# OVERVIEW AND SCOPE

| Acronym: | MODPATH | HISI ID: | [] | Software Grade: | [C] |
| --- | --- | --- | --- | --- | --- |
| Acronym: | MPDPATH3DU | HISI ID: | [] | Software Grade: | [C] |

The objective of the testing reported in this acceptance test report (ATR) is to demonstrate applicability and suitability for use of the MODPATH and MODPATH3DU software for intended uses at the Hanford Site by the CH2M-HILL Plateau Remediation Company (CHPRC).

MODPATH is a particle-tracking post-processing model that computes three-dimensional flow paths using output from groundwater flow simulations based on MODFLOW, the U.S. Geological Survey (USGS) finite-difference groundwater flow model. The program uses a semianalytical particle-tracking scheme that allows an analytical expression of a particle’s flow path to be obtained within each finite-difference grid cell. The versions tested here include both MODPATH version 6 distributed by the USGS, and MODPATH 3DU [a variant of MODPATH [6? 7?] built by S. S. Papadopulos and Associates to calculate particle tracking on unstructured grids built in MODFLOW USG]. Both MODPATH and MODPATH 3DU are tested and controlled as both are needed to support CHPRC modeling needs.

The testing was conducted following [CHPRC-XXXX, *MODPATH Software Test Plan* (STP)]. The acceptance tests for MODPATH and MODPATH 3DU were performed on [a ThinkPad P50 Signature Edition Workstation computer with an Intel® Xeon® CPU E3-1505M v5 @ 2.80 GHz, 16 GB of RAM, and 500 GB Hard Disk, running (64-bit) Windows 10 Professional Service Pack 0]. The minimum configuration required to run the software is listed in [Section 6 of CHPRC-XXXX, *MODPATH Software Management Plan*].

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| --- | --- | --- | --- | --- |
| Table 2. MODPATH Executable Files | | | | |
| **Software** | **Code Source** | **Version** | **Executable File1** | **[MD5 Signature]** |
| MODPATH | USGS 1 | Build 6.0.01 | mp6.exe 2 | [EAF037703ADD2C62CDD9CBC47468D2F6] |
| MODPATH 3DU | [S.S.P.&A.] | [?] | [?] | [?] |

# TEST SUMMARY

The acceptance tests specified in [CHPRC-XXXXX, *MODPATH Software Test Plan]*, were conducted. This document included the test plan, test design, test procedures, and test logs to use for the acceptance test cases.

## Test Case 1: Forward Particle Tracking from an Injection Well

This test is designed to calculate forward particle tracking in a steady-state system with an injection well. This test is repeated from and compared against a test in Pollock, 1988, *Semianalytical Computation of Path Lines for Finite-Difference Models*, which is used to validate the solution obtained in this test. Details of this test and expected results are presented in the STP. The test is conducted for MODPATH.

### Test Results

The logs maintained during the conduct of this test are provided in Attachment 1.

The acceptance criteria for these results specified in the STP is that the MODPATH-produced solution for particle tracking in this test shall:

* Produce straight particle tracks that radiate outward.
* Have a percent difference of no more than [10%] between the length of the flow paths digitized from Pollock, 1988, and those calculated by MODPATH.

The passing condition of the first criteria can be determined by examining the figures “2500\_days.png”, “5000\_days.png”, and “7500\_days.png” in Test\_Case\_1/output/figures and checking that the particle tracks in these figures are straight and radiating outwards from the well. These results are seen in [figure x].

The passing condition of the second criteria can be determined by opening the file “pass\_fail.csv” in the root directory [insert description of that csv]. The more detailed account of the passing condition of the second criteria can be determined by opening tc1\_results.csv in Test\_Case\_1/output. The results of this test case are listed below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time elapsed in days (Time\_Days) | Particle track distance from the well as digitized from Pollock, 1988 (Digitized\_dist\_ft) | Particle track distance from the well as calculated by MODPATH (Current\_run\_ft) | Percent difference between the digitized and the MODPATH particle track distance from the well (Percent\_difference) | Pass/Fail |
| 2500 | 2072.753716 | 2071.040117 | 0.055130246 | Pass |
| 5000 | 2920.183221 | 2921.260914 | -0.024600301 | Pass |
| 7500 | 3575.155671 | 3574.768797 | 0.007214387 | Pass |

All results are within the acceptance criteria, and MODPATH is therefore considered to pass this acceptance test.

## Test Case 2: Particle Tracking in Non-Uniform Flow

This test is designed to calculate forward particle tracking for flow under an impermeable wall in a steady-state system. This test is repeated from and compared against a test in Pollock, 1988, which is used to validate the solution obtained in this test. Details of this test and expected results are presented in the STP. The test is conducted for MODPATH.

### Test Results

The acceptance criteria for these results specified in the STP is that the MODPATH-produced solution for particle tracking in this test shall:

* Produce particle tracks that are visually similar to those seen in [Figure 2-6 in Pollock, 1988], according to professional judgment.
* Have a percent difference of no more than [10%] between the particle end points digitized from [Figure 2-6 in Pollock, 1988] and the MODPATH-calculated particle end points.

The passing condition of the first criteria can be determined by examining the figure “[].png” in Test\_Case\_2/output/figures and checking that the particle tracks created using the MODPATH output are visually similar to the particle tracks created by digitizing [Figure X from Pollock, 1988]. These results are seen in [figure x].

The passing condition of the second criteria can be determined by opening the file “pass\_fail.csv” in the root directory [insert description of that csv]. The more detailed account of the passing condition of the second criteria can be determined by opening [tc2\_results.csv] in Test\_Case\_2/output. The results of this test case are listed below, in [table x].

[WE NEED THIS TABLE]

## Test Case 3: Capture Zone in an Unconfined Aquifer

This test is designed to calculate the shape of the capture zone in an unconfined aquifer using reverse particle tracking. This test is compared to the analytical solution described in Grubb, 1993, *Analytical Model for Estimation of Steady-State Capture Zones of Pumping Wells in Confined and Unconfined Aquifers*. Details of this test and expected results are presented in the STP. The test is conducted for MODPATH.

### Test Results

The acceptance criteria for these results specified in the STP is that the MODPATH-produced solution for particle tracking in this test shall produce a stagnation point and maximum y value within [10%] of the analytical value.

The passing condition can be determined by opening the file “pass\_fail.csv” in the root directory [insert description of that csv]. The more detailed account of the passing condition of the second criteria can be determined by opening [tc2\_results.csv] in [Test\_Case\_3/output]. The results of this test case are listed below, in [table x].

[insert table]

## Comprehensive Assessment

The test plan intentionally did not exhaustively test all the features and modules of MODPATH and MODPATH 3DU; such a testing program would be prohibitive in terms of schedule, scope, and budget. Instead, test problems were devised to demonstrate applicability of these software tools with respect to critical processes that will be simulated for Hanford problems, with emphasis on groundwater flow, pumping, boundary conditions, and drawdown for aquifer properties representative of those found at the Hanford Site.

Computer resource utilization for model runs with MODPATH and MODPATH 3DU codes was minimal for all of these tests.

## Incident Reporting

There are no unresolved incidents and no impact on placing this software into operation.

ATTACHMENT 1

Completed Test Log: MODFLOW Acceptance Test Case 1 (MF-ATC-1): MODFLOW-2000 Executable Files for Windows® Operating System

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MODFLOW Acceptance Test Case 1  Description: Theis Transient Drawdown Problem | | | Test Case #:  MF-ATC-1 | Date:  4 Mar 2015 |
| System Attributes:  Version #: MODFLOW-2000  Release #: CHPRC Build 8 (Identical to Build 6)  Environment: Windows 7® Enterprise SP1  Server: WF22668 | | | Test Performed by:  William E. Nichols, CHPRC  [Signed in Previous Revision 6 to this document] | |
| Test Step # | Requirement # | Test Instruction | Expected Result | Actual Result |
| 1 | Obtain source code or executable for MODFLOW-2000-MST code from software owner & install on target computer | Compile using appropriate Fortran compiler, if necessary | MODFLOW executable is ready and functional | Copied source code obtained from USGS website and archived in MKS Integrity™ to computer WC95463.  Updated “build” batch files to compile and link all necessary code to build the executable files for single and double precision (build-lahey-sp.bat and build-lahey-dp.bat):   * Compiles all C source code using Fujitsu C (fcc) compiler * Compiles all Fortran source code using Lahey/Fujitsu Fortran (Release 7.20) for Windows® compiler * Links all object files with required library statically   Invoked these “build” batch files to compile and link the single- and double-precision executable for Windows. The compilation and link returned no errors.  Executable files copied to directory …\bin (with local PATH variable assigned) as executable files mf2k-chprc07spl.exe and mf2k-chprc07dpl.exe. |
| 2 | Obtain files for test problem from software owner | Copy files to appropriate test directory | Test files are ready for use | Test files obtained from MKS Integrity™ for acceptance test case MF-ATC-1. Copied to test directory on external hard drive in directory:  …\test\MODFLOW\Build-7  Subdirectories:  \mf-atc-1\_dp (double precision test)  \mf-atc-1\_sp (single precision test) |
| 3 | Run MODFLOW to solve for flow problem | Execute MODFLOW against mf-atc-1.nam name file in test directory | MODFLOW executes without error | While logged onto WF22668 as a user without administrator privileges, executed mf2k-chprc07spl.exe and mf2k‑chprc07dpl.exe successfully for both pumping durations problems (in test subdirectories /pumping-05-d and /pumping-10-d). |
| 4 | Extract results and transfer to validation spreadsheet | Using a text editor, copy MODFLOW-calculated drawdown values from end of list file mf-atc-1.lis and paste into appropriate cells in validation spreadsheet “mt-atc-1.xlsx” | Spreadsheet will update tables, graphics, and acceptance test results | Used a text editor program to open the THEIS.LIS file for each pumping duration case and copy the drawdowns for the first row of results, representing the radial drawdown results. Pasted these results into the respective worksheets of validation spreadsheets “mf-atc-1\_mf2k-sp.xlsx” and “mf-atc-1\_mf2k-dp.xlsx” (separate copy of this spreadsheet for testing single and double precision versions, kept in appropriate testing subdirectories). |
| 5 | Use test results and graphics from spreadsheet to complete test reporting in ATR | Copy and paste graphics and note acceptance test results in ATR | MODFLOW acceptance test criterion are met | Copied and pasted resulting graphics to the acceptance test report to show comparison of analytic and MODFLOW results; noted results in ATR for acceptance criteria calculated in copies the spreadsheets “mf-atc-1\_mf2k-sp.xlsx” and “mf-atc-1\_mf2k-dp.xlsx” for each repeated test by precision.  All criteria were met for this software.  Test directory contents were committed to MKS Integrity© for this test. |