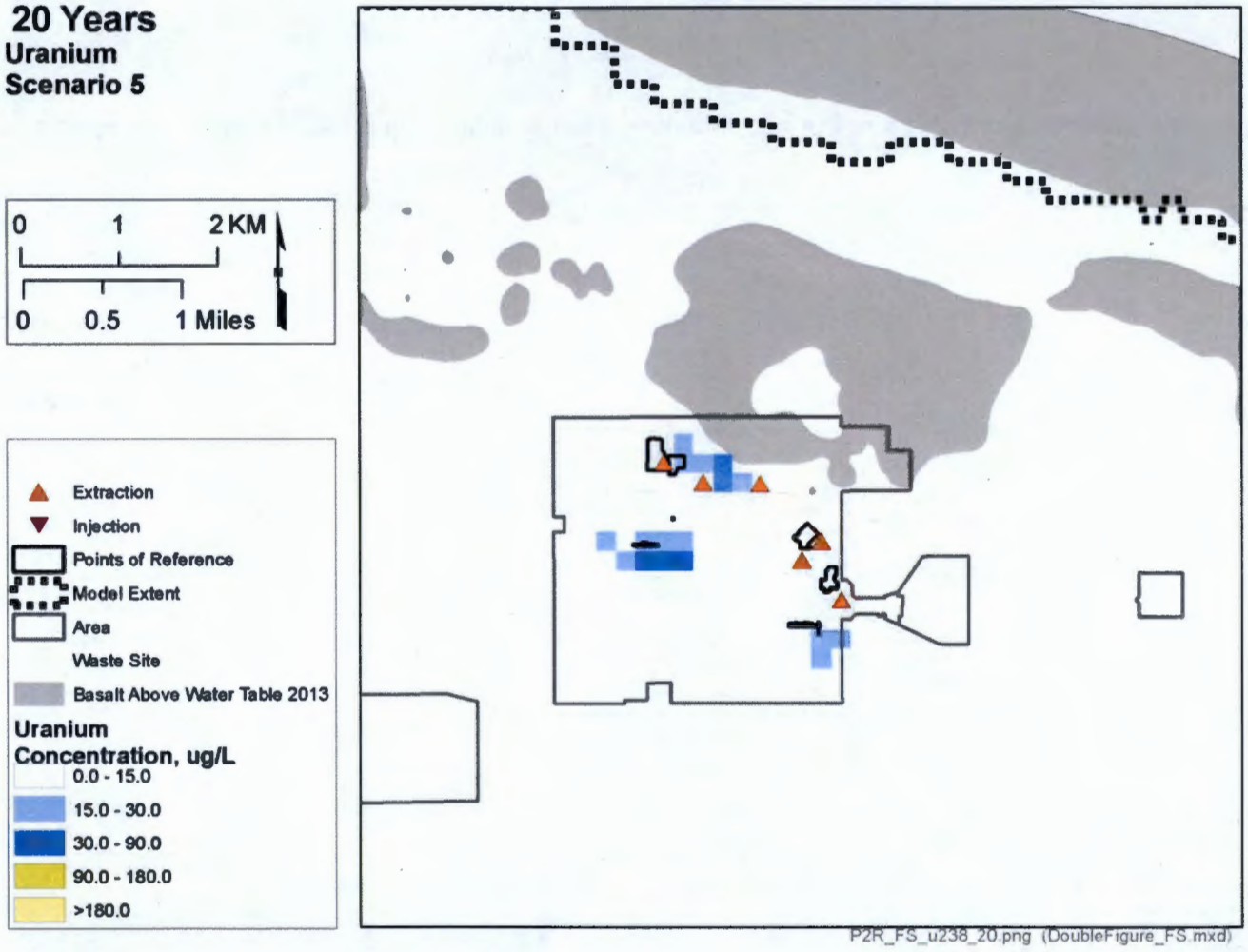

Figure B-245 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 5 simulation.

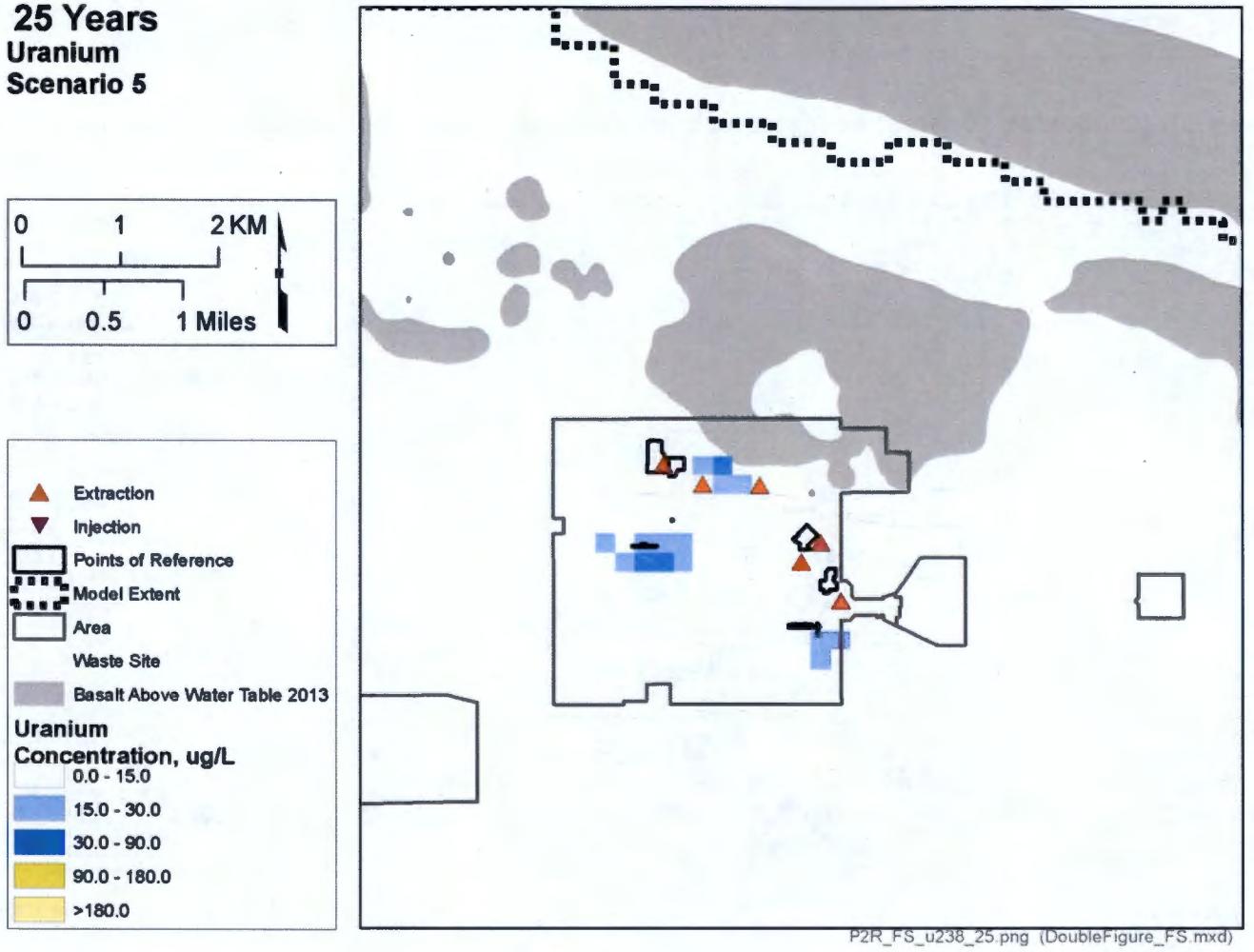

Figure B-246 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 5 simulation.

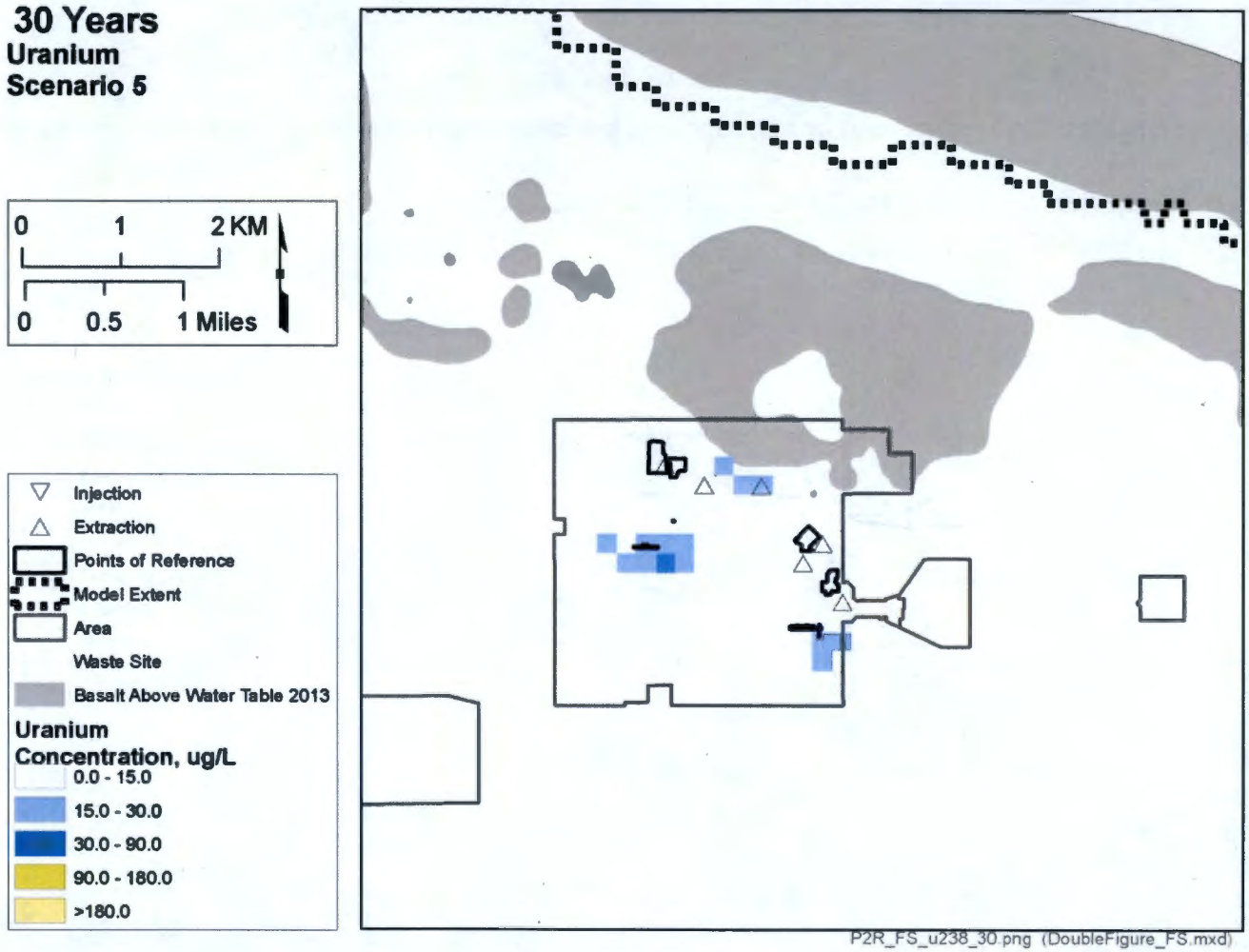

Figure B-247 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 5 simulation.

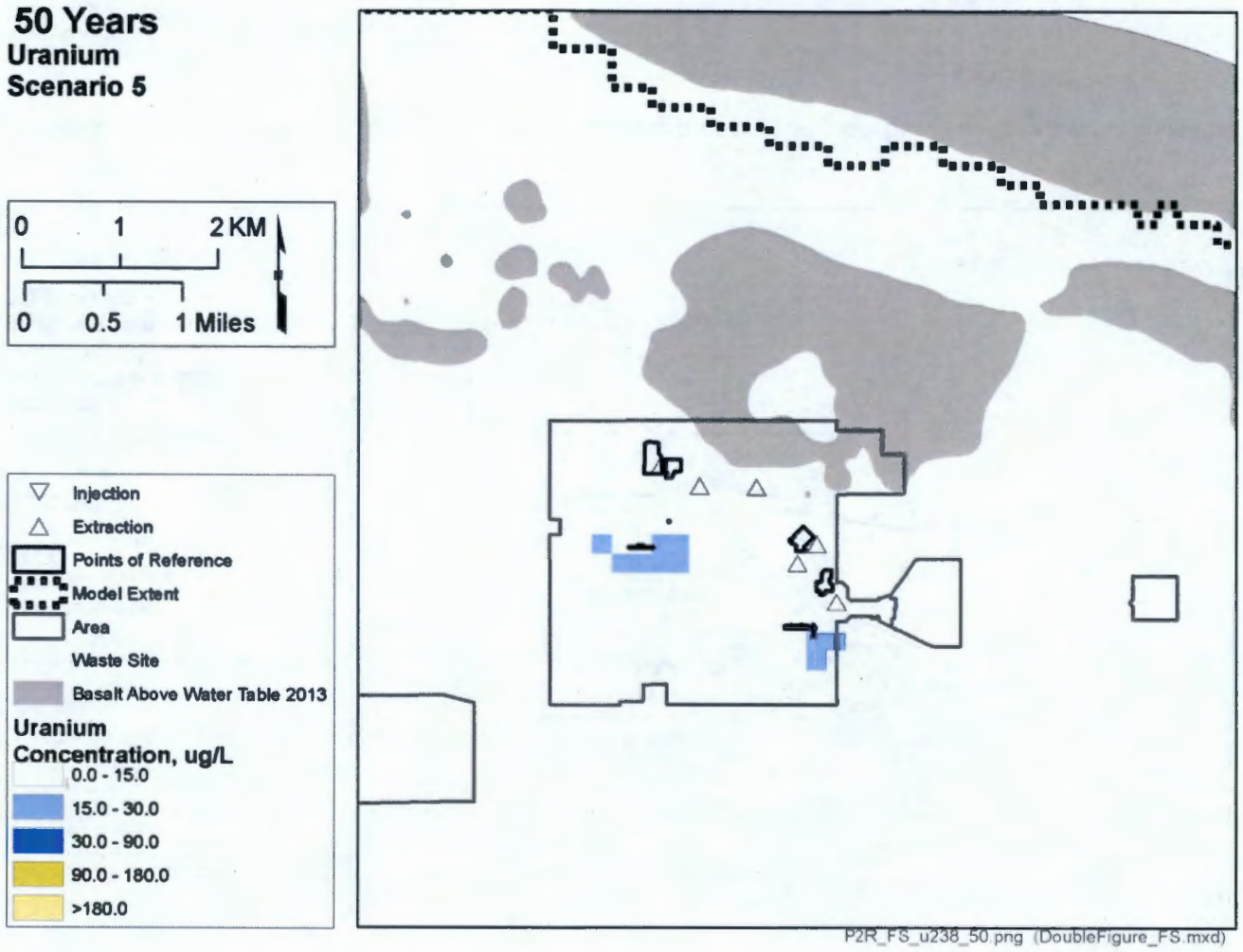

Figure B-248 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 5 simulation.

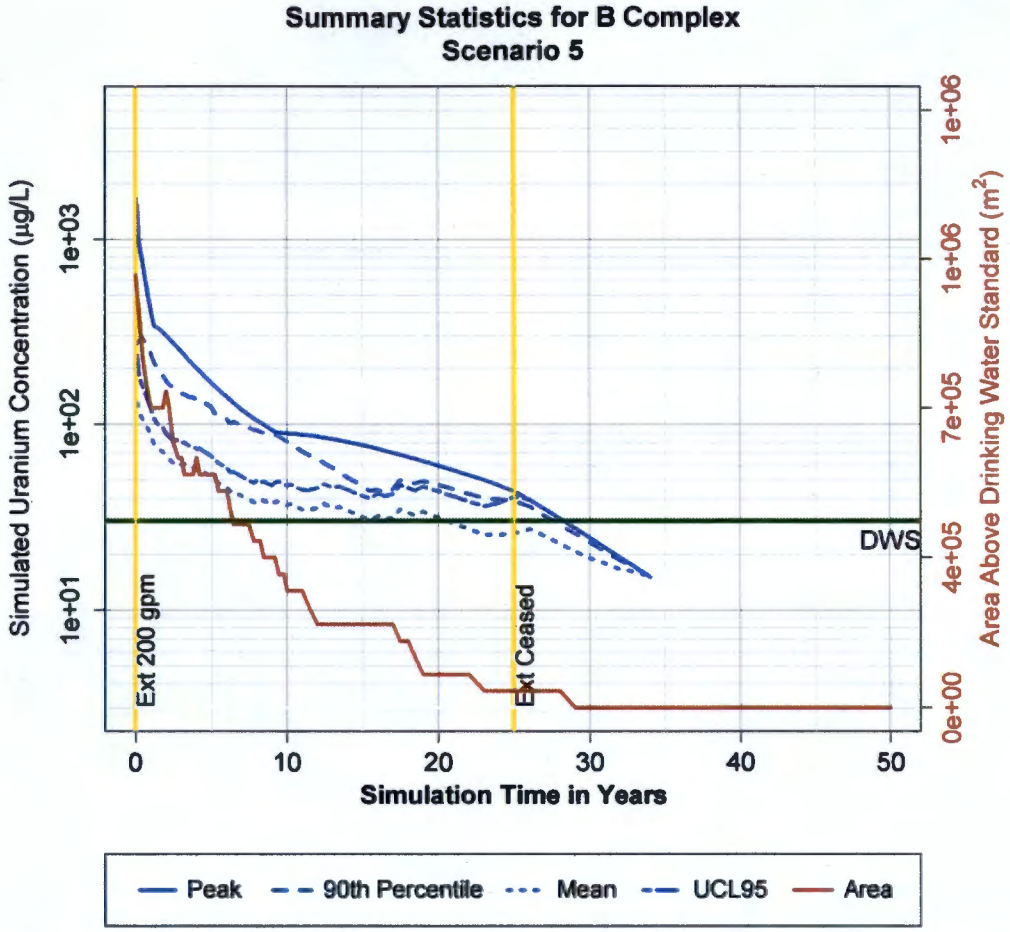

Figure B-249 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

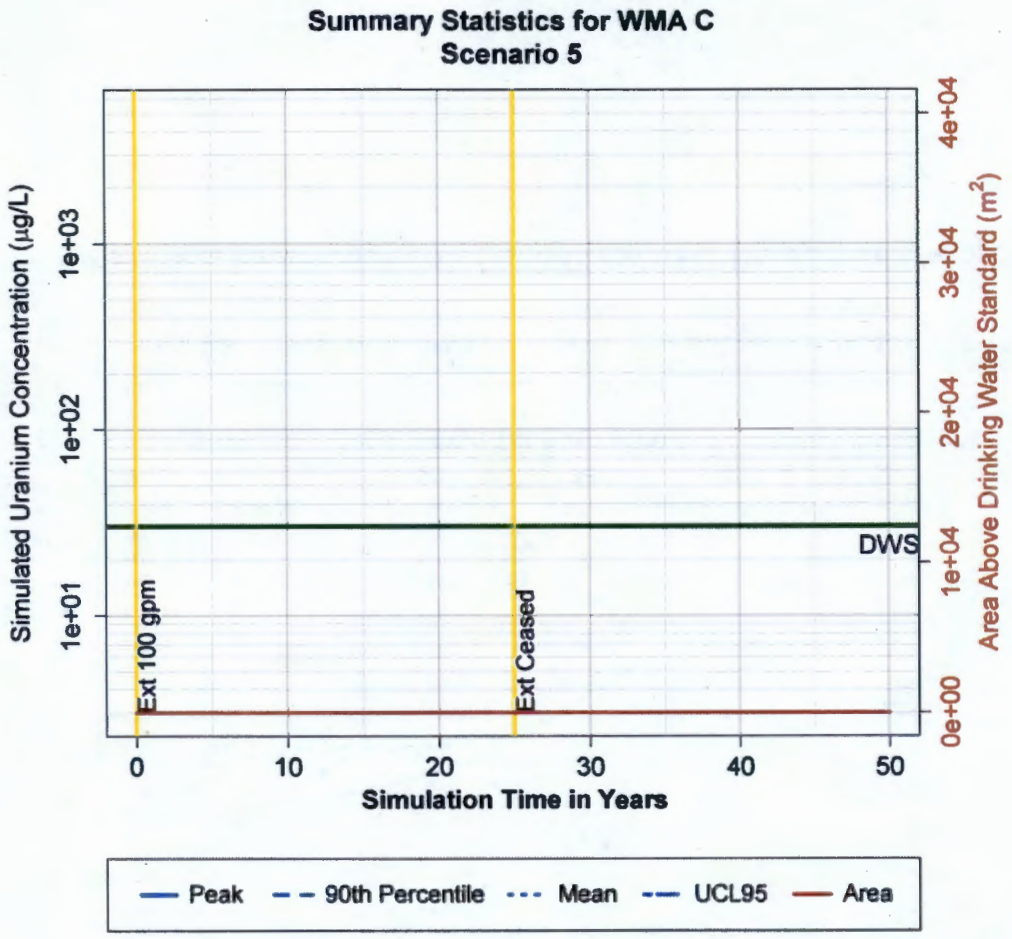

Figure B-250 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

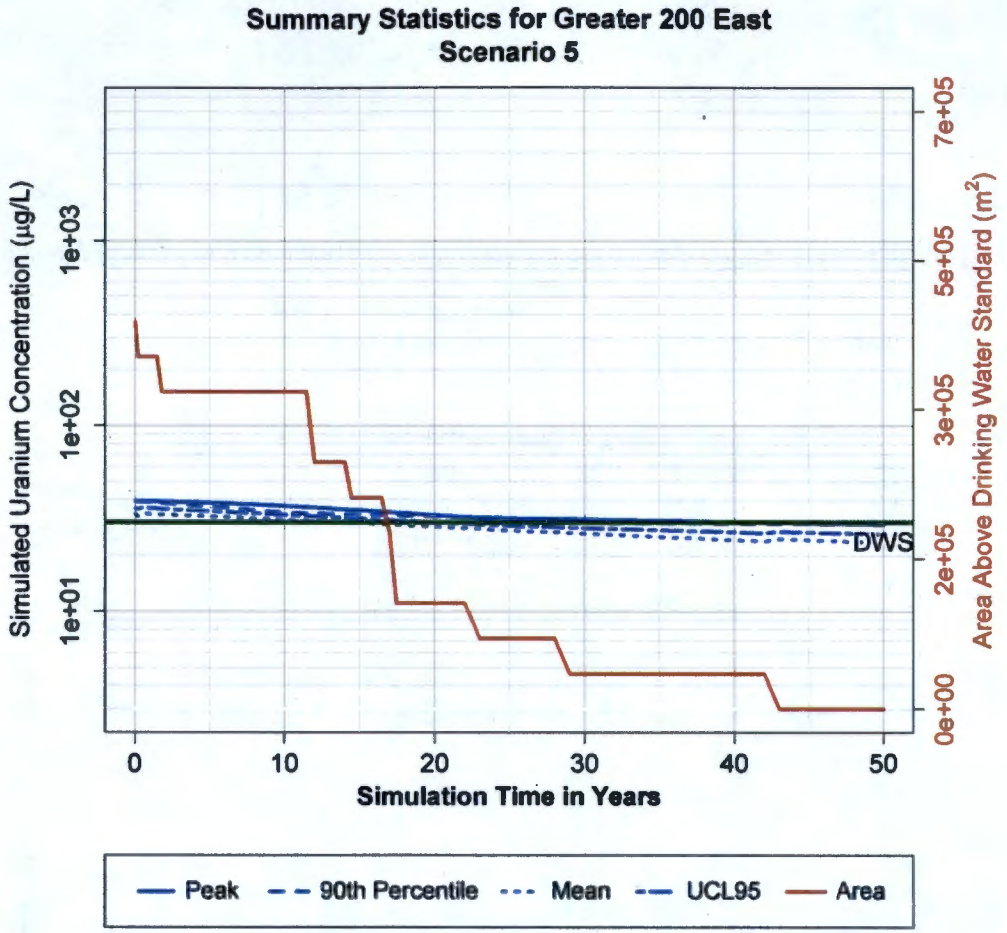

Figure B-251 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

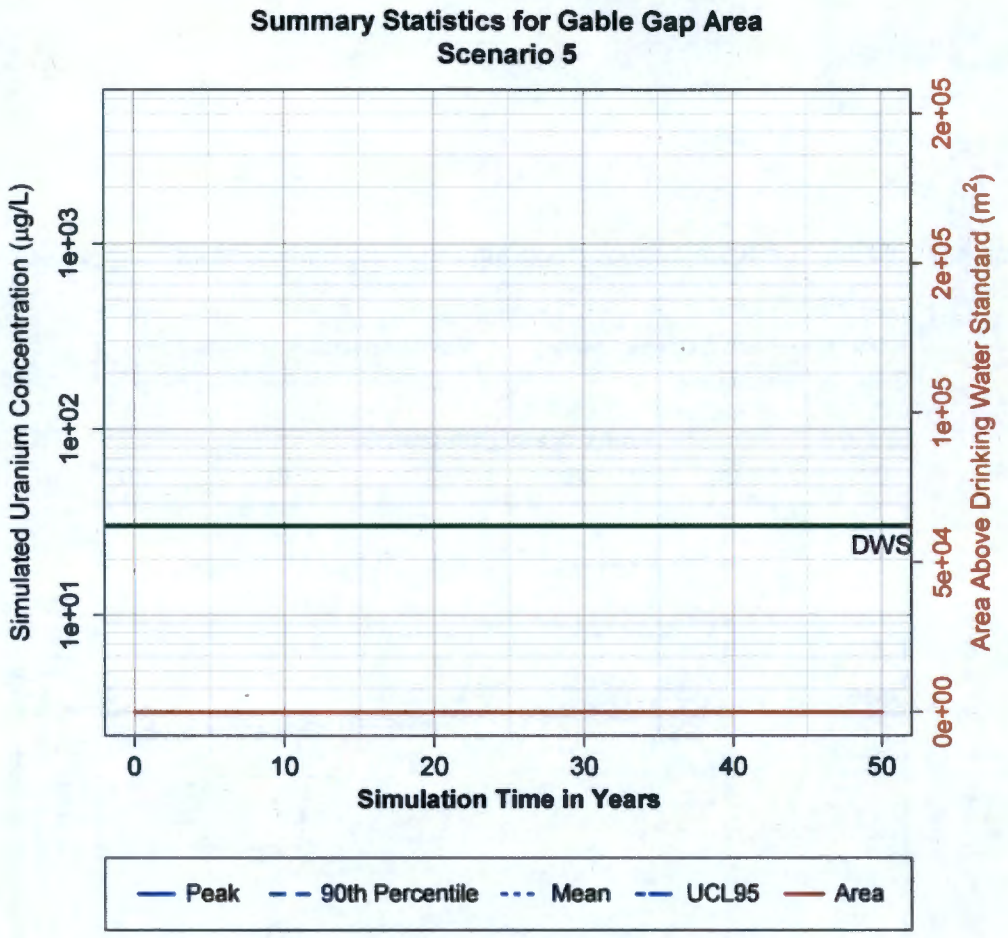

Figure B-252 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

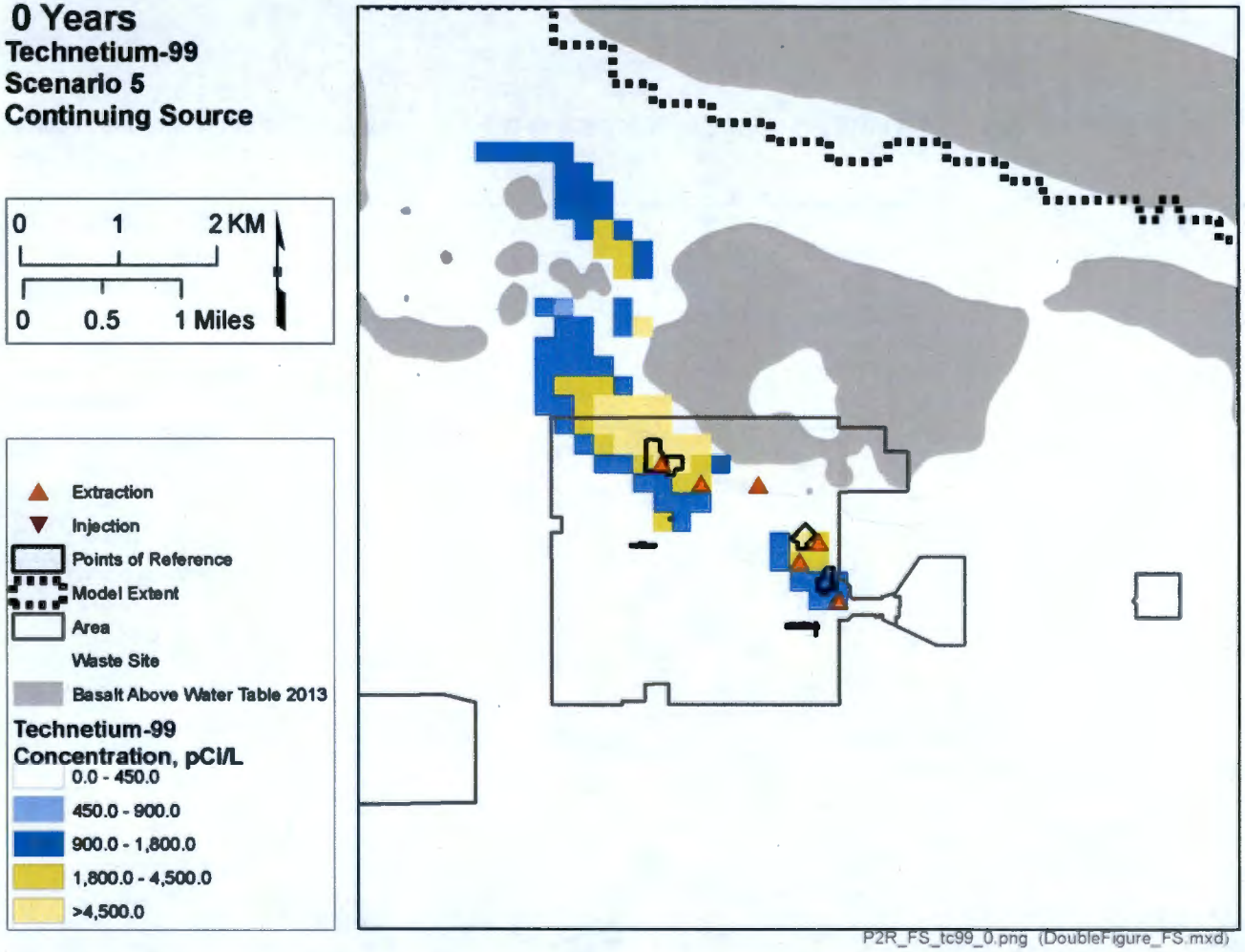

Figure B-253 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 5 simulation with a continuing source term.

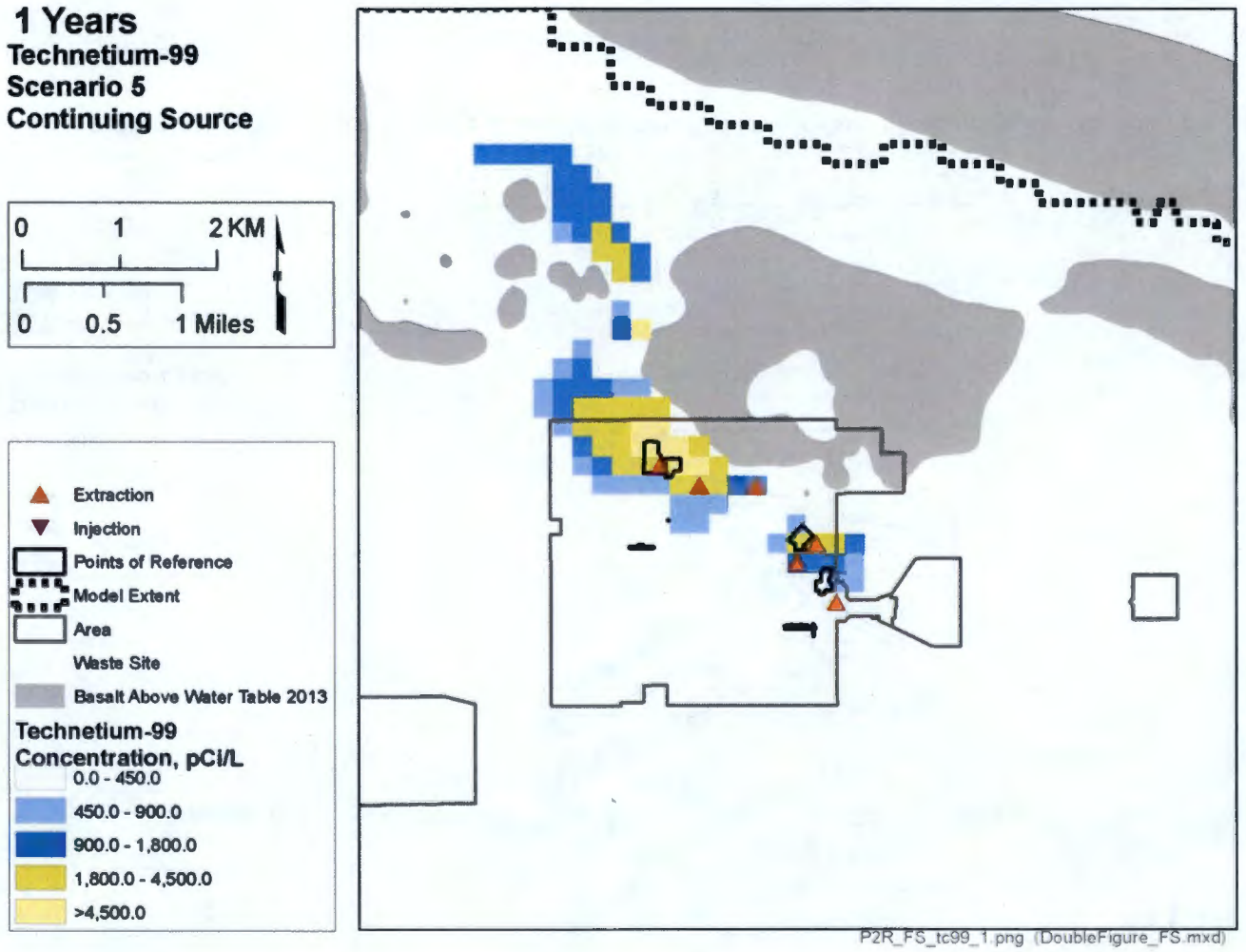

Figure B-254 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 5 simulation with a continuing source term.

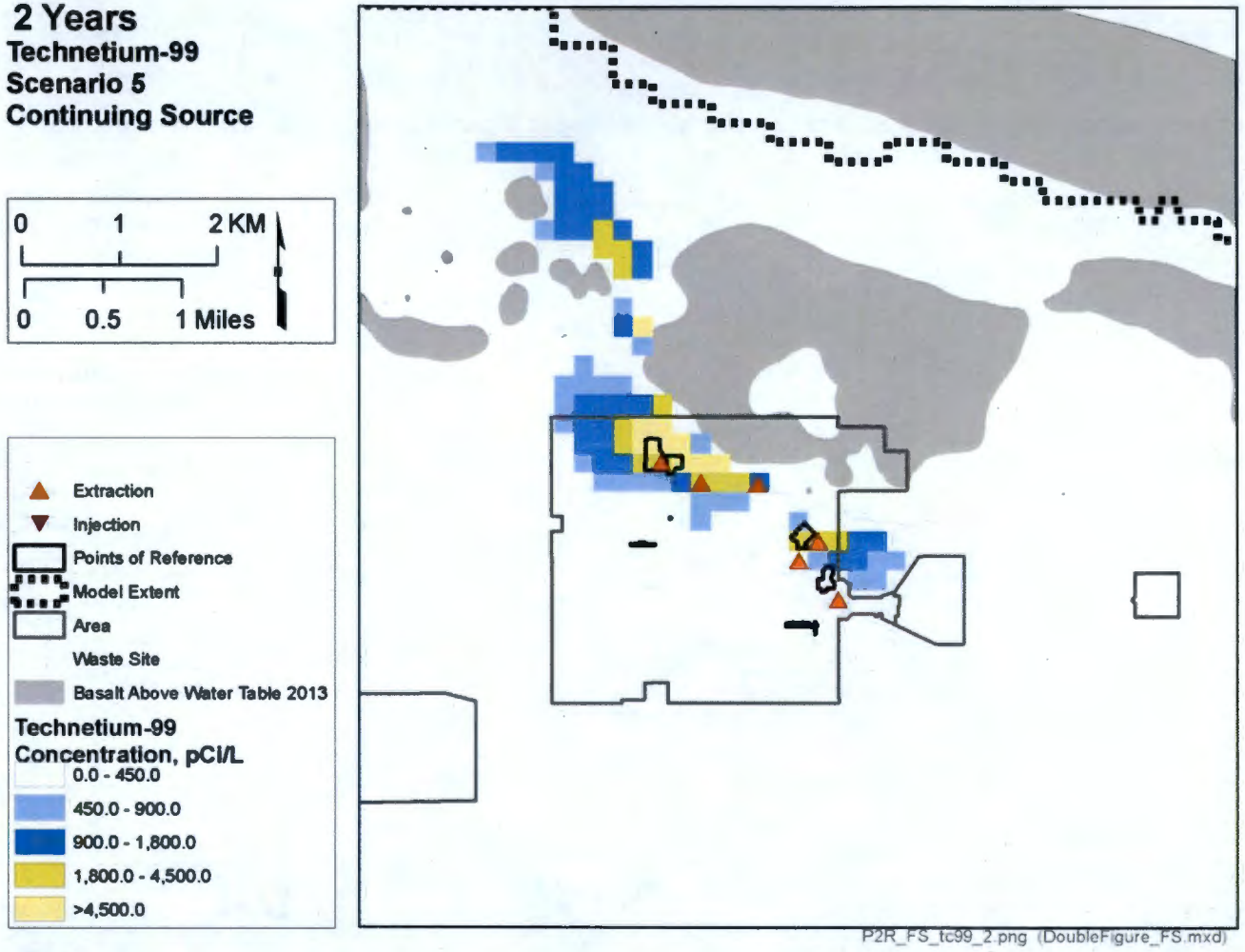

Figure B-255 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 5 simulation with a continuing source term.

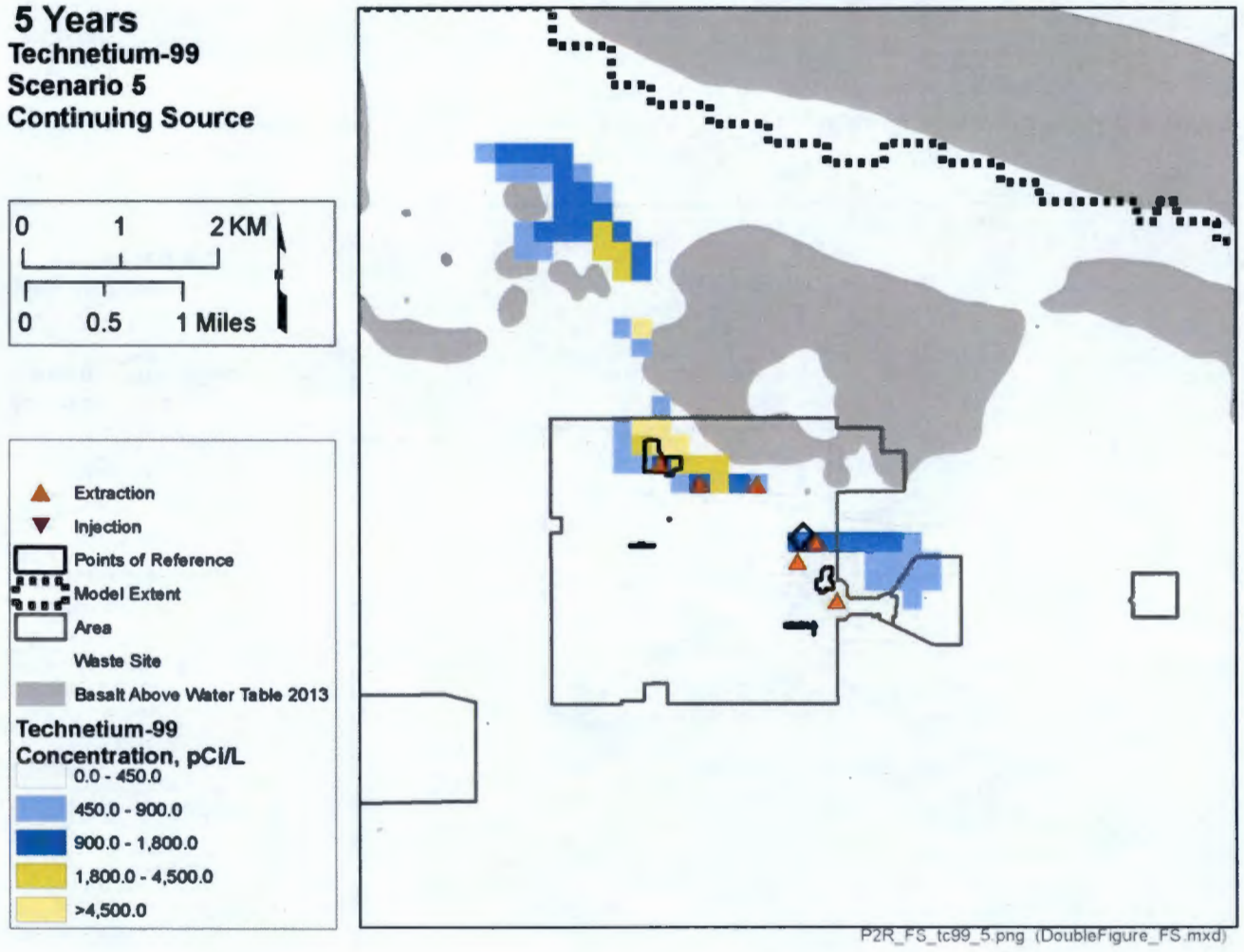

Figure B-256 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 5 simulation with a continuing source term.

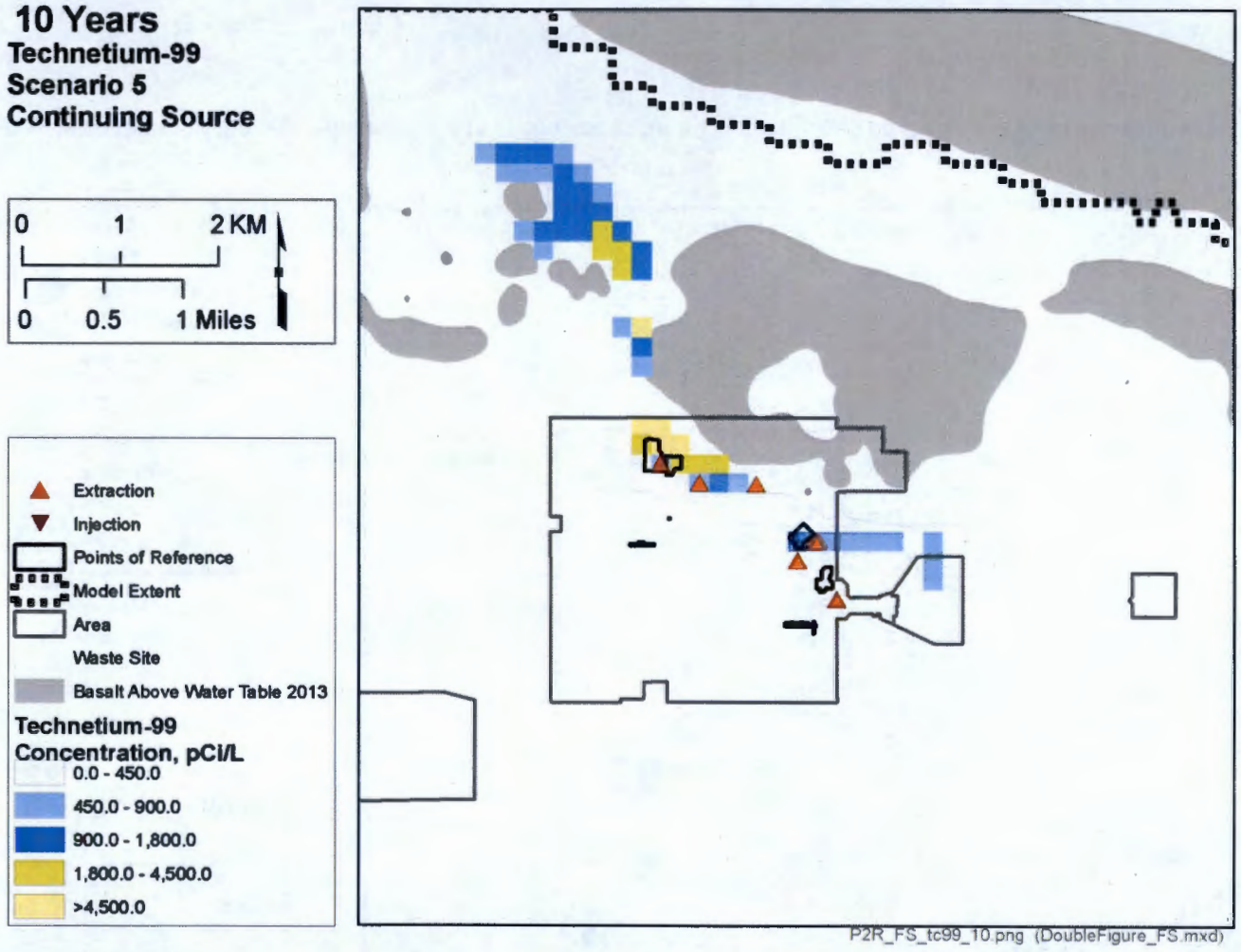

Figure B-257 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 5 simulation with a continuing source term.

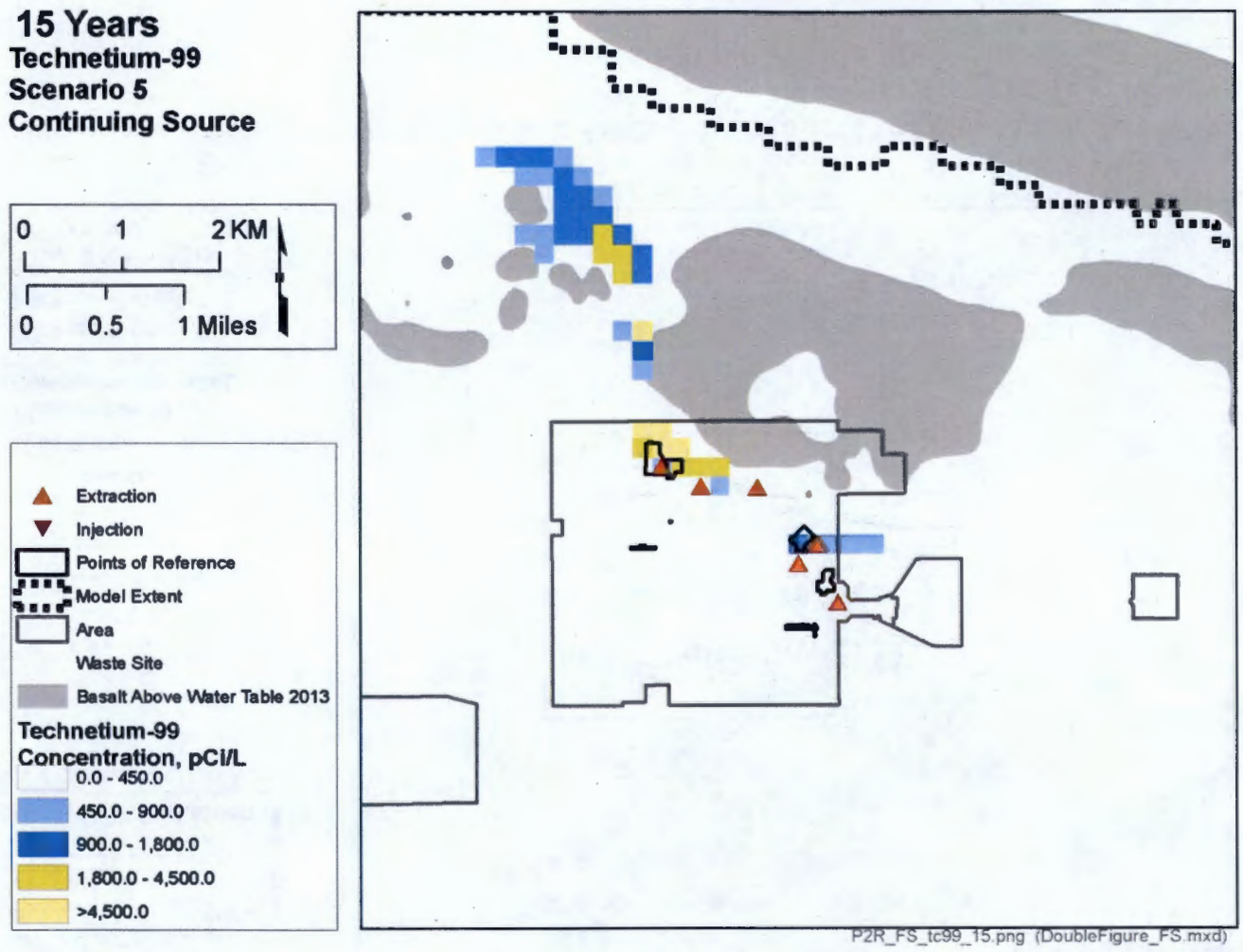

Figure B-258 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 5 simulation with a continuing source term.

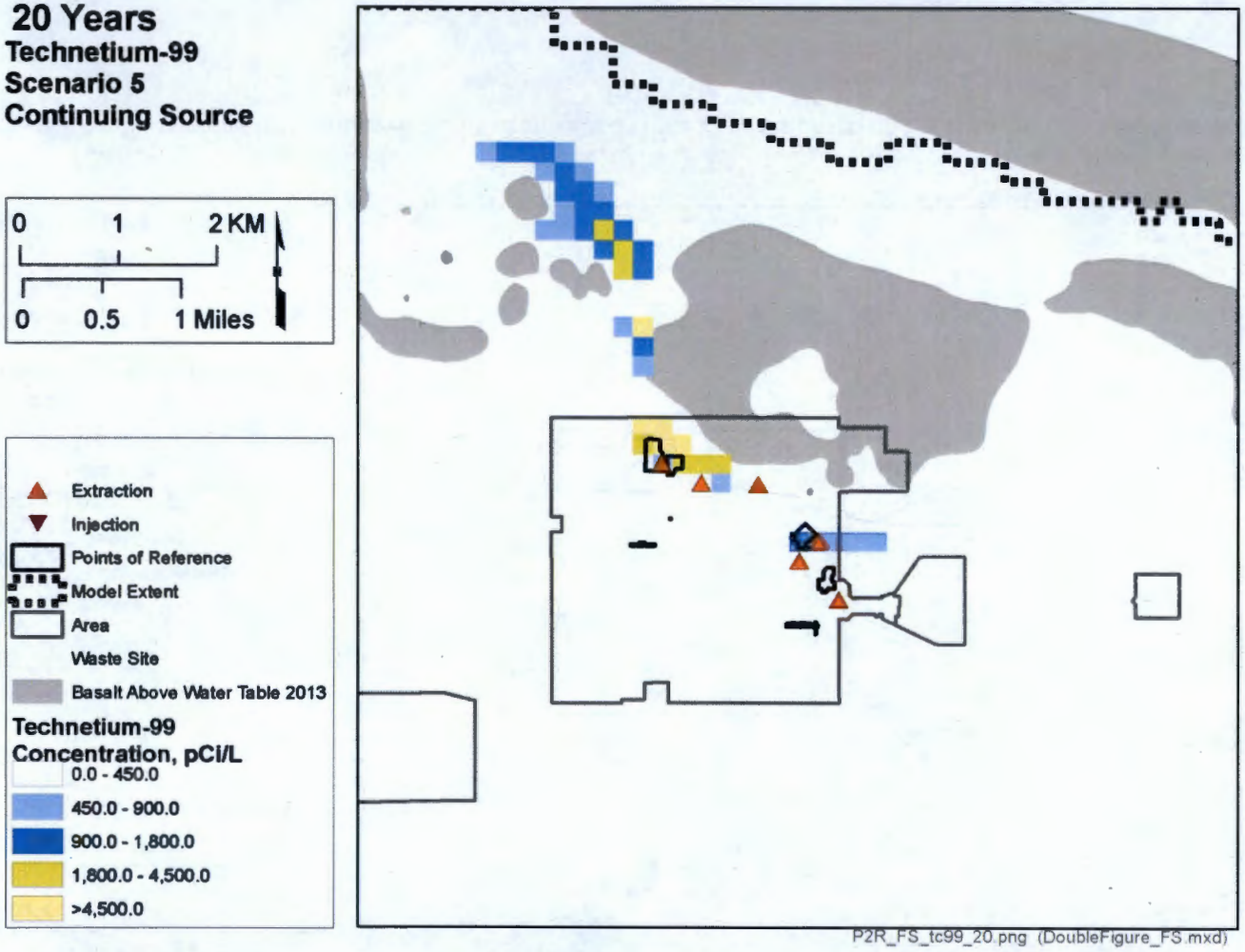

Figure B-259 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 5 simulation with a continuing source term.

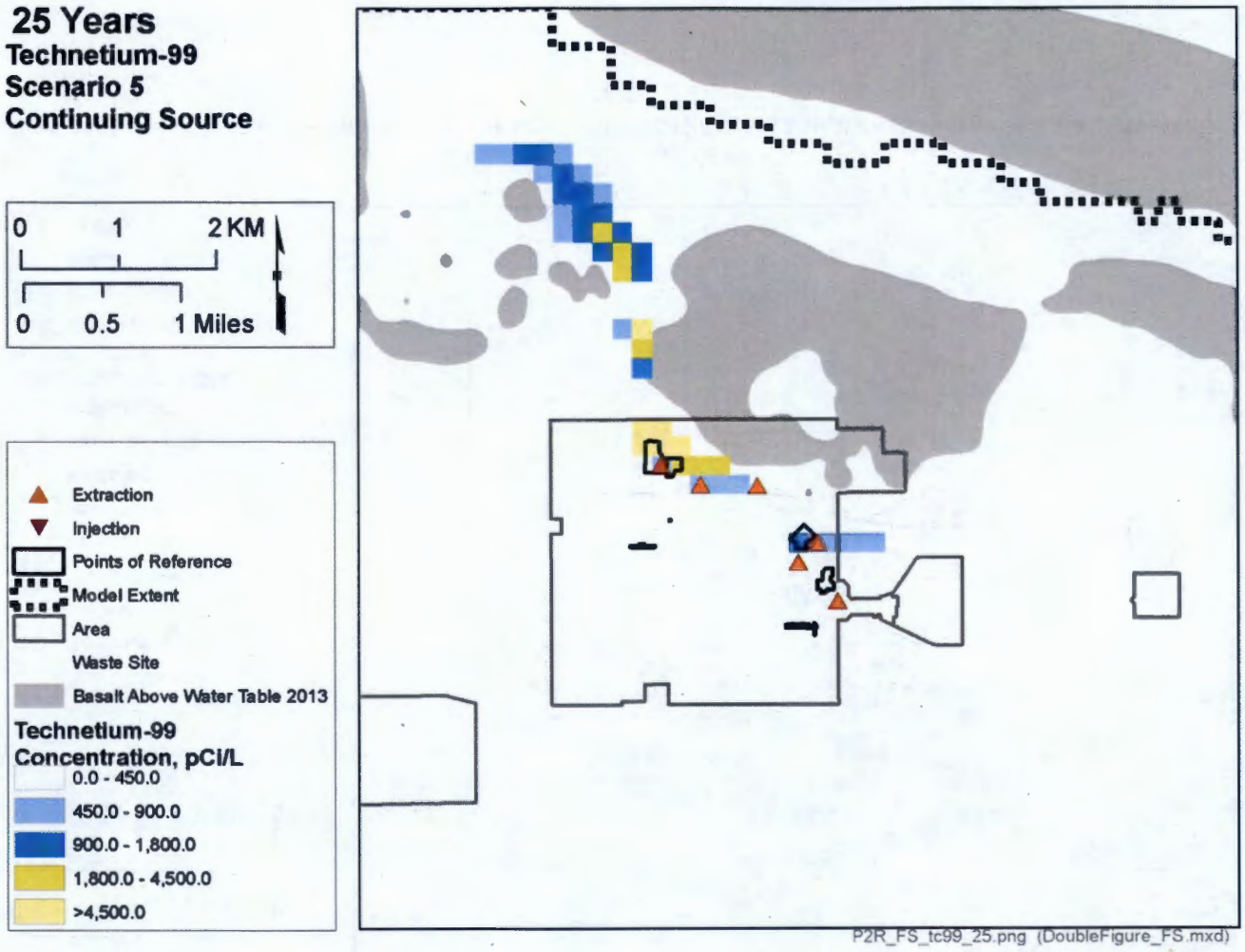

Figure B-260 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 5 simulation with a continuing source term.

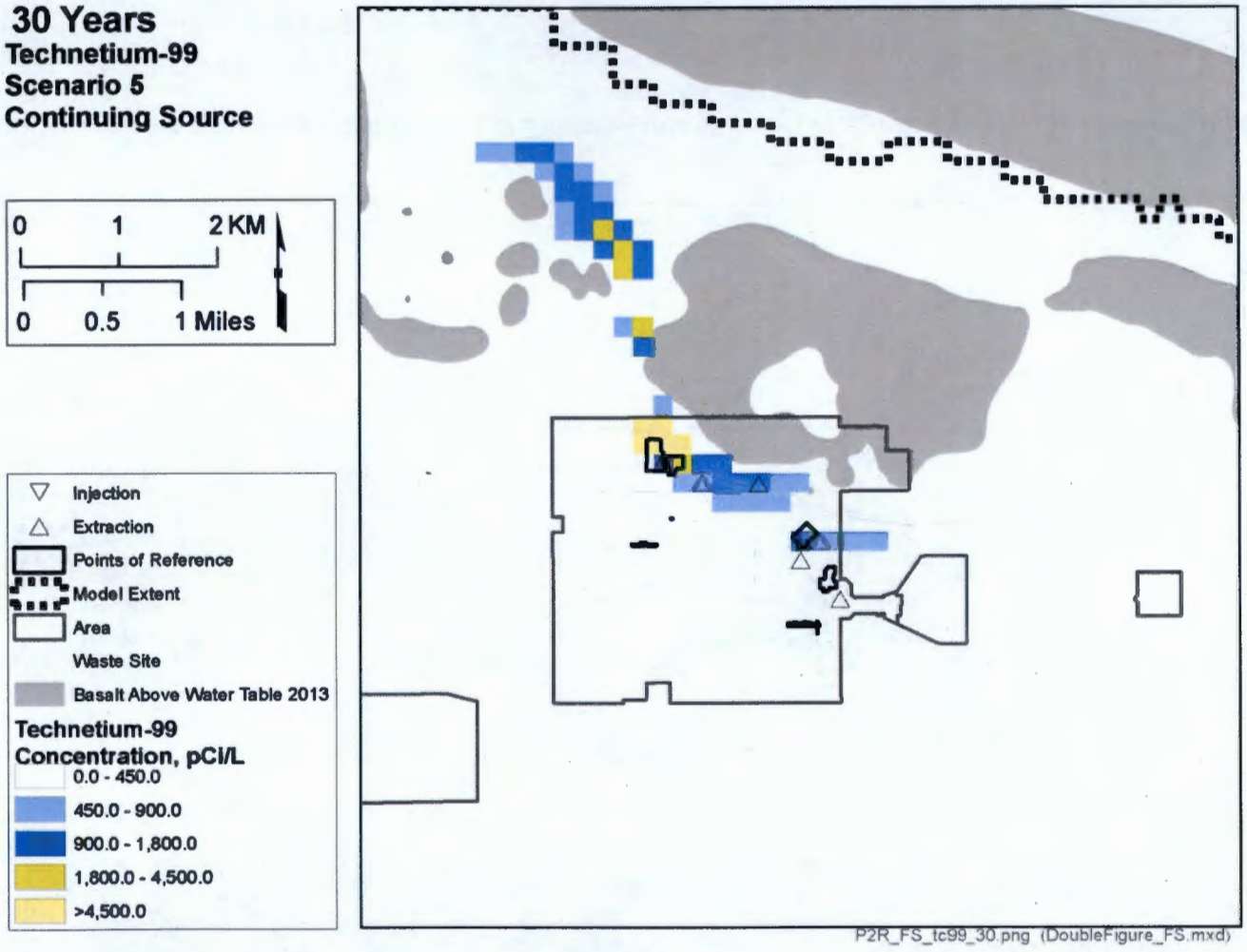

Figure B-261 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 5 simulation with a continuing source term.

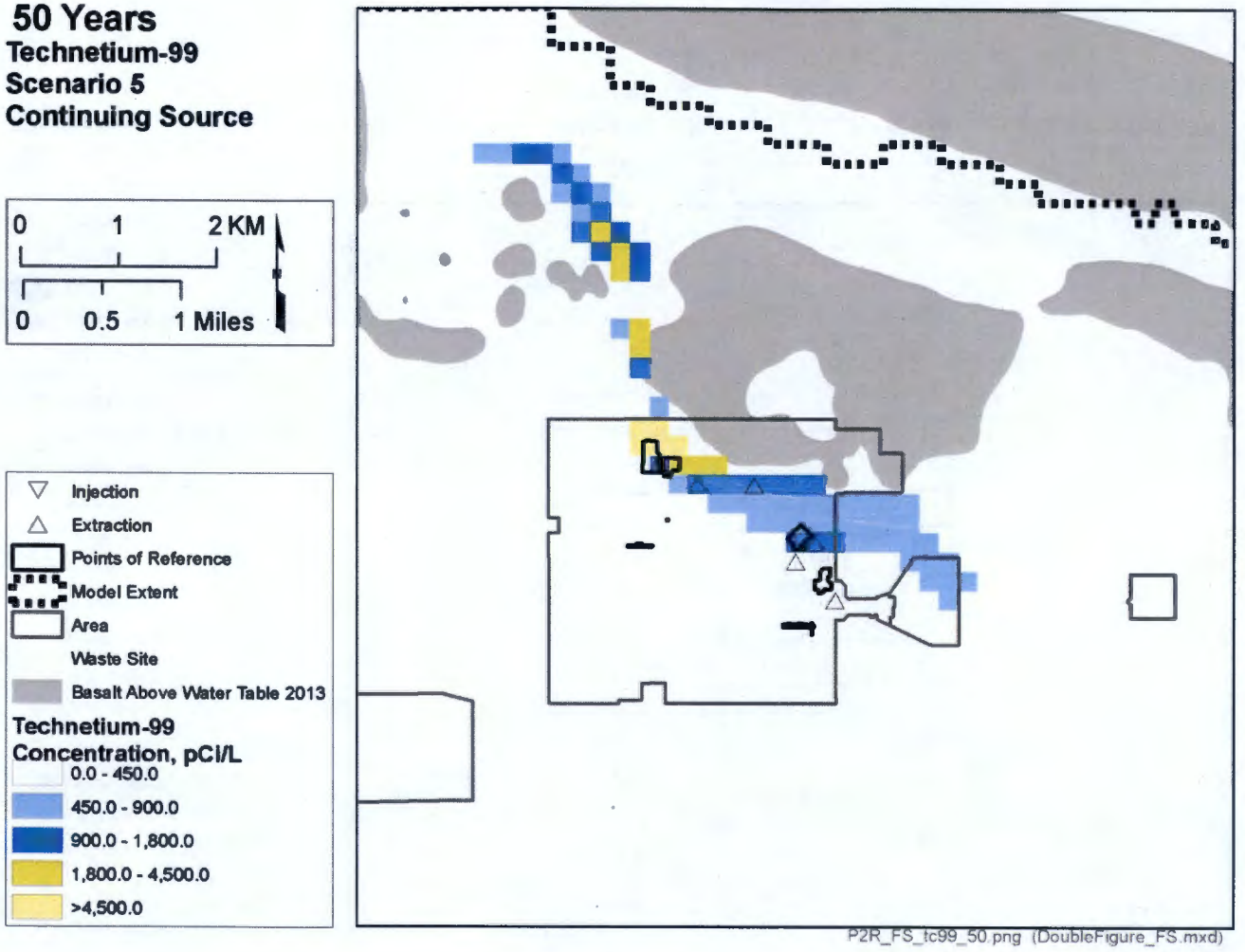

Figure B-262 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 5 simulation with a continuing source term.

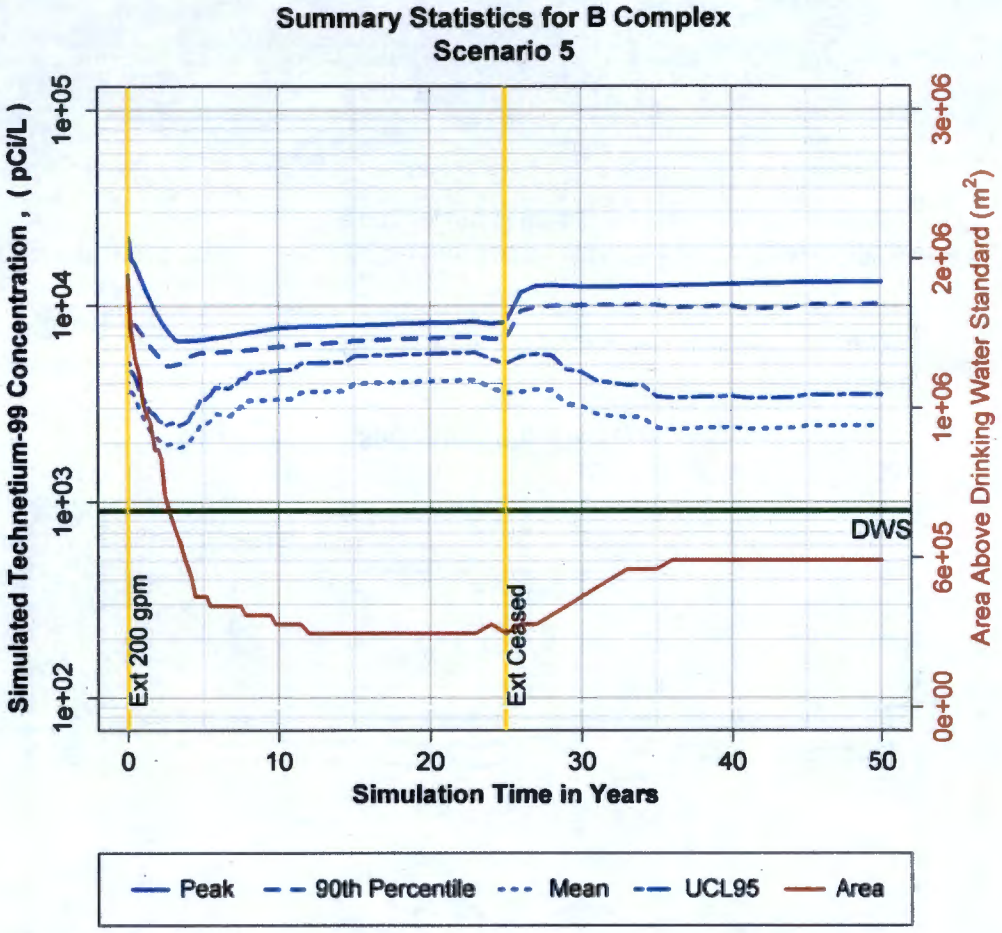

Figure B-263 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

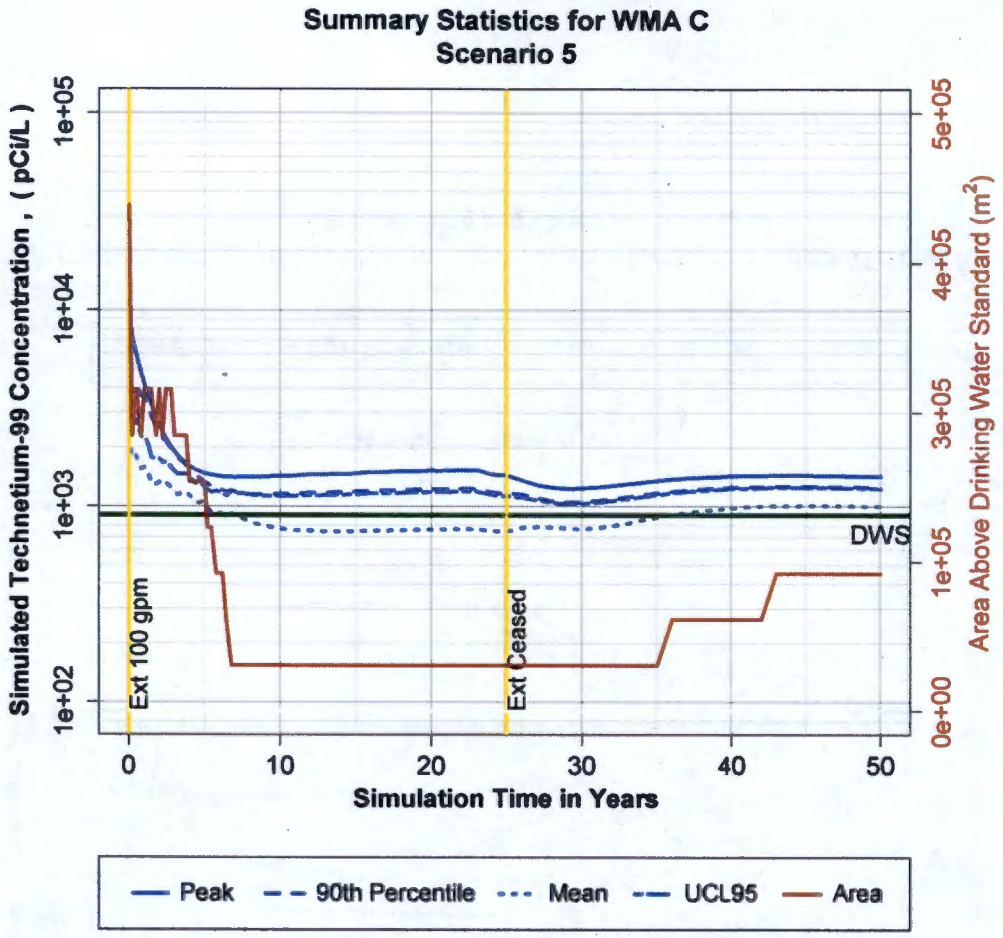

Figure B-264 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

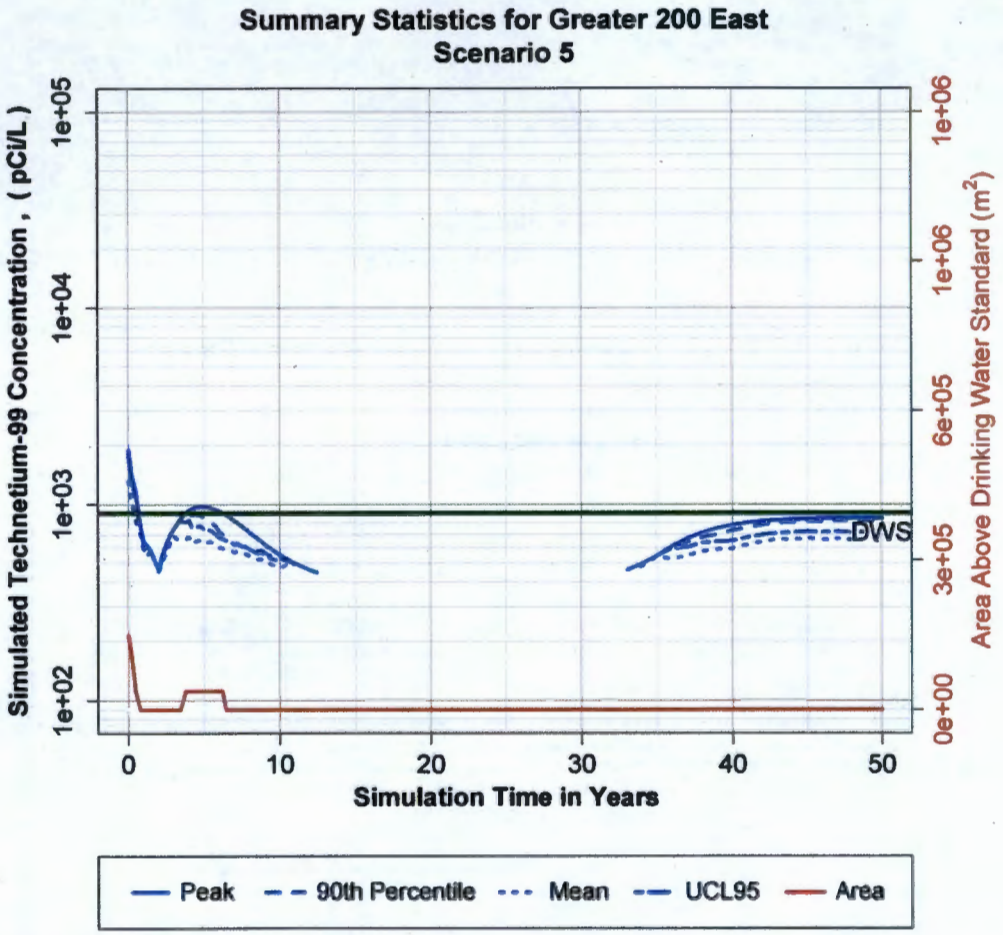

Figure B-265 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

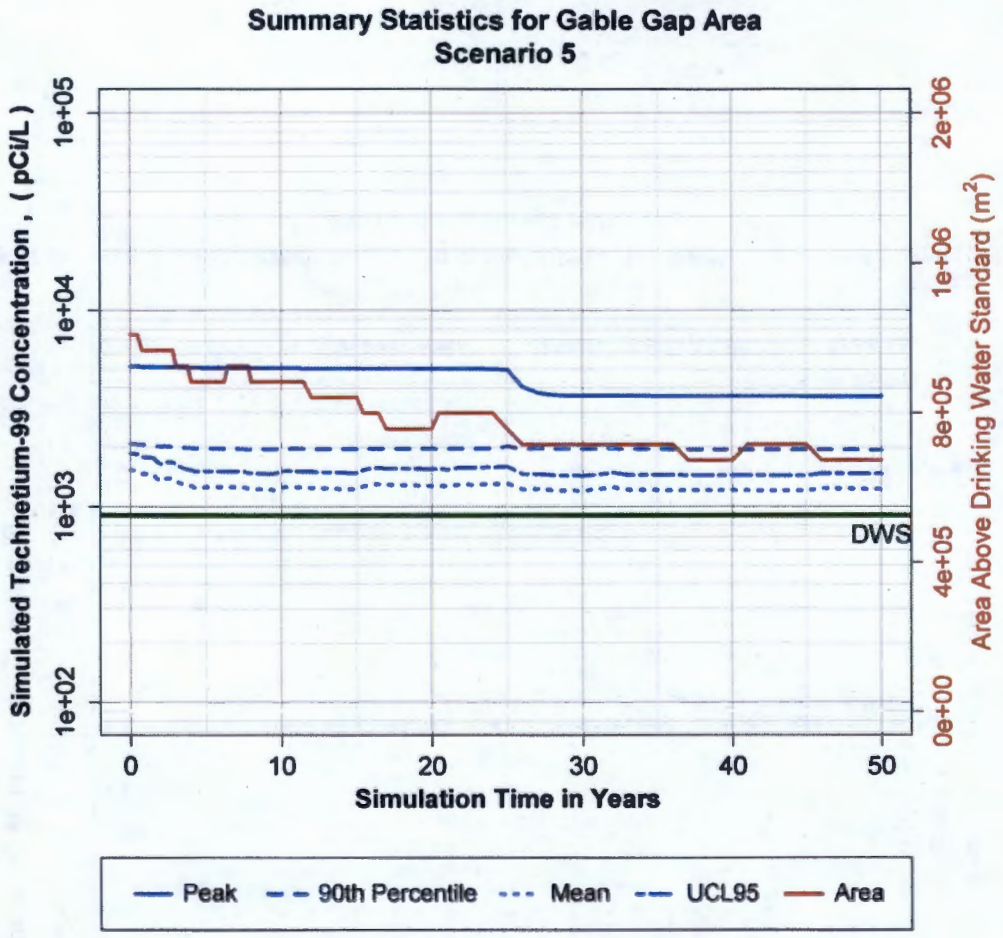

Figure B-266 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

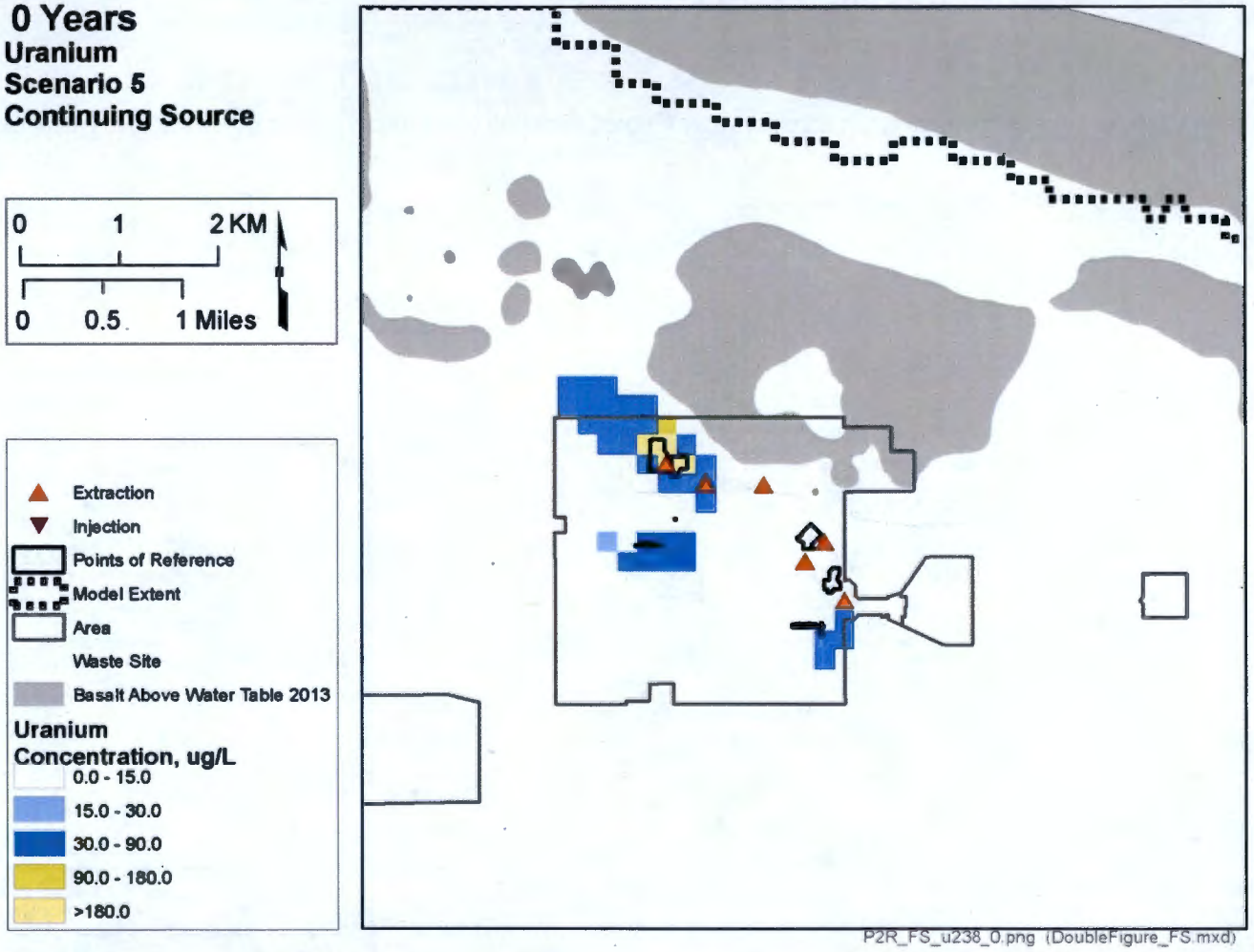

Figure B-267 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 5 simulation with a continuing source term.

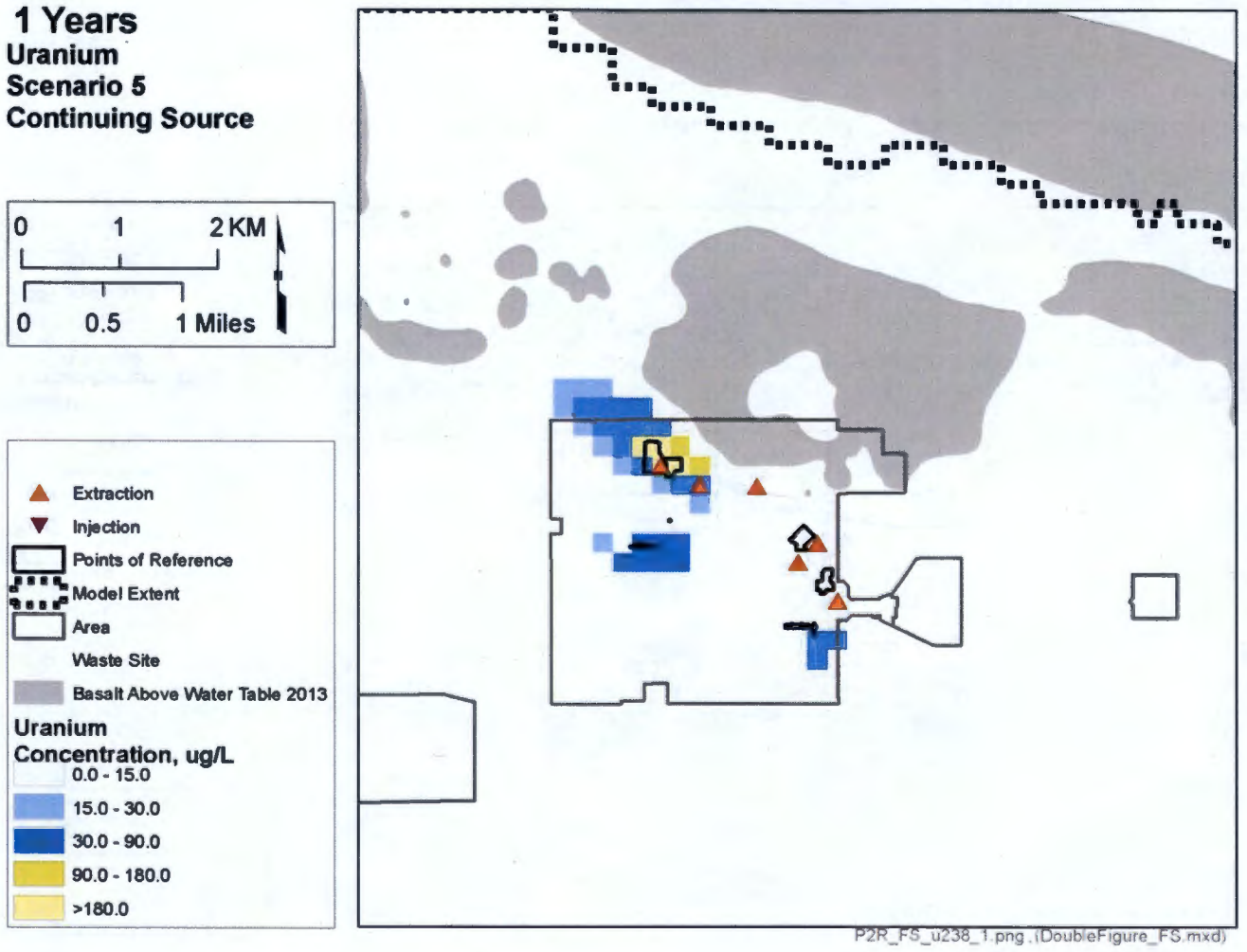

Figure B-268 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 5 simulation with a continuing source term.

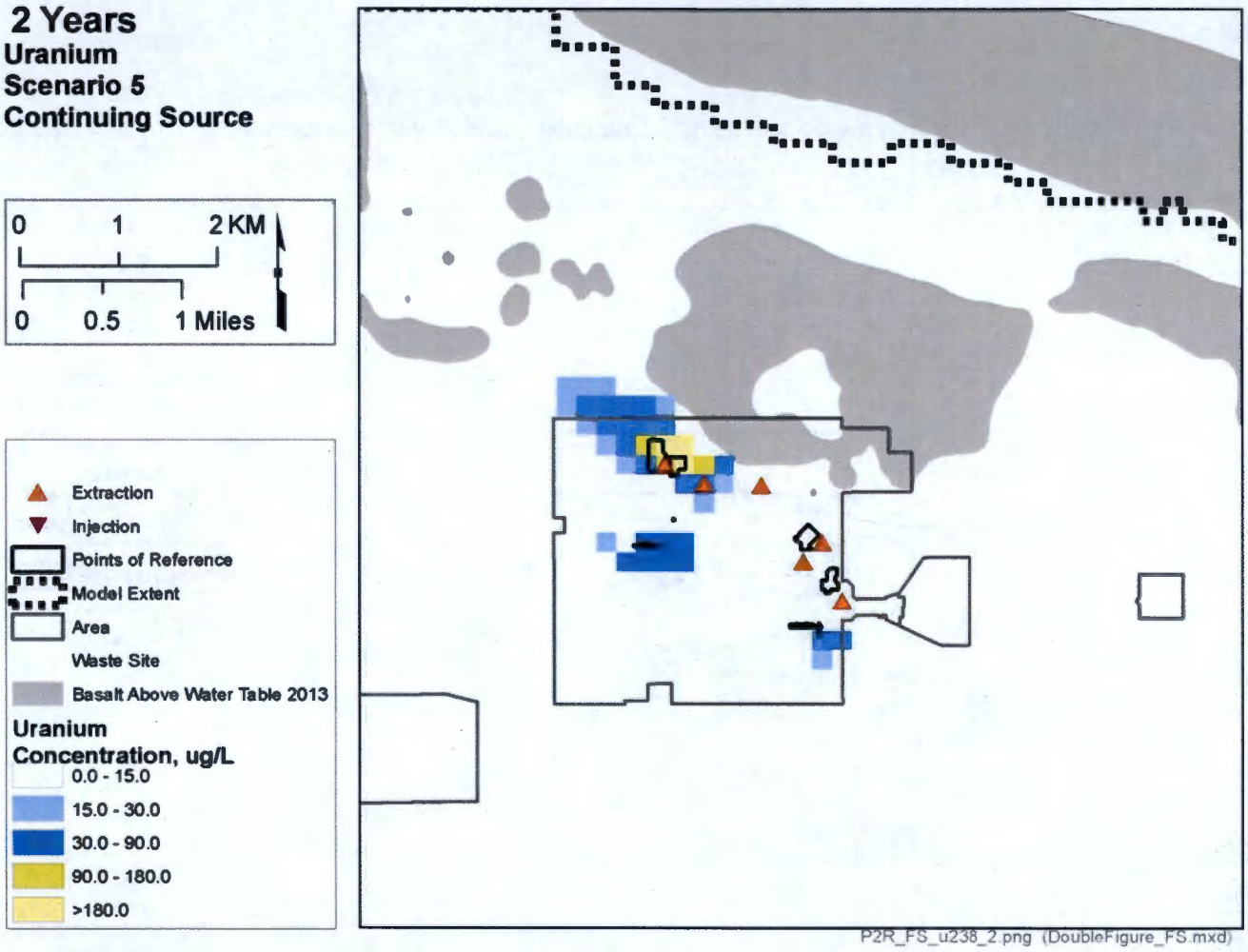

Figure B-269 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 5 simulation with a continuing source term.

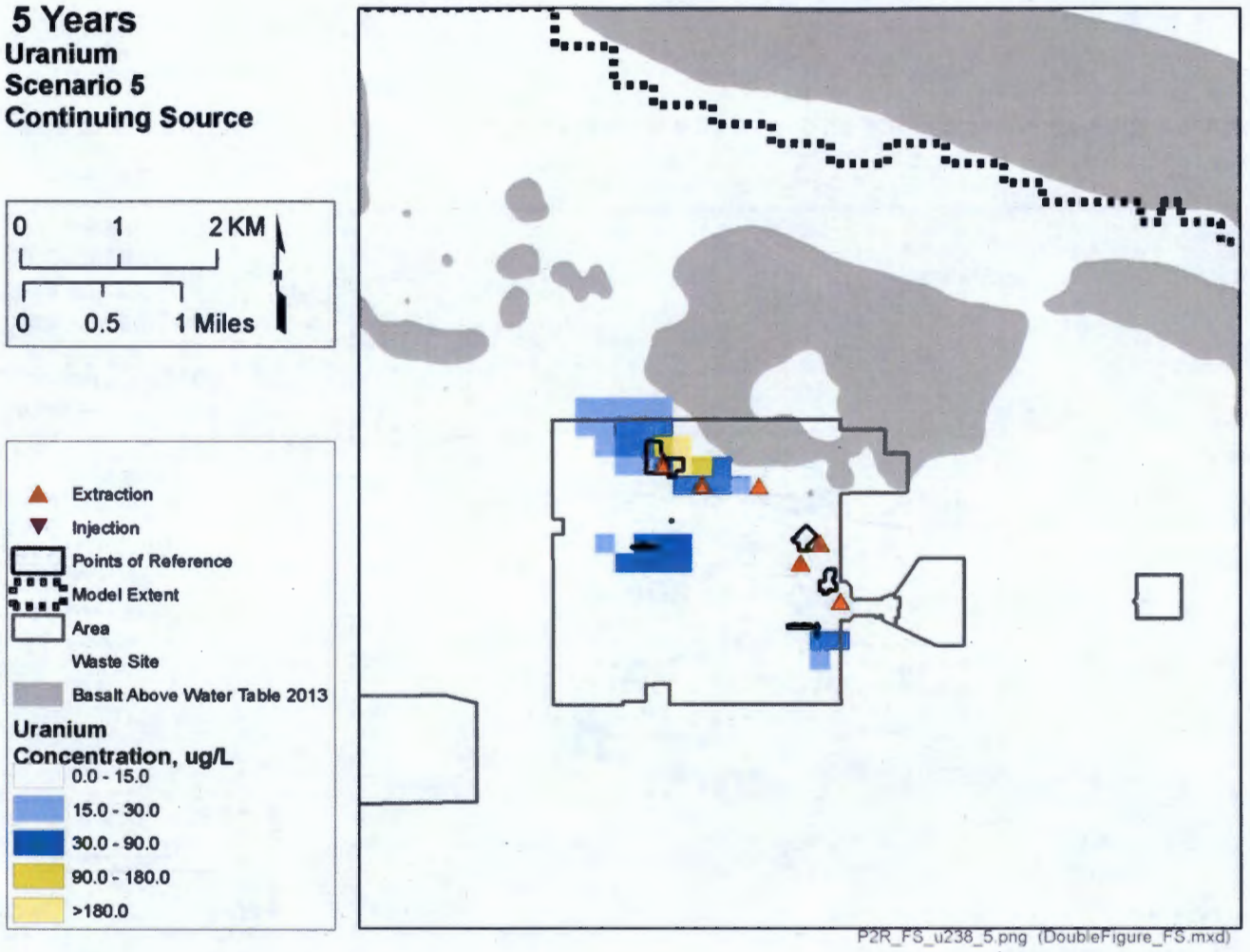

Figure B-270 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 5 simulation with a continuing source term.

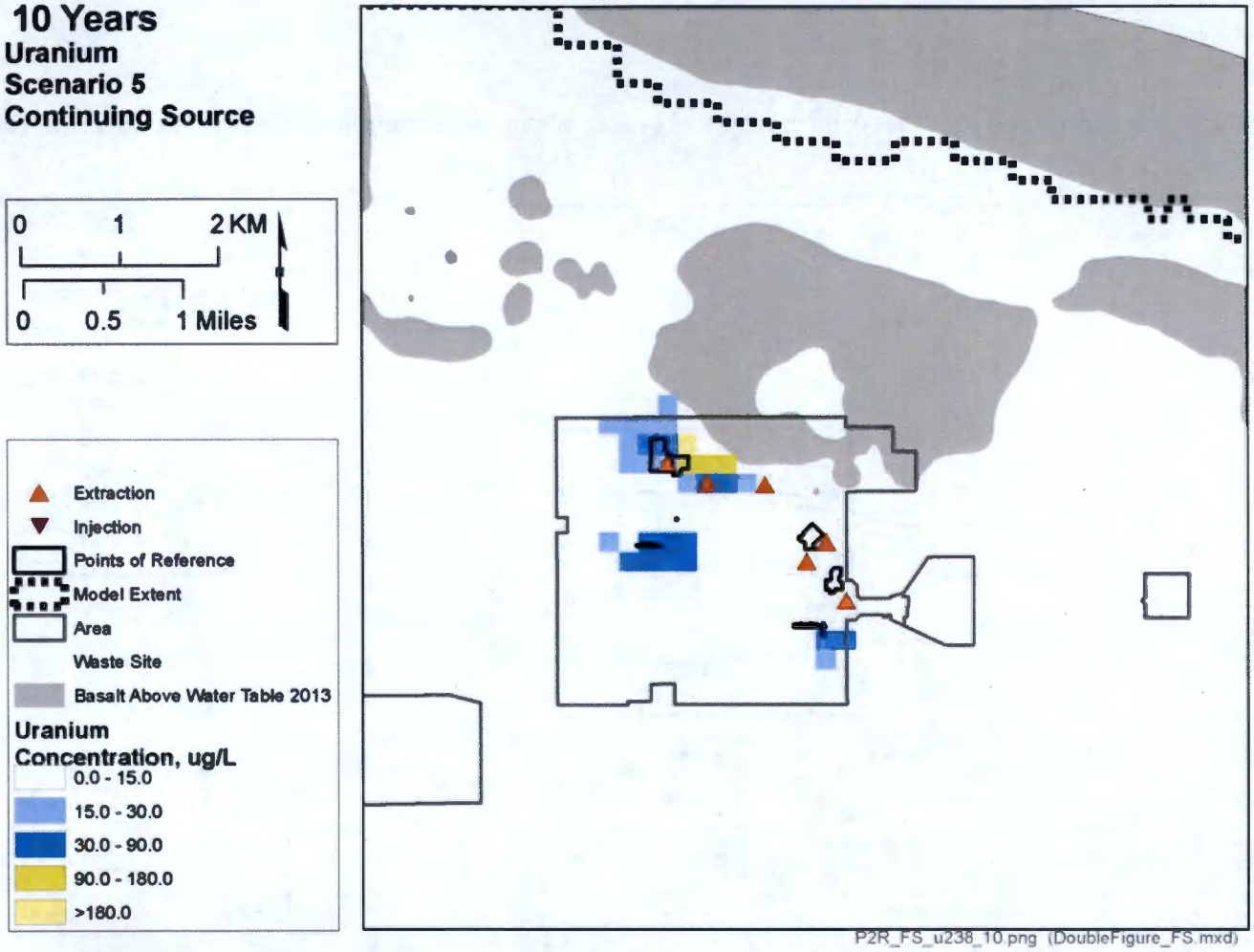

Figure B-271 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 5 simulation with a continuing source term.

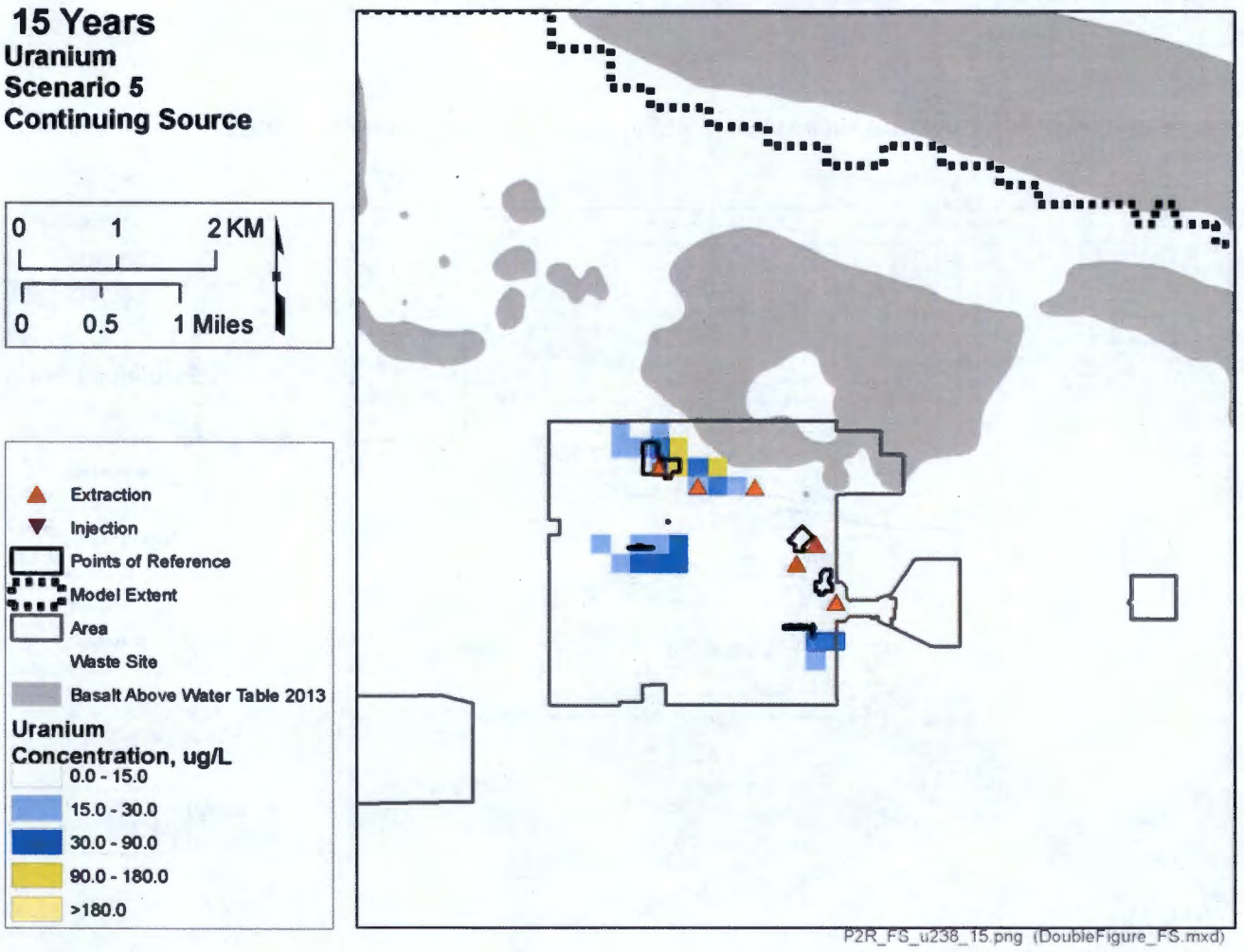

Figure B-272 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 5 simulation with a continuing source term.

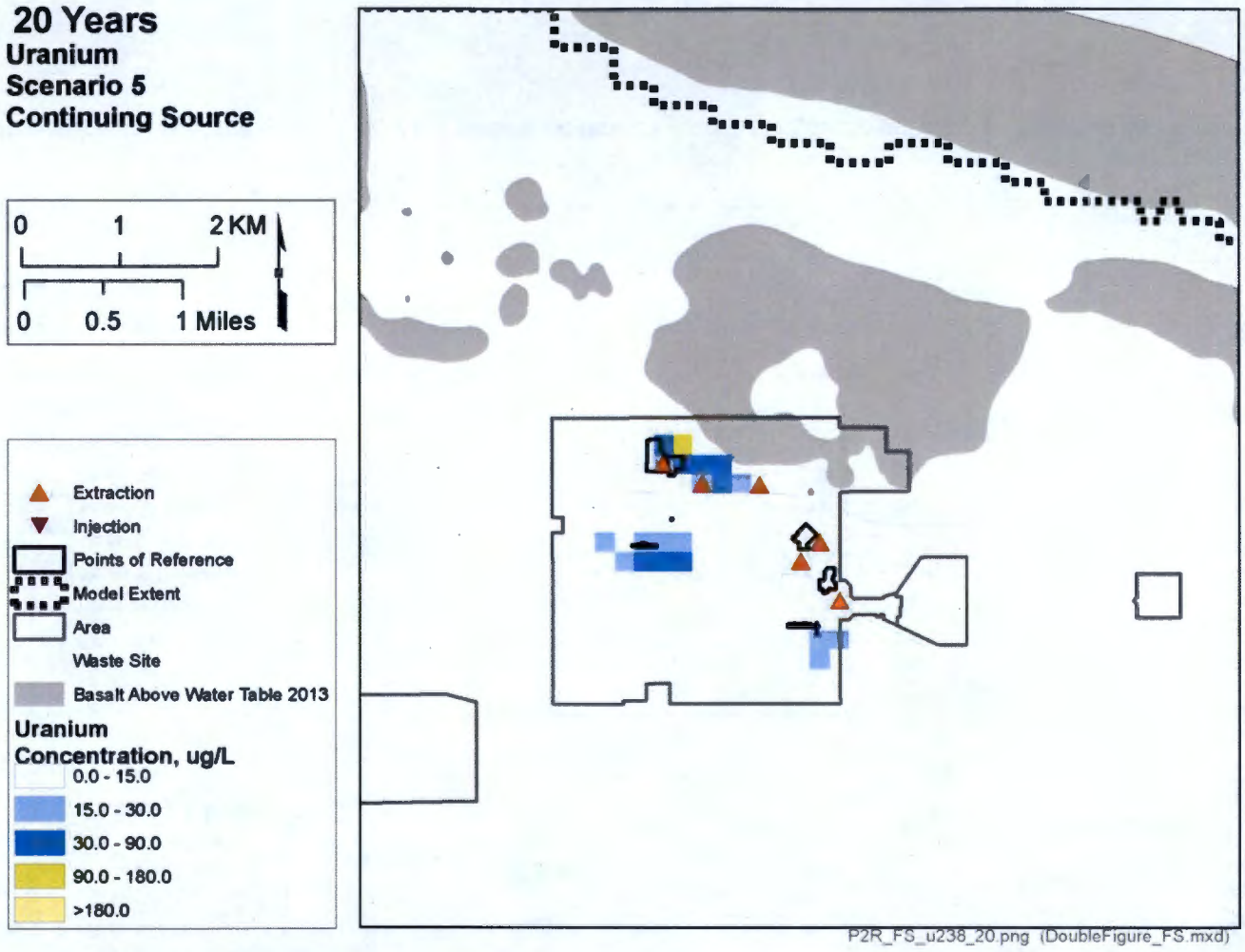

Figure B-273 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 5 simulation with a continuing source term.

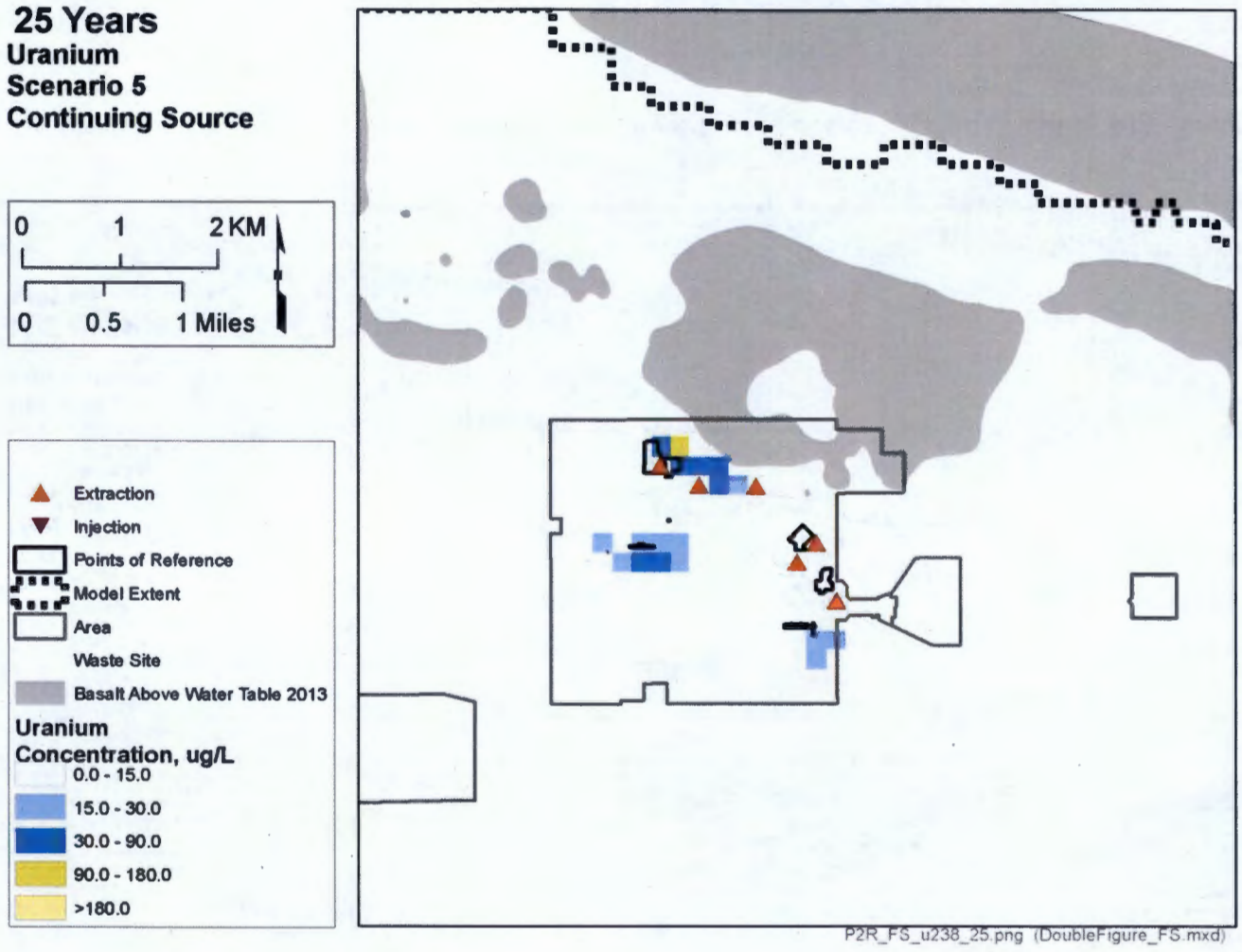

Figure B-274 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 5 simulation with a continuing source term.

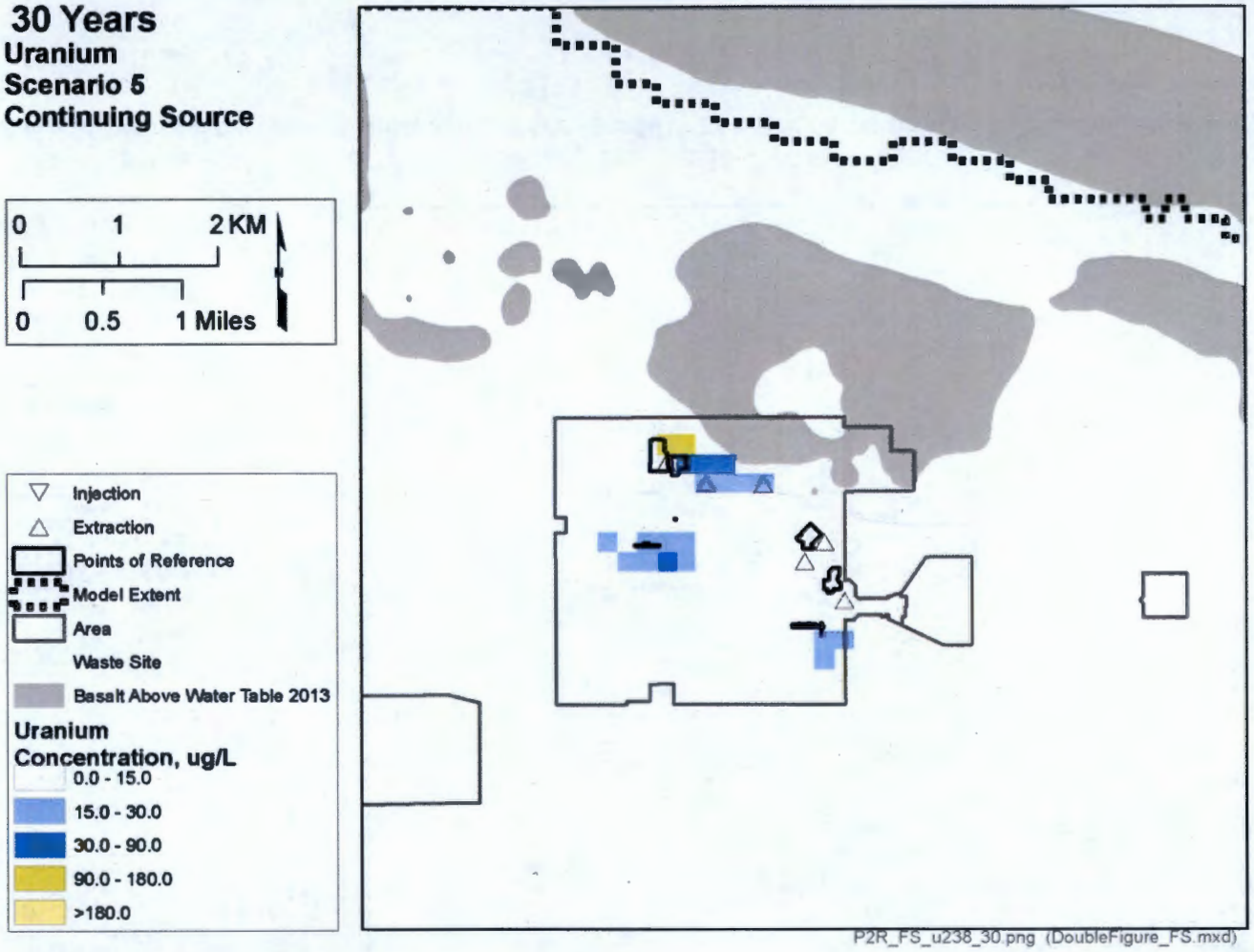

Figure B-275 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 5 simulation with a continuing source term.

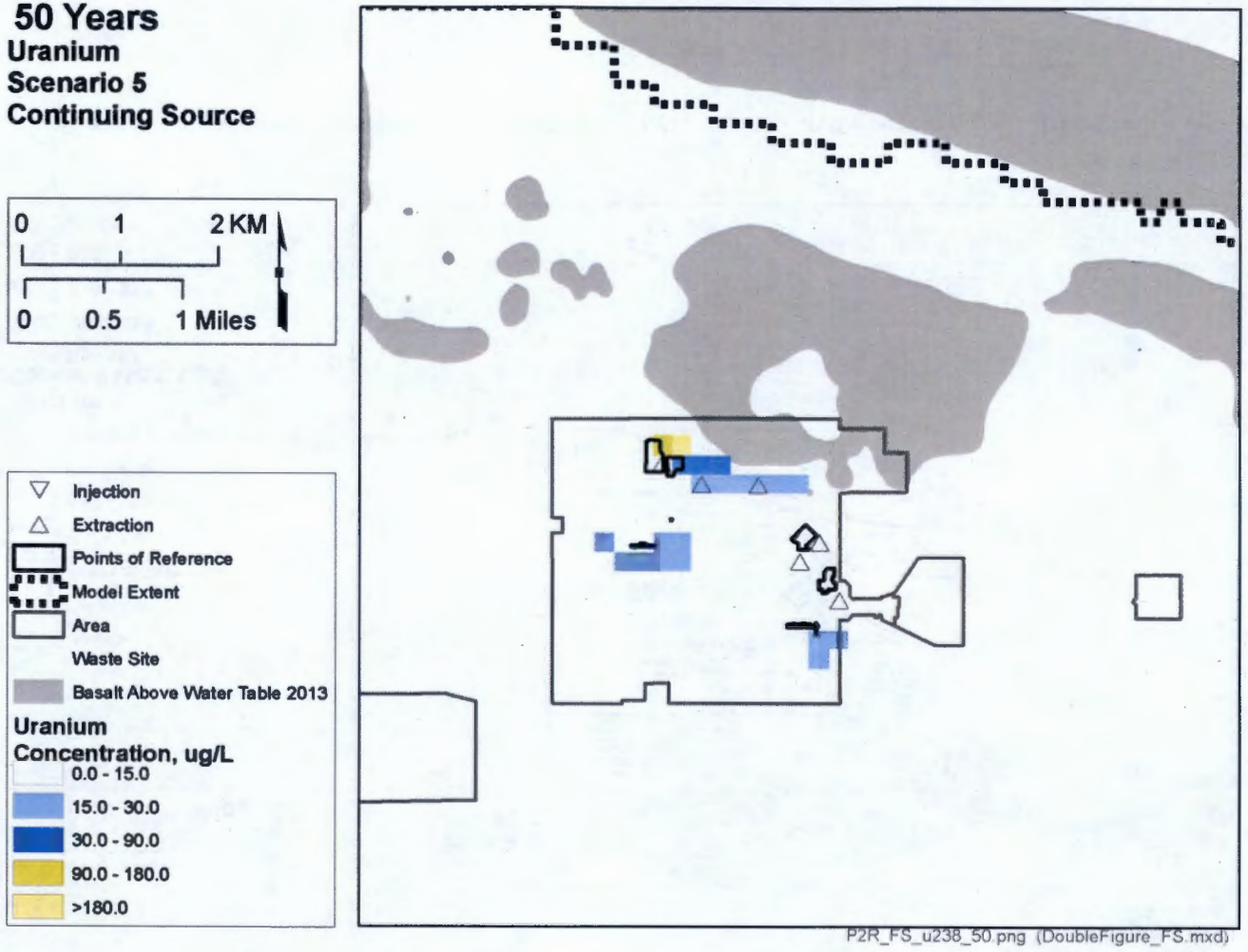

Figure B-276 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 5 simulation with a continuing source term.

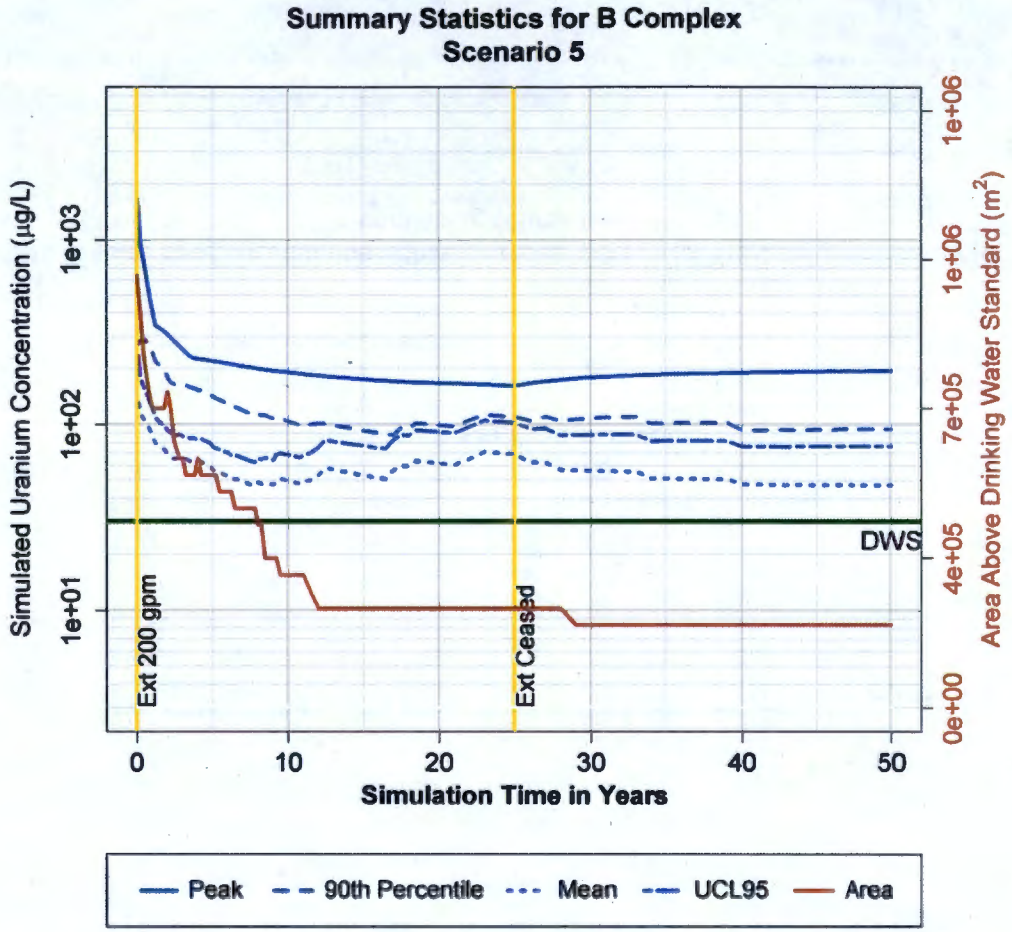

Figure B-277 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

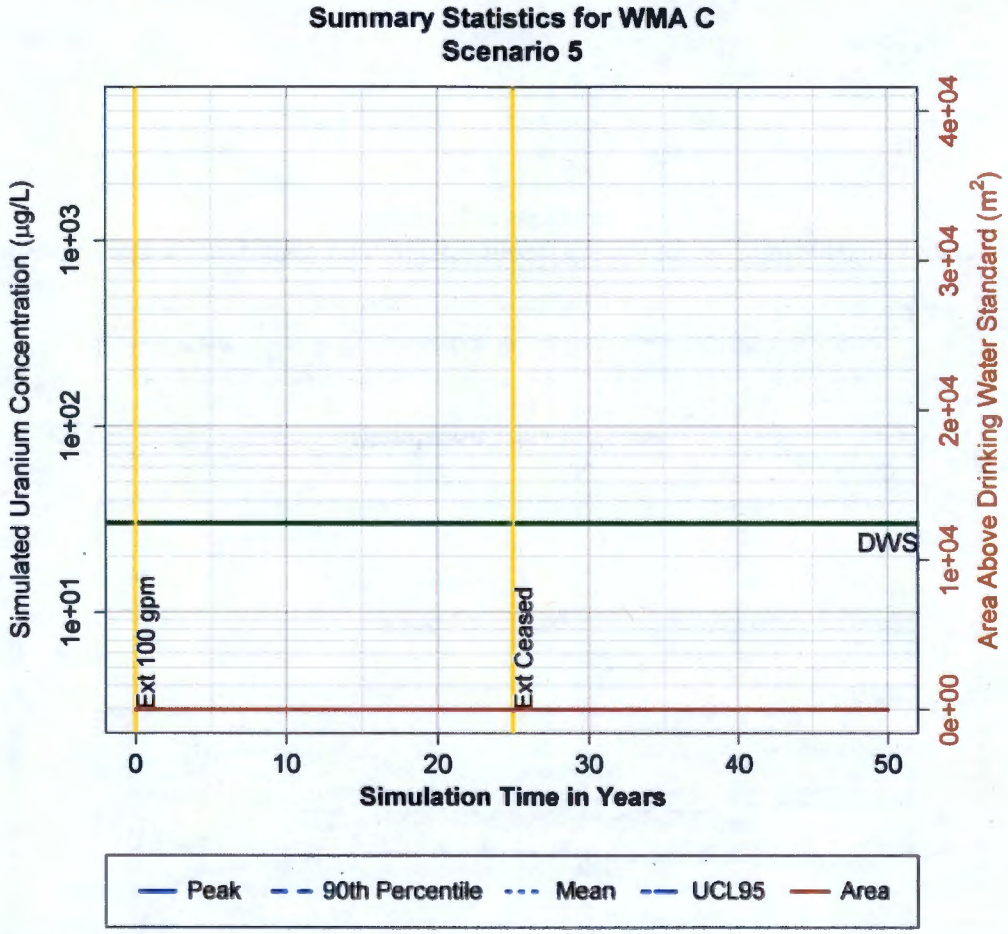

Figure B-278 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

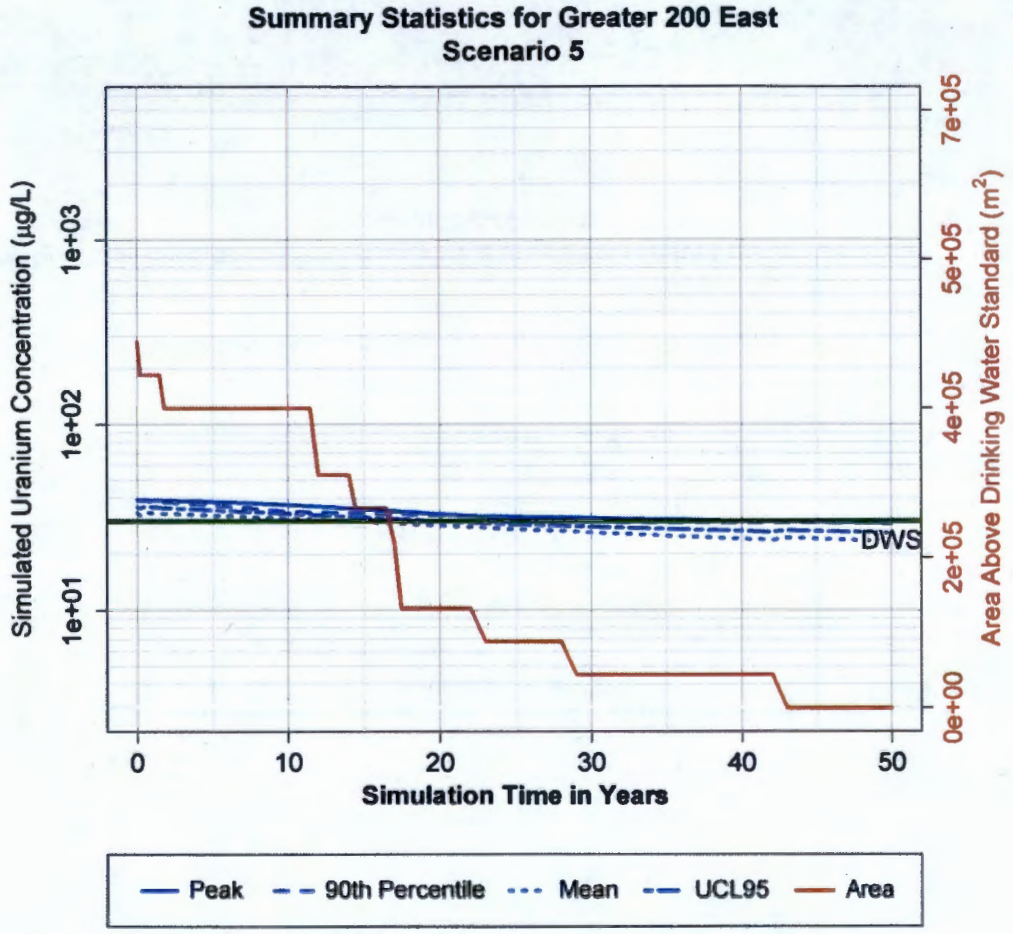

Figure B-279 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

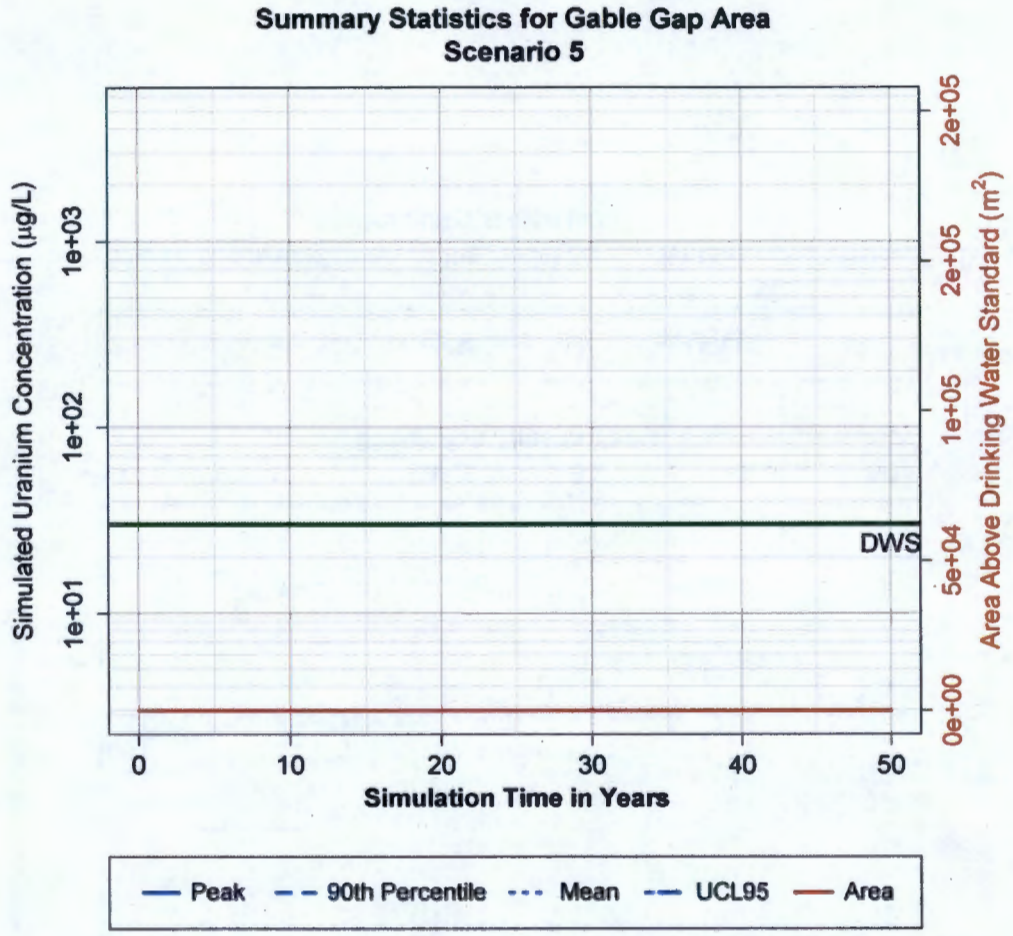

Figure B-280 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

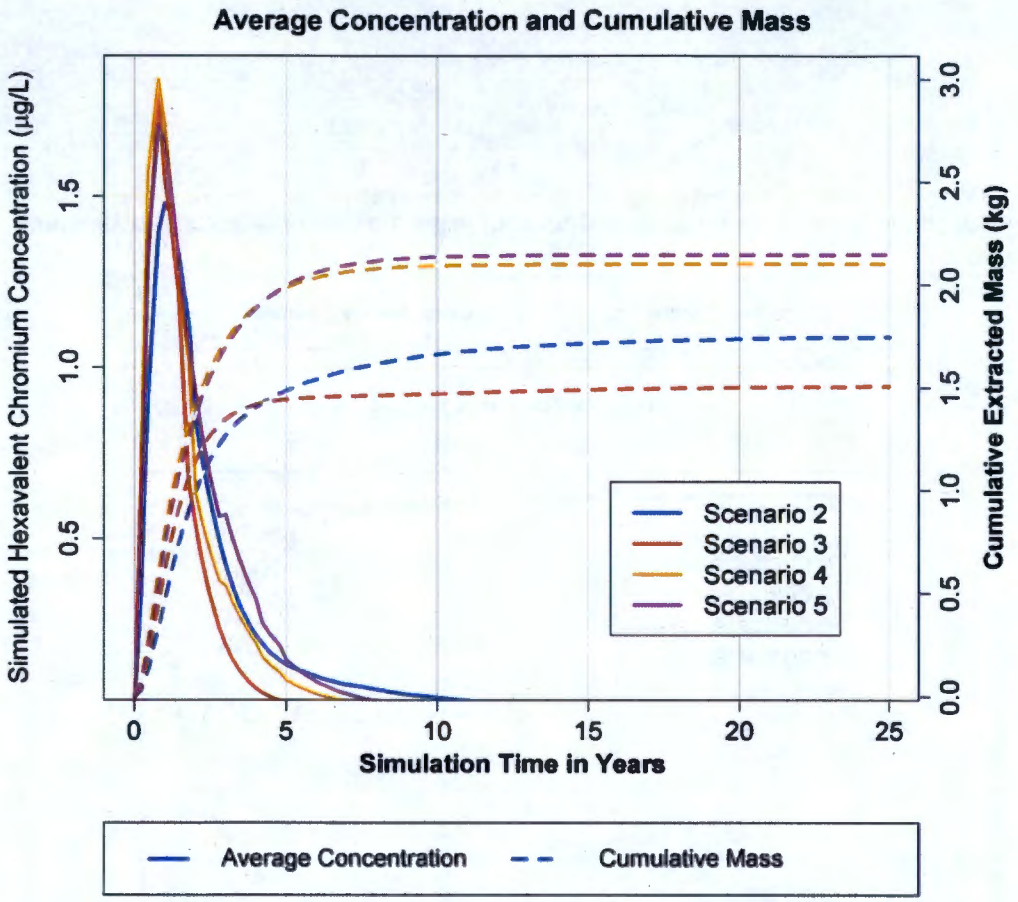

Figure B-281 - Summary of simulated extraction within the model domain for the hexavalent chromium plume for all scenarios.

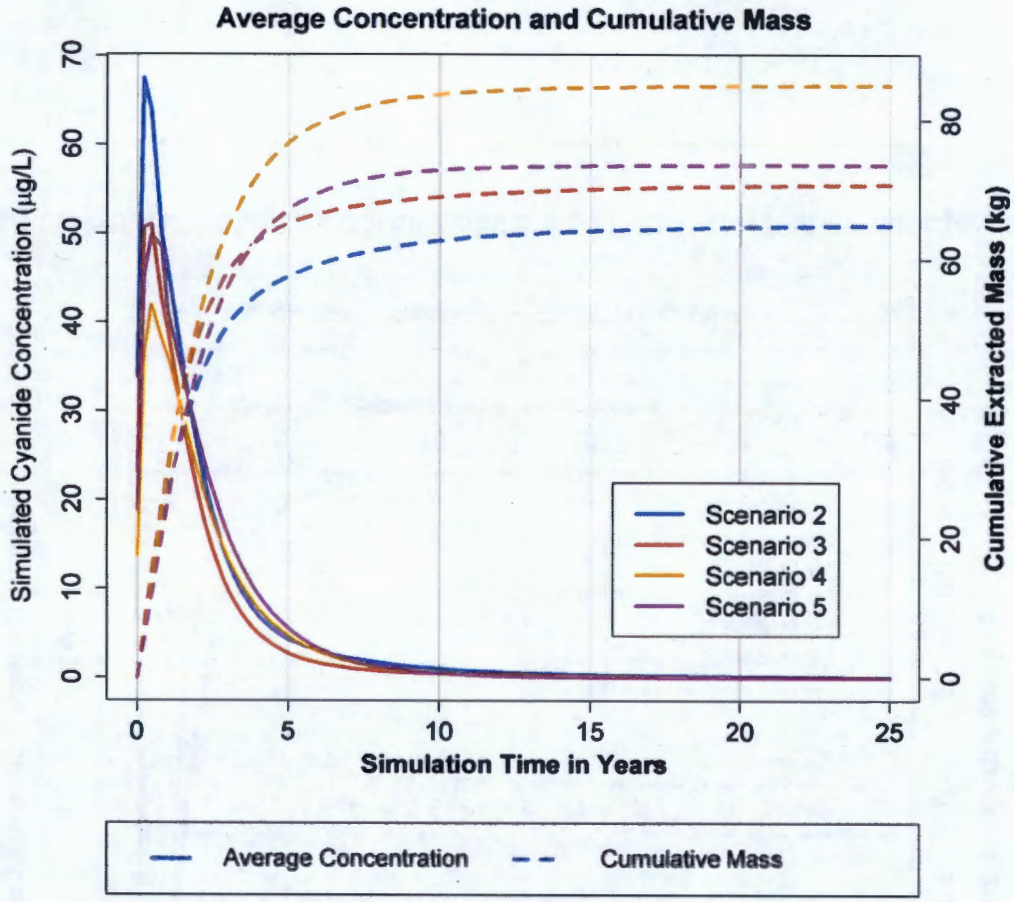

Figure B-282 - Summary of simulated extraction within the model domain for the cyanide plume for all scenarios.

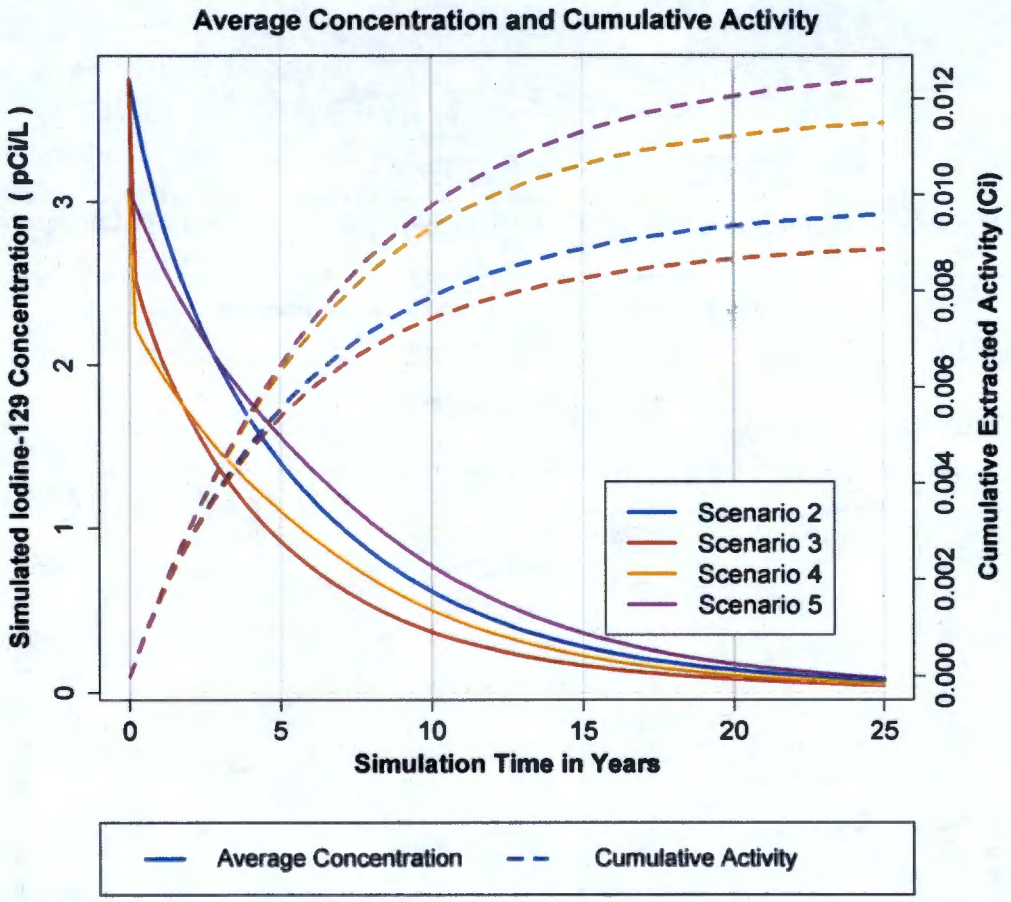

Figure B-283 - Summary of simulated extraction within the model domain for the iodine-129 plume for all scenarios.

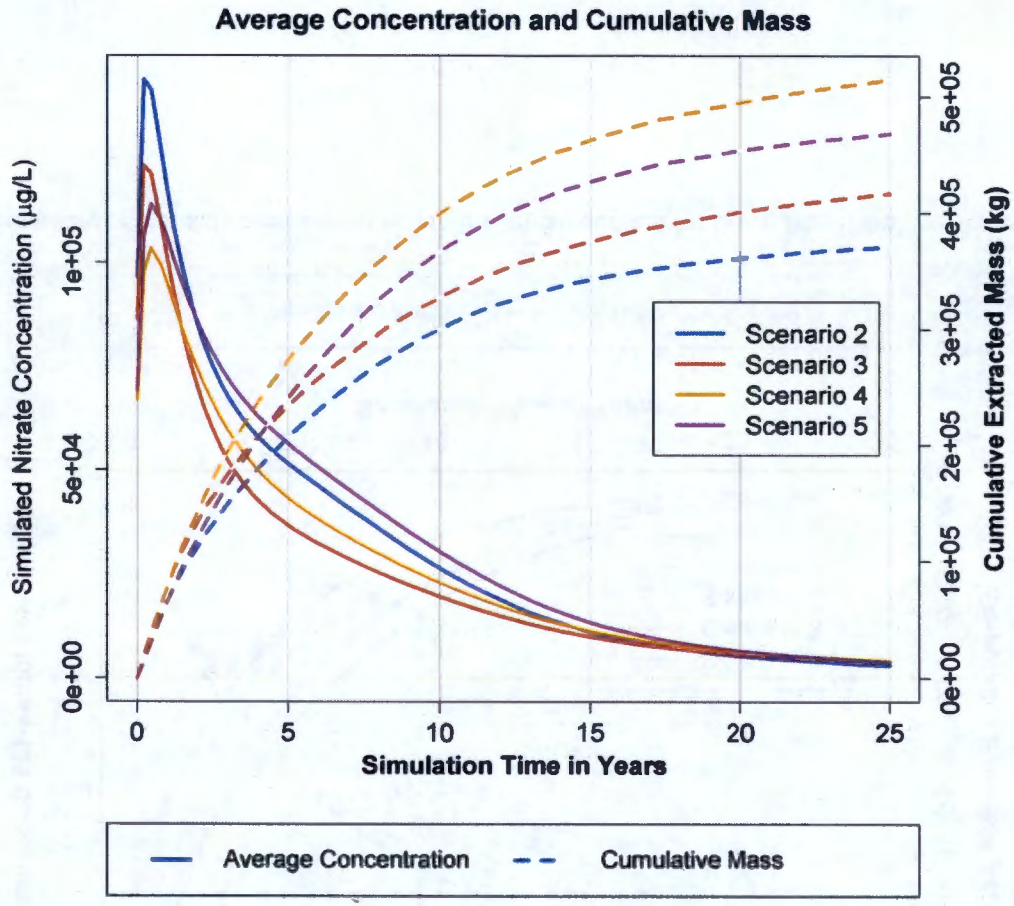

Figure B-284 - Summary of simulated extraction within the model domain for the nitrate plume for all scenarios.

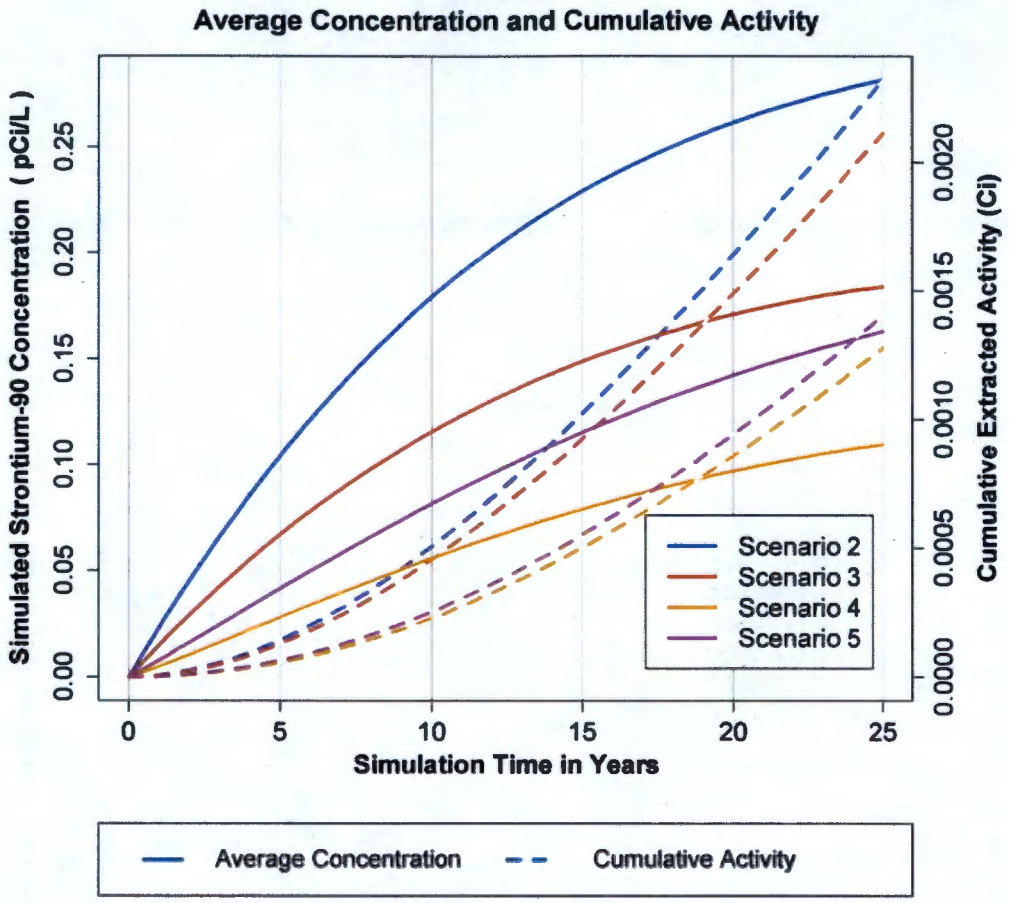

Figure B-285 - Summary of simulated extraction within the model domain for the strontium-90 plume for all scenarios.

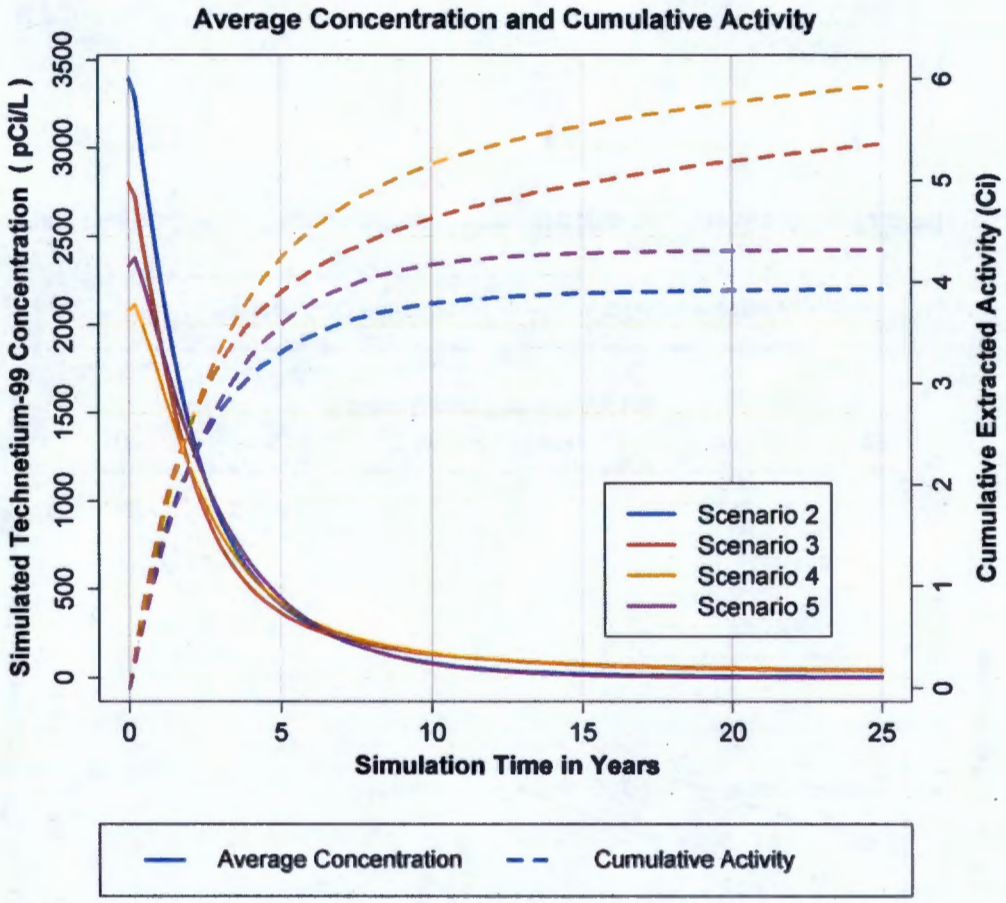

Figure B-286 - Summary of simulated extraction within the model domain for the technetium-99 plume for all scenarios.

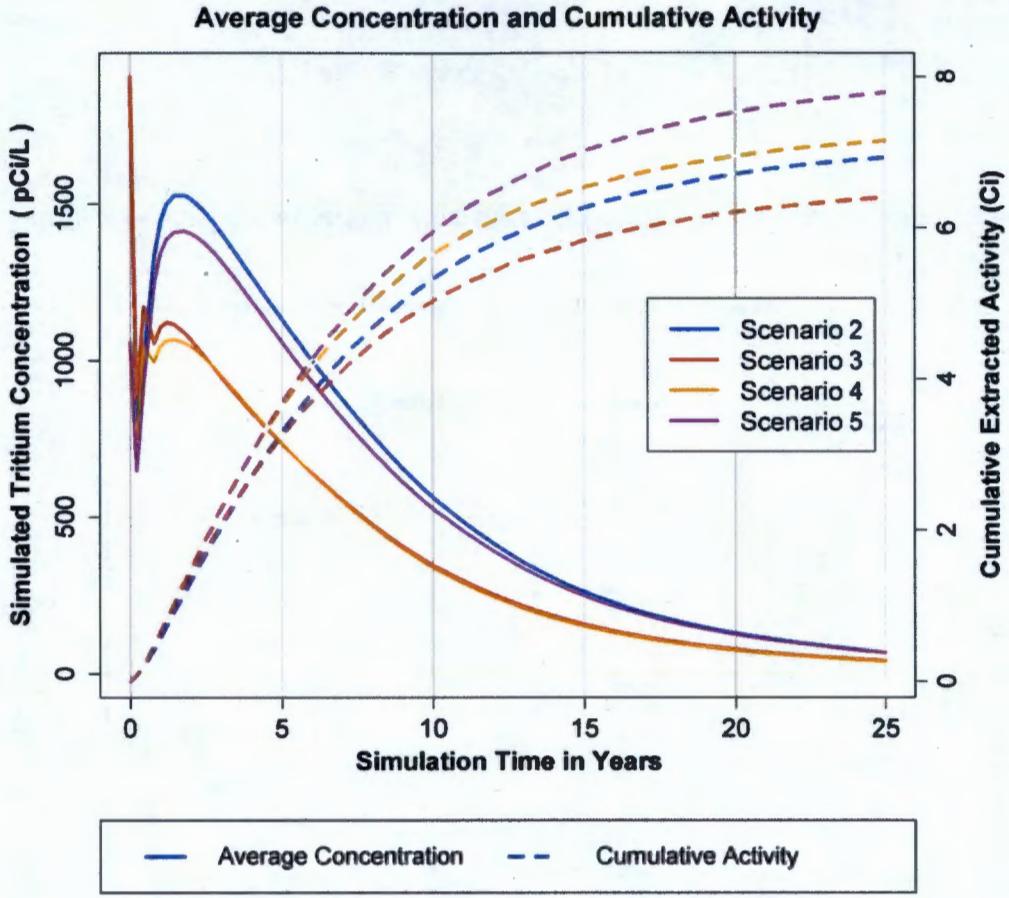

Figure B-287 - Summary of simulated extraction within the model domain for the tritium plume for all scenarios.

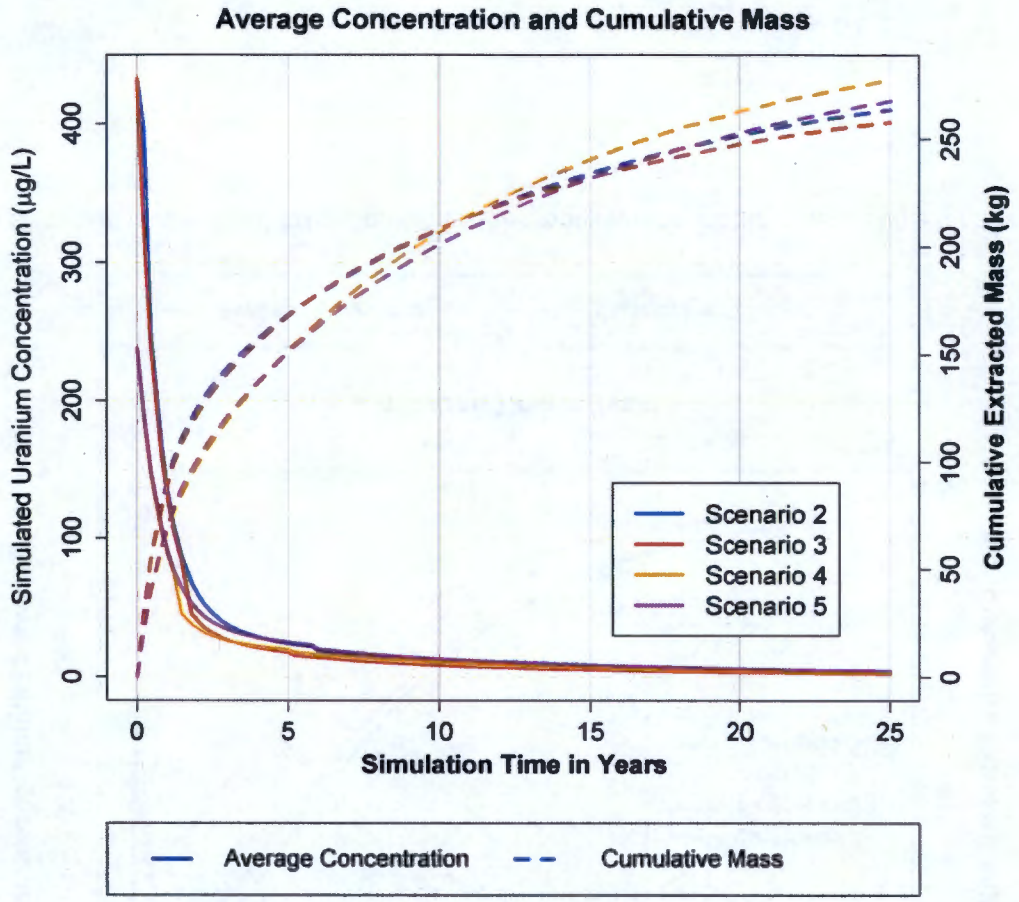

Figure B-288 - Summary of simulated extraction within the model domain for the uranium plume for all scenarios.

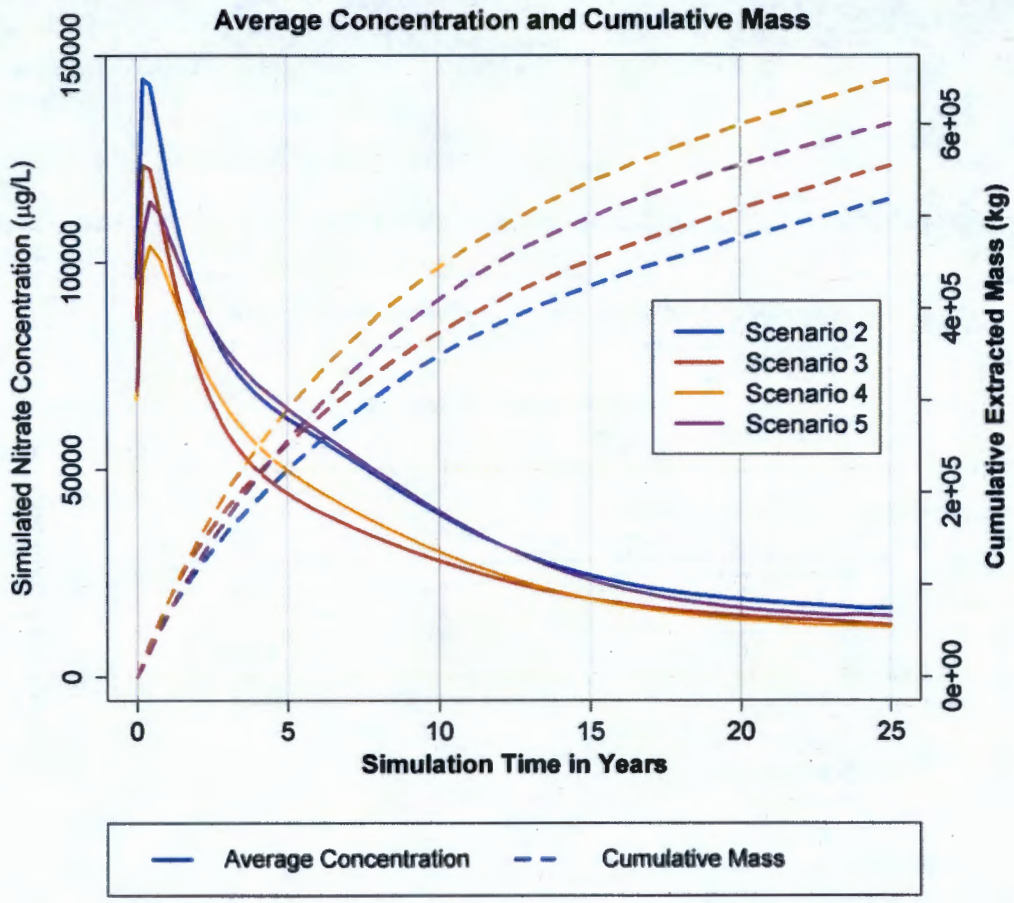

Figure B-289 - Summary of simulated extraction within the model domain for the nitrate plume for all scenarios with a continuing source term.

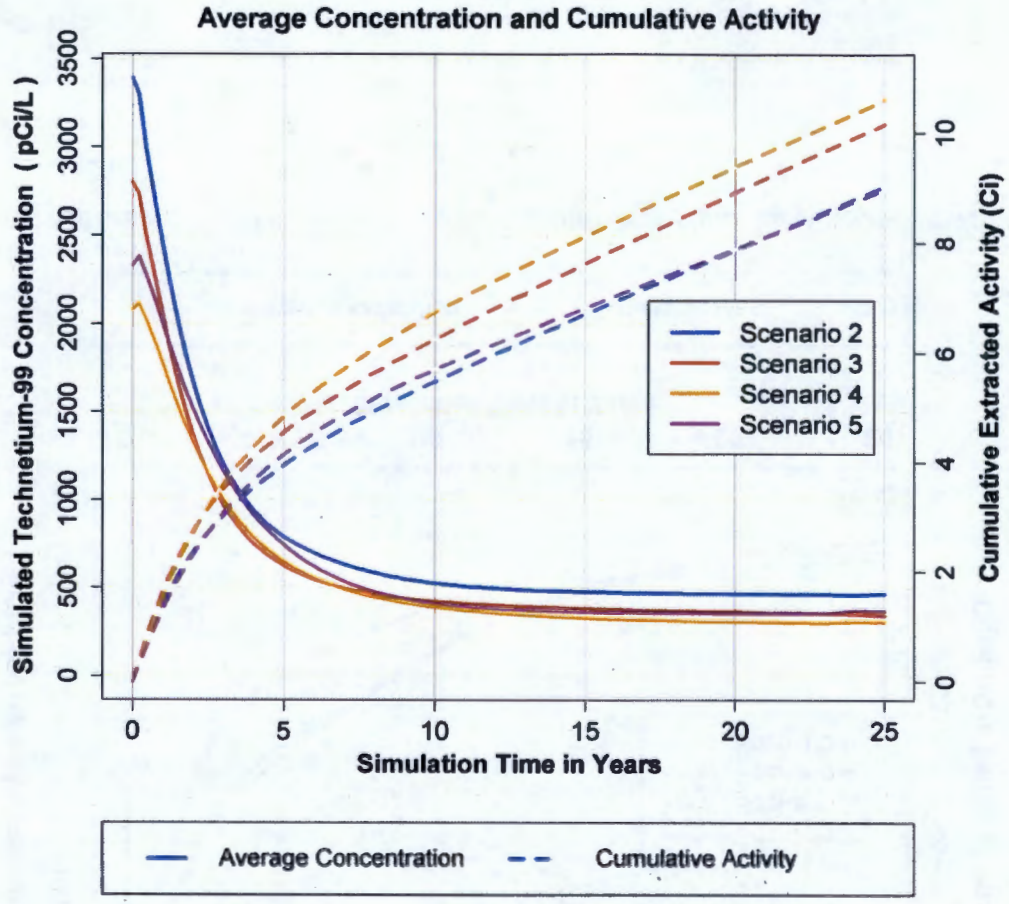

Figure B-290 - Summary of simulated extraction within the model domain for the technetium-99 plume for all scenarios with a continuing source term.

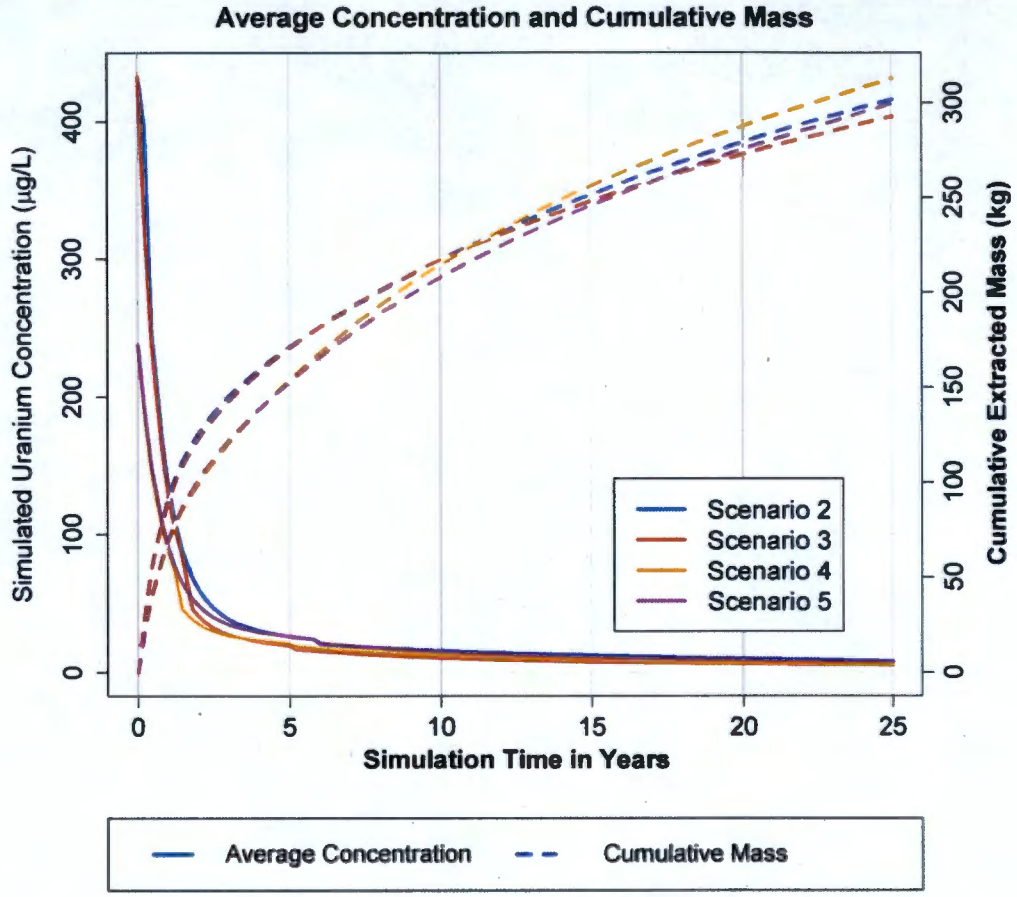

Figure B-291 - Summary of simulated extraction within the model domain for the uranium plume for all scenarios with a continuing source term.