Hanford Site River Corridor Cleanup – Effectiveness of Interim Actions and Transition to Final Actions - 14468

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ABSRACT

Cleanup actions in the River Corridor, a 220-square-mile area of the Hanford Site bordered to the east and north by the Columbia River, were initiated in 1994 to address soil and groundwater contamination resulting from decades of plutonium production and fuels fabrication operations. Remedial action objectives and associated cleanup levels were established through interim action records of decision (IRODs) developed in accordance with a "bias for action" strategy. Known as the *Hanford Past-Practice Strategy*, the approach streamlined the CERCLA remedial investigation/feasibility study process to enable early application of cleanup dollars on actual remediation instead of extensive characterization for contaminated waste sites that were considered to be principal threats to human health and the environment.

Use and application of the interim action cleanup levels was viewed by the DOE, EPA, and Washington State Department of Ecology (Tri-Parties) as supporting a range of potential future land uses within the River Corridor since anticipated land use expectations and decisions were not fully resolved during the decision making process. Source waste site (soil and debris) and groundwater cleanup actions in the River Corridor have been conducted under the framework of IRODs for nearly 20 years and continue today.

In parallel with continuing interim action cleanup operations, the Tri-Parties are conducting the CERCLA remedial investigation/feasibility study (RI/FS) process to develop integrated final action cleanup decisions for the River Corridor. These decisions are necessary to determine whether past cleanup actions in the River Corridor are protective of human health and the environment and to identify any course corrections that may be needed to ensure that ongoing and future cleanup actions are protective based on current assumptions regarding future land use and updated state and federal standards.

Based on the strategy developed by the Tri-Parties, the River Corridor was divided into six geographic areas to achieve integrated source and groundwater remedy decisions. The strategy to pursue six records of decision (RODs) was based on organizing the development and review processes into manageable pieces and aligning operational function or historical use (e.g., reactor areas).

The RI/FS reports for the six decision areas are at various stages of development. Evaluations of each waste site with completed interim actions against the updated cleanup objectives and standards being proposed through development of the RI/FS documents have shown that the interim actions have been very effective in achieving post-cleanup conditions that are protective of human health and the environment. Of more than 1,200 waste sites with completed interim actions

that have been evaluated in the RI/FS documents, more than 98% are anticipated to require no further action to achieve protectiveness under the updated cleanup standards being proposed. Examples of supplemental work that may be required for a small number of waste sites include phosphate sequestration of uranium in the 300 Area to address leaching threats and surface barrier placement at a 100 Area waste site to reduce tritium migration to groundwater during the decay period. The updated cleanup objectives will also be applied to several hundred waste sites that have been identified for future cleanup.

Final determinations on the cleanup standards will be made through continued regulatory review of the RI/FS documents, public review of proposed plans, and development of the RODs. The first final action ROD for the River Corridor is anticipated to be issued by the end of 2013. Final action RODs for the remaining five decision areas are anticipated between 2014 and 2017.

Many of the final action RODs will be issued while interim actions are still in progress. It is in the best interest of all parties to maintain continuous cleanup and work to the updated cleanup standards as soon as the final action ROD for a given decision area is issued. Cleanup contractors CH2M Hill Plateau Remediation Company (CHPRC) and Washington Closure Hanford (WCH) are partnering with the Tri-Parties to enable a smooth transition from interim to final cleanup standards. This approach can be translated to benefit any site that is being remediated under an IROD and desires to maintain progress during transition to implementing a final action ROD.

INTRODUCTION

The Hanford Site is a 1,517-km^2 (586-mi^2) DOE facility located within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington State. The site is situated north and west of the cities of Richland, Kennewick, and Pasco, an area commonly known as the Tri-Cities. The Columbia River flows through the northern part of the Hanford Site and forms part of the site's eastern boundary (Fig. 1).

Past nuclear production and processing at the Hanford Site released hazardous substances to the environment and resulted in areas of contaminated soil and groundwater that pose a risk to human health and the environment. Cleanup of the Hanford Site releases is a complex and challenging undertaking that has been organized into three major components – River Corridor, Central Plateau, and Tank Waste. The River Corridor consists of more than 569 km^2 (220 mi^2) of the Hanford Site adjacent to the Columbia River (Fig. 1).

Cleanup of the River Corridor has been a top priority for the Hanford Site since the early 1990s. This urgency is due to the proximity of contaminated groundwater plumes and hundreds of waste sites to the Columbia River, which is recognized as a critical resource for the people and ecology of the Pacific Northwest. As one of the largest rivers in North America, its waters support a multitude of uses that are vital to the economic and environmental well being of the region and it is particularly important in sustaining the culture of Native Americans.

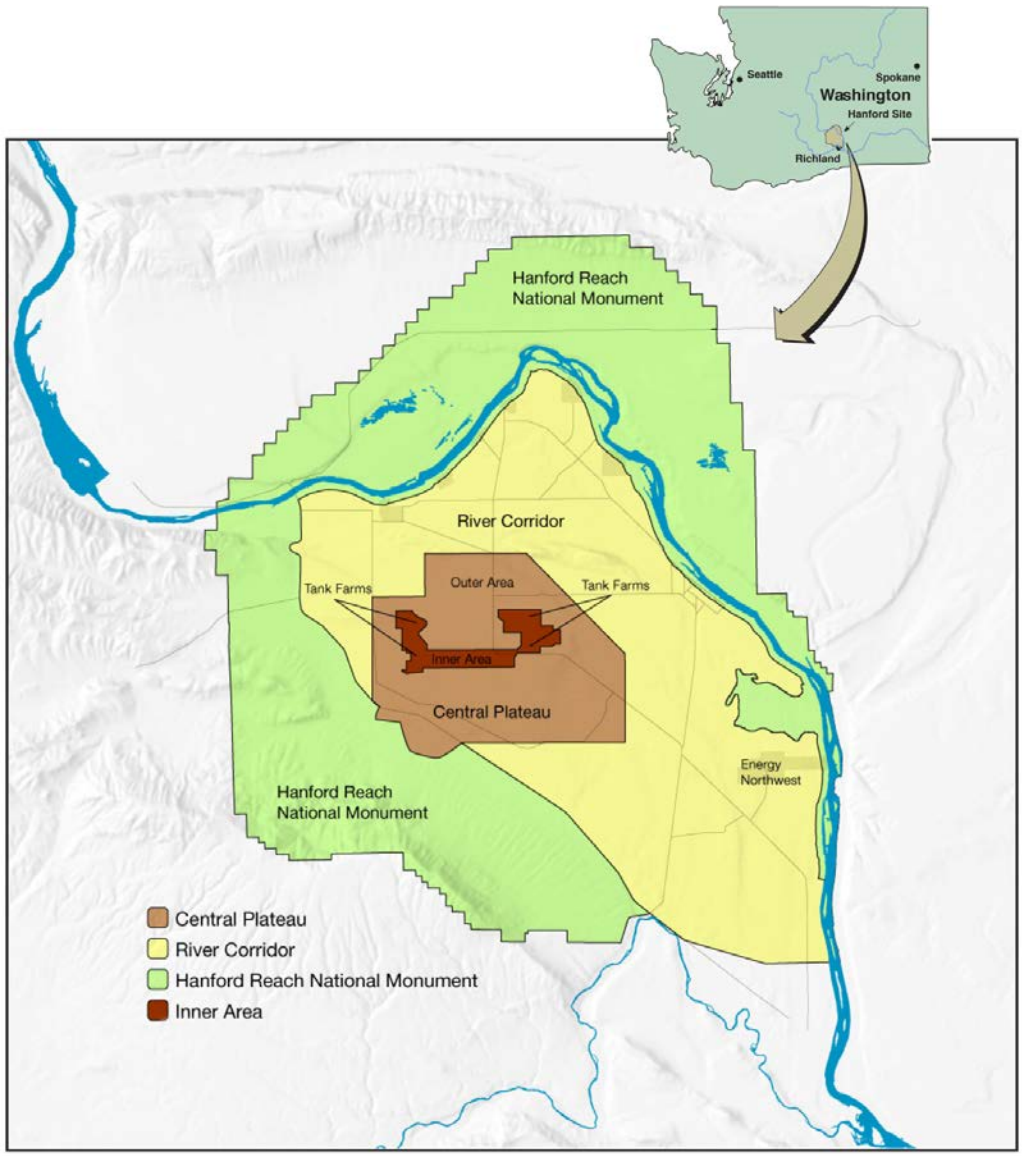

Fig. 1. Principal components of Hanford Site cleanup completion framework - River Corridor, Central Plateau, and tank waste.

Remedial actions in the River Corridor are expected to restore groundwater to drinking water standards and to ensure that the aquatic life in the Columbia River is protected. Where remedial action objectives are not achievable in a reasonable time frame or are determined to be technically impracticable, programs will be implemented to contain the plume, prevent exposure to contaminated groundwater, and evaluate further risk reduction opportunities as new technologies become available. River Corridor cleanup work also removes sources of contamination close to the Columbia River to the Central Plateau for final disposal. The intent is to shrink the footprint of active cleanup to within the 195-km^2 (75-mi^2) area of the Central Plateau by removing excess facilities and remediating waste sites. At the conclusion of cleanup actions, the federal government will retain ownership of land in the River Corridor and will implement long-term stewardship activities to ensure protection of human health and the environment.

HANFORD SITE OPERATIONS IN THE RIVER CORRIDOR

In 1943, the Hanford Site became a federal facility when the U.S. Government took possession of the land to produce weapons-grade plutonium as a part of the Manhattan Project during World War II. Between 1943 and 1963, nine plutonium-production reactors were built in the northern part of the Hanford Site along the Columbia River in six areas identified as the 100-B, 100-K, 100-N, 100-D, 100-H, and 100-F Areas. In the southern area of the River Corridor, the 300 Area was developed to support fuels fabrication and research and development activities.

During 5 decades of Hanford Site operations and nuclear material production, large quantities of by-products were released to the environment. Liquid effluents from plutonium production reactors were discharged to retention ponds and trenches or directly to the Columbia River. Disposal of solid waste and debris occurred in unlined burial grounds/landfills or in surface dumps. In addition, plumes of contaminated groundwater developed in portions of the Hanford Site as a result of waste disposal practices and subsequent contaminant migration through the soil. Some of these contaminated groundwater plumes have reached the Columbia River, discharging as springs along the shoreline and upwelling through the river bottom. The Hanford Site production mission continued until the late 1980s when the mission changed to cleaning up the radioactive and hazardous wastes that had been generated during production in the previous decades.

CLEANUP ACTIONS IN THE RIVER CORRIDOR

Nuclear production and processing operations at the Hanford Site released hazardous substances to the environment and resulted in areas of contaminated soil and groundwater that pose a risk to human health and the environment. Between 1985 and 1988, preliminary assessment/site inspection activities were completed to identify waste sites and prioritize the relative hazards. Waste disposal information was collected through exhaustive reviews of historical process records and maps, employee interviews, and visual inspections. The results from this process provided information to support adding the Hanford Site to the CERCLA [1] National Priority List (NPL).

In 1989, the DOE entered into the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) [2] with the Tri-Parties, thereby establishing the legal framework and schedule for cleanup of the Hanford Site. In order to allow cleanup to begin as soon as possible, the Tri-Parties developed a “bias for action” approach to the CERCLA process in 1991. This approach, known as the *Hanford Past-Practice Strategy* (HPPS) [3], streamlined the remedial investigation/feasibility study (RI/FS) process to enable early application of cleanup dollars on actual remediation of contaminated waste sites.

Early cleanup decisions were established through IRODs that specified cleanup goals for achieving protectiveness of potentially exposed receptors, groundwater, and the Columbia River. The IRODs were based on existing knowledge of the waste sites (e.g., site types, processes, contaminants) as supplemented by limited amounts of characterization and qualitative risk assessments that provided a basis for action. In 1994, cleanup actions were initiated focusing on removal of contaminated soil and debris from waste sites with the highest potential to impact

groundwater and the Columbia River. Actions to cleanup existing plumes of groundwater contamination were also initiated with the objective of addressing principal threats to the Columbia River.

The process for establishing cleanup goals during development of the IRODs considered residential and industrial exposure scenarios to evaluate risks from contaminants in soil and groundwater. Interim action cleanup levels in the 100 Area of the River Corridor are based on a residential exposure scenario, whereas the 300 Area cleanup levels are based on a mix of residential and industrial exposure scenarios. Remedial action goals related to radiation dose were developed using the RESidual RADioactivity (RESRAD) computer code [4]. Remedial action goals related to chemical cancer risk and hazards were based on screening models of the 1996 *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act" (MTCA) [5]. Use and application of the interim action cleanup levels was viewed by the Tri-Parties as supporting a range of possible future land uses within the River Corridor. However, it was recognized that final cleanup requirements would be established when final action RODs were issued.

Waste site and groundwater cleanup actions in the River Corridor have continued from 1995 to the present. During that time, about 15 million tons of contaminated soil and debris have been removed from waste sites in the River Corridor and disposed of at authorized facilities, primarily within the Hanford Site Central Plateau at the Environmental Restoration Disposal Facility. At each waste site where remediation has occurred, the goals and objectives of the IRODs have been met as demonstrated by verification documentation that has been completed and approved by the DOE and the regulatory agencies. In addition to removal of contaminated soil and debris from waste sites, more than 2 billion gallons of contaminated groundwater has been processed through pump-and-treat systems.

STRATEGY FOR FINAL ACTION CLEANUP DECISIONS

Many waste sites and groundwater plumes that have been identified for cleanup actions in the IRODs have yet to be addressed. In parallel with continuing the cleanup actions outlined in the existing IRODs, the Tri-Parties established a strategy to develop final action cleanup decisions for the River Corridor. These decisions are necessary to determine whether past cleanup actions in the River Corridor are protective of human health and the environment and to identify any course corrections that may be needed to ensure that ongoing and future cleanup actions are protective.

In accordance with the strategy developed by the Tri-Parties, the River Corridor has been divided into six geographic areas to achieve source and groundwater remedy decisions. The strategy to pursue six RODs was based on organizing the development and review processes into manageable pieces that are generally aligned with an operational function or historical use (e.g., reactor areas). Final remedy RODs will be developed for the areas depicted in Fig. 2 and listed in Table I.

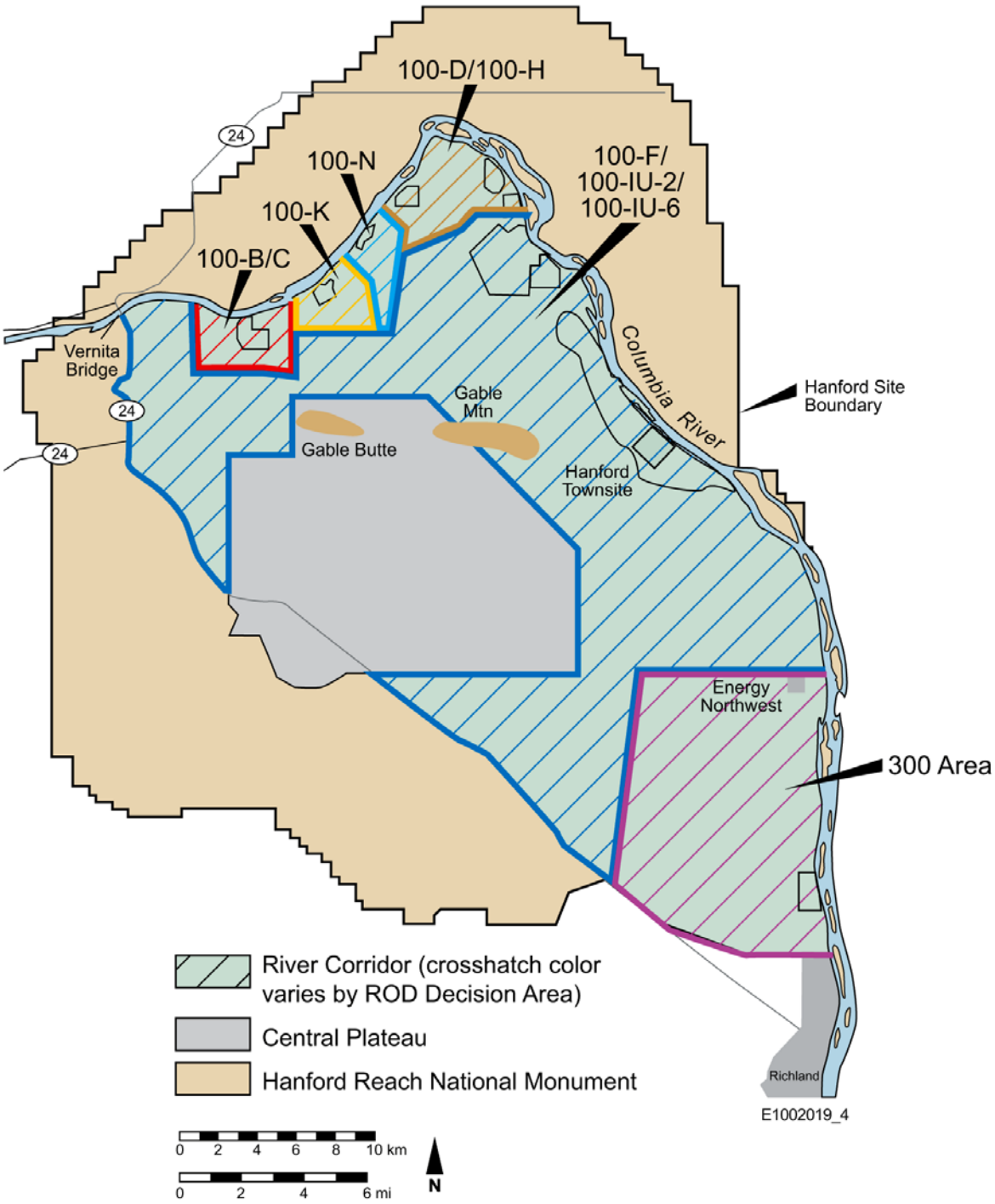

Fig. 2. River Corridor decision areas.

Table I. River Corridor decision areas for remedy selection.

Decision Area	Reactors/Operations	Source Operable Units	Groundwater Operable Units
100-B/C Area	B Reactor C Reactor	100-BC-1, 100-BC-2	100-BC-5
100-D/H Area	D Reactor DR Reactor H Reactor	100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2,	100-HR-3
100-K Area	KE Reactor KW Reactor	100-KR-1, 100-KR-2,	100KR-4
100-F & IU-2/6 Area	F Reactor	100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6	100-FR-3
100-N Area	N Reactor	100-NR-1	100-NR-2
300 Area	Fuels Fabrication, research and development	300-FF-1, 300-FF-2	300-FF-5

The RODs that are produced from this effort will establish the final remedial goals and objectives and any associated actions required to complete the CERCLA process for the River Corridor 100 Area and 300 Area NPL sites. Each of the six final remedy RODs will be integrated to address both source and groundwater remedial actions. These decisions will provide comprehensive coverage for all areas within the River Corridor and will incorporate ongoing interim action cleanup activities. Cleanup levels will be established that support the current and reasonably anticipated future land uses of conservation and preservation for most of this area and industrial use for the 300 Area. At the conclusion of cleanup actions, the federal government will retain ownership of land in the River Corridor and will implement long-term stewardship activities to ensure protection of human health and the environment.

RI/FS DEVELOPMENT AND PROTECTIVENESS OF INTERIM ACTIONS

Historical information, ongoing site clean-up and monitoring results, risk assessment results for a range of exposure scenarios, and remedial investigation data are being integrated into RI/FS reports for each of the six decision areas in the River Corridor. Along with the RI/FS reports, proposed plans summarizing the remedial investigation and identifying the preferred remedial alternative are being developed for public review and comment. Following completion of the review cycle, final action RODs for each decision area will be developed and approved by the Tri-Parties.

The six River Corridor RI/FS reports are in various stages of development. The 300 Area RI/FS report and proposed plan were issued in July 2013 and the associated final action ROD is anticipated by the end of 2013. The RI/FS reports and proposed plans for the remaining five decision areas are anticipated to be issued between 2014 and 2017.

Developing preliminary remediation goals (PRGs) as a basis for the proposed cleanup actions is one of the key aspects of the RI/FS. Results from human health risk assessments along with state

and federal regulations have been used to develop PRGs for a range of potential exposure scenarios. Goals for protection of ecological receptors have also been developed based on risk assessment results, bioassay studies, and published standards. For the River Corridor, it is anticipated that the final action cleanup standards for soil will continue to be based on an unrestricted or industrial exposure scenario as updated to reflect current regulations. Table II provides a comparison between the basis for interim action cleanup levels and PRGs that are anticipated to support the final actions. Groundwater cleanup actions will continue to be based on restoration of contaminated aquifers to meet drinking water standards.

Table II. River Corridor soil cleanup level development for interim and final actions.

	Interim Action Cleanup	**Final Action PRG Development**
Direct Exposure - Chemicals	• MTCA method B unrestricted (1996) • Surface to -15ft	• MTCA method B unrestricted (2007) • Surface to -15ft
Direct Exposure - Radionuclides	• 15 mRem/yr dose above background (RESRAD) • Rural resident scenario • Surface to -15ft	• 10^{-4} excess cancer risk or 15mRem/yr dose above background (most restrictive) • Rural resident scenario • Surface to -15ft
Groundwater Protection	• Migration modeling (RESRAD) with irrigation and revegetation • 100x drinking water standard or MTCA Method B [5] groundwater cleanup levels for contaminants predicted to reach groundwater • Surface to groundwater	• Migration modeling (STOMP) with irrigation and natural recharge (considering revegetation) • Calculation of soil concentration that will not result in drinking water standard exceedence[a] • Surface to groundwater
River Protection	• 100x groundwater value that will prevent release to river exceeding ambient water quality standards • 1:1 dilution before groundwater river interface	• Protect groundwater to prevent release to river exceeding ambient water quality standards • No dilution at groundwater river interface
Ecological Protection	• Limited ecological evaluation that human health and groundwater protection values would be more restrictive than ecological values	• Calculated values from bioassay, eco studies, risk modeling, and published standards • Surface to -15ft

[a] If residual value exceeds irrigation based cleanup level but is less than natural recharge cleanup level, the agencies may elect to apply institutional controls to prohibit irrigation instead of continuing soil excavation.

The bias for action cleanup approach was implemented to accelerate cleanup and address principle threats in the River Corridor. Of interest to all parties involved in the cleanup is the effectiveness of the interim actions in the River Corridor and the potential for "rework" to meet final action cleanup standards. This is especially applicable to waste sites where contaminated soil and debris have been removed and disposed, the excavation has been backfilled with clean soil, and the disturbed area has been replanted with the intent of re-establishing native vegetation. The RI/FS reports and proposed plans incorporate the remedial actions completed under the existing IRODs and evaluate whether or not the results are protective of human health and the environment in the context of the anticipated final action cleanup standards.

More than 1,200 waste sites that have been addressed under interim action have been screened and evaluated against the PRGs anticipated to support final action as part of the RI/FS development. This evaluation includes both waste sites where a determination was made that interim action cleanup standards were met with "no action" and waste sites where active cleanup was performed in accordance with the remove, treat, and dispose (RTD) remedy. As summarized in Table III, evaluations across the six decision areas show that the completed interim actions have been effective and that very little "rework" is anticipated – more than 98% of evaluated waste sites require "no further action" to achieve protectiveness of human health and the environment. Where waste sites need to be revisited under final action, the scope of work is anticipated to range from additional characterization activities to surface barrier construction or additional RTD actions.

Table III. Summary waste site metrics – PRG screening (December 2012 snapshot).

Decision Area	Total Waste Sites[a]	Cleanup Actions To Go[b]	No Further Action[c]	Sites to be Revisited Under Final Action[d]
100-B/C	140	4	131	5
100-D/H	343	104	234	5
100-F/IU	400	116	283	1
100-K	169	113	53	3
100-N	192	113	79	0
300	552	86	460	6
Totals	***1796***	***536***	***1240***	***20***

[a] Subsites are accounted for individually for this metric.
[b] Sites that have not been remediated as of the cutoff date that are expected to have continuing further action under existing interim action RODs and/or final action RODs.
[c] Includes sites that are not anticipated to have further final actions beyond general institutional controls.
[d] Examples of anticipated supplemental work includes phosphate sequestration of uranium in the 300 Area to address leaching threats, surface barrier placement at a 100 Area burial ground to reduce tritium migration to groundwater during decay period, additional characterization or excavation.

PREPARING FOR A TRANSITION TO FINAL ACTION CLEANUP

Continuing to drive the interim action cleanup program in parallel with RI/FS activities to establish final action cleanup decisions for the River Corridor present a big challenge to the Tri-Parties and Hanford Site cleanup contractors. The schedules for cleanup actions and RI/FS development are both dynamic based on conditions encountered in the field during cleanup operations, review and comment processes for the regulatory documents, and site funding levels. The fact that final action decisions are anticipated before interim actions will be completed at many of the waste sites identified for cleanup adds further complications. Consequently, it is important for the parties to understand where the cleanup and RI/FS development processes are anticipated to intersect and to develop a strategy for how to efficiently transition from interim to final cleanup actions.

Table IV summarizes the excavation and backfill operations that will be active between the anticipated issue dates for the RI/FS report and final action ROD or "to go" after the anticipated issue date for the final action ROD. The urgency and importance of this information has been lessened to some degree by two factors. The evaluation of completed interim actions against the PRGs anticipated to support final action decisions has shown that interim actions are effective, thus easing concerns about the potential for extensive "rework" under final actions. Secondly, the RI/FS development schedules have been extended for various reasons resulting in the completion of interim actions at more waste sites before the anticipate issue dates for final action RODs. However, understanding the dynamics of the processes and the associated points of intersection are still important considerations for the transition strategy.

Table IV. Summary of interim action field activities at key RI/FS process points.

Decision Area	**Interim Actions In-Progress Between Anticipated RI/FS and ROD Approval Dates**			**Interim Actions In-Progress Or To-Go after Anticipated ROD Approval Date**		
	RI/FS Approval (anticipated)	**Waste Site Excavation**	**Waste Site Backfill**	**ROD Approval (anticipated)**	**Waste Site Excavation**	**Waste Site Backfill**
300	July 2013 (actual)	8	4	Dec 2013	30	43
100-F/IU	Jan 2014	7	13	July 2014	1	16
100-D/H	April 2014	1	8	Oct 2014	0	38
100-N	July 2014	0	61	Dec 2014	0	30
100-K	a	a	a	a	a	a
100-B/C	Jun 2017	0	0	Dec 2017	0	0

[a] RI/FS development for 100-K area on hold pending additional characterization activities near the reactor.

The Hanford Site cleanup contractors have been working closely with DOE-RL and the regulators to develop a strategy for efficient transition, using the pending 300 Area decision as a model because it is furthest along in the process. Maintaining the momentum of nearly 20 years of cleanup actions in the River Corridor through continuous cleanup during transition has been a key objective of the strategy. Given this objective, several trigger points were considered for transition from interim to final actions.

- Trigger 1 - Regulator approval of RI/FS and Proposed Plan. This trigger was considered as an option primarily to minimize the amount of potential rework at sites with completed interim actions through an early transition to the anticipated final action cleanup standards. However, this decision would be at the initiative of DOE-RL and at risk because the CERCLA process including public review and ROD issuance would not yet be complete at transition. This risk coupled with RI/FS evaluation results that showed completed interim actions were effective with little anticipated "rework" led to a decision to drop this trigger option from further consideration.

- Trigger 2 - Approval of the Final Action ROD. This trigger is desirable because the public review would be complete and the final action cleanup standards would be formally established in the issued final action ROD. However, implementing documents such as the remedial design report/remedial action work plan (RDR/RAWP) would still need to be developed based on the standard CERCLA process. This issue was viewed to be manageable whereby an agreement could be made to use the ROD cleanup levels immediately while continuing to work within the existing RDR/RAWP framework and was chosen by the parties as the primary trigger.

- Trigger 3 - Approval of RDR/RAWP. This trigger would follow the standard CERCLA process following ROD issuance but result in one of two undesirable outcomes given the objective of maintaining continuous cleanup during transition. Either cleanup under the interim action standards would need to continue after ROD issuance or cleanup would need to be suspended while the RDR/RAWP was developed and approved, a process that could take 6 months or more. Consequently, this option was not selected as the primary trigger.

Trigger 2 was considered as a best fit to support transition from interim to final cleanup actions in the 300 Area with a focus on waste sites where RTD is the selected remedy, which will address a majority of waste sites in the River Corridor with remaining cleanup actions. The parties have agreed to use the ROD cleanup levels while continuing other aspects of the remedial actions in accordance with the existing RDR/RAWP framework. This approach supports real time transition to the new cleanup levels to guide excavation when the ROD is issued. In parallel with performing RTD cleanup actions to the ROD cleanup levels, a new RDR/RAWP will be developed and approved to fully implement the final action ROD. For the small number of waste sites where a remedy other than RTD is identified and for groundwater actions, cleanup will be implemented once a new RDR/RAWP is approved.

CONCLUSIONS AND PATH FORWARD

The schedules for interim action cleanup and RI/FS development continue to be dynamic. As activities progress, the intersection points and transition approach will be periodically revisited to determine if the current approach is still a best fit or if modification is needed. In addition, lessons learned will be considered as transitions are completed for the six River Corridor decision areas. The need for a transition strategy, the approach anticipated for the River Corridor, and any lessons learned that result from implementation could be applicable to any site where maintaining progress during a transition from interim to final action cleanup is desired.

Following the completion of Hanford Site cleanup actions identified by the upcoming final action RODs, there may be areas of the River Corridor that require long-term management activities. DOE-RL has established a Hanford Long-Term Stewardship Program to ensure continued protectiveness of cleanup remedies and to ensure protection of natural resources, the environment, and human health. Long-term stewardship will include monitoring and maintenance activities to ensure continued protectiveness. DOE is committed to maintaining the protection of human health and the environment and to meeting its long-term, post-cleanup obligations in a safe and cost-effective manner.

REFERENCES

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