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TRANSWEST EXPRESS TRANSMISSION PROJECT

GREATER SAGE-GROUSE MITIGATION AND HABITAT EQUIVALENCY ANALYSIS PLAN

The **TransWest Express Transmission Project** (TWE Project) is a proposed extra-high-voltage direct-current electric transmission system under development by TransWest Express LLC (TransWest). The proposed 725 mile route will begin in south-central Wyoming, extend through northwestern Colorado and central Utah, and end near Las Vegas. The TWE Project will provide the transmission infrastructure and capacity necessary to reliably and cost-effectively deliver approximately 3,000 megawatts of clean and sustainable electric power generated in Wyoming to the Desert Southwest region (Arizona, California, Nevada), ultimately helping contribute to a cleaner world, strengthen the electric grid, and provide much-needed electricity to millions of homes and businesses every year. National, regional and state environmental policies have significantly increased the need for renewable resources in this area. At the same time, Wyoming has an abundance of high-quality, low-cost renewable resources in the form of wind energy. In fact, the vast majority of the best winds in the Continental U.S. are available in Wyoming. The need for the TWE Project is supported by numerous studies that have documented the increase in demand for renewable energy resources within the Desert Southwest. For purposes of electric supply reliability, the TWE Project will be built in accordance to standards developed and enforced by the North American Electrical Reliability Corporation and the Western Electricity Coordinating Council.

In 2010, Western Area Power Administration (Western) decided to pursue a 50 percent equity partnership in the TWE Project, as part of Western's Transmission Infrastructure Program. In September 2011, Western finalized an agreement with TransWest to co-fund the TWE Project's development phase. Western will decide whether to continue its participation into the construction phase after the environmental analysis is complete. The TWE Project has been selected by a new federal "Rapid Response Team for Transmission" as one of five priority transmission projects in the Western U.S. and the only one to connect into California balancing authorities.

The TWE Project will cross federal, state and private lands along its route from Wyoming to Nevada. Approximately 67% of the proposed route is on federal land. These lands are primarily public lands administered by the Bureau of Land Management (BLM). As such, TransWest filed an application with BLM for a Right-of-Way (ROW) grant across public lands. The BLM, in compliance with the National Environmental Policy Act of 1969 (NEPA), is preparing an environmental impact statement (EIS) for the TWE Project to inform its decision making on TransWest's ROW grant application. Western also is

required to comply with NEPA as it considers its final decision to participate in the TWE Project. Consequently, the BLM Wyoming State Office and Western have been designated joint-lead federal agencies for the NEPA process, and are jointly overseeing the preparation of the EIS.

In December 2011, BLM released an instruction memorandum to help guide conservation actions aimed at conserving greater sage-grouse (*Centrocercus urophasianus*) and its sagebrush habitat. Instruction Memorandum No. 2012-043 (IM 2012-43) seeks to balance conservation actions benefiting sage-grouse while maintaining a robust economy in the West. Among other things including on-site mitigation, IM 2012-43 encourages BLM to cooperate with project proponents to develop and consider implementing appropriate off-site mitigation that the BLM, coordinating with the respective state wildlife agency, determines would avoid or minimize habitat and population-level effects. The IM states that when developing such mitigation, the BLM should consider compensating for the short-term and long-term direct and indirect loss of greater sage-grouse and its habitat.

The BLM, working in concert with the U. S. Fish and Wildlife Service (Service), has developed a Framework for Sage-grouse Impacts Analysis for the TransWest Express Transmission Project (draft dated January 2012, Framework). The Framework addresses project-related impacts to sage-grouse habitat that bear directly on listing factors considered by the Service when evaluating the need to provide full listing protection under the Endangered Species Act (ESA). An important part of the Framework considers mitigation. According to the Framework, mitigation is addressed after the impacts analysis for the TWE Project has been conducted by agency biologists leading to an adequate understanding of impacts to sage-grouse populations and habitat, which is described in the EIS. The Framework specifies the use of Habitat Equivalency Analysis (HEA), conducted by the project proponent, as a standardized basis for determining for determining appropriate mitigation for project impacts.

The Framework states, “The HEA is not meant to be an impacts analysis in and of itself; rather, it is one part of an overall wildlife impacts analysis that objectively determines quantity of project-related habitat impacts and provides the quantity and type of mitigation necessary to offset loss of habitat services as a form of output.” This HEA is not an impacts analysis for the Project. Rather, it is a decision-support tool intended to be used to develop an appropriate mitigation package for the preferred alternative identified by the BLM. It is anticipated that the HEA will model loss of habitat services associated with vegetation loss (direct effect), noise (indirect effect), and human presence (indirect effect). Additional Project effects (e.g., introduction and spread of invasive species; decreased lek attendance; habitat loss caused by behavioral avoidance of transmission corridors; increased public access and associated impacts [e.g., noise, trash]; and increased predation and nesting by raptors and corvids due to the presence of transmission structures) may not be included in the HEA because of lack of information necessary to establish a quantified relationship between the construction and operation of the transmission line and response by greater sage-grouse.

The proposed route and alternative routes for the TWE Project under consideration by BLM and Western cross lands in Wyoming, Colorado and Utah identified as Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH) pursuant to IM 2012-43. As such, TransWest has been requested to consider mitigation (both on-site and off-site) appropriate to avoid and minimize habitat and population-level effects to sage-grouse.

TransWest, in compliance with IM 2012-43 and the Framework, will complete a HEA to determine the amount of compensatory mitigation necessary to offset the impacts to sage-grouse resulting from the construction, operation and maintenance of the TWE Project. The HEA will be completed for areas of Colorado, Utah and Wyoming having known sage-grouse habitat intersected by the Agency Preferred Alternative selected by BLM and Western through the NEPA process. The HEA will be performed by TransWest through qualified environmental consultants and will require close coordination with the BLM, Western, and other stakeholders to ensure that the compensatory mitigation identified in the HEA process avoids and minimizes impacts from the TWE project to the extent practicable.

The following sections describe the HEA process and identify the potential types of mitigation measures that could be used to compensate for the interim and permanent impacts to sage-grouse and its habitat.

Overview of Habitat Equivalency Analysis

HEA is a science-based, peer-reviewed method of quantifying interim and permanent habitat injuries, measured as a loss of habitat services from pre-disturbance conditions, and scaling compensatory habitat requirements to those injuries (King 1997; Dunford et al. 2004; Allen et al. 2005; Kohler and Dodge 2006; National Oceanic and Atmospheric Administration [NOAA] 2006, 2009). Habitat services include those ecosystem features (i.e., physical site-specific characteristics of an ecosystem) and ecosystem functions (i.e., biophysical processes that occur within an ecosystem) that support wildlife and human populations (King 1997).

Habitat services are generally quantified using a metric that represents the functionality or quality of habitat (i.e., the ability of that habitat to provide wildlife “services” such as nest sites, forage, cover from predators, etc.). When wildlife habitat is the primary service of interest, areas with the highest habitat service levels are those areas with highest habitat quality. Interim (or short-term) habitat injuries are those services that are absent during certain phases of the project that would have been available if that disturbance had not occurred (e.g., temporary vegetation losses, temporary soil partitioning, temporary displacement of wildlife populations). Permanent habitat injuries are those habitat injuries remaining after project completion and interim reclamation and recovery are complete (e.g., permanent vegetation loss, permanent loss of wildlife or fisheries populations, irrecoverable impacts to soils or water as a result of contamination).

HEA uses a service-to-service approach to scaling. HEA does not assume a one-to-one trade-off in resources (e.g., number of acres). Rather, HEA balances the number of services lost with those that are gained as a result of conservation activities (NOAA 2006). For example, one acre of land with a diverse vegetative structure and abundant tree canopy can support higher numbers of nesting songbirds (the resource service of interest) than one acre of land with few trees and little vegetative diversity. The two land parcels, although equal in size, provide unequal resource services.

What Does Habitat Equivalency Analysis Do?

HEA is an economics model that:

- Quantifies current resources provided in a project area or landscape (commonly referred to as the baseline habitat service level)
- Quantifies the interim and permanent injuries to the baseline habitat service level
- Determines appropriately scaled restoration and conservation activities to offset habitat services lost as a result of project impacts

Benefits of Habitat Equivalency Analysis

The benefits of HEA include:

- High credibility – the approach has been evaluated and documented in scientific peer-reviewed literature and has held up in numerous court cases
- Quantitative rather than qualitative in nature
- Equations are straightforward, but have enough input variables to allow flexibility in project design
- Provides a replicable method for negotiation of mitigation ratios, acceptable compensatory restoration, and/or fines
- Valuable planning tool; can be used to evaluate the cost of multiple compensatory mitigation measures
- Applicable to any ecosystem type where an appropriate habitat services metric can be defined
- Currently the most commonly used method by natural resource trustees to assess damages to ecosystems
- Used by federal regulatory agencies, such as the U.S. Fish and Wildlife Service, NOAA, BLM, Environmental Protection Agency, Department of Interior, U.S. Army Corps of Engineers

When Habitat Equivalency Analysis Should Be Used (Chapman 2004)

HEA is an appropriate tool for scaling mitigation:

- When resource services can be defined or modeled
- When quantification of project impacts is possible
- When replacement of services lost is feasible
- When conservation methods are sufficiently known

Compensation Components

Compensation for impacts includes two components: (1) recovery of the injured area (primary restoration; Figure 1), and (2) compensation for the interim loss of habitat services occurring prior to full recovery (compensatory restoration; Figure 2).

HEA quantifies the habitat services lost during the lifetime of a project compared to baseline (Area X in Figure 1) and scales the compensatory project so that it provides services that are equal to that loss (Area Y in Figure 2). Baseline refers to the condition of the resources and quantity of habitat services that would have existed had the disturbance not occurred. The quantity of services lost (Area X) depends on the extent of the injury and the time required for restoration; actions taken to accelerate the rate of primary restoration would decrease the interim loss of habitat services, requiring less compensatory restoration. In some cases, full restoration of the lost services may not be feasible, in which case the area required for compensation (Area Y) would be larger. Compensatory restoration may occur off-site (e.g., the purchase of additional habitat), or on-site through habitat improvements that increase habitat services above baseline (e.g., non-native vegetation removal, shrub thinning, or understory planting).

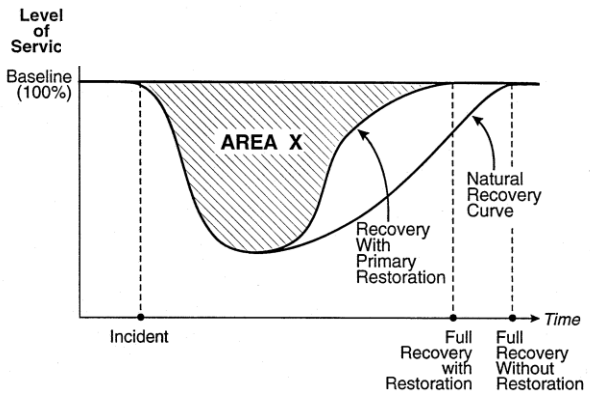

Figure 1. Changes in resource service level compared to the baseline service level during construction and restoration (copied from King 1997). Area X represents the services lost at an injury site with Primary Restoration expressed as percent of baseline.

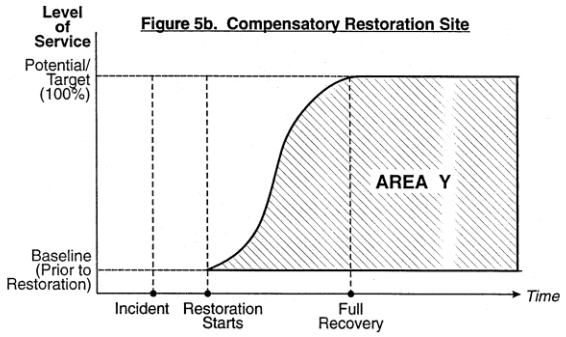

Figure 2. Changes in resource service level with compensatory restoration (copied from King 1997). Area Y represents the services gained at the compensatory restoration site expressed as percent of potential/target level less baseline (pre-restoration) percent.

Measuring Habitat Services (Ecological Economics)

Quantifying the services provided by an ecosystem is a complex task. This complexity can be reduced through the use of an attribute, or metric, that provides a measure of the services of interest. The metric must be able to capture the relative differences in the quality and quantity of services being provided before and after restoration and between primary and compensatory sites (NOAA 2009).

Measurements of habitat services over the lifetime and area of a project are used in the HEA. These measurements have three components: land area, service level (or habitat quality level), and time. The relative service level can be quantified using a metric that measures or scores one or more key habitat elements for a species or wildlife community of interest (e.g., vegetation stem density, vegetation type, nest density, percentage of canopy cover, proximity to critical habitat, etc.). Habitat services are commonly expressed in service-acres or service-acre-years.

Data Needed for Habitat Equivalency Analysis

Developing appropriate baseline metrics, quantifying project impacts, and identifying appropriate compensatory mitigation require substantial and consistent datasets (i.e., vegetation height, vegetation cover, existing anthropogenic disturbances, project footprint, etc.) Data are needed for the following to conduct an HEA:

- Evaluation of baseline services at the primary project site
- Extent of the disturbance at the primary project site
- Project timeline
- Percentage of services predicted to be lost during initial (short-term) disturbance and expected rate of recovery with restoration at the primary project site
- Timeline for compensatory restoration
- Services associated with compensatory projects
- Timeline of compensatory projects
- Discount rate for each time period (3% is commonly used in HEAs)

Habitat Equivalency Analysis Process for the TWE Project

Completion of the HEA process for the TWE Project Agency Preferred Alternative will require close coordination with the BLM, Western, and other appropriate agencies and stakeholders. Such coordination will ensure that the best available scientific data are being used, the habitat service metric is appropriate for resources in the TWE Project area, the results of the HEA are understood, and the compensation offsets the interim and permanent loss of habitat services modeled. The following steps will be completed as part of the development of the HEA for the TWE Project:

1. **Establishing baseline habitat services prior to disturbance.**

   TransWest will work closely with the appropriate agencies and stakeholders to finalize a habitat services metric that will quantify the baseline sage-grouse habitat services available prior to TWE Project construction. Appendix A provides information related to the development of the habitat services metric that will serve as the basis for quantifying baseline habitat services and determining project impacts and appropriate mitigation. Appendix B presents information related to how this metric will be applied to establish baselines habitat services for the project. Development of the baseline habitat service metric presented in Appendix A has considered the best available scientific information regarding sage-grouse habitat and response to disturbance.

2. **Quantifying the permanent and interim losses to the baseline service level that result from the TWE Project disturbance.**

   Permanent and interim losses of habitat services caused by the construction and operation of the TWE Project will be subtracted from the baseline habitat services. Direct and indirect losses that remain following reclamation efforts and vegetation recovery in the ROW over the life of the TWE Project will provide the basis for assessing the adequacy of mitigation proffered by TransWest. Appendix C describes the approaches that will be used to assess the direct and indirect losses that will occur as a result of project construction and operations.

3. **Identifying appropriate mitigation measures that may be used to compensate for lost services.**

   TransWest will work with the agencies and stakeholders to identify mitigation measures that may be used to compensate for the permanent and interim losses of habitat services. All mitigation measures would be subject to appropriate land management agency or landowner approval, permits, and planning. Appendix D describes the methods that will be used to quantify habitat service gains resulting from mitigation measures. Mitigation measures likely to be considered and quantified in the HEA include, but are not limited to:

   - <u>Fence marking, modification, or removal</u> – Fences would be marked, modified, or removed to reduce or remove threats to sage-grouse. Marking would be prioritized in areas near leks, in winter concentration areas, in known migratory corridors, or in areas between known roosting and foraging habitats. Appropriate land management agency or landowner coordination would be important to ensure fence-related conservation activities support current and future land use objectives.

- Sagebrush restoration or enhancement projects – Sagebrush restoration or enhancement projects might include seeding sagebrush and associated understory vegetation into previously disturbed or burned areas or transplanting already established sagebrush stems and seedlings into areas where sagebrush has been removed or thinned. Appropriate land management agency or landowner coordination would be important to ensure sagebrush enhancement activities support ongoing and future land use objectives.

- Understory improvement projects – Understory habitat conditions could be improved by overseeding existing sage-grouse habitats with appropriate forbs, grasses, or other desirable plant species; seeding previously disturbed areas with forbs and grasses to create a suitable mosaic of habitat for various life stages of sage-grouse; removing undesirable non-native understory species; or improving residual cover of existing understory species to increase cover and improve nest success. Appropriate land management agency or landowner coordination would be important to ensure activities support ongoing and future land use objectives.

- Conifer removal – In areas where conifers are encroaching into suitable sage-grouse habitat, conifer removal (specifically removal of pinyon pine and juniper) could be used to reduce habitat fragmentation and to restore previously unsuitable habitat. Priorities for conifer removal would include lop-and-scatter removal of Phase I[1] conifer encroachment and cut-pile-dispose or mastication of Phase II (mid conifer encroachment. Phase III conifer treatment would also be evaluated but unlikely to be selected as an appropriate compensatory tool. Appropriate land management agency or landowner coordination would be important to ensure activities support ongoing and future land use objectives.

- Brood-rearing habitat improvement – During summer months, mesic habitats adjacent to appropriate cover are necessary for brood-rearing and summer use. In areas where these habitats have been removed, altered, or are not available for other reasons, habitat enhancements focused on restoring or creating mesic habitats could be used to improve brood-rearing conditions.

- Conservation easements – Where possible, conservation easements could be used to provide long-term contractual protection of high-quality sage-grouse habitat, conservation efforts, and improvement projects. TransWest's ability to acquire conservation easements would be dependent upon the willingness of private

[1] Miller et al. (2005) characterized the three stages of woodland succession:
Phase I - early-succession, trees are present but shrubs and herbs are the dominant vegetation that influence ecological processes (hydrologic, nutrient, and energy cycles) on the site;
Phase II - mid-succession, trees are co-dominant with shrubs and herbs and all three vegetation layers influence ecological processes on the site;
Phase III - late-succession, trees are the dominant vegetation and the primary plant layer influencing ecological processes on the site.

landowner's to participate in a conservation program. Landowner coordination would be important to ensure activities support ongoing and future land use objectives.

In the HEA process, the benefits of mitigation measures must be quantifiable using the habitat services metric. The above list consists of those mitigation measures with benefits that could be quantified in the HEA. As the TWE Project HEA is completed for the Agency Preferred Alternative, other mitigation measures are likely to be identified. Additional mitigation measures with benefits that cannot be quantified in the HEA will be considered separately and their compensatory value determined in coordination with the lead agencies and other stakeholders.

4. **Quantifying the amount of mitigation necessary to compensate for the losses to baseline services that remain after project implementation.**

   Once final mitigation measures have been identified and approved by TransWest, the lead agencies and involved stakeholders, the average habitat service gain and cost per service returned will be quantified for each project type. The resulting values will be balanced with the services lost to determine the compensatory mitigation appropriate to offset the permanent and interim loss of sage-grouse habitat services resulting from development of the TWE Project. Appendix C describes the approach that will be used to identify appropriate levels of compensatory mitigation for direct and indirect losses of habitat services that will occur as a result of project construction and operations. A final conservation and mitigation plan/report documenting the scaled compensatory mitigation would be provided to BLM and Western as a voluntary applicant-committed mitigation measure for sage-grouse.

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APPENDIX A

Proposed Habitat Service Metric for the TransWest Express Transmission Line

DEVELOPMENT OF HABITAT SERVICE METRIC FOR HABITAT EQUIVALENCY ANALYSIS

A habitat service metric was developed for the greater sage-grouse (*Centrocercus urophasianus*; henceforth, sage-grouse) using variables identified in the peer-reviewed literature as representative of sage-grouse habitat. For each of the model variables, a habitat service score ranging from 0 to 3 (no services [non habitat] to high services [suitable habitat]) was assigned, similar to the sage-grouse habitat assessment framework developed by Stiver et al. (2010) and the sage-grouse habitat suitability index developed by LaGory et al. (2012). Scoring habitat services is a critical step in the HEA process, because it provides a way to measure the relative quality of specific habitat functions in a specific area.

The scores for this HEA were primarily based on information contained in the literature regarding sage-grouse habitat use and selection. When literature did not allow for direct assignment of value ranges for HEA scores, professional judgments, which were based on peer-reviewed literature, were used. Professional judgments were associated with specific literature references when possible and/or confirmed with academic and agency biologists. When a basic life requisite of sage-grouse was absent (e.g., vegetation was absent or forested, slopes were >40%, high levels of disturbance were present), the assigned score for the associated variable was 0. When a particular variable (e.g., % sagebrush cover) matched literature-based recommended conditions (e.g., 15%–25%), that variable was given a service score of 3.

Scoring of the variables was categorical and each variable was given the same weight in the model. This approach is based on the best available data and is consistent with the general approach of LaGory et al. (2012). LaGory et al. (2012) describe their approach: "In general, there was insufficient information in existing studies to determine relationships among variables and habitat suitability or relative contributions between variables/components. Therefore, for simplicity, we developed piecewise linear functions of suitability based on the assumption that all variables are of equal weight and applied these functions to geospatial layers to generate indices ranging from 0 (poor) to 100 (optimal). This approach is similar to that used for many of the U.S. Fish and Wildlife Service (USFWS) Habitat Suitability Index models in their Habitat Evaluation Procedure, (available at http://www.fws.gov/policy/ESMindex.html)."

While the individual variables were not weighted, the number of variables relating to a habitat attribute (e.g., six for vegetation vs. one for slope) gave some attribute categories more influence than others. In the metric, there were three variables that score sagebrush characteristics (i.e., sagebrush abundance index, sagebrush % cover, and sagebrush canopy height), so areas that are not dominated by sagebrush will score low for those three variables, resulting in a lower overall score.

Sage-grouse habitat suitability publications vary in their baseline environmental conditions affecting a particular study site. Even studies within the same state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site. No specific habitat studies have been conducted on the Project's transmission line corridor alternatives, therefore the habitat metrics described below mostly rely on information presented in Bureau of Land Management (BLM) et al. (2000), Cagney et al. (2009), Connelly et al. (2000), Connelly et al. (2011), and other summary

publications. Specific citations are given to support the habitat model framework when applicable. The following sections describe the development of the habitat service model variables.

METRIC OF SAGE-GROUSE HABITAT SERVICES

The metric for sage-grouse habitat services used in this HEA is a simple additive model (Table A1). Each cell in the analysis area is scored separately by multiplying the sum of Variables 01 through 03 and 05 through 11 by the exclusion Variable 04. Vegetation types, developed areas, and landforms that are not habitat for sage-grouse were not modeled, being excluded by Variable 04. Each of the variables is described in detail below.

Table A1. Anthropogenic and Habitat Variables Used as a Metric of Sage-Grouse Habitat Services

Variable Number	Variables	3	2	1	0	Primary Citations
VAR01	Distance to interstate highway or high-traffic federal or state highway (meters [m])	>1,000	650–1,000	100–650	NA	Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR02	Distance to low-traffic federal or state highway, other paved roads, or heavily travelled gravel roads, well pads, or mine footprints (m)	>200	50–200	25–50	NA	Connelly et al. (2004); Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009); Rogers (1964)
VAR03	Distance to fence (kilometers)*	>2.0	0.4–2.0	<0.4	N/A	Christiansen (2009); Stevens (2011)
VAR04	Lands excluded from analysis	N/A	N/A	All areas except those identified as scoring 0	Areas that are forested, urban, open water, roads, well pads, or mine footprints. Additionally, areas with slopes >40%, areas <100 meters from interstate or high-traffic roadway, or <25 meters from paved road or light-moderate traffic highway	Multiple sources per U.S. Fish and Wildlife listing decision in *Federal Register;* Johnson et al. (2011)
VAR05	Percent slope	<10	10–30	30–40	N/A	Beck (1977); Lincoln County Sage Grouse Technical Review Team (2004)
VAR06	Distance to occupied lek (kilometers)	0–5	5–8.5	>8.5	N/A	Cagney et al. (2009); Connelly et al. (2000); Connelly et al. (2011); Holloran and Anderson (2005)

Variable Number	Variables	3	2	1	0	Primary Citations
VAR07	Sagebrush abundance index (% of vegetation that is sagebrush within a 1 km^2 moving window)	30-80	80-100	10-30	0-10	Carpenter et al. (2010); Walker et al. (2007); Aldridge and Boyce (2007), Wisdom et al. (2011)
VAR08	Percent sagebrush canopy cover	15–25	5–15 or >25	1-5	<1	Cagney et al. (2009); Connelly et al. (2000); Stiver et al. (2010)
VAR09	Sagebrush canopy height (centimeters)	30–80	20 to <30 or >80	5-20	<5	Crawford et al. (2004); Connelly et al. (2000); Stiver et al. (2010)
VAR10	Distance (meters) to mesic habitat types containing suitable forage	<250	250-1000	1000-2000	>2000	Hanser et al. (2011); Connelly et al. 2000; Crawford et al. 2004; Connelly et al. 2011
VAR11	Distance of habitat to sage or shrub dominant (m)	<90	90–275	275-1000	>1000	BLM et al. (2000); Connelly et al. (2000); Lincoln County Sage Grouse Technical Review Team (2004)

DESCRIPTIONS OF METRIC VARIABLES

Anthropogenic Variables

Habitat within and surrounding the Project transmission line corridor is currently influenced by fences used for livestock management (e.g., to control livestock movements and vegetation use within grazing allotments and pastures, to delineate or protect private property and agricultural croplands, and to restrict livestock from improved and unimproved roadways) and by roads that fragment the vegetative landscape and alter wildlife use patterns. Two anthropogenic-influenced variables were used to address the effects of roads and fences on sage-grouse habitat suitability.

Distance to Roads and Highways

Research into the effects of roads on sage-grouse is varied. For instance in Colorado, Rogers (1964) mapped 120 leks with regard to distance from roads and found that 42% of leks were over 1.6 kilometers (1 mile) from the nearest improved road, but that 26% of leks were within about 90 meters (m) (about 100 yards) of a county or state highway, and two leks were on a road. Connelly et al. (2004) also note the use of roads for lek sites. In contrast, Craighead Beringia South (2008) reported results from a 2007 to 2009 study of sage-grouse seasonal habitat use in Jackson Hole, Wyoming. Results indicate that sage-grouse avoid areas within approximately 100 m of paved roads. Similarly, Pruett et al. (2009) found that lesser prairie-chickens avoided one of the two highways in the study by 100 m; however, some prairie-chickens crossed roads and had home ranges that overlapped the highways, thus roads did not completely exclude them from neighboring habitat. Johnson et al. (2011) examined the correlation between trends in lek attendance and the environmental and anthropogenic features within 5- and 18-kilometer (km) buffers around leks. They found that lek attendance declined over time with length of interstate highway within 5 km, although the authors note that this trend was based on relatively few data

points and no pre-highway data were available for comparison. Interstate highways >5 km away and smaller state and federal highways had little or no effect on trends in lek attendance. Thresholds less than 5 km were not examined.

In the habitat services metric, those habitats located within 100-mof a high traffic paved road (e.g., interstate highway or high-traffic federal or state highway), or within 25-m of a low-traffic paved road (e.g., low-traffic federal or state highway, other paved roads) were considered to provide no services to sage-grouse due to traffic and associated noise/human disturbance and were given a score of 0 (no services). Unpaved roads with high traffic loads (i.e., oil and gas service roads, mine service roads, etc.) were scored similarly to paved roads with similar traffic loads (e.g., low-traffic state highway). Those habitats located farther than 200 m and 1,000 m, respectively, of a low-traffic road or high-traffic road were considered the most serviceable to sage-grouse (i.e., exhibited no decrease in lek attendance) and given a score of 3. A logarithmic curve was fit between the highest and lowest categories so that score increased with distance from the road to estimate the distance breaks associated with scores 1 and 2. A logarithmic rate of change simulates sound attenuation rates better than a linear rate of change (Crocker 2007). Conflicting research results regarding sage-grouse use near and on unpaved resource/collector roads (e.g., two-track roads) did not allow for quantification of the disturbance caused these roads in the model.

While the application of distances to all scores (0–3) is not perfectly supported in the peer-reviewed literature, our approach places a penalty upon habitats that are bisected by all types of large roadways. Penalties are higher for roads that typically have higher traffic levels and risk to sage-grouse (e.g., mortality from collision, noise disturbance) than less-utilized secondary roads that generally have less traffic and implied risk.

Distance to Fence

Fence collisions have been reported as a cause of significant injury and mortality to grouse species (sage-grouse [Braun 2006; Call and Maser 1985; Connelly et al. 2004; Christiansen 2009; Danvir 2002; Stevens 2011]; lesser prairie-chicken [Wolfe et al. 2007]; ptarmigan [Bevanger and Broseth 2000]; and red grouse, black grouse, and capercaillie [Baines and Summers 1997; Catt et al. 1994; Petty 1995]). In addition to direct mortality, fences provide corridors for mammalian predators increasing the opportunity for predation of hens and broods (Braun 1998).

In Wyoming, Christiansen (2009) reported preliminary results of a multi-year study (2005–ongoing) near Farson on sage-grouse fence strikes and mortalities and the utility of fence markers on reducing collisions. After installation of fence markers on portions of high risk fences, grouse mortality decreased by 70%. Although the study did not compare the number of strikes with regard to distance to lek, the author recommends that fences should not be located within 0.25 mile (0.4 km) of leks. Therefore, all habitats within 0.25 mile (0.4 km) of a fence were scored as a 1 (few services) due to the increased risk that sage-grouse in those areas might collide with that fence.

In Idaho, Stevens (2011) evaluated sage-grouse and fence collision risk, and tested the efficacy of reflective vinyl fence markers at eight study sites. Modeling predicted marking reduced collision rates by 74% at the mean lek size and fence distance from lek. Collision probability

varied by region, topography, fence type, fence density, and lek proximity. Areas with high slope or terrain ruggedness generally showed lower collision risk than flat areas. Collisions were more common on fence segments bound by steel t-posts with spans between posts exceeding 4 m. Collision probability increased with fence length per km^2 and proximity to nearest active lek. The author recommended 2-km mitigation buffers around leks in high risk areas, which is consistent with the recommendation by Braun (2006).

As the distance to fence increases, there is decreased likelihood of a sage-grouse striking a fence and potentially less risk of depredation by mammalian and avian predators. Consistent with recommendations by Stevens (2011) and Braun (2006), habitats at least 2 km from a fence were given the highest score of 3. A linear relationship was then used to determine the remaining metric scores (i.e., score of 2 between 0.4 and 2.0 km, and score of 1 <0.4 km of a fence). Scoring did not change with fence proximity to lek, region, or topography because these variables are already accounted for in the model. Habitats near fences received the same score for this variable, regardless of fence type or configuration, because data were not sufficient to differentiate among them in the model.

Lands Excluded from Analysis and Slope

Two metric variables used to refine sage-grouse habitat potential were lands excluded and slope. Lands excluded removed land cover types that were not sage-grouse habitat and slopes greater than >40% from the analysis. Slope prioritized areas with slopes <5%.

Lands Excluded from Analysis

To more accurately model sage-grouse utilization areas, land cover types typically avoided by sage-grouse were scored 0 for the Lands Excluded variable. These land cover types include roadways, urban and developed areas, open water, and all forest types. Additionally, areas within 100 meters of interstate highways and high-traffic state or federal highways and areas within 25 meters of paved roads and low-moderate traffic highways were excluded from analysis.

This is a multiplicative variable, so a score of 0 for this variable resulted in a total score of 0 for whole habitat service metric; disturbances of these areas would require no mitigation in this model. All other vegetation types received a score of 1 because they provide some level of service to sage-grouse.

Slope

Sage-grouse generally use flat or gently sloping terrain (Connelly et al. 2011; Eng and Schladweiler 1972; Nisbet et al. 1983; Rogers 1964). Beck (1977) plotted the distribution of 199 sage-grouse flocks in Colorado and found that 66% of flocks were on slopes less than 5% and only 13% of flocks were on slopes greater than 10%. Slopes greater than 40% are unsuitable nesting habitat (Lincoln County Sage Grouse Technical Review Team 2004). Therefore, areas with less than 5% slope were assigned a habitat service score of 3, and those exceeding 10% subjectively received incrementally lower habitat service scores. Slopes >40% provided no service value and were excluded using the Lands Excluded variable..

Distance to Lek (10-year Average Count >0 Males)

Current sage-grouse habitat management guidance uses occupied leks as focal points for nesting habitat management (Connelly et al. 2000; Connelly et al. 2011); therefore, distance to lek was used as a variable in the Habitat Services Metric. These guidelines recommend protecting sagebrush communities within 3.2 km of a lek in uniformly distributed habitats and 5.0 km in non-uniformly distributed habitats. Holloran and Anderson (2005) studied nesting sage-grouse at 30 leks in central and western Wyoming and determined that 45% and 64% of female sage-grouse nested within 3.2 km and 5.0 km, respectively, of the lek where the hen was radio-collared. Moreover, statistical analyses suggested that the area of interest for nesting sage-grouse should be truncated at 8.5 km from a lek. Similar frequencies are reported in Cagney et al. (2009)—66% within 5.0 km and 75% within 6.4 km of a lek where the female bred.

Female sage-grouse do nest at distances greater than 8.5 km (farthest distance reported in Holloran and Anderson [2005] was 27.4 km), so all distances >8.5 km from occupied leks were given a service score of 1 to reflect some potential use by nesting sage-grouse. Conversely, because the sagebrush community within approximately 5 km of a lek also provides other services to female grouse during the lekking season, such as forage, roost sites, and cover from predators and inclement weather (Cagney et al. 2009), the 5 km around an occupied lek represents habitat that provides the most services (service score of 3).

Sagebrush Abundance Index

Walker et al. (2007) found that the proportion of habitat that was sagebrush within a 6.4-km moving window was a strong predictor of lek persistence in the Powder River Basin of Wyoming. Areas with less than 30% of sagebrush within 6.4 km of the lek center had a lower probability of lek persistence. Aldridge and Boyce (2007) also used a moving window (1 km^2) to measure sagebrush cover and abundance. Their resource selection function found that sage-grouse selected nesting habitat that contained large patches (1 km^2) of sagebrush with moderate canopy cover and moderate sagebrush abundance (i.e., heterogeneous distribution of sagebrush). Carpenter et al. (2010) found similar results. Their top resource selection functions included a quadratic function for sagebrush abundance, which indicates that areas of moderate sagebrush abundance were selected more frequently than areas of homogenous sagebrush. While sagebrush is a vital component of sage-grouse habitat, very thick shrub cover may inhibit understory vegetation growth and reduce the birds' ability to detect predators (Wiebe and Martin 1998).

Aldridge et al. (2008) [per Wisdom et al. (2011)] found that at least 25% of the landscape in a 30.77 km analysis area needed to be dominated by sagebrush for sage-grouse persistence, with 65% being preferred. Wisdom et al. (2011) found that landscapes with less than 27% sagebrush were not different from landscapes from which sage-grouse have been extirpated. Similar to Aldridge et al. (2008), Wisdom et al. (2011) found that 50% sagebrush across a landscape was a good indicator of sage-grouse persistence.

Sagebrush Canopy Cover

Recommended sagebrush canopy cover for sage-grouse habitat varies seasonally. Because of lack of suitable data available across all Project alternatives, seasonal habitats were not modeled. However, seasonal differences in the selection for sagebrush cover was considered when developing habitat services metrics. The seasonal habitat needs of sage-grouse are described below, followed by scoring of percent sagebrush cover in the habitat services metric.

Seasonal Habitat Use

Nesting

Connelly et al. (2000) cite 13 references to sagebrush coverage that range from 15% to 38% mean canopy cover surrounding the nest. Citations contained within Crawford et al. (2004) reported 12% to 20% cover and 41% cover in nesting habitat. In their species assessment, Connelly et al. (2000) conclude that 15% to 25% canopy cover is the recommended range for productive sage-grouse nesting habitat. This is also the range identified in the sage-grouse habitat assessment framework (Stiver et al. 2010) as providing the highest service level for sage-grouse based on a review of the available literature. Wallestad and Pyrah (1974) reported that successful nests were in stands where sagebrush cover approximated 27%. This cover range is used as a goal in some sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). Cagney et al. (2009) guidelines for grazing in grouse habitat, which uses information synthesized from over 300 sources, states that hens tend to select an average 23% live sagebrush canopy cover when selecting for nesting sites.

Brood Rearing

Connelly et al. (2000) found that productive brood-rearing habitat should include 10% to 25% cover of sagebrush. This is the range used as a goal in sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000).

Winter

Connelly et al. (2000) cite 10 references to sagebrush coverage in winter-use areas that range from 15% to 43% mean canopy cover (Crawford et al. [2004] also cite two of these references in their assessment); however, they considered a canopy of 10% to 30% cover (above the snow) as a characteristic of sagebrush needed for productive sage-grouse winter habitat. This is the cover range used as a goal in sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000).

Scoring in Habitat Services Metric

In general, the recommended sagebrush cover for nesting habitats was intermediate to and overlapped that of brood-rearing and winter habitats. Thus, favorable conditions for nesting were given the highest scores for percent sagebrush cover in the sage-grouse habitat services metric.

The sagebrush cover scores assigned for nesting habitat in the sage-grouse habitat assessment framework by Stiver et al. (2010) to different sagebrush cover categories were assigned to this variable. Sagebrush percent canopy cover of 15% to 25% was assumed to provide the highest level of services (score of 3) to nesting sage-grouse. It is the same as the range given in Connelly

et al. (2000) and similar to the average range reported in Cagney et al. (2009). Areas with slightly less or more cover than this were given a habitat services score of 2 (e.g., 5–15 or >25). Habitats with <5% cover received a score of 1.

Sagebrush Canopy Height

Sagebrush canopy height is an important aspect of all sage-grouse seasonal habitats. As described above, seasonal habitat models will not be developed for the Project. However, seasonal habitat requirements were considered when developing habitat metric values. The seasonal habitat needs of sage-grouse are described below, followed by scoring of percent sagebrush cover in the habitat services metric.

Seasonal Habitat Use

Nesting

Gregg et al. (1994, cited in Crawford et al. 2004) found that the area surrounding successful nests in Oregon consisted of medium-height (40 to 80 centimeters [cm]) sagebrush. Connelly et al. (2000) cite 11 references to sagebrush height that range from 29 to 79 cm mean height. In their assessment, Connelly et al. (2000) conclude that sagebrush with a height of 30 to 80 cm is needed for productive sage-grouse nesting habitat in arid sites and 40 to 80 cm in mesic sites. These ranges are supported by Stiver et al. (2010), who recommend a range of 30 to 80 cm, and BLM et al. (2000), which state that optimum sage-grouse nesting habitat consists of sagebrush stands containing plants 40 to 80 cm tall.

Winter

Important structural components in winter habitat include medium to tall (25–80 cm) sagebrush stands (Crawford et al. 2004). Connelly et al. (2000) cite 10 references to sagebrush height in winter habitat that range from 20 to 46 cm above the snow. Two studies measured the entire plant height and provided a range from 41 to 56 cm. In their assessment, Connelly et al. (2000) conclude that characteristics of productive winter habitat include sagebrush that is 25 to 35 cm in height above the snow. This is the height range used as a goal in sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000).

Scoring in Habitat Services Metric

Sagebrush canopy heights that provided high-quality nesting habitat generally also provided high-quality winter habitat for sage-grouse. Thus, favorable conditions for nesting were given the highest scores for sagebrush canopy height in the sage-grouse habitat services metric.

The sagebrush cover scores assigned for nesting habitat in the sage-grouse habitat assessment framework by Stiver et al. (2010) to different sagebrush cover categories were assigned to this variable. Areas of sagebrush with a height of 30 to 80 cm were assigned a habitat services score of 3. As sagebrush canopy height decreases, the value of a sagebrush plant to provide cover for nesting females and their nests is diminished. Additionally, low-lying sagebrush is less available to sage-grouse during the winter due to snow cover. Areas with canopy heights greater than 80 cm provided intermediate levels of services because they may provide relatively poor cover for nesting sage-grouse and have foliage that is difficult for sage-grouse to access during mild and moderate winters. Sites with lower and higher sagebrush canopy heights were scored lower

(i.e., sagebrush 12 to <30 cm or >80 cm in height received a score of 2). Areas with minimal sagebrush canopy heights were considered to have the lowest habitat service value (i.e., sagebrush <20 cm received a score of 1).

Distance to Mesic Habitats

Greater sage-grouse are not dependent on mesic habitats; however, the presence of these habitats increase the potential for an area to support succulent forbs that young greater sage-grouse depend on during the early brood rearing season.

Characterization of sites used by greater sage-grouse broods universally includes mention of forb abundance and cover (Connelly et al. 2000; Crawford et al. 2004; others cited below). Studies have indicated a positive relationship to plant species richness, especially forbs, with brood rearing areas (Autenrieth 1981; Dunn and Braun 1986; Klott and Lindzey 1990; Drut et al. 1994; Apa 1998). Generally, as abundance and diversity of herbaceous vegetation, including forbs, increases, insect biomass and diversity also increase. This increase provides better foraging opportunities during two critical life stages: 1) egg-laying females, and, 2) chicks within the first few months of life (Blenden et al. 1986; Brush and Stiles 1986). The diet of greater sage-grouse chicks is primarily comprised of forbs during their first 12 weeks (Klebenow and Gray 1968; Peterson 1970).

However, the importance of mesic habitats is not limited to the brood rearing season. LaGory et al. (2012) included adjacency to mesic habitat in their summer HSI because this habitat type potentially provides an important source of food for sage-grouse adults. Additionally, Hanser et al. (2011) detected a strong relationship between roosting habitat use and riparian vegetation based pellet densities.

Therefore, the habitat service metric scored sage-grouse habitats higher near riparian vegetation and National Wetlands Inventory (NWI) lands that support suitable forage types than sage-grouse habitats farther from these mesic vegetation types.

Distance to Vegetation Dominated by Sagebrush or Shrub

Sage-grouse will use shrubby habitats other than sagebrush during the brood-rearing season (Connelly et al. 2000) and for grouse movement and dispersal (Stiver et al. 2010), so all shrub species were considered for this model variable. The Lincoln County Sage Grouse Technical Review Team (2004) identified proximity to sagebrush cover as an important component in habitat suitability of non-sagebrush, brood-rearing habitats (e.g., mesic lowland habitats, hay meadows). The team considered brood-rearing areas within <100 yards, 100 to 300 yards, and >300 yards of sagebrush cover as suitable, marginal, and unsuitable habitat, respectively. Similarly, Sitver et al. (2010) considered mesic habitats <90 m, 90 to 275 m, and >275 m to be suitable, marginal, and unsuitable late brood-rearing/summer habitat, respectively.

For this variable, habitats (regardless of vegetation type) <90 m, 20 to 275 m, and >275 m were assigned scores of 3, 2, and 1, respectively. The scoring was applied to all vegetation types, not just to mesic habitats, because this variable is relevant to bird movement and dispersal from all habitat types and the model is not restricted to the brood-rearing period.

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APPENDIX B

Quantification of Baseline Habitat Service Level

QUANTIFICATION OF BASELINE HABITAT SERVICE LEVEL

The pre-construction baseline of the habitat services will be based on existing datasets to the extent possible. It is not anticipated that additional data collection will be necessary to complete the HEA. The baseline service level will be determined by applying the habitat service metrics described in Appendix A to the Assessment Area that is identified for the Project. For other similar projects, the Assessment Area included the footprint of the project and a buffer around the footprint, because greater sage-grouse (*Centrocercus urophasianus*; henceforth, sage-grouse) habitat service losses were expected to extend beyond the area of direct disturbance.

ESRI ArcGIS ArcInfo 10.X, Spatial Analyst, and ModelBuilder software and tools will be used to conduct analyses. To facilitate calculations across the entire assessment area, it is anticipated that all data will be converted to a raster/grid format. Raster or grid algebra processing is significantly faster for a project of this size.

PREPARATION OF GIS MODEL INPUT LAYERS

Habitats within and surrounding the corridor for the preferred alternative will be summarized in a series of representative raster layers for the eleven metric variables (see Appendix A). These eleven variables consist of data representations within the project area for human disturbance, landscape characteristics, proximity to greater sage-grouse lek locations, and vegetation characteristics that may influence the use of habitat by sage-grouse. A spatial resolution of 30-meters is anticipated to be sufficient to capture a 'landscape level' perspective of habitat across the Assessment Area.

Representative raster data will be created for each variable in the HEA metric (Appendix A). Scores for each cell in each raster will be assigned per the variable scores listed in Table A1 of Appendix A. The following sections describe the datasets anticipated to be necessary to describe each of the variables described in Appendix A:

Distance to Roads and Highways or Other Infrastructure

Road layers used in developing the baseline HEA model are available from the BLM, Forest Service, state agencies, or from readily available standard road and infrastructure layers. Road layers will be compared between states to ensure consistency in classification prior to using them in the HEA model development. HEA model scores will be applied to 30-meter raster cells according to the process described in Table A1, Appendix A. For example, all cells that are more than 1,000 meters from interstate highways or high traffic volume state and federal highways will be given a score of 3, those between 650 and 1,000 meters will be given a score of 2, those between 100 and 650 meters will be given a score of 1, and those cells within 100 meters will be removed from consideration in the model per the description provided for Variable 4 in Table A1 and the supporting text.

Distance to Fence

Fence locations will be used if the data are available for the entire assessment area. In the event that fence data are not available, grazing allotment boundaries will be used as surrogates for fence layers in the HEA baseline model development. Scores for distance to fence will be applied to the 30-meter grid cells in the model in the same manner as described for roads and highways with cells closest to fences receiving the lowest scores and those farthest from fences receiving the highest scores.

Lands Excluded From Analysis

As described in Appendix A, land cover types and terrain features that do not provide suitable habitat for sage-grouse will be removed from the HEA model. All vegetation types and landforms that potentially provide habitat for sage-grouse will remain in the model.

Slope

Slope will be calculated using 30-meter digital elevation models and scored according to the process described in Appendix A.

Distance to Lek (10-year Average Count >0 Males)

Lek data will be obtained from the wildlife management agencies in each state. Lek status will be determined for all leks. Leks that have been active in the past 10 years or that have an unknown status will be included in the HEA model. Those that are labeled as unoccupied or inactive will not be included. Cells surrounding leks will be scored according to the methods described in Appendix A with cells closest to leks receiving the highest scores.

Sagebrush Abundance Index

A sagebrush abundance index will be determined from available vegetation layers by calculating the proportion of sagebrush in a 1-km^2 area surrounding each 30-meter cell in the assessment area. Scores will be applied using the methods described in Appendix A. Areas with a high proportion of sagebrush in the landscape and some habitat heterogeneity will be score higher than areas with little habitat heterogeneity or areas with little or no sagebrush.

Sagebrush Cover, Sagebrush Canopy Height

When possible, percent cover and height will be determined directly from the vegetation attribute data included in the GAP and Landfire vegetation datasets. Where data are not available, attributes for percent cover and height will be determined using other data sources. Sampling data from GAP/Landfire datasets as well as datasets obtained from BLM and the state agencies will be used to attribute vegetation percent cover and height for segments of the landscape with the most similar characteristics. Once vegetation values have been applied to the 30-meter grid, HEA scores will be applied using the methods described in Appendix A.

Distance to Mesic Habitat Types

The distance from each 30-meter cell to the nearest mesic habitat will be calculated directly and scored using the methods described in Appendix A. Habitats closer to riparian vegetation, mesic meadows and other mesic habitats, and National Wetlands Inventory (NWI) lands will be scored higher than those areas that are greater distances from the mesic habitats.

Distance to Vegetation Dominated by Sagebrush or Shrub

The distance from each cell to the nearest sagebrush or shrub dominated cell will be calculated. Cells within or closest to sagebrush or shrub landscapes will be scored higher than those that are distant from shrub-dominated cells.

SUMMATION OF BASELINE SERVICES IN THE HEA MODEL

Spatial grids representing the above HEA variables will be combined through additive and multiplicative raster calculations to create a final raster layer. A simple additive overlay process will be used to calculate the HEA metric value for each cell. The value of each cell will be the sum of variables 1-3 and 5-11. The resulting value will be multiplied by the variable 4 score of 0 or 1 to remove all vegetation types that do not provide habitat for sage-grouse and to retain those habitats that do provide value for sage-grouse. The final numeric value for each cell is the habitat services provided to greater sage-grouse by that cell.

The resulting habitat service values and the number of acres associated with each of the habitat service values will be multiplied together and summed across the assessment area to calculate the total habitat services (expressed in service acres) (Equation 1). The total habitat services provided by the Assessment Area will be calculated and will serve as the pre-construction baseline for the Project.

Equation 1.

$$VJ = \sum_{1}^{i} (V_i * J_{V_i})$$

where:

VJ is the habitat services (service-acres) provided by the Assessment Area,

V is the habitat service score (i.e., the sum of the variable scores in the habitat service metric),

i is the number of possible unique values for *V*, and

J_{V_i} is the number of acres for each value of V_i , where $\sum_{1}^{i} J_{V_i}$ would equal the total acreage of the Assessment Area (*J*).

APPENDIX C

Quantification of Habitat Service Losses

QUANTIFICATION OF HABITAT SERVICE LOSSES

Habitat service losses caused by the Project will be modeled using geographic information system (GIS) technology for important Project milestones by decreasing the variable scores for the habitat services metric below the Baseline level in the footprint of the project (direct disturbances) and in buffers around the footprint (indirect disturbances). The habitat service scores for each milestone will be summed across the Assessment Area to calculate the estimated interim and permanent habitat service losses associated with the Project.

DESCRIPTION OF DISTURBANCES BY PROJECT MILESTONE

The habitat services provided by the Assessment Area will be measured at several different Project milestones that reflected varying levels of disturbance.

The Project milestones modeled for the HEA will be:

1. **Baseline**—the baseline milestone quantifies habitat services available to sage-grouse before disturbance. The calculation of the habitat services available to sage-grouse at Baseline is described in Appendix B.
2. **Construction—**the transmission line construction milestone quantifies habitat services available to sage-grouse during the construction of the Project.
3. **Restoration**—the restoration milestone quantifies habitat services available to sage-grouse after Project construction is complete and some services return with the reduction in noise and human presence.
4. **Recovery**—the recovery milestone quantifies habitat services available to sage-grouse after a vegetation type has recovered to the greatest extent expected after Project restoration is complete. Habitat services return to baseline conditions in restored areas with the time to recovery being dependent on the vegetation type. It is anticipated that there will be multiple vegetation-based recovery endpoints. Vegetation recovery endpoints will be determined upon identification of the vegetation communities impacted by the Project.

QUANTIFYING LOSS OF HABITAT SERVICES DUE TO SURFACE DISTURBANCE DURING CONSTRUCTION

For the Construction milestone, direct disturbances will be defined as the loss of habitat services associated with vegetation removal and ground disturbing activities within the construction footprint (Table C1). The habitat service scores for all 30-m^2 raster cells in the project footprint where vegetation removal or ground disturbance occur will be changed from the Baseline service scores to 0 in the GIS model for this milestone. Recovery from the disturbed state will be applied per the vegetation-specific recovery curves for the project.

Table C1. Direct Disturbance Levels Modeled by Project Milestone and Disturbance Type

Project Milestones	Percent Baseline Services Present by Direct Disturbance Type		
	AC/DC Converter Station	Transmission Towers	Access Roads, Transmission Lines, and Temporary Infrastructure
Baseline	100%	100%	100%
Construction	0%	0%	0%
Restoration	0%	0%	0%
Progressive Vegetation Recovery	0%	0% within permanent tower footprint Elsewhere baseline services will be retuned per the vegetation-specific recovery curves developed for the Project.	Baseline services will be retuned per the vegetation-specific recovery curves developed for the Project.

QUANTIFYING LOSS OF HABITAT SERVICES DUE TO INDIRECT DISTURBANCES DURING CONSTRUCTION

Indirect disturbances will be simulated by applying buffers to the construction footprint and decreasing the habitat service scores below the Baseline habitat service scores within the buffers. Because of uncertainties in the indirect impacts of transmission on sage-grouse, at this time, noise and human presence will be the only indirect disturbance modeled in the HEA.

Use of construction equipment such as backhoes, cranes, front-end loaders, bulldozers, graders, excavators, compressors, generators, and various trucks would be needed for mobilizing crew, transportation and use of materials, line work, site clearing, and preparation during the construction phase of the Project. Construction of and improvements to access roads would require use of earthmoving equipment such as bulldozers and graders. Table C2 provides the typical noise levels for the construction equipment that could potentially be used during the construction phase of the Project (ranging 80 to 90 A-weighted decibels [dBA] at 50 feet [15 meters (m)] from any work site).[2]

Table C2. Typical Noise Levels from Construction Equipment

Equipment Type	Noise Level at 50 feet (dBA)
Crane	88
Backhoe	85
Pan loader	87

[2] Construction noise values taken from Energy Gateway West HEA report.

Bulldozer	89
Fuel truck	88
Water truck	88
Grader	85
Roller	80
Mechanic truck	88
Flatbed truck	88
Dump truck	88
Tractor	80
Concrete truck	86
Concrete pump	82
Front end loader	83
Scraper	87
Air compressor	82
Average construction site	85

Noise during the construction phase of the Project would be similar in magnitude to noise produced by vehicles using secondary roads (county highways, state highways, and heavily travelled gravel roads [e.g., access roads for oil and gas development, mining, etc.]). Passenger vehicles, medium trucks, and heavy trucks going 55 miles per hour (mph) produce typical noise levels of 72 to 74 dBA, 80 to 82 dBA, and 84 to 86 dBA, respectively, from a distance of 50 feet. Therefore, the noise disturbance associated with construction will be modeled as if the construction area was a secondary road (Table C3).

In the model, buffers will be placed around active construction areas in a manner that is identical to the methods used for secondary roads. The cells that fall within these buffers will be scored in a manner identical to a secondary road (i.e., the score for VAR02 decreased).

Table C3. Indirect Disturbance Levels Modeled by Project Year and Disturbance Type

Project Milestones	Indirect Disturbance Buffers Applied by Disturbance Type		
	AC/DC Converter Station	**Transmission Towers**	**Access Roads, Transmission Lines, and Temporary Infrastructure**
Baseline	None	None	None
Construction	Secondary Road	Secondary Road	Secondary Road
Restoration	Secondary Road	None	None
Progressive Vegetation Recovery	Secondary Road	None	None
	Secondary Road	None	None
	Secondary Road	None	None
	Secondary Road	None	None

QUANTIFYING HABITAT SERVICES LOSSES DURING RESTORATION AND RECOVERY

Project-related habitat service losses are anticipated to decrease once construction is complete. Although still below baseline levels, the habitat service scores rise during restoration and recovery with vegetation regrowth (direct disturbances) and decreased levels of noise and human presence (indirect disturbances).

Restoration Milestone

For the Restoration milestone, direct disturbances will be defined as the loss of all habitat services in the construction footprint where vegetation clearing and ground disturbance occurs because the vegetation has not regrown sufficiently to provide habitat (see Table C1).

The indirect disturbance buffers that are applied to the power conversion terminal during construction will remain during the restoration milestone and for the life of the Project because of the noise human activity associated with operation of the facility. No indirect disturbances will be modeled for the rest of the Project because little vehicle traffic or human presence is anticipated in these areas after construction of the line is complete.

Progressive Recovery Milestone

For the Recovery milestone, direct disturbances will be defined as the loss of all habitat services in the footprint of the transmission structure pads and the partial loss of services in areas of vegetation regrowth (see Table C1). Indirect disturbances will be applied in a manner identical to the Construction milestone (see Table C3).

Habitat services in areas where the vegetation is reclaimed (i.e., outside the footprint of permanent facilities) will gradually return to baseline conditions at a rate dependent on the vegetation type. Services will return more rapidly for vegetation having rapid recovery rates (e.g., agriculture, grassland, wetland, or riparian) than for those with slower recovery times (e.g., shrub-dominated including sagebrush). Vegetation recovery curves will be developed for the vegetation communities that are impacted by Project activities.

To calculate the progressive return of services, the percentage of the baseline service value for a cell will be calculated based on the appropriate vegetation recovery curve. For example, in those vegetation types with rapid restoration potential (agricultural areas, some grasslands, etc.), habitat services could be returned to 100% of Baseline in the first year following construction. Those with longer recovery times may only achieve partial service returns per year until achieving their maximum value. For example, a vegetation community with a 50 year recovery period might achieve 10% value in year 5 after restoration, 20% in year 10, 30% in year 15, etc. until all services are returned in year 50.

HEA TO QUANTIFY INTERIM AND PERMANENT HABITAT INJURIES

The approach described above will produce a measure of habitat services (in service-acres) for each of the Project milestones for each of the modeled project segments. The HEA is a stepwise model which quantifies the habitat injury separately in each year (Figure C1) and each of the milestones will be assigned to a calendar year per the schedule provided by the Project proponents after the preferred alternative is identified. It is likely that a linear change in habitat services will be used to estimate annual service-acre increases between restoration and recovery and between the vegetation-specific recovery times. The total number of service-acres lost per year will be summed across the analysis period and expressed as service-acre-years. This value is the estimated sum of the interim and permanent losses to sage-grouse habitat that would occur as a result of project construction and operation.

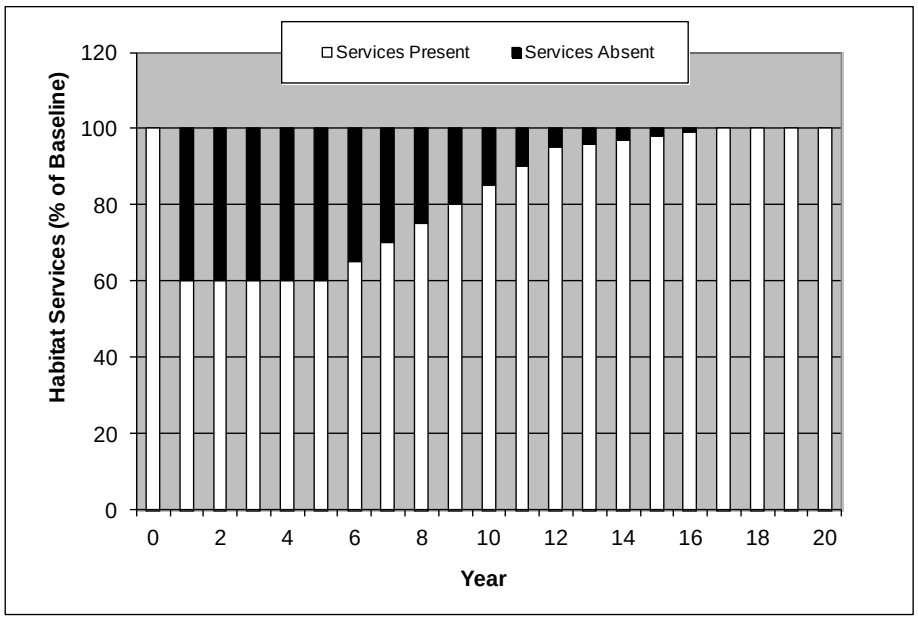

Figure C1. Hypothetical example of how the HEA model considers habitat services absent and habitat services present in each year to calculate the total services lost over the Project period (i.e., sum of the black bars).

The HEA model balances the cumulative injury (*I*, service-acre-years) over the lifetime of the Project with the cumulative benefit of habitat restoration and mitigation (*R*, service-acre-years), so that the services returned by habitat restoration and mitigation are greater than or equal to the cumulative injury ($R \geq I$). The habitat injury (*I*, service-acre-years) will be quantified for the life of the Project using Equation 2. Equation 2 was adapted from Equation 8.1 in Allen et al. (2005). The discount rate (*r*) is anticipated to be set to 3%, which is standard for this type of analysis. The discount rate converts services being provided in different time periods into current time period equivalents (Allen et al. 2005). The discount rate effectively weighs the habitat service losses so that losses occurring

early in the project result in a greater overall injury than losses occurring later in the project. Likewise, habitat restoration and mitigation occurring early in the project would result in a greater benefit than habitat restoration and mitigation occurring late in the project.

Equation 2. $$I = \sum_{t=0}^{y} JV^{j} * \rho_{t} * \left[(b^{j} - x_{t}^{j}) / b^{j} \right]$$

where:

I is the present value of the service-acre-years lost over *y* due to interim and permanent injury,

t = 0 is the year the project begins,

y is the analysis period, in years (i.e., 107),

JV^j is the value of the habitat services provided by the injured habitat (service-acres) before injury (i.e., at the Baseline milestone),

b^j is the mean service score provided by the Assessment Area (JV^j/J, where J is the injury Assessment Area in acres) at the Baseline milestone (time [*t*] = 0),

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (*C* = Project Year 1), and

x_t^j is the mean service score provided by the Assessment Area at the end of year *t* if Project disturbances are applied.

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APPENDIX D

Quantification of Habitat Service Gains Produced by Habitat Restoration and Mitigation Measures

MODELING MITIGATION PROJECT HABITAT SERVICE GAINS

Habitat restoration and mitigation measures are intended to create new, or protect existing, greater sage-grouse habitat services (Table D1). These measures serve as a "toolbox" from which mitigation options may be selected by TransWest Express for inclusion in a mitigation package once the BLM has identified the preferred alternative and final HEA results are available for that alternative. The purpose of implementing the habitat restoration and mitigation measures is to offset the cumulative sage-grouse habitat service losses in the Assessment Area over the Project lifetime (i.e., *I* in Equation 2 from Appendix C). The HEA will used to evaluate the benefit of a sample of conservation projects in the Assessment Area.

Table D1. Potential Habitat Restoration and Mitigation Measures for Inclusion in the HEA.

Measure	Brief Project Description	Anticipated Benefits
Fence removal and marking with flight diverters	Fences would be removed or marked in: 1) Sections of fence known to cause sage-grouse collisions, 2) Fences within 2 km (1.2 mi) of leks (Braun 2006; Stevens 2011) or other high risk area, 3) Fences in areas with low slope and terrain ruggedness (Stevens 2011), and 4) Fence segments bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	• Reduce mortality due to sage-grouse collisions • Increase visibility of fences • Increase contiguous patches of shrub-steppe habitat • Remove localized grazing pressure and increase habitat
Sagebrush restoration and improvement projects	Seeding, planting seedlings, or transplanting containerized sagebrush plants (one plant per 5 m^2) and seeding a bunchgrass understory.	• Create contiguous patches of shrub-steppe habitat with optimal sagebrush cover and height and a bunchgrass understory • Increase availability of high quality nesting, brood rearing, and winter habitats
Juniper/conifer removal	Mechanical removal (lop and scatter, cut-pile-cover, or mastication) of juniper/confer adjacent to areas with optimal sagebrush cover and height	• Reverse juniper/conifer encroachment on shrub-steppe habitat to increase contiguous patches of sage-grouse habitat • Increase light penetration to support a forb and grass understory
Bunchgrass seeding projects	Bunchgrass seeding and prescriptive grazing to increase bunchgrass communities	• Create contiguous patches of sagebrush habitat with bunchgrass understory • Increase suitable forage and insect availability for sage-grouse browsing during brood rearing
Conservation easements	Removes threat of specific land uses to sensitive wildlife populations	• Prevent sage-grouse habitat destruction or degradation near urban areas and oil and gas development • Reduce future fragmentation of shrub-steppe habitat
Brood-rearing and summer use habitat improvement	Enhances existing or creates new mesic habitats or enhances forb availability	• Increases forage availability during early and late-brood rearing periods and for general summer use by adults • Increases potential recruitment and survival of chicks

GIS MODELING OF CONSERVATION BENEFITS

The analysis of habitat service benefits produced by each habitat restoration or mitigation measure in Table D1 will be completed using an approach similar to that described or quantifying habitat losses. It is necessary that both analyses (i.e., quantification of habitat service losses and habitat service gains) use the same habitat services metric (see Appendix A), the same unit of measure (service-acres and service-

acre-years), the same analysis period, and the same discount rate. Figure D1 illustrates a hypothetical example of how mitigation would be added to the baseline service metric over time to derive an estimate of the service-acre-years provided by the mitigation measures that will be modeled for the Project.

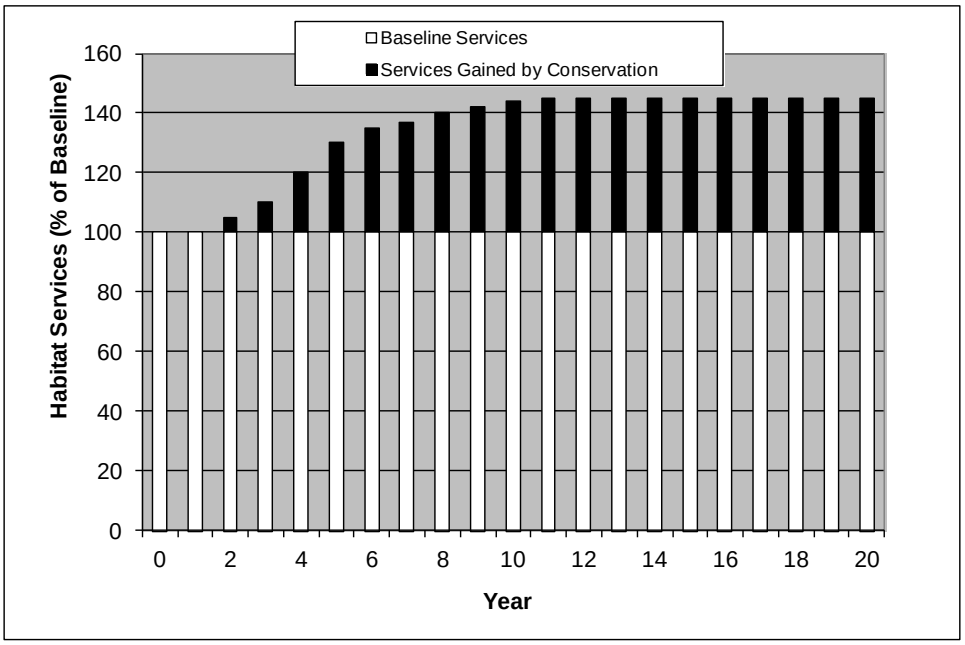

Figure D1. Hypothetical example of how the HEA model considers habitat services gained by habitat restoration and mitigation to calculate the total services gained over the project period (i.e., sum of the black bars).

Modeling Habitat Restoration and Mitigation Measures

Ideally, locations of possible habitat restoration and mitigation projects will be identified prior to finalization of the HEA process. In the event that these locations are not known, hypothetical habitat restoration and mitigation project areas will be used to estimate average habitat service gain.

Once actual or hypothetical habitat restoration and mitigation project locations are identified, variable scores in the HEA model will be changed to approximate the change in habitat services expected with implementation of the measure. The new habitat service score will be calculated for each cell in the Assessment Area using the same habitat services metric used to quantify baseline and impacts (see Appendix A). The habitat service benefit of a modeled project will be calculated by determining the difference in the habitat services provided at baseline and after implementation of the habitat restoration or mitigation measure.

For each habitat restoration/mitigation project, the time to full benefit and project initiation timing will be determined and accounted for in the HEA model to estimate of the present value habitat service gain

that would be created. The present value habitat service gain (*R*, service-acre-years) will be quantified for the life of the Project using Equation 3 (adapted from Equation 8.1 in Allen et al. 2005).

Equation 3. $$R = \sum_{t=0}^{y} PV^{p} * \rho_{t} * \left[(x_{t}^{p} - b^{p}) / b^{p} \right]$$

where:

R is the present value of the service-acre-years gained by the habitat restoration or mitigation measure,

t = 0 is the year the transmission line Project begins,

y is the analysis period, in years (i.e., 107),

PV^p is the value of the habitat services provided by the improved habitat (service-acres) before habitat restoration or mitigation measure (i.e., at the Baseline milestone),

b^p is the mean service score provided by the Assessment Area (PV^p/P, where *P* is the injury Assessment Area in acres) at the Baseline milestone (time [*t*] = 0),

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (*C* = Project Year 1), and

x_t^p is the mean service score provided by the Assessment Area at the end of year *t* if habitat restoration or mitigation measure benefits are applied.

The present value habitat service gain (*R*) will be standardized among projects by dividing by size of project (units in acres or linear mile depending on the conservation measure modeled) and averaged among hypothetical projects applying the same conservation measure to produce the service-years gained per unit of treatment ($\overline{R}^{m}$). This value will be used in mitigation calculations.

ESTIMATING COST TO IMPLEMENT MODELED HABITAT RESTORATION AND MITIGATION MEASURES

The cost of the modeled habitat conservation measures will be estimated by averaging the known cost of similar projects previously implemented (in current year U.S. dollars). The cost per unit treated will be divided by the average service-acre-years per unit area treated (calculated in the previous section), to estimate the price per service-acre-year gained for each of the habitat restoration and mitigation measures. This is the currency that will be used to offset the permanent and interim habitat service losses associated with Project construction and operation for the duration of the analysis.

APPROACH TO OFFSET HABITAT SERVICE LOSSES WITH HABITAT SERVICE GAINS

An HEA scales the mitigation package (i.e., funding to create habitat services) to offset the loss of habitat services over the lifetime of the Project. The injury is offset by planned habitat restoration and

mitigation projects in Equation 4, where the project size (P^m) can be solved for each habitat restoration or mitigation measure type (*m*).

Equation 4 $$I = \sum_{m1}^{i} P^m * \overline{R}^m$$

where:

I is the present value of the service-acre-years lost over y due to interim and permanent injury,

i is the number of habitat restoration and mitigation measures modeled,

Pm is the size of the habitat restoration or mitigation project of type m (in units of acres or miles), and

$\overline{R}^m$ is mean service-years gained per unit (acres or miles) of treatment.

Once the P^m is defined for each habitat improvement and mitigation measure, the costs per unit can be applied. Mitigation due is the sum of the costs to implement each of the habitat improvement and mitigation projects needed to offset the Project