NYE COUNTY NUCLEAR WASTE REPOSITORY PROJECT OFFICE

WORK PLAN 9

TITLE: Work Plan for Tracer Testing		Revision: 0 Date: 07-30-03 Page: 1 of 29
APPLICABILITY: Work Package No.: 9	SUPERSEDES: New Document	
APPROVAL [signature] 7-31-03 Project Manager Date	CONCURRENCE Dale Hammermeister 7/31/03 On-Site Geotechnical Representative Date Dale Hammermeister for John Campanella 7/31/03 Principal Investigator Date [signature] 7/31/03 Project Quality Assurance Officer Date	

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE OF THE WORK PLAN

The purpose of this work plan is to ensure that Nye County tracer tests are conducted in an environmentally and occupationally safe and technically defensible manner. The information obtained from the Nye County Tracer Test program will help reduce the uncertainty in the transport parameters and pathways of the saturated zone at Fortymile Wash.

1.2 SCOPE OF THE WORK PLAN

The scope of this work plan encompasses the majority of activities associated with conducting single well push/pull tracer tests and cross-hole tracer tests using the Nye County wells. The work plan covers the design and implementation of tracer testing in the saturated zone at Fortymile Wash and the analysis of the recorded tracer data for hydrodynamic dispersion and other transport properties. The work plan also includes the comparison of the Nye County tracer test results to U.S. Department of Energy (DOE) Yucca Mountain Project (YMP) tracer test results obtained at the Alluvial Testing Complex (ATC), and the documentation of the results in Nye County reports.

1.3 TECHNICAL TASK SUPPORTED

This work plan has been designed to meet the objectives and deliverables specified in Nye County Independent Scientific Investigation Program (ISIP) Work Element 9 (Nye County Tracer Test) and provides supporting information to Work Element 8 (Data Management, Analysis and Modeling) and Work Element 10 (Regional Geologic Characterization). The Nye County tracer tests will also help to reduce uncertainty in DOE performance and risk assessment calculations. Copies of all verified data and the results of the analysis performed will be made available to DOE and the general public.

1.4 PLAN ORGANIZATION

The work plan has been organized into several major sections. Section 2.0 states the purpose and objectives of the Nye County Tracer Test program. Section 3.0 reviews the background of the Nye County and ATC tracer tests. Section 4.0 presents the scope of work and provides details of the planned activities; methods and procedures for accomplishing these activities; estimated time required to complete the tests; and supplies, equipment and labor requirements. Section 5.0 describes the organization and management system that will ensure that the tracer tests will be quality controlled and conducted in accordance with the project scope and objectives. Section 6.0 is the Nye County Tracer Test health and safety plan. Section 7.0 is a list of documents referenced in this work plan. Section 8.0 includes figures, tables, and attachments referenced in this document.

2.0 TRACER TEST PURPOSE AND CONSTRAINTS

The Nye County Tracer Test and other NWPRO programs have been developed with the overall goal of protecting human health, the environment, and water resources in southern Nye County. The tracer tests are designed to help reduce uncertainty in saturated zone transport parameters and pathways. Tracer tests, analyses, and reporting must be completed by March 31, 2004, and within a budget of approximately $550K.

3.0 BACKGROUND

3.1 ATC TESTING

Since 1999, the DOE has been implementing planned tracer tests at the ATC, located west of Fortymile Wash immediately southwest of the Nevada Test Site.

The ATC data are the only tracer information currently available in the alluvial and valley-fill aquifer down-gradient of Yucca Mountain. A single-well hydraulic test and three push/pull tracer tests were performed in NC-EWDP-19D from July of 2000 till April of 2001. An open-hole hydraulic test along with isolated interval hydraulic testing of intervals #1, #2, #3 and #4 was performed and the push/pull tracer tests were performed in interval #1 (STIP-02-SZ-003 REV 01 ICN 1, 2002). Nye County has been an active participant in the ATC testing program through the drilling and completion of the test and observation wells at the complex, logistical support to testing operation, participation in planning and progress meetings, and independent evaluations of the testing results.

3.2 PRELIMINARY NYE COUNTY TRACER TEST MEETING

Based upon Nye County's participation in the ATC and the findings from its ISIP studies, the NWPRO recognized the need for additional tracer testing in the critical area down gradient of the proposed repository site at Yucca Mountain. The first preliminary Nye County Tracer Test planning meeting was held at the Federal Center in Lakewood, Colorado on August 22, 2002. Attendees on behalf of Nye County included Dale Hammermeister, Reina Downing, John Wright, Scott Stinson, John Campanella, and Dave Cox. The U.S. Geological Survey (USGS) representatives included M. J. Umari, John Earle, Jon Darnell, Mike Fahey, and Tom Oliver. Paul Reimus and Al Eddebbarrh from Los Alamos National Laboratory (LANL) and Irene Farnham from the University of Nevada Las Vegas Harry Reid Center (UNLV HRC) were present, as were Ezra Wasson and Michael Schuhen from Bechtel SAIC Corporation and Drew Coleman from DOE.

Key points and questions raised during the meeting included: tracer site, sampling, laboratory analysis, tracer selection, use of microspheres, recirculation versus non-recirculation, operational considerations, permitting, current concepts and recommendations, and follow up meetings. Information gained from this meeting and follow-up conversations with several of the above participants have been used in developing this work plan.

4.0 TRACER TEST SCOPE OF WORK

4.1 WELL SELECTION

4.1.1 Selection Criteria and Prospective Sites

Cross-well tracer testing requires a tracer input well and a tracer output well. The time required for a cross-well tracer test is directly related to the distance between the wells. The need for results in a time interval of one year or less limits the choice of wells to those that are closely spaced. The available Nye County wells which meet the requirements of cross-well alluvial tracer testing are limited to two sites: the -10 Site, with wells NC-EWDP-10S and NC-EWDP-10P; and the -22 Site, with wells NC-EWDP-22S, NC-EWDP-22PA and NC-EWDP-22PB.

4.1.2 Tracer Test Characteristics of Prospective ISIP Sites

4.1.2.1 NC-EWDP-10 Well Complex Discussion

The NC-EWDP-10S and NC-EWDP-10P well pair has several positive characteristics for the Nye County Tracer Test program:

- The wells are located immediately east of Fortymile Wash and along a potential alluvial flow path,
- Only 45.7 ft (13.9 m) separate the bottomhole locations of the wells,
- NC-EWDP-10P has good zonal isolation; and
- NC-EWDP-10S has exhibited limited wellbore gradients.

Negative characteristics associated with this well pair include:

- Limited saturated zone thickness,
- Spinner survey data not presently available,
- There are only two wells, and
- The analysis of a 48-hr. pump test in -10S indicates low permeability of 2.2 darcy (2.2×10^{-12} m^2).

NC-EWDP-10S would be the producer well (i.e., pump well) if this well pair were chosen due to minimum casing size requirements for pump clearance.

4.1.2.2 NC-EWDP-22 Well Complex Discussion

Positive aspects of the NC-EWDP-22S, NC-EWDP-22PA, and NC-EWDP-22PB well complex include:

- The wells are located in Fortymile Wash and along a potential alluvial flow path,
- Only 59 ft (18 m) separate the bottomhole locations of the wells,
- Good saturation zone thickness,
- High permeability, averaging 14.5 darcy (14.3×10^{-12} m^2) overall,
- Limited hydraulic gradients between screened intervals,
- Two piezometer wells (NC-EWDP-22PA, NC-EWDP-22PB) are present,
- There is good zonal isolation in the two piezometer wells, and
- Static spinner surveys and pump-spinner test results are available.

The main potential negative attribute of this well complex is its location at the eastern edge of Fortymile Wash, in that wells east of Fortymile Wash might be in a different geohydrologic setting than wells west of Fortymile Wash. Additionally, there is some uncertainty about the stratigraphy of the lowest zone (Screen #4), with competing interpretations being either volcanic breccia or conglomeratic volcanic sediments.

NC-EWDP-22S will be the producer well if this well complex is chosen due to minimum casing size requirements for pump clearance.

4.1.3 Selected Site around NC-EWDP-22S

The NC-EWDP-22 well complex has been chosen for the Nye County Tracer Test program.

Figure 1 shows the layout of this complex. Figures 2 through 4 display the well completion diagrams for NC-EWDP-22S, NC-EWDP-22PA, and NC-EWDP-22PB, respectively. The push/pull tracer test will be performed at NC-EWDP-22S due to its larger casing diameter of 5-in. (0.127 m) versus 2-in. (0.051m) in the piezometer wells. Additionally, in cross well tracer testing, NC-EWDP-22S will be the producer while either NC-EWDP-22PA or NC-EWDP-22PB will be the source of the tracer slug. Casing size is the most critical parameter for selecting the pumping well at this site because casing size limits the pump capacity, and having the highest possible pump capacity will lead to the shortest test duration.

4.2 ZONE SELECTION

4.2.1 Available Zones

Well NC-EWDP-22S has three screens completed in the saturated alluvium available for tracer testing, and one screen in either volcanic breccia or conglomeratic volcanic sediments (Figure 2). Well NC-EWDP-22PA, a dual completion piezometer well, was completed in alluvium intervals corresponding to upper two screens completed in NC-EWDP-22S (Figure 3). The other offset dual completion piezometer well, NC-EWDP-22PB, has been completed in intervals corresponding to the lower two screens completed in NC-EWDP-22S (Figure 4), which include an alluvial interval and an interval comprised of either volcanic breccia or conglomeratic volcanic sediments.

4.2.2 Tracer Testing Characteristics of Individual Zones

The completed intervals in all the Nye County wells are designated in ascending order from the upper most screened interval to the deepest screen interval. Thus, Screen #1 denotes the uppermost screen in a Nye County well. Hydraulic properties of the screen intervals in NC-EWDP-22S, -22PA, and -22PB were determined from analysis of spinner and pump-spinner tests conducted in the -22S well (NWRPO, 2002a). Specific considerations for each screen include:

- Screen #1, in NC-EWDP-22S is completed from 521.5 to 581.3 ft (159 to 177.2 m), and is completed in silty sand with gravel. This interval has the benefit of being the least difficult screen to hydraulically isolate in the pumping well, needing only a bottom seal. Screen #1 has excellent permeability, 16 darcy (15.8 x 10^{-12} m^2) and is the thinnest of the alluvial intervals at 73 ft (22.2 m) sand pack thickness. A thinner zone would require less tracer volume. The pump-spinner test results (NWRPO, 2002a) indicate this interval acts as an unconfined aquifer (storage coefficient of 0.00160), which suggests that vapor phase or free surface effects might influence tracer transport.

- Screen #2, completed from 661.2 to 760.6 ft (201.5 to 231.8 m), is completed in silty sand with gravel. This interval has been shown from hydraulic testing to act as a confined aquifer (storage coefficient of 0.00031) with excellent flow characteristics (transmissivity of 5,900 ft^2/day or 548.1 m^2/day, and permeability of 18 darcy or 17.8 x 10^{-12} m^2). Screen #2 requires isolation above and below, and is thicker (115 ft or 35.1 m sand pack thickness) than Screen #1. The thicker interval will require larger tracer slug volumes, which would increase the tracer test costs.

- Screen #3, completed from 880.2 to 980 ft (268.3 to 298.7 m), is also completed in silty sand with gravel. This interval has almost the same thickness (117 ft or 35.7 m sand pack thickness) as Screen #2, but has considerably poorer flow characteristics (transmissivity of 2,550 ft^2/day or 236.9 m^2/day, and permeability of 7.5 darcy or 7.4 x 10^{-12} m^2). In addition, this interval has a substantially lower storage coefficient (0.00002) than that of Screen #2, which might indicate the presence of fast or preferential pathways. The depth, thickness, relatively low transmissivity and possibility of fast pathways make this interval a less attractive candidate for tracer testing.

- Screen #4, completed from 1140 to 1180 ft (347.5 to 359.7 m), is completed in of either volcanic breccia or conglomeratic volcanic sediments. Inasmuch as the purpose of the Nye County tracer test program is to determine the flow and transport properties of alluvial sediments down gradient of Yucca Mountain, this interval is considered unsuitable for these tests.

4.2.3 Selected Zone

Tracer tests might be conducted on each interval separately, to provide information about transport properties of the various intervals. In this case, time and budget limitations will only allow for one interval to be tested at this time. Based on the information and considerations outlined above, Screen #2 is the most promising candidate for tracer testing for the Nye County Alluvial tracer test. Although this interval is relatively thick, its high transmissivity and confined aquifer characteristics make this zone the best choice for the Nye County tracer tests.

If subsequent testing or analysis indicates Screen #2 is unsuitable for some reason, the second best alternative would be Screen #1. It should be recognized that response from Screen #1 might be complicated by unconfined aquifer characteristics (either free surface or vapor phase effects). If additional testing were contemplated in the future, Screen #1 would be a useful second zone to assess the comparative impacts of these factors.

Screen #3 is a poor third choice. The lower transmissivity would potentially lead to long test times, but the extremely low storage coefficient might be indicative of preferential or fast pathways. Once again, if additional testing is contemplated in the future, a tracer test in Screen #3 might be helpful to assess the comparative impacts of these factors.

4.3 TRACER SELECTION

Tracers available for the Nye County Tracer Test program have been narrowed to tracers found on the approved YMP tracer list (Table 1). Tracers have been restricted to the approved list to minimize possible permitting issues associated with tracer selection.

4.3.1 Conservative Tracers

Conservative tracers are used to evaluate effective porosity and dispersivity. Two non-sorbing solute tracers with differing diffusion coefficients will be used for the single well push/pull tracer test and the cross-well tracer test to evaluate porosity and dispersivity, and to provide information on possible diffusion into less mobile water in the system.

A fluorinated benzoate, pentafluorobenzoate (PFBA) and sodium iodide (NaI) have been selected for possible use in the single well push/pull tracer test. Both tracers are easily available and relatively inexpensive, and have been successfully utilized in numerous other field studies including the recent tracer testing at the ATC (Farnham, et al., 2000), and are safe and environmentally friendly.

Four conservative tracers have been selected for possible use in the cross-well tracer test, including a fluorinated benzoate, 2,3,4,5 -Tetrafluorobenzoic Acid (2,3,4,5,-TeFBA), and halide, Lithium Bromide (LiBr) along with two low concentration fluorinated benzoate tracers, 2,5-Difluorobenzoic Acid (2,5 DFBA) and 2,4,5-Trifluorbenzoic Acid (2,4,5-TFBA). The fluorinated benzoate and halide, which have differing diffusion coefficients, will be utilized as quantitative tracers and will be injected into Screen #2 while the low concentration tracers will be utilized qualitatively and will be injected into Screen #1 and #3 to test for possible stratigraphic communication. As with all the tracers, the final choice of qualitative tracer is dependent upon acquiring the necessary permits from the State of Nevada and will be at the discretion of the PI and the regulatory authority.

The 2,3,4,5-tetrafluorobenzoic acid (2,3,4,5-TeFBA) and lithium bromide (LiBr) tracers are easily available and relatively inexpensive, and have been successfully utilized in other field studies (Farnham, et al., 2000). These conservative tracers will be used quantitatively to study longitudinal dispersion and effective porosity, and to provide information on possible diffusion into less mobile water in the system.

Stratigraphic communication will be tested qualitatively through the introduction of two Nye County approved fluorinated benzoates in other zones. The fluorinated benzoates will be introduced at low concentrations into Screens #1 and #3 at NC-EWDP-22PA and NC-EWDP-22PB respectively. Low concentration fluorinated benzoates have been chosen because of the likelihood that neither of these tracers will be fully recovered during the test period.

Conservative tracers that have been chosen for use in the Nye County tracer tests are shown in Table 2 along with their respective maximum quantities and maximum concentrations. Maximum test concentrations and quantities were selected based on detection limits for each tracer.

4.3.2 Reactive Tracers

Reactive tracers are designed to model reactive contaminant transport. In reactive transport, the tracer or contaminant partitions between the solid matrix and ground water. Sorption of the tracer or contaminant on the solid matrix (i.e., mineral surfaces) may cause a retardation of the solute transport where the solute travels at a slower rate than the average linear velocity of the ground water, however; sorption will depend on reaction rate and it can take place at the average linear groundwater velocity.

Table 3 displays calculations made with Tracer_Predictions.xls for Screen #2 in NC-EWDP-22S. All calculations assumed well separation of 59 ft (18 m), interval thickness of 115 ft (35 m), equal large-scale and flow pathway porosities of 30%.

Variables considered in Table 3 include the pumping rate, Peclet Number and distribution or partition coefficients (lithium K_d). The Peclet number refers to a ratio between advection effects and diffusion effects. As seen from Table 3, the inclusion of reactive tracers could greatly increase the time required to reach peak tracer concentration and tracer mean residence time. The use of Lithium as the anion in the halide tracer for the cross-well tracer test will allow Nye County to gather reactive transport properties as a secondary objective. Lithium concentrations will be measured and recorded but will not be utilized to determine the length of the cross-hole tracer test.

The main goal of the Nye County tracer tests is to reduce uncertainty in advective transport properties of the saturated zone in the alluvium. Because of time and budget constraints, reactive transport is not the primary objective but will be evaluated as a secondary objective in the initial Nye County tracer tests.

4.3.3 Microspheres

Microspheres are designed to investigate colloid and colloid facilitated transport properties. Fluorescent polystyrene microspheres were incorporated in the ATC to study colloid filtration in the near wellbore environment. The main purpose of the Nye County tracer tests is to study effective flow porosity and longitudinal advective transport characteristics of the saturated zone. The Nye County Tracer Test program will not incorporate microspheres due to budgetary constraints.

4.3.4 Other Tracers (Viral)

Virus tracers are also designed to investigate colloid and colloid facilitated transport properties. Since colloidal transport properties are not the focus of Nye County tracer tests, viruses will not be used. Additionally, there are no viruses on the approved Nye County tracer list. Addition of viruses as tracers could significantly delay the tracer test timeline, and their use is therefore precluded.

4.4 PERMITTING ISSUES

The Nye County tracer test and hydraulic tests personnel shall obtain all required permits prior to proceeding with on-site activities. No site-disturbing activities may take place until the necessary right(s)-of-way grant(s) are approved and all necessary permits and/or waivers have been obtained.

Nye County Nuclear Waste Repository Project Office (NWRPO) has obtained a right-of-way grant from the Bureau of Land Management for access to the NC-EWDP-22S testing site and for the conduct of site-disturbing activities and restoration. Nye County NWRPO will obtain the following waivers from the Nevada Division of Water Resources, if required:

- Monitoring Well Testing - Waiver from NAC 534.4353.2 permit for sampling and testing of nonconforming well designs.

- Temporary Groundwater Waiver or Appropriation - Requirements of NRS 534.050 - A temporary groundwater appropriation or waiver will be obtained from the Nevada Division of Water Resources, as necessary, for the conduct of aquifer tests.

- Underground Injection Control - Permit for tracer injection per the requirements of NAC 445A.810 through 445A.925.

Nye County NWRPO also will obtain permits or modify existing permits, as required for the work planned. Temporary discharge permits per NRS 445A.485 will be obtained, as necessary for well sampling and aquifer testing, from the Nevada Bureau of Water Pollution Control. Air quality permits and waivers will be obtained from the Nevada Bureau of Air Quality in accordance with the provisions of NAC 445B.291 for surface disturbing activities and mobile source emissions, respectively, as required. All required permits will be submitted to the NWRPO Quality Assurance Records Center and copies of same will be posted on site during testing operations.

4.5 ANALYSIS ISSUES

Calibrated pressure/temperature transducers controlled by Nye County technical procedure, TP-9.2 (NWRPO, 2002b) and QAP 12.1 (NWRPO, 2002c) will be used to record pressures and temperatures (MOSDAX™) in all hydraulic and tracer tests. Screens will be isolated with inflatable packers. Flow rates will be recorded using calibrated flow meters. Additionally, barometric pressure and ambient surface temperature will be recorded by the MOSDAX™ system controlled by TP-9.2. All water samples will be collected and transported to the UNLV HRC following applicable Nye County test plans (Section 4.6). Tracer analyses will be conducted by UNLV HRC following approved UNLV HRC QA technical procedures, including the *UCCSN Quality Assurance Program* (UCCSN, 2002). Water samples will be collected using both a programmable automatic sampler and by manually sampling from faucets in the discharge piping. An electrical submersible pump (ESP) will be used to produce water from isolated intervals.

4.6 OVERVIEW OF PROPOSED TRACER TESTS

4.6.1 Purpose and Objectives

The Nye County Tracer Tests and other NWPRO programs have been developed with the overall goal of protecting human health, the environment, and water resources in southern Nye County. The tracer tests are designed to help reduce uncertainty in saturated zone transport parameters and pathways.

Specifically the Nye County tracer tests are designed to study effective porosity and longitudinal advective transport characteristics of the saturated zone. Additionally, using two tracers with differing diffusion coefficients in both the single well push/pull and the cross-hole tracer tests provides information on possible diffusion into less mobile water in the system. Stratigraphic communication will be tested qualitatively through the introduction of two Nye County approved conservative tracers in Screen #1 and Screen #3.

4.6.2 Tracer Test Design

The tracer tests will be designed using available programs or methods. Programs to be considered include rcv2amos.exe, MOENCHO2.vi, Tracer_Predictions.xls, and INJECTION-PUMPBACK.vi. The mathematical derivation, assumptions, and usage for these programs can be found in the *Test Plan for Alluvial Testing Complex – Single Well, Multi-well, and Laboratory Studies* (STIP-02-SZ-003 REV 01 ICN 1, 2002). These programs are briefly described below.

4.6.3 Software

4.6.3.1 Rcv2amos.exe

The software routine rcv2amos.exe, V2.0, is used to analyze cross-hole tracer tests. rcv2amos.exe is a FORTRAN program developed to solve the advection-dispersion equation using Laplace transforms.

4.6.3.2 MOENCH02.vi

MOENCHO2.vi is used in conjunction with use of rcv2amos.exe. The routine MOENCH02.vi was developed to serve as a user interface and to display the results from rcv2amos.exe, V2.0.

4.6.3.3 Tracer_Predictions.xls

A Microsoft Excel spreadsheet was set up for estimating first and peak arrival times while accounting for dispersion, sorption, unconfined flow, and recirculation ratio in cross-hole tracer tests.

4.6.3.4 INJECTION-PUMPBACK.vi

INJECTION-PUMPBACK.vi is used for analyzing single-well injection-pumpback tracer tests. Analysis considers tracer injection, drift, and pumpback phases.

4.6.4 Software Inputs

Input data for the porosity, permeability, thickness, and productivity index for Screen #1-#4 of NC-EWDP-22S were obtained from the previous hydraulic testing performed on NC-EWDP-22S in March of 2002 (NWPRO, 2002a). Input data for estimates of longitudinal dispersivity and lithium partitioning coefficient were obtained from the ATC tracer testing study (STIP-02-SZ-003 REV 01 ICN 1, 2002).

4.6.5 Single Well Push/Pull Test

4.6.5.1 Supporting Calculations

Single well push/pull tracer testing involves injection of a tracer material into the formation and leaving it to diffuse and migrate with the natural groundwater flow. The tracer is then produced back through the same wellbore. Simple volumetric calculations were made to determine the expected radius of the injected tracer material out from the wellbore into the formation.

The radius of the injected fluid can be determined from the following derived equation:

$$r_{if} = \sqrt{\frac{V_{if}}{(7.48\pi h \phi)} + r_w^2}$$

where

r_{if} = radius of injected fluid, ft
r_w = radius of wellbore, ft
V_{if} = volume of injected fluid, gallons
ϕ = effective porosity
h = height of formation, ft

Inserting the proper values for NC-EWDP-22S along with 1,321 gallons (5,000 L) of injected tracer plus 21,000 gallons of produced water flush into the equation yields a radius of injected fluid of 10.6 feet (3.2 m). The pump back time for retrieving the tracer in the absence of diffusion and natural advection at a rate of 15 gpm (56.8 L/min.) would be approximately 24.8 hours. Although the exact pump back time is unknown at this time, pumping the well for 1 week at 48 gpm (181.7 L/min.) would produce 484,000 gallons of water and exchange water out to a radius of 24.5 feet.

4.6.5.2 Test Plan

The single well push/pull tracer test will consist of simultaneously injecting two non-sorbing tracers with different diffusion coefficients into Screen #2 of NC-EWDP-22S. Sodium iodide and pentafluorobenzoate have been identified as the most likely tracers; however the actual tracers utilized will be at the discretion of the PI. The tracers will be allowed to diffuse and migrate with natural groundwater flow for a period of time not to exceed two days. After allowing the slug to diffuse and migrate, the tracers will be pumped backed with a submersible pump (ESP). The differences in the observed tracer responses provide information on possible diffusion into immobile water in the system along as well. A detailed procedure for this test is found in Nye County test plan, TPN-9.2, *Single Well Push/Pull Tracer Test at NC-EWDP-22S* (NWRPO, 2003a).

4.6.6 Cross-Hole Multiple-Well Test

4.6.6.1 Supporting Calculations

Two programs were utilized to estimate the tracer response for the cross-hole multiple well test: Tracer_Predictions.xls and MOENCH02.vi. All tracer response curves are based on Screen #2 properties of 115 ft (35.1 m) thickness, 30% porosity, and a distance of 59 ft (18 m) between the injection and production points, NC-EWDP-22PA and NC-EWDP-22S respectively.

Table 3 displays the output of Tracer_Predictions.xls for various production rates, lithium partitioning coefficients and Peclet numbers. Higher Peclet numbers indicate that the system is dominated by advection while lower Peclet numbers indicate the system is increasingly dominated by diffusion. This can be seen in Table 3 when identical pumping rates of 48 gpm and Peclet numbers of 6.43 and 59 are compared. The lower Peclet number case has early breakthrough and peak responses times in comparison to the higher Peclet number case. Also shown in Table 3 is the effect of lithium partitioning coefficients. As discussed in Section 4.3.1.2 on Reactive Tracers, sorption greatly increases breakthrough and peak response times.

Additionally, predictions were made using the MOENCH02.vi package for cross-hole multiple well tracer tests. The MOENCH02.vi output displayed in the Figures 5 – 10 are in concentration of fluorinated benzoate in parts per billion (ppb) versus time in days. Figure 5 displays the predicted breakthrough curve for a fluorinated benzoate tracer based on a pump rate of 48 gpm and Peclet number of 6.56. Figures 6, 7 and 8 show the effect of the Peclet number on the predicted tracer response curve. Figures 9 and 10 display the effect of pumping rates of 40 and 25 gpm (151.4 and 94.6 L/min.), respectively. As can be seen from Figures 9 and 10, higher pump rates are desirable because they reduce the time required to capture the injected tracer and hence the overall length of the tracer test.

4.6.6.2 Test Plan

The cross-hole multiple well tracer tests will consist of simultaneously injecting two non-sorbing tracers with different diffusion coefficients, a fluorinated benzoate and a halide into the lower completion of NC-EWDP-22PA. 2,3,4,5-TeFBA and LiBr have been identified as the most likely tracers; however the actual tracers utilized will be at the discretion of the principal investigator. The tracers will be displaced out into the formation by a small volume of compatible chase water. Prior to introducing the tracers into the formation, the flow port in the Westbay® assembly will be opened to flow from Screen #2 and the pump will be turned on at NC-EWDP-22S. Screen #2 will be pumped until tracer concentrations reach permitted levels. Stratigraphic communication will be tested qualitatively through the introduction of two Nye County approved fluorinated benzoates at low concentrations in Screen #1 and Screen #3. 2,5-DFBA and 2,4,5-TFBA have been identified as the most likely tracers; however the actual tracers utilized will be at the discretion of the principal investigator. A detailed plan for this test is found in Nye County test plan, TPN-9.3, *Cross-Hole Multiple-Well Tracer Test at Site 22* (NWRPO, 2003b).

4.6.7 Supporting Isolated Zone Hydraulic Tests

4.6.7.1 Purpose and Objective

The purpose of these tests is to fill gaps in aquifer parameter data in alluvium and upper Tertiary sediments along a potential flow path between Yucca Mountain, Nevada and populated areas of Amargosa Valley, Nevada. These additional pump tests are anticipated to provide more detailed interpretations than the pump testing conducted in March 2002 at NC-EWDP-22S. Pumping and pressure monitoring will occur in a single NC-EWDP-22S screen while pressure is simultaneously monitored in the remaining isolated -22S screens and in both deep and shallow completions in -22PA and -22PB. Monitoring the pressure response of the pumped screen along with the pressures of the adjacent non-pumped screens will assists in the evaluation of potential communication between strata. If significant communication is identified the subsequent tracer tests will be modified to account for the communication.

4.6.7.2 Test Plan

The current installation in NC-EWDP-22S will be modified by removing the current 4-inch poly-vinyl chloride (PVC) casing and replacing it with 5-inch PVC casing. This will allow a larger submersible pump to be installed above the Westbay® system. The final pressure probe instrumentation of NC-EWDP-22S will allow for pressure monitoring of each individual screen during both the hydraulic and tracer tests.

Calibrated Stand Alone Module (SAMs) pressure probes and data loggers will be placed in the deep and shallow completions in -22PA and -22PB during the hydraulic test. Each hydraulic test will consist of a pumping phase and corresponding recovery phase. A detailed Test Plan with the final Westbay® installation is found in Nye County test plan, TPN-9.1, *Pump Test of Individual Screens in NC-EWDP-22S* (NWRPO, 2003c).

4.7 SCHEDULE

4.7.1 Work Plan

The QA work plan (this document) and supporting calculations are to be finished and approved by August 1, 2003.

4.7.2 Test Plans

The supporting QA test plans and supporting calculations are to be finished September 15, 2003.

4.7.3 Tracer Tests

The Nye County tracer tests are to be conducted in the second year of the grant period (2003-2004). The cross-well tracer tests will continue to be pumped until all tracer material is at or below the maximum allowable concentration as determined by the permits.

4.7.4 Analysis and Reporting

All data collected will be submitted to the NWPRO QARC (raw, processed, and analyzed) along with the appropriate metadata. Summary reports will be prepared for each tracer test and will include analyses and results after the tracer samples have been analyzed.

4.8 SUPPLIES

4.8.1 Tracers

Tracers for the Nye County Tracer Test program may be purchased directly from the manufacturer or may be obtained through existing stocks available from the University of Nevada at Las Vegas, Harry Reid Center for Environmental Studies.

4.8.2 Tracer mixing equipment

All tracers are to be pre-mixed under the supervision of staff members of the University of Nevada at Las Vegas, Harry Reid Center for Environmental Studies and delivered to location.

4.8.3 Tracer injection equipment

Tracers will be introduced into the respective screen intervals through gravity flow down the casing. It is yet to be determined whether the tracer will be pumped from the shipping containers to the wellhead. All tracers will be displaced with compatible water into the formation via gravity flow.

4.8.4 Production Well Pump

The choice of the production well pump is a critical parameter for the Nye County Tracer Test program. The production well pump selection controls the overall length of the tracer test through the water production rate. It is therefore an important component of the overall cost of the test. The pump will be sized to maximize groundwater production while maintaining net positive suction pressure on the pump.

As currently completed, NC-EWDP-22S is tied back from the Westbay® assembly by 4-in. (0.1 m) PVC casing. The inside diameter of this casing is too small to house a pump of sufficient capacity for either the pre-tracer hydraulic test or the tracer tests. Therefore, prior to running either series of tests, the 4-in. (0.1 m) PVC casing will be pulled and replaced with 5-in. (0.127 m) PVC casing.

Two alternative pumping technologies were investigated for use in NC-EWDP-22S: progressive cavity screw pumps or ESP. The ESP was chosen because of its superior pump capacity. Hydraulic properties of the screen intervals in NC-EWDP-22S were determined from analysis of spinner and pump-spinner tests conducted in the -22S well (NWRPO, 2002a). Based upon these properties an ESP with similar pumping characteristics to the GRUNFOS® model 40S100-30 pump will be purchased for the Nye County Tracer Test program. The selected pumping system should provide a flow rate of approximately 48 gpm (181.7 L/min) for the Nye County tracer tests and hydraulic tests. The final ESP purchased for the Nye County tracer tests and hydraulic tests may change as new data become available and is at the discretion of the PI.

4.8.5 Pressure gauges for the pre-tracer hydraulic tests

Calibrated MOSDAX™ pressure/temperature transducers will be used to record pressures and temperatures in all hydraulic and tracer tests.

4.8.6 Sampling Equipment

Groundwater samples will be collected for tracer analyses using both a programmable automatic sampler and by manually sampling from faucets in the discharge piping.

4.8.7 Personal Protective Equipment

All personal protective equipment (PPE) required by the Material Data Safety Sheets for the applicable tracer materials shall be worn at all times when handling concentrated tracer materials. Required PPE as put forth in the Nye County Health and Safety Plan shall be worn when on location (NWRPO, 2002d).

4.9 LABOR REQUIREMENTS

Labor requirements shall be met by Nye County employees, UNLV HRC staff, or approved contractors acting on the behalf of Nye County.

4.10 PERMITTING REQUIREMENTS

The Nye County Tracer Test and Hydraulic Tests programs shall obtain all required permits prior to proceeding with on-site activities.

4.11 TRACER SAMPLING

4.11.1 Background Levels

Prior to beginning the Nye County tracer tests, water samples from Screens #1-#4 will be analyzed for background levels of all the proposed tracers. Individual screen water samples will be obtained during the isolated hydraulic tests.

4.11.2 Sampling Procedures

Sampling procedures shall conform to those given in TPN-9.2, *Single Well Push/Pull Tracer Test at NC-EWDP-22S* (NWRPO, 2003a) and TPN-9.3, *Cross-Hole Multiple-Well Tracer Test at Site 22* (NWRPO, 2003b).

4.11.3 Sampling Frequency

Sampling frequencies shall conform to those given in TPN-9.2, *Single Well Push/Pull Tracer Test at NC-EWDP-22S* (NWRPO, 2003a) and TPN-9.9, *Cross-Hole Multiple-Well Tracer Test at Site 22* (NWRPO, 2003b).

4.11.4 Sample Analysis

4.11.4.1 Recommended Laboratory

The recommended laboratory for analysis of Nye County Tracer Test program is the University of Nevada at Las Vegas, Harry Reid Center for Environmental Studies

4.11.4.2 Recommended Techniques

Recommend techniques for sample analysis shall conform to standard analysis techniques utilized by the recommended laboratory (Farnham, et al., 2000).

4.12 TRACER TEST ANALYSIS

4.12.1 Software

In addition to the software listed in Section 4.4.3 of this document, the commercial software Microsoft Excel will be used for statistical analysis of data and for plotting of graphs. Microsoft Excel was also used to generate estimated flow rates and friction drops for the recommended pumping system.

4.12.2 Tracer Test Analysis Reporting

Analysis of the Nye County tracer tests shall be documented in a reasonable and timely manner. Documentation will be technically defensible and include assumptions, critical equations, data, summary of results, conclusions, and references.

5.0 TRACER TEST MANAGEMENT

To ensure that the work involved will be quality controlled and accomplished in accordance with the scope and objectives of the ISIP, the following training and associated documentation will be implemented prior to conducting tests. All individuals performing the tracer tests described in the above sections shall be trained in procedures specifically applicable to the instrumentation used before conducting work, and shall document that they have read and understood the applicable technical procedures.

The Project QA Officer shall be responsible for the coordination of the internal review of this work plan. The Project QA Officer is also responsible for ensuring the proper training of NWRPO personnel and verifying compliance with the requirements of this plan. The Principal Investigator shall be responsible for the preparation and modification of this work plan, as well as the oversight of the performance of the plan.

6.0 TRACER TEST HEALTH AND SAFETY PLAN

All Nye County personnel or designated Nye County contractors will conduct all operations in accordance with all local, state, and federal regulations or regulations in effect concerning employee health and safety. In the event that any of these regulations and requirements requires variance from the provisions set forth in this work plan, the regulatory requirements shall take precedence. NWPRO personnel and designated contractors will comply with the above regulations and the NWPRO Health and Safety Plan (NWPRO, 2002d).

7.0 REFERENCES

Farnham, I.M., Meigs, L.C., Dominguez, M.E., Lindley, K., Daniels, J.M. and Stetzenbach, K.J. (2000) *Appendix H: Evaluation of Tracers Used for the WIPP Tracer Tests, Interpretations of Tracer Tests Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant Site*, editors Lucy Meigs, Richard Beauheim and Toya L. Jones, Sandia Report SAND97-3109.

NWRPO (Nuclear Waste Repository Office). 2002a. *Preliminary Analysis of Pump-Spinner Tests and Pump Tests in Well NC-EWDP-22S, Near Yucca Mountain, Nevada*. NWRPO-2002-06 DRAFT. Pahrump, Nevada: Nuclear Waste Repository Project Office. January 2003.

NWRPO. 2002b. TP-9.2, *Borehole Calibration and Field Procedures.* Pahrump, Nevada: Nuclear Waste Repository Project Office.

NWRPO. 2002c. QAP-12.1, *Procedures for Control of Measuring and Test Equipment.* Pahrump, Nevada: Nuclear Waste Repository Project Office.

NWRPO. 2002d. *Health and Safety Plan*. Pahrump, Nevada: Nuclear Waste Repository Project Office.

NWRPO. 2003a. TPN-9.2 (draft), *Single Well Push/Pull Tracer Test at NC-EWDP-22S.* Pahrump, Nevada: Nuclear Waste Repository Project Office.

NWRPO. 2003b. TPN-9.3 (draft), *Cross-Hole Multiple-Well Tracer Test at Site 22*. Pahrump, Nevada: Nuclear Waste Repository Project Office.

NWRPO. 2003c. TPN-9.1 (draft), *Pump Test of Individual Screens in NC-EWDP-22S.* Pahrump, Nevada: Nuclear Waste Repository Project Office.

SITP-02-SZ-003 REV 01 ICN 1, 2002. *Test Plan for Alluvial Testing Complex –Single Well, Multi-well, and Laboratory Studies.* U.S. Department of Energy, Yucca Mountain Site Characterization Office

UCCSN. 2002. "UCCSN Quality Assurance Program." University of Nevada Las Vegas, Las Vegas, NV. Accessed February 13, 2003. <http://hrcweb.nevada.edu/qa/OnlineDocs.htm>.

FIGURES, TABLES, AND ATTACHMENTS

Figures

Tables

Attachments

Table 1. Approved Yucca Mountain Project Tracers

Original Approved Tracers		Per 1996 Modification		Per 1998 Modification
Pyridone		Sodium Tungstate Dihydrate		Nickel (II) Chloride Hexahydrate
Sodium Chloride		Sodium Molybdate Dihydrate		Cobalt Chloride Hexahydrate
Lithium Bromide		Sodium Fluoride		Manganese Chloride Tetrahydrate
Fluorescent microspheres		Fluorescein, sodium derivative		Samarium Chloride Hexahydrate
Polystyrene spheres		Potassium Fluoride		Cerium (III) Chloride Heptahydrate
Sulfur Hexafluoride – (gas)		Magnesium Fluoride		Sodium Perrhenate
Nitrogen		Magnesium Iodide		Lithium Chloride
"SUVA" cold-MP (tetra fluorethane) (gas)		Helium		Calcium Iodide Hydrate
2,4,6 – Trifluorobenzoic Acid		Neon		Calcium Bromide Dihydrate
2,4,5 – Trifluorobenzoic Acid		Krypton		Amino G Acid (7-amino-1,3-naphthalenedisulfonic acid)
2,3,4 – Trifluorobenzoic Acid		Xenon		Pyranine(8-hydroxy-1,3,6 – pyrenetrisulfonic acid trisodium salt)
2,3,6 - Trifluorobenzoic Acid		Argon		**Dyes**
2,3,4,5 – Terafluorobenzoic Acid		Sodium Iodide		Lissamine FF(Acid Yellow 7)
2,3,4,6 – Terafluorobenzoic Acid		Sodium Bromide		Rhodamine WT
3,4,5 – Trifluorobenzoic Acid		Potassium Iodide		Rhodamine B
2,3 – Difluorobenzoic Acid		Potassium Bromide		Sulforhodamine B
2,4 – Difluorobenzoic Acid				FD&C Blue 1
2,5 – Difluorobenzoic Acid				FD&LC Red 40
2,6 – Difluorobenzoic Acid				FD&C Yellow 6
3,4 – Difluorobenzoic Acid				FD&C Yellow 5
3,5 – Difluorobenzoic Acid				
Pentafluorobenzoic Acid				

Table 2. Potential Tracers for Nye County Tracer Test

Tracers	Maximum Quantity (grams)	Maximum Test Concentration (mg/L)
Sodium Iodide (NaI)	3,000	600
Pentafluorbenzoate (PFBA)	2,500	500
Lithium Bromide (LiBr)	25,000	25,000
2,3,4,5-Tetrafluorobenzoic Acid (2,3,4,5,-TeFBA)	15,000	15,000
2,5–Difluorobenzoic Acid (2,5- DFBA)	1,500	1,500
2,4,5-Trifluorobenzoic Acid (2,4,5-TFBA)	1,500	1,500
Lithium Chloride (LiCl)	100,000	100,000
Lithium Hydroxide (LiOH)	3,500	3,500

Table 3. Predicted Cross-Hole Response Times for Screen #2

Q Producing Rate (gpm)	Peclet Number	Conservative Tracer Arrival Times (days)		Reactive Tracer Kd = 1 mg/l Arrival Times (days)		Reactive Tracer Kd = 6 mg/l Arrival Times (days)	
		First	Peak	First	Peak	First	Peak
48	6.43	5	22	36	156	193	830
40	6.43	6	26	44	188	231	996
25	6.43	10	42	70	300	370	1594
48	59	20	38	144	276	762	1464

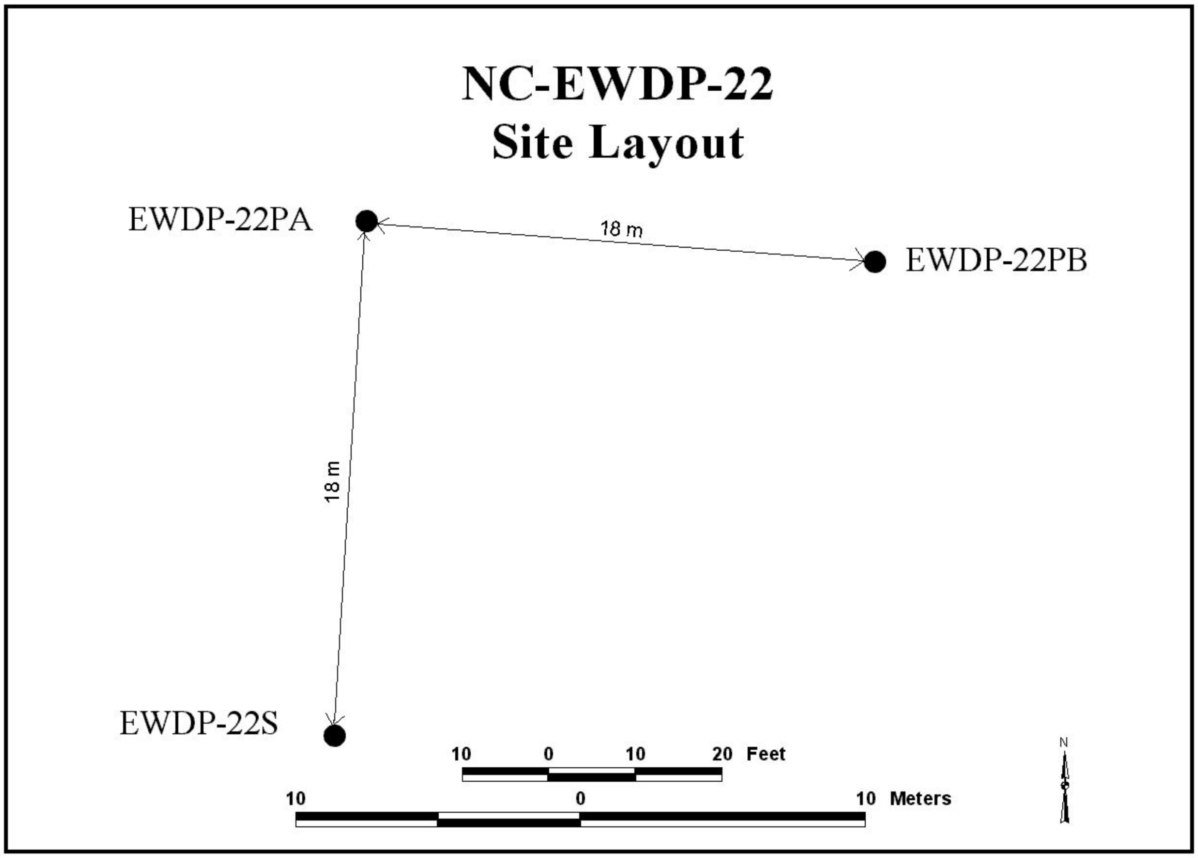


Figure 1. NC-EWDP-22 Tracer Complex Site Diagram

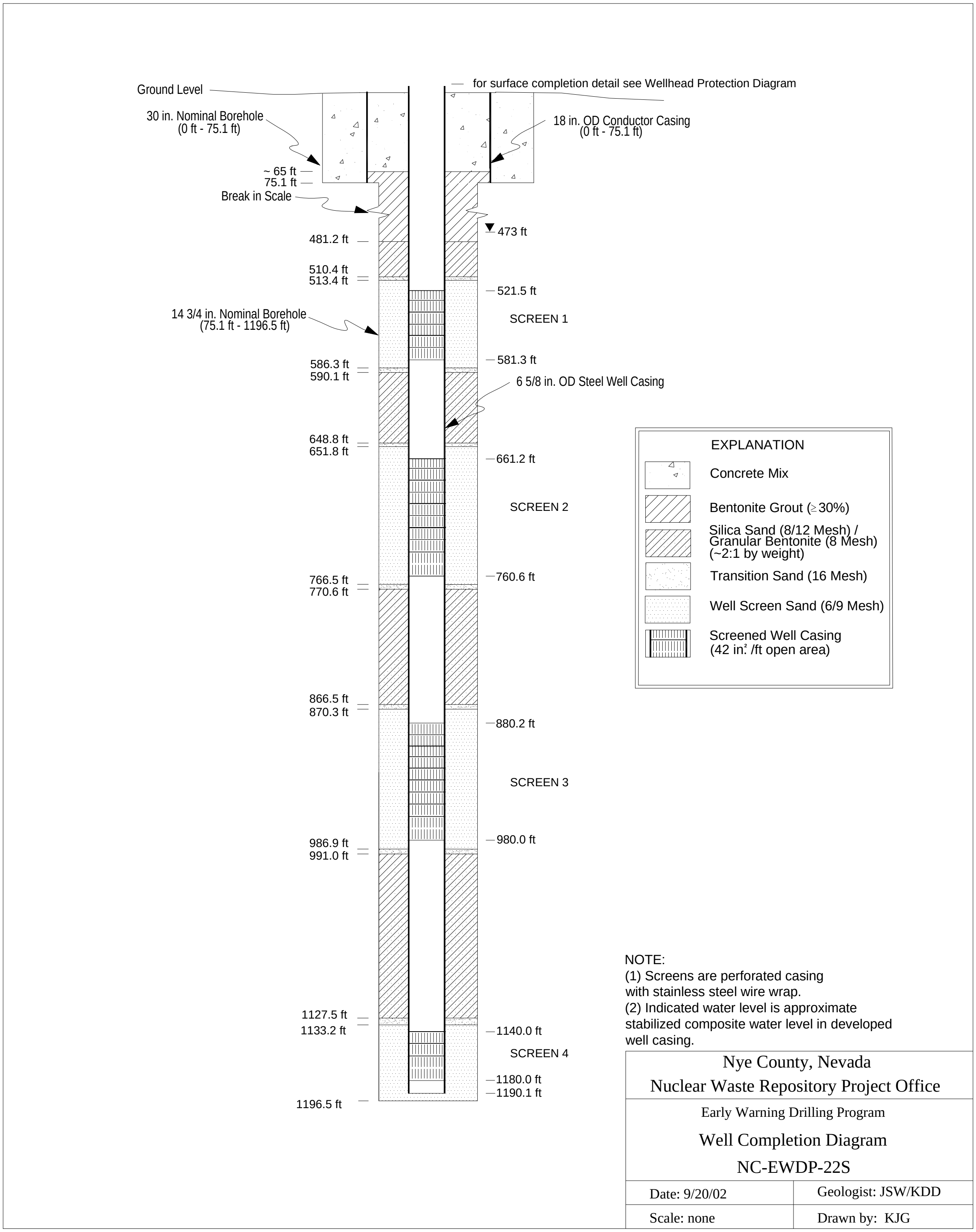


Figure 2. Completion Diagram for Well NC-EWDP-22S

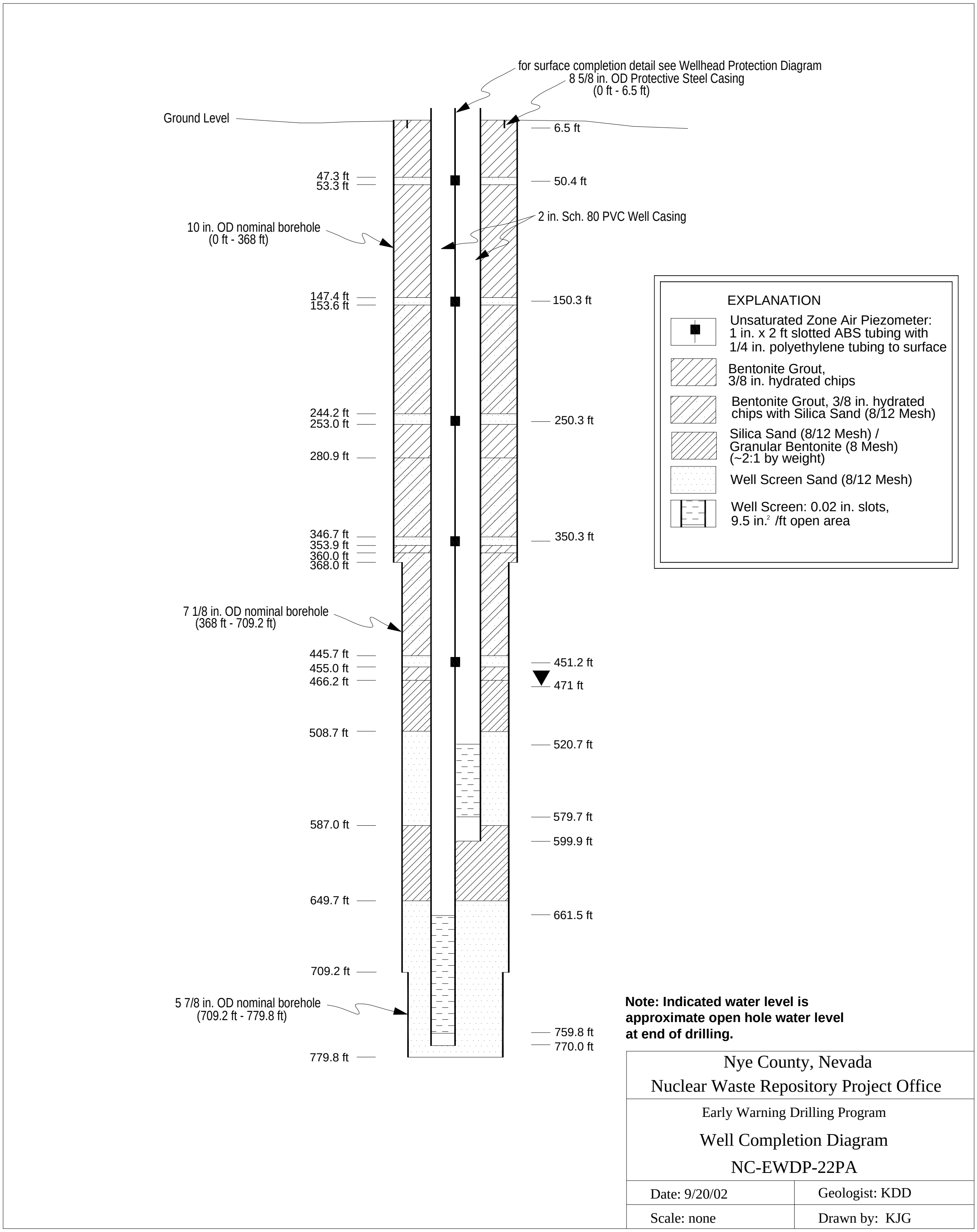


Figure 3. Completion Diagram for Well NC-EWDP-22PA

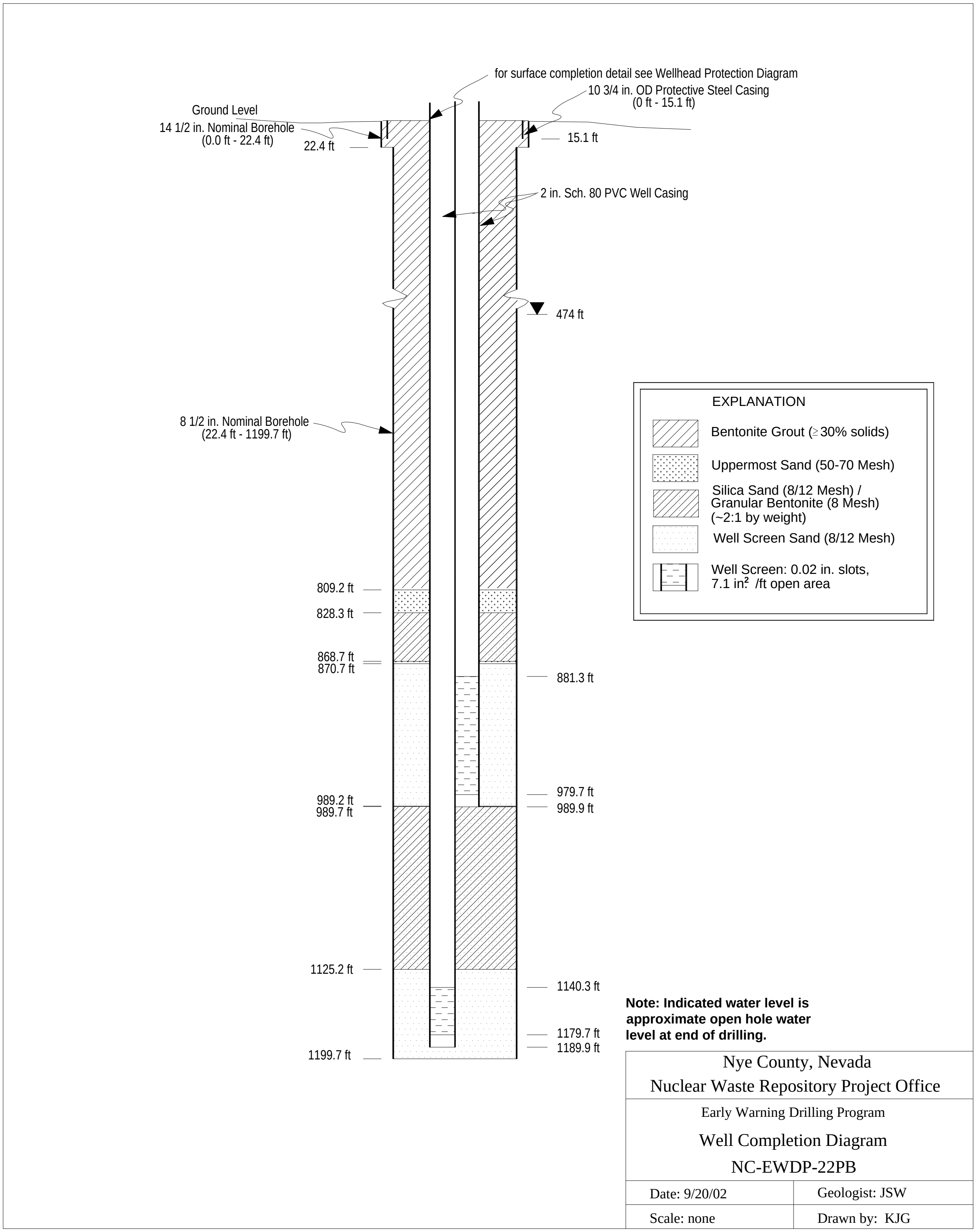


Figure 4. Completion Diagram for Well NC-EWDP-22PB

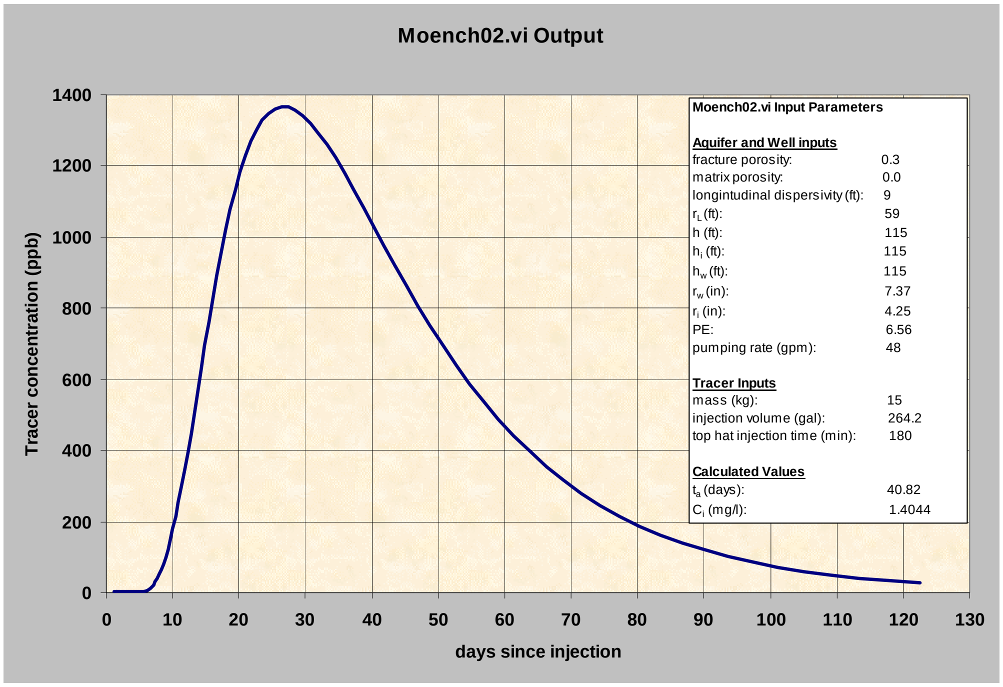


Figure 5. Prediction of Cross-Hole Conservative Tracer Testing in Screen #2 (q=48 gpm, PE=6.56)

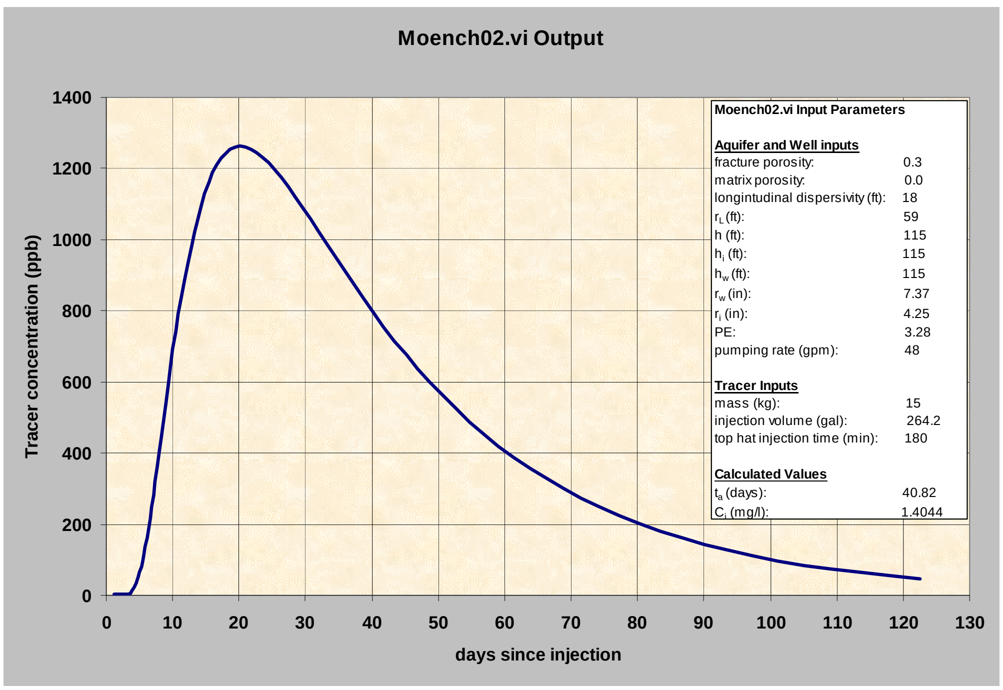


Figure 6. Prediction of Cross-Hole Conservative Tracer Testing in Screen #2 (q=48 gpm, PE=3.28)

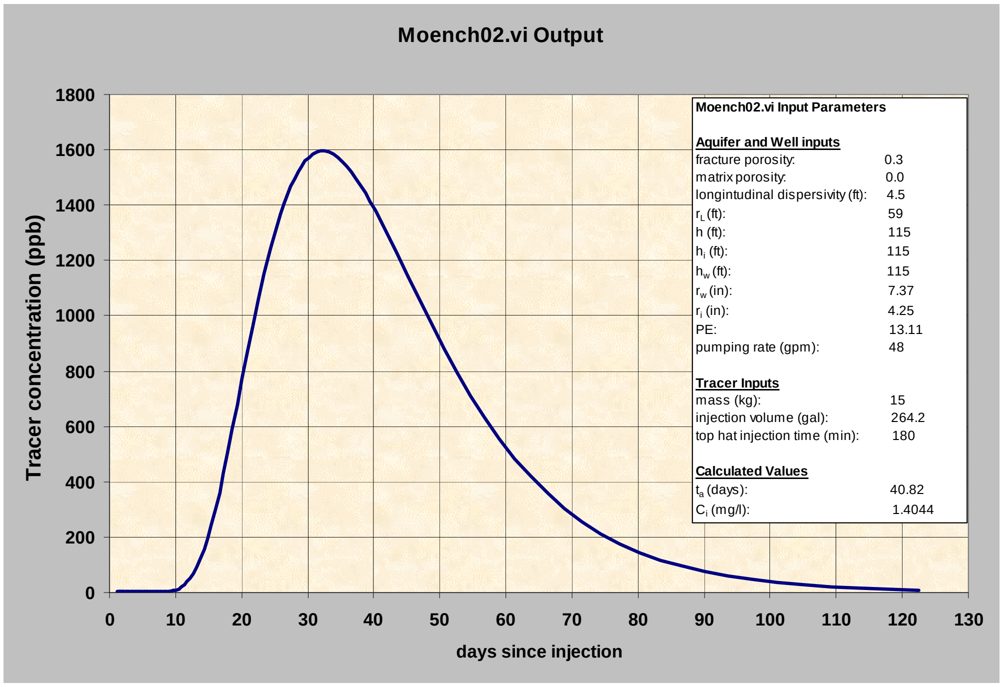


Figure 7. Prediction of Cross-Hole Conservative Tracer Testing in Screen #2 (q=48 gpm, PE=13.11)

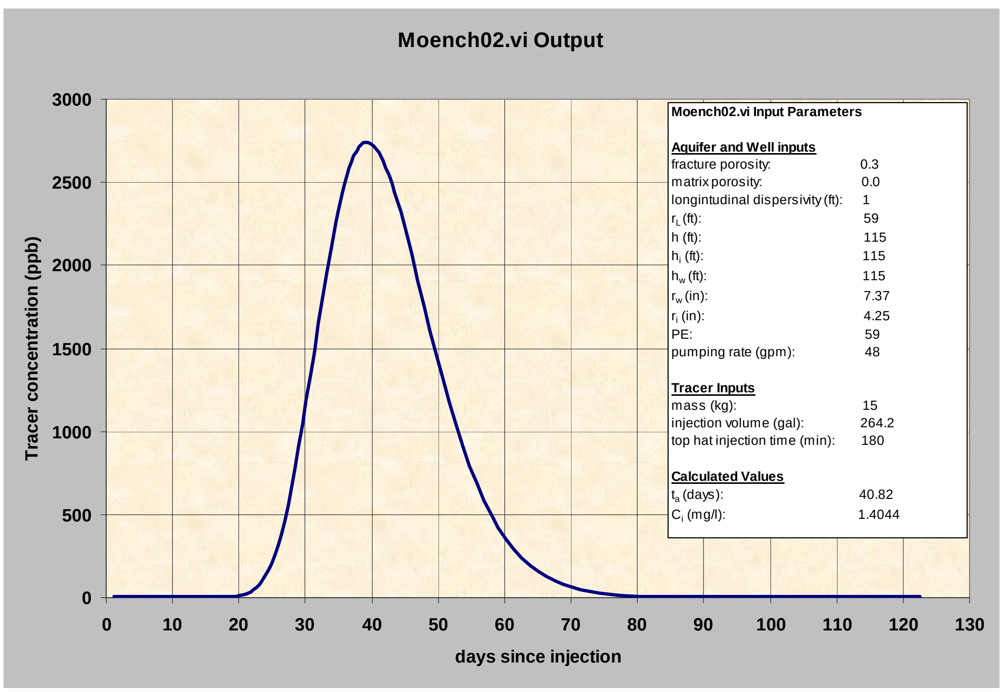


Figure 8. Prediction of Cross-Hole Conservative Tracer Testing in Screen #2 (q=48 gpm, PE=59)

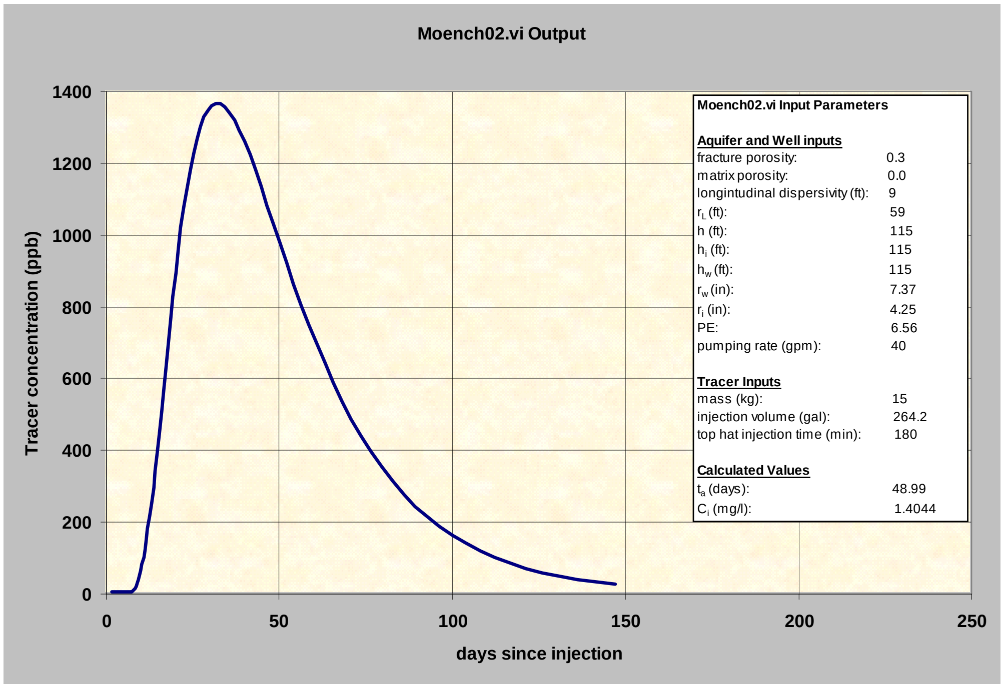


Figure 9. Prediction of Cross-Hole Conservative Tracer Testing in Screen #2 (q=40 gpm, PE=6.56)

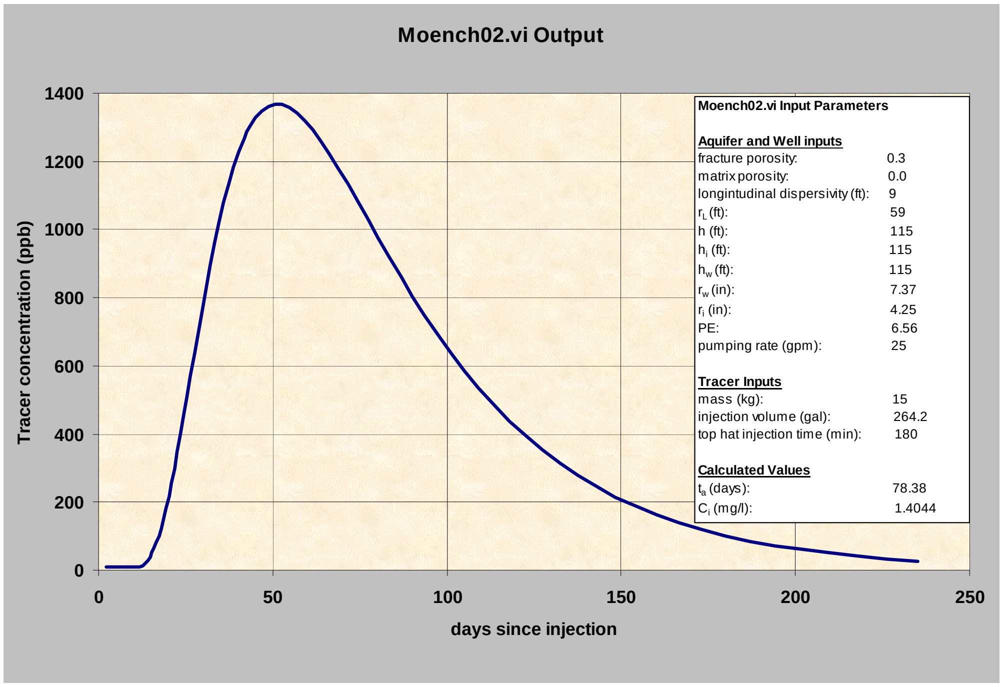
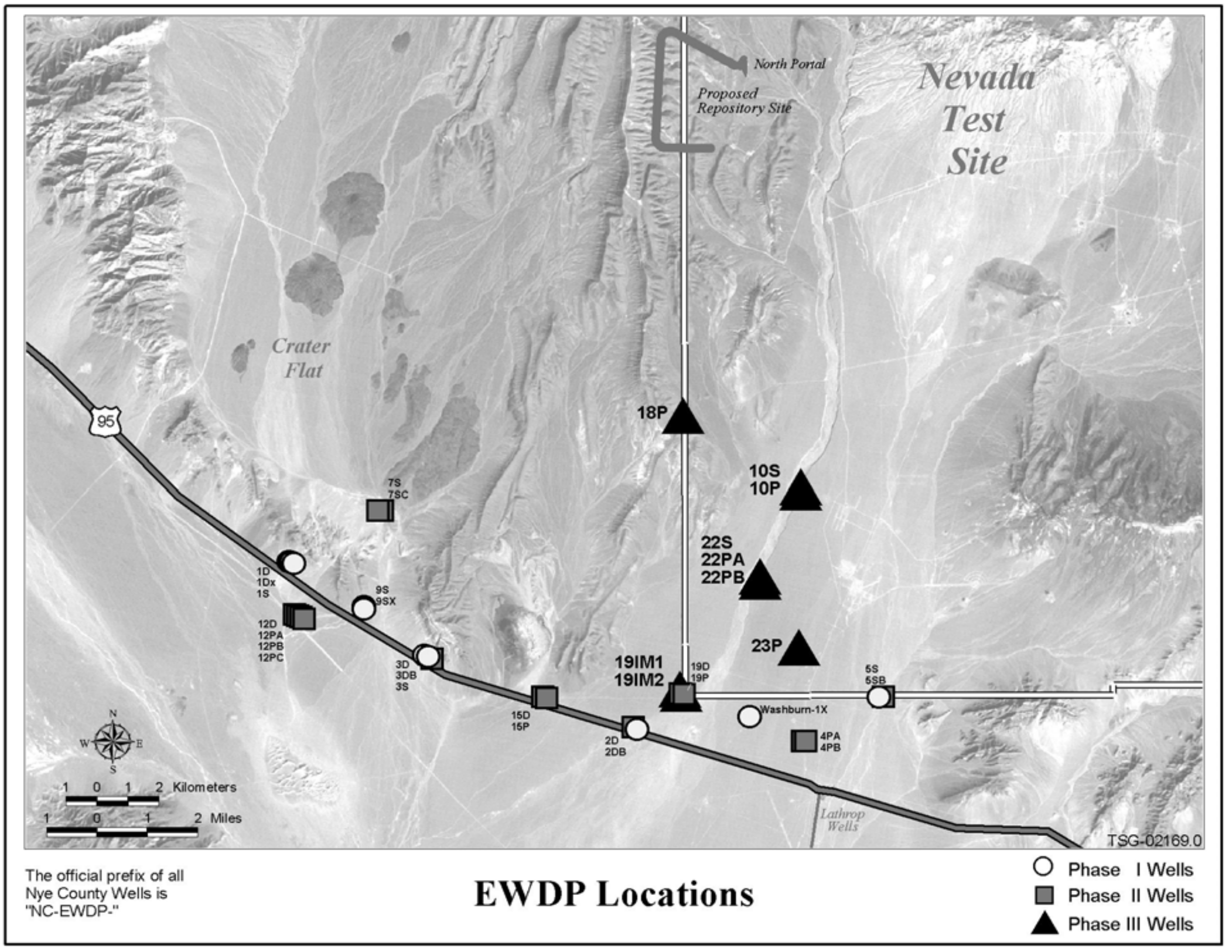


Figure 10. Prediction of Cross-Hole Conservative Tracer Testing in Screen#2 (q=25 gpm, PE=6.56)

Attachment 1.
Early Warning Drilling Program Phase III Well Locations



NOTE: EWDP = Early Warning Drilling Program