B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Hooper Springs Transmission Project

Draft Environmental Impact Statement

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Appendix A

Caribou National Forest

Revised Forest Plan Amendment

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Appendix A Caribou Forest Plan Amendment

This proposed amendment to the Caribou National Forest (CNF) Revised Forest Plan would establish a new corridor of Management Prescription 8.1—Concentrated Development Area, to authorize transmission line construction, operation, and maintenance on CNF lands within the proposed transmission line right-of-way (ROW).

A.1 Reason for Amendment

Currently, Bonneville Power Administration (BPA) is the lead agency preparing a draft environmental impact statement (EIS) to construct, own, operate, and maintain a new, 115-kilovolt (kV) transmission line in Caribou County, Idaho. This proposed line would extend from a proposed new 138/115-kV BPA substation, referred to as the Hooper Springs Substation, near the city of Soda Springs, Idaho, to a proposed interconnection facility that would connect with Lower Valley Energy's (LVE) existing transmission system in northeastern Caribou County (see Map 1-1). BPA also would construct an approximately 0.5-mile-long, single-circuit 138-kV transmission line between the proposed Hooper Springs Substation and PacifiCorp's existing Threemile Knoll Substation to connect the new line to the regional transmission grid. The proposed 115-kV transmission line, substation, and ancillary facilities are collectively referred to as the Hooper Springs Transmission Project (project). BPA is considering a North Alternative, including two routing options, a South Alternative, including four routing options, and a No Action Alternative.

Portions of the North Alternative and its route options cross areas of the Soda Springs Ranger District of the CNF that are currently designated as Management Prescriptions 5.2b – Forest Vegetation Management; 2.7.2 – Elk and Deer Winter Range; 2.1.2b – Visual Quality Maintenance; 3.2b – Semi-Primitive Recreation; and 2.1.6b – Gravel Creek Special Emphasis Area; 6.2 – Rangeland Vegetation Management; and 2.8.3 – Aquatic Influence Zone.

Portions of the South Alternative and its route options cross areas of the Soda Springs Ranger District of the CNF Forest that are currently designated as Management Prescriptions 5.2b – Forest Vegetation Management; 2.7.2 – Elk and Deer Winter Range; and 2.8.3 – Aquatic Influence Zone.

To be consistent with Forest Plan direction, an amendment is needed to designate the Project ROW and access roads for a portion of the single-circuit 115 kV line as Prescription 8.1 – Concentrated Development Areas.

This amendment to the *Revised Forest Plan for the Caribou National Forest* (hereafter referred to as the Forest Plan) would allow for approval of a special use permit for the construction and operation of the proposed transmission line on the Soda Springs Ranger District of the CNF, Idaho.

The EIS would be used in support of an application for a ROW grant to use U.S. Forest Service (USFS) lands for portions of the proposed transmission line ROW (either the North or South alternative) extending through the CNF.

Approximately 5.5 miles of the North Alternative corridor would be located on the CNF. The North Highland Option would place roughly an additional 1.2 miles of the corridor on CNF land, for a total of 7.7 miles. The South Alternative corridor and its routing options would cross approximately 3.4 miles of CNF land.

As a cooperating agency, USFS has and will continue to participate in all aspects of the environmental analysis, and will use this EIS as a basis for its decision regarding issuance of the special use permit and determination of terms and conditions under which the permit should be issued. The Forest Plan establishes management direction including Standards and Guidelines for land and resource management on the CNF. Under 36 C.F.R. 219, the National Forest Management Act (NFMA), consistency with these Standards and Guidelines must be demonstrated prior to project approval (16 U.S.C. 1604[i] and 36 C.F.R. 219.10[e]). The Forest Plan may be amended to permit projects that are inconsistent with Forest Plan direction (36 C.F.R. 219.10[f] and CNF Forest Plan pages 1-3 and 1-4). The National Environmental Policy Act (NEPA) analysis for the Project (North or South alternative) indicates that approval of the special use permit would be inconsistent, in some instances, with Standards and Guidelines in the CNF Forest Plan. See Table A-1 for analysis of the project's consistency with forest-wide Standards and Guidelines.

A.2 Applicability to the Project

This Forest Plan amendment would apply only for those lands identified in the Hooper Springs Transmission Project EIS and Record of Decision (ROD), and only to decisions on those lands impacted by the North Alternative, South Alternative, and their respective route options. CNF lands not analyzed must undergo analysis following the Guidelines set forth in 36 C.F.R. 220 prior to any additional authorizations.

A.2.1 Management Prescriptions

Management Prescriptions are a set of management practices applied to a specific area of land in order to attain multiple-use and other goals and objectives. They identify the emphasis and focus of multiple-use management activities in a specific area; however, emphasis as used in this context is defined as a focus or a highlight and does not necessarily entail exclusive use. The specific direction stated in a Management Prescription determines what uses are allowed and to what extent the uses are permitted. Forest-wide Standards and Guidelines apply unless specified in the Management Prescription direction.

A.2.2 Standards

Standards are used to promote the achievement of the desired future conditions and objectives at the CNF or Management Prescription level. Standards are binding limitations on management activities that are within the authority of USFS to enforce. A Standard can also be expressed as a constraint on management activities or practices (See CNF Forest Plan, page 3-1). Exceptions to Standards require analysis to be disclosed in a NEPA document and a Forest Plan Amendment.

A.2.3 Guidelines

Guidelines are used in the same way as Standards but intended to be flexible to respond to variations, such as changing site conditions or management circumstances. Under the CNF

Forest Plan, Guidelines are a preferred or advisable course of action, and they are expected to be carried out, unless site-specific analysis identifies a better approach (See CNF Forest Plan, page 3-1). Exceptions to Guidelines require that the analysis be disclosed in a NEPA document. A Forest Plan Amendment is needed unless a better site-specific approach is identified in the NEPA document.

A.3 Forest Plan Direction to be Amended

A.3.1 Vegetation, Guideline 1

Guideline: Manage to reduce the decline of aspen and promote aspen regeneration and establishment. Provide protection from grazing where needed and consistent with management objectives.

Need for Amendment – North Alternative: The North Alternative would permanently impact approximately 38.8 acres of aspen-dominated forest types as a result of access road construction and ROW clearing conversion.

Need for Amendment – South Alternative: The South Alternative would permanently impact approximately 6.3 acres of aspen-dominated forest types as a result of access road construction and ROW clearing conversion.

Therefore, a Forest Plan amendment to change the ROW to Prescription 8.1 would be required. Impacts to aspen-dominated forest types would be limited to the transmission line and access roadway ROWs, and would not be expected to impact the overall representation of this forest type on the CNF. See Section, 3.4, Vegetation, for further discussion.

Mitigation: To the extent practical, both alternatives would avoid vegetation removal except as necessary for ROW and access road clearing and to remove trees and snags that would pose a danger to the transmission line.

A.3.2 Plant Species Diversity, Guideline 4

Guideline: Maintain, and where possible, increase unique or difficult-to-replace elements such as areas of high species diversity aspen, riparian areas, tall forbs, rare plant communities, etc.

Need for Amendment – North Alternative: As described in A.3.1 above, the North Alternative would impact approximately 38.8 acres of aspen-dominated forest.

Need for Amendment – South Alternative: The South Alternative would impact approximately 6.3 acres of aspen-dominated forest types.

See Section, 3.4, Vegetation, for further discussion. Similar to A.3.1 above, impacts to unique or difficult-to-replace forest types would be limited to the transmission line and access roadway ROWs, and would not be expected to impact the overall representation of this forest type on the CNF.

Mitigation: To the extent practical, both alternatives would avoid vegetation removal except as necessary for ROW clearing and to remove trees and snags that would pose a danger to the transmission line.

A.3.3 Bald Eagle Habitat—Occupied nesting zones (Zone I, 0.25 mile radius of nest) and primary use areas (Zone II, 0.5 mile radius of nest), Guideline 3

Guideline: All human activities should be minimized from February 1 to August 1 [within Zones I and II].

Need for Amendment- North Alternative: Surveys conducted by BPA contractors in 2011 did not document any bald eagle nests within 2.5 miles of the North Alternative (ROW and access roads) on CNF lands; however, suitable foraging habitat exists within the North Alternative corridor, and impacts to forested vegetation could remove potentially suitable nesting or perching trees.

Need for Amendment- South Alternative: Raptor surveys conducted in April 2007 in support of a preliminary EA for the South Alternative located one bald eagle soaring within the South Alternative corridor near the Blackfoot River Narrows, but there are no known bald eagle nests in the vicinity of the South Alternative corridor. Suitable foraging habitat exists within the South Alternative corridor, and impacts to forested vegetation could remove potentially suitable nesting or perching trees. Additional raptor surveys will be conducted within the South Alternative corridor during spring and summer 2013.

All construction activities associated with the project would take place from June to September; therefore, human activities cannot be minimized between February 1 and August 1. However, the activities would not occur within Zones I and II as it relates to CNF.

Mitigation: Pre-construction nesting bird surveys would be conducted prior to tree removal.

A.3.4 Snag/Cavity Nesting Habitat, Standards 2-3 and Guidelines 1-3

Standard 2: Snags with existing cavities or nests shall be the priority for retention.

Need for Amendment- North Alternative: Vegetation clearing would be necessary for construction of the proposed transmission line ROW (100 feet clearing width) and access roads (30 feet clearing width, though on 20 feet maintained as road). These areas (100 feet and 30 feet widths) would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Need for Amendment- South Alternative: Vegetation clearing would be necessary for construction of the proposed transmission line ROW (120 feet clearing width) and access roads (30 feet clearing width, though on 20 feet maintained as road). These areas (120 feet and 30 feet widths) would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Mitigation: Snags with existing cavities or nests would be preserved off-ROW and access road when there is no danger to the transmission line.

Standard 3: Snag height shall be 15 feet or greater for all forest types.

Need for Amendment: Vegetation clearing would be necessary for construction of the proposed transmission line ROW and access roads for both alternatives. These areas would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Mitigation: Snags of 15 feet in height or greater would be retained off-ROW to the extent practical, when there is no danger to the transmission line.

Guideline 1: Snag dbh (diameter at breast height) > 12 inches or largest diameter for the stand for all forest types and should be retained in clusters, where possible.

Need for Amendment: Vegetation clearing would be necessary for construction of the proposed transmission line ROW and access roads for both alternatives. These areas would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Mitigation: Snags of dbh greater than 12 inches, or largest diameter for the stand, would be retained in clusters where possible, provided they are located off-ROW and pose no danger to the line.

Guideline 2: Hard-snag densities for various biological potentials should be approximately as follows by forest type (See Table A-1).

Need for Amendment: Vegetation clearing would be necessary for construction of the proposed transmission line ROW and access roads for both alternatives. These areas would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Mitigation: Snags cannot be retained within the ROW or where they pose a threat to the transmission line; however, hard-snag densities for various biological potentials as discussed in Guideline 2 would be maintained to the extent practical. Standards and Guidelines regarding biological potential for woodpeckers are not a management consideration within the 8.1 Management Prescription.

Guideline 3: Retain live trees for future snag recruitment using the following guidelines (See Table A-1).

Need for Amendment: Vegetation clearing would be necessary for construction of the proposed transmission line ROW and access roads for both alternatives. These areas would be kept clear of all tall vegetation, and would permanently convert forested habitat to non-forested area.

Mitigation: Live trees cannot be retained in the ROW or where they pose a threat to the transmission line; however, live trees off ROW and that do not pose a risk to the transmission line would be retained for future snag recruitment to the extent practical.

A.3.5 Transportation and Utility Corridors, Guideline 3

Guideline: Utility structures should be made to blend with the existing landscape to the extent feasible.

Need for Amendment – North Alternative: The North Alternative would be visible from Highway 34 on USFS Retention lands upon the approach to the Lanes Creek Substation, and therefore potentially not consistent with this guideline. It should be noted that the visual landscape in the area surrounding the North Alternative corridor in the vicinity of the Lanes Creek Substation is currently impacted by existing utility lines and Highway 34.

Need for Amendment – South Alternative: The South Alternative would be visible from the Blackfoot River and Blackfoot River Road on USFS Partial Retention and Modification lands and therefore potentially not consistent with this guideline. The visual landscape surrounding the South Alternative corridor is relatively natural-appearing but VQOs in that area allow for some visual evidence of human activity if it remains subordinate to the general character of the landscape.

Mitigation: Wooden H-frame structures would be used to minimize the visual impact of the proposed transmission line to the extent practical on the North Alternative. The structures would blend into the background shades of green and brown and thus be generally consistent with the line, form, color and texture of the landscape. The color of the steel structures used for the South Alternative would be reflective initially, but would dull after 2 to 3 years and would thus be expected to blend with the line, form, color and texture of the landscape. See Section 3.3, Visual Resources, for further discussion.

A.3.6 Scenic Resources, Standard 1

Standard: Objectives for scenery (either VQOs or SIOs) shall be met along Scenic or Historic Byways, Wild and Scenic Rivers, and other sensitive travel routes and special emphasis areas.

Need for Amendment – North Alternative: Approximately 1 mile of Highway 34, the Pioneer Historic Byway, crosses through USFS Retention lands in close proximity to the North Alternative corridor upon its approach to the Lanes Creek substation. The transmission line would be visible from this section of highway. As discussed above, the visual landscape in the area surrounding the North Alternative upon its approach to the Lanes Creek Substation is currently impacted by existing utility lines.

Need for Amendment – South Alternative: The portion of the South Alternative traversing USFS lands in and near the Blackfoot River Narrows passes through an area with a Partial Retention VQO. In this area, the transmission line would be visible from the Blackfoot River, which is listed on the NRI as potentially eligible for listing under the Wild and Scenic Rivers Act because of its scenic and fisheries resources.

Mitigation: The proposed structures under the North Alternative on CNF land would be wooden, blending into the background shades of green and brown and thus generally consistent with the line, form, color and texture of the landscape. Motorists or residents using Highway 34 would move through the affected area quickly, moderating the visual impact of the line. The color of the steel structures used for the South Alternative would be reflective initially, but would dull after 2 to 3 years and would thus be expected to blend with the line, form, color and texture of the landscape. BPA would consult with NPS regarding any potential impacts to the eligibility of the Blackfoot River for listing under the Wild and Scenic Rivers Act. See Section 3.3, Visual Resources, for further discussion.

A.4 Proposed Amendment

The proposed amendment would designate a new corridor of Management Prescription 8.1 – Concentrated Development Area to accommodate the Project. As described in the Forest Plan (RFP 4-78), these lands are “generally highly developed areas with much evidence of people, structures, roads, and often disturbed ground." The North Alternative would require a ROW approximately 5 miles long by 100 feet wide (on C-TNF lands) and the South Alternative would require a ROW approximately 3.4 miles long by 120 feet wide (on C-TNF lands) as discussed in Section 2.2.2 of the Hooper Springs Transmission Project draft EIS. Table A-1 details the acreage of each existing management prescription that would need to be converted to Management Prescription 8.1 for the two alternatives and route options.

Table A-1. Acreage Added to Prescription 8.1 by Existing Management Prescription

Management Prescription	North Alternative and Long Valley Road Option (Acres)	North Alternative including North Highland Option (Acres)	South Alternative and all Route Options (Acres)
3.2 Semi-Primitive Recreation	6.1	4.8	0.0
2.1.2 Visual Quality Maintenance	7.3	15.8	0.0
2.1.6 Gravel Creek Special Emphasis Area	1.2	1.2	0.0
5.2 Forest Vegetation Management	22.5	22.5	43.0
2.7.2 Elk and Deer Winter Range	29.4	29.4	6.5
6.2 Rangeland Vegetation Management	0.0	7.6	0.0
TOTAL	**66.5**	**81.3**	**49.5**

Access roads necessary to construct and maintain the transmission line regardless of alternative would remain in their respective Management Prescriptions (3.2b; 2.1.2b; 2.1.6b; 5.2b; 2.7.2; 6.2; and 2.8.3) and would be managed to comply with those Prescriptions. The area surrounding the proposed transmission line and new access roads under the North Alternative would retain its existing ROS class of Roaded Modified. The area surrounding the proposed transmission line and new access roads under the South Alternative would retain its existing ROS classes of Roaded Modified and Semi-primitive Motorized.

The proposed amendment would allow "concentrated development in small areas for development and infrastructure needs," consistent with the goals of Management Prescription 8.1. In accordance with standards for Management Prescription 8.1, if through opportunistic or incidental monitoring of the transmission line by BPA maintenance or USFS personnel, or consistent anecdotal reports, the line is found to be causing mortality, BPA will work with USFS to correct the problem. Standards and Guidelines regarding biological potential for woodpeckers are not a management consideration within the 8.1 Management Prescription.

A.5 NEPA Analysis

The NEPA evaluation of this proposed amendment, as called for by 36 C.F.R. Part 219, Section 219.10(f), is being performed as part of the Hooper Springs Transmission Project EIS process. As part of the proposed Forest Plan Amendment evaluation, a determination as to whether the proposed amendment is a significant or non-significant amendment to the Forest Plan will be made and documented in the ROD. This amendment is consistent with NEPA, 40 C.F.R. Parts 1500 to 1508, FSH 1909.15 (09/20/10), and 26 C.F.R. 220.

A.6 Effects

The direct, indirect, and cumulative impacts of the Project are discussed in Chapter 3 of the draft EIS. Also refer to Section 3.3 and Appendix C for an analysis of the effects on visual resources; Sections 3.1 and 3.2 for impacts to land use and recreation; Section 3.4 for impacts to vegetation and appendix D and E; Section 3.5 for impacts to geology and soils; Section 3.6 for impacts to water resources and wetlands; Section 3.7 for impacts to wildlife and appendix F and G; and Sections 3.4, 3.6 and 3.7 for impacts to special status species. Changing the management to Concentrated Development would allow actions that would impact vegetation and wildlife within the area. However, the long-term impacts associated with operation and maintenance of the line regardless of alternative would be intermittent and low.

Refer to Table A-1 for analysis of the Project's consistency with applicable forest-wide Standards and Guidelines. Impacts and mitigation associated with each Standard and Guideline are also discussed where applicable.

Table A-2 Consistency with Forest-wide Standards and Guidelines

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
FOREST-WIDE GUIDANCE	
Fire	
Standard 1. All fires shall be suppressed if they are in areas not covered by a pre-approved fire management plan.	Fire management measures in the BPA master contract for the Project would include provisions for monitoring under certain conditions. BPA would also coordinate fire suppression measures with the USFS.
Caves	
Standard 1. Retain vegetation in the vicinity of a cave or cave course if it is required to protect the cave's microenvironment (habitat, climate, vegetation, etc.).	N/A. The Project would not be located near, nor would it disturb any known caves.
Guideline 2. Management activities may be permitted within any area draining into or away from a cave if they are not likely to adversely affect the cave ecosystem.	N/A. The Project would not be located near, nor would it disturb any known caves.
Soils—All Ecosystems	
Standard 1. Land types identified as being unstable or marginally unstable in the Caribou National Forest Soil Resource Inventory shall be ground verified prior to soil disturbing activities to determine the capability of the land to sustain resource development activities including road construction.	BPA and contractors will perform ground verification during summer of 2012 to determine the capability of the land to sustain road and transmission line construction activities.
Standard 2. Suitability for resource management activities shall be disclosed in the site-specific analysis.	The suitability of the project area for each alternative is analyzed in this EIS document. See Section 3.5, Geology and Soils, for further discussion.
Standard 3. For ground-disturbing activities where detrimental soil disturbances (defined in Forest Service Handbook 2509.18) occur on areas of 10 acres or greater, plan and implement rehabilitation to meet desired future conditions.	Ground disturbance associated with ROW clearing and road construction for both alternatives exceeds 10 acres. Within the ROW, low-growing vegetation would largely be allowed to reestablish, but tall vegetation that could interfere with operation and maintenance of the transmission line would not. See Section 3.4, Vegetation, for further discussion. Permanent and improved access roads would not be rehabilitated; however, roads would use low grades, out sloping, intercepting dips, water bars, and ditch-outs as needed to minimize erosion. See Section 3.5, Geology and Soils, for further discussion of mitigation measures. Ground disturbing activities associated with either alternative would not prevent the area surrounding the proposed transmission line ROW and access roads from meeting Desired Future Conditions as described on Page RFP 3-2 of the CNF RFP.
Standard 4. On land types where landslides or landslide prone areas have been identified, a site-specific analysis shall be conducted to ensure project implementation is compatible with desired future conditions.	Based on analysis detailed in Section 3.5, Geology and Soils, the project would not be intentionally sited on any land types that are landslide-prone. BPA will be conducting engineering geotechnical surveys during fall 2012.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Guideline 1. Resource developments and utilization should be restricted to lands identified in the Soil Resource Inventory as being capable of sustaining such impacts.	The soils within the project area are expected to be capable of sustaining the impacts from the North and South alternatives. See Section 3.5, Geology and Soils. BPA will coordinate with USFS as needed concerning review of the Soil Resource Inventory as applicable to the Project.
Guideline 2. Maintain ground cover, microbiotic crusts, and fine organic matter that would protect the soil from erosion in excess of soil loss tolerance limits and provide nutrient cycling.	Grubbing would be limited to areas around structure sites to reduce the impact on low-lying vegetation. **<u>North Alternative</u>** Disturbance associated with permanent and reconstructed access roads for the North Alternative would result in the permanent loss of ground cover on up to approximately 30 acres. **<u>South Alternative</u>** Disturbance associated with permanent and reconstructed access roads for the South Alternative would result in the permanent loss of ground cover on up to approximately 15 acres. See Section 3.4, Vegetation and Section 3.5, Geology and Soils for further discussion.
Guideline 3. Detrimental soil disturbance such as compaction, erosion, puddling, displacement, and severely burned soils caused by management practices should be limited or mitigated to meet long-term soil productivity goals.	Mitigation measures would be implemented to minimize impacts to long-term soil productivity, including retention and on-site reuse of all topsoils removed; revegetation of all temporarily disturbed areas; break-up of compacted soils prior to reseeding; and monitoring of all reseeded areas. See Section 3.4, Vegetation and Section 3.5, Geology and Soils for further discussion.
Soils—Forested Ecosystems	
Guideline 1. Reduce soil erosion to less than the soil loss tolerance limits on lands disturbed by management activities within one growing season after disturbance.	BPA would implement erosion control measures on all permanent access roads and would also initiate reclamation of all temporarily disturbed areas immediately following construction. BPA would replant all temporarily disturbed areas, but plans to allow for two growing seasons in order to measure success. See Section 3.4 Vegetation and 3.5, Geology and Soils for further discussion.

Caribou National Forest U.S. Forest Service (2003)

<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Guideline 2. Sustain site productivity by providing the following minimum amounts of woody residue =3 inches in diameter dispersed on the site as outlined in Table 3.1, below. These do not apply within a 300-foot corridor on either side of roads designated as open on the most current version of the Travel Plan.
Table 3.1 Minimum Woody Residue by Forest Habitat Type
<u>3-5 tons/acre:</u>
Limber pine/curlleaf mountain mahogany (Pifl/Cele)
Douglas-fir /mountain snowberry (Psme/Syor)
Douglas-fir /common juniper (Psme/Juco)
Lodgepole pine/heartleaf arnica (Pico/Arco)
<u>5-10 tons/acre</u>
Douglas-fir/ninebark (Psme/Phma)
Subalpine fir/pine grass (Abla/Caru)
Douglas-fir/mountain maple (Psme/Acgl)
Subalpine fir/heartleaf arnica (Abla/Arco)
Subalpine fir/Ross sedge (Abla/Caro)
Douglas-fir/blue huckleberry (Psme/Vagl)
Lodgepole pine/blue huckleberry (Pico/Vagl)
Douglas-fir/Oregon grape (Psme/Bere)
Lodgepole pine/grouse whortleberry (Pico/Vasc)
Douglas-fir/white spirea (Psme/Spbe)
Lodgepole pine/pine grass (Pico/Caru)
Douglas-fir/pine grass (Psme/Caru)
Lodgepole pine/elk sedge (Pico/Cage)
Subalpine fir/white spirea (Abla/Spbe)
<u>10-15 tons/acre</u>
Douglas-fir/mountain sweetroot (Psme/Osch)
Subalpine fir/mountain arnica (Abla/Arla)
Subalpine fir/mountain maple (Abla/Acgl)
Subalpine fir/common snowberry (Abla/Syal)
Subalpine fir/grouse whortleberry (Abla/Vasc)
Subalpine fir/ninebark (Abla/Phma)
Subalpine fir/western meadow -rue (Abla/Thoc)
Subalpine fir/blue huckleberry (Abla/Vagl)
Subalpine fir/oregon grape (Abla/Bere)
<u>15-20 tons/acre</u>
Engelmann spruce/sweetscented bedstraw(Pien/Gatr)
Subalpine fir/mountain sweetroot (Abla/Osch)</td><td>BPA would incorporate measures to provide minimum amounts of woody residue to the extent practical. This could include the retention of woody residue within the transmission line ROW as well as placement of woody residue within the ROW following construction.</td></tr>
<tr><td>Lands and Land Exchanges</td><td></td></tr>
<tr><td>Standard 2. Any planned activities on the National Forest which might disturb Geodetic control survey monuments and boundary markers shall be evaluated at the time of project planning and environmental analysis for each specific project.</td><td>BPA survey crews would verify the locations of any geodetic survey control monuments and/or boundary markers, and would coordinate with USFS as needed to avoid implementation of any activities that would disturb such markers.</td></tr>
</table>

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Guideline 1. Access to the Forest should be maintained or improved, as needed, for administration, protection, and public access. Small scale adjustments of landownership may be made through sale and/or exchanges to facilitate economical and logical administration of Federal lands.	Upon completion of construction of the transmission line regardless of alternative, new permanent and improved access roads would be gated to exclude public motorized access. Open public roadways would remain open. Traffic associated with maintenance vehicles would be infrequent and would have no impact on access to the Forest. Roadways that may be damaged by construction vehicles and heavy equipment during construction would be repaired and improved as needed. See Section 3.2, Recreation, and Section 3.11, Transportation, for further discussion.
Special Uses	
Standard 1. Allow special uses that are compatible with other resources.	The intent of this EIS is to support a decision that ensures the Project would be constructed and maintained in such a way as to be compatible with other resources.
Transportation and Utility Corridors	
Standard 1. Existing and proposed ROWs of the following types shall be designated as corridors (Prescription 8.1). This does not prevent the inclusion of lower-rated transmission lines or smaller pipelines within the corridors. Communication lines and zones for interstate use. Railroads. Federal, state, interstate, and forest highways. Electric transmission lines of 66KV and greater, including fiberoptics. Oil, gas, slurry, or other pipelines 10 inches or larger in diameter.	The Project is the subject of an application for amendment to the Caribou Forest Plan to designate the portion of the North or South alternative transmission line ROW located on CNF lands as Prescription 8.1 – Concentrated Development Area
Standard 2. Proponents of new facilities within existing corridors, and new corridor routes, shall demonstrate that the proposal is in the public interest, and that no other reasonable alternative exists to public land routing.	The Project is the subject of an EIS. Chapter 1 of the EIS describes the underlying public need it intends to serve. Given the somewhat linear nature of the CNF it would be very difficult to site around the Forest. **<u>North Alternative</u>** The LVE Lanes Creek Substation is already located on CNF lands; therefore, it is technically impossible to route North Alternative in such a way that it does not traverse public lands. **<u>South Alternative</u>** The interconnection with the existing LVE transmission line at the eastern terminus of the South Alternative lies on the opposite side of an approximately 3-mile wide section of CNF land from the western portion of the South Alternative corridor. Given the linear nature of the CNF in the South Alternative corridor, it would be infeasible to site around the Forest.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Standard 3. Allow for essential access for repair and maintenance of facilities within energy corridors.	**North Alternative** The North Alternative would include approximately 8.1 miles of permanent and reconstructed access roads. **South Alternative** The South Alternative would include approximately 4.1 miles of permanent and reconstructed access roads. Access roads would be constructed and used specifically for essential repair of and maintenance access to the proposed transmission line ROW. These roads would be gated during the operation and maintenance phase of the proposed transmission line to exclude public motorized access. See Section 3.2, Recreation, for further discussion.
Guideline 1. Utility corridors should have irregular clearing widths and follow patterns of existing natural openings.	The edges of the ROW located on C-TNF lands along either the North or South alternative would be feathered, and BPA would coordinate with USFS to ensure that ROW clearing is consistent with Forest Plan standards and guidelines for utility corridors.
Guideline 3. Utility structures should be made to blend with the existing landscape to the extent feasible.	**North Alternative** Under the North Alternative, the transmission line ROW and structures would be visible upon the approach to the Lanes Creek Substation.Wooden H-frame structures would be used to minimize the visual impact of the proposed transmission line. See Section 3.3, Visual Resources, for further discussion. **South Alternative** Under the South Alternative, the transmission line ROW and structures would be visible from Blackfoot River Road and the Blackfoot River in the vicinity of the Blackfoot River Narrows.
Guideline 4. Where feasible, new facilities should be limited to existing ROWs having widening potential	The alternatives analyzed in the EIS were selected as the most feasible options based upon an alternatives analysis conducted in support of a preliminary EA. See Chapter 2, Proposed Project and Alternatives, for further discussion. All new facilities on USFS lands would be restricted to the proposed transmission line ROW.
Guideline 5. Before new corridors or widening of existing corridors are approved, consideration should be given to wheeling, uprating, or multiple circuiting of transmission lines or increasing pipeline capacity by addition of compressors or looping.	The alternatives analyzed in the EIS were selected as the most feasible options based upon alternatives analysis conducted in support of a preliminary EA. See Chapter 2, Proposed Project and Alternatives, for further discussion.
Guideline 6. Avoid parallel corridors. Consolidate facilities within existing energy corridors where feasible.	The Project would avoid parallel utility corridors.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Guideline 7. Pipelines and other related utilities should share utility corridors except as needed to meet other resource goals	N/A. The Project would not include the routing of any pipelines.
Minerals and Geology—Drastically Disturbed Lands	
NOTE: Drastically disturbed lands are extremely large areas where the surface soil layers or topography have been highly altered or rearranged through human activities such as mining, etc. (Caribou Revised Forest Plan, p. 3-14)	The Project would not disturb a large area of surface soils or highly alter topography. Therefore, it is not expected that lands impacted by the Project would be considered "drastically disturbed" under either alternative. Revegetation and other mitigation measures associated with the Project are discussed below as they apply to the Standards and Guidelines for Drastically Disturbed Lands.
Standard 3. oil resources shall be inventoried to National Cooperative Soil Survey standards for Order 2 or more detailed levels. Volumes and suitability of soil resources for reclamation shall be determined before disturbance.	N/A. As the Standards and Guidelines for Drastically Disturbed Lands would likely not apply, it is not expected that an Order 2 or more detailed soil survey would be necessary.
Standard 4. Topsoil and selected subsoils suitable for reclamation, as identified in the soil inventory, shall be salvaged on all slopes where equipment can safely operate and either stockpiled and protected or directly placed.	All native topsoil removed for structure and access road construction would be stockpiled and reused on-site for restoration activities. See Section 3.5, Geology and Soils, for further discussion of proposed mitigation measures.
Standard 8. The lessee/operator shall monitor reclamation work annually and report to the Forest Service until reclamation is accepted and the bond released.	N/A. As the Standards and Guidelines for Drastically Disturbed Lands would likely not apply, it is not expected that a bond would be required. Reclamation and reseeding efforts would be monitored during construction and afterward as needed. BPA would conduct monitoring of all ground-disturbed areas for 5years for noxious weed invasions, and take corrective action as necessary, in coordination with CNF personnel and in adherence to the Forest's weed management efforts. See Section 3.4, Vegetation, and Section 3.5, Geology and Soils, for further discussion of proposed mitigation measures.
Guideline 2. Selection of plant species for establishment should reflect the surrounding ecosystem and post remedial land use. Plant materials used should be adapted to the climate of the site. Consideration and preference should be given to promoting natural succession, native plant species, and structural diversity.	Appropriate seed mixes, application rates, and seeding dates would be used to revegetate temporarily disturbed areas following completion of construction activities. Native topsoil removed for structure and access road construction would be stockpiled and reused on-site for restoration activities to promote regrowth from the native seed bank in the topsoil. BPA would coordinate with the Forest botanist and silviculturalist for proper seed mixes to be used in revegetation efforts. See Section 3.4, Vegetation, and Section 3.5, Geology and Soils, for further discussion of proposed mitigation measures.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Guideline 4. Reclaimed areas should be graded and shaped, where possible, to a stable topographic relief that conforms and blends in with the variability of surrounding slopes. Final reclaimed slopes shall not be steeper than 3:1.	N/A. The Standards and Guidelines for Drastically Disturbed Lands would likely not apply to the project, and no large areas of land would need to be reclaimed. BPA construction plans would include re-grading temporarily disturbed areas to their original morphology.
Guideline 7. In reclaimed areas, vegetation should include species that meet wildlife habitat needs. Wildlife structures (slash piles, logs, rock piles) using native vegetation and materials are designed to provide cover for wildlife movements in created openings.	To the extent practical, both alternatives would avoid the removal of vegetation and vegetation communities that provide important wildlife habitat, including large trees and snags and tall, thick sagebrush stands. Appropriate seed mixes, application rates, and seeding dates would be used to revegetate temporarily disturbed areas following completion of construction activities. Wildlife habitat structures including slash piles or logs would be retained or placed on the ROW as practicable. See Section 3.4, Vegetation, and 3.7, Wildlife, for further discussion.
Watershed and Riparian Resources	
Guideline 1. Not more than 30 percent of any of the principal watershed[1] and/or their subwatersheds (6th HUC) should be in a hydrologically disturbed condition[2] at any one time.	**<u>North Alternative</u>** Of the 6th level HUC (12-digit) watersheds that contain Forest Service land and are affected by the North Alternative, the project would only impact 0.1 percent. **<u>South Alternative</u>** Of the 6th level HUC (12-digit) watersheds that contain Forest Service land affected by the South Alternative, the project would impact no more than 0.4 percent.

[1] These Project Work Inventory (PWI) watersheds have been delineated on the Caribou National Forest and are at approximately the same scale as 5th level hydrologic unit codes (HUC) which were used in the ICEBMP assessment effort.

[2] Hydrologically Disturbed Condition. Changes in natural canopy cover (vegetation removal) or a change in surface soil characteristics (such as compaction) that may alter natural streamflow quantities and character. Hydrologically Recovered Condition. Vegetative life form where natural canopy coverage is achieved and subsequent streamflow quantities and character (timing and amount) reflect more natural conditions. Roads are considered hydrologically recovered if obliterated or ripped and drained and have 80% or more ground cover.

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Standards and Guidelines	Consistency
Guideline 2. Proposed actions analyzed under NEPA should adhere to the State Source Water Assessment Plan to achieve consistency with the Safe Drinking Water Act, and amendments, to emphasize the protection of surface and ground water sources used for public drinking water.	**North Alternative** There are no anticipated direct impacts to groundwater or wells for the North Alternative, as only one well is located within the transmission line ROW for the North Alternative and this well is off the Forest. **South Alternative** Two groundwater monitoring wells are located within the South Alternative corridor. One is within both the transmission line and access road ROW and another within the transmission line ROW only. Neither is located on Forest Service land There are therefore no anticipated direct impacts to groundwater or wells for the South Alternative. See Section 3.6, Water Resources, Floodplains, and Wetlands, for further discussion.
Guideline 3. Projects in watersheds with 303(d) listed waterbodies and/or delineated Source Water Protection Areas should be supported by scale and level of analysis sufficient to permit an understanding of the implications of the project within the larger watershed context.	Within the project area, the Blackfoot River, Little Blackfoot River, Meadow Creek and Mill Canyon Creek are listed on the 2010 303(d) list. See Section 3.6, Water Resources, Floodplains, and Wetlands for specific analysis of impacts associated with these waterbodies. The Project would not impact Tin Cup Creek or Chippy Creek, their intermittent tributaries or associated AIZs. **North Alternative** As stated above, approximately 0.1 percent of the 6^{th} level HUC watersheds would be affected by the North Alternative and impacts to the waters within these watersheds would be primarily short term. **South Alternative** No more than 0.4 percent of any 6^{th} level HUC watershed would be affected by the South Alternative, and impacts to the waters within these watersheds would be primarily short term. At a watershed level these impacts would be de minimis.
Guideline 4. Proposed actions analyzed under NEPA should adhere to the State Nonpoint Source Management Plan to best achieve consistency with both Sections 313 and 319 of the Federal Water Pollution Control Act.	The Idaho state plan was considered in evaluating the Project. Many of the mitigation measures proposed are intended to reduce increased sedimentation, a major non-point source of pollution, in area waterbodies as a result of construction. See Sections 3.5 Geology and Soils and 3.6, Water Resources, Floodplains, and Wetlands.

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Standards and Guidelines	Consistency
Vegetation	
Standard 1. Do not conduct management activities that may alter canopy vegetation within 400 feet of a Natural Resource Conservation Service (NRCS) snow measuring site without first contacting NRCS.	BPA would confirm the location of any NRCS snow measuring sites within the project area, and would contact NRCS regarding any canopy-altering management activities that may take place within 400 feet of a snow measuring site.
Standard 2. In each 5th code HUC which has the ecological capability to produce forested vegetation, the combination of mature and old age classes (including old growth) shall be at least 20 percent of the forested acres. At least 15 percent of all the forested acres in the HUC are to meet or be actively managed to attain old growth characteristics.	The removal of forest vegetation in the affected HUCs should not limit the Forest's ability to meet this standard. See Section 3.4, Vegetation, for further detail.
Standard 3. The definition of old growth characteristics by forest type found in "Characteristics of Old-Growth Forests in the Intermountain Region (Hamilton 1993) shall be used unless more current direction is developed.	**North Alternative** Surveys conducted by BPA and contractors in 2011 found no old growth within the North Alternative corridor. **South Alternative** Based on a 2009 Preliminary EA conducted in support of the project, there are no known stands of old growth within the South Alternative corridor. BPA and contractors will be conducting additional old growth surveys for the South Alternative corridor in 2013.

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Standards and Guidelines	Consistency
Guideline 1. Manage to reduce the decline of aspen and promote aspen regeneration and establishment. Provide protection from grazing where needed and consistent with management objectives.	**North Alternative** The North Alternative would permanently impact approximately 38.8 acres of aspen-dominated forest types as a result of access road construction and ROW clearing conversion. Apart from the North Highland Option, the North Alternative corridor does not traverse areas of CNF land where grazing is prevalent. If necessary, protection from grazing would be provided as is consistent with management objectives. The North Highland Option traverses areas of CNF land managed under Management Prescription 6.2, Rangeland Vegetation Management. The purpose of this management prescription is to achieve and maintain healthy rangelands for livestock forage production, therefore it is not anticipated that protection from grazing would be necessary. **South Alternative** The South Alternative would permanently impact approximately 6.3 acres of aspen-dominated forest types. The North Alternative corridor traverses areas of CNF land where grazing is allowed but not specifically identified as a management goal. If necessary, protection from grazing would be provided as is consistent with management objectives. Impacts to aspen-dominated communities would be limited to the transmission line ROW and access roads. See Section 3.4, Vegetation, for further discussion.

Caribou National Forest U.S. Forest Service (2003)

<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Guideline 4. When delineating old forests, use the definitions of late seral stages by forest type as shown in the Table 3.2 below. These are guidelines and site-specific stand structure should determine delineation of late seral stands.

Table 3.2 Characteristics of Late Seral Forests by Vegetation Overstory Type.

<table>
<tr><th>Forest Type</th><th>Age</th><th>Trees per Acre</th><th>DBH in inches (diameter at breast height)</th></tr>
<tr><td>Lodgepole pine</td><td>100+</td><td>40+</td><td>9+</td></tr>
<tr><td>Mixed Conifer</td><td>100+</td><td>40+</td><td>12+</td></tr>
<tr><td>Spruce/fir</td><td>110+</td><td>20+</td><td>12</td></tr>
<tr><td>Douglas-fir</td><td>14+</td><td>25+</td><td>14+</td></tr>
<tr><td>Aspen</td><td>0+</td><td>20+</td><td>10+</td></tr>
</table></td><td><u>North Alternative</u>
Forest inventory surveys were conducted within the North Alternative corridor during summer 2011 to determine if any of the stands within the project corridor meet or were close to meeting the criteria for old-growth forests as defined in the CNF RFP. These survey results indicated that the forest stands within the North Alternative corridor did not meet Region 4 old-growth criteria.

South Alternative
Based on a 2009 Preliminary EA prepared in support of the project, there are no known stands of old growth within the South Alternative corridor. Additional forest inventory surveys will be conducted for the South Alternative corridor during the spring of 2013.

See Section 3.4, Vegetation, for further discussion.</td></tr>
<tr><td>Guideline 7. Vegetation manipulation may include mechanical treatments, chemical treatments, commercial or non-commercial timber harvest of wood products, prescribed fire, wildfire for resource benefit, or other appropriate methods. Manipulations should emphasize ecological and multiple use outcomes over being “above-cost”.</td><td>Vegetation manipulation associated with either alternative would include mechanical treatment within the ROW, and adjacent to the ROW as needed to remove danger trees. Merchantable timber removed as a result of ROW clearing would be sold commercially. Vegetation manipulation would emphasize ecological and multiple-use outcomes over being “above cost.” See Section 3.4, Vegetation, for further discussion of mitigation measures. Future vegetation management may include mechanical and chemical treatments.</td></tr>
<tr><td>Noxious Weeds and Invasive Plant Species</td><td></td></tr>
<tr><td>Standard 1. Only weed-free hay, straw, pellets, and mulch shall be used on Forest.</td><td>Only weed-free hay, straw and mulch would be used to control erosion during construction and revegetation activities. See Section 3.4, Vegetation, for further discussion of mitigation measures.</td></tr>
<tr><td>Standard 2. All seed used shall be certified to be free of noxious weed seeds from weeds listed on the current All States Noxious Weeds List.</td><td>All seed used would be certified to be free of noxious weed seeds from weeds listed on the current All States Noxious Weeds List. Seed mix would be coordinated with the Forest botanist. See Section 3.4, Vegetation, for further discussion of mitigation measures.</td></tr>
<tr><td>Standard 3. Gravel or borrow material sources shall be monitored for noxious weeds and other invasive species. Sources infested with noxious weeds shall be closed until the weeds are successfully controlled.</td><td>Gravel or borrow material sources would be monitored for noxious weeds and other invasive species. Sources infested with noxious weeds would be closed until the weeds are successfully controlled. BPA may need to coordinate with USFS to inspect borrow source.</td></tr>
</table>

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Standard 4. Noxious weeds shall be aggressively treated throughout the Forest, unless specifically prohibited, following the Caribou Noxious Weed Strategy. Using Integrated Weed Management, methods of control and access shall be consistent with the goals of each prescription area.	BPA would conduct monitoring of all ground-disturbed areas for 5 years for noxious weeds invasions, and take corrective action as necessary, according to the Caribou Noxious Weed Strategy and the BPA Transmission System Vegetation Management EIS. See Section 3.4, Vegetation, for further discussion of mitigation measures.
Guideline 1. Weed treatment projects, especially those using herbicides, should be timed to achieve desired effects on target vegetation, while having minimal effects on non-target vegetation.	The BPA Transmission System Vegetation Management EIS calls for the use of localized and spot application of herbicides as needed. BPA would coordinate closely with USFS land managers to time herbicide applications appropriately to avoid effects on non-target vegetation. See Section 3.4, Vegetation, for further discussion of mitigation measures.
Guideline 3. Monitor, as needed, disturbed areas, such as landings, skid trails, roads, mines, burned areas, etc., for noxious weeds or invasive species and treat where necessary.	All reclaimed areas would be surveyed and/or monitored to determine whether noxious weeds have been spread within the project area. Corrective actions would be taken as needed. See Section 3.4, Vegetation, for further discussion of mitigation measures.
Plant Species Diversity	
Standard 1. Projects and activities shall be managed to avoid adverse impacts to sensitive plant species that would result in a trend toward federal listing or loss of viability.	Construction and operation of the Project under either alternative would be managed to avoid adverse impacts to sensitive plant species that would result in a trend toward federal listing or loss of viability. See Section 3.4, Vegetation, for further discussion of sensitive plant species and mitigation measures.
Guideline 1. Native plant species from genetically local sources should be used to the extent practical for erosion control, fire rehabilitation, riparian restoration, road ROWs seedings, and other revegetation projects.	Native plant species from genetically local sources would be used to the extent practical for erosion control, fire rehabilitation, riparian restoration, road ROW seedings, and other revegetation projects per coordination with the Forest botanist.
Guideline 2. Where practical, disturbed sites should be allowed to revegetate naturally where the seed source and soil conditions are favorable (e.g. low erosion potential, deeper soils) and noxious weeds are not expected to be a problem.	Where practical, disturbed sites would be allowed to revegetate naturally where the seed source and soil conditions are favorable (e.g. low erosion potential, deeper soils) and noxious weeds are not expected to be a problem. Native topsoil removed for structure and access road construction would be stockpiled and reused on-site for restoration activities to promote regrowth from the native seed bank in the topsoil. See Section 3.4, Vegetation and Section 3.5, Geology and Soils.

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Standards and Guidelines	Consistency
Guideline 3. Known occurrences or habitat for rare plants on the "Forest Watch" list and rare or unique plant communities on the Forest should be maintained.	**<u>North Alternative</u>** No rare plants were identified during vegetation surveys for the North Alternative in 2011. **<u>South Alternative</u>** Surveys conducted in 2007 in support of a Preliminary EA for the South Alternative located no rare plants within the South Alternative corridor. BPA and contractors will conduct additional rare plant surveys for the South Alternative corridor during 2013. Both alternatives would limit vegetation removal, such as danger tree clearing, to the minimum amount necessary to minimize loss of potential habitat for special status species. See Section 3.4, Vegetation, for further discussion of rare plant presence and mitigation measures.
Guideline 4. Maintain, and where possible, increase unique or difficult-to-replace elements such as areas of high species diversity aspen, riparian areas, tall forbs, rare plant communities, etc.	The Project would limit vegetation removal to the minimum amount necessary to minimize loss of potential habitat for special status species and unique or difficult-to-replace plant communities. **<u>North Alternative</u>** The North Alternative would permanently impact approximately 38.8 acres of aspen-dominated forest types as a result of access road construction and ROW clearing conversion. **<u>South Alternative</u>** The South Alternative would permanently impact approximately 6.3 acres of aspen-dominated forest types. See Section, 3.4, Vegetation, for further discussion.
Guideline 5. The Forest Botanist or Ecologist should review seed mixes used for revegetation to insure no adverse impacts to threatened, endangered, sensitive species , other species at risk and the overall native flora within the analysis area.	BPA would coordinate with USFS regarding seed mixes to be used for revegetation.
Management Indicator Species	
1. In project analyses affecting the habitats listed below, assess impacts to habitat and populations for the following management indicator species: • Grassland and open canopy sagebrush habitats--Columbian Sharp-tailed Grouse • Sagebrush habitats--Sage Grouse • Mature and old forest habitats--Northern Goshawk	The EIS analyzes the impacts of both alternatives as they relate to the Columbian sharp-tailed grouse, sage grouse, and northern goshawk, as well as these species' respective habitats. See Section 3.7, Wildlife, for further discussion.

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Standards and Guidelines	Consistency
Sensitive Species	
Guideline 1. Survey for the presence of sensitive species if suitable habitats are found within a project area a minimum of once prior to or during project development.	**North Alternative** Surveys were conducted in 2011 to verify the presence of sensitive species within the North Alternative corridor. **South Alternative** Surveys were conducted in 2007 to verify the presence of sensitive species within the South Alternative corridor. BPA and contractors will conduct additional surveys for the South Alternative corridor during 2013. Pre-construction surveys will be conducted for nesting bird species in furtherance of the Migratory Bird Treaty Act and Forest goals.
Dead and Down Material	
Guideline 1. Following forested vegetation treatments, an average of 11 logs per acre should be left consisting of logs in decomposition classes 1, 2, and/or 3 (where they exist). • In specific areas where fuel loading and fire hazards are a concern (i.e. urban interface areas), the number of logs per acre can be reduced to meet acceptable fuel loading standards. • This guideline does not apply within 300 feet of an open designated route. • These requirements can be achieved, in part, with the down woody debris requirements for soils; they are interrelated and are not cumulative. • Logs do not need to be evenly distributed over the forested acres. Some acres may have no logs, while others may have many more than 11 logs per acre. The guideline is to have an average of 11 logs per acre on a least 60 percent of the forest acres of each analysis area.	BPA would retain and/or place dead and down woody material within the ROW to the extent practical regardless of alternative. Because it would be limited to a maximum ROW width of 100 feet, the presence of the line should not affect the average amount of down woody debris per acre to an extent that would create a detrimental impact or cause an area to fall below the average levels stated in the guideline.
Snag/Cavity Nesting Habitat	
Standard 1. Public, workforce, and contractor safety shall be considered and provided for in selecting the arrangement of retained snags and trees.	BPA would only remove snags that posed a risk to the public, workforce, contractor, and integrity of the transmission line.
Standard 2. Snags with existing cavities or nests shall be the priority for retention.	**North Alternative** Roadway and transmission line ROW clearing widths would be 30 and 100 feet, respectively. Snags with existing cavities or nests would be preserved off-ROW when there is no danger to the line **South Alternative** Roadway and transmission line ROW clearing widths would be 30 and 120 feet, respectively. Snags with existing cavities or nests would be preserved off-ROW when there is no danger to the line

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<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Standard 3. Snag height shall be 15 feet or greater for all forest types.</td><td>Snags of 15 feet in height or greater would be retained off-ROW, when there is no danger to the line.</td></tr>
<tr><td>Guideline 1. Snag dbh (diameter at breast height) > 12 inches or largest diameter for the stand for all forest types and should be retained in clusters, where possible.</td><td>Snags of dbh greater than 12 inches, or largest diameter for the stand, would be retained in clusters where possible, provided they are located off-ROW and pose no danger to the line.</td></tr>
<tr><td>Guideline 2. Hard-snag densities for various biological potentials should be approximately as follows by forest type. Biological potentials for woodpeckers were determined through analysis during the Targhee RFP (1997) and are incorporated in Table 3.3, below. The analysis area for calculating biological potential for woodpeckers should usually be the specific management prescription area polygon. Smaller analysis areas can be used when identified for site-specific projects.
Table 3.3 Biological Potentials by Forested Vegetation Type.
<table>
<tr><td></td><td colspan="3">Number of Snags per 100 Forested Acres[1]</td></tr>
<tr><td>Percent of Biological Potential</td><td>Aspen</td><td>Douglas-fir Spruce/Fir</td><td>Lodgepole</td></tr>
<tr><td>100</td><td>828</td><td>978</td><td>877</td></tr>
<tr><td>80</td><td>62</td><td>782</td><td>702</td></tr>
<tr><td>60</td><td>497</td><td>587</td><td>526</td></tr>
<tr><td>40</td><td>331</td><td>391</td><td>351</td></tr>
<tr><td>20</td><td>16</td><td>196</td><td>175</td></tr>
<tr><td colspan="4">[1]In mixed species stands, use the average number of snags for dominant forest types.</td></tr>
</table></td><td>Snags cannot be retained within the ROW or where they pose a threat to the transmission line; however, hard-snag densities for various biological potentials as discussed in Guideline 2 would be maintained to the extent practical.</td></tr>
<tr><td>Guideline 3. Retain live trees for future snag recruitment using the following guidelines in Table 3.4:
Table 3.4 Live Trees for Snag Recruitment
<table>
<tr><td></td><td colspan="5">Number of Live Trees per 100 Forested Acre s</td></tr>
<tr><td>Percent of Biological Potential</td><td>≥1 inch dbh</td><td>≥7-9.9 inch dbh</td><td>≥5-6.9 inch dbh</td><td><5.0 inch dbh</td><td>Total Trees per acre</td></tr>
<tr><td>1□0</td><td>800</td><td>500</td><td>500</td><td>700</td><td>2500</td></tr>
<tr><td>80</td><td>600</td><td>400</td><td>400</td><td>600</td><td>2000</td></tr>
<tr><td>6</td><td>500</td><td>300</td><td>300</td><td>40</td><td>1500</td></tr>
<tr><td>40</td><td>300</td><td>200</td><td>200</td><td>300</td><td>1000</td></tr>
<tr><td>20</td><td>00</td><td>10</td><td>100</td><td>100</td><td>500</td></tr>
</table></td><td>Live trees cannot be retained in the ROW or where they pose a threat to the transmission line; however, live trees would be retained for future snag recruitment to the extent practical as discussed in Guideline 3.</td></tr>
<tr><td>Guideline 5. Strive not to disturb or destroy existing nests, whether active or inactive.</td><td>The Project would strive not to disturb or destroy existing nests, whether active or inactive. Pre-construction nest surveys would be conducted to limit disturbance.</td></tr>
</table>

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Standards and Guidelines	Consistency
Bald Eagle Habitat—Occupied nesting zones (Zone I, 0.25 mile radius of nest) and primary use areas (Zone II, 0.5 mile radius of nest)	
Standard 3. Prohibit new structures, such as power lines, that have the potential to cause direct mortality to bald eagles.	**North Alternative** Surveys by BPA contractors have indicated there are no occupied nesting zones within 0.25 mile of the North Alternative corridor, nor any primary use areas within 0.5 mile of the North Alternative on USFS lands. **South Alternative** Additional surveys will be conducted for the South Alternative corridor during the spring of 2013, and pre-construction nesting bird surveys would be conducted prior to tree removal.
Guideline 3. All human activities should be minimized from February 1 to August 1.	All proposed construction would take place from September to September over a 2-year period; therefore, human activities cannot be minimized during the entire period between February 1 and August 1.
Bald Eagle Habitat—Home ranges (Zone III, 2.5 mile radius of nest)	
Standard 1. Follow existing, site-specific management plans (when they exist) for each bald eagle territory or ZONE III management direction in the Bald Eagle Management Plan for the Greater Yellowstone Area when site-specific management plans do not exist.	Both alternatives would follow existing, site-specific management plans (when they exist) for each bald eagle territory or ZONE III management direction in the Bald Eagle Management Plan for the Greater Yellowstone Area when site-specific management plans do not exist. **North Alternative** There is one known bald eagle nest located approximately 1.5 miles southeast of the southern portion of the North Alternative corridor; however it is not within 2.5 miles of CNF lands. **South Alternative** Raptor surveys conducted in April 2007 in support of a preliminary EA for the South Alternative located no evidence of bald eagle nests in the vicinity of the project corridor. Additional raptor surveys will be conducted for the South Alternative corridor during the spring and summer of 2013.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Standard 2. Within a 2.5-mile radius of nest, prohibit all use of herbicides and pesticides which cause egg shell thinning as determined by EPA labeling.	**North Alternative** Surveys by BPA and contractors have documented no bald eagle nests within 1 mile of the North Alternative **South Alternative** Surveys by BPA and contractors in 2007 documented no bald eagle nests within 1 mile of the South Alternative corridor. Additional raptor surveys will be conducted within the South Alternative corridor during the spring of 2013. Pre-construction nesting bird surveys would be conducted prior to any tree removal associated with either alternative. BPA does not use any herbicides which cause eggshell thinning as determined by EPA labeling.
Bald Eagle Habitat—Winter Foraging and Roosting	
Guideline 1. Activities and developments should be designed to minimize conflicts with bald eagle wintering and migration habitat.	The construction period would be from September to September; therefore, activities and development should have no impacts on bald eagle winter habitat.
Gray Wolf	
Standard 1. Restrict intrusive human disturbances (motorized access, vegetation management, livestock grazing, etc.) within one mile around active den sites and rendezvous sites between April 1 and June 30 when there are five or fewer breeding pairs of wolves in the Yellowstone Nonessential Experimental Population Area (applies to the portion of the Forest east of Interstate 15) or the Central Idaho Nonessential Experimental Population Area (applies to the portion of the Forest west of Interstate 15). After six or more breeding pairs become established in each experimental population area, land use restrictions will not be necessary (USFS 2003).	Forested habitats in the CNF may provide some foraging and migratory habitat for gray wolves; however, documented and anticipated use of the project corridor by wolves is low. The project would not disturb, nor would it be located near, any known, active gray wolf denning or rendezvous sites. See Section 3.7, Wildlife, for further discussion.
Standard 2. If and when wolves are de-listed, they will be managed in accordance with approved state management plans.	BPA would coordinate with the State of Idaho Department of Fish and Game (IDF&G) concerning any management activities that may impact wolves.
Peregrine Falcon Habitat	
Standard 1. Within 15 miles of all known nest sites, prohibit all use of herbicides and pesticides which cause egg shell thinning as determined by risk assessment (USFS 2003).	Vegetation management activities associated with the project would not use any herbicides that cause egg shell thinning.

Caribou National Forest U.S. Forest Service (2003)

<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Goshawk Habitat</td><td></td></tr>
<tr><td>
The management standards and guidelines in Table 3.5 below apply to all forest types within active and historic goshawk nesting territories.
Table 3.5 Management Standards and Guidelines within Active Goshawk Nesting Territories.
<table>
<tr><th>Attribute</th><th>Nest Area</th><th>Post-Fledging Family Area</th><th>Foraging Area</th></tr>
<tr><td>Number of Areas (S)</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Size of each area (acres) (S)</td><td>> 200 acres</td><td>> 400 acres</td><td>> 5,400 acres</td></tr>
<tr><td>Management Season[5] (G)</td><td>Sept-Mar</td><td>Sept-Mar</td><td>Year-long</td></tr>
<tr><td>Open Road Density[4] (G)</td><td>No new system roads</td><td>No new system roads</td><td>Use management Prescription density</td></tr>
<tr><td>Size Class Distribution For Forested Acres (%) (G):</td><td></td><td></td><td></td></tr>
<tr><td>Nonstocked/seeding</td><td>0%</td><td>< 20%</td><td>< 25%</td></tr>
<tr><td>Sapling</td><td>0%</td><td>< 20%</td><td>< 25%</td></tr>
<tr><td>Pole</td><td>0%</td><td>< 20%</td><td>< 25%</td></tr>
<tr><td>Mature/old[1]</td><td>100%</td><td>> 40%</td><td>= 30%</td></tr>
<tr><td>Rotation Age (years)(G)</td><td>--</td><td>60 to 240 years</td><td>60 to 240 years</td></tr>
<tr><td>Maximum Created Opening (Acres) (G)</td><td>0</td><td>< 40 acres</td><td>< 40 acres</td></tr>
<tr><td>Snags and Reserve Trees[2] (G)</td><td colspan="3">as specified in management prescription</td></tr>
<tr><td>Downed Logs (average/acre) (G)</td><td>Forest-wide S&Gs</td><td>Forest-wide S&Gs</td><td>Forest-wide S&Gs</td></tr>
<tr><td>Thinning (G)</td><td>Non-uniform[3]</td><td>Non-uniform</td><td>By silvicultural prescription</td></tr>
</table>
[1] Mature and old age canopy closure for nest sites and post-fledging family areas should range between 75% and 100%.
[2] Refer to previous section on snag/cavity nesting habitat for explanation of biological potential.
[3] Maximize diversity of structure.
[4] Open roads in goshawk territories shall be given priority for closure to meet management prescription road density standards. First priority shall be to close roads in nest areas; second priority in post-fledging family areas; third priority in foraging areas. Where possible, open road density should be zero in the nest areas and the post-fledging family areas.
[5] This applies only to active nests. There is no restriction for nest areas where current surveys have documented that the nest is unoccupied. Management activities are defined as mechanical treatments and road building.
</td><td>To the extent practical, snags would be maintained at the levels prescribed in the CNF RFP, and tree removal within mature and late seral forest stands would be limited to the minimum extent necessary, provided trees are not in the ROW and do not pose a danger to the transmission line. Sufficient mature aspen and conifer forest habitat would remain functional at both the local and range-wide scales to maintain goshawk viability. The project is therefore not likely result in any measurable impact to the species. See Section 3.7, Wildlife, for further discussion.</td></tr>
</table>

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Flammulated Owl Habitat	
Standard 1. Do not allow timber harvest activities within a 30-acre area around all known flammulated owl nest sites.	**North Alternative** Surveys for this species were conducted in 2011 for the North Alternative corridor. There are no known flammulated owl nest sites within 30 acres of North Alternative corridor. **South Alternative** Surveys for this species were conducted in 2007 for the South Alternative corridor. There are no known flammulated owl nest sites within 30 acres of the South Alternative corridor. Additional raptor surveys will be conducted within the South Alternative corridor during the spring of 2013, and Pre-construction nesting bird surveys would be conducted prior to any tree removal associated with either alternative. If a nest is identified prior to tree clearing activities, BPA would consult with FS and USFWS personnel on mitigation or avoidance protocols.
Boreal Owl Habitat	
Guideline 1. Within a 3,600-acre area around all known boreal owl nest sites, maintain over 40% of the forested acres in mature and old age classes. (Hayward and Verner, 1994, Hayward, 1997)	**North Alternative** Surveys for this species were conducted in 2011 for the North Alternative corridor. There are no known boreal owl nest sites within a 3,600-acre area surrounding the North Alternative corridor. **South Alternative** Surveys for this species were conducted in 2007 for the South Alternative corridor. There are no known boreal owl nest sites within a 3,600-acre area surrounding the South Alternative corridor. Additional surveys will be conducted within the South Alternative corridor during the spring of 2013, Pre-construction nesting bird surveys would be conducted prior to any tree removal associated with either alternative. If a nest is identified prior to tree clearing activities, BPA would consult with FS and USFWS personnel on mitigation or avoidance protocols.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Great Gray Owl Habitat	
Guideline 1. Within a 1,600-acre area around all known great gray owl nest sites, maintain over 40% of the forested acres in mature and old age classes. (Hayward and Verner, 1994)	Surveys for this species were conducted in 2011 for the North Alternative corridor and in 2007 for the South Alternative corridor. There are no known great gray owl nest sites within a 1,600-acre area surrounding the North Alternative corridor. Additional raptor surveys will be conducted for the South Alternative corridor during the spring of 2013, and pre-construction nesting bird surveys would be conducted prior to tree removal. If a nest is identified prior to tree clearing activities, BPA would consult with FS and USFWS personnel on mitigation or avoidance protocols.
Big Game	
Guideline 1. Provide for vegetation buffers of at least one sight distance (Thomas et al. 1979) around big game concentration/use areas, such as wallows and mineral licks. Sight distance is the distance at which 90 percent of a deer or elk is hidden from an observer. This will vary depending on site specific stand conditions.	Conversion of forested habitat within the transmission line and access road ROWs to low-growing vegetation could provide for increased foraging habitat for big game animals, but would also provide reduced cover for these species and could subject them to greater predatory pressures. Cover would remain available beyond the edge of the ROW, however, and a network of forested habitat would remain at the regional scale to ensure no net loss of habitat function. See Section 3.7, Wildlife, for further discussion.
Guideline 2. Provide for security or travel corridors near created openings.	Security would be available adjacent to the ROW. It is likely that some animals would utilize the cleared ROW as a travel corridor or for forage.
Sage Grouse and Columbian Sharp-Tailed Grouse	
Standard 1. Cooperate with other state and federal agencies and private landowners to survey, inventory, and manage habitats for sage grouse and Columbian sharp-tailed grouse.	**North Alternative** Surveys for these species were conducted in 2011 for the North Alternative corridor. Neither species was found during surveys. **South Alternative** BPA and contractors will be conducting additional sage and sharp-tailed grouse surveys for the South Alternative corridor during 2013. BPA would consult with state and federal agencies including USFWS and IDF&G, along with private landowners, to survey, inventory, and manage habitats for sage grouse and Columbian sharp-tailed grouse prior to construction of the project, if necessary. If active leks are identified prior to ROW clearing activities, BPA will consult with USFWS personnel on mitigation or avoidance protocols.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Guideline 1. Current guidelines for sage and sharp-tailed grouse management, such as Connelly et al. (2000), should be used as a basis to develop site-specific recommendations for proposed sagebrush treatments.	**North Alternative** Current guidelines for sage and sharp-tailed grouse management, including Connelly et. al 2000, were used to inform survey design for lek surveys conducted for the North Alternative corridor in 2011, and would be used to develop sagebrush treatments associated with the project. **South Alternative** Current guidelines for sage and sharp-tailed grouse management, including Connelly et. al 2000, will be used as a basis for additional sage and sharp-tailed grouse surveys to be conducted for the South Alternative in 2013, and would be used to develop sagebrush treatments associated with the project.
Guideline 2. Management activities should consider proximity to active lek locations during site-specific project planning. Those within 10 miles of an active sage grouse lek and 2 miles of active sharp-tailed grouse leks should be considered further for suitability as grouse habitat.	**North Alternative** Surveys by BPA contractors in 2011 identified two historic sharp-tailed grouse leks, but no active leks, between 2 and 3 miles west of the North Alternative corridor. No active sage grouse leks have been documented within 10 miles of the North Alternative corridor. **South Alternative** According to surveys conducted in support of a 2009 preliminary EA, no sage grouse or sharp-tailed grouse leks have been documented within the South Alternative corridor. Additional surveys will be conducted for the South Alternative corridor in 2013. When possible, construction activity would be prohibited within 10 miles of an active greater sage grouse lek and within 2 miles of active Columbian sharp-tailed grouse leks between the end of March and the beginning of May. See Section 3.7, Wildlife, for further discussion.
Guideline 3. If management activities would impact courtship, limit physical, mechanical, and audible disturbances in the breeding complex during the breeding season (March to May) within three hours of sunrise and sunset each day.	Construction would take place from September to September; therefore, impacts to courtship would not be expected.
Guideline 4. Where management actions will disturb nesting grouse, avoid manipulation or alteration of vegetation during the nesting period (May to June).	Pre-construction nesting bird surveys would be conducted prior to tree removal. See Section 3.7, Wildlife, for further discussion.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Amphibians	
Guideline 3. Maintain amphibian habitats when developing and modifying springs and wetlands.	**North Alternative** The North Alternative would temporarily impact approximately 0.05acres of wetlands, and permanently impact approximately 1.21 acres of wetlands. **South Alternative** The South Alternative would temporarily impact approximately 0.08 acres of wetlands, and permanently impact approximately 0.03 acres of wetlands. Impacts on riparian and wetland habitats as a result of the Project would mostly be of short duration and would not result in any measurable impacts to potential amphibian habitat. See Section 3.6, Water Resources, Floodplains, and Wetlands for further discussion.
Landbirds	
Guideline 1. Stands of mature trees (including snags and dead-topped trees) should be maintained next to wet meadows.	Stands of mature trees (including snags and dead-topped trees) would be maintained next to wet meadows, provided they are off-ROW and do not pose a danger to the line.
Guideline 2. Where feasible, maintain 30 to 50 percent of the sagebrush habitat in a 5th code HUC in contiguous blocks greater than 320 acres to support sagebrush obligate species. (Page and Ritter 1999)	Given the limited sage brush removal necessary for the project, at least 30-50 percent of the habitat would be retained.
Guideline 3. Practices which stabilize or increase native grass and forbs cover in sagebrush habitats with 5% to 25% sagebrush canopy cover should be implemented. (Page and Ritter 1999)	Practices which stabilize or increase native grass and forbs cover in sagebrush habitats with 5% to 25% sagebrush canopy cover would be implemented, except for permanent access road ROWs. Native grasses and forbs would be retained to the extent possible. See Section 3.4 Vegetation.
Wolverine	
Guideline 1. Restrict intrusive human disturbance within one mile around known active den sites, March 1 to May 15 (Idaho State Conservation Effort 1995).	The Project would not be located near, nor would it disturb, any known wolverine den sites. Construction activities would take place between September and September.
Tribal Coordination	
Standard 1. Forest consultation procedures and intergovernmental agreements with the tribes to guide future cooperative efforts shall comply with the protocols set forth in the National Resource Book on American Indian and Alaska Native Relations Working Draft 1995 or its successor.	The Project would not require any intergovernmental agreements between tribes and USFS or BPA. BPA is conducting its own NHPA consultation as part of its planning and decision-making process.
Transportation—Roads	
Standard 1. Roads analysis (currently in Part 212 of Title 36 of the Code of Federal Regulations) shall be used to inform road management decisions; including construction, reconstruction, or obliteration of roads.	BPA would work with the USFS on all access road design to ensure that road design is consistent with the Forest Plan.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Standard 2. Road construction, reconstruction and maintenance standards and criteria shall be guided by roads analysis and documented through the use of road management objectives (RMOs).	BPA would work with CNF officials to ensure that road construction, improvement, and maintenance standards and criteria would be guided by roads analysis and documented through the use of road management objectives (RMOs).
Guideline 1. Minimize construction of new transportation routes, evaluate existing routes, and reconstruct or relocate those routes not meeting management goals.	All access roads constructed specifically for the Project would be closed to the public and gated to exclude motorized use after completion of construction regardless of alternative. All existing roads and other transportation routes currently open to the public would remain open following completion of construction.
Guideline 3. Design and construct roads to a standard appropriate to their intended use, considering safety, cost, and resource impacts, emphasizing protection of water quality.	BPA would work with CNF officials to ensure that roads are designed and constructed to a standard appropriate to their intended use, considering safety, cost, and resource impacts, emphasizing protection of water quality.
Guideline 4. Avoid road construction on unstable slopes and highly erosive soils.	The Project would avoid road construction on unstable slopes and highly erosive soils. See Section 3.5 Geology and Soils.
Guideline 6. As needed, schedule roads to receive maintenance, repairs, or improvements to protect investment, maintain the intended serviceability, and protect other resources. Prioritize road maintenance activities using factors such as safety, resource protection needs, administrative needs, user comfort, and the identified traffic service level.	As needed, BPA would maintain, repair, or improve access roads to protect investment, maintain intended serviceability, and protect other resources.
Guideline 7. Surface gravel should be placed on roads where necessary to reduce rutting, surface erosion and to reduce maintenance costs.	Surface gravel would be placed on access roads where necessary. See Section 3.5, Soils and Geology, for further discussion.
Guideline 8. Conserve surface materials when blading and shaping roads.	All native topsoil removed for access road construction would be stockpiled and reused on-site for restoration activities. See Section 3.5, Geology and Soils, for further discussion.
Guideline 9. Existing cut slopes that contain suitable material may be widened and material used for surfacing.	Existing cut slopes that contain suitable material would be widened and material used for surfacing if necessary.
Guideline 11. Roads identified as unneeded in a roads analysis should be decommissioned, stabilized and returned to production.	Only those roads deemed necessary for transmission line maintenance would be maintained.
Guideline 12. Road closures should be located and designed to effectively control motorized use and minimize safety hazards.	All access roads would be closed and gated to exclude public motorized access. Road closures would be located and designed to effectively control motorized use and minimize safety hazards.
Guideline 13. All roads should be properly drained before closure.	All roads would be properly drained before closure.
Guideline 14. When a road is closed at the forest boundary, a vehicular turnaround should be provided on the forest to avoid impacts to adjacent non-federal lands.	BPA would work with the USFS on all access road design to ensure that road design is consistent with the Forest Plan.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Transportation—Access	
Standard 1. Open Motorized Route Density (OMRD) shall not exceed the levels identified on the Plan ORMD Map. OMRD is defined as the miles of designated motorized roads and trails per square mile within a specific prescription area polygon.	All new access roads constructed specifically for the North or South alternative would be closed to the public and gated to exclude motorized use after completion of construction. All existing motorized roads and trails currently open to the public would remain open following completion of construction. Therefore, the Project would have no impact on OMRD regardless of alternative.
Standard 4. Any motorized vehicle access on a restricted road or trail or in a restricted area shall be for official administrative business only and shall be officially approved.	All new access roads constructed specifically for the Project would be gated to exclude public motorized access. Authorized motorized vehicle access on these roads would be restricted to BPA personnel or USFS official administrative business only. All existing motorized roads and trails currently open to the public would remain open after completion of construction. See Section 3.2, Recreation, for further discussion.
Standard 5. Unless otherwise posted motorized access is allowed for parking, wood gathering, and dispersed camping within 300 feet of an open designated road.	All existing motorized roads and trails currently open to the public would remain open after completion of construction regardless of alternative. Following completion of construction, the Project would not restrict any uses currently allowed within 300 feet of an open designated road, including parking, wood gathering, and dispersed camping See Section 3.2, Recreation, for further discussion.
Guideline 1. The construction of new or maintenance of existing, motorized and non-motorized access routes should be consistent with the ROS class in which they are located.	All access roads constructed specifically for the Project would be closed to the public and gated to exclude motorized use after completion of construction. All existing motorized and non-motorized access routes currently open to the public would remain open following completion of construction. The project would therefore be consistent with the existing Roaded Modified ROS class. See Section 3.2, Recreation, for further discussion.
Recreation	
Guideline 4. Projects should be planned and implemented to meet the Recreation Opportunity Spectrum (ROS) as depicted on the Forest ROS map.	The ROS for both alternatives is Roaded Modified. Both alternatives are consistent with the Roaded Modified ROS class.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Scenic Resources	
Standard 1. Objectives for scenery (either VQOs or SIOs) shall be met along Scenic or Historic Byways, Wild and Scenic Rivers, and other sensitive travel routes and special emphasis areas.	**North Alternative** The North Alternative would be visible from the Pioneer Historic Byway on USFS retention lands upon the approach to Lanes Creek Substation. Objectives for scenery would be met to the extent practicable along the Pioneer Historic Byway. The North Alternative would not impact any Wild and Scenic Rivers on the CNF, as none are present on the portion of the Forest traversed by the proposed transmission line. **South Alternative** The South Alternative would traverse USFS Partial Retention and Modification lands and would meet these VQOs to the extent practicable. The South Alternative would cross the Blackfoot River on CNF land in the vicinity of the Blackfoot River Narrows. The Blackfoot River is listed on the NRI as potentially eligible for listing under the Wild and Scenic Rivers Act because of its scenic and fisheries resources. The South Alternative is not expected to foreclose any opportunities for listing of the Blackfoot River as a wild, scenic, or recreation river. BPA would consult with NPS and CNF officials regarding any potential visual impacts along the Blackfoot River.
Guideline 1. New and reconstructed structures and facilities should be built to blend with the surrounding landscape, using the concepts outlined in the Built Environment Image Guide or current direction.	**North Alternative** Under the North Alternative, transmission line structures on CNF land would be wood and thus generally consistent with the line, form, color and texture of the landscape It is expected this will minimize the visual impact of the transmission line on the visual landscape. In addition, only substation equipment would be added to the already constructed Lanes Creek substation, limiting visual disturbances. **South Alternative** Under the South Alternative, transmission line structures on CNF land would be steel. The color of the steel structures, while reflective initially, would dull over time, reducing visual impacts. Generally, it is expected that the structures would remain consistent with the line, form, color and texture of the landscape thus minimizing to the extent practical the visual impact of the transmission line on the visual landscape. See Section 3.3, Visual Resources, for further discussion.

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<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Guideline 2. Until the Scenery Management System is fully implemented, projects should be planned and implemented to meet the VQOs as displayed on the Forest VQO map.</td><td>Both alternatives would be planned and implemented to meet the VQOs as displayed on the Forest VQO map. See Section 3.3, Visual Resources.</td></tr>
<tr><td>Heritage Resources</td><td></td></tr>
<tr><td>Standard 1. Cultural resources inventories shall be conducted in consultation with the Idaho State Historic Preservation Office, Local Native American Tribes, and interested individuals or organizations likely to have knowledge or interest in the historic properties in the area.</td><td>Cultural resource surveys have been conducted on the North and South alternative corridors. Consultation with the state SHPO, potentially affected tribes, and land management agencies is on going. See Section 3.9, Cultural Resources, for further discussion.</td></tr>
<tr><td>Standard 2. Unevaluated cultural resource sites[3] shall be treated as significant until comprehensive evaluations are completed.</td><td>Unevaluated cultural resource sites would be treated as significant until comprehensive evaluations are completed. See Section 3.9, Cultural Resources, for further discussion.</td></tr>
<tr><td>Timber Management</td><td></td></tr>
<tr><td>Standard 1. All commercial sales, including sawtimber, convertible products, select material, and commercial firewood, shall be advertised and sold on a bid basis, unless demand can be met and "sale on demand" sales can be justified.</td><td>Merchantable timber cleared during tree removal for ROW clearing would be advertised and sold on a bid basis, unless demand can be met and "sale on demand" sales can be justified in consultation with the Forest.</td></tr>
<tr><td>Minimum Stocking Guidelines</td><td></td></tr>
<tr><td>Guideline 1. Table 3.7, below, shows the minimum stocking which should occur before a regenerated area can be certified as stocked.
Table 3.7 Minimum Stocking by Forested Vegetation Type.
<table>
<tr><th>Species</th><th>Minimum Stocking (Trees/Acre)[1]</th><th>Percent of Area Meeting Minimum Stocking</th></tr>
<tr><td>Lodgepole pine</td><td>170</td><td>70</td></tr>
<tr><td>Douglas-fir</td><td>140</td><td>70</td></tr>
<tr><td>Mixed Conifer[2]</td><td>200</td><td>70</td></tr>
<tr><td>Spruce-fir</td><td>200</td><td>70</td></tr>
<tr><td>Aspen</td><td>5000</td><td>70</td></tr>
<tr><td colspan="3">[1]Healthy, free-to-grow seedlings at least six (6 inches in height. Aspen may comprise a percentage of the stocking on conifer sites, dependent on the site-specific prescription (Rangelands 20(1): Decline of quaking aspen in the Interior West).</td></tr>
<tr><td colspan="3">[2]Douglas-fir, lodgepole pine, subalpine fir and Engelmann spruce.</td></tr>
</table></td><td>No restocking would take place in the ROW or on permanent access roads.</td></tr>
</table>

[3] 36 CFR 800.4 requires that when proposing undertakings that might affect historic properties the Agency must 1) determine the scope of effects; 2) identify historic properties; and 3) evaluate the historic significance of the property.

Caribou National Forest U.S. Forest Service (2003)

Standards and Guidelines	Consistency
Created Openings	
Standard 1. The maximum size limit for forested vegetation openings created in one harvest operation by the even-aged silvicultural system shall normally be 40 acres. Openings may exceed 40 acres in aspen and lodgepole pine types contingent on Regional Forester approval, or as a result of natural catastrophic conditions such as fire, insect and disease, or windstorm.	The Project is not a typical timber harvest and therefore would create a larger, but linear opening. **North Alternative** The North Alternative ROW would convert up to approximately 88 acres of forested land to non-forested vegetation. Proposed off-ROW access roads would convert up to an additional 30 acres of forested land to non-forested vegetation. **South Alternative** The South Alternative ROW would convert up to approximately 49 acres of forested land to non-forested vegetation and proposed off-ROW access roads would convert up to an additional 4.4 acres of forested land to non-forested vegetation.
Standard 2. A harvested area of commercial forestland shall not be considered a created opening for silvicultural purposes when stocking surveys indicate that minimum stocking is achieved and average tree height equals or exceeds seven feet. When other resource management considerations (such as wildlife habitat, watershed needs, or visual requirements) prevail, a created opening shall no longer be considered an opening when the vegetation meets a particular management objective stated in the applicable management prescription.	No stocking would be conducted on the ROW. See above.
Logging Systems	
Guideline 1. Limit tractor skidding to slopes less than 40 percent and generally prohibit logging on slopes over 60 percent.	Tractor skidding would be limited to slopes less than 40 percent, and logging would generally be prohibited on slopes greater than 60 percent.
Guideline 2. Consider use of helicopter logging methods or other specialized logging methods on slopes in excess of 40 percent.	For slopes in excess of 40 percent, BPA would consider helicopter logging or other specialized methods as practical.
Guideline 3. Yarding operations should not take place when ground conditions are wet enough that there is a risk of rutting and compaction as determined by the sale administrator.	Yarding operations would not take place if ground conditions are wet enough that there is a risk of rutting and compaction.
Guideline 4. Minimize skid trails and temporary roads during logging operations. Identify skid trails and temporary roads requiring construction in the sale planning process and assure appropriate rehabilitation of these trails by the purchaser or in post-sale activities.	No temporary roads would be constructed on USFS lands as part of the North or South alternatives; however, all permanent and reconstructed access roadways constructed specifically for the Project would be gated and closed to public motorized use. Any skid trails would be rehabilitated appropriately following construction of the project. All existing motorized routes currently open to the public would remain open following completion of construction.

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<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>SUBSECTION AND PRESCRIPTION AREAS</td><td></td></tr>
<tr><td>PRESCRIPTION 2.7.2 (D) – ELK AND DEER WINTER RANGE</td><td></td></tr>
<tr><td>Access</td><td></td></tr>
<tr><td>The following table defines access allowable under prescription 2.7.1 (d)
Table (d)
<table>
<tr><th>Season</th><th>Type of Access</th></tr>
<tr><td>Snow free season</td><td>Motorized use allowed only on designated roads and trails</td></tr>
<tr><td>Snow Season</td><td>Motorized use allowed only on designated trails, some winter range has no designated routes</td></tr>
<tr><td colspan="2">Some site specific exceptions may apply; travel plan maps supersede this direction. Some winter range has no snow season designated routes</td></tr>
</table></td><td>All access roadways constructed specifically for the Project regardless of alternative would be closed to exclude public motorized access upon completion of construction. All existing motorized routes currently open to the public would remain open following completion of construction. Motorized use by BPA maintenance personnel and vehicles would take place mostly during summer months or in response to an emergency. Emergency responses would last only as long as necessary to restore power.</td></tr>
<tr><td>PRESCRIPTION 3.2 (B, E, F) – SEMI-PRIMITIVE RECREATION</td><td></td></tr>
<tr><td>Fire/Fuels</td><td></td></tr>
<tr><td>Guideline 1. Employ Minimum Impact Suppression Tactics to the extent possible.</td><td>Minimum Impact Suppression Tactics would be employed to the extent possible.</td></tr>
<tr><td>Wildlife</td><td></td></tr>
<tr><td>Guideline 1. Maintain snags at =60 percent biological potential for woodpeckers.</td><td><u>North Alternative</u>
The North Alternative ROW as currently designed would only impact areas of the 3.2 Management Prescription that support scrub-shrub and grassland herbaceous vegetation types as defined by the USGS National Land Cover Database (NLCD) and are currently not forested. See Map 3-2.

<u>South Alternative</u>
The 3.2 Management Prescription does not occur on any areas of the CNF that would be crossed by the South Alternative ROW</td></tr>
<tr><td>Access</td><td></td></tr>
<tr><td>Standard 1. The following table defines access allowable under prescription 3.2(b):
Table (b)
<table>
<tr><td>Season</td><td>Type of Access</td></tr>
<tr><td>Snow free season</td><td>Motorized use allowed only on designated roads and trails</td></tr>
<tr><td>Snow Season</td><td>Cross-country motorized allowed</td></tr>
<tr><td colspan="2">Some site specific exceptions may apply; travel plan maps supersede this direction.</td></tr>
</table></td><td>In the short term, the Project could restrict public access to designated roads and trails as a result of area closures for safety reasons regardless of alternative. The North or South alternative would not create any additional designated roads, as all access roads constructed specifically for the Project would be closed to exclude public motorized access upon completion of construction. All existing motorized routes currently open to the public would remain open following completion of construction of either alternative. The Project would therefore have no impact on access in the long term. See Sections 3.1, Land Use, and 3.2, Recreation, for further discussion.</td></tr>
</table>

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<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>PRESCRIPTION 5.2 (B, C, F) – FOREST VEGETATION MANAGEMENT</td><td></td></tr>
<tr><td>Fire</td><td></td></tr>
<tr><td>Guideline 1. Wildfires should be suppressed.</td><td>Wildfires would be suppressed.</td></tr>
<tr><td>Wildlife</td><td></td></tr>
<tr><td>Guideline 1. Maintain snag habitat at =40 percent of the biological potential for woodpeckers.</td><td>For both the North and South Alternatives, snag habitat would be maintained to approach 40 percent of biological potential for woodpeckers to the extent practical; however, no snags would be retained within ROWs or where they would pose a danger to the transmission line.</td></tr>
<tr><td>Vegetation</td><td></td></tr>
<tr><td>Guideline 1. Where aspen exists, it should be maintained or enhanced as a component through restoration treatments.</td><td><u>North Alternative</u>
The North Alternative would permanently impact approximately 38.8 acres of aspen-dominated forest types as a result of access road construction and ROW clearing conversion.

<u>South Alternative</u>
The South Alternative would permanently impact approximately 86.3 acres of aspen-dominated forest types.</td></tr>
<tr><td>Guideline 2. All ground-disturbed areas within an activity area should be monitored for five years for noxious weeds invasions.</td><td>BPA would conduct monitoring of all ground-disturbed areas for five years for noxious weeds invasions, and take corrective action as necessary.</td></tr>
<tr><td>Access</td><td></td></tr>
<tr><td>Standard 1. The following table defines access allowable under prescription 5.2(b):
Table (b)
<table>
<tr><td>Season</td><td>Type of Access</td></tr>
<tr><td>Snow free season</td><td>Motorized use allowed only on designated roads and trails</td></tr>
<tr><td>Snow Season</td><td>Cross-country motorized allowed</td></tr>
<tr><td colspan="2">Some site specific exceptions may apply; travel plan maps supersede this direction.</td></tr>
</table></td><td>In the short term, the Project could restrict public access to designated roads and trails as a result of area closures for safety reasons. The Project would not create any additional designated roads, as all access roads would be closed and gated to exclude motorized access. The Project would therefore have no impact on access in the long term. See Sections 3.1, Land Use, 3.2, Recreation, and 3.11, Transportation, for further discussion.</td></tr>
<tr><td>Recreation</td><td></td></tr>
<tr><td>Guideline 1. Avoid and mitigate impacts to recreation facilities and trails.</td><td>There are no developed recreation facilities in the project area; trails would be avoided and any impacts mitigated. Trails crossing the North or South alternative ROWs could be closed temporarily for safety reasons, but would remain open following construction of the transmission line. See Section 3.2, Recreation, for further discussion.</td></tr>
</table>

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<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>Scenic</td><td></td></tr>
<tr><td>Guideline 1. Opportunities to improve scenic integrity should be considered in proposed vegetation treatments.</td><td>BPA would incorporate various measures to preserve scenic integrity, which may include such management action as feathering of the ROW to minimize visual impact regardless of alternative. BPA would work with the USFS forester to ensure that tree clearing is consistent with the forest plan</td></tr>
<tr><td>PRESCRIPTION 6.2 (B, E, F) – RANGELAND VEGETATION MANAGEMENT</td><td><u>North Alternative</u>
This management prescription only occurs on approximately 7.6 acres of the CNF traversed by the North Highland Option. The 6.2 Management Prescription does not occur on other areas of the CNF traversed by the North Alternative.

<u>South Alternative</u>
The 6.2 Management Prescription does not occur on areas of the CNF traversed by the South Alternative, or any of its routing options, and therefore does not apply to the South Alternative.</td></tr>
<tr><td>Wildlife</td><td></td></tr>
<tr><td>Standard 1. Maintain snags at = 40 percent of biological potential for woodpeckers.</td><td>In areas where the North Highland Option crosses the 6.2 management prescription, snag habitat would be maintained to approach 40 percent of biological potential for woodpeckers to the extent practical. However, no snags would be retained within the ROW or where they would pose a danger to the transmission line.</td></tr>
<tr><td>Access</td><td></td></tr>
<tr><td>Standard 2. The following table defines access allowable under prescription 6.2 (e)
Table (e)
<table>
<tr><th>Season</th><th>Type of Access</th></tr>
<tr><td>Snow free season</td><td>Non-motorized travel only allowed</td></tr>
<tr><td>Snow Season</td><td>Cross-country motorized allowed</td></tr>
<tr><td colspan="2">Some site specific exceptions may apply; travel plan maps supersede this direction.</td></tr>
</table>
</td><td><u>North Alternative</u>
N/A. The 6.2(e) management prescription does not occur on any of the areas of the CNF traversed by the North Alternative, including the North Highland Option.

<u>South Alternative</u>
N/A. The 6.2(e) management prescription does not occur on any of the areas of the CNF traversed by the South Alternative corridor.</td></tr>
</table>

Caribou National Forest U.S. Forest Service (2003)

<table>
<tr><th>Standards and Guidelines</th><th>Consistency</th></tr>
<tr><td>PRESCRIPTION 2.8.3 - AQUATIC INFLUENCE ZONE</td><td></td></tr>
<tr><td>This management prescription applies to the Aquatic Influence Zone (AIZ) associated with lakes, reservoirs, ponds, perennial and intermittent streams, and wetlands, such as wet meadows, springs, seeps, bogs and other areas. These areas control the hydrologic, geomorphic, and ecological processes that directly affect water quality and aquatic life. They also provide unique habitat characteristics important to plant and animal species that rely on aquatic, wetland, or riparian ecosystems for all or a portion of their life cycle.

The AIZ management prescription provides an extensive set of goals, standards, and guidelines regarding ecological processes and patterns, land use, fish and wildlife management, and access within the AIZ. These goals, standards and guidelines are discussed on pages RFP 4-45 through RFP 4-53 of the CNF Forest Plan.</td><td><u>North Alternative</u>
Under the North Alternative, no structures would be sited within the AIZ. The North Alternative corridor would avoid siting roads and utility corridors within the AIZ to the extent practical.

South Alternative
Under the South Alternative, six structures would be placed in areas defined as AIZs. However, all structures would be in the buffer zones of the AIZs and would be located above the high water line of the streams. Additionally, implementation of mitigation would further protect AIZ resources. Similar to the North Alternative, the South Alternative corridor would avoid siting roads and utility corridors within the AIZ to the extent practical.

Goals, standards and guidelines for management prescription 2.8.3 that are applicable to the North and South alternatives are discussed in Sections 3.1, Land Use , 3.2, Recreation, and 4.17.6, “Guidelines – Management Prescription 2.8.3 Aquatic Influence Zone.”

Mitigation measures associated with impacts of the Project on AIZs are discussed in Section 3.6, Water Resources, Floodplains, and Wetlands.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>PRESCRIPTION 2.1.6(b) – GRAVEL CREEK SPECIAL EMPHASIS AREA</td><td></td></tr>
<tr><td>Goal 2. The area is managed according to the Memorandum of Understanding with the Idaho Dept. of Transportation, Federal Highway Administration, and the Army Corps of Engineers.</td><td rowspan="2"><u>North Alternative</u>
BPA would undertake consultation with the USFS, IDT, FHWA, and USACE regarding routing of the transmission line ROW over lands within management prescription 2.1.6(b), per the aforementioned Memorandum of Understanding.

<u>South Alternative</u>
N/A. The 2.1.6(b) management prescription does not occur on any of the areas of the CNF traversed by the South Alternative corridor.</td></tr>
<tr><td>Objective 1. Coordinate a review of the status of the property with Idaho Department of Transportation, Federal Highway Administration, and the Army Corps of Engineers every three years.</td></tr>
</table>

A.7 References

Connelly, J.W., M.A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin. 28(4):967-985.

Haywood, G.D. 1997. Forest management and conservation of boreal owls in North America. Journal of Raptor Research. 31:114-124.

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Idaho State Conservation Effort. 1995. The Idaho Sate Conservation Effort, draft dated February 1995. The wolverine (*Gulo gulo*) in Idaho: habitat conservation assessment (HCA) and conservation strategy (CS). Prepared by J. Copeland and H. Hudak, Idaho Fish and Game Department.

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Thomas J.W., H Black, Jr., J Scherzinger, and R.J. Pederson. 1979. Deer and Elk. Pages 104-127 in J.W. Thomas (ed.) Wildlife habitats in managed forests-the Blue Mountains of Oregon and Washington. USDA Forest Service. Agriculture Handbook No. 553.

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Appendix B

Visual Resources Assessment

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Visual Resource Assessment

This appendix provides the overall methodology and accompanying analyses conducted to inform the impact analysis completed in Chapter 3 of the draft EIS. It describes the different federal land managers' visual resource management approaches, and provides viewshed analyses throughout the project area for both the North and South alternatives.

Basis for Analysis

Both the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) place a special emphasis on preserving the natural landscape and, as such, have developed specific manuals for evaluating an existing landscape and assessing potential impacts to visual resources. The U.S. Department of Agriculture and USFS developed Landscape Aesthetics: A Handbook for Scenery Management, defining a Scenery Management System (USFS 1995) and the Department of the Interior and BLM developed a Visual Resource Management (VRM) program (BLM 1980). Guidance from both documents was used to complete the visual assessment for this project.

USFS was founded with a mission "to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations" (USFS 2011). With this mission the USFS coined the motto "caring for the land and serving the people." A guiding point of this mission statement is to advocate conservation ethics in order to promote the health, productivity, diversity and beauty of forests and associated lands. Likewise, BLM's mission statement is "to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations." An important aspect of preserving and protecting an area for future enjoyment is the preservation of the natural landscape. The viewscape of a given area consists of the landforms, vegetation, water features, and cultural modifications (physical changes caused by human activities) that impart an overall visual impression of the area landscape.

Caribou-Targhee National Forest Visual Quality Objectives

The EIS for the Caribou Revised Forest Plan used the Visual Management System developed in the 1970s to establish Visual Quality Objectives (VQOs) for parcels within the Caribou-Targhee National Forest (C-TNF). The plan identified five classes of VQOs: preservation, retention, partial retention, modification, and maximum modification (USFS 2003b).

Preservation—allows ecological changes only. Management activities except for very low visual impact recreation facilities are prohibited. Applies to wilderness areas, primitive areas, wild river corridors, other specialty-classified areas, areas awaiting classification, and some unique management units that do not justify special classification.

- **Retention**—allows management activities that are not visually evident. Activities may only repeat form, line, color, and texture that are frequently found in the character landscape. Changes in size, amount, intensity, direction, pattern, etc., should not be evident.

- **Partial Retention**—allows management activities that remain visually subordinate to the characteristic landscape. Activities may repeat form, line, color, and texture common to the characteristic landscape but changes in their qualities of size, amount, intensity, direction, pattern, etc., remain visually subordinate to the characteristic landscape. Activities may also introduce form line, color, or textures that are found infrequently or not at all in the characteristic landscape but they should remain subordinate to the visual strength of the characteristic landscape.

- **Modification**—allows management activities that may visually dominate the original characteristic landscape. However, activities of vegetative and land form alteration must borrow from naturally established form, line, color, or texture so completely and at such scale that its visual characteristics are those of natural occurrences within the surrounding area or character type. Additional parts of these activities such as structures, roads, slash, root wads, etc., must remain visually subordinate to the proposed composition. Introduction of facilities such as buildings, signs, roads, etc., should borrow naturally established form, line, color, or texture so completely and at such scale that its visual characteristics are compatible with the natural surroundings.

- **Maximum Modification**—allows management activities that may dominate the characteristic landscape. However, when viewed as background, the visual characteristics must be those of natural occurrences within the surrounding area or character type. When viewed as foreground or middle ground, they may not appear to completely borrow from naturally established form, line, color, or texture. Alterations may be out of scale or contain details that are incongruent with natural occurrences as seen in foreground or middle ground. Introduction of structures, roads, slash, and root wads, etc., must remain visually subordinate to the proposed composition as viewed in the background.

The Revised Forest Plan outlines a prescription for visual quality maintenance within the C-TNF. The prescription emphasizes maintaining the existing scenery within major travel corridors with high quality natural vistas, while allowing livestock production, and other compatible commodity outputs. Logging is permitted, but the areas to which the visual quality maintenance prescription applies are not part of the suitable timber base. Goals associated with this prescription include the following:

- Manage travel corridors to protect the natural visual quality. Manage in an environmentally sensitive manner to promote the production of non-commodity resources at varying levels, and limited commodity production.

- Manage to provide various dispersed recreational opportunities.

- Provide interpretive opportunities to enhance visitors' experience.

In addition to meeting the VQO directives for the C-TNF lands from which the transmission line would be visible, the project would also need to be consistent with the Revised Forest Plan's Transportation and Utility corridor guidelines (USFS 2003a).

- Utility corridors should have irregular clearing widths and follow patterns of existing natural openings.

- Utility structures should be made to blend with the existing landscape to the extent feasible.
- Avoid parallel corridors. Consolidate facilities within existing energy corridors where feasible.

The C-TNF lands within the project area include those areas classified as Retention and Partial Retention.

BLM Visual Resource Management (VRM) Classes

BLM conducted a visual resource inventory, as part of the Pocatello Field Office Proposed Resource Management Plan (RMP) and Final EIS, completed in April 2010 (BLM 2010). All parcels within the Pocatello Field Office lands were assigned management classes with the following established objectives:

- **Class I**—to preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
- **Class II**—to retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- **Class III**—to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.
- **Class IV**—to provide for management activities that requires major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

BLM lands within the project area fall into Class II and IV areas.

In addition, the BLM methodology was also used to assess BIA lands, which lack a specific visual designation. These BIA lands fell into a BLM Classes II and III. Class III lands are just east of the reservoir and adjacent to Highway 34 (BLM 2010). BIA Class II lands are those that consist of areas with shallow to deep canyons, rolling hills, and open meadows.

BLM guidance speaks specifically to assessing impacts of linear alignments such as right-of-ways (ROWs), roads, trails, pipeline developments, and underground and overhead utility lines (BLM 2007). The guidance states that major considerations for determining an alignment include the following:

- **Topography**—visually, it can be used to subordinate or hide man-made changes in the landscape. Projects located at breaks in topography or behind existing tree groupings are usually of much less visual impact than projects located on steep side slopes. By taking advantage of natural topographic features, cut and fill slopes can be greatly minimized.
- **Topographic Breaks**—typically, these exhibit a natural line element that the proposed alignments can repeat or blend with to strengthen the design. This line element is partly

established by a visual shadow zone, which will further aid in reducing the contrast of the project.

- **Soils**—soils should be analyzed for stability and fertility and a re-vegetation program should be planned.
- **Hydrology**—hydrological conditions can strongly affect the visual impact of buried and surface construction. The risks of surface and subsurface erosion within the corridor should be analyzed and evaluated.
- **Linear Crossings**—crossings with other linear features or structures should be designed to minimize their visual impact:
    - When possible, crossings should be made at a right angle.
    - Structures should be set as far back from the crossing as possible.
    - In areas with tree and shrub cover, the ROW and structures should be screened from the crossing area.

Potential Viewers and Sensitivities

An assessment of the visual impact of any project should consider the viewer, including their expectations, activities, and frequency of viewing direct and indirect results of the project. Four types of viewers were identified within the project area.

Local Residents

Local residents are people who live in the area of the proposed project and who may view the Project from their yards or homes, while driving on local roads, or during other activities in their daily lives. Local residents can be highly sensitive to changes in the landscape that can be viewed from their homes and neighborhoods. The sensitivity of local residents to the visual impact of the Project may be mitigated by exposure to other existing transmission lines and associated facilities and other dissonant features such as phosphate mines already within the viewshed. Local residents can be highly sensitive to changes in the landscape that can be viewed from their homes and neighborhoods.

Commuters and Travelers

Commuters and travelers are people who travel near the proposed project on their way to other destinations. They may view the Project on a regular basis or only once. Typically, drivers would have limited views of the Project where vegetation or structures provide screening and where the transmission line is running high above the road surface. The visual perception of the Project for commuters and travelers is anticipated to be relatively low because they are typically moving and have a relatively short duration of visual exposure to it. Drivers tend to be occupied with traffic and navigation and are to a much lesser degree concerned with off-road views. Passengers would have a greater occasion for off-road views. The exception to this assessment is scenic roads and byways, which are considered to provide scenic value as part of the driving experience for drivers as well as passengers.

Employees

Employees who work at local businesses, primarily in commercial areas along the routes, will experience the Project as they commute and potentially from their place of employment. They may view the Project from the parking lot as they enter their place of business. Workers may not have views to the outside from within their building and will likely be focused on their work rather than views of the landscape. Due to limited views and focus, employees are not anticipated to have high sensitivity to the proposed project near their place of work.

Recreational Users

Recreational users include local residents and tourists involved in recreational activities at the Blackfoot Reservoir, C-TNF, Soda Springs geyser, Pioneer Historic Byway, state and local parks; waterfronts and boating facilities, historic and cultural sites; and natural areas. Scenery and visual quality may or may not be an important recreational experience for these viewers. For some recreational users, scenery may be an important part of their experience as their activities may include attentiveness to views of the landscape for a long period of time. Such viewers also may have a high appreciation for visual quality and high sensitivity to visual change, as many of these users may be present in the area because of the pristine natural character of the landscape and scenic views

Scenic Integrity and Visual Absorption

Scenic integrity is the degree from which the landscape character deviates from a natural, natural-appearing landscape in line, form, color, and texture of the landscape. In general, natural and natural-appearing landscapes have the greatest scenic integrity. As man-made incongruities are added to the landscape the scenic integrity diminishes.

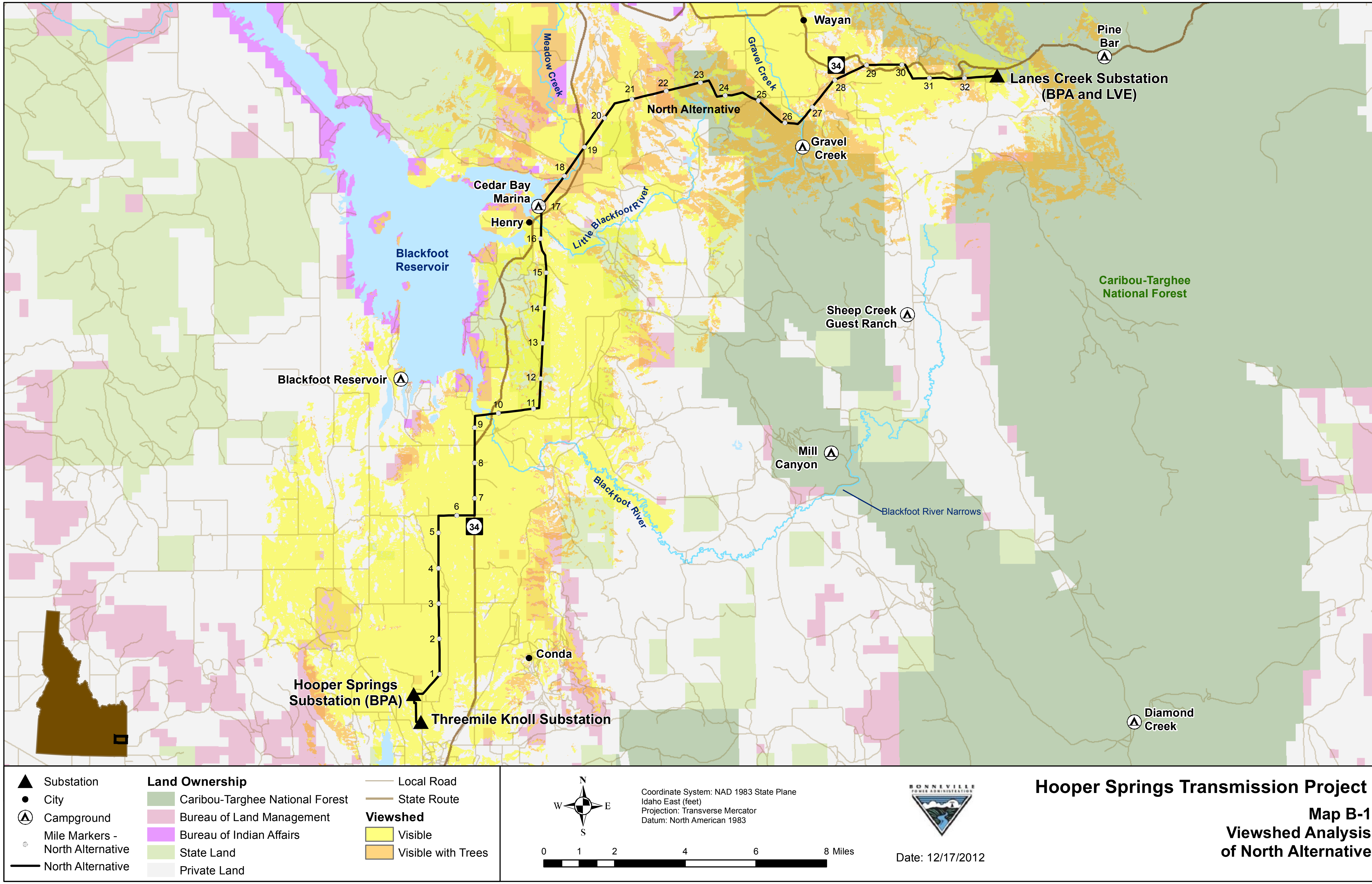
The ability of a landscape to absorb or incorporate alterations with limited reduction in scenic integrity depends on the landscape's character, complexity, and other environmental factors. A new transmission line next to an existing line provides less contrast, and therefore can be absorbed into that landscape better than introducing a transmission line as a new feature in an undeveloped area.

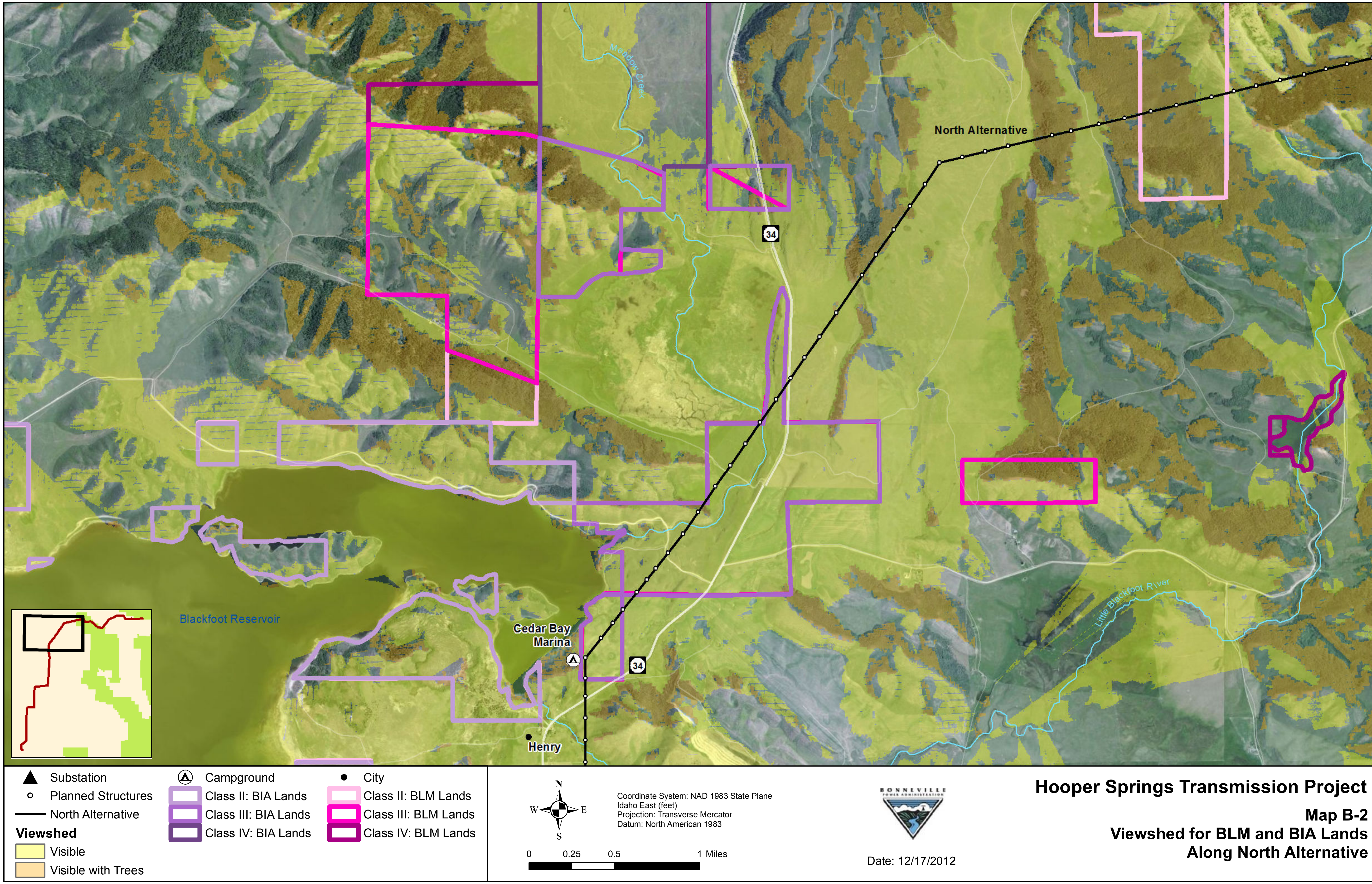
Landscape character encompasses the patterns of landform (topography), vegetation, land use, and aquatic resources (i.e., lakes, streams, and wetlands). The visual character is influenced by natural systems as well as by human interactions and use of land. In natural settings, visual character attributes are natural elements, whereas in rural or pastoral/agricultural settings they may include man-made elements such as fences, walls, barns and outbuildings, and occasional residences. In a more developed setting, the visual character may include buildings, lawn areas and landscaping, pavement, and utility infrastructure. Landscape character throughout the project area has been broken into four categories: C-TNF lands, BLM lands, BIA lands, and non-federal lands. An element common to all land categories, and important to visual resources, is the Pioneer Historic Byway or Highway 34, which runs through the majority of the project area. Highway 34 is an Idaho state and nationally recognized scenic byway with several points of interest within the Project, including Hooper Springs, China Hat Geological formation, Henry-Chester Country Store and the Gray’s Lake Wildlife Refuge.

Viewshed Analysis

Viewshed analyses was conducted for the North and South alternatives to simulate potential views that would be blocked by forest cover or topography and showcase areas where the proposed project structures may be visible. Structure visibility is illustrated in Maps B-1 and B-6. Potentially visible areas are shown in yellow or green. Yellow indicates areas from which the structure is predicted to be visible from ground level and would likely be visible to a visitor. The light green areas are those from which the structure would be visible if the intervening forest cover was removed. Since an observer would be at ground level or the base of the tree cover, it is assumed that the proposed transmission line would not be visible from the areas shaded in light green. Maps B-1 and B-6 show the results of the viewshed analyses, the proposed alternatives, and photography locations.

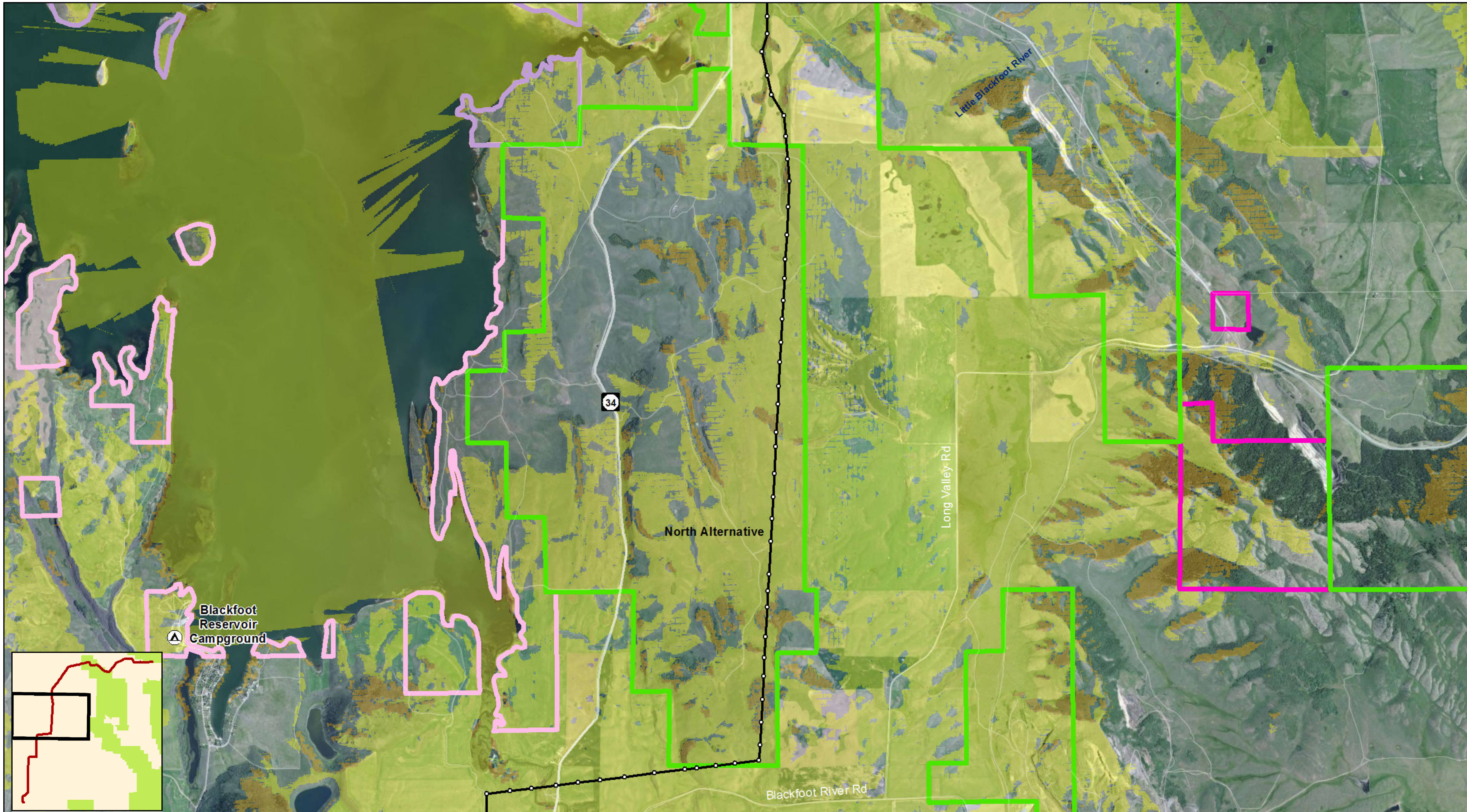
Initial review of the viewshed for the North Alternative shows that views would be limited in the northeast portion of the transmission line corridor, while the transmission line in the southern half of the corridor would be largely visible (Map B-1). In addition, Maps B-2 through B-5 identify the different federal land management categories for each area associated with the standards described above. BLM standards are used for areas managed by BIA. The South Alternative would be largely visible in the southwest portion of the corridor and while paralleling the Blackfoot River and Blackfoot River Road (Map B-6). It would have reduced visibility along its western boundary, between line miles 5 and 9, and as it enters the C-TNF between line miles 19-22. Maps B-7 through B-9 identify the different federal land management categories for each area associated with the standards described above.


Wayan
Pine
Bar
Meadow Creek
Gravel Creek
Lanes Creek Substation
(BPA and LVE)
North Alternative
Gravel
Creek
Cedar Bay
Marina
Henry
Little Blackfoot River
Blackfoot
Reservoir
Caribou-Targhee
National Forest
Sheep Creek
Guest Ranch
Blackfoot Reservoir
Mill
Canyon
Blackfoot River
Blackfoot River Narrows
Conda
Hooper Springs
Substation (BPA)
Threemile Knoll Substation
Diamond
Creek
34
Substation
City
Campground
Mile Markers -
North Alternative
North Alternative
Land Ownership
Caribou-Targhee National Forest
Bureau of Land Management
Bureau of Indian Affairs
State Land
Private Land
Local Road
State Route
Viewshed
Visible
Visible with Trees
N
W
E
S
Coordinate System: NAD 1983 State Plane
Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0 1 2 4 6 8 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-1
Viewshed Analysis
of North Alternative



Hooper Springs Transmission Project

Map B-2
Viewshed for BLM and BIA Lands
Along North Alternative



Substation
City
Planned Structures
North Alternative
Class II: BIA Lands
Class II: BLM Lands
Class III: BLM Lands
State Land
Campground
Viewshed
Visible
Visible with Trees

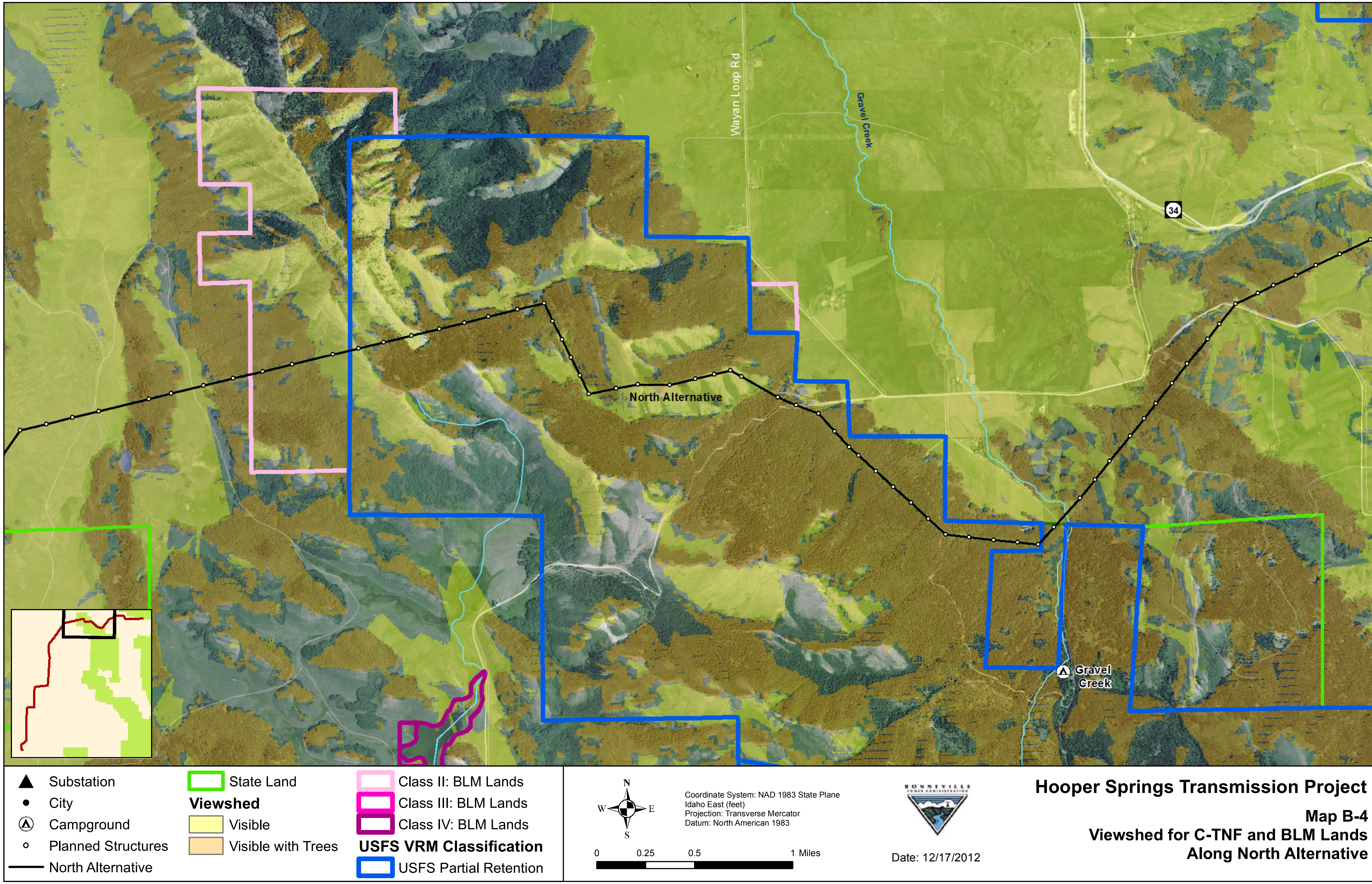
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983

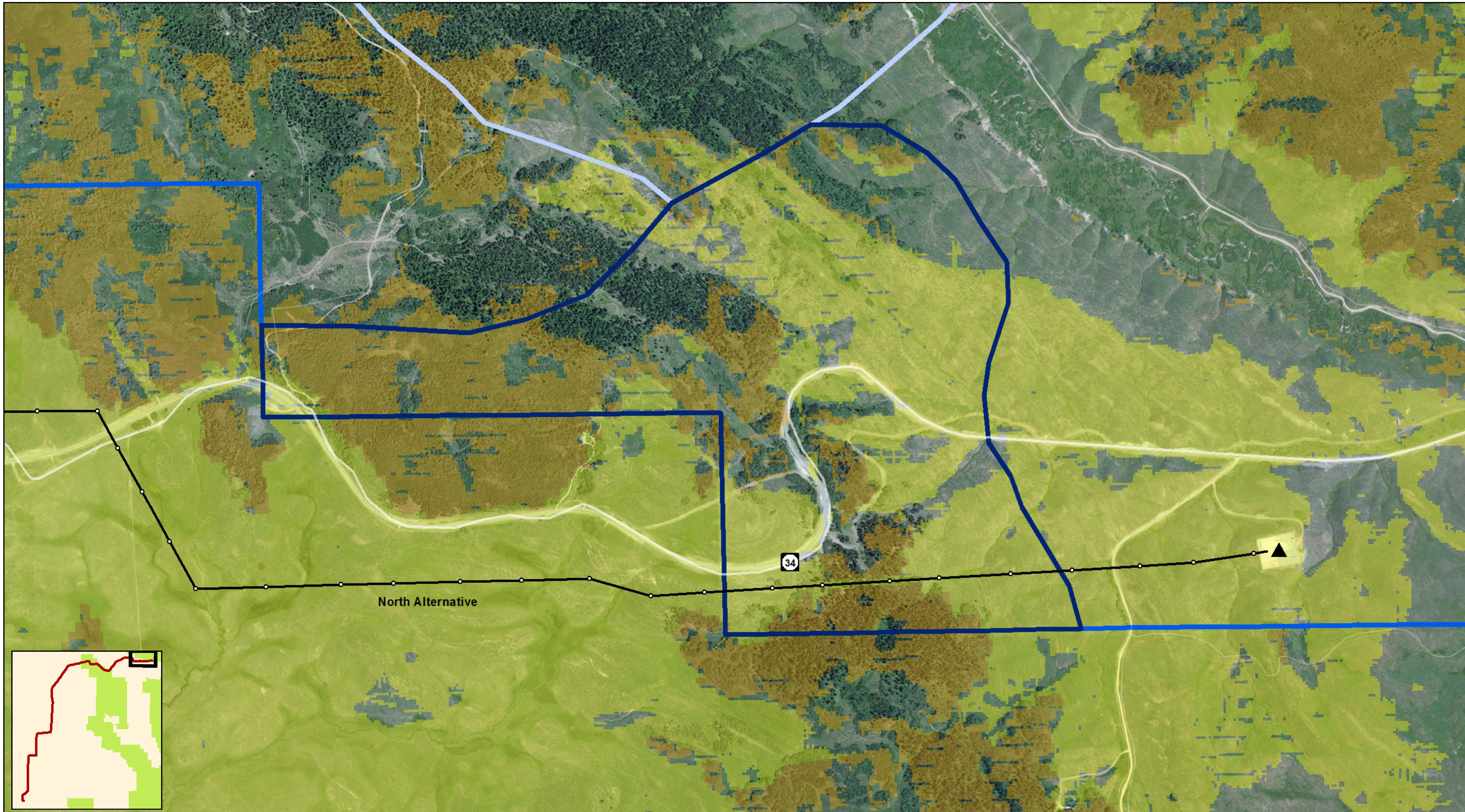
0 0.25 0.5 1 Miles

Date: 12/17/2012

Hooper Springs Transmission Project

Map B-3
Viewshed for Non-Federal Lands and Blackfoot Reservoir Campground Along North Alternative


Wayan Loop Rd
Gravel Creek
34
North Alternative
Gravel Creek
Substation
City
Campground
Planned Structures
North Alternative
State Land
Viewshed
Visible
Visible with Trees
Class II: BLM Lands
Class III: BLM Lands
Class IV: BLM Lands
USFS VRM Classification
USFS Partial Retention
N
W
E
S
Coordinate System: NAD 1983 State Plane
Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0
0.25
0.5
1 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-4
Viewshed for C-TNF and BLM Lands
Along North Alternative



Substation
Planned Structures
North Alternative

USFS VRM Classification
Retention
USFS Partial Retention
Modification

Viewshed
Visible
Visible with Trees

N
W E
S

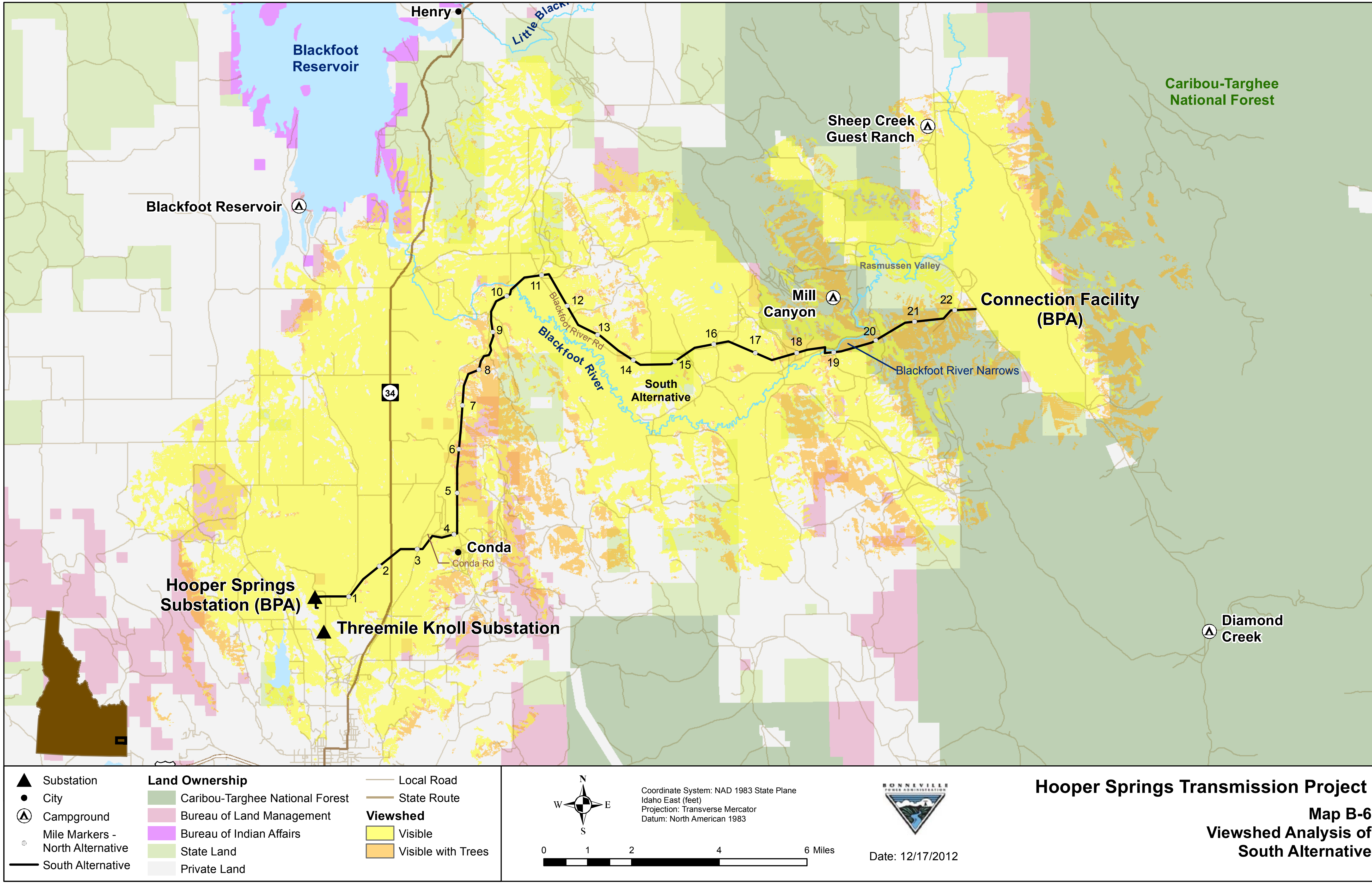
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983

0 0.25 0.5 Miles

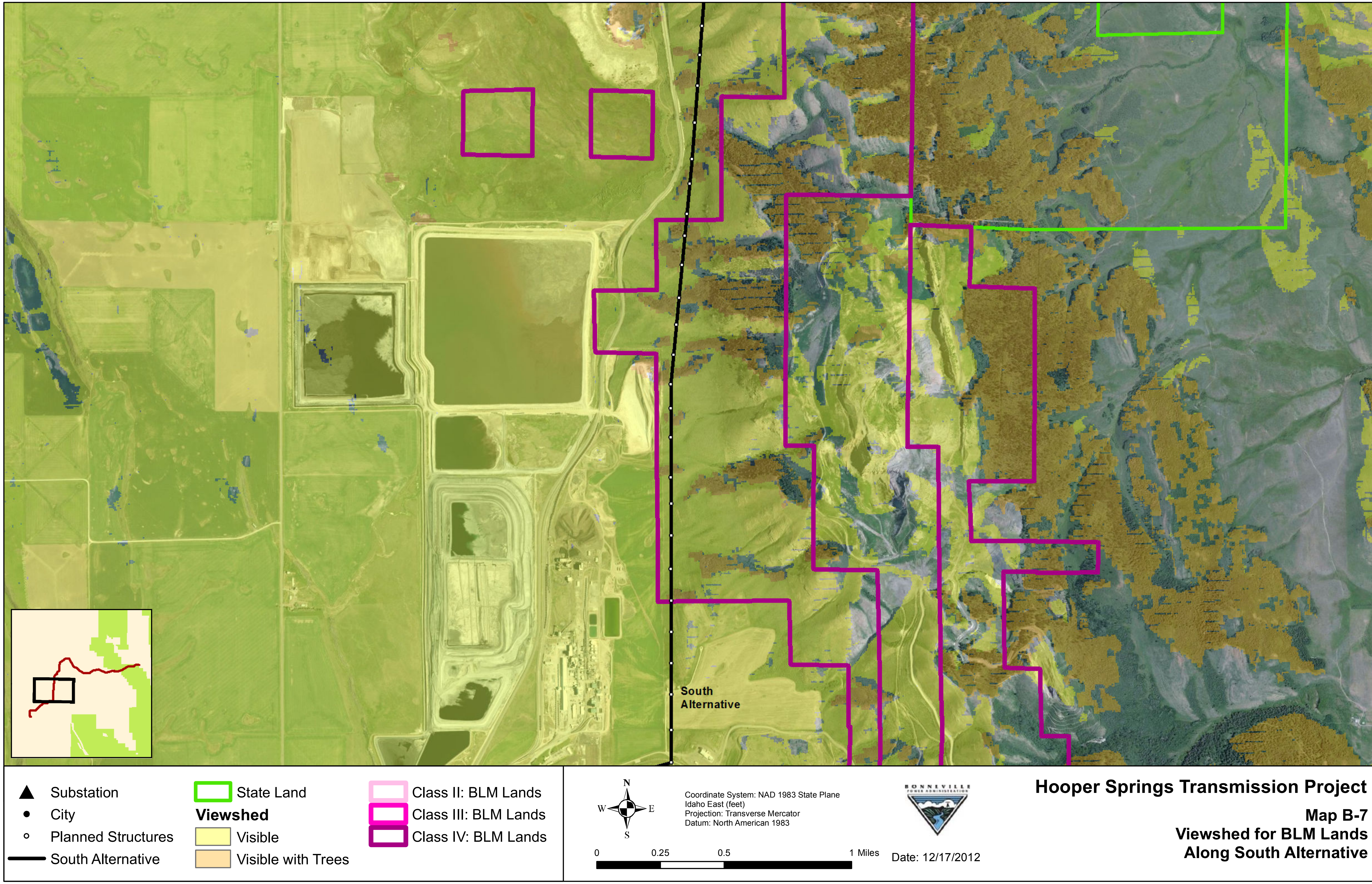
Date: 12/17/2012

Hooper Springs Transmission Project

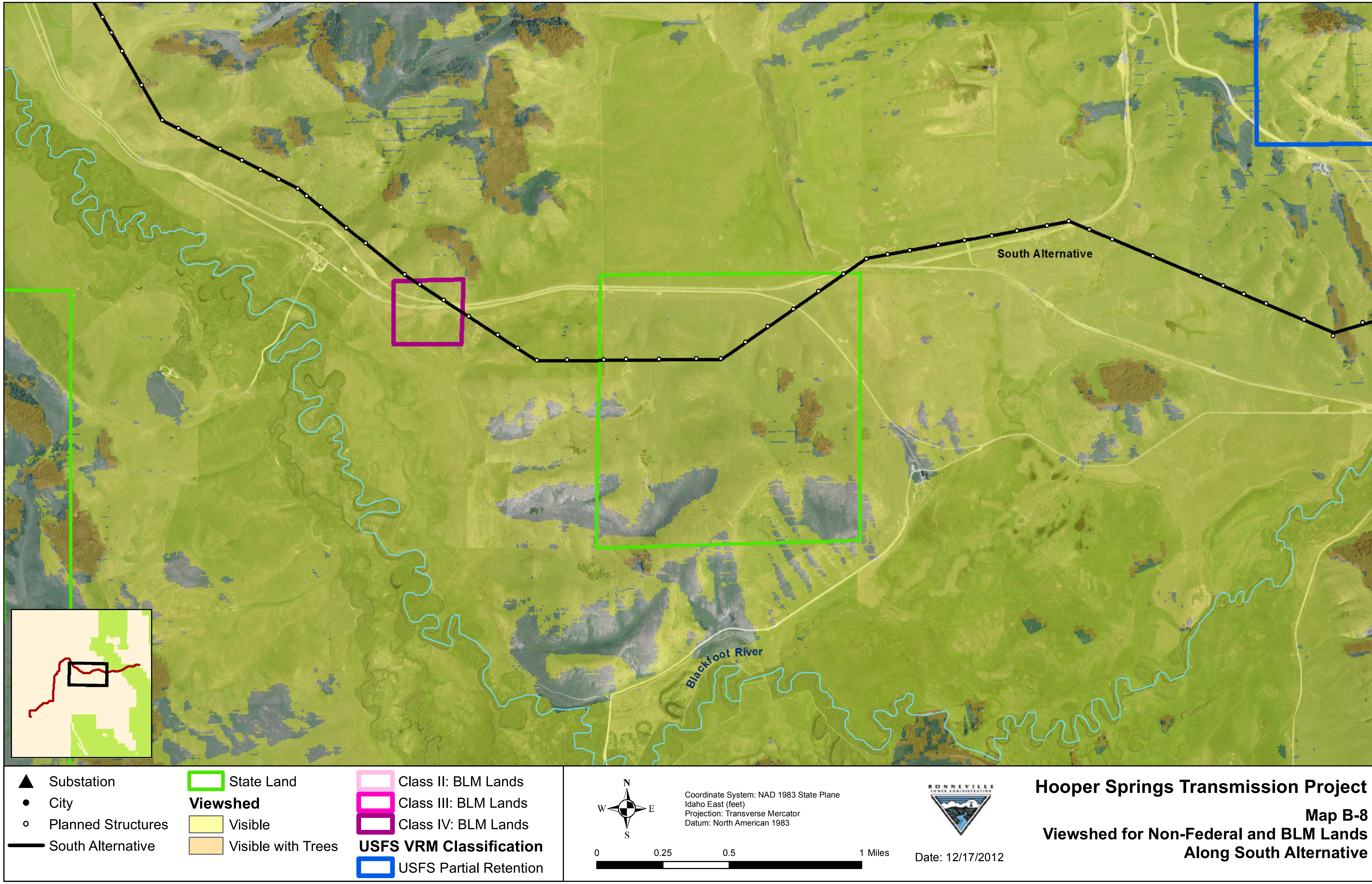
Map B-5
Viewshed for C-TNF Lands Along North Alternative

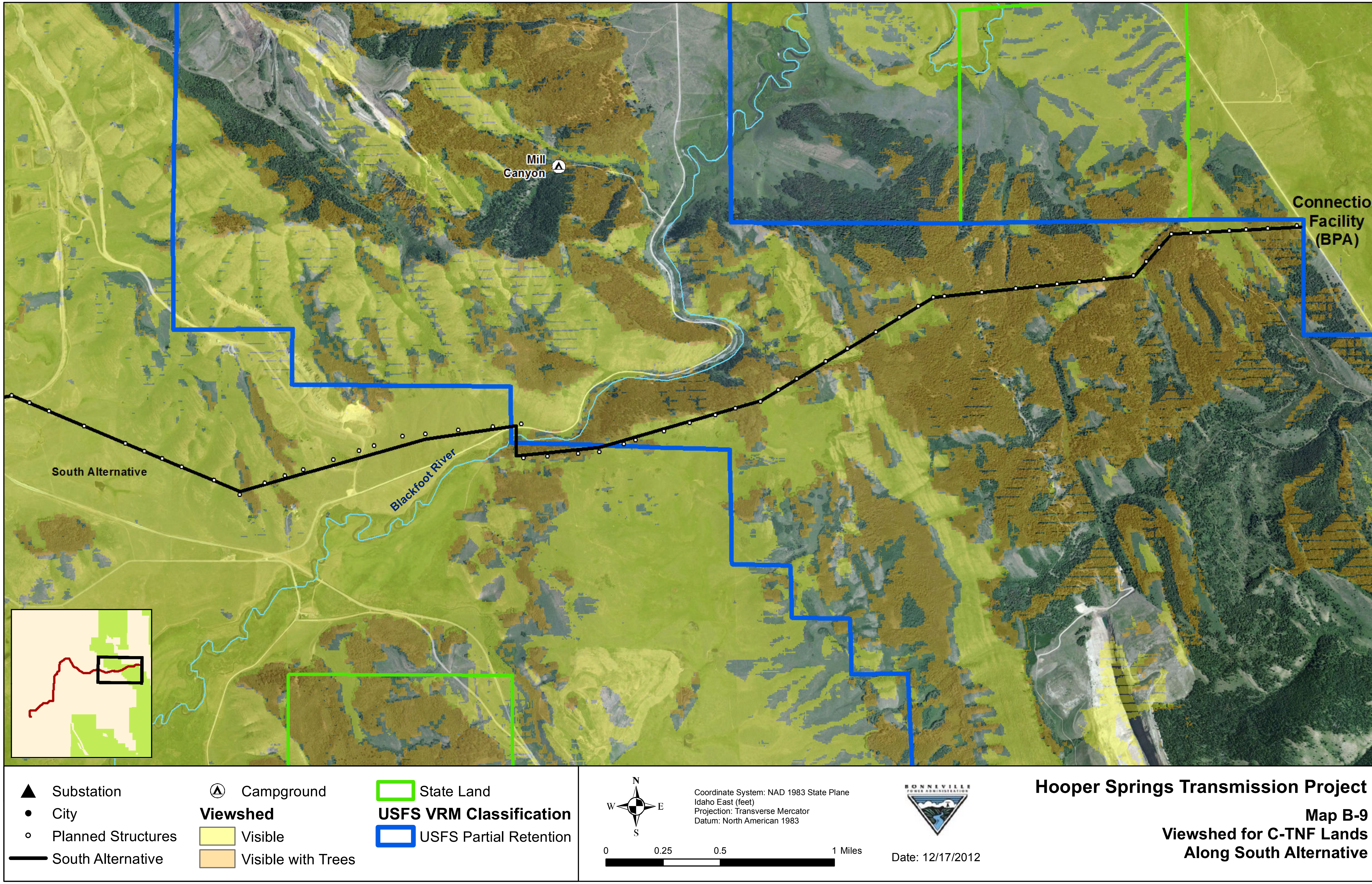


Henry
Little Blackfoot
Blackfoot Reservoir
Blackfoot Reservoir
Caribou-Targhee National Forest
Sheep Creek Guest Ranch
Rasmussen Valley
Mill Canyon
Connection Facility (BPA)
Blackfoot River Rd
Blackfoot River
South Alternative
Blackfoot River Narrows
34
Conda
Conda Rd
Hooper Springs Substation (BPA)
Threemile Knoll Substation
Diamond Creek
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
Substation
City
Campground
Mile Markers - North Alternative
South Alternative
Land Ownership
Caribou-Targhee National Forest
Bureau of Land Management
Bureau of Indian Affairs
State Land
Private Land
Local Road
State Route
Viewshed
Visible
Visible with Trees
N
S
E
W
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0 1 2 4 6 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-6
Viewshed Analysis of South Alternative



South Alternative
Substation
City
Planned Structures
South Alternative
State Land
Viewshed
Visible
Visible with Trees
Class II: BLM Lands
Class III: BLM Lands
Class IV: BLM Lands
N
W
E
S
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0
0.25
0.5
1 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-7
Viewshed for BLM Lands
Along South Alternative


South Alternative
Blackfoot River
Substation
City
Planned Structures
South Alternative
State Land
Viewshed
Visible
Visible with Trees
Class II: BLM Lands
Class III: BLM Lands
Class IV: BLM Lands
USFS VRM Classification
USFS Partial Retention
N
W
E
S
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0
0.25
0.5
1 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-8
Viewshed for Non-Federal and BLM Lands Along South Alternative


Mill
Canyon
Connection
Facility
(BPA)
South Alternative
Blackfoot River
Substation
City
Planned Structures
South Alternative
Campground
Viewshed
Visible
Visible with Trees
State Land
USFS VRM Classification
USFS Partial Retention
N
W
E
S
Coordinate System: NAD 1983 State Plane
Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983
0
0.25
0.5
1 Miles
Date: 12/17/2012
Hooper Springs Transmission Project
Map B-9
Viewshed for C-TNF Lands
Along South Alternative

Transmission Line Photographic Simulations

Photographic simulations provide representative views of the transmission line from specific locations. The simulations are intended to provide a visual picture of a 115-kV transmission line in several representative sensitive settings within the landscape surrounding the project corridor. As mentioned previously, both wooden H-frame and steel mono-pole structures would be used for the North Alternative and steel poles would be used for the South Alternative. In addition, steel towers on the North Alternative would be single circuit while those structures on the South Alternative would be double circuit. A set of 3-D models was used to complete the photo simulations (Figures B-1, B-2, and B-3 shown below). The structures would be made of stainless steel.

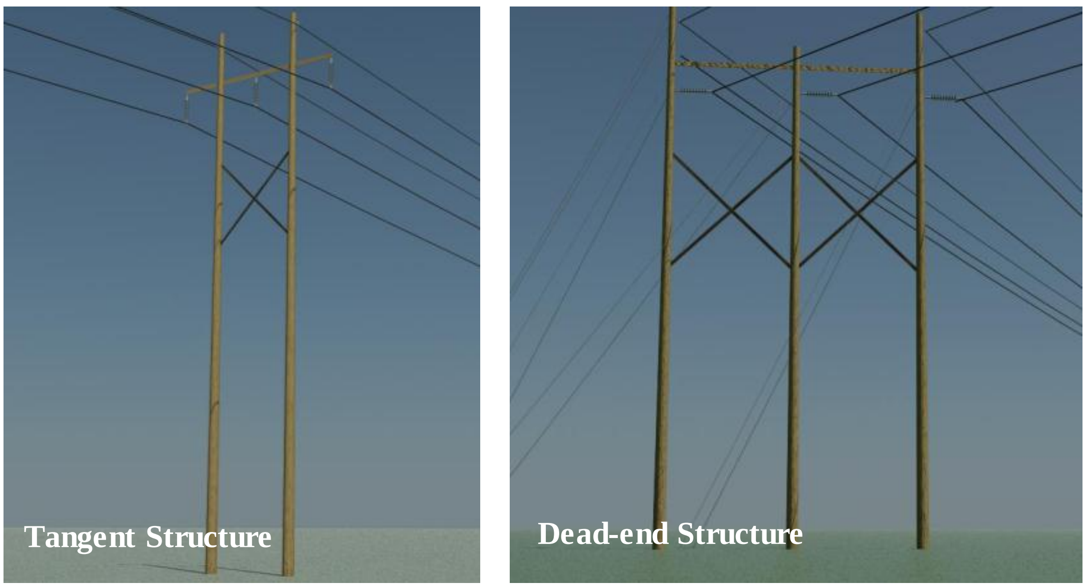


Figure B-1. 3-D models of wood pole structures used for photographic simulations

Figure B-2. 3-D model of steel single circuit monopole structures used for photographic simulations

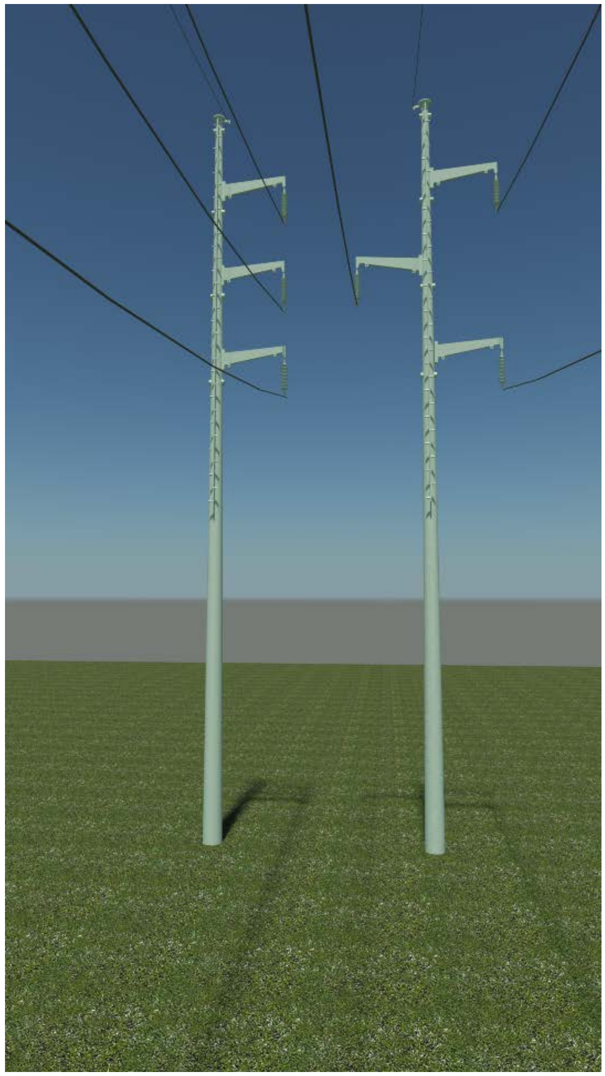
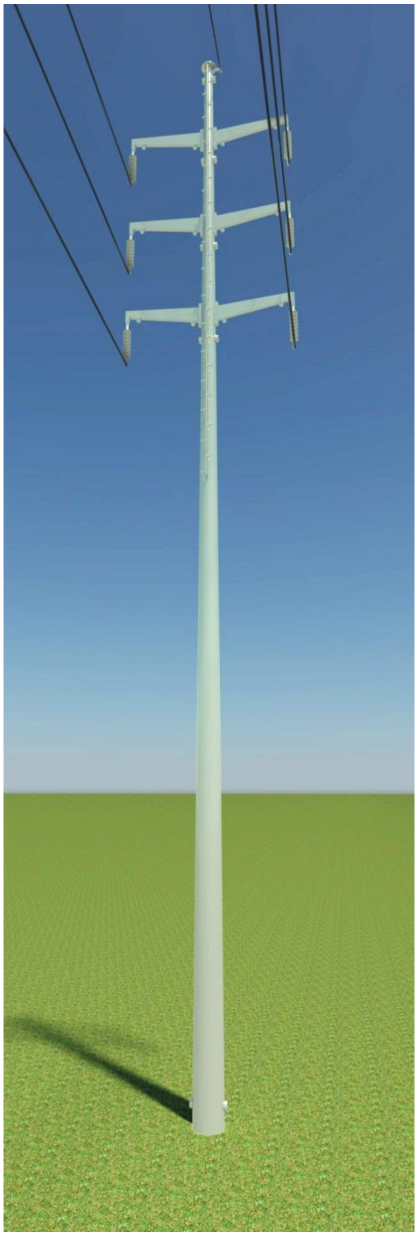


Figure B-3. 3-D model of steel double circuit monopole structures used for photographic simulations



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Appendix C

Plant Species Inventory

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Vascular Plant Species Documented During Plant Inventory Surveys Conducted within the Project Area.

Scientific Name	Common Name
Abies lasiocarpa	Subalpine fir
Acer glabrum	Rocky mountain maple
Achillea millefolium	Common yarrow
Agropyron cristatum	Crested wheatgrass
Agrostis alba	Redtop
Alopecurus pratensis	Meadow foxtail
Amelanchier alnifolia	Serviceberry
Anaphalis margaritacea	Pearly everlasting
Antennaria alpina	Alpine pussytoes
Arnica cordifolia	Heartleaf arnica
Artemisia cana	Silver sagebrush
Artemisia ludoviciana	White sagebrush
Artemisia tridentata var. tridentata	Big sagebrush
Artemisia tridentata var. wyomingensis	Wyoming big sagebrush
Artemisia tripartita	Threetip sagebrush
Aster perelegans	Elegant aster
Berberis repens	Oregon grape
Bromus inermis	Smooth brome
Bromus tectorum	Cheatgrass
Calochortus nuttallii	Sego lily
Carex geyeri	Elk sedge
Carex lenticularis	Shore sedge
Carex pachystachya	Thick-head sedge
Carex rostrata	Beaked sedge
Carex rupestris	Curly sedge
Calamagrostis rubescens	Pinegrass
Castilleja miniata	Common red paintbrush
Castilleja flava	Yellow paintbrush
Chrysothamnus nauseosus	Green rabbitbrush
Chrysothamnus viscidiflorus	Yellow rabbitbrush
Cirsium arvense	Canada thistle
Cirsium scariosum	Elk thistle
Cornus sericea	Red-osier dogwood
Cryptantha sp.	Cryptantha
Cynoglossum officinale	Gypsyflower

Scientific Name	Common Name
Delphinium sp.	Larkspur
Deschampsia caespitosa	Tufted hairgrass
Eleocharis palustris	Creeping spikerush
Epilobium ciliatum	Hairy willow-herb
Epilobium ciliatum ssp. Watsonii	Fringed willowherb
Eriogonum ovalifolium	Cushion buckwheat
Eriogonum heracleoides	Parsnip-leaved buckwheat
Festuca idahoensis	Idaho fescue
Fragaria vesca	Woodland strawberry
Fritillaria pudica	Yellow bell
Galium boreale	Northern bedstraw
Geranium viscosissimum	Sticky crane's-bill
Geum macrophyllum	Large-leaf avens
Geum triflorum	Prairie smoke
Glyceria striata	Fowl manna grass
Grindelia squarrosa	Curly-cup gumweed
Juncus acuminatus	Taper-tip rush
Juncus balticus	Baltic rush
Juncus effusus	Soft rush
Juncus patens	Spreading rush
Juniperus scopulorum	Rocky Mountain juniper
Lupinus sp.	Lupine
Madia glomerata	Mountain tarweed
Osmorhiza chilensis	Licorice root
Penstemon acuminatus	Sharpleaf penstemon
Phalaris arundinacea	Reed canary grass
Phleum pratense	Timothy
Phlox sp.	Phlox
Pinus contorta	Lodgepole pine
Poa bulbosa	Bulbous bluegrass
Poa palustris	Fowl bluegrass
Poa pratensis	Kentucky bluegrass
Populus tremuloides	Quaking aspen
Potentilla gracilis	Northwest cinquefoil
Prunella vulgaris	Heal-all
Prunus virginiana	Chokecherry
Purshia tridentata	Bitterbrush

Scientific Name	Common Name
Pseudotsuga menziesii	Douglas-fir
Rhamnus alnifolia	Buckthorn
Ribes lacustre	Black gooseberry
Rosa nutkana	Nootka rose
Rudbeckia occidentalis	Western coneflower
Salix boothii	Booth willow
Salix exigua	Coyote willow
Salix sitchensis	Sitka willow
Salix wolfii	Wolf willow
Senecio sp.	Groundsel
Spiranthes romanzoffiana	Hooded ladies-tresses
Stachys cooleyae	Cooley's hedge nettle
Stellaria longifolia	Long-leaf starwort
Symphoricarpos alba	Snowberry
Taraxacum officinale	Common dandelion
Thlaspi arvense	Field penny-cress
Urtica dioica	Stinging nettle
Vaccinium membranaceum	Black huckleberry
Vccinium ovatum	Evergreen huckleberry
Wyethia amplexicaulis	Northern muleears

Appendix D

Vegetation Special Status Species

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Vegetation

Special Status Species

Federally Listed and Candidate Species

Ute ladies'-tresses (*Spiranthes diluvialis*)

Ute ladies'-tresses is the only ESA-listed species with documented occurrence in Southeast Idaho. There have been documented sightings in Bonneville, Jefferson, and Madison counties in Idaho, but the U.S. Fish and Wildlife Service (USFWS) considers all of Idaho to be within the potential range of the species (IDFG 2011a). A review of information published by the Idaho Conservation Data Center and the Idaho Department of Fish and Game (IDFG) (IDFG 2011b; IDFG 2011c) indicates there are no documented occurrences within the project area. Personal communications with USFWS biologists indicated that Ute ladies'-tresses is unexpected to occur within the project area (Matthews 2011). This species was not encountered during field surveys conducted in May and July 2011 associated with the North Alternative corridor. Similarly, no Ute ladies'-tresses were documented during field surveys of the South Alternative.

Whitebark pine (*Pinus albicaulis*)

Whitebark pine, a Candidate species, is a 5-needled conifer classified as a stone pine. Whitebark pine is typically found in cold, windy, high elevation or high latitude sites in western North America and as a result, many stands are geographically isolated. It is a stress-tolerant pine and its hardiness allows it to grow where other conifer species cannot. The species is distributed in Coastal Mountain Ranges (from British Columbia, Washington, Oregon, down to east-central California) and Rocky Mountain Ranges (from northern British Columbia and Alberta to Idaho, Montana, Wyoming, and Nevada) (USFWS 2012). In Idaho this species is found at elevations between 7,300-10,500 feet (2,225-3,200 m) (USFWS 2012). This species was not encountered during field surveys for the North Alternative, including old growth surveys conducted at the highest elevations in the project area, and the majority of the project area is below 7,300 feet in elevation, so there is no potential habitat for this species in the project area. The potential for whitebark pine presence in the South Alternative will be assessed during summer 2013 and appropriate avoidance measures will be developed to the extent possible. However, the current routing.

U.S. Forest Service Sensitive Species

Payson's Bladderpod (*Lesquerella paysonii*)

Payson's bladderpod is a U.S. Forest Service (USFS) sensitive species, and is listed as S2 by the Idaho State Department of Natural Heritage. In Idaho, Payson's bladderpod populations are typically found on ridgelines in sagebrush or forest openings on gravelly soils that have carbonate parent material, and microhabitat for this species is very specific (Moseley 1996). Suitable microhabitats consist of dry and open, gravelly, well-drained substrates that, in most cases, are exposed to prevailing winds throughout the year. This micro-habitat is in topography that indicates low snow deposition: the windward side ridgelines and upper slopes. Payson's bladderpod occurs on montane, subalpine, and alpine ridgelines and the upper portions of southerly slopes in highly dissected mountains. Elevations range from 6,000 to 9,950 feet, with most populations occurring above 8,000 feet (Moseley 1996).

Distribution of Payson's bladderpod is largely restricted to the carbonate mountain ranges of west-central Wyoming and adjacent Idaho, although two disjunct populations have also been found in southwestern Montana (Moseley 1996). In Idaho, it occurs on the ridges and high peaks of the Snake River Range above the escarpment that parallels the Snake River (Moseley 1996). These populations are contiguous with its known distribution in Wyoming and extend about 12 miles northwest into Idaho from the Wyoming border. A lone population on Caribou Mountain is separated from other known populations in Idaho by 19 miles.

The nearest known population of this species is located on Caribou-Targhee National Forest (C-TNF) land on Caribou Mountain, approximately 2 miles north of the project area (IDFG 2011b). This species was not documented during botanical inventory surveys conducted on C-TNF lands in 2007 for the South Alternative and 2011 for the North Alternative. The North Alternative crosses a rocky ridge top with a western aspect slope, which represents potentially suitable habitat for Payson's bladderpod; however, because it was not located during surveys it is not likely to be impacted by the Project. New surveys of the South Alternative are scheduled for summer 2013 to reassess the existence any new occurrences.

Compact (Cache) Beardtongue (*Penstemon compactus*)

Compact (Cache) beardtongue is a federal species of concern, a USFS sensitive species, and is listed as S2 by the Idaho State Department of Natural Heritage. It is endemic to the northern part of the Bear River Range in Cache County, Utah and adjacent Franklin County, Idaho. Cache beardtongue occurs on bedrock slabs, rock outcrops, cliff bands, or gravelly, shallow soil habitats. It occurs on various aspects along high-elevation ridge crests and associated summit or upper slopes areas, ranging from flat to moderately steep (Mancuso 2003). All Idaho populations of Cache beardtongue occur on carbonate substrate, either St. Charles limestone or Fish Haven dolomite (Mitchell and Bennett 1979), between 8,600 to 9,400 feet elevation (Mancuso 2003).

Seven small populations of this species are known to occur in Idaho, all on C-TNF in the upper Logan River-Franklin Basin area, approximately 40 to 50 miles south of the project area (Mancuso 2003). There are areas with potentially suitable habitat for this species on dolomitic limestone (limestone that is composed of over 50 percent dolomite) rocks within the project area on the C-TNF, but the project area is largely outside the known range of this species and no portions of the North or South Alternatives are above approximately 7,500 feet elevation.

This species was not documented during the botanical inventory surveys conducted of the South Alternative in 2007 or the North Alternative in 2011.

Starveling Milkvetch (*Astragalus jejunus* var. *jejunus*)

Starveling milkvetch is a Bureau of Land Management (BLM) Type 2 sensitive species, a USFS sensitive species, and is listed as S2 by the Idaho State Department of Natural Heritage. It has been documented on the Montpelier District of C-TNF (Mancuso and Moseley 1990). These occurrences were restricted to barren, eroding, shale substrate belonging to the Twin Creek limestone formation (Mancuso and Moseley 1990), which is not present within the project area. Outcrops of Twin Creek limestone exhibit a white to gray to bluish-green, porcelain-like appearance that is distinctive even from a distance. All populations are restricted to a narrow range of habitat conditions that are generally discontinuous and not very extensive, particularly on C-TNF (Mancuso and Moseley 1990).

Suitable limestone habitat for starveling milkvetch does not occur within the project area nor was it detected during vegetation surveys.

Bureau of Land Management Sensitive and State Review Species

Hoary Willow (*Salix candida*)

Hoary willow is a BLM Type 4 sensitive species and is listed as S2 by the Idaho State Department of Natural Heritage. It has been documented approximately 1 mile east of the North Alternative ROW, near the town of Henry, Idaho (IDFG 2011b). Hoary willow is a low-growing willow species that grows on floating mats and in bogs, fens, and willow thickets around ponds, primarily between 6,600 and 9,200 feet elevation (Walford et al. 1997).

Riparian wetland habitats on BLM-owned lands associated with Meadow Creek within the North Alternative represent potentially suitable habitat for hoary willow. Additionally, riparian wetland habitats on non-BLM-owned lands associated with the Blackfoot River, Little Blackfoot River, and Gravel Creek also represent potentially suitable habitat for hoary willow. In addition, past occurrence of hoary willow were documented within a mile of the South Alternative. However, this species was not documented during special status plant surveys and botanical inventory surveys conducted along the South Alterative in 2007 and the North Alternative in 2011.

Idaho Sedge (*Carex idahoa*)

Idaho sedge is a BLM Type 2 sensitive species and is listed as S2 by the Idaho State Department of Natural Heritage. It is a relatively low, inconspicuous sedge that typically grows scattered in small patches in the border between wet meadow, emergent wetlands, and sagebrush-steppe vegetation (Mancuso and Severud 2004). It commonly occurs in moist mountain and riparian meadows.

Idaho sedge has been documented at several locations on C-TNF within the vicinity of the North Alternative (IDFG 2011b), but has not been documented on BLM-owned lands within the vicinity of the North Alternative. In addition, Idaho sedge has not been documented within the North Alternative. Potentially suitable habitat for Idaho sedge occurs within the mountain meadows and wetlands of Reservoir Canyon on C-TNF, portions of which are within the North Alternative corridor. Similarly, no occurrences of Idaho sedge have been documented in the South Alternative, though potentially suitable habitat is also present. This species was not encountered during botanical inventory surveys conducted along the South Alternative during 2007 and along the North Alternative during 2011.

Green Needlegrass (*Nassella viridula = Stipa viridula*)

Green needlegrass is a BLM Type 4 sensitive species and is listed as S2 by the Idaho State Department of Natural Heritage. Green needlegrass is a widespread species occurring mostly east of the Continental Divide, especially in the northern Great Plains region. Idaho populations are at the species' western periphery (Mancuso and Mosely 1992). One of the few Idaho occurrences is located at the northern end of the Bear River Range, near the town of Alexander, Idaho (Mancuso 2003).

Suitable habitat for green needlegrass consists of sandy, well-drained soils in grassland and sagebrush habitats. Much of the sagebrush-dominated land under BLM and state of Idaho ownership represent potentially suitable habitat for green needlegrass. However, this species was not encountered during either botanical inventory surveys conducted within the South or North Alternatives in 2007 and 2011, respectively.

Red Glasswort (*Salicornia rubra*)

Red glasswort is a BLM Type 4 sensitive species and is listed as S2 by the Idaho State Department of Natural Heritage. It is a succulent halophyte, characteristic of salt flats and the margins of alkaline lakes in arid regions of the West. The range of red glasswort is relatively widespread, but because of its specialized habitat, its distribution is local and sporadic. It prefers moist or seasonally moist stream banks and meadows high in salt concentrations with open and exposed soils (Jankovsky-Jones 2001).

No populations of red glasswort have been documented within the project vicinity (IDFG 2011b) and based on field review and desktop review there are no saline or alkaline lakes or ponds identified within the South or North Alternatives or their vicinity. This species was not encountered during botanical inventory surveys conducted in 2007 for the South Alternative or 2011 for the North Alternative.

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Appendix E

Soil Descriptions

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Introduction

Soils in the project area were described using the State Soil Geographic Database (STATSGO). More refined data for non-CNF lands was unavailable as the NRCS is in the process of classifying soils in Caribou County (See Map E-1). However, the C-TNF conducted a soil survey of the Caribou portion of the Forest in 1990. The CNF Soil Survey (USFS 1990) was used in combination with additional soil characterizations conducted in support of project planning.

The CNF Soil Survey maps are provided below (Maps E-2 and E-3) and associated soil characteristic descriptions. Once a preferred route is identified, BPA will conduct additional soil survey verifications on C-TNF lands, as required by the Forest Plan.

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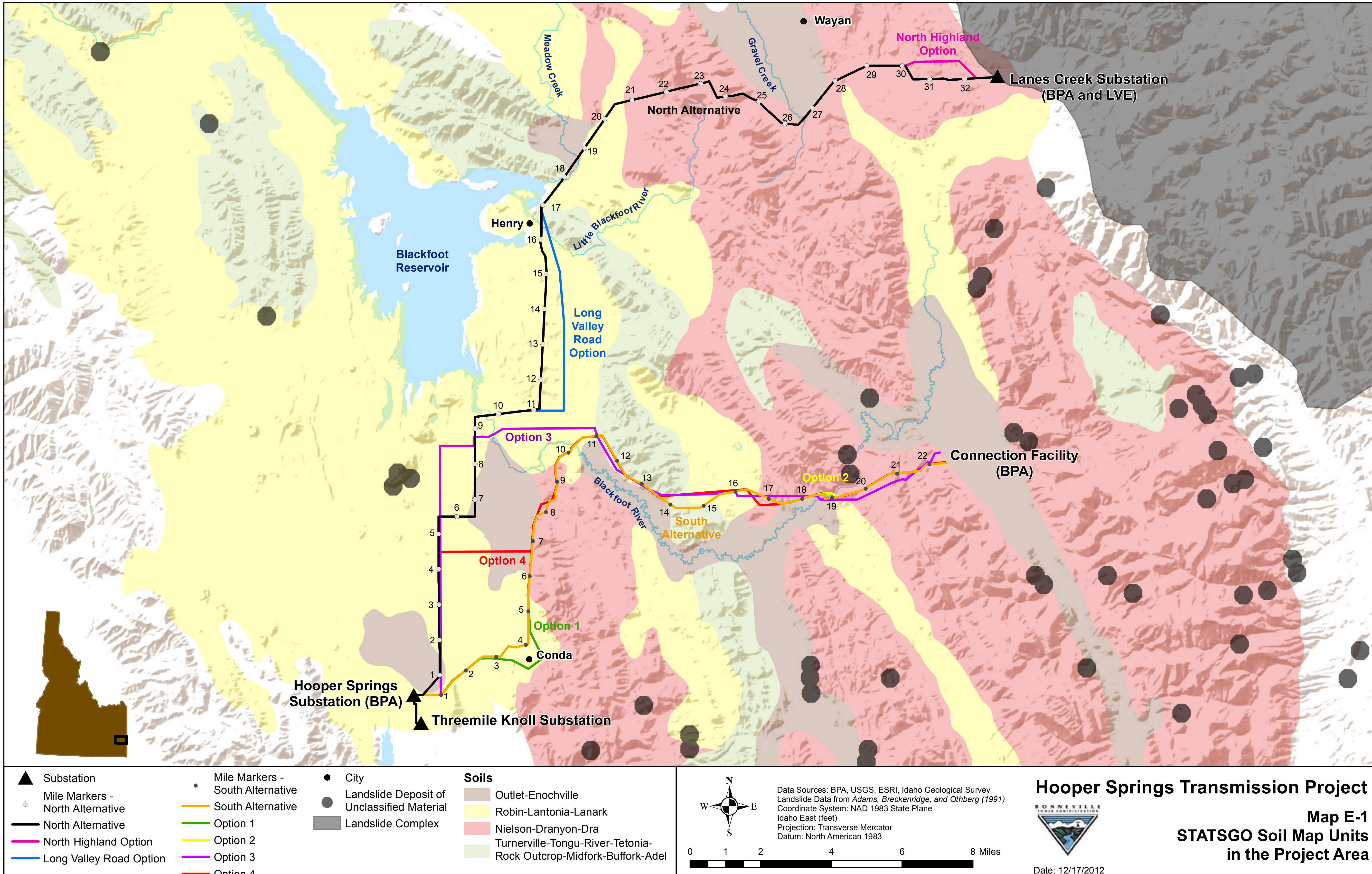
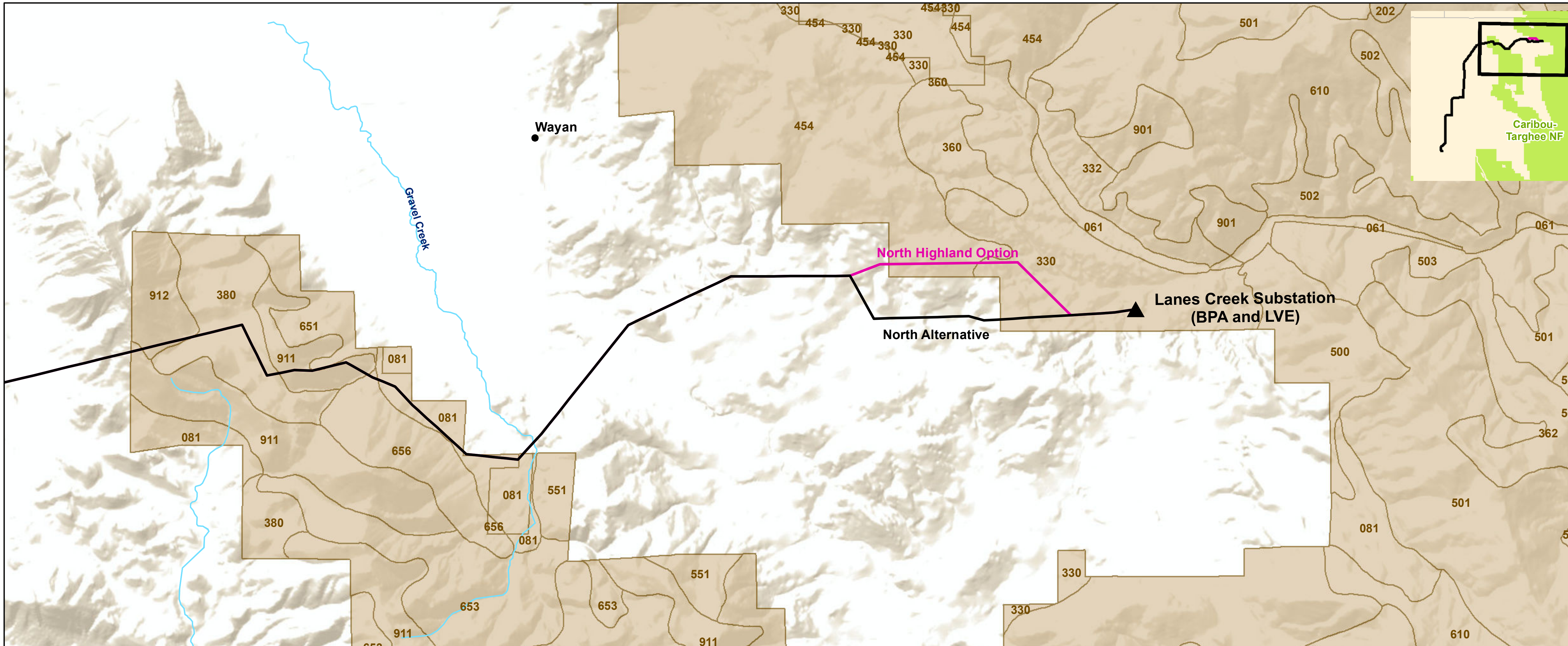


Hooper Springs Transmission Project

Map E-1
STATSGO Soil Map Units in the Project Area

Date: 12/17/2012



Caribou National Forest Soil Survey, 1990 (unpublished data)

Code	Soil Type (% slope)	Code	Soil Type (% slope)	Code	Soil Type (% slope)
901	Beaverdam – Blaine – Nisula Familes complex (30-50%)	602	Judkins – Farlow Families complex (35-55%)	362	Swede – Dranyon – Nisula Familes complex (20-50%)
330	Beaverdam – Swede – Toponce Families complex (5-25%)	653	Judkins – Nisula – Farlow Families complex (40-60%)	500	Swede – Dranyon – Toponce Families complex (20-35%)
610	Beaverdam – Toponce – Ericson Families complex (35-55%)	432	Nisula – Starman – Blaine Families complex (50-70%)	503	Swede – Mikesell – Nisula Families complex (35-55%)
912	Calcic Cryoborolls – Starley Family – Judkins Family complex (35-60%)	911	Parkay Family – Calcic Pachic Cryoborolls – Starley Familiy complex (30-60%)	456	Swede – Nisula – Ketchum Families association (10-25%)
656	Cloud Peak – Jughandle – Swede Families complex (30-50%)	380	Povey – Alpon – Ketchum Families complex (30-55%)	360	Swede – Rooset – Nisula Familes complex (35-55%)
502	Dranyon – Beaverdam – Blaine Families complex (20-50%)	651	Povey – Blaine Families association (30-50%)	332	Swede Family – Typic Cryoboralfs, fine loamy – Typic Cryoboralfs, loamy association (20-45%)
300	Ericson – Cloud Peak – Ketchum Families complex (15-40%)	081	Red Spur – Harkness Families Association (10-20%)	501	Toponce – Swede – Beaverdam Families (35-50%)
433	Harkness Familiy – Mollic Cryoboralfs – Typic Cryoboralfs complex (2-45%)	202	Swede – Blaine – Povey Families Complex (20-35%)	454	Toponce – Swede – Dranyon Families complex (25-50%)
551	Judkins – Cloud Peak – Farlow Families complex (30-50%)			061	Venable Family – Argic Cryaquolls – Coski Family Complex (0-5%)

▲ Substation
● City
North Alternative
Caribou NF Soil Survey
Northern Highland Option

N E S W

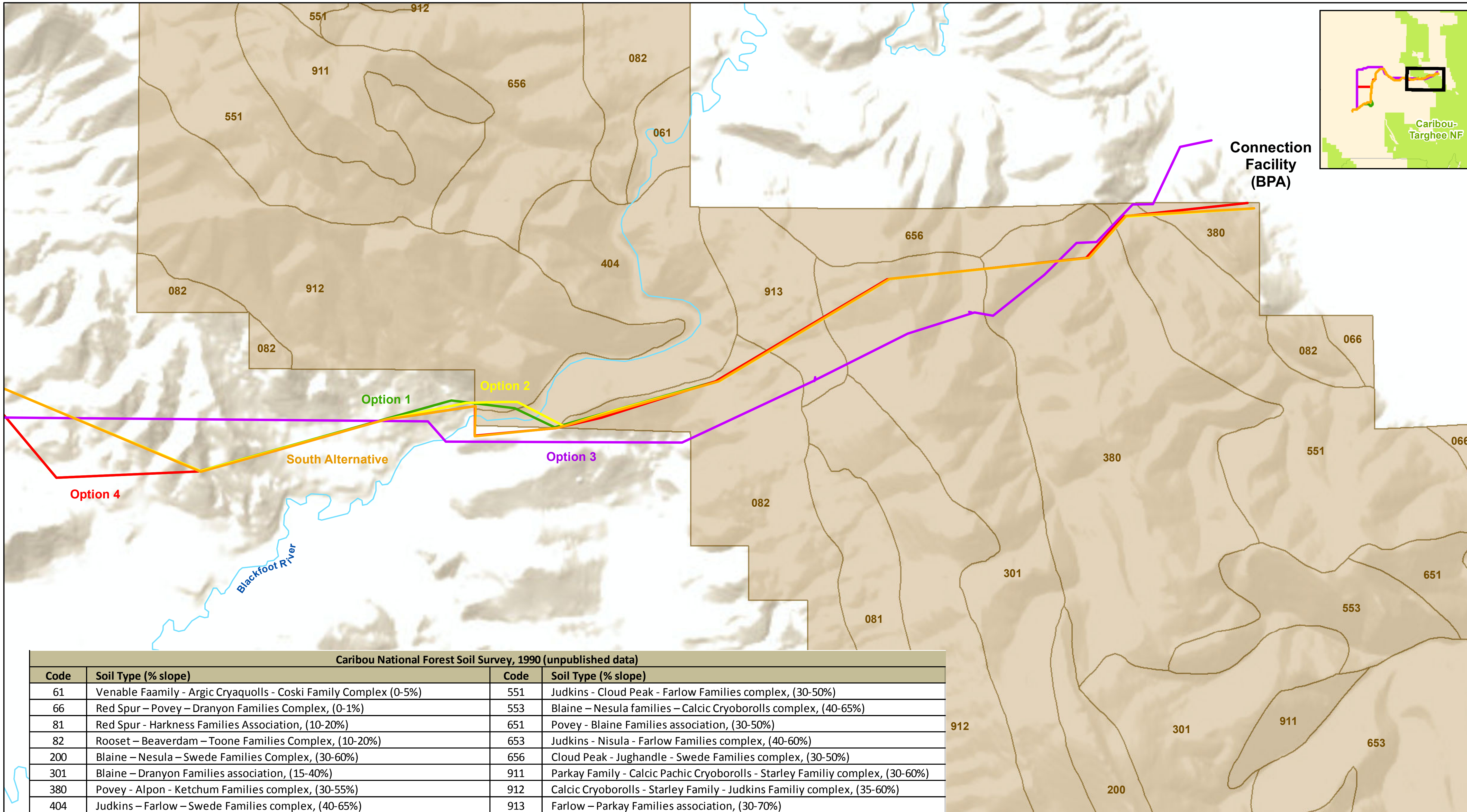
Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983

0 0.5 1 2 3 Miles

Date: 12/17/2012

Hooper Springs Transmission Project

Map E-2
CNF Soil Survey Map Units Along the North Alternative



Caribou National Forest Soil Survey, 1990 (unpublished data)

Code	Soil Type (% slope)	Code	Soil Type (% slope)
61	Venable Faamily - Argic Cryaquolls - Coski Family Complex (0-5%)	551	Judkins - Cloud Peak - Farlow Families complex, (30-50%)
66	Red Spur – Povey – Dranyon Families Complex, (0-1%)	553	Blaine – Nesula families – Calcic Cryoborolls complex, (40-65%)
81	Red Spur - Harkness Families Association, (10-20%)	651	Povey - Blaine Families association, (30-50%)
82	Rooset – Beaverdam – Toone Families Complex, (10-20%)	653	Judkins - Nisula - Farlow Families complex, (40-60%)
200	Blaine – Nesula – Swede Families Complex, (30-60%)	656	Cloud Peak - Jughandle - Swede Families complex, (30-50%)
301	Blaine – Dranyon Families association, (15-40%)	911	Parkay Family - Calcic Pachic Cryoborolls - Starley Familiy complex, (30-60%)
380	Povey - Alpon - Ketchum Families complex, (30-55%)	912	Calcic Cryoborolls - Starley Family - Judkins Familiy complex, (35-60%)
404	Judkins – Farlow – Swede Families complex, (40-65%)	913	Farlow – Parkay Families association, (30-70%)

South Alternative
Option 1
Option 2
Option 3
Option 4
Substation
Soil Pit
Caribou NF Soil Survey

N W E S

Coordinate System: NAD 1983 State Plane Idaho East (feet)
Projection: Transverse Mercator
Datum: North American 1983

0 0.25 0.5 1 Miles

BONNEVILLE POWER ADMINISTRATION

Date: 12/17/2012

Hooper Springs Transmission Project

Map E-3
CNF Soil Survey Map Units Along the South Alternative

Review of Soil Survey of the Caribou National Forest Idaho

The soil map units from the Caribou National Forest Soil Survey (USFS 1990) (Maps E-2- and E-3) identified within the project area include the following:

North Alternative

- 081 – Red Spur - Harkness Families association, 10 to 20 percent slopEes;
- 330 - Beaverdam – Swede – Toponce Families complex, 5 to 25 percent slopes
- 380 - Povey – Alpon – Ketchum Families complex, 30 to 55 percent slopes
- 651 - Povey – Blaine Families association, 30 to 50 percent slopes
- 656 - Cloud Peak – Jughandle – Swede Families complex, 30 to 50 percent slopes
- 911 - Parkay Family – Calcic Pachic Cryoborolls – Starley Family complex, 30 to 60 percent slopes
- 912 - Calcic Cryoborolls – Starley Family – Judkins Family complex, 35 to 60 percent slopes

South Alternative

- 082 – Rooset-Beaverdam – Toone Families complex, 10 to 20 percent slopes
- 301 – Blaine – Dranyon Families association, 15 to 45 percent slopes
- 380 – Povey – Alpon – Ketchum Families complex, 30 to 55 percent slopes
- 551 – Judkins – Cloud Peak – Farlow Families complex, 30 to 50 percent slopes
- 913 – Farlow – Parkay Families association, 30 to 70 percent slopes

The soils described in the Soil Survey of the Caribou National Forest, Idaho, 1990 (USFS 1990) were originally classified using an older version of Keys to Soil Taxonomy. In this analysis their classification was updated using the most recent Keys to Soil Taxonomy (Soil Survey Staff 2010). The descriptions of these soil map units are provided below.

081 - Red Spur - Harkness Families Association

The Red Spur - Harkness Families association is made up of soils from the Red Spur and Harkness Families which are generally located on gently to moderately sloping toe slopes or fans. This map unit was located on elevations between 6,200 and 6,700 feet above mean sea level (msl) and supports dense stands of lodgepole pine and aspen trees. Neither Family in the association are hydric soils, which are soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. The Red Spur Family consists of very deep and well drained loam and cobbly clay loam soils. These soils are derived from alluvium and colluvium from sandstone limestone, shale, conglomerate, siltstone, or quartzite. Alluvium is the process where materials are transported and deposited by water and colluvium is the process where materials are transported and deposited by the force of gravity in the form of soil creep, mass wasting, and erosion. Flooding is rare on Red Spur soils but may occur from April through June after annual snow melt. Under older versions of Soil Taxonomy, Red Spur soils were classified as fine-loamy, mixed Cryic Pachic Paleborolls, but would now likely be classified as fine-loamy, mixed Pachic Palecryolls (Soil Survey Staff 2010).

The Harkness Family consists of deep and well drained silt loam and clayey soils. These soils are derived from residuum, alluvium, and colluvium from shale, sandstone, siltstone, mudstone, and limestone. Residuum refers to soil material that has formed in place by physical and chemical erosion. Flooding and ponding are not associated with the Harkness Family. Under older versions of Soil Taxonomy, Harkness Family soils were classified as fine, montmorillonitic Mollic Cryoboralfs but would now likely be classified as Fine, montmorillonitic Mollic Haplocryalfs (Soil Survey Staff 2010).

082 - Rooset – Beaverdam – Toone Families Complex

The Rooset – Beaverdam – Toone Families complex is comprised of soils from the Rooset, Beaverdam, and Toone Families which are generally located on gently to moderately sloping toeslopes and foothills of broad valleys. This map unit is located on elevations between 6,200 and 6,500 feet above msl and supports vegetation communities of big sagebrush and grass with small components of aspen trees. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Rooset Family consists of deep, well drained cobbly loam and cobbly clay loam. Rooset soils are formed from alluvium and colluvium. Under older versions of Soil Taxonomy, Rooset soils were classified as Clayey-skeletal, montmorollonitic Argic Cryoborolls but would now likely be classified as Clayey-skeletal, montmorollonitic Typic Srgicrolls (Soil Survey Staff, 2010).

The Beaverdam Family consists of deep and well drained loams and clay loams. Beaverdam soils are formed from residuum, alluvium, and colluvium from sandstone, limestone, shale, siltstone, mudstone, dolomite, tuff, and conglomerate. Under older versions of Soil Taxonomy, the Beaverdam Family soils were classified as Fine, montmorillonitic Argic Cryoborolls but would now likely be classified as Fine, montmorillonitic Typic Argicryolls (Soil Survey Staff, 2010).

The Toone Family consists of deep and well drained loam and gravelly clay. Toone soils are formed from residuum of diorite and conglomerate of sandstone and quartzite. Under older versions of Soil Taxonomy, Toone soils were classified as Clayey-skeletal, montmorollonitic Cryic Pachic Paleborolls but would now likely be classified as Clayey-skeletal, montmorollonitic Pachic Palecryolls (Soil Survey Staff, 2010).

301 - Blaine – Dranyon Families Association

The Blaine – Dranyon Families association is comprised of soils from the Blaine and Dranyon Families which are generally located on moderately steep and moderately sloping low-relief uplands. This map unit is located on elevations between 6,500 and 8,500 feet above msl and supports vegetation communities of big sagebrush and mountain shrubs. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Blaine Family consists of moderately deep and well drained gravely silt loam and cobbly clay loams. Blaine Family soils are derived from colluvium and residuum of igneous rock, conglomerate shalestone, and sandstone. Under older versions of Soil Taxonomy, Blaine Family soils were classified as Loamy-skeletal, mixed Argic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Typic Argicryolls (Soil Survey Staff, 2010).

The Dranyon Family consists of deep and well drained loams and gravelly clay loams. Dranyon Family soils are derived from colluvium of sandstone, rhyolite, and loess. Under older versions of Soil Taxonomy, Dranyon Family soils were classified as Fine-loamy, mixed Argic Pachic Cryoborolls but would now likely be classified as Fine-loamy, mixed, Pachic, Argicryolls (Soil Survey Staff, 2010).

330 - Beaverdam – Swede – Toponce Families Complex

The Beaverdam – Swede – Toponce Families complex is made up of soils from the Beaverdam, Swede, and Toponce Families which are generally located on gently to moderately sloping upland basins. This map unit was located on elevations between 6,500 and 7,500 feet above msl and supports a vegetative mosaic consisting of big sagebrush interspersed with forbs and grasses. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Beaverdam Family consists of deep and well drained loams and clay loams. Beaverdam soils are formed from residuum, alluvium, and colluvium from sandstone, limestone, shale, siltstone, mudstone, dolomite, tuff, and conglomerate. Under older versions of Soil Taxonomy, the Beaverdam Family soils were classified as Fine, montmorillonitic Argic Cryoborolls but would now likely be classified as Fine, montmorillonitic Typic Argicryolls (Soil Survey Staff 2010).

The Swede Family consists of moderately deep and well drained loam and clay loam soils. Swede soils are formed from residuum, alluvium, and colluvium from limestone, sandstone, conglomerate, chert, siltstone, quartzite, dolomite, and shale. Under older versions of Soil Taxonomy, Swede Family soils were classified as Fine-loamy, mixed Argic Cryoborolls but would now likely be classified as Fine-loamy, mixed Typic Argicryolls (Soil Survey Staff 2010).

The Toponce Family consists of moderately deep and well drained loam and clayey soils. Toponce soils are formed from residuum, alluvium, and colluvium from sandstone, shale, conglomerate, siltstone, mudstone, and limestone. Under older versions of Soil Taxonomy, the Toponce Family was classified as Fine, montmorillonitic Argic Pachic Cryoborolls but would now likely be classified as Fine, montmorillonitic Pachic Argicryolls (soil Survey Staff 2010).

380 - Povey – Alpon - Ketchum Families Complex

The Povey – Alpon - Ketchum Families complex is comprised of soils from the Povey, Alpon and Ketchum Families which are generally located on moderately steep to steep sloping scarps and dip slopes. This map unit was located on elevations between 6,500 and 7,500 feet above msl and supports a variety of vegetation complexes including aspen/mountain bush, conifer/forbs, and sagebrush/grass. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Povey Family consists of moderately deep to very deep well drained loam, gravelly loam, and cobbly loam soil. Povey soils are formed from alluvium and colluvium from slate, sale, granite, mudstone, conglomerate, limestone, sandstone, quartzite, and dolomite. Under older versions of Soil Taxonomy, Povey soils were classified as

Loamy-skeletal, mixed Pachic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Pachic Haplocryolls (Soil Survey Staff 2010).

The Alpon Family consists of very deep well drained gravelly loam and gravelly clay loam soil. Alpon soils are formed from residuum from sandstone, limestone, siltstone, and shale. Under older versions of Soil Taxonomy, the Alpon Family soils were classified as Fine-loamy, mixed Cryic Paleborolls but would now likely be classified as Fine-loamy, mixed Typic Palecryolls (Soil Survey Staff 2010).

The Ketchum Family consists of moderately deep to very deep somewhat excessively drained gravelly loam and cobbly loam soil. Ketchum soils are formed from residuum and colluvium from sandstone, dolomite, quartzite, shale, siltstone, mudstone, conglomerate, chert, slate, and limestone. Under older versions of Soil Taxonomy, Ketchum Family sols were classified as Loamy-skeletal, mixed Typic Cryochrepts but would now likely be classified as Loamy-skeletal, mixed Typic Haplochrepts (Soil Survey Staff 2010).

551 - Judkins – Cloud Peak – Farlow Families Complex

The Judkins – Cloud Peak – Farlow Families complex is comprised from soils from the Judkins, Cloud Peak, and Farlow Families which are generally located on moderately to steeply sloping dissected valley sideslopes. The map unit is located on elevations between 6,500 and 8,000 feet above msl and supports vegetation communities of conifer and aspen trees. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Judkins Family consists of moderately deep and well drained gravelly loam soils. The Judkins Family is formed from residuum, colluvium, and alluvium from shale, sandstone, granite, limestone, quartzite, chert, conglomerate, mudstone, siltstone, and dolomite. Under older versions of Soil Taxonomy, Judkins Family soils were classified as Loamy-skeletal, mixed Mollic Cryoboralfs but now would likely be classified as Loamy-skeletal, mixed Mollic Haplocryalfs (Soil Survey Staff, 2010).

The Cloud Peak Family consists of very deep and well drained gravelly and cobbly loams. The Cloud Peak Family is formed from residuum from quartzite, limestone, shale, mudstone, dolomite, and chert. Under older versions of Soil Taxonomy, Cloud Peak Family soils were classified as Loamy-skeletal, mixed Typic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Typic Haplocryborolls (Soil Survey Staff, 2010).

The Farlow Family consists of moderately deep and well drained gravelly loam. Farlow soils are derived from residuum and colluvium of limestone and calcareous sandstone. Under older versions of soil taxonomy, Farlow soils were classified as Loamy-skeletal, mixed, Typic Cryoborolls but would now likely be classified as Loamy-skeltal, mixed, Typic Haplocryolls (Soil Survey Staff, 2010).

651 - Povey – Blaine Families Association

The Povey - Blaine Families association is comprised of soils from the Povey and Blaine Families which are generally located on moderately steep to steep sloping valley sideslopes. This map unit was located at elevations between 6,700 and 8,500 feet above msl and supports primarily aspen with inclusions of Douglas fir and lodgepole pine. Flooding and ponding are not associated with the association and none of the Families in the association are hydric soils. The Povey Family was described above.

The Blaine Family consists of deep and well drained gravelly loam soils. Blaine soils formed from residuum, alluvium, and colluvium from glacial till, quartzite, limestone, dolomite, sandstone, mudstone, slate, shale, and conglomerate. Under older versions of Soil Taxonomy, Blaine Family soils were classified as Loamy-skeletal, mixed Argic Cryoborolls but would now likely be classified as Loamy-skeltal, mixed Typic Argicryolls (Soil Survey Staff 2010).

656 - Cloud Peak – Jughandle – Swede Families Complex

The Cloud Peak – Jughandle - Swede Families complex is comprised of soils from the Cloud Peak, Jughandle, and Swede Families located on moderately steep to steep valley sideslopes. This map unit was located at elevations between 6,500 and 8,500 feet above msl and primarily supports intermixed conifer-shrub communities. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Cloud Peak Family consists of very deep and well drained gravelly and cobbly loams. The Cloud Peak Family is formed from residuum from quartzite, limestone, shale, mudstone, dolomite, and chert. Under older versions of Soil Taxonomy, Cloud Peak Family soils were classified as Loamy-skeletal, mixed Typic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Typic Haplocryborolls (Soil Survey Staff 2010).

The Jughandle Family consists of deep and somewhat excessively drained loam and cobbly sandy loam soil. The Jughandle Family is formed from residuum from shale and sandstone. Under older versions of Soil Taxonomy, Jughandle Family soils were classified as Coarse-loamy, mixed Typic Chryochrepts but would now likely be classified as Coarse-loamy, mixed Typic Haplocryepts (Soil Survey Staff 2010). The Swede Family is described above.

911 - Parkay Family – Calcic Pachic Cryoborolls – Starley Family Complex

The Parkay Family - Calcic Pachic Cryoborolls - Starley Family complex is comprised of soils from the Parkay and Starley Families and soils classified as Calcic Pachic Cryoborolls; the map unit was located on moderately steep to steep escarpments. This map unit was located at elevations between 6,700 and 8,200 feet above msl and supports a dominantly sagebrush-grass community. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Parkay Family consists of very deep and well drained loam and cobbly loam soils. The Parkay Family is formed from colluvium and residuum from limestone, siltstone, sandstone, dolomite, mudstone, conglomerate, shale, slate, or quartz. Under older versions of Soil Taxonomy, Parkay Family soils were classified as Loamy-skeletal, mixed Argic Pachic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Pachic Argicryolls (Soil Survey Staff 2010).

The Starley Family consists of shallow and somewhat excessively drained gravelly loam soils. The Starley Family is formed from residuum from sandstone, siltstone, conglomerate, quartzite, and limestone. Under older versions of Soil Taxonomy, Starley Family soils were classified as Loamy-skeletal, mixed Lithic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Lithic Haplocryolls (Soil Survey Staff 2010).

The Calcic Pachic Cryoborolls are moderately deep and well drained gravely loam and cobbly loam soils. The Calcic Pachic Cryoborolls are formed from residuum and colluvium from sandstone or limestone. Calcic Pachic Cryoborolls would now likely be classified as Aclcic Pachic Argicryolls (Soil Survey Staff 2010).

912 - Calcic Cryoborolls – Starley Family – Judkins Family Complex

The Calcic Cryoborolls - Starley Family - Judkins Family complex is comprised of soils from the Starley and Judkins Families and soils classified as Calcic Cryoborolls located on moderately steep to steep dissected escarpments. This map unit was located at elevations between 6,200 and 8,700 feet above msl and supports mainly big sagebrush and grass communities with an occasional aspen or Douglas fir stand. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils.

The Judkins Family consists of moderately deep and well drained gravelly loam soils. The Judkins Family is formed from residuum, colluvium, and alluvium from shale, sandstone, granite, limestone, quartzite, chert, conglomerate, mudstone, siltstone, and dolomite. Under older versions of Soil Taxonomy, Judkins Family soils were classified as Loamy-skeletal, mixed Mollic Cryoboralfs but now would likely be classified as Loamy-skeletal, mixed Mollic Haplocryalfs (Soil Survey Staff 2010).

The Calcic Cryoborolls consist of moderately deep and well drained gravelly loam and cobbly loam. The Calcic Cryoborolls are formed from residuum from limestone, shale, and sandstone. Calcic Cryoborolls would now likely be classified as Haplic Calcicryolls (Soil Survey Staff 2010). The Starley Family is described above.

913 - Farlow – Parkay Families Association

The Farlow – Parkay Families association is comprised of soils from the Farlow and Parkay Families which are generally located on steep to very steeply sloping escarpments. The map unit is located on elevations between 6,500 and 8,500 feet above msl and supports vegetation communities of sagebrush and grass interspersed with aspen, conifer, and shrubs. Flooding and ponding are not associated with the complex and none of the Families in the complex are hydric soils. The Farlow Family consists of moderately deep and well drained gravelly loam. Farlow soils are derived from residuum and colluvium of limestone and calcareous sandstone. Under older versions of Soil Taxonomy, Farlow soils were classified as Loamy-skeletal, mixed, Typic Cryoborolls but would now likely be classified as Loamy-skeltal, mixed, Typic Haplocryolls (Soil Survey Staff, 2010).

The Parkay Family consists of moderately deep and well drained gravelly silt loam and cobbly loam. Parkay soils are derived from alluvium, colluvium, and residuum of igneous rocks. Under older versions of Soil Taxonomy, Parkay soils were classified as Loamy-skeletal, mixed, Argic Pachic Cryoborolls but would now likely be classified as Loamy-skeletal, mixed Pachic Argicryolls (Soil Survey Staff, 2010).

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Appendix F

Wildlife Species Inventory

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Wildlife Species Documented within the Project during Wildlife and Vegetation Surveys

Common Name	Scientific Name	Habitat	Abundance
Birds			
Red-Tailed Hawk	*Buteo jamaicensis*	Edges of fields and roads	High
Sandhill Crane	*Grus canadensis*	Wetlands	High
Flammulated Owl	*Otus flammeolus*	Conifer/aspen forest	Low
Bald Eagle	*Haliaeetus leucocephalus*	Lakes and rivers with mature trees	High
Northern Goshawk	*Accipiter gentilis*	Conifer/aspen forest	High
Three-Toed Woodpecker	*Picoides dorsalis*	Mature conifer forests	Low
Killdeer	*Charadrius vociferus*	Open grasslands, wetlands, and croplands	High
Mourning Dove	*Zenaida macroura*	Edge habitat where forests and open areas meet	High
Common Raven	*Corvus corax*	Open grassland forested habitats	High
Northern Flicker	*Colaptes auratus*	Woodlands, forest edges, and open fields with scattered trees	High
Ring-Necked Pheasant	*Phasianus colchicus*	Open fields, brushy hedgerows, and forest edges	Low
Turkey Vulture	*Cathartes aura*	Open areas including mixed farmland, forest, and rangeland	High
Ruffed Grouse	*Bonasa umbellus*	Aspen and conifer forest habitats	High
Great Horned Owl	*Bubo virginianus*	Forest edges and aspen stands	High
Mammals			
Snowshoe Hair	*Lepus americanus*	Immature forests with abundant understory vegetation	High
Cottontail Rabbit	*Sylvilagus sp.*	Sagebrush, grasslands, and roadsides	High
Black Bear	*Ursus americanus*	Deciduous, coniferous, and mixed forests	Moderate
Mule Deer	*Odocoileus hemionus*	Open sagebrush areas and rocky hillsides	Moderate
White-Tailed Deer	*Odocoileus virginianus*	Forested areas	High
Coyote	*Canis latrans*	All areas	High
Elk	*Cervus canadensis*	Forested and forest edge habitat	High
Moose	*Alces alces*	Forested areas with plenty of snowpack and nearby streams, lakes, and wetlands	High
Skunk	*Mephitis mephitis*	Woods, grasslands, agricultural fields, and roadsides	High
Columbian Ground Squirrel	*Urocitellus columbianus*	Open alpine meadows, dry grasslands, and brushy areas	High
Yellow Pine Chipmunk	*Tamias amoenus*	Open coniferous forest	High
Yellow-Bellied Marmot	*Marmota flaviventris*	Open high elevation habitat	
Red Fox	*Vulpes vulpes*	Road crossing in forested habitat	Low
Amphibians			
Leopard Frog	*Rana pipiens*	Lakes, ponds, slow moving streams, and marshes	High

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Appendix G

Wildlife Special Status Species

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Wildlife

Special Status Species

The following analysis does not consider the risk of collision with the transmission line in describing potential impacts, because those impacts are described in Section 3.7.4 of the environmental impact statement and would be in addition to the impacts described below for all bird species considered.

Federally Listed and Candidate Species

Canada Lynx (*Lynx canadensis*)

The Canada lynx is an ESA-listed threatened species, a BLM Type 1 special-status species, and an IDFG threatened species. Critical habitat for Canada lynx was designated in 2009, with none being designated in Caribou County. Lynx are solitary carnivores, generally occurring at low densities in boreal forest habitats. Throughout most of their range, Canada lynx densities and population dynamics are strongly tied to the distribution and abundance of snowshoe hare, their primary prey (Koehler and Brittell 1990). Kittens are born in May or June after a 60- to 74-day gestation period, and typically remain with their mothers until about 10 months of age (Koehler 1990). Females may not reproduce during food shortages, and food availability directly correlates with the survival probability of young Canada lynx. Few kittens survive when food is scarce (Koehler 1990).

On a landscape scale, suitable Canada lynx habitat includes a mosaic of early seral stages that support snowshoe hare populations and late seral stages of dense old growth forest that provide ideal denning, security, and red squirrel habitat. Connectivity between Canada lynx populations is critical. They require dispersal corridors several miles wide with only narrow gaps. Large tracts of continuous coniferous forest are the most desirable for Canada lynx travel and dispersal (Ruediger et al. 2000).

The historic range of the Canada lynx in the Greater Yellowstone Area includes Idaho, Montana, and Wyoming (Ruediger et al. 2000). Lynx have not historically been found within 2 miles of the west side of the North Alternative on C-TNF lands (IDFG 2011b). USFS has not designated any lynx analysis units within the project area; however it is within an area that has been designated as linkage habitat by USFS (2007a). Suitable foraging habitat for lynx occurs in the project area on C-TNF lands.

Surveys conducted within the project area resulted in no evidence of lynx presence. Several snowshoe hare were observed, however, and the mature and late seral stands of Douglas-fir may provide potentially suitable foraging/linkage habitat for lynx.

Vegetation clearing within the project area and long-term impacts to forested vegetation associated with access roads would affect conifer-dominated and aspen-dominated forest. Impacts to forested habitats would fragment the existing habitat, reducing its suitability for Canada lynx foraging and cover. However, roads like Henry Cutoff Road and Blackfoot River

Road, are much more significant north–south barriers to lynx travel because of traffic and human activity, and lynx are not known to use the area as a migratory corridor. Sufficient habitat would remain functional at both the local and range-wide scales to maintain the viability of the species and to maintain the forested habitats within the project corridor as linkage habitat to documented lynx habitats on other portions of C-TNF and the Bridger-Teton National Forest. Given the limited extent of potential impacts from further habitat fragmentation and the low level of documented and anticipated use of the project area, the construction and operation of either alternative would have no effect on the Canada lynx.

Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*)

The yellow-billed cuckoo is a candidate species under ESA, but is not reported as present in Caribou County. It is also a Bureau of Land Management (BLM) Type 1 special-status species and an IDFG protected non-game species. In the west, yellow-billed cuckoos prefer sites with a dense understory of willow (*Salix* spp.) combined with mature cottonwoods (*Populus* spp.), generally within approximately 328 feet of slow or standing water (Gaines and Laymon 1984). The yellow-billed cuckoo is also known to use non-riparian, dense vegetation such as wooded parks, cemeteries, farmsteads, tree islands, Great Basin shrub-steppe, and high-elevation willow thickets (DeGraff et al. 1991).

Surveys conducted in 2005 in Idaho for all areas with historic records of yellow-billed cuckoos indicate that more than half (51 percent; 40 of 78) of the historic yellow-billed cuckoo records in Idaho were from southeastern Idaho, most from the Snake River Corridor (Reynolds and Hinckley 2005). Results indicate that yellow-billed cuckoos in Idaho are mainly associated with cottonwood galleries along the Snake River in southeast Idaho.

There is a low potential for yellow-billed cuckoos to be present within the project area. There is little riparian shrub habitat and there are no cottonwood stands within the North Alternative corridor. Some small stands of willow are found within the riparian habitat adjacent to the portion of Gravel Creek within the project corridor. Other riparian habitats consist primarily of emergent vegetation, which is not suitable habitat for yellow-billed cuckoo.

There have been no documented occurrences of yellow-billed cuckoo within 2 miles of the North Alternative (IDFG 2011b) and it is not on the U.S. Fish and Wildlife Service (USFWS) Endangered Species Act (ESA) candidate species list for Caribou County. No yellow-billed cuckoos were observed during wildlife surveys conducted in 2011 within the North Alternative. For these reasons, the North Alternative would have no effect on the yellow-billed cuckoo or its habitat. Additionally, no birds were documented during surveys along the South Alternative, though the dense willow and willow-dogwood habitat along the Blackfoot River may provide some potentially suitable habitat.

Greater Sage Grouse (*Centrocercus urophasianus*)

The greater sage grouse is a candidate species for listing in Caribou County under ESA. It is listed as a USFS sensitive species and an MIS for sagebrush habitats. It is also a BLM Type 2 special-status species. IDFG lists it as a game species. Sage grouse are closely linked to sagebrush habitats during all seasons of the year. They prefer relatively tall sagebrush for nesting areas and open sites surrounded by sagebrush for lekking (Connelly et al. 2000).

Lek surveys were conducted on state and BIA lands. Most of the sagebrush-dominated habitats within the project area provide potentially suitable habitat for sage grouse lekking, nesting, brooding, and/or wintering. No sage grouse surveys were conducted on USFS land because there are no known leks and suitable habitat does not exist.

A documented sage grouse lek site is located approximately 1,500 feet west of the North Alternative, on the large piece of state-owned land east of the Blackfoot Reservoir (IDFG 2011b). Lek surveys were conducted at this lek on three occasions in 2011 and no evidence of sage grouse, feathers, droppings, or tracks were observed. The lek is approximately 30 feet wide, and is located adjacent to an off highway vehicle (OHV) track.

Construction of the North Alternative would result in short-term impacts on 14.9 acres of sagebrush habitat and approximately 53.4 acres of long-term impacts to sagebrush habitat. These long-term impacts would reduce the amount of available sagebrush habitat for greater sage grouse. However, sufficient amounts of suitable sagebrush habitat would remain functional at both the local and range-wide scales to maintain the viability of this species. Any grouse within the immediate vicinity of the North Alternative may be displaced temporarily during construction due to temporarily elevated construction noise and increased human presence. Displacement of grouse could potentially temporarily increase predation as grouse seek out alternative suitable habitat. While some individual birds may be affected at a low level, the North Alternative would not be expected to result in any measurable impact on the species.

Along the South Alternative, there is a lek site near the eastern boundary. On the west side of the South Alternative, a sage grouse was flushed on C-TNF land in 2007, during great gray owl and northern goshawk surveys. Sage grouse also use areas of South Alternative where it crosses BLM parcels. Grouse droppings were found during surveys in 2007. There is a lek location adjacent to the South Alternative very near the easternmost BLM parcel. Additional surveys will be conducted in 2013 to reassess sage grouse occurrence and presentence along the South Alternative.

Construction of the South Alternative would result in short-term impacts on 15.8 acres of sagebrush habitat and approximately 24 acres of long-term impacts to sagebrush habitat. Impacts would be of a similar nature as those described for the North Alternative.

Wolverine (*Gulo gulo*)

The wolverine is a candidate for listing in Caribou County under the ESA. It is also listed as a USFS sensitive species, a BLM Type 3 special-status species, and an IDFG protected non-game species. Wolverines inhabit high mountain forests of dense conifers, primarily in true fir (*Abies* sp.) cover types as well as subarctic-alpine tundra. Lack of human disturbance is an important component of wolverine habitat (Groves et al. 1997). They are solitary animals, with females requiring approximately 148 square miles of land for a single territory, and males requiring up to 610 square miles (Groves et al. 1997). Wolverines seasonally move between higher and lower elevation areas in search of food. Wolverines prefer subalpine rock and scree habitats with boulders and wood debris for denning (Krebs and Lewis 1999).

In southeast Idaho, spring snow cover is thought to be one of the most important characteristics for defining suitable denning habitat, especially snow cover that remains into the latter part of the denning cycle from mid-April to mid-May (Aubry et al. 2007). USFS aerial surveys conducted in 2002 reported wolverine trails in the snow in mountains east of Soda Springs (IDFG 2011b). There have also been documented historical observations of wolverines approximately 2 miles south of the North Alternative, in a drainage on C-TNF land northeast of Henry Peak (IDFG 2011b). Recently, an unconfirmed wolverine sighting was made near Enoch Valley (D. Green 2012, personal communication).

Winter tracking surveys conducted within the North Alternative did not identify any wolverine tracks or any suitable denning habitat or signs of denning activity. None of the high-elevation subalpine habitats within the North Alternative provide suitable conditions for wolverine denning. The North Alternative also does not provide significant migratory habitat, as it is situated near the northern end of the Gray's Range, and does not provide habitat connectivity to the north.

Wolverines are not known or expected to use the habitat within the North Alternative extensively, but documented sightings within the vicinity indicate that the area does provide suitable foraging habitat. Impacts to forested habitats would further fragment existing habitat, reducing its suitability for wolverine foraging. Sufficient foraging habitat would remain functional at both the local and range-wide scales to maintain the viability of the species. For this reason, impacts to the wolverine associated with the construction and operation of the North Alternative would be low.

The South Alternative has several flat rocky, steep-sloped areas adjacent to dense stands of conifers, but these areas do not meet talus criteria necessary to provide suitable denning sites. No potential denning areas were found within the South Alternative. No wolverine snow trails or tracks were found in the South Alternative during late spring raptor surveys in 2007. Additional winter tracking surveys will be completed on C-TNF lands during 2013.

Columbia Spotted Frog (*Rana luteiventris*)

The Columbia spotted frog is a candidate for listing under the ESA (although is not known to occur in Caribou County), a USFS sensitive species, a BLM Type 1 special-status species, and an IDFG protected non-game species. Columbia spotted frogs are adapted to mountainous areas near cold, slow moving streams, springs, or marshes where emergent vegetation is not extensive (USFS 2007b). Columbia spotted frogs can move a considerable distance from water after breeding and tend to frequent mixed conifer and subalpine forests, grasslands, and shrublands of sagebrush and rabbitbrush (USFS 2007b). There are no known occurrences of Columbia Spotted frogs in C-TNF and frogs were not documented during surveys conducted during wetland delineations within either alternative.

Impacts on riparian habitats as a result of the either alternative would mostly be short term and would not result in any measurable impacts to potential habitat for the Columbia spotted frog. For these reasons, the construction and operation of the project would have no effect on the Columbia spotted frog.

U.S. Forest Service Sensitive Species

Bald Eagle (*Haliaeetus leucocephalus*)

The bald eagle is listed as sensitive by USFS, as a BLM Type 2 special-status species, and as a protected non-game species by Idaho Department of Fish and Game (IDFG). They are also protected by the Bald and Golden Eagle Protection Act of 1940 (BGEPA). Bald eagles are closely associated with lakes and large rivers in open areas, forests, and mountains. They nest near open water in late-successional forest with multiple perches and nest sites and low levels of human disturbance (McGarigal 1988; Wright and Escano 1986). Nest sites are usually within 0.25 mile to 1 mile of open water, with less than 5 percent of the lakeshore or riverbank developed within 1 mile. Bald eagles need large trees, preferably snags, along rivers with good visibility, but also use trees or boulders for perching. Protected, deep ravines with large trees are often used as night roosts (Wright and Escano 1986).

Bald eagle habitat suitability within the project area is high. Suitable foraging habitat exists within the project area in open water habitats, meadows, and roadways. Suitable nesting habitat also occurs throughout the forested habitats within the project area, due to the abundance of large snags and perch trees. Bald eagles were observed on several occasions foraging within the project area.

Noise during project construction could disturb or displace nesting or roosting bald eagles temporarily, but no nests have been documented within 1 mile of the North Alternative corridor (IDFG 2011b). An active nest, with a fledgling in the nest and an adult observed foraging in the vicinity was documented on private lands north of Soda Springs, 1.5 miles southeast of the southern end of the North Alternative. This location puts it in Zone III under the Bald Eagle Management Plan for the Greater Yellowstone Area (Greater Yellowstone Bald Eagle Working Team 1983). Zone III includes all potential foraging habitat within a 2.5 mile radius of the nest and calls for all utility lines in this zone to be limited and restricted to locations where the potential for eagle collisions and electrocutions is minimal. The primary focus of this management zone is to maintain adequate foraging conditions and aid in maintaining the integrity of Zones I and II. The North Alternative does not pose an electrocution risk to bald eagles. Furthermore, the North Alternative does not bisect the nest from any prime foraging habitat or cross any prime foraging habitat. The avian collision risk model discussed in Section 3.7.4 of the EIS found the area within 2.5 miles of the bald eagle nest to have relatively low collision risk.

Bald eagle presence was also documented in the South Alternative, specifically near the Narrows. The suitability of this area for foraging may be due to the open water area and the potential for road-killed ungulates. Raptor nest surveys for the South Alternative will be completed in 2013.

Bald eagles would experience similar impacts regardless of the alternative implemented. Clearing of forested vegetation could remove potentially suitable nesting or perching trees, but would not adversely affect foraging habitat. During project construction, bald eagles would most likely avoid the immediate area, due to noise and human presence; therefore, incidental mortality would not be likely to occur. Even though some potential bald eagle habitat may be impacted through forest clearing, sufficient habitat would remain functional at both the local and range-wide scales to maintain the viability of the species. Therefore, project impacts on bald eagles would be ***low***.

Boreal Owl (*Aegolius funereus*)

The boreal owl is a USFS sensitive species and an IDFG protected non-game species. The species typically prefers high-elevation spruce/fir forests or aspen forest for foraging and nesting. Boreal owls prefer nesting habitat that consists of forests with a relatively high density of large trees, an open understory, and a multi-layered canopy (Hayward 1994). The boreal owl is a secondary cavity nester, and relies on woodpeckers to excavate snags and decaying trees, which the owls subsequently use for nesting and roosting. Habitat structural diversity is important in order to provide suitable habitat for both nesting and foraging (Hayward 1994).

This species occurs in the Caribou-Targhee National Forest (C-TNF) in several high-elevation mixed conifer breeding habitats. Surveys have documented them in Cold Spring (Bear Camp Gulch), Danish Flat, Mill Creek (Bear River Range) and Johnson Creek (Aspen Range) (USFS 2005). This species is not known to occur within either alternative. Habitat suitability is high, however, within the high-elevation conifer- and aspen-dominated forest habitats in C-TNF. These stands provide potentially suitable nesting and foraging habitat for boreal owl because typically, they are structurally diverse, mature and late seral stands with large trees, snags, and cavity trees.

Vocalization surveys conducted in April 2011 on C-TNF lands within the North Alternative corridor and vicinity did not result in any responses or observations of boreal owls. These surveys were conducted according to protocols developed in close coordination with USFS (Green 2011, personal communication).

Surveys for boreal owl presence along the South Alternative will be conducted in 2013. Owl presence or absence will be documented and if present, appropriate mitigation measures to reduce impacts will be developed.

Great Gray Owl (*Strix nebulosa*)

The great gray owl is a USFS sensitive species and an IDFG protected non-game species. The species typically inhabits mixed coniferous forests, usually bordering meadows or small open areas in the forest. Semi-open areas, where small rodents are abundant, near dense coniferous forests, for roosting and nesting, are optimum habitats for great gray owls. Broken top snags, stumps, dwarf mistletoe platforms, or old hawk and raven nests are used for nesting (Hayward 1994). Great gray owls have been documented in many areas of C-TNF, including one historic observation within approximately 2.5 miles of the North Alternative corridor (IDFG 2011b).

Vocalization surveys conducted on C-TNF lands within the North Alternative corridor and vicinity did not result in any responses or observations of great gray owls.

Great gray owls have been found in many areas of the C-TNF. Observations are particularly concentrated near the South Alternative. Early season, evening callback surveys were completed along the South Alternative within the C-TNF in 2007; however, there were no replies to the calls.

In 2006 and 2007, suitable nesting sites consisting of mature conifers with large mistletoe clumps were mapped. In addition to mistletoe clumps, a hawk nest was mapped that could potentially become a nest site as well. Additional surveys will be conducted in 2013.

Flammulated Owl (*Otus flammeolus*)

The flammulated owl is a USFS sensitive species, a BLM Type 3 special-status species, and an IDFG protected non-game species. Flammulated owls are secondary cavity nesters that primarily feed on nocturnal lepidopteron moths (Hayward 1994). They typically prefer ponderosa pine habitat, but also use Douglas-fir, aspen, and limber pine habitat. Two key habitat features that limit flammulated owl populations are availability of nest cavities and availability of foraging habitat (Linkhart and Reynolds 1997).

Flammulated owls have been documented in the Bannock Range, Bear River Range, and Smoky Canyon area (USFS 2005), but none have been documented within 2 miles of the North Alternative corridor (IDFG 2011b). Forested habitat in C-TNF associated with the North Alternative provides suitable foraging and nesting habitat for flammulated owls because the forests typically are structurally diverse, mature and late seral stands with large trees, snags, and cavity trees.

Vocalization surveys on C-TNF lands within the North Alternative corridor documented one flammulated owl response within a dense stand of Douglas-fir.

The South Alternatives and its route options possess suitable flammulated owl habitat. Owl surveys will be conducted in 2013 and presence or absence documented. If present, appropriate mitigation measures will be developed to reduce potential impacts

Vegetation clearing associated with either alternative and long-term impacts to forested vegetation associated with access roads would affect conifer-dominated forest and aspen-dominated forest.

This disturbance would represent a direct impact to potentially suitable habitat, and could also indirectly affect habitat suitability because of forest fragmentation and the potential for increased human presence. Individual owls could also be temporarily displaced during construction due to temporarily elevated construction noise and increased human presence. While some individual owls could be negatively affected, the neither alternative would likely result in any measurable impact to the species. Sufficient habitat would remain functional at both the local and range-wide scales to maintain the viability of the species. In addition, clearing vegetation outside the nesting season could further reduce overall impacts to owls. Impacts to western boreal owls, great gray owls, and flammulated owls associated with the construction and operation of the project would be low.

Northern Goshawk (*Accipiter gentilis*)

The northern goshawk is a USFS sensitive species, a Management Indicator Species (MIS) for mature and old forest habitats, and an IDFG-protected non-game species. Northern goshawks nest in mature to old forest stands with relatively large-diameter trees and high canopy closure (Hayward and Escano 1989; Siders and Kennedy 1996). They nest in a variety of forest types, including Douglas-fir, lodgepole pine, aspen, ponderosa pine, Engelmann spruce, and subalpine fir (Siders and Kennedy 1996; Squires and Ruggiero 1996; Weber 2006).

Northern goshawks have been documented as nesting in many areas of C-TNF, but no nests were documented within or adjacent to the North or South alternatives (IDFG 2011b). Mature aspen and conifer stands associated with the alternative corridors represent suitable nesting habitat for northern goshawk because the stands typically are structurally diverse, mature and late seral stands with large trees and snags.

Vocalization surveys conducted for the North Alternative in 2011 documented one northern goshawk response within a dense stand of Douglas-fir. A northern goshawk was also heard during forest inventory surveys from a location approximately 3,500 feet south of the first response, in the same mixed aspen/conifer stand. No northern goshawks or nests were observed.

Vocalization surveys of the South Alternative under taken in 2006 and 2007; however, did not yield any conclusive goshawk responses. Additional surveys will be conducted in 2013 to document goshawk presence or absence associate with the South Alternative. If goshawks are found to be present, mitigation measures will be developed to reduce potential impacts.

Vegetation clearing within the North and South alternative corridors and long-term impacts to forested vegetation associated with access roads would affect conifer-dominated forest and aspen-dominated forest. This disturbance would represent a direct impact to potentially suitable nesting habitat for northern goshawks and could also indirectly affect habitat suitability through fragmentation and the potential for increased human presence; however, because the ROW would be only 100 feet wide, goshawks are likely to continue to forage in the ROW following construction (Reynolds et al. 1992). Individual birds could also be temporarily displaced during construction due to temporarily elevated construction noise and increased human presence. While some individual birds could be negatively affected, the project would not likely result in any measurable impact to the species. Snags would be maintained at the levels prescribed in the C-TNF RFP, and tree removal within mature and late seral forest stands would be limited to the minimum extent necessary. Sufficient mature aspen and conifer forest habitat would remain functional at both the local and range-wide scales to maintain the viability of these species. Impacts to northern goshawks associated with the construction and operation of the North Alternative would be low.

Three-toed Woodpecker *(Picoides tridactylus)*

The three-toed woodpecker is a USFS sensitive species and an IDFG protected non-game species. Three-toed woodpeckers are typically found in mature stands of spruce/fir and lodgepole pine, where they forage for insects in dead or dying trees (Imbeau and Desrochers 2002). Snags are highly preferred over live trees for foraging (possibly because of the kinds or number of insect species involved) (Imbeau and Desrochers 2002). Post-fire conditions are important to this species for both feeding and nesting purposes. They are primarily associated with mature forests because of snag requirements for nesting (Imbeau and Desrochers 2002).

In C-TNF, three-toed woodpeckers have been documented in the Bear River Range, at the north end of the Soda Springs Ranger District, and in the Manning Creek area. Mature aspen and conifer stands associated with the North Alternative corridor represent potentially suitable nesting habitat for the three-toed woodpecker because the stands typically are structurally diverse, mature and late seral stands with large trees and snags. The North Alternative did not display any evidence of recent burning activity or insect outbreaks, but the mature and late seral conifer stands associated with the alternative likely have the structural complexity necessary to provide suitable nesting and foraging habitat for three-toed woodpeckers.

Vocalization surveys conducted in on C-TNF lands within the North Alternative documented one three-toed woodpecker adjacent to a trail at the base of a mature Douglas-fir stand. The bird was foraging in a live aspen tree. Several unidentified woodpeckers were documented during wildlife surveys within the North Alternative corridor; most were heard foraging in snags. There was no response to any of the vocalization calls.

Vegetation clearing within the North and South alternative corridors and long-term impacts to forested vegetation associated with access roads would affect conifer-dominated forest and aspen-dominated forest and result in similar impacts to three-toes woodpeckers, as described for northern goshawks.

Columbian Sharp-Tailed Grouse (*Tympanuchus phasianellus columbianus*)

The Columbian sharp-tailed grouse is listed as a USFS sensitive species and an MIS for grassland and open canopy sagebrush habitats. It is also a BLM Type 3 special-status species. The IDFG lists it as a game species. Columbian sharp-tailed grouse use a variety of seasonal habitats each year. These habitats are in areas of high quality shrub/meadow steppe, primarily grasslands and open-canopy sagebrush. Columbian sharp-tailed grouse need grassland and low shrub–dominated habitats for nesting and brood-rearing habitat (Moyles 1981).

Several Columbian sharp-tailed grouse leks (male breeding display areas) have been documented within the vicinity of the project area, but none have been documented within either alternative corridors (IDFG 2011b). Two sharp-tailed grouse leks have previously been documented between 2 and 3 miles west of the North Alternative corridor, along the northern and western edge of Fivemile Meadows (IDFG 2011b). Sagebrush, grassland, and mountain shrub cover types on state and BIA lands within the North Alternative corridor likely provide suitable nesting, brood-rearing, and winter habitat for Columbian sharp-tailed grouse.

No Columbian sharp-tailed grouse or any grouse leks were documented during lek surveys conducted on state and BIA lands within the North Alternative corridor. Surveys were not conducted on USFS land because it does not provide suitable habitat.

Like the greater sage grouse, discussed above, the sharp-tailed grouse uses sagebrush habitat which would be affected by the North Alternative. However, the sharp-tailed grouse is also known to occur in grasslands, mountain-shrub, aspen, and riparian dominated habitats (Marks and Marks 1987; Ulliman 1995; Apa 1998; and Giesen and Connell 1993). Construction of the North Alternative would result in short-term impacts on grassland, mountain-shrub, , and wetland habitat of which some would be riparian. The North Alternative would result in permanent impacts on mountain-shrub, grassland, aspen, and wetland habitat. These long-term impacts would reduce the amount of available habitat for the sharp-tailed grouse; however, the sharp-tailed grouse is a habitat generalist and sufficient amounts of suitable habitat would remain functional at both the local and range-wide scales to maintain the viability of this species. Any grouse within the immediate vicinity may be displaced temporarily during construction due to temporarily elevated construction noise and increased human presence. Displacement of grouse could potentially temporarily increase predation as they seek out alternative suitable habitat. While some individual birds may be affected, the North Alternative would not be expected to result in any measurable impact on the species.

Although no sharp-tailed grouse were documented along the South Alternative, it also provides suitable nesting, brood-rearing, and winter habitat. Construction of the South Alternative would result in similar though fewer impacts to habitat that could be used by the grouse. However, these habitats are wide-spread and stuffiest alternative areas are available. Therefore impacts to sharp-tailed grouse would be the same as described for the North Alternative.

Peregrine Falcon (*Falco peregrinus*)

The peregrine falcon is listed as a USFS sensitive species, a BLM Type 3 special-status species, and an IDFG threatened species. The species forages in a variety of habitats, but requires large cliffs for nesting. Peregrines most commonly nest on large cliffs less than 9,500 feet in elevation, and in areas closely associated with open water, wetlands, and riparian habitat (Cade 1982).

The nearest documented peregrine falcon nest is located approximately 1.5 miles north of the North Alternative, in the northwestern corner of the USFS-administered portion of Little Gray Ridge (IDFG 2011b). No peregrine falcons or nests were documented within a 1-mile radius of the North Alternative corridor. There are some rocky outcrops and cliffs on ridgetops and southern-aspect slopes within the vicinity of the alternative's alignment, but none within the corridor. The wetlands and riparian habitats in C-TNF within the North Alternative likely provide suitable foraging habitat for peregrine falcon.

Surveyors did not observe any peregrine falcons during wildlife surveys and raptor nest surveys and there is no suitable peregrine falcon nesting habitat within the North Alternative corridor., Impacts to these habitats would be low, and mostly short in duration. If present, peregrine falcons could be temporarily disturbed during project construction, due to temporarily elevated construction noise and increased human presence. However, there are sufficient suitable foraging habitats within the vicinity that no individual peregrine falcon would be substantially affected. Impacts to the peregrine falcon associated with the construction and operation of the North Alternative would be low.

Surveys for peregrine falcons and other raptors in the South Alternative will be conducted in spring/summer 2013. If falcons are determined to be present, measures will be developed to avoid or reduce impacts, as appropriate. However, if peregrine falcons are found to be present, impacts would likely be similar to those described for the North Alternative.

Trumpeter Swan (Cygnus buccinator)

The trumpeter swan is listed as a USFS sensitive species and a BLM Type 3 special-status species. The IDFG lists it as a game species. Trumpeter swans are the largest waterfowl in North America. Suitable breeding habitat includes lakes and ponds and adjacent marshes containing sufficient vegetation and nesting locations (Mitchell 1994). Habitat requirements for breeding include room to take off (approximately 328 feet [100 meters]), shallow, unpolluted water with sufficient emergent vegetation and invertebrates, appropriate nest sites (e.g., muskrat lodges), and areas with little human disturbance (Mitchell 1994). Appropriate winter habitat occurs in areas where water does not freeze and food is plentiful and accessible. Trumpeter swans will move from one lake or pond to another if conditions become too severe (Mitchell 1994).

Trumpeter swans are found on the Gray's Lake National Wildlife Refuge and the Blackfoot Reservoir, and the area between the two water bodies is an important flyway for trumpeter swans (Mende 2011; IDFG 2011b). On the Blackfoot Reservoir, trumpeter swans have been documented at the boat ramp in the town of Henry, approximately 400 feet west of the North Alternative, and near the mouth of Meadow Creek, approximately 2,500 feet west of the North Alternative (IDFG 2011b). Trumpeter swans have also been documented in the vicinity of Meadow Creek, in the Chubb Flat area, approximately 2.5 miles northwest of the alignment (IDFG 2011b). The portions of Goose Lake and Meadow Creek that are within the North Alternative corridor represent potentially suitable breeding habitat for trumpeter swans.

Construction of the North Alternative would result in very small amounts of temporary impacts to potential trumpeter swan breeding habitat in riparian wetlands adjacent to Meadow Creek. However, this very small amount of impact would not significantly affect the habitat suitability within the rest of Meadow Creek and the adjacent Goose Lake. Some individual trumpeter swans could be temporarily displaced during construction due to temporarily elevated construction noise and increased human presence. If these disturbances occurred during a sensitive time during the breeding period it could result in reduced reproductive success. However, while the North Alternative might impact some individual birds, it would not be expected to result in substantial impacts to the species, given the availability of high quality habitats present within the project vicinity. Impacts to the trumpeter swan associated with the construction and operation of the North Alternative would be low. The location of transmission lines could increase the collision risk for trumpeter swans as they enter and depart from the area. Marking the lines in these areas to increase line visibility would reduce this potential collision risk.

Trumpeter swan presence in the area of the South Alternative was no documented during initial surveys. Subsequent surveys will be conducted in spring/summer 2013. If swans are found to be present, measures will be developed to reduce or avoid potential impacts, as appropriate. It is likely that swans would be affected in a similar manner as described for the North Alternative.

Gray Wolf (*Canis lupus*)

The gray wolf is listed as a USFS sensitive species, a BLM Type 1 special-status species, and as a game animal by IDFG. The project area is within the range of the Northern Rocky Mountain Distinct Population Segment of gray wolves, which includes wolves in Montana, Idaho, Wyoming, the eastern one-third of Washington and Oregon, and a small port of north-central Utah. In March 2009, this entire distinct population segment (except for the Wyoming portion) was removed from ESA listing by USFWS. This delisting was temporarily overturned by court decisions in 2010, but as of May 2011, the Northern Rocky Mountain Distinct Population Segment of gray wolves has again been removed from listing under the ESA.

Gray wolves use a variety of habitats, including coniferous forests, montane meadows, and shrub-steppe. Key components of suitable habitat include a sufficient year-round prey base of ungulates and alternative prey; suitable and semi-secluded denning and rendezvous sites; and sufficient space with minimal exposure to humans. Preferred wolf prey species, including deer, elk, and moose, are all found in and adjacent to the North and South alternative corridors (USFWS 2002).

Neither alternative corridor provides significant habitat for gray wolves, but there may be some foraging and migratory habitat. Neither wolf packs nor den sites have been documented in southeast Idaho (IDFG 2011b), but sightings of wolves (usually single animals) have been documented. The project area is within dispersal distance of wolves from packs in northeast Idaho and northwest Wyoming; specifically, the packs south of Yellowstone National Park have ranges that are close to southeast Idaho and the Caribou Zone of C-TNF.

No wolves, wolf tracks, or signs of denning activity were found during surveys conducted in project area.

Vegetation impacts to forested vegetation associated with access road construction have the potential to impact suitable gray wolf foraging and migration habitat through fragmentation. However, gray wolves are not known to use the area as a migratory corridor. The project would not result in a measurable decrease in available prey species at both the local and range-wide scales to maintain the viability of the species and to allow for functional gray wolf migration. Given the limited extent of potential impacts from further habitat fragmentation and the level of anticipated use of the project area, the construction and operation of the North or South alternative would have no effect on the gray wolf.

Pygmy Rabbit (*Brachylagus idahoensis*)

The pygmy rabbit is listed as a USFS sensitive species and a BLM Type 3 special-status species. The IDFG classifies the species as a game animal. Pygmy rabbits are a sagebrush obligate species that is uniquely dependent on sagebrush, which composes up to 99 percent of its winter diet (Green and Flinders 1980). Occupied pygmy rabbit habitats typically have a high cover of shrubs, especially big sagebrush; high forb cover; and sandy soils (Heady et al. 2001). In southeast Idaho, this species occupies sites with dense shrubs, particularly big sagebrush, bitterbrush, and three-tip sagebrush (Green and Flinders 1980). It typically inhabits either big sagebrush and rabbitbrush communities with deep soil for digging burrows, or rocky habitats.

Sagebrush occurs in the North and South alternatives on state and BLM parcels, but most deep soils have been converted to agriculture. This species is documented in adjacent counties to the west, but there is very little tall, dense sagebrush habitat anywhere within the project area. Historical records of pygmy rabbit occurrences within the BLM Pocatello Field Office management area are rare, at only four. Extensive BLM surveys in Idaho in 2002 included lands managed by the Pocatello Field Office and produced two new records; both on BLM land from the Pegram Creek area in Bear Lake County, approximately 40 miles south of the proposed project corridor (Roberts 2003). These surveys did not document any pygmy rabbits within the vicinity of the project area. No occurrence observations are on record with the IDFG Idaho Conservation Data Center within 2 miles of the North or South alternative corridors (IDFG 2011b).

No evidence of pygmy rabbits or pygmy rabbit burrows was documented during vegetation and wildlife surveys conducted in sagebrush-dominated habitats within the North Alternative. These habitats likely do provide potentially suitable habitat for pygmy rabbits, but pygmy rabbits are not expected to occur within the project area.

Given the limited extent of potential impacts on potentially suitable habitat and the lack of documented or anticipated use of the project area, the construction and operation of the Project would have no effect on the pygmy rabbit.

Western Boreal Toad (*Bufo boreas boreas*)

The western boreal toad is a USFS sensitive species, a BLM Type 3 special-status species, and an IDFG protected non-game species. The western toad (*Bufo boreas*) is currently recognized as two subspecies ranging from the Rocky Mountains to the Pacific Coast and from Baja Mexico to southeast Alaska and the Yukon Territory (Maxell 2000). The toads are found in a variety of habitats, including wetlands, forests, sagebrush meadows, and floodplains. Western toads inhabit all types of aquatic habitats, ranging from sea level to 12,000 feet in elevation (Maxell 2000). The subspecies of western toad found in Idaho is the western boreal toad.

Western boreal toads are documented from several locations within approximately 1 mile of the project area (IDFG 2011b). There are two documented occurrences along Tincup Creek on C-TNF land, approximately 1/2 mile north of the Lanes Creek Substation. Wetlands and riparian habitats within the North Alternative corridor likely provide potentially suitable habitat for boreal toads.

Surveys were conducted for western boreal toads within wetlands and riparian habitats, but no boreal toads, eggs, or tadpoles were documented.

Impacts on riparian habitats as a result of the North Alternative would mostly be of short duration and would not result in any measurable impacts to potential habitat for the western boreal toad. However, the Project would result in long-term impacts to forested aquatic influence zones in C TNF, which could reduce habitat suitability for boreal toads. If any western boreal toads were present during construction, limited mortality could occur; however, this would not represent a significant threat to the species. While the North Alternative might affect some individual boreal toads, it would not be expected to result in significant impacts on the species, given the relative availability of high quality habitats present within the project vicinity. Impacts on the western boreal toad associated with the construction and operation of the Project would be low.

Western boreal toad presence in the area of the South Alternative was no documented during initial surveys. Subsequent surveys will be conducted in spring/summer 2013. If toads are found to be present, measures will be developed to reduce or avoid potential impacts, as appropriate. It is likely that toads would be affected in a similar manner as described for the North Alternative.

Other Bureau of Land Management Sensitive and State Review Species

Ferruginous Hawk (*Buteo regalis*)

The ferruginous hawk is a BLM Type 3 special-status species and an IDFG protected non-game species. Ferruginous hawks occur across southern Idaho in the vicinity of the Snake River Plain, with extensions southward toward Utah and Nevada. Breeding ferruginous hawks consume ground squirrels, black-tailed jackrabbits, pocket gophers, western meadowlarks, and snakes, depending on abundance in their territory (Fitzner et al. 1977; Schmutz 1989; Smith et al. 1981). They nest on cliffs and small trees (typically, junipers less than 30 feet tall) in dry habitats (Bechard et al. 1990). Some research indicates that ferruginous hawks that nest in junipers are more successful at fledging young (Fitzner et al. 1977). They nest at relatively low elevations relatively far from water and human disturbance in a variety of grasslands, shrublands, and juniper forest, even when these areas are interspersed with patches of wheat fields (Bechard et al. 1990; Schmutz 1989).

No ferruginous hawks were documented within the project area. The state, BLM, and BIA parcels within the project area are all close to relatively high levels of human disturbance from mining, grazing, and highway traffic disturbance, and there are few junipers present. Ferruginous hawk nests were not identified within 1 mile of the project area; however, sagebrush and grassland habitats may represent suitable foraging habitat, if ferruginous hawks nest within the project vicinity.

Since ferruginous hawks have not been documented within the project area or vicinity, and are not expected to occur frequently within the vicinity, any potential for impacts associated with the project is considered discountable. The construction and operation of the project would have no effect on the ferruginous hawk.

Loggerhead Shrike (*Lanius ludovicianus*)

The loggerhead shrike is a BLM Type 3 special-status species, and an IDFG protected non-game species. It is passerine bird that occupies sagebrush-steppe habitats in southern Idaho. Loggerhead shrikes nest in both shrubs and trees across their broad range of distribution (Woods and Cade 1996). Loggerhead shrike nests in Idaho are primarily placed in sagebrush (65 percent) or in large bitterbrush or greasewood shrubs (Woods and Cade 1996). Loggerhead shrikes forage on a broad range of insects, small birds, lizards, and rodents (Craig 1978; Morrison 1980; Groves et al. 1997).

Although sagebrush and grassland habitats within the project area contain suitable nesting and foraging habitat, loggerhead shrikes are not known to occur frequently in Caribou County (Groves et al. 1997). Loggerhead shrikes have not been documented within 2 miles of the project area (IDFG 2011b) and were not observed during wildlife surveys.

Impacts on sagebrush habitats could potentially reduce habitat suitability for ferruginous hawks and loggerhead shrikes, but there is ample suitable foraging habitat at both the local and range-wide scales to maintain the viability of these species. If any individual birds are present during project construction they could be temporarily displaced, due to temporarily elevated construction noise and increased human presence. Since loggerhead shrikes have not been documented within the project area or vicinity, and are not expected to occur frequently within the vicinity, any potential for impacts associated with the Project is considered discountable. The construction and operation of the Project would have no effect on the loggerhead shrike.

Long-Billed Curlew (*Numenius americanus*)

The long-billed curlew is an IDFG-protected non-game species that inhabits prairies and grassy meadows, often near water (Groves et al. 1997). It prefers areas with both low vertical and horizontal canopy for nesting and breeding displays (McCallum et al. 1977; Pampush and Anthony 1993). Long-billed curlews apparently prefer nest sites with low vegetation, including shortgrass prairie, grazed pastures, areas infested with cheatgrass, and fallow fields, possibly because the young can get tangled in tall-growing vegetation; however, research indicates that nest survival is significantly lower on sites with low vegetation values, such as brome and recent burns, and higher on sites with higher grass and forb cover (Clarke 2006). Long-billed curlews forage on the ground in breeding territories, although they can also probe into loose soil for insect larvae (Groves et al. 1997).

There is one previously documented long-billed curlew breeding area within approximately 1 mile of the North Alternative (IDFG 2011b). Grass-dominated habitats on state and BIA lands within the North Alternative corridor likely represent suitable nesting and foraging habitat for long-billed curlew. However, long-billed curlews typically return to known breeding locations for nesting (Redmond and Jenni 1986), and nesting sites have not been documented within the North Alternative. No long-billed curlews were observed during wildlife surveys.

The South Alternative passes between five known long-billed curlew breeding areas that are within 2 miles of the South Alternative centerline. However, no occurrences are listed within 1 mile of the alternative, including BLM parcels within the corridor.

Short-term impacts to grassland habitats would temporarily reduce habitat suitability for long-billed curlews within the North or South alternative. The project would result in only minor amounts of long-term impacts to grassland habitats, and would not significantly reduce the habitat base for long-billed curlews within the project vicinity. Impacts on the long-billed curlew associated with the construction and operation of the Project would be low.

Brewer's Sparrow (*Spizella breweri*)

The Brewer's sparrow is a BLM Type 3 special-status species and an IDFG protected non-game species that prefers to nest at mid-level in tall, living sagebrush plants (Schroeder and Sturges 1975). Brewer's sparrows select tall, dense sagebrush plants for nest sites to help conceal both the nest and the adults' activities near the nest site (Peterson and Best 1985). This species has widespread distribution across southern Idaho and could potentially occur on any land with relatively dense sagebrush cover. Brewer's sparrows were not observed during wildlife surveys for either alternative.

Short- and long-term impacts on sagebrush habitats would reduce the amount of available sagebrush habitat for the Brewer's sparrow. However, sufficient amounts of suitable sagebrush habitat would remain functional at both the local and range-wide scales to maintain the viability of these species. Any birds present within the immediate vicinity would be displaced temporarily during construction due to temporarily elevated construction noise and increased human presence. While some individual birds may be affected, the Project would not be expected to result in any measurable impact to these species. Impacts to the Brewer's sparrow associated with the construction and operation of the Project would be low.

Sage Sparrow (Amphispiza belli)

The sage sparrow is a BLM Type 3 special-status species that is a sagebrush habitat obligate. Sage sparrows typically nest in the canopy of the peripheral smaller branches of larger sagebrush plants (Reynolds 1981; Rich 1980). If large sagebrush plants are in short supply, such as after a range fire, sage sparrows nest on the ground under remnant short sagebrush (Winter and Best 1985). Sage sparrows are distributed throughout southern Idaho where relatively large patches of sagebrush habitats persist (Groves et al. 1997). Although sagebrush habitats within the project area contain suitable nesting and foraging habitat for sage sparrows, they were not documented during wildlife surveys.

Common Garter Snake (*Thamnophis sirtalis*)

The common garter snake is a BLM Type 3 special-status species. Garter snakes are found in a variety of habitats, but are most commonly associated with wetlands or moist sites, such as wet meadows, damp woodlands, streambanks, and the fringes of ponds and lakes. Although they prefer dense cattails, bulrush, and spikerush along pond margins that are near open hillsides where they can sun, feed, and find cover in rodent burrows, they are able to successfully use less optimal sites (Groves et al. 1997). This species primarily feeds on frogs, toads, salamanders, fish, and earthworms, but on rare occasions also eats slugs, leeches, small mammals, birds, and even insects (Groves et al. 1997).

Garter snakes occur throughout the Pocatello BLM Management Area in many habitats, including grasslands and wooded areas, but it prefers moist habitats (BLM 2006). BLM is concerned that this once-common species appears to be decreasing in abundance. Within the project area, wetlands and riparian habitats provide suitable habitat for garter snakes.

Previous surveys have not documented any garter snakes within 2 miles of the project area (IDFG 2011b), and none were observed during field surveys.

However, wetlands and riparian habitats within the project area (including either alternative) do provide potentially suitable habitat for garter snakes. Impacts on riparian and wetland habitats as a result of the Project would mostly be of short duration and would not result in any measurable impacts to potential habitat for the common garter snake. However, the Project would result in some long-term impacts to wetlands and riparian habitats, which would reduce the amount of potentially suitable habitat for the common garter snake. If any garter snakes were present during construction, they could be killed; however, this would not represent a significant threat to the species. While the Project might affect some individual garter snakes, it would not be expected to result in significant impacts to the species, given the relative availability of high quality habitats present within the project area. Impacts to the common garter snake associated with the construction and operation of the Project would be low.

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Appendix H

Electric Fields, Magnetic Fields, Audible Noise, and Radio Noise

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Acronyms and Abbreviations

AC	Alternating Current
ACGIH	American Conference of Governmental and Industrial Hygienists
AM	Amplitude Modulation
AN	Audible Noise
ANSI	American National Standards Institute
BPA	Bonneville Power Administration
dBA or dB(A)	decibels – A weighted
dBµV/m	decibel relative to 1 microvolt per meter
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EPA	Environmental Protection Agency
FCC	Federal Communications Commission
FM	Frequency Modulation
G	Gauss
Hz	Hertz (cycles per second)
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Committee on Non-Ionization Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
kHz	kiloHertz
kV	kiloVolt
kV/m	kiloVolts per meter
LVE	Lower Valley Energy
m	Meter
mG	milliGauss
MHz	Megahertz
RF	Radio Frequency
RN	Radio Noise
ROW	Right-of-Way
USEPA	United States Environmental Protection Agency
V/m	Volts per meter
WHO	World Health Organization
µV/m	microvolt per meter
µT	microtesla

Limitations

At the request of the Bonneville Power Administration (BPA), Exponent conducted specific modeling and evaluations of components of the electrical environment of this project. This report summarizes work performed to date and presents the findings resulting from that work. In the analysis, we have relied on transmission line design geometry, usage, specifications, and various other types of information provided by BPA. We cannot verify the correctness of this input data, and rely on the client for the data's accuracy. Although Exponent has exercised usual and customary care in the conduct of this analysis, the responsibility for the design and operation of the project remains fully with the client.

The findings presented herein are made to a reasonable degree of engineering and scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Executive Summary

The Bonneville Power Administration (BPA) has proposed the construction of a new transmission line in eastern Idaho to address reliability and stability concerns in the southern portion of Lower Valley Energy's (LVE) transmission system and to meet projected load demands in southeastern Idaho and the Jackson Hole region of Wyoming. The proposed project includes a 32-mile-long, single-circuit 115-kilovolt (kV) transmission line between the Hooper Springs Substation and the Lanes Creek Substation.

This report provides calculations of the electric and magnetic fields (EMF) as well as the audible noise (AN) and radio noise (RN) associated with the proposed 115-kV transmission line between Hooper Springs Substation and Lane Creek Substation in Caribou County, Idaho. The calculated values of these parameters are compared to national and international standards and guidelines to assess project-related changes to EMF, AN, and RN levels

Two types of structures are proposed to support the transmission line on different portions of the route: a steel monopole covering the first approximately 10.8 miles of the line and an H-frame wood structure on the remaining approximately 21.2 miles of the line. The calculated levels of EMF, AN, and RN are quite low at the edge of the right-of-way (ROW) compared to national and international standards and guidelines (ICES, 2002; ICNIRP, 2010), and there is only one residence within 300 feet of the edge of the ROW.

Along the section of the route where H-frame structures are proposed, the highest calculated electric field is 1.50 kilovolts per meter (kV/m) under the line and drops to 0.43 kV/m at the edge of the ROW. The highest calculated magnetic-field on the ROW in this section under the line at average loading is 113.5 milligauss (mG) and at peak loading is 231.8 mG. At the edge of the ROW these magnetic field levels are calculated to decrease to 22.7 mG under average loading and to 46.3 mG under peak loading, respectively.

On the section of the proposed route where the steel monopole structures are proposed, the highest calculated electric field is 1.54 kV/m under the line and drops to 0.31 kV/m or lower at the edge of the ROW. The highest calculated magnetic-field value at average line loading in

this section is 75.3 mG and at peak loading is 153.8 mG. These magnetic-field levels are calculated to decrease at the edge of the ROW to below 20.2 mG at average loading and to 41.3 mG or lower at peak loading, respectively.

Short-term responses to the electric and magnetic fields of the proposed transmission line related to nuisance shocks from induced currents and voltages may be possible. These responses are well understood and are likely to be rare due to the low levels of electric fields from the proposed line. If such a problem is noted and action is necessary, these effects can be effectively mitigated.

The highest levels of corona-generated AN and RN will occur in foul weather and are calculated to be similar for both the H-frame and steel monopole sections of the proposed route. The highest calculated AN on the route is 31 decibels on the A-weighted scale (dBA) or less and occurs under the line. At the edge of the ROW, the highest calculated level of AN is 26 dBA. At a distance of 100 feet from the outermost conductor, the highest calculated level of RN is 33 dB above 1 microvolt per meter (dBμV/m). These calculated AN and RN levels are far below the Environmental Protection Agency's (EPA) and Institute of Electrical and Electronics Engineers' (IEEE) guidelines, respectively (USEPA, 1974; IEEE, 1971). Under fair weather conditions the levels of both AN and RN would be much lower than for foul weather conditions discussed above.

1. Introduction

The Bonneville Power Administration (BPA) has proposed the construction of a new transmission line in eastern Idaho to address reliability and stability concerns in the southern portion of Lower Valley Energy's (LVE) transmission system and to meet projected load demands in southeastern Idaho and the Jackson Hole region of Wyoming. The proposed project includes a 32-mile-long, single-circuit 115-kilovolt (kV) transmission line between the Hooper Springs Substation and the Lanes Creek Substation.

The proposed route of the 115-kV transmission line begins at the Hooper Springs Substation, runs northeast for about 1 mile, north for another 5 miles, then north-northeast for an additional 10 miles to a point along the eastern side of the Blackfoot Reservoir near Henry, Idaho. From Henry, the line continues in a northeasterly direction for about 8 miles to a point 1 mile west of Wayan, Idaho. From Wayan, the line continues east for about another 8 miles to the LVE's Lane Creek Substation.

An alternative route for the 115-kV transmission line called the Long Valley Road option is also under consideration. This alternative route generally parallels Long Valley Road, but deviates from the proposed route at transmission line mile 11 and rejoins the proposed route at transmission line mile 17 (approximately 6.8 miles). This route would increase the length of the transmission line by approximately 0.6 miles and traverse agricultural and grazing lands.

The proposed 115-kV transmission line would be built on two different support structures over separate portions of the route. A system diagram describing these separate portions of the route is shown in Figure 1 (Appendix A).

The two different support structures are either a single steel monopole structure or an H-frame wood pole structure. Steel monopoles are proposed in certain agricultural areas to minimize impacts to crop cultivation activities, since they have a smaller footprint than H-frame structures.

- **Steel Monopoles** would be used in the first portion of the route[1] (approximately 10.8 miles). The steel monopoles would be between 40 and 48 inches in diameter at the base and range from 70 to 105 feet tall with an average height of 100 feet.
- **H-frame** wood structures would be used in the second portion of the transmission line route (approximately 21.2 miles). Each leg of the wood H-frame structures would be approximately 20 inches in diameter at the base and range from 55 to 105 feet tall with an average height of 70 feet.

Typical steel monopole and H-frame structures are shown in Figure 2 (Appendix A). Both configurations would be strung with ACSR/TW 795 kcmil (0.951” diameter) Toutle conductors and 3/8” EHS shield wire and have a minimum midspan conductor height of 24.5 feet. A summary of both transmission line configurations is shown in Table 1 (Appendix B).

[1] The Long Valley Road Option would also be built on steel monopole structures.

2. Scientific Background

2.1 Electric and Magnetic Fields

Electric and magnetic fields (EMF) are produced by any source that generates, transmits, or uses electricity. Electricity travels as current from distant generating sources on high-voltage transmission lines, to substations, then on to local distribution lines, and finally to our homes and workplaces for consumption. All things connected to our electrical system—power lines; wiring in our homes, businesses, and schools; and all electric appliances and machines—are a source of EMF. In North America, the vast majority of electricity is transmitted as alternating current (AC) at a frequency of 60 cycles per second measured in Hertz (Hz), i.e., 60 Hz. The EMF from these AC sources is commonly referred to as power-frequency or extremely low frequency (ELF) EMF.

Electric fields and magnetic fields are properties of the space near all electrical sources. Electric fields exert a force on electrically charged objects while magnetic fields exert a force on moving electrical charges. Although commonly referred to together as EMF, they each have different properties.

2.1.1 Electric Fields: Basic Concepts

Electric fields are produced by voltage applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); 1 kV/m is equal to 1,000 V/m. The electric-field level increases as the voltage increases. Electric fields are present even when an appliance is turned off if it is still connected to the power source.

Since conducting objects such as buildings, fences, and trees easily block electric fields, the major sources of exposure to electric fields indoors are appliances, equipment, and machines within homes, office, and factories. Transmission lines, distribution lines, and other power-related infrastructure are the major source of electric fields outdoors.

Transmission line electric fields emanate radially outward from the charged conductor and terminate at any other conducting object such as trees, fences, vehicles, people, or transmission line towers. Electric fields are vector quantities meaning that they have both a magnitude and direction.

2.1.2 Magnetic Fields: Basic Concepts

Magnetic fields are the result of the flow of electric currents through wires and electrical devices. The strength of a magnetic field is expressed as magnetic flux density in units called gauss (G), or in mG, where 1 G = 1,000 mG.[2] In general, the strength of a magnetic field increases as the current increases, but at any point also depends on characteristics of the source, including the arrangement of and separation of the conductors. Unlike electric fields, magnetic fields are not easily blocked by conducting objects. In addition, a time-varying magnetic field (such as is used in power transmission systems) induces an electric field and currents in nearby conducting objects. Like electric fields, magnetic fields are vector quantities described by both their magnitude and direction.

The intensity of both electric fields and magnetic fields diminishes with increasing distance from the source. In the case of transmission lines, electric and magnetic fields generally decrease with distance from the conductors in proportion to the square of the distance. Since line voltage is quite stable and does not change very much over time, electric-field levels are also stable. Magnetic-field levels, however, can vary depending on load conditions (i.e., the currents flowing in a conductor).

2.2 Corona

The presence of electrical charge on the surface of any conducting surface at a voltage potential produces an electric field. When the electric field at a localized portion of the conductor surface, such as at an irregularity, exceeds the breakdown field of air a tiny amount of energy is released in the form of conductor vibration, light, AN, and RN in a process known as corona.

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[2] Scientists also refer to magnetic flux density at these levels in units of microtesla (μT). Magnetic flux density in milligauss (mG) units can be converted to μT by dividing by 10, i.e., 1 mG = 0.1 μT.

Corona is more often considered on conductors held at a voltage of 345 kV or higher, but may also be present under certain conditions for conductors held at lower voltages.

2.2.1 Corona: Basic concepts

The presence and prevalence of corona are affected by a number of factors such as line voltage, conductor size, conductor material, conductor geometry, and the presence of an irregularity on the surface of the conductor such as a nick or foreign particle. In addition, environmental factors such as air pressure (altitude), presence of water vapor (humidity and precipitation), and presence of incident photoionization also affect corona. Corona can occur in different forms, which depend on the magnitude and polarity of the applied voltage. For instance, negative corona (when the polarity of the conductor during a voltage cycle is negative) includes Trichel pulses, pulseless glow and negative streamers while positive corona (when the polarity of the conductor during a voltage cycle is positive) includes onset pulses, Hermstein's glow, and positive streamers each of which has different characteristics.[3] For AC transmission lines such as those considered here both positive and negative corona may be present.

2.2.2 Corona properties

Transmission lines are designed to be free of corona under ideal conditions because the smooth conductor surface will not result in localized electric-field gradients sufficient to lead to the breakdown of air and thus corona. Consequently, corona from AC transmission lines is less frequent and severe during fair-weather conditions than when the conductor surface is covered in water droplets (i.e., during foul weather precipitation). Even in fair weather, however, there are a variety of factors that can contribute to the generation of corona. For instance, nicks and cuts or other imperfections of a conductor surface results in corona. These imperfections are often removed naturally over time due to corona itself since the ionization resulting from corona at these imperfections results in ion bombardment and heating at the site, which tends to dull the jagged edges responsible for the corona in the first place. A more common cause of corona under typical fair-weather conditions is the presence of airborne substances such as dust, leaf

[3] For a more in-depth discussion the reader is referred to Corona Phenomena on AC Transmission Lines (Comber et al., 1982).

particles, bird droppings, insects, spider webs, and the oil coating of a new transmission line conductor. In a similar fashion to the removal of conductor imperfections, the corona itself serves to reduce or remove these contaminants. The corona occurrence rate will therefore decrease over time and fair-weather corona will be rare after roughly 1 year of conductor "weathering" (Comber et al., 1982).

As mentioned above, AC transmission line corona is typically a foul-weather phenomenon because the rain drops (or other forms of precipitation) themselves form the protrusions which result in high electric-field gradients and thus corona. The difference in corona rate between fair weather and foul weather is marked enough that corona-related effects such as AN and RN are typically 10 times more intense during foul weather conditions as discussed in more detail below.

2.3 Audible noise

AN is a direct result of corona on the AC transmission line as discussed above. The frequency spectrum of AN for an AC transmission line is primarily broad-band with some discrete pure tones at multiples of the power frequency. AN is thus typically characterized as a hissing, crackling sound that may be accompanied by a 120-Hz hum.

2.3.1 Audible noise: Basic concepts

The sound level from AN is a measure of the pressure of a sound wave which characterizes the 'loudness' or 'volume' of a particular sound. AN is measured in decibels (dB) referenced to 20 micropascals, which is approximately the pressure threshold of human hearing at 1 kilohertz (kHz). The range of audible frequencies for the human ear is approximately 20 Hz to 20 kHz with a significant difference in hearing sensitivity as a function of frequency and a peak in the sensitivity at about 1-4 kHz. This change in sensitivity of the human ear with frequency is reflected in measurements by weighting the contribution of sound at different frequencies so that sound at frequencies where the ear is less sensitive (20 Hz or 20 kHz) is given much less weight than at frequencies near 1-4 kHz, where the ear is most sensitive. The weighting of sound over the frequency spectrum to account for the sensitivity of the human ear is called the A-weighted sound level (ANSI S1.4, 1971).

When the A-weighting scale is applied to a sound-pressure measurement, the level is often reported as dBA or dB(A), referenced on a logarithmic scale to the audible pressure threshold of 20 micropascals. The logarithmic scale is important in order to express the ability to hear very quiet sounds as well as very loud sounds. For example the threshold of pain is approximately 128 dBA which represents a sound pressure level (i.e., magnitude of a sound wave) which is more than 2.5 million times higher than the hearing threshold (0 dB). The sound level of typical human speech is approximately 60 dBA, and background levels of noise in rural and urban environments are about 30 to 40 dBA. Specific identifiable noises such as birdcalls, neighborhood activity, and traffic can produce AN levels of 50 to 75 dBA Table 2 (Appendix B) lists the sound intensities of common acoustic sources.

2.4 Radio noise

Overhead transmission lines can generate RN in the bands used for the reception of radio signals. Two potential mechanisms for RN are gap discharges and corona. Corona activity, described above as a source of AN, also induces impulsive currents along a transmission line. These induced currents result in broad-band radiofrequency (RF) “noise” fields that can affect RF signal reception.

2.4.1 Radio noise: Basic concepts

Gap discharges are an intermittent phenomenon that are more common in distribution lines and low-voltage transmission lines. Electrical discharges on these lines can occur where small gaps develop between metallic line hardware, such as insulators, clamps, or brackets. Discharge across these gaps can cause incidental interference to radio communication services, in which event the sources of gap-type interference can be located and repaired. Gap discharges occur less frequently on high-voltage transmission lines, and the proposed line would be constructed with modern hardware that is designed to eliminate gap-type interference.

As in the case with AN, the magnitude of the RN is an important factor in determining the potential for interference. In many cases, however, the characteristics of the RF signal are just as important. In particular, the frequency of the RF signal is of primary importance because the magnitude of RN from a transmission line decreases rapidly with increasing frequency. For instance, the power level of typical corona-generated RN at a distance of 50 feet from the outermost phase conductor and at a frequency of 1 megahertz (MHz) is approximately 50 times higher than at a frequency of 10 MHz and more than 200 times higher than at a frequency of 100 MHz (Comber and Nigbor, 1982).

Therefore, while RN from a transmission line may exist at any frequency between 1 MHz and 1,000 MHz, it more strongly affects devices operating at lower frequencies. For example, RN can produce interference with an amplitude-modulated (AM) signal such as a commercial AM radio audio signal (520-1,720 kHz), but frequency modulated (FM) radio stations (approximately 88-108 MHz) are generally not affected by RN from a transmission line because their frequency of operation is much higher than the frequencies where transmission line corona produces its greatest levels of RN and their mode of operation involves frequency modulation instead of amplitude modulation. In the past, RN was also a concern for the video portion of analog television signals, since it also uses amplitude modulation; however, this is no longer a concern in the United States because commercial broadcast television stations have switched to digital broadcasting and no longer transmit older analog amplitude-modulated video signals.

3. Calculation Methods

3.1 Transmission line electric fields

The most important parameters for determining the electric fields associated with a transmission line are the voltage of the conductors, their height above ground, and the number of conductors used for each phase. The current or load carried on the transmission line does not directly affect the electric field.[4]

Electric-field levels based upon the configurations detailed above were calculated using computer algorithms previously developed by the BPA (BPA 1991) and are based upon fundamental laws of physics. These algorithms have been shown to accurately predict EMF levels measured near power lines. The electric fields were calculated as the resultant of x, y, and z field vectors at a height of 1 meter (m) (3.28 feet) above ground along a transect perpendicular to midspan, in accordance with IEEE Std. C95.3.1-2010 and are expressed in units of kV/m.

3.2 Calculated electric fields

A simplifying assumption in making these calculations is that the conductors of the transmission line are parallel to a flat earth and are infinite in extent. Such an assumption does not reduce the accuracy of the model, but instead ascribes the calculated field levels to a particular location corresponding to a specific conductor height above ground. Choosing this conductor height is therefore an important parameter in the modeling process. Electric-field calculations are performed at the point where the conductors are closest to the ground (a midspan ground clearance of 24.5 feet). A conservative overvoltage condition of 10% was used for calculating the electric fields, AN, and RN from the 115-kV transmission line. Lower levels would result if a lower overvoltage condition, such as 5%, were to be used. These modeling assumptions are made to ensure that the calculated values represent the maximum expected electric field at 1 m (3.28 feet) above ground.

[4] In contrast, the current or load of the transmission line is a parameter of critical importance for determining the magnetic fields associated with the transmission line as described below.

The results of the electric field calculations are shown in Table 3 (Appendix B) including the maximum electric field on the ROW, as well as at both ROW edges and at 100 feet beyond the edge of the ROW. Along the portion of the route where H-frame structures are used, the highest calculated electric-field level is 1.50 kV/m and drops to 0.43 kV/m at the edge of the ROW. Along the portion of the route where the steel monopole structures are used, the highest calculated electric-field level is 1.54 kV/m which decreases to 0.31 kV/m or less at the edge of the ROW. Figure 3 and Figure 4 (Appendix A) show the electric-field profile as a function of distance from the center of the transmission line ROW.

In practice, the electric-field level at 1 m (3.28 feet) above ground along the entire route will be similar to or lower than the calculated levels. For instance, in a gully under the conductors or at points closer to the structures the height of the conductors above ground increases thereby decreasing the electric field at ground level.

3.3 Transmission line magnetic fields

Like electric fields, magnetic fields depend on the conductor height above ground, however, the most important parameter for determining the magnetic-field level is the transmission line loading (or current), and the relative location of each conductor phase, i.e., the phasing of the circuit. In addition, unlike electric fields, magnetic fields are not blocked by most ordinary materials such as fences or walls.

As with electric fields, the magnetic-field levels were calculated using computer algorithms previously developed by the BPA (BPA 1991). The magnetic fields were calculated as the resultant of x, y, and z field vectors at a height of 1 m (3.28 feet) above ground along a transect perpendicular to midspan, in accordance with IEEE Std. C95.3.1-2010 and are expressed as magnetic flux density in units of milligauss (mG).

3.4 Calculated magnetic fields

Similar to the electric-field calculations, these magnetic-field calculations are made assuming that the conductors of the transmission line are parallel to a flat earth, infinite in extent, and are located at a minimum midspan ground clearance height. These modeling assumptions are made to ensure that the calculated values represent the maximum expected magnetic field at 1 m (3.28 feet) above ground for a given load.

The results of the magnetic field analysis for average loading are shown in Table 4 (Appendix B) including the maximum magnetic-field level on the ROW as well as at both ROW edges and at 100 feet beyond the edge of the ROW. Along the portion of the route where H-frame structures are used the highest calculated magnetic-field level is 113.5 mG and drops to 22.7 mG at the edge of the ROW. Along the portion of the route where the steel monopole structures are used, the highest calculated magnetic-field level is 75.3 mG which decreases to 20.2 mG or lower at the edge of the ROW. Figure 5 and Figure 6 (Appendix A) show the magnetic-field profile as a function of distance from the center of the transmission line ROW.

It is also important to remember that because electric current is the primary factor that determines the magnitude of magnetic fields around transmission-line conductors, those measurements or calculations of the magnetic-field levels present only a “snapshot” of the magnetic field at only one moment in time determined by the prevailing load conditions. On a given day, throughout a week, or over the course of months and years, the magnetic field can change depending upon the patterns of power demand on the bulk transmission system. For this reason, magnetic fields are calculated both for average load and peak load. Average load is likely to result in the best estimate of the magnetic-field level on any randomly-selected day of the year, and while the peak load (as shown in Table 4, Appendix B) is likely to occur only for a few hours or a few days each year, it represents the maximum expected magnetic field associated with the normal operation of the transmission line.

3.5 Transmission line audible noise

Corona-generated AN varies in time due to variations in the environment as described above. In order to account for fluctuating sound levels, statistical descriptors are used to describe environmental noise. Exceedance levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the L_5 level refers to the sound level that is exceeded only 5% of the time. L_{50} refers to the sound level exceeded 50% of the time.

Sound-level measurements in this report are expressed in the L_{50} level (median level) in foul-weather conditions.

As discussed above in reference to corona, the altitude of a particular line is a very important parameter in determining the average level of AN. The average altitude along the proposed route is approximately 6,450 feet above sea-level with a peak height of approximately 7,450 feet. The decreased density of air at this altitude results in increased AN levels compared to an identical configuration constructed at sea-level.

3.6 Calculated audible noise

The calculation of AN levels is carried out assuming foul weather conditions, an altitude of 7,450 feet, a 10% overvoltage condition on the transmission lines, and a measurement height of 5 feet above ground. The combination of these assumptions in the calculation describes an upper-bound for the AN levels that may be encountered along the proposed route. This upper-bound would occur, for example, only at the midspan location between a few towers at the highest portion of the proposed route during foul weather. The AN in all other locations (e.g., away from midspan and at lower altitudes) and in fair weather are expected to be far lower than the calculated values reported below.

The results of the AN analysis shown in

Table 5 (Appendix B) include the maximum AN on the ROW as well as at both ROW edges and at 100 feet beyond the edge of the ROW. Along the portion of the route where H-frame structures are used, the highest median (L_{50}) calculated level of AN on the ROW is 31 dBA near the centerline of the ROW and decreases to 26 dBA at the edge of the ROW. Along the portion of the route where the steel monopole structures are used, the highest calculated level of AN is 28 dBA near the centerline of the ROW and decreases to 24 dBA or lower at the edge of the ROW. Figure 7 and Figure 8 (Appendix A) show the AN profile as a function of distance from the center of the transmission line ROW.

The above calculations are made assuming foul-weather conditions, however, based upon hourly precipitation records from Soda Springs, Idaho during 2008 to 2010 (NOAA, 2012), foul weather occurred less than 1% of the time in area of the proposed route. During fair weather conditions the AN values are estimated to be 25 dBA lower and will be imperceptible under most conditions.[5]

3.7 Transmission line radio noise

RN levels in this report are expressed as dB above 1 microvolt per meter (dBµV/m) to describe the electric-field intensity incident upon a reference antenna at 500 kHz as recommended by the IEEE (IEEE, 1971). Weather has a large influence on corona-generated RN, as it does for AN. As with AN, corona-generated RN also varies in time. In order to account for fluctuating noise levels, statistical descriptors are used to describe RN. RN levels in this report are expressed as 50% exceedance values (median or L_{50} values) during foul weather conditions. RN, like AN, is also more pronounced at higher altitudes.

The RN levels from a transmission line may also be affected by the configuration of the transmission line. At a frequency of 1 MHz for instance, the line geometry plays an important role in the magnitude of RN out to a distance of approximately 50 feet (15 m). Between approximately 130 and 200 feet (40-60 m), the rate at which the RN decreases with distance is affected by the height of the particular transmission line conductor closest to that point, and beyond approximately 200 feet (60 m) the rate of RN decay is relatively independent of transmission line geometry (Comber and Nigbor, 1982).

RN also theoretically can be a source of interference for other communications systems and other sensitive receivers, but RN levels are typically low and effects are typically rare.

3.8 Calculated radio noise

The calculation of RN levels is carried out under the same assumptions as AN; assuming foul weather conditions, an altitude of 7,450 feet, and a 10% overvoltage condition on the transmission lines. In contrast to AN calculations, however, RN calculations are carried out at a height of 1 m (3.28 feet) above ground. The combination of these assumptions in the

5 At locations where the foul-weather AN level is below 25 dBA, the fair-weather AN level will be below the threshold of human hearing.

calculation describes an upper-bound for the RN levels which may be encountered along the proposed route. The RN in all other locations (e.g., away from midspan and at lower altitudes) are expected to be similar or lower than the calculated values.

Calculations of RN as a function of distance from the centerline of the transmission line for the H-frame and steel monopole configurations are shown in Figure 9 and Figure 10 (Appendix A), respectively. In addition, the results of the RN analysis at selected locations are shown in Table 6 (Appendix B). These locations include the maximum RN level on the ROW as well as the RN level at both ROW edges and at 100 feet beyond the outermost conductor. Along the portion of the route where H-frame structures are used, the highest median (L_{50}) calculated level of RN is 61 dBµV/m which decreases to 32 dBµV/m at a distance of 100 feet from the outermost conductor. Along the portion of the route where the steel monopole structures are used, the calculated level of RN along the ROW is 33 dBµV/m at a distance of 100 feet from the outermost conductor.

The above calculations are made assuming foul-weather conditions, however, based upon hourly precipitation records from Soda Springs, Idaho during 2008-2010 (NOAA, 2012) foul weather occurred less than 1% of the time in the area of the proposed route. During fair weather conditions, the RN values are estimated to be 16-22 dBµV/m lower and will likely be imperceptible away from the line.

4. Electric and Magnetic Fields Environment

4.1 Sources and exposure

Electricity plays such an integral role in modern society that we are surrounded by EMF whether at home, at school, or at work. Exposure levels, however, are difficult to calculate. The locations where one spends time regularly influences exposure levels so that no one case can be seen as representative, and while spot exposure to high field levels can be measured accurately, this type of measurement does not take into account a person's overall average exposure over time. General exposure levels can be determined though, which allow scientists to approximate typical background EMF levels.

Figure 11 (Appendix A) illustrates ambient background levels of EMF and common exposure potentials measured in residential and occupational environments, compared to levels measured on or at the edge of typical transmission-line ROW. While EMF levels decrease with distance from the source, any home, school, or office will have an ambient background level that is not attributable to a specific source as a result of the combined effect of the numerous EMF sources.

The World Health Organization (WHO) found that AC magnetic-field exposure in the home does not vary greatly throughout the developed world. In general, the background AC magnetic-field level as estimated from the average of measurements throughout a house away from appliances is typically between 1 to 2 mG, while levels can be hundreds of mG in close proximity to appliances. Background levels of AC electric fields range from 0.01-0.02 kV/m, while appliances produce levels up to several tens of kV/m (NIEHS, 2002; WHO, 2007).

Experimental research has yet to determine an aspect of ELF EMF exposure that may be relevant to biological systems. In health research, the current metric for EMF exposure is long-term, average personal exposure, which is the average of all exposures to the varied electrical sources encountered by an individual going about his or her daily routines. As mentioned, this exposure is difficult to approximate. Exposure assessment in health-related research is a major source of uncertainty in studies of ELF EMF (WHO, 2007). There are some basic conclusions about typical exposure that have resulted from research on the characterization of exposure.

- *Personal magnetic-field exposure:*
  - The vast majority of persons in the United States have a time-weighted average (TWA) exposure to magnetic fields less than 2 mG (Zaffanella and Kalton, 1998).[6]
  - In general, personal magnetic-field exposure is greatest at work and when traveling (Zaffanella and Kalton, 1998).
- *Residential magnetic-field exposure:*
  - The highest magnetic-field levels are typically found directly next to appliances (Zaffanella, 1993). For example, Gauger (1985) reported the maximum AC magnetic field at 3 centimeters from a sampling of appliances as 3,000 mG (can opener), 2,000 mG (hair dryer), 5 mG (oven), and 0.7 mG (refrigerator).
  - The following parameters affect the distribution of personal magnetic-field exposures at home: residence type, residence size, type of water line, and proximity to overhead power lines. Persons living in small homes, apartments, homes with metallic piping, and homes close to three-phase electric power distribution and transmission lines tended to have higher at-home magnetic-field levels (Zaffanella and Kalton, 1998).
  - Residential magnetic-field levels are caused by currents from nearby transmission and distribution systems, pipes or other conductive paths, and electrical appliances (Zaffanella, 1993).

[6] TWA is the average exposure over a given specified time period (i.e., an 8-hour workday or a 24-hour day) of a person's exposure to a chemical or physical agent. The average is determined by sampling the exposure of interest throughout the time period.

- *Workplace magnetic-field exposure*
    - Some occupations (e.g., electric utility workers, sewing machine operators, telecommunication workers, etc.) have higher exposures due to work near equipment with high EMF levels.[7]
- *Power-line magnetic-field exposure*
    - The EMF levels associated with power lines vary substantially depending on their configuration, current load, and other factors. At a distance of 300 feet and during average electricity demand, however, the magnetic field levels from many lines are often similar to the background levels found in most homes (see also Figure 11, Appendix A).

4.2 Acute short-term effects

There is a greater opportunity for long-term exposure to magnetic fields since electric fields are blocked by common objects. For this reason, among others, research on long-term health effects has focused on magnetic fields rather than electric fields.

Like virtually any exposure, adverse effects can be expected from exposure to very high levels of ELF EMF. If the current density or electric field induced by a very, very strong magnetic field exceeds a certain threshold, excitation of muscles and nerves is possible. Also, strong electric fields can produce charges on the surface of the body that can lead to small shocks, i.e., micro shocks, when touching grounded objects The effects caused by strong magnetic and electric fields are acute, shock-like effects that cause no long-term damage or health consequences. Limits for the general public and workplace have been set to prevent these effects, but there are no real-life situations where these levels are exceeded on a regular basis, a fact that has been supported by a recent body of literature that investigated specialized occupations where workers are more likely to have the potential of high exposure levels, discussed below (Contessa et al., 2010; Korpinen et al., 2011a, 2011b, 2012; Ubeda et al., 2011).

The recent literature includes a number of studies of workers with the potential for high field exposures that characterize occupational exposure and evaluate compliance with standards. They include a study of spot measurements of EMF during work tasks at 110-kV switching and

[7] http://www.niehs.nih.gov/health/assets/docs_p_z/emf-02.pdf

transforming stations in Finland to evaluate compliance with ICNIRP reference levels (Korpinen et al., 2011a) and a study of occupational electric field exposure at the same 110-kV switching station that evaluated compliance with the European Union's Directive 2004/40/EC (Korpinen et al., 2012); spot measurements and personal monitoring of magnetic fields in hospital personnel in Spain (Ubeda et al., 2011); spot measurements and personal monitoring of magnetic fields in railway workers in Italy (Contessa et al., 2010); and a study of electric fields, current densities, and contact currents at a 400-kV substation in Finland (Korpinen et al., 2011b). In general, the measured magnetic fields were below the reference values of ICNIRP in these studies. Some electric-field levels exceeded reference levels within the substations (Korpinen et al., 2011a, 2011b), but the induced current density in the central nervous system did not exceed the basic restriction value.

The guidelines to protect against these acute short-term effects are discussed in the following section.

5. Standards and Guidelines

5.1 Electric and magnetic fields

There are currently no health-based standards in the United States at either the federal or state level that apply to EMF from transmission lines or other sources at power frequencies. Some states, such as New York and Florida, have enacted statutory limits on electric or magnetic field levels, or both, at transmission line ROWs (Table 7, Appendix B). The approach of both Florida and New York is one of "prudent avoidance." These limits, therefore, were designed to apply only to future transmission line facilities in order to maintain the status quo for power line infrastructure throughout the state. They are not health-based standards. Other states have enacted limits for electric fields either on the ROW or at the edge of the ROW to prevent acute effects or in some cases states have limited electric field strength at road crossings to prevent electric shock hazard from electric current induced into metal trucks or buses. Finally, Connecticut and California have established EMF policy guidelines that require no cost or low cost measures to minimize magnetic fields from transmission lines.

Two international scientific organizations, ICNIRP and the ICES, have published guidelines for limiting public exposure to ELF EMF to protect against the acute short-term effects discussed in Section 7.3 (ICES, 2002; ICNIRP, 2010). These guidelines were developed following a weight-of-evidence review of the literature, including epidemiologic and experimental evidence related to both short-term and long-term exposure. Both reviews concluded that the stimulation of nerves and the central nervous system could occur at very high exposure levels immediately upon exposure, but that the research did not suggest any long-term health effects.

To prevent such acute, shock-like effects, ICNIRP recommends screening values for magnetic fields of 2,000 mG for the general public and 4,200 mG for workers (ICNIRP, 2010). The ICES recommends a maximum permissible magnetic-field exposure of 9,040 mG for the general public (ICES, 2002). For reference, in a survey by Zaffanella and Kalton (1998), only about 1.6% of the general public experienced exposure to magnetic fields of at least 1,000 mG during a 24-hour period.

The ICNIRP screening value for exposure to 60-Hz electric fields for the general public is 4.2 kV/m and the ICES screening value is 5 kV/m. Both organizations allow higher exposures if it can be demonstrated that exposures do not produce electric fields within tissues that exceed basic restrictions on internal electric fields. Several other organizations have also published guidelines to prevent short-term effects (Table 8, Appendix B).

As can be seen by comparing the results of the current EMF analysis discussed above and summarized in Table 3 and Table 4 (Appendix B) as well as in Figure 3, Figure 4, Figure 5, and Figure 6 (Appendix A), the calculated electric and magnetic fields due to the proposed Hooper Springs transmission line are much lower than any state or international reference level.

5.2 Audible Noise

The AN from transmission lines is compared to the Environmental Protection Agency's (EPA) guideline value of 55 dBA for the annual average day-night level (L_{dn}) in outdoor areas (USEPA, 1978). In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 p.m. and 7 a.m. Table 9 (Appendix B) describes the method by which L_{dn} values are derived from L_{50} values. AN is typically a foul weather phenomenon and therefore the occurrence rate of foul weather significantly affects the day-night sound level (L_{dn}). In addition, the sensitivity to AN is affected by ambient noise conditions. Thus, the same level of AN from a transmission line is perceived differently in quiet conditions (little ambient noise) compared to typical conditions (40 dBA of ambient noise). L_{dn} is calculated from L_{50} values by taking account of the occurrence rate of foul weather and the ambient noise level.

Using an estimated 1% foul weather occurrence rate and no ambient noise (a conservative but unrealistic condition), the correction factor listed in Table 9 (Appendix B) is −12 dBA and the L_{dn} at the edge of the ROW is 14 dBA and 12 dBA for the H-frame and steel monopole portions of the route, respectively. This level is well below the EPA's guideline level of 55 dB even accounting for the 10 dBA penalty imposed during night time.

Along the proposed route there is only one residence within 300 feet of the edge of the ROW. Even during foul weather the AN from the proposed transmission lines would be below 26 dBA and would be comparable to the noise level in a typical bedroom as shown in Table 2 (Appendix B).

5.3 Radio Noise

Idaho has not enacted a limit for RN. Likewise, the Federal Communication Commission (FCC) Rules and Regulations (2008) contain no guideline regarding the RN levels near high-voltage transmission lines. Power transmission lines fall into the FCC category of "incidental radiator," which is defined as "a device that generates radio frequency energy during the course of its operation although the device is not intentionally designed to generate or emit radio frequency energy." Operation of an incidental radiator "is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical equipment, or by an incidental radiator." Section 15.1(m) of the FCC regulations defines "harmful interference" as "any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communications service operating in accordance with this Chapter."

Historically, transmission-line operators have not had difficulty in operating under the present FCC rules, since most sources of "harmful interference" from power lines in fair weather are due to gap-type discharges that can be identified and repaired (USDOE, 1980). Amplitude-moldulated radio reception at residences very near transmission lines, however, may be affected by corona-type RN in foul-weather. For this reason, the IEEE Radio Noise Design Guide (IEEE, 1971) identifies an acceptable level of average fair-weather RN of 40 dBμV/m at 100 feet (30 meters) from the outside conductor. As shown in Table 6 (Appendix B), even in foul weather the RN values 100 feet from the outer conductor in the proposed configurations are substantially below this recommended level and under fair weather conditions would be 16 to 22 dBμV/m lower than the foul-weather levels.

6. Summary

This report has assessed the electric and magnetic field levels as well as the AN and RN associated with the proposed 115-kV transmission line between the Hooper Springs Substation and Lane Creek Substation in Caribou County, Idaho. These calculations have been made using well-known techniques, which have been found to match well with measurements and are accepted within the scientific and engineering community.

There are two distinct structures proposed to support the transmission line on different portions of the route: an H-frame wood structure and a steel monopole. The Long Valley Road option, though located approximately 0.4 miles to the east of the proposed route, would also be constructed on the same steel monopole structures and resulting calculations of EMF, AN, and RN are the same. The calculated levels of EMF, AN, and RN are quite low at the edge of the ROW compared to national and international standards and guidelines (ICES, 2002; ICNIRP 2010) and there is only one residence within 300 feet.

Along the section of the route where H-frame structures are proposed, the highest calculated electric field is 1.50 kV/m under the line and drops to 0.43 kV/m at the edge of the ROW. The highest calculated magnetic field on the ROW in this section under the line at average loading is 113.5 mG and at peak loading is 231.8 mG. At the edge of the ROW these magnetic-field levels are calculated to decrease to 22.7 mG under average loading and to 46.3 mG under peak loading, respectively.

On the section of the proposed route where the steel monopole structures are proposed, the highest calculated electric field is 1.54 kV/m under the line and drops to 0.31 kV/m or lower at the edge of the ROW. The highest calculated magnetic-field value at average line loading in this section is under the line is 75.3 mG and at peak loading is 153.8 mG. These magnetic-field levels are calculated to decrease at the edge of the ROW to below 20.2 mG at average loading and to 41.3 mG or lower at peak loading, respectively.

Short-term responses to the electric and magnetic fields of the proposed transmission line related to nuisance shocks from induced currents and voltages may be possible. These responses are well understood and are likely to be rare due to the low levels of electric fields from the proposed line. If such a problem is noted and action is necessary these effects can be effectively mitigated. The highest levels of corona-generated AN and RN will occur in foul weather and are calculated to be similar for both the H-frame and steel monopole sections of the proposed route. The highest calculated AN on the route is 31 dBA or less and occurs under the line. At the edge of the ROW the highest calculated level of AN is 26 dBA. At a distance of 100 feet from the outermost conductor, the highest calculated level of RN is 33 dBµV/m. These calculated AN and RN levels are far below the EPA and IEEE guidelines, respectively (USEPA 1974; IEEE 1971). Under fair weather conditions the levels of both AN and RN would be much lower than for foul weather conditions discussed above.

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Appendix A

Figures

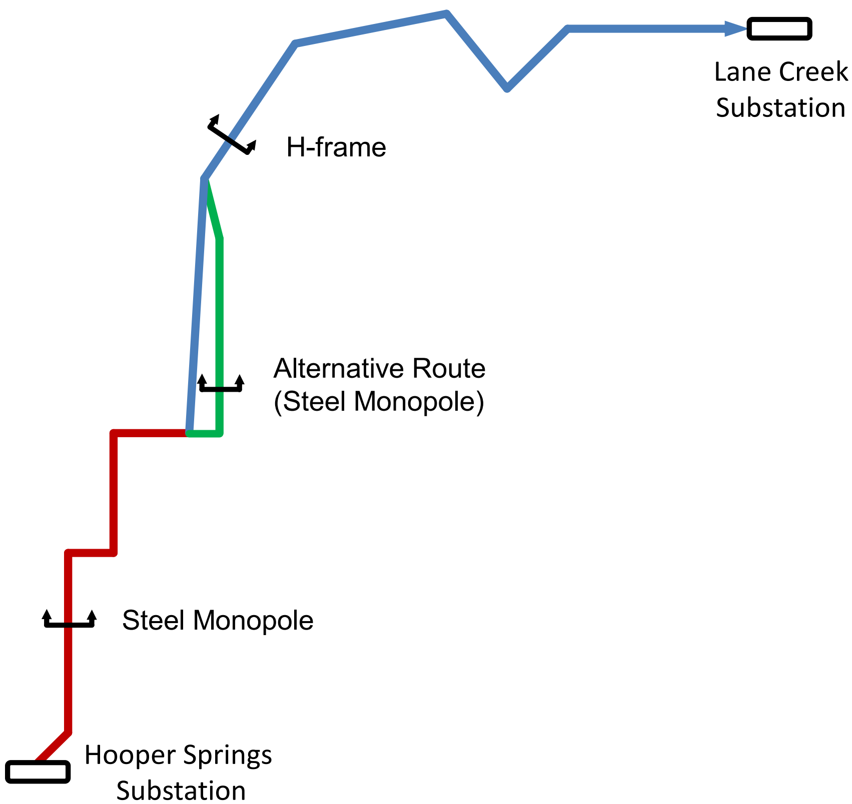

Figure 1. System diagram of proposed transmission line route

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A-1

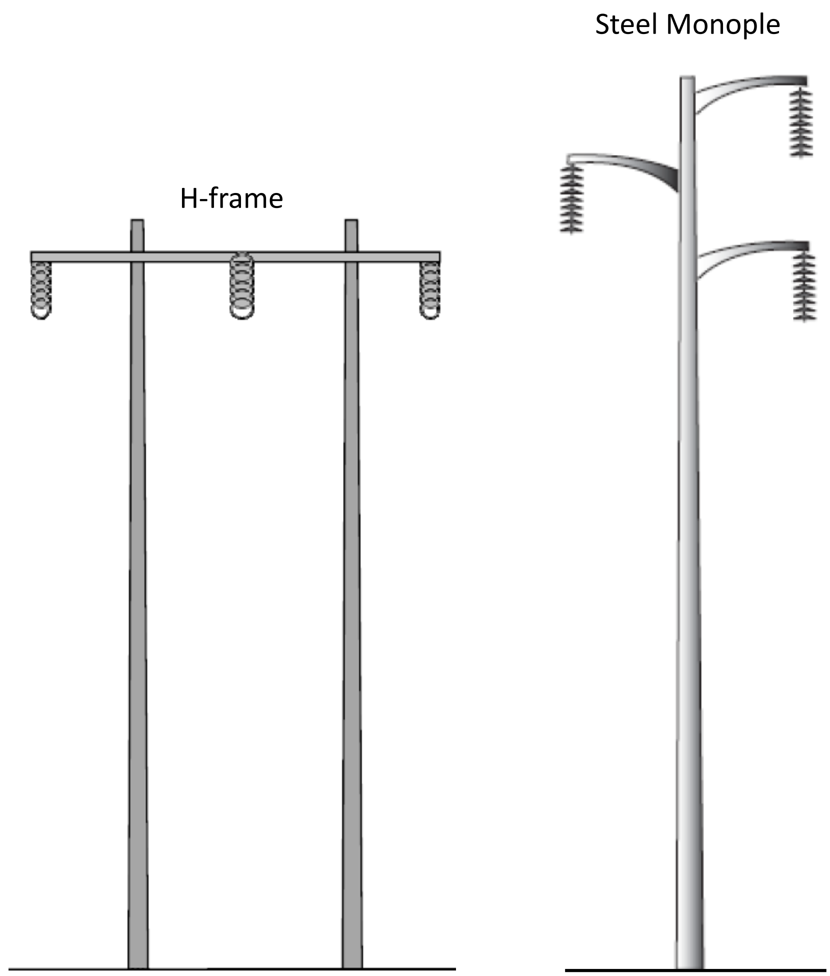

Figure 2. Transmission line structures used in the two portions of the proposed route

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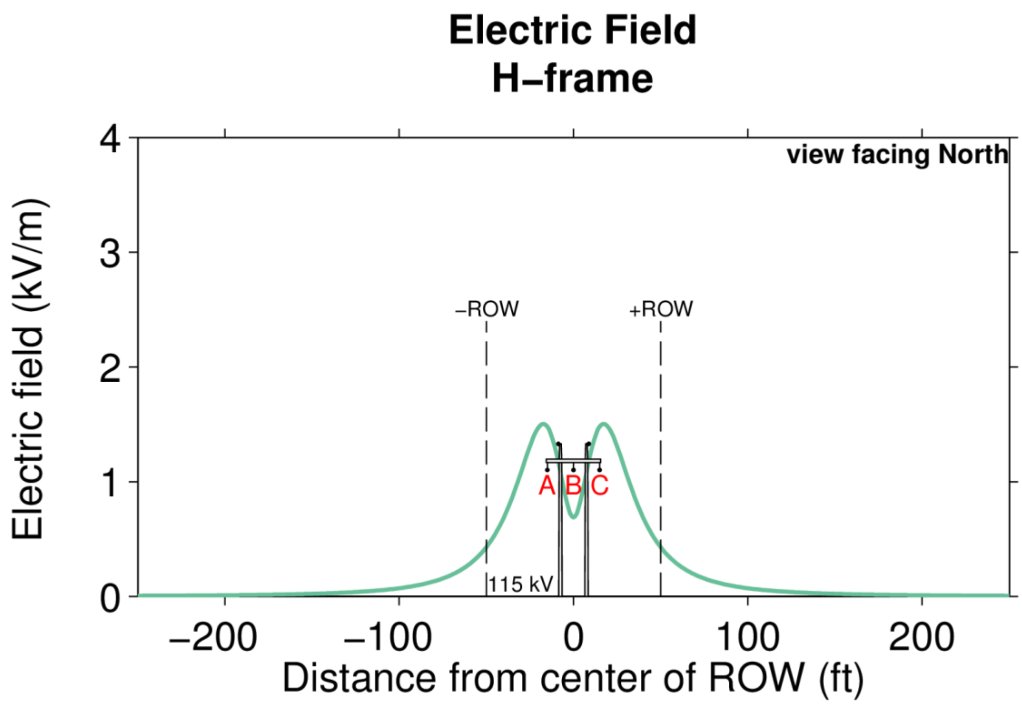

Figure 3. Calculated electric field for the H-frame tower configuration

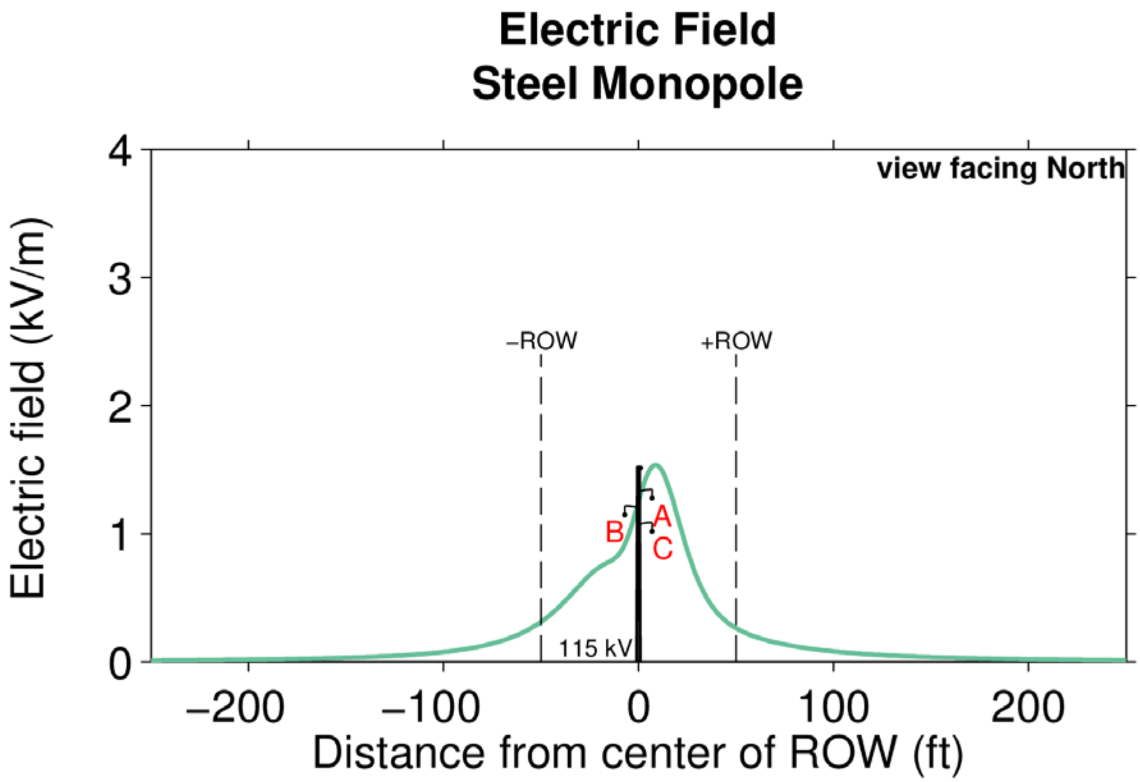

Figure 4. Calculated electric field for the steel monopole tower configuration

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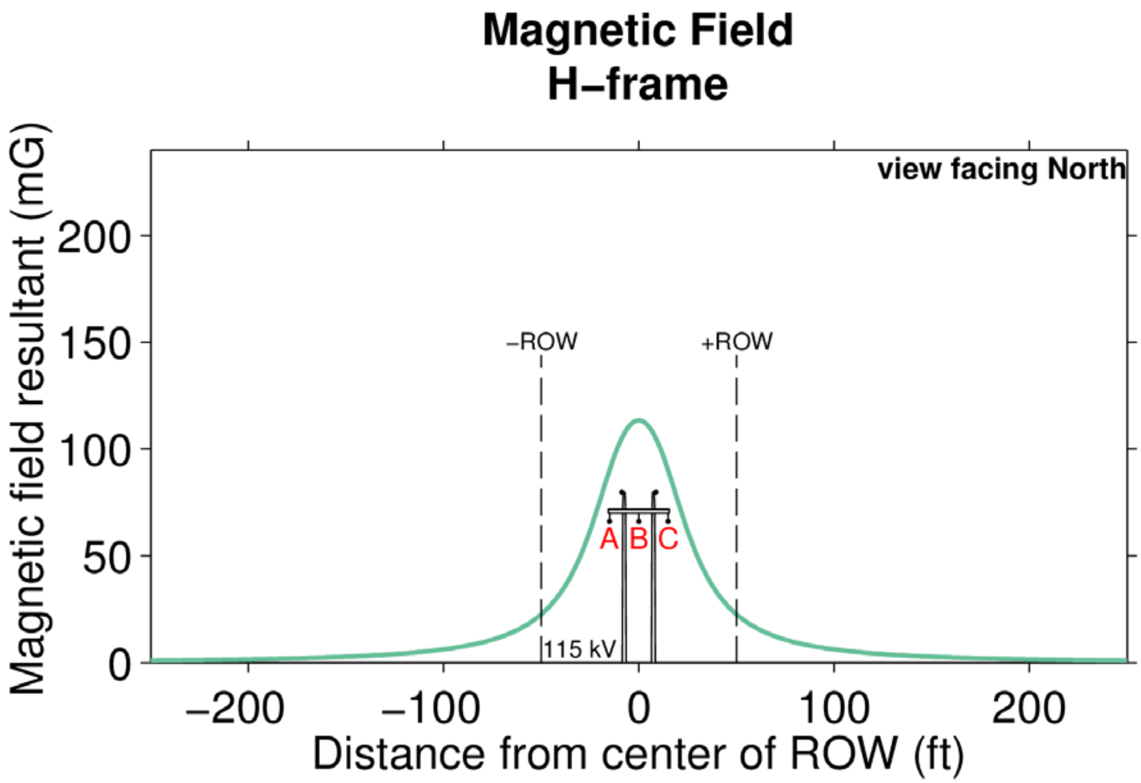

Figure 5. Calculated magnetic field for the H-frame tower configuration at average line load loading

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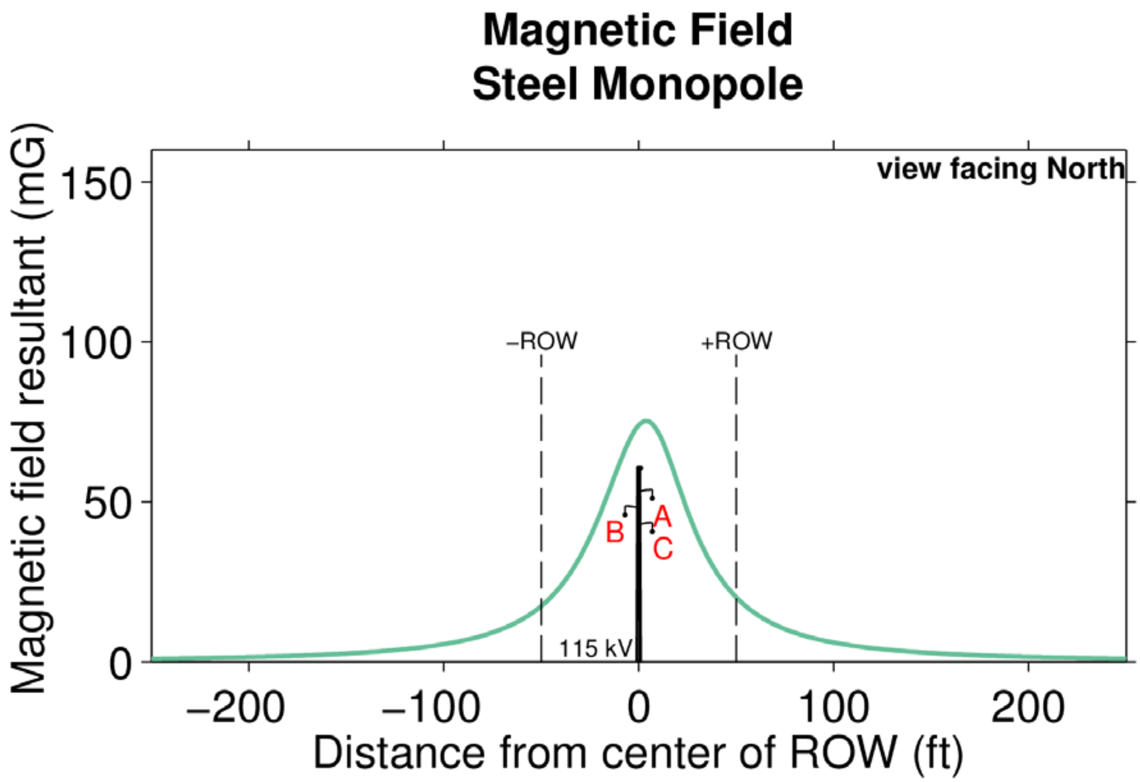

Figure 6. Calculated magnetic field for the steel monopole tower configuration at average line load loading

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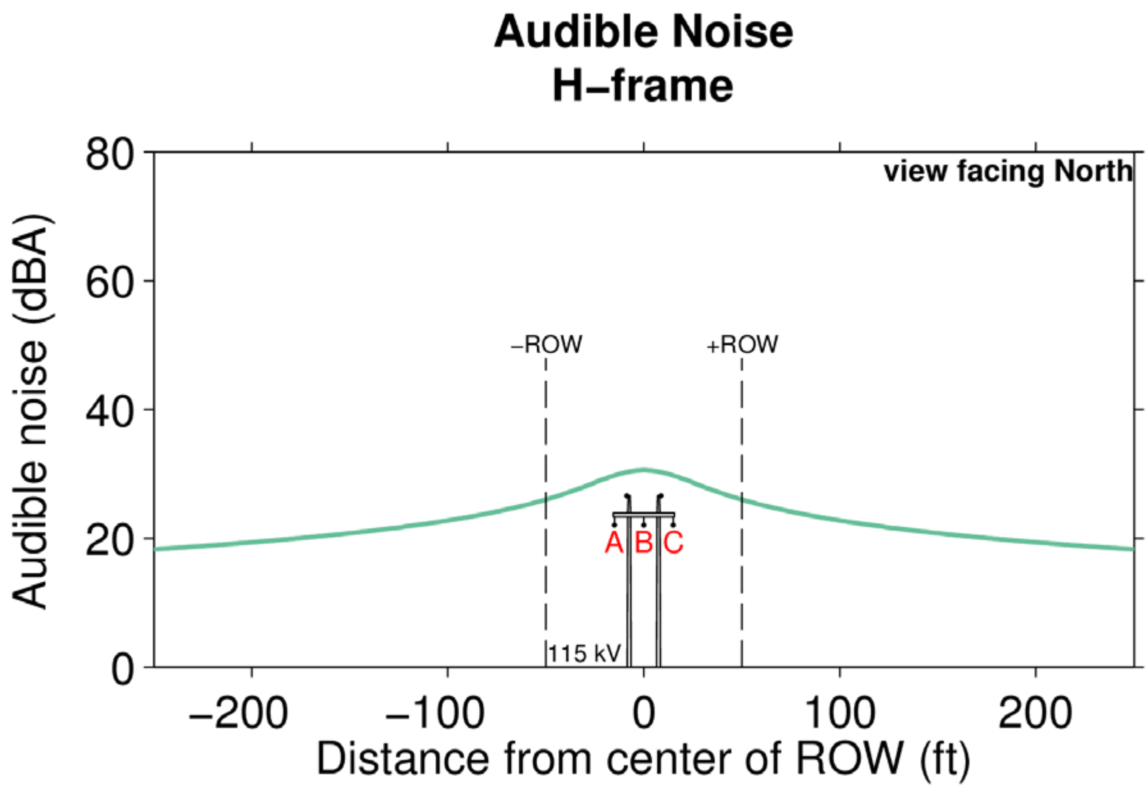

Figure 7. Calculated audible noise for the H-frame tower configuration for foul weather conditions

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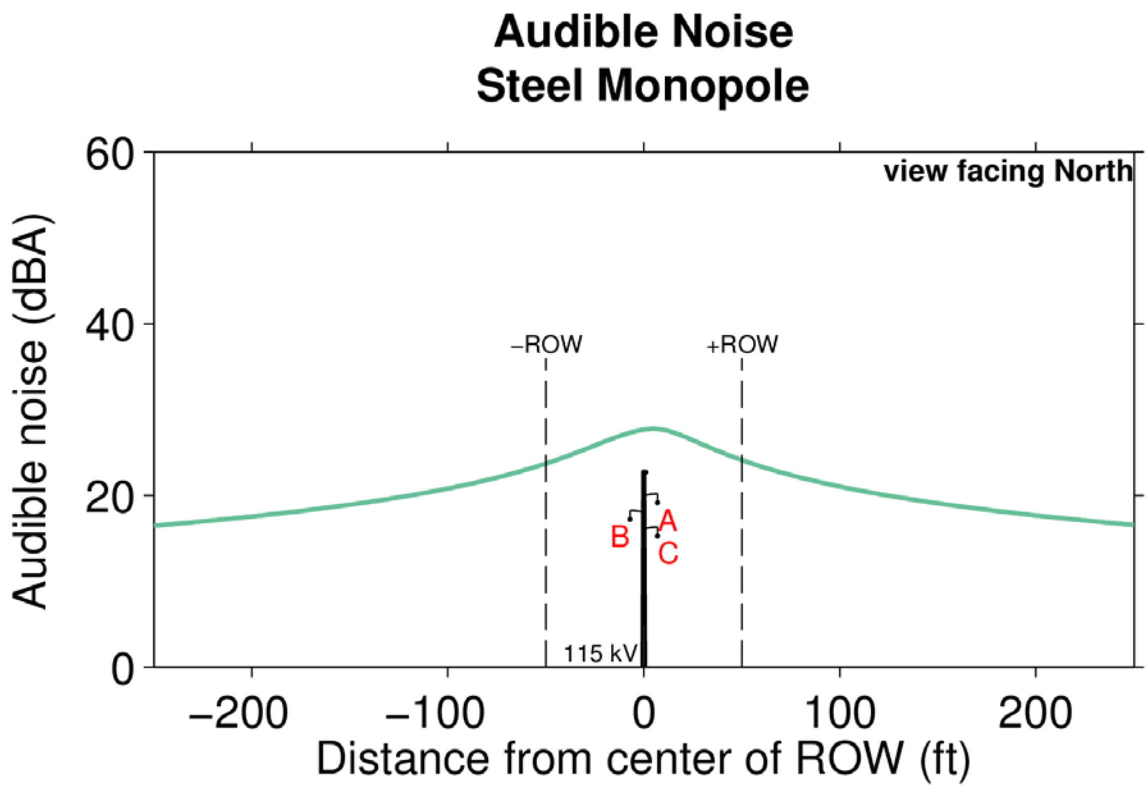

Figure 8. Calculated audible noise for the steel monopole tower configuration for foul weather conditions

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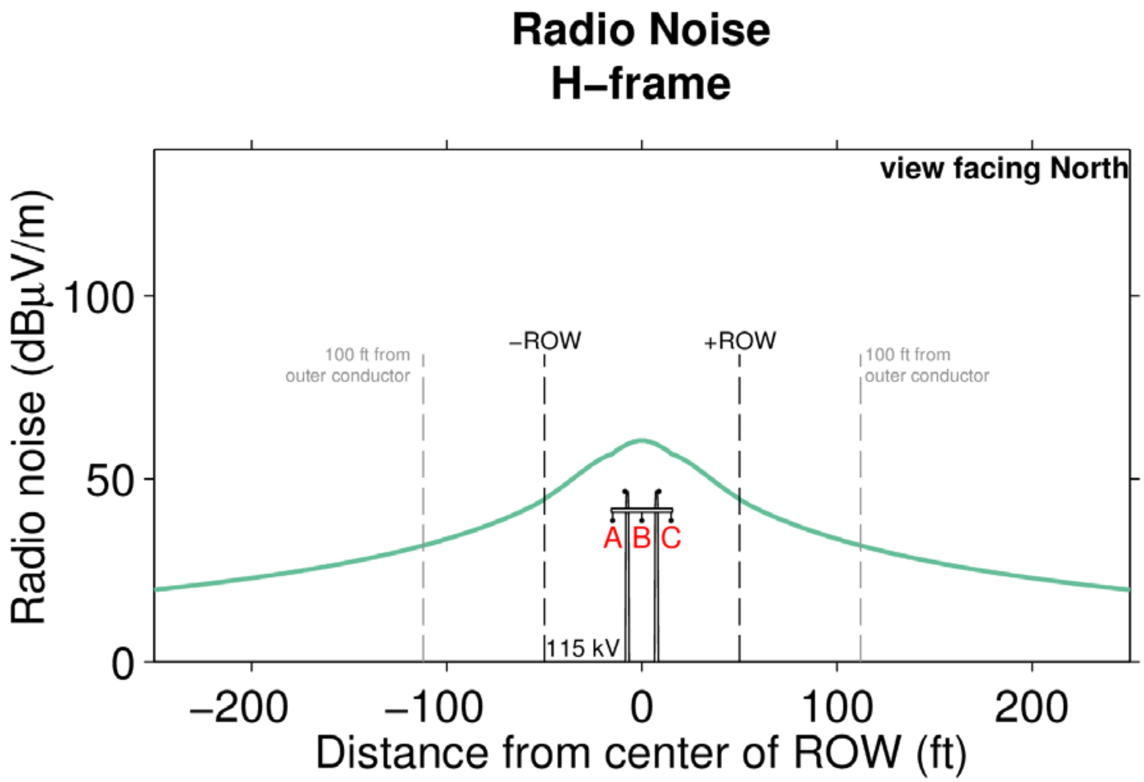

Figure 9. Calculated radio noise for the H-frame tower configuration for foul weather conditions

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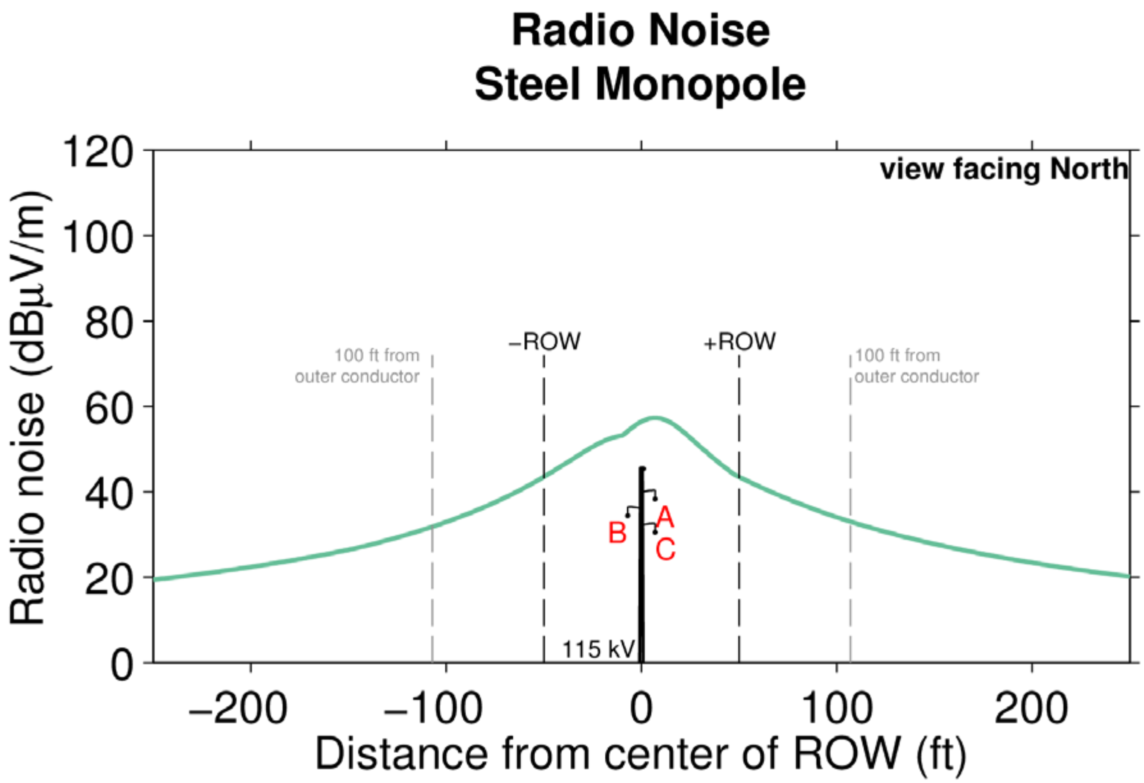

Figure 10. Calculated radio noise for the steel monopole tower configuration for foul weather conditions

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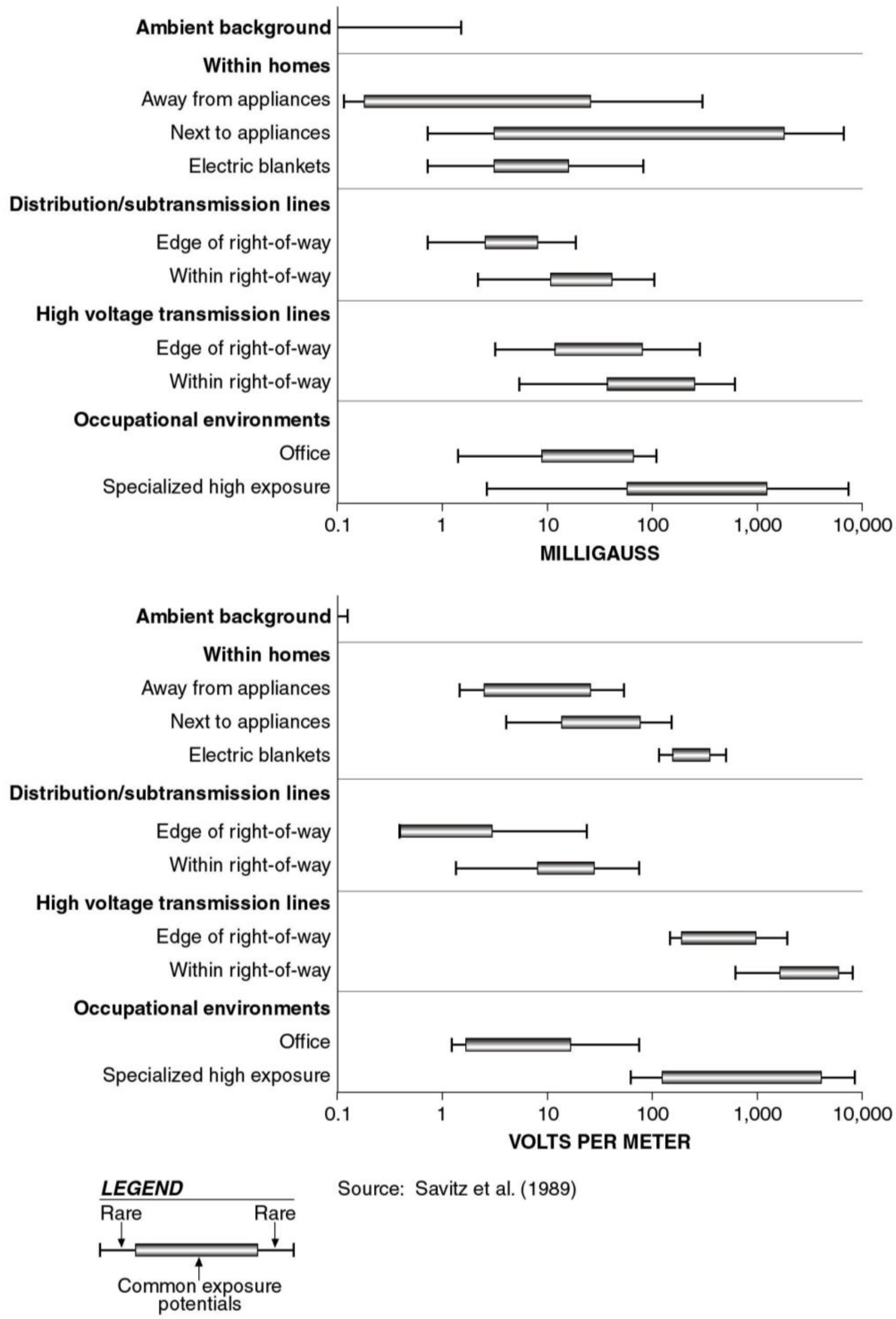

Figure 11. Electric and magnetic field levels in the environment

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Appendix B

Tables

Table 1. Circuit Configuration Summary

	H-frame	Steel Monopole
Voltage[1] [kV]	115	115
Average Current	470	470
Maximum Current	960	960
Phasing	A-B-C[2]	A-B-C[3]
Min. Conductor Height	24.5	24.5
Phase Spacing[4] [ft]	12 H	14 H 8.5V
Conductor Diameter [in]	0.951	0.951

[1] Electric fields are modeled assuming a 10% overvoltage
[2] H-frame phasing is reported left-to-right,
[3] Steel Monopole phasing is top-to-bottom
[4] H = horizontal spacing, V = vertical spacing

Table 2. Commonly encountered acoustic sources and audible noise levels

Noise Source	A-weighted sound level (dBA)
Pain Threshold	128
Auto horn	110
Inside subway	95
Traffic	75
Conversation	65
Office	55
Living Room	45
Library	35
Bedroom	24
Hearing Threshold	0

Adapted from USDOE, 1996

Table 3. Calculated electric field values (kV/m)

	Location				
Configuration	100 ft beyond –ROW Edge	–ROW Edge	Max	+ROW Edge	100 ft beyond +ROW Edge
H-frame	0.02	0.43	1.50	0.43	0.02
Steel Monopole	0.03	0.31	1.54	0.26	0.04

Table 4. Calculated magnetic-field values (mG) for average and peak loading

		Location				
Configuration	Loading	100 ft beyond –ROW Edge	–ROW Edge	Max	+ROW Edge	100 ft beyond +ROW Edge
H-frame	average	2.8	22.7	113.5	22.7	2.8
	peak	5.7	46.3	231.8	46.3	5.7
Steel Monopole	average	2.6	17.4	75.3	20.2	2.8
	peak	5.3	35.6	153.8	41.3	5.7

Table 5. Calculated audible noise values in foul weather (dBA)

	Location				
Configuration	100 ft beyond –ROW Edge	–ROW Edge	Max	+ROW Edge	100 ft beyond +ROW Edge
H-frame	21	26	31	26	21
Steel Monopole	19	24	28	24	19

Table 6. Calculated radio noise values in foul weather (dBμV/m)

	Location				
Configuration	100 ft beyond –outside conductor	–ROW Edge	Max	+ROW Edge	100 ft beyond + outside conductor
H-frame	32	45	61	45	32
Steel Monopole	32	44	57	44	33

Table 7. State standards and guidelines for transmission lines and substations

State	Transmission Line Rating	Property Boundary at Substation		At Edge of Transmission Line ROW		On Transmission Line ROW	
		Electric Field (kV/m)	Magnetic Field (mG)	Electric Field (kV/m)	Magnetic Field (mG)	Electric Field (kV/m)	Magnetic Field (mG)
New York	All	--	--	1.6	200	--	--
Florida	≤230 kV	2	150	2	150	8	--
	>230 kV - ≤ 500	2	200	2	200	10	--
	>500	5.5	250	5.5	250	15	
Minnesota	All					8	
Montana	All			1[a]		7[b]	
New Jersey	All					3	
Oregon	All					9	

[a]Can be waived by landowner; [b]Maximum for highway crossings.
Source: NIEHS, 2002, p. 46

Table 8. Reference levels for whole body exposure to 60-Hz fields

Organization recommending limit	Occupational Limit		General Public Limit	
	Magnetic Field (mG)	Electric Field (k/Vm)	Magnetic Field (mG)	Electric Field (k/Vm)
ICNIRP	4,200	4.2	2,000	
ICES			9,040	5 or 10[a]
American Conference of Governmental and Industrial Hygienists (ACGIH)	10,000	25		
Institute of Electrical and Electronics Engineers (IEEE) Standard C95.6			9,040	5
Australian Radiation Protection and Nuclear Safety Agency			3,000	5

[a]This is an exception within transmission line ROWs because people do not spend a substantial amount of time in ROWs and very specific conditions are needed before a response is likely to occur (i.e., a person must be well insulated from ground and must contact a grounded conductor) (ICES, 2002, p. 27).

Table 9. Correction factors to obtain day-night sound level (Ldn) from median (L50) foul weather transmission line sound level

	L_{dn}-L_{50} foul	
% Foul weather	**40 dBA ambient**	**No ambient**
0	-7.6	-17.6
1	-6.6	-12.0
5	-4.0	-6.0
10	-2.0	-2.9
100	+6.7	+6.7

Source: Dietrich (1982)

Appendix I

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

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Health Sciences

Exponent®

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

Research on Extremely Low Frequency Electric and Magnetic Fields and Health

Prepared for:

The Bonneville Power Administration

Prepared by:

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420 Lexington Avenue, Suite 1740
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January 2011

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Acronyms and Abbreviations

AC	Alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
ALL	Acute lymphoblastic leukemia
AML	Acute myeloid leukemia
BNU	n-butylnitrosourea
BPA	Bonneville Power Administration
CI	Confidence interval
DMBA	7,12-dimethylbenz[a]anthracene
G	Gauss
ELF	Extremely low frequency
EMF	Electric and magnetic fields
EMI	Electromagnetic interference
ENU	ethylnitrosourea
EPRI	Electric Power Research Institute
HR	Hazard ratio
Hz	Hertz
IARC	International Agency for Research on Cancer
ICD	Implanted cardiac device
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IGF-1	Insulin-like growth factor 1
m	Meter
mG	Milligauss
MPD	Myeloproliferative disorder
NIEHS	National Institute of Environmental Health Sciences
NHL	Non-Hodgkin's lymphoma
NK	Natural killer
OR	Odds Ratio
ROW	Right-of-way
RR	Relative risk
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks

SES	Socioeconomic status
SSI	Swedish Radiation Protection Authority
TWA	Time-weighted average
WHO	World Health Organization

Introduction

Electrical objects produce two field types—electric fields and magnetic fields. The term field is used to describe the way an object influences its surrounding area. A temperature field, for example, surrounds a warm object, such as a space heater or campfire. Electric and magnetic fields (EMF) surround any object that generates, transmits, or uses electricity, including appliances, electrical wiring, office equipment, generators, and any other electrical devices. These fields are invisible, and they cannot be felt or heard.

Electric fields occur as a result of the electric potential (i.e., voltage) on these objects, and **magnetic fields** occur as a result of current flow through these objects.[1] Just like a temperature field, both electric fields and magnetic fields can be measured, and their levels depend on the properties of the source of the field (e.g., voltage, current, and configuration) and the distance from the source of the field, among other things.

Both electric fields and magnetic fields decrease rapidly with distance from the source, such that a magnetic field of 300 milligauss (mG) within 6 inches of a vacuum cleaner diminishes to 1 mG at 4 feet (NIEHS, 2002). This is similar to the way that the heat generated by a space heater or a campfire lessens as a person moves farther away from it. Although ordinary objects do not block magnetic fields, objects such as trees and buildings easily block electric fields.

The electrical power system in the United States produces alternating current (AC) EMF that changes direction and intensity 60 times per second—i.e., a frequency of 60 Hertz (Hz).[2] This frequency is in the extremely low frequency (ELF) range of the electromagnetic spectrum. Electricity produced by generating stations flows as 60-Hz current through transmission and distribution lines and provides power to the many appliances and electrical devices that we use in our homes, schools, and workplaces. Magnetic fields are found throughout our environment

1 The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); 1 kilovolt per meter is equal to 1,000 V/m. The strength of magnetic fields is expressed as magnetic flux density in units called gauss (G), or in milligauss (mG), where 1 G is equal to 1,000 mG.

2 Europe's electrical system produces 50-Hz EMF. Since 50-Hz EMF is also in the ELF range, research on 50-Hz EMF is relevant to questions on 60-Hz EMF.

because electricity is needed for so many things in our daily lives, from lighting, heating, and cooling our homes to powering our refrigerators and computers.

Questions about whether these ubiquitous exposures could affect our health began to be raised in the 1970s. Since then, researchers from many different scientific disciplines have investigated this question, and hundreds of studies have been conducted. The public frequently expresses concern about ELF EMF, particularly in the context of new transmission lines. The intent of this report is to describe what this large body of research has told us about ELF EMF and the precautions, if any, recommended by public health agencies

In July 2007, Exponent provided a report to the Bonneville Power Administration (BPA) that described the conclusions of a comprehensive, weight-of-evidence review published by the World Health Organization (WHO) in June 2007; the portion of Exponent's 2007 report that describes the conclusions of the WHO report is attached as Appendix 1 for reference.[3] The WHO review still represents the most recent comprehensive review of the literature by a multidisciplinary scientific panel. The WHO organized a multidisciplinary Task Group of 21 scientists from around the world to draft a Monograph that summarized the research and provided conclusions as to whether there are risks associated with ELF EMF and, if so, at what exposure levels (WHO, 2007a). The report concluded that the only established effects of ELF EMF exposure are acute neurostimulatory effects (i.e., shock-like effects) that occur at very high levels of exposure; these exposure levels are not encountered in ordinary residential or occupational environments. The fact sheet from the WHO review is attached as Appendix 2 (WHO, 2007b) and can be found at http://www.who.int/mediacentre/factsheets/fs322/en/print.html.

Research is a constantly evolving process. Despite the volume of research available on ELF EMF and the large reduction in uncertainty that research has achieved over the years, scientists continue research in this area with the goal of clarifying and replicating old findings and testing new hypotheses. New studies on ELF EMF are published every month. While the WHO review provides a comprehensive and relatively up-to-date summary of the status of research on

3 Exponent. Assessment of Research Regarding EMF and Health and Environmental Effects. Olympic Peninsula Reinforcement Transmission Line Project. July 2007.

this topic, new research has the potential to modify or strengthen conclusions. The BPA has, therefore, requested an update on the research with regard to ELF EMF and health. This report provides an overview of the cumulative body of research published since the WHO review (January 1, 2006-October 1, 2010) and provides the reader with perspective on if, and how, recent research changes the WHO's conclusions.

A summary of the methods scientists use to conduct studies and make decisions about health risks is included in Section 1 as a framework for understanding later discussions. In Section 2, the discussion of new research is broadly grouped by health outcome—cancer, reproductive effects, developmental effects, and neurodegenerative diseases. This discussion summarizes two types of research—epidemiology studies and experimental studies in animals (*in vivo*)—within each health outcome category. Experimental studies in cells and tissues (*in vitro*) of carcinogenesis are discussed briefly in Section 2. Other areas of research not reviewed by WHO are discussed in Section 3, including the possible effects of ELF EMF on the functioning of pacemakers, on flora and fauna, and on marine life. Finally, guidelines for ELF EMF exposure developed by scientific organizations to prevent against established health effects are summarized in Section 4.

1 Scientific Methods

Weight-of-evidence review

Most of what we encounter in our every day environment has no effect on our health. Other exposures, however, may affect our health in either a beneficial or a harmful way, including such ubiquitous interactions with our environment as the air we breathe, the water we drink, and our exposure to sunlight. Much time and money is spent by scientists around the world designing, conducting, and publishing research to determine what factors may affect our health, including environmental exposures (like ELF EMF), infectious agents, and our genetics. The process for arriving at a conclusion about whether there is a health risk associated with any of these factors often is not straightforward or definitive. Rather, it is a long process that requires repeated hypothesis generation and testing.

The process begins when a scientist forms a hypothesis and conducts a study to test that hypothesis. Studies are conducted by scientists at academic universities and scientific institutions around the world. Once a study is complete, the authors submit it to a scientific journal for publication, where it undergoes peer review prior to publication. The evidence to evaluate any health risk includes all of the relevant studies published in the peer-reviewed literature.

These individual research studies can be thought of as puzzle pieces. When all of the research is placed together, we have some understanding of possible health effects; no conclusions can be reached, however, by looking at only one study, just as no picture can be formed with just one puzzle piece. Each study provides a different piece of information to the puzzle because of its unique strengths and weaknesses—if the study used valid methods and had no obvious sources of bias, it may provide a wealth of information or, if the study was not well conducted, it may add little or no information to our understanding.

This process of evaluating all of the research together to determine whether something poses either a health benefit or health risk is referred to as a weight-of-evidence review. There are three types of research that are considered in a weight-of-evidence review: epidemiology studies of people, experimental studies in animals (*in vivo* research), and experimental studies in cells and tissues (*in vitro* research). It is important to consider all three types of research together because they provide complementary information:

- Epidemiology studies collect observational data about human populations in their every day environments to determine whether there are patterns between exposures and diseases. These studies measure statistical associations to evaluate whether a disease and exposure occur together more often than expected. An important limitation of these studies is that, if an association is measured, they do not tell scientists how the exposure is truly related to the disease. That conclusion can only be reached by considering the entire body of research. Most of the studies evaluating ELF EMF examine whether people with a particular disease have had higher estimates of ELF EMF exposure in the past compared to people without that disease.

- Experimental studies in which scientists expose animals (*in vivo*) to varying levels of electric or magnetic fields (some as high as 50,000 mG) are an important source of information. These studies compare the amount of disease they observe in exposed animals to the amount of disease they observe in animals that have not been exposed. The strength of animal studies is that scientists are able to control all aspects of the animals' lives to minimize the potential confounding effects of factors other than the exposure of interest. The most valuable experimental studies for understanding disease are those in which the animals receive life-long exposures.

- Experimental studies *in vitro* involve the exposure of isolated cells and tissues to the agent of interest, in this case ELF EMF, and compare the characteristics of exposed and unexposed samples to look for differences that are indicative of a disease process. These studies are limited because what occurs to exposed cells or tissues outside of a human body may not be the same as what occurs to cells and tissues inside a body.

The weight-of-evidence approach is the standard process used worldwide by scientists, scientific organizations, and regulatory agencies to assess the possible health benefits and risks associated with exposures. A weight-of-evidence review begins with a systematic review of published, peer-reviewed epidemiology, *in vivo*, and *in vitro* research. The weight that individual studies provide to the overall conclusions is not equal—studies vary widely in terms of the sophistication and validity of their methods. Therefore, each study from each discipline must be evaluated critically and assigned a weight. A final conclusion is then reached by considering the cumulative body of research, giving more weight to studies of higher quality (Figure 1).

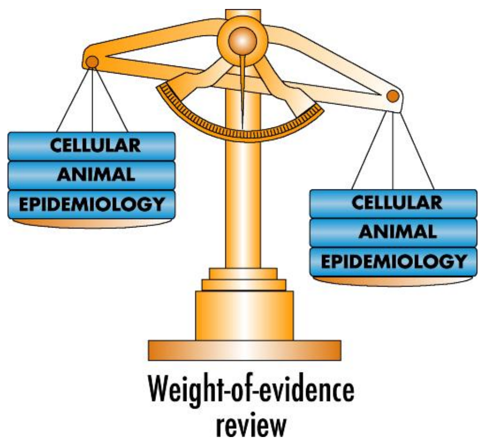

Figure 1. Weight-of-evidence reviews consider three types of research

Continuing with the puzzle example from above, the picture that is formed when the individual studies are assembled can take on many different shapes. In some cases (e.g., smoking and lung cancer), a clear picture of an adverse health effect was presented by the research within a relatively short time. In most cases, however, the picture is unclear and more questions are raised than answered. It is impossible to prove the negative in science—i.e., to say that any exposure is completely safe—therefore, research studies can only reduce the uncertainty that there is a health effect through continued research. The only way to reduce this uncertainty is to conduct high quality studies with meaningful results that are replicated across study populations (in the case of epidemiology studies) and by different laboratories (in the case of *in vivo* and *in vitro* research). Thus, in most areas of research, unless the data clearly indicate an increased risk at defined exposure levels, scientific panels will conclude that the research is inadequate or limited and requires further study until the uncertainty has been reduced below an acceptable level. While the public may interpret this conclusion as indicating concern, it is natural for scientists to recommend future research to reduce uncertainty around a largely negative body of research or to replicate findings that appear positive.

Scientific and health organizations put together panels of scientists to conduct weight-of-evidence reviews. These panels consist of experts from around the world in the areas of interest (e.g., epidemiology, neurophysiology, toxicology, etc.) and they follow standard scientific methods for arriving at conclusions about possible health risks. The conclusions of these reviews are looked to for the current scientific consensus on a particular topic and form the basis of recommendations made by organizations and governments on exposure standards and precautionary measures.

Scientific reviews on ELF EMF

Numerous national and international organizations responsible for public health have convened multidisciplinary panels of scientists to conduct weight-of-evidence reviews and arrive at conclusions about the possible risks associated with ELF EMF. These organizations include the following (in ascending, chronological order of their most recent publication):

- The **National Institute for Environmental Health Sciences** (**NIEHS**) in the United States assembled a 30-person Working Group to review the cumulative body of epidemiologic and experimental data on ELF EMF and provide conclusions and recommendations to the government (NIEHS, 1998, 1999).

- The **International Agency for Research on Cancer** (**IARC**) completed a full carcinogenic evaluation of ELF EMF in 2002 (IARC, 2002).

- The **World Health Organization (WHO)** released a review in June 2007 as part of its International EMF Program to assess the scientific evidence related to ELF EMF in the frequency range from 0 to 300 GHz (WHO, 2007a). Appendix 1 summarizes the conclusions of this review.

- The **Swedish Radiation Protection Authority (SSI),**[4] using other major scientific reviews as a starting point, evaluated new studies in consecutive annual reports (SSI, 2007; SSI, 2008).

- The **Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR)** issued a report in March 2007 and March 2009 (SCENIHR, 2007; SCENIHR, 2009) updating previous conclusions (SSC, 1998; CSTEE, 2001) to the Health Directorate of the European Commission.

- The **National Radiological Protection Board** (**NRPB**)[5] of the United Kingdom issued full evaluations of the research in 1992, 2001, and 2004, with supplemental updates (NRPB, 1993; NRPB, 1994a) and topic-specific reports (NRPB, 1994b; NRPB, 2001b; HPA, 2006) published in the interim. In a letter addressing a related topic, the Director of the Health Protection Agency of Great Britain (HPA) reiterated their position on ELF EMF and appropriate precautionary measures (HMG, 2009).

- The **International Commission on Non-Ionizing Radiation Protection** (**ICNIRP**), the formally recognized organization for providing guidance on standards for non-ionizing radiation exposure for the WHO**,** published a review of the cumulative body of epidemiologic and experimental data on ELF EMF in 2003. The ICNIRP released draft exposure guidelines for ELF EMF in July 2009 (ICNIRP, 2009). While the ICNIRP panel stated that they relied heavily on previous reviews of the literature related to long-term ELF EMF exposures, they provided relevant conclusions as part of the drafting of these guidelines. Final guidelines for ELF EMF exposure were issued in late 2010 (ICNIRP, 2010).

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[4] The Swedish Radiation Safety Authority (Strål säkerhets myndigheten [SSM]) has superseded the SSI, which ceased to exist on 30 June 2008. The SSM is a managing authority of Sweden's Ministry of the Environment and has "national collective responsibility within the areas of radiation protection and nuclear safety," which includes EMF research (http://www.stralsakerhetsmyndigheten.se).

[5] The NRPB merged with the Health Protection Agency in April 2005 to form its new Radiation Protection Division.

Dissenting opinion on ELF EMF

In August 2007, an *ad hoc* group of 14 scientists and public health and policy consultants published an on-line report titled "*The BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)*." The group's objective was to "assess scientific evidence on health impacts from electromagnetic radiation below current public exposure limits and evaluate what changes in these limits are warranted now to reduce possible public health risks in the future" (p. 4). The report was followed by several publications related to ELF EMF that summarized some of the online report's conclusions (Hardell and Sage, 2008; Davanipour and Sobel, 2009; Johansson 2009). The individuals who comprised this group did not represent any well-established regulatory agency nor were they convened by a recognized scientific authority. The report has been criticized by scientific agencies because it did not follow the methods of a standard weight-of-evidence review and, for this reason, its conclusions and recommendations are not considered further in this report (Danish National Board of Health, 2007; ACRBR, 2008; HCN, 2008).[6] Appendix 3 provides a full criticism of the report.

Epidemiology basics

This section briefly describes the main types of epidemiology studies and the major issues that are relevant to evaluating their results. The two, main types of epidemiology studies are cohort studies and case-control studies (Figure 2).

[6] http://www.gezondheidsraad.nl/en/publications/bioinitiative-report-0

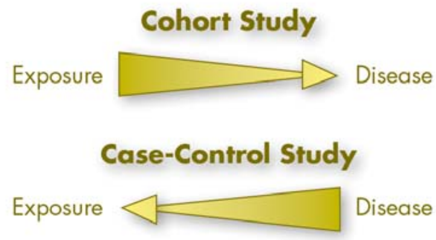


Figure 2. Basic design of cohort and case-control studies

A case-control study compares the characteristics of people that have been diagnosed with a disease (i.e., cases) to a similar group of people who do not have the disease (i.e., controls). The prevalence and extent of past exposure to a particular agent is estimated in both groups and compared to assess whether the cases have a higher exposure level than the controls, or vice versa.

In a case-control study, this comparison (or statistical association) is estimated quantitatively with an odds ratio (OR). An OR is the ratio of the odds of exposure among persons with a disease to the odds of exposure among persons without a disease. The general interpretation of an OR equal to 1.0 is that the odds of exposure are the same in the case and control groups (i.e., there is no statistical association between the exposure and disease). If the OR is greater than 1.0, the inference is that the odds of exposure are greater in the case group or, in other words, the exposure may increase the risk of the disease (Figure 3).

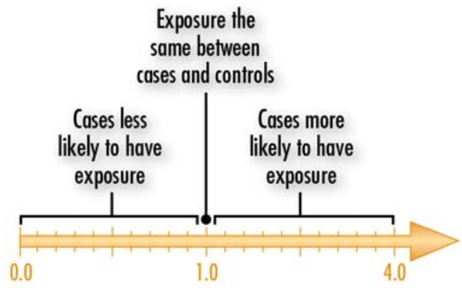


Figure 3. Interpretation of an odds ratio in a case-control study

Each OR is reported with a confidence interval (CI), which is a range of OR values that have a specified probability of occurring if the study is assumed to be repeated a large number of times. A 95% CI, for example, provides the range of values that are likely to occur in 95% of repeated experiments. In short, a CI indicates how certain (or confident) the researcher is about the OR calculated from his or her data; if the CI includes 1.0, the researcher cannot statistically exclude the possibility that the OR is 1.0, meaning the odds of exposure are the same in the case and control groups.

A cohort study is conducted in the reverse manner—in the most traditional sense, researchers study a population *without disease* and follow them over time to see if persons with a certain exposure develop disease at a higher rate than unexposed persons. The comparisons conducted in cohort studies are similar to the comparisons conducted in case-control studies, although the risk estimate is referred to as a relative risk (RR) rather than an OR. The RR is equal to rate of disease in the exposed group divided by the rate of disease in the unexposed group, with values greater than 1.0 suggesting that the exposed group has a higher rate of disease.

The resulting RR or OR is simply a comparative measure of how often a disease and exposure occur together in exposed and unexposed study populations—it does not mean that there is a known or causal relationship. Before any conclusions can be drawn, all studies considering a particular exposure and disease must be identified, and each study must be evaluated to determine the possible role that factors such as chance, bias, and confounding may have played in the study's results.

- *Chance* refers to a random event, i.e., a coincidence. An association can be observed between an exposure and disease that simply is the result of a chance occurrence. Statistics, such as the CI, are calculated to determine whether chance is a likely explanation for the findings.
- *Bias* refers to any error in the design, conduct, or analysis of a study that would cause a distorted estimate of an exposure's effect on the risk of disease. There are many different types of bias; for example, selection bias may occur if the characteristics of persons that participate in a study differ in a meaningful way from the characteristics of those subjects that do not participate (e.g., cases living near power lines might be more likely to participate than controls because the cases are concerned about this possible exposure).
- *Confounding* is a situation in which an association is distorted because the exposure being studied is associated with other risk factors for the disease. For example, a link between coffee drinking in mothers and low birth weight babies may be observed in a study, but some women who drink coffee also smoke cigarettes. When the smoking habits of mothers are taken into account, coffee drinking may not be associated with low birth weight babies because the confounding effect of smoking has been removed.

As part of the weight-of-evidence review process, each study's design and methods are evaluated critically to determine if and how chance, bias, and confounding may have affected the results and, subsequently, the weight that should be placed on the study's findings.

IARC classifications

This section briefly describes the method that the IARC uses following a weight-of-evidence review to classify exposures based on the evidence in support of carcinogenicity. The WHO adopted this method in their 2007 review on ELF EMF, and other scientific agencies refer to this classification system, as well.

First, each research type (epidemiology, *in vivo*, and *in vitro*) is evaluated to determine the strength of evidence in support of carcinogenicity (as defined in Figure 4). Epidemiology studies are characterized as having *sufficient evidence* for carcinogenicity if an association is found and chance, bias, and confounding can be ruled out with "reasonable confidence." *Limited evidence* is used to describe a body of research where the findings are inconsistent or where an association is observed but there are outstanding questions about study design or other methodological issues that preclude making strong conclusions. *Inadequate evidence* describes a body of research where it is unclear whether the data is supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues. The same overall categories apply for *in vivo* research. *In vitro* research is not described in Figure 4 because it provides ancillary information and, therefore, is used to a lesser degree in evaluating carcinogenicity and is classified simply as strong, moderate, or weak.

Agents are then classified into five overall categories using the combined categories from epidemiology, *in vivo*, and *in vitro* research (listed from highest to lowest risk): (1) known carcinogen, (2) probable carcinogen, (3) possible carcinogen, (4) non-classifiable, and (5) probably not a carcinogen.

As summarized in Figure 4, the category possible carcinogen typically denotes exposures for which there is limited evidence of carcinogenicity in epidemiology studies, and *in vivo* studies provide limited or inadequate evidence of carcinogenicity.

The IARC has reviewed over 900 substances and exposure circumstances to evaluate their potential carcinogenicity. Figure 5 provides examples of some of the more common exposures that have been classified in each category. As Figure 5 shows, over 80% of exposures fall in the categories possible carcinogen (27%) or non-classifiable (55%). This occurs because, as described above, it is nearly impossible to prove that something is completely safe and few exposures show a clear-cut or probable risk, so most agents will end up in either of these two categories. Throughout the history of the IARC, only one agent has been classified as probably not a carcinogen, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.

Over half of the agents are non-classifiable in terms of carcinogenicity, i.e., it is unclear whether they can cause cancer—hair coloring products, jet fuel, and tea are included in this category. Possible carcinogens include occupation as a firefighter, coffee, and pickled vegetables, in addition to magnetic fields. Exposures identified as probable carcinogens include high temperature frying and occupation as a hairdresser. Finally, known carcinogens include benzene, asbestos, solar radiation, use of tanning beds, and tobacco smoking. As Figure 5 shows, there is much uncertainty about whether certain agents will lead to cancer, and possible and probable carcinogens include substances to which we are commonly exposed or are common exposure circumstances.

	Epidemiology Studies				Animal Studies			
	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity	Sufficient evidence	Limited evidence	Inadequate evidence	Evidence suggesting lack of carcinogenicity
Known Carcinogen	✔							
Probable Carcinogen		✔			✔			
Possible Carcinogen		✔				✔	✔	
Not Classifiable			✔			✔	✔	
Probably not a Carcinogen				✔				✔

Sufficient evidence in epidemiology studies—A positive association is observed between the exposure and cancer in studies, in which chance, bias and confounding were ruled out with "reasonable confidence."

Limited evidence in epidemiology studies—A positive association has been observed between the exposure and cancer for which a causal interpretation is considered to be credible, but chance, bias or confounding could not be ruled out with "reasonable confidence."

Inadequate evidence in epidemiology studies—The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available.

Evidence suggesting a lack of carcinogenicity in epidemiology studies—There are several adequate studies covering the full range of levels of exposure that humans are known to encounter, which are mutually consistent in not showing a positive association between exposure to the agent and any studied cancer at any observed level of exposure. The results from these studies alone or combined should have narrow confidence intervals with an upper limit close to the null value (e.g. a relative risk of 1.0). Bias and confounding should be ruled out with reasonable confidence, and the studies should have an adequate length of follow-up.

Sufficient evidence in animal studies—An increased incidence of malignant neoplasms is observed in (a) two or more species of animals or (b) two or more independent studies in one species carried out at different times or indifferent laboratories or under different protocols. An increased incidence of tumors in both sexes of a single species in a well-conducted study, ideally conducted under Good Laboratory Practices, can also provide sufficient evidence.

Limited evidence in animal studies—The data suggest a carcinogenic effect but are limited for making a definitive evaluation, e.g. (a) the evidence of carcinogenicity is restricted to a single experiment; (b) there are unresolved questions regarding the adequacy of the design, conduct or interpretation of the studies; etc.

Inadequate evidence in animal studies—The studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect because of major qualitative or quantitative limitations, or no data on cancer in experimental animals are available

Evidence suggesting a lack of carcinogenicity in animal studies—Adequate studies involving at least two species are available which show that, within the limits of the tests used, the agent is not carcinogenic.

Figure 4. Basic IARC method for classifying exposures based on potential carcinogenicity

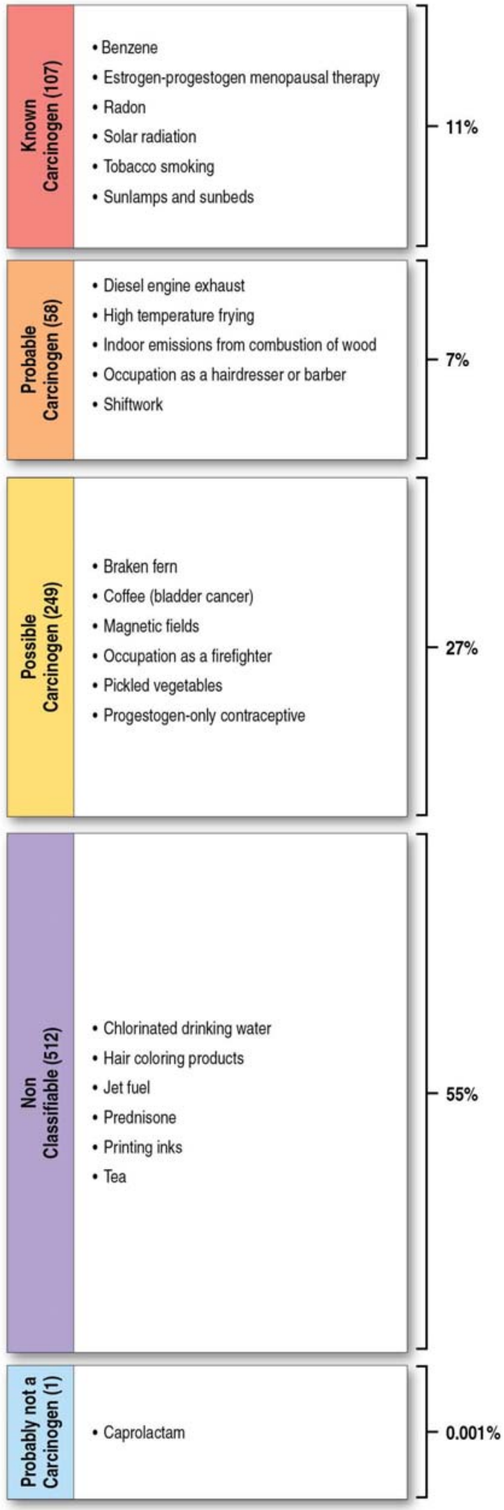


Figure 5. Percentage of substances classified in each IARC category with examples

2 Human Health Research

The following sections provide an overview of peer-reviewed research published between January 1, 2006 and October 1, 2010. A literature review was conducted to identify new epidemiologic, *in vivo,* and *in vitro* research published on 50 or 60-Hz ELF EMF. A large number of search strings referencing the exposure and diseases of interest, as well as authors who regularly publish in this area, were included as search terms in the PubMed database, a service of the U.S. National Library of Medicine that includes over 17 million citations from MEDLINE and other life science journals for biomedical articles dating to the 1950s.[7] A scientist with experience in this area reviewed the search results to identify relevant studies.

This report focuses on the diseases that have received the most attention—cancer, reproductive effects, developmental effects, and neurodegenerative diseases. Other health effects have been studied (i.e., rare cancer types, suicide, depression, electrical hypersensitivity, and cardiovascular effects), but for brevity and because research on these topics evolves slowly, these topics are not summarized here. The WHO review provides a good resource for the status of research on these additional health effects.

This update focuses on identifying and summarizing new epidemiologic and major *in vivo* research, since these study types are the most informative for risk assessment in this field; for the status of *in vitro* research, we include our discussion from the July 2007 report.

Cancer

Childhood leukemia

What was previously known about childhood leukemia and what did the WHO review conclude?

Scientific panels have concluded consistently that magnetic fields are a possible carcinogen largely because of findings from studies of childhood leukemia. Since 1979, approximately 35

7 PubMed includes links to full text articles and other related resources (http://www.ncbi.nlm.nih.gov/PubMed/).

studies conducted in the United States, Canada, Europe, New Zealand, and Asia have evaluated the relationship between childhood leukemia and magnetic fields using various methods to estimate exposure. These methods have included long-term (48-hour) personal monitoring; spot or long-term (24- or 48-hour) measurements in structures and outdoors; calculations using loading, line configuration, and distance of nearby power installations to estimate historical, residential exposure; and wire code categories.[8] As a group of independent studies, they did not show a clear or consistent association between magnetic fields and childhood leukemia. The largest and most methodologically sound case-control studies to estimate personal magnetic field exposure directly did not report a consistent relationship (Linet et al., 1997; McBride et al., 1999; UKCCS, 2000). When two independent pooled analyses combined the data from these case-control studies, however, a statistically significant association was observed between rare average magnetic field exposure above 3-4 mG and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). Both pooled analyses indicated that children with leukemia were about two times more likely to have had estimated magnetic field exposures above 3-4 mG. Average exposures at this level are uncommon; according to the WHO, results from several extensive surveys showed that approximately 0.5–7.0% of children had time-averaged exposures in excess of 3 mG and 0.4–3.3% had time-averaged exposures in excess of 4 mG (WHO, 2007a). While these analyses provide a valuable quantitative summary of the data, pooled analyses are limited by the disparate methods used to collect the underlying data. Questions have been raised as to whether the original studies, particularly those that are large and estimated exposure directly, provide a more valid estimate of the association than the pooled analyses (Elwood, 2006).

Despite the association observed in these pooled analyses, health agencies have not concluded that magnetic fields are a known or probable cause of childhood leukemia. The studies are of insufficient strength to rule out with "reasonable confidence" the role that chance, bias, and confounding may have had on the observed statistical association. In other words, researchers do not have enough confidence in the way these studies were conducted to conclude that the measured statistical association represents a true relationship between magnetic fields and childhood leukemia. Furthermore, experimental data do not provide evidence for a risk in the

8 Wire code categories are categories used to classify the potential magnetic field exposures at residences based on the characteristics of nearby power installations.

more highly-controlled *in vivo* studies, and *in vitro* studies do not provide evidence of a plausible biological mechanism whereby magnetic fields lead to carcinogenesis.

Since chance, bias, and confounding could not be ruled out as an explanation for the association, the IARC concluded in 2002 that the data on childhood leukemia provided limited evidence of carcinogenicity (IARC, 2002). In 2007, the WHO reviewed studies on childhood leukemia and magnetic field exposure published since the 2002 IARC review (WHO, 2007a). They concluded that the new epidemiologic studies were consistent with the classification of limited epidemiologic evidence in support of carcinogenicity and, together with the largely negative *in vivo* and *in vitro* research, consistent with the classification of magnetic fields as a possible carcinogen (Figure 4).[9]

Since it is unclear whether the association is real, the WHO review evaluated other factors that might be partially, or fully, responsible for the association, including chance, control selection bias, confounding from hypothesized or unknown risk factors, and misclassification of magnetic field exposure (Figure 6). The following is a summary of their evaluation:

- ✓ The WHO review concluded that **chance** is an unlikely explanation since the pooled analyses had a large sample size and decreased variability.

- ✓ **Control selection bias** occurs when the controls that decide to participate in the study do not represent the true exposure experience of the non-diseased population. In the case of magnetic fields, the WHO speculates that controls with a higher socioeconomic status (SES) may participate in studies more often than controls with a lower SES. Since persons with a higher SES may have lower magnetic field exposures or tend to live farther from transmission lines, the control group's magnetic field exposure may be artificially low. Thus, when the exposure experience of the control group is compared to the case group, there is a difference between the case and control group that does not exist in the source population. The WHO concluded that **control selection bias** is

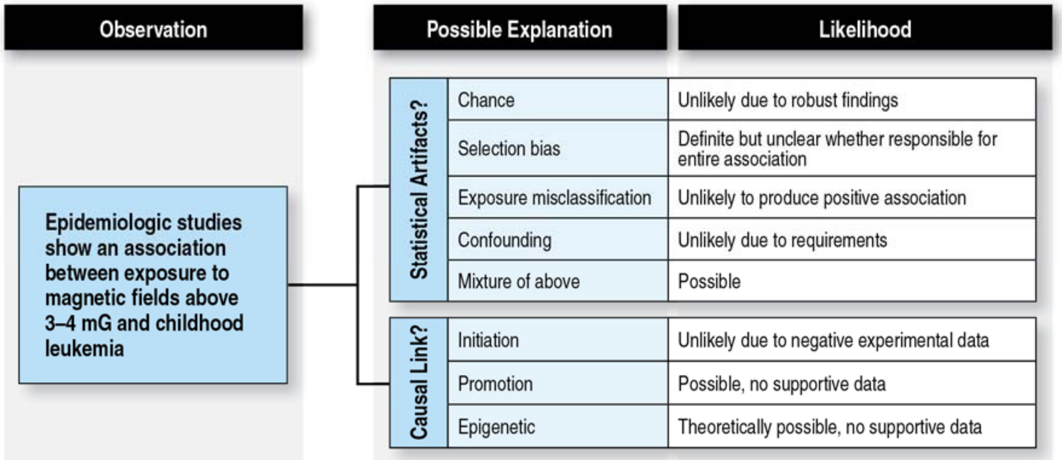
[9] The WHO concluded the following: "Consistent epidemiological evidence suggests that chronic low intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted" (p. 355-6, WHO, 2007a).

probably occurring in these studies and would result in an overestimate of the true association, but would not explain the entire observed statistical association

- ✓ The WHO panel concluded that **confounding** is less likely to be causing the observed association than other factors, although the possibility that some yet-to-be identified confounder is responsible for the association cannot be excluded completely. Suggested risk factors that may be confounding the relationship include SES, residential mobility, contact currents, and traffic density.[10]

- ✓ The WHO stated that the possible effects of **exposure misclassification** are the most difficult to predict. EMF presents unique challenges in exposure assessment because it is ubiquitous, imperceptible, and has many sources (Kheifets and Oksuzyan, 2008). No target exposure or exposure window has been identified, and the numerous methods of estimating exposure likely result in a different degree of error within and between studies. Most reviews have concluded that exposure misclassification would likely result in an underestimate of the true association, meaning the association we observe is lower than the true value; however, the extent to which this might occur varies widely and is difficult to assess (Greenland et al., 2000). The WHO concluded that exposure misclassification likely is present in these studies, but is unlikely to provide an entire explanation for the association.

[10] For example, if dwellings near power lines encounter higher traffic density and pollution from traffic density causes childhood leukemia, traffic density may cause an association between magnetic field exposure and childhood leukemia, where a relationship does not truly exist.



Source: Adapted from Schüz and Ahlbom (2008)

Figure 6. Possible explanations for the observed association between magnetic fields and childhood leukemia

The WHO review stated that reconciling the epidemiologic data on childhood leukemia and the negative (i.e., no hazard or risk observed) experimental findings through innovative research is currently the highest priority in the field of ELF EMF research. Given that few children are expected to have average magnetic field exposures greater than 3-4 mG, however, the WHO stated that the public health impact of magnetic fields on childhood leukemia would be low if the association was determined to be causal.

What relevant studies have been published since the WHO review?

A number of studies investigating childhood leukemia and magnetic fields have been published since the WHO review (Table 1). Recent studies continue to support a weak association between elevated magnetic field levels and childhood leukemia, but they lack the methodological improvements required to advance this field; the evidence remains limited and the observed statistical association is still unexplained. Some scientists have opined that epidemiology has reached its limits in this area and any future research must demonstrate a significant methodological advancement (e.g., an improved exposure metric or a large sample size in high exposure categories) to be justified (Savitz, 2010; Schmiedel and Blettner, 2010).

Most notably, Kheifets et al. (2010a) conducted a pooled analysis of studies published between 2000 and 2010 that was intended to mirror the earlier pooled analyses of studies published between 1974 and 1999 (Ahlbom et al., 2000; Greenland et al., 2000). Kheifets et al. identified six studies for the main analysis that met their inclusion criteria (i.e., population-based studies of childhood leukemia that measured or calculated magnetic fields inside a home); three of the studies in this analysis were considered in the WHO review, while two are described here (Kroll et al., 2010; Malagoli et al., 2010).[11] An additional Brazilian study remains unpublished, but the results were provided via personal communication to Kheifets et al. (Wunsch Filho, personal communication, 2009).[12] A large number of cases were identified by Kheifets et al. (10,865), but a relatively small number of cases (23) were classified in the highest exposure category (>3 mG). A positive association was reported (OR=1.44), but it was weaker than the previous pooled estimates and not statistically significant (95% CI=0.88–2.36); a dose-response relationship was apparent and the association was stronger when the Brazilian study was excluded.

The largest number of cases in Kheifets et al. (2010a) was from a large, case-control study conducted in the United Kingdom by Kroll et al. (2010). Kroll et al. expands upon an earlier study (Draper et al., 2005) by replacing residential distance to nearby transmission lines as the exposure metric with calculated magnetic fields from nearby transmission lines; both studies included all children diagnosed with cancer in the United Kingdom from 1962 through 1995. Draper et al. (2005) reported that children with leukemia were more likely to have lived at birth within 600 meters (m) of a high-voltage transmission line, although the authors questioned the significance of this finding since magnetic fields from power lines do not extend to distances of 600 m.[13] Kroll et al. calculated average yearly residential magnetic-field levels for children

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[11] A seventh study was included in Kheifets et al. (2010a), but only in the pooled analysis of childhood leukemia and residential distance to power lines (Lowenthal et al., 2007). This study is not discussed further in this section because published findings only report on a combined category of lymphoproliferative and myeloproliferative disorders for both adults and children combined.

[12] The study evaluated acute lymphoblastic leukemia among children less than 8 years of age and measured exposure using 24-hour measurements in the children's bedrooms.

[13] The WHO concluded the following with respect to the Draper et al. (2005) findings: "[the] observation of the excess risk so far from the power lines, both noted by the authors and others, is surprising. Furthermore, distance is known to be a very poor predictor of magnetic field exposure, and therefore, results of this material based on calculated magnetic fields, when completed, should be much more informative" (p. 270, WHO 2007a).

living within 400 m of power lines at birth; modeling estimated that magnetic field levels above 1 mG could be predicted reliability only at residences within 400 m of a transmission line. Only 1% of children had a residence at birth within 400 m of a transmission line and only 0.07% had calculated exposures greater than 1 mG. Furthermore, nearly 25% of the residences within 400 m of a transmission line lacked data to calculate residential magnetic-field levels. An OR of 2.0 was calculated for the two cases of childhood leukemia and one control with calculated magnetic fields greater than 4 mG (95% CI=0.18 to 22.04); no dose-response relationship was apparent. As a result of small numbers and incomplete information, no strong conclusions can be drawn from this study. The authors stated that the study "slightly strengthens" the evidence for an association between magnetic fields and childhood leukemia.

Malagoli et al. (2010) was also included in the pooled analysis. This Italian study identified all childhood hematological malignancies diagnosed between 1967 and 2007 in two Italian municipalities (64 cases) and recruited four controls per case matched on sex, age, and municipality of residence.[14] Exposure was defined as having lived for at least 6 months prior to diagnosis at a residence with calculated power-line magnetic field levels above 1 mG or above 4 mG; magnetic-field levels were calculated using 2001 average line loading, rather than loading during the year of birth or diagnosis. Few children lived in a residence with power-line magnetic field levels above 1 mG (2 cases and 5 controls) or 4 mG (1 case and 2 controls); thus, estimated associations were unstable. The RR for leukemia and residence in an area with exposure $\geq$1 mG was 3.2 (6.7 adjusting for SES), but the estimate was statistically unstable (95% CI=0.4-23.4), and there was no indication of a dose-response relationship. Similar to Kroll et al. (2010), this study's strength is the lack of participation required, but it is limited by small numbers, the related imprecision, and the lack of an exposure-response relationship.

Three studies published since the WHO review confirmed an association with residential distance to power lines and childhood leukemia in countries with populations living in closer proximity to power lines (Feizi and Arabi, 2007 [< 500 m vs. >500 m]; Abdul Rahman et al., 2008 [< 200 m vs. >200 m]; Sohrabi et al., 2010 [<400 m vs. >400 m]). The consistency of the association between childhood leukemia and residential distance to power lines is noteworthy,

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[14] Hematological cancers include all types of leukemias, lymphomas, and Hodgkin's disease.

but these studies do not provide strong evidence of a relationship between magnetic fields and childhood leukemia because of their limited quality, e.g., lack of control for SES. While these three studies were excluded from the pooled analysis because they were hospital-based, Kheifets et al. (2010a) pooled data on distance and childhood leukemia from other studies and confirmed an elevated OR at distances less than 200 m. The association remains unexplained, however, and a recent study confirms that distance is a poor proxy for measurements of residential magnetic fields; Maslanyj et al. (2009) reported that only 13% of homes in a 100 m corridor of 220-440-kV power lines had a measured magnetic field level above 2 mG.

Other recent studies were not included in the pooled analysis because they reported on leukemia subgroups and magnetic fields. These studies reported that children with leukemia and estimates of average magnetic-field exposures greater than 3-4 mG had poorer survival (Foliart et al., 2006, 2007; Svendsen et al., 2007); children with Down syndrome and childhood leukemia were more likely to have spot measurements at the door of their home greater than 6 mG compared to children with Down syndrome only (Mejia-Arangure et al., 2007); and one genetic polymorphism related to DNA repair (but with no known relationship to leukemia) was reported to be more common among children with leukemia living close to an electrical installation compared to children with leukemia living at a distance (Yang et al., 2008). The results of these recent studies were limited by small numbers, incomplete adjustment for potential risk factors, and the lack of a biological explanation to explain the observed associations, among other methodological issues. Additional epidemiologic and biological research is required in these new fields of inquiry.

Another new field of inquiry is the relevance of pre- or post-conception EMF exposure of a parent to cancer in their offspring. Hug et al (2010) studied the pre-conception occupational exposures of parents of children with leukemia and compared them to the exposures of parents of healthy children. No association was found between childhood leukemia and magnetic-field exposure pre-conception in either parent. Another recent study reported an association between childhood leukemia and a paternal history of electrical work, but is limited because exposure is based solely on occupational title (Pearce et al., 2007).

Scientists have also pursued the influence of bias and confounding in recent years. Recent studies confirmed that control selection bias appears to be operating in case-control studies of childhood leukemia and magnetic fields, although the exact degree of its influence is still unknown (Mezei and Kheifets, 2006; Mezei et al., 2008a, 2008b). A study has also found that contact currents from residential grounding systems show characteristics of a confounding variable (Kavet and Hooper, 2009). Finally, a recent study confirmed that the time of day when magnetic-field measurement are made is not contributing to exposure misclassification; no difference in the magnitude or pattern of results was found for nighttime vs. 24-hour or 48-hour measurements, refuting the hypothesis that nighttime exposures are more strongly associated with childhood leukemia because magnetic fields might affect carcinogenesis through a melatonin-driven pathway (Schüz et al., 2007).

In summary, the studies conducted since the WHO review support an association with magnetic fields and childhood leukemia. In particular, scientific data published since the WHO review:

- confirms the rarity of living in close proximity to a power line or having estimated or measured exposures greater than 1 mG;
- confirms a positive association between average magnetic field levels greater than 3 mG and childhood leukemia, but the association cannot be distinguished from chance due to small numbers;
- confirms an association with residential proximity to power lines and childhood leukemia, but reports that distance is not a reliable predictor of in-home magnetic field levels; and,
- suggests that control selection bias may play some role in the observed association.

These findings do not alter previous conclusions that the epidemiologic evidence on magnetic fields and childhood leukemia is limited. Chance, confounding, and several sources of bias cannot be ruled out. Conclusions from reviews (Kheifets and Oksuzyan, 2008; Schüz and Ahlbom, 2008) and scientific organizations (SSI, 2007; SSI, 2008; HCN, 2009; SCENIHR, 2009) published since the WHO review support this conclusion.

Table 1. Relevant studies of childhood leukemia published after the WHO review

Author	Year	Study Title
Abdul Rahman et al.	2008	A case-control study on the association between environmental factors and the occurrence of acute leukemia among children in Klang Valley, Malaysia.
Fezei and Arabi	2007	Acute childhood leukemias and exposure to magnetic fields generated by high voltage overhead power lines – a risk factor in Iran
Foliart et al.	2006	Magnetic field exposure and long-term survival among children with leukaemia
Foliart et al.	2007	Magnetic field exposure and prognostic factors in childhood leukemia
Hug et al.	2010	Parental occupational exposure to extremely low frequency magnetic fields and childhood cancer: a German case-control study
Kavet and Hooper	2009	Residential magnetic fields and measures of neutral-to-earth voltage: variability within and between residences
Kheifets et al.	2010a	Pooled analysis of recent studies on magnetic fields and childhood leukaemia
Kroll et al.	2010	Childhood cancer and magnetic fields from high-voltage power lines in England and Wales: a case-control study
Malagoli et al.	2010	Risk of hematological malignancies associated with magnetic fields exposure from power lines: a case control study in two municipalities in northern Italy
Maslanyj et al.	2009	Power frequency magnetic fields and risk of childhood leukaemia: Misclassification of exposure from the use of the 'distance from power line' exposure surrogate
Mejia-Arangure et al.	2007	Magnetic fields and acute leukemia in children with Down syndrome
Mezei and Kheifets	2006	Selection bias and its implications for case-control studies: A case study of magnetic field exposure and childhood leukaemia
Mezei et al.	2008a	Assessment of selection bias in the Canadian case-control study of residential magnetic field exposure and childhood leukemia
Pearce et al.	2007	Paternal occupational exposure to electro-magnetic fields as a risk factor for cancer in children and young adults: A case-control study from the North of England
Schüz et al.	2007	Nighttime exposure to electromagnetic fields and childhood leukemia: An extended pooled analysis
Sohrabi et al.	2010	Living near overhead high voltage transmission power lines as a risk factor for childhood acute lymphoblastic leukemia: a case-control study
Svendson et al.	2007	Exposure to magnetic fields and survival after diagnosis of childhood leukemia: An extended pooled analysis
Yang et al.	2008	Case-only of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1, and XPD) and low frequency electromagnetic fields in childhood acute leukemia

Childhood brain cancer

What was previously known about childhood brain cancer and what did the WHO review conclude?

The research related to magnetic fields and childhood brain cancer has been less consistent than that observed for childhood leukemia. The WHO review recommended the following:

> *As with childhood leukaemia, a pooled analysis of childhood brain cancer studies should be very informative and is therefore recommended. A pooled analysis of this kind can inexpensively provide a greater and improved insight into the existing data, including the possibility of selection bias and, if the studies are sufficiently homogeneous, can offer the best estimate of risk (p. 18, WHO 2007a).*

What relevant studies have been published since the WHO review?

The relevant studies of childhood brain cancer and magnetic field exposure are listed in Table 2 below. In response to the WHO recommendation above, a meta-analysis (Mezei et al., 2008b) and a pooled analysis (Kheifets et al., 2010b) of studies on childhood brain tumors and residential magnetic field exposure were conducted. In the meta-analysis, thirteen epidemiologic studies were identified that used various proxies of magnetic field exposure (distance, wire codes, calculated magnetic fields, and measured magnetic fields). The combined effect estimate was close to 1.0 and not statistically significant, indicating no association between magnetic field exposure and childhood brain tumors. A sub-group of five studies, however, with information on childhood brain tumors and calculated or measured magnetic fields greater than 3-4 mG reported a combined OR that was elevated but not statistically significant (OR=1.68, 95% CI=0.83-3.43). The authors suggested two explanations for this elevated OR. First, they suggested that an increased risk of childhood brain tumors could not be excluded at high exposure levels (i.e., >3-4 mG). Second, they stated that the similarity of this result to the findings of the pooled analyses of childhood leukemia suggests that control selection bias is operating in both analyses. Similar to the meta-analysis, some categories of high exposure in the pooled analysis of studies with measured or calculated magnetic-field levels had an OR $\geq$1.0, but none of the findings were statistically significant and enhanced calculations showed inconsistency in the results of subgroup analyses and no dose-response pattern (Kheifets et al., 2010b). The main analysis reported no association between childhood brain cancer and magnetic-field exposure >4 mG, compared to magnetic-field exposure <1 mG (OR=1.14, 95% CI=0.61-2.13). Both the authors of the meta-analysis and the pooled analysis concluded that their results provide little evidence for an association between magnetic fields and childhood brain tumors.

The pooled analysis included two case-control studies published after the WHO 2007 review (Kroll et al., 2010; Saito et al., 2010). In their study of 55 cases of childhood brain cancer, Saito et al. (2010) reported that children with brain cancer were more likely to have average magnetic-field exposure levels greater than 4 mG, compared to children without brain cancer.[15] The association was based on three cases and one control; interpretations of the data were, therefore, limited by small numbers in the upper exposure category. The strength of this study is the exposure assessment; measurements were taken continuously over a weeklong period in the child's bedroom approximately 1 year after diagnosis. An important limitation, however, is the very poor participation rates among study subjects; poor participation rates introduce the possibility of selection bias, among other biases. As described above, Kroll et al. (2010) included 6,584 cases of brain cancer diagnosed over a 33-year period in the United Kingdom. No associations were reported in any analysis of brain cancer, including calculated magnetic fields ≥1-2 mG, 2-4 mG, and 4mG.

Studies of parental occupational magnetic field exposure and childhood brain tumors have produced inconsistent results. In a recent pooled analysis of two Canadian case-control studies, Li et al. (2009) calculated individual maternal occupational magnetic field exposure pre- and post-conception and analyzed these estimates in relation to brain cancer in offspring. Associations were reported between childhood brain cancer and average magnetic-field exposures greater than approximately 3 mG for exposure in the 2 years prior to conception and during conception; no associations were found using the cumulative and peak exposure metrics. More research is required in this area.

Recent studies provide some suggestion of an association between magnetic field exposures prior to diagnosis or *in utero* and the development of childhood brain cancer. The data receive little weight in an overall assessment, however, due to methodological shortcomings. The recent data do not alter the classification of the epidemiologic data in this field as inadequate.

[15] The unpublished results of this study were included in Mezei et al. (2008b).

Table 2. Relevant studies of childhood brain cancer published after the WHO review

Authors	Year	Study
Kheifets et al.	2010b	A pooled analysis of extremely low-frequency magnetic fields and childhood brain tumors
Kroll et al.	2010	Pooled analysis of recent studies on magnetic fields and childhood leukaemia
Li et al.	2009	Maternal occupational exposure to extremely low frequency magnetic fields and the risk of brain cancer in the offspring
Mezei et al.	2008b	Residential magnetic field exposure and childhood brain cancer: a meta-analysis
Saito et al.	2010	Power frequency magnetic fields and childhood brain tumors: A case-control study in Japan

Breast cancer

What was previously known about breast cancer and what did the WHO review conclude?

The WHO reviewed studies of breast cancer and residential magnetic field exposure, electric blanket usage, and occupational magnetic field exposure. These studies did not report consistent associations between magnetic field exposure and breast cancer, and the WHO concluded that, since the recent body of research was higher in quality compared with previous studies, it provided strong support to previous consensus statements that magnetic field exposure does not influence the risk of breast cancer.[16] The WHO recommended no further research with respect to breast cancer and magnetic field exposure.

What relevant studies have been published since the WHO review?

Two case-control studies (McElroy et al., 2007; Ray et al., 2007) and one cohort study (Johansen et al., 2007) have been published, all of which evaluated occupational magnetic field exposure.[17] In addition, a meta-analysis of 15 studies of breast cancer and occupational

[16] The WHO concluded, "Subsequent to the IARC monograph a number of reports have been published concerning the risk of female breast cancer in adults associated with ELF magnetic field exposure. These studies are larger than the previous ones and less susceptible to bias, and overall are negative. With these studies, the evidence for an association between ELF exposure and the risk of breast cancer is weakened considerably and does not support an association of this kind" (p. 307, WHO 2007a).

[17] In addition to the studies described in the text, another study was identified. Peplonska et al. (2007) is a case-control study of female breast cancer reporting associations for a wide range of occupations and industries. It is not considered in depth in this report because no qualitative or quantitative estimates of magnetic field exposure were made, beyond occupation and industry titles.

magnetic field exposure was published (Chen et al., 2010), which included one of the case-control studies (McElroy et al 2007).

Ray et al. (2007) was a nested case-control study in a cohort of approximately 250,000 textile workers in China followed for breast cancer incidence, and McElroy et al. (2007) evaluated occupational exposures to high, low, medium, or background EMF levels in a large number of breast cancer cases and controls. Neither study observed a significant association between breast cancer and higher estimated magnetic field exposure. A large cohort study of utility workers in Denmark also reported that women exposed to higher occupational magnetic field levels did not have higher rates of breast cancer (Johansen et al., 2007).

Chen et al. (2010) published a meta-analysis of all published case-control studies of female breast cancer and magnetic field exposure meeting defined inclusion criteria. Fifteen studies published between 2000 and 2009 were identified examining residential and occupational exposure and electric blanket usage. The authors crudely re-categorized data from the original studies to reflect a common comparison of <2 mG and >2mG and reported an overall OR of 0.988 (95% CI = 0.898–1.088). The advantage of this meta-analysis is its very large size. Its main limitation is that data from a wide range of exposure definitions and cut-points were combined.

These studies, particularly the large cohort of utility workers, add to growing support against a causal role for magnetic fields in breast cancer. This is consistent with the conclusion by the SCENIHR, which stated that an association is "unlikely" (p. 7, SCENIHR 2007).

Table 3. Relevant studies of breast cancer published after the WHO review

Authors	Year	Study
Chen et al.	2010	Extremely low-frequency electromagnetic fields exposure and female breast cancer risk: a meta-analysis based on 24,338 cases and 60,628 controls
Johansen et al.	2007	Risk for leukaemia and brain and breast cancer among Danish utility workers: A second follow-up
McElroy et al.	2007	Occupational exposure to electromagnetic field and breast cancer risk in a large, population-based, case-control study in the United States
Ray et al.	2007	Occupational exposures and breast cancer among women textile workers in Shanghai

Other adult cancers

What was previously known about other adult cancers and what did the WHO review conclude?

In general, scientific panels have concluded that there is not a strong or consistent relationship between other adult cancers (leukemia, lymphoma, or brain cancers) and exposure to magnetic fields; however, the possibility cannot be entirely ruled out because the findings have been inconsistent (IARC, 2002; WHO, 2007a). Stronger findings have not been observed in studies with better exposure assessment methods, which have led scientific panels to conclude that the evidence for an association is weak. The IARC classified the epidemiologic data with regard to adult leukemia, lymphoma, and brain cancer as “inadequate” in 2002, and the WHO confirmed this classification in 2007, with much of the remaining uncertainty attributed to limitations in exposure assessment methods.

Much of the research on EMF and adult cancers is related to occupational exposures, given the higher range of exposures encountered in the occupational environment. The main limitation of these studies, however, has been the methods used to assess exposure, with early studies relying simply on a person’s occupational title (often taken from a death certificate) and later studies linking a person’s full or partial occupational history to representative average exposures for each occupation (i.e., a job exposure matrix). The latter method, while advanced, still has some important limitations, as highlighted in a review summarizing an expert panel’s findings by Kheifets et al. (2009).[18] While a person’s occupation may provide some indication of the overall magnitude of their occupational magnetic field exposure, it does not take into account the possible variation in exposure due to different job tasks within occupational titles, the frequency and intensity of contact to relevant exposure sources, or variation by calendar time. Furthermore, since scientists do not know any mechanism by which magnetic fields could lead to cancer, an appropriate exposure metric is unknown.

[18] Kheifets et al. (2009) reports on the conclusions of an independent panel organized by the Energy Networks Association in the United Kingdom in 2006 to review the current status of the science on occupational EMF exposure and identify the highest priority research needs.

In order to reduce the remaining uncertainty about whether there is an association between magnetic fields and these cancers, researchers have recommended (1) meta-analyses to clarify inconsistencies and (2) better exposure assessment methods that incorporate a greater level of detail on tasks and exposure characteristics such as spark discharge, contact current, harmonics, etc. (WHO, 2007a; Kheifets et al., 2009).

Adult brain cancer

What was previously known about adult brain cancer and what did the WHO review conclude?

As described above, the WHO classified the epidemiologic data on adult brain cancer as inadequate and recommended (1) updating the existing cohorts of occupationally-exposed individuals in Europe and (2) pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association. [19]

What relevant studies have been published since the WHO review?

Epidemiologic studies published after 2006 on adult brain cancer and EMF exposure are listed in Table 6 and include two case-control studies, two cohort studies, and a meta-analysis, all of which are related to occupational magnetic field exposure.

In response to the WHO's recommendation, two cohorts of approximately 20,000 occupationally-exposed persons each were updated: a cohort of utility workers in Denmark and a cohort of railway workers in Switzerland (Johansen et al., 2007; Röösli et al, 2007a). In both cohorts, brain cancer rates were similar between jobs with high magnetic field exposure and jobs with lower exposures. A case-control study of gliomas was conducted in Australia and reported no associations with higher estimated magnetic field exposure, using a standard job-exposure matrix (Karipidis et al., 2007a). Forssén et al. (2006) performed a large registry-based case-control study of acoustic neuroma and reported no association between higher occupational magnetic field exposures and this benign and rare brain cancer type. Another large case-control study was recently published of gliomas and meningiomas in the United States (Coble et al.,

[19] The WHO concluded, "In the case of adult brain cancer and leukaemia, the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these disease remains inadequate" (p. 307, WHO 2007a).

2009). For the first time, the exposure metric in this study incorporated the frequency of exposure to EMF sources, as well as the distance people worked from these sources, on an individual basis. The authors also evaluated exposure metrics in addition to the time-weighted average (TWA) exposure (maximum exposed job, total years of exposure above 1.5 mG, cumulative lifetime exposure, and average lifetime exposure). No association was reported between any of these exposure metrics and brain cancer.

As recommended in the WHO review, a meta-analysis of occupationally-exposed cohorts was performed by Khefeits et al. (2008). All relevant publications of occupational EMF exposure and adult leukemia or brain cancer were collected and summary risk estimates were calculated using various schemes to weight and categorize the study data. The authors reported a small and statistically significant increase of leukemia and brain cancer in relation to the highest estimate of magnetic field exposure in the individual studies. Several findings, however, led the authors to conclude that magnetic field exposure is not responsible for the observed associations, including the lack of a consistent pattern among leukemia subtypes when the past and new meta-analyses were compared. In addition, for brain cancer, the recent meta-analysis reported a weaker association than the previous meta-analysis, whereas a stronger association would be expected since the quality of studies has increased over time. The authors concluded, "the lack of a clear pattern of EMF exposure and outcome risk does not support a hypothesis that these exposures are responsible for the observed excess risk" (p. 677).

Recent studies have reduced possible exposure misclassification by improving exposure assessment methods (i.e., the expanded job-exposure matrix in Coble et al., 2009) and attempted to clarify inconsistencies by updating studies and meta-analyzing data (Johansen et al., 2007; Röösli et al., 2007a; Kheifets et al., 2008); however, despite these advancements, no association has been observed. While an association still cannot be *entirely* ruled out because of the remaining deficiencies in exposure assessment methods, the current database of studies provides weak evidence of an association between magnetic fields and brain cancer.[20] The recent report by the SCENIHR described the data on brain cancers as “uncertain” (p. 43, SCENIHR 2009).

Table 4. Relevant studies of adult brain cancer published after WHO review

Authors	Year	Study
Coble et al.	2009	Occupational exposure to magnetic fields and the risk of brain tumors
Forssén et al.	2006	Occupational magnetic field exposure and the risk of acoustic neuroma
Johansen et al.	2007	Risk for leukaemia and brain and breast cancer among Danish utility workers: A second follow-up
Karipidis et al.	2007a	Occupational exposure to low frequency magnetic fields and the risk of low grade and high grade glioma
Kheifets et al.	2008	Occupational electromagnetic fields and leukemia and brain cancer: An update to two meta-analyses
Röösli et al.	2007a	Leukaemia, brain tumours and exposure to extremely low frequency magnetic fields: cohort study of Swiss railway employees

Adult leukemia and lymphoma

What was previously known about adult leukemia/lymphoma and what did the WHO review conclude?

The same issues discussed above with regard to adult brain cancer are relevant to research on adult leukemia and lymphoma. The WHO classified the epidemiologic evidence as “inadequate” and recommended updating the existing occupationally-exposed cohorts in Europe and the meta-analysis on occupational magnetic field exposure (p. 307, WHO 2007a).[21]

What relevant studies have been published since the WHO review?

Two cohorts of occupationally-exposed workers and a meta-analysis of occupational magnetic field exposure (all of which were described above) reported on the possible association of occupational magnetic field exposure and adult leukemia. Also, a case-control study described patterns of estimated residential magnetic field exposure and combined lymphoma and leukemia diagnostic categories (Lowenthal et al., 2007).

[20] A recent consensus statement by the National Cancer Institute’s Brain Tumor Epidemiology Consortium confirms this statement. They classified residential power frequency EMF in the category “probably not risk factors” and described the epidemiologic data as “unresolved” (p. 1958, Bondy et al., 2008).

[21] No specific conclusions were provided by the WHO with regard to lymphoma.

In the occupational cohort of Swiss railway workers, the authors noted a stronger association among occupations with higher estimates of magnetic field exposures, but the associations were not statistically significant (Röösli et al, 2007a). In the study of Danish utility workers, no increases in leukemia rates were observed in job titles that involved higher exposures to magnetic fields (Johansen et al., 2007). As described above, the updated meta-analysis by Kheifets et al. (2008) reported a weak association between estimated occupational magnetic field exposure and leukemia, but the authors felt that the data was not indicative of a true association.

Lowenthal et al. (2007) grouped cases in five diagnostic categories as lymphoproliferative disorders (LPD) (including acute lymphoblastic leukemia [ALL]) and cases in three diagnostic categories (including acute myeloid leukemia [AML] and other leukemias) as myeloproliferative disorders (MPD). These groups included both adults and children of all ages. The authors estimated exposure by obtaining a lifetime residential history and assessing distance of residences from 88-kV, 110-kV, and 220-kV power lines. They reported elevated, but not statistically significant, ORs for those who lived within 50 m of any of these power lines, and an indication of decreasing ORs with increasing distance. This study adds very little to the existing database of information on adult leukemia and residential exposure, however, because of fundamental limitations. For example, different cancer types were combined as were different ages of diagnosis. It is well known that cancer etiology varies by cancer type, cancer subtype, and diagnostic age.[22]

Very little is known about the etiology of Non-Hodgkin lymphoma (NHL), and few studies have been conducted in relation to magnetic field exposure. In one of the first studies to estimate cumulative occupational magnetic field exposure among NHL cases, Karipidis et al. (2007b) reported a statistically significant association between NHL and the highest category of exposure (OR=1.59, 95% CI=1.07-2.36). Overall, the study was well conducted, with its most significant limitation being the possibility of uncontrolled confounding. In another case-control study of NHL, Wong et al. (2010) identified 649 cases from a hospital in Shanghai. Among numerous questions in the interview, cases and controls were asked whether they had ever lived

[22] The recent meta-analysis by Kheifets et al. (2010) implies that data are available from Lowenthal et al. (2007) for childhood leukemia as a separate diagnostic category. This information is not publicly accessible, however.

within 100 m of a high-voltage power line. Results showed no association (i.e., no differences in residential history between cases and controls), but the strength of the study is limited by the use of distance as a proxy for exposure. Another recent case-control study did not report an association between NHL and self-report of occupations likely to involve EMF exposure derived from a JEM (Richardson et al., 2008).

Of note, the cohort of railway workers in Switzerland did not report an increase in NHL deaths among the more highly exposed workers (Röösli et al, 2007a). Further research in this area is required.

The recent literature also includes a novel study examining whether there are differences in the activity of the natural killer (NK) cell, a cytotoxic immune cell which attacks tumor cells and cells infected with viruses, among persons occupationally exposed to magnetic fields (Gobba et al., 2008). Higher measured magnetic field levels (i.e., >10 mG) during three complete work shifts were associated with reduced NK activity. Future studies are required to replicate this finding and understand the potential significance of NK activity in cancer.

A number of studies of adult leukemia have attempted to clarify inconsistencies by updating studies and meta-analyzing data (Johansen et al., 2007; Kheifets et al., 2008; Röösli et al, 2007a); however, despite these advancements, no clear or statistically significant association has been observed. While an association still cannot be *entirely* ruled out because of the remaining deficiencies in exposure assessment methods, the current database of studies provides weak evidence of an association between magnetic fields and leukemia. Preliminary results related to NHL have been published and require further investigation.

Table 5. Relevant studies of adult leukemia/lymphoma published after the WHO review

Authors	Year	Study
Gobba et al.	2008	Extremely low frequency-magnetic fields (ELF-EMF) occupational exposure and natural killer activity in peripheral blood lymphocytes
Johansen et al.	2007	Risk for leukaemia and brain and breast cancer among Danish utility workers: A second follow-up
Karipidis et al.	2007b	Occupational exposure to power frequency magnetic fields and risk of non-Hodgkin lymphoma
Kheifets et al.	2008	Occupational electromagnetic fields and leukemia and brain cancer: An update to two meta-analyses
Lowenthal et al.	2007	Residential exposure to electric power transmission lines and risk of lymphoproliferative and myeloproliferative disorders: a case-control study
Richardson et al.	2008	Occupational risk factors for non-Hodgkin's lymphoma: a population-based case-control study in northern Germany
Röösli et al.	2007a	Leukaemia, brain tumours and exposure to extremely low frequency magnetic fields: cohort study of Swiss railway employees
Wong et al.	2010	A hospital-based case-control study of non-Hodgkin lymphoid neoplasms in Shanghai: Analysis of personal characteristics, lifestyle, and environmental risk factors by subtypes of the WHO classification

In vivo studies of carcinogenesis

What was previously known about *in vivo* studies of carcinogenesis and what did the WHO review conclude?

It is standard procedure to conduct studies on laboratory animals to determine whether exposure to a specific agent leads to the development of cancer (USEPA, 2005). This approach is used because all known human carcinogens cause cancer in laboratory animals. In the field of ELF EMF research, a number of research laboratories have exposed rodents, including those with a particular genetic susceptibility to cancer, to high levels of magnetic fields over the course of the animals' lifetime and performed tissue evaluations to assess the incidence of cancer in many organs. In these studies, magnetic field exposure has been administered alone (to test for the ability of magnetic fields to act as a complete carcinogen), in combination with a known carcinogen (to test for a promotional or co-carcinogenetic effect), or in combination with a known carcinogen and a known promoter (to test for a co-promotional effect).

The WHO review described four large-scale, long-term studies of rodents exposed to magnetic fields over the course of their lifetime that did not report increases in any type of cancer (Mandeville et al., 1997; Yasui et al., 1997; Boorman et al., 1999a, 1999b; McCormick et al., 1999). No directly relevant animal model for childhood ALL existed at the time of the WHO report. Some animals, however, develop a type of lymphoma similar to childhood ALL and studies exposing predisposed transgenic mice to ELF magnetic fields did not report an increased incidence of lymphoma (Harris et al., 1998; McCormick et al., 1998; Sommer and Lerchel, 2004).

Studies investigating whether exposure to magnetic fields can promote cancer or act as a co-carcinogen used known cancer-causing agents, such as ionizing radiation, ultraviolet radiation, or other chemicals. No effects were observed for studies on chemically-induced preneoplastic liver lesions, leukemia or lymphoma, skin tumors, or brain tumors; however, the incidence of 7,12-dimethylbenz[a]anthracene (DMBA)-induced mammary tumors was increased with magnetic field exposure in a series of experiments in Germany (Löscher et al., 1993, 1994, 1997; Baum et al., 1995; Löscher and Mevissen, 1995; Mevissen et al., 1993a,1993b, 1996a, 1996b, 1998), suggesting that magnetic field exposure increased the proliferation of mammary tumor cells. These results were not replicated in a subsequent series of experiments in a laboratory in the United States (Anderson et al., 1999; Boorman et al.1999a, 1999b), possibly due to differences in experimental protocol and the species strain. In Fedrowitz et al. (2004), exposure enhanced mammary tumor development in one sub-strain (Fischer 344 rats), but not in another sub-strain that was obtained from the same breeder, which argues against a promotional effect of magnetic fields.[23]

Some studies have reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice [Lai and Singh, 2004]), although the results have not been replicated.

In summary, the WHO concluded the following with respect to *in vivo* research: "There is no evidence that ELF exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate" (p. 322, WHO 2007a). Recommendations for future research included the development of a rodent model for childhood ALL and the continued investigation of whether magnetic fields can act as a promoter or co-carcinogen.

[23] The WHO concluded with respect to the German studies of mammary carcinogenesis, "Inconsistent results were obtained that may be due in whole or in part to differences in experimental protocols, such as the use of specific substrains" (p. 321, WHO 2007a).

What relevant studies have been published since the WHO review?

In view of the available evidence that exposure to magnetic fields *alone* does not increase the occurrence of cancer, the literature published following the WHO review includes numerous *in vivo* studies testing different hypotheses of cancer promotion, including effects on brain cancer (Chung et al., 2008), breast cancer (Fedrowitz and Löscher, 2008), and lymphoma or leukemia (Bernard et al., 2008; Negishi et al., 2008; Chung et al., 2010), as referenced below. Studies of genotoxicity and oxidative damage *in vivo* have also been published since 2006, but these studies are just conceptually linked to carcinogenicity; this summary focuses on studies of tumor progression since these studies are the most relevant. In most of these studies, the animals were treated first with chemicals known to initiate the cancer process. Initiated animals are more likely to develop cancer, and a subsequent exposure, known as a promoter, is often needed for an initiated cell to reproduce into many cancer cells. Several studies treated the animals with the initiators ethylnitrosourea (ENU) (Chung et al., 2008), n-butylnitrosourea (BNU) (Bernard et al., 2008), and DMBA (Fedrowitz and Löscher, 2008; Negishi et al., 2008). In Chung et al. (2010), mice that are genetically predisposed to develop thymic lymphoblastic lymphoma were exposed to magnetic fields to assess whether such exposure increased incidence of lymphoma or reduced survival. An additional study by Sommer and Lerchel (2006) tested whether magnetic fields alone increased the incidence of lymphoma in mice virally predisposed to lymphoblastic lymphoma.

Chung et al. (2008) examined the possible role of 60-Hz magnetic fields in promoting brain tumors initiated by ENU injections *in utero*; the authors concluded that there was no evidence that exposure to 60-Hz magnetic fields up to 5,000 mG promoted tumor development in this study.

Fedrowitz and Löscher (2008) is the most recent study from the German laboratory that previously reported increases in DMBA-induced mammary tumors with high magnetic field exposure. In this recent study, the researchers exposed DMBA-treated Fischer 344 rats (the strain of inbred rats used in previous experiments) to either high levels of magnetic fields (1,000 mG) or no exposure for 26 weeks and reported that the incidence of mammary tumors was significantly elevated in the group exposed to magnetic fields (Fedrowitz and Löscher, 2008).

No independent replication of this experiment has yet occurred and questions still remain about the effect of experimental protocol and species strain.

Sommer and Lerchl (2006) is a follow-up to an earlier study (Sommer and Lerchl, 2004) that reported no increases in lymphoma among predisposed animals chronically exposed to magnetic fields (up to 1,000 mG for 24 hours per day for 32 weeks). Sommer and Lerchl (2006) increased magnetic field exposure to 10,000 mG and exposed some of the animals only during the night to test the hypothesis that nighttime exposure may have a stronger effect than continuous exposure. Magnetic fields did not influence body weight, time to tumor, cancer incidence, or survival time in this study. In another study of lymphatic system cancers, researchers treated newborn mice with DMBA and magnetic fields up to 3,500 mG (Negishi et al., 2008). The authors reported that the percentage of mice with lymphoma or lymphatic leukemia was not higher in magnetic field-exposed groups, compared to the sham-exposed group.

In another study of lymphoid leukemia, Chung et al (2010) evaluated the effect of magnetic fields on AKR mice, which are genetically predisposed to thymic lymphoblastic lymphoma. Exposures ranged from 50-500 mG for 21 hours per day for 40 weeks, and cancer incidence was compared with a sham-exposed control group. Potential confounding variables (such as temperature, humidity, and magnetic-field variations) were monitored daily. The experiment was performed blind to ensure that biases were not introduced by investigator knowledge of exposure conditions. Magnetic-field exposures were not associated with changes in body weight, survival time, or the incidence of lymphoma compared to sham-treated controls. Exposure also did not affect components of the blood, micronuclei formation, or gene expression in the thymus.

A study by Bernard et al. (2008) provides a significant development, in that it is the first study to use an animal model of ALL, the most common leukemia type in children. All rats were exposed to BNU to initiate the leukemogenic process, and a sub-group of rats was exposed to magnetic fields of 1,000 mG for 18 hours per day for 52 weeks. No difference in leukemia incidence was observed between the BNU-treated group exposed to magnetic fields and the BNU-treated unexposed group. This study supports the hypothesis that magnetic fields do not affect the development of ALL and provides additional support to the conclusion that experimental data is not supportive for a role of magnetic fields in the incidence of childhood leukemia. The researchers followed guidelines for the experimentation and care of laboratory animals and conducted the analyses blind to the treatment group. Experience with this strain of rat is limited, however, so it is unclear whether the results are more or less reliable than other animal models; replication is required.

Thus, aside from the most recent replication of enhanced mammary carcinogenesis in a specific sub-strain of rats in a German laboratory, recent studies provide further evidence against a role for magnetic fields as a co-carcinogen. These studies strengthen the conclusion that there is inadequate evidence of carcinogenicity from *in vivo* research, although independent confirmation of the German results is of high priority.

Table 6. Relevant *in vivo* studies of carcinogenesis published after the WHO review

Authors	Year	Study
Bernard et al.	2008	Assessing the potential Leukemogenic effects of 50 Hz and their harmonics using an animal leukemia model
Chung et al.	2008	Lack of a co-promotion effect of 60 Hz rotating magnetic fields on n-ethyl-n-nitrosourea induced neurogenic tumors in F344 rats
Chung et al.	2010	Lack of co-promotion effect of 60 Hz circularly polarized magnetic fields on spontaneous development of lymphoma in AKR mice
Fedrowitz and Löscher	2008	Exposure of Fischer 344 rats to a weak power frequency magnetic field facilitates mammary tumorigenesis in the DMBA model of breast cancer
Negishi et al.	2008	Lack of promotion effects of 50 Hz magnetic fields on 7,12-dimethylbenz(a)anthracene-induced malignant lymphoma/lymphatic leukemia in mice
Sommer and Lerchl	2006	50 Hz magnetic fields of 1 mT do not promote lymphoma development in AKR/J mice

In vitro studies of carcinogenesis

What did the WHO and other scientific panels conclude with respect to *in vitro* studies of carcinogenesis?

In vitro studies are widely used to investigate the mechanisms for effects that are observed in humans and animals. The relative value of *in vitro* tests to human health risk assessment, however, is much less than that of *in vivo* and epidemiology studies. Responses of cells and tissues outside the body may not always reflect the response of those same cells if maintained in a living system, so the relevance of *in vitro* studies cannot be assumed (IARC, 1992).

The IARC and other scientific review panels that systematically evaluated *in vitro* studies concluded that there is no clear evidence indicating how ELF magnetic fields could adversely affect biological processes in cells (IARC, 2002; ICNIRP, 2003; NRPB, 2004). The WHO panel reviewed the *in vitro* research published since the time of these reviews and reached the same conclusion. The WHO noted that previous studies have not indicated a genotoxic effect of ELF magnetic fields on mammalian cells, however a series of experiments reported DNA damage in human fibroblasts exposed intermittently to 50 Hz magnetic fields (Ivancsits et al., 2002a, 2002b; Ivancsits et al., 2003a, 2003b). These findings have not been replicated by other laboratories (Scarfi et al., 2005), and the WHO recommended continued research in this area. Recently, investigators reported that they were unable to confirm any evidence for damage to DNA in cells exposed to magnetic fields over a range of exposures from 50 to 10,000 mG (Burdak-Rothkamm et al., 2009). Research in the field of *in vitro* genotoxicity of magnetic fields combined with known DNA-damaging agents is also recommended, following suggestive findings from several laboratories. As noted by the SSI, however, the levels at which these effects were observed are much higher than the levels to which we are exposed in our everyday environments and are, therefore, not directly relevant to questions about low-level, chronic exposures (SSI, 2007). *In vitro* studies investigating other possible mechanisms, including gene activation, cell proliferation, apoptosis, calcium signaling, intercellular communication, heat shock protein expression, and malignant transformation have produced "inconsistent and inconclusive" results, according to the WHO (p. 347, WHO, 2007a).

Reproductive and developmental effects

What was previously known about reproductive and developmental effects and what did the WHO review conclude?

Two studies received considerable attention because of a reported association between peak magnetic field exposure greater than approximately 16 mG and miscarriage: a prospective cohort study of women in early pregnancy (Li et al., 2002) and a nested case-control study of women who miscarried compared to their late-pregnancy counterparts (Lee et al., 2002).

These two studies improved on the existing body of literature because average exposure was assessed using 24-hour personal magnetic field measurements (early studies on miscarriage were limited because they used surrogate measures of exposure, including visual display terminal use, electric blanket use, or wire code data). Following the publication of these two studies, however, a hypothesis was put forth that the observed association may be the result of behavioral differences between women with "healthy" pregnancies that went to term (less physically active) and women who miscarried (more physically active) (Savitz, 2002). It was proposed that physical activity is associated with an increased opportunity for peak magnetic field exposures, and the nausea experienced in early, healthy pregnancies and the cumbersomeness of late, healthy pregnancies would reduce physical activity levels, thereby decreasing the opportunity for exposure to peak magnetic fields. Furthermore, nearly half of the miscarriages reported in the cohort by Li et al. had magnetic field measurements taken after miscarriage occurred, when changes in physical activity may have already occurred, and all measurements in Lee et al. occurred post-miscarriage.

The scientific panels that have considered these two studies concluded that the possibility of this bias precludes making any conclusions about the effect of magnetic fields on miscarriage (NRPB, 2004; FPTRPC, 2005; WHO, 2007a). The WHO concluded, "There is some evidence for increased risk of miscarriage associated with measured maternal magnetic field exposure, but this evidence is inadequate" (p. 254, WHO 2007a). The WHO stated that, given the potentially high public health impact of such an association, further epidemiologic research is recommended.

What relevant studies have been published since the WHO review?

No new original studies on magnetic field exposure and miscarriage have been conducted; however, recent methodological studies evaluated the likelihood that the observed association was due to bias. Epidemiologic and *in vivo* studies of ELF EMF and reproductive and developmental effects are summarized in Table 7.

It is not possible to directly "test" for the effects of this bias in the original studies, but two recent analyses examined whether reduced physical activity was associated with a lower probability of encountering peak magnetic fields (Mezei et al., 2006; Savitz et al., 2006). In a 7-day study of personal magnetic field measurements in 100 pregnant women, Savitz et al. (2006)

reported that active pregnant women were more likely to encounter peak magnetic fields. In addition, an analysis by Mezei et al. (2006) of pre-existing databases of magnetic field measurements among pregnant and non-pregnant women found that increased activity levels were associated with peak magnetic fields. These findings are broadly supportive of the hypothesis that reduced activity among women in early pregnancies because of nausea and in later pregnancies because of cumbersomeness may explain the observed association between peak magnetic fields and miscarriage. As noted in a recent commentary on this issue, however, the possibility that there is a relationship between peak magnetic field exposure and miscarriage still cannot be excluded and further research that accounts for this possible bias should be conducted (Neutra and Li, 2008; Mezei et al., 2006). There remains no biological basis, however, to indicate that magnetic field exposure increases the risk of miscarriage (WHO, 2007a).

Two additional studies were published related to developmental outcomes and growth. Fadel et al. (2006) conducted a cross-sectional study in Egypt of 390 children 0-12 years of age living in an area within 50 m of an electrical power line and 390 children 0-12 years of age living in a region with no power lines in close proximity. Measurements were taken as proxies of growth retardation, and radiological assessments were performed on carpal bones. The authors reported that children living in the region near power lines had a statistically significant lower weight at birth and a reduced head and chest circumference and height at all ages. The authors concluded that "exposure to low frequency electromagnetic fields emerged [*sic*] from high voltage electric power lines increases the incidence of growth retardation among children" (p. 211). This conclusion, however, fails to adequately take into account the many limitations of their cross-sectional analysis (namely, inadequate control for the possible confounding effects of nutritional and SES status) and the pre-existing body of literature, which does not support such an association (WHO, 2007a). Public health statistics indicate that detrimental birth outcomes, including pre-term birth, low birth weight, or small for gestational age, occur more frequently in populations of lower SES (HHS, 2004); thus, analyses of adverse birth outcomes should be adjusted for these factors.

Auger et al. (2010) studied whether maternal residence near transmission lines was associated with adverse birth outcomes, adjusting for socioeconomic factors, among all live births in

Montreal and Canada between 1990 and 2004. Maternal residential distances were measured within 400 m of nearby transmission lines for over 700,000 live births, and the proportion of adverse events was compared between mothers living >400 m and within 400 m, adjusting for mother's age, education, household income, and other potential confounding factors. The analysis found no association with distances in 50 m increments for any of the outcomes: pre-term birth, low birth weight, small for gestational age, or proportion of male births. The use of distance as a surrogate of EMF exposure limits the value of this study.

Among recent *in vivo* reproductive studies of ELF EMF, seven examined effects on the female reproductive system (Aksen et al., 2006; Roushanger and Soleimani Rad, 2007; Al-Akhras et al., 2008; Anselmo et al., 2009; Aydin et al., 2009; De Bruyen and De Jager, 2010; Rajaei et al., 2010). In most of these studies, the researchers did not clarify whether they incorporated blinding to minimize bias and failed to indicate whether they used appropriate statistical analyses (e.g., use of the litter, rather than the pup, as the unit for analysis since littermates are known to be more similar to each other than offspring derived from separate litters). Other limitations included the use of animals with extremely deficient diets and the use of only one magnetic field level so that dose-response could not be assessed. Although some of the studies reported biological changes, none of the studies reported strong evidence of adverse reproductive outcomes.

Studies of reproductive effects on males were conducted across a broad range of exposures and duration and reported various responses of the male reproductive and accessory sex organs, as well as alterations in sex hormone concentrations (Akdag et al., 2006; Al-Akhras et al., 2006; Mostafa et al., 2006; Saad El-Din et al., 2006; Erpek et al., 2007; Farkhad et al., 2007; Khaki et al., 2008; Geng et al., 2009; Kim et al., 2009; Rajeai et al., 2009; Bernabo et al., 2010; De Bruyn and de Jager, 2010). These studies also suffered from flaws that affect validity; most failed to report methods to ensure blinding, few studies examined dose-response patterns, and some used only short-term exposures to extremely high fields. In a study involving exposure to two generations of mice, De Bruyn and de Jager (2010) reported decreases in sperm motility; however, these did not translate to functional decrements in reproductive capacity. Although these studies suggest possible male reproductive system alterations from EMF exposure, the evidence is not strong and no firm conclusions can be drawn due to the conflicting nature of the reported responses.

Studies also were conducted of exposure during pregnancy (Anselmo et al., 2006, 2008; Okudan et al., 2006; Yao et al., 2007; Dundar et al., 2009; De Bruyn and De Jager, 2010). The studies entailed high and short-term exposures and had specific and narrows goals, e.g., evaluating changes in the eye or bone. Of note, De Bruyn and De Jager (2010) continuously exposed mice to a randomly varying 50-Hz magnetic field between 5 mG and 770 mG from conception through two generations of offspring in a double-blind study. Both the treated and sham-exposed groups consisted of ten pairs of mice in each generation. No effects of exposure were observed on mean gestational and generational days, mean litter size, or total number of stillborn pups. Like the other studies, however, the authors did not indicate whether appropriate statistical methods were used to control for potential litter effects.

Thus, the recent epidemiologic research does not provide sufficient evidence to alter the conclusion that the evidence for reproductive or developmental effects is inadequate. Recent studies of animals *in vivo* also do not provide evidence to change the conclusions expressed by the WHO. Various deficiencies in the methods and reporting of these studies limit their use in health risk assessment.

Table 7. Relevant studies of reproductive and developmental effects published after the WHO review

Authors	Year	Study
Akdag et al.	2006	Effect of ELF magnetic fields on lipid peroxidation, sperm count, p53 and trace elements
Aksen et al.	2006	Effect of 50-Hz 1-mT magnetic field on the uterus and ovaries of rats (electron microscopy evaluation)
Al-Akhras et al.	2006	Influence of 50 Hz magnetic field on sex hormones and other fertility parameters of adult male rats
Al-Akhras et al.	2008	Influence of 50 Hz magnetic field on sex hormones and body, uterine, and ovarian weights of adult female rats
Anselmo et al.	2006	Influence of a 60 Hz, 3 microT, electromagnetic field on the reflex maturation of Wistar rats offspring from mothers fed a regional basic diet during pregnancy
Anselmo et al.	2008	Influence of a 60 Hz, microT, electromagnetic field on the somatic maturation of wistar rat offspring fed a regional basic diet during pregnancy
Anselmo et al.	2009	Effects of the electromagnetic field, 60 Hz, 3 microT, on the hormonal and metabolic regulation of undernourished pregnant rats

Authors	Year	Study
Auger et al.	2010	The relationship between residential proximity to extremely low frequency power transmission lines and adverse birth outcomes
Aydin et al.	2009	Evaluation of hormonal change, biochemical parameters, and histopathological status of uterus in rats exposed to 50-Hz electromagnetic field
Bernabó et al.	2010	Extremely low frequency electromagnetic field exposure affects fertilization outcome in swine animal model
De Bruyen and De Jager	2010	Effect of long-term exposure to a randomly varied 50 Hz power frequency magnetic field on the fertility of the mouse
Dundar et al.	2009	The effect of the prenatal and post-natal long-term exposure to 50 Hz electric field on growth, pubertal development and IGF-1 levels in female Wistar rats
Erpek et al.	2007	The effects of low frequency electric field in rat testis
Fadel et al.	2006	Growth assessment of children exposed to low frequency electromagnetic fields at the Abu Sultan area in Ismailia (Egypt)
Farkhad et al.	2007	Effects of extremely low frequency electromagnetic field on testes in guinea pig
Geng et al.	2009	Effects of electromagnetic field of UHV transmission lines exposure on testis tissue in mice
Khaki et al.	2008	The effects of electromagnetic field on the microstructure of seminal vesicles in rat: a light and transmission electron microscope study
Kim et al.	2009	Effects of 60 Hz 14 μT magnetic field on the apoptosis of testicular germ cell in mice
Mezei et al.	2006	Analyses of magnetic-field peak-exposure summary measures
Mostafa et al	2006	Sex hormone status in male rats after exposure to 50 Hz, mT magnetic field
Neutra and Li	2008	Letter to the Editor – Magnetic fields and miscarriage: A commentary on Mezei et al., JESEE 2006
Okudan et al.	2006	DEXA analysis on the bones of rats exposed in utero and neonatally to static and 50 Hz electric fields
Rajaei et al.	2009	Effects of extremely low-frequency magnetic field on mouse epididymis and deferens ducts
Rajaei et al.	2010	Effects of extremely low-frequency electromagnetic field on fertility and heights of epithelial cells in pre-implantation stage, endometrium and fallopian tube in mice
Roushanger and Soleimani Rad	2007	Ultrastructural alterations an occurrence of apoptosis in developing follicles exposed to low frequency electromagnetic field in rat ovary
Saad El-Din et al.	2006	Evaluation of the structural changes of extremely low frequency electromagnetic fields on brain and testes of adult male mice
Savitz et al.	2006	Physical activity and magnetic field exposure in pregnancy
Yao et al.	2007	Absence of effect of power-frequency magnetic fields on exposure on mouse embryonic lens development

Neurodegenerative disease

What was previously known about neurodegenerative disease and what did the WHO review conclude?

Research into the possible effect of magnetic fields on the development of neurodegenerative diseases began in 1995, and the majority of research since then has focused on Alzheimer's disease and a specific type of motor neuron disease called amyotrophic lateral sclerosis (ALS), which is also known as Lou Gehrig's disease. The inconsistency of early Alzheimer's disease studies prompted the NRPB to conclude that there is "only weak evidence to suggest that it [ELF magnetic fields] could cause Alzheimer's disease" (p. 20, NRPB, 2001). Early studies on ALS, which had no obvious biases and were well conducted, reported an association between ALS mortality and estimated occupational magnetic field exposure. The review panels, however, were hesitant to conclude that the associations provided strong support for a causal relationship. Rather, they felt that an alternative explanation (i.e., electric shocks received at work) may be the source of the observed association.

The majority of the more recent studies discussed by the WHO reported statistically significant associations between occupational magnetic field exposure and mortality from Alzheimer's disease and ALS, although the design and methods of these studies were relatively weak (e.g., disease status was based on death certificate data, exposure was based on incomplete occupational information from census data, and there was no control for confounding factors). Furthermore, there was no biological data to support an association between magnetic fields and neurodegenerative diseases. The WHO panel concluded that there is "inadequate" data in support of an association between magnetic fields and Alzheimer's disease or ALS.[24] The panel recommended more research in this area using better methods; in particular, studies that enrolled incident Alzheimer's disease cases (rather than ascertaining cases from death certificates) and studies that estimated electrical shock history in ALS cases were recommended.

[24] After considering the entire body of literature and its limitations, the WHO report concluded, "When evaluated across all the studies, there is only very limited evidence of an association between estimated ELF exposure and [Alzheimer's] disease risk" (p. 194, WHO 2007a).

What relevant studies have been published since the WHO review?

Six studies have been published since the WHO review. Two occupational cohorts were followed for neurodegenerative diseases—approximately 20,000 railroad workers in Switzerland (Röösli et al., 2007b) and over 80,000 electrical and generation workers in the United Kingdom (Sorahan and Kheifets, 2007). Two case-control studies collected incident cases of Alzheimer's disease and estimated occupational magnetic field exposure (Davanipour et al., 2007; Seidler et al., 2007), and a meta-analysis was conducted of occupational magnetic field exposure and Alzheimer's disease studies (García et al., 2008). The first study of non-occupational exposure followed the Swiss population to evaluate associations with residential distance to power lines and death due to neurodegenerative diseases (Huss et al., 2009).

García et al. (2008) identified 14 epidemiologic studies with information on Alzheimer's disease and occupational EMF exposure; the WHO considered the majority of these studies in their 2007 review. A statistically significant association between Alzheimer's disease and occupational EMF exposure was observed for both case-control and cohort studies (OR =2.03, 95% CI=1.38-3.00 and RR =1.62, 95% CI=1.16-2.27, respectively), although the results from the individual studies were so different that the authors cautioned against the validity of these combined results. While some subgroup analyses had statistically significant increased risks and were not significantly heterogeneous between studies, the findings were contradictory between study design types (e.g., elevated pooled risk estimates were reported for *men* in cohort studies and elevated pooled risk estimates were reported for *women* in case-control studies). The authors concluded that their results suggest an association between Alzheimer's disease and occupational magnetic field exposure, but noted the numerous limitations associated with these studies, including the difficulty of assessing EMF exposure during the appropriate time period, case ascertainment issues due to diagnostic difficulties, and differences in control selection. They recommended further research that uses more advanced methods.

An earlier publication by the same group of investigators documented the relatively poor quality of the studies included in the meta-analysis. Santibáñez et al. (2007) evaluated studies related to occupational exposure and Alzheimer's disease, which included seven of the studies in the García et al. meta-analysis. Two epidemiologists blindly evaluated each of these studies using a questionnaire to assess the possibility of a number of biases, with a score assigned to each study that represented the percentage of possible points that the study obtained (range 0-100%). Only one of the seven studies obtained a score above 50% (a retrospective cohort study by Savitz et al. in 1998), and disease and exposure misclassifications were the most prevalent biases.

Davanipour et al. (2007) extended an earlier hypothesis-generating study by Sobel et al. (1996) by collecting cases from eight California Alzheimer's Disease Diagnostic and Treatment Centers. Self-reported primary occupation was collected from patients with verified diagnoses of Alzheimer's disease and compared to occupational information collected from persons diagnosed with other dementia-related problems at the Centers. The results of this study were consistent with the previous studies by Sobel et al.; cases were approximately twice as likely to be classified as having medium/high magnetic field exposures, compared with controls. The strengths of this study included its large size and self-reported occupational information. The main limitation of this study was that the exposure assessment only considered a person's primary occupation, classified as low, medium, or high magnetic field exposure. The WHO noted limitations of the 1996 publication that are relevant to this publication as well, including the use of controls with dementia (which some studies report have an increased risk of Alzheimer's disease) and the classification of seamstresses, dressmakers, and tailors as "high exposure" occupations, which drives the increase in risk.

Seidler et al. (2007) conducted a similar case-control study in Germany, except cases included all types of dementia (55% of which had Alzheimer's disease). Cumulative magnetic field exposure was estimated from occupational histories taken from proxy respondents, and no difference was reported between cases of dementia or probable Alzheimer's disease and controls, although an association was reported among electrical and electronics workers. The authors reported that exposure misclassification was likely to be a significant problem and concluded that their results indicate a strong effect of low-dose EMF is "rather improbable" (p. 114).

Sorahan and Kheifets (2007) followed a cohort of approximately 84,000 electrical and generation workers in the United Kingdom for deaths attributed to neurodegenerative disease on death certificates. Cumulative magnetic field exposure was calculated for each worker, using job and facility information. The authors reported that the cohort did not have a significantly greater number of deaths due to Alzheimer's disease or motor neuron disease compared to the general population in the United Kingdom. They also reported that persons with higher estimated magnetic field exposures did not have a consistent excess of death due to Alzheimer's disease or motor neuron disease compared to persons with lower estimated magnetic field exposure. A statistically significant excess of deaths due to Parkinson's disease was observed in the cohort, although there was no association between calculated magnetic field exposure and Parkinson's disease. The authors concluded "our results provide no convincing evidence for an association between occupational exposure to magnetic fields and neurodegenerative disease" (p. 14). This result is consistent with two other Alzheimer's mortality follow-up studies of electric utility workers in the United States (Savitz et al., 1998) and Denmark (Johansen and Olsen, 1998). The findings may be limited by the use of death certificate data, but are strengthened by the detailed exposure assessment.

Death from several neurodegenerative conditions was also evaluated in the cohort of more than 20,000 Swiss railway workers described above (Röösli et al., 2007b). Magnetic field exposure was characterized by specific job titles as recorded in employment records; stationmasters were considered to be in the lowest exposure category and were, therefore, used as the reference group. Train drivers were considered to have the highest exposure, and shunting yard engineers and train attendants were considered to have exposure intermediate to stationmasters and train drivers. Cumulative magnetic field exposure was also estimated for each occupation using on-site measurements and modeling of past exposures. The authors reported an excess of senile dementia disease among train drivers, compared to station masters, however, the difference was not statistically significant. The association was larger when restricted to Alzheimer's disease, but was still not statistically significant (hazard ratio [HR]=3.15, 95% CI=0.90-11.04); an association was observed between cumulative magnetic field exposure and Alzheimer's disease/senile dementia. No elevation in mortality was reported for multiple sclerosis, Parkinson's disease, or ALS among train drivers, shunting yard engineers, or train attendants, compared with stationmasters, nor were more deaths from these causes observed for higher estimated magnetic field exposures. Similar to another recent Swedish study (Feychting et al., 2003), the authors reported that recent exposure was more strongly associated with Alzheimer's disease than past exposure.

There are several strengths of this study relative to the existing body of data. First, there is little turnover among Swiss railway employees, which means that study participants are enrolled in the cohort and possibly exposed for long periods of time. The wide variation in exposure levels between different occupations in the same industry allows for comparison of similar workers with different levels of exposure. Another advantage is that the company kept detailed registers of employees, which means there is less potential for bias in the enumeration of the cohort and reconstruction of exposures. Finally, the authors reported that exposures to chemicals or electric shocks, which often occur in other occupational settings (for example, in electric utility workers or welders), are rare in this occupation.

Another cohort study conducted in Switzerland linked all persons older than 30 years of age at the 2000 census with a national database of death certificates from 2000 through 2005 (Huss et al., 2009). Residential location was also extracted from 1990 and 2000 census data and the closest distance of a person's home in 2000 to nearby 220-380 kV transmission lines was calculated. The authors reported that persons living within 50 m of these high-voltage transmission lines were more likely to have died from Alzheimer's disease, compared to those living farther than 600 m, although chance could not be ruled out as an explanation (HR=1.24, 95% CI=0.80-1.92). The association was stronger for persons that lived at the residence for at least 15 years (HR=2.00, 95% CI=1.21-3.33). Associations of similar magnitude were reported for senile dementia and residence within 50 m of a high-voltage line. No associations were reported beyond 50 m for Alzheimer's disease or senile dementia, and no associations were reported at any distance for Parkinson's disease, ALS, or multiple sclerosis.

The study's main limitation is the use of residential distance from transmission lines as a proxy for magnetic-field exposure (Maslanyj et al., 2009). It is also limited by the use of death certificate data, which are known to under-report Alzheimer's disease, and the lack of a full residential and occupational history. Furthermore, while the underlying cohort was very large, relatively few cases of Alzheimer's disease lived within 50 m of a high-voltage transmission line—20 cases total and 15 cases who lived at the residence for at least 15 years. This means that misclassification of a small number of cases could have a large impact on the risk estimate.

Another recent study used Sweden's large twin registry to assess whether occupational exposure to EMF was associated with dementia or Alzheimer's disease (Andel et al., 2010). Twins over the age of 65 were interviewed by phone to screen for possible dementia, and cases were identified for further evaluation to determine whether they had dementia or Alzheimer's disease (cases); study subjects without either diagnosis were considered the control group. Study subjects or their proxies were asked to identify their major lifetime occupation, which was linked with a job-exposure matrix to categorize EMF exposure into three, broad categories. In the overall twin population, EMF exposure was not associated with either dementia or Alzheimer's disease. An association with EMF was observed for those employed in manual labor and for those with early onset dementia (≤ 75 years at diagnosis), but not Alzheimer's disease. This study's strength is the recruitment of living cases; however, small numbers limited the subgroup analyses and robust associations were not found.

In summary, two cohort studies of the Swiss population of relatively high quality were followed for death due to neurodegenerative disease. Röösli et al. (2007b) reported an association between Alzheimer's disease or senile dementia and occupational magnetic-field exposure, while Huss et al. (2009) reported an association between Alzheimer's disease or senile dementia and living within 50 m of a high-voltage transmission line for at least 15 years. Neither study reported an association with any other neurodegenerative disease, including ALS. A cohort of utility workers, however, did not confirm an association with Alzheimer's disease mortality and magnetic field exposure. The meta-analysis and supporting evaluation of study quality by García, Santibáñez, and colleagues confirmed that the associations reported in previous occupational studies are highly inconsistent and the studies have many limitations (Santibáñez et al., 2007; García et al., 2008).

The main limitations of these studies include the difficulty in diagnosing Alzheimer's disease; the difficulty of identifying a relevant exposure window given the long and nebulous course of this disease; the difficulty of estimating magnetic field exposure prior to the appearance of the disease; the under-reporting of Alzheimer's disease on death certificates; crude exposure evaluations that are often based on the recollection of occupational histories by friends and family given the cognitive impairment of the study participants; and the lack of consideration of both residential and occupational exposures or confounding variables.

The recent epidemiologic studies do not alter the conclusion that there is inadequate data on Alzheimer's disease or ALS. While a good number of studies have been published since the WHO review, little progress has been made on clarifying these associations. Further research is still required, particularly on electrical occupations and ALS (Kheifets et al., 2008). There is currently no body of *in vivo* research to suggest an effect and two studies reported no effect of magnetic fields on ALS progression (Seyhan and Canseven, 2006; Poulletier de Gannes et al., 2009). These conclusions are consistent with the recent review by the SCENIHR (SCENIHR, 2009).

Table 8. Relevant studies of neurodegenerative disease published after the WHO review

Authors	Year	Study
Andel et al.	2010	Work-related exposure to extremely low-frequency magnetic fields and dementia: Results from the population-based study of dementia in Swedish twins
Davanipour et al.	2007	A case-control study of occupational magnetic field exposure and Alzheimer's disease: results from the California Alzheimer's Disease Diagnosis and Treatment Centers
García, et al.	2008	Occupational exposure to extremely low frequency electric and magnetic fields and Alzheimer disease: a meta-analysis
Huss, et al.	2009	Residence near power lines and mortality from neurodegenerative diseases: longitudinal study of the Swiss population
Poulletier de Gannes et al.	2009	Amyotrophic lateral sclerosis (ALS) and extremely-low frequency (ELF) magnetic fields: a study in the SOD-1 transgenic mouse model
Röösli, et al.	2007b	Mortality from neurodegenerative disease and exposure to extremely low-frequency magnetic fields: 31 years of observations on Swiss railway employees
Santibáñez, et al.	2007	Occupational risk factors in Alzheimer's disease: a review assessing the quality of published epidemiological studies
Seidler et al.	2007	Occupational exposure to low frequency magnetic fields and dementia: a case-control study
Seyhan and Canseven	2006	In vivo effects of ELF MFs on collagen synthesis, free radical processes, natural antioxidant system, respiratory burst system, immune system activities, and electrolytes in the skin, plasma, spleen, lung, kidney, and brain tissues
Sorahan and Kheifets	2007	Mortality from Alzheimer's, motor neurone and Parkinson's disease in relation to magnetic field exposure: findings from the study of UK electricity generation and transmission workers, 1973-2004

3 Other Areas of Research

Pacemakers and implanted cardiac devices

The sensing system of pacemakers and other implanted cardiac devices (ICD) is designed to be responsive to the heart's electrical signal. For this reason, other electrical signals potentially can interfere with the normal functioning of pacemakers and ICDs, a phenomenon called electromagnetic interference (EMI). Most sources of EMF are too weak to affect a pacemaker or ICD; however, EMF from certain sources, e.g., some appliances and industrial equipment, may cause interference. This section considers potential EMI with implanted cardiac devices such as pacemakers and defibrillators.

In the presence of electromagnetic fields, pacemakers and ICDs can respond in different ways, defined as modes. The probability of interference occurring and the mode of the response depend on the strength of the interference signal, the patient's orientation in the electromagnetic field, the exact location of the device, and the variable parameters of the device that are specific to a patient.

There are a number of experimental studies dating back to the 1990s that were conducted to assess whether interference may occur when currents are induced in the patient's body by electric or magnetic fields (e.g., Toivonen et al., 1991; Astridge et al., 1993; Scholten and Silny, 2001). In general, pacing abnormalities in these tests occurred at magnetic field levels that are much higher than the levels a person would encounter on a daily basis. Electric fields did produce interference at levels that can be produced by certain electrical sources, but most pacemakers were not affected by high levels of electric fields (up to 20 kV/m) and did not exhibit any pacing abnormalities. Unipolar (single lead) pacemakers tended to be more sensitive to electric fields compared to bipolar (two lead) devices, which are designed specifically to reduce the effects of EMI.

A recent study by Joosten et al. (2009) confirmed earlier work by Scholten and Silny (2001). Both studies found that the performance of a pacemaker in the presence of external ELF electric fields varied considerably based on anatomical and physiological conditions. The 15 study subjects in Joosten et al. experienced a variance of up to 200% when the interference voltage was applied at the input of their cardiac pacemakers. This variance was due to individual, personal factors such as state of respiration, systole and diastole of the heart, filling of the stomach, and muscle activity. The authors' analyses further suggested that for a 50-Hz electric field to affect the function of the most sensitive unipolar pacemaker, the field levels would have to be between 4.3 kV/m and 6.2 kV/m. Unipolar pacemakers are less and less common today; the study authors found that in Germany, only 6% of the pacemakers in use have a unipolar sensing system.

Suggested exposure levels have been determined by the American Conference of Governmental Industrial Hygienists (ACGIH) and the Electric Power Research Institute (EPRI) to prevent against pacemaker EMI. Both organizations suggest that exposures be kept below 1.5-2 kV/m for electric fields and the ACGIH recommends an exposure level not to exceed 1 G for magnetic fields (ACGIH 2001, EPRI 2004). These recommendations are general in nature and do not address that classes of pacemakers from some manufacturers are quite immune to interference even at levels much greater than these recommended guidelines. Both the ACGIH and EPRI recommend that patients consult their physicians and the respective pacemaker manufacturers before following these organizations' guidelines.

In addition, the Food and Drug Administration's Center for Devices and Radiological Health has issued guidelines for both the development of pacemakers and the design of new electrical devices to minimize susceptibility to electrical interference from any source. Pacemakers are designed to filter out electrical stimuli from sources other than the heart, e.g., the muscles of the chest, currents encountered from touching household appliances, or currents induced by external electric or magnetic fields. Used in both temporary and permanent pacemakers, these electrical filters increase the pacemaker's ability to distinguish extraneous signals from legitimate cardiac signals (Toivonen et al., 1991). Furthermore, most circuitry of modern pacemakers is encapsulated by titanium metal, which insulates the device by shielding the pacemaker's pulse generator from electric fields. Some pacemakers also may be programmed to pace the heart automatically if interference from electric or magnetic fields is detected (fixed pacing mode). This supports cardiac function and allows the subject to feel the pacing and move away from the source.

Due to recent design improvements, many pacemakers currently in use would not be susceptible to low intensity electric fields. There remains a very small possibility that some pacemakers, particularly those of older design and with single-lead electrodes, may sense potentials induced on the electrodes and leads of the pacemaker and provide unnecessary stimulation to the heart.

In summary, interference from strong electric fields is theoretically possible under certain circumstances. The likelihood of interference occurring is low, however, particularly with respect to sources that produce low levels of electric fields and when modern devices are implanted. It is recommended that concerned patients contact their doctors to discuss the make and model of their implanted device, their clinical condition, and any lifestyle factors that put them in close contact with strong electric or magnetic fields.

Flora

Electric currents are involved in cell to cell communication in plants (Framm and Lautner, 2007). For this reason, numerous laboratory and on-site studies over the past 35 years have been conducted to assess the possible effects of exposure to ELF EMF from transmission lines on flora—including agricultural crops, trees, and forest and woodland vegetation (e.g., Hodges et al., 1975; Bankoske et al., 1976; McKee et al., 1978; Miller et al., 1979; Rogers et al., 1980; Lee and Clark, 1981; Warren et al., 1981; Rogers et al., 1982; Greene 1983; Hilson et al., 1983; Hodges and Mitchell, 1984; Brulfert et al., 1985; Parsch and Norman, 1986; Conti et al., 1989; Krizaj and Valencic 1989; Ruzic et al., 1992; Reed et al., 1993; Smith et al., 1993; Mihai et al., 1994; Davies 1996; Zapotosky et al., 1996). Researchers have found no adverse effects on plant responses from exposure to EMF levels comparable to that produced by high-voltage transmission lines, including seed germination, seedling emergence and growth, leaf area per plant, flowering, seed production, longevity, and biomass production. The one confirmed adverse effect was damage to the tops of trees growing under or within 40 feet of an *experimental* transmission line operating at a voltage of 1,200 kV, attributable to corona-induced damage to branch tips. The right-of-way (ROW) clearance on *operational* transmission lines is typically a 100 to 200 foot clearance on each side of the line; this area would be cleared of trees or the branches trimmed back sufficiently to prevent flashover and other interference. This effect is not relevant to trees growing at greater distances from the ROW clearance area.

Experimental studies of plants have suggested that magnetic fields increased plant size and weight for radish and barley but not mustard plants (Davies, 1996). A group of studies evaluated the influence of ELF EMF on germination, seedling growth, and subsequent yield. Huang and Wang (2008) evaluated the effects of magnetic fields on the early seed germination of mung beans. The exposures from an inverter system were applied at six different frequencies between 10 Hz and 60 Hz, producing magnetic-field levels from 6 mG to 20 mG. The authors found that magnetic-field exposure at frequencies of 20 and 60 Hz enhanced early mung bean growth, while magnetic fields induced by 10, 30, 40, and 50 Hz frequencies had an inhibitory effect on early mung bean growth. Costanzo (2008) performed a similar study of soy beans exposed *in vitro* to 50-Hz electric fields at strengths of 1.3 kV/m and 2.5 kV/m (root mean square). The author found that this exposure increased soy bean growth in length. In addition, this same study reported that direct current (DC) electric fields of the same peak to peak value had no effect (Costanzo, 2008). A study of 60 Hz magnetic-field treatments of 80,000-200,000 mG on tomato seeds found exposure significantly improved seed performance *in vitro* and plant yield in the soil (De Souza et al., 2010).

Thus, researchers have found no adverse effects on plant responses at the levels of EMF produced by typical high- or low-voltage transmission lines.

Fauna

Since the 1970s, research has been conducted on the possible effect of EMF on wild and domestic animals in response to concerns about the effects of high-voltage and ultra-high-voltage transmission lines in the vicinity of farms and the natural habitat of wild animals. National agencies and universities have conducted research on an assortment of fauna using a variety of study designs including observational studies of animals in their natural habitats and highly-controlled experimental studies. The research to date does not suggest that AC magnetic or electric fields (or any other aspect of high-voltage transmission lines, such as audible noise) result in adverse effects on the health, behavior, or productivity of fauna, including livestock (e.g., dairy cows, sheep, and pigs) and a variety of other species (e.g., small mammals, deer, elk, birds, and bees).

Dairy Cattle and Deer

Burchard et al. (2007) is the most recent publication in a long-term series of controlled studies conducted at McGill University (e.g., Rodriquez et al., 2002, 2003, 2004; Burchard et al., 2003; 2004) on the possible effects of strong and continuous EMF exposure on the health, behavior, and productivity of dairy cattle. The broad goal of this research program was to assess whether EMF exposure could mimic the effect of days with long periods of light and increase milk production and feed intake through a hormonal pathway involving melatonin. In previous studies, some differences were reported between EMF-exposed and unexposed cows; however, they were not reported consistently between studies, the changes were still within the range of what is considered normal, and it did not appear that the changes were adverse in nature.

The study by Burchard et al. in 2007 differed from previous studies in that the exposure was restricted to magnetic fields; the outcomes evaluated included the hormones progesterone, melatonin, prolactin, and insulin-like growth factor 1 (IGF-1), as well as feed consumption. No significant differences in melatonin levels, progesterone levels, or feed intake were reported. Significant decreases in prolactin and IGF-1 levels were reported. Thus, similar to the previous studies by this group of investigators, Burchard et al. (2007) did not report findings that suggest magnetic fields cause changes in the melatonin pathway that could result in effects on reproduction or milk production.

The research does indicate that some species of animals are able to detect and orient to DC magnetic fields at levels associated with the earth's static geomagnetic field (~ 500 mG), and this detection may be important for navigational purposes (in particular for species such as birds). Based upon the characteristics of the major hypothesized detection mechanisms and testing in some species, it seems unlikely that a weak 60-Hz magnetic field would be detected or that it would perturb navigational functions.

Along these lines, two studies, both of which received considerable press attention, published analyses of the orientation of cattle and deer using satellite images and field observations that identify a possible geomagnetic component influencing the animals' behavior. A report by Begall et al. (2008) found that domestic cattle and red and roe deer tend to orient their bodies pointing in a northerly direction. The authors' hypothesize that this body orientation is related to the earth's static geomagnetic field because in areas where the earth's magnetic North Pole can be distinguished more easily from the geographic North Pole's high magnetic declination, body orientation appeared to point more towards the magnetic north rather than the geographic north. This northerly body orientation was not correlated with time of day or the position of the sun, and although the authors speculated that the orientation of the animals was not influenced by wind, no analyses were presented. Based on these limited and indirect data the authors raised the possibility that these species can detect the earth's geomagnetic field.

In the second study, Burda et al. (2009) also explored the possible magnetic basis for the northerly orientation of cattle and deer by analyzing their behavior in the vicinity of high-voltage power lines. They report that cattle within 150 m and deer within 50 m of high-voltage power lines exhibit a random body orientation with respect to magnetic north. Some of the effect might be attributed to the deflection of the geomagnetic field by steel towers close to the line, but the authors did not test this possibility. Other analyses indicated that the orientation of cattle differed around power lines running in an east-west or north-south direction, which suggests that neither sun nor wind cues explain the orientation of these animals with respect to magnetic north. If the observed orientations of cattle and deer are attributable to the earth's geomagnetic field, the biological significance is not clear and the authors suggest additional experimental study. With respect to deer, the authors commented that deer prefer to locate near power lines, perhaps because of the browse or shelter afforded.

Wild Bees and Honey Bees

Wild bees have an important role in natural plant and forest ecosystems. Research on wild bees was conducted at a site near a United States Navy communications system in Northern Michigan where two species of honeybees were observed living in the vicinity of this facility. The researchers studied the bees' exposure to 76-Hz electric and magnetic fields produced by the facility's communications system and compared the mortality, foraging behavior, and nest architecture to a group of honeybees living at a distance from the facility. A few differences were found in nesting parameters, although the effects were small, inconsistent, and likely due to other factors. Although a small increase in the overwinter mortality was reported in one of the two species studied, the researchers concluded that since the reported differences were small and inconsistent between experiments, there were no findings that raised concern about ELF EMF exposures to wild bees (Zapotosky et al., 1996). This conclusion was confirmed in a review by the United States National Academy of Sciences (NAS, 1997).

More research has focused on commercial honeybees since farmers often place hives on fields near transmission lines. Greenberg et al. (1981) studied the effect of a 765-kV transmission line on honeybee colonies placed at varying distances from the transmission line's centerline, with some hives exposed to EMF from the line and some shielded. Differences between the shielded and unshielded hives were reported at exposures above 4.1 kV/m, including decreases in hive weight, abnormal amounts of propolis at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overwinter survival.

These adverse effects were reported only in the unshielded group. Since the shielding only prevented exposure to electric fields, not magnetic fields, the results indicate that these adverse effects are attributable to electric field exposure. These results have been replicated by other investigators (Rogers et al., 1980, 1981, 1982). Further studies indicated that the effects were indirect, i.e., the electric fields were not affecting the bees directly, and that field levels greater than 200 kV/m were required to affect the behavior of free-flying bees. Thus, heating of the hive by induced currents caused some of the adverse effects and the rest were attributed to shocks within the hive (Bindokas et al., 1988a, 1988b, 1989). Prevention is easily accomplished by placing a grounded metal cover on top of the hive.

Since the nests of wild bees in the ground or in trees contain no metal or highly conductive materials, there appears to be little relevance of such effects to wild bees. At these locations, wild bees also are naturally shielded from electric fields. Laboratory studies indicate that bees are unable to discriminate 60-Hz magnetic fields reliably at intensities less than 4,300 mG, although they can detect fluctuations in the earth's static geomagnetic field as weak as 0.26 mG (Kirschvink et al., 1997). The difference in the sensitivity of honey bees is an illustration that a sensory mechanism has developed to detect static magnetic fields that effectively rejects extraneous signals, in this case AC (60-Hz) magnetic fields.

Birds

A recent study by Dell'omo et al. (2009) analyzed the effects of exposure to magnetic fields from high-voltage power lines during the embryonic and post-hatching period of kestrel nestling. The authors found that exposure does not have any significant short-term physiological effects on these birds.

The ability of birds to detect and use of the earth's geomagnetic field during migration does not translate to a capability to detect 60-Hz magnetic fields. Scientists have hypothesized that the mechanism for detection of the earth's geomagnetic field by birds (and bees), for which there is the most evidence, indicates they would be far less sensitive to 60-Hz magnetic fields. The WHO suggested that power frequency fields at intensities much less than the earth's geomagnetic field of around 500 mG are unlikely to be of much biological significance in relation to birds' navigational abilities because the changes produced by ELF magnetic fields and static magnetic fields are similar (WHO, 2007).

Finally, in a study by Elmusharaf et al. (2007), veterinarians in the Netherlands noted the beneficial effects of AC magnetic fields in poultry. The researchers infected broiler chickens with coccidiosis and reported that exposure to a 50 mG AC magnetic field for 30 minutes each day for a course of 15 days prior to infection provided significant protection against intestinal lesions and reduced growth characteristic of this disease.

Overall, the research over the course of the past 35 to 40 years does not suggest that electric or magnetic fields result in any adverse effects on the health, behavior, or productivity of fauna, including livestock, small mammals, deer, elk, birds, and bees.

Marine Life

Although transmission lines mostly traverse the land they also frequently cross water bodies as well. Therefore, the potential for effects on certain marine ecological systems are evaluated regarding the potential impact of EMF on aquatic species in rivers and creeks. To date, there is little or no evidence that fish, mammals, or birds exhibit any harmful effects when exposed to EMF of frequencies close to or at power frequencies (50-60 Hz) at levels found under transmission lines, even for a prolonged period of time (e.g., NRC, 1997a, 1997b; NIEHS 1998; WHO, 2007a). Thus, there is no concern that EMF would have any direct toxic effects on the marine biota.

A number of fish species, however, are reported to make use of the earth's geomagnetic field in navigation and migration, including Pacific salmon (*Oncorhynchus spp.*); the chinook salmon (*O. tschawytscha*) and the steelhead (*O. mykiss*) species particularly spend their adult lives in estuarine or oceanic environments and are well known for their annual spawning runs into freshwater, returning to the home streams and rivers where they were spawned and spent the first few months of their lives (Groot and Margolis, 1998). Pacific salmon are an important part of the history, ecology, and economy of the Pacific Northwest region.

Transmission lines will be a source of potential exposure to 60-Hz magnetic fields in rivers and streams below the conductors, but not electric field exposure because the water shields the fish from electric fields. Since the level of EMF decreases with distance from the source, maximum magnetic-field exposures of fish will occur when they are directly under the lines. The magnetic field levels in rivers and streams below transmission lines would be expected to be significantly lower than for spans on land because clearances for river and stream crossings are usually much higher. Additionally, prolonged exposure is not a critical issue as the fish species of most interest are migratory by nature and will only be exposed to magnetic fields during the relatively short time they take to spawn or travel down or up the river during their life cycle.

The Pacific salmon have been thought to navigate by several mechanisms: detecting and orienting to the earth's geomagnetic field, using a celestial compass (i.e., based on the position of the sun in the sky), and using their innate ability to imprint on their home stream by odor (Groot and Margolis, 1998, Quinn et al, 1981).

Generally, scientific studies have reported that, along with other cues or biological mechanisms, certain species of birds, bees, and fish may have magnetite in certain organs in their bodies, and use magnetite crystals as an aid in navigation (Bullock, 1977; Wiltschko and Wiltschko, 1991, Kirschvink et al, 1993, Walker et al. 1988). Crystals of magnetite have been found in Pacific salmon (Mann et al, 1998; Walker et al, 1998). These magnetite crystals are believed to serve as a compass that orients to the earth's magnetic field. Other studies, however, have not found magnetite in sockeye salmon (*Oncorhynchus nerka*) fry (Quinn et al., 1981). While salmon can apparently detect the geomagnetic field, their behavior is governed by multiple stimuli as demonstrated by the ineffectiveness of magnetic field stimuli in the daytime (Quinn et al., 1982) and the inability of strong magnetic fields from permanent magnets attached to sockeye salmon (Ueda et al., 1998) or other salmon (Yano et al., 1997) to alter their migration behavior.

An important consideration is that the earth's geomagnetic field is static (0 Hz), in contrast to the oscillating magnetic field created by AC transmission lines, which produce current that changes direction and intensity 60 times per second. Static magnetic fields have fixed polarity, i.e. the earth's magnetic north and south poles. AC transmission lines produce magnetic fields that do not have fixed polarity.

No studies have been conducted to date that specifically examine the effects of AC magnetic fields on the salmon's ability to orient to the earth's geomagnetic field. Theoretical calculations do not suggest that 60-Hz magnetic fields could affect magnetite at levels less than 50 mG (Adair 1994). Studies on the response of other organisms that also use magnetite crystals as one means of navigation can, however, provide useful insight regarding salmon. Kirschvink et al. (1993) reports studies of the effects of AC magnetic fields on honey bees, which use magnetite crystals to navigate. In this study, the honey bees only oriented to an AC magnetic field when it was one million times greater in intensity than the DC field needed to elicit the same orientation response. This difference in intensity indicates that the AC magnetic field is less influential than the DC magnetic field in the navigation of honey bees and potentially other organisms that orient to the earth's geomagnetic field using magnetite crystals (Kirschvink et al., 1993). The level of AC magnetic fields under transmission lines are well below the levels reported in that study.

The scientific literature does not support the conclusion that the EMF associated with the proposed transmission line will have an adverse impact on the survival, growth, and reproduction of organisms in a marine ecosystem. There are no data on the effects of AC EMF on salmon navigation, but based on a study with honey bees, it appears that organisms that use magnetite crystals to orient to the earth's geomagnetic field would be affected only when the field levels are very much greater than the levels expected from a transmission line. Given this evidence and the salmon's ability to navigate using multiple sensory cues, overhead transmission lines are unlikely to have an adverse impact on these species of interest and the aquatic ecosystems of these creeks.

4 Standards and Guidelines

Scientific agencies develop exposure standards and guidelines to protect against known health effects following a thorough review of the relevant research. One of the main objectives of weight-of-evidence reviews is to identify the lowest exposure level below which no health hazards have been found (i.e., a threshold level). Exposure limits are then set *well below* the threshold level established by these reviews to take into account individual variability and sensitivity that may exist in susceptible populations.

The only effects known to be produced in humans by exposure to ELF EMF are seen at very high field levels to which the average person is not typically exposed. The effects are short-term, immediate, perceptible reactions to the electrical stimulation of the muscle and the nervous system. These effects are neither severe nor life-threatening.

Two international scientific organizations, ICNIRP and ICES, have published guidelines for limiting public exposure to ELF EMF to protect against these effects (ICNIRP, 1998, 2010; ICES, 2002). ICNIRP is an independent organization of scientists from various disciplines with expertise in the field of non-ionizing radiation assembled from around the world. It is the formally recognized, non-governmental organization that develops safety guidance for non-ionizing radiation for the WHO, the International Labour Organization, and the European Union.

The ICES is sponsored by the American National Standards Institute and IEEE. The mandate for ICES is the "Development of standards for the safe use of electromagnetic energy in the range of 0 Hz to 300 GHz relative to the hazards of exposure to man … to such energy."[25] The ICES encourages a balanced international volunteer participation from several sectors: the interested general public; the scientific, health and engineering communities; agencies of governments; energy producers; and energy users.

[25] The ICES is a 50-year-old internationally recognized, EMF standard-setting organization, which is sponsored by the IEEE that itself was established in 1884. The ICES should not be confused with a group of scientists who have acted together as an advocacy group and banded together under the similar name of the International Commission for Electromagnetic Safety in 2003.

Although both organizations have the same objectives and use similar methods, their recommended exposure limits to 60-Hz EMF for the general public differ (Table 9). The ICNIRP recommends screening values for magnetic fields of2,000 mG for the general public and 10,000 mG for workers (ICNIRP,2010). The ICES recommends maximum permissible exposure of 9,040 mG for magnetic fields (ICES, 2002). The ICNIRP's screening value for exposure to 60-Hz electric fields for the general public is 4.2 kV/m and the ICES screening value is 5 kV/m. Both organizations allow higher exposures if it can be demonstrated that exposures do not produce current densities or electric fields within tissues that exceed basic restrictions on internal current densities or electric fields.

Table 9. Reference levels for whole body exposure to 60-Hz fields: general public

Organization recommending limit	Magnetic fields	Electric fields
ICNIRP restriction level	2,000 mG	4.2 kV/m
ICES maximum permissible exposure (MPE)	9,040 mG	5 kV/m 10 kV/m[a]

[a] This is an exception within transmission line ROWs because people do not spend a substantial amount of time in ROWs and very specific conditions are needed before a response is likely to occur (i.e., a person must be well insulated from ground and must contact a grounded conductor) (ICES, 2002, p. 27).

These guidelines were developed following a weight-of-evidence review of the literature by each organization, including epidemiologic and experimental evidence related to both short-term and long-term exposure. Both reviews concluded that the stimulation of nerves and the central nervous system could occur at very high exposure levels immediately upon exposure. While ICNIRP and ICES reference levels for electric fields are similar, the reference levels for magnetic fields differ by a factor of 10. As explained by Reilly (2005), this difference results from the way the two guidelines have extrapolated responses of the retina of the eye to magnetic fields at around 20 Hz to higher frequencies and other tissues. Their reviews also concluded that there was not sufficient evidence to support a causal role for EMF in the development of cancer or other long-term adverse health effects. Therefore, neither organization found a basis to recommend quantitative exposure guidelines to prevent effects at lower exposure levels.

Following the publication of their 1998 guidelines, the ICNIRP published an evaluation of the epidemiologic literature (ICNIRP, 2001) and a full weight-of-evidence evaluation of health research on EMF (ICNIRP, 2003), concluding again that there is no basis for exposure restrictions for long-term health effects. In June 2009, the ICNIRP published an updated review of the scientific literature related to potential short- and long-term adverse effects, and *draft* guidelines to replace their 1998 ELF EMF exposure guidelines (ICNIRP, 2009). The final guideline was published in December 2010 and those screening vales are listed in Table 9.

There are no national or state standards in the United States limiting exposures to ELF EMF based on health effects. Two states, Florida and New York, have enacted standards to limit magnetic fields at the edge of transmission line ROWs (150 mG and 200 mG, respectively) (NYPSC, 1978, 1990; FDER, 1989; FDEP, 1996). The basis for limiting magnetic fields from transmission lines was to maintain the status quo so that fields from new transmission lines would be no higher than those produced by existing transmission lines.

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Appendix 1

World Health Organization International EMF Project Summary of Conclusions

Overview

The World Health Organization (WHO) is a scientific organization within the United Nations system whose mandate includes providing leadership on global health matters, shaping the health research agenda, and setting norms and standards. WHO established the International EMF Project in 1996, in response to public concerns about exposures to electric and magnetic fields (EMF) and possible adverse health effects. The Project's membership includes 8 international organizations, 8 collaborating institutions, and over 54 national authorities. The overall purpose of the project is to assess health and environmental effects of exposure to static and time-varying EMF in the frequency range 0-300 gigahertz (GHz). A key objective is to evaluate the scientific literature and make a status report on health effects, to be used as the basis for a coherent international response, including the identification of important research gaps and the development of internationally acceptable standards for EMF exposure. This status report was published in June 2007 as part of WHO's Environmental Health Criteria (EHC) Programme.

The Monograph used standard scientific procedures, as outlined in the Preamble, to conduct its weight-of-evidence review.[1] The Task Group responsible for the report's overall conclusions consisted of 21 scientists from around the world with expertise in a wide range of disciplines. The Task Group relied on the conclusions of previous weight-of-evidence reviews, where possible, and (with regard to cancer) mainly focused on evaluating studies published after the IARC review in 2002. Specific terms were used by the Task Group to describe the strength of the evidence in support of causality. *Limited evidence* describes a body of research where the findings are inconsistent or there are outstanding questions about study design or other methodological issues that preclude making strong conclusions. *Inadequate evidence* describes a body of research where it is unclear whether the data is supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues.

The following sections describe the conclusions of the WHO by health outcome (cancer, reproductive effects, and neurodegenerative diseases). The conclusions and perspectives of

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[1] The term "weight-of-evidence review" is used in this report to denote a systematic review process by a multidisciplinary, scientific panel involving experimental and epidemiologic research to arrive at conclusions about possible health risks. The WHO Monograph on EMF does not specifically describe their report as a weight-of-evidence review. Rather, they describe conducting a health risk assessment. Although the two terms are similar, a health risk assessment differs from a weight-of-evidence review in that it also incorporates an exposure assessment and an exposure-response assessment.

weight-of-evidence reviews conducted by other scientific organizations are discussed, where appropriate, to highlight consistencies and inconsistencies in conclusions.

Conclusions

Cancer

The overwhelming majority of health research related to EMF has focused on the possibility of a relationship with cancer, including leukemia, lymphoma, breast cancer, and brain cancer. The vast majority of epidemiologic studies in this field enrolled persons with a specific cancer type (*cases*); selected a group of individuals similar to the cancer cases (*controls*); estimated past magnetic or electric field exposures, or both; and compared these exposures between the cases and controls to test for statistical differences. Some of these studies looked for statistical associations of these diseases with magnetic fields produced by nearby power lines (estimated through calculations or distance) or appliances, while other studies actually measured magnetic field levels in homes or estimated personal magnetic field exposures from all sources. In studies of adult cancers, occupational magnetic field exposures were estimated in some studies, as well. *In vivo* studies in this field exposed animals to high levels of magnetic fields (up to 50,000 milligauss [mG]) over the course of their entire lifetime to observe whether exposed animals had higher rates of cancer than unexposed animals. Some of these studies exposed animals to magnetic fields in tandem with a known carcinogen to test whether magnetic field exposure promoted carcinogenesis. Since there is relatively low energy associated with extremely low-frequency (ELF) EMF, researchers believe it is highly unlikely that electric or magnetic fields can directly damage DNA. Therefore, *in vitro* studies in this field have largely focused on investigating whether ELF EMF could promote damage from other known carcinogens or cause cancer through a pathway other than DNA damage (e.g., hormonal or immune effects or alterations in signal transduction).

The International Agency for Research on Cancer (IARC) is the division of the WHO with responsibility to coordinate and conduct research on the causes of human cancer and the mechanisms of carcinogenesis and to develop scientific strategies for cancer control. The IARC convened a scientific panel in 2001 to conduct an extensive review and arrive at a conclusion about the possible carcinogenicity of EMF (IARC, 2002). The IARC has a standard method for classifying exposures based on the strength of the scientific research in support of carcinogenicity.

Categories include (from highest to lowest risk): carcinogenic to humans, probably carcinogenic to humans, possibly carcinogenic to humans, unclassifiable, and probably not carcinogenic to humans. As a result of two pooled analyses reporting an association between high, average magnetic field exposure and childhood leukemia, the epidemiology data was classified as providing "limited evidence of carcinogenicity"[2] in relation to childhood leukemia. With regard to all other cancer types, the epidemiology evidence was classified as inadequate. The IARC panel also reported that there was "inadequate evidence of carcinogenicity" in studies of experimental animals. Overall, magnetic fields were evaluated as "possibly carcinogenic to humans." The IARC usage of "*possible*" denotes an exposure in which epidemiologic evidence points to a statistical association, but other explanations cannot be ruled out as the cause of that statistical association (e.g., bias and confounding)[3] and experimental evidence does not support a cause-and-effect relationship. Considering recently published epidemiology, *in vivo,* and *in vitro* research, the WHO concluded that the classification of "possible carcinogen" remains accurate (WHO, 2007).

Childhood Leukemia

The issue that has received the most attention is childhood leukemia. Research in this area was prompted by an epidemiology study of children in the United States that reported a statistical association between childhood leukemia and a higher predicted magnetic field level in the home based on characteristics of nearby distribution and transmission lines (Wertheimer and Leeper, 1979). Subsequently, some epidemiologic studies reported that children with leukemia were more likely to live closer to power lines or have higher estimates of magnetic field exposure (compared to children without leukemia), while other epidemiologic studies did not report this statistical association. Of note, the largest epidemiology studies of childhood leukemia that actually measured personal magnetic field exposure (as opposed to estimating exposure through

[2] Each type of evidence is categorized based on the strength of the evidence in support of carcinogenicity. The categories include: sufficient evidence of carcinogenicity, limited evidence of carcinogenicity, inadequate evidence of carcinogenicity, and evidence suggesting lack of carcinogenicity. If a positive association between an exposure and cancer is found (although factors such as chance, bias and confounding cannot be ruled out with reasonable confidence), the epidemiologic evidence is rated as "limited evidence of carcinogenicity." If chance, bias and confounding can be ruled out with reasonable confidence, then the evidence is classified as "sufficient evidence of carcinogenicity." The *in vivo* studies are ranked using a similar system, and the totality of the evidence is then considered to reach a conclusion about a particular exposure's carcinogenicity.

[3] Bias refers to any systematic error in the design, implementation or analysis of a study that results in a mistaken estimate of an exposure's effect on the risk of disease. A confounder is something that is related to both the disease under study and the exposure of interest such that we cannot be sure what causes the observed association - the confounder or the exposure of interest.

calculations or distance) did not report evidence to support a causal relationship, nor did they report a dose-response relationship with exposure to higher magnetic field levels (Linet et al., 1997; McBride et al., 1999; UKCCS, 1999).

In 2000, researchers combined the data from previously published epidemiology studies of magnetic fields and childhood leukemia that met specified criteria (Ahlbom et al., 2000; Greenland et al., 2000). The researchers pooled the data on the individuals from each of the studies, creating a study with a much larger number of subjects and, as a result, greater statistical power to detect an effect (should one exist) than any single study. In both pooled analyses, a weak association was reported between childhood leukemia and estimates of average magnetic field exposures greater than 3-4 mG. The authors were appropriately cautious in the interpretation of their analyses, and noted the uncertainty related to pooling estimates of exposure obtained by different methods from studies of diverse design, as did other researchers (e.g., Elwood, 2006). Because of the inherent uncertainty associated with observational epidemiologic studies, the results of these pooled analyses were not considered to provide strong epidemiologic support for a causal relationship. Furthermore, *in vivo* studies have not found that magnetic fields induce or promote cancer in animals exposed under highly controlled conditions for their entire lifespan, nor have *in vitro* studies found a cellular mechanism by which magnetic fields could induce carcinogenesis. As discussed above, these findings resulted in the classification of magnetic fields as a possible carcinogen (IARC, 2002).

The WHO evaluated two more recently published studies related to childhood leukemia and magnetic fields (Draper et al, 2005; Kabuto et al., 2006). Draper et al. conducted a case-control study of childhood cancer, which included 9,700 children with leukemia (i.e., cases) and an equal number of children that did not have leukemia (i.e., controls). The study compared the distance of birth address to high-voltage transmission lines among cases and controls and reported a weak association between childhood leukemia and birth addresses within 600 feet of high-voltage transmission lines. Kabuto et al. conducted a smaller case-control study in Japan that measured the average weekly magnetic field in the bedrooms of 312 children with leukemia and 603 children without leukemia. The investigators reported that children with leukemia were more likely to have average magnetic field levels >4 mG compared to children without leukemia.

The WHO did not assign a high weight or significance to these studies in their overall evaluation, stating that the low participation rate in Kabuto et al. and the use of distance as a proxy for magnetic field exposure in Draper et al. were important limitations. Less weight should be placed on these studies relative to studies that used good exposure assessment techniques and had high participation rates. The WHO described the results of these two studies as consistent with the classification of limited epidemiologic evidence in support of carcinogenicity and, together with the largely negative *in vivo* and *in vitro* research, consistent with the classification of magnetic fields as a possible carcinogen.

The WHO concluded that several factors might be fully, or partially, responsible for the consistent association observed between high, average magnetic fields and childhood leukemia, including misclassification of magnetic field exposure due to poor exposure assessment methods, confounding from unknown risk factors, and selection bias.[4] The WHO concluded that reconciling the epidemiologic data on childhood leukemia and the negative (i.e., no hazard) experimental findings through innovative research is currently the highest priority in the field of ELF EMF research. Given that few children are expected to have average magnetic field exposures greater than 3-4 mG, however, the WHO stated that the public health impact of magnetic fields on childhood leukemia would be low if the association were causal.

Breast Cancer

Research on breast cancer has examined the possible effects of ELF EMF from three sources: workplace exposures, residential exposure from power lines, and electric blankets. Some of the early epidemiology studies in this field reported a weak association between breast cancer and higher magnetic field exposures, while others did not; however, the conclusions that could be drawn from this initial body of research were limited because of study quality issues (e.g., poor exposure assessment, inadequate control for confounding variables, and small sample sizes within subgroups with reported associations). Review panels evaluating this initial body of research

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4 Selection bias arises if there are differences in the persons who participate in a study compared to the persons who do not participate in a study that are related to the exposure and differential by case/control status. For example, if the parents of a child with leukemia were informed that the study was investigating magnetic field exposure and they resided close to a transmission line, they may be more likely to participate than a family that lived far from a transmission line. As a result, children with leukemia that lived closer to transmission lines (and with a presumably higher magnetic field exposure) would be over-represented in the study population compared to the source population. In this scenario, the study may report that children with leukemia are more likely to have higher magnetic field exposure when, if the entire source population of leukemia cases were to be considered, there would be no difference in the exposure levels between leukemia cases and controls.

concluded that the evidence in support of an association was weak, but should be further evaluated with higher quality studies (NRPB, 2001; IARC, 2002; ICNIRP, 2003).

A large number of studies on breast cancer and magnetic field exposure have been conducted since the publication of the IARC review in 2002. These studies were systematically reviewed by the WHO and included seven studies that estimated residential magnetic field exposure, four studies reporting associations with electric blanket usage, and nine studies that estimated occupational magnetic field exposure. No consistent associations between magnetic field exposure and breast cancer were reported in these studies. The WHO concluded that this recent body of research was higher in quality compared with previous studies, and, for that reason, provides strong support to previous consensus statements that magnetic field exposure does not influence the risk of breast cancer. In summary, the WHO stated "With these [recent] studies, the evidence for an association between ELF magnetic field exposure and the risk of female breast cancer is weakened considerably and does not support an association of this kind" (p. 9). The WHO recommended no further research with respect to breast cancer and magnetic field exposure.

Breast cancer has received additional attention because of some initial epidemiologic and experimental findings suggesting that magnetic fields may depress levels of the hormone melatonin (which is believed to have anti-carcinogenetic effects), leading to the development of breast cancer. A comprehensive weight-of-evidence review by the Health Protection Agency of Great Britain (HPA) in 2006 concluded that the evidence to date did not support the hypothesis that exposure to magnetic fields affects melatonin levels, or the risk of breast cancer in general (HPA, 2006). The WHO also considered this body of research, concluding "Overall, these data do not indicate that ELF electric and/or magnetic fields affect the neuroendocrine system in a way that would have an adverse impact on human health and the evidence is thus considered inadequate" (p. 186).

Adult leukemia and brain cancer

A large number of studies of variable quality and using a wide range of techniques have been conducted in both occupational and residential settings to explore the possible relationship between EMF exposure and adult brain cancer and leukemia. The scientific committees assembled by the IARC, NRPB, and ICNIRP concluded that the evidence is weak and does not support a role for electric or magnetic fields in the etiology of brain cancer or leukemia among adults (NRPB, 2001a; IARC, 2002; ICNIRP, 2003). The WHO reviewed the body of research published since the time of these reviews, including three studies estimating residential exposure, four cohort studies estimating occupational exposures, and eight case-control studies reported on occupation and brain cancer or leukemia risk. The WHO concluded, "In the case of adult brain cancer and leukaemia, the new studies published after the IARC monograph do not change the conclusion that the overall evidence for an association between ELF [EMF] and the risk of these disease remains inadequate" (p. 307). The WHO panel recommended updating the existing European cohorts of occupationally exposed individuals and then pooling the epidemiologic data on brain cancer and adult leukemia to confirm the absence of an association.

***In vivo* and *in vitro* research on carcinogenesis**

It is standard procedure to conduct studies of laboratory animals to determine whether exposure to a specific agent leads to the development of cancer (USEPA, 2005). This approach is used because all known human carcinogens cause cancer in laboratory animals. In the field of ELF EMF research, a number of research laboratories have exposed rodents with a particular genetic susceptibility to cancer to high levels of magnetic fields over the course of their lifetime and performed tissue evaluations to assess the incidence of cancer in many organs. In these studies, magnetic field exposure has been administered alone (to test for the ability of magnetic fields to act as a complete carcinogen), in combination with a known carcinogen (to test for a promotional or co-carcinogenetic effect), or in combination with a known carcinogen and a known promoter (to test for a co-promotional effect). The WHO described four large-scale, long-term studies of rodents exposed to magnetic fields over the course of their lifetime that did not report increases in any type of cancer (Mandeville et al., 1997; Yasui et al., 1997; Boorman et al., 1999a, 1999b; McCormick et al., 1999). No directly relevant animal model for childhood acute lymphoblastic leukemia (ALL) currently exists. Some animals, however, develop a type of lymphoma similar to childhood ALL and studies exposing transgenic mice predisposed to this lymphoma to power-frequency magnetic fields have not reported an increased incidence of lymphoma associated with exposure (Harris et al., 1998; McCormick et al., 1998; Sommer and Lerchel 2004). Based on this body of research, the WHO panel concluded that exposure to ELF magnetic fields, does not appear to cause cancer alone, although it is a high priority to identify and perform studies on an animal model that is more directly relevant to childhood ALL.

Studies investigating whether exposure to magnetic fields can promote cancer or act as a co-carcinogen used known cancer-causing agents, such as ionizing radiation, ultraviolet radiation, or other chemicals. No effects were observed for studies on chemically-induced preneoplastic liver lesions, leukemia/lymphoma, skin tumors, or brain tumors; however, the incidence of DMBA-induced mammary tumors was increased with magnetic field exposure in a series of experiments (Löscher et al., 1993, 1994, 1997; Baum et al., 1995; Löscher and Mevissen, 1995; Mevissen et al., 1993a, 1993b, 1996a, 1996b, 1998), suggesting that magnetic field exposure increased the proliferation of mammary tumor cells. These results were not replicated in subsequent series of experiments in another laboratory (Anderson et al., 1999; Boorman et al.1999; NTP, 1999), possibly due to differences in experimental protocol and the species strain (Fedrowitz et al., 2004). Some studies have reported an increase in genotoxic effects among exposed animals (e.g., DNA strand breaks in the brains of mice [Lai and Singh, 2004]), although the results have not been replicated.

In summary, the WHO concluded with respect to *in vivo* research, "There is no evidence that ELF exposure alone causes tumours. The evidence that ELF field exposure can enhance tumour development in combination with carcinogens is inadequate." Recommendations for future research include the development of a rodent model for childhood ALL and the continued investigation of whether magnetic fields can act as a co-carcinogen.

In vitro studies are widely used to investigate the mechanisms for effects that are observed in humans and animals. The relative value of *in vitro* tests to human health risk assessment, however, is much less than that of *in vivo* and epidemiology studies. Responses of cells and tissues outside the body may not always reflect the response of those same cells if maintained in a living system, so the relevance of *in vitro* studies cannot be assumed (IARC, 1992).

The IARC and other scientific review panels that systematically evaluated *in vitro* studies concluded that there is no clear evidence indicating how ELF magnetic fields could adversely affect biological processes in cells (IARC, 2002; ICNIRP, 2003; NRPB, 2004). The WHO panel reviewed the *in vitro* research published since the time of these reviews and reached the same conclusion. The WHO noted that previous studies have not indicated a genotoxic effect of ELF magnetic fields on mammalian cells, however a recent series of experiments reported DNA damage in human fibroblasts exposed intermittently to 50-Hz magnetic fields (Ivancsits et al., 2002a, 2002b; Ivancsits et al., 2003a, 2003b). These findings have not been replicated by other laboratories (Scarfi et al., 2005), and the WHO recommended continued research in this area. Research in the field of *in vitro* genotoxicity of magnetic fields combined with known DNA-damaging agents is also recommended, following suggestive findings from several laboratories. As noted by the Swedish Radiation Protection Authority, the levels at which these effects were observed are much higher than the levels we are exposed to in our everyday environments and therefore are not directly relevant to questions about low-level, chronic exposures (SSI, 2007). *In vitro* studies investigating other possible mechanisms, including gene activation, cell proliferation, apoptosis, calcium signaling, intercellular communication, heat shock protein expression and malignant transformation, have produced "inconsistent and inconclusive" results (p. 347, WHO, 2007).

Reproductive Effects

Epidemiology studies have been conducted to observe whether maternal or paternal EMF exposures are associated with adverse reproductive effects, including effects on fertility, reproduction, miscarriage, and prenatal and postnatal growth and development. A body of *in vivo* literature is also available on this topic. Early studies on the potential effect of EMF exposures on reproductive outcomes were limited because the majority of the studies used surrogate measures of exposure (including visual display terminal use, electric blanket use, or wire code data) or assessed exposure retrospectively.

Two recent studies related to miscarriage improved exposure assessment by directly measuring magnetic field exposure. These two studies reported a positive association between miscarriage and exposure to high maximum, or instantaneous, peak magnetic fields (Li et al., 2002; Lee et al., 2002). No consistent associations were reported, however, with high, average magnetic field levels, the typical method for assessing magnetic field exposure. The WHO noted several issues that have been raised by other investigators and scientific review panels concerning the validity of these associations (HCN, 2004; NRPB, 2004; Feychting et al., 2005; Mezei et al., 2005; Savitz et al., 2006). First, the studies had a low response rate, which means that the case and control groups may not be comparable because those who participated in the study may have differed from those who declined (i.e., selection bias). Second, in the study by Lee et al. (2002), magnetic field measurements were taken 30 weeks after a woman's last menstrual period. Some of these women had already miscarried at 30 weeks when magnetic field exposure was measured. This introduces the possibility for bias because pregnancy may alter physical activity levels and physical activity may be associated with magnetic field exposure in pregnant women, as recently confirmed in a study by Savitz et al. (2006). It is possible that the women who miscarried prior to 30 weeks in the study by Lee et al. (2002) subsequently increased their physical activity levels (i.e., returned to work or their normal routine), which resulted in greater opportunities to encounter higher peak magnetic field levels. Furthermore, there is no biological basis to indicate that EMF increases the risk of reproductive effects. *In vivo* studies exposed animals to high levels of electric and magnetic fields and reported no significant, adverse developmental effects. The WHO stated that *in vivo* studies on other reproductive outcomes are inadequate at this time.

The WHO concluded that, overall, the body of research does not suggest that maternal or paternal exposures to ELF EMF cause adverse reproductive outcomes. The evidence from epidemiology studies on miscarriage is inadequate, and further research on this possible association is recommended, although low priority was given to this recommendation.

Neurodegenerative Diseases

Research into the possible effect of magnetic fields on the development of neurodegenerative diseases began in 1995, and the majority of research since then has focused on Alzheimer's disease and a specific type of motor neuron disease called amyotrophic lateral sclerosis (ALS) or Lou Gehrig's disease. The inconsistency of the Alzheimer's studies prompted the National Radiological Protection Board of Great Britain (NRPB)[5] to conclude that there is "only weak evidence to suggest that it [i.e., extremely low frequency magnetic fields] could cause Alzheimer's

[5] The NRPB merged with the Health Protection Agency in April 2005 to form its new Radiation Protection Division.

disease" (p. 20, NRPB, 2001b). Early studies on ALS, which had no obvious biases and were well conducted, reported an association between ALS mortality and estimated occupational magnetic field exposure. The review panels, however, were hesitant to conclude that the associations provided strong support for a causal relationship between ALS and occupational magnetic field exposure. The scientific panels felt that an alternative explanation (i.e., electric shocks received at work) may be the source of the observed association. The NRPB concluded: "In summary, the epidemiological evidence suggests that employment in electrical occupations may increase the risk of ALS, possibly, however, as a result of the increased risk of receiving an electric shock rather than from the increased exposure to electromagnetic fields" (p.20, NRPB, 2001b).

Most recent studies reported associations between occupational magnetic field exposure and mortality from Alzheimer's disease and ALS, although the design and methods of these studies were relatively weak (disease status based on death certificate data, exposure based on incomplete occupational information from census data, and no control for confounding factors). There is currently no biological data to support an association between magnetic fields and neurodegenerative diseases. The WHO concluded that there is inadequate data in support of an association between magnetic fields and Alzheimer's disease or ALS. The panel highly recommended that further studies be conducted in this area, particularly studies where the association between magnetic fields and ALS is estimated while controlling for the possible confounding effect of electric shocks.

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Appendix 2

WHO Fact Sheet

Fact sheet N°322
June 2007

Electromagnetic fields and public health
Exposure to extremely low frequency fields

The use of electricity has become an integral part of everyday life. Whenever electricity flows, both electric and magnetic fields exist close to the lines that carry electricity, and close to appliances. Since the late 1970s, questions have been raised whether exposure to these extremely low frequency (ELF) electric and magnetic fields (EMF) produces adverse health consequences. Since then, much research has been done, successfully resolving important issues and narrowing the focus of future research.

In 1996, the World Health Organization (WHO) established the International Electromagnetic Fields Project to investigate potential health risks associated with technologies emitting EMF. A WHO Task Group recently concluded a review of the health implications of ELF fields (WHO, 2007).

This Fact Sheet is based on the findings of that Task Group and updates recent reviews on the health effects of ELF EMF published in 2002 by the International Agency for Research on Cancer (IARC), established under the auspices of WHO, and by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2003.

ELF field sources and residential exposures

Electric and magnetic fields exist wherever electric current flows - in power lines and cables, residential wiring and electrical appliances. **Electric** fields arise from electric charges, are measured in volts per metre (V/m) and are shielded by common materials, such as wood and metal. **Magnetic** fields arise from the motion of electric charges (i.e. a current), are expressed in tesla (T), or more commonly in millitesla (mT) or microtesla (µT). In some countries another unit called the gauss, (G), is commonly used (10,000 G = 1 T). These fields are not shielded by most common materials, and pass easily through them. Both types of fields are strongest close to the source and diminish with distance.

Most electric power operates at a frequency of 50 or 60 cycles per second, or hertz (Hz). Close to certain appliances, the magnetic field values can be of the order of a few hundred microtesla. Underneath power lines, magnetic fields can be about 20 µT and electric fields can be several thousand volts per metre. However, average residential power-frequency magnetic fields in homes are much lower - about 0.07 µT in Europe and 0.11 µT in North America. Mean values of the electric field in the home are up to several tens of volts per metre.

Task group evaluation

In October 2005, WHO convened a Task Group of scientific experts to assess any risks to health that might exist from exposure to ELF electric and magnetic fields in the frequency range >0 to 100,000 Hz (100 kHz). While IARC examined the evidence regarding cancer in 2002, this Task Group reviewed evidence for a number of health effects, and updated the evidence regarding cancer. The conclusions and recommendations of the Task Group are presented in a WHO Environmental Health Criteria (EHC) monograph (WHO, 2007).

Following a standard health risk assessment process, the Task Group concluded that there are no substantive health issues related to ELF electric fields at levels generally encountered by members of the public. Thus the remainder of this fact sheet addresses predominantly the effects of exposure to ELF magnetic fields.

Short-term effects

There are established biological effects from acute exposure at high levels (well above 100 μT) that are explained by recognized biophysical mechanisms. External ELF magnetic fields induce electric fields and currents in the body which, at very high field strengths, cause nerve and muscle stimulation and changes in nerve cell excitability in the central nervous system.

Potential long-term effects

Much of the scientific research examining long-term risks from ELF magnetic field exposure has focused on childhood leukaemia. In 2002, IARC published a monograph classifying ELF magnetic fields as "possibly carcinogenic to humans". This classification is used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals (other examples include coffee and welding fumes). This classification was based on pooled analyses of epidemiological studies demonstrating a consistent pattern of a two-fold increase in childhood leukaemia associated with average exposure to residential power-frequency magnetic field above 0.3 to 0.4 μT. The Task Group concluded that additional studies since then do not alter the status of this classification.

However, the epidemiological evidence is weakened by methodological problems, such as potential selection bias. In addition, there are no accepted biophysical mechanisms that would suggest that low-level exposures are involved in cancer development. Thus, if there were any effects from exposures to these low-level fields, it would have to be through a biological mechanism that is as yet unknown. Additionally, animal studies have been largely negative. Thus, on balance, the evidence related to childhood leukaemia is not strong enough to be considered causal.

Childhood leukaemia is a comparatively rare disease with a total annual number of new cases estimated to be 49,000 worldwide in 2000. Average magnetic field exposures above 0.3 μT in homes are rare: it is estimated that only between 1% and 4% of children live in such conditions. If the association between magnetic fields and childhood leukaemia is causal, the number of cases worldwide that might be attributable to magnetic field exposure is estimated to range from 100 to 2400 cases per year, based on values for the year 2000, representing 0.2 to 4.95% of the total incidence for that year. Thus, if ELF magnetic fields actually do increase the risk of the disease, when considered in a global context, the impact on public health of ELF EMF exposure would be limited.

A number of other adverse health effects have been studied for possible association with ELF magnetic field exposure. These include other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease. The WHO Task Group concluded that scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukaemia. In some instances (i.e. for cardiovascular disease or breast cancer) the evidence suggests that these fields do not cause them.

International exposure guidelines

Health effects related to short-term, high-level exposure have been established and form the basis of two international exposure limit guidelines (ICNIRP, 1998; IEEE, 2002). At present, these bodies consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits.

WHO's guidance

For high-level short-term exposures to EMF, adverse health effects have been scientifically established (ICNIRP, 2003). International exposure guidelines designed to protect workers and the public from these effects should be adopted by policy makers. EMF protection programs should include exposure measurements from sources where exposures might be expected to exceed limit values.

Regarding long-term effects, given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia, the benefits of exposure reduction on health are unclear. In view of this situation, the following recommendations are given:

- Government and industry should monitor science and promote research programmes to further reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure. Through the ELF risk assessment process, gaps in knowledge have been identified and these form the basis of a new research agenda.
- Member States are encouraged to establish effective and open communication programmes with all stakeholders to enable informed decision-making. These may include improving coordination and consultation among industry, local government, and citizens in the planning process for ELF EMF-emitting facilities.
- When constructing new facilities and designing new equipment, including appliances, low-cost ways of reducing exposures may be explored. Appropriate exposure reduction measures will vary from one country to another. However, policies based on the adoption of arbitrary low exposure limits are not warranted.

Further reading

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Appendix 3

Comment on the BioInitiative Report

Background

In August 2007, an *ad hoc* group of 14 scientists and public health and policy consultants published an on-line report titled "*The BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)*." The group's objective was to "assess scientific evidence on health impacts from electromagnetic radiation below current public exposure limits and evaluate what changes in these limits are warranted now to reduce possible public health risks in the future" (p. 4). The individuals who comprised this group did not represent any well-established regulatory agency, nor were they convened by a recognized scientific authority. The report is a collection of 17 sections on various topics each authored by 1 to 3 persons from the working group. The research on both ELF and radio frequency (RF) EMF was addressed, with major portions of the report focused largely or entirely on RF research. Epidemiologic literature related to ELF EMF and childhood cancers, Alzheimer's disease, and breast cancer was discussed, as well as experimental data for a number of mechanistic hypotheses.

Conclusions and comments

The authors of the BioInitiative Report contended that the standard procedure for developing exposure guidelines—i.e., to set guidelines where adverse health effects have been established by using a weight-of-evidence approach—is not appropriate and should be replaced by a process that sets guidelines at exposure levels where biological effects have been reported in some studies, but not substantiated in a rigorous review of the science or linked to adverse health effects.

Based on this argument, the main conclusion of the BioInitiative Report was that existing standards for exposure to ELF EMF are insufficient because "effects are now widely reported to occur at exposure levels significantly below most current national and international limits" (Table 1-1). Specifically, the authors concluded that there was strong evidence to suggest that magnetic fields were a cause of childhood leukemia based on epidemiologic findings.

The report recommended the following:

> *ELF limits should be set below those exposure levels that have been linked in childhood leukemia studies to increased risk of disease, plus an additional safety factor … While new ELF limits are being developed and implemented, a reasonable approach would be a 1 mG (0.1 µT) planning limit for habitable space adjacent to all new or upgraded power lines and a 2 mG (0.2 µT) limit for all other new construction. It is also recommended that a 1 mG (0.1 µT) limit be established for existing habitable space for children and/or women who are pregnant. (p. 22)*

The recommendations made in the BioInitiative Report are not based on appropriate scientific methods and, therefore, do not warrant any changes to the conclusions from the numerous scientific agencies that have already considered this issue. These organizations are consistent in their conclusions that the research does not support the setting of exposure standards at these low levels of magnetic field exposure.

The World Health Organization (WHO) published the most recent weight-of-evidence review in June 2007 and concluded the following:

> *Everyday, low-intensity ELF magnetic field exposure poses a possible increased risk of childhood leukaemia, but the evidence is not strong enough to be considered causal and therefore ELF magnetic fields remain classified as possibly carcinogenic. (p. 357)*

The report continued:

> *Given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia and the limited potential impact on public health, the benefits of exposure reduction on health are unclear and thus the cost of reducing exposure should be very low. (p. 372)*

The WHO made no recommendations for exposure standards at the magnetic field levels where an association has been reported in some epidemiologic studies of childhood leukemia. In a fact sheet created for the general public and published on their website, the WHO stated,

> *When constructing new facilities and designing new equipment, including appliances, low-cost ways of reducing exposures may be explored…However, policies based on the adoption of arbitrary low exposure limits are not warranted* (WHO, 2007b).

As stated, the conclusions in the BioInitiative Report deviate substantially from those of reputable scientific organizations because they were not based on standard, scientific methods. Valid scientific conclusions are based on weight-of-evidence reviews, which entail a systematic evaluation of the entire body of scientific evidence in three areas of research (i.e., epidemiology, *in vivo* research, and *in vitro* research), by panels of experts in these relevant disciplines. The report by the BioInitiative working group does not represent a valid weight-of-evidence review for the following key reasons:

1. **Review panels should consist of a multidisciplinary team of experts that reach consensus statements by collaboratively contributing to and reviewing the final work product.** This process ensures that overall conclusions represent a valid and balanced view of each relevant area of research. The document released by the BioInitiative working group was a compilation of sections, with each authored by one to three members of the group. It does not appear that the report was developed collaboratively or reviewed in its entirety by each member.

2. **Valid conclusions about causality are based on systematic evaluations of three lines of evidence—epidemiology, *in vivo* research, and *in vitro* research.** The conclusions in the BioInitiative Report are not based on this multidisciplinary approach. In particular, little attention is provided to the results from *in vivo* studies on cancer and disproportionate weight is given to the results of *in vitro* studies reporting biological effects.

3. **The entire body of evidence to date should be considered when drawing conclusions regarding the strength of evidence in support of a hypothesis.** The BioInitiative Report is not a comprehensive review of the cumulative evidence. Rather, results from specific studies are cited, but no rationale is provided for their inclusion relative to the many other relevant, published studies.

4. **The evidence from each study must be evaluated critically to determine its validity and the degree to which it is relevant and able to support or refute the hypothesis under question.** The significance of the results reported in any study depends on the validity of the methods used in that study, so weight-of-evidence reviews must include an evaluation of the strengths and limitations of each study. In some discussions, the report claimed to use a weight-of-evidence approach, but the individual sections of the report provide little evidence that the strengths and limitations of individual studies (e.g., the quality of exposure assessment, sample size, biases, and confounding factors) were evaluated systematically.

5. **Support for a causal relationship is based on consistent findings from methodologically sound epidemiology studies that are coherent with the results reported from *in vivo* and *in vitro* studies**. The BioInitiative group often arrived at conclusions about causality by considering only a few studies from one discipline, with no consideration of the significance and validity of the study's results.

In summary, the authors of this report largely ignored basic scientific methods that should be followed in the review and evaluation of scientific evidence. These methods are fundamental to scientific inquiry and are not, as the BioInitiative Report states, "unreasonably high."

The policy responses proposed in the report are cast as consistent with the precautionary principle, i.e., taking action in situations of scientific uncertainty before there is strong proof of harm. A central tenet of the precautionary principle is that precautionary recommendations are proportional to the perceived level of risk and that this perception is founded largely on the weight of the available scientific evidence. The BioInitiative Report recommends precautionary measures on the basis of argument, rather than the basis of sound peer-reviewed scientific evidence.

Unlike the BioInitiative Report, the WHO review was the product of a multidisciplinary scientific panel assembled by an established public health agency that followed appropriate scientific methods, including the systematic and critical examination of all the relevant evidence. The recommendations from the WHO report (pp. 372-373) are presented below:

- *Policy-makers should establish guidelines for ELF field exposure for both the general public and workers. The best source of guidance for both exposure levels and the principles of scientific review are the international guidelines.*

- *Policy-makers should establish an ELF EMF protection programme that includes measurements of fields from all sources to ensure that the exposure limits are not exceeded either for the general public or workers.*

- *Provided that the health, social and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposures is reasonable and warranted.*

- *Policy-makers and community planners should implement very low-cost measures when constructing new facilities and designing new equipment including appliances.*

- *Changes to engineering practice to reduce ELF exposure from equipment or devices should be considered, provided that they yield other additional benefits, such as greater safety, or involve little or no cost.*

- *When changes to existing ELF sources are contemplated, ELF field reduction should be considered alongside safety, reliability and economic aspects.*

- *Local authorities should enforce wiring regulations to reduce unintentional ground currents when building new or rewiring existing facilities, while maintaining safety. Proactive measures to identify violations or existing problems in wiring would be expensive and unlikely to be justified.*

- *National authorities should implement an effective and open communication strategy to enable informed decision-making by all stakeholders; this should include information on how individuals can reduce their own exposure.*

- *Local authorities should improve planning of ELF EMF-emitting facilities, including better consultation between industry, local government, and citizens when siting major ELF EMF-emitting sources.*

- *Government and industry should promote research programmes to reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure.*

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Appendix J

Greenhouse Gases

Greenhouse Gases

Introduction

Greenhouse gases (GHG) are chemical compounds found in the Earth's atmosphere that absorb and trap infrared radiation as heat. They are released both naturally and through human activities such as deforestation, soil disturbance, and burning of fossil fuels. These activities disrupt the natural cycle by increasing the GHG emission rate over the storage rate, which results in a net increase of GHGs in the atmosphere. The resulting buildup of heat in the atmosphere due to increased GHG levels causes warming of the planet through a greenhouse-like effect (EIA 2009a). Increasing levels of GHGs could increase the Earth's temperature by up to 7.2 degrees Fahrenheit by the end of the 21st century (EPA 2010a).

The principal GHGs emitted into the atmosphere through human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (EPA 2010a).

- **Carbon dioxide** is the major GHG emitted (EPA 2010a; Houghton 2010). CO_2 enters the atmosphere as a result of such activities as land use changes, the burning of fossil fuels (e.g., coal, natural gas, oil, and wood products), and the manufacturing of cement. CO_2 emissions resulting from the combustion of coal, oil, and gas constitute 81 percent of all U.S. GHG emissions (EIA 2009b). Before the industrial revolution, CO_2 concentrations in the atmosphere were roughly stable at 280 parts per million. By 2005, CO_2 levels had increased to 379 parts per million, a 36 percent increase, as a result of human activities (IPCC 2007).
- **Methane** is emitted during the processing and transport of fossil fuels, through intensive animal farming, and by the degradation of organic waste. Concentrations of CH_4 in the atmosphere have increased 148 percent above preindustrial levels (EPA 2010a).
- **Nitrous oxide** is emitted during agricultural and industrial activities and during the combustion of fossil fuels and solid waste. Atmospheric levels of N_2O have increased 18 percent since the beginning of industrial activities (EPA 2010a, 2010b).
- **Fluorinated gases**, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), are synthetic compounds emitted through industrial processes. They are replacing ozone-depleting compounds such as chlorofluorocarbons (CFCs) in insulating foams, refrigeration, and air conditioning. Although they are emitted in small quantities, fluorinated gases have the ability to trap more heat than CO_2 and are considered gases with a high global warming potential. Atmospheric concentrations of fluorinated gases have been increasing over the last 20 years and this trend is expected to continue (EPA 2010a).

While models predict that atmospheric concentrations of all GHGs will increase over the next century due to human activity, the extent and rate of change is difficult to predict, especially on a global scale. As a response to concerns over the predicted increase of global GHG levels, various federal and state mandates address the need to reduce GHG emissions, including those described below.

- The federal **Clean Air Act** establishes regulations to control emissions from large generation sources such as power plants: limited regulation of GHG emissions occurs through a review of new sources.
- The U.S. Environmental Protection Agency (EPA) has issued the **Final Mandatory Reporting of Greenhouse Gases Rule** that requires reporting of GHG emissions from large sources. Under the rule, suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHGs are required to submit annual reports to EPA (EPA 2010b), although no other action is required (40 Code of Federal Regulations Parts 86, 87, 89.).
- **Executive Orders 13423 and 13514** require federal agencies to measure, manage, and reduce GHG emissions by agency-defined target amounts and dates.
- In **Idaho, Executive Order 2007-05** requires the Idaho Department of Environmental Quality to coordinate GHG reduction activities between state agencies, produce a greenhouse gas emissions inventory and to "provide recommendations to the Governor on how to reduce greenhouse gas emissions in Idaho, recognizing Idaho's interest in continued growth, economic development and energy security."

Activities that Would Contribute to Greenhouse Gas Emissions

The proposed project and associated alternatives would involve building the Hooper Springs-Lanes Creek 115-kV transmission line. Under the No Action Alternative, the transmission line would not be built and no operation and maintenance activities would occur. Implementation of the proposed project would contribute to an increase in GHG concentrations through the following activities, each discussed in more detail below:

- **Construction:** use of gasoline and diesel-powered vehicles, including cars, trucks, construction equipment, and helicopters
- **Ongoing operation and maintenance:** use of gasoline and diesel-powered vehicles for routine patrols, maintenance project work (vegetation management and site-specific repairs of roads and transmission line structures and associated hardware), emergency maintenance, and resource review, use of helicopters for aerial inspections of the transmission line corridor, and vegetation management

Methods Used to Calculate Greenhouse Gas Emissions

Construction

Project construction for each of the alternatives would take about 16 months over a two year construction period. Non-peak construction activities would include installing and removing best management practice measures, establishing staging areas, moving equipment and materials into and out of the project area, and site preparation and restoration work.

The transportation components of GHG emissions were estimated based on the approximate number of vehicles that would be used during project construction and the approximate distance those vehicles would travel. GHG emissions were calculated for both the 6-month-long peak construction period and the 3-month-long non-peak period based on estimates of vehicle round trips per day.

The number of round trips was conservatively estimated using the following assumptions.

- All workers would travel in separate vehicles to and within the project area each day.
- A maximum number of workers would be required to construct the project.
- The round-trip distance to the project area is the distance from Richland, Washington, to the Midway Substation and back (about 68 miles round trip).
- All workers would travel the full length of the project area each day. Although this is true for some workers such as inspectors, other workers could be localized.
- Fuel consumption is based on the average fuel economy for standard pickup trucks of 18 miles per gallon. Again, this is likely an overestimation as more efficient vehicles may be occasionally used.
- Average helicopter fuel consumption is estimated by BPA pilots at 1 mile per gallon.

Up to 50 construction workers would be at work on the transmission line during the peak construction period and an estimated 10 workers could be present during the non-peak construction period.

BPA staff would travel to the transmission line for various purposes, such as road inspection, work inspection, staff meetings, environmental compliance monitoring, and meetings with landowners. An estimated two round trips per week from the Spokane, Washington, BPA offices during the 9-month-long construction period would result in a total of 77 round trips at an estimated 1,228 miles per trip.

Helicopters may be used to replace the conductor. After the equipment (puller and tensioner) is positioned, a sock line (usually a rope) is strung through all of the structures using a helicopter. It was assumed that the helicopter would be used for approximately 1 month (20 work days) to conduct this work. An estimated two round trips from Soda Springs each day would result in a total of 40 round trips at an estimated 72 miles per trip.

Fuel consumption and GHG emissions would also result from operation of on-site heavy construction equipment. Heavy construction equipment may include augers, bulldozers, excavators, graders, heavy-duty trucks, and front-end-loaders. Similar to the transportation activities listed above, increased use of heavy construction equipment would occur during peak construction.

Although it is difficult to develop an accurate estimation of total fuel consumption associated with heavy construction equipment operation, the following assumptions were used.

- A maximum of 50 equipment machines would be in operation during peak construction and 25 equipment machines would be in operation during off-peak construction.
- The average size of the equipment would not exceed 250 horsepower. All equipment would operate at maximum power for 8 hours per day and 5 days per week throughout the construction phase. This is a significant overestimation because equipment commonly operates in idle or at reduced power.
- Equipment would operate at approximately 35 percent efficiency, representing the percentage of productive energy extracted from the diesel fuel relative to the maximum potential energy within the fuel (i.e., 138,000 British thermal units per gallon of diesel) (DOE and EPA 2011).

GHG emissions associated with equipment operation were overestimated to account for all potential construction activities and associated material deliveries to and from the construction site. They are also expected to account for the low levels of GHG emissions related to temporary soil disruption and damaged vegetation from construction activities, which were not estimated separately in this analysis. GHG emissions that result from soil disturbance are short-lived and return to background levels within several hours (Kessavalou et al. 1998). Emissions from decomposing vegetation would also be relatively short-lived where vegetation would be allowed to reestablish following construction.

Permanent Vegetation Removal

The permanent removal of trees and other vegetation would occur as a result of the construction of roads and ROW clearing. Although permanent tree removal would not immediately emit any GHGs, it would reduce the level of solid carbon storage in the area. Tree growth and future carbon sequestration rates are highly variable and depend on several factors, including the species of tree, age of tree, climate, forest density, and soil conditions. In the Rocky Mountain region, the average carbon storage associated with a forest is 125,000 pounds of carbon per acre (USFS 1992).

In total, approximately 118.8 acres of tree cover would be permanently converted as a result of the proposed North Alternative and approximately 64.5 acres as a result of the proposed South Alternative. The operation of tree removal equipment to clear new road areas of trees was included within the construction section analysis described above.

Operations and Maintenance

During operation and maintenance of the transmission line, the following annual activities would result in GHG emissions:

- Routine patrols (access road, structure, and vegetation inspections): 1 round trip per year, from the BPA Idaho Falls office, 214 miles round trip;
- Maintenance of roads and structures and associated hardware: 1 round trip every other year, from the BPA Idaho Falls office, 214 miles;

- Emergency maintenance to address line outages, landslides, and other unpredicted events: 0.25 round trips per year (approximately 1 trip every 4 years), from BPA Idaho Falls office, 214 miles round trip;
- Natural resource review: 0.25 round trips per year (approximately 1 trip every 4 years), from the BPA Kalispell MT office, 1,046 miles round trip; and
- Aerial inspections by helicopter: 2 round trips from Idaho Falls to Soda Springs, 194 miles round trip.

Vegetation management activities, including mowing along roadsides and weed control, would be conducted during most years. Because vegetation management does not include permanent vegetation removal, this activity was not included in GHG calculations.

Calculations of GHG emissions include operations and maintenance work for the estimated 50-year life span of the rebuilt transmission line.

Results

GHG emissions were calculated using the estimated values described above for two types of activities: construction and ongoing annual operations and maintenance for the estimated 50-year life span of the transmission lines. Each type of activity is discussed separately below. Calculations were not completed for any of the routing options as design information related to roads and towers have not been completed to date; however, they are compared in relationship to the North and South Alternatives, respectively.

Construction Emissions

Table J-1 displays the results of calculations for the construction activities that would contribute to GHG emissions. Construction of the North Alternative would result in an estimated 12,244 metric tons of CO_2e (equivalent carbon dioxide) emissions. CO_2e is a unit of measure used by the IPCC that takes into account the global warming potential of each of the emitted GHGs using global warming potential factors. While, the construction assumptions for the North Alternative were used to calculate GHG emissions for the South Alternative, the South Alternative is approximately two-thirds the distance of the North Alternative, and assuming that GHG emissions as a result of construction activities would be proportional to distance the estimated emissions for the South Alternative would be 8,081, as presented in Table J-3.

All GHG emissions associated with construction activities would occur in the first year. The project's contribution to GHG emissions during construction would be ***low***.

Permanent Vegetation Removal Emissions

Assuming each affected acre contains the average carbon content for the Rocky Mountain Region, the net carbon footprint associated with the removal of trees under the North Alternative would be an estimated 6,747 metric tons of CO2e. Under the same assumption for the South Alternative, the net carbon footprint associated with the removal of trees would be an estimated

3,685. Given these estimates, the impact of vegetation removal on GHG emissions from the implementation of either alternative would be considered ***low***.

Operations and Maintenance Emissions

Table J-2 displays the contribution to GHG emissions that would result from operations and maintenance activities for the North Alternative. Proposed North Alternative operations and maintenance would result in an estimated 126.5 metric tons of CO_2e emissions over the life of the project. Similarly, to construction emissions, operation and maintenance assumptions and emissions for the South Alternative would be the same as those presented for the North Alternative, but would be proportional to distance with estimated emissions of 84 metric tons of CO_2e emissions over the life of the project as presented in Table J-4.

Given this estimate, the impact of operations and maintenance activities on GHG emissions would be ***low***.

Table J-1. North Alternative Estimated Greenhouse Gas Emissions from Project Construction

Estimated GHG Emissions of Construction Activities	CO_2 (metric tons)	CH_4 (CO_2e)[1] (metric tons)	N_2O (CO_2e)[1] (metric tons)	Total CO_2e (metric tons)[3]
Peak construction transportation	438.8	304.4	1,819.3	2,562.4
Off-peak construction transportation	109.7	76.1	454.8	640.6
BPA employee transportation	47.3	32.8	196.0	276.0
Helicopter operation	6.5	0.1	0.0	6.6
Peak construction: equipment operation	6,952.6	7.3	46.7	7,006.7
Off-peak construction: equipment operation	1,738.2	1.8	11.7	1,751.7
Total[3]	**9,293.1**	**422.5**	**2,528.5**	**12,244.0**

1 CO_2 emission factors calculated from DOE and EIA 2005. CH_4 and N_2O emission factors from EPA 2007.

2 CH_4 and N_2O emissions have been converted into units of equivalent carbon dioxide (CO_2e) using the IPCC global warming potential (GWP) factors of 21 GWP for CH_4 and 310 GWP for N_2O (ICBE 2000).

3 The sum of the individual entries may not sum to the total depicted due to rounding.

Table J-2. North Alternative Estimated Greenhouse Gas Emissions from Operations and Maintenance for the Life of the Project

Type of Operation and Maintenance Activity	CO_2 (metric tons)	CH_4 (CO_2e)[1] (metric tons)	N_2O (CO_2e)[1] (metric tons)	Total CO_2e (metric tons)[3]
Routine patrols	5.3	1.5	21.9	28.7
Maintenance work	2.6	0.7	10.9	14.3
Emergency maintenance	1.3	0.4	5.5	7.2
Natural resource review	6.5	1.8	26.8	35.0
Helicopter surveys	40.4	0.7	0.2	41.3
Total[3]	**56.1**	**5.1**	**65.2**	**126.5**

1 CO2 emission factors calculated from DOE and EIA 2005. CH4 and N2O emission factors from EPA 2007.

2 CH4 and N2O emissions have been converted into units of equivalent carbon dioxide (CO2e) using the IPCC global warming potential (GWP) factors of 21 GWP for CH4 and 310 GWP for N2O (ICBE 2000).

3 The sum of the individual entries may not sum to the total depicted due to rounding.

Table J-3. South Alternative Estimated Greenhouse Gas Emissions from Project Construction

Estimated GHG Emissions of Construction Activities	CO_2 (metric tons)	CH_4 (CO_2e)[1] (metric tons)	N_2O (CO_2e)[1] (metric tons)	Total CO_2e (metric tons)[3]
Peak construction transportation	289.6	200.9	1,200.7	1,691.2
Off-peak construction transportation	72.4	50.2	300.2	422.8
BPA employee transportation	31.2	21.7	129.4	182.3
Helicopter operation	4.3	0.1	0.0	4.4
Peak construction: equipment operation	4,588.7	4.8	30.8	4,624.3
Off-peak construction: equipment operation	1,147.2	1.2	7.7	1,156.1
Total[3]	**6,133.4**	**278.9**	**1,668.8**	**8,081.1**

1 CO_2 emission factors calculated from DOE and EIA 2005. CH_4 and N_2O emission factors from EPA 2007.

2 CH_4 and N_2O emissions have been converted into units of equivalent carbon dioxide (CO_2e) using the IPCC global warming potential (GWP) factors of 21 GWP for CH_4 and 310 GWP for N_2O (ICBE 2000).

3 The sum of the individual entries may not sum to the total depicted due to rounding.

Table J-4. South Alternative Estimated Greenhouse Gas Emissions from Operations and Maintenance for the Life of the Project

Type of Operation and Maintenance Activity	CO_2 (metric tons)	CH_4 (CO_2e)[1] (metric tons)	N_2O (CO_2e)[1] (metric tons)	Total CO_2e (metric tons)[3]
Routine patrols	3.5	1.0	14.5	19.0
Maintenance work	1.7	0.5	7.2	9.4
Emergency maintenance	0.9	0.3	3.6	4.8
Natural resource review	4.3	1.2	17.7	23.2
Helicopter surveys	26.7	0.5	0.1	27.3
Total[3]	**37.1**	**3.5**	**43.1**	**83.7**

1 CO2 emission factors calculated from DOE and EIA 2005. CH4 and N2O emission factors from EPA 2007.

2 CH4 and N2O emissions have been converted into units of equivalent carbon dioxide (CO2e) using the IPCC global warming potential (GWP) factors of 21 GWP for CH4 and 310 GWP for N2O (ICBE 2000).

3 The sum of the individual entries may not sum to the total depicted due to rounding.

Summary of Results

To summarize, the North Alternative would result in an estimated total of 12,244 metric tons of CO_2e emissions during the construction phase, and an estimated 126.5 metric tons of CO_2e emissions from ongoing operation and maintenance activities over the life of the project, whereas the South Alternative would result in an estimated total of 8,081 metric tons of CO_2e emissions during the construction phase, and an estimated 84 CO_2e emissions from ongoing operation and maintenance activities. Vegetation removal would result in lost carbon storage equivalent to 6,747 metric tons of CO2 for the North Alternative and 3,685 tons of CO2 for the South Alternative.

To provide context for this level of emissions, EPA's mandatory reporting threshold for annual CO_2 emissions from major sources (not including vegetation removal effects) is 25,000 metric tons of CO_2e, roughly the amount of CO_2 generated by 4,400 passenger vehicles per year. The North Alternative construction emissions would be equivalent to the emissions from approximately 2,156 passenger vehicles per year, with the South Alterative be equivalent to 1,423 passenger vehicles. Project operation and maintenance emissions for the North Alternative would be equivalent to the emissions from approximately 22 passenger vehicles per year and the South Alternative would equate to 15 passenger vehicles. Vegetation removal would result in a loss of carbon storage equivalent to 1,188 passenger vehicles per year for the North Alternative and 649 for the South Alternative. All levels of GHG emissions are significant in that they contribute to global GHG concentrations and climate change, but given the small anticipated contribution from the project, the project's impact on GHG concentrations would be ***low***.

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Appendix K

NEPA Disclosure Forms

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NEPA Financial Disclosure Statement for Preparation of the Environmental Impact Statement for the Proposed Hooper Springs Transmission Project

CEQ regulations at 40 CFR 1506.5(c), which have been adopted by DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project," for the purposes of this disclosure, is defined in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Question 17a and b.

Financial or other interest in the outcome of the project 'includes' any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." 46 FR 18026- 18038 at 18031.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows: [check either (a) or (b) to assure consideration of your proposal]

(a) ___X___ Offeror and any proposed subcontractor have no financial interest in the outcome of the project.

(b) ____________ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests:

1.

2.

3.

Certified by:

William H. Bailey
Signature

William H. Bailey
Name

2/5/2013
Date

NEPA Financial Disclosure Statement for Preparation of the Environmental Impact Statement for the Proposed Hooper Springs Transmission Project

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(b) _____________ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests:

1.

2.

3.

Certified by:

____
Signature

Michel S. Mayer
____
Name

02/05/13
____
Date

NEPA Financial Disclosure Statement for Preparation of the Environmental Impact Statement for the Proposed Hooper Springs Transmission Project

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Financial or Other Interests:

1.

2.

3.

Certified by:

____
Signature

Zachary Gustafson
Name

2/11/13
Date

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Financial or Other Interests:

1.

2.

3.

Certified by:

____
Signature

Todd Ahlman
Name

8 FEBRUARY 2013
Date

BONNEVILLE POWER ADMINISTRATION
DOE/BP-4497 • March 2013