Technical Evaluation of Iodine Remediation for 200-UP-1 — 16379

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ABSTRACT

From the 1940s through the 1990s, liquid wastes from materials used and produced at the Hanford Site were disposed to the ground through cribs, ditches, ponds, and trenches. The major sources that contributed to groundwater contamination within the 200-UP-1 Operable Unit (OU) were associated with plutonium-separation and uranium recovery operations at the S Plant and U Plant facilities, as well groundwater migration from 200-ZP-1 OU.

Iodine-129 is present in the groundwater and vadose zone beneath the 200-UP-1 OU, and is one of the primary risk drivers for the site. Hydraulic containment is the currently selected remedy for I-129 in the groundwater. There is currently no remedy selected for controlling migration of I-129 from the vadose zone to the groundwater. A UP-1 Evaluation Plan for I-129 was developed to provide the scientific and technical understanding necessary for developing remediation approaches for I-contaminated groundwater as well as risk-based approaches for managing I-129 present in the vadose zone. A site conceptual model for understanding the biogeochemical drivers for iodine speciation and determine the processes that drive the fate and transport of I-129 through the vadose zone and into groundwater was included. These data will provide the information to decrease the uncertainty related to the inventory, distribution, and transport properties which will lead to appropriate treatment strategies for the I-129 plume(s). A wide range of technologies and approaches are being evaluated including consideration of removal, cost, and long-term impacts to the site.

INTRODUCTION

The Record of Decision (ROD) for the 200-UP-1 Operable Unit (OU) at the Hanford Site in southeastern Washington State requires the preparation of a technology evaluation plan for remediation of iodine-129 (I-129) contamination in the subsurface. Currently, groundwater in the 200-UP-1 OU is contaminated with carbon tetrachloride, uranium, nitrate, chromium (total and hexavalent), I-129, technetium-99 (Tc-99), and tritium. The preferred alternative in the ROD specifies 35 years active remediation using groundwater pump-and treat, monitored natural attenuation (MNA) for portions of the contaminated groundwater, and institutional controls until cleanup levels for unrestricted use are met [1]. Hydraulic containment of groundwater is being performed while the treatment technology evaluation, as described in this plan, is performed and until a subsequent remedial decision for the I-129 plume is made.

The 200-UP-1 Remedial Design/Remedial Action Work Plan [2] defines the requirements for the iodine-129 technology evaluation.   From this guidance, a technology evaluation plan will be prepared to outline the study approach and provide an updated feasibility analysis of potential treatment options. The feasibility analysis will evaluate available I-129 treatment options based on cost, effectiveness, and implementability to identify viable options. Once completed, the plan will be reviewed and approved by the lead regulatory agency. When viable technologies are identified as a result of the feasibility analysis, treatability testing will likely be performed to evaluate the technology or process options in more detail.

In addition, the plan for evaluation of technologies for remediating I-129 is provided. Particular emphasis has been placed on updating critical biogeochemical information that was not available at the time of the 200-UP-1 feasibility study. This new information is important to understanding the fate and transport of I-129 and the applicability of some remediation options. This evaluation plan includes the following:

- A review of regulatory guidance for I-129
- Identification of processes that control I-129 fate and transport in the environment
- An updated conceptual model for I-129 in the 200-UP-1 OU
- An evaluation of exposure risk from I-129
- A review of remediation options for both vadose zone and saturated zone I-129

HANFORD SITE SOURCES AND SUBSURFACE DISTRIBUTION OF IODINE-129

In 1943, construction began on the first of nine nuclear reactors at the Hanford Site to produce plutonium for the development of atomic weapons for the Manhattan Project during World War II and throughout the Cold War. Over a production period lasting from 1944 to 1987, approximately 110,000 tons of nuclear fuel was processed [3]. During the production period, billions of gallons of liquid nuclear waste and millions of tons of solid waste were produced. Isotopes of iodine were generated during plutonium production within the nine production reactors at the Hanford Site. The short half-life I-131 that was released from the fuel into the atmosphere during the dissolution process (when the fuel was dissolved) in the Hanford Site 200 Area is no longer present at concentrations of concern in the environment.

The primary sources known or suspected to have contributed to contamination in the 200-UP-1 OU include liquid process wastes and wastewater generated during historical operations of S Plant (REDOX) Plant, U Plant, S-SX Tank Farm, and U Tank Farm [1]. The contaminants observed in groundwater within the 200-UP-1 OU resulted from planned releases of these process liquid wastes and wastewater to the soil via discharge to engineered structures (cribs, trenches, ditches, ponds, leach fields, or injection wells). Unplanned releases resulted from inadvertent releases of the same or similar waste materials from tanks, pipelines, or other waste storage or conveyance components. Most of the liquid waste and wastewater that contributed to observed groundwater contamination migrated downward through the soil column by gravity to reach the underlying groundwater. Vadose zone flux is continuing to contribute contaminants to the groundwater. Additional investigation of vadose zone

contamination will be conducted before a final remedy is selected for the 200-UP-1 OU [1].

The total amount of I-129 generated at Hanford during reactor operations is well known: 49.4 Ci of I-129 was produced during reactor operations according to ORIGEN2 fuel activity estimates [4]. However, the distribution of that well-defined inventory is very uncertain. The inventory has been distributed among the following mechanisms:

- Stored in single-shell and double-shell tanks
- Discharged to liquid disposal sites (e.g., cribs and trenches)
- Released to the atmosphere during fuel reprocessing operations
- Captured by offgas absorbent devices (silver reactors) at chemical separations plants (PUREX, B-Plant, T-Plant, and REDOX)

TABLE 1 summarizes current estimates for these disposition pathways. This table does not include the I-129 inventory that may be disposed at Hanford from receipt of offsite waste.

TABLE 1. Current estimates of I-129 distribution at Hanford.

I-129 Inventory Category	Estimate	Discussion and References
Total generated by production reactors	49.4 Ci	Based on calculation using the 2002 ORIGIN2 fuel activity estimate [2]. This estimate is well known and based on fuel irradiation histories.
Stored in single-shell and double-shell tanks	29.0 Ci[a]	Best Basis Inventory (BBI) obtained from the Tank Waste Information Network System (April 23, 2015) (https://twins.labworks.org/twinsdata/default.htm). Significant uncertainty remains with this estimate.
Discharged to liquid disposal sites	4.7 Ci	From Hanford's Soil Inventory Model [5]. Uncertainty estimates were developed for individual waste sites that ranged from 20% to almost 400%.
Released to the atmosphere	Unknown	Estimates of magnitude of these potential releases are not available. This remains one of the main uncertainties limiting development of a true mass balance for Hanford I-129.
Captured by offgas absorbent devices	Unknown	Devices known as "silver reactors" were used to capture iodine at chemical separations plants (PUREX, B-Plant, T-Plant, and REDOX). The I-129 inventory captured in this manner is not known. Some of these devices remain at the canyon facilities and some are in solid waste burial grounds.

(a) The BBI underwent a significant update in 2004 [6], which reduced the tank inventory estimate from 48.2 to 31.8 Ci based on improved models of separations processes. This change removed the previous conservative assumption that essentially all of the I-129 sent to the separations plants exited those plants in

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waste streams sent to tank farms. Subsequent revisions to the BBI have replaced generic estimates for specific waste streams with sample-based estimates from the tanks.

Once I-129 and other mobile contaminants reached the aquifer, they spread, producing large-scale plumes. Three I-129 plumes in groundwater at the Hanford Site cover an area greater than 50 km^2. In general, the plume emanating from the 200 East Area is larger because of differences in subsurface geology. The water table beneath the 200 East Area and extending to the Columbia River is within more-permeable sediments. In the 200 West Area, the water table is primarily within the lower permeability Ringold Formation. This results in faster groundwater flow and shorter travel times in the 200 East Area than in the 200 West Area (Freshley and Graham 1988). The largest I-129 plume extends toward the southeast from the 200 East Area. A smaller arm of the plume has moved toward the northwest between Gable Mountain and Gable Butte. The largest i-129 plume associated with the 200 West Area is in the 200-UP-1 OU.

The I-129 plumes in the Hanford Site Central Plateau are very large and dilute. The lengths of the leading edges of the plumes are on the scale of kilometers. The I-129 concentrations are all less than 50 pCi/L, with most less than 10 pCi/L, though above the DWS of 1 pCi/L. Furthermore, natural stable iodine (I-127) is also present in the aquifer at much greater concentrations than I-129. The presence of I-127 is important because most remediation technologies are not specific for a particular iodine isotope (e.g., [7]). In addition, I-127 and I-129 have the same chemical behavior in the subsurface, so the presence of I-127 will influence the biogeochemical processes for I-129.

BIOGEOCHEMICAL PROCESSES CONTROLLING IODINE-129 SPECIATION

The subsurface behavior of radioiodine is complex because it can exist in multiple physical states (solid, liquid, or gas) and oxidation states (-1, 0, +1, +5, and +7) at environmentally relevant conditions [7]. Initial studies to understand iodine biogeochemistry in both groundwater and on mineral surfaces was performed using groundwater and soils from the Hanford 200 West Area [8-9]. Iodine speciation and isotope analysis was performed on groundwater from seven monitoring wells [8]. Average total stable iodine-127 (I-127) concentrations ranged from 8.4 to 75 µg/L, with an average of 30.8 µg/L. Iodate (IO_3^-) accounted for the bulk of the I-127 (22.6 µg/L), followed by organo-iodine (6.95 µg/L) and iodide (0.46 µg/L). Radioiodine concentrations were orders of magnitude lower, with an average concentration of 0.1 µg/L, which was calculated from IO_3^--associated I-129 concentrations because organo-iodine and I^- forms of I-129 were below detection limits. Although the mass-based I-129 concentrations are low, in the seven wells tested, I-129 activity ranged from 3.6 to 42.5 pCi/L, concentrations above the 1 pCi/L drinking water standard. One unexpected result from these studies was the formation of $CaCO_3$ precipitates in sample bottles used during the study. These precipitates had concentrations averaging 107.6 mg/L and contained high amounts of both I-127 (74.0 µg/g) and I-129 (0.15 µg/g). These precipitates were thought to be formed during degassing of CO_2 when the groundwater was pumped to the surface.

Precipitation of I-127/I-129-laden $CaCO_3$ could be stimulated by the addition of $CaCl_2$ and Na_2CO_3.

Aqueous-phase iodine species interact with sediments, allowing adsorption/surface complex formation, as well as transformation, depending on the geochemistry of the sediment used [9]. In the study by Xu et al. [9], sequential extraction of the three sediments showed that there were strongly bound forms of iodine on the mineral surface. Only 0.4 to 6.6 wt% of the iodine was readily released, 0% to 1.2% was associated with Fe and Mn oxides, and 2.9% to 39.4% of the iodine was associated with $CaCO_3$ on the mineral surface. Organic carbon associated with the surface of the sediments was hypothesized to account for 57.1% to 90.6% of the total iodine present. Iodine adsorption isotherms indicated that IO_3^- was more strongly sorbed to the sediments than iodide. Likewise, desorption of iodine from the sediment surface was always greater than sorption, regardless of the species tested. These studies showed that even low organic carbon on the soils appeared to control iodine binding because as organic carbon concentration increased, greater values of uptake, desorption, and residual iodine were found for these sediments. One other interesting finding for these sediments was that IO_3^- was readily reduced, meaning the IO_3^- is sorbed and then reduced, yielding I^- which would desorb.

Microbes isolated from sediment traps incubated in monitoring wells within the I-129 the 200 West UP-1 OU showed the ability to transform both IO_3^- and I^-. Bacteria common to groundwater were shown to reductively transform IO_3^- to I^- when grown in the presence of simple carbon sources and nitrate. Likewise, a number of bacterial isolates, as well as mixed communities isolated from these sediment traps, were able to oxidize I^- to I_2 when stimulated with a variety of carbon sources.

CONCEPTUAL MODEL FOR IODINE-129 IN THE 200-UP-1 OU

Available groundwater monitoring data can be used to evaluate iodine transport. However, it is important to consider waste discharge timing and volume, vadose zone transport, changing water tables, and the potential for differential transport of different iodine species.

For the 200-UP-1 OU, I-129 plumes in southern 200 West Area originated from U-Plant and REDOX Plant waste sites, with the latter being the primary sources[10]. These plumes, one from the 216-U-1 and 216-U-2 cribs near U-Plant and a second from the REDOX Plant waste sites (e.g., 216-S-1&2, 216-S-7, and 216-S-9) in the southern portion of the 200 West Area, merge downgradient, becoming one indistinguishable groundwater contaminant plume. Plume maps over a 20-year period beginning in 1993 [11] show that the 200-UP-1 plume (the primary plume in the 200 West Area) has oscillated, but declined, in areal extent, although the plume core area above 10 pCi/L has not declined. The overall plume extent (as defined by the 1 pCi/L contour) is large and the plume thickness is up to tens of meters, although there is uncertainty in this estimate. The recent I-129 concentration results range from 1 pCi/L (MCL) to 10+ pCi/L within the 200-UP-1 plume. The 90th percentile I-129 concentration is 3.5 pCi/L, meaning that 90% of the data for I-129 in the plume falls below this value [12]. However, there are a few recently recorded groundwater

concentrations that exceed 10 pCi/L. The temporal concentration profiles for wells within the central portion of the plume indicate stable to declining trends in most portions of the plume and some increases in a downgradient portion of the plume where concentrations are above 10 pCi/L [11].

These data, in conjunction with the plume maps, are consistent with influences from (1) historical pulses of iodine into the groundwater that have now diminished in magnitude and (2) declining hydraulic gradients from dissipation of the historical 200 West Area groundwater mound that existed during processing operations. Thus, the current plume was generated from a historical source that has diminished and a discrete plume is now migrating in the aquifer. The overall declines in plume area and concentration are consistent with natural attenuation processes affecting the plume. Increases in concentrations for discrete locations in the central portion of the plume are consistent with movement of a higher concentration core along a flow path. A higher concentration core may still be attenuating, but temporal data at individual wells may be showing the progression of a plume core past the location of the well. In addition, I-129 currently in the vadose zone may still be a future source for groundwater contamination, even though the existing plume appears to be in a stable-to-declining condition [13].

Several co-contaminants are present within the I-129 plumes, including chromium, nitrate, ^{99}Tc, uranium, and tritium. Chromium, nitrate, uranium, and technetium may be present in forms that could interact with the same reactive facies as I-129. These co-contaminants will be addressed by a pump-and-treat remediation approach for the 200-ZP-1 and 200-UP-1 operable units. The pumping operations will also affect the I-129 plumes because of the altered hydraulic gradients and by displacement of I-129 that is extracted and reinjected.

In summary, a discussion of key conceptual model elements in relation to remedy evaluation and identification of data gaps is given and outlined below.

Key Conceptual Model Points for Remedy Evaluation:
- The iodine plume dynamics are influenced at the large scale by the history of and projected future contaminant discharges from the vadose zone and large-scale hydrologic conditions. Plume dynamics suggest high contaminant discharge conditions in the past led to plume development and that these discharges are lower now. Future contaminant discharge from the vadose zone has not been estimated, but is likely to be lower than the historical discharge and may continue over a long duration. Large-scale hydrologic conditions for consideration are the declining water table and associated hydraulic gradient and the flow characteristics of the Ringold Formation.
- Remediation approaches will need to consider impacts of the low iodine concentration on effectiveness.
- Co-contaminants are present in some portions of the iodine plume. These co-contaminants may impact some remediation processes through competition (e.g., redox/microbial reactions) or interference mechanisms (sorption) or facilitation (co-metabolism).

- There are limited in situ geochemical sequestration mechanisms because of the solubility of most iodine species and associated complexes (exceptions being Ag, Cu, and Hg salts). However, interactions with organic materials, bacteria, or calcite precipitation may provide mechanisms for enhanced sorption and accumulation.
- As with most sites, subsurface characteristics need to be considered with respect to plume behavior controls and impact to remediation technology performance. Heterogeneities related to plume distribution and performance of amendment distribution or plume extraction efficiency need to be considered in light of the large scale of the plume.

Conceptual Model Data Gaps:

- Speciation of iodine from discharge and reactions caused by waste disposal chemistry. This information is important in defining the source term and associated source flux that is needed as part of evaluating groundwater plume behavior.
- Improved estimates of future contaminant flux from the vadose zone to the groundwater. Application of improved speciation information and methods to evaluate flux through the vadose zone are needed to improve the estimate of the source flux important to groundwater plume behavior.
- Role of abiotic reductive reactions in iodine transformation within the groundwater and vadose zone. Reduction of iodate to iodide results in greater mobility of iodine that is important to consider in fate and transport analyses or for application of remediation technologies. The role of these processes at Hanford needs to be evaluated in conjunction with the presence and distribution of reactive facies.
- Type and role of organic material and its participation in reaction, sorption, facilitated transport, and accumulation of iodine. Organo-iodine compounds are important with respect to natural attenuation and for application of active remedies, and have been shown to be present in the Hanford aquifer, even though organic content in the aquifer is generally low.
- Microbial reactions mediate many of the important transformations of iodine that relate to its mobility and effectiveness of treatment processes. However, site-specific information about these processes is needed.
- Improved data on sorption for different iodine species and the distribution of sorbents within the subsurface. Along with fundamental knowledge of iodine speciation and reactive facies, improved transport parameters are needed to enable refined fate and transport estimates as part of natural attenuation and remedy evaluation efforts.
- Impact of co-contaminants on transformation and sorption. Multiple co-contaminants are present and may have co-metabolic or competitive impacts on biogeochemical processes as well as ion-exchange interactions that impact iodine sorption. As part of developing site-specific information for Hanford, these co-contaminants need to be considered.
- Recent information has shown the potential for co-precipitation of iodate with calcite. Site-specific information is needed on the occurrence of this process and the solubility of substituted versus non-substituted calcite to interpret the effectiveness of this process as an attenuation mechanism for iodine.

HEALTH RISKS ASSOCATED WITH IODINE-129

The technical evaluation plan also outlines health risks associated with I-129, and represents a basis for why I-129 remediation is being evaluated for 200 UP-1 groundwater.   Iodine is an essential nutrient for humans and animals; however, it also poses a risk because it concentrates in the thyroid gland where it decays and causes damage. Twenty-three radioactive isotopes of iodine have been identified [14], but only one stable isotope exists, I-127, which is widely distributed in the ocean, rocks, and in organisms. It is generally found as iodide or iodate. Iodine is more prevalent in marine than in terrestrial environments. Atmospheric concentrations generally diminish inland from the oceans, reducing the amount transferred to inland soils from precipitation scavenging (rainfall) and dry deposition. At 15.7 million years, I-129 has the longest half-life of iodine isotopes. Because it decays very slowly, any I-129 released to the environment represents a permanent addition to the total inventory of iodine in the biosphere [14]. The mobility of I-129, its long half-life, and toxicity make it a risk driver for remediation where abundant quantities were disposed to the environment.

The risk posed by iodine can be broadly categorized as both long-term and short-term. The short-term risks result from exposure to the short-lived isotope, I-131, with a half-life of 8 days. Iodine-131 decays to stable xenon-131 quickly, but the high specific activity of ^{131}I makes it an immediate threat to exposed individuals. An example of short-term risk from ^{131}I is exposure to discharges during the Chernobyl accident [15]. More than 90% of stable or radioactive iodine in the human body is concentrated in the thyroid [16] and once there, beta particles (primarily 606 keV, 89% abundance) and gamma rays (primarily 364 keV, 81% abundance) bombard nearby tissue, promoting thyroid cancer. The long-term risks of iodine are those resulting from exposure to and biological uptake of the long-lived isotope, I-129. By virtue of these differences in radioactivity (or half-lives), I-129 is a long-term risk, associated with DOE's current groundwater contamination and nuclear waste disposal.

REMEDIATION OPTIONS FOR IODINE

A comprehensive identification and inventory of potentially applicable iodine remediation technologies was conducted through a literature search and the results are summarized in this section. Potential remediation technologies are organized by the purpose of the treatment, including ex situ treatment (for media extracted from the subsurface or secondary waste streams), source removal, control of contaminant flux through the vadose zone, and groundwater plume remediation. The list of technologies is summarized in TABLE 2, with a brief description of the technology (including a list of common variations), notes on technology maturity, a rough guide to the technology cost (in terms of low, moderate, or high. Note that mature technologies have been deployed in a wide range of settings over many years, technologies at the bench scale have been demonstrated in the laboratory, while developmental technologies are innovative and are still in the initial development stages. The semi-qualitative assignment of relative cost is based on development

status and historical experience; more definitive costs would only come from definition of specific remedial alternatives as part (typically) of a feasibility study. The remedial approaches, along with the conceptual model regulatory context, provide a basis for evaluation of suitable remedies. The site-specific context will help determine which remedial approaches are sufficiently developed and are conducive with the site conditions (iodine speciation, contaminated media, etc.) to potentially meet the remedial action objectives (RAOs). For groundwater contamination, key aspects are likely to be control of source flux to the groundwater, as well as treatment of contamination already in the groundwater. It may be important for a remedy to utilize a combination of remedial approaches to achieve remedial action goals. The process of assessing potential remedies should also take into account other remedial actions being implemented or planned to address adjacent or co-existing contaminants. Such concurrent remedies could impact the CSM for iodine and should be integrated into the remedy for the iodine contamination.

Fig. 1 shows an overview of the remediation technology evaluation process. This approach is consistent with the requirements for CERCLA technology evaluations [17] and expands on the previous 200-UP-1 OU RI/FS evaluation by including treatability testing elements to adequately evaluate some of the candidate technologies. To conduct the evaluation, fate and transport simulations must be updated to incorporate new information about iodine speciation for the 200-UP-1 OU and relevant biogeochemical reactions of the various iodine species. The species of I-129 present (iodide, iodate, and organo-iodine) affect transport behavior along exposure pathways. Several alternative conceptual models were developed by Truex et al. [11] to represent variations in the controlling factors for future iodine plume behavior. These alternatives are related to the type of groundwater iodine species present, whether specific transformation reactions are significant within the aquifer, and whether a significant flux of contaminants from the vadose zone will occur. The evaluation will include investigations and updated modeling developed based on the recommendations in Truex et al. [11] to support refining the CSM and for potential reconsideration of the baseline risk assessment. Using the refined CSM, potential remediation configurations to meet the RAOs can be identified (e.g., scenarios that identify treatment volumes and concentration or flux reduction targets). This information supports the subsequent remediation technology evaluation and associated treatability testing elements.
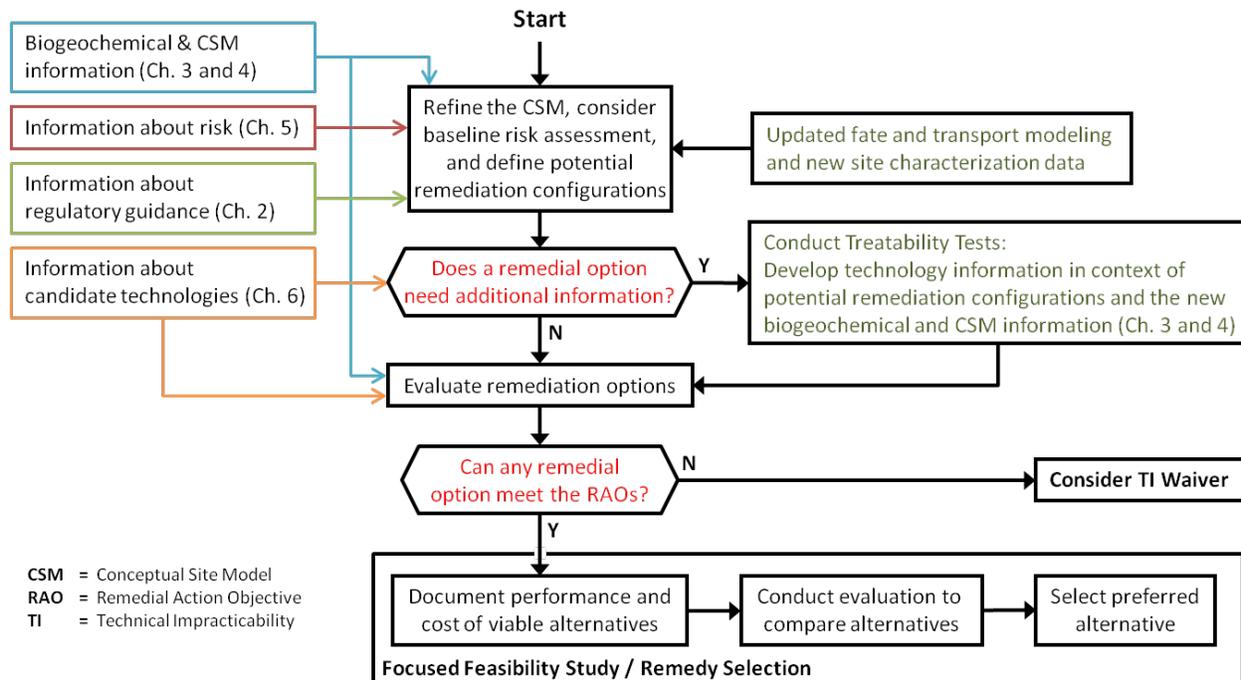
Fig. 1. Comprehensive Remedy Evaluation Process that will followed for selection of I-129 remediation technologies.

The "evaluate remediation options" portion of Figure 1 will be conducted in two primary steps, using an approach similar the remediation technology evaluations for the 200-BP-5 and 200-ZP-1 OUs [18-19]. The initial screening step will evaluate potential remediation options based on whether they can be effectively applied within the environmental setting of the 200-UP-1 OU. In the second step, potential remediation methods will be screened using scoping calculations to estimate the scale of infrastructure, overall quantities of reagents, and conceptual approach. Based on these estimates, each method will be screened with respect to effectiveness, implementability, and relative cost criteria of the CERCLA feasibility study screening process defined in EPA guidance (EPA 1988). In general, the effectiveness evaluation is related to (1) the estimated reliability of the process and whether it has been proven successful; (2) the expected ability of the method to treat the necessary volume of contaminated media; and (3) the potential for negative human or environmental impacts during construction and operation. Implementability is generally related to (1) the scale of effort and technical certainty that the method can be implemented at the site; (2) the availability of consumables, equipment, and services; and (3) the ability to obtain permits and administratively manage the method. The relative cost is evaluated using a conceptual design and relative cost estimates based on the relative capital and operation and maintenance required for each option. As noted previously, some candidate technologies will require treatability testing to effectively evaluate their potential for use at the 200-UP-1 OU.

The remediation technology evaluation will compile sufficient information about the technology options to demonstrate whether they are viable with respect to meeting

the 200-UP-1 OU RAOs identified for I-129. Based on the remedial evaluation results, the OU can either pursue a technical impracticability or other ARAR waiver, or conduct a focused feasibility study to select an I-129 remedy other than the hydraulic control remedy that was identified in the 200-UP-1 OU ROD.

CONCLUSIONS

Iodine-129 is a key contaminant of concern at Hanford because of its long half-life, high mobility in groundwater, and long-term risk to human health and the environment. The plan outlines an approach for DOE and EPA to take in evaluating technologies for remediating iodine-129 contamination in the subsurface. In preparing the plan, researchers:
- updated critical biogeochemical information that was not available for previous studies
- reviewed regulatory guidance for iodine-129
- identified processes that control iodine-129 fate and transport in the environment
- developed an updated conceptual model for iodine-129 in the 200-UP-1 OU
- evaluated the exposure risk from iodine-129
- reviewed remediation options for both vadose zone and saturated zone iodine.

In a key step toward remediating soil and groundwater contamination from Cold War efforts at the Hanford Site in Richland, Wash., a draft technology evaluation plan for iodine-129 at the Hanford Site's 200-UP-1 Operable Unit (OU) was completed. The plan was submitted to the Department of Energy and Environmental Protection Agency in November for review, meeting an important DOE Richland Operations Office (RL) milestone 10 months ahead of schedule.

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