Refining Groundwater Monitoring Approaches Through an Objectives-Driven Process – 16333

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ABSTRACT

Groundwater monitoring is conducted throughout the groundwater remediation process, from initial site characterization through demonstration of cleanup objectives attainment. The DOE uses the groundwater monitoring data to define plumes, manage ongoing remediation, and determine how close the contamination levels are to meeting an endpoint criteria, such as a drinking water standard. Due to the expense of groundwater sampling and analysis, the DOE Office of Environmental Management compiled a synopsis of monitoring technologies and approaches, and defined opportunities for improving environmental remediation monitoring. This information included techniques to optimize and streamline groundwater monitoring. At the Hanford Site, years of extensive groundwater monitoring have been applied to support characterization and remedy-selection activities. Continuation of this monitoring intensity would be costly and would need to be reviewed in the context of future activities for groundwater remedy implementation. A structured review of monitoring plans is underway and has identified significant potential changes to the monitoring approach. These changes have been developed based on careful definition of monitoring objectives and consideration of innovative and targeted techniques to gather the appropriate data for remedy performance monitoring and transition to longer-term monitoring and closure.

INTRODUCTION

The DOE Hanford Site has multiple groundwater contaminant plumes associated with 11 groundwater operable units and groundwater interest areas (Fig. 1) [1]. The groundwater plumes in the 100 and 300 Areas (the River Corridor, Fig. 2) have sources related to nuclear reactor operations (100 Areas) and nuclear fuel fabrication and research operations (300 Area) [1]. These plumes are in close proximity to the Columbia River, which is hydraulically connected to the site groundwater. The groundwater plumes in the 200 Area (the Central Plateau, Fig. 3) have sources from chemical processing of nuclear materials, with many of these wastes discharged or leaked at ground surface and then reaching groundwater after transporting through a 70- to 100-m-thick vadose zone [1]. The groundwater beneath the Central Plateau eventually discharges to the Columbia River.

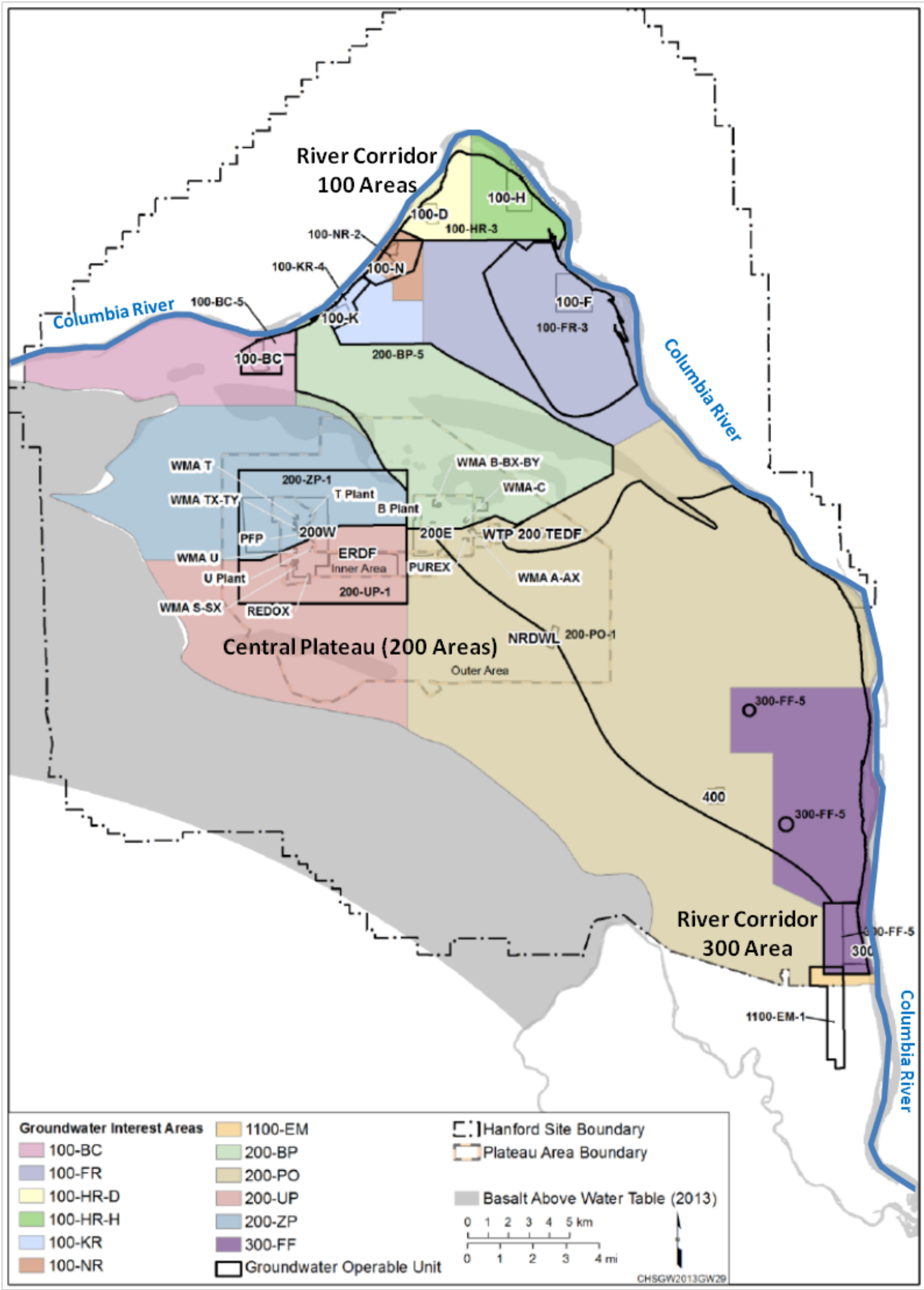

Fig. 1. Hanford Site groundwater operable units and interest areas (adapted from [1]). Labels also show other facilities (e.g., Waste Management Areas [WMAs]).

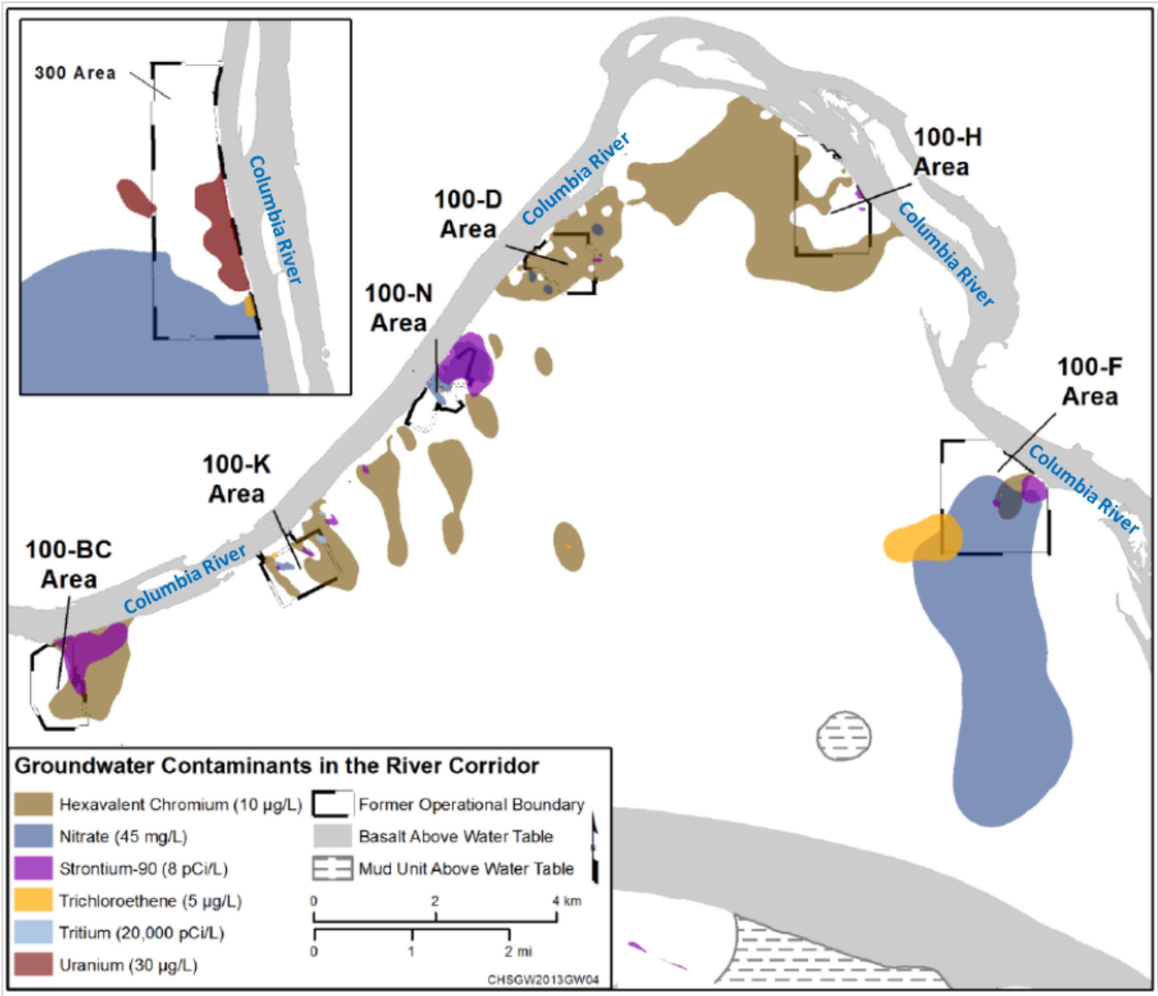

Fig. 2. Hanford Site groundwater contaminant plumes in the River Corridor, consisting of the 100 Areas and the 300 Area (adapted from [1]).

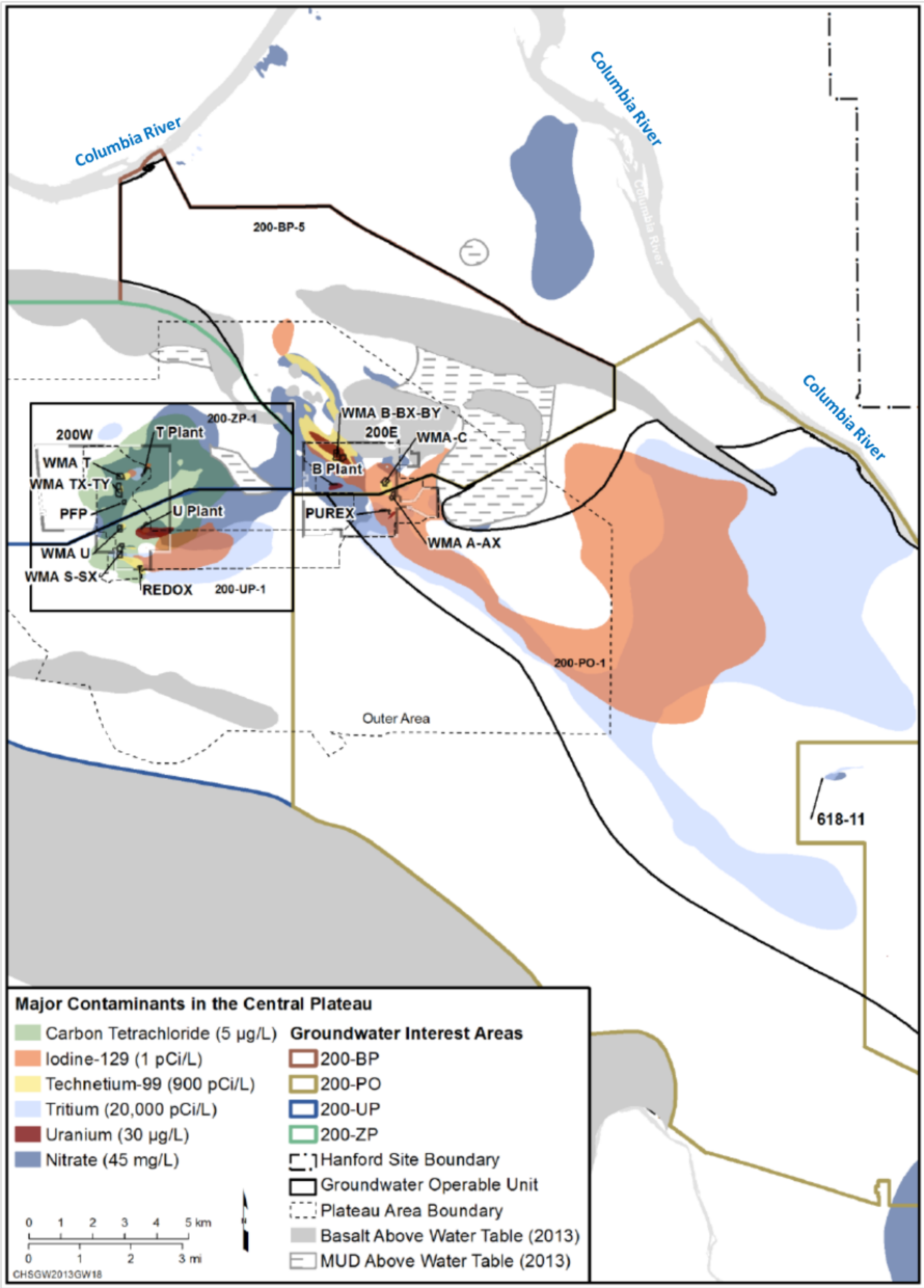

Fig. 3. Hanford Site groundwater contaminant plumes within and emanating from the Central Plateau (200 Areas) (adapted from [1]). Labels also show other facilities (e.g., Waste Management Areas [WMAs]).

Groundwater monitoring data is used as a primary metric for DOE to define plumes, manage ongoing remediation, and determine how close the contamination levels are to meeting an endpoint criteria, such as the drinking water standard. The groundwater plumes at the Hanford Site are in varying stages of the groundwater remediation process. As efforts progress through different stages of remediation, monitoring objectives may change and refinement of the monitoring approach may be appropriate. In addition, monitoring approaches should consider the factors controlling groundwater plume fate and transport and the type of information appropriate to support necessary remediation decisions and to comply with the remedial action objectives. These monitoring considerations were recently evaluated by the DOE Office of Environmental Management (EM) when compiling a synopsis of monitoring technologies and approaches and defining opportunities for improving environmental remediation monitoring [2]. Review of the existing Hanford Site groundwater monitoring plans in relation to the recommendations in this EM document was initiated because many of the Hanford groundwater plume remediation efforts have or are currently transitioning from the remedial investigation stage to remedy selection and implementation. Several types of proposed monitoring plan refinements show promise for more effective groundwater monitoring at the Hanford Site and are highlighted herein. A successful element of identifying proposed refinements was use of a data quality objectives approach with participation of DOE, operable unit engineers and scientists, regulators, and independent technical consultants.

DISCUSSION

Groundwater plumes are in different stages of remediation throughout the Hanford Site. To ensure effective monitoring, monitoring objectives need to be defined based on the stage of remediation. The stages of remediation for the Hanford Site groundwater operable units span from characterization to post- CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980) remedial investigation. The operable units that are post-remedial-investigation are well characterized, with an effective baseline data set available for contaminant plumes and aquifer conditions. Thus, the monitoring plan review considered post-remedial-investigation monitoring objectives that were focused on verifying trends based on remedy performance projections and demonstrating that exposure pathways are being controlled. For example, the Hanford Site 100-N Area groundwater has a Sr-90 plume that has been well characterized. The plume is currently being addressed by a permeable reactive barrier (PRB) near the downgradient edge of the plume to reduce contaminant discharge to the Columbia River, with natural attenuation of the plume upgradient of this PRB. Data describing plume behavior have been collected for more than 20 years in many locations of the plume. These data indicate the plume behavior is consistent with natural attenuation due to radioactive decay, while Sr-90 migration is slow due to the high Sr-90 retardation factor. Thus, the objective for future monitoring upgradient of the PRB can be to demonstrate continuation of these conditions with decline of the plume at the expected rate. Because the rate of plume change is slow and the plume is not migrating, a monitoring approach taking “snap shots” of the plume every 5 years with a consistent well network distributed across the plume can effectively meet the monitoring objective. This type of monitoring can significantly decrease monitoring cost compared to the previous approach, but provides the data necessary to manage remediation. During this time, more frequent data collection can be applied to manage performance of the PRB and ensure that objectives related to protection of the Columbia River are met.

In some areas, significant contaminant source remediation has been completed, causing plume dynamics to change toward a steady decreasing trend either by natural attenuation or in conjunction with other remedial actions. These plume conditions, and progress toward cleanup criteria, can be monitored with streamlined approaches and do not require the same level of monitoring as the previous, more dynamic plume conditions. In these cases, proposed monitoring frequency and spatial density were streamlined to focus on verifying expected trends within plumes rather than to achieve extensive plume mapping. At the Hanford 100-F Area, Monitored Natural Attenuation (MNA) is the selected remedy for nitrate, trichloroethene, chromium, and Sr-90 plumes. Predictions of plume behavior under natural attenuation conditions are available because they were used as part of selecting the MNA remedy. Under these conditions, the proposed monitoring network includes a subset of the existing wells and some new downgradient wells to verify expected declines in plumes before discharge to the river. Minimal upgradient well coverage was proposed for the network. Instead, the proposed network focuses on wells within the plumes for which contaminant trend data over time can be used as a metric to verify the expected natural attenuation of the plumes. Automated water level data is integrated into the plan to assess hydraulic conditions in comparison to those used for the natural attenuation predictions.

For some areas where significant contaminant source remediation has been completed, data from remediation systems, such as pump-and-treat (P&T) extraction wells, were also proposed to minimize the need for a large monitoring-well network. For example, chromium plumes in the 100-D and 100-H Areas are being addressed through a large network of P&T extraction and injection wells. Surface disposal sites (i.e., groundwater contamination sources) have been largely remediated by excavation. Plume remediation is designed to reduce existing plumes to the extent needed to reach conditions that are protective of the Columbia River. With sources effectively minimized, monitoring objectives can be focused on monitoring plume reduction and mitigating the discharge of contaminants to the river (discussed below). To assess plume reduction, concentration trends in P&T wells provide a robust data set distributed across the plume area. Thus, only a limited set of separate monitoring wells within the plumes are needed to verify declining concentration trends at key locations away from extraction wells. These data, combined with automated water level data to quantify hydraulic conditions and data to evaluate discharge to the river, can be sufficient to manage remediation.

Mitigating the discharge of contaminants to the adjacent Columbia River is important for controlling exposure pathways at the Hanford Site. River stage fluctuation causes variation in groundwater flow and contaminant transport. Existing data trends were evaluated to support a proposed monitoring approach focused on the known period of highest contaminant flux toward the river as a way to effectively quantify exposure pathway control. For example, chromium plumes in all of the 100 Areas are of concern for protection of the Columbia River. The Columbia River stage varies seasonally, affecting the rate of groundwater discharge from the aquifer to the river. Previous data were collected from multiple sampling events during the year as the river stage varied. For continued monitoring during remediation (e.g., P&T), a suitable monitoring objective is to collect data to demonstrate that the contaminant discharge to the river is declining over time (years) as expected. A proposed single, comprehensive monitoring event occurring annually during the period of highest groundwater discharge to the river and using a consistent set of wells can provide effective data for this objective and could decrease the monitoring costs compared to previous, more frequent monitoring. Automated water level monitoring can track aquifer-river flow dynamics and provide input to selection of the timing for monitoring during the period of highest groundwater discharge to the river.

In addition to remedy and exposure control monitoring, the proposed monitoring plan revisions also document how the monitoring program will transition over time to incorporate longer-term monitoring needs and attainment monitoring. For example, monitoring frequency specifications in proposed plans include metrics that will be used to identify when it is appropriate to transition to a less frequent monitoring schedule. For instance, establishing or confirming a trend in the near term may require frequent monitoring events. However, once a trend is established, less frequent monitoring is suitable to verify that the trend is continuing. A trigger for transition to attainment monitoring is also included, where appropriate.

CONCLUSIONS

In summary, at the Hanford Site, years of extensive groundwater monitoring have been applied to support characterization and remedy-selection activities. Continuation of this monitoring intensity would be costly and would need to be reviewed in the context of future activities for groundwater remedy implementation. A structured review of monitoring plans is underway and has identified significant changes to the monitoring approach. These changes have been based on careful definition of monitoring objectives and applying innovative and targeted techniques to gather the appropriate data to support remedy performance monitoring and transition to longer-term monitoring and closure.

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