Site-Wide Integrated Water Monitoring – Defining and Implementing Sampling Objectives to Support Site Closure - 13060

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ABSTRACT

The Underground Test Area (UGTA) activity is responsible for assessing and evaluating the effects of the underground nuclear weapons tests on groundwater at the Nevada National Security Site (NNSS), formerly the Nevada Test Site (NTS), and implementing a corrective action closure strategy. The UGTA strategy is based on a combination of characterization, modeling studies, monitoring, and institutional controls (i.e., monitored natural attenuation). The closure strategy verifies through appropriate monitoring activities that contaminants of concern do not exceed the SDWA at the regulatory boundary and that adequate institutional controls are established and administered to ensure protection of the public. Other programs conducted at the NNSS supporting the environmental mission include the Routine Radiological Environmental Monitoring Program (RREMP), Waste Management, and the Infrastructure Program. Given the current programmatic and operational demands for various water-monitoring activities at the same locations, and the ever-increasing resource challenges, cooperative and collaborative approaches to conducting the work are necessary. For this reason, an integrated sampling plan is being developed by the UGTA activity to define sampling and analysis objectives, reduce duplication, eliminate unnecessary activities, and minimize costs. The sampling plan will ensure the right data sets are developed to support closure and efficient transition to long-term monitoring. The plan will include an integrated reporting mechanism for communicating results and integrating process improvements within the UGTA activity as well as between other U.S. Department of Energy (DOE) Programs.

INTRODUCTION

The Nevada National Security Site (NNSS), formerly the Nevada Test Site (NTS), has long been a vital and unique national resource. The site was established in 1950 and was the primary location for testing the nation's nuclear explosive devices from 1951 to 1992. The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) initiated Underground Test Area (UGTA) activities to assess and evaluate the effects of the underground nuclear weapons tests on groundwater and implement a corrective action closure strategy that meets regulatory objectives. The nuclear testing locations assigned to UGTA are grouped into these corrective action units (CAUs): Yucca Flat/Climax Mine, Frenchman Flat, Rainier Mesa/Shoshone Mountain, and Pahute Mesa (Western and Central).

The UGTA strategy assumes that active remediation is not feasible with current technology [1]. As a result, the corrective action is based on a combination of characterization and modeling studies, monitoring, and institutional controls (i.e., monitored natural attenuation). The primary purpose of the UGTA activity is to define perimeter boundaries over the next 1,000 years that enclose areas potentially exceeding the radiological standards of the *Safe Drinking Water Act* (SDWA) [2]. The primary method to define these boundaries is by developing and evaluating flow and contaminant transport models that forecast the extent of potentially contaminated groundwater. Assessments of the contaminant boundary forecasts are used to aid in identifying use-restriction boundaries [1].

The strategy is implemented through four stages, similar to the CERCLA Remedial Investigation/Feasibility Study/Record of Decision process, including the Corrective Action Investigation Plan (CAIP), Corrective Action Investigation (CAI), Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), and Closure Report (CR) stages. During the CAI stage, activities are focused on groundwater characterization and supporting flow and contaminant transport model development. The goal of the CADD/CAP stage is to build confidence that the modeling results can be used for the regulatory decisions required for CAU closure. The regulatory decisions include identifying and establishing CAU regulatory objectives and boundaries; identifying institutional controls, including use-restriction boundaries; and developing a long-term closure monitoring program [1].During the CR stage, final use-restriction boundaries and CAU regulatory boundaries are negotiated and established, a long-term closure monitoring program is developed and implemented, and the approaches and policies for institutional controls are established and implemented. Groundwater sampling and analysis therefore serves a variety of functions throughout the UGTA lifecycle.

The closure strategy essentially verifies through appropriate monitoring activities that contaminants of concern do not exceed the SDWA [2] at the regulatory boundary and that adequate institutional controls are established and administered to ensure protection of the public. Monitoring for changed conditions (e.g., seismicity, water levels, and water development) will also be included. The long-term closure monitoring program will include conducting activities such as performing periodic analysis of monitoring results, determining optimum performance indicators, evaluating performance criteria, locating new monitoring wells, and replacing monitoring wells as needed. The monitoring network design includes the technical requirements and physical layout of the well system. The location of and distance between the monitoring well(s) and the use-restriction and regulatory boundaries is predicated on the need to provide adequate early warning. Periodic water sampling of the monitoring well(s) is expected to confirm that use-restriction and regulatory boundaries are sufficient, as well as verify that conceptual models of the groundwater system continue to be valid.

Associated with the UGTA activity, other programs conducted at the NNSS support the environmental mission of the site. As an interim pre-closure monitoring activity, monitoring is conducted under the Routine Radiological Environmental Monitoring Program (RREMP). This monitoring was designed as “down-stream” from the UGTA activity to monitor for contaminant migration, and for demonstrating that site operations-related contamination has not impacted on-site and off-site drinking water supplies in comparison to SDWA levels. Waste Management is another NNSS activity that involves management, safe disposal, and storage of low-level radioactive waste and mixed low-level waste in accordance with RCRA. Permit conditions require that groundwater be monitored to ensure waste constituents have not migrated to the water table. In some case, wells monitored under the permit may provide value to addressing some UGTA activity and RREMP monitoring objectives. Buildings, roads, utilities and facilities are maintained by the Infrastructure Program (Nondefense Mission). In the course of performing this work, water monitoring is conducted in accordance with permits established for compliance with SDWA and Clean Water Act requirements.

Given the current programmatic and operational demands for various water-monitoring activities at the same locations, and the ever-increasing resource challenges, cooperative and collaborative approaches to conducting the work are necessary. An UGTA sampling plan is being developed to provide a comprehensive, integrated approach for collecting and analyzing groundwater samples and water levels. The sampling plan will ensure coordination with other NNSA/NSO programs including RREMP, Waste Management, and the Infrastructure Program. The intent of the Plan is to define sampling and analysis objectives, reduce duplication, eliminate unnecessary activities, and minimize costs. The sampling plan will ensure the right data sets are developed to support closure and efficient transition to long-term monitoring.

DISCUSSION

The objectives of the UGTA sampling plan include defining specific sampling and analysis objectives; data collection criteria (e.g., purging requirements, analytes, minimum detection levels [MDLs], sampling frequency, and accuracy requirements); and standard processes and procedures for collecting and analyzing water samples and water levels. Another sampling plan objective is to provide a planning and reporting process that ensures effective communication amongst U.S. Department of Energy (DOE) Programs.

Sampling and Analysis Objectives

A series of well types have been identified based on the well's location relative to the detonations(s), groundwater radionuclide activity, and well purpose (Table I). An example of the distribution of these wells is presented for Pahute Mesa in Figure 1. The objectives of the sampling and analysis are related to the well type. The UGTA wells all begin as Characterization wells. Analyses of the groundwater of the Characterization wells are generally intended to answer questions regarding groundwater sources, flow paths, travel times, and contaminant migration in support of the groundwater flow and transport modeling. Source Term Investigation wells are located within, near or immediately downgradient of a test cavity and have tritium activities above10,000 pCi/L (one half of the SDWA maximum contaminant level). Since tritium is the most prevalent and mobile of the contaminants of concern. These wells have the greatest likelihood of encountering other test-related radionuclides and are used to characterize the source term, monitor natural attenuation, and identify potential contaminants of concern. Early Detection wells are located immediately downgradient of a test cavity and have tritium concentrations below 10,000 pCi/L. These wells are used to detect the plume front and to monitor natural attenuation. Distal wells are located outside the early detection boundary but are on government land and tritium activities are less than 300 pCi/L. Distal wells are used to verify that contaminants of concern are well below the SDWA maximum contaminant levels, and for ensuring compliance at the regulatory boundary. Point of Use wells are private or public water supply sources. Samples from the point of use wells are used to verify that the contaminants of concern (primarily tritium) do not exceed the maximum contaminant levels.

TABLE I. Well Types

Well Type	Description	Purpose
Characterization	Located in study area and used to characterize system or model evaluation	• Identify flow paths • Assess contaminant migration • Estimate travel times • Evaluate the model(s)
Source Term Investigation	Located within, near, and/or immediately downgradient of underground detonation and tritium ≥ 10,000 pCi/L	• Characterize source term • Monitor natural attenuation • Identify potential COC
Early Detection	Located immediately downgradient of an underground detonation and tritium <10,000 pCi/L	• Detect plume front • Monitor natural attenuation
Distal	Outside the early detection boundary but on government land. Tritium < 300 pCi/L	• Verify COCs do not exceed the MCL. • Support the Regulatory Boundary.
Point of Use	Used as private or public water supply source.	• Verify COCs do not exceed the MCL.

Data Collection Criteria

Purging requirements will be established that ensure a representative sample while avoiding pumping excessively large volumes. Sampling pump alternatives are presently being evaluated that allow for low flow purging and sampling multiple access zones in as cost effective manner as possible. A large parameter suite (major ions, trace elements, stable isotopes, age/migration parameters, select radioisotopes) is measured for Characterization wells. Sample results, contaminant transport model forecasts, and results of other well type samples are used to develop subsequent parameter suites. For instance, Source Term Investigation wells are analyzed for a large suite of source-term inventory radioisotopes. Generally, the only radionuclides associated with testing that are detected in these wells are tritium, carbon-14 (^{14}C), chlorine-36 (^{36}Cl), iodine-129 (^{129}I), and technetium-99 (^{99}Tc). These five beta emitters make up 92 percent of the source-term inventory based on radionuclide activity [3]. As a group, these species are the most mobile within the source-term inventory and generally have short half-lives, which lead to high activities. Out of these detected radionuclides, only tritium exceeds the SDWA maximum contaminant level in most cases, which is also seen in the Source Term Investigation wells. Monitoring of these wells provides the basis for selecting appropriate radionuclides for the downgradient early warning wells (i.e., there is little point in analyzing for radionuclides that are not currently detected or are detected at very low levels in the wells in or near the test cavities). An analysis method with an appropriate detection limit is selected for early detection well samples. A method with a low detection limit is used to ensure detection of the plume front. A method with a higher detection limit may be used once the analyte has reached a level that the method is capable of detecting. Establishing these criteria is in progress.

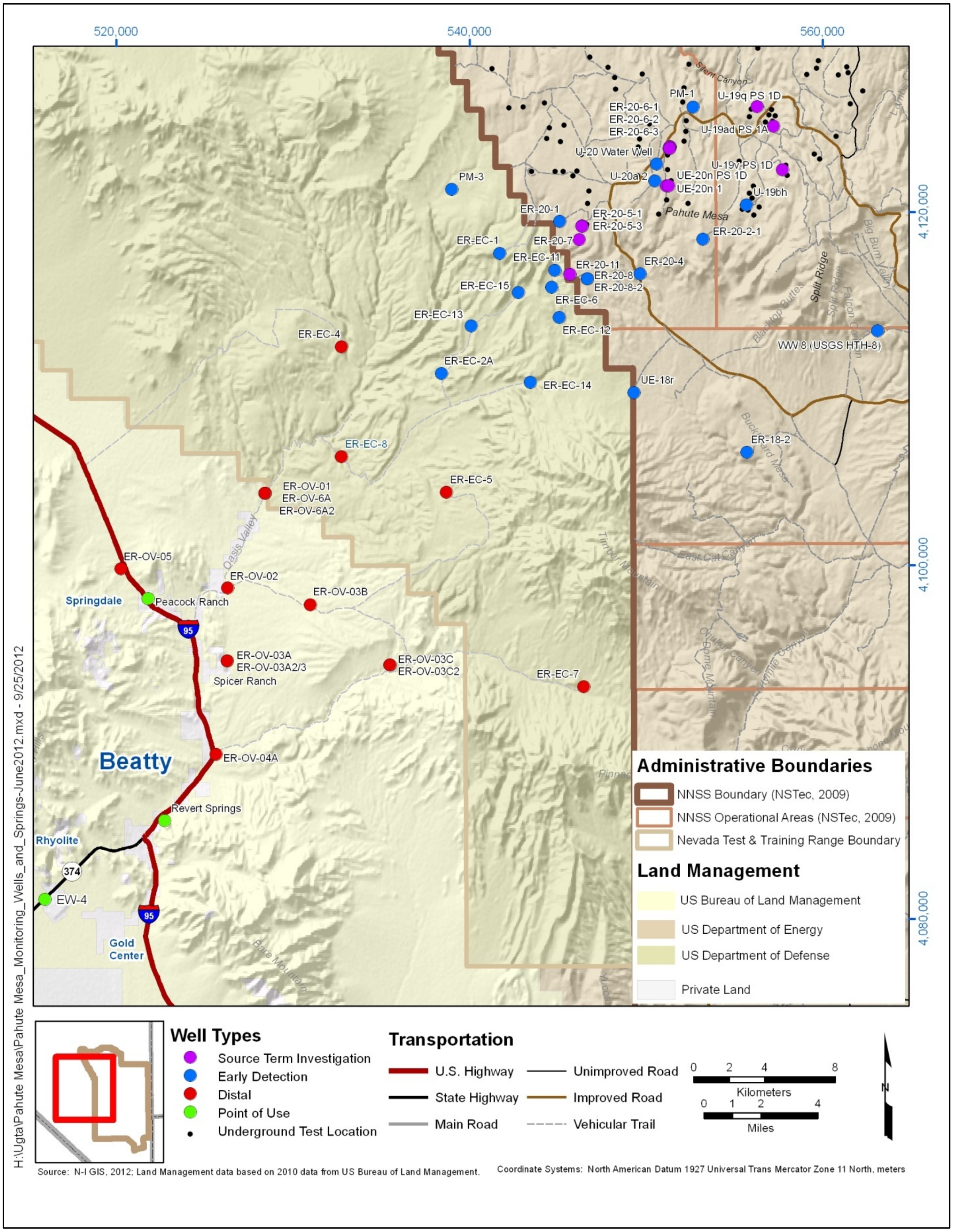

Fig. 1. Well Types for Pahute Mesa Corrective Action Unit

Standard Procedures and Processes

The UGTA Quality Assurance Plan (QAP) establishes requirements for all participants including data collection, data management, model development, and reporting. Standardizing sampling and analytical procedures and processes allows for direct comparisons of results and more effective establishment of analytical baselines.

Reporting

Development of an effective, integrated reporting mechanism is critical to communicating results within the UGTA activity as well as between the DOE Programs. Reporting will include an annual report, analytical reports, reporting levels, information/data management, and schedules.

Three reporting levels have been identified: investigation, notification, and action levels to ensure effective communication to management, DOE, and the regulator, the Nevada Division of Environmental Protection.

(1) **Investigation Level** is when contaminant of concern significantly increases (e.g., >three sigma) from the baseline or previous analyses (if baseline has not been established). A contaminant of concern is a radionuclide associated with underground nuclear testing [2]. The baseline is well specific and will consist of a minimum of three samples analyzed for potential contaminant of concern (preferably biennially).
(2) **Notification Level** to DOE is when tritium is present at or greater than ten percent of the SDWA maximum contaminant level. The notification level for other COCs will be established based on analytical detection capabilities and possibly well location.
(3) **Action Level** is when a COC is confirmed present at or greater than the MCL at a well off of the Nevada Test and Training Range or at the Regulatory Boundary.

If any of the three levels are reached, an evaluation will be performed to determine the appropriate response which may include increased sampling frequency, additional analytes, additional statistical analyses, or modified institutional controls (such as limiting groundwater access or providing alternate water supply if exceedances have occurred at the Regulatory Boundary). Evaluations associated with the Notification and Action levels would include discussions and concurrence with DOE, the regulators and/or stakeholders.

CONCLUSIONS

Cooperative and collaborative approaches to groundwater monitoring at the NNSS are necessary because of the current programmatic and operational demands at the NNSA/NSO. To aid in integrating and streamlining monitoring efforts, the UGTA activity is developing a sampling plan that will define sampling and analysis objectives, reduce duplication, eliminate unnecessary activities, and minimize costs. The sampling plan will ensure the right data sets are developed to support monitored natural attenuation and transition to long-term monitoring efficiently. An integrated reporting mechanism will be established for communicating results and integrating process improvements within the UGTA activity as well as between other DOE Programs at the NNSS.

REFERENCES

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