OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL COVER SHEET

Complete Only Applicable Items

2. ☒ Analysis   ☐ Engineering   3. ☐ Model   ☐ Conceptual Model Documentation

             ☒ Performance Assessment   ☐ Model Documentation

             ☐ Scientific   ☐ Model Validation Documentation

4. Title: Recharge and Lateral Groundwater Flow Boundary Conditions for the Saturated Zone Site-Scale Flow and Transport Model

5. Document Identifier (including Rev. No. and Change No., if applicable):

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12. Remarks:

This analysis does not affect a discipline or functional area other than the originating discipline. This analysis provides the site-scale flow and transport model flow component with recharge and boundaries. This analysis does not directly affect organizations and users outside NEPO, therefore a Review is not required.   ARE 9-22-99

NM3507

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL REVISION RECORD

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ANL-NBS-MD-000010   Rev. 00

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<div align="right">**Page**</div>

1. PURPOSE

The purpose of the flow boundary conditions analysis is to provide the specified-flux boundary conditions to the saturated zone (SZ) site-scale flow and transport model. This analysis is designed to use existing modeling and analysis results as the basis for estimated groundwater flow rates into the SZ site-scale model domain, both as recharge at the upper (water table) boundary and as underflow at the lateral boundaries. The objective is to provide consistency at the boundaries between the SZ site-scale flow model and other groundwater flow models. The scope of this analysis includes extraction of the volumetric groundwater flow rates simulated by the SZ regional-scale flow model to occur at the lateral boundaries of the SZ site-scale flow model. In addition, the scope includes compilation of information on the recharge boundary condition taken from three sources: 1) distributed recharge as taken from the SZ regional-scale flow model, 2) recharge below the area of the unsaturated zone (UZ) site-scale flow model, and 3) focused recharge along the Fortymile Wash channel.

This analysis is governed by the OCRWM Work Direction and Planning Document entitled "Development of Flow Boundary Conditions for SZ Flow and Transport Model" (CRWMS M&O 1999).

2. QUALITY ASSURANCE

This document follows the activity evaluation for QAP-2-0, *Conduct of Activities*, as completed by Dan Wilkins on 3/17/99, that determines this work activity applicable to the QA program. The applicable implementing procedures are defined in the OCRWM Work Direction and Planning Document entitled "Development of Flow Boundary Conditions for SZ Flow and Transport Model" (CRWMS M&O 1999).

3. COMPUTER SOFTWARE AND MODEL USAGE

The following industry standard software was used in this analysis and documentation:

Excel 97-SR-1

    Used for spreadsheet calculations.

Surfer 6.03

    Used for plotting and visualization of analysis results in figures shown in this report.

3.1. RECHARGE

No controlled software codes are used to synthesize the estimates of recharge for the boundary conditions of the SZ site-scale model. A Microsoft Excel spreadsheet is used to combine the components of the recharge model.

3.1.1. Distributed Recharge

A set of software routines is developed and used to extract the distributed recharge from the USGS SZ regional-scale flow model and write the values of recharge for input to the SZ site-scale flow model. The software routines *xread_distr_rech.f (version 1.0)* and *xread_distr_rech_-uz.f (version 1.0)* are documented in the "Analysis" section of this report.

3.1.2. Recharge From UZ Site-Scale Model Area

A Microsoft Excel spreadsheet is used to perform calculations and unit conversions of data extracted from the output files of the UZ site-scale flow model.

3.1.3. Focused Recharge From Fortymile Wash

A software routine is used to designate the value of recharge from Fortymile Wash and superimpose this value on the distributed recharge from the USGS SZ regional-scale flow model. The software routine *xread_reaches.f (version 1.0)* is documented in the "Analysis" section of this report.

A software routine is used to superimpose the values of recharge from the three recharge components for use in the SZ site-scale flow model. The software routine *xwrite_flow_new.f (version 1.0)* is documented in the "Analysis" section of this report.

3.2. LATERAL BOUNDARIES

A Microsoft Excel spreadsheet is used to compile simulated groundwater flux values from the USGS SZ regional-scale flow model. The regional scale model results are calculated using the MODFLOWP computer code. An executable file (Modflowp) and a set of input files were obtained from the Technical Data Management System (TDMS) (DTN: GS960808312144.003) and copied these files to a Sun workstation. The source code for the MODFLOWP program indicates that this is revision 2.1 of the code. Issues of software configuration management and QA status for this software must be addressed in the verification process for TBV-1249 (see Table 4-1 of this report).

4. INPUTS

Input information used in this analysis comes from several sources that are summarized in Table 4-1.

Table 4-1. Input Data Sources

Data Set	Data Description	Data Tracking Number	Data Type	Data Status
Distributed Recharge File: *"rchp"*	Recharge input file from USGS SZ regional-scale flow model (D'Agnese et al., 1997)	GS960808312144.003	Developed	TBV-1249
Recharge from UZ Site-Scale Model Area Files: *"mnaqb_p.out"* and *"mesh_bas.2k"*	Output file from UZ site-scale flow model	LB970601233129.001	Developed	TBV-1250
Focused Recharge from Fortymile Wash Table: Table 5.	Estimates of recharge along four reaches of Fortymile Wash (Savard, 1998)	GS970308312133.001	Developed	TBV-1251
Lateral Boundaries File: *"cbcf.new"*	Output file from USGS SZ regional-scale flow model (D'Agnese et al., 1997)	GS960808312144.003	Developed	TBV-1249

5. ASSUMPTIONS

5.1. RECHARGE

In the analysis presented in this report it is assumed that the three components of recharge (i.e., distributed recharge, recharge from the UZ site-scale model area, and focused recharge from Fortymile Wash) considered in the analysis provide a reasonable estimate of the magnitude and spatial pattern of recharge, when combined. In particular, it is assumed that the resulting estimate of groundwater recharge is suitable and adequate for the purposes of flow model calibration for the SZ site-scale flow model. Although the estimates of recharge for the three different components of the recharge analysis were derived by different methods, it is assumed that the results are sufficiently consistent for the purposes of the combined recharge model in the SZ site-scale flow model. This assumption is supported by the observation that the total volumetric flow rate of recharge is a relatively small fraction of the total volumetric groundwater flow rate through the SZ

site-scale model domain from the lateral boundaries of the model, as shown in Sections 7.1 and 7.2 of this report.

5.1.1. Distributed Recharge

The pattern of distributed recharge is taken from the SZ regional-scale flow model, which is constructed with a grid resolution of 1500 m. It is assumed that this relatively coarse resolution is adequate for use at the higher resolution of the SZ site-scale flow model. All of the underlying assumptions embodied in the recharge model for the SZ regional-scale flow model (D'Agnese et al., 1997) apply to the results of that model as extracted in this analysis. The basis of these assumptions is that the SZ regional-scale flow model is based on measurements of groundwater discharge and is consequently constrained by the water balance of the entire groundwater system. As such, the regional-scale flow model results provide the best available estimate of the volumetric groundwater flow rate at the scale of the SZ site-scale flow model.

5.1.2. Recharge From UZ Site-Scale Model Area

The pattern of recharge is taken from the bottom boundary of the UZ site-scale flow model in the area of the UZ model. The UZ site-scale flow model has variable grid resolution that is generally finer than the grid resolution for the SZ site-scale flow model. It is assumed that the integration of recharge flux extracted from the UZ model for use at the grid resolution of the SZ site-scale flow model is adequate to represent the recharge pattern in this area.

The infiltration model employed in the UZ site-scale flow model differs in resolution and conceptual basis from the recharge model used in the SZ regional-scale model. It is assumed that this inconsistency is not significant for the purpose of model calibration of the SZ site-scale flow model. In addition, the UZ site-scale flow model results used in this analysis are from the expected case among several alternative models that consider uncertainty in the infiltration flux and UZ flow model parameters. It is assumed that the expected case of the UZ site-scale flow model is the most representative estimate to use for the recharge analysis. The relatively small total groundwater contribution from the UZ model area relative to the distributed recharge model (see Section 7.1 of this report) indicates that these assumptions are not of large consequence for the purpose of SZ site-scale flow model calibration.

5.1.3. Focused Recharge From Fortymile Wash

The estimates of recharge from the Fortymile Wash channel (Savard, 1988) are based on streamflow losses during brief runoff events over a maximum of 26 years. It is assumed that the observations are representative of the long-term recharge from this source. The estimates of recharge for the Fortymile Canyon reach and the Amargosa Desert reach are extrapolated and interpolated, respectively, to estimate the recharge rates for reaches of the wash within the area of the SZ site-scale model (see Section 6.1.3 of this report). It is

assumed that the recharge is uniform along each of the stream reaches and that the effective width of the Fortymile Wash channel for recharge at the water table is approximately 500 m. It is also assumed that recharge is uniformly distributed over the area of the distributary channels of Fortymile Wash in the Amargosa Desert. One basis for these assumptions is the relatively small total groundwater contribution from the focused recharge along Fortymile Wash relative to the distributed recharge model (see Section 7.1 of this report).

5.2. LATERAL BOUNDARIES

The TDMS contains an executable file of the MODFLOWP code and input files. It is assumed that running this executable with these input files accurately calculates the cell-by-cell flow terms of the final 1997 USGS model. In addition, it is assumed that modifying the input files, as discussed in the Analysis section below, does not alter the calculated flow terms. The basis of this assumption is that the authors of the USGS regional-scale flow model provided the executable file of MODFLOWP in the TDMS to allow generation of the output files from the input files contained therein. The source code for the MODFLOWP program indicates that this is revision 2.1 of the code. Issues of software configuration management and QA status for this software must be addressed in the verification process for TBV-1249 (see Table 4-1 of this report).

The regional model assumes that the density of water is constant, but does not specify a specific value. An arbitrary value of 1000 kg/m^3 is assumed for fluid density in this analysis to convert from volumetric [m^3/day] to mass [kg/s] flows. The mass flow rates presented by this analysis could be easily modified to represent an alternative assumption about fluid density.

6. ANALYSIS

6.1. RECHARGE

The approach taken to the analysis of recharge over the domain of the SZ site-scale flow model involves taking interpretations of recharge from three sources and combining this information into a single model for the spatial distribution of recharge. The starting point of the analysis is the model of distributed recharge used in the SZ regional-scale flow model. Within the area of the UZ site-scale flow model the estimates of distributed recharge are replaced by the simulated values of groundwater flow at the water table boundary of the UZ flow model. In the areas beneath the Fortymile Wash channel the distributed recharge estimate is replaced by the estimates of recharge based on streamflow loss measurements.

6.1.1. Distributed Recharge

The values of distributed recharge are extracted from the SZ regional-scale flow model input file for recharge. The recharge input file for the SZ regional-scale flow model is "*rchp*" and is taken from the TDMS (DTN: GS960808312144.003). The FORTRAN routine "*xread_distr_rech.f*" is used to extract the values of recharge from the "*rchp*" file and write an output file "*rech_site.dat*" that contains the UTM coordinates on 1500 m centers and the recharge in units of m/year. Electronic copies of these files are included in the electronic archive (DTN: SN9908T0581999.001) along with this report. A listing of the software routine "*xread_distr_rech.f*" is included as Attachment I of this report.

The FORTRAN routine "*xread_distr_rech_-uz.f*" is used to convert the values of distributed recharge contained in the file "*rech_site.dat*" to a 125 m grid within the area of the SZ site-scale model and writes the output to file "*rech_distr.dat*" in units of mm/year. The 125 m grid is used because this is the finest discetization anticipated for the SZ site-scale flow model. In addition, this routine excludes any grid locations inside the area of the UZ site-scale flow model. A plot of the spatial distribution of recharge in file "*rech_distr.dat*" is shown in Figure 6.1.1-1. Electronic copies of these files are included in the electronic archive (DTN: SN9908T0581999.001) along with this report. A listing of the software routine "*xread_distr_rech_-uz.f*" is included as Attachment II of this report.
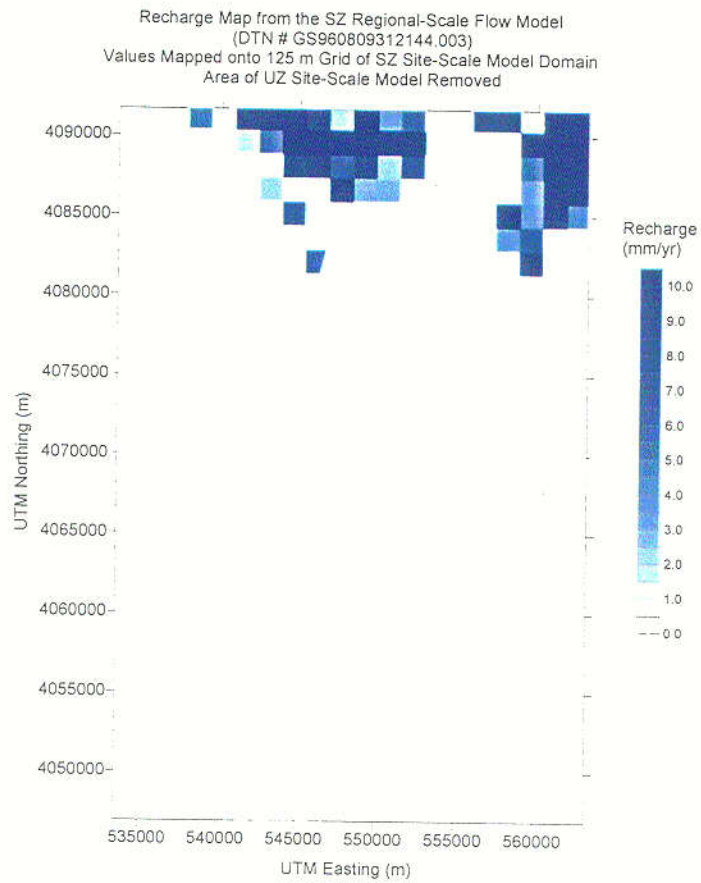
Figure 6.1.1-1. Map of distributed recharge from the SZ regional-scale flow model. Recharge within the area of the UZ site-scale model is not included. Recharge data taken from file "rech_distr.dat".

6.1.2. Recharge From UZ Site-Scale Model Area

The recharge in the area of the UZ site-scale flow model is taken from the output file for the UZ flow simulations "*mnaqb_p.out*", which is taken from the TDMS (DTN: LB970601233129.001). This TOUGH2 output file corresponds to the base-case, mean alpha, present day infiltration scenario in Total System Performance Assessment – Viability Assessment (TSPA-VA) (CRWMS M&O 1998).

Elements in the UZ site-scale flow model at the bottom boundary of the model (i.e., the water table) are identified by the prefix "BT" in the input and output files. Elements that are associated with fracture flow use the prefix "F" and elements for matrix flow use the prefix "M" in this dual-permeability model. These prefixes are used to extract the 1470 elements at the water table in the UZ site-scale flow model using the UNIX "grep" command. The following two commands are used to perform the extraction:

> "grep BT.....F mnaqb_p.out>extract_F.out"
> "grep BT.....M mnaqb_p.out>extract_M.out"

The two output files "*extract_F.out*" and "*extract_M.out*" contain the groundwater flux at the water table boundary (in kg/s) in the fourth column of the files for the fracture and matrix components of flow, respectively.

The numerical grid file for the UZ site-scale flow model "*mesh_bas.2k*" is taken from the TDMS (DTN: LB970601233129.001) to obtain information on the x and y coordinates of each element and information on the connection area for each element. The following UNIX command is used to perform the extraction:

> "grep "BT.....   " mesh_bas.2k>meshgrep2.out"

The output file "*meshgrep2.out*" contains the connection area of the element in column numbers 21 to 29, the x coordinate (Nevada State Plane in meters) in column numbers 51 to 60 and the y coordinate in column numbers 61 to 70.

These data are combined in an Excel spreadsheet in the file "*wt_flux_uz.xls*". This spreadsheet is constructed by taking columns from the "*extract_F.out*", "*extract_M.out*", and "*meshgrep2.out*" files and performing additional operations to calculate total volumetric flow rate and average percolation flux. The results are plotted in Figure 6.1.2-1 and are overlain by the UZ site-scale flow model grid.

Groundwater Flux at the Water Table from UZ Site-Scale Flow Model
Base Case, Present Climate, Output File: mnaqb_p.out
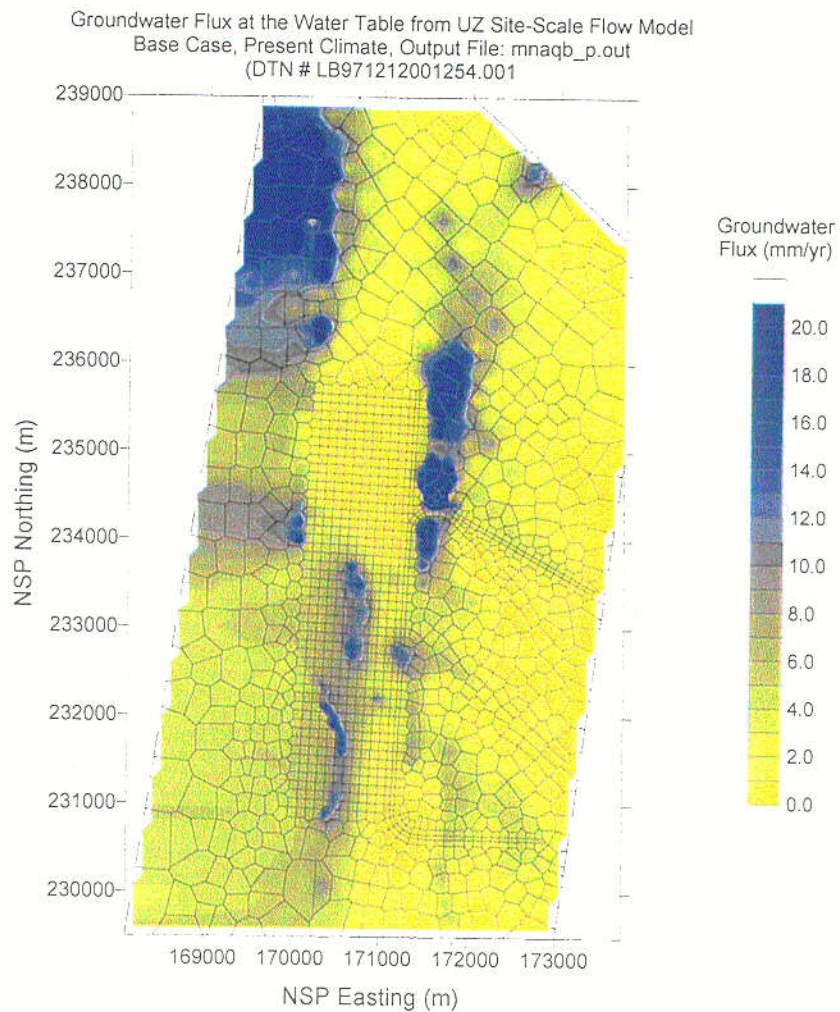(DTN # LB971212001254.001)

Figure 6.1.2-1. Map of groundwater flux simulated at the bottom boundary of the UZ site-scale
flow model. The model grid is shown overlain on the map of simulated recharge to the SZ.

To combine the output from the UZ site-scale flow model with the other components of the recharge model, the geographical coordinates from the UZ model are converted from the Nevada State Plane coordinate system to the UTM coordinate system. The results of this coordinate transformation are given in the spreadsheet in the file "*wt_flux_uz.xls*". The software routine "Corpscon" is used to perform the coordinate transformation. This Windows routine is included in the archive of files (DTN: SN9908T0581999.001) for this analysis. Checking and verification of the coordinate transformation was conducted by visual inspection of the plotted recharge location, as shown in Figure 6.1.3-2. In addition, validation of the Corpscon routine output with some example coordinate transformations is contained in Attachment VI.

6.1.3. Focused Recharge From Fortymile Wash

Recharge from infiltration along Fortymile Wash is based on estimates of streamflow loss along four reaches of Fortymile Wash as documented in Savard (1998). These reaches are the Fortymile Canyon reach, Upper Jackass Flats reach, Lower Jackass Flats reach, and Amargosa Desert reach, listed from north to south and shown in Figure 6.1.3-1. The estimate of recharge along the northernmost reach of Fortymile Wash (Fortymile Canyon reach) has been extrapolated to the north boundary of the SZ site-scale model domain. The lengths of the Fortymile Canyon reach within the Savard (1998) study and within the SZ site-scale model domain were estimated graphically from Figure 6.1.3-1. The estimate of recharge along the Upper Jackass Flats reach presented in Savard (1998) is anomalously low relative to the other reaches as estimated in the same report. Consequently, an interpolated value of recharge for the Upper Jackass Flats reach is applied. The volumetric groundwater recharge rates per kilometer of reach are averaged for the Fortymile Canyon reach and the Lower Jackass Flats reach and this value is applied for the Upper Jackass Flats reach. The recharge rate along the Amargosa Desert reach is scaled in proportion to the length of this reach within the SZ site-scale model area. The resulting estimates of the recharge rates are summarized in Table 6.1.3-1.

Table 6.1.3-1. Fortymile Wash Recharge Estimates

Fortymile Wash Reach	Reach Length (from Savard, 1998) (km)	Estimated Recharge (m³/year) (Savard, 1998, Table 5)	Reach Length in SZ Site-Scale Model (km)	Estimated Recharge in SZ Site-Scale Model Area (m³/year)	Estimated Recharge Flux (mm/year)
Fortymile Canyon	6.5	27000	9.5	39500[b]	5.77
Upper Jackass Flats	10.1	13600[a]	10.1	13600	2.21
Lower Jackass Flats	16.8	16400	16.8	16400	1.53
Amargosa Desert	25.0	64300	10.0	25700[b]	0.22

[a] Interpolated value.
[b] Scaled in proportion to length within the SZ site-scale model area.

The first step of the analysis is to identify those nodes that correspond to the Fortymile Wash channel for each of the reaches on a 125 m resolution grid as shown in Figure 6.1.3-1. Along most of the length of the Fortymile Wash channel, nodes within an approximately 500 m wide zone are designated to receive recharge from the wash. The nodes corresponding to a broad area of distributary channels in the Amargosa Desert are identified for the southernmost reach within the area of the SZ site-scale model domain. The results are 438 nodes in the Fortymile Canyon reach, 394 nodes in the Upper Jackass Flats reach, 687 nodes in the Lower Jackass Flats reach, and 7544 nodes in the Amargosa Desert reach.

Processing of the data is performed with the FORTRAN routine "*xread_reaches.f*", which is included as Attachment III to this report. This routine reads in the file "*digit.dat*", which contains a set of digitized points defining the stream channel location for the four reaches of Fortymile Wash within the SZ site-scale model domain and the recharge rates for those reaches as tabulated in Table 6.1.3-1. The file "*digit.dat*" was generated using the digitize function from the Surfer program from Figure 6.1.3-1. The routine also reads in the file "*rech_distr.dat*", which contains the values of distributed recharge within the SZ site-scale model domain, as described in section 6.1.1 of this report. The routine "*xread_reaches.f*" combines the estimates of distributed recharge and the estimates of focused recharge and outputs the file "*rech_distr_stream.dat*". This file contains location coordintates (UTM m) and recharge (mm/year) on a 125 m grid for all locations with nonzero values of recharge. The file "*rech_distr_stream.dat*" also excludes grid locations within the area of the UZ site-scale model.

6.1.4. Combined Recharge Model

The estimates of distributed recharge and focused recharge contained in the file "*rech_distr_stream.dat*" are combined with the simulated recharge at the water table boundary of the UZ site-scale flow model contained in file "*wt_flux_uz.xls*" in an Excel spreadsheet in the file "*rech_all_new.xls*". In the "*rech_all_new.xls*" spreadsheet, the groundwater mass flux (kg/s) into each grid node is calculated. The first 1470 entries in the spreadsheet are for the output of the UZ site-scale flow model and the remaining entries are for the distributed recharge and focused recharge components of the analysis. The result of the combined estimates is shown in the map in Figure 6.1.3-2.

These results are reformatted for input to the FEHM code using the FORTRAN routine "*xwrite_flow_new.f*", which is included as Attachment IV of this report. The "*xwrite_flow_new.f*" routine reads in the data in the "*rech_all_new.xls*" spreadsheet (saved in the text file "*rech_all_new.txt*", which has the header lines removed). The "*xwrite_flow_new.f*" routine writes output in a format suitable for input to the "flow" macro of FEHM for specified groundwater mass flux (kg/s). The resolution of the grid nodes in the output from the "*xwrite_flow_new.f*" routine is specified within the routine. The output assumes that grid nodes are numbered sequentially from the southwest corner

of the SZ site-scale model domain, moving from west to east and south to north. Output files were generated for 1000 m, 500 m, 250 m, and 125 m nodal resolutions in the files "*wt_flow_1000.dat*", "*wt_flow_500.dat*", "*wt_flow_250.dat*", "*wt_flow_125.dat*", respectively.
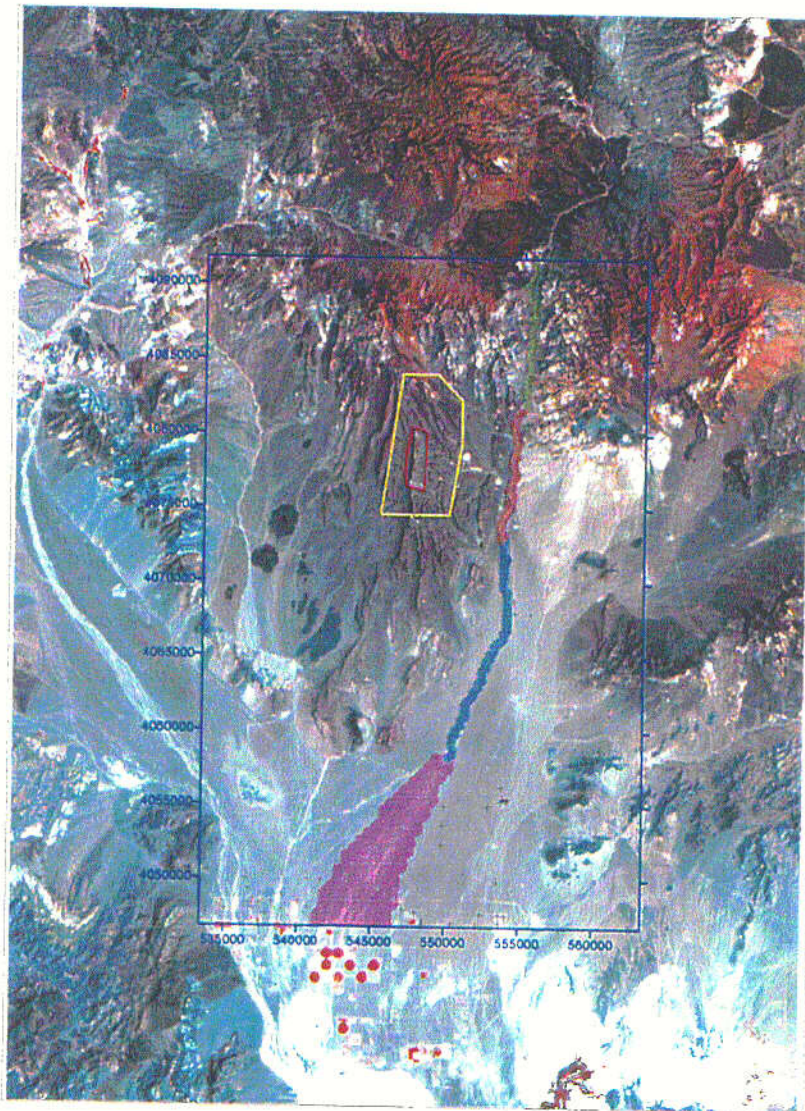
Figure 6.1.3-1. Map of recharge along the Fortymile Wash stream channel. The base image of
the figure is a false-color satellite photo of the Yucca Mountain area. The four reaches of
Fortymile Wash are shown by the different colors overlying the wash. The boundaries of the SZ
site-scale model and the UTM coordinates (m) are shown by the blue line. The approximate
outline of the repository is shown by the red line and the outline of the UZ site-scale model is
shown with the yellow line.

Recharge Map from the SZ Regional-Scale Flow Model
Output file: rchp (DTN # GS960809312144.003)
Recharge Along Fortymile Wash Taken from Savard (1998)
Groundwater Flux at the Water Table from UZ Site-Scale Flow Model
Base Case, Present Climate, Output File: mnaqb_p.out
(DTN # LB971212001254.001)
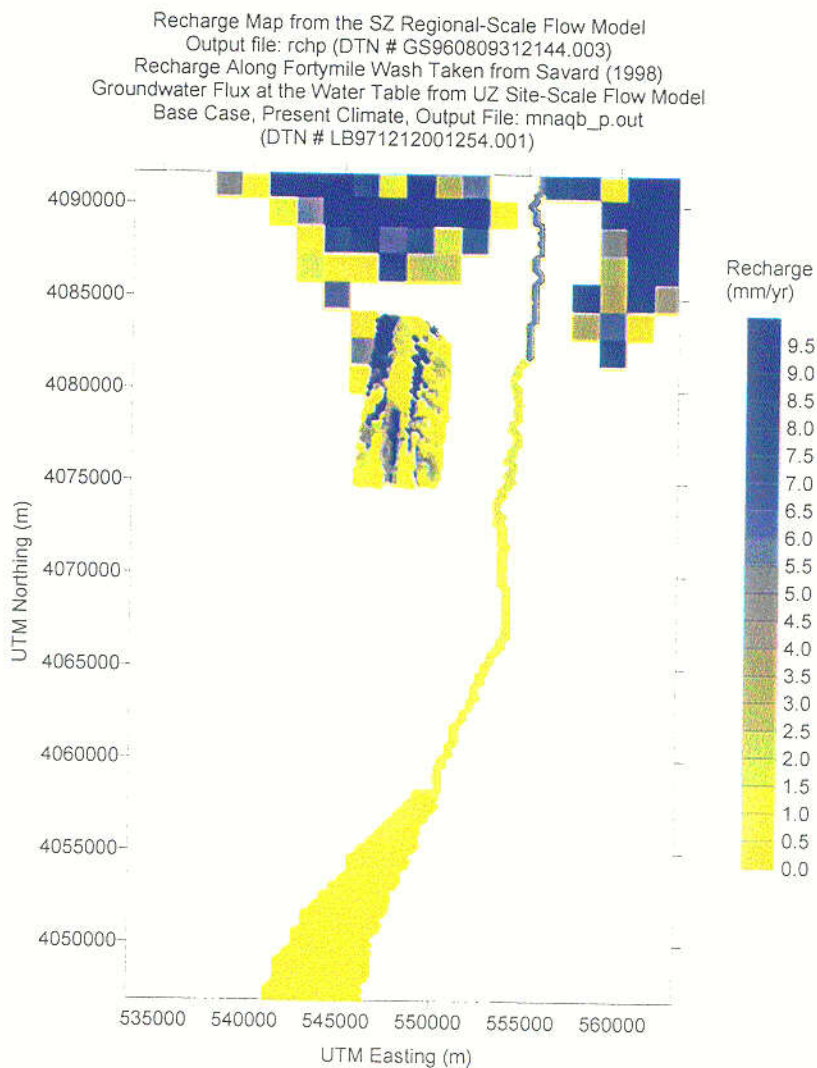
Figure 6.1.3-2. Map of recharge to the SZ site-scale flow model, combining the components of distributed recharge, recharge below the UZ site-scale flow model domain, and focused recharge along Fortymile Wash.

C4

6.2. LATERAL BOUNDARIES

Extracting fluxes from the SZ regional-scale flow model is performed in three steps. Because the TDMS does not include output files from the 1977 U. S. Geological Survey model of the Death Valley regional ground-water flow system, the first step is to re-run the regional model to generate an unformatted output file containing cell-by-cell flow values. Second, a FORTRAN routine is used to read the unformatted file and write selected values to formatted files. Finally, an Excel spreadsheet is used to sum the flow terms for selected segments along the site-scale boundaries and convert from volumetric to mass flows.

Running the regional model:

1) The regional scale model results are calculated using the MODFLOWP computer code. An executable file (*Modflowp*) and a set of input files are obtained from the TDMS (DTN GS960808312144.003) and copied to a Sun workstation, node=Picard, with the following 4 processors:

```
cpu0:  SUNW,UltraSPARC-II  (upaid  0  impl  0x11  ver  0x11  clock  296  MHz)
cpu1:  SUNW,UltraSPARC-II  (upaid  1  impl  0x11  ver  0x11  clock  296  MHz)
cpu2:  SUNW,UltraSPARC-II  (upaid  2  impl  0x11  ver  0x11  clock  296  MHz)
cpu3: SUNW,UltraSPARC-II (upaid 3 impl 0x11 ver 0x11 clock 296 MHz).
```

2) The input files for the SZ regional-scale flow model in the TDMS are set up to calculate certain statistics, but the input files required for these statistics (*BEALE.DAT* and *BEALE2.DAT*) are not present. Because these statistics are not required for this analysis, two changes are made to the input files to allow MODFLOWP to run without these files. In the input file "*dvparwell4*", the 5th entry of line 7 (in columns 24 and 25) is changed from 72 to zero. This is a switch which tells MODFLOWP not to calculate the statistics that require "*BEALE.DAT*" and "*BEALE2.DAT*". Second, the a line containing the file name "*BEALE.DAT*" and a line containing the filename "*BEALE2.DAT*" are deleted from the input file "*Files*". This file contains file names and their corresponding logical unit numbers. Deleting these file names from "*Files*" prevents MODFLOWP from trying to open a file that was not present.

3) The executable (*Modflowp*) is then run. The output file used in this analysis is the "*cbcf.new*" file, which contains cell-by-cell flow terms.

Extract cell-by-cell flow terms along the boundaries of the site-scale domain:

The coordinates of site-scale domain are:

xmin   533,340 m E

  xmax 563,340 m E
  ymin 4,046,780 m N
  ymax 4,091,780 m N

The regional model is 163 rows by 153 columns, SW corner at 440,340; 3,944,782 (D'Agnese et al, 1997, page 75). Row 1 is to the north. Column 1 is to the west. Each model cell is 1,500 m square in the lateral directions. Then,

the x coordinates at east face of column 62 = 440340+((62)(1500))= 533,340
the x coordinates at east face of column 82 = 440340+((82)(1500))= 563,340
the y coordinates at south face of row 95 = 3,944,782+((163-95)(1500))=4,046,782
the y coordinates at south face of row 65 = 3,944,782+((163-65)(1500))=4,091,782

Thus the domain outlined by the east faces of columns 62 and 82, and the south faces of rows 65 and 95 of the regional model form a domain that is shifted 2 m north of the site-scale domain. The west boundary of the site-scale model consists of the east face of column 62 for rows 66-95. The east boundary consists of the east face of column 82 for rows 66-95. The north boundary consists of the south face of row 65 for columns 63-82. The south boundary consists of the south face of row 95 for columns 63-82.

A FORTRAN routine (*extract.f*) to extract and write the flow terms was developed and used. The routine is compiled using the FORTRAN77 compiler on the Sun workstation (WorkShop Compilers 4.2 30 Oct 1996 FORTRAN 77 4.2). The routine is included as Attachment V. This routine writes the flow terms along each boundary to a separate file. The files are named "*west_bdy*", "*east_bdy*", "*north_bdy*", and "*south_bdy*". Details of the routine are given in comment statements in the source code of the routine.

These files were entered into an Excel workbook (electronic copy attached, file "*boundaries.xls*"). Excel is used for two calculations, to sum flow terms for segments along the site model boundaries and to convert the volumetric flows [m^3/day] to mass flows [kg/s]. The segments are selected to group fluxes of similar direction and magnitude.

7. CONCLUSIONS

Unqualified input data were used in this analysis. Therefore, any conclusions from this analysis and the use of the results from this analysis must be controlled as having "to be verified" status, in accordance with appropriate quality assurance procedures.

7.1. RECHARGE

The results of the combined estimates of recharge from distributed recharge, focused recharge along Fortymile Wash, and recharge in the area of the UZ site-scale flow model

are shown graphically in Figure 6.1.3-2. The majority of the recharge entering the system in the area of the SZ site-scale flow model occurs in the northern part of the model domain. An estimated total of 48.9 kg/s (1.55 x 10^6 m³/year) of groundwater enters the saturated-zone system as recharge in the SZ site-scale model area. Of this total, about 6.7 kg/s recharge occurs in the area of the UZ site-scale flow model and about 3.0 kg/s recharge occurs from focused recharge along Fortymile Wash.

7.2. LATERAL BOUNDARIES

The cell-by-cell flow terms extracted from the 1977 U. S. Geological Survey model of the Death Valley regional ground-water flow system are given in Tables 7.2-1 to 7.2-4. These tables contain the flow terms as calculated by MODFLOWP, i.e. in units of m³/day. The final column of each table is the sum of the terms for the three model layers for each row/column position. Flow terms for the west and east boundaries are for the (east) right cell faces, and terms for the north and south boundaries are for the south (front) faces. Row, column, and layer numbers are those of the regional model grid.

The total mass flux [kg/s] for segments along the west, north, and east site model boundaries follows. These boundaries are the current candidates for specified flux in the SZ site-scale flow model. The fluxes are for the boundaries of a region that is shifted 2 m north relative to the domain of the site-scale model. The coordinates of the boundary segments are in UTM (meters). Fluxes are the total flux for that boundary segment, from the water table to a depth of 2750 m (i.e., all three layers of the SZ regional-scale flow model). A positive value indicates flow into the SZ site-scale model domain.

East Boundary:

from y=4,046,780 to 4,058,780:	flux = +555.45 kg/s
from y=4,058,780 to 4,081,280:	flux = +5.46
from y=4,081,280 to 4,087,280:	flux = -2.65
from y=4,087,280 to 4,091,780:	flux = +3.07

North Boundary:

from x=533340 to 543840:	flux = +101.64 kg/s
from x=543840 to 552840:	flux = +18.86
from x=552840 to 560340:	flux = +64.70
from x=560340 to 563340:	flux = +10.63

West Boundary:

from y=4,046,780 to 4,054,280:	flux = -3.45 kg/s
from y=4,054,280 to 4,063,280:	flux = +71.00
from y=4,063,280 to 4,072,280:	flux = +6.90

from y=4,072,280 to 4,082,780:   flux = -2.73
from y=4,082,780 to 4,091,780:   flux = +46.99

Table 7.2-1. Cell-by-cell flow terms [m³/day] from the 1977 U. S. Geological Survey model of the
Death Valley regional ground-water flow system along the west boundary of the site-scale model

column	row	layer1	layer2	layer3	sum
62	66	300.2210	116.4051	172.6758	589.3019
62	67	385.4388	128.9357	283.9898	798.3643
62	68	91.2969	118.8400	182.6684	392.8053
62	69	81.6321	528.7921	163.5032	773.9274
62	70	119.7977	761.6837	117.8837	999.3651
62	71	102.2948	226.3122	177.2012	505.8082
62	72	3.5854	4.5799	4.5910	12.7563
62	73	0.9552	1.5968	-0.2015	2.3505
62	74	-43.1638	-0.7436	0.2239	-43.6835
62	75	-22.9567	-0.5382	1.9569	-21.5380
62	76	-26.6496	-0.5568	2.1711	-25.0353
62	77	-132.7272	-0.6117	1.8454	-131.4935
62	78	-30.6877	-0.1970	1.3879	-29.4968
62	79	67.7964	0.1506	1.0450	68.9920
62	80	99.1461	0.2877	0.9304	100.3642
62	81	102.5495	0.2189	0.6025	103.3709
62	82	150.8397	0.5854	0.4216	151.8467
62	83	33.8089	0.4745	0.6808	34.9642
62	84	23.4775	112.0292	0.8068	136.3135
62	85	115.8098	156.8466	45.4742	318.1306
62	86	545.1091	226.8207	656.8904	1428.8202
62	87	435.0265	644.8766	799.3350	1879.2381
62	88	389.4053	582.7269	31.7153	1003.8475
62	89	339.5885	482.1666	16.0400	837.7951
62	90	63.1286	604.9294	-1.8066	666.2514
62	91	-0.7494	7.4360	-1.9344	4.7522
62	92	-51.7265	-1.1885	-2.1722	-55.0872
62	93	-59.8463	-2.5714	-2.6846	-65.1023
62	94	-80.7184	-3.5531	-3.7052	-87.9767
62	95	-86.0093	-4.1979	-4.3128	-94.5200

Table 7.2-2. Cell-by-cell flow terms [m^3/day] from the 1977 U. S. Geological Survey model of the
Death Valley regional ground-water flow system along the east boundary of the site-scale model

column	row	layer1	layer2	layer3	sum
82	66	35.0744	104.1892	1.0335	140.2971
82	67	32.4961	59.5407	2.8732	94.9100
82	68	10.3283	17.9262	1.8526	30.1071
82	69	-3.4922	-6.7300	0.0019	-10.2203
82	70	-21.2585	-30.6522	0.0163	-51.8944
82	71	-31.1982	-40.6015	0.0209	-71.7788
82	72	-95.0790	-0.0151	0.0088	-95.0853
82	73	0.0957	22.1619	0.1119	22.3695
82	74	-0.0253	-4.9123	0.3112	-4.6264
82	75	5.1671	38.1532	0.3185	43.6388
82	76	5.3195	32.5464	14.2158	52.0817
82	77	23.1081	29.8514	36.8918	89.8513
82	78	21.1946	19.7791	14.2273	55.2010
82	79	5.6187	15.7595	4.4241	25.8023
82	80	1.4321	1.8868	-0.6955	2.6234
82	81	4.4139	1.3365	-0.0422	5.7082
82	82	14.2843	3.2528	0.0438	17.5809
82	83	13.3643	3.5229	-0.7694	16.1178
82	84	7.0857	2.9896	-1.4877	8.5876
82	85	6.2192	5.0456	0.1849	11.4497
82	86	29.3401	5.3988	31.3175	66.0564
82	87	1.9728	16.1808	41.1021	59.2557
82	88	0.2848	1548.8440	3119.2073	4668.3361
82	89	0.3887	2089.5090	4151.5591	6241.4568
82	90	0.4157	2228.8079	4423.1963	6652.4199
82	91	0.4114	2201.4536	4385.2954	6587.1604
82	92	3.1997	2140.7375	4301.0850	6445.0222
82	93	5.1691	2058.0015	4210.7461	6273.9167
82	94	14.4602	1854.5498	3990.9055	5859.9155
82	95	13.8338	1559.0319	3689.5305	5262.3962

Table 7.2-3. Cell-by-cell flow terms [m³/day] from the 1977 U. S. Geological Survey model of the Death Valley regional ground-water flow system along the north boundary of the site-scale model

column	row	layer1	layer2	layer3	sum
63	65	436.7631	158.6168	88.8833	684.2632
64	65	445.4616	666.2696	126.6694	1238.4006
65	65	470.4084	705.4063	142.2845	1318.0992
66	65	496.7751	743.2569	145.7451	1385.7771
67	65	511.1288	766.8786	141.3761	1419.3835
68	65	513.3553	770.7878	131.1927	1415.3358
69	65	500.4772	703.2574	116.6735	1320.4081
70	65	90.0194	124.4723	99.4196	313.9113
71	65	94.3074	135.7408	79.1619	309.2101
72	65	81.8713	125.9834	54.6917	262.5464
73	65	79.1612	122.4325	45.4847	247.0784
74	65	81.7757	123.9266	2.4599	208.1622
75	65	78.1031	207.5337	3.3195	288.9563
76	65	71.3560	834.7631	24.5218	930.6409
77	65	77.1166	911.6486	24.9287	1013.6939
78	65	84.7914	990.1692	26.3804	1101.3410
79	65	160.8794	1060.8494	27.2710	1248.9998
80	65	166.6360	1100.9541	27.4993	1295.0894
81	65	204.6464	321.8176	38.1635	564.6275
82	65	82.4114	226.1308	45.4612	354.0034

Table 7.2-4. Cell-by-cell flow terms [m^3/day] from the 1977 U. S. Geological Survey model of the
Death Valley regional ground-water flow system along the south boundary of the site-scale model

column	row	layer1	layer2	layer3	sum
63	95	-10.1696	-27.0123	-2.3935	-39.5754
64	95	-162.1753	-65.2793	-3.1454	-230.6000
65	95	-82.6131	-757.2695	-165.6998	-1005.5824
66	95	-358.8732	-600.8329	-192.5924	-1152.2985
67	95	-371.3719	-612.0051	-242.7134	-1226.0904
68	95	-511.8046	-755.4321	-249.1117	-1516.3484
69	95	-555.7947	-830.3972	-1310.7151	-2696.9070
70	95	-592.0862	-885.5881	-1346.3021	-2823.9764
71	95	-609.6418	-913.7783	-1431.5834	-2955.0035
72	95	-557.9603	-853.9814	-1365.4269	-2777.3686
73	95	-487.4033	-749.4507	-1280.9761	-2517.8301
74	95	-296.7092	-462.6852	-1192.6534	-1952.0478
75	95	-134.0494	-45.4739	-1074.3965	-1253.9198
76	95	-75.9106	-35.3944	-54.2203	-165.5253
77	95	-1.0317	16.2062	21.8088	36.9833
78	95	-10.1687	-97.8409	-152.0629	-260.0725
79	95	-6.4307	-3467.8037	-7410.0439	-10884.2783
80	95	-5.3251	-3423.5581	-7539.6074	-10968.4906
81	95	-32.0253	-3663.1204	-7828.6636	-11523.8093
82	95	-35.7936	-4120.3281	-8149.0601	-12305.1818

8. REFERENCES

8.1. DOCUMENTS CITED

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TRW Environmental Safety Systems 1997. *Yucca Mountain Site Characterization Project Site Atlas 1997*. Las Vegas, Nevada: TRW Environmental Safety Systems. ACC: MOL.19980623.0385.

8.2. PROCEDURES

QAP-2-0, Rev. 5. *Conduct of Activities*. ACC: MOL.19980826.0209.

8.3. SOURCE DATA, LISTED BY DATA TRACKING NUMBER

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GS970308312133.001. Estimated Ground-Water Recharge From Streamflow in Fortymile Wash Near Yucca Mountain. Submittal date: 03/24/97.

LB970601233129.001. The Site-Scale Unsaturated Zone Model of Yucca Mountain, Nevada for the Viability Assessment. Submittal date: 06/09/97.

LB971212001254.001. DKM Basecase Parameter Set for UZ Model with Mean Fracture Alpha, Present Day Infiltration, and Estimated Welded, Non-Welded and Zeolitic FMX. Submittal date: 12/12/97.

MO9907YMP99025.001. List of Boreholes. Submittal date: 07/19/99.

9. ATTACHMENTS

Attachment	Title
I	Listing of the xread_distr_rech.f FORTRAN Routine
II	Listing of the xread_distr_rech_-uz.f FORTRAN Routine
III	Listing of the xread_reaches.f FORTRAN Routine
IV	Listing of the xwrite_flow_new.f FORTRAN Routine
V	Listing of the extract.f FORTRAN Routine
VI	Validation of the Corpscon Routine

ATTACHMENT I

LISTING OF THE xread_distr_rech.f FORTRAN ROUTINE

This routine begins by reading in the values of recharge from the SZ regional-scale model as a one-dimensional array with variable "rech1" in the loop ending with line 10. This array is converted to a two-dimensional array with variable "rech2" consisting of 163 rows and 153 columns in the loop ending with line 20. The rows and columns correspond to the rows and columns in the SZ regional-scale flow model (D'Agnese et al., 1997, p. 75). Output is written for those rows (66 to 95) and columns (63 to 82) that correspond to the area of the SZ site-scale model (see Section 6.2 of this report) with the loop ending with line 30. The xo and yo values defined in the routine are the UTM coordinates of the middle of the 1500 m cell in the southwest corner of the SZ site-scale model domain.

```
C
      program xread_distr_rech
C
C     This program extracts the values of recharge in the SZ
C     regional-scale flow model input file "rchp" within the
C     domain of the SZ site-scale flow model.  The output
C     consists of x and y coordinates (UTM) on 1500 m centers and
C     the value of recharge (m/year).
C
      DIMENSION rech1(24939),rech2(153,163)

      open(file='rchp',unit=11,status='old')
      open(file='rech_site.dat',unit=12,status='new')

      xo=534090.
      yo=4091030.

      do 10 i=1,3
        READ(11,*)
   10 continue

      read (11,*) rech1

      do 20 j=1,163
        do 20 i=1,153
          nnum=((j-1)*153)+i
          rech2(i,j)=rech1(nnum)
   20 continue

      do 30 j=95,66,-1
        do 30 i=63,82
          x=xo+(i-63)*1500.
          y=yo+(66-j)*1500.
          WRITE(12,*) x,y,rech2(i,j)
   30 continue

   99 format (i6,3f12.1)

      end
```

ATTACHMENT II

LISTING OF THE xread_distr_rech_-uz.f FORTRAN ROUTINE

This routine begins by reading in the coordinates and values of recharge from the SZ regional-scale flow model within the area of the SZ site-scale model in the loop ending at line 10. The routine then loops through a 125 m grid (239 columns by 359 rows) for the SZ site-scale model domain in the loop that ends at line 100. For each fine grid location the routine finds the nearest node from the 1500 m grid of the SZ regional-scale model and assigns that value of recharge to the 125 m grid node in the loop ending at line 110. The values of recharge are converted from m/year to mm/year by multiplying by 1000 mm/m. The routine then uses a function call to the "inside" function to determine if the 125 m grid node is inside or outside of the UZ site-scale flow model area. The area of the UZ site-scale flow model is defined by the six points at the vertices of a polygon. Finally, the coordinates of the 125 m grid node and the value of recharge are written out by the routine, if the node is outside the area of the UZ site-scale flow model domain.

```
C
        program xread_distr_rech_uz
C
C       This routine reads in the values of recharge (m/year) taken
C       from the SZ regional-scale flow model within the area of the
C       SZ site-scale flow model on a 1500 m grid.  The routine writes
C       out values of recharge (mm/year) on a 125 m grid over the same
C       domain with grid points inside the area of the UZ site-scale
C       flow model excluded.

        dimension x(20),y(20)
        dimension rech1(600)
        dimension x_reg(600),y_reg(600)

        open(file='rech_site.dat',unit=11,status='old')
        open(file='rech_distr.dat',unit=12,status='new')

C       Limits of the SZ site-scale model domain
        xmin=533340.
        xmax=563340.
        ymin=4046780.
        ymax=4091780.

C          Coordinates of the polygon bounding the UZ site-scale model
domain
        x(1)=545424.9
        x(2)=546891.3
        x(3)=549290.6
        x(4)=551045.7
        x(5)=551054.5
        x(6)=550323.5
        y(1)=4074660.5
        y(2)=4084163.0
        y(3)=4084171.4
        y(4)=4082578.0
        y(5)=4080078.7
        y(6)=4074677.6
```

```
      cx=548308.
      cy=4079169.

      delx=125.

      n=6

      do 10 i=1,600
        read(11,*) x_reg(i),y_reg(i),rech1(i)
  10  continue

      do 100 j=2,360
        do 100 i=2,240
          distmin=10000.
          do 110 k=1,600
            xx=(i-1)*delx+xmin
            yy=(j-1)*delx+ymin
            xdist=xx-x_reg(k)
            ydist=yy-y_reg(k)
            dist=sqrt((xdist*xdist)+(ydist*ydist))
            if(dist.lt.distmin) then
              distmin=dist
              nmin=k
            endif
 110      continue
          rech=rech1(nmin)*1000.

          nin=inside(xx,yy,n,x,y,cx,cy)
          if(nin.eq.0) then
            write(12,99) xx,yy,rech
          endif

 100  continue

  99  format(3f15.2)

C
      end


      INTEGER FUNCTION INSIDE (XX, YY, N, X, Y, CX, CY)
C
C
C     (CX,CY) is a point inside the polygon
C     (X,Y) are the vectors of the coordinates of the polygon
C        (XX,YY) is the point in question as to whether it is in the
polygon
C
C     Returns
C     0 - if outside polygon
C     1 - if inside polygon
C
      dimension x(20),y(20)
C
      INSIDE = 0
```

```
      K = N

      xmin=x(1)
      xmax=x(1)
      ymin=y(1)
      ymax=y(1)
      do 50 i=2,n
         if(x(i).le.xmin) xmin=x(i)
         if(x(i).ge.xmax) xmax=x(i)
         if(y(i).le.ymin) ymin=y(i)
         if(y(i).ge.ymax) ymax=y(i)
   50 continue

      if(xx.le.xmin) goto 100
      if(xx.ge.xmax) goto 100
      if(yy.le.ymin) goto 100
      if(yy.ge.ymax) goto 100
C
      DO 20  I = 1, N
C
         IF (X(I) .EQ. X(K) )   THEN
C
            IF ( (YY .LE. Y(I)  .AND.  YY .GE. Y(K) )  .OR.
     *           (YY .GE. Y(I)  .AND.  YY .LE. Y(K) ) )  THEN
              IF ((XX .LT. X(I)  .AND.  CX .GT. X(K) )  .OR.
     *         (XX .GT. X(I)  .AND.  CX .LT. X(K) )) GO TO 100
            END IF
C
         ELSE
            sM = (Y(K) - Y(I) ) / (X(K) - X(I) )
            Y1 = Y(K) + (XX - X(K) ) * sM
            Y2 = Y(K) + (CX - X(K) ) * sM
C
            IF ( (YY .LE. Y(I)  .AND.  YY .GE. Y(K) )  .OR.
     *           (YY .GE. Y(I)  .AND.  YY .LE. Y(K) ) ) THEN
              IF ( (YY .LT. Y1  .AND.  CY .GT. Y2)  .OR.
     *           (YY .GT. Y1  .AND.  CY .LT. Y2) ) GO TO 100
            END IF
C
         END IF
C
         K = I
C
   20  CONTINUE
       INSIDE = 1
C
  100  CONTINUE
       RETURN
       END
```

ATTACHMENT III

LISTING OF THE xread_reaches.f FORTRAN ROUTINE

This routine begins by reading in the coordinates and values of recharge on the 125 m grid within the SZ site-scale model domain in the loop ending at line 100. The routine then reads in the coordinates of digitized locations within the stream channel reaches of Fortymile Wash, finds all 125 m grid nodes within 250 m of those locations, and resets the value of recharge at those nodes to the value assigned to that reach of Fortymile Wash in the nested loops ending at line 400. This process is repeated for the Amargosa Reach of Fortymile Wash for all nodes within 500 m of the digitized locations in the loops ending at line 310. The coordinates and values of recharge are then written out for the 125 m grid nodes in the loop ending at line 40.

```fortran
program xreadreaches
C
C       This program reads approximate nodal coordinates digitized
C       from map of stream reaches.  It finds the nearest node in the
C       125 m recharge map and changes the infiltration value to
C       the value specified in the first line of the digitized
C       coordinate file.

        dimension x(83054),y(83054),rech(83054)

        open(file='digit.dat',unit=10,status='old')
        open(file='rech_distr.dat',unit=11,status='old')
        open(file='rech_distr_stream.dat',unit=12,status='new')

C       Read in values of distributed recharge on 125 m mesh.
C       This file contains "hole" where UZ flow model exists.

        do 100 i=1,83054
           read(11,*) x(i),y(i),rech(i)
  100   continue

C       Read in approximate digitized locations of nodes (on 250 m
C       centers) of the Fortymile Canyon reach, Upper Jackass Flats
C       reach and the Lower Jackass Flats reach of Fortymile Wash.
C       Loop through locations on 125 m grid and find nodes within
C       250 m of digitized channel locations.  Assign recharge (mm/year)
C       associated with that reach to the 125 m grid node.

        do 400 k=1,3

        read(10,*)rech_new,ndig

        do 300 j=1,ndig
           read(10,*) xx,yy
           distmin=5000.
           do 200 i=1,83054
             xadj=xx-250.

             dist=sqrt((xadj-x(i))*(xadj-x(i))+(yy-y(i))*
     &         (yy-y(i)))
             if(dist.lt.250.) then
```

```
                 rech(i)=rech_new
             endif
  200    continue
  300 continue
  400 continue

C      Read in approximate digitized locations of nodes (on 250 m
C      centers) of the Amargosa Desert reach of Fortymile Wash.
C      Loop through locations on 125 m grid and find nodes within
C      500 m of digitized channel locations.  Assign recharge (mm/year)
C      associated with that reach to the 125 m grid node.

       read(10,*)rech_new,ndig

       do 310 j=1,ndig
         read(10,*) xx,yy
         distmin=5000.
         do 210 i=1,83054
           xadj=xx

           dist=sqrt((xadj-x(i))*(xadj-x(i))+(yy-y(i))*
     &        (yy-y(i)))
           if(dist.lt.500.) then
             rech(i)=rech_new
           endif
  210    continue
  310 continue

C      Write out locations and recharge value (mm/year) for all
C      125 m grid nodes that have nonzero recharge (for distributed
C      recharge and focused recharge along Fortymile Wash.

       do 40 i=1,83054
         if(rech(i).ne.0.) then
           write(12,99) x(i),y(i),rech(i)
         endif
   40 continue


   99 format(3f15.2)

C
       end
```

ATTACHMENT IV

LISTING OF THE xwrite_flow_new.f FORTRAN ROUTINE

This routine begins by reading in the coordinates and value of flux for all nodes at the 125 m grid and from the UZ site-scale flow model. The total flux for the output grid, as defined by the number of nodes in the x direction (nx), number of nodes in the y direction (ny) and the grid spacing (delx), is calculated by finding the nearest node in the output grid for each node on the finer grid and summing the contribution to each output grid node. This is accomplished in the loops ending on line 300. The resolution of the output grid was changed to correspond to various resolution grids used in the SZ site-scale flow model by changing the values of nx, ny, and delx and recompiling the routine. Finally, the routine writes out the values of flux in the format required by the "flow" macro in the FEHM simulator for each node in the loop ending on line 40.

```
program xwrite_flow_new
C
C     This program reads in the file containing the spatial distribution
C     of estimated recharge which combines distributed recharge, focused
C     recharge, and recharge from the area of the UZ site-scale model.
C     This program also loops through a regular grid and sums up the
C     groundwater mass flux (kg/s) for each grid node.  Note that the
C     grid node spacing is defined by the delx parameter below and the
C     number of nodes in the x and y directions by the parameters nx
C     and ny.  To generate output at different nodal spacings the values
C     of delx, nx, and ny must be changed accordingly and the code must
C     be recompiled.  The output file from this routine is in the
C     format required by the "flow" macro in FEHM for specified flux.
C     The node numbering in the output file assumes that nodes are
C     numbered sequentially from the southwest corner of the grid,
C     begining with node number 1 and cycling west to east and south
C     to north.

      dimension totflux(100000)

      open(file='rech_all_new.txt',unit=10,status='old')
      open(file='wt_flow.dat',unit=12,status='new')

      xmin=533340.
      xmax=563340.
      ymin=4046780.
      ymax=4091780.

      delx=1000.
      nx=31
      ny=46

      do 300 j=1,13489
        read(10,*) xx,yy,stuff1,stuff2,flux
        distmin=5000.
        do 200 i=2,ny-1
          do 200 ii=2,nx-1
          x=(ii-1)*delx+xmin
          y=(i-1)*delx+ymin
          nnode=(i-1)*nx+ii

          dist=sqrt((xx-x)*(xx-x)+(yy-y)*
```

```
     &       (yy-y))
             if(dist.lt.distmin) then
               distmin=dist
               imin=nnode
             endif
200    continue
       totflux(imin)=totflux(imin)+flux

300 continue


     do 40 j=2,ny-1
       do 40 i=2,nx-1
       nn=((j-1)*nx)+i
       if(totflux(nn).ne.0.) then
         write(12,99) nn,nn,1,-1*totflux(nn),1.,0.
       endif
 40 continue


 99 format(3i6,e12.4,2f10.2)

C
       end
```

ATTACHMENT V

LISTING OF THE extract.f FORTRAN ROUTINE

```
            program extract
c
c           T. Corbet
c           5 May 1999
c
c           This program extracts cell-by-cell flow values from a
c           Modflowp binary output file (cbcf.new).  This output
c           file was generated by running the executable and input
c           files contained in the Technical Data Management
c           System DTN GS960808312144.003 for the USGS 1997
c           flow model of the Death Valley regional ground-water
c           flow system.  The flow terms extracted are for the
c           lateral boundaries of the site-scale model. The
c           following values are extracted:
c             west boundary:  east (right) face of column 62 for rows 66-95
c             east boundary: east (right) face of column 82 for rows 66-95
c             north boundary: south (front) face of row 65 for columns 63-82
c             south boundary: south (front) face of row 95 for columns 63-82
c
c           The Modflowp output is written in arrays dimensioned
c           (number columns, number rows, number layers) or
c           (153,163,3).  Four arrarys are in the file.  The first
c           records flows due to constant head nodes and is read
c           but not written by this program.  The next three arrays contain
c           flows across the right (xcomp), front (ycomp), and lower (zcomp)
c           faces of each model cell,respectively. Values for flow
c           across the lower face are also read but not written.
c
c            Values are for volumetric flows with units of cubic meters per
day.
c
c           This program reads the unformatted file cbcf.new and
c           writes to formatted files west_bdy, east_bdy, north_bdy,
c           south_bdy, and headers.  The headers file contains an
c           echo of the header line for each of the four data
c           arrays.
c
c           Modflowp writes flows such that positive values are in
c           the direction of increasing index value, i.e positive
c           to the east (right), south (front), and downward.
c           This progarm reverses the sign for flows on the east
c           and south boundaries so that flows into the
c           site-scale domain are positive inward on all
c           boundaries.
c
            character*4 text
            character*4 textx
            character*4 texty
            character*4 textz
c
            dimension text(4)
            dimension textx(4)
            dimension texty(4)
            dimension textz(4)
```

```
      dimension dummy(153,163,3)
      dimension xcomp(153,163,3),ycomp(153,163,3),zcomp(153,163,3)
c
      open (10,file='cbcf.new',status='old',form='unformatted')
      open (11,file='west_bdy',status='unknown')
      open (12,file='east_bdy',status='unknown')
      open (13,file='north_bdy',status='unknown')
      open (14,file='south_bdy',status='unknown')
      open (15,file='headers',status='unknown')
c
c     read Modflowp cell-by-cell flow terms from binary file
      read (10) kstp,kper,text,ncol,nrow,nlay
      read (10) dummy
      read (10) kstpx,kperx,textx,ncolx,nrowx,nlayx
      read (10) xcomp
      read (10) kstpy,kpery,texty,ncoly,nrowy,nlayy
      read (10) ycomp
      read (10) kstpz,kperz,textz,ncolz,nrowz,nlayz
      read (10) zcomp
c
c     echo header information
      write (15,*) kstp,kper,text,ncol,nrow,nlay
      write (15,*) kstpx,kperx,textx,ncolx,nrowx,nlayx
      write (15,*) kstpy,kpery,texty,ncoly,nrowy,nlayy
      write (15,*) kstpz,kperz,textz,ncolz,nrowz,nlayz
c
c     write new headers
      write (11,*) ' col  row     layer1    layer2    layer3'
      write (12,*) ' col  row     layer1    layer2    layer3'
      write (13,*) ' col  row     layer1    layer2    layer3'  ,
      write (14,*) ' col  row     layer1    layer2    layer3'
c
c     extract flows on west boundary
      i=62
      do 20 j=66,95
         write (11,1) i,j,(xcomp(i,j,k),  k=1,3)
   20 continue
c
c     extract flows on east boundary, reverse sign
      i=82
      do 40 j=66,95
         write (12,1) i,j,(-xcomp(i,j,k),  k=1,3)
   40 continue
c
c     extract flows on north boundary
      j=65
      do 60 i=63,82
         write (13,1) i,j,(ycomp(i,j,k),  k=1,3)
   60 continue
c
c     extract flows on south boundary, reverse sign
      j=95
      do 80 i=63,82
         write (14,1) i,j,(-ycomp(i,j,k),  k=1,3)
   80 continue
```

```
c
    1 format (2i5,3f12.4)
c
      stop
      end
```

ATTACHMENT VI

VALIDATION OF THE CORPSCON ROUTINE

The Corpscon routine is a Windows-based routine for performing geographical coordinate transformations. The executable file and supporting files for this routine are contained in the electronic archive for this report in the TDMS (DTN: SN9908T0581999.001).

Validation of the Corpscon routine is performed by using the routine to calculate the UTM coordinates for some example locations, given the coordinates in the Nevada State Plane coordinate system. The results are compared to published values of the UTM coordinates for those example locations. The example locations used in the validation are for borehole locations taken from the Yucca Mountain Project Geographical Information database. The coordinates of the boreholes in the Nevada State Plane coordinate system are contained in a table (DTN: MO9907YMP99025.001) and the coordinates of the same boreholes in the UTM system are contained in another table (TRW Environmental Safety Systems 1997, table YMP97-05-04). The results of the validation exercise are shown in Table VI-1.

Table VI-1. Validation Results for the Corpscon Software Routine.

Borehole Identifier	Nevada State Plane Northing (ft) [a]	Nevada State Plane Easting (ft) [a]	UTM Northing (m) [b]	UTM Easting (m) [b]	UTM Northing (m) (Corpscon)	UTM Easting (m) (Corpscon)
WT-10	748771.56	553302.31	4073388.6	545976.0	4073388.8	545976.1
WT-12	739726.69	567011.81	4070647.0	550162.9	4070647.2	550163.1
WT-14	761651.38	575210.19	4077336.5	552638.0	4077336.7	552638.0
WT-15	766117.00	579806.25	4078702.2	554033.6	4078702.4	554033.8

[a] Source: DTN: MO9907YMP99025.001.
[b] Source: TRW Environmental Safety Systems 1997, table YMP97-05-04.

Comparison of the UTM coordinate values from the published source (TRW Environmental Safety Systems 1997, table YMP97-05-04) and from the Corpscon routine indicate a maximum discrepancy of 0.2 m. This degree of accuracy is sufficient for the application of the routine in this analysis.