

Cliff Knox Project

Watershed Report

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Malheur National Forest

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Table of Contents

Introduction	6
Regulatory Framework	6
Land and Resource Management Plan	6
Malheur Forest Plan Amendment 29	7
Inland Native Fish Strategy (INFISH)	8
Watershed Condition Framework	8
Clean Water Act	9
Endangered Species Act – Bull Trout Recovery Plan	10
Climate Change Considerations	10
Undeveloped Lands	10
Resource Indicators and Measures for Assessing Effects	11
Streamflow	13
Peak Flows	13
Background	13
Desired Condition	14
Methodology	14
Environmental Consequences	16
Summary of effects to peak flows for all alternatives	19
Base Flows	19
Background	19
Desired Condition	20
Methodology	20
Environmental Consequences	22
Summary of effects to baseflows for all alternatives	25
Stream Temperature	26
Methodology	26
Information Sources	26
Background	27
Riparian Habitat Conservation Areas	27
Incomplete and Unavailable Information	28
Spatial and Temporal Context for Effects Analysis	28
Site Potential Vegetation	29
Desired Condition	29
Affected Environment	30
Environmental Consequences	32
Stream Shade	38
Desired Condition	38
Affected Environment	39
Environmental Consequences	40
Alternative 2 – Proposed Action	41
Alternative 3	44
Summary of effects to stream shade for all alternatives	44
Sediment Delivery	45
Methodology	45
Information Sources	45
Incomplete and Unavailable Information	46
Spatial and Temporal Context for Effects Analysis	47
Riparian Habitat Conservation Area Ground Disturbance	47

Background.....	47
Desired Condition.....	48
Affected Environment.....	49
Existing Condition.....	49
Environmental Consequences.....	49
Alternative 1 – No Action.....	49
Alternative 2 – Proposed Action.....	49
Alternative 3 – Focused Restoration.....	52
Summary of effects to RHCA Ground Disturbance for all alternatives	52
Road/Stream Connectivity	53
Background.....	53
Desired Condition.....	55
Affected Environment.....	56
Environmental Consequences.....	57
Alternative 2 – Proposed Action.....	57
Alternative 3	64
Summary of effects to road/stream connectivity for all alternatives	64
Summary of Environmental Effects	66
Compliance with Malheur Forest Plan and Other Relevant Laws, Regulations, Policies and Plans.....	68
Malheur Forest Plan.....	68
Clean Water Act.....	69
Background.....	69
Information Sources.....	71
Incomplete and Unavailable Information	72
Oregon Department of Environmental Quality Water quality impaired streams.....	72
Summary Clean Water Act compliance for alternatives 1-3	74
Short-term Uses and Long-term Productivity	76
Unavoidable Adverse Effects.....	76
Irreversible and Irretrievable Commitments of Resources	76
Appendix A – Project Design Criteria.....	83
Project Design Criteria and Mitigation Measures.....	83
Appendix B – Oregon Department of Environmental Quality Supplemental Information.....	84
Appendix C – Stream Temperature	91
Standards and Guidelines.....	91
Malheur River Ford.....	92
Malheur River lower sites.....	93
Appendix D – Consistency with the Malheur Forest Plan.....	102

List of Tables

Table 1. Resource element indicators and measures for assessing effects to hydrology	11
Table 2. Acres of hydrologic immaturity by subwatershed	16
Table 3. Thinning treatments for aspen, mountain mahogany, meadow, and wildlife enhancement units	17
Table 4. Acres and percent of hydrologic immaturity by subwatershed as a result of alternative 2.....	17
Table 5. Acres of hydrologic immaturity by subwatershed as a result of alternative 2 and past, present, and reasonably future activities.....	18
Table 6. Differences in acres between alternative 2 and 3 for activities with potential to impact peak flows	18
Table 7. Summary of effects to peak flow from all alternatives.....	19
Table 8. Percent of historical range of variability (HRV) for warm dry plant association group in the planning area for existing conditions	21

Table 9. Percent of historical range of variability (HRV) for hot dry plant association group in the planning area for existing conditions	22
Table 10. Percent of historical ranges of variability for warm dry plant association group in the planning area under alternative 2	23
Table 11. Percent of historical ranges of variability for hot dry plant association group in the planning area under alternative 2	23
Table 12. Differences in acres between alternative 2 and 3 for activities with potential to impact base flow	24
Table 13. Summary of effects to baseflows from all alternatives	25
Table 14. Stream miles by stream category in the Cliff Knox planning area	27
Table 15. RHCA acres by stream category in the Cliff Knox planning area	28
Table 16. Percent of stream at site potential vegetation in the Bluebucket subwatershed	31
Table 17. Percent of stream at site potential vegetation in the Cliff-Malheur subwatershed	31
Table 18. Percent of stream at site potential vegetation across the Cliff Knox planning area	31
Table 19. Miles of stream moving towards site potential vegetation under alternative 2	35
Table 20. Percent of stream moving towards site potential vegetation under alternative 2	36
Table 21. Miles of stream meeting or moving towards site potential vegetation under alternative 2 when considered cumulatively with past, present, and reasonably foreseeable activities	37
Table 22. Percent of streams moving towards site potential vegetation under alternative 2 when considered cumulatively with past, present, and reasonably foreseeable activities	37
Table 23. Summary of effects to site potential vegetation from all alternatives	38
Table 24. Malheur Forest Plan standards for shade/canopy closure by forest type	39
Table 25. ODEQ standards for shade/canopy closure by stream type relevant to the Cliff Knox planning area	39
Table 26. Existing conditions for stream shade at a subset of streams in the Cliff Knox planning area	39
Table 27. Miles of recent canopy-opening thinning in the RHCA	40
Table 28. Miles of canopy-opening thinning in the RHCA under alternative 2	42
Table 29. Percent of canopy-opening thinning in the RHCA under alternative 2	43
Table 30. Miles of canopy-opening thinning in the RHCA under alternative 2 when considered with past, present, and reasonably foreseeable activities.	43
Table 31. Percent of canopy-opening thinning in the RHCA under alternative 2 when considered with past, present, and reasonably foreseeable activities.	44
Table 32. Summary of effects to stream shade from all alternatives	44
Table 33. Acres of RHCA mechanical areas (skidding and decking) under alternative 2	50
Table 34. Summary of effects to RHCA ground disturbance from all alternatives	52
Table 35. Existing roads affecting RHCA and streams	57
Table 36. Roads affecting riparian habitat conservation area (RHCA) and streams under alternative 2 ..	58
Table 37. Roads proposed for decommission under the aquatic restoration environmental assessment	63
Table 38. Roads affecting riparian habitat conservation areas (RHCA) and streams under alternative 2 when considered with past, present, and reasonably foreseeable activities	64
Table 39. Summary of effects to road/stream connectivity from all alternatives	65
Table 40. Summary of resource indicators and measures by alternative	66
Table 41. Summary requirements for compliance under the Clean Water Act	69
Table 42. Water quality impairments based on the 2012 Integrated Report (ODEQ, 2012)	73
Table 43. Summary of compliance with the Clean Water Act (CWA) for alternatives 1-3 within the Cliff Knox planning area	74
Table 44. Summary of site potential vegetation based on ODEQ (2010)	86
Table 45. Percent of stream at site potential vegetation across the Cliff Knox planning area	89
Table 46. Miles of stream at site potential vegetation across the Cliff Knox planning area	89
Table 47. Miles of stream at site potential vegetation in the Bluebucket subwatershed	89
Table 48. Percent of stream at site potential vegetation in the Bluebucket subwatershed	89

Table 49. Miles of stream at site potential vegetation in the Cliff-Malheur subwatershed	89
Table 50. Percent of stream at site potential vegetation in the Cliff-Malheur subwatershed	90
Table 51. Project consistency with the most relevant standards under the Malheur Forest Plan, INFISH, and Amendment 29	102

List of Figures

Figure 1. Example of high severity burn on the 2019 Cow Fire. Full consumption of the riparian shrubs and conifer over-story on category 1 fish-bearing stream.....	32
Figure 2. Examples of riparian vegetation within pockets of high severity burn, from the Cow Fire in 2019.....	51
Figure 3. Effective shade cure for Aspen-dominated streams in Ecoregion 11h.....	84
Figure 4. Effective shade cure for shrub-dominated streams in Ecoregion 11h	84
Figure 5. Effective shade cure for conifer-dominated streams in Ecoregion 11h.....	85
Figure 6. 11H continental zone highlands site potential vegetation (ODEQ, 2010).....	87
Figure 7. Stream temperature monitoring locations within the Cliff Knox planning area.....	91
Figure 8. Long term stream monitoring on the Malheur River at the Malheur Ford	92
Figure 9. Stream monitoring results on the Malheur River at multiple sites from 2014-2019	93
Figure 10. Stream monitoring results on Skookum Creek from 2014-2019	94
Figure 11. Stream monitoring results on Lee Creek from 2014-2019	95
Figure 12. Stream monitoring results on Black Canyon Creek from 2014.....	96
Figure 13. Stream monitoring results on Cliff Creek from 2014.....	97
Figure 14. Stream monitoring results on Bluebucket Creek from 2014	98
Figure 15. Stream monitoring results on North Fork Bluebucket Creek from 2014	99
Figure 16. Stream monitoring results on Cougar Creek from 2014.....	100

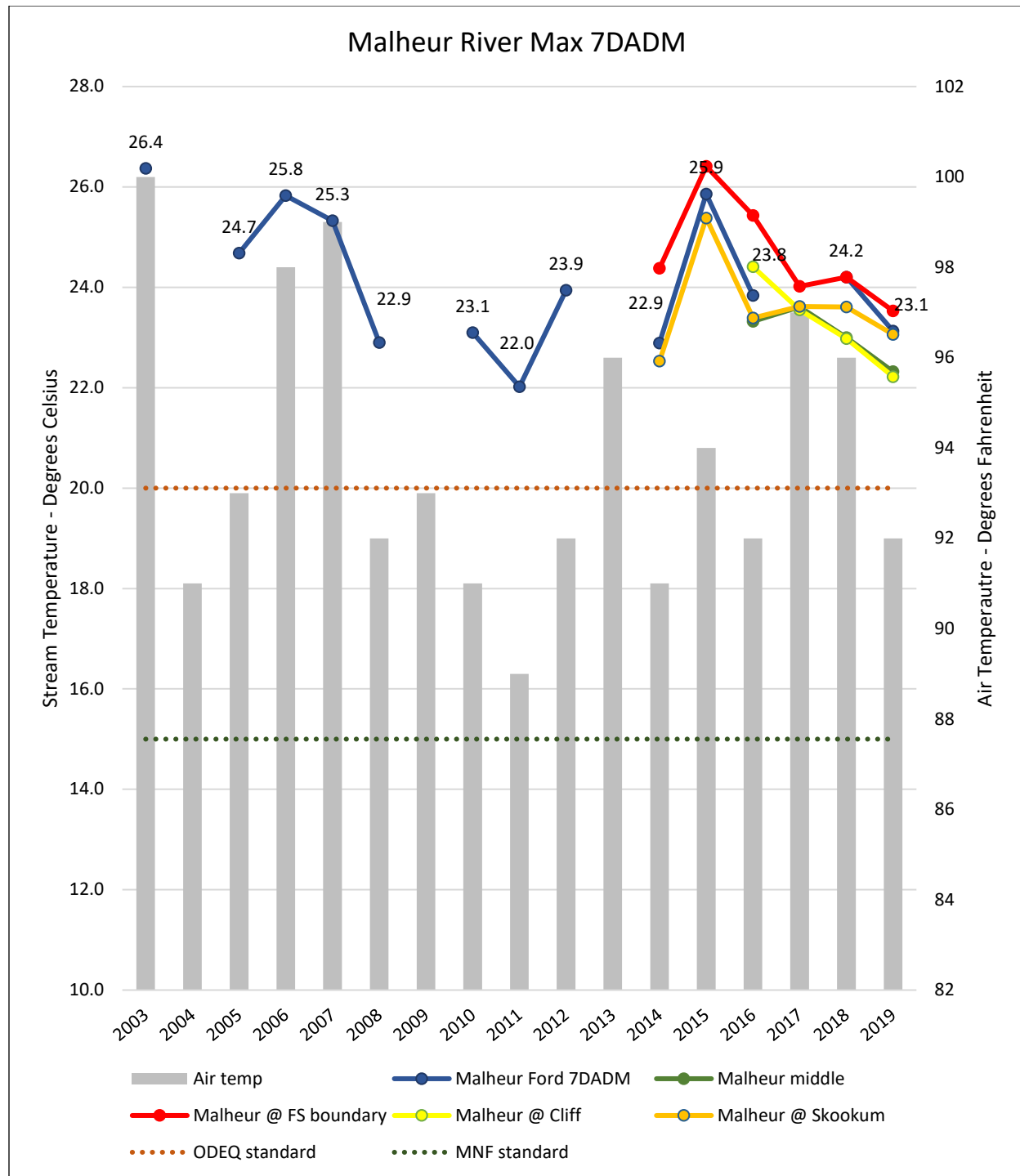


Figure 17. Long-term stream monitoring on the Malheur River at multiple monitoring sites..... 101

Introduction

The watershed analysis considers the environmental effects of alternatives in the Cliff Knox Project on streamflow, stream temperature, and sediment delivery in respect to the Malheur National Forest Land and Resource Management Plan and the Clean Water Act. Hydrologic analysis indicators and measures were selected based on the potential for effect from actions listed in the alternatives, combined with key issues identified during the scoping process.

In a separate analysis, the fisheries report analyzes impacts to aquatic organisms, including federally threatened Middle Columbia bull trout, and the habitat on which they depend. The watershed analysis includes the main body of the report and multiple appendices that support the analysis.

Regulatory Framework

Land and Resource Management Plan

The Malheur National Forest Land and Resource Management Plan (hereafter Malheur Forest Plan) provides standards and guidelines for watershed and hydrologic resources. In 1994 the Malheur Forest Plan was amended (Amendment 29) to incorporate the Columbia River Anadromous Fish Habitat Management Policy and Implementation Guide (USDA Forest Service 1994). The amendment included changes to both Management Areas 3A (inland fish habitat) and 3B (anadromous fish habitat).

In 1995 the Inland Native Fish Strategy (INFISH) defined riparian habitat conservation areas (RHCAs) and provided riparian management objectives, and standard and guidelines that amended the Regional Guides and the Malheur Forest Plan. The riparian management objectives and standards and guidelines provide the specific measurements and guidance to implement the riparian goals identified in INFISH. See Desired Conditions for specific standards and guidelines. The watershed report analyzes watershed resource elements with the potential to be affected by the proposed action and other alternatives.

Pertinent standards and guidelines to the Cliff Knox Project from the Malheur Forest Plan, as amended by Amendment #29 and INFISH include:

- INFISH standard FM-1 (a-11)
- INFISH standard WR-1 (A-12)
- INFISH standard TM-1b (A-7)
- INFISH standard RF1-RF5 (A-7)
- Forest-wide Standard 56-57 (IV-31)
- Forest plan standards MA3A: 8, 9, 10, 11, 12, 14 (IV-56)
- Forest plan standards 5a, 5b, 5c, and 5d as amended by Amendment #29
- Forest plan standards MA3A #40, 41, 43, 44, 46 (IV-60)

Stream categories and standard buffer widths for RHCAs are defined as:

Category 1 – Fish-bearing streams: Interim RHCAs consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of two site-potential trees, or 300 feet slope distance (600 feet, including both sides of the stream channel), whichever is greatest.

Category 2 – Permanently flowing non-fish-bearing streams: Interim RHCAs consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of

the inner gorge, or to the outer edges of the 100-year flood plain, or to the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet, including both sides of the stream channel), whichever is greatest.

Category 3 - Ponds, lakes, reservoirs, and wetlands greater than 1 acre: Interim RHCAs consist of the body of water or wetland and the area to the outer edges of the riparian vegetation, or to the extent of the seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance from the edge of the maximum pool elevation of constructed ponds and reservoirs or from the edge of the wetland, pond or lake, whichever is greatest.

Category 4 - Seasonally flowing or Intermittent streams, wetlands less than 1 acre, landslides, and landslide-prone areas: This category includes features high variability in size and site-specific characteristics. At a minimum the interim RHCA must include:

- a. the extent of landslides and landslide-prone areas
- b. the intermittent stream channel and the area to the top of the inner gorge
- c. the intermittent stream channel or wetland and the area to the outer edges of the
- d. riparian vegetation
- e. for Priority Watersheds, the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one site potential tree, or 100 feet slope distance, whichever is greatest
- f. for watersheds not identified as Priority Watersheds, the area from the edges of the stream channel, wetland, landslide, or landslide-prone area to a distance equal to the height of one-half site potential tree, or 50 feet slope distance, whichever is greatest

Malheur Forest Plan Amendment 29

Manage riparian areas to achieve the following desired conditions by habitat element, sub-element and numeric value. These values are to be measured on a subwatershed basis, and to the degree the individual riparian area contains the specific habitat elements listed below.

Sediment/Substrate

- Cobble embeddedness is less than or equal to 20 percent ¹

Water Quality

- See the Inland Native Fish Strategy (INFISH) water temperature objectives below.

Channel Morphology

- Maintain large woody debris within the following ecosystems:

Ecosystem	Number of pieces	Minimum length	Diameter	Key pieces
Ponderosa Pine	20 to 70	35' or 1.5 x bankfull	12"	20% greater than 20"
Mixed Conifer	80 to 120	35' or 1.5 x bankfull	12"	20% greater than 20"
Lodgepole Pine	100 to 350	18' or 1.5 x bankfull	6"	20% greater than 12"

- Pool Frequency (see INFISH objectives where data was measured at wetted width):

¹ Where embeddedness values are unavailable, percent fines are used at the same value of 20 percent.

Bankfull width (feet)	5	10	20	25	50	75
Pools per mile	151-264	75-132	28-66	30-53	15-26	10-23

- Bank stability for forested ecosystems is 90 percent stable, no decrease if above 90 percent stable.
- For non-forested ecosystems: see INFISH bank stability and undercut banks objectives.
- The wetted width to depth ratio is less than 10² for all systems (same as INFISH objective).

Riparian Vegetation

- Provide a rate of input to maintain large wood debris standard (Channel Morphology).
- The ground cover is at 90 percent of site potential, covered by herbaceous species, litter, rock, moss, or lichens.
- Stream bank vegetation is at 90 percent of site potential.
- Maintain shade/canopy closure for the following ecosystems:

Ecosystem	Ponderosa Pine	Mixed Conifer	Lodgepole Pine	Hardwood Meadow
Shade/Closure	40-50%	50-60%	60-75%	80%

Inland Native Fish Strategy (INFISH)

Minimum pool frequency (See Amendment 29 desired condition where data was measured at bankfull width):

Wetted width (feet)	10	20	25	50	75
Pools per mile	96	56	47	26	23

- There is no measurable increase in maximum water temperature (7-day moving average of daily maximum temperature measured as the average of the maximum daily temperature of the warmest consecutive 7-day period). Maximum water temperatures are below 59 degrees Fahrenheit within adult holding habitat and below 48 degrees Fahrenheit within spawning and rearing habitats.
- Large woody debris; see Amendment 29 desired conditions for large woody debris.
- Bank stability should be greater than 80 percent for non-forested systems.
- There should be greater than 75 percent undercut banks for non-forested systems.
- The wetted width to depth ratio is less than 10 for all systems (same as Amendment 29).

Watershed Condition Framework

The 2011 Watershed Condition Framework is a comprehensive approach for proactively implementing integrated restoration on priority watersheds on national forests and grasslands. The Watershed Condition Framework was implemented across all national forests to improve the Forest Service approach to watershed restoration by establishing a nationally consistent methodology for condition assessment and targeting the implementation of integrated collections of enhancement activities on those watersheds identified as priorities for restoration (USDA Forest Service, 2011).

The Watershed Condition Class for the Bluebucket Creek and Cliff Creek-Malheur River subwatersheds are listed as functioning at risk due to poor habitat condition for (1) aquatic physical, (2) aquatic biological, (3) terrestrial physical, and (4) terrestrial biological habitat indicators (USDA Forest Service, 2011).

Restoration proposed under the Cliff Knox Project is expected to improve 3) terrestrial physical and 4) terrestrial biological indicators but would have no impact on the aquatic indicators. Actions to improve 'aquatic' indicators are outside the scope of the project and are not proposed under the Cliff Knox Project.

² Where channel type is defined, the width: depth values are based on channel type (Rosgen 1996).

As a result, modeling has shown that the overall Watershed Condition Class would continue to be functioning at risk for all alternatives.

The Watershed Condition Framework provides a convenient and consistent approach to evaluating watershed condition in the planning area. However, a Watershed Restoration Action Plan (WRAP) is not being developed for these two subwatersheds at this time, due to higher priority watersheds on the district. When a Watershed Restoration Action Plan is developed in the future, essential aquatic restoration actions would be identified and implemented. Activities implemented under the Cliff Knox Project, such as road closing, road decommissioning, and upland forest thinning, would help move both subwatersheds towards a more properly functioning condition.

Clean Water Act

The anti-degradation Environmental Protection Agency policy 40 CFR Section 131.12 policy states that existing water quality, even when it exceeds required levels for stated beneficial uses, will be maintained.

The 1977 Clean Water Act and the Water Quality Act of 1987 states that the potential effects of the proposed action shall not constitute a significant degradation of quality or impair existing beneficial uses, either through surface runoff of sediment and chemicals or chemicals entering water bodies through groundwater sources.

Congress has designated the State of Oregon the responsibility to implement the Clean Water Act. This act requires that water quality standards be developed to protect beneficial uses and a list be developed of water-quality-impaired streams (303d list). Water quality standards are based on life stages of fish and the most restrictive need sets the standard. The Cliff Knox planning area is located in the Upper Malheur subbasin and contains streams considered under the 2012 Integrated Report and the 2010 Malheur River Total Maximum Daily Load and Water Quality Management Plan (Oregon Department of Environmental Quality, 2012; Oregon Department of Environmental Quality, 2010). All water quality listings are for aquatic life, resident fish, or salmonid fish rearing, spawning or migratory beneficial uses.

The Forest Service's responsibilities under the Clean Water Act are described in a May 2014 Memorandum of Understanding (MOU) between the Oregon Department of Environmental Quality and the Pacific Northwest Region of the USDA Forest Service. Collectively, the Total Maximum Daily Load & Memorandum of Understanding direct the USDA Forest Service to (USDA Forest Service, 2014):

- 1) "Manage water-quality-limited water bodies on USDA Forest Service- administered lands ***to protect and restore water quality***. Management would involve development and implementation of strategies such as best management practices to protect and restore water quality conditions when USDA Forest Service actions affect or have the potential to affect the 303(d) listed waters" (USDA Forest Service, 2014).
- 2) Participate in the development of a Water Quality Restoration Plan (WQRP) for the Malheur River Basin Total Maximum Daily Load.
- 3) Conduct best management practices effectiveness and implementation monitoring.
- 4) "Target establishment of site potential vegetation and the corresponding effective shade as the surrogate measure to meet the load reductions for agriculture, grazing, forest, or urban nonpoint source activities in the riparian area" (Pg. 9-46-47 of the Malheur Basin TMDL, ODEQ, 2010).

- 5) Follow INFISH riparian management objectives and standards and guidelines for activities in the riparian habitat conservation area. Follow management action to improve water quality from Water Quality Restoration Plan (USDA Forest Service, 2018).

Endangered Species Act – Bull Trout Recovery Plan

For information on consistency with the Endangered Species Act, see chapter 3 - Aquatic Resources section.

Climate Change Considerations

Halofsky and Peterson (2017) conducted a state-of-the-science climate change vulnerability assessment and developed adaptation options for national forests within the Blue Mountains region. The assessment emphasized four resource areas – water, fish, upland vegetation, and special habitats – regarded as the most important resources for local ecosystems and communities. The Cliff Knox Project primarily focuses on one of the four resource areas, upland vegetation; but also, indirectly assesses the other three, water, fish, and special habitats.

The assessment noted that effects to water resources and infrastructure will include decreased snowpack and declining summer flows that will alter availability of water supply, affecting municipal and public uses downstream from and in national forests, and other forest uses including livestock grazing, wildlife, recreation, firefighting, road maintenance, and instream fisheries flows. Declining summer low flows will affect water availability during late summer. Increased magnitude of peak streamflows will damage roads near perennial streams, thus affecting public safety, access for resource management, water quality, and aquatic habitat. Bridges, campgrounds, and national forest facilities near streams and floodplains will be especially vulnerable, reducing access.

The assessment also noted adaption strategies that include restoring watershed functions, connecting floodplains, reducing drainage efficiency, maximizing valley storage, and reducing fire hazard. Tactics include adding wood to streams, restoring beaver populations, modifying livestock management, and reducing surface fuels and forest stand densities. Primary strategies for infrastructure include increasing the resilience of stream crossings, culverts, and bridges to higher peak flows and facilitating response to higher peak flows by reducing the road system and disconnecting roads from streams. Tactics include completing geospatial databases of infrastructure and drainage components, installing higher capacity culverts, and decommissioning roads or converting them to alternative uses.

The Cliff Knox Project is designed to minimize negative effects of climate change and facilitate transition of diverse ecosystems to a warmer climate. This will be accomplished by reducing surface fuels and forest stand densities; encouraging regeneration and preventing damage from disturbance; decreasing road/stream connectivity through road decommissioning and relocation; and reducing conifer encroachment in riparian areas.

Undeveloped Lands

Undeveloped lands within the project footprint were not identified to have special or unique hydrologic resource values. Hydrologic resources identified within the project footprint are summarized in the Cliff Knox Project Final Environmental Impact Statement and fully described in the Watershed Report in the project record. Effects to the hydrologic resource from proposed project treatment activities would not differ based on the description of land (undeveloped). Management direction and project design criteria are required to ensure compliance and avoid adverse impacts to hydrology and would be implemented during operations across all National Forest System lands. Therefore, the description of effects is not

differentiated further in the analysis and include proposed vegetation activities and the associated connected actions to complete project activities. Activities proposed within undeveloped areas greater than 1,000 acres are described in the undeveloped areas section of the Cliff Knox Project Final Environmental Impact Statement.

Resource Indicators and Measures for Assessing Effects

The following elements of wildland hydrology are analyzed under the Cliff Knox Project.

- Streamflow – Baseflows and peak flows – removing forest vegetation through commercial and noncommercial thinning and prescribed burning have the potential to alter forest stand densities. Forest canopy condition and stand water use are directly related to streamflow within a watershed. Stream flow (including peak flows and summer baseflows) may be affected.
- Stream temperature – Stream shade, site potential vegetation – Stream shade is the largest factor in anthropogenic changes in stream temperature. The species composition, age class, density, and structure of riparian vegetation impacts stream shade. Removing conifers in the riparian habitat conservation area (RHCA) through commercial and noncommercial thinning, roads maintenance, and associated activities such as skidding and landing in the RHCA have the potential to alter riparian vegetation and stream shade. Road decommissioning in the RHCA has the potential to increase stream shade in the long term.
- Sediment delivery – RHCA ground disturbance, road/stream connectivity – Project activities in the RHCA roads maintenance, log haul, skidding, temporary roads, and roadside decking, which all have the potential to disturb soil and deliver sediment to stream channels. Road decommissioning has the potential to reduce road densities and deliver sediment.

Table 1. Resource element indicators and measures for assessing effects to hydrology

Resource element	Resource indicator	Measure (quantify if possible)	Indicator source ¹
Streamflow	Peak flows	Hydrologic immaturity (percent of subwatershed)	Malheur Forest Plan goal 27 (IV-2-27)
	Base flows	Historical range of variability (percent deviation from normal across planning area)	INFISH goal 2,3 (A-1) Powell, 2011 Helvey, 1995 Grant G.E., 2008
Stream temperature	Stream shade	Stream miles with overstory canopy or shade removal (miles/subwatershed)	Clean Water Act Malheur Forest Plan goal 28 (IV-2-28)
	Site potential vegetation	Stream miles with RHCA thinning (miles/subwatershed)	Malheur Forest Plan Amendment 29 elements B, D Malheur Forest Plan forest-wide standards 117, 119, 120 INFISH riparian management objectives
Sediment delivery	RHCA ground disturbance	Skidding/decking in the RHCA (acres of RHCA /subwatershed)	Clean Water Act Malheur Forest Plan goal 28 (IV-2-28)
	Road/stream connectivity	Miles of road within RHCA (miles/subwatershed)	Malheur Forest Plan forest-wide standards 117-120
		Number of road-stream crossings (#/subwatershed)	

Resource element	Resource indicator	Measure (quantify if possible)	Indicator source ¹
		Native surface haul routes within 50' of stream channel (miles/subwatershed)	Malheur Forest Plan Amendment 29 elements A
		Roads with observed sediment delivery (miles/subwatershed)	

¹Indicator sources may include, but are not limited to, the Malheur Forest Plan standards and guidelines, law or policy, best management practices, etc.

Hydrologic factors are addressed below because they are important to watershed health but not expected to change between alternatives as a result of project design criteria or design elements requiring avoidance or protection. They are considered below but are not analyzed further in this report.

- **Springs and wetlands** – springs provide water for wildlife and domestic livestock across the Cliff Knox planning area. Springs were inventoried during project planning. Within the planning area, there are 134 mapped springs with approximately 95 acres of RHCA protection buffers. Springs are often a type of wetland, but true wetland delineation was not conducted for this project. The following project design criteria and design elements are in place to protect springs from project activities:
 - ♦ There would be no operational activities within 100 feet of springs (Wildlife-22 and Botany 1).
 - ♦ As a result of prescribed burning, individual springs and wetlands may experience low severity fire that may incur short term (less than one year) changes to the wetland obligate vegetation. However, springs on this landscape evolved with fire, and there would be no long-term impact on water availability or spring integrity so long as burning objectives are met (Wildlife-22 and Botany 1, Aquatics-2).

In summary, the Cliff Knox Project is not proposing to do any activities that have the potential to impact (increase or decrease) the number or long-term integrity of springs and wetlands in the planning area. Springs and wetlands would remain the same between alternatives.

- **Large wood** – All streams are subject to Malheur Forest Plan standards for large wood. A large amount of data is collected to understand large wood loadings, and overall, the majority of streams are not meeting standards for large wood (see Cliff Knox Watershed Report supporting documents - Cliff Knox Streams Inventory and Condition located in the project record). This is largely a result of past forest management such as logging, stream cleaning, skidding, landing, road construction, and historical grazing practices. Project design criteria and design elements limiting and directing activities in the RHCA are in place to protect large wood volumes from proposed activities:
 - ♦ There would be no commercial thinning within RHCAs (Aquatics-8)
 - ♦ The Malheur Forest Plan standard for large wood is 12 inches in mixed conifer and ponderosa pine stands. Coarse wood less than 9 inches may be increased by non-commercial thinning within RHCA, which permits directional felling of conifers less than 9 inches diameter at breast height towards the stream (see Cliff Knox Project Final Environmental Impact Statement, chapter 2). However, directional felling would have no effect on the miles of stream meeting the large wood standard as defined by the standard.
 - ♦ Prescribed burning is not expected to impact large wood standards per adherence with the burn objectives and project design criteria for large wood retention and mortality (Aquatics-2).
 - ♦ Location of danger trees are unknown and cannot be quantified during project planning. Project design criteria Aquatics-10 requires all danger trees to be left within the RHCA. Due to lack of

commercial thinning in the RHCA, the majority of danger trees are expected to be felled on the uphill side of roads, resulting in likely negligible increases to large wood. Large wood may slightly increase as a result of danger tree felling in both action alternatives but would not be in sufficient quantities to meet large wood standards.

- ◆ In all forest types, the non-commercial thinning prescription would preserve all conifers greater than nine inches diameter at breast height, thus ensuring the presence of future large wood, and enhancing growth potential of remaining trees in the RHCA (Aquatics-8).

As a result, the Cliff Knox Project is not proposing to do any activities that have the potential to impact (increase or decrease) the number of miles of stream meeting large wood standards within the planning area. Large wood would remain the same between alternatives.

- **Stream morphology** – Streams are subject to Malheur Forest Plan standards for pool frequency, undercut banks, bank stability and width to depth ratios. A large amount of data is collected to understand these channel conditions, and overall, the majority of streams are not meeting standards, as a result of past forest management activities (see Cliff Knox Aquatic Resources Report and Watershed Report Supporting Documents - Cliff Knox Streams Inventory and Condition). The following project design criteria and design elements are in place to protect stream morphology from direct impacts due to project activities:
 - ◆ The Cliff Knox Project is not proposing to do any activities within streams, except at previously altered road crossings.
 - ◆ There would be no heavy equipment within streams (Aquatics-11).

Potential indirect impacts to stream morphology are analyzed in other parts of the Watershed and Aquatic Resources Reports:

- ◆ The Stream Flow section addresses indirect effects to stream morphology if peak-flows are increased as a result of forest thinning.
- ◆ The Sediment Delivery section addresses direct effects to water quality from proposed activities at road-stream crossings.
- ◆ The Sediment Delivery section addresses indirect effects to stream morphology as a result of changes to the sediment regime.
- ◆ The Aquatic Resources Report analyzes the impacts to pool frequency and other stream morphology indicators in greater detail.

There is no direct impact (increase or decrease) to the number of miles of stream meeting standards for pool frequency, undercut banks, bank stability, width to depth ratios, and other stream morphology indicators within any streams in the planning area. Therefore, stream morphology indicators would remain the same between alternatives. For more information, see Cliff Knox Aquatic Resources Report.

Streamflow

Peak Flows

Background

Timber harvest has the potential to impact streamflow (Grant G.E., 2008). This relationship is well-documented, although the proportion of the watershed removed and the resulting increase in streamflow is highly variable, depending on local factors as climate, soils, geology, and forest type (Stednick, 1996; Grant G.E., 2008; Bosch, 1982). This potential effect can increase bedload mobility and effect bank erosion, number of pools, etc. that have measurable standards under the Malheur Forest Plan, as amended

by the Inland Native Fish Strategy, hereafter INFISH (USDA Forest Service, 1995). While timber harvest has received the most attention on this subject, wildfire, prescribed fire, insects and disease, and presence of forest roads can also alter canopy closure and influence peak flows (National Research Council, 2008).

Despite a well-documented relationship between streamflow and watershed disturbance, there are no relevant Malheur Forest Plan standards. Due to the high variability in documented watershed response across the literature, this analysis focuses on results from local studies to determine thresholds for measurable effects. First, a paired watershed study in the northern Blue Mountains on the neighboring Umatilla National Forest demonstrated that effects to peak flows and water yield were detectable after forest canopy was removed in 50 percent of the watershed due to clearcutting (Helvey, 1995). Modern day thinning on the Malheur National Forest no longer includes widespread clearcutting typical of the mid-20th century. Unfortunately, relevant science regarding the effects of modern silviculture practices (thinning as opposed to clearcutting) on streamflow at the subwatershed scale is generally lacking.

Triggers for measurable effects comes from a blend of two local studies:

Potential increases in peak streamflow as a result of past harvest, fires, disease, etc. would be considered measurable when greater than 50 percent of the forested watershed is hydrologically immature, meaning the canopy closure is at or below 20 percent (Helvey, 1995; USDA Forest Service, 2000).

The first study helps us determine stand level thresholds of ‘hydrologically immaturity’ based on the 2005 Upper Malheur watershed analysis (USDA Forest Service, 2000). Hydrologically immature stands are defined as having a canopy closure less than 20 percent (aka stand initiation stage). The second study is a paired watershed study from the northern Blue Mountains, which helps us determine how much of the subwatershed can be treated before we see detectable changes in streamflow (Helvey, 1995).

Desired Condition

Many aquatic riparian management objectives and standards and guidelines from INFISH and the Malheur Forest Plan are impacted by streamflow, but no standards are explicitly stated for watershed-level forest management related to peak flows. The following desired conditions were developed based on best available science described under the Background section above.

The desired future condition for peak flow includes a diversity of flow within the historical range, which allows for a diversity of species to exist within riparian areas and sustains natural patterns of sediment, nutrient, and wood transport based on the natural variability in climatic and weather conditions. Forest thinning would maintain hydrologic immaturity below 50 percent in each subwatershed.

Methodology

Information Sources

LiDAR (Light Detecting and Ranging) was used to analyze canopy closure within forested stands in the planning area. LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth (National Oceanic and Atmospheric Administration, 2015). LiDAR is collected with 1-meter accuracy and is considered a precise and accurate method for measuring canopy parameters (Korhonen, 2011). Existing hydrologic immaturity was determined by using LiDAR canopy closure to identify forested stands with canopy less than 20 percent. The sum of those acres were then divided by the total forested area of a given subwatershed to determine what percent of the subwatershed was hydrologically immature.

Calculations do not include naturally forested openings such as meadows, prairies, and scabs but is restricted to forested areas that have been altered by past disturbances to forest canopy (e.g. logging units, roads, and wildfires). For this analysis, canopy closure at the 30-meter by 30-meter grid size was used to identify stands or larger openings with a canopy closure below 20 percent. Both subwatersheds extend beyond the forest boundary into high desert country dominated by sage, juniper, and grasslands, with limited forested area along stream corridors. As a result, forested area outside the planning area but within the subwatershed was considered negligible and not included in summations of total forested area. More information on the hydrologic immaturity analysis is available in the Cliff Knox Environmental Impact Statement project record.

Incomplete and Unavailable Information

For action alternatives, the silviculture models used in the Cliff Knox analysis do not provide canopy closure as an output, so stands expected to have canopy closure less than 20 percent after thinning were identified based on objective-based prescriptions and the professional judgement of an experienced silviculturist. Treatments expected to reduce canopy closure below 20 percent include the pine savannah habitat restoration, aspen restoration treatments, and meadow enhancement. Commercial thinning in remaining treatment types would thin from below to retain overstory canopy and are designed to maintain canopy closure above 20 percent. Skips and gaps were not considered due to their small size compared to the overall forest stands.

Spatial and Temporal Context for Effects Analysis

Direct/Indirect Effects Boundaries

Identification of hydrologic immaturity post-thinning was done at the stand level because that is smallest scale at which hydrologic response may be initiated; heterogeneity in canopy closure within a thinned stand, as a result of variable spaced thinning, is not captured. Peak flow analysis takes place at the subwatershed scale. Historical range of variability analysis took place at the project scale which includes both subwatersheds.

Short term is defined as less than three years, or those that are fully recovered within three wet seasons. Three years was selected due to the dry nature of the planning area and slower expected vegetation response compared to other parts of the forest. Long term effects are those that recover within approximately 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005).

Cumulative Effects Boundaries

The spatial boundaries for analyzing the cumulative effects of hydrologic indicators are the 6th field Hydrologic Unit Code, also known as the subwatershed scale. Hydrologic processes are restricted to the watershed boundary for the first, second, and third order streams in the planning area. In the Cliff Knox planning area, this includes the Bluebucket subwatershed and all tributaries in the Cliff-Malheur subwatershed. The Malheur River has the potential to be influenced by upstream watersheds such as the Summit, Bosenberg, Lake Creek, Big Creek, and Crooked Creek subwatersheds. These subwatersheds are considered in cumulative effects analysis for the Malheur River only.

The temporal boundaries for analyzing the cumulative effects include any projects that have occurred within the last 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005). Reasonably foreseeable projects include any projects occurring on the Schedule of Proposed Actions (SOPA) and the Aquatic Restoration website.

Affected Environment

Existing Condition

Today, hydrologic immaturity is approximately eight percent of the forested Cliff Creek-Malheur River subwatershed and five percent of the forested Bluebucket Creek subwatershed (see Table 1 and Table 2). Well below the 50 percent threshold for measurable effects, there are no expected alterations to peak flows today as a result of recent past timber harvest, wildfires, insect activity, or roads for either subwatershed.

Hydrologically immature areas are contained within past wildfires, plantations, old clear-cuts, and roads. Open areas that were naturally non-forested such as meadows, prairies, and scablands were not included in this estimate.

Table 2. Acres of hydrologic immaturity by subwatershed

Subwatershed	Total forested acres	Hydrologic immaturity (acres)	Hydrologic immaturity (percent)	Hydrologic maturity (acres)	Hydrologic maturity (percent)
Bluebucket Creek	8,118	428	5%	7,690	95%
Cliff Creek-Malheur River	26,010	2,135	8%	23,875	92%

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to peak flows

There would be no direct effect to peak flows from the no action alternative because no activities would take place. Over time, the percentage of hydrologically immatures stands (i.e. canopy closure less than 20 percent) is expected to decrease as stands grow and canopies continue to close. The proportion of hydrologically immature stands would remain well below the 50 percent threshold of measurable changes, and there would be no expected increases in peak streamflow as stands continue to mature.

However, in the event of a large catastrophic wildfire, peak flows could be increased by no action if high intensity burns affected as much as 41 percent of the Cliff-Malheur subwatershed or 45 percent of the Bluebucket subwatershed. The location and severity of wildfires cannot be predicted, but in recent years, forest stand densities, drought, and weather conditions have contributed to multiple large fires in the southern Blue Mountains that have burned within and across entire subwatersheds (e.g. South Fork Complex 2014, Canyon Creek Complex 2015, Rail Fire 2017).

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

Direct and Indirect Effects to peak flows– Alternative 2

The thinning activities in alternative 2 that are likely to reduce canopy closure below 20 percent include aspen restoration (commercial and non-commercial), pine savannah habitat restoration (commercial), mountain mahogany restoration (commercial), and meadow enhancement (commercial).

Other thinning activities are not expected to reduce canopy closure below 20 percent, because those commercial treatments would leave behind overstory canopy, including all large trees. The basal area prescriptions would retain 35-80 square foot of basal area per acre. Based on existing data, stands with 40 square foot of basal area per acre have, on average, 25 percent canopy closure. Despite using a variable density, on average, the canopy closure should stay above 20 percent in those units. Units with small diameter thinning only would cut trees less than 9 inches only and retain all overstory canopy.

Approximately 1,894 acres of thinning would reduce canopy closure below 20 percent across the planning area, as a result of aspen, meadow, pine savannah, and mountain mahogany treatments (see Table 3). This includes 962 acres in the Bluebucket subwatershed and 931 acres in the Cliff-Malheur subwatershed.

Table 3. Thinning treatments for aspen, mountain mahogany, meadow, and wildlife enhancement units

Subwatershed	Aspen	Meadow enhancement	Mountain mahogany	Wildlife habitat enhancement	Total
Bluebucket Creek	372	0	296	295	962
Cliff Creek-Malheur River	224	180	0	527	931
Total	596	180	296	822	1,894

As a result of project thinning in alternative 2, approximately 12 percent of forested acres in the Bluebucket subwatershed would have canopy closure reduced below 20 percent. Approximately four percent of the Cliff-Malheur forested subwatershed would have canopy closure reduced below 20 percent. This is well under the 50 percent threshold for measurable increases to peak flows (see Table 4). Therefore, no increase in peak flows are expected as a result of forest thinning in alternative 2.

Table 4. Acres and percent of hydrologic immaturity by subwatershed as a result of alternative 2

Subwatershed	Less than 20 percent canopy closure (hydrologically immature) (acres)	Less than 20 percent canopy closure (hydrologically immature) (percent)
Bluebucket Creek	962	12%
Cliff Creek-Malheur River	931	4%

Cumulative Effects to peak flows – Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

All projects listed under the Cliff Knox Project Final Environmental Impact Statement, Appendix D – Past, Ongoing, and Reasonably Foreseeable Actions were evaluated for inclusion in the cumulative effects analysis for water quantity.

Cumulative effects for peak flows includes the combined impact of forest thinning under alternative 2 and forest thinning less than 30 years old, aspen thinning, and old fires.

Cumulatively, past activities and thinning under alternative 2, would reduce canopy closure below 20 percent in 1,390 and 3,066 acres of the Bluebucket and Cliff-Malheur subwatersheds, respectively. This corresponds to 17 percent and 12 percent hydrologic immaturity in those subwatersheds (see Table 5). This is well under the 50 percent threshold for measurable increases to peak flows; therefore, no increase in peak flows are expected as a result of forest thinning in alternative 2 when considered with other past, present, and reasonably foreseeable activities.

Table 5. Acres of hydrologic immaturity by subwatershed as a result of alternative 2 and past, present, and reasonably future activities

Subwatershed	Past, present, future activities (acres)	Alternative 2 (acres)	Total (acres)	Hydrologic immaturity (percent)
Bluebucket Creek	428	962	1,390	17%
Cliff Creek-Malheur River	2,135	931	3,066	12%

Not included in the above calculations are the following activities listed under the Past, Present, and Reasonably Foreseeable Activities section. Justifications are provided below.

- Non-commercial small diameter thinning in riparian habitat conservation areas (RHCA), as part of the Central Malheur Environmental Analysis. These activities had no effect on canopy closure based on correspondence with specialists at the Emigrant Creek Ranger District. (note- recent or proposed aspen thinning from the Central Malheur Environmental Assessment was incorporated into the analysis due to expected reduction in canopy closure at these locations).
- Future thinning. There are no additional thinning activities proposed in the reasonably foreseeable future.
- Spring developments were not considered because the project design criteria protects these springs to less than 10 percent of flow, and the timing of use of these developments typically does not overlap with the timing of peak streamflow.
- Cumulatively, firewood cutting, which extracts isolated, dead trees that have no transpiration, is not expected to affect peak flows.

Approximately 27,000 of 108,000 acres within the Big Creek, Lake Creek, Bosenberg-Malheur, Summit Creek, and Cliff-Malheur subwatersheds are affected by past wildfires and current or proposed thinning under the Summit and Cliff Knox vegetation projects. This is approximately 25 percent of the watershed area, which is well below the 50 percent threshold for measurable effects. Best available science has shown that as basin size increases the threshold for measurable effects also increases, and that observed flow increases are within the natural range of variability (Grant G.E., 2008). Peak flows on the Malheur River are not expected to measurably increase in the short term or long term, as a result of activities and past wildfires upstream of the Malheur River.

Alternative 3

Alternatives 2 and 3 have very similar proposed actions; the significant issues that drove those differences were not related to peak flows or other aquatics issues. As it pertains to water quantity, the differences between alternative 2 and alternative 3 are negligible. There are 47 more acres of treatment expected to increase hydrologic immaturity in alternative 2 compared to alternative 3, and all are located in the Cliff-Malheur subwatershed (see Table 6). That is approximately 0.2 percent of the total forested area and is negligible to the hydrologic analysis for peak flows. Results for peak flows are the same for alternative 3 as were reported in alternative 2.

Table 6. Differences in acres between alternative 2 and 3 for activities with potential to impact peak flows

Project activity	Alternative 2	Alternative 3	Difference	Percent difference
Aspen restoration	596 acres	596 acres	No difference	0%
Meadow enhancement	180 acres	180 acres	No difference	0%
Mountain mahogany restoration	296 acres	296 acres	No difference	0%

Wildlife habitat enhancement – stand improvement	822 acres	775 acres	47 less acres in alternative 3 in Cliff-Malheur subwatershed	0.18% of forested acres in Cliff-Malheur subwatershed
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Summary of effects to peak flows for all alternatives

Table 7 below provides a summary of effects to peak flows from all alternatives. Effects are measured at the subwatershed scale. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to the peak flow analysis, were negligible at the subwatershed scale. Results for both action alternatives are the same and reported together below.

Table 7. Summary of effects to peak flow from all alternatives

Alternative	Bluebucket subwatershed hydrologic immaturity (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed hydrologic immaturity (percent of subwatershed)	Effects to the Cliff-Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	5%	No direct or indirect effects	8%	No direct or indirect effects
Alternative 2 and 3 <i>When considered with past, present, future activities³</i>	17%	No measurable effects in the short term or long term	12%	No measurable effects in the short term or long term

Summary: There is no standard for peak flows in the Malheur Forest Plan, yet peak flows were considered because they have potential to effect bank stability, pool frequency, undercut banks, and width to depth ratios, which have standards under the Malheur Forest Plan. Increases in peak flows are expected once hydrologic immaturity exceeds 50 percent for a given subwatershed based on best available science. Both action alternatives (combined with the impacts of past, present, and future activities), are expected to increase hydrologic immaturity in both subwatersheds (increase from 5 percent to 17 percent in the Bluebucket subwatershed and increase from 8 percent to 12 percent in the Cliff-Malheur subwatershed). However, expected increases are well below the threshold of 50 percent and would not measurably increase peak flows in either subwatershed. As a result, there would be no indirect impacts from peak flows on bank stability, pool frequency, undercut banks, and width to depth ratios.

Base Flows

Background

The term baseflow is used in this analysis. Baseflow is synonymous with low flow. It is the proportion of streamflow contributed by groundwater, after snowmelt ends and surface water and shallow soil water start to dry up. Baseflows are largely influenced by a variety of factors outside of management's control, such as geology, soil depth, climate, and weather. However, the number of rooted trees with access to that water table can influence the quantity of baseflow, through the process of transpiration. Transpiration is the process by which plants remove water from the soil and convert it to vapor.

³ Values include cumulative effects

The Cliff Knox planning area is a water-limited environment; water provides the primary physical control on forest productivity. As forest stand densities increase, the pressure on soil water and groundwater increases. Overly dense stands have the potential to reduce streamflow by increasing demand for water and increasing transpirational losses (Robles, Turner, & Haney, 2017; Andreassian, 2004) though these relationships are very difficult to quantify (Singh, 1968; Bond, et al., 2002; Moore & Wondzell, 2005; Andreassian, 2004; Zhang, et al., 2016; Goeking & Tarboton, 2020). Studies regarding the impacts of restoration thinning on baseflows for this climate, forest type, and silvicultural methods are generally lacking. Studies regarding the impacts of older logging methods (e.g. clearcutting) on low flows/base flows in small catchments are well established but are not applicable to the Cliff Knox Project.

Desired Condition

Many aquatic riparian management objectives and standards and guidelines from INFISH and the Malheur Forest Plan are impacted by streamflow, but no standards or thresholds are explicitly stated for forest management in relation to base flows. Yet they are an important consideration in hydrologic analysis due to the functional role they play in supporting riparian vegetation and downstream aquatic organisms. Riparian goals from INFISH relevant to baseflow are to maintain or restore:

3- instream flows to support healthy riparian vegetation and aquatic habitats, the stability and effective function of stream channels, [and the ability to route flood discharges].

4- natural timing and variability of the water table elevation in meadows and wetlands.

Tools for accurately modelling baseflows in a project area of this size and with the thinning techniques proposed are not readily available. As it pertains to vegetation management, we assume that a forest within the historical range of variability produces baseflows within the historical range of variability. This relationship is simplified but sufficient for the purposes of this analysis, considering the lack of standards and thresholds in the Malheur Forest Plan or scientific literature.

The desired future condition for baseflows includes forest stands, and therefore groundwater tables, within the historical range of variability to support healthy conifer stands, riparian hardwoods, and aquatic ecosystems. The analysis will rely on forest stand modelling results for historic range of variability.

Methodology

Information Sources

Model analysis of historical range of variability and fire behavior is based on stand exam data collected within the planning area. Details about stand exam data collection and model analysis are described in detail in the Silviculture and Fire, Fuels, and Air Quality reports.

Incomplete and Unavailable Information

Analysis for historical range of variability is based on silviculture models. For more information on model limitations, see the Cliff Knox Silviculture Report. Quantifying changes in the water budget (e.g. transpiration, evaporative losses, sublimation, etc.) are extremely difficult to obtain or accurately model at the subwatershed scale and are analyzed generally based on physical processes and best available science.

Spatial and Temporal Context for Effects Analysis

Direct/Indirect Effects Boundaries

Historical range of variability analysis took place at the project scale which includes both subwatersheds. This is because historical range of variability analysis was developed at the forest landscape level (Powell, 2011).

Short term is defined as less than three years, or those that are fully recovered within three wet seasons. Three years was selected due to the dry nature of the planning area and slower expected vegetation response compared to other parts of the forest. Long term effects are those that recover within approximately 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005). Model predictions for historical range of variability and fire behavior were based on project harvest occurring in 2020. See the Cliff Knox Silviculture Report for more information regarding historical range of variability and predicted fire behavior analyses.

Cumulative Effects Boundaries

Historical range of variability analysis for cumulative effects also takes place at the project level (see above).

The temporal boundaries for analyzing the cumulative effects include any projects that have occurred within the last 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005). Reasonably foreseeable projects include any projects occurring on the Schedule of Proposed Action (SOPA) and the Aquatic Restoration website.

Affected Environment

Existing Condition

Forest stand structures are generally outside historical range of variability (see Table 8 and Table 9). As reflected in Table 8, the Warm Dry plant association group makes up 70 percent of the overall planning area. In Table 9, the Hot Dry plant association group makes up 15 percent of the overall planning area. Generally, forest stands have moved from old growth open pine stands towards overcrowded stands with high regeneration. For more detailed information on historical range of variability, see the Cliff Knox Silviculture Report.

Table 8. Percent of historical range of variability (HRV) for warm dry plant association group in the planning area for existing conditions

Structure	Desired HRV (percent)	Existing condition (percent)	Status
OLD FOREST SINGLE STORY	15-55%	3%	under
OLD FOREST MULTI STORY	5-20%	25%	over
YOUNG FOREST MULTI STORY	5-25%	26%	over
STEM EXCLUSION OPEN CANOPY	5-20%	12%	within
STEM EXCLUSION CLOSED CANOPY	1-10%	16%	over
UNDERSTORY REINITIATION	1-10%	16%	over
STAND INITIATION	5-15%	2%	under

Table 9. Percent of historical range of variability (HRV) for hot dry plant association group in the planning area for existing conditions

Structure	Desired HRV (percent)	Existing condition (percent)	Status
OLD FOREST SINGLE STORY	20-70%	8%	under
OLD FOREST MULTI STORY	5-15%	49%	over
YOUNG FOREST MULTI STORY	5-10%	20%	over
STEM EXCLUSION OPEN CANOPY	5-20%	15%	within
STEM EXCLUSION CLOSED CANOPY	0-5%	0%	within
UNDERSTORY REINITIATION	0-5%	6%	over
STAND INITIATION	5-15%	2%	under

For the Warm Dry plant association group, forest stands are departed from Old Forest Single Story (older, more open stands) and towards stem exclusion closed canopy and understory reinitiation (younger, thicker stands). For the Hot Dry plant association group, forest stands are departed from old forest single strata (older, open stands) and towards old forest multi story and young forest multi story (multi-structure stands). The result includes more trees on the landscape and a higher proportion of younger trees.

Young trees can use up to two times more water than mature trees and can increase demand on water resources (Moore G. W., 2004). Meanwhile, high stand densities change how snow accumulates and alters how fast the snow melts compared to more open old-growth forest stands (Moore & Wondzell, 2005; Luce, et al., 2012), resulting in an overall reduction in snowpack and faster snowmelt. The observed deviation from historical range of variability combined with anticipated effects of more young trees and less old growth type stands is expected to 1) reduce snowpack and 2) increase pressure on soil water during the summer growing season. Combined, less water supply and higher pressure on water is expected to reduce summer streamflow compared to the historical range of variability, throughout both subwatersheds (Robles, Turner, & Haney, 2017).

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to baseflows

There would be no direct effect to baseflows from the no action alternative because no activities would take place. Over time, stands maintained at current levels would continue to deviate from historical range of variability (see the Cliff Knox Silviculture Report). As stand densities increase, snowpack accumulation would be reduced due to increased interception and ⁴sublimation. Competition for soil water would continue to increase. Low flows are expected to continue to decrease over time with increased pressure on water resources in a water-limited environment.

In the event of a large catastrophic wildfire, stands would likely continue to deviate from historical range of variability but with an increase towards stand re-initiation. Depending on scale and severity, baseflows would likely be increased above the normal range of variability, for 1-20 years, until younger trees regenerate across the planning area (National Research Council, 2008).

⁴ Sublimation is the process of water changing from solid form (aka snow) directly to vapor form, without first melting into liquid form

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

Direct and Indirect Effects to Baseflows– Alternative 2

Stand structures would move towards historical range of variability in the short term based on silvicultural models of historic range of variability (see Table 10 and Table 11). Historic range of variability results are reported below for the Warm Dry plant association group, which makes up 70 percent of the overall planning area, and the Hot Dry plant association group, which makes up 15 percent of the overall planning area.

Table 10. Percent of historical ranges of variability for warm dry plant association group in the planning area under alternative 2

Structure	Desired (percent)	Existing condition (percent)	Existing condition - status	2023 predicted (percent)	2023 predicted - status
OLD FOREST SINGLE STORY	20-70%	3%	under	20%	Within
OLD FOREST MULTI STORY	5-15%	25%	over	13%	Within
YOUNG FOREST MULTI STORY	5-10%	26%	over	7%	Within
STEM EXCLUSION OPEN CANOPY	5-20%	12%	within	36%	over
STEM EXCLUSION CLOSED CANOPY	0-5%	16%	over	6%	within
UNDERSTORY REINITIATION	0-5%	16%	over	4%	within
STAND INITIATION	5-15%	2%	under	14%	within

Table 11. Percent of historical ranges of variability for hot dry plant association group in the planning area under alternative 2

Structure	Desired (percent)	Existing condition (percent)	Existing condition - status	2023 predicted (percent)	2023 predicted - status
OLD FOREST SINGLE STORY	20-70%	8%	under	47	within
OLD FOREST MULTI STORY	5-15%	49%	over	19	over
YOUNG FOREST MULTI STORY	5-10%	20%	over	5	within
STEM EXCLUSION OPEN CANOPY	5-20%	15%	within	15	within
STEM EXCLUSION CLOSED CANOPY	0-5%	0%	within	0	within
UNDERSTORY REINITIATION	0-5%	6%	over	10	over
STAND INITIATION	5-15%	2%	under	4	below

Based on the silvicultural modelling results, thinning treatments would move more stands towards old growth structures with a higher proportion of large mature trees and reduce the abundance of small diameter trees (see Cliff Knox Silviculture Report for more information). Mature, old growth stands have lower transpiration rates and less pressure on water resources (Moore G. W., 2004). Removal of younger trees would likely increase soil water initially, though the amount is very difficult to predict (Robles, Turner, & Haney, 2017; Zhang, et al., 2016; Andreassian, 2004; Moore & Wondzell, 2005; Dung, et al., 2012). In water-limited environments, remaining soil water may be taken up by the remaining vegetation (Helvey, 1995).

Since water is the primary limiting growth factor in forest stands, and a healthy stand would be retained after thinning, it is expected that some water would be redistributed to remaining vegetation. However, during periods of abundant groundwater (early summer and/or wet years) some of that water would likely end up in the channel network. Therefore, forest thinning and burning is expected to slightly increase baseflows at the reach or drainage level under alternative 2 during the early summer, for approximately 1-5 years post-thinning (Robles, Turner, & Haney, 2017; Zhang, et al., 2016; Andreassian, 2004; Luce, et al., 2012; Moore G. W., 2004; Dung, et al., 2012). Because forest stands would be moved closer to the historical range of variability, projected increases in baseflow are expected to fall within natural and historical ranges of variability for streams in the Cliff Knox planning area.

Cumulative Effects to baseflows – Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

All projects listed under the Cliff Knox Environmental Impact Statement, Appendix D – Past, Ongoing, and Reasonably Foreseeable Actions were evaluated for inclusion in the cumulative effects analysis for water quantity.

There are no other vegetation projects within the Cliff Knox Project that would affect historical range of variability or baseflows at a drainage level or subwatershed scale. Recent aspen thinning and non-commercial thinning as part of the Central Malheur Environmental Analysis, are designed to move those stands toward historical range of variability, by removing small diameter conifers such as lodgepole encroachment in riparian areas. Thinning has the potential to increase groundwater locally at nearby springs and intermittent drainages, to a level within the historical range of variability. Water availability to an existing irrigation ditch in the Bluebucket subwatershed would not be affected when considered with past, present, and ongoing activities.

Spring protection improvement and developments at 16 springs as part of the Central Malheur, Blue Dollar complex, and Aquatic Restoration Environmental Analysis are expected to improve springs by reducing cattle trampling effects and grazing of hydric graminoids. These projects would withdraw water from specific springs, but project design criteria is in place to protect 90 percent of the streamflow where spring sources are connected. When considered with the Cliff Knox Project, thinning would be negligible or help offset these water withdrawals.

Cumulatively, firewood cutting, which extracts isolated, dead trees that have no transpiration, is not expected to affect baseflow.

Alternative 3

Alternatives 2 and 3 have very similar proposed actions; the significant issues that drove those differences were not related to baseflows or other aquatics issues. As it pertains to baseflows, the differences between alternative 2 and alternative 3 are negligible. There are 47 more acres of treatment expected to increase hydrologic immaturity in alternative 2 compared to alternative 3, and all are located in the Cliff-Malheur subwatershed (see Table 12). That is approximately 0.2 percent of the total forested area and is negligible to the hydrologic analysis. As it pertains to water quantity, the results for baseflows) are the same for alternative 3 as were reported in alternative 2.

Table 12. Differences in acres between alternative 2 and 3 for activities with potential to impact base flow

Project activity	Alternative 2	Alternative 3	Difference	Percent difference
Aspen restoration	596 acres	596 acres	No difference	0%

Meadow enhancement	180 acres	180 acres	No difference	0%
Mountain mahogany restoration	296 acres	296 acres	No difference	0%
Pine Savannah Habitat Restoration	822 acres	775 acres	47 less acres in alternative 3 in Cliff-Malheur subwatershed	0.18% of forested acres in Cliff-Malheur subwatershed

Summary of effects to baseflows for all alternatives

Table 13 below provides a summary of effect to baseflows from all alternatives. Historical range of variability is measured at the project level. Effects are determined at the drainage level. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to the baseflow analysis, were negligible at the subwatershed scale. Results for both action alternatives are the same and reported together below.

Table 13. Summary of effects to baseflows from all alternatives

	Bluebucket subwatershed historical range of variability (HRV)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed historical range of variability (HRV)	Effects to the Cliff-Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	Area continues to be deficient in old growth open pine stands and to have overcrowded stands with high regeneration.	Subwatershed continues to deviate from HRV. Baseflows continue to decrease from increased pressure on limited water resources	Area continues to be deficient in old growth open pine stands and to have overcrowded stands with high regeneration.	Subwatershed continues to deviate from HRV. Baseflows continue to decrease from increased pressure on limited water resources
Alternative 2 and 3 <i>When considered with past, present, future activities⁵</i>	Treatments move stands toward HRV and increase old growth structures with more large mature trees and less small diameter trees.	Treatments move planning area towards HRV. Baseflow may be increased at local streams and springs to levels more consistent with historical conditions, for 1-5 years	Treatments move stands toward HRV and increase old growth structures with more large mature trees and less small diameter trees.	Treatments move planning area towards HRV. Baseflow may be increased at local streams and springs to levels more consistent with historical conditions, for 1-5 years

Summary: There are no quantified thresholds or standards for baseflows in the Malheur Forest Plan, yet baseflows were considered due to potentials on effect riparian vegetation, aquatic ecosystems, and stream temperatures which do have goals and standards under the Malheur Forest Plan. The desired condition for baseflows is tied to forest stand structure (see Desired Conditions above); forest stands within the historic range of variability are expected to have baseflows within the natural range of variability. This

⁵ Values include cumulative effects⁶ Existing condition summaries were developed using data collected prior to implementation of riparian thinning under the Central Malheur Environmental Assessment.

relationship is simplified but appropriate for the analysis based on the lack of standards/thresholds/modelling tools relevant to the Cliff Knox Project. The existing conditions are outside the historic range of variability, with a much higher density of younger trees. This is likely reducing baseflows compared to pre-settlement condition. Both action alternatives (combined with the impacts of past, present, and future activities), are expected to move forest stands towards the historic range of variability in both subwatersheds (see Table 10 and Table 11). The removal of younger conifers is expected to increase available soil water and groundwater, which would likely translate to higher baseflows for up to 1-5 years. Increases in baseflows would be within the natural range of variability for those streams. Indirect impacts from baseflows on riparian vegetation, aquatic habitat, and stream temperature would likely be positive and move them towards the desired conditions.

Stream Temperature

Methodology

Information Sources

Analysis is based on field review of the streams, riparian areas, springs, and meadows within the Cliff Knox planning area. All data was collected by the Malheur National Forest and is located in the project record.

Field crews mapped stream channels and inventoried category 2 and 4 riparian habitat conservation area (RHCA) conditions during the summer of 2014-2018. Types of information surveyed included: valley form and gradient; river left and right riparian vegetative widths, sizes, species, and densities; channel characteristics of width, depth, entrenchment, sinuosity, substrate, form, trend, stability, beaver activity, road crossing issues, and wood supply; photographs of special characteristics or issues, solar pathfinder shade measurements; restoration opportunities and general comments per reach. Photos and GPS points were collected where issues with channel stability or riparian health were observed.

Level II stream surveys were conducted on fish-bearing stream channels in 2014-2018. See Cliff Knox Aquatic Resources Report for methodological information for level II stream surveys. Follow-up field reviews were conducted by a Fisheries biologist and hydrologist in the summers of 2017 and 2018. Field reconnaissance was used to update stream and RHCA categories for project planning.

Field data was digitized and integrated into the Malheur National Forest Geographic Information System (GIS) database for landscape analysis. Existing datasets from the Malheur National Forest GIS corporate database were also used to aid in analysis (e.g. NHD springs, watershed boundaries, past activities, etc.)

Site potential vegetation was determined at the reach level. Data from stream inventory and level II stream surveys were analyzed and compared to site potential vegetation descriptions from the Desired Condition section and

Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report. Professional experience and judgement of hydrology staff at the Prairie City Ranger District was used to determine if a reach meets site potential vegetation.

Background

Stream temperature is highly influenced by stream shade and riparian condition, which can be directly impacted by forest management. The Oregon Department of Environmental Quality requires the Malheur National Forest to focus on stream shade and site potential vegetation as a surrogate for stream temperature, due to the high natural variability in stream temperature and confounding factors that can affect it. Oregon Department of Environmental Quality defines site potential vegetation as “the near stream vegetation that can grow and reproduce on a site given natural plant biology, site elevation, soil characteristics, local climate, channel morphology, hydrology, and natural disturbance regime” (Oregon Department of Environmental Quality, 2010). More information on requirements under the Clean Water Act are addressed under Clean Water Act section.

Malheur Forest Plan standards for Riparian Vegetation are described under the Regulatory Framework section above and pasted below:

- Provide a rate of input to maintain large wood debris standard
- The ground cover is at 90 percent of site potential, covered by herbaceous species, litter, rock, moss, or lichens.
- Stream bank vegetation is at 90 percent of site potential.
- Maintain shade/canopy closure for the following ecosystems:

Ecosystem	Ponderosa Pine	Mixed Conifer	Lodgepole Pine	Hardwood Meadow
Shade/Closure	40-50%	50-60%	60-75%	80%

For this analysis, indicators of stream shade and site potential vegetation are used as surrogates for stream temperature to track changes resulting from forest management with the Cliff Knox Project. Both indicators align with Malheur Forest Plan standards and guidelines and Oregon Department of Environmental Quality regulatory guidance. Standards and analysis of existing conditions for stream temperature are listed in Appendix C – Stream Temperature of this report. Additional analysis of stream temperature on fish-bearing streams can be found in the Cliff Knox Aquatic Resources Report.

Riparian Habitat Conservation Areas

Riparian areas provide stream shade, stabilize stream banks, capture sediment, and provide food and cover for aquatic food-webs and terrestrial wildlife. Stream shade provided by healthy riparian vegetation provides the critical role of helping moderate stream temperature. Riparian habitat conservation areas (RHCA) were established with the adoption of INFISH in 1995 to protect streams and riparian areas (USDA Forest Service, 1995). Within the Cliff Knox planning area there are 2,891 acres of RHCAs associated with 105 miles of streams (see Table 14 and Table 15).

Table 14. Stream miles by stream category in the Cliff Knox planning area

Subwatershed	Category 1 (miles)	Category 2 (miles)	Category 4 (miles)	Total (miles)
Bluebucket Creek	4.6	4.4	15.8	24.9
Cliff Creek-Malheur River	21.8	5.3	52.5	79.6
Grand total	26.4	9.7	68.3	104.5

Table 15. RHCA acres by stream category in the Cliff Knox planning area

Subwatershed	Category 1 (acres)	Category 2 (acres)	Category 4 (acres)	Total (acres)
Bluebucket Creek	351	155	159	665
Cliff Creek-Malheur River	1,092	99	1,035	2,226
Grand total	1,443	254	1,194	2,891

Riparian shrubs are the backbone of a healthy riparian area. Aspen is an important hardwood in riparian areas in the Cliff Knox planning area. Aspen provides stream shade, riparian habitat, and high quality litter material to the stream network that benefits productivity, macroinvertebrates, and in-stream large wood (Swanson, et al., 2010; Bennett, Bouwes, & Rogers, 2019; DeByle, 1985; Oregon Department of Environmental Quality, 2010).

Incomplete and Unavailable Information

Field reconnaissance of streams, meadows, and seeps/springs included the majority of the category 1, 2, and 4 RHCAs in the planning area, but 100 percent of drainages were not surveyed due to time, resource, and access constraints. Similarly, stand evaluations were not conducted in all RHCAs. Stand density in RHCAs that did not have stand evaluations was measured qualitatively by experienced field techs. Surveys characterized channel and riparian conditions at the reach level, but conditions can vary within a given reach (for example, a channel may have isolated gullied areas amongst stable sections). Reach length varied by stream based on streamflow, vegetation type, gradient, road access, etc.

Stream shade was collected on a subset of streams, primarily category 1 fish-bearing streams. Collecting stream shade across all streams in the planning area is not feasible for a planning area of this size.

GIS was used as an analysis tool for much of the environmental analyses. The project GIS layers are considered relatively accurate at the project level, and many layers are field validated during data collection, but the spatial accuracy of many project features (streams, roads, watershed boundaries, etc.) ranges from meters to hundreds of meters. This may be a result of stream meandering or GIS spatial data being developed prior to the widespread availability of LiDAR or GPS devices. To the extent practical, LiDAR and field validation was used to identify errors resulting from GIS analyses.

Site potential vegetation is determined based on the riparian vegetation information collected, which is not consistent across Level II and stream inventory protocols. Riparian condition, hardwood species present, conifer species present, size ranges, and stocking levels are all used to determine site potential vegetation. Where field data is lacking, field photos were used to support determination. If data and/or photos were not available, site potential vegetation was not evaluated.

Spatial and Temporal Context for Effects Analysis

Direct/Indirect Effects Boundaries

Analysis took place at the drainage (i.e. stream) scale and the subwatershed scale. Impacts from project activities for each hydrologic measure are considered at the drainage level and summarized at the subwatershed scale. Consistency with the Clean Water Act (i.e. streams with a 303d listing or Total Maximum Daily Load) are analyzed at the drainage level and consider any impacts that may occur upstream, including intermittent stream channels and ephemeral draws.

Short term is defined as less than three years, or those that are fully recovered within three wet seasons. Three years was selected due to the dry nature of the planning area and slower expected vegetation

response compared to other parts of the forest. Long term effects are those that recover within approximately 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005).

Cumulative Effects Boundaries

The spatial boundaries for analyzing the cumulative effects to all hydrologic indicators are the subwatershed. In the Cliff Knox planning area, hydrologic processes are restricted to the watershed boundary.

The temporal boundaries for analyzing the cumulative effects include any projects that have occurred within the last 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005). Reasonably foreseeable projects include any projects occurring on the Schedule of Proposed Action and the Aquatic Restoration website.

Site Potential Vegetation

Desired Condition

The desired condition for site potential vegetation in the Cliff Knox planning area would meet or move towards site-specific standards described below. Site-specific desired conditions for site potential vegetation were pulled together based on ODEQ criteria (Oregon Department of Environmental Quality, 2010), INFISH (USDA Forest Service, 1995), field observations, and best available science regarding riparian fire regimes.

Forested perennial streams – Streambanks dominated by wetland obligate and/or wetland facultative species. Hardwood shrubs (willow, aspen, alder) would be prolific along stream banks. Large-diameter conifers (ponderosa pine, western larch, Douglas-fir, grand fir) in the outer margins of the riparian area and throughout the riparian habitat conservation area (RHCA). Species composition would vary by plant association group.

Meadows and wetlands – Hardwood shrubs (willow, aspen) and wetland obligate graminoids (e.g. sedges, rushes) would dominate the shallow groundwater saturation zone. Large conifers (ponderosa pine, western larch, Douglas-fir, grand fir) would occur on the edge of the wetted area.

Small forested intermittent streams – Streambanks dominated by wetland facultative graminoids and shrubs. Riparian hardwoods may be present, often aspen, depending on groundwater levels or abundance of springs. Large-diameter conifers (ponderosa pine, western larch, Douglas-fir, grand fir) would be present throughout the RHCA, including the inner riparian area. Species composition would vary by plant association group. In drier sites near the southern end of the project, old growth. Juniper may also be present in small proportions of the outer RHCA.

Malheur River – Streambanks would be dominated by hardwood shrubs (willow, aspen, cottonwood, alder, dogwood, currant, etc.). Large-diameter conifers (ponderosa pine, western larch, grand fir, Douglas-fir) in the outer margins of the riparian area and throughout the RHCA.

Affected Environment

Existing Condition

Riparian vegetation data was assessed for most streams in the Cliff Knox planning area. Riparian condition data was compared to descriptions of site potential vegetation as described by stream category under the Desired Conditions section above and

Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report. The majority of streams in the planning area are not at site potential vegetation. For all stream categories combined, 74 percent of streams are not at site potential vegetation, 13 percent are at site potential vegetation, and 13 percent have no data collected for this parameter (see Table 18). When broken out by subwatershed the trends are similar. For all stream categories combined in the Bluebucket subwatershed, 61 percent of streams are not at site potential vegetation, two percent are at site potential vegetation, and 35 percent have no data collected for this parameter (see Table 16). For all stream categories combined in the Cliff-Malheur subwatershed, 68 percent of streams are not at site potential vegetation, 15 percent are at site potential vegetation, and 17 percent have insufficient data to make that determination (see Table 17).

Table 16. Percent of stream at site potential vegetation in the Bluebucket subwatershed

Stream category	Percent deviated from site potential vegetation	Percent at site potential vegetation	Percent no data
1	19%	12%	68%
2	100%	0%	0%
4	67%	2%	31%
Combined	61%	4%	35%

Table 17. Percent of stream at site potential vegetation in the Cliff-Malheur subwatershed

Stream category	Percent deviated from site potential vegetation	Percent at site potential vegetation	Percent no data
1	45%	27%	28%
2	57%	43%	0%
4	78%	9%	13%
Combined	68%	15%	17%

Table 18. Percent of stream at site potential vegetation across the Cliff Knox planning area

Stream category	Percent deviated from site potential vegetation	Percent at site potential vegetation	Percent no data
1	47%	28%	25%
2	83%	17%	0%
4	82%	7%	10%
Combined	74%	13%	13%

In general, the majority of conifer stands that border the riparian area are overstocked due to a century of fire suppression. An abundance of small, young conifers are present. In the Hot, Dry portions of the planning area, forest stands are dense with younger pine, Douglas-fir, and juniper. In the mixed conifers stands, younger lodgepole, grand fir, and Douglas-fir are increasing stand density.

In addition, the lack of site potential vegetation across the planning area can be attributed to the poor condition of riparian hardwoods such willow, alder, aspen, and dogwood. The exceptions seems to be on small, steep perennial streams near the bottom of the Malheur River Canyon, where dogwood and alder are vigorous (e.g. bottom of Skookum Creek), and in riparian exclosures such as at Cougar Riparian (a tributary to Bluebucket Creek). Riparian conditions have suffered from historical grazing, which reduced the distribution and abundance of riparian shrubs. Modern grazing, while much improved from the past,

now has a disproportionate impact on these relic shrubs. Road construction in valley bottoms and lowered water tables at incised stream channels have also contributed to the poor condition of riparian areas across the planning area.

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to site potential vegetation Indicators

There would be no direct effect to site potential vegetation from the no action alternative because no activities would take place within the RHCA. Site potential vegetation would be maintained at current levels. Over time, as conifer encroachment continues to outcompete aspen and other riparian shrubs, vegetation would continue to deviate from site potential vegetation.

As described in the Cliff Knox Fire, Fuels, and Air Quality Report, much of the planning area (including RHCAs) would continue to be at elevated risk of active and passive crown fire. The location and severity of wildfires cannot be predicted, but in recent years, forest stand densities, drought, and weather conditions have contributed to multiple large fires in the southern Blue Mountains that have burned within and across entire subwatersheds (e.g. Bald Sisters 2014, South Fork Complex 2014, Canyon Creek Complex 2015, Rail Fire 2017).

In the event of a large catastrophic wildfire, site potential vegetation would likely depart from desired conditions if high intensity burns were to concentrate in the drainages. Recent wildfires on the Malheur National Forest outside the project boundary have shown that when combined with extreme weather, high stand densities, ladder fuels, and topography in untreated riparian corridors have facilitated RHCAs to burn with high intensity and total consumption of stream cover (Menakis, 2016) (See Figure 1). These effects are typically short-lived (3-10 years) in perennial streams where riparian shrubs can bounce back quickly but could have long-term impacts on the majority of intermittent streams where shallow groundwater tables are lowered by incising stream channels.



Figure 1. Example of high severity burn on the 2019 Cow Fire. Full consumption of the riparian shrubs and conifer over-story on category 1 fish-bearing stream.

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

The majority of proposed activities would take place outside of RHCAs and have no effect to site potential vegetation. Treatments outside the RHCA are not considered in the analysis of riparian condition. Below is a summary of activities within RHCAs and the potential for effect to site potential vegetation:

1. **Non-commercial aspen restoration in the RHCA.** This treatment is expected to cut all conifers less than 20.9 inches diameter at breast height within aspen stands. Effects to site potential vegetation are analyzed below.
2. **Non-commercial non-aspen thinning in the RHCA.** This treatment is expected to remove all conifers less than 9 inches diameter at breast height outside of aspen stands. Effects to site potential vegetation are analyzed below.
3. **Prescribed burning would be allowed to burn within RHCAs.** Effects to site potential vegetation are analyzed below.
4. **Skidding/decking mechanical areas in the RHCA (RHCA mechanical areas).** To support logging systems of upland thinning units outside the RHCA, small slivers of the RHCA on the uphill side of the road may be used to transport and store wood products to haul routes. Per adherence with the design criteria, trees within the RHCA would not be removed and overstory canopy would not be affected. These areas are located within the RHCA but outside the true riparian area and have vegetation characteristics consistent with the surrounding uplands. Based on location of these treatments, skidding and decking in the RHCA is not expected to affect site potential vegetation.
5. **Roads maintenance in the RHCA** would not affect site potential vegetation, per adherence with Aquatics-16 to maintain or protect riparian shrubs. All overgrown roads paralleling streams in the RHCA are prohibited from haul to protect riparian condition. Roads maintenance for log haul is not expected to affect site potential vegetation.
6. **Roads Decommissioning in the RHCA.** Administrative roads decommissioning of overgrown roads in the RHCA would protect and maintain riparian condition in those locations. Roads decommissioning is not expected to affect site potential vegetation.

Project Design Criteria and Mitigation Measures

Project design elements were developed to protect riparian vegetation and stream shade during project activities. Aquatics-8 is designed to protect stream shade during non-commercial thinning and fuels reduction activities. Aquatics-2 is designed to reduce consumption of large wood and limit mortality in the RHCA during prescribed burning. Aquatics-16 is designed to minimize brushing in riparian areas.

Monitoring and Adaptive Management

Aspen treated in category 4 RHCAs would be monitored for the need to protect from ungulates. If three years after completion of aspen restoration thinning, more than 75 percent of any treated aspen stand is showing high concentrations of browse (50 to 100 percent) on regenerating aspen seedlings and saplings, fencing would be constructed around these pockets to impede access by wild and domestic ungulates (Aquatics-8).

Direct and Indirect Effects to Site Potential Vegetation – Alternative 2

Aspen restoration in the RHCA includes the cutting of all conifers less than 20.9 inches diameter at breast height. With access to water tables and the removal of competition, aspen are expected to proliferate within 5 years post-treatment, based on monitoring of similar treatments on the Malheur National Forest. Treated aspen stands are expected to meet site potential vegetation within 5 years. Aspen is a valuable riparian hardwood with multiple benefits to water quality and aquatic ecosystems (Swanson, et al., 2010; Bennett, Bouwes, & Rogers, 2019; DeByle, 1985; Oregon Department of Environmental Quality, 2010). Enhancing aspen stands in riparian areas is consistent with the Malheur Forest Plan and ODEQ Site Potential Vegetation desired conditions (see the Desired Condition section and

Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report).

Additional RHCA non-commercial thinning outside of aspens stands is expected to improve growing conditions for desirable conifers in the RHCA, such as large western larch, ponderosa pine, and Douglas-fir, and where they exist, riparian hardwoods such as willow, alder and dogwood. However, the benefits of thinning treatments are tempered by project design criteria that protects stream shade. Trees less than 9 inches diameter at breast height would be cut and the overstory canopy would be maintained. While the impacts of these treatments are limited, treatments would improve site potential vegetation by 1) reducing competition for water and other stand stressors such as insect and disease, 2) improving growth conditions for larger, remaining conifers (Ferguson, Byrne, Wykoff, Kummet, & Hensold, 2011) and 3) reducing fuel loadings and ladder fuels to promote beneficial fire effects for wildfire and prescribed burning. No-cut-buffers would also help maintain the riparian microclimate (Rambo & North, 2009; Anderson, Larson, & Chan, 2007).

The risk of catastrophic wildfire is slightly lower under alternative 2 compared with alternative 3 due to 1) the slightly greater extent of non-commercial RHCA treatments under alternative 2 and 2) the inclusion of the Malheur Inventoried Roadless Area to prescribed burning treatments in alternative 2. However, the differences in the number of acres proposed for non-commercial treatments between alternatives 2 and 3, relevant to site potential vegetation, were negligible at the subwatershed scale. In alternative 3, direct and indirect effects within the Wild and Scenic River corridor would be similar to those described in the no action alternative. However, by treating areas surrounding the Wild and Scenic River corridor as described in alternative 2, the risk of catastrophic wildfire would be less than in the no action alternative. Additional information may be found in the Cliff Knox Project Final Environmental Impact Statement, chapter 3 – Fire, Fuels, and Air Quality section.

In some cases, treatment may be sufficient to restore stands to site potential vegetation. In others, it would improve the stand condition but would not be enough to restore site potential vegetation. Prescribed burning within RHCAs is expected to enhance thinning treatments (see Aquatics-2) and would further help move stands closer to desired site potential vegetation (Pettit, 2007).

In summary, non-commercial thinning within aspen stands is expected to restore site potential vegetation in isolated aspen stands within 5 years. Outside aspen stands, RHCA non-commercial thinning and prescribed burning would improve stand health and move it towards site potential vegetation. In total, site potential vegetation would be restored or improved along 10.6 miles of the Bluebucket subwatershed and 3.7 miles of the Cliff-Malheur subwatershed (see Table 19 and Table 20). Restoring site potential vegetation is consistent with long term objectives to maintain or improve stream temperature within both basins. No other treatments are expected to affect site potential vegetation as discussed above.

Table 19. Miles of stream moving towards site potential vegetation under alternative 2

Subwatershed	Activity type within the RHCA	Stream category 1 (miles)	Stream category 2 (miles)	Stream category 4 (miles)	Total stream category (miles)
Bluebucket Creek	Aspen restoration	0.5	0.9	1.6	3.0
	Non-commercial thinning	1.8	2.6	3.2	7.7
	Combined	2.4	3.5	4.8	10.6

Subwatershed	Activity type within the RHCA	Stream category 1 (miles)	Stream category 2 (miles)	Stream category 4 (miles)	Total stream category (miles)
Cliff Creek-Malheur River	Aspen restoration	0.1	0.3	2.2	2.5
	Non-commercial thinning	0.5		0.6	1.2
	Combined	0.6	0.3	2.8	3.7

Table 20. Percent of stream moving towards site potential vegetation under alternative 2

Subwatershed	Activity type within the RHCA	Stream category 1 (%)	Stream category 2 (%)	Stream category 4 (%)	Total stream category (%)
Bluebucket Creek	Aspen restoration	11%	19%	10%	12%
	Non-commercial thinning	40%	60%	20%	31%
	Combined	51%	79%	30%	43%
Cliff Creek-Malheur River	Aspen restoration	Less than 1%	5%	4%	3%
	Non-commercial thinning	2%	0%	1%	1%
	Combined	3%	5%	5%	5%

Cumulative Effects to Site Potential Vegetation– Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Analysis of past grazing, past timber harvest, fire suppression, and past roads were considered in the existing conditions analysis.

Cattle grazing was analyzed under the Central Malheur Environmental Analysis in 2015 and Blue Dollar Complex in 2017. These projects developed grazing systems and utilization standards that are consistent with long term sustainability of the allotments in the planning area. Livestock utilization monitoring helps protect riparian shrubs by measuring utilization and triggering livestock removal/movement when utilization is approaching standards. However, due the reduced vigor and abundance of hardwoods in the planning area, ungulate pressure has been observed to impact young aspen suckering within the Cliff Knox planning area and other nearby allotments. However, due to the protection and monitoring requirements built into the aspen thinning treatments within RHCAs, effectiveness of aspen treatments would still be high when considered cumulatively with active livestock grazing. In addition, a number of spring protection, aspen enhancement, and water improvement projects were proposed to enhance and protect riparian condition. Many have been implemented on the west side of the Malheur River.

Recent small diameter aspen restoration within the planning area has improved site potential vegetation at approximately 2.5 of stream miles, primarily in category 4 streams. Small diameter thinning helps improve site conditions for aspen but retains larger conifers that would continue to compete with aspen. In addition to aspen thinning there have been 15 miles of non-commercial RHCA thinning along

intermittent streams (category 4) as part of the Central Malheur Environmental Analysis. Effects of these treatments are similar to those described for non-commercial thinning in the Cliff Knox Project under Direct and Indirect Effects. These treatments may not change the percent of streams meeting site potential vegetation but would move them towards desired conditions. When considered cumulatively with the Cliff Knox Project, there would be 12.4 miles of treatment moving riparian areas towards site potential vegetation in the Bluebucket subwatershed and 20.7 in the Cliff Malheur subwatershed (see Table 21 and Table 22). Cumulatively, site potential vegetation would be improved for up to 15-20 years until young trees start replacing those that were removed.

Table 21. Miles of stream meeting or moving towards site potential vegetation under alternative 2 when considered cumulatively with past, present, and reasonably foreseeable activities⁶

Subwatershed	Activity type	Stream category 1 (miles)	Stream category 2 (miles)	Stream category 4 (miles)	Total stream category (miles)
Bluebucket Creek	Existing conditions	0.8	0.0	0.4	1.2
	Past, ongoing, future activities	0.0	0.0	0.6	0.6
	Alternative 2	2.4	3.5	4.8	10.6
	Combined	3.2	3.5	5.8	12.4
Cliff Creek-Malheur River	Existing conditions	4.4	1.2	3.8	9.4
	Past, ongoing, future activities	0.0	0.0	17.0	17.0
	Alternative 2	0.6	0.3	2.8	3.7
	All conditions	0.6	0.3	09.8	20.7

Table 22. Percent of streams moving towards site potential vegetation under alternative 2 when considered cumulatively with past, present, and reasonably foreseeable activities

Subwatershed	Activity type	Stream category 1 (%)	Stream category 2 (%)	Stream category 4 (%)	Total stream category (%)
Bluebucket Creek	All activities combined	69%	79%	36%	50%
Cliff Creek-Malheur River	All activities combined	23%	28%	45%	38%

Alternative 3

Alternatives 2 and 3 have very similar proposed actions; the significant issues that drove those differences were not related to site potential vegetation or other aquatics issues. As it pertains to site potential vegetation, acres of RHCA aspen restoration and RHCA, non-aspen, non-commercial thinning are the same between alternatives. Results are the same for alternative 3 as were reported in alternative 2.

Summary of effects to site potential vegetation for all alternatives

The table below provides a summary of effects to site potential vegetation from all alternatives. Results are summarized at the subwatershed scale, but effects are determined at the drainage level. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to

⁶ Existing condition summaries were developed using data collected prior to implementation of riparian thinning under the Central Malheur Environmental Assessment.

site potential vegetation, were negligible at the subwatershed scale. Results for both action alternatives are the same and reported together below.

Table 23. Summary of effects to site potential vegetation from all alternatives

Alternative	Bluebucket subwatershed site potential vegetation (miles) (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed site potential vegetation (miles) (percent of subwatershed)	Effects to the Cliff-Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	1.2 miles (4%)	Streams continue to deviate from desired conditions for site potential vegetation due to conifer overstocking	9.4 miles (15%)	Streams continue to deviate from desired conditions for site potential vegetation due to conifer overstocking
⁷ Alternative 2 and 3 <i>When considered with past, present, future activities</i>	12.4 miles (50%)	Treatments move streams towards desired conditions for site potential vegetation on 10.6 miles of streams. Effects would last for up to 15-20 years or until encroachment returns.	20.7 miles (38%)	Treatments move streams towards desired conditions for site potential vegetation on 3.7 miles of streams. Effects would last for up to 15-20 years or until encroachment returns.

Summary: Site potential vegetation is used as a surrogate for stream temperature because the condition of riparian vegetation is most closely tied to management-related impacts on stream temperature. This standard is directly linked to guidance from Oregon Department of Environmental Quality (ODEQ) through the Malheur sub-basin Total Maximum Daily Load (ODEQ, 2010), and compliments Malheur Forest Plan standards for riparian vegetation, as amended. Desired conditions for site potential vegetation are summarized under Site Potential Vegetation Desired Conditions above and detailed in Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report. Thinning would occur by hand treatment only, minimizing the potential for damage or adverse impact to riparian plant communities. Non-commercial thinning activities within the RHCA are expected to enhance site potential vegetation by reducing overstocked small conifers and retaining riparian shrubs and large conifers. Non-commercial aspen treatments are expected to meet the desired condition for site potential vegetation within 5-10 years. Non-commercial non-aspen treatments would move riparian areas towards the desired condition for site potential vegetation but may not fully meet desired conditions with a single entry due to lighter prescriptions protecting stream shade. Overall, site potential vegetation would be improved in 12.4 and 20.7 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively (see Table 23 above), when considered with past, present, and future activities. Restoring site potential vegetation is consistent with long term objectives to move towards stream temperature standards within both basins. For more information on stream temperature standards, see Appendix C – Stream Temperature of this report.

Stream Shade

Desired Condition

The desired condition for stream shade in the Cliff Knox planning area would meet or move towards Malheur Forest Plan standards and Oregon Department of Environmental Quality (ODEQ) standards for

⁷ Values include cumulative effects

stream shade, as described below. The assumption is that as streams move towards standards for stream shade, they are also moving towards standards for stream temperature.

The Malheur National Forest standards and guidelines for stream shade come from Amendment 29:

Table 24. Malheur Forest Plan standards for shade/canopy closure by forest type

Ecosystem	Ponderosa Pine	Mixed Conifer	Lodgepole Pine	Hardwood Meadow
Shade/Closure	40-50%	50-60%	60-75%	80%

The ODEQ standards for stream shade are below (see Table 25). These criteria were developed by relating stream characteristics from field reconnaissance to effective shade curve standards from the Malheur Total Maximum Daily Load (TMDL; ODEQ, 2010; Appendix B – Oregon Department of Environmental Quality Supplemental Information). The standard for the Malheur River comes from the Malheur Water Quality Restoration Plan (WQRP; 2018).

Table 25. ODEQ standards for shade/canopy closure by stream type relevant to the Cliff Knox planning area

Ecosystem	11h-Ecoregion Conifer	11h-Ecoregion Aspen	11h-Ecoregion Shrubs
Small headwater tributary (less than 2 meters channel width)	92-96%	88-94%	80-90%
Small headwater tributary (less than 3 meters channel width)			70-80%
Malheur River	40-48%		

Note that standards for stream shade are different between the Oregon Department of Environmental Quality and the Malheur Forest Plan as amended by INFISH and Amendment 29 (see Table 24 and Table 25). Short term goals are to move towards both sets of standards. In the long term, both standards should be met where physically feasible.

Affected Environment

Existing Condition

Stream shade was not collected for all streams in the planning area. Shade was collected during level II stream surveys on a subset of streams, primarily category 1 fish-bearing streams. The following table, Table 26, summarizes available stream shade information.

Table 26. Existing conditions for stream shade at a subset of streams in the Cliff Knox planning area

Stream name	Stream category	Stream segment (miles)	July shade (percent)	July shade meets Malheur Forest Plan standards	Average bankfull width (meters)	July shade meets TMDL ¹	At site potential vegetation
Malheur River, Reach 1	1	3.8	62.4%	Yes	22.0	Yes	Yes
Malheur River, Reach 2	1	1.0	11%	No	20.1	No	No

Stream name	Stream category	Stream segment (miles)	July shade (percent)	July shade meets Malheur Forest Plan standards	Average bankfull width (meters)	July shade meets TMDL ¹	At site potential vegetation
Bluebucket Creek	1	1.2	57.3%	Yes	3.0	No	No
Skookum Creek	1	0.6	83.7%	Yes	2.7	Yes	Yes
Lee Creek	1	1.3	72.2%	Yes	1.3	No	No
Black Canyon Creek	1/4	1.7	48.9%	No	1.8	No	No

¹Total Maximum Daily Load

As part evaluating compliance with the Total Maximum Daily Load, the Malheur National Forest has established 41 sites where effective shade will be monitored approximately every 5 years. These sites are scattered throughout the Upper Malheur River subbasin, and intentionally overlap established PIBO (PACFISH/INFISH Biological Opinion) effectiveness monitoring sites. Two of these sites are located within the Cliff Knox planning area, the Upper Malheur and Lower Malheur. In 2014, effective shade was measured at these sites as 21 percent and 35 percent (August) respectively (ODEQ, 2018).

Due to the lack of existing condition information, miles of canopy opening in the RHCA is used to track changes in stream shade caused by forest management. As of October 2019, there have been 0.6 and 2.0 miles of canopy opening aspen treatments in the Bluebucket and Cliff-Malheur subwatersheds, respectively (see Table 27). Recent aspen restoration treatments in the RHCA (described under Cumulative Effects for Site Potential Vegetation section above) created canopy openings over the stream with the expectation that aspen would recover within 5 years.

Up to 15 miles of non-commercial non-aspen restoration has also been completed in the RHCA on the west side of the Malheur River within the last 5 years. These treatments removed small diameter conifers less than 10 inches diameter at breast height. Monitoring of these treatments on the Emigrant Creek Ranger District have shown that canopy closure was unaffected, and there were no impacts to stream shade.

Table 27. Miles of recent canopy-opening thinning in the RHCA

Subwatershed	Recent RHCA aspen restoration (miles)	Percent of subwatershed (percent)	Max treatment per stream (mile)
Bluebucket Creek	0.6	1.9%	0.01
Cliff Creek-Malheur River	2.0	2.1%	0.5

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to Stream Shade

Stream shade on all streams would be maintained at current levels. There would be no direct effect to stream shade from the no action alternative. Over time, conifer encroachment is expected to increase competition with aspen and other riparian shrubs. In reaches with young conifer stands in the RHCA, stream shade would be expected to increase as stands mature. While the conifer canopy would continue to

close and effective shade would increase, riparian areas would deviate from site potential vegetation as conifers shade and outcompete riparian hardwoods. Based on the expected rate of tree growth in overstocked stands, stream temperatures are expected to take many decades to benefit from natural recruitment to the mid-story canopy.

As described above in Effects to Site Potential Vegetation with the No Action Alternative, a large catastrophic wildfire could negatively impact riparian condition if high intensity fire is concentrated in the drainages. In the event of high mortality to riparian areas (see Figure 1), stream shade would be temporarily decreased. These effects are typically short-lived (3-10 years) in perennial streams where riparian shrubs can bounce back quickly but could have long-term impacts on the majority of intermittent streams where shallow groundwater tables are lowered by incising stream channels.

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

The majority of forest thinning would take place outside of RHCAs and have no effect to stream shade or site potential vegetation. Treatments outside the RHCA are not considered in the analysis of riparian condition. Below is a summary of activities within RHCAs and the potential for effect to stream shade

1. **Non-commercial aspen restoration in the RHCA.** This treatment is expected to cut all conifers less than 20.9 inches diameter at breast height within aspen stands. Effects to stream shade are analyzed below.
2. **Non-commercial non-aspen thinning in the RHCA.** This treatment is expected to remove all conifers less than 9 inches diameter at breast height outside of aspen stands. This treatment would retain all overstory conifers. It is not expected to affect stream shade per adherence with Aquatics-8.
3. **Prescribed burning would be allowed to burn within RHCAs.** Prescribed burning is not expected to affect stream shade per adherence with the prescription and project design criteria to retain all shrubs, large wood, and overstory canopy.
4. **Skidding/decking mechanical areas in the RHCA (RHCA mechanical areas).** To support logging systems of upland thinning units, small slivers of the RHCA on the uphill side of the road may be used to transport and store wood products to haul routes. Per adherence with the design criteria, skidding and decking would not occur within 50 feet of a stream and trees within the RHCA would not be removed and overstory canopy would not be affected (Aquatics-11). All RHCA mechanical areas are located within the RHCA but outside the true riparian area and have vegetation characteristics consistent with the surrounding uplands. Skidding and decking in the RHCA is not expected to affect stream shade.
5. **Roads maintenance in the RHCA** would maintain or protect riparian shrubs per adherence with Aquatics-16. All overgrown roads paralleling streams in the RHCA are prohibited from haul to protect riparian condition. As a result, roads maintenance for log haul is not expected to affect stream shade.
6. **Decommissioning roads in the RHCA.** Administrative roads decommissioning of overgrown roads in the RHCA would protect and maintain stream shade in those locations. Stream shade would not change but decommissioning approximately 10 miles of RHCA roads prevents the reduction of stream shade along those streams into the future.

Project Design Criteria and Mitigation Measures

Project design elements were developed to protect stream shade during project activities. Aquatics-8 is designed to protect stream shade during non-commercial thinning and fuels reduction activities. Aquatics-2 is designed to reduce consumption of large wood and limit mortality in the RHCA during prescribed burning. Aquatics-16 is designed to minimize brushing in riparian areas. Aquatics-11 is designed to prevent cutting of trees in RHCA mechanical areas to maintain canopy cover and shade.

Monitoring and Adaptive Management

Aspen treated in category 4 RHCA would be monitored for the need to protect from ungulates. If three years after completion of aspen restoration thinning, more than 75 percent of any treated aspen stand is showing high concentrations of browse (50 to 100 percent) on regenerating aspen seedlings and saplings, fencing would be constructed around these pockets to impede access by wild and domestic ungulates (Aquatic-8).

Direct and Indirect Effects to Stream Shade – Alternative 2

The prescription to remove all conifers less than 20.9 inches diameter at breast height in RHCA aspen stands would eliminate the majority of the overstory canopy over the stream, but not all. Topography, remaining aspen, and large overstory conifers would provide some shade over the stream until aspen regeneration recovers to a height where stream shading can occur. Stream shade at each aspen stand is expected to be at 10 – 40 percent based on local variability. Stream shade at isolated aspen stands (less than one half mile treatment reaches) would likely fall below Malheur Forest Plan standards and Oregon Department of Environmental Quality (ODEQ) criteria for up to 5 years. With access to water and the removal of competition, aspen are expected to proliferate and provide adequate shade over streams within 5 years post-treatment, based on monitoring of similar treatments on the Malheur National Forest. Once recovered, shade provided by aspen stands would exceed the pre-existing shade condition at these sites. These short term impacts are outweighed by the long term benefits to aquatic habitat by moving towards site potential vegetation and improving stream shade, litter inputs, and other aquatic benefits within 5 years (Swanson, et al., 2010; Bennett, Bouwes, & Rogers, 2019; DeByle, 1985; Oregon Department of Environmental Quality, 2010).

Reductions in stream shade at these isolated locations has the potential to increase stream temperatures, but impacts would not be measurable at the stream level because of spatial and temporal restrictions to treat less than one half mile per stream per year and expected rate of recovery of aspen canopy closure. Non-commercial treatments would improve aspen canopy cover within 5-10 years, which has well-documented benefits for fish and wildlife (Swanson et al. 2010).

In summary, non-commercial thinning within aspen stands is expected to reduce stream shade in isolated aspen stands for up to 5-10 years, but effects would not be measurable at the drainage level. The maximum treatment length is one half mile per stream per year. Non-commercial thinning would occur non-continuously along 3.0 stream miles of the Bluebucket subwatershed and 2.5 stream miles of the Cliff-Malheur subwatershed (see Table 28 and Table 29). No other treatments are expected to affect stream shade, as discussed above.

Table 28. Miles of canopy-opening thinning in the RHCA under alternative 2

Subwatershed	Stream category 1 (miles)	Stream category 2 (miles)	Stream category 4 (miles)	Total stream category (miles)
Bluebucket Creek	0.5	0.9	1.6	3.0
Cliff Creek-Malheur River	0.1	0.3	2.2	2.6

Total planning area	0.6	1.2	3.8	5.6
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Table 29. Percent of canopy-opening thinning in the RHCA under alternative 2

Subwatershed	Stream category 1 (percent)	Stream category 2 (percent)	Stream category 4 (percent)	Total stream category (percent)
Bluebucket Creek	11%	20%	10%	12%
Cliff Creek-Malheur River	0%	6%	4%	3%
Total planning area	2%	12%	6%	5%

Cumulative Effects to Stream Shade – Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Analysis of past grazing, past timber harvest, fire suppression, and past roads were considered in the existing conditions analysis.

Cattle grazing was analyzed under the Central Malheur Environmental Analysis in 2015 and Blue Dollar Complex in 2017. These projects developed grazing systems and utilization standards that are consistent with long term sustainability of the allotments in the planning area. Livestock utilization monitoring helps protect riparian shrubs by measuring utilization and triggering livestock removal/movement when utilization is approaching standards. However, due the reduced vigor and abundance of hardwoods in the planning area, ungulate pressure has been observed to impact young aspen suckering within the Cliff Knox planning area and other nearby allotments. However, due to the protection and monitoring requirements built into the aspen thinning treatments within RHCA, effectiveness of aspen treatments would still be high when considered cumulatively with active livestock grazing. In addition, a number of spring protection, aspen enhancement, and water improvement projects were proposed to enhance and protect riparian condition. Many have been implemented on the west side of the Malheur River.

Recent aspen restoration along 2.6 miles of streams are all proposed for follow-up treatments under the Cliff Knox Project, except one unit totaling 0.25 miles along a category 4 stream in the Cliff-Malheur subwatershed. Remaining conifers would be felled under the aspen restoration treatment. Since these treatments are occurring in the same location, miles of canopy openings in the RHCA would only change by 0.25 miles when considered with past, present, and reasonably foreseeable future activities (see Table 30). Cumulatively, stream shade may be locally reduced at aspen stands for the next 5-10 years until aspen stands recover.

Table 30. Miles of canopy-opening thinning in the RHCA under alternative 2 when considered with past, present, and reasonably foreseeable activities.

Subwatershed	Stream category 1 (miles)	Stream category 2 (miles)	Stream category 4 (miles)	Total stream category (miles)
Bluebucket Creek	0.5	0.9	1.6	3.0
Cliff Creek-Malheur River	0.1	0.3	2.5	2.9
Total planning area	0.6	1.2	4.1	5.9

Table 31. Percent of canopy-opening thinning in the RHCA under alternative 2 when considered with past, present, and reasonably foreseeable activities.

Subwatershed	Stream category 1 (percent)	Stream category 2 (percent)	Stream category 4 (percent)	Total stream category (percent)
Bluebucket Creek	11%	20%	10%	12%
Cliff Creek-Malheur River	0%	6%	5%	4%
Total planning area	2%	12%	6%	6%

Alternative 3

Alternatives 2 and 3 have very similar proposed actions; the significant issues that drove those differences were not related to stream shade or other aquatics issues. As it pertains to stream shade, proposed activities within the RHCA aspen are the same in both action alternatives. Acres of RHCA thinning and RHCA non-aspen non-commercial thinning are the same between alternatives. Results are the same for alternative 3 as were reported in alternative 2.

Summary of effects to stream shade for all alternatives

Table 32 below provides a summary of effects to stream shade from all alternatives. Results are summarized at the subwatershed scale. Effects are determined at the drainage level. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to stream shade, were negligible at the subwatershed scale. Results for both action alternatives are the same and reported together below.

Table 32. Summary of effects to stream shade from all alternatives

Alternative	Bluebucket subwatershed miles of RHCA canopy opening (miles) (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed miles of RHCA canopy opening (miles) (percent of subwatershed)	Effects to the Cliff Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	0.6 miles (2%)	No effect to stream shade from no action alternative	2.0 miles (2%)	No effect to stream shade from no action alternative
⁸ Alternative 2 and 3 <i>When considered with past, present, future activities</i>	3.0 miles (12%)	For up to 5 years, aspen thinning treatments in the RHCA would likely decrease stream shade below Malheur Forest Plan and ODEQ standards at isolated aspen stands. Once aspen recovers, stream shade would meet or exceed stream shade standards. Short term effects are offset by	2.9 miles (4%)	For up to 5 years, aspen thinning treatments in the RHCA would likely decrease stream shade below forest plan and ODEQ standards at isolated aspen stands. Once aspen recovers, stream shade would meet or exceed stream shade standards. Short term effects are offset by

⁸ Values include cumulative effects

Alternative	Bluebucket subwatershed miles of RHCA canopy opening (miles) (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed miles of RHCA canopy opening (miles) (percent of subwatershed)	Effects to the Cliff Malheur subwatershed
		numerous benefits of healthy riparian aspen stands. Treatments would be limited to one half mile per stream per year to protect water temperatures. Effects to stream temperature would not be measurable at the drainage scale.		numerous benefits of healthy riparian aspen stands. Treatments would be limited to one half mile per stream per year to protect water temperatures. Effects to stream temperature would not be measurable at the drainage scale.

Summary: Stream shade is used as a surrogate for stream temperature because near-stream shade is closely tied to management-related impacts on stream temperature. This standard is directly linked to guidance from Oregon Department of Environmental Quality through the Malheur subbasin Total Maximum Daily Load (ODEQ, 2010), and Malheur Forest Plan standards for stream shade, as amended (USDS Forest Service, 1995). Desired conditions for stream shade are summarized under Stream Shade Desired Conditions above. Thinning would occur by hand treatment only, minimizing the potential for damage or adverse impact to riparian plant communities. Non-commercial aspen restoration within the RHCA is expected to reduce stream shade at isolated locations, no greater than one half mile of stream per year, with recovery expected within 5-10 years based on previous aspen management. These impacts are not expected to meaningfully reduce stream temperature at any spatial scale due to limitations on how much of a stream can be treated in a given year, the adaptive management and/or required protection from ungulate browse, and the rapid recovery typified by riparian aspen treatments. Overall, stream shade would be initially reduced for 5-10 years and then move towards desired conditions in 3.0 and 2.9 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively (see Table 32 above), when considered with past, present, and future activities. Aspen is a desired shrub species and short-term reductions in stream shade, at isolated locations, is consistent with Malheur Forest Plan and ODEQ direction (USFS, 2018). Restoring aspen is consistent with long term objectives to move towards stream temperature standards within both basins. For more information on stream temperature standards, see Appendix C – Stream Temperature of this report.

Sediment Delivery

Methodology

Information Sources

There are two common approaches for addressing sediment delivery to streams from forest management: 1) use models to estimate sediment delivery rates from hillslopes and roads based primarily on remote sensing information and field calibrations, or 2) conduct field work to identify all human-caused sediment delivery sources (e.g., roads, trails, etc.). For the Cliff Knox Project, the watershed analysis uses the second approach. This approach requires data to be collected on roads within riparian habitat conservation

areas (RHCA). True sediment studies, which measure in-stream sediment, sediment transport rates, and ascertain sediment sources, are not practical for projects of this size.

Analysis is based on field review of roads, streams, and RHCA within the Cliff Knox planning area. Field crews evaluated streams and roads in the planning area in the summers of 2014-2018 (see Riparian Condition section above). Road surveys included complete inventory of Maintenance Level 1 & Maintenance Level 2 roads for condition, hydrologic function, and utility to support administrative uses (e.g., log haul). Every road identified for haul was visited and the drainage features were examined for connectivity to streams.

Stream inventory protocols include assigning stream categories. Differentiating between ephemeral draws and intermittent streams was of particular importance within this dry, low elevation planning area. If the drainage had a continuous channel, evidence of annual scour and deposition, and/or hydric vegetation it was categorized as an intermittent channel. If the channel was discontinuous with long reaches of intact upland grass and forb communities, it was determined to be a degraded ephemeral draw.

Field data was digitized and integrated into the Malheur National Forest GIS database for landscape analysis. Existing datasets from the Malheur National Forest GIS corporate database were also used to aid in analysis (e.g., NHD springs, watershed boundaries, past activities, etc.).

GIS and field reconnaissance were used to identify the most at-risk roads for sediment delivery. All roads within 50 feet of a stream were identified using GIS analysis. Surface type, segment length within 50 feet of a stream channel, number of stream crossings, and approximate number of log loads were used to determine the most appropriate best management practice at each road to minimize sediment delivery from log haul. Each site-specific best management practices prescription was then validated by a hydrologist and fish biologist in the field.

Incomplete and Unavailable Information

The majority of roads, but not all roads in the planning area were surveyed by an aquatics specialist due to time, resource, and access constraints. All roads that overlap RHCA were surveyed. Degraded ephemeral draws were identified where encountered during field work, particularly where they overlap with roads, but the total miles of degraded ephemeral draws are not known in either subwatershed.

GIS was used as an analysis tool for much of the environmental analyses. The project GIS layers are considered relatively accurate at the project level, and many layers are field validated during data collection, but the exact location of project features (streams, roads, watershed boundaries, etc.) may not always be 100 percent accurate in GIS. This may be a result of stream meandering or GIS spatial data being developed at a coarse resolution and prior to the widespread availability of LiDAR or GPS devices. To the extent practical, LiDAR and field validation was used to identify errors resulting from GIS analyses.

Mileage for road indicators (roads within the RHCA, roads with observed sediment delivery, and roads and within 50 feet of a stream channel) are calculated in GIS based on road segment length, not a clipped distance. This provides consistency in the analysis, but it also likely overestimates mileage. This decision is based on a few guiding principles; 1) while some indicators lend themselves to different approaches, a consistent approach allows for comparisons across indicators; 2) stream segments outside the sediment delivery zone may be routing sediment into those delivery points. Road rills and gullies on unmaintained roads can persist for hundreds of feet before exiting the road surface; 3) site-specific roads information provides the basis for all analysis and proposed mitigations.

Models such as the Water Erosion Prediction Project (WEPP) are often used in sediment analysis by USDA Forest Service hydrologists. This analysis does not use Water Erosion Prediction Project for a variety of reasons. The primary reason is because the analysis uses site-specific roads data collected from field surveys to identify the roads with the highest effects and proposes site-specific best management practices to resolve those issues. There is also concern over model accuracy at the 50,000-acre planning area. Finally, quantifying sediment production can be informative, but State and Malheur Forest Plan standards are based on the implementation of best management practices, not on numeric criteria. In other words, there is no numeric standard for natural and anthropogenic sediment delivery for any stream in the Cliff Knox planning area.

Spatial and Temporal Context for Effects Analysis

Direct/Indirect Effects Boundaries

Analysis took place at the drainage (i.e., stream) scale and the subwatershed scale. Impacts from project activities for each hydrologic measure are considered at the drainage level and summarized at the subwatershed scale.

Short term is defined as less than three years, or those that are fully recovered within three wet seasons. Three years was selected due to the dry nature of the planning area and slower expected vegetation response compared to other parts of the forest. Long term effects are those that recover within approximately 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005).

Cumulative Effects Boundaries

The spatial boundaries for analyzing the cumulative effects to all hydrologic indicators are the subwatershed. In the Cliff Knox planning area, hydrologic processes are restricted to the watershed boundary.

The temporal boundaries for analyzing the cumulative effects include any projects that have occurred within the last 30 years, based on hydrologic recovery coefficients for the Blue Mountains (Ager & Clifton, 2005). Reasonably foreseeable projects include any projects occurring on the Schedule of Proposed Action and the Aquatic Restoration website.

Riparian Habitat Conservation Area Ground Disturbance

Background

Stream sediment is a complicated, yet important component of wildland hydrology. A key contributor to stream sediment is soil erosion, or soil that comes from the hillslopes. Forests generally have low erosion rates, until disturbed (Elliot, 2000), because ground cover and vegetation are stable (USDA Forest Service, 2000; Johnson, 1980); In the event of a soil disturbance, surface erosion can occur until ground vegetation and leaf litter recover. Recovery can take weeks to years, depending on site conditions. Soil disturbances can be natural such as with wildfire and landslides, or human-caused, such as road construction, or logging activities. With wildfire, post-fire soil erosion increases as the proportion of high severity fire increases.

Sediment delivery is widely considered a problem because excess sediment can overload streams and degrade aquatic habitat (Rehg, 2005). Yet, natural disturbances such as historical wildfires that burned with low-mixed severity (Olson, 2000; Pettit, 2007; Powell, 2011) can be beneficial (Nakamura, Swanson, & Wondzell, 2000). This apparent contradiction can be explained by a couple important factors:

1) impacts from natural disturbances are usually episodic with short term impacts (Kirchner, 2001; Lake, 2000) and 2) initial sediment inputs may be negative, but over time become positive as sediment moves through the system and is captured and stored in floodplains and depositional valleys (Cluer & Thorne, 2013).

On the other hand, non-natural disturbances, such as with forest roads and timber operations are often higher in frequency, and more long-lived where managed forests have been dissected by road networks. Modern wildfires linked to a century of fire suppression have higher proportions of high severity burn and erodibility (Agee, 1998; Halofsky & Peterson, 2017; Doerr, et al., 2006). Timber harvest operations (e.g. landings, skid trails, etc.) compact and displace soil, channelize flow, reduce infiltration, and increase soil erodibility (Johnson, 1980; Najafi, 2010; Solgi & Najafi, 2014). If skid trails occur within the sediment delivery zone of riparian areas, displaced sediment could be delivered directly to streams. Compacted surfaces such as landings and skid trails can eventually recover (Johnson, 1980; Najafi, 2010) especially those that receive restoration treatments (Wade, Bolding, Aust, & Lakel III, 2012; Wade, Bolding, Aust, Lakel III, & Schilling, 2012; Vinson, Barrett, Aust, & Bolding, 2017). Road effects are analyzed in depth under Road/Stream Connectivity below.

Degraded ephemerals are pervasive in the Cliff Knox Project are due to past disturbances. Degraded ephemeral draws have discontinuous stream channels interrupted by long reaches of undisturbed valley bottom with ground cover sufficient to trap and capture fine sediment from reaching the stream network. See the Methodology section for more information on classification of degraded ephemeral draws.

In summary, sediment is a complex and natural component of stream systems. The baseline amount of fine sediment in a system would depend on gradient, climate, bedload, stream power, and vegetation. As a result, there are no state or Malheur Forest Plan standard for sediment delivery. However, the science is relatively consistent regarding the negative impacts of anthropogenic sediment and the value of best management practices to reduce management-caused sediment delivery associated with harvest operations.

Desired Condition

The desired condition would be to maintain ground cover within riparian habitat conservation areas (RHCAs). This means minimizing or preventing management-caused ground disturbance in the sediment delivery zone of RHCAs. This may be achieved by exclusion of activities in the sediment delivery zone of the RHCA and/or best management practices to prevent compacted soils from conveying fine sediment towards the sediment delivery zone.

The following Malheur Forest Plan standard for riparian management objectives is relevant to the Cliff Knox Project, to minimize or prevent fine sediment delivery from forest management (USDA Forest Service 1995b):

TM-1 Prohibit timber harvest, including fuelwood cutting, in RHCAs, except as described below.

- a. Apply silvicultural practices for RHCAs to acquire desired vegetation characteristics where needed to attain riparian management objectives. Apply silvicultural practices in a manner that does not retard attainment of riparian management objectives and that avoids adverse effects on Inland native fish.

Affected Environment

Existing Condition

Since the adoption of the Malheur Forest Plan and INFISH, riparian areas have been managed with a “hands-off approach” in which active management of riparian areas have been avoided. Based on field surveys, riparian habitat conservation areas (RHCAs) are well-vegetated due to the absence of ground-disturbing activities within the RHCA. Many historical skid trails were observed, but none of them were actively eroding. Ground cover in the RHCA appears relatively stable. Exceptions include cattle concentration areas, ungulate trails, and road surfaces within the RHCA. Roads are analyzed under Road/Stream Connectivity below.

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to RHCA ground disturbance

There would be no direct effect to riparian habitat conservation area (RHCA) ground disturbance from the no action alternative because no activities would take place within the RHCA.

The no action alternative maintains the existing risk of large, high-severity wildfire. If riparian area were to burn with high severity at a large scale, streams may receive pulses of sediment from the uplands and riparian areas while vegetation and ground cover recover (0-2 years) (Van de Water, 2011; Burton, 2005; Pettit, 2007). Streams deficient in large wood and sediment storage capacity could be overwhelmed with sediment with effects that would likely persist downstream. Suppression activities could also result in soil disturbance in the RHCA or retardant incidentally entering the stream network. The effects of fire retardant on aquatic biota are still poorly understood and controversial (Luce, et al., 2012). Depending on fire size and location, which cannot be predicted, sediment delivery could occur as a result of wildfire or suppression activities.

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

All road-related activities (including haul) with the potential to deliver sediment are analyzed separately under Road/Stream Connectivity.

Non-road project activities that may affect RHCA ground disturbance include skidding and decking in the RHCA mechanical areas and prescribed burning activities. Effects are analyzed below. Non-commercial thinning in the RHCA was considered for analysis but was determined to have no effect because all treatments would be completed by hand, ground cover would be maintained, and there would be no mechanism for sediment delivery to streams.

Non-road project activities outside the RHCA, such as upland thinning and prescribed burning, are not considered in the analysis due to the sufficient travel distance from project activities to stream channels (50–300 feet from streams) and results from the soils analysis that all sediment produced within harvest units would not leave the unit (for more information, see Cliff Knox Soils Report).

Project Design Criteria and Mitigation Measures

Project design criteria are the interface for best management practices on the Cliff Knox Project. Project design criteria are designed to minimize or prevent sediment delivery from project activities. Aquatics-2 – 11 are designed to minimize or prevent sediment delivery from reaching the stream channel as a result of RHCA mechanical areas, fuels activities, and prescribed burning. Aquatics- project design criteria -3, -7, -12, and -14 are in place to protect degraded ephemeral draws from further degradation and preventing sediment from project activities from entering the stream network below.

Direct and Indirect Effects to RHCA Ground Disturbance – Alternative 2

Commercial thinning would not occur within any RHCAs, but there would be about 80 acres of ground disturbance in the RHCA as a result of skidding and decking above the road (RHCA mechanical areas). This includes approximately 32 acres in the Bluebucket subwatershed and 49 acres in the Cliff-Malheur subwatershed (see Table 33). Skidding and decking operations would allow heavy equipment to operate in the RHCA, uphill of a road and at least 50 feet from a stream channel, where slopes are less than 25 percent per adherence with Aquatic-11. The distance and low slope requirements greatly reduce the chance that sediment production would occur, but heavy equipment operations within the RHCA still pose a low risk to sediment delivery due to the compaction of soil on heavy equipment trails.

The risk of sediment delivery to streams is further reduced by a variety of best management practices that require existing trails to be slashed and seeded. Based on monitoring of past projects and best available science, logging slash and ground cover are sufficient to slow down and disperse flow paths that may form on compacted surfaces when placed properly on low-moderate slopes (Wade, Bolding, Aust, & Lakel III, 2012; Wade, Bolding, Aust, Lakel III, & Schilling, 2012; Vinson, Barrett, Aust, & Bolding, 2017). As surface flow moves through RHCA mechanical areas, the majority of fine sediment should be attenuated within the slash treatments prior to intercepting the road and being redirected to the road drainage system (see Road/Stream Connectivity analysis). Effects of equipment in the outer edges of the RHCA above the road would last 1-3 years post-implementation, which is the anticipated time for grass and forbs to recover in the uplands of the Cliff Knox planning area.

Table 33. Acres of RHCA mechanical areas (skidding and decking) under alternative 2

Subwatershed	Stream category	RHCA mechanical areas	
		(acres)	(miles)
Bluebucket	1	11.8	0.8
	2	19.4	2.7
	4	0.5	1.0
	TOTAL	31.7	4.5
Cliff-Malheur	1	21.9	0.9
	2	4.2	0.6
	4	22.6	6.1
	TOTAL	48.7	7.6

Prescribed burning within RHCAs would burn with primarily low soil severity and maintain high volumes of down wood in the stream channel and floodplain, per adherence with Aquatics-2 – 8, more consistent with historical fire disturbance (Agee, 1998). Studies have shown that that low severity fire has low erosion rates due to the preservation of forest duff layers, root mass, and needle cast. Monitoring on prescribed burns and wildfire on the Malheur National Forest is consistent with these findings. Regrowth

of grasses and other graminoids is dependent on weather and timing but has been observed within weeks of fire activity (based on professional observation of natural and prescribed fires on the Prairie City Ranger District).

This is especially true in RHCA where soil moisture is naturally higher. As a result, sediment delivery from low soil burn severity areas is highly unlikely. Figure 2, Image 1 shows potential for rapid recovery of wetland obligate vegetation. In this example, riparian sedges at a perennial seep showed signs of recovering within weeks of wildfire activity. Image 2 shows an island of no burn along the streambanks surrounded by high burn severity.



Figure 2. Examples of riparian vegetation within pockets of high severity burn, from the Cow Fire in 2019

Prescribed burning can be a coarse tool for forest management and some patches of higher burn severity may occur. However, per adherence with the Aquatics-2, these patches of higher burn would be restricted to less than one acre and less than 10 percent of a drainage. Burn severity of pile burning in the RHCA would also be minimized per adherence with Aquatics-4. Ground cover in burned areas would recover quickly in riparian areas (within 1 year based on professional observation of natural and prescribed fires on the Prairie City Ranger District). Designated burn blocks also minimize the area affected each year.

For reasons outlined above, there is a very low risk of sediment delivery from prescribed burning and pile burning, even in the event of small pockets of high burn severity, per adherence with project design criteria that aim to keep soil burn severity as low as possible. Sediment delivered to the stream would be highly localized and consistent with natural background sedimentation levels, and not measurable at the drainage or subwatershed scale. Effects would last 0-2 years.

Risk of anthropogenic sediment from skidding and decking within RHCA mechanical areas is also low. Sediment produced by this treatment would be minimized per adherence with aquatics Aquatics-11 and is not expected to leave the treatment areas. Roads located downhill of RHCA mechanical areas would capture residual fine sediment and direct them to road drainage features. See Road/Stream Connectivity below.

Cumulative Effects to RHCA Ground Disturbance– Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

There are no other vegetation projects within the Cliff Knox Project that would affect RHCA ground disturbance. Cumulatively, firewood cutting, which is done by hand, without heavy equipment, is not expected to increase RHCA ground disturbance.

Cattle grazing was analyzed under the Blue Dollar Environmental Analysis and Central Malheur Environmental Analysis, which developed a grazing system and utilization standards that are consistent with long term sustainability and recovery of allotments in the planning area. If livestock grazing is consistent with those analyses, Malheur Forest Plan and INFISH standards for livestock grazing would be met, and best management practices to minimize RHCA ground disturbance would be in place. Utilization monitoring helps monitor impacts to streambanks and trigger livestock removal/movement when utilization is approaching standards. Spring protection improvement and developments at 16 springs as part of the Central Malheur, Blue Dollar complex, and Aquatic Restoration Decision are expected to maintain/enhance RHCA ground cover by reducing cattle trampling effects and grazing of hydric graminoids.

Roads decommission projects as implemented under the Aquatic Restoration Decision are analyzed under Road/Stream Connectivity below. No other aquatic restoration projects are planned in the Cliff Knox planning area at this time. Cumulatively, the effects of present, ongoing, and reasonably foreseeable activities would reduce stream sediment delivery and improve sediment storage, and transport in the long term when considered with alternative 2.

Alternative 3 – Focused Restoration

Alternatives 2 and 3 have very similar proposed actions; the significant issues that drove those differences were not related to sediment delivery or other aquatics issues. As it pertains to RHCA ground disturbance, the differences between alternative 2 and alternative 3 are negligible. Acres of RHCA mechanical areas and prescribed burning are the same between alternatives. Results are the same for alternative 3 as were reported in alternative 2.

Summary of effects to RHCA Ground Disturbance for all alternatives

Table 34 below provides a summary of effects to RHCA ground disturbance from all alternatives. Results are summarized at the subwatershed scale, but effects are determined at the drainage level. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to RHCA ground disturbance were negligible. Results for both action alternatives are the same and reported together below.

Table 34. Summary of effects to RHCA ground disturbance from all alternatives

Alternative	Bluebucket subwatershed RHCA acres (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed RHCA acres (percent of subwatershed)	Effects to the Cliff-Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	0 acres (0%)	No effect to RHCA ground disturbance from no action alternative	0 acres (0%)	No effect to RHCA ground disturbance from no action alternative

Alternative	Bluebucket subwatershed RHCA acres (percent of subwatershed)	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed RHCA acres (percent of subwatershed)	Effects to the Cliff-Malheur subwatershed
⁹ Alternative 2 and 3 <i>When considered with past, present, future activities</i>	32 acres (12%)	For up to 3 years, sediment produced at landings and skid trails in the outer RHCA is not expected to reach the stream per adherence with Aquatics-11 For 0-2 years, there is very low risk of sediment delivery from prescribed burning per adherence with Aquatics-2 – 8	49 acres (4%)	For up to 3 years, sediment produced at landings and skid trails in the outer RHCA is not expected to reach the stream per adherence with Aquatics-11 For 0-2 years, there is very low risk of sediment delivery from prescribed burning per adherence with Aquatics-2 – 8

Summary: RHCA ground disturbance is used a surrogate for sediment delivery due to lack of numeric standards for sediment delivery in the Malheur Forest Plan or Oregon Department of Environmental Quality through the Malheur subbasin Total Maximum Daily Load (ODEQ, 2010) or other Clean Water Act direction (see Clean Water Act section below). Desired conditions are to prevent or minimize sediment delivery within RHCAs by maintaining ground cover (see Desired Conditions above). The proposed activity with greatest potential to reduce ground cover would be skidding and decking within the RHCA mechanical areas, which would occur within 32 acres and 49 acres of the Bluebucket and Cliff-Malheur subwatersheds, respectively (see Table 32 above). Project design criteria (also known as best management practices) are in place to set limits on location of treatment areas and proximity to stream channels, and to rehabilitate lost ground cover with slash and seed. As a result, the risk of anthropogenic sediment from skidding and decking within RHCA mechanical areas is low; sediment produced by this treatment would be minimized per adherence with Aquatics-11 and is not expected to leave the treatment areas to measurably increase fine sediment in streams. Prescribed burning throughout the planning area also poses a very low risk of sediment delivery to ground disturbance due to project design criteria that minimize burn severity and ground consumption. Minimizing sediment delivery in the RHCAs through best management practices is consistent with Malheur Forest Plan guidance and the Clean Water Act (for more information on Clean Water Act compliance, see Clean Water Act section below).

Road/Stream Connectivity

Background

Numerous studies have documented that forest roads are a leading contributor of sediment to stream channels in managed forests (Duncan, 1987; Bilby R. K., 1989; Weaver, 1994; Gucinski, 2001; Al-Chokhachy, et al., 2016). Sediment from roads tends to be fine (i.e. smaller in size), which has more ecologically damaging properties to native salmonids, including redband trout and threatened bull trout (Hicks, Hall, Bisson, & Sedell, 1991). Road sedimentation is often chronic due to sustained soil

⁹ Values include cumulative effects

compaction, which is not compatible with the natural rate or frequency of sediment inputs to forest streams that native salmonids have evolved with over time (Nakamura, Swanson, & Wondzell, 2000)

Much of the Cliff Knox planning area is Management Areas 1 and 2, General Forest and Rangeland, under the Malheur Forest Plan, which means that active forest management is expected to continue into the future. Best management practices can be used to minimize, mitigate, and prevent sediment delivery during forest management. Best management practices are the backbone of water quality protection under the Clean Water Act and the Malheur Forest Plan, and are supported by a long history of research and monitoring (USDA Forest Service, 1995; USDA Forest Service, 2012; USDA Forest Service, 2018; USDA Forest Service, 2014). For the Cliff Knox Project, best management practices are catalogued in the project design criteria and are also incorporated into project planning.

A variety of best management practices can be applied to roads within close proximity to streams, depending on the site-specific details. Best management practices that can be effective at minimizing sediment delivery include: road surface rocking (Dangle, et al., 2019; Brown, McGuire, Aust, Hession, & Dolloff, 2015; Swift, 1984; U.S. Environmental Protection Agency, 2005), installing slash barriers to increase roughness and energy dissipation (Dangle, et al., 2019; Burroughs & King, 1989; Wade, Bolding, Aust, & Lakel III, 2012; Idaho Department of Lands; MacDonald & Coe, 2008; Vinson, Barrett, Aust, & Bolding, 2017), avoiding wet weather haul (Oregon Department of Forestry, 2003), installing road drainage (Lang, Aust, Bolding, & K.J., 2015; MacDonald & Coe, 2008; Vinson, Barrett, Aust, & Bolding, 2017), and adding coarse wood in the stream channel to trap and store fine sediment (Bilby & Ward, 1989; Bilby & Likens, 1980; Wheaton, Bennett, Bouwes, Maestas, & Shahverdian, 2019; Pfeiffer & Wohl, 2018; Cramer, 2012; Yochum, 2018).

The highest rates of sediment delivery occur at stream crossings, although roads that run parallel to streams within the sediment delivery zone can also have chronic delivery, particularly on native road surfaces (Egan, 1999). Site-specific conditions and characteristics have a major determination on probability and magnitude of erosion from forest roads being delivered to streams, including factors such as road proximity, ditch length, orientation of stream crossings, road surface composition, and intensity and season of use. Rocking of native surface/improved native surface roads has been shown to reduce erosion of soil from use of forest roads. Much of the literature has evaluated the effectiveness of crushed 1.5 inch minus rock at varying depths (typically 15 to 20 cm rock depth evaluated) (Swift, 1984; National Council for Air and Stream Improvement, Inc. (NCASI), 2012; U.S. Environmental Protection Agency, 2005). Some studies and reports have found less than 15-20 cm of rock as partially effective (Coe, 2006; Brown, McGuire, Aust, Hession, & Dolloff, 2015; Renteria, 2015). Some studies have also shown 20 centimeters of large stone as effective (Swift 1986). Some studies have also investigated the extent of road-stream connectivity, showing connectivity dropping significantly with distances over 100 feet from streams (Cooke, Luce, T., & Tarboton, 2016).

Numerous indicators were selected to determine effects on road/stream connectivity. Roads with observed sediment delivery, roads with the greatest potential for sediment delivery, and number of stream crossings are used as surrogates for the sediment delivery analysis. The width of the sediment delivery zone can vary based on slope, vegetation, and soils (Burroughs & King, 1989), but field observations in the Cliff Knox planning area have determined that roads within 50 feet of the stream channel had the highest probability of sediment delivery through rilling and gully development. A study from the Malheur National Forest by Robert McNeil, Soil Scientist, in 1999 found that under normal conditions, sediment was found no farther than 32 feet from road disturbance. The study concluded that buffer widths of 50 feet are sufficient to protect streams from sediment from existing roads, except near scabs. "Not normal

conditions” in the study were 1) scabs (non-forested areas with shallow soils limited ground cover), or 2) where runoff hit an abandoned road (McNeil, 1999).

There is no indicator used to track miles of road closed in the riparian habitat conservation area (RHCA), despite research showing that a benefit from road closure in the RHCA, once traffic is removed and the road bed is stabilized (Al-Chokhachy, et al., 2016). This is because existing conditions collected in the planning area, and other parts of the Prairie City Ranger District, have shown no predictable relationship between sediment delivery and operation maintenance level. This is primarily caused by ineffective implementation of road closures, or due to the method of closure. Closed roads (maintenance level 1) and open roads (maintenance level 2) have both been shown to deliver fine road sediment to streams. For this analysis, roads with observed sediment delivery is considered a more accurate and dependable indicator than maintenance level.

Desired Condition

There are no Malheur Forest Plan standards for sediment delivery from roads. The desired condition would be to minimize fine sediment delivery from roads entering the stream network. This would include zero miles of road with observed sediment delivery to stream networks, and 100 percent of roads within 50 feet of the stream network would follow best management practices to minimize sediment delivery. This may be achieved by exclusion of log haul on inappropriate roads, decommissioning, improving, and/or closing of roads with observed sediment delivery, improving drainage on roads with the potential to deliver sediment, and by utilizing a variety of best management practices to minimize sediment delivery during roads maintenance.

The following Malheur Forest Plan standard for riparian management objectives are relevant to the Cliff Knox Project, to minimize or prevent fine sediment delivery from roads management (USDA Forest Service 1995b).

RF-2 For each existing or planned road, meet the riparian management objectives and avoid adverse effects to inland native fish by:

- 1) Completing watershed analyses prior to construction of new roads or landings in RHCA within priority watersheds.
- 2) Minimizing road and landing locations in RHCAs.
- 3) Avoiding sediment delivery to streams from the road surface.
 1. Outslowing of the roadway surface is preferred, except in cases where outslowing would increase sediment delivery to streams or where outslowing is infeasible or unsafe.
 2. Route road drainage away from potentially unstable stream channels, fills, and hillslopes.
- 4) Avoiding disruption of natural hydrologic flow paths.
- 5) Avoiding sidecasting of soils or snow. Sidecasting of road material is prohibited on road segments within or abutting RHCAs in priority watersheds.

RF-3 Determine the influence of each road on the riparian management objectives. Meet riparian management objectives and avoid adverse effects on inland native fish by:

- a. Reconstructing road and drainage features that do not meet design criteria [from the Transportation Management plan (RF-2c1)] or operation and maintenance standards [from the Transportation Management plan (RF-2c2)], or that have been shown to be less effective than designed for controlling sediment delivery, or that retard attainment of riparian management objectives, or do not protect priority watersheds from increase sedimentation.

- b. Prioritizing reconstruction based on the current and potential damage to inland native fish and their priority watersheds, the ecological value or the riparian resources affected, and the feasibility of options such as helicopter logging and road relocation out of RHCAs.
- c. Closing and stabilizing or obliterating, and stabilizing roads not needed for future management activities. Prioritize these actions based on the current and potential damage to inland native fish in priority watersheds, and the ecological value of the riparian resources affected.

RF-4 Construct new, improve existing, culverts, bridges, and other stream crossings to accommodate a 100-year flood, including associated bedload and debris, where those improvements would or do pose a substantial risk to riparian conditions. Substantial risk improvements include those that do not meet design and operation maintenance criteria [RF-2c1&2], or that have been shown to be less effective than designed for controlling erosion, or that retard attainment of riparian management objectives, or that do not protect priority watersheds from increased sedimentation. Base priority for upgrading on risks in priority watersheds and the ecological value of the riparian resources affected. Construct and maintain crossings to prevent diversion of stream flow out of the channel and down the road in event of crossing failure.

RF-5 Provide and maintain fish passage at all road crossings of existing and potential fish-bearing streams.

Affected Environment

Existing Condition

There are 205 total miles of road in the Cliff Knox planning area. 49.6 miles are located in the Bluebucket subwatershed and 163.7 in the Cliff-Malheur subwatershed. An additional 128 miles of main haul routes surfaced with well-maintained aggregate and pavement are located outside the planning area. These roads are not further considered in the analysis of road/stream connectivity due to the very low probability of sediment delivery associated with main aggregate and paved roads. Of 205 road miles, approximately 191 miles, or 90 percent, were determined to be stable and functioning properly. Approximately 22 miles of roads, or 10 percent, were identified as having sediment delivery to the stream network (see Table 35). All observed sediment delivery was present on native surface road segments; none occurred on aggregate surface type roads. Of roads with sediment delivery, 38.4 percent are closed (maintenance level 1) and 61.6 percent are open (maintenance level 2) roads.

Approximately 10.2 and 22.4 miles of road are located primarily within the RHCA for those subwatersheds, respectively (see Table 35). Of these, 5.9 miles (1.0 miles in the Bluebucket subwatershed and 4.9 miles in the Cliff-Malheur subwatershed) are overgrown and on their way towards self-decommissioning. This indicator includes road segments that run parallel to stream channels on the lower hillslope and/or within a historical floodplain and does not include roads that are located primarily outside the RHCA except at stream crossing(s).

There are 24 and 53 stream crossings in the Bluebucket and Cliff-Malheur subwatersheds, respectively. Road surface type is native for the majority of stream crossings (22, or 92 percent, in the Bluebucket subwatershed and 34, or 64 percent, in the Cliff-Malheur subwatershed). Stream crossings with native surfaces have the highest occurrence of chronic sediment delivery (Brown, McGuire, Aust, Hession, & Dolloff, 2015). The majority of culverts are stable, but due to the lack of maintenance, many pose some degree of risk to stream sediment delivery over time. This is especially true where culverts are undersized and/or prone to plugging. Ford crossings are common in the Cliff Knox planning area, likely due to its drier nature. Surveys identified eight ford crossings on intermittent category 4 streams that were

improperly installed and delivering sediment, and three on degraded ephemeral draws that posed a slight risk to the stream network below. There is also a major ford on the Malheur River.

There are currently no large vegetation projects in the Cliff Knox planning area and therefore no native surface haul routes being actively hauled on at this time.

Table 35. Existing roads affecting RHCA and streams

Subwatershed	Bluebucket subwatershed	Cliff-Malheur subwatershed	Total planning area
Total miles of road (miles)	48.1 miles	157.4 miles	205.4 miles
Roads within RHCA (miles/subwatershed)	10.2 miles	22.4 miles	32.6 miles
Number of road-stream crossings (number/subwatershed)	24 crossings	53 crossings	77 crossings
Native surface haul routes within 50 feet of stream channel (miles/subwatershed)	0 miles	0 miles	0 miles
Roads with observed sediment delivery (miles/subwatershed)	4.9 miles	17.3 miles	22.2 miles

Environmental Consequences

Alternative 1 – No Action

Direct and Indirect Effects to Road/Stream Connectivity

There would be no direct effect to road/stream connectivity from the no action alternative. The number of system roads within the planning area would remain the same (see Table 35). This includes the miles of roads within and outside the RHCA and the number of stream crossings. Maintenance would continue to be deferred on the large majority of roads, due to lack of funding. This means that roads with observed sediment delivery would continue into the future. With continued lack of maintenance, roads within the RHCA that are currently stable may start to deliver sediment as additional culverts fill and small rills develop into gullies along native surface roads. This is more likely to occur in the event of a high-intensity short duration summer thunderstorm, such as cannot be predicted in space and time, but are not uncommon on the Malheur National Forest (based on professional observation).

Cumulative Effects

Because there are no direct or indirect effects, no cumulative effects would occur.

Alternative 2 – Proposed Action

The project activities that may affect road/stream connectivity include all road-related activities within the RHCA. This includes roads decommissioning, roads maintenance, log haul, maintenance level changes, and some road construction (temporary roads and new construction) in the RHCA.

Road-related project activities outside the RHCA are not considered in the Sediment analysis due to the sufficient travel distance from project activities to stream channels (50 – 300 from streams). This includes

activities such as roads maintenance, log haul, maintenance level changes, and the majority of road construction (temporary roads and new construction) outside the RHCA.

Project Design Criteria and Mitigation Measures

Project design criteria are the interface for best management practices on the Cliff Knox Project. Project design criteria are designed to minimize or prevent sediment delivery from project activities. Aquatics-15 – 29 are designed to minimize or prevent sediment delivery from reaching the stream channel as a result of roads-related project activities in the RHCA.

Direct and Indirect Effects to Road/Stream Connectivity– Alternative 2

Table 36 below shows how indicators of road/stream connectivity would change under alternative 2. Analysis follows.

Table 36. Roads affecting riparian habitat conservation area (RHCA) and streams under alternative 2

Subwatershed	Bluebucket subwatershed	Cliff-Malheur subwatershed	Total planning area
Total miles of road (miles)	47.4 miles	148.8 miles	196.1 miles
Roads within RHCA (miles/subwatershed)	9.5 miles	13.8 miles	23.3 miles
Number of road-stream crossings (number/subwatershed)	21 crossings	43 crossings	64 crossings
Native surface haul routes within 50' of stream channel (miles/subwatershed)	8.5 miles	28.6 miles	37.1 miles
Roads with observed sediment delivery (miles/subwatershed)	0 miles	5.5 miles	5.5 miles

Road Decommissioning

Total road miles would be reduced as a result of alternative 2. Decommissioning permanently removes roads from the road system, whereas new construction (outside the RHCA) would permanently add road miles to the system. The total road miles in the Bluebucket subwatershed would be reduced by approximately 0.5 miles and 6.7 miles in the Cliff-Malheur subwatershed (see Table 36).

The majority of road decommissioning would take place on roads that are located primarily within the RHCA (exceptions include National Forest System roads 1647213 and 1450490 which are outside the RHCA but along degraded ephemeral draws). Decommissioning removes approximately 0.7 miles of the RHCA road in the Bluebucket subwatershed and 8.6 miles in the Cliff-Malheur subwatershed. Stream crossings would be reduced by three and 10 in the Bluebucket and Cliff-Malheur subwatersheds, respectively (see Table 46). All 5.9 miles of overgrown roads in the RHCA would be decommissioned and would not require ground-disturbing activities. These roads are overgrown and hydrologically stable. No sediment would be delivered to the stream network with the decommissioning of these roads.

Remaining roads would be removed from the road system and driving access would be eliminated through the use of berms and/or other barriers. Otherwise, no ground-disturbing activities would take place on those roads. Approximately 5.5 miles of road in the Cliff-Malheur subwatershed were identified as native surface roads with existing sediment delivery issues. This includes National Forest System roads 1647481 (up to 0.2 miles), 1643146 (up to 0.8 miles), 1647760 (up to 1.3 miles), 1647449 (up to 2.6

miles), 1643212 (up to 0.2 miles), and 1540116 (up to 0.2 miles). Because no actions are taking place on the ground, these roads would continue to deliver sediment, but the rate of delivery would be reduced within 3-10 years, depending on the degree of road compaction, by reducing vehicular traffic and allowing ground cover to re-establish on the road surface (MacDonald & Coe, 2008; Perez, 2016).

Overall, road decommissioning would not measurably increase stream sediment on any drainage for any amount of time due to the lack of ground-disturbing activities proposed. Road decommissioning helps reduce ongoing road impacts within both subwatersheds by permanently removing these roads and allowing natural recovery to begin.

Road relocation includes new road construction that facilitates road decommissioning. All six road relocations are designed to facilitate road decommissioning for roads that are causing sediment delivery and other adverse effects to the stream network. The majority of new road construction would take place outside the RHCA. Two segments of new road construction to facilitate decommissioning would occur partially within RHCAs and warrant site-specific analysis. New road construction to facilitate decommissioning of Road 1450505 starts in the outside edge of a category 2 RHCA, greater than 100 feet from the stream. New road construction to facilitate decommissioning of Roads 1450509 and 1450511 starts within a category 2 RHCA, greater than 50 feet from the stream. The planned segments originate from existing roads within RHCAs but mostly occur within upland areas. Both roads would be closed after haul. Project design criteria for new road construction specify no construction within 50 feet of RHCA category 1, 2, or 4 streams, and the use of slash sediment filters within 100 feet of streams to minimize potential for sediment delivery (see Aquatics-29; Cliff Knox Project Final Environmental Impact Statement, Appendix C for a full listing of project design criteria relevant to new road construction).

Project design criteria requiring erosion control (slash treatments) when ground disturbance occurs within 100 feet of a stream (Aquatics-29) is expected to capture the majority of sediment prior to entering the stream network, based on past monitoring from similar treatments on the Malheur National Forest (McNeil, 1999). Yet, there is a risk that precipitation event(s) following construction could produce very small quantities of fine sediment that escape erosion control features. Stream sediment is not expected to be measurably increased at any scale from new road construction, due to the small number of occurrences (two roads), road location with sufficient buffer distance from the stream network, and adherence with project design criteria Aquatics-27 and -29. When considered with road decommissioning activities, sediment delivery from new road construction would be reduced compared to existing conditions, due to the removal of problem roads and adherence to best management practices.

Temporary road construction

The majority of the 14 miles of proposed temporary roads in the project area would be constructed in the uplands. Two locations would require temp road construction originating within the RHCA, for approximately 200 feet at each site. Both segments would be constructed off of roads located within the RHCA and extend into the uplands. In both cases, as with the majority of temporary roads in this project, proposed sites were selected to help compensate a loss of road access where roads are prohibited from haul and/or proposed for decommission due to sediment delivery and other adverse effects to the stream network, yielding a net benefit to the stream network through permanent removal of problem roads. Temporary roads would be located on the uphill side of the road and no stream crossings would occur

One of the temporary road segments would occur within a category 2 RHCA (T9) starting off Road 1450000. The other temporary road segment would occur within a category 4 RHCA (T42) off Road 1643148. Both road segments would be located greater than 50 feet from the streams.

Ground disturbance as part of temporary road construction is mitigated sufficient buffer distance from the stream to minimize likelihood of delivery and by project design criteria to prevent and minimize sediment delivery at both sites. As described in the proposed action, temporary roads would be completely decommissioned after haul activities are complete. Decommissioning would include:

- Waterbarring as needed to restore natural drainage patterns.
- Re-contouring slopes (removing cut and fill slopes) and pulling berms from the edge of the road back onto the road.
- Subsoiling (loosening) compact soils in a “J” pattern to a depth of approximately 16 inches (unless prevented by bedrock or rock content of soils).
- Planting or seeding disturbed areas with native species that naturally occur in the planning area to achieve a minimum of 35 percent ground cover.
- Placing slash, boulders, and logs on the roadbed (where available).
- Disguising the visible entrance with pieces of cull logs, tops of cut trees, and/or rocks, etc. to prevent vehicle use.

Temporary road construction within the habitat conservation area at both sites is sufficiently far from the streams to pose serious risk of sediment delivery. There is a risk that precipitation event(s) following construction could produce very small quantities of fine sediment that escape erosion control features. Stream sediment is not expected to be measurably increased at any scale from temporary road construction, due to the small number of occurrences (two segments), road location with sufficient buffer distance from the stream network, and per adherence with project design criteria Aquatics-28.

Roads maintenance and log haul

All potential haul routes within the RHCA were analyzed by the interdisciplinary team during project planning based on site-specific roads information. Haul routes within the RHCA were analyzed to provide a haul route system with the lowest risk of sediment delivery to streams by including the most hydrologically stable roads and excluding roads that could not be fixed with maintenance or mitigated using project design criteria. For example, there would be no re-opening of overgrown roads prisms that would require reconstruction in the sediment delivery zone (see Road Decommissioning section above) or RHCA roads causing chronic resource damage. As a result of project planning, log haul is prohibited on 2.9 miles and 10 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively, that were highest risk for sediment delivery from grading during haul maintenance (MacDonald & Coe, 2008; Luce & Black, 2001b)

Residual risk to sediment delivery from log haul in the Cliff Knox planning area comes from the following situations:

- 1) **Native surface haul routes within 50 feet of a stream.** Log haul is proposed on 37.1 miles of native and improved native surface roads with at least one segment located within 50 feet of a stream (8.5 in the Bluebucket subwatershed and 28.6 miles in the Cliff-Malheur subwatershed). Road miles are reported by adding up all road segments with one or more locations mapped within 50 feet of a stream for all native and improved native haul routes. This includes roads that are primarily located within the RHCA in addition to roads that are primarily outside the RHCA, except at crossing(s). Actual clipped distance of road segments located within 50 feet of a stream channel, based on GIS, are 2.4 miles and 3.8 miles for the Bluebucket and Cliff-Malheur subwatersheds, respectively (6.2 total).

Based on proximity, 37.1 miles of road within 50 feet of a stream pose an inherent risk of sediment delivery: 22.2 miles show existing sediment issues, 9.3 miles have drainage issues with

no observed sediment delivery issues at this time and 5.6 no issues at this time but with potential in the future based on location to stream. Aquatics-22 was developed to minimize sediment delivery from log haul on all native surface roads within 50 feet of the stream miles. See Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A for site-specific description of proposed mitigations at higher risk roads.

- 2) **Roads with existing sediment delivery.** 22.2 miles of road were identified as having existing sediment delivery point(s) (4.9 in the Bluebucket subwatershed and 17.3 in the Cliff-Malheur subwatershed). These roads have the highest intrinsic risk of sediment delivery based on existing condition. Road improvements to stop active sediment delivery is proposed for 16.7 miles through blading, cleaning ditches, cleaning culverts, and installing drainage, etc. The remaining 5.5 miles of roads were discussed under decommissioning above. See Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A for site-specific description of proposed mitigations at higher risk roads.
- 3) **Stream crossings.** All existing stream crossings were surveyed. All stream crossings causing resource damage, or with the potential to cause resource damage, are proposed for improvement. Improvements include adding surface aggregate at five stream crossings over existing culverts, cleaning two culverts on category 4 streams, replacing one culvert on a category 4 stream, installing hydrologically functional ford crossings on eight category 4 streams and three ephemeral draws, and administratively decommissioning 13 stream crossings on category 1, 2, and 4 streams (analyzed above). See Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A for site-specific description of proposed mitigations at higher risk roads. All in-channel improvements would occur on dry channels only.

Sediment issues and proposed mitigations are site-specific for this project (Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A for site-specific description of proposed mitigations at higher risk roads). Project design criteria designed to fix and/or mitigate sediment delivery from pre- and post-haul maintenance and are based on site-specific information regarding the hydrologic function of all roads in the Cliff Knox Project. Road maintenance would be required to make all haul routes hydrologically functional prior to and after haul. This includes grading roads, improving drainage, adding drainage features, adding erosion control features, maintaining ditches, and routing road drainage away from streams, etc. See project design criteria Aquatics-16-23. Cleaning culverts, replacing culverts, and stream crossing reconstruction would occur at locations where existing crossings are not appropriate and/or delivering sediment to streams, such as at non-functioning fords.

All ground-disturbing activities would serve to improve drainage on high-risk roads, and fix locations with existing sediment delivery. Activities would take place outside of the active floodplain and during dry conditions but may take place within the sediment delivery zone (within 50 feet from a stream channel) for approximately 2.4 and 3.8 miles of road in the Bluebucket and Cliff-Malheur subwatersheds, respectively (6.2 total). Project design criteria requiring erosion control (slash treatments, rocking, and/or seed) when ground disturbance occurs within 50 feet of a stream (see project design criteria Aquatics-22) is expected to capture the majority of sediment prior to entering the stream network, based on past monitoring from similar treatments on the Malheur National Forest (McNeil, 1999). Yet, there is a risk that precipitation event(s) following maintenance could produce small quantities of fine sediment that escape erosion control features. Stream sediment from roads activities may have small localized increases for up to 3 years as vegetation recovers (Luce & Black, 2001). Stream sediment is not expected to be measurably increased at the drainage scale per adherence with project design criteria Aquatics-15-22.

Sediment delivery from roads would be reduced compared to existing conditions, due to best management practices that address and minimize sediment delivery on up to 22.2 road miles.

Project design criteria were also developed to mitigate sediment delivery as a result of log haul on all roads within the RHCA. Oregon Department of Forestry, states that “wet season road use [timber haul] can be the most significant forest practice-associated source of chronic turbidity and fine sediment in streams” (Oregon Department of Forestry, 2003). Best management practices were incorporated into numerous design criteria to reduce the potential for sediment delivery from wet season road use by preventing haul on native roads except when dry or frozen or by adding aggregate to the road prism at stream crossings, monitoring of road conditions, and ceasing haul on gravel roads when roads and ditch lines become turbid, among others (see Aquatics-24 – 25). As a result, sediment delivery to the stream from log haul would be mitigated per adherence with these design criteria and not measurable at the drainage scale for either subwatershed.

Approximately 12.4 miles of road in the project are expected to be closed to motorized access under alternative 2 (2.7 and 9.8 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively). This reduces the probability of sediment delivery in both subwatersheds in the long term; studies have shown that driven roads consistently have higher sediment delivery than non-drivable roads (Al-Chokhachy, et al., 2016; Brown, McGuire, Aust, Hession, & Dolloff, 2015; MacDonald & Coe, 2008; Perez, 2016). Activities associated with road closure involve hydrologically stabilizing roads by adding erosion control such as water bars and eliminating motorized access. Closed roads would be left in a hydrologically stable condition per adherence with project design criteria (Aquatics-27).

In summary, roads with existing sediment delivery would be improved as a result of maintenance prior to and after haul (4.9 and 11.8 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively). Effects would last for the duration of the project. The remaining 5.5 miles would be moved towards improvement within 3-10 years as a result of passive roads decommissioning as described above.

In summary, roads maintenance and log haul in the Cliff Knox planning area creates inherent risk of fine sediment delivery at stream crossings and road segments within 50 feet of a stream channel. Site-specific prescriptions to repair roads with observed sediment delivery, minimize delivery at roads in close proximity, and improve stream crossings are designed to prevent and/or minimize sediment delivery as a result of these activities. Per adherence with project design criteria Aquatics-15 – 27, there are no expected measurable increases in fine road sediment at the drainage scale in the short term in either subwatershed due to best management practices to control and minimize sediment delivery at site-specific locations (See Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A for site-specific description of proposed mitigations at higher risk roads. Effects would be short term (up to 3 years).

Cumulative Effects to Road/Stream Connectivity – Alternative 2

Past, Present, and Reasonably Foreseeable Activities Relevant to Cumulative Effects Analysis

Roads decommission projects as implemented under the aquatic restoration environmental analysis would eliminate sediment delivery from 5.5 miles of road in the Cliff Knox subwatershed through active decommissioning of road beds within the sediment delivery zone (see Table 48). Road decommissioning would also remove culverts, such as on Roads 1647449 and 1450437. Best management practices to minimize sediment would be utilized per adherence with the project design criteria of the Aquatic Restoration Decision. Some localized sediment may enter the stream for 0-2 years after decommissioning activities take place when occurring within the active floodplain such as on Roads 1647449 and 1450511,

although best management practices monitoring of similar projects on the Malheur National Forest has shown no evidence of sediment delivery post-decommissioning where sufficient erosion control measures are placed (e.g. logs, slash, seeding). Any resulting sediment delivery would stop once vegetation recovers, which occurs more rapidly in wet environments such as a floodplain. Sediment may be measurable downstream of the project during the first precipitation events post-construction but would not be measurable at a subwatershed scale. Active road decommissioning may incur a short-term adverse effect for the long-term benefit of the stream. Cumulatively, the effects of decommissioning under the aquatics restoration environmental analysis would reduce streams with sediment delivery to zero in both subwatersheds within 0-2 years after decommissioning activities take place.

Table 37. Roads proposed for decommission under the aquatic restoration environmental assessment

Road number	Road miles	Stream miles affected	Subwatershed	Stream category	Work
1540116	0.2	Less than 0.1	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain.
1643146	0.9	Less than 0.1	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain.
1643212	0.2	Less than 0.1	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain.
1647449	2.6	Up to 0.6	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain. Remove stream crossings on intermittent channel
1647481	0.2	Up to 0.20	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain.
1647760	1.3	Up to 0.25	Cliff-Malheur	4	Remove and/or subsoil portions of the road within floodplain.
1450437	Less than 0.1	Less than 0.1	Bluebucket	4	Remove and/or subsoil portions of the road within floodplain. Remove stream crossings on intermittent channel
1450511	Less than 0.1	Less than 0.1	Bluebucket	2	Remove and/or subsoil portions of the road within floodplain.

There are no other vegetation projects within the Cliff Knox Project with proposed roads maintenance or log haul. Cumulatively, sediment delivery from roads is not expected to increase measurably as a result of firewood cutting and other recreational uses in the Cliff Knox Project. Additional road closures and re-enforced road closures as part of the Cliff Knox Project would reduce access to roads that may have previously had impacts from recreational driving and would reduce probability of sediment on those roads into the future. Permitted livestock grazing was analyzed under the Blue Dollar Environmental Analysis and Central Malheur Environmental Analysis. Road/stream connectivity is not expected to be impacted by permitted livestock grazing in the Cliff Knox Project. Road impacts are typically minimal and similar to recreational use. Closed roads requiring permittee access would be done under permits that include terms and conditions to prevent resource damage.

Cumulatively, the effects of present, ongoing, and reasonably foreseeable activities would be the same as for alternative 2, except 'roads with observed sediment delivery' would be reduced to zero for both subwatersheds due to active roads decommissioning (see Table 38).

Table 38. Roads affecting riparian habitat conservation areas (RHCA) and streams under alternative 2 when considered with past, present, and reasonably foreseeable activities

Subwatershed	Bluebucket subwatershed	Cliff-Malheur subwatershed	Total planning area
Total miles of road (miles)	47.4 miles	148.8 miles	196.1 miles
Roads within RHCA (miles/subwatershed)	9.5 miles	13.8 miles	23.3 miles
Number of road-stream crossings (number/subwatershed)	21 crossings	43 crossings	64 crossings
Native surface haul routes within 50' of stream channel (miles/subwatershed)	8.5 miles	28.6 miles	37.1 miles
Roads with observed sediment delivery (miles/subwatershed)	0 miles	0 miles	0 miles

Alternative 3

The differences between alternative 2 and alternative 3 are negligible as it pertains to road/stream connectivity. Alternatives 2 and 3 have very similar proposed actions; the key issues that drove those differences were not related to sediment delivery or other aquatics issues. As it pertains to road stream connectivity, the proposed actions are very similar:

- Road proposed for decommission is the same between both alternatives
- Roads prohibited for haul are the same between both alternatives
- Roads proposed for haul are greater by 1.5 miles greater in alternative 2 than alternative 3. Two roads have been dropped from the haul route in alternative 3:
 - ◆ Road 1643142 is located outside the RHCA and would have no effect to road/stream connectivity
 - ◆ Road 1647560 is 0.25 miles long and located within 50 feet of a stream for 0.01 miles. The current condition is stable, with no concerns. This road would not be hauled on under alternative 3. This would reduce the miles of native surface haul route by 0.25.
- Road closures under alternative 3 are higher than alternative 2 by 31.8 miles (3.0 in the Bluebucket subwatershed and 28.8 in the Cliff-Malheur subwatershed). Additional road closures provide additional benefit to the watershed, by reducing vehicular traffic and encouraging revegetation on roads within the RHCA. While this alternative is an overall benefit to the watershed, these differences have no effect on indicators used in this analysis for analyzing road/stream connectivity (See Road/Stream Connectivity Background section above for more information on selection of indicators).

Based on above, results are the same for alternative 3 as were reported in alternative 2.

Summary of effects to road/stream connectivity for all alternatives

Table 39 below provides a summary of effects to road/stream connectivity from all alternatives. Results are summarized at the subwatershed scale, but effects are determined at the drainage level. As described above, differences in the number of acres proposed for treatment between alternatives 2 and 3, relevant to the road/stream connectivity, were negligible at the subwatershed scale. Results for both action alternatives are the same and reported together below.

Table 39. Summary of effects to road/stream connectivity from all alternatives

Alternative	Bluebucket subwatershed road/stream connectivity results	Effects to the Bluebucket subwatershed	Cliff-Malheur subwatershed road/stream connectivity results	Effects to the Cliff-Malheur subwatershed
Alternative 1 – No action <i>When considered with existing conditions</i>	See Table 35	No direct effect to road/stream connectivity with the no action alternative. Sediment delivery from 4.9 miles of road would continue.	See Table 35	No direct effect to road/stream connectivity with the no action alternative. Sediment delivery from 17.3 miles of road would continue
¹⁰ Alternative 2 and 3 <i>When considered with past, present, future activities</i>	See Table 38	Total road miles in the RHCA and would be reduced by 0.7 miles as a result of administrative (from 10.2 to 9.5) as a result of roads decommissioning. Three stream crossings would be removed (from 24 to 21). Roads decommissioning (including road relocation) and maintenance in the RHCA would address and improve all 4.9 miles of road currently delivering sediment to streams. Two segments of temporary road construction are not expected to measurably increase stream sediment due to buffer distance from the stream and adherence to project design criteria. Roads maintenance activities, and log haul would utilize best management practices at all 8.5 miles of high-risk road (stream crossings and road segments within 50 feet of a stream). Project design criteria (PDC) Aquatics 15-27 were designed to minimize sediment delivery from these activities. Effects would be short term (up to 3 years), and stream sediment would not be measurable at the drainage level per adherence with best management practices.	See Table 38	Total road miles in the RHCA and would be reduced by 8.6 miles as a result of administrative (from 22.2 to 13.8) as a result of roads decommissioning. Ten stream crossings would be removed (from 53 to 43). Roads decommissioning (including road relocation) and maintenance in the RHCA would address and improve all 17.3 miles of road currently delivering sediment to streams. Two segments of temporary road construction are not expected to measurably increase stream sediment due to buffer distance from the stream and adherence to project design criteria. Roads maintenance activities, and log haul would utilize best management practices at all 28.6 miles of high-risk road (stream crossings and road segments within 50 feet of a stream). PDCs Aquatics 15-27 were designed to minimize sediment delivery from these activities. Effects would be short term (up to 3 years), and stream sediment would not be measurable at the drainage level per adherence with best management practices.

¹⁰ Values include cumulative effects

Summary: RHCA road/stream connectivity is used a surrogate for sediment delivery due to lack of numeric standards for sediment delivery in the Malheur Forest Plan or Oregon Department of Environmental Quality through the Malheur subbasin Total Maximum Daily Load (ODEQ, 2010) or other Clean Water Act direction (see Clean Water Act section below). Desired conditions are to prevent or minimize fine sediment delivery from roads entering the stream network (see Desired Conditions above). Road decommissioning would reduce miles of road within the RHCA by 0.7 and 8.6 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively, reduce stream crossings by 3 and 10 in the Bluebucket and Cliff-Malheur subwatersheds, respectively, and reduce chronic sediment delivery by 4.9 and 17.3 miles in the Bluebucket and Cliff-Malheur subwatersheds, respectively. Roads maintenance activities, and log haul would utilize best management practices at all 8.5 and 28.6 miles of high-risk road in the Bluebucket and Cliff-Malheur subwatersheds, respectively. Project design criteria Aquatics 15-27 were designed to minimize sediment delivery from these activities. Effects would be short term (up to 3 years), and stream sediment would not be measurable at the drainage level per adherence with best management practices. Minimizing sediment delivery in the RHCA through watershed planning and implementation of best management practices is consistent with Malheur Forest Plan guidance and the Clean Water Act (for more information on Clean Water Act compliance, see Clean Water Act section below).

Summary of Environmental Effects

Table 40 below is a summary of environmental effects to watershed indicators from alternatives 1-3. Note: alternatives 2 and 3 have very similar proposed actions, as the significant issues that drove those differences were not aquatics related.

Table 40. Summary of resource indicators and measures by alternative

Resource element and indicator	Measure	Alternative 1	Alternative 2	Alternative 3
Stream flow	Peak flows	No direct effects to peak flows from the no action alternative. Existing condition of hydrologic immaturity is 5% and 8% in the Bluebucket and Cliff-Malheur subwatersheds, respectively. This is well below the threshold of measurable effects at the subwatershed scale.	No measurable effects to peak flows as a result of alternative 2; Hydrologic immaturity would be moved to 17% and 12% in the Bluebucket and Cliff-Malheur subwatersheds, respectively when considered with past, present, and reasonably foreseeable activities. This is well below the threshold of measurable effects at the subwatershed scale.	Same as for alternative 2
Stream flow	Baseflows	No direct effects to baseflow from the no action alternative. Existing condition of historical range of variability (HRV) shows that forest stands are overstocked with young trees, which have increased demand on local	Treatments would move planning area towards HRV at the project level (see Table 10 and Table 11). In both subwatersheds, baseflow may be increased locally at streams and springs to levels more consistent with historical conditions, for 1-5 years.	Same as for alternative 2

Resource element and indicator	Measure	Alternative 1	Alternative 2	Alternative 3
		water tables. Baseflows would continue to decrease from increased pressure on limited water resources		
Stream temperature	Site potential vegetation	No direct effects to site potential vegetation from the no action alternative. Existing condition includes less than 4% and 15% currently meeting site potential vegetation in the Bluebucket and Cliff-Malheur subwatersheds respectively. Streams continue to deviate from desired conditions for site potential vegetation due to conifer overstocking	Treatments would move 50% and 38% of streams Bluebucket and Cliff-Malheur subwatersheds, respectively, towards the desired condition for site potential vegetation through non-commercial thinning in the RHCA's. Effects would last for up to 15-20 years or until encroachment returns.	Same as for alternative 2
Stream temperature	Stream shade	No effect to stream shade from no action alternative. RHCA canopy openings would be less than 2% of either subwatershed as a result of past thinning.	Treatments would open the RHCA canopy in 12% and 4% of the Bluebucket and Cliff-Malheur subwatersheds, respectively, when considered with past, present, and reasonably foreseeable activities. For up to 5 years, aspen thinning treatments in the RHCA's would likely decrease stream shade below Malheur Forest Plan and ODEQ standards at isolated aspen stands. Once aspen recovered, stream shade would meet or exceed stream shade standards. Short term effects are offset by numerous benefits of healthy riparian aspen stands. Treatments would be limited to one half mile per stream per year to protect water temperatures. Effects to stream temperature would not be measurable at the drainage scale.	Same as for alternative 2
Sediment delivery	RHCA ground disturbance	No effect to RHCA ground disturbance from no action alternative.	Treatments would increase RHCA ground disturbance to 12% and 4% of RHCA area in the Bluebucket and Cliff-Malheur subwatersheds, respectively as a result of	Same as for alternative 2

Resource element and indicator	Measure	Alternative 1	Alternative 2	Alternative 3
			decking and skidding in the outer RHCA. For up to 3 years, sediment produced in the outer RHCA is not expected to reach the stream per adherence with PDCs Aquatics-11. There is very low risk of sediment delivery from prescribed burning per adherence with PDCs Aquatics 2-8.	
Sediment delivery	Road/stream connectivity	There are no direct effects to road/stream connectivity in the no action alternative. Existing sediment delivery on 22 miles of road would persist in the absence of roads maintenance. Roads located in the floodplain and/or with problem stream crossings would persist.	See Table 35. Total road miles in the RHCA and stream crossings would be reduced as a result of administrative roads decommissioning (7.2 miles and 13 stream crossings total in the planning area). Roads decommissioning and maintenance in the RHCA would address and improve all 22 miles of road currently delivering sediment to streams. Roads maintenance activities and log haul would utilize best management practices at all high-risk locations (stream crossings and road segments within 50 feet of a stream). Roads activities may locally increase sediment delivery in the short term (up to 3 years), but stream sediment would not be measurable at the drainage level per adherence with project design criteria Aquatics 15-27.	Same as for alternative 2. Additional 32 miles of road closure would benefit watersheds but would not measurably change analysis indicators.

Compliance with Malheur Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Malheur Forest Plan

A thorough assessment of applicable (riparian management objectives) and consistency with the Malheur Forest Plan as amended by INFISH and Amendment 29 is located in Appendix D – Consistency with the Malheur Forest Plan of this report. The Cliff Knox Project is consistent with all relevant standards and guidelines from the Malheur Forest Plan, INFISH, and Amendment 29 related to aquatic habitat listed under Regulatory Framework due to project planning and project design criteria to minimize project activities within riparian habitat conservation areas (RHCA) and streams, and by preventing retarding attainment of riparian management objectives on projects proposed within RHCA's. For more details, see Table 51 under Appendix D – Consistency with the Malheur Forest Plan of this report.

Clean Water Act

Background

The Oregon Department of Environmental Quality (ODEQ) has been delegated authority to regulate water quality under the Clean Water Act (CWA) (USDA Forest Service, 2014; Oregon Department of Environmental Quality, 2010). In 2010, ODEQ developed the Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) for the Malheur basin, which describes a plan for restoring impaired waters by quantifying the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards (Oregon Department of Environmental Quality, 2010). The Forest Service's responsibilities under the Clean Water Act were further described in a May 2014 Memorandum of Understanding (MOU) between the ODEQ and the Pacific Northwest Region of the USDA Forest Service (USDA Forest Service, 2014). In 2018, ODEQ approved the Upper Malheur River subbasin Water Quality Restoration Plan (WQRP); (ODEQ, 2018). Collectively, these are robust documents that describe various elements of USDA Forest Service responsibility under the Clean Water Act for the Malheur Basin. As it pertains to the Cliff Knox vegetation management, a summary of the primary elements that constitute compliance with the CWA are listed in Table 41 below:

Table 41. Summary requirements for compliance under the Clean Water Act

Clean Water Act element/indicator	Explanation	Source
1. Development of best management practices for project activities with the potential to impact water quality	MOU-Obligations of the US Forest Service Items A-D For example, "B. The U.S. Forest Service would manage water-quality-limited water bodies on US Forest Service- administered lands to protect and restore water quality. Management would involve development and implementation of strategies such as best management practices to protect and restore water quality conditions when US Forest Service actions affect or have the potential to affect the 303(d) listed waters.	MOU, 2014, pp 5
2. Conduct annual best management practices monitoring	MOU-Obligations of the US Forest Service Item E: "E. The US Forest Service would conduct best management practices implementation and effectiveness monitoring required in Forest Plans and projects following the U.S. Forest Service National best management practices for Water Quality monitoring protocols..."	MOU (2014, pp 6).
3. Participate in the Development of a WQRP	MOU-Obligations of the US Forest Service Items H-L: For example, "J. The U.S. Forest Service would coordinate with DEQ in developing WQRPs for the U.S. Forest Service-administered lands and would revise or adapt them as necessary to be consistent with and applicable to both the final TMDL and the current Malheur Forest Plan"	MOU
4. Comply with TMDL and WQRP by moving riparian areas towards site potential vegetation and shade standards.	ODEQ, TMDL Pg. 9-46-47 "target establishment of site potential vegetation and the corresponding effective shade as the surrogate measure to meet the load reductions for agriculture, grazing, forest, or urban nonpoint source activities in the riparian area" MOU-Obligations of the US Forest Service Item N: The U.S. Forest Service would incorporate the WQRP goals, objectives, and provisions into activity level planning including, but not limited to, project planning that includes National Environmental Policy Act (NEPA) analysis and the opportunity for public review" WQRP (2018, pp35-36) Surrogate measures for stream temperature include: "Effective shade targets translate nonpoint source solar radiation loads into measurable stream side site potential vegetation conditions." DEQ would evaluate compliance with the load allocations based on the following factors: 1-	MOU TMDL (Pg. 9-46-47 of the Malheur Basin TMDL, ODEQ, 2010) WQRP

Clean Water Act element/indicator	Explanation	Source
	Implementation Plans and actions, 2- Riparian Area Management, and 3- Improving Trends	
5. Implement vegetation management consistent with INFISH and the WQRP.	WQRP, 2018, Vegetation and Roads Management: pp 53-57 Follow INFISH riparian management objectives and standards and guidelines for activities in the RHCA. Follow management action to improve water quality from WQRP: “Increase growth rate and lower risk of stand replacement fire in forested riparian areas using silvicultural practices... Consider road closure, storage and decommissioning where transportation analysis identifies low need and high impact to watershed, riparian and stream function. “	WQRP, 2018

As of December 2020, ODEQ water quality listings are found in the 2018/2020 Integrated Report database (ODEQ, 2020). The database provides the stream name and listing status. Listing status is determined based on the assessment category (Categories 1-5).

- Streams with category 4 and 5 listings have been or are currently identified as an impaired waterbody under Section 303(d) of the Clean Water Act:
 - Category 5 streams do not meet state water quality standards, and activities conducted by the U.S. Forest Service may not further degrade water-quality-impaired streams (USDA Forest Service, 2014).
 - Category 4 streams have been converted from category 5 to category 4 through the development of a TMDL (Total Maximum Daily Load). Actions with potential to impact streams with category 4 listing must be consistent with the Total Maximum Daily Load and WQRP (Water Quality Restoration Plan).
- Category 3 listings highlight waterbodies that do not have enough data to classify as impaired but do indicate a cause for concern. According to ODEQ, these are waters that could be targeted for additional monitoring and/or restoration efforts (ODEQ, 2019).
- Category 1 and 2 listings are not considered in the watershed analysis for the Cliff Knox Project due to lack of concern and/or lack of guidance from ODEQ on management of those water quality parameters.

In 2018, many streams were re-categorized from Category 4a to category 5 as a result of ongoing litigation. Guidance for management on these streams comes from the following excerpt from ODEQ/USDA Forest Service correspondence, September 2019 (ODEQ, 2019):

In a 2012 ruling, a federal district court struck down the Natural Conditions Criterion of Oregon’s water quality standard for temperature. A follow-up lawsuit challenged the validity of temperature Total Maximum Daily Loads (TMDLs) based upon that criterion, asserting that they were not valid if the criterion on which they are based is no longer valid. The federal court confirmed that reasoning, ruling that those TMDLs must be redone and that DEQ must put together a schedule to do so. That schedule is in progress. Because those TMDLs must be redone and the water bodies in question are not meeting water quality standards for temperature, the US EPA changed the status of those waterbodies from Category 4a (not meeting standards, TMDL in place) to Category 5 (not meeting standards, TMDL needed; “the 303(d) list”) in the 2012 305(b) Water Quality Integrated Report. (This is the currently effective water quality status document for Oregon; the 2018/2020 draft Integrated Report would go out for public comment on September 30th, 2019). Although new TMDLs need to be developed and adopted for the affected water bodies, in the meantime the previous TMDLs remain in effect and load

allocations and surrogate measures (i.e. shade targets) must be met through management practices. Forestry sector load allocations and shade surrogates are unlikely to become less protective in the redone TMDLs.

Information Sources

Water quality listings for streams associated with the Cliff Knox planning area came from Oregon's 2018/2020 Integrated Report (<https://www.oregon.gov/deq/wq/Pages/epaApprovedIR.aspx>). Oregon's archived 2012 Integrated Report was also referenced for comparison (<https://www.deq.state.or.us/wq/assessment/rpt2012/search.asp>). Stream data for 303(d) listing was collected by analyzed by ODEQ or collected by an ODEQ-approved affiliate.

Existing condition for stream habitat and roads condition comes from USDA Forest Service data collected by field technicians, as described in Riparian Condition and Sediment Delivery Methodology sections above.

Effects to water quality from the Stream Temperature Analysis above were compared with ODEQ's water quality listings and requirements for compliance with the Clean Water Act (see also

Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report). Compliance determinations were based on the five criteria described under Background and Desired Conditions sections above.

Incomplete and Unavailable Information

See Riparian and Sediment sections above.

Oregon Department of Environmental Quality Water quality impaired streams

Table 42 below lists water quality listings within or immediately downstream of the Cliff Knox planning area. No other streams in the planning area are listed in the 2018/2020 integrated report database, as of December 2020 (ODEQ, 2020).

Table 42. Water quality impairments based on the 2012 Integrated Report (ODEQ, 2012)

Record ID	Water body	River miles	Parameter	Season	*Status	Assessment year	Relation to planning area	Cliff Knox analysis
*12604	Bluebucket Creek	0 to 12.1	Temperature	Year Round (Non-spawning)	**Cat 5/Cat 4A: Water quality limited, TMDL approved	2010	Within/below planning area	Analyzed under Stream Temperature
OR_SR_1705011601_05_102746	Malheur River	Crooked Creek to Wolf Creek	Temperature	Year Round	**Cat 5/Cat 4A: Water quality limited, TMDL approved	2010	Within/below planning area	Analyzed under Stream Temperature

***Status – Category 4:** Water is water quality limited but a TMDL is not needed. This includes: **4A:** TMDL approved – TMDLs needed to attain applicable water quality standards have been approved. **4B:** Other pollution control requirements are expected to address all pollutants and would attain water quality standards. **4C:** Impairment is not caused by a pollutant (e.g., flow or lack of flow is not considered a pollutant.) **Category 5:** Water is water quality limited and a TMDL is needed, Section 303(d) list.

**Bluebucket Creek was omitted from the 2018/2020 integrated report in error. This listing is still valid based on direct email correspondence with ODEQ. Information comes from 2012 Integrated Report

***As of December 2018, the EPA changed the status of these waterbodies from Category 4a to Category 5. However, pending litigation, existing TMDLs remain in effect until new TMDLs are developed (ODEQ, 2019).

Differences Between the 2012 and 2018/2020 Integrated Report

The 2020 Integrated Report made changes to their methodology that affected listings between the 2012 and 2018/2020 Integrated Reports (ODEQ, 2020). One primary change was in their assessment units; smaller order streams (stream order 4 or less) are now displayed as subwatersheds and larger river systems were re-segmented following new methodology (ODEQ, 2020).

The temperature listing on Bluebucket Creek was listed in the Oregon Department of Environmental Quality 2012 Integrated Report (ODEQ, 2012) but was omitted from the 2018/2020 Integrated Report in error, according to staff at the Oregon Department of Environmental Quality (information comes from direct email correspondence, December 2020). The 2012 Integrated Report also listed numerous additional Category 2-5 impairments on the Malheur River (e.g., Arsenic, Dissolved Oxygen, and others). These listings were removed on the ‘Crooked Creek to Wolf Creek’ segment of the Malheur River due to new methodology that allowed re-segmenting of larger rivers (ODEQ, 2020).

Summary Clean Water Act compliance for alternatives 1-3

The Stream Temperature section of the watershed analysis is used to determine compliance with the Clean Water Act for listings on the Bluebucket Creek and the Malheur River. Overall, all alternatives proposed under the Cliff Knox Project are consistent with the Clean Water Act, as administered by the Oregon Department of Environmental Quality due to inclusion of 1) best management practices to protect water quality, 2) actions to restore and protect site potential vegetation and stream shade, and 3) monitoring. See Table 43 below for detailed analysis of compliance with the Clean Water Act.

Table 43. Summary of compliance with the Clean Water Act (CWA) for alternatives 1-3 within the Cliff Knox planning area

CWA element	Alternative 1	Alternative 2	Alternative 3
Development of best management practices for actions with the potential to affect listed waters	N/A. No actions requiring best management practices are proposed under alternative 1	Consistent for both alternatives. Best management practices were developed for all activities with the potential to impact water quality. The activities and associated project design criteria/best management practices as part of alternative 2 and 3 within the Cliff Knox Project are designed to prevent any meaningful carry-over effects. For a detailed list of best management practices, see Cliff Knox Project Final Environmental Impact Statement, Appendix A – Project Design Criteria.	
Development of a Water Quality Restoration Plan (WQRP)	Consistent for all alternatives. A WQRP for the Upper Malheur was developed by the Malheur National Forest and accepted by ODEQ in 2018.		
Best management practice monitoring	Consistent for all alternatives. Best management practices monitoring is conducted annually at the forest level following a monitoring protocol developed by the Forest Service at the national level. This monitoring is not specific to any alternative or this project and is conducted randomly across the forest. Best management practice monitoring is focused on implementation and effectiveness on best management practices to protect water quality and		

CWA element	Alternative 1	Alternative 2	Alternative 3
	includes activities such as Mechanical Vegetation Management Activities, Use of Prescribed Fire, and Road Management Activities. This monitoring focuses on sediment delivery but also includes petroleum pollutants		
Restore site potential vegetation and effective shade	N/A. There are no activities proposed in the no action alternative. However, other NEPA within the planning area include actions to improve site potential vegetation, including the Central Malheur Environmental Assessment (EA), Dollar Basin EA, aquatic restoration EA, etc. See Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis for a list of projects that would occur in the planning area.	Consistent for both alternatives. Alternatives 2 & 3 propose to move riparian areas towards site potential vegetation along approximately 43% of stream in the Bluebucket subwatershed and 5% of stream in the Cliff-Malheur subwatershed through non-commercial thinning in the RHCA (see Site Potential Vegetation analysis). When combined with actions proposed under the Aquatic Restoration environmental assessment, 50% of the Bluebucket subwatershed and 38% of the Cliff-Malheur subwatershed would meet site potential vegetation within 3-30 years depending on site conditions, stand conditions, and shrub abundance. A short-term reduction of stream shade would occur as a result of non-commercial aspen thinning along 3 miles (12%) in the Bluebucket subwatershed and 2.9 miles (4%) in the Cliff-Malheur subwatershed. Non-commercial aspen thinning is expected to reduce stream shade below ODEQ and INFISH standards for up to 5 years at isolated aspen stands. Once aspen recovers, stream shade would meet or exceed stream shade standards. Short term effects are offset by numerous benefits of healthy riparian aspen stands. Treatments would be limited to ½ mile per stream per year to protect water temperature. Additional protective measures to ensure rapid recovery of aspen shade include fencing of all aspen stands along category 1 and 2 streams, and management triggers with monitoring of aspen stands along category 4 streams. This treatment constitutes a short-term adverse effect to stream shade with a long-term benefit. For more information, see Stream Temperature analysis.	
Implement vegetation management consistent with INFISH and the Water Quality Restoration Plan.	N/A. There are no activities proposed in the no action alternative.	Consistent for both alternatives. The WQRP describes actions that the Forest Service would do to protect or improve water quality on listed streams and tributary inputs. Activities proposed within the Cliff Knox Project are consistent with Chapter 4.3 to enhance and protect riparian vegetation during vegetation management, specifically to: "Increase growth rate and lower risk of stand replacement fire in forested riparian areas using silvicultural practices..." and "consider road closure, storage and decommissioning where transportation analysis identifies low need and high impact to watershed, riparian and stream function." Chapter 5 of the WQRP emphasizes monitoring for improving trends (USDA Forest Service, 2018). In areas which do not meet the current effective shade surrogates, an improving trend in riparian vegetation growth, effective shade, channel morphology, large wood abundance, or floodplain connectivity is considered to be in compliance with the TMDL and WQRP. Monitoring on the Prairie City Ranger District includes 1) annual stream temperature monitoring on listed streams (including the Malheur River), 2) stream shade monitoring every 5 years on listed streams (including the Malheur River and Bluebucket Creek), and 3) ongoing Pacfish/INFISH Biological Opinion monitoring of stream and riparian attributes.	

CWA element	Alternative 1	Alternative 2	Alternative 3
		Category 5 Water Quality listings (i.e. on the 303d list) in the Cliff Knox Project include stream temperature on Bluebucket Creek and the Malheur River. Management direction is to adhere to previous TMDLs for load allocations and surrogate measures (see Background section). As described above, a short-term reduction of stream shade would occur as a result of non-commercial aspen thinning along 3 miles (12%) in the Bluebucket subwatershed and 2.9 miles (4%) in the Cliff-Malheur subwatershed. These impacts are expected to fully recover within 5 years and are consistent with the TMDL and WQRP direction to manage these recently changed category 5 streams with existing TMDLs, which directs the Forest Service to follow WQRPs and enhance site potential vegetation at aspen-dominated riparian areas (see Appendix B – Oregon Department of Environmental Quality Supplemental Information of this report)	

Short-term Uses and Long-term Productivity

Consideration of short-term uses and long-term productivity (40 CFR 1502.16) is addressed under analysis sections for Stream Flow, Stream Temperature, and Sediment Delivery above. All effects to watershed indicators are short term, with the exception of forest roads. Forest roads maintained as maintenance level 1 and maintenance level 2 are constructed for long term forest management. Roads proposed for decommission would be allowed to naturally recover upland and riparian vegetation to protect stream shade and other riparian management objectives as defined by INFISH, Amendment 29, and the Malheur Forest Plan. Non-commercial thinning in the riparian habitat conservation area and skidding and decking in RHCA mechanical areas would have no long-term effects to riparian management objectives as defined by INFISH, Amendment 29, and the Malheur Forest Plan per adherence with project design criteria Aquatics-8, and Aquatics-11.

Unavoidable Adverse Effects

Based on analysis for sediment delivery, there is an inherent risk of sediment delivery where maintenance activities on native surface roads occurs within 50 feet within the stream channel. This action is proposed in both action alternatives. These effects are unavoidable as long as the road remains part of the road network in the existing location. Decommissioning and/or relocating all 30 miles of high-risk road segment was considered unfeasible; best management practices are applied to reduce the risk as much as possible.

Irreversible and Irretrievable Commitments of Resources

There are no watershed indicators that would suffer irreversible and irretrievable commitments of resources. See analysis above for more information.

Glossary

base flows – Baseflow is the proportion of streamflow contributed by groundwater, after snowmelt ends and surface water and shallow soil water start to dry up.

canopy closure – The amount of ground surface shaded by tree canopies as seen from above. Used to describe how open or dense a stand of trees is, often expressed in 10 percent increments.

fine sediment – Fine particulate material within a waterbody (e.g. stream), such as silt and clay particles typically of less than 0.85-millimeter diameter.

historical range of variability – Commonly used as the reference for the desired conditions for forest stand structure.

HUC – HUC is a national system for classifying watersheds developed by the U.S. Geological Survey (USGS) (U.S. Geological Survey, 2015).

hydric graminoids – Sedges, rushes, and grasses that are adapted to wet environments, commonly present in riparian areas.

hydrologic immaturity – Canopy closure is at or below 20 percent for a given forest stand.

hydrologic maturity – Canopy closure is above 20 percent for a given forest stand.

peak flow – Annual peak streamflow, also known as the maximum instantaneous flow in a given water year (the water year is defined as October 1 – September 30).

riparian habitat conservation areas – Land management areas that include streams and riparian areas. They have been identified by INFISH as special management areas. Category 1 riparian habitat conservation areas (RHCAs) contain fish bearing streams, Category 2 RHCAs contain perennial, non-fish bearing streams, Category 3 RHCAs contain ponds, lakes, reservoirs and wetlands greater than 1 acre, and Category 4 RHCAs contain seasonally flowing or intermittent streams, wetlands less than 1 acre, landslides, or land-slide prone areas. Standard buffer widths for Category 1, 2, 3, and 4 RHCAs are 600 feet, 300 feet, 150 feet, and 200 feet, respectively.

riparian shrubs – Also known as hardwoods, including woody vegetation that grow along the stream. Includes willows, alder, aspen, dogwood, cottonwood, etc.

riparian vegetation – Plants that grow near streams or rivers. Includes riparian shrubs and hydric graminoids.

site potential vegetation – the near stream vegetation that can grow and reproduce on a site given natural plant biology, site elevation, soil characteristics, local climate, channel morphology, hydrology, and natural disturbance regime.

subwatershed – the subwatershed is the smallest extent in the HUC system and is the primary scale at which analysis for the watershed report takes place. Also referred to as the 6th field HUC.

7DADM – The 7-day moving average of the daily maximum stream temperature. The stream temperature standard used by the Oregon Department of Environmental Quality for regulatory purposes.

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Appendix A – Project Design Criteria

Project Design Criteria and Mitigation Measures

Project design criteria relevant to the Watershed Analysis includes:

- Aquatics 1-30
- Soils 1-14
- Aspen 1-4
- Wildlife-22 and Botany-1
- Botany-2
- Juvenile Fish Screen Criteria for Pump Intakes and Water Drifting Guidance
- The Aquatics Site-Specific Project Design Criteria

For a full description of each, see the Cliff Knox Project Final Environmental Impact Statement, Appendix C – Project Design Criteria.

Appendix B – Oregon Department of Environmental Quality Supplemental Information

The Total Maximum Daily Load provides guidance on how defining effective stream shade and site potential vegetation based on ecoregion and stream size. The following figures and tables come from the Oregon Department of Environmental Quality (ODEQ) Water Quality Management Plan (Oregon Department of Environmental Quality, 2010) and were used to define the desired conditions under Site Potential Vegetation and Stream Shade sections.

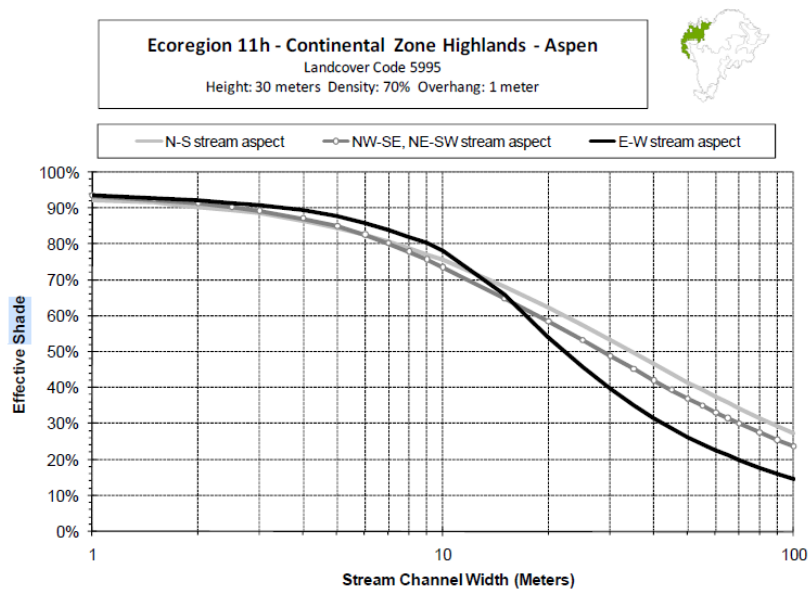


Figure 3. Effective shade curve for Aspen-dominated streams in Ecoregion 11h

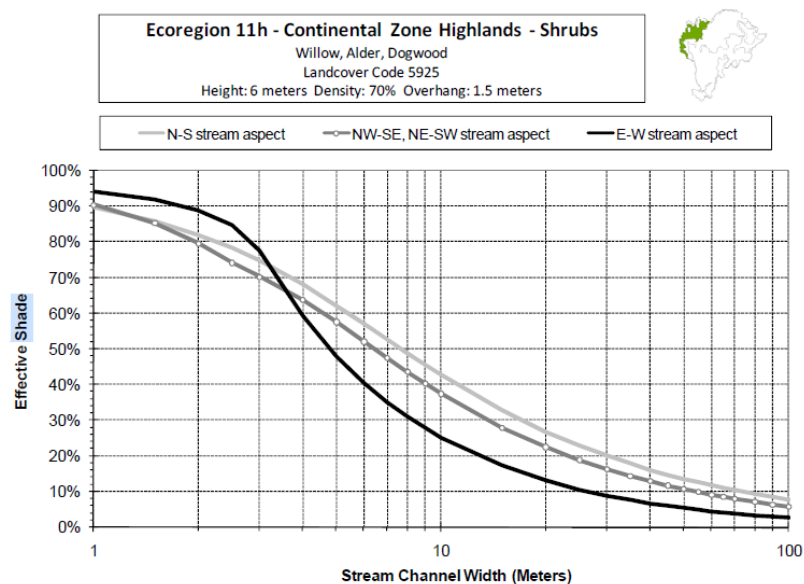


Figure 4. Effective shade curve for shrub-dominated streams in Ecoregion 11h

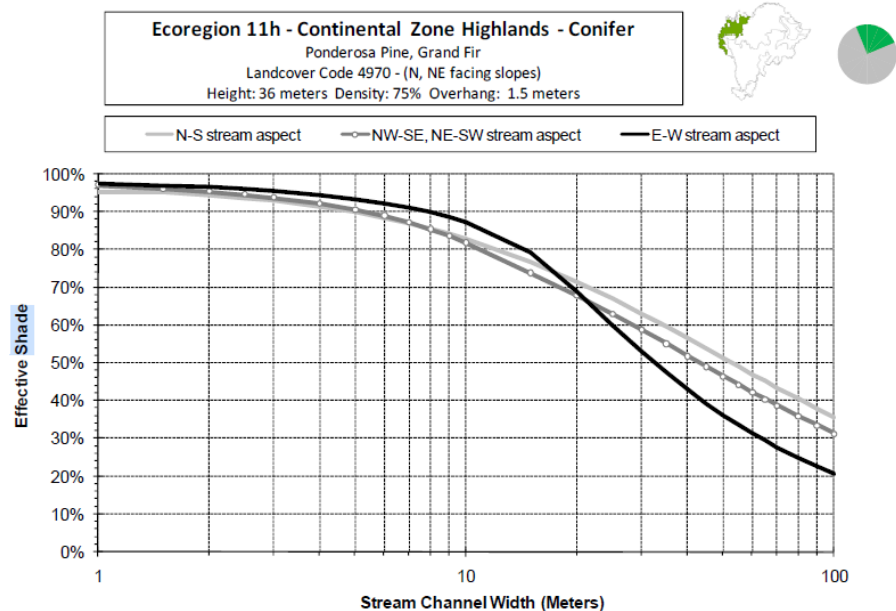


Figure 5. Effective shade curve for conifer-dominated streams in Ecoregion 11h

Oregon Department of Environmental Quality defines site potential vegetation as “the near stream vegetation that can grow and reproduce on a site given natural plant biology, site elevation, soil characteristics, local climate, channel morphology, hydrology, and natural disturbance regime”. Site potential vegetation varies by stream type (intermittent or perennial), elevation, and disturbance regime.

Site-specific desired conditions for site potential vegetation were pulled together based on ODEQ criteria (Oregon Department of Environmental Quality, 2010), INFISH (USDA Forest Service, 1995), field observations, and best available science regarding riparian fire regimes.

Forested perennial streams – Streambanks dominated by wetland obligate and/or wetland facultative species. Hardwood shrubs (willow, aspen, alder) would be prolific along stream banks. Large-diameter conifers (ponderosa pine, western larch, Douglas-fir, grand fir) in the outer margins of the riparian area and throughout the riparian habitat conservation area (RHCA). Species composition would vary by plant association group.

Meadows and wetlands – Hardwood shrubs (willow, aspen) and wetland obligate graminoids (e.g., sedges, rushes) would dominate the shallow groundwater saturation zone. Large conifers (ponderosa pine, western larch, Douglas-fir, grand fir) would occur on the edge of the wetted area.

Small forested intermittent streams – Streambanks dominated by wetland facultative graminoids and shrubs. Riparian hardwoods may be present, often aspen, depending on ground-water levels or abundance of springs. Large-diameter conifers (ponderosa pine, western larch, Douglas-fir, grand fir) would be present throughout the RHCA, including the inner riparian area. Species composition would vary by plant association group. In drier sites near the southern end of the project, old growth. Juniper may also be present in small proportions of the outer RHCA.

Malheur River – Streambanks would be dominated by hardwood shrubs (willow, aspen, cottonwood, alder, dogwood, currant, etc.). Large-diameter conifers (ponderosa pine, western larch, grand fir, Douglas-fir) in the outer margins of the riparian area and throughout the RHCA.

Site potential vegetation has the following qualities (ODEQ, 2010):

- Vegetation is native to the Malheur River Basin
- Vegetation is allowed to grow at its natural growth rate to reach maturity
- Vegetation height and density is at or near the potential expected for the given plant community and site conditions
- Vegetation buffer is sufficiently wide to maximize solar attenuation
- Vegetation buffer width accommodates natural channel migrations

See Table 44 below for a summary of site potential vegetation that applies to the planning area.

Table 44. Summary of site potential vegetation based on ODEQ (2010)

Planning area location	Site potential ecoregion	Geomorphic reach types relevant to planning area	Fluvial feature	Possible site potential vegetation
Malheur River and tributaries (95%+ of subwatershed)	LLH- continental zone highlands (see ODEQ tables above and below for definition of ecoregion)	Broad valley less than 2% gradient 3,000-6,000 feet & 4,500-6,500 feet	Floodplains and channels	Floodplain grasses, shrubs (willows, mountain alder), cottonwood, aspen, conifer forest (ponderosa pine at 3,000-6,000 feet & lodgepole pine at 4,500-6,500 feet)
			Terraces	Upland scrub (sagebrush, grasses), aspen, cottonwood, conifer forest (ponderosa pine, Douglas-fir at 3,000-6,000 feet & subalpine fir at 4,500-6,500 feet)
		Narrow valley 2-4% gradient 3,000-6,000 feet	Floodplains and channels	Shrubs (alder, dogwood, mesic forbs), floodplain grasses
			Terraces	Upland scrubland (sagebrush, grasses), conifer forest (ponderosa pine, Douglas-fir)
		Narrow V-shaped valley greater than 4% gradient 5,000-7,000 feet	Streambanks	Shrub (alder, mesic forbs)
		All valley types, gradients, and elevations	Seeps and springs	Floodplain grasses, shrub (alder), aquatic sedges

This guide is based on Crowe and Clausnitzer (1997). It is not exhaustive. This information should be used as a guide but always defer to site-specific conditions when establishing or identifying site potential plant associations.

Figure 6. 11H continental zone highlands site potential vegetation (ODEQ, 2010)

Valley Morph.	Elevation (Feet)	Fluvial Surface	Soil Grain Size / Moisture Content	Plant Associations	TMDL Vegetation [code] class
Broad or moderately broad flat or trough shaped Valley gradient <2%	3,000 - 6,000	Alluvial Bars	Sand/Gravel/Cobble	Creeping spikerush Common horsetail	[2000] Floodplain grass
				Coyote willow Rigid willow	[5920/5925] Shrub
				Black cottonwood/Pacific willow	[5990] Cottonwood
		Floodplains and overflow channels	Silt Saturated Soils	Aquatic sedge Bladder sedge Inflated sedge	[2000] Floodplain grass
			Silt Partially Saturated Soils	Wooly sedge Tufted hairgrass Silver sagebrush/Tufted hairgrass Shrubby cinquefoil/Tufted hairgrass	[2000] Floodplain grass
			Silt Unsaturated Soils	Quaking aspen/Common snowberry	[5995] Aspen
				Ponderosa pine/Common snowberry	[4925/4950/4955/4970] Conifer Forest
			Gravel/sand/Silt/Clay Saturated Soils	Willow/Bladder sedge Willow/Aquatic sedge Mountain alder/Bladder sedge	[5920/5925] Shrub
			Gravel/sand/Silt/Clay Partially Saturated Soils	Willow/Woolly sedge	[5920/5925] Shrub
			Gravel/sand/Silt/Clay Unsaturated Soils	Willow/Kentucky bluegrass	[5920/5925] Shrub
		Terraces	All	Mountain big sagebrush/Cusick's bluegrass	[2800] Upland Scrubland
				Quaking Aspen/Common Snowberry	[5995] Aspen
				Black Cottonwood/Common Snowberry	[5990] Cottonwood
				Ponderosa Pine/Common Snowberry Douglas Fir/Common Snowberry	[4925/4950/4955/4970] Conifer Forest
	4,500-6,500	Streambanks		Mountain alder-Currants/Mesic forb Mountain alder/Red-osier dogwood/Mesic forb	[5925/5975] Shrub
		Floodplains	Saturated Soils	Bladder sedge Aquatic sedge	[2000] Floodplain grass
				Lodge pine/Aquatic sedge	[4950] Conifer Forest
			Partially Saturated Soils	Tufted hairgrass	[2000] Floodplain grass
				Lodgepole pine/Tufted hairgrass	[4950/4970] Conifer Forest
		Terraces	Unsaturated Soils	Lodgepole pine/Kentucky bluegrass	[4950/4970] Conifer Forest
			All	Subalpine fir/Grouse huckleberry Subalpine fir/Big huckleberry	[4950/4970] Conifer Forest
				XXXXXXXX	
	Headwaters (> 6,500)			Short beak sedge Bladder sedge Aquatic sedge Tufted hairgrass	[2000] Floodplain grass
				Quaking aspen/Mesic forb	[5995] Aspen

Figure 6 continued. 11H continental zone highlands site potential vegetation (ODEQ, 2010)

Valley Morph.	Elevation (Feet)	Fluvial Surface	Soil Grain Size / Moisture Content	Plant Associations	TMDL Vegetation [code] class
Narrow to moderately wide V-shaped or trough spaded Valley gradient 2%-4%	3,000 - 6,000	Alluvial Bars	Sand/Gravel/Cobble	Common horsetail	[2000] Floodplain grass
		Floodplain	All	Mountain alder/Red-osier dogwood/Mesic Forb Mountain alder/Common snowberry Mountain alder/Common horsetail Mountain alder/Tall mannagrass Red-osier dogwood	[5925] Shrub
		Terraces	All	Mountain big sagebrush/Cusick's bluegrass	[2800] Upland Scrubland
				Ponderosa pine/Common snowberry Douglas fir/Common snowberry	[4925/4950/4955/4970] Conifer Forest
Narrow V shaped Valley gradient >4%	5,000 – 7,000	Streambanks	Sand/Gravel/Cobble	Mountain alder/Mesic forbs Mountain alder/Tall mannagrass	[5925] Shrub
Springs and Seeps	All	All	All	Big-leaved sedge Small-fruit bulrush Aquatic sedge Sheldon's sedge	[2000] Floodplain grass
				Mountain alder/Big-leaved sedge	[5920] Shrub

The following tables provide additional detail about the existing condition for site potential vegetation in the Cliff Knox planning area.

Table 45. Percent of stream at site potential vegetation across the Cliff Knox planning area

Stream category	Deviated from site potential vegetation (percent)	At site potential vegetation (percent)	No data (percent)	Total (percent)
1	47%	28%	25%	100%
2	83%	17%	0%	100%
4	82%	7%	10%	100%
Combined	74%	13%	13%	100%

Table 46. Miles of stream at site potential vegetation across the Cliff Knox planning area

Stream category	Deviated from site potential vegetation (miles)	At site potential vegetation (miles)	No data (miles)	Total (miles)
1	8.8	5.3	4.7	18.8
2	5.9	1.2		7.1
4	46.2	4.2	5.7	56.1
Combined	61.0	10.7	10.4	82.0

Table 47. Miles of stream at site potential vegetation in the Bluebucket subwatershed

Stream category	Deviated from site potential vegetation (miles)	At site potential vegetation (miles)	No data (Miles)	Total (miles)
1	1.3	0.8	4.7	6.9
2	4.3			4.3
4	12.5	0.4	5.7	18.6
Combined	18.2	1.2	10.4	29.8

Table 48. Percent of stream at site potential vegetation in the Bluebucket subwatershed

Stream category	Deviated from site potential vegetation (percent)	At site potential vegetation (percent)	No data (percent)	Total (percent)
1	19%	12%	68%	100%
2	100%	0%	0%	100%
4	67%	2%	31%	100%
Combined	61%	4%	35%	100%

Table 49. Miles of stream at site potential vegetation in the Cliff-Malheur subwatershed

Stream category	Deviated from site potential vegetation (miles)	At site potential vegetation (miles)	No data (Miles)	Total (miles)
1	7.5	4.4	4.7	16.6
2	1.6	1.2	0.0	2.8
4	33.7	3.8	5.7	43.3
Combined	42.8	9.4	10.4	62.7

Table 50. Percent of stream at site potential vegetation in the Cliff-Malheur subwatershed

Stream category	Deviated from site potential vegetation (percent)	At site potential vegetation (percent)	No data (percent)	Total (percent)
1	45%	27%	28%	100%
2	57%	43%	0%	100%
4	78%	9%	13%	100%
Combined	68%	15%	17%	100%

Appendix C – Stream Temperature

Stream water temperature on a subset of streams in the planning area comes from ongoing monitoring by the Prairie City Ranger District Hydrology program. Streams have been monitored since as early as 2003 using HOBO brand thermistors. HOBO brand thermistors are deployed in late spring/early summer and collected in the fall.

Stream temperature data was collected at multiple sites on the Malheur River, Lee Creek, Skookum Creek, Cliff Creek, Black Canyon Creek, North Fork Bluebucket Creek, Bluebucket Creek, and Cougar Creek (see Figure 7). One long term monitoring site on the Malheur River has been monitored since 2003, while other sites have been monitored since 2014. Remaining sites were only monitored in the summer of 2014.

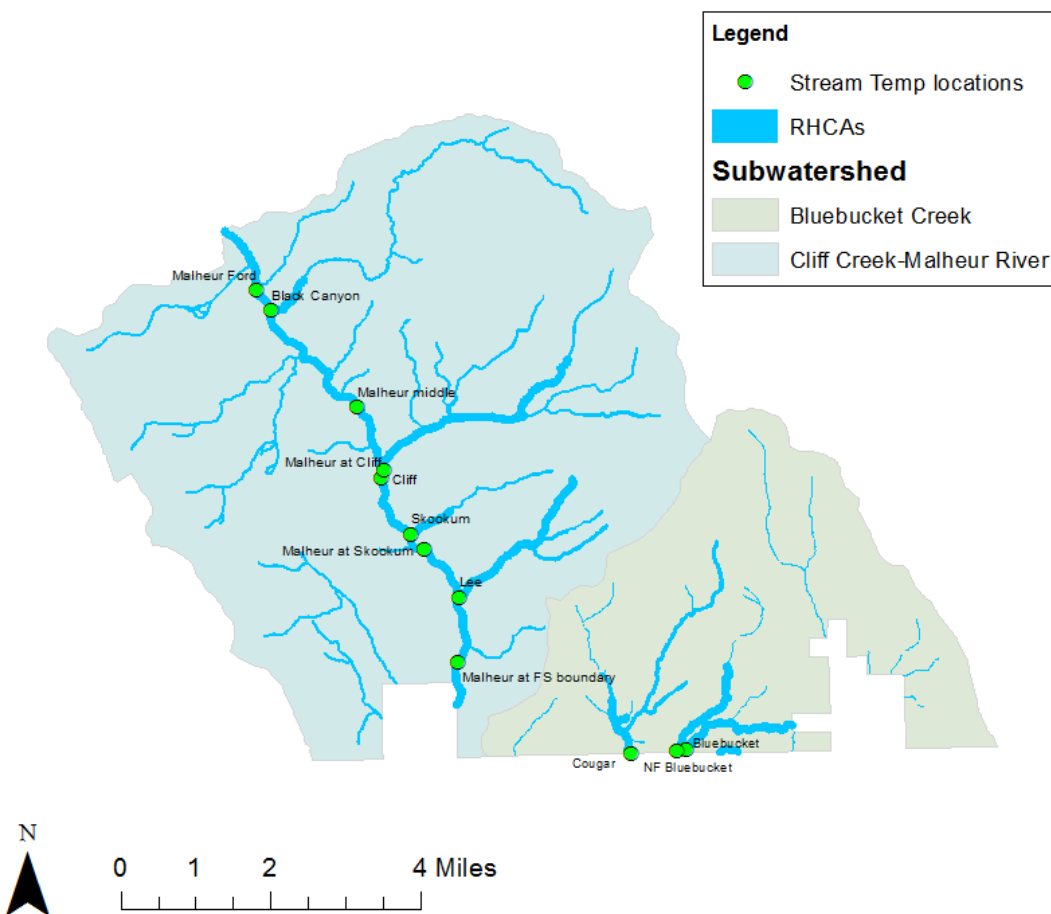


Figure 7. Stream temperature monitoring locations within the Cliff Knox planning area

Standards and Guidelines

The Malheur National Forest standards and guidelines for stream temperature come from INFISH: There is no measurable increase in maximum water temperature (7-day moving average of daily maximum temperature measured as the average of the maximum daily temperature of the warmest consecutive 7-day period). Maximum water temperatures are below 59 degrees Fahrenheit (15 degrees Celsius) within adult holding habitat and below 48 degrees Fahrenheit within spawning and rearing habitats.

The Oregon Department of Environmental Quality identifies water temperature standards of 20 degrees Celsius (68 degrees Fahrenheit) for all streams in the Cliff Knox planning area, including the Malheur River, for the beneficial use of redband trout (Oregon Department of Environmental Quality, 2010).

Both temperature standards are based on the 7-day moving average of the daily maximum (7DADM). Stream temperature is inherently dynamic; midsummer stream temperatures on the Malheur River can rise and fall up to 10 degrees Celsius in a given day due to diurnal patterns of solar irradiation. However, standards are based on maximum temperatures due to the documented impacts of high-water temperature on salmonids. In all cases, the stream thermographs below are based on the 7DADM or the maximum annual 7DADM (e.g., the highest 7DADM value for a given year).

Sites with more than one year of data are reported using the maximum annual 7DADM. Natural variability in streamflow, air temperature, and other factors may contribute to inter-annual variability in maximum stream temperature. Statistical analysis was not conducted, but the maximum air temperature has been overlain with stream temperature to help visualize relationships, where they exist, between maximum stream temperatures and maximum air temperatures. This is a simplification of a complex physical process, but it is a helpful tool in visualizing natural background variability.

A number of streams were only monitored in the summer 2014. In streams with only one year of data, thermographs of the daily 7DADM are provided. Summer air temperatures from National Oceanic and Atmospheric Administration's Climate Data Online, Crane Prairie Guard Station (National Oceanic and Atmospheric Administration, 2019).

Malheur River Ford

The Malheur River at the Malheur Ford has been monitored since 2003. Not all years are monitored due to personnel restraints, flow conditions, lost and failed equipment, and other factors. The annual maximum 7DADM on the Malheur River has ranged from 22.0 to 26.4 between 2003 and 2019 (See Figure 8). For every year sampled, the annual maximum 7DADM exceeds the ODEQ standard of 20 degrees Celsius and the Malheur Forest Plan standard of 15 degrees Celsius. 7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

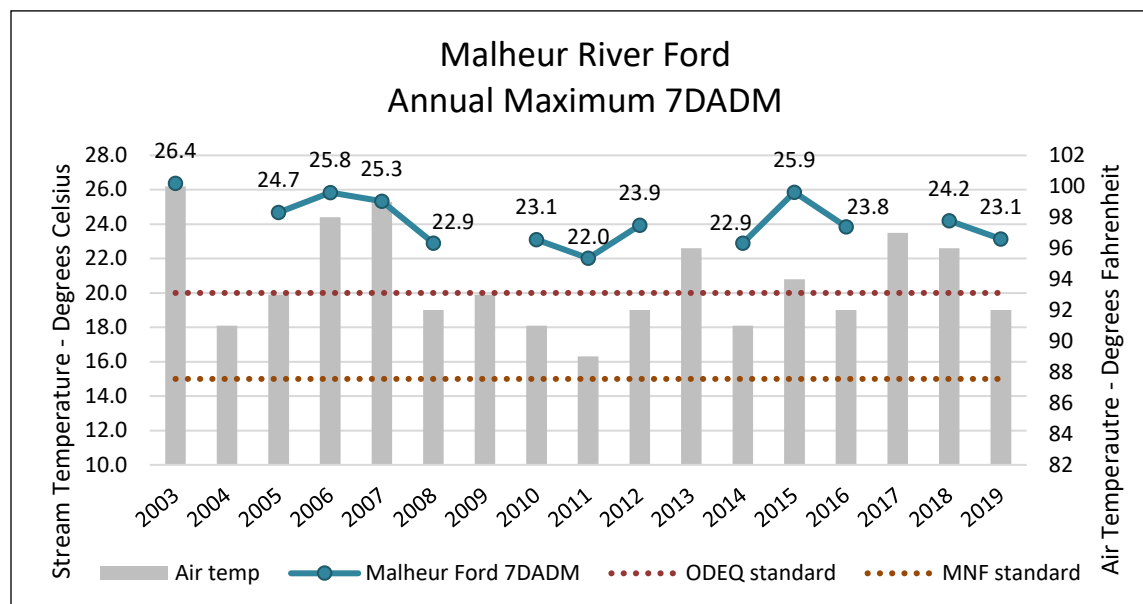


Figure 8. Long term stream monitoring on the Malheur River at the Malheur Ford

Malheur River lower sites

A number of monitoring sites were added to the Malheur River in 2014. Not all years are monitored due to personnel restraints, flow conditions, lost and failed equipment, and other factors. Collectively, the annual maximum 7DADM is above 22 degrees Celsius, with the maximum observed annual 7DADM of 26.4 at the lowermost site on the Malheur National Forest (see Figure 9). For every year sampled at each site, the annual maximum 7DADM exceeds the ODEQ standard of 20 degrees Celsius and the Malheur Forest Plan standard of 15 degrees Celsius.

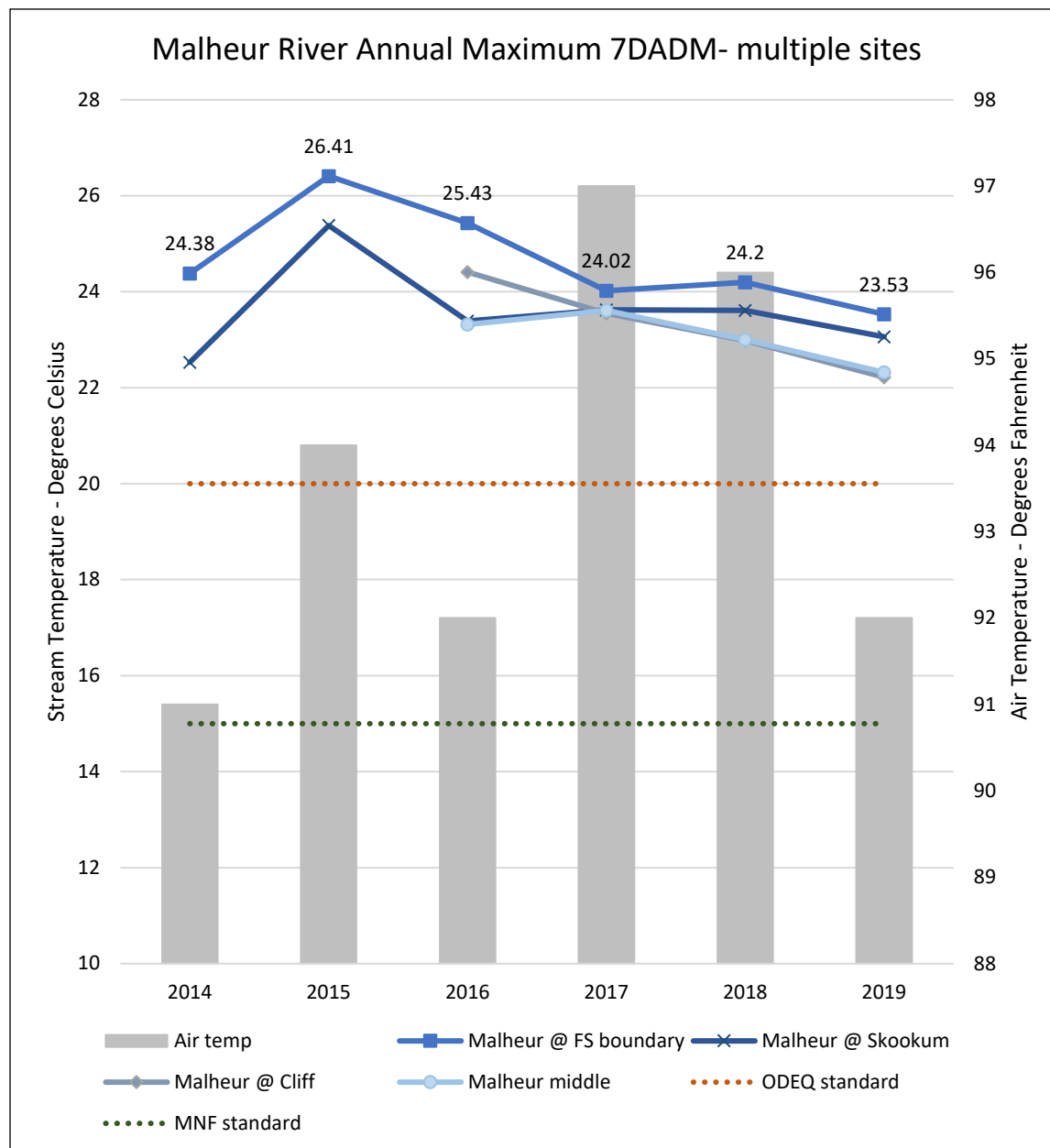


Figure 9. Stream monitoring results on the Malheur River at multiple sites from 2014-2019

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Skookum Creek

Skookum Creek has been monitored since 2014, with no data in 2017. The annual maximum 7DADM on Skookum Creek has ranged from 11.8 to 12.2 (see Figure 10). For every year sampled, the maximum stream temperature is below the ODEQ standard of 20 degrees Celsius and the Malheur Forest Plan standard of 15 degrees Celsius. Based on the 5 years of available data, maximum stream temperatures are highly similar, regardless of air temperatures, which indicates that stream temperature on Skookum Creek is relatively consistent from year to year. Skookum Creek is a spring-fed stream with the majority of its perennial length in the canyon of the Malheur River. Riparian vegetation is healthy and provides good shade. Topographic shading in the canyon may also contribute to cold stream temperatures. Skookum Creek is an important cold-water tributary to the Malheur River, which has elevated stream temperatures throughout its length in the Cliff Knox planning area.

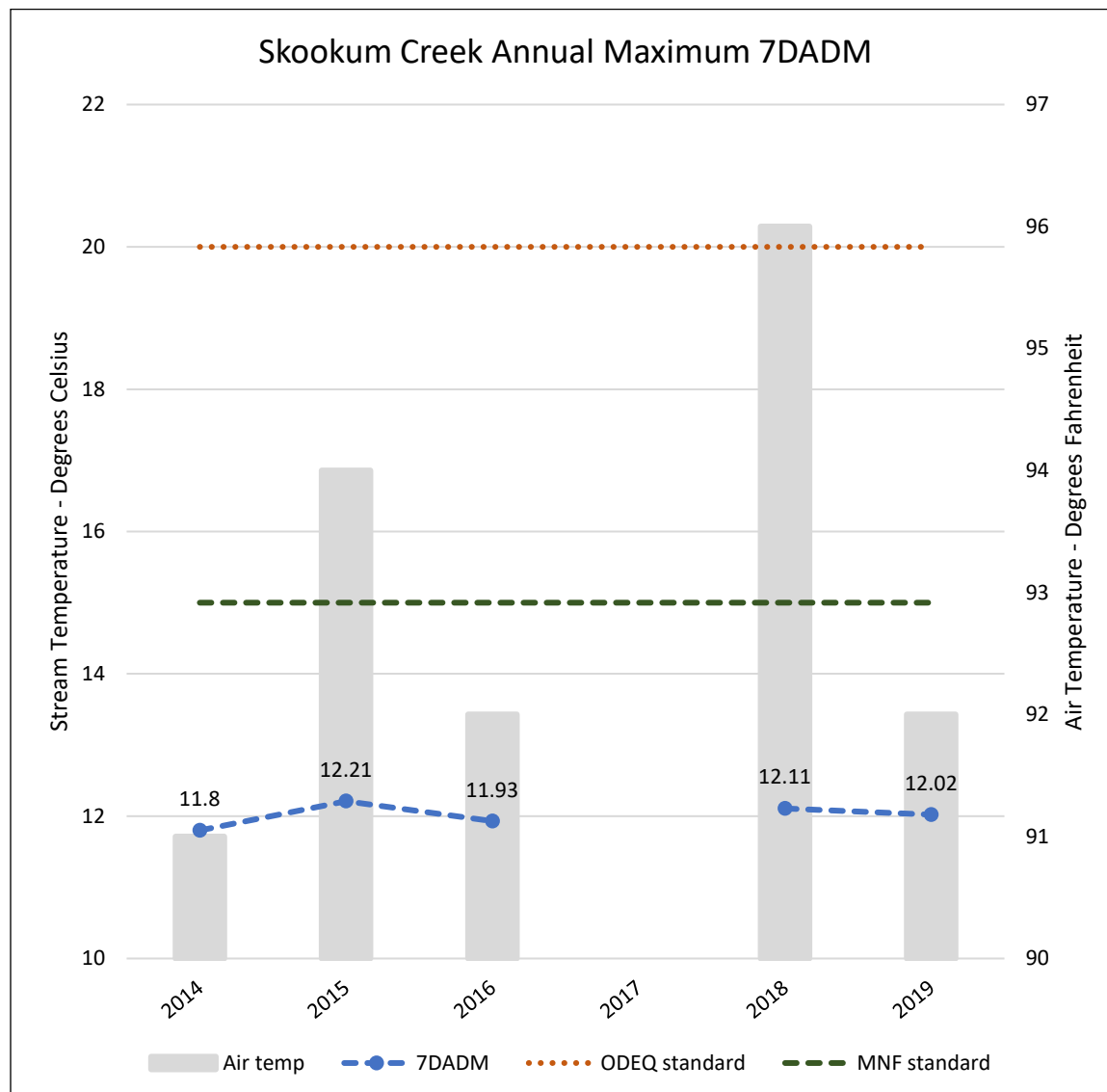


Figure 10. Stream monitoring results on Skookum Creek from 2014-2019

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Lee Creek

Lee Creek has been monitored since 2014, with no data in 2017. The annual maximum 7DADM on Lee Creek has ranged from 13.6 to 14.9 (see Figure 11). For every year sampled, stream temperature meets the ODEQ standard of 20 degrees Celsius and the Malheur Forest Plan standard of 15 degrees Celsius. Like Skookum Creek, the inter-annual variability in maximum stream temperature is very low. Lee Creek is spring fed with much of its perennial length located in the canyon of the Malheur River. Lee Creek is also an important cold-water tributary to the Malheur River.

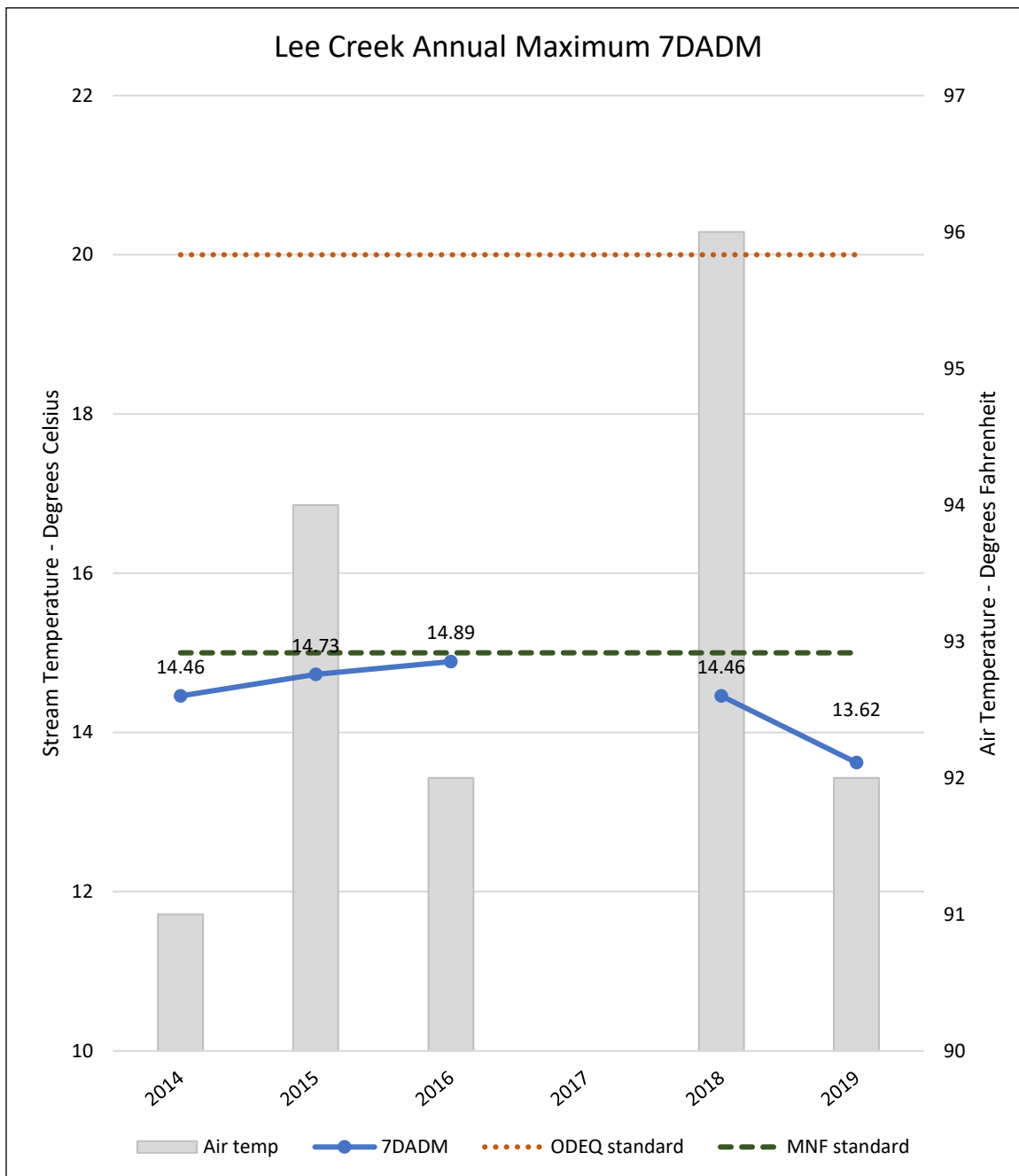


Figure 11. Stream monitoring results on Lee Creek from 2014-2019

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Black Canyon Creek

Black Canyon Creek was monitored in 2014 (see Figure 12). The annual maximum 7DADM was 15.3 degrees Celsius, which slightly exceeds the INFISH standard but meets the ODEQ standard of 20 degrees Celsius. While Black Canyon Creek is not as cold as Lee or Skookum Creeks, the cold water it provides to the Malheur River is likely to have ecological benefits (see Cliff Knox Aquatic Resources Report).

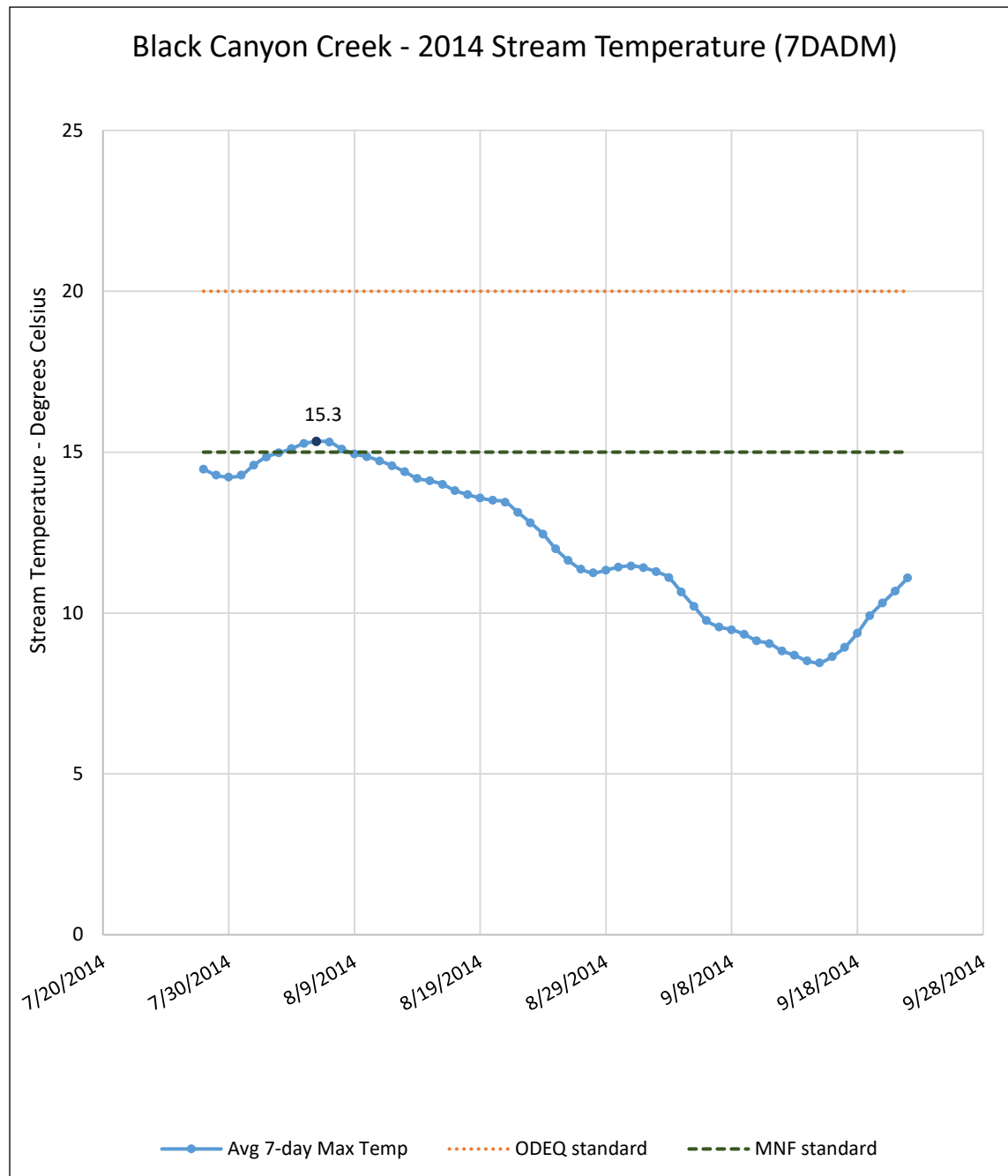


Figure 12. Stream monitoring results on Black Canyon Creek from 2014

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Cliff Creek

Cliff Creek was monitored in 2014 (see Figure 13). The annual maximum 7DADM was 18.5 degrees Celsius, which exceeds the INFISH standard but meets the ODEQ standard of 20 degrees Celsius. Cliff Creek is the warmest of the perennial tributaries to the Malheur River in the Cliff-Malheur subwatershed, but the cold water it provides to the Malheur River is likely to have ecological benefits.

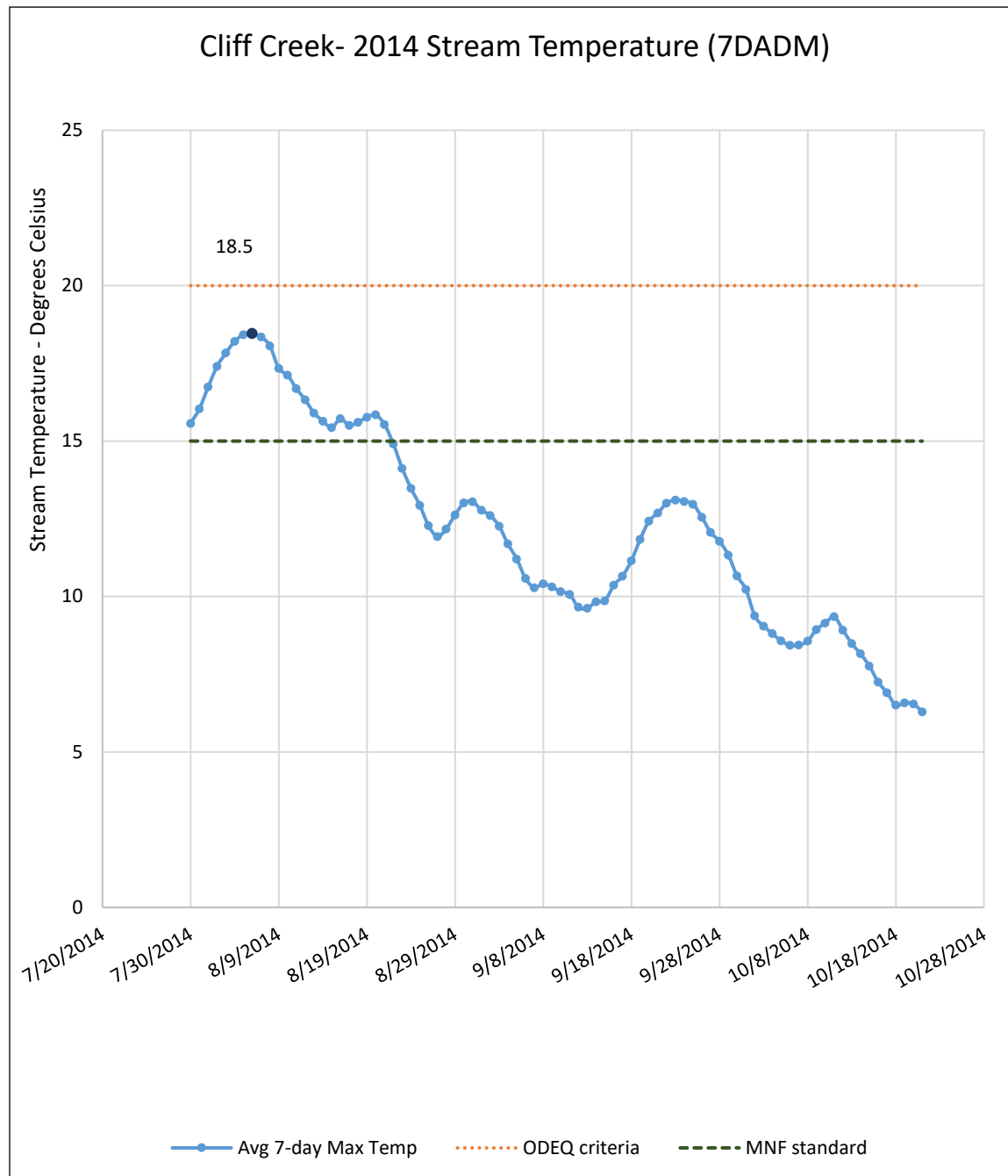


Figure 13. Stream monitoring results on Cliff Creek from 2014

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Bluebucket Creek

Bluebucket Creek was monitored in 2014 (see Figure 14). The annual maximum 7DADM was 19.9 degrees Celsius, which exceeds the INFISH standard and barely meets the ODEQ standard of 20 degrees Celsius. Bluebucket Creek flows into the Malheur River many miles below Forest Service lands. The extent of cold-water benefits is unknown.

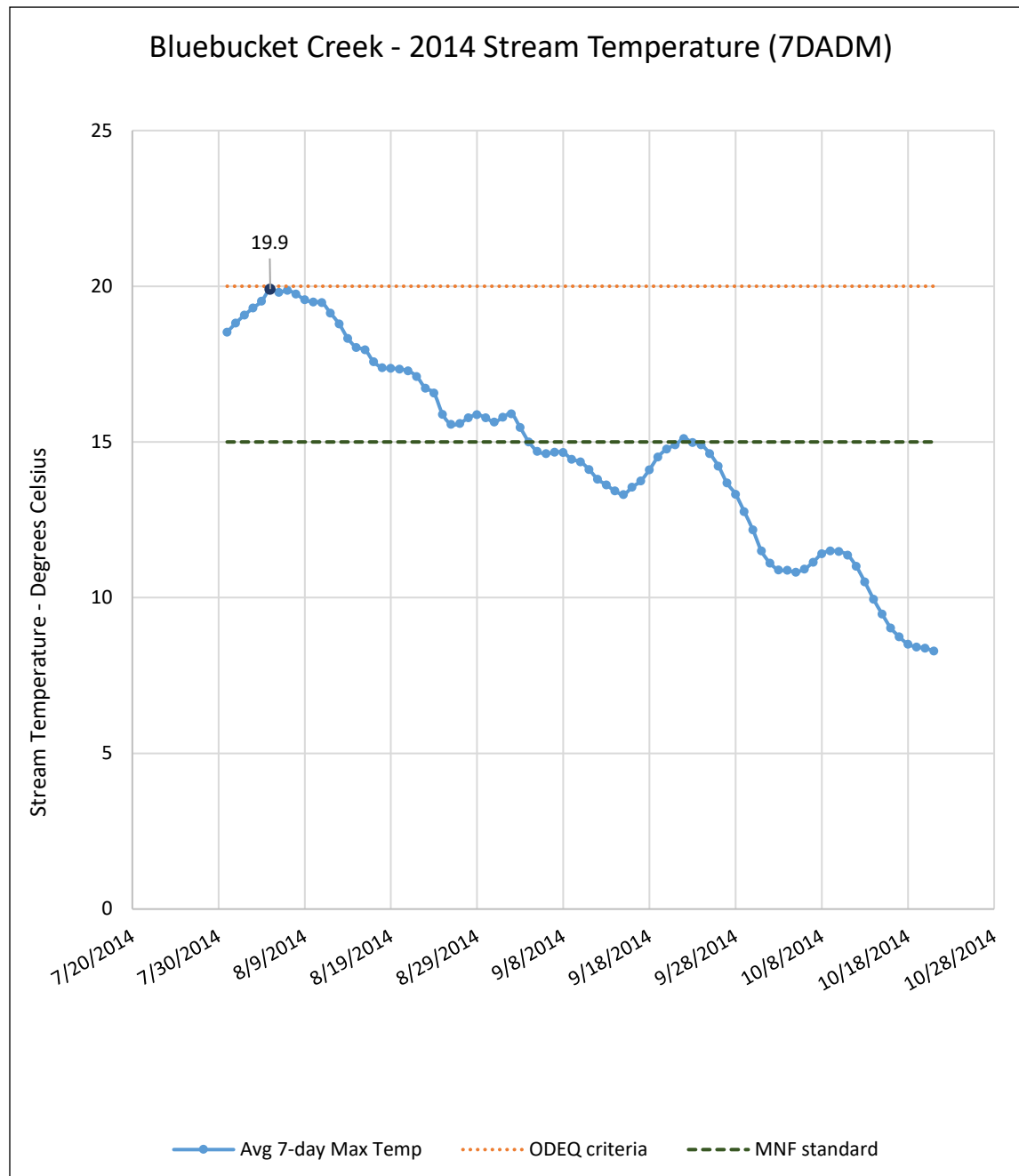


Figure 14. Stream monitoring results on Bluebucket Creek from 2014

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

North Fork Bluebucket Creek

North Fork Bluebucket Creek was monitored in 2014 (see Figure 15). The annual maximum 7DADM was 16.0 degrees Celsius, which exceeds the INFISH standard but meets the ODEQ standard of 20 degrees Celsius. North Fork Bluebucket Creek is a small tributary to Bluebucket.

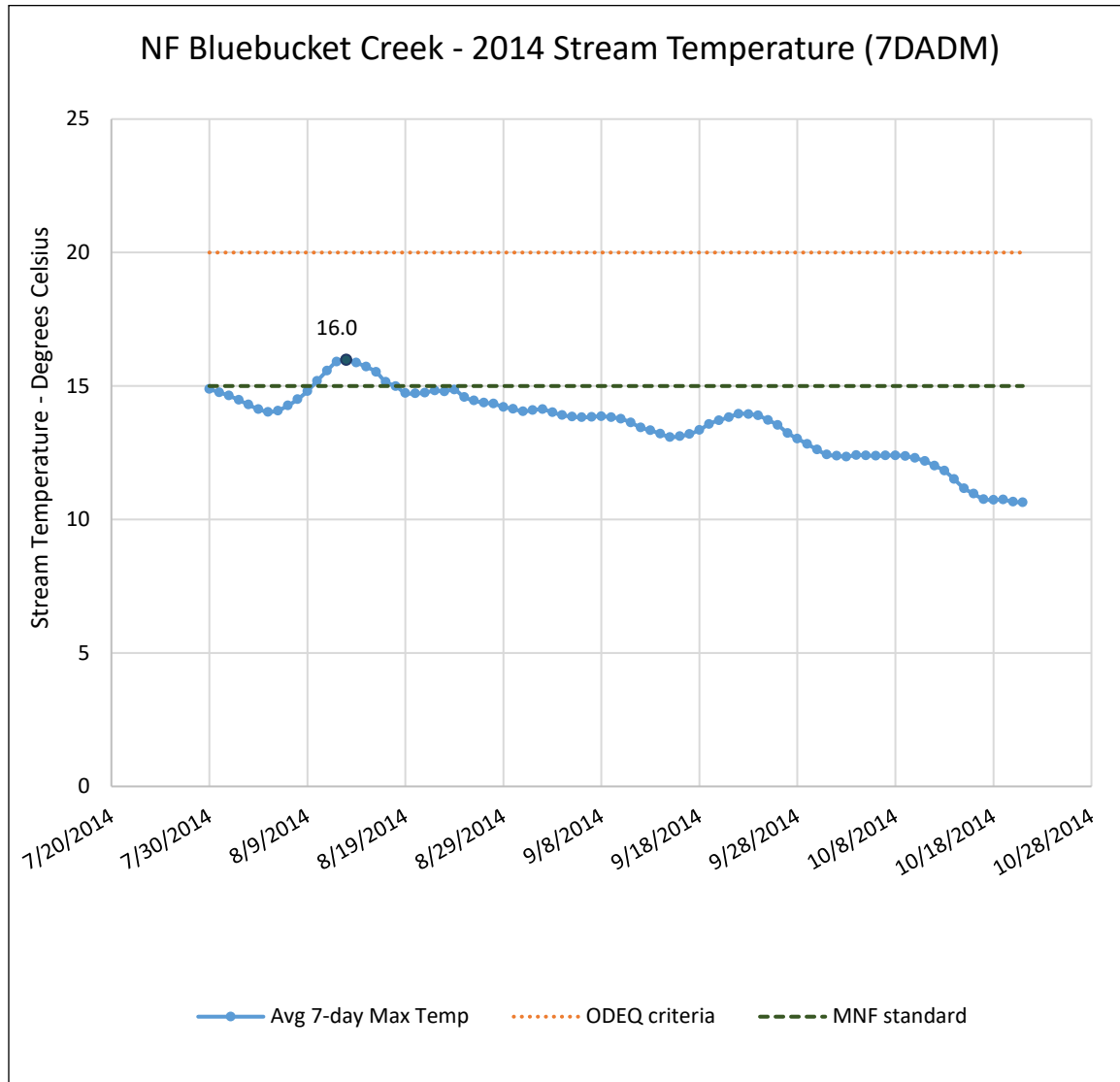


Figure 15. Stream monitoring results on North Fork Bluebucket Creek from 2014
7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Cougar Creek

Cougar Creek was monitored in 2014 (see Figure 16). The annual maximum 7DADM was 20.5 degrees Celsius, which exceeds the INFISH standard and the ODEQ standard of 20 degrees Celsius. Cougar Creek is a small tributary to Bluebucket, with low streamflow and inadequate riparian vegetation, except within the cougar riparian exclosure which has robust riparian vegetation. Cougar Creek is considered at site potential vegetation within the cougar riparian exclosure.

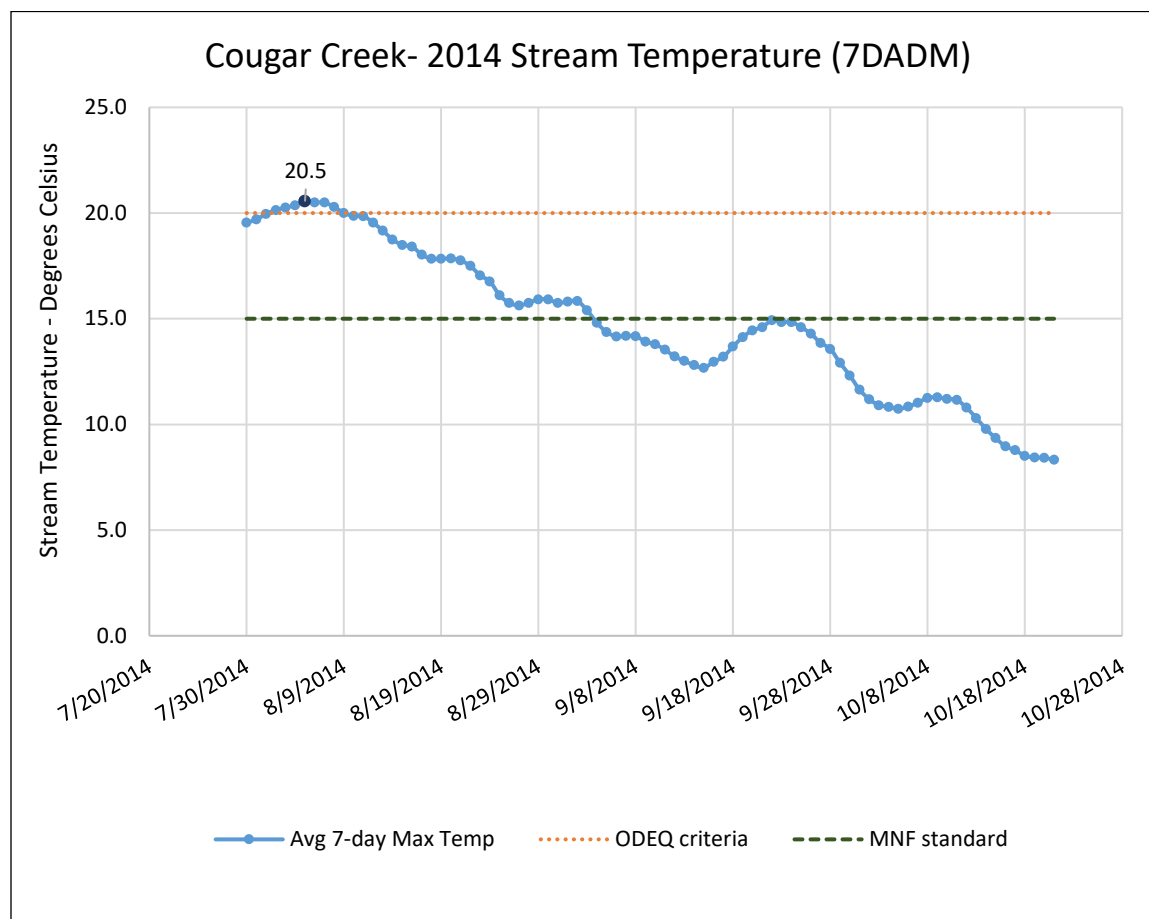


Figure 16. Stream monitoring results on Cougar Creek from 2014

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Summary

The Malheur River within the planning area is up to nine miles long. For most rivers, water temperature increases as they flow downstream, but stream shading, tributary inputs, groundwater inputs, streamflow volume, annual snowpack, and other factors can influence that rate of warming (see Figure 17). Annual maximum 7DADM between the uppermost and lowermost sites show warming of up to 0.4 to 1.6 degrees Celsius, based on years available for comparison. Sites in between the Malheur Ford and the Forest Service boundary do not follow typical trends, as some of them have lower maximum stream temperatures than the Malheur Ford site in some years. This may be attributed to cold water spring and streams entering the canyon through this reach, in addition to topographic shading provided by the canyon and moderate abundance of riparian shrubs. Drought conditions and volume of streamflow may account for some of that inter-annual variability, in addition to temperature logger inaccuracy and/or deployment inconsistency.

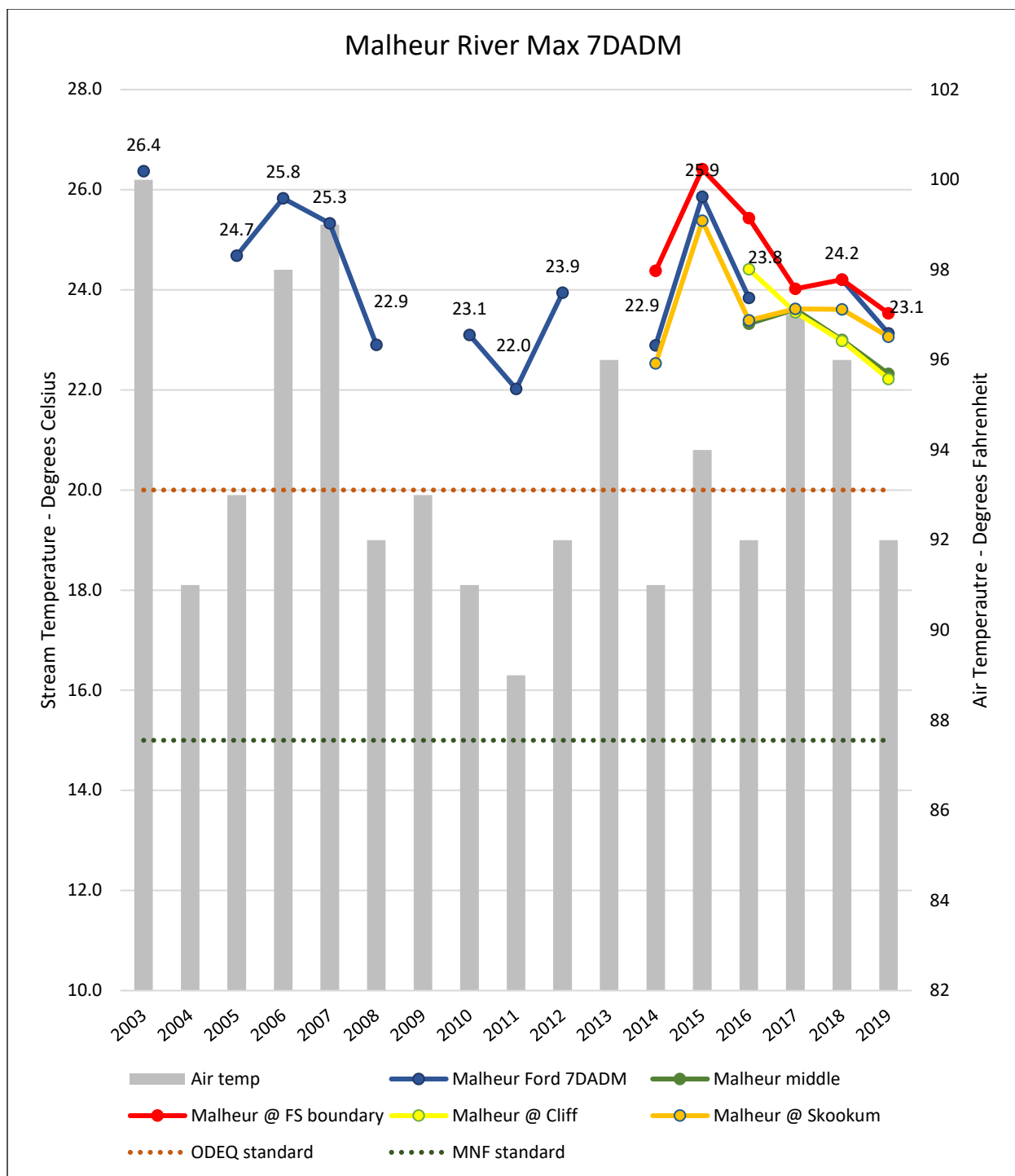


Figure 17. Long-term stream monitoring on the Malheur River at multiple monitoring sites

7DADM is the 7-day moving average of the daily maximum (ODEQ, 2010).

Overall, stream temperatures on the Malheur River exceed desired temperatures. Stream warming within the planning area is relatively low when considered with the overall stream length, suggesting that the majority of warming on the river is taking place upstream of the Cliff Knox planning area boundary. Smaller tributaries with cold-water inputs have high ecological benefits, by providing cold-water refugia both within these small streams and as they flow into the Malheur River.

Appendix D – Consistency with the Malheur Forest Plan

Table 51. Project consistency with the most relevant standards under the Malheur Forest Plan, INFISH, and Amendment 29

Malheur Forest Plan standards and guideline/riparian management objectives					Consistent	Justification										
INFISH standards for riparian habitat conservation areas (RHCAs)					Yes	RHCAs were delineated based on INFISH distance standards for both subwatersheds										
INFISH riparian management objectives for substrate Cobble embeddedness is less than or equal to 20% ¹¹					Yes	This standard and guideline is closely related to sediment. See sediment analysis. There would be no measurable changes to stream sediment at the drainage level. Project planning was used to minimize the types of activities occurring within the sediment delivery zone. Site-specific best management practices are prescribed for all activities within the sediment delivery zone.										
INFISH riparian management objectives for stream temperature: There is no measurable increase in maximum water temperature (7-day moving average of daily maximum temperature measured as the average of the maximum daily temperature of the warmest consecutive 7-day period). Maximum water temperatures are below 59 degrees Fahrenheit within adult holding habitat and below 48 degrees Fahrenheit within spawning and rearing habitats.					Yes	There would be no measurable changes to stream temperature. See stream temperature analysis										
Amendment 29 standards for Stream Shade: Maintain shade/canopy closure for the following ecosystems: <table><tr><th>Ecosystem</th><th>Ponderosa Pine</th><th>Mixed Conifer</th><th>Lodgepole Pine</th><th>Hardwood Meadow</th></tr><tr><td>Shade/Closure</td><td>40-50%</td><td>50-60%</td><td>60-75%</td><td>80%</td></tr></table>					Ecosystem	Ponderosa Pine	Mixed Conifer	Lodgepole Pine	Hardwood Meadow	Shade/Closure	40-50%	50-60%	60-75%	80%	Yes	There would be measurable reductions to stream shade at isolated aspen stands in the short term. Within five years, stream shade would exceed the existing condition and meet shade standards.
Ecosystem	Ponderosa Pine	Mixed Conifer	Lodgepole Pine	Hardwood Meadow												
Shade/Closure	40-50%	50-60%	60-75%	80%												
INFISH riparian management objectives and Amendment 29 standards for Riparian Condition: - The ground cover is at 90% of site potential, covered by herbaceous species, litter, rock, moss, or lichens. - Stream bank vegetation is at 90% of site potential.					Yes	There would be no reductions in ground cover or stream bank vegetation. See sections on Site Potential Vegetation.										

¹¹ Where embeddedness values are unavailable, percent fines are used at the same value of 20 percent.

Malheur Forest Plan standards and guideline/riparian management objectives							Consistent	Justification	
<i>Amendment 29 standards for large wood:</i> Maintain large woody debris within the following ecosystems:							Yes	See Issues section. There are no activities proposed that would affect forest plan wood standards in the planning area. Some small wood may be added to the stream channel but would not affect consistency with forest plan standards. Activities would enhance growth of RHCA conifers and improve the quality of future large wood.	
Ecosystem	# of Pieces	Minimum Length	Diameter	Key Pieces					
Ponderosa Pine	20 to 70	35' or 1.5 x bankfull	12"	20% greater than 20"					
Mixed Conifer	80 to 120	35' or 1.5 x bankfull	12"	20% greater than 20"					
Lodgepole Pine	100 to 350	18' or 1.5 x bankfull	6"	20% greater than 12"					
<i>INFISH and Amendment 29 riparian management objectives for Pool frequency:</i>							Yes	There are no direct actions proposed that would impact pool frequency. There are no indirect actions that would affect pool frequency because channel altering peak flows are not expected to increase as a result of the Cliff Knox Project.	
Wetted width (feet)		10	20	25	50	75			
Pools per mile		96	56	47	26	23			
and									
Bankfull width (feet)	5	10	20	25	50	75			
Pools per mile		151-264	75-132	28-66	30-53	15-26	10-23		
<i>INFISH riparian management objectives for Bank Stability:</i> Bank stability for forested ecosystems is 90% stable, no decrease if above 90% stable. Bank stability should be greater than 80% for non-forested systems.							Yes	There are no direct actions proposed that would impact bank stability. There are no indirect actions that would affect bank stability because channel altering peak flows are not expected to increase as a result of the Cliff Knox Project.	
<i>INFISH riparian management objectives for Undercut Banks:</i> There should be greater than 75% undercut banks for non-forested systems.							Yes	There are no direct actions proposed that would impact undercut banks. There are no indirect actions that would affect undercut banks because channel altering peak flows are not expected to increase as a result of the Cliff Knox Project.	
<i>INFISH riparian management objectives for Width: Depth Ratios:</i>							Yes	There are no direct actions proposed that would impact width to depth ratios. There are no indirect actions that would affect width to depth ratios because	

Malheur Forest Plan standards and guideline/riparian management objectives	Consistent	Justification
The wetted width to depth ratio is less than 10 ¹² for all systems (same as INFISH objective).		channel altering peak flows are not expected to increase as a result of the Cliff Knox Project.
INFISH Standard and Guideline TM-1 Prohibit timber harvest, including fuelwood cutting, in RHCAs, except as described below. b. Apply silvicultural practices for RHCAs to acquire desired vegetation characteristics where needed to attain riparian management objectives (RMOs). Apply silvicultural practices in a manner that does not retard attainment of RMOs and that avoids adverse effects on Inland native fish.	Yes	The Cliff Knox Project is consistent due to project planning to prevent commercial harvest within the RHCAs. Noncommercial thinning within the RHCA is consistent with TM1b by improving vegetation characteristics while not retarding stream shade, stream temperature, or other RMOs in the long term. Short term reductions in stream shade at isolated aspen stands are consistent with INFISH because they have long term benefit to the riparian ecosystem.
INFISH Standard and Guideline RF1 Cooperate with Federal Tribal, State, and county agencies and cost-share partners in road design, operation, and maintenance necessary to attain riparian management objectives.	Yes	See Cliff Knox Environmental Impact Statement, chapter 4 for a full list of agencies contacted. The USFWS participated in a field review of Cliff Knox roads and RHCA mechanical areas in the summer of 2017.
INFISH Standard and Guideline RF2 for each existing road or planned road, meet the riparian management objectives and avoid adverse effects to inland fish by: - Completing watershed analysis prior to construction of new roads or landings - Minimizing road and landing locations in RHCAs. - Initiating development and implementation of a road management plan or a transportation management plan. At a minimum, address the following items in the plan: - Road design criteria, elements, and standards that govern construction and reconstruction. - Road management objectives for each road - Criteria that govern road operation, maintenance, and management - Requirements for pre-, during-, and post-storm inspections and maintenance - Regulations of traffic during wet periods to minimize erosion and sediment delivery and accomplish other objectives. - Implementation and effectiveness monitoring plans for road stability, drainage, and erosion control - Mitigation plans for road failures - Avoiding sediment delivery to streams from the road surface		- There are no new roads constructed in the RHCAs. Landings were avoided in the RHCA through the use of small roadside decks that maintain forest cover and utilize existing openings. - The interdisciplinary team assessed all RHCA roads with existing or potential aquatic resource damage and developed the roads Proposed Action, which includes a combination of decommissioning, closing, and improving roads in the RHCA. For more site-specific information, see Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A Best management practices were developed for all roads maintenance and log haul; see - Appendix A – Project Design Criteria - Best management practices monitoring occurs annually on the Malheur National Forest.

¹² Where channel type is defined, the width: depth values are based on channel type (Rosgen 1996).

Malheur Forest Plan standards and guideline/riparian management objectives	Consistent	Justification
• Out sloping of the roadway surface is preferred, except in cases where out sloping would increase sediment delivery to streams or where out sloping is infeasible or unsafe • Route drainage away from potential unstable stream channels, fills, and hillslopes e. Avoiding disruption of natural hydrologic flow paths f. Avoiding sidecasting of soils or snow. Sidecasting of road material is prohibited on road segments within or abutting RHCA in priority watersheds		
INFISH Standard and Guideline RF-3 Determine the influence of each road on the riparian management objectives (RMOs). Meet RMOs and avoid adverse effects on inland native fish by: a. Reconstructing road and drainage features that do not meet design criteria or operation and maintenance standards, or that have been shown to be less effective than designed for controlling sediment delivery, or that retard attainment of RMOs, or do not protect priority watersheds from increased sedimentation b. Prioritizing reconstruction based on the current and potential damage to inland native fish and their priority watersheds, the ecological value of the riparian resources affected, and the feasibility of options such as helicopter logging and road relocation out of the RHCA c. Closing and stabilizing or obliterating, and stabilizing roads not needed for future management activities. Prioritize these actions based on the current and potential damage to the inland native fish in priority watersheds, and the ecological value of the riparian resources affected	Yes	• The interdisciplinary team assessed all RHCA roads with existing or potential aquatic resource damage and developed the roads proposed action, which includes a combination of decommissioning, closing, and improving roads in the RHCA. For more site-specific information, see Cliff Knox Project Final Environmental Impact Statement, Appendix C- Project Design Criteria, Attachment A. • Road reconstruction would occur on roads outside the RHCA to facilitate decommissioning roads in the RHCA that are currently causing unavoidable adverse effects to aquatic resources.
INFISH Standard and Guideline RF-4 construct new, and improve existing culverts, bridges, and other stream crossings to accommodate a 100-year flood, including associated bedload and debris, where those improvements would/pose a substantial risk to riparian conditions. Substantial risk improvements include those that do not meet design and operation maintenance criteria, or that have been shown to be less effective than designed for controlling erosion, or that retard attainment of riparian management objectives, or that do not protect priority watersheds from increased sedimentation. Base priority for upgrading on risks in priority watersheds and the ecological value of the riparian resources affected. Construct and maintain crossings to prevent diversion of streamflow out of the channel and down the road in the event of a crossing failure.	Yes	See Project Design Criteria for new culverts and ford crossings. Culvert replacements are only proposed on intermittent streams.
INFISH Standard and Guideline RF-5 provide and maintain fish passage at all road crossings of existing and potential fish-bearing streams.	Yes	All fish-bearing stream crossings were assessed for passage. No treatments were necessary.
INFISH Standard and Guideline FM-1 Design fuel treatments and fire suppression strategies, practices, and actions so as not to prevent attainment of riparian management objectives (RMOs) and to minimize disturbance of riparian ground cover and vegetation. Strategies should recognize the role of fire in ecosystems function and	Yes	Fuels management treatments were designed to allow natural wildfire to occur in RHCA, to reintroduce natural and beneficial disturbance processes. Project design criteria were developed to protect stream

Malheur Forest Plan standards and guideline/riparian management objectives	Consistent	Justification
identify those instances where fire suppression or fuel management actions could perpetuate or be damaging to long-term ecosystem function or inland native fish.		shade, maintain large wood, and minimize moderate and high burn severity within the RHCA. See Project Design Criteria.
INFISH Standard and Guideline FM-4 design prescribed burn projects and prescriptions to contribute to the attainment of the RMOs.	Yes	See FM-1 above.
INFISH Standard and Guideline RA-2 Trees may be felled in RHCAs when they pose a safety risk. Keep felled trees on site when needed to meet woody debris objectives.	Yes	The project proposed hand-felling within the RHCA and includes retention of felled trees on-site to meet wood objectives.
INFISH Standard and Guideline RA-4 prohibit storage of fuels and other toxicants within the RHCA. Prohibit refueling within RHCAs unless there are no other alternatives. Refueling sites within a RHCA must be approved by the Forest Service or Bureau of Land Management and have an approved spill containment plan.	Yes	Fuels and toxicants are restricted within the RHCA. See Appendix A – Project Design Criteria of this report.
INFISH Standard and Guideline RA-5 Locate water drafting sites to avoid adverse effects to inland native fish and instream flows, and in a manner that does not retard attainment of RMOs.	Yes	Water drafting must be consistent with Guidelines provided by USFWS; see Appendix A – Project Design Criteria.
Malheur Forest Plan Forest-Wide Standard 56. Maintain the integrity of unique habitats including meadows, rimrocks, talus slopes, cliffs, animal dens, wallows, bogs, seeps and springs by incorporating cover buffers approximately 100 feet in width. Utilize additional mitigation/enhancement measures identified through project level analysis.	Yes	Consistent per adherence to Botany-1 and Wildlife-22 to retain 100’ buffers on springs and seeps. USFWS; see Appendix A – Project Design Criteria.
Malheur Forest Plan Forest-Wide Standard 57. Maintain or enhance quaking aspen stands using clearcutting and prescribed burning as the principal means of regeneration where appropriate. Protect sprouts where needed and practical.	Yes	The Cliff Knox Project would cut all conifers less than 21” diameter at breast height in RHCAs, utilizing non-commercial thinning (hand treatments only). Protection (fencing) would be used to protect category 1 and 2 streams, and a combination of monitoring and fencing on category 4 streams.
Malheur Forest Plan Standard MA3A:8. Maintain or enhance the productivity of key riparian vegetation to protect or enhance riparian-dependent resources. Emphasis would be on the re-establishment of remnant hardwood shrub and tree communities.	Yes	Non-commercial thinning in RHCAs maintains and enhances productivity of aspen and key conifer species. Treatments would be done by hand to protect soils.

Malheur Forest Plan standards and guideline/riparian management objectives	Consistent	Justification
Malheur Forest Plan Standard MA3A:9. Plan, design, and implement riparian habitat improvement activities to upgrade riparian areas that are not in a condition to meet management objectives or the desired future condition.	Yes	See above for MA3A-8.
Malheur Forest Plan Standard MA3A:10. Improve the rate of recovery in riparian areas that are not in a condition to meet management objectives by eliminating or reducing the impacts of management activities by eliminating or reducing the impacts of management activities that may slow riparian recovery.	Yes	See above for Malheur Forest Plan forest-wide standard 57 and MA3A-8.
Malheur Forest Plan Standard MA3A:11. Maintain or enhance water quality and/or fish habitat through instream or riparian improvements. Implement instream activities outside of the spawning and egg incubation period.	Yes	The Cliff Knox Project proposes to improve stream crossings causing sediment delivery. Improving these crossings would enhance water quality. In-stream crossings must be completed during dry conditions or during the In-Water-Work-Period (see Appendix A – Project Design Criteria of this report).
Malheur Forest Plan Standard MA3A:12. Provide for input of large, woody debris into all classes of streams and evaluate to determine if objectives are being met. Remove material that causes unacceptable channel and/or bank damage.	Yes	The project proposes to add small wood to stream channels during non-commercial thinning.
Malheur Forest Plan Standard MA3A:14. Maintain non-stream associated riparian areas such as seeps, springs, bogs, wallows together with their associated vegetative structure. Develop mitigation measures for management activities during project level environmental analysis.	Yes	Springs and seeps would be protected by project design criteria. See Appendix A – Project Design Criteria of this report for more information.
Malheur Forest Plan Standard MA3A:40. Avoid locating roads in riparian areas while providing adequate local road access for management activities (e.g. timber management, fisheries structural improvements, etc.). Minimize the density of open roads in this management area by obliterating, revegetating, or closing unnecessary roads or any roads causing significant resource damage.	Yes	There would be no new roads within RHCAs. Where RHCA roads causing resource damage could be not mitigated, roads were relocated outside the RHCA to support ongoing timber management and other administrative uses. Numerous roads were proposed for closure or decommission within the RHCA to minimize open road density within RHCAs.
Malheur Forest Plan Standard MA3A:41. Design and maintain roads to protect fisheries values and riparian area habitat.	Yes	A combination of upgrading stream crossings, relocating roads outside the RHCA, road

Malheur Forest Plan standards and guideline/riparian management objectives	Consistent	Justification
		decommission, and road improvements were designed to protect fisheries values and riparian areas.
Malheur Forest Plan Standard MA3A:43. Leave stream channels of Class 1 to IV streams undisturbed by roads, except for crossings. Minimize adverse impacts to water and fisheries resources when designing necessary crossings.	Yes	The majority of roads that adversely affecting stream channel and floodplain function were proposed for decommission. All stream crossings were evaluated, and upgrades/improvements were proposed where needed.
Malheur Forest Plan Standard MA3A:44. Apply erosion seeding on (a) all disturbed soil that occurs within 100-200 feet of a Class 1, II, III, or IV stream or where eroded material could reach a stream; and (b) on compacted skid trails with slopes greater than 20%.	Yes	All skid trails and other ground disturbance within the RHCA (i.e. roads maintenance) were proposed for slash and seed treatments (see Appendix A – Project Design Criteria of this report).
Malheur Forest Plan Standard MA3A:46. Mitigate unavoidable adverse impacts on floodplains or wetlands.	Yes	There are no project activities proposed that would cause unavoidable adverse impacts to floodplains or wetlands. See also response to Malheur Forest Plan Standard MA3A:43.