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Database Dictionary for the
Results of
Groundwater Tracer Tests
Using Tritiated Water,
Conducted at the
Oak Ridge National Laboratory

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Lockheed Martin Energy Research Groundwater Program Office

DATABASE DICTIONARY FOR THE RESULTS OF
GROUNDWATER TRACER TESTS USING TRITIATED WATER,
CONDUCTED AT THE OAK RIDGE NATIONAL LABORATORY

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ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
DOE	U.S. Department of Energy
dpm/ml	disintegrations per minute per milliliter
ft/d	feet per day
ft ² /d	feet squared per day
ORNL	Oak Ridge National Laboratory
SAS	Statistical Analysis System, registered trademark of the SAS Institute, Inc., Cary, North Carolina
USGS	United States Geologic Survey
YY-MM-DD	date: year year–month month–day day

EXECUTIVE SUMMARY

In 1977, the United States Geological Survey (USGS) conducted two tracer tests at the Oak Ridge National Laboratory (ORNL) using tritiated water to study the relative importance of bedding-plane openings on shallow groundwater flow. Through a cooperative agreement between the USGS and the U.S. Department of Energy (DOE), the data were made available to researchers at the Oak Ridge National Laboratory (ORNL), who organized the data into a data management format. The results of these groundwater tracer tests have been compiled into a collection of four SAS data sets. This report documents these SAS data sets, including their structure, methodology, and content.

The SAS data sets include information on precipitation, tritium, water levels, and well construction for wells at or near ORNL radioactive waste burial grounds 4, 5, and 6. The precipitation data set (**precip.ssd01**) contains precipitation dates, burial ground identifiers, precipitation amounts, and measurement qualifiers. The tritium data set (**tritium.ssd01**) contains well sampling dates, tritium activities, and laboratory and quality control qualifiers. The water level data set (**watelev.ssd01**) contains well names, water measurement dates, water surface depths, and estimated water level elevations. The well data set (**well.ssd01**) contains well names and locations, water column heights, apparent transmissivities and hydraulic conductivities, heights of well casings above the land surface, top-of-casing elevations, top- and bottom-of-sample-interval elevations, and land surface elevations. In each SAS data set, one or more of the variables were designated as key variables; these variables allow the records to be identified uniquely and make possible the merging of data from different data sets to form secondary files to meet specialized needs.

Four ASCII files [OR.PRECIP (precipitation data), TABLE-41 (tritium data), ORNL.SUBF (water level data), and OR.HYD.TESTS (well data)] supplied by USGS provided the basis for the SAS data sets. The information in these files was supplemented by information from D. A. Webster at USGS and D. D. Huff at ORNL. The ASCII files are archived on gwater.esd.ornl.gov in the directory `/data/bhy/usgs`, and the SAS data sets are stored on the same workstation in the directory `/lib1/bhy/usgs`.

An interpretive report that discusses the results of the tracer tests is available as Water Resources Investigation Report 95-4182, prepared by the USGS in cooperation with the DOE (Webster, D. A., 1996). Questions concerning the data collection process should be directed to the USGS District Office in Nashville, Tennessee.

1. INTRODUCTION

In 1977, the United States Geological Survey (USGS) initiated two tracer tests to study the relative importance of bedding-plane openings on shallow groundwater flow. The data collected during those tests have remained unpublished. Recently, however, scientists have recognized the value of these data in aiding understanding of the importance of the diffusion process on transport of contaminants in groundwater. Through a cooperative agreement between the USGS and the U.S. Department of Energy (DOE), the data were made available to researchers at the Oak Ridge National Laboratory (ORNL), who organized the data into a data management format.

The results of groundwater tracer tests using tritiated water, conducted at the Oak Ridge National Laboratory (ORNL), have been compiled into a collection of four SAS¹ data sets. The SAS data sets include information on precipitation, tritium, water levels, and well construction at or near burial grounds 4, 5, and 6. The information included in the SAS data sets came from four ASCII files, personal communications with D. A. Webster at the United States Geological Survey (USGS), and comments from D. D. Huff at ORNL. The ASCII files are archived on gwater.esd.ornl.gov in the directory `/data/bhy/usgs`, and the SAS data sets are stored on the same workstation in the directory `/lib1/bhy/usgs`. This report documents the four SAS data sets, including their structure, methodology, and content.

An interpretive report that discusses the results of the tracer tests is available as Water Resources Investigation Report 95-4182, prepared by the USGS in cooperation with the DOE (Webster, D. A., 1996)². Questions concerning the data collection process should be directed to the USGS District Office in Nashville, Tennessee.

¹SAS is the registered trademark of SAS Institute, Inc., Cary, North Carolina.

²Copies of the report may be purchased from:

US Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

2. STRUCTURE OF THE DATABASE

The groundwater tracer-test data files are stored in SAS. The database contains four files: precipitation (**precip.ssd01**), tritium (**tritium.ssd01**), water levels (**watelev.ssd01**), and well information (**well.ssd01**). Appendix A describes the structure of each database file, including the variable name, the type of variable (character, date, or numeric), the width of each variable, and a complete description of each variable, including units and abbreviations.

2.1 DATA SOURCES

The information used to create **precip.ssd01** came from the ASCII file called OR.PRECIP. OR.PRECIP contains the date the precipitation occurred, the amount of precipitation at burial grounds 5 and 6, and precipitation qualifiers.

The information used to create **tritium.ssd01** came from the ASCII file called TABLE-41. TABLE-41 contains the date each sample was taken, the tritium concentration at each well, and a laboratory qualifier. X qualifiers were added to **tritium.ssd01** on the basis of comments by D. D. Huff at ORNL (see Sect. 2.2 for details).

The information used to create **watelev.ssd01** came from the ASCII file called ORNL.SUBF. ORNL.SUBF contains the well names, the date each measurement was taken, and each well's depth to water from land surface. The elevations of the water levels were calculated from estimated top-of-casing elevations (see Sect. 3.4 for details).

The information used to create **well.ssd01** came from the ASCII file called OR.HYD.TESTS and from D. A. Webster. OR.HYD.TESTS contains the height of the water column in each well, the apparent transmissivity, the apparent hydraulic conductivity, and the well name. D. A. Webster supplied the top-of-casing elevations, the eastings and northings, the distances the casings extend above the land surface, and the well names. Elevations of the bottom and top of the sample interval, the land surface, and the top of casing were calculated for this data set (see Sect. 3.4 for details).

2.2 DATA QUALIFIERS

The precipitation qualifiers are either a C or an M. C indicates clock failure: precipitation occurred during the period indicated, but date of precipitation is indefinite. M indicates a gage malfunction: the precipitation data is incomplete or missing. The laboratory qualifier in the tritium data set is <, which indicates that the concentration of tritium is equal to or less than the reported value. X qualifiers were added to observations in this data set on the basis of comments from D. D. Huff at ORNL. An X indicates the sample was cross-contaminated in the field or the laboratory.

2.3 KEY VARIABLES

The database files contain variables, called key variables, that allow the records to be identified uniquely. The key variables also make possible the merging of information from different data sets to form secondary files to meet specialized needs. The key variables for **precip.ssd01** are (1) the burial ground where the precipitation was measured (BURIAL_G) and (2) the date the precipitation was recorded (DATE). The key variables for **tritium.ssd01** are (1) the date the sample was taken (DATE); (2) the time of sampling relative to the time of tritium injection (INITIAL), i.e., whether prior to injection (INITIAL = YES) or after injection (INITIAL = NO); and (3) the well name (WELL). The key variable INITIAL was necessary because wells 4–11 and 6–7 were sampled twice on the day the tracers were injected—once before injection and once after. All other records in **tritium.ssd01** can be uniquely identified by the DATE and WELL variables. The key variables for **watelev.ssd01** are (1) the date the water-level measurement was taken (DATE) and (2) the well name (WELL). The key variable for **well.ssd01** is the well name (WELL).

3. METHODOLOGY

The files OR.PRECIP, TABLE-41, ORNL.SUBF, and OR.HYD.TESTS were modified in a text editor before they were imported into SAS. This editing included column alignment, removal of descriptive text, removal of blank spaces when numbers were reported in scientific notation, and replacement of a double hyphen (--) by a period (.). The double hyphen indicated that no sample was collected in the original data; a period is the SAS character for a missing numeric value. The ASCII files were imported into SAS, after which the SAS file structures were modified to fit the database structures defined in Appendix A. X qualifiers, which were not part of the original data, were added to some records in the **tritium.ssd01** file (see Sect. 2.2).

Some of the data had to be keyed in by hand. These included a single record in **tritium.ssd01** and several records in **well.ssd01**. Because **well.ssd01** has only 16 records, double checking the data entry was not difficult. All date variables are displayed by a two-digit year, a two-digit month, and a two-digit day: YY-MM-DD.

3.1 PRECIPITATION DATA METHODOLOGY

The structure of **precip.ssd01** was modified from the original data file, TABLE-41. The original file had separate columns for burial grounds 5 and 6. Data for each burial ground were imported into SAS separately and then merged into one data set, **precip.ssd01**. In **precip.ssd01** the variables include (1) the date the precipitation was measured (DATE), (2) the precipitation amount (PRECIP), (3) the precipitation qualifiers (PRECIP_C), and (4) the burial ground where the precipitation was measured (BURIAL_G).

3.2 TRITIUM DATA METHODOLOGY

The structure of **tritium.ssd01** was modified from the original data file, TABLE-41. The original file had separate columns for each well and two groups of data, one for burial ground 4 and one for burial ground 6. Data for each burial ground were imported into SAS separately, transposed, and then merged into one data set, **tritium.ssd01**. The restructuring of this file produced some records with missing tritium values. These records were deleted. In **tritium.ssd01**, the variables include (1) the date the tritium sample was taken (DATE); (2) the time of sampling relative to the time of tritium injection (INITIAL), i.e., whether prior to injection (INITIAL = YES) or after injection (INITIAL = NO); (3) the tritium activity (TRIT); (4) the tritium-activity qualifiers (TRIT_C); and (5) the well from which the tritium sample was taken (WELL).

3.3 WATER-LEVEL DATA METHODOLOGY

Although the structure of **watelev.ssd01** was not modified from that of the original data file, ORNL.SUBF, the well names were converted to the same format found

in the other data files (e.g., the well name RN:M-6-TR-5 ORNL was changed to 6-5), and a calculated variable was added for the water-level elevations (ELEV_WAT). ELEV_WAT was calculated [see Eq. (1)] in a SAS data step by subtracting the depth to water (WAT_DEP) from the calculated land-surface elevation (ELEV_SUR) [see Eq. (4)] in **well.ssd01**.

$$\text{ELEV_WAT} = \text{ELEV_SUR} - \text{WAT_DEP} . \quad (1)$$

In addition, **watelev.ssd01** contains a variable for the date that the water elevations were measured (DATE) and a variable for the well where the water-elevation measurements were taken (WELL).

3.4 WELL DATA METHODOLOGY

Several tables (in hard copy only), several ASCII files, and an original data file (OR.HYD.TESTS) were combined to create **well.ssd01**. In **well.ssd01** the variables include (1) two variables for the top of casing (CASTOP_B and CASTOP_P), (2) the easting and the northing (EAST and NORTH), (3) the hydraulic conductivity (HYD_COND), (4) the distance the casing extends above the land surface (STICK_UP), (5) the transmissivity (TRANS), (6) the height of the water column in the well shortly after construction minus the depth to the water at the time of the slug test (WATER_HT), (7) the well depth (WEL_DEP), and (8) the name of the well (WELL).

Two top-of-casing variables were created because two surveys for the top of casings were done. One survey, completed by Bernie Frederick, measured the top-of-casing elevations to a hundredth of a foot. This survey was assigned the variable CASTOP_B. At each site the elevations of the observation wells were calculated in reference to the elevation of the injection well at that site, which was arbitrarily assigned a value of 100.00 ft. The other survey was done by the Engineering Division at ORNL. This survey was assigned the variable CASTOP_P. The results of the Engineering survey were reported in feet above mean sea level; however, the results were rounded off to the nearest tenth of a foot.

Because the water levels were measured to the hundredth of a foot and the differences in water level elevations between wells were sometimes small, using the top-of-casing elevations measured to the nearest hundredth of a foot (i.e., CASTOP_B) was advantageous. However, because those measurements reflected the relative elevations for the top of the casings and not the elevations above mean sea level, the top-of-casing elevation (ELEV_TOC) was calculated by subtracting 100.00 ft. from each injection well's elevation above mean sea level, given by CASTOP_P, then adding the relative elevation given by CASTOP_B for each observation well. In burial ground 4, the injection well (4-11) has an elevation above mean sea level (CASTOP_P) equal to 843.5. Thus, for burial ground 4,

$$\text{ELEV_TOC} = 843.5 - 100 + \text{CASTOP_B} . \quad (2)$$

In burial ground 6, the injection well's (6-11) value for CASTOP_P is equal to 774.7. Thus, for burial ground 6,

$$\text{ELEV_TOC} = 774.7 - 100 + \text{CASTOP_B} . \quad (3)$$

The estimated elevation given by ELEV_TOC was used to calculate (1) the land-surface elevation (ELEV_SUR), (2) the elevation of the bottom of the sample interval (ELEV_BOT), and (3) the elevation of the top of the sample interval (ELEV_TOP).

ELEV_SUR was calculated by subtracting the distance the casing extends above the land surface (STICK_UP) from the calculated top-of-casing elevation (ELEV_TOC):

$$\text{ELEV_SUR} = \text{ELEV_TOC} - \text{STICK_UP} . \quad (4)$$

ELEV_BOT is the bottom of the open interval for wells in burial ground 4 and the bottom of the screened interval for wells in burial ground 6 at the time of construction. Some sloughing of uncased borehole walls has probably occurred since then. ELEV_BOT was calculated by subtracting the well depth (WEL_DEP) from the calculated land-surface elevation (ELEV_SUR) [see Eq. (4)]:

$$\text{ELEV_BOT} = \text{ELEV_SUR} - \text{WEL_DEP} . \quad (5)$$

ELEV_TOP is the top of the open interval for wells in burial ground 4 and the top of the screened interval for wells in burial ground 6. In burial ground 4, ELEV_TOP was calculated by subtracting the length of the casing hole (5 ft) from ELEV_SUR:

$$\text{ELEV_TOP} = \text{ELEV_SUR} - 5 . \quad (6)$$

For all wells in burial ground 6 except well 6-11 (where the length of the screen was 5 ft), ELEV_TOP was calculated by adding the length of the screen (10 ft) to ELEV_BOT:

$$\text{ELEV_TOP} = \text{ELEV_BOT} + 10 . \quad (7)$$

For well 6-11,

$$\text{ELEV_TOP} = \text{ELEV_BOT} + 5 . \quad (8)$$

4. REFERENCES

Webster, D. A., 1996. Results of Ground-Water Tracing Tests Using Tritiated Water at Oak Ridge National Laboratory, Tennessee, US Geological Survey Water-Resources Investigations Report 95-4182, Nashville, Tennessee, 50p.

APPENDIX A. FILE DESCRIPTIONS

Table 1 Description of precip.ssd01 file

Variable name	Type	Width	Description
BURIAL_G	Character	1	Burial ground where precipitation measurement was taken (key)
DATE	Date	8	Date when precipitation measurement was taken (key)
PRECIP	Numeric	8	Precipitation (in.)
PRECIP_C	Character	2	Precipitation qualifier C = clock failure M = gage malfunction (record for date is incomplete or missing)

Table 2 Description of tritium.ssd01 file

Variable name	Type	Width	Description
DATE	Date	8	Date when sample was taken (key)
INITIAL	Character	10	Time of sampling relative to the time of tritium injection YES = sample taken prior to injection (i.e., initially) NO = sample taken after injection (i.e., not initially)
TRIT	Numeric	8	Tritium activity (dpm/ml) ^a
TRIT_C	Character	2	Qualifier for tritium activity < = concentration of tritium is equal to or less than the reported value X = the sample was cross contaminated in the field or the laboratory
WELL	Character	8	Well name (key)

^a Disintegrations per minute per milliliter of sample

Table 3 Description of watelev.ssd01 file

Variable name	Type	Width	Description
DATE	Date	8	Date when the water level measurement was taken (key)
ELEV_WAT	Numeric	8	Estimated water-level elevation (ft above mean sea level)
WAT_DEP	Numeric	8	Depth to water (ft below land surface)
WELL	Character	8	Well name (key)

Table 4 Description of well.ssd01 file

Variable name	Type	Width	Description
CASTOP_B	Numeric	8	Top-of-casing elevations (ft), provided by Bernie Frederick. The elevation of each observation well was referenced to that of the nearest injection well; each injection well was arbitrarily assigned an elevation of 100.00 ft
CASTOP_P	Numeric	8	Top-of-casing elevations (ft above mean sea level), provided by the Engineering Division at ORNL ^a
EAST	Numeric	8	East coordinate (ORNL coordinate system, ft)
ELEV_BOT	Numeric	8	Estimated bottom-of-sample-interval elevation (ft above mean sea level)
ELEV_SUR	Numeric	8	Estimated land surface elevation (ft above mean sea level)
ELEV_TOC	Numeric	8	Estimated top-of-casing elevation (ft above mean sea level)
ELEV_TOP	Numeric	8	Estimated top-of-sample-interval elevation (ft above mean sea level)
HYD_COND	Numeric	8	Apparent hydraulic conductivity (ft/d)
NORTH	Numeric	8	North coordinate (ORNL coordinate system, ft)
STICK_UP	Numeric	8	Distance the top of the well casing extends above land surface (ft)
TRANS	Numeric	8	Apparent transmissivity (ft ² /d)
WATER_HT	Numeric	8	Height of water column in the well; value equals well depth shortly after construction minus the depth to water at the time of the slug test
WELDEP	Numeric	8	Completed well depth below land surface (ft)
WELL	Character	8	Well name (key)

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