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Conservation Habitat Assessment and Mitigation Prioritization for the Hanford Site: Proposed Methodology

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

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Conservation Habitat Assessment and Mitigation Prioritization for the Hanford Site: Proposed Methodology

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1.0 THE DEPARTMENT OF ENERGY'S HANFORD SITE

The central Hanford Site extends over 312 mi^2 in south-central Washington State, with State Route 240 providing the main boundary to the south and west and the Columbia River bounding it on the north and east. The Hanford Site is within the largest remaining area of contiguous native shrub-steppe and grasslands in Washington State. It also contains some of the most extensive dune systems in the region and is home to hundreds of plant and wildlife species. The natural resources on the Hanford Site are of notable value, both locally and regionally. This area has been home to several Native American Tribes. Remnants, artifacts, and burial sites associated with historical Tribal activity are found throughout the Hanford Site, highlighting that this area is also culturally significant and important to the Tribes today.

The U.S. Department of Energy (DOE) currently manages the Hanford Site. In 1989 DOE entered into the Tri-Party Agreement with the U.S. Environmental Protection Agency and the Washington State Department of Ecology. Since then DOE has invested in cleanup of the Hanford Site to address the nuclear waste and pollution remaining from the nuclear reactors constructed to produce plutonium during World War II as part of the Manhattan Project and the Cold War Era. As described on DOE's website (https://www.energy.gov/em/hanford-site), "after more than two decades of cleanup, considerable progress has been made at Hanford, reducing the risk the site poses to the health and safety of workers, the public, and the environment."

2.0 ECOLOGICAL MONITORING PROGRAM

The DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, (BRMP) is the DOE's primary implementation plan for managing natural resources under DOE/EIS-0222-F, *Hanford Comprehensive Land-Use Plan*. The BRMP details the following three overarching objectives that guide the management of natural resources on the Hanford Site:

- Foster preservation of important biological resources.
- Minimize adverse impacts to biological resources from Hanford Site development and other management activities.
- Balance the Hanford Site cleanup mission with resource stewardship obligations.

Implementation of much of this management plan is assigned to the Ecological Monitoring (EM) program, currently managed by Mission Support Alliance (MSA). MSA's implementation responsibilities include, among other actions, ecological monitoring, compliance reviews, resource monitoring reporting, implementing protective measures or administrative controls, and determining mitigation requirements. Since May 2011, MSA's ecological monitoring program has fulfilled these objectives by monitoring and reporting on the status of species of interest (mainly state, federal, and Tribal species of concern), mapping vegetation, and tracking and evaluating trends in species occurrences and other natural resources of interest. These data are used to support environmental cleanup and restoration activities, mitigation actions, land-use planning, and compliance reviews to maintain compliance with ecological resource laws.

As the cleanup of the remaining war legacy facilities along the Columbia River corridor is completed on the Hanford Site (Figure 1), and as ongoing activities are consolidated onto the 200 Areas Plateau, the infrastructure in the area north of Route 11 is being removed, areas restored, and impacted habitat is slowly recovering. As cleanup progresses, larger portions of the Hanford Site are becoming less impacted by the day-to-day operations of the Hanford mission, allowing additional opportunities to arise for mitigating impacts on biological resources.

3.0 PURPOSE OF THE HABITAT ASSESSMENT

The MSA Ecological Monitoring Program has established a goal for 2018 of taking a holistic look at the area of the DOE-managed portion of the Hanford Site in order to assess habitat quality. The plan is to carry out a spatially explicit habitat assessment and prioritization that will allow MSA to analyze the vegetation and species-specific data compiled through monitoring and mapping efforts in the Hanford Site Ecological Monitoring Program. In addition to the historical ecological resource data, MSA will use the plan to achieve the following purpose:

- To identify, on the Hanford Site landscape, areas of high habitat value and areas for restoration of habitat that meet the conservations goals and objectives of the Hanford Site.

Such a habitat assessment and prioritization would allow Hanford Site staff and and contractors implementing the BRMP (DOE/RL-96-32) at the Hanford Site to:

- Develop a whole ecosystem approach for the landscape
- Identify potential areas on the Hanford Site that would benefit from mitigation work
- Incorporate the results of the assessment to analyze ecosystem services to inform future management decisions.

The scope and scale of such a habitat assessment and prioritization would, by design, help DOE and its contractors integrate and share key ecological data from the Hanford Site with data of other parties with aligned natural resource protection and restoration goals within the broader landscape surrounding the Hanford Site, and even across the whole Columbia Plateau Ecoregion. This integration of data and coordination of actions is especially important between the DOE-managed portion of the Hanford Site and the adjacent U.S. Fish and Wildlife Service (USFWS)-managed Hanford Reach National Monument. However, the long-term persistence and value of biological resources at the Hanford Site are linked through ecosystem structure and function to the larger area of native shrub-steppe and grasslands habitat that extends northwestward across the L.T. Murray Wildlife Area and up the Wenas and Umtanum Valleys (between Yakima and Ellensburg) to the forested slopes of the Cascades; west and then north, through the Yakima Training Center and connecting to the Whiskey Dick, Quilomene, and Colockum Wildlife Areas; north and then west along the Saddle Mountains; and south and west across the Arid Lands Ecology Reserve and along Rattlesnake Mountain.

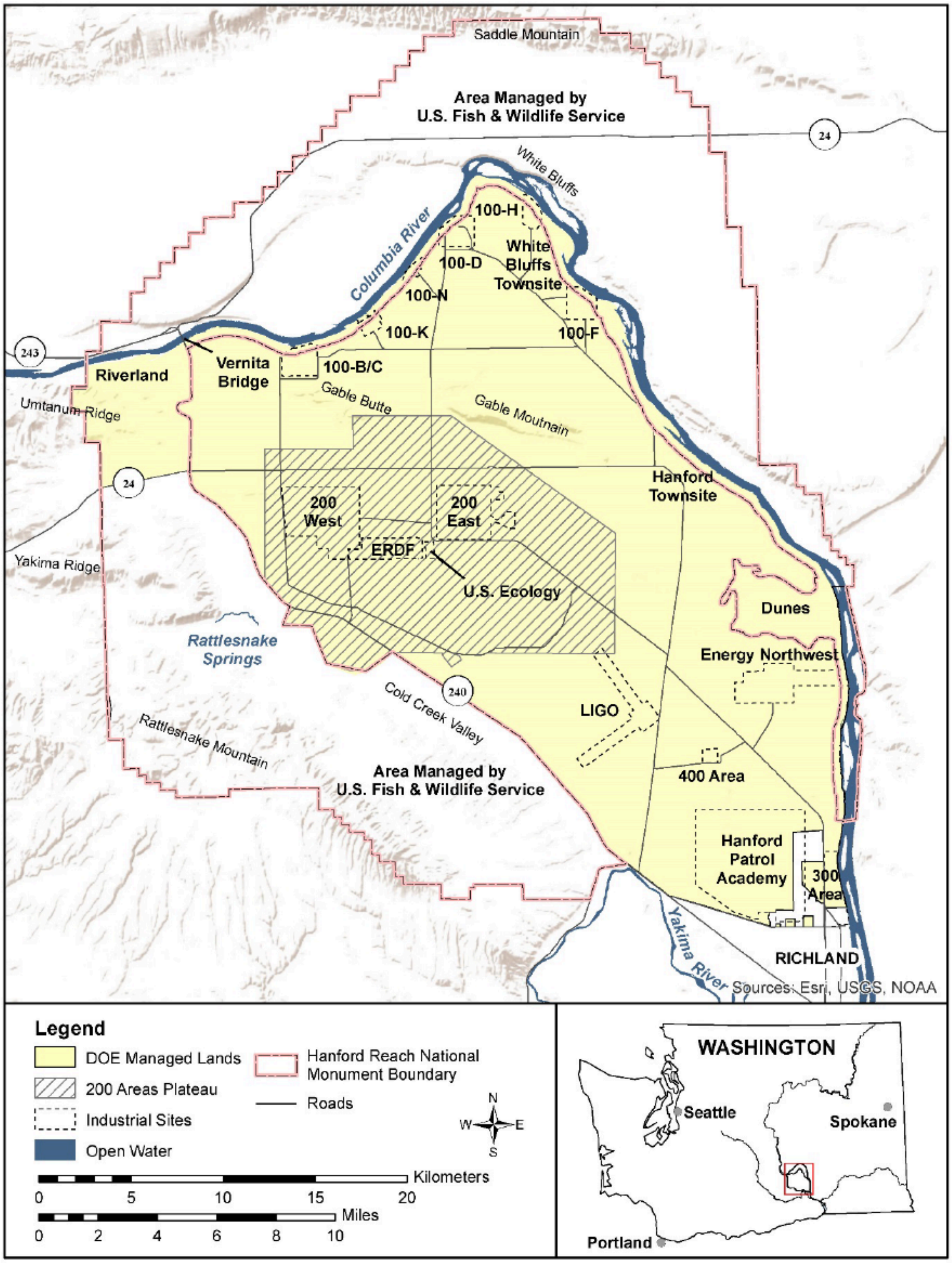

Figure 1 The U.S. Department of Energy managed lands and their relationship to the Hanford Reach National Monument. Map copied, with permission, from DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*.

3.1 RELEVANT LANDSCAPE SCALE EFFORTS

MSA recognized early on that carrying out a habitat assessment and prioritization for the Hanford Site provided an opportunity for aligning with other relevant landscape scale efforts in the Columbia Plateau Ecoregion. One dimension of such alignment is technical, through approaches compatible and complementary to those carried out by the Arid Lands Initiative (ALI) (ALI 2014; USFWS 2015, 2017) and the Washington Wildlife Habitat Connectivity Working Group (WHCWG 2012, 2013) (Figure 2).

Figure 2. Arid Lands Initiative and Washington Wildlife Habitat Connectivity Working Group Project Background.

4.0 PURPOSE OF THIS REPORT

This report summarizes the MSA EM team's (hereafter referred to as team or the project) plan for carrying out the habitat assessment and prioritization for the Hanford Site. Through a series of workshops facilitated by Sonia A. Hall, who has previously been part of the spatial planning and analyses carried out by both the ALI and the WHCWG in the Columbia Plateau Ecoregion, the project agreed on key aspects of the habitat assessment and prioritization for the Hanford Site. These meetings, key decisions made, and initial efforts to develop foundational descriptions for the habitat assessment and prioritization are detailed in this report. To the extent possible, the decisions and descriptions captured here are written in a way that will facilitate their integration into the final report for the resulting habitat assessment and prioritization, expected in fall 2018.

5.0 PLAN FOR THE HABITAT ASSESSMENT OF THE HANFORD SITE

5.1 PURPOSE AND GOALS OF THE HABITAT ASSESSMENT

The overarching purpose of the habitat assessment and prioritization is to identify areas in the Hanford landscape for protection of current habitat and species distribution, and restoration of habitat and species that meet the conservations goals and objectives of the Hanford Site. As described above, the completed habitat assessment and prioritization is intended to support a variety of activities and decisions that the project makes. However, there are two driving goals that the assessment and prioritization must achieve:

1. Identify priority conservation areas based on current health, size, and status of native habitats and species.

2. Identify priority mitigation areas based on status of surrounding areas, their long-term viability, connectivity, and the immediate impact that restoration actions could have on native habitats and species.

In addition, given MSA's function as a DOE contractor, a third goal — communications-focused, but just as critical as the two goals articulated above — was defined:

- The habitat assessment and prioritization must summarize the data from the development of the spatial model and from completion of goals detailed above in an understandable and useable written report.

This report is to be submitted to DOE. These three goals were articulated as Phase I goals, as the project acknowledges that the data compilation, management, and analysis carried out in completing a habitat assessment and prioritization will provide additional products that, with relatively little additional effort, could meet other related goals in the future.

5.2 SELECTED APPROACH FOR THE HABITAT ASSESSMENT

The project has decided to use MARXAN as the tool to carry out the habitat assessment and prioritization. MARXAN is a systematic conservation planning tool that uses optimization techniques to "identify areas that efficiently meet targets for a range of biodiversity features for minimal cost" (http://marxan.org/about.html), among other capabilities. The use of this tool in the habitat assessment and prioritization at the Hanford Site is expected to help align fine-scale priorities within Hanford boundaries with the ALI's ecoregion-wide priority areas, based in part on a MARXAN analysis as well (ALI 2014). This alignment, in turn, is important for fulfilling DOE's intent, as implementing a landscape-scale approach in addition to the existing resource-specific approach will help streamline any coordination and collaboration with state, federal, and Tribal entities with land management interests and authorities in the region.

The approach taken to make key guiding decisions on what the habitat assessment and prioritization should target mirrors that taken by the ALI. This partnership used a common conservation approach, the Nature Conservancy's Conservation Action Planning process (TNC 2007). To make key decisions that guided the spatial priorities analysis the Action is currently merged with similar processes to become the Open Standards for the Practice of Conservation (http://cmp-openstandards.org/). The Open Standards process is aspatial, yet provides a standardized and proven framework for agencies to think through critical steps in defining the biological priorities that will drive the selection of priority areas for conservation and, potentially, for restoration.

Two facilitated workshops, one of which included biological experts from agencies with land management authority in the surrounding area, led to the initial selection of:

- A small set of **focal species and habitats**, whose conservation is expected to ensure or support the conservation of the majority of ecosystems, communities, and species of concern at the Hanford Site.

- A **geographic scope** that is both relevant to work at the Hanford Site, and sets the stage for future iterations of the habitat assessment and prioritization that can foster the necessary coordination and collaboration with entities with land management interests and authorities in the region.

- **Key ecological attributes** that characterize the viability or integrity of each focal species and habitat. Though traditionally MARXAN has been applied to a wealth of data on the distribution and abundance of a large list of ecosystems and species, this effort followed the ALI's approach, which focused on these key ecological attributes. This was based on the assumption that achieving certain goals for these structural and functional characteristics of each focal habitat and species would allow them to select areas that were particularly important for maintaining the integrity and viability of these habitats and species.

- **Indicators** that would allow the project to quantify and map the key ecological attributes across the Hanford Site. Effective indicators are a key linkage between attributes important for the health of the focal species and habitats, and the data necessary to represent them, as inputs to MARXAN.

- **Ratings**, by which ecological and biological expertise and information is brought to bear, to define thresholds that quantify what condition the indicator and associated attribute are in.

- **Constraints** that are expected to make conservation or restoration of the land more costly in monetary terms or otherwise.

Each of these points is discussed in more detail below and the outcomes of the facilitated workshops, modified as appropriate by follow-up work, are described. These provide foundational pieces for the habitat assessment and prioritization process.

5.2.1 Focal Habitats and Species

5.2.1.1 Guidance. The team was asked to select no more than eight priority habitats and species that collectively:

- Represent biodiversity at the Hanford Site and the functions occurring across this landscape
- Reflect ecoregional priorities for the Columbia Plateau Ecoregion
- Are considered viable or restorable within this landscape
- Are threatened and, therefore, in need of conservation attention or otherwise strategic for achieving DOE's objectives for the Hanford Site.

Starting from individual suggestions, the facilitated discussion led to compilation, discussion, and organization of proposed species and habitats in a way that resulted in a small number of focal habitats and species. These discussions were meant to identify whether, for example, some species could be considered conserved if the habitats they depended on were the focus of conservation and could they, therefore, be considered nested under that habitat.

This was done with native forbs, if shrub-steppe, grasslands, and dunes were in good condition this would require a diverse component of native forbs and, therefore, the forbs would likely be viable as well. Species could be grouped under analogous rationale. In the case of the Hanford Site discussion, for example, the project considered that a limiting factor for raptors was the availability of prey, namely ground squirrels. Therefore, if investments led to viable and healthy populations of ground squirrels, the raptors should be conserved as well and could, therefore, be considered to be nested, from a conservation need perspective, under the ground squirrels.

5.2.1.2 Selected focal habitats and species. Three focal habitats and one group of species were selected to guide the habitat assessment and prioritization. See Appendix A for a full description of these focal habitats and group of species.

- Extensive shrub-steppe and shrublands occur as matrix with grasslands and dunes, or as large patch systems. On the Hanford Site this aggregation of systems generally appears across the elevation range, on varied landforms, and on a diversity of soil types. Vegetation may include shrubs and dwarf-shrubs, perennial herbaceous species (grasses and forbs), and annuals. This focal habitat includes the following ecological systems: Inter-Mountain Basins Big Sagebrush Steppe, Inter-Mountain Semi-Desert Shrub-Steppe, and Columbia Plateau Scabland Shrubland.
- Grasslands occur as a matrix with shrub-steppe, shrublands and dunes, or as large patch systems. On the Hanford Site this aggregation of systems generally appears across the elevation range, on varied landforms, and on a diversity of soil types. Vegetation may include perennial herbaceous species (grasses and forbs), a non-dominant overstory of shrubs and sub-shrubs, and annuals. A healthy grassland ecosystem is marked by a dominant vegetative layer of native grasses with minimal invasive grasses, and at most a minimal shrub overstory.
- Dunes are large patch systems that occur on active and stabilized sand dunes and sandsheets. This focal habitat, comprised of the Inter-Mountain Basins Active and Stabilized Dune ecological system,

is found on roughly 38% of the Hanford Site. Plant species occupying the dune environment are often adapted to shifting, coarse-textured substrates and form patchy or open grasslands or shrublands. Vegetation coverage ranges from devoid areas on the active dunes to moderately vegetated areas where the dune has stabilized.The species composition of the vegetation is related to the degree of sand stabilization and the position on the dune.

- This group of species captures burrowing animals and associated species, as well as the soils and vegetation community types that characterize their preferred habitats. A range of burrowing animals and associated species occur on the Hanford Site, most notably the Townsend's ground squirrel (*Urocitellus townsendii*). Habitat characteristics selected by the Townsend's ground squirrel will be used to represent habitat requirements for burrowing animals and associated species on the Hanford Site.

Additional species, communities, or habitats were considered to be nested under those four focal habitats and species. Table 1 shows a preliminary list of these species and communities. As the process continues, other decisions may lead the project to reevaluate and adjust the lists.

Table 1. Preliminary Lists of Species and Communities That the Project Considered Could be Nested Under the Four Focal Habitats and Species Selected.

Shrub-steppe	Grassland	Dunes	Burrowing Animals
• Native forbs • Pollinators • Endemic species • Rare plants • Mature (climax) shrub-steppe • Sagebrush • Obligatory and facultative sagebrush species (sage sparrow, birds) • Jackrabbits • Grouse • Unique, critical habitat elements	• Native forbs • Pollinators • Endemic species • Rare plants • Unique, critical habitat elements	• Native forbs • Pollinators • Endemic species • Rare plants • Unique, critical habitat elements	• Townsend's ground squirrel • Burrowing owls • Ferruginous hawk • Other Birds of prey • Badger

5.2.2 Geographical Scope

5.2.2.1 Guidance. The Open Standards process typically requires that the project select a geographical scope in the first stage of decisions and use that scope to bound the focal habitats and species that are selected (TNC 2007). In this case, the selection of a geographical scope and the focal habitats and species of interest were inverted. The Open Standards process acknowledges that these two steps are linked and often iterative. In the case of the Hanford Site, the boundaries of the Site delineate the area where MSA, as a DOE contractor, has ability to make decisions informed by the habitat assessment and prioritization. Once the focal habitats and species that represent the biological resources of interest at the Hanford Site were selected, the question of the appropriate geographic scope became a question of whether the Site boundaries were ecologically the most appropriate boundary for determining the requirements for those focal habitats and species' integrity and viability.

Through the facilitated discussion, the project drew potential boundaries on printed maps that captured alternative geographic scopes for the MARXAN analysis, with a focus on capturing:

- The geographic or ecological "frame" important for this landscape
- The basic ecological needs of focal habitats and species, including considerations of size, condition, and landscape context (processes such as fire, connectivity).

Proposed scope outlines were discussed, and a final decision on scope was proposed.

5.2.2.2 Selected geographic scope. The project discussed two scopes (Figure 3):

- The Hanford Site where they have direct access to data, and the data are of known quality, consistency, and availability. The project understood that key ecological attributes could be selected that would provide information on the value of areas within the Hanford Site based on their connections or adjacency to areas or values outside of the Hanford Site.
- A broader landscape capturing all of the Hanford Site, Saddle Mountains, and the Yakima Training Center, which better reflects an ecologically meaningful boundary in which to conserve the selected focal species and habitats. A draft boundary was delineated after the meeting (Figure 3).

For the Phase I MARXAN analysis, the decision was made to carry out the analysis for the Hanford Site itself in order to provide initial guidance for conservation and restoration decisions and as a pilot to show what the MARXAN analysis can provide. The results of this Phase I analysis are expected to become the basis for conversations with agencies managing lands in the surrounding landscape as MSA strives to engage more deeply with them and to obtain support to carry out an, ideally, shared Phase II MARXAN analysis at the broader landscape scale. This second analysis would allow comparisons to the landscape-scale priority areas to these initial results and determine the impact of that broader context, as well as the potential impacts on the selection of priority areas for conservation and restoration of different and possibly inconsistent data sources across ownership boundaries.

5.2.3 Viability Assessment – Key Ecological Attributes, Indicators, and Ratings

In accordance with the approach taken by the ALI (ALI 2014), the project, with input from expert biologists from other agencies, developed a viability assessment for the four focal habitats and species. The intent of the viability assessment is to organize current understanding and knowledge of each habitat or species in a way that evaluates how to know whether that habitat has ecological integrity or the species is viable. Viability, or ecological integrity, quantifies whether the habitat or species is resistant to change in its structure or composition in the face of external stresses or resilient in light of those stresses — that is, able to recover from occasional severe stress (FOS, 2009).

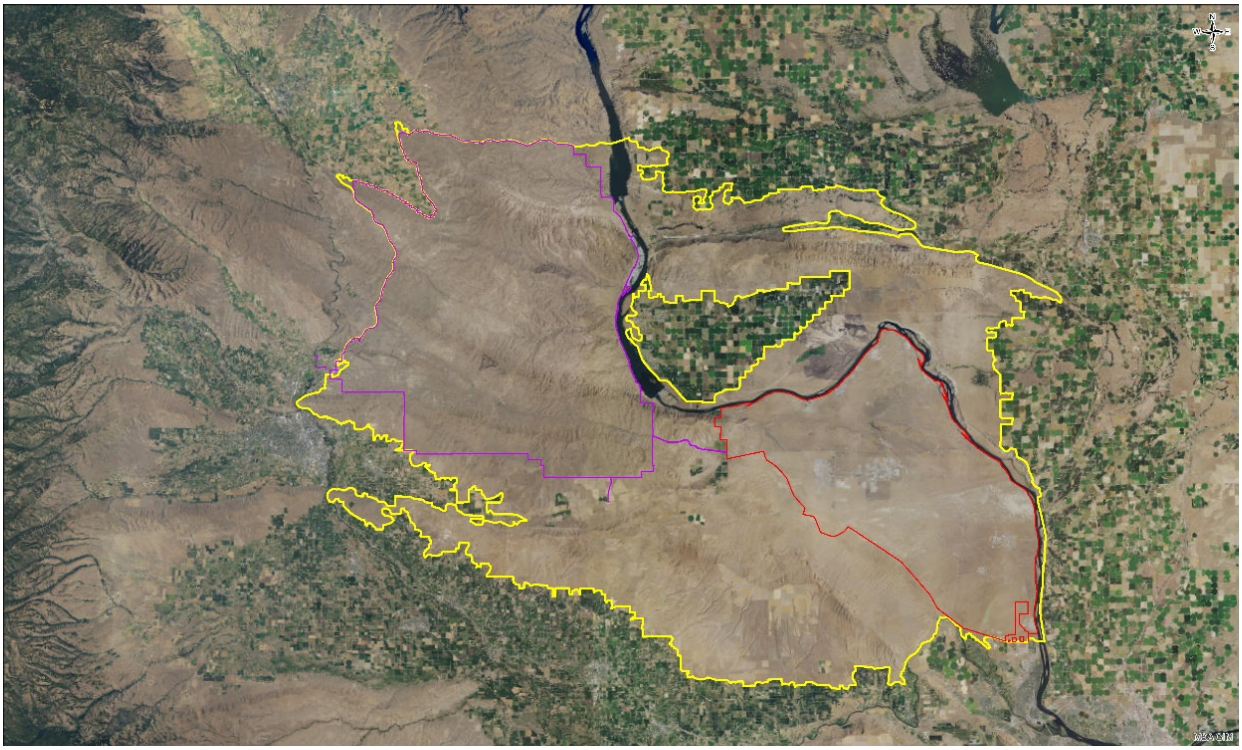

Figure 3. Draft Map Showing the Phase I MARXAN Analysis Boundary. The Hanford Site is in red; a preliminary boundary for a potential Phase II analysis is in yellow. The yellow boundary could include the U.S. Fish and Wildlife Service-managed portion of the Hanford Reach National Monument (boundary not shown) and the Yakima Training Center (in purple).

The viability assessment for each focal habitat and species was carried out through the following three sequential steps in a facilitated workshop, with additional follow-up by the project.

- STEP 1. The project collaborated with other biological experts with land management agencies in the surrounding area to identify and develop key ecological attributes (KEAs) for each focal habitat or species, and identified the indicators that would be used to measure each attribute. The guidance provided under the Open Standards methodology is that key ecological attributes should identify aspects of a habitat's or species' biology or ecology that (1) if present, define a healthy habitat or species or (2) if missing or altered, would lead to the loss or extreme degradation of that habitat or species over time.

Team members were expected to consider key ecological attributes of size, condition, and landscape context for each focal habitat and species. Resources provided included examples of key ecological attributes and indicators, including those developed by the ALI (http://aridlandsinitiative.org/our-projects/the-science/, under *Assessing Ecosystem Viability*) and a preliminary list that the project had compiled as they began preparing for the habitat assessment and prioritization.

- STEP 2. The team then identified indicators that would be used to assess the quality of each key ecological attribute. One or more indicators are necessary to quantify each key ecological attribute. Indicators are measurable aspects of the key ecological attribute that provide information on its status. These are the metrics that can be measured and will allow the project to determine the condition of each attribute for particular habitat patches or species populations.

- STEP 3. In order for the indicator values to be compatible with the MARXAN model they must be categorized using a rating system, the values of which were determined by the project. The ratings allow the project to interpret specific indicator values in light of the overall understanding of the thresholds that determine what condition an attribute is in and, therefore, the habitat or species it is associated with. At its most detailed, the viability assessment developed following the Open Standards methodology would define thresholds that distinguish “poor,” “fair,” “good,” and “very good” categories for each attribute, as measured with its associated indicator. The attribute is considered to be in the “good” to “very good” range when the indicator is within an acceptable range of variation, which is defined in the viability assessment. If existing information suggests the indicator may be trending out of that range, or if it is only within the range thanks to ongoing human intervention, the attribute would be classified as “good.” If the attribute is in an ecologically desirable status and requires little intervention for maintenance, the attribute would be classified as “very good.” Similarly, “fair” and “poor” categories indicate the attribute is outside its acceptable range of variation and differ in whether intervention is likely to improve it to within this range (“fair” category) or not (“poor” category).

An initial draft of the viability assessment for shrub-steppe, grasslands, dunes, and burrowing animals was developed in the facilitated session. The project then reviewed and improved the viability assessment in subsequent meetings, filling in any critical gaps and evaluating whether the resulting sets of attributes, indicators, and ratings effectively and efficiently captured whether these four focal habitats and species were in good condition at the Hanford Site (see Appendix B). The project also evaluated what attribute-indicator pairs they already had data available for and which would require further data collection (see Section 5.2.5).

5.2.4 Potential Constraints

MARXAN, the tool that the project proposes to use for the habitat assessment and prioritization, is an optimization tool. By definition, optimization methods will pursue a maximum or minimum value of a function, usually involving several variables subject to a set of constraints defined by the project. In applying MARXAN to a spatial prioritization exercise, this definition translates to needing an input layer that represents how constraints vary across the landscape. Constraints can be factors that limit the ability of the habitat to function as normal (e.g., physical barriers like roads) or factors that limit the project’s ability to intervene or manage biological resources (e.g, contamination or zoned areas). Depending on the particular application MARXAN is being used for, the constraints that this input layer represents can be based on physical or biological limitations, management guidelines, or rules and policies governing the future use of the land.

In this initial process to plan for the habitat assessment and prioritization, the project did not define the constraint layer to be used. However, during the facilitated workshop with expert biologists, the potential constraints were discussed and input was obtained on what factors MSA should consider in determining what constraint layer to use. These factors included:

- Areas currently under industrial use
- Distance to utility towers and lines
- Climate change

- Culturally and historically protected areas
- Areas zoned for development
- Contamination areas
- Roads
- Mandates, policies, and political contexts
- Fire considerations
- Columbia River.

MARXAN requires a single constraint layer as an input and applies this constraint to all the biological and ecological features the MARXAN model is being asked to maximize in the solution (the MARXAN targets). The project will need to consider these proposed factors and determine how to represent those it considers priority constraints on its ability to conserve and restore particular parcels within the Hanford Site in a single complex layer. For this layer to be useful, it must also show a range of variability across the geographic scope of the analysis. That is, if the differences in constraints between different areas of the Hanford Site are negligible, then the use of the constraint layer will not effectively inform the solution. As one of MARXAN's strengths is its ability to optimize a solution, using a constraint layer that has little influence may lead to the costs of using MARXAN outweighing its benefits.

5.2.5 Data Available and Data Gaps

Spatially explicit, digital layers that represent each key ecological attribute-indicator pair are inputs that MARXAN requires. These input layers will each represent a MARXAN target; that is, a feature for which the project will define a goal to be achieved and that the MARXAN model will strive to achieve through its selection of spatial planning units included in the solution. The project, therefore, crosswalked the key ecological attributes and indicators defined in the viability assessment for the four focal habitats and species with existing data for the Hanford Site. Based on this crosswalk, the project categorized the key ecological attribute-indicator pairs into three classes:

- Key ecological attribute-indicator pairs for which they **already have all the information they need** as inputs to MARXAN (green cells in Appendix C).

- Key ecological attribute-indicator pairs for which they **have some information but need to collect more data** (yellow cells in Appendix C). These data may be collected utilizing a Rapid Assessment-style field protocol. As the Rapid Assessment was not feasible in the 2018 field season, this proposed data collection would be considered in future phases or iterations of the habitat assessment and prioritization.

- Key ecological attribute-indicator pairs for which they **have no information** and can, therefore, not be used currently as input to MARXAN (red cells in Appendix C). Depending on the ability to collect these data across the whole Hanford Site through a Rapid Assessment and on whether other indicators provide some redundancy relative to these, the project will decide whether to include this attribute-indicator pair in the MARXAN analysis.

As the project moves forward in preparing the data layers as inputs for the habitat assessment and prioritization, more detailed decisions may be needed to translate the ecological understanding that the viability assessment captures into the specific format and structure that data inputs to a MARXAN model need to have. These detailed decisions may lead to changes in the use of the viability assessment (such as some attribute-indicator pairs not being included in this Phase I analysis) or the indicator being modified to take advantage of existing data (as a surrogate for the key ecological attribute). In addition, as further data are collected in the future, for this or other projects, the project may be able to include more or different MARXAN targets in further iterations of the habitat assessment and prioritization.

5.3 PRINCIPLES TO GUIDE THE HABITAT ASSESSMENT

Developing a habitat assessment and prioritization requires making multiple methodological and biologically-based decisions and, in some cases, assumptions. As this is a team effort, and meant to inform the work of multiple people and entities, it is important that such decisions are made in a consistent way across contributors and throughout the length of the process. Establishing guiding principles up front can help a team achieve this consistency. As part of a facilitated discussion among the members that will be most involved in this project, the following guiding principles were delineated:

- The MSA Ecological Monitoring Program will make the final decisions on the inputs into the MARXAN model to produce the habitat assessment and prioritization for the Hanford Site. Such decisions include when and whether to invite input and feedback from experts in different fields.

- The habitat assessment and prioritization targets general conservation at the Hanford Site. That is, specific areas important for specific species may or may not be included in the outputs of the assessment and prioritization. These outputs may, therefore, need to be complemented with future runs and iterations that focus on a particular species or habitat, or with other existing analyses and priorities.

- The habitat assessment and prioritization will also help identify target areas important for restoring vegetation at the Hanford Site. As with conservation, this may not satisfy the restoration needs of particular communities, habitats, or species. Such specifics may need to be considered through complementary analyses.

- The habitat assessment and prioritization will identify priority areas at a fairly coarse scale. Given existing capacity, time, and funding, decisions on whether certain factors can be included or data collected to allow inclusion will be made through a lens of what is feasible with the understanding that efforts such as this one can be iterative. Future iterations will provide opportunities for including data or approaches currently not considered feasible.

- All decisions made in the habitat assessment and prioritization process will be documented and communicated to the rest of the project in a timely fashion; that is, when they are made, not at the end of the process.

- All assumptions that are made when making technical and biological decisions will be documented and, to the extent possible, evaluated and confirmed (for example, through post-hoc analyses). The project recognizes that making assumptions will be necessary as knowledge of the habitats and species on the Hanford Site is not perfect.

- The habitat assessment and prioritization of the Hanford Site will be a standalone set of maps and associated products that can be used to guide ecological actions and decisions on the Hanford Site. The project will, however, consider in its decisions the broader-scale Phase II analysis they aspire to complete at a later date, so as to foster scalability of the analysis.

- The priority areas identified through the habitat assessment and prioritization need to function as a network within and outside the Hanford Site. The key role connectivity plays in maintaining the integrity and viability of the focal habitats and species could influence many decisions made during the assessment and prioritization process.

- The intent of the project is to obtain a workable, parsimonious product that can inform where to focus conservation and restoration efforts. Due to this focus, the scale of the analysis, and the capacity constraints of the team, not every issue can or should be addressed. The project acknowledges that trade-offs will be required.

Conditions can and will change as the project moves forward with the habitat assessment and prioritization for the Hanford Site. As they do, the project may need to revisit and revise these guiding principles. It is important that any revisions are effectively communicated to the whole team, to ensure everyone is clear on what has changed, and any issues that could impact their ability to support and follow these principles are addressed. Circling back to these principles on a regular basis can also help the project stay aligned and on the same page as they move through what can sometimes be a complex and stressful group process.

5.4 WORK PLAN FOR THE HABITAT ASSESSMENT

There are multiple tasks that must be completed to carry out a habitat assessment and prioritization using MARXAN. This section contains brief descriptions of the main tasks and activities, to help organize efforts to complete this project, and to determine any additional expertise or capacity that might be needed. Some of these tasks have been initiated and even completed in this initial phase of planning for the habitat assessment and prioritization. Such instances are noted.

In coordination with the project lead, target dates were established to help the project track progress towards completing the Phase I habitat assessment and prioritization for the Hanford Site by the target date of September 30, 2018.

5.4.1 Key Tasks or Activities

5.4.1.1 Define team roles. As with any project, definition of roles will be established for different team members including, but not limited to:

- Oversight. Who will make biologically-based and methodological decisions.

- Data management responsibilities. Who will carry out the analysis, be involved in interpretation and write-up of results, and document decisions made in the process.

5.4.1.2 Finalize geographic scope of the analysis. The scope for the Phase I analysis, the Hanford Site boundary, has been finalized.

5.4.1.3 Finalize definitions of focal habitats and species, and what they represent (nested species and communities). The focal habitats and species that will guide the habitat assessment and prioritization have been selected, and what they include has been defined (see Section 5.2.1). Species and communities that are expected to be nested under each focal habitat and species have been articulated. As with the scope, these definitions, nested species, and communities may change as data and other decisions are made and the ability of the focal habitats and species to meet the needs of the nested species is reevaluated.

5.4.1.4 Finalize viability assessment for the four focal habitats and species. A draft viability assessment was developed for the four focal habitats and species through a facilitated workshop. However, this draft assessment was based solely on the expertise in the room at the time; additional resources, published or from additional experts, can and should be brought to bear as the project has continued to do. Finally, the key ecological attribute-indicator pairs need to be translated to MARXAN targets and data layers developed to represent them (see Sections 5.4.1.6 and 5.4.1.7).

5.4.1.5 Investigate how MARXAN has been used. Myriad publications exist that describe how MARXAN has been used to select areas for conservation. The use of MARXAN to identify areas for restoration is less common and was not an explicit objective of the ALI effort, the most regionally-relevant example of using this tool (Schloss et al. 2011 was also focused on the Columbia Plateau Ecoregion and did consider restoration). In addition, the Hanford Site habitat assessment and prioritization will be at a finer scale than the ALI effort. Research into applications to restoration and at similar scale will benefit the project, giving useful guidance on how to do so most effectively and efficiently.

5.4.1.6 Make initial set of technical decisions. As described earlier, there are many methodological and biologically-based decisions that must be made to run a MARXAN analysis. An initial set that needs to be defined early on includes the following:

- Deciding on the planning units' shape and size
- Defining each MARXAN target based on each key ecological attribute-indicator pair
- Selecting datasets that will represent the spatial variation in each MARXAN target (see Section 5.2.5)
- Setting goals for each MARXAN target, a complex decision that determines what solution the MARXAN model is trying to achieve
- Deciding on whether to spatially stratify the solution; that is, require that the solution includes portions of different geographical zones within the Hanford Site to satisfy the goals for each MARXAN target
- Defining the constraint layer (see Section 5.2.4) and identifying data that can represent the spatial variation in these constraints
- Deciding whether any areas should be locked in or locked out of the potential solution space.

5.4.1.7 Create input layers. The spatially explicit data that will be used as inputs to the MARXAN model are not organized and formatted in a way that the MARXAN model requires. Processing of the input data is necessary to ultimately assign what amount of each MARXAN target occurs within each planning unit across the whole geographic scope. Developing these planning-unit-based input layers for each MARXAN target, a GIS exercise, will also involve nuanced decisions that must be understood and documented. A similar process will be needed to assign a constraint value to each planning unit across the whole geographic scope. This last input layer can also be scaled to influence the results in different ways (see Section 5.4.1.8).

5.4.1.8 Calibrate MARXAN parameters. In addition to the input layers, there are some parameters that the MARXAN user needs to define. These include the following:

- The number of iterations and runs. The number of iterations defines how many times MARXAN is allowed to include or exclude planning units from the solution in its pursuit of an optimal solution; the number of runs determines how many times MARXAN develops a new solution that only differs from the other runs in the first planning unit(s) selected to be part of the solution

- A boundary length modifier that quantifies how much emphasis the MARXAN model gives to trying to clump the solution into fewer, larger groups of planning units

- A penalty factor by which the user can penalize solutions that do not achieve the goals for certain MARXAN targets.

The relative influence all these parameters have on the solution is also a function of the range of absolute values of the constraint layer. A constraint layer with values ranging from zero to one will influence the solution differently than that same constraint layer but whose values are stretched from zero to 100. The range of values most appropriate for this analysis will need to be calibrated.

5.4.1.9 Decide on scenarios and sensitivity analyses. There are many decisions that will need to be made that may not have conclusive evidence supporting the rationale for making that decision. An alternative to be considered as these decisions are made is to select those that appear most controversial or critical and to evaluate alternatives. This can be done in different ways. If there is a small set of clearly defined alternative decisions that need to be explored, specific scenarios can be developed and a separate MARXAN analysis can be completed under each scenario; the results of these different scenarios interpreted and shared. If a range of values for a given parameter are equally possible, and it is unclear how influential the parameter is in the solution, multiple MARXAN analyses can be completed with systematically different parameter values and the differences in results compared. Depending on how sensitive the solutions are to the value of the parameter, the project can either select a reasonable and justifiable parameter value or decide that further evidentiary data is needed before a parameter can be selected. An additional approach to uncertainty surrounding decisions is described in Section 5.4.1.15.

5.4.1.10 Obtain feedback from ecological experts on the MARXAN target goals. As with any analysis, review by experts can help strengthen the foundation and credibility of the resulting products. One of the decisions that is both critical and likely to include some subjectivity (due to lack of evidentiary guidance) is the selection of goals for each MARXAN target (see Section 5.4.1.6). The project may share the proposed approach to setting goals with external biological and ecological experts and obtain their input before finalizing the goals for each MARXAN target. Even after this review is completed, uncertainty will likely remain. The project may, therefore, also choose to explore scenarios, sensitivity analyses, or post-hoc analyses to further explore this issue (see Sections 5.4.1.9 and 5.4.1.15).

5.4.1.11 Finalize and document inputs and parameters. Many of the tasks detailed above may require test runs of the MARXAN model to help inform key decisions on inputs and parameters. Once these test runs are complete it is important to explicitly articulate the decision made and to document the decision, the underlying rationale, and how it was informed (if at all) by trial runs. This task is also a milestone of some importance, as it marks the point where the project will shift from testing and making decisions to carrying out the runs that will comprise the final results of the habitat assessment and prioritization.

5.4.1.12 Run MARXAN. As with the task in Section 5.4.1.11, running MARXAN for the final set of scenarios that will produce the final results of the habitat assessment and prioritization is a milestone for the project, even if it will likely take a small amount of time relative to the time invested in data preparation, testing, and decision-making in the tasks outlined above.

5.4.1.13 Analyze and interpret results. The MARXAN results include a variety of datasets including the following:

- A best solution map where each planning unit is either part of the solution or not
- An irreplaceability map where each planning unit is assigned a value that reflects the proportion of runs that it was selected as part of the solution
- Tabular information quantifying how much each planning unit contributed to each MARXAN target's goals
- To what extent the MARXAN goals were fully achieved in the final solution.

This body on results will be produced for each scenario that is considered. It is critical that the project interprets this wealth of information in terms of what it represents for the focal habitats and species of interest, how it can or should inform management actions moving forward, and what the differences between scenarios mean for such actions.

5.4.1.14 Obtain early input on MARXAN outputs. Before finalizing the habitat assessment and prioritization, there is an opportunity to provide a preview to DOE and adjacent land managers (e.g., USFWS) to obtain their early input on these results. Not only can this improve the projects communication efforts (see Section 5.4.1.16) but it can also help build support and open opportunities for coordination on land management activities with surrounding lands.

5.4.1.15 Post-hoc analyses. There will almost certainly be aspects of the MARXAN analysis that remain as concerns to the project or to reviewers. Some of these are amenable to post-hoc evaluation. For example, if a particular set of data on a particular species was not included as an input, a simple GIS exercise can explore how much of that species' abundance is captured in the final solution; thereby, informing whether additional, complementary work is necessary to ensure conservation of that species. Which post-hoc analyses are most important to carry out will arise as different decisions are made in the tasks articulated above; however, ensuring time is allocated to carry those out from the beginning is important. Hence the inclusion of this task in the work plan.

5.4.1.16 Write up report and communications products. As described above, the habitat assessment and prioritization has as an explicit goal to summarize the data from the development of the spatial model in an understandable and useable written report. The products of a MARXAN analysis can sometimes appear opaque and black box like. The project's efforts in interpretation of these results, coupled with completing this communications-based task, will allow them to avoid this issue and share with the DOE (and others, as appropriate) a product that can help inform ecological decisions on the

Hanford Site. There may also be other communications products that, in the course of carrying out the habitat assessment and prioritization, the project considers necessary to help explain and support these products and their use in decision making.

5.4.2 Timeline

Table 2 identifies target due dates for completion of key tasks and milestones in order to help the project track and prioritize progress towards completing the MARXAN-based habitat assessment by September 30, 2018.

Table 2. Timeline of Target Due Dates for Completion of Key Tasks and Milestones.

Task	Mar	Apr	May	Jun	Jul	Aug	Sep
Define roles	22-Mar						
Finalize geographic scope of the analysis	15-Mar						
Finalize definitions of focal habitats and species, and what they represent (nested species and communities)	29-Mar						
Finalize viability assessment for the four focal habitats and species		5-Apr					
Research on how MARXAN has been used		5-Apr					
Make initial set of technical decisions			1-May				
Create input layers					1-Jul		
Calibrate MARXAN parameters				20-Jun			
Decide on scenarios and/or sensitivities				20-Jun			
Review 1: Obtain feedback on the goals and scenario/sensitivity analyses					19-Jul		
Finalize and document inputs and parameters					19-Jul		
Run MARXAN						1-Aug	
Analyze and interpret results						16-Aug	13-Sep
Review 2: Obtain feedback on the mapped priority areas						22-Aug	
Post-hoc analysis to address issues and uncertainties							13-Sep
Write up report and/or communications products							30-Sep
Clearance to publish							30-Sep

5.5 ADDITIONAL CONSIDERATIONS AND CONCERNS TO BE ADDRESSED

The habitat assessment and prioritization that the project proposes to carry out and use is the MARXAN tool. They propose its use will add a landscape-level approach to the current tools used to fulfill the goals at the Hanford Site. Throughout the conversations and decisions made so far, the project has voiced a series of concerns related to how the habitat assessment and prioritization could and would be carried out, and how it would meet the identified needs. These concerns need to be considered as the analysis moves forward. It is important that the project reevaluate, as needed and appropriate, the guiding decisions made. Should these concerns not be addressed, the following should be considered.

- Careful consideration needs to be given to the inputs to the MARXAN model to ensure that they are balanced, such that the output provides a holistic view of the habitats and species at the Hanford Site.

- The results of the MARXAN model needs to be scalable so that results are useful for management of the landscape, as well as finer-scale species and habitats actions.

- The habitat assessment and prioritization should be designed in such a way that it is compatible with monitoring results, so that these bodies of information can lead to action.

- The project will strive to develop and communicate the results of the habitat assessment and prioritization so as to ensure that the products can and do provide guidance and help prioritize future work at the Hanford Site, even after MSA’s current contract with the DOE ends on May 25, 2019.

- The project recognized that there might be few, if any, examples of projects using MARXAN to identify priority areas for restoration. Further exploration of this topic, and careful consideration of how to apply this tool to this objective, will be part of the habitat assessment and prioritization. Should the project find that MARXAN is not the best tool to use for this objective, they may consider alternative approaches.

- The intent of the project is to set up the MARXAN model and the input layers in such a way that they are able to build on this foundation and improve or modify, as needed, in future iterations of the habitat assessment and prioritization.

- When carrying out the viability assessment, the project felt there were certain areas where there was insufficient in-house expertise to make the decisions on attributes and ratings that were needed. They expect to be able to fill those gaps through reviewing published information or consulting with other experts.

These concerns are not uncommon when starting a new process with new tools, striving for a different way of focusing efforts. By articulating and documenting the concerns and ideas for addressing them, the project is laying the foundation for understanding the implications for the interpretation and use of the results of the habitat assessment and prioritization of any concerns they are unable to address through the process.

6.0 CONCLUSION

MSA's Ecological Monitoring Program is taking an ambitious and challenging step in response to the ever-changing progress being made in cleanup and the evolving needs of stewardship of natural resources on the Hanford Site. The proposed habitat assessment and prioritization is a major step in continuing habitat and resource protection and achieving the DOE's goals for the Hanford Site, articulated in the BRMP (DOE/RL-96-32).

Part of the challenge the project is taking on is using a new and sophisticated planning tool, MARXAN, to identify priority areas for the conservation and restoration efforts on the Hanford Site. This report and the facilitated workshops and discussions it captures the outcomes of describes the steps taken so far to frame the MARXAN-based analysis and initial important decisions that guide the process. Though MARXAN is a new tool for the project, there are resources available (published materials and people with specific expertise) to help the project effectively and efficiently apply this tool to achieve the stated goals for this Phase I habitat assessment and prioritization.

Many of the decisions that need to be made in the process, whether methodological or biologically-based, may lead to iterative loops, adjusting decisions made earlier in the process. This iterative nature brings with it many challenges. However, it also opens the opportunity for adjusting the process, where feasible, to produce useable products while recognizing that future iterations can improve those products as new and better data become available, other entities are interested in collaborating, or the needs at the Hanford Site change through time. Embracing that need for adaptability and flexibility will support the project's efforts to complete this ambitious habitat assessment and prioritization, producing key products to inform ecological resource decisions at the Hanford Site well into the future.

7.0 ACKNOWLEDGEMENTS

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- So Yon Bedlington and Annabelle Rodriguez (DOE) for their participation during the viability assessment workshop, and their support for the habitat assessment and prioritization.

The materials discussed in this report are a synthesis of the knowledge and expertise of the project and all these people. Thank you for the support in the preparation of this document.

8.0 REFERENCES

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APPENDIX A

DESCRIPTION OF FOCAL HABITATS AND SPECIES

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APPENDIX A
DESCRIPTION OF FOCAL HABITATS AND SPECIES

The Hanford Site is located within the Columbia Basin Ecoregion, an area that historically included over 6 million ha (14.8 million ac) of steppe and shrub-steppe vegetation across most of central and southeastern Washington State (Franklin and Dyrness 1973), as well as portions of north-central Oregon. The current Hanford Site occupies about 1,516 km^2 (586 mi^2) at the approximate center of the ecoregion and represents one of the largest tracts of native shrub-steppe habitat remaining in Washington State.

The climate at Hanford is semi-arid with hot, dry summers and cold, wet winters. Based on data collected from 1945 through 2015 (http://www.hanford.gov/hms), the average monthly temperatures at the Hanford Meteorological Station ranged from a low of -0.4 °C (31.3 °F) in January to a high of 24.9 °C (76.9 °F) in July. Average annual precipitation at the Hanford Meteorological Station during this period was 17 cm (6.8 in). Most precipitation is received between October and April.

Although the Hanford Site's biological resources are characteristic of the Columbia Plateau Ecoregion, the site is unique in that it is located within the driest and hottest portion of the ecoregion (Franklin and Dyrness 1973). These climatic conditions result in somewhat unusual species assemblages relative to the rest of the ecoregion. These same conditions also may result in Hanford shrub-steppe communities being less resilient to disturbance, making restoration and rehabilitation after large-scale disturbance more difficult than other areas that are cooler and receive more precipitation.

A.1 SHRUB-STEPPE HABITAT

Extensive shrub-steppe and shrublands occur as a matrix with grasslands and dunes, or as large patch systems across eastern Washington's arid lands, with annual precipitation between 15 and 50 cm (6-20 inches). On the Hanford Site, this aggregation of systems generally appears across an elevation range from 150 to 230 m (490 to 750 ft), although there are higher elevations on Umtanum Ridge (550 m [1800 ft]), Gable Mountain (330 m [1,083 ft]), varied landforms (flats, plateaus, gentle slopes, rolling hills, broad basins, plains, foothills, alluvial slopes, steep open slopes, canyons, valleys, swales, mesa tops, alluvial flats), and on a diversity of soils (shallow, lithic soils; deep, well-drained and non-saline; saline, alkaline or calcareous; stony, volcanic-derived clays; alluvial sands; well-drained sandy or loamy soils; fine-textured soils). Vegetation may include shrubs and dwarf-shrubs, perennial herbaceous species (grasses and forbs), and annuals. The shrub layer is generally dominated by sagebrush (*Artemisia spp*.), bitterbrush (*Purshia tridentata*), spiny hopsage (*Grayia spinosa*), winterfat (*Krascheninnikovia lanata*), or buckwheat (*Eriogonum spp.*) and varies in composition and cover in response to soil characteristics, water availability, and disturbance (e.g. fire, frost-heaving, slope failure). Herbaceous cover also varies due to soil attributes, water availability, and past disturbance, generally increasing in cover from shrublands to shrub-steppe. Common bunchgrasses include bluebunch wheatgrass (*Psudoroegneria spicata*), Sandberg's bluegrass (*Poa secunda*), Idaho fescue (*Festuca idahoensis*), needle-and-thread grass (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), and sand dropseed (*Sporobolus cryptandrus*). Mosses, lichens and microphytic soil crusts are also characteristic.

This focal habitat includes the following ecological systems.

A.1.1 Inter-Mountain Basins Big Sagebrush Steppe (38% of the Hanford Site)

The Inter-Mountain Basins Big Sagebrush Steppe system is dominated by sagebrush and/or bitterbrush (*Purshia tridentata*) in an open to moderately dense (5 to 40% cover) shrub layer with at least 25% total perennial herbaceous cover. Depending on the site, associated grasses can include bluebunch wheatgrass (*Pseudoregnaria spicata*), Sandberg bluegrass (*Poa secunda*), Cusick's bluegrass (*Poa cusickii*), prairie junegrass (*Koeleria macrantha*), needle-and-thread grass (*Hesperostipa comata*), and Thurber's needlegrass (*Achnatherum thurberianum*).

Landforms that support shrub-steppe are a mosaic of patch types or plant associations that reflect differences in site (soils, precipitation zones) and fire effects. Soils can be deep (greater than 15 cm [6 in.]) to shallow and non-saline. The space between vascular plants often supports a biological crust that can cover up to 90% or more if there is no disturbance on the site. Biological crust cover generally decreases with increasing vascular plant cover, elevation, and soil disturbance.

This ecological system has a wide distribution, however, large areas are in poor to fair condition. Good to excellent condition areas are rare in communities where bluebunch wheatgrass and needle-and-thread grass are the dominant grasses (such as the Hanford Site) due to weed invasion. Conversion to agriculture is a serious threat outside of the Hanford Site within the Columbia Basin. The Inter-Mountain Basins Big Sagebrush Steppe is considered Imperiled (S2) within Washington State.

A.1.2 Inter-Mountain Semi-Desert Shrub-Steppe (16% of the Hanford Site)

This ecological system occurs in the hottest, driest (less than 20 cm [8 in.] per year) areas within the Columbia Basin. It is characterized by an open shrub to moderately dense woody layer and a strong grass layer. The woody layer is often a mixture of shrubs and dwarf shrubs, however, it can be dominated by a single shrub species. Characteristic shrubs in this system include spiny hopsage or winterfat with rubber rabbitbrush. Big sagebrush can also be present and grayball sage can be found in stonier sites. Characteristic grasses include Indian ricegrass, Thurber's needlegrass (*Achnatherum thurberiana*), squirreltail bottlebrush (*Elymus elymoides*), Sandberg bluegrass, and needle-and-thread grass. Annual grasses, especially cheatgrass, can be present to abundant in semi-desert shrub-steppe systems.

Within Washington State, the Inter-Mountain Basins Semi-Desert Shrub-Steppe is uncommon and has a limited range, thus the conservation status of this ecological system is Critically Imperiled (S1) within the State. Following fire or site disturbance, non-native annual species tend to replace perennials; there is a high potential for invasion of cheatgrass. In much of this system's likely historical range, it has been replaced by irrigated agriculture.

A.1.3 Columbia Plateau Scabland Shrubland (1.3% of the Hanford Site)

This ecological system is characteristicaly associated with flats, plateaus, and gentle to steep slopes with rock. Occurring on site with little soil development and areas of exposed rock, gravel, or compacted soil, these shrublands are extremely xeric and the vegetation is low (less than 0.5 m [1.6 ft]) with an open canopy. On Central Hanford, this ecological system is found primarily on Gable Mountain, Gable Butte, and Umtanum Ridge.

Scabland shrublands are generally dominated by stiff sagebrush (*Artemisia rigida*) along with other dwarf-shrub species, particularly buckwheat (*Erigonum*) species (e.g., slender buckwheat [*E. microthecum*], rock buckwheat [*E. sphaerocephalum*], strict buckwheat [*E. strictum*], and thymeleaf buckwheat [*E. thymoides*]).

Land uses in this system are few due to the rocky soils. The primary stressor on the Hanford Site is the introduction of invasive plant species and fire. Because this system provides little forage it is used little by livestock and the conservation status of the Columbia Plateau Scabland Shrubland ecological system is considered Secure (S5) in Washington State (Rocchio and Crawford 2015). On the study site, this system frequently forms a complex matrix with the Inter-Mountain Basins Big Sagebrush Steppe or the Inter-Mountain Basins Semi-Desert Shrub-Steppe ecological systems.

A.1.4 References

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A.2 GRASSLANDS HABITAT

Grasslands occur as a matrix with shrub-steppe, shrublands, and dunes or as large patch systems across the Hanford Site and within the Columbia Basin ecoregion. On the Hanford Site, this aggregation of systems generally appears across an elevation range from 150 to 230 m (490 to 750 ft), on varied landforms (e.g., flats, plateaus, gentle slopes, rolling hills, broad basins, plains, foothills, alluvial slopes, steep open slopes, canyons, valleys, swales, mesa tops, alluvial flats), and on a diversity of soils (e.g., shallow, lithic soils; deep, well-drained and non-saline; alluvial sands; well-drained sandy or loamy soils; fine-textured soils). Vegetation may include perennial herbaceous species (i.e., grasses and forbs), shrubs and sub-shrubs, and annuals. A healthy grassland ecosystem is marked by a dominant vegetative layer of native grasses with minimal invasive grasses, and a shrub overstory that is minimal to non-existent.

Most native perennial grass species commonly found on the Hanford Site are cool-season bunchgrasses. The vegetative layer of grasslands is dominated (greater than 25% cover) by native perennial bunchgrasses such as *Pseudoroegneria spicata*, *Hesperostipa comata*, *Achnatherum hymenoides*, *Festuca idahoensis*, *Sporobolus cryptandrus*, and *Poa secunda*. The shrub layer is minimal to non-existent and may include *Artemisia tridentata, Grayia spinosa, Purshia tridentata, Chrysothamnus viscidiflorus, Ericameria nauseosa,* and/or sub-shrubs such as *Eriogonum* species. Native forbs may represent a minor component of the community and include species such as balsamroot (*Balsamorhiza* spp.), primrose (*Oenothera* spp.), globemallow (*Sphaeralcea* spp.), and desert parsley (*Lomatium* spp.). The presence of a biological crust in the space between plants is also characteristic and indicates a lack of disturbance.

Habitats that are dominated by annual or perennial non-native species such as *Bromus tectorum*, *Agropyron cristatum*, and *Poa bulbosa* are degraded grasslands and do not represent the focal grassland habitat. These areas are common within the Hanford Site, especially within abandoned cultivated fields, areas disturbed by construction or other Hanford project activities, and in some areas that have been disturbed by wildfire. Grassland habitat in good condition has a significantly higher (greater than 10%) proportion of native grasses relative to the non-native grasses.

Though grasslands are not always created as a result of fire, fire is a significant component in the creation of grassland habitats. Often, shrub-steppe ecosystems with significant shrub coverage and a native grass understory that are affected by fire will see a reduction in the shrub overstory. The perennial bunchgrasses may rejuvenate and become the dominant vegetative layer in the habitat. After decades, the shrub overstory may grow back to the point of dominance. This transition from shrub-dominated to grass-dominated habitats is characteristic of shrub-steppe ecosystems undergoing a natural fire regime.

A.2.1 References

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A.3 DUNES HABITAT

Dunes are a large patch, unvegetated to moderately vegetated system occurring on active and stabilized sand dunes and sandsheets in the Columbia Basin. This focal habitat is comprised of the Inter-Mountain Basins Active and Stabilized Dune ecological system and is found on roughly 38% of the land area of the Hanford Site.

Inland active or stabilized dunes and sandsheets with patchy or sparse vegetation occur across the Columbia Basin. In general, the vegetation cover is related to the amount of annual rainfall and rate of evapotranspiration. Species occupying the dune environment are often adapted to shifting, coarse-textured substrates and form patchy or open grasslands, shrublands, or steppe. Vegetation cover ranges from sparse (less than 20%) to moderate (greater than 60%) and species composition is related to the degree of sand stabilization, vegetation cover, and position on the dune.

Scurf pea (*Psoralidium lanceolatum*) and Indian ricegrass typically dominate the initial stages of stabilization and are also commonly found on dunes with varying stages of stabilization. Prior to stabilization, shrubs are spare and thickspike wheatgrass (*Elymus lanceolatus*), a rhizomatous grass, and herbs such as winged dock (*Rumex venosus*) and whiteleaf scorpionweed (*Phacelia hastata*) are common. With increased sand stabilization, shrubs are often dominant(e.g., rubber and yellow rabbitbrush, bitterbrush, snow buckwheat, and big sagebrush). Forbs such as pale evening-primrose (*Oenothera pallida*), sand beardtongue (*Penstemon acuminatus*), whiteleaf scorpionweed, terpentine springparsley (*Pterixia terebintha*), Columbia cutleaf (*Hymenopappus filifolius*), thread leaf scorpianweed (*Phacelia linearis*), Carey’s balsamroot (*Balsamorhiza careyana*), terpentine springparsley (*Pterixia terebinthua*), Columbia cutleaf (*Hymenopappus filifolius*), threadleaf fleabane (*Erigeron filifolius*), and prairie junegrass (*Koeleria macrantha*) are common but contribute little to the total vegetation cover. Non-native weedy species like cheatgrass, Russian thistle (*Salsola tragus*), and tumblemustard (*Sisymbrium altissimum*) are common and sometimes abundant. Where dunes have overridden or partially covered other soil types, Sandberg bluegrass or other shrub-steppe species are often present.

The inland dune ecological system has always been relatively rare in Washington State. The total extent of this system has declined approximately 76% since the early 1970s due primarily to agricultural conversion, reservoir flooding, and dune stabilization. Inter-Mountain Basins Active and Stabilized Dune systems are ranked as Critically Imperiled (S1) in Washington State. The Washington State

Natural Heritage Program has issued the *Conservation Strategy for Washington State Inland Sand Dunes* (Hallock et al. 2007) that identifies management strategies for the conservation of these systems. Two areas on the Central Hanford Site are identified in this strategy document as having significant conservation value.

A.3.1 References

Hallock, L.A., R.D. Haugo, and R. Crawford. 2007. *Conservation Strategy for Washington State Inland Sand Dunes*. Washington Natural Heritage Program Report 2007-5. Washington State Department of Natural Resources, Olympia, Washington. Available online at http://file.dnr.wa.gov/publications/amp_nh_inland_dunes.pdf

A.4 BURROWING ANIMALS AND ASSOCIATED SPECIES

This focal group of species captures burrowing animals and associated species and their specific habitat selection characteristics, including soil and vegetation community types. A range of burrowing animals and associated species from American badgers (*Taxidea taxus*) and northern pocket gophers (*Thomomys talpoides*) to harvester ants (*Pogonomyrmex owyheei*) and Burrowing Owls (*Athene cunicularia*) occur on the Hanford Site. Two species of ground squirrels are found on the Hanford Site: the Washington ground squirrel (*Urocitellus washingtoni*), which occurs north and east of the Columbia River, and the Townsend's ground squirrel (*Urocitellus townsendii*), which occurs south and west of the Columbia River (Central Hanford). Habitat characteristics selected by the Townsend's ground squirrel will be used to represent habitat requirements for burrowing animals and associated species on the Hanford Site.

A.4.1 Townsend's Ground Squirrel (*Urocitellus townsendii*)

Townsend's ground squirrels are important to the shrub-steppe ecosystem for many reasons. They serve as a food source for mammals (e.g., badgers and coyotes) and fall prey to predatory birds (e.g., hawks, falcons, and owls). Ground squirrels are an important food item for Ferruginous Hawks, a Washington State threatened species, in many portions of their range (Fitzner et al. 1981). The ground squirrel diet consists of a variety of foods including seeds, which contributes to native plant seed dispersal. The burrows that ground squirrels dig help to aerate the soil and provide burrows for other species including Burrowing Owls, which are a federal species of concern (Sato 2012).

During much of the year, ground squirrels are underground for hibernation and estivation. The ground squirrels' lifecycle consists of several seasonal components. During mid- to late January, squirrels emerge from their burrows after hibernation. They spend the next month breeding followed by gestation and rearing of young. The young become active outside the burrow by mid-April. Ground squirrels become dormant again starting in late May to late June, entering a type of torpor called estivation that is used to avoid the hot and dry portion of the year (WDFW 2012). After estivation, ground squirrels emerge and spend late September and October foraging in preparation for hibernation.

Ground squirrels require soils that are easily excavated yet provide stability for their burrow networks. Soil texture strongly influences the ability of a burrow to remain stable, as well as the nutrient-holding ability of a soil, the amount of water the soil can store, the amount of this water that is available to plants, how fast water moves through the soil, and many other properties. Soil depth is also important for ground squirrels as deeper burrow networks can provide insulation from extreme temperatures. Regional studies have shown that ground squirrels may select sites based on soil characteristics more than other variables and have a preference for deep silt loam soils (Greene 1999).

Townsend's ground squirrels consume green vegetation during their active period from early winter into late spring, then shift their focus to the seeds of grasses and forbs to prepare for estivation (Yensen et al. 1992). A study on the diets of Townsend's ground squirrels on the Arid Lands Ecology Reserve showed that their intake was primarily Sandberg's bluegrass followed by a variety of forbs, including western tansymustard, lupine, and long-leaf phlox (Rogers and Gano 1980). In areas where fire destroyed the native shrub and bunchgrasses, cheatgrass (*Bromus tectorum*) can be an important food source; however, wild fluctuations in productivity due to year-to-year changes in precipitation can cause populations in these areas to be much less stable (Yensen et al. 1992). While shrubs could potentially offer cover and some level of burrow stability, ground squirrels can detect predators at a greater distance in areas with little to no shrub canopy. It is believed that line-of-sight availability prevails in site selection (Sharpe and Van Horne 1998).

A.4.2 References

Fitzner, R.E., W.H. Rickard, L.L. Cadwell, and L.E. Rogers. 1981. *Raptors of the Hanford Site and Nearby Areas of Southcentral Washington*. PNL-3212. Pacific Northwest National Laboratory, Richland, Washington.

Greene, E. 1999. *Abundance and habitat associations of Washington ground squirrels in north-central Oregon*, Master's thesis, Oregon State University, Corvallis, Oregon.

Rogers, L.E. and K.A. Gano. 1980. "Townsend Ground Squirrel Diets in the Shrub-Steppe of Southcentral Washington." *Journal of Range Management* 33 (6): 463–465.

Sato, C. 2012. "Appendix A.5: Habitat Connectivity for Townsend's Ground Squirrel (*Urocitellus townsendii*) in the Columbia Plateau Ecoregion." In *Washington Connected Landscapes Project: Analysis of the Columbia Plateau Ecoregion*. Washington Wildlife Habitat Connectivity Working Group. Washington's Department of Fish and Wildlife and Department of Transportation, Olympia, Washington. Specific Appendix Online at: http://www.waconnected.org/wp-content/themes/whcwg/docs/A5_TownsendsGroundSq_ColumbiaPlateau_2012.pdf.

Sharpe, P.B. and B. Van Horne. 1998. "Influence of habitat on behavior of Townsend's ground squirrels (*Spermophilus townsendii*)." *Journal of Mammalogy* 79 (3): 906–918.

WDFW. 2012. *Threatened and Endangered Wildlife in Washington: 2011 Annual Report*. Endangered Species Section, Wildlife Program, Washington State Department of Fish and Wildlife, Olympia, Washington. Online at: http://wdfw.wa.gov/publications/01385/wdfw01385.pdf.

Yensen, E., D.L. Quinney, K. Johnson, K. Timmerman, and K. Steenhof. 1992. "Fire, vegetation changes, and population fluctuations of Townsend's ground squirrels." *American Midland Naturalist* 128:299–312.

APPENDIX B

VIABILITY ASSESSMENT FOR FOCAL HABITATS AND SPECIES

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APPENDIX B
VIABILITY ASSESSMENT FOR FOCAL HABITATS AND SPECIES

B.1 COMPLETED VIABILITY ASSESSMENT

The Mission Support Alliance's Ecological Monitoring Program team completed a viability assessment for the four focal habitats and species selected as the focus for the habitat assessment and prioritization for the Hanford Site (Table B-1). The focal habitats, species, and viability assessment were carried out following Open Standards methodology (http://cmp-openstandards.org/; TNC 2007; FOS 2009). The rationale for selection of each key ecological attribute, the sources of information used, and notes pertaining to how to relate the ratings to existing datasets or translate these attribute-indicator pairs into a Geographic Information System are further documented in an Excel file available upon request from MSA staff. This file contains any changes made as the habitat assessment and prioritization progresses.

B.1.1 References

FOS. 2009. *Conceptualizing and Planning Conservation Projects and Programs: A Training Manual*. Foundations of Success, Bethesda, Maryland. Available online at http://cmp-openstandards.org/wp-content/uploads/2016/02/FOS-CMP-Online-Training-Guide-Steps-1-and-2-updated-8-Feb-2012.pdf.

TNC. 2007. *Conservation Action Planning Handbook: Developing Strategies, Taking Action and Measuring Success at Any Scale*. The Nature Conservancy, Arlington, Virginia. Available online at http://conserveonline.org/workspaces/cbdgateway/cap/practices.

Table B-1. Completed Viability Assessment for Focal Species and Habitats. (3 Pages)

Category	Key Ecological Attribute	Indicator	Excellent	Good	Fair	Poor
Focal Habitat: Shrub-Steppe						
Landscape Context	Fire Regime	Fire Return Interval	> 15 years	12-15 years	3-12 years	< 3 years
Condition	Wildlife Community	Presence of Sagebrush Obligate Wildlife Species (Sagebrush Sparrows, Sage Thrasher, Loggerhead Shrike, Brewer's Sparrow, Black Tailed Jackrabbits)	5 species	3-4 species	1-2 species	0 Species
Condition	Critical/Unique Habitats	Presence of Critical/Unique Habitats (Talus slopes/cliffs, lithosols, vernal pools, snake hibernacula, rookeries, bat roosting sites, riparian habitats, critical habitat for federal threatened or endangered species).	3 or more present	2 present	1 present	0 present
Condition	Native Shrub Cover	Percent Cover	> 3% Cover	Present to approximately 3%	Irregular or patchy distribution within a polygon	No shrubs
Condition	Vegetative Composition	Vegetation Cover Type	Level 5 Element Occurrence - Not Sand Dune Complex Types	Level 4 Vegetation Cover Types	Level 3 Vegetation Cover Types	Level 2 Vegetation Cover Types, Level 1 Vegetation Cover Types, Level 0 Resources
Landscape Context	Connectivity	Proximity to Other Patches	TBD	TBD	TBD	TBD
Size	Patch Size	Area	>1000 ha	> 500-1,000 ha	16-500 ha	< 16 ha
Condition	Vegetative Composition	Lack of Noxious Weeds	0/ha	<5/ha	5-25/ha	>25/ha

Table B-1. Completed Viability Assessment for Focal Species and Habitats. (3 Pages)

Category	Key Ecological Attribute	Indicator	Excellent	Good	Fair	Poor
Focal Habitat: Grasslands						
Size	Patch Size	Area	100 ha	50-100 ha	10-50 ha	<10 ha
Landscape Context	Connectivity	Proximity to Other Patches	TBD	TBD	TBD	TBD
Landscape Context	Fire Regime	Fire Return Interval	<3 years	3-12 years	12-15 years	>15 years
Condition	Vegetation Composition	Vegetation Cover Type	Bunchgrasses, [Snow buckwheat]/Bunchgrasses, Half-Shrubs/Bunchgrasses	Bunchgrasses with patchy / < 3% shrub cover	> 3% shrub cover with bunchgrass understory	Cheatgrass understory
Condition	Native Shrub Cover	Percent Cover	No shrubs	Irregular or patchy distribution within a polygon (Indicated by brackets in Vegetation Report)	Present to approximately 3% (Indicated by parentheses in Vegetation Report)	> 3% Cover (Indicated by no modifier in Vegetation Report)
Condition	Presence of Critical/Unique Habitats	Presence of Critical/Unique Habitats (Talus slopes/cliffs, lithosols, vernal pools, snake hibernacula, rookeries, bat roosting sites, riparian habitats, critical habitat for federal threatened or endangered species).	3 or more present	2 present	1 present	0 present
Condition	Vegetative Composition	Lack of Noxious Weeds	0/ha	<5/ha	5-25/ha	>25/ha
Focal Habitat: Dunes						
Condition	Ecosystem Intactness	Indicator Rare Dune Plant Species	3 or more species	2 species	1 specie	0 species

Table B-1. Completed Viability Assessment for Focal Species and Habitats. (3 Pages)

Category	Key Ecological Attribute	Indicator	Excellent	Good	Fair	Poor
Size	Large System Acreage	Acreage of Open Sand	> 800 ha	400-800 ha	160-400 ha	< 160 ha
Condition	Vegetation Composition	Vegetation Cover Type	Element occurrence designated areas and open sand (no vegetation)	Bunchgrass dominated ynderstory	Cheatgrass dominated understory	Non vegetated/Industrial areas
Condition	Soil Type	Presence of Sandy Soil		Sand present	Sand absent	
Condition	Vegetative Composition	Lack of Noxious Weeds	0/ha	<5/ha	5-25/ha	>25/ha
Landscape Context	Connectivity	Proximity to Other Patches	TBD	TBD	TBD	TBD
Focal Species Group: Burrowing Animals						
Landscape Context	Connectivity among Communities	Dispersal Distance	0-500 m	500-1,000 m	1,000-2,000 m	>2,000m
Condition	Soil Type & Depth	Type & Depth	Deep silt loam	Shallow silt loam	Silty/loamy	Sandy soil
Landscape Context	Townsend's Ground Squirrel Habitat [a]	Concentration Areas	>95%	90-95%	85-90%	<85%
Landscape Context	Burrowing Owl Habitat [a]	Concentration Areas	TBD	TBD	TBD	TBD

[a] From habitat suitability models created in previous scopes of work within the Ecological Monitoring program.

TBD = to be determined

APPENDIX C

DATA AVAILABILITY AND DATA GAPS

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APPENDIX C
DATA AVAILABILITY AND DATA GAPS

In the process of developing and completing the viability assessment for the four focal habitats and species that will guide the habitat assessment and prioritization, the Mission Support Alliance Ecological Monitoring Program team crosswalked potential key ecological attributes and indicators with the data they have available for the Hanford Site. The project categorized each potential attribute-indicator pair based on data availability and potential for filling remaining data gaps (Tables C-1 and C-2). This availability of data then informed the final set of attributes-indicators contained in the viability assessment. Therefore, the attributes and indicators in this evaluation of data availability do not directly match those in the final viability assessment (Appendix B). As the project moves forward in preparing the data layers as inputs to the MARXAN model, and as further data are collected in the future (for this or other projects), the project may be able to include more or different attribute-indicator pairs as MARXAN targets in further iterations of the habitat assessment and prioritization.

Note: Entries listed in Table C-2 that contain strikeout formatting (~~Entry~~) were items that were developed during the workshops and modified or removed by the publication of this document.

Table C-1. Cell Format and Color-Coding Showing Decisions the Project Made on Data Availability and Data Gaps

Green Boxes indicate we have all the information we need.	**Yellow Boxes** indicate we have some information, but are planning on collecting more data through a Rapid Assessment.
Red Boxes indicate we have No Information and cannot use this KEA without collecting data through a Rapid Assessment.	~~**Boxes with crossed out text**~~ are key ecological attributes that have been eliminated from the list due to data availability issues.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes
Focal Habitat: Shrub-Steppe					
Landscape Context	Fire Regime	Departure from Historical Fire Regime	Fire Map	No	Must match Indicator for Grassland and Shrub-steppe Fire Regimes. The Ratings should be different to reflect different impacts of fire to the habitats, but Indicator should be the same. **Action:** Determine Indicator. **Action:** Determine feasibility of mapping.
Condition	Wildlife Community	Presence of Sagebrush Obligate Wildlife Species (e.g., Sagebrush Sparrows, Jackrabbits)	Species Presence Layers (Jackrabbits, Sagebrush Sparrows)	Add Indicator to Rapid Assessment	Added Sage Thrashers and Brewer's Sparrow to indicator list with Sagebrush Sparrows and Jackrabbits. **Action:** Determine if there are any other sagebrush obligate species we should add to list.
Condition	Biological Crust	Coverage	None	Add Indicator to Rapid Assessment	Added Biological Crust to Grasslands as well. Rapid assessment would give general idea of presence in area. Without Rapid Assessment, we will not be able to use this KEA.
Condition	Critical/Unique Habitats	Presence of Critical/Unique Habitats	Critical/Unique Habitats layers	No	Added Critical Unique Habitat to Grasslands and Dunes. **Action:** Define critical unique habitats for all areas.
Condition	Native Shrub Cover	% Cover	Some data in Vegetation Layer	Marginal; Could add to Rapid Assessment (same as Grasslands)	Currently only have information on >3% shrub cover. Would likely need more intensive field work that cannot be satisfied in a Rapid Assessment. **Action:** Decide between Options (1) work with >3% data; (2) determine feasible field methods for rapid assessment; or (3) work with >3% data and perform extensive survey in 2019.
Condition	Understory Composition	Ratio between Natives & Non-natives Native vs. Non-native species composition	Some Data in Vegetation Layer	Yes Can change indicator to work with our Vegetation Layer Data	Will be same indicator as in Grasslands and Dunes. Can use vegetation layer data to determine relative levels of native and non-native species and rate sites based on dominant species composition.
Landscape Context	Connectivity	Proximity to Other Patches	Vegetation Layer	No	Have GIS data in the Vegetation Layer. No additional data/actions needed.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes
Size	Patch Size	Area	Vegetation Layer	No	Have GIS data in the Vegetation Layer. No additional data/actions needed.
Condition	BRMP Level [a]	Area	BRMP Layers	No	KEAs adequately cover the information that would be displayed in BRMP, with the exception of Bald Eagles and FEHA, which are not indicators of good shrub-steppe habitat.
Condition	Vegetative Composition	Lack of Noxious Weeds	Some data in vegetation layer	Add indicator to Rapid Assessment	Added to list. Current KEAs do not take presence of noxious weeds into account. Lack of noxious weeds indicates the habitat is resistant to invasion and higher quality than one with noxious weeds. Easy to add to Rapid Assessment.
Focal Habitat: Grasslands					
Size	Patch Size	Area	Vegetation Layer	No	Have GIS data in the Vegetation Layer. No additional data/actions needed.
Condition	Vegetation Composition	Native Forbs, Abundance & Diversity	~~Some Data in Vegetation Layer~~ None	Could add to Rapid Assessment	No data on forbs. Would require intensive field survey in 2019 to get good information. Could add to Rapid Assessment in simplified form to capture some data on forb presence. **Action:** Determine what component of the forb community (abundance, diversity) it is feasible to measure in the Rapid Assessment. **Action:** If we add this to Grasslands, should we add it to Shrub-steppe and Dunes?
Landscape Context	Connectivity	Proximity to Other Patches	Vegetation Layer	No	Have GIS data in the Vegetation Layer. No additional data/actions needed. Remember proximity to good/very good Shrub-steppe and Dune habitat should be counted in this.
Landscape Context	Fire Regime	Departure from Historical Fire Regime	Fire Map	No	Must match Indicator for Grassland and Shrub-steppe Fire Regimes. The Ratings should be different to reflect different impacts of fire to the habitats, but Indicator should be the same. **Action:** Determine Indicator. **Action:** Determine feasibility of mapping.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes
Condition	Vegetation Composition	~~Ratio of Perennial Natives vs. Invasives~~ Native vs. Non-native species composition	Some Data in Vegetation Layer	~~Yes~~ Can change indicator to work with our Vegetation Layer Data	Will be same indicator as in Shrub-steppe and Dunes. Can use vegetation layer data to determine relative levels of native and non-native species and rate sites based on dominant species composition.
~~Condition~~	~~Interstitial Spacing/Fragmentation~~	~~Distance between Perennials~~	~~None~~	~~Yes~~	Removed due to lack of supporting research and difficulty of collecting this information.
Condition	Native Shrub Cover	Percent Cover	Some Data in Vegetation Layer	Marginal; Could add to Rapid Assessment (same as Shrub-steppe)	Currently only have information on >3% shrub cover. Would likely need more intensive field work that cannot be satisfied in a Rapid Assessment. **Action:** Decide between options (1) work with >3% data, (2) determine feasible field methods for rapid assessment, or (3) work with >3% data and perform extensive survey in 2019. For grasslands it is easier to use our current data, if we want to say that "good" grasslands have <3% shrub cover.
~~Condition~~	~~BRMP Level~~ [a]	~~Area~~	~~BRMP Layers~~	~~No~~	
Condition	Biological Crust	Coverage	None	Add Indicator to Rapid Assessment	Added Biological Crust to Shrub-steppe as well. Rapid assessment would give general idea of presence in area. Without Rapid Assessment, we will not be able to use this KEA.
Condition	Critical Unique Habitat	Presence of Critical/Unique Habitats	Critical/Unique Habitats layers	No	Added Critical Unique Habitat to Grasslands and Dunes. **Action:** Define critical unique habitats for all areas.
Condition	Vegetative Composition	Lack of Noxious Weeds	Some data in vegetation layer	Add indicator to Rapid Assessment	Added to list. Current KEAs do not take presence of noxious weeds into account. Lack of noxious weeds indicates the habitat is resistant to invasion and higher quality than one with noxious weeds. Easy to add to Rapid Assessment.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes
Focal Habitat: Dunes					
Condition	Ecosystem Intactness	Indicator Rare Dune Plant Species	Rare Plants	Add indicator to Rapid Assessment	Rapid assessment provides good opportunity to identify new rare plant locations within the dunes. Would just be incidental sightings, not full survey. Would be fine with data we have if necessary.
Condition	Non-Fragmentation	Intact without Fragmentation	Infrastructure Layers	Conceptualize & Create Layer	Have the data. Important in keeping matrix of active dunes and allowing movement. **Action:** Need to figure out how to create layer with the data we have. Could use similar method to Ground Squirrel model.
Condition	Ecosystem Intactness	Indicator Wildlife Species	Some Wildlife Data Points	Add indicator to Rapid Assessment	Have limited data on reptiles. Found sagebrush lizards prefer the Southern face of dunes. More species information would be useful in determining highly “used” areas of dune by noting tracks and animal sightings. **Action:** Finalize list of indicator wildlife species/signs.
Size	Large System Acreage	Acreage of Open Sand	Vegetation, Soils, & Surface Geology Maps	No	Have GIS data. Richard used methods in veg map that could be used to identify open sand.
Condition	Successional Diversity	Appropriate Amount of Active Dune & Stabilized Dune	Vegetation & Surface Geology Maps	Conceptualize & Create Layer	**Action:** Need clarification on what this group wanted to know/measure with this Indicator. Where do we find supporting information about what a “good” amount of active vs. stabilized dune looks like? If not enough supporting research, remove Indicator.
Condition	Vegetation Composition	~~Native Forbs, % Cover, & Diversity~~ Native vs. Non-native species composition	Data in Vegetation Layer	~~Yes~~ Can change indicator to work with our data	Same methods as shrub-steppe and grasslands. Importance in dune habitat as cheatgrass with artificially stabilize dunes.
~~Condition~~	~~BRMP Level [a]*~~	~~Area~~	~~BRMP Layers~~	~~No~~	
Condition	Soil Type	Presence of Sandy Soil	Soil data	No	Need soil information as key characteristic in distinguishing dunes from most other habitats.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes
Condition	Vegetative Composition	Lack of Noxious Weeds	Some data in vegetation layer	Add indicator to Rapid Assessment	Added to list. Current KEAs do not take presence of noxious weeds into account. Lack of noxious weeds indicates the habitat is resistant to invasion and higher quality than one with noxious weeds. Easy to add to Rapid Assessment.
Landscape Context	Connectivity	Proximity to Other Patches	Vegetation Layer	No	Have GIS data in the Vegetation Layer. No additional data needed. Remember proximity to good/very good Shrub-steppe and Grasslands habitat should be counted in this. **Thought**: this could replace our "appropriate amount of active and stabilized dune" indicator.
Focal Species Group: Burrowing Animals					
Landscape Context	Connectivity among Communities	Dispersal Distance	Ground Squirrel Colonies	No	Have data. No further collection required.
Condition	Soil Type & Depth	Type & Depth	Soils & Surface Geology Maps	Maybe (Soil Depth)	**Action:** Needs further discussion. Is measuring soil depth feasible/efficient in a Rapid Assessment? If not, may have to stick to only soil type.
~~Condition~~	~~Vegetation Composition~~	~~% Native Grasses & Forbs~~	~~None~~	~~Yes~~	~~Included in Townsend's Ground Squirrel Habitat Assessment.~~
Condition	Protection Structure	% Structure Cover	Vegetation Layer, Possibly Digitize Small Structures	Maybe	**Action:** Needs further discussion about feasibility of digitizing small protection structures. If not feasible, remove from Indicators.
Size	Population	Active Burrow Density	Some Data	No	Have data on active burrows.
~~Size~~	~~Topography~~	~~Slope, Covariance of Slope~~	~~Slope, Covariance of Slope Layers~~	~~No~~	~~Included in Townsend's Ground Squirrel Habitat Assessment.~~
Landscape Context	Townsend's Ground Squirrel Habitat [a]	Concentration Areas	Model Output	No	
Landscape Context	Burrowing Owl Habitat [a]	Concentration Areas	Model Output	No	**Action:** Are these concentration areas covered by the Townsend's Ground Squirrel habitat? Could add into model and if it doesn't significantly change the output, do not include.

Table C-2. Data Availability and Data Gap Decision for Focal Species and Habitats. (6 Pages)

Category	Key Ecological Attribute	Indicator	Map Layer Available	Additional Data Collection	Meeting Notes

[a] From habitat suitability models created in previous scopes of work within the Ecological Monitoring program.

BRMP = *Biological Resources Management Plan*
FEHA =
GIS = Geographic Information System
KEA = key ecological attributes

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