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Key Fish and Wildlife Species and Habitats in the Columbia River Basin Potentially Affected in a Cumulative Manner by Hydroelectric Development

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KEY FISH AND WILDLIFE SPECIES AND HABITATS IN THE
COLUMBIA RIVER BASIN POTENTIALLY AFFECTED IN A
CUMULATIVE MANNER BY HYDROELECTRIC DEVELOPMENT

Final Report

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FOREWORD

The work described herein was conducted under Agreement DE-AI79-84BP19461--"Determination of Methods for Assessing Cumulative Effects of Hydroelectric Development in the Columbia River Basin"--between the Bonneville Power Administration and Argonne National Laboratory. This final report summarizes the results of Task 1, which was the development of a list of key fish and wildlife species and habitat types that could potentially be impacted by hydroelectric development in a cumulative manner. Information developed in Task 1 is to be utilized in Tasks 3, 4, 5, and 6 to identify specific pathways of cumulative effects, to assess current cumulative impact assessment methodologies, and to recommend alternative approaches for use in the Columbia River Basin. The Task 1 report accompanies the Task 2 report, "Significant Cumulative Effects from Hydropower Development Occurring in the Columbia River Basin." Much of the technical information contained in this report was included in a subcontractor report prepared by Envirosphere Co. of Bellevue, Washington, for the Environmental Research Division, Argonne National Laboratory. Participating in the preparation of the subcontractor's report were Douglas Martin, John Knutzen, and Clifford Whitnus of Envirosphere Co. John Irving and Gary Witmer of Argonne National Laboratory reviewed the document, while John DePue edited and prepared the final document for publication. The authors wish to thank members of the Hydropower Assessment Steering Committee and personnel of resource and tribal agencies who commented on the draft.

TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	iv
1. INTRODUCTION	1
2. LISTS OF KEY SPECIES AND HABITATS	3
2.1 Initial HASC List	3
2.2 Expanded List	3
2.3 Short List of Species and Habitat Types	4
2.4 Additions to the Short List Based on Agency Comments and Author Evaluation	8
2.5 Combined List of Key Species and Habitats	8
APPENDIX A. SUMMARY OF LITERATURE DOCUMENTATION FOR SPECIES AND HABITATS POTENTIALLY SUBJECT TO SIGNIFICANT IMPACTS FROM HYDROELECTRIC DEVELOPMENT	A-1
APPENDIX B. RATIONALE FOR ADDITIONS TO THE LIST OF KEY SPECIES AND HABITATS POTENTIALLY SUBJECT TO SIGNIFICANT IMPACTS FROM HYDROELECTRIC DEVELOPMENT	B-1

LIST OF TABLES

<u>Table</u>	<u>Page</u>
2-1 Hydropower Assessment Steering Committee List of Key Fish and Wildlife Species of Concern in the Columbia River Basin.....	3
2-2 Expanded List of Important Fish and Wildlife Species in the Columbia Basin to Be Evaluated for Potential Cumulative Impacts from Hydroelectric Development.....	5
2-3 List of Fish and Wildlife Habitats Considered for Potential Cumulative Impacts from Hydroelectric Development in the Columbia River Basin.....	7
2-4 Short List of Fish and Wildlife Species and Habitats Potentially Subject to Significant Cumulative Impacts from Hydroelectric Development in the Columbia River Basin as Determined by Review of Published Literature.....	9
2-5 Additional Fish and Wildlife Species and/or Habitats That May Be Cumulatively and Significantly Impacted by Hydroelectric Development in the Columbia River Basin as Determined by Agency Review.....	10
2-6 Additional Fish and Wildlife Species and/or Habitats That May Be Cumulatively and Significantly Impacted by Hydroelectric Development in the Columbia River Basin as Determined by Professional Judgment of Authors and Their Staffs.....	11
2-7 Combined List of Fish and Wildlife Species and Habitats Potentially Affected in a Cumulative Manner by Hydroelectric Development in the Columbia River Basin.....	12

1. INTRODUCTION

In Measure 1204(b)(2) of the Columbia River Basin Fish and Wildlife Program the Bonneville Power Administration (BPA) is mandated to fund a study to develop criteria and methods for assessment of cumulative environmental effects* from hydroelectric development. The study is subject to the approval of the Northwest Power Planning Council (NWPPC). The Hydropower Assessment Steering Committee (HASC) of the NWPPC has outlined an approach for developing methods for assessing cumulative impacts that includes creation of a list of key Columbia River Basin fish and wildlife species and habitat types with the potential of being impacted in a cumulative manner by hydroelectric development. The list is to include the types of fish and wildlife species and habitats outlined below:

- **Species Types:** Anadromous and resident fishes, big game, upland game, furbearers, raptors, waterfowl, and threatened and endangered species;
- **Habitat Types:** Spawning, rearing, and migration areas for anadromous fish; spawning, nesting, and rearing areas for resident fish; wildlife denning, wintering, and migration areas; and riparian, wetland, and other important use areas.

The term 'cumulative impacts' has been defined in many ways. These various definitions usually include one or more of the following concepts: (1) interaction between multiple projects of the same type; (2) interaction between a single project and other, different types of activities; (3) interaction between existing and planned development; and (4) synergism between different impacts. This diversity of interpretation is in part a result of the nature of the Council on Environmental Quality's (CEQ) 1978 definition (as contained in Federal Register Vol. 43, No. 230):

"..impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency. ..undertakes such actions..."

In this report, the scope of the term "cumulative impacts" has been narrowed to include only the effects of hydroelectric development on fish and wildlife and their habitat. Based on guidance from HASC and on review of the definition of "cumulative impact" in other sources, cumulative impacts (or effects) are defined, for the purpose of this work, as:

Environmental changes resulting from interactions of the effects from one hydroelectric power project with the effects from one or more other hydroelectric power projects.

*The words "effects" and "impacts" are used interchangeably throughout the report.

Cumulative environmental effects can be physical or biological in nature and can involve fish and wildlife populations and/or habitats. Because the resources of concern in this analysis are biological populations with complex relationships to their habitats, cumulative effects may be additive, synergistic, or operate at some threshold level. Cumulative effects may impact species, populations within species, or other units of a species that are used for management. These units of a species may suffer serial impacts through time and/or simultaneous impacts within one time period. In broad perspective, cumulative environmental effects from hydroelectric development may interact with one or more other types of development activity, such as logging, irrigation, or mining. However, this analysis of key species and habitats is exclusively directed toward impacts from multiple hydroelectric developments.

The lists of key species and habitats presented in this report were assembled in several steps, including review and comment by resource agencies. An initial list provided by HASC was expanded into a preliminary list that included other important species, and then the preliminary list was reduced to a short list of 30 key species and 15 habitat types based on the perceived significance of hydropower impacts on those species. The length of the short list was specified by HASC. The draft of the short list was distributed to BPA, HASC, and other interested agencies for comments, and the comments were incorporated as additions to the short list.

2. LISTS OF KEY SPECIES AND HABITATS

2.1 INITIAL HASC LIST

HASC recommended that the development of the list of key species and habitats begin with an initial list that the committee developed and end with a list of no more than 30 key species and 15 habitat types. HASC specified that species be added or deleted from their list based on impact importance* and significance.** The HASC list of species is presented in Table 2-1. This list separates races of some salmon species but aggregates wildlife species and some resident fish species.

2.2 EXPANDED LIST

The initial HASC list was expanded by disaggregating species groups and by adding other species and habitat types on the basis of their importance to society. A species was considered important to society if the catch or harvest of that species in the Columbia River Basin is specifically regulated or managed by a federal or state resource agency or if the species is designated as threatened or endangered by a state

Table 2-1. Hydropower Assessment Steering Committee (HASC) List of Key Fish and Wildlife Species of Concern in the Columbia River Basin.

<u>Anadromous Fish</u>	
Spring chinook salmon	Winter steelhead trout
Summer chinook salmon	Sea-run cutthroat trout
Fall chinook salmon	Sockeye salmon
Summer steelhead trout	Coho salmon
<u>Resident Fish</u>	
Westslope cutthroat trout	Kokanee salmon
Warmwater game fish	White sturgeon
Migratory resident trout	
<u>Wildlife</u>	
Big game	Raptors
Upland game	Furbearers
Waterfowl	

*The term "importance" refers to concern to society as reflected by management plans and ecological interest.

**The term "significance" refers to the degree of literature support that the impact is real.

of federal agency. This expanded list of species is presented in Table 2-2. Not all possible species in the Columbia River Basin are included in the list. Some species that could be impacted by hydroelectric development but that are not specifically managed by federal and state agencies are not listed. Other unlisted species are represented on the list by species of similar habitat and trophic requirements. For example, other fish-eating furbearers are represented by mink, and other waterfowl are represented by the Canada goose.

The HASC list of habitats was also expanded (Table 2-3). Habitats for rearing and migration of fish were separated into juvenile rearing (anadromous and resident fish), juvenile migration (anadromous fish), adult rearing (resident fish), and adult migration (anadromous fish). Since the life-cycle terminologies distinguishing birds and mammals are different, the habitats of these two classes of animals were listed separately. Since many birds migrate and change food habitats seasonally, winter and Summer feeding areas are listed separately. Rearing habitats are separated into those habitats in which the fledging broods are reared and those in which adults live. Cover is listed separately from the other habitats, which are distinguished by different activities and life stages, because many of the activities of ground-nesting and open-country birds are closely tied to the availability of bushy or riparian habitats. Habitats for mammals include those used for birth, rearing, and protection of young, such as fawning (large mammals) or denning (furbearers). Wintering areas, which are often limiting habitats for big game, are included, as are migration areas in which game moves between summer and winter habitats.

2.3 SHORT LIST OF SPECIES AND HABITAT TYPES

The analysis to select 30 key fish and wildlife species and 15 habitats that could potentially be cumulatively impacted by hydroelectric development in the Columbia River Basin was begun by evaluating the existence and importance of cumulative impacts for each species/habitat combination from Tables 2-2 and 2-3. The analysis was not limited only to literature reports of cumulative impacts to fish and wildlife, since cumulative impact assessment is a relatively new field of study and cumulative impacts have been specifically addressed only in a few assessment documents. Demonstration of the importance and mechanisms of action of cumulative impacts to fish and wildlife in the Columbia River Basin is primarily limited to data on historical changes in species abundance and distribution associated with the large, mainstem dams. In the future, studies of cumulative effects will come from the analysis of river basins with many small hydroelectric developments. Any anticipated impact to a species or habitat was regarded as potentially cumulative even if that impact has only been demonstrated to cause effects individually and independently of other potential impacts. This reasoning was based on the assumption that any single impact could become cumulative with multiple-project development. To determine whether multiple single impacts are cumulative, additional information beyond the scope of this report would be necessary. Such information would include specific project type and design, impact zone, and location of habitats.

Table 2-2. Expanded List of Important Fish and Wildlife Species in the Columbia Basin to Be Evaluated for Potential Cumulative Impacts from Hydro-electric Development.

Species	Management Entities	
	State	Federal
<u>Fish</u>		
White sturgeon	X	
Green sturgeon	X	
American shad	X	
Spring chinook salmon	X	X
Fall chinook salmon	X	X
Summer chinook salmon	X	X
Coho salmon	X	X
Sockeye salmon	X	X
Resident sockeye salmon (kokanee)	X	
Chum salmon	X	X
Pink salmon	X	X
Winter steelhead trout	X	X
Summer steelhead trout	X	X
Sea-run cutthroat trout	X	X
Resident cutthroat trout	X	
Rainbow trout	X	X
Brown trout	X	
Dolly Varden/bull trout	X	
Brook trout	X	
Mountain whitefish	X	
Eulachon	X	
Channel catfish	X	
Bullheads (spp.)	X	
Burbot	X	
Largemouth bass	X	
Smallmouth bass	X	
Crappie (spp.)		
Sunfish (spp.)	X	
Walleye	X	
Yellow perch	X	
Starry flounder	X	
<u>Birds</u>		
Canada goose	X	X
Red-tailed hawk	X	
Bald eagle	X	X
Osprey	X	
Peregrine falcon	X	

Table 2-2. Continued.

Species	Management Entities	
	State	Federal
Grouse (spp.)	X	
Quail (spp.)	X	
Ring-necked pheasant	X	
Great blue heron	X	
California gull	X	
Ring-billed gull	X	
Forster's tern	X	
Caspian tern	X	
<u>Mammals</u>		
Mink	X	
Beaver	X	
Muskrat	X	
Elk	X	
Mule deer/black-tailed deer	X	
White-tailed deer	X	

Table 2-3. List of Fish and Wildlife Habitats Considered for Potential Cumulative Impacts from Hydroelectric Development in the Columbia River Basin.

Species	Habitat Type
Fish	Spawning and incubation Juvenile rearing Juvenile migration Adult rearing Adult migration
Birds	Nesting Brood rearing Winter feeding Summer feeding Adult rearing Adult migration Cover
Mammals	Fawning (calving) Denning Wintering Feeding Adult migration

An analysis of significant environmental effects of hydroelectric development being simultaneously conducted by Argonne National Laboratory was used for guidance on physical environmental changes and biological effects caused by hydroelectric development. For a particular species or habitat type to be included on the short list of key species and habitats, the biological effect of a given impact had to be considered important to the management of the abundance and distribution of the species. If existence of the impact was documented adequately in the published literature and was regarded in that documentation as serious or significant, then the habitat being evaluated and its dependent species were entered on the short list.

If the existence of an impact was documented in the literature, but no documentation of impact importance was available, the authors relied on the professional judgment of their staff to determine whether the impact could be important to the abundance and distribution of the species. Because not all species and habitat combinations have been extensively studied and reported in the published literature, professional judgment was an important and necessary part of the evaluation of impact significance. In some cases, while the occurrence of an impact from hydroelectric development has been reported, the importance of that impact to species abundance and distribution has not been empirically demonstrated or quantitatively assessed. The authors recognize that unpublished data residing with various resource agencies and tribes

might be able to fill some of the gaps in the published literature; however, this information could not have been located, identified, retrieved, inspected, and analyzed within the timeframe of the project.

The documentation of significant hydroelectric power impacts to species and habitats is summarized in the tables in Appendix A. Those tables include the species and habitat combinations being considered, the specific physical environmental changes due to hydropower development, the biological effects of those physical changes, and supporting literature citations.

Based on the literature documentation presented in Appendix A, a short list (Table 2-4) of approximately 30 key species and 15 habitats was developed from the lists of species in Table 2-2 and habitats in Table 2-3. The fish and wildlife entries on the short list include races and species of anadromous and resident salmon and trout, other anadromous fish, resident warmwater fish, waterfowl, raptors, big game, and furbearers. No upland game birds are included. Habitats include those used for reproduction, juvenile and adult rearing, and migration.

2.4 ADDITIONS TO THE SHORT LIST BASED ON AGENCY COMMENTS AND AUTHOR EVALUATION

The short list of key species and key habitats, along with the details of the analysis, was submitted to BPA and HASC for comment. A general consensus of reviewers was that limiting the list to only those impacts reported in the public literature was too restrictive and did not adequately address the concerns of the agencies and tribes involved in management of Columbia River Basin resources. The agencies and tribes offered arguments for including other species and habitats on the lists. The bases for these arguments included professional judgment from experience and observations gathered in management of Columbia River Basin resources and specific knowledge of unpublished data residing with the agencies. Table 2-5 lists additional species and habitats suggested by resource agencies and tribes as a result of their review of the short list.

Argonne National Laboratory and EnviroSphere Company personnel also reviewed the short list and recognized that some species for which documentation of impacts was lacking were, in their best professional judgment, likely to suffer important impacts due to hydroelectric development. Table 2-6 lists additional species and habitats as determined by reexamination of the short list. The basis for adding these species and habitats was professional judgment of the authors and their staffs. Further documentation of recommended additions to the short list is presented in Appendix B.

2.5 COMBINED LIST OF KEY SPECIES AND HABITATS

In all, more than 60 species were recommended for inclusion in the list of key species and habitats potentially impacted in a cumulative manner by hydroelectric development in the Columbia River Basin. These are included in the combined list presented in Table 2-7.

Table 2-4. Short List of Fish and Wildlife Species and Habitats Potentially Subject to Significant Cumulative impacts from Hydroelectric Development in the Columbia River Basin as Determined by Review of Published Literature.

Species	Habitat ¹
<u>Fish</u>	
White sturgeon	S, JM AM
American shad	JM AM
Spring chinook salmon	S, JR, JM AM
Fall chinook salmon	S, JR, JM AM
Summer chinook salmon	S, JR, JM AM
Coho salmon	S, JM AM
Sockeye salmon	S, JM AM
Resident sockeye salmon (kokanee)	S, AR
Winter steelhead trout	S, JR, AM
Summer steel head trout	S, JR, JM AM
Resident cutthroat trout	S, JR
Rainbow trout	S, JR
Channel catfish	S, JR
Bullheads (spp.)	S, JR
Burbot	S
Smallmouth bass	S, JR
Largemouth bass	S, JR
Crappie (spp.)	S, JR
Sunfish (spp.)	S, JR
Walleye	S, JR
Yellow perch	S, JR
<u>Birds</u>	
Canada goose	N, RR
Bald eagle	W
Great blue heron	N
California gull	N
Ring-billed gull	N
Forster's tern	N
<u>Mammals</u>	
Beaver	D
Muskrat	D
Elk	AM
Mile deer/black-tailed deer	F, W AM
White-tailed deer	W AM

¹ Legend: AM = Adult migration JM = Juvenile migration
AR = Adult rearing JR = Juvenile rearing
BR = Brood rearing N = Nesting
D = Denning S = Spawning and incubation
F = Fawning (calving) W = Wintering

Table 2-5. Additional Fish and Wildlife Species and/or Habitats That May Be Cumulatively and Significantly Impacted by Hydroelectric Development in the Columbia River Basin as Determined by Agency Review.

Species	Habitat¹
<u>Fish</u>	
Dolly Varden	S, AM
<u>Birds</u>	
Great blue heron	BR, AM
Mallard duck	N, BR
Teal (spp.)	N, BR
Wood duck	N, BR
Ring-necked duck	N, BR, FD
Goldeneye	N, BR, FD
Hooded merganser	N, BR
Red-tailed hawk	FD
Bald eagle	N, BR, AR
Osprey	FD
Peregrine falcon	FD
Grouse (spp.)	BR
Quail (spp.)	BR
Ring-necked pheasant	BR
Partridge	BR
Doves	BR
Long-eared owl	N, FD
Kingfisher	N, FD
Yellow-bellied sapsucker	N, FD
Downy woodpecker	N, FD
Dipper	N, FD
<u>Mammals</u>	
Grizzly bear	
Black bear	FD
River otter	D, FD, AM
Grey wolf	
Bobcat	FD
Mountain cottontail	FD
Elk	F, W
Mile deer/black-tailed deer	AR
White-tailed deer	AR
Moose	F, W

¹Legend: AM = Adult migration FD = Feeding
AR = Adult rearing JM = Juvenile migration
BR = Brood rearing JR = Juvenile rearing
C = Cover N = Nesting
D = Denning S = Spawning and incubation
F = Fawning (calving) W = Wintering

Table 2-6. Additional Fish and Wildlife Species and/or Habitats That May Be Cumulatively and Significantly Impacted by Hydroelectric Development in the Columbia River Basin as Determined by Professional Judgment of Authors and Their Staffs.

Species	Habitat¹
<u>Fish</u>	
White sturgeon	JR, AR
Coho salmon	JR
Chum salmon	S, JR, JM, AM
Resident sockeye salmon (kokanee)	JM
Pink salmon	S, JM, AM
Winter steelhead trout	JM
Sea-run cutthroat trout	S, JR, JM, AM
Rainbow trout	JM, AR
Brown trout	S, JR, AR
Dolly Varden/bull trout	JR, AR
Brook trout	JR, AR
Channel catfish	AR
Bullheads (spp.)	AR
Burbot	JR
Smallmouth bass	AR
Crappie (spp.)	AR
Sunfish (spp.)	AR
Walleye	AR
Yellow perch	AR
<u>Birds</u>	
Ring-necked pheasant	C
Osprey	N
Peregrine falcon	N
Grouse (spp.)	C
Partridge (spp.)	C
Quail (spp.)	C
<u>Mammals</u>	
Mile deer/black-tailed deer	W
White-tailed deer	W, AM

¹ Legend: AM = Adult migration FD = Feeding
AR = Adult rearing JM = Juvenile migration
BR = Brood rearing JR = Juvenile rearing
C = Cover N = Nesting
D = Denning S = Spawning and incubation
F = Fawning (calving) W = Wintering

Table 2-7. Combined List of Fish and Wildlife Species and Habitats Potentially Affected in a Cumulative Manner by Hydroelectric Development in the Columbia River Basin.

Species	Habitat¹
<u>Fish</u>	
White sturgeon	S, JM AM
American shad	JM AM
Spring chinook salmon	S, JR, JM AM
Fall chinook salmon	S, JR, JM AM
Summer chinook salmon	S, JR, JM AM
Coho salmon	S, JR, JM AM
Pink salmon	S, JM AM
Sockeye salmon	S, JM AM
Resident sockeye salmon (kokanee)	S, JM AR
Chum salmon	S, JR, JM AM
Winter steelhead trout	S, JR, JM AM
Summer steelhead trout	S, JR, JM AM
Rainbow trout	S, JR, JM AR
Sea-run cutthroat trout	S, JR, JM AR
Resident cutthroat trout	S, JR
Brown trout	S, JR, AR
Dolly Varden/bull trout	S, JR, AR, AM
Brook trout	JR, AR
Channel catfish	S, JR, AR
Bullheads (spp.)	S, JR, AR
Burbot	S, JR, AR
Largemouth bass	S, JR, AR
Smallmouth bass	S, JR, AR
Sunfish (ssp.)	S, JR, AR
Crappie (spp.)	S, JR, AR
Walleye	S, JR, AR
Yellow perch	S, JR, AR
<u>Birds</u>	
Canada goose	N, BR
Great blue heron	N, BR, AM
Mallard duck	N, BR
Teal (spp.)	N, BR
Wood duck	N, BR
Ring-necked duck	N, BR, FD
Goldeneye	N, BR, FD
Hooded merganser	N, BR
California gull	N
Ring-billed gull	N

Table 2-7. Continued.

Species	Habitat ¹
Forster's tern	N
Caspian tern	N
Red-tailed hawk	N, FD
Bald eagle	W, N, BR, AR
Osprey	N, FD
Peregrine falcon	N, FD
Grouse (spp.)	RR
Quail (spp.)	C, BR
Ring-necked pheasant	C, BR
Partridge	C, BR
Doves	C, BR
Long-eared owl	N, FD
Kingfisher	N, FD
Yellow-bellied sapsucker	N, FD
Downy woodpecker	N, FD
Willow flycatcher	AR
Dipper	N, FD
<u>Mammals</u>	
Grizzly bear	
Black bear	FD
River otter	D, FD, AM
Grey wolf	
Bobcat	FD
Mountain cottontail	FD
Elk	F, W, AM
Mule deer/black-tailed deer	F, W, AR, AM
White-tailed deer	W, AR, AM
Moose	F, W

¹Legend: AM = Adult migration JM = Juvenile migration
AR = Adult rearing JR = Juvenile rearing
BR = Brood rearing N = Nesting
D = Denning S = Spawning and incubation
F = Fawning (calving) W = Wintering
FD = Feeding

APPENDIX A

**SUMMARY OF LITERATURE DOCUMENTATION FOR SPECIES AND HABITATS
POTENTIALLY SUBJECT TO SIGNIFICANT IMPACTS FROM
HYDROELECTRIC DEVELOPMENT**

Appendix A provides the literature documentation for designation of "key" species and habitats relative to potential significant impact from hydroelectric development. This appendix consists of six tables. Anadromous salmonids are included in Table A-1, resident salmonids in Table A-2, resident non-salmonids in Table A-3, other fish species in Table A-4, birds in Table A-5, and mammals in Table A-6.

The first line item of Table A-1 is an example of the documentation for key species and habitats. The spawning and incubation habitats of spring, summer, and fall chinook were evaluated for impacts from inundation (i.e., flooding) due to impoundment. A review of the published literature revealed that one investigator (see Reference 7 [Mirs 1977]) observed decreases in spawning and incubation habitats of chinook due to inundation by reservoir formation behind dams.

Table A-1. Summary of Literature Documentation for Species and Habitats of Anadromous Salmonids Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
Chinook salmon (spring, summer, and fall)	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
		Flow fluctuation	Fluctuating water elevation strands eggs (1,42,43)
		Temperature	Emergence timing may be altered (46,47)
		Gravel recruitment	Gravel recruitment to spawning reaches reduced (48)
	Juvenile rearing	Flow fluctuation	Fluctuating water elevation strands juveniles (2,3,8,42)
	Migration (juvenile)	Predation	Impoundments increase number of potential predators (9)
		Passage mortality	Turbines and spillways kill juveniles (11,13,14,41)
		Residualism	Impoundments may cause loss of migration cues (9,49,50)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Chinook salmon (cont' d)	Migration (adult)	Passage	Dams or diversions may limit access or fish passage facilities may cause mortalities (15,16)
		Reservoir loss	Returning adults may lose homing cues (7,45)
		Nitrogen	Nitrogen supersaturation is harmful to fish (44)
		Temperature	High or low water temperatures may be harmful or inhibit movement (57)
Coho salmon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
		Juvenile rearing	Fluctuating water elevation strands juveniles (2,3,42)
	Diversion	Diversion around rearing areas reduces rearing habitat (39)	
	Migration (juvenile)	Predation	Impoundments increase number of potential predators (56)
		Passage mortality	Turbines and spillways kill juveniles (11,12,14,40,41)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Coho salmon (cont' d)	Migration (juvenile)	Residualism	Impoundments may cause loss of migration cues (40.52)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Passage	Dams or diversions may limit access or fish passage facilities may cause mortalities (15)
Sockeye salmon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
		Temperature	High water temperatures are harmful to juveniles (58)
	Migration (juvenile)	Passage mortality	Turbines and spillways kill juveniles (14)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Passage	Dams may limit access or fish passage facilities may cause mortalities (15)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Sockeye salmon (cont'd)	Migration (adult)	Reservoir loss	Returning adults may lose homing cues (7)
		Nitrogen	Nitrogen supersaturation is harmful to fish (44)
Chum salmon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
	Juvenile rearing	Flow fluctuation	Fluctuating water elevation strands juveniles (3)
	Migration (juvenile)	Passage mortality	Turbines and spillways kill juveniles (11,12,14)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Nitrogen	Nitrogen supersaturation is harmful to fish (10)
Winter steelhead trout	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
		Gravel recruitment	Gravel recruitment to spawning reaches reduced (48)
	Juvenile rearing	Flow fluctuation	Fluctuating water elevation strands juveniles (3,8)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Winter steelhead trout (cont'd)	Juvenile rearing	Diversion	Diversion around rearing areas reduces rearing habitat (4)
	Migration (juvenile)	Predation	Impoundments increase number of potential predators (9)
		Passage mortality	Turbines and spillways kill juveniles (11,12,14)
		Residualism	Impoundments may cause loss of migration cues (9,40,51,53,54,55)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Passage	Dams or diversions may limit access or fish passage facilities may cause mortalities (15,16)
		Reservoir loss	Returning adults may lose homing cues (7)
Nitrogen		Nitrogen supersaturation is harmful to fish (10)	
Summer steelhead trout	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Summer steelhead trout (cont' d)	Spawning & incubation	Gravel recruitment	Gravel recruitment to spawning reaches reduced (48)
	Juvenile rearing	Flow fluctuation	Fluctuating water elevation strands juveniles (3,8)
		Diversion	Diversion around rearing areas reduces rearing habitat (4)
	Migration (juvenile)	Predation	Inpoundments increase number of potential predators (9)
		Passage mortality	Turbines and spillways kill juveniles (12,13,14)
		Residualism	Inpoundments may cause loss of migration cues (9,5)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Passage	Dams or diversions may limit access or fish passage facilities may cause mortalities (15,16)
		Reservoir loss	Returning adults may lose homing cues (7)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
Summer steelhead trout (cont'd)	Migration (adult)	Nitrogen	Nitrogen supersaturation is harmful to fish (10,44)
Sea-run cutthroat trout	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
	Migration (juvenile)	Passage mortality	Turbines and spillways kill juveniles (11,12,14)
		Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Nitrogen	Nitrogen supersaturation is harmful to fish (10)
Pink salmon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (7)
		Flow fluctuation	Fluctuating water elevation strands eggs (46)
		Siltation	Egg survival and spawning area reduced (6)
	Migration (juvenile)	Passage mortality	Turbines and spillways kill juveniles (11,12,14)

Table A-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Pink salmon (cont'd)	Migration (juvenile)	Nitrogen	Nitrogen supersaturation is harmful to fish (10)
	Migration (adult)	Nitrogen	Nitrogen supersaturation is harmful to fish (10)

'Numbers in parentheses correspond to numbered references listed at the end of this appendix.

Table A-2. Summary of Literature Documentation for Species and Habitats of Resident Salmonids Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Cutthroat & rainbow trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat (17)
		Siltation	Reduced egg survival and spawning area (17)
	Juvenile rearing	Flow fluctuations	Fluctuating water elevation strands juveniles (3,20)
		Diversion	Diversion around rearing areas reduces rearing habitat (17,18,4)
		Food supply	Physical and chemical alterations reduce food supply (20)
	Migration (juvenile)	Passage mortality	Turbines and spillways kill juveniles (4)
Brown trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat (17)
		Siltation	Egg survival and spawning area reduced (17)
Dolly Varden (bull) & brook trout	Juvenile rearing	Diversion	Diversion around rearing areas reduces rearing habitat (18)

Table A-2. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
Kokanee salmon	Spawning & incubation	Flow fluctuation	Fluctuating water elevation strands eggs (19,20)
	Adult rearing	Migration loss	Migration past dams may be unidirectional (19)

¹ Numbers in parentheses correspond to numbered references listed at the end of this appendix.

Table A-3. Summary of Literature Documentation for Species and Habitats for Resident Non-Salmonids Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Cool-water species (smallmouth bass, walleye, & yellow perch)	Spawning & incubation	Flow fluctuation	Fluctuating water elevation strands eggs (42)
	Juvenile rearing	Stranding	Fluctuating water elevation may strand juveniles (42)
		Cover	Utilizable cover may be reduced by fluctuating water elevation (25,42)
		Adult rearing	Cover
Warm-water species (largemouth bass, crappie, sunfish, channel catfish, & bullhead)	Spawning & incubation	Flow fluctuation	Fluctuating water elevation strands eggs (21-24,38,42)
	Juvenile rearing	Stranding	Fluctuating water elevation may strand juveniles (38,42)
		Food supply	Physical and chemical alteration reduce food supply (24)
		Cover	Utilizable cover may be reduced by fluctuating water elevation (24,38,42)

Table A-3. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Warm water species (cont'd)	Adult rearing	Food supply	Physical and chemical alterations reduce food supply (24)
		Cover	Utilizable cover may be reduced by fluctuating water elevation (24)
Burbot	Juvenile rearing	Food supply	Physical and chemical alterations reduce food supply (26)

'Numbers in parentheses correspond to numbered references listed at the end of this appendix.

Table A-4. Summary of Literature Documentation for Species and Habitats of Other Fish Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
White sturgeon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat (1)
	Juvenile rearing	Food supply	Physical and chemical alterations reduce food supply (27,26)
	Adult rearing	Food supply	Physical and chemical alterations reduce food supply (27)
	Adult migration	Passage	Dams may limit access or fish passage facilities may cause mortality (27)

¹Numbers in parentheses correspond to numbered references listed after this table.

Table A-5. Summary of Literature Documentation for Species and Habitats of Birds Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
Canada goose	Nesting (islands and shore-lines)	Fluctuating water levels & filling of reservoir	Inundation of nests and nesting habitat (28,30,31,34)
		Erosion by wave action	Loss of previously suitable habitat (35)
		Lowered water levels	Lowered water levels during nesting season allow coyotes access to islands to prey on geese, eggs, or goslings (28,34)
	Brood-rearing (open shore-line or nearby areas with gentle slope and tender vegetation)	Elevation of water levels	Filling of reservoir will flood some such habitats, making them unusable at the critical time (34)
		Erosion	Wave action in a reservoir and power peaking flows can erode habitats (e. g. , delta areas) (28,35)
		Reduction in sediment recruitment	Loss of some habitats such as reduction of sand bar and delta building (8,35)

Table A-5. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact'
Gulls (e.g., California & ring-billed) & terns (e.g., Forster's & Caspian)	Nesting (islands)	Seasonal water fluctuation Lowered water levels	Established nests may be flooded (28) Lower water level during nesting season allows coyotes access to islands to prey on adults, young and eggs (2)
Great blue heron	Rookery (riparian tree grove)	Erosion or flooding	Riparian tree grove may be removed or nest trees killed (28)
Upland game birds (e.g., ring-necked pheasant, quail species, grouse species, part-ridge species, doves)	Riparian cover	Inundation or excessive erosion	Elimination of riparian vegetation (30,31)
Bald eagle	Winter feeding	Destruction of fish habitat	Loss of anadromous fish as food base (30,31)
Other raptors (e.g., osprey, red-tailed hawk)	Nest trees	Tree removal	Nest trees may be removed (32)

'Numbers in parentheses correspond to numbered references listed at end of this appendix.

Table A-6. Summary of Literature Documentation of Species and Habitats of Mammals Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact¹
Deer (mule/black-tailed and white-tailed)	Fawning (islands)	Lowered water levels	During fawning season lowered water levels allow island access by coyotes (28,34)
	Wintering	Filling of reservoir	Inundation of riparian habitat (28,31,30,34,37)
		Fluctuating water levels and reduced incidence of natural flooding	May reduce extent of riparian habitat (36,31,37)
	Migratory routes	Presence of reservoir	Presents an obstacle to movement and migration
Beaver (also applies to muskrat and mink)	Denning	Fluctuating water levels	Dens may be flooded or entrances left high and dry, making beavers more vulnerable to predators and cause drowning of young (28,34,36)

¹Numbers in parentheses correspond to numbered references listed at end of this appendix.

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APPENDIX B

**RATIONALE FOR ADDITIONS TO THE LIST OF KEY SPECIES
AND HABITATS POTENTIALLY SUBJECT TO SIGNIFICANT
IMPACTS FROM HYDROELECTRIC DEVELOPMENT**

Appendix B provides the rationale for additions to the list of key species and habitats on the basis of professional judgment of the evaluators or expression of concern by resource agencies. The format and organization of the tables presented in this appendix parallel those of Appendix A. The basis for considering a potential impact significant is shown in the last column of the tables. The letter "A" followed by a number indicates that a resource agency (see key to codes at end of each table) expressed concern over the potential impact; the letter "P" indicates that a potential impact was considered significant on the basis of the professional judgment of the authors and their staffs.

The first line of Table B-1 provides an example of addition of a species or habitat as a result of concern expressed by a resource agency. In this case, the Columbia Basin Fish and Wildlife Council (coded AI) expressed concern that diversion around chinook salmon spawning reaches could result in removal of spawning habitat. An example where professional judgment was used to recommend additions to the list of key species and habitats is provided on the second page of Table B-1. The spawning and incubation habitats of summer steelhead were assessed for their sensitivity to flow fluctuation. No such effects were documented during the literature search, but on the basis of their professional judgment, the evaluators concluded that fluctuating water elevations could strand steelhead eggs sufficiently to be regarded as a potentially serious or significant cumulative impact.

Table B-1. Rationale for Additions of Species and Habitats of Anadromous Salmonids to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Chinook salmon (spring, summer, and fall)	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	AI
		Siltation	Egg survival and spawning area reduced	AI
	Juvenile rearing	Diversion	Diversion around rearing areas reduces rearing habitat	AI
		Temperature	High water temperatures are harmful to juveniles	AI
Coho salmon	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	AI
		Temperature	Emergence timing may be altered	AI
		Gravel recruitment	Gravel recruitment to spawning reaches reduced	AI
		Siltation	Egg survival and spawning area reduced	AI

Table B-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Coho salmon (cont'd)	Juvenile rearing	Temperature	High water temperatures are harmful to juveniles	AI
	Migration (adult)	Temperature	High or low water temperatures may be harmful or inhibit movement	AI
Sockeye salmon	Spawning & incubation	Siltation	Egg survival and spawning area reduced	AI
	Migration (juvenile)	Residualism	Impoundments may cause loss of migration cues	AI
Chum salmon	Spawning & incubation	Siltation	Egg survival and spawning area reduced	AI
Winter steelhead trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	AI
		Siltation	Egg survival and spawning area reduced	AI

Table B-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Summer steelhead trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	Al
		Flow fluctuation	Fluctuating water elevation strands eggs	P
		Siltation	Egg survival and spawning area reduced	Al
Sea-run cutthroat trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	Al
		Gravel recruitment	Gravel recruitment to spawning reaches reduced	Al
		Siltation	Egg survival and spawning area reduced	Al
	Juvenile rearing	Flow fluctuations	Fluctuating water elevation strands juveniles	P
		Diversion	Diversion around rearing areas reduces rearing habitat	Al

Table B-1. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Sea-run cutthroat trout (cont'd)	Juvenile rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
	Migration (juvenile)	Predation	Inpoundments increase number of potential predators	A1
		Residualism	Inpoundments may cause loss of migration cues	A1
Migration (adult)	Passage	Dams or diversions may limit access or fish passage facilities may cause mortalities	A1	

¹Agencies that made judgments about potential impacts were: A1 = Columbia Basin Fish and Wildlife Council, A2 = U.S. Fish and Wildlife Service, A3 = Washington State Department of Game, A4 = Montana Department of Fish, Wildlife, and Parks, A5 = Idaho Department of Fish and Game.

Table B-2. Rationale for Additions of Species and Habitats of Resident Salmonids to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Cutthroat & rainbow trout	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat	P
		Gravel recruitment	Gravel recruitment to spawning reaches reduced	A1
	Migration (juvenile)	Predation	Impoundments increase number of potential predators	A1
	Adult rearing	Concern expressed, rationale not given		A2
		Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
	Migration (adult)	Access	Stream access may be inhibited by low stream flows	A1
	Juvenile rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P

Table B-2. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Cutthroat & rainbow trout (cont'd)	Adult rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
Brown trout	Juvenile rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
	Adult rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
Dolly Varden (bull) & brook trout	Spawning & incubation	Diversion	Diversion around spawning reaches removes spawning habitat	A4
		Flow fluctuation	Fluctuating water elevation strands eggs	A4
		Siltation	Egg survival and spawning area reduced	A1, A4
	Juvenile rearing	Flow fluctuation	Fluctuating water elevation strands juveniles	A4

Table B-2. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern ¹ P=Professional Judgment
Dolly Varden (bull) & brook trout (cont'd)	Juvenile rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
	Adult rearing	Food supply	Reduced flows and reduced wetted surface area in diversion reaches may reduce food supply	P
	Migration (adult)	Access	Stream access may be inhibited by low stream flows	A4
Kokanee salmon	Spawning & incubation	Inundation	Inundation of spawning grounds decreases available habitat	A4
		Temperature	Emergence timing may be altered	A4
	Migration (juvenile)	Predation	Impoundments increase number of potential predators	P
	Concern expressed, rationale not given			A2

¹Agencies that made judgments about potential impacts were: A1 = Columbia Basin Fish and Wildlife Council, A2 = U.S. Fish and Wildlife Service, A3 = Washington State Department of Game, A4 = Montana Department of Fish, Wildlife, and Parks, A5 = Idaho Department of Fish and Game.

Table B-3. Rationale for Additions of Species and Habitats of Resident Non-salmonid Fish to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A-Agency Concern P=Professional Judgment
Burbot	Spawning & incubation	Flow fluctuation	Fluctuating water elevation strands eggs	P

Table B-4. Rationale for Additions of Species and Habitats of Other Fish Species to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
White sturgeon	Juvenile rearing	Concern expressed,	rationale not given	A2
	Adult rearing	Concern expressed,	rationale not given	A2
	Juvenile migration	Residualism	Impoundments may cause loss of migration cues	P
	Adult migration	Reservoir loss	Returning adults may lose homing cues	
American shad	Migration (juvenile)	Predation	Impoundments increase number of potential predators	P
		Passage mortality	Turbines and spillways kill juveniles	P
	Migration (adult)	Passage mortality	Dams may limit access or fish passage facilities may cause mortalities	P

¹Agencies that made judgments about potential impacts were: A1 = Columbia Basin Fish and Wildlife Council, A2 = U.S. Fish and Wildlife Service, A3 = Washington State Department of Game, A4 = Montana Department of Fish, Wildlife, and Parks, A5 = Idaho Department of Fish and Game.

Table B-5. Rationale for Additions of Species and Habitats for Birds to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Great blue heron	Brood rearing	Concern expressed,	rationale not given	A2
	Adult migration	Concern expressed,	rationale not given	A2
Upland game birds (e.g., ring-necked pheasant, quail species, grouse species, partridge species, doves)	Riparian cover	Loss of brooding habitat		A3
		Brood rearing habitat	Above-ground penstocks could block daily movement of forest grouse species before young are fledged	A2
		Loss of thermal cover		A3
Bald eagle	Nesting	Concern expressed,	rationale not given	A2
	Brood rearing	Concern expressed,	rationale not given	A2
	Adult migration	Migratory and perching birds suffer powerline strikes		A2

Table B-5. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Bald eagle (cont'd)	Adult rearing	Migratory and perching birds suffer powerline strikes		A2
Peregrine falcon	Feeding	Loss of habitat for prey		A3
Mallard, wood duck, teal spp., and hooded merganser	Nesting	Loss of habitat		A3
	Brooding	Loss of habitat		A3
Ring-necked duck and goldeneye	Nesting	Loss of habitat		A3
	Brooding	Loss of habitat		A3
Long-eared owl	Nesting	Loss of habitat		A3
Downy woodpecker and yellow-bellied sapsucker	Nesting	Loss of habitat		A3
	Feeding	Loss of habitat		A3

Table B-5. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Water ouzel and kingfisher	Nesting	Loss of habitat		A3
	Feeding	Loss of habitat		A3
Willow flycatcher	Nesting	Loss of habitat		A3
	Feeding	Loss of habitat		A3

¹Agencies that made judgments about potential impacts were: A1 = Columbia Basin Fish and Wildlife Council, A2 = U.S. Fish and Wildlife Service, A3 = Washington State Department of Game, A4 = Montana Department of Fish, Wildlife, and Parks, A5 = Idaho Department of Fish and Game.

Table B-6. Rationale for Additions of Species and Habitats of Mammals to the List of Key Species and Habitats Potentially Subject to Significant Impacts from Hydroelectric Development.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Deer (mule/black-tailed and white-tailed)	Adult rearing	Concern expressed,	rationale not given	A2
	Calving	Concern expressed,	rationale not given	A5
	Wintering	Concern expressed,	rationale not given	A5
River otter	Denning	Potential loss of denning habitat		A3
	Feeding	Potential loss of food source		A3
	Migratory routes	Dams may inhibit movement		A3
Moose	Calving	Concern expressed,	rationale not given	A5
	Wintering	Concern expressed,	rationale not given	A5
Gray wolf		Concern expressed,	rationale not given	A5

Table B-6. Continued.

Species	Habitat	Potential Physical Impact	Potential Biological Impact	Basis for Considering Impact Significant: A=Agency Concern¹ P=Professional Judgment
Grizzly bear		Concern expressed,	rationale not given	A5
Black bear	Feeding	Loss of feeding habitat		A3
Bobcat	Feeding	Loss of prey		A3
Mountain cottontail	Feeding	Loss of habitat		A3

¹Agencies that made judgments about potential impacts were: A1 = Columbia Basin Fish and Wildlife Council, A2 = U.S. Fish and Wildlife Service, A3 = Washington State Department of Game, A4 = Montana Department of Fish, Wildlife, and Parks, A5 = Idaho Department of Fish and Game.