APPENDIX A
Assessment Methods

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ASSESSMENT METHODS

SPATIAL DOMAIN

The spatial boundary of this project is the Birch Creek Watershed, which corresponds to the Hydrologic Unit Code (HUC) 10-digit level of 1707010306 (5^{th} field HUC), and all subwatersheds at the HUC12 level (6^{th} field HUC) (Table A-1).

TABLE A-1. HUC12 LEVEL SUBWATERSHEDS IN THE BIRCH CREEK WATERSHED

HUC12 Code	HUC12 Name
170701030601	Pearson Creek
170701030602	Upper East Birch Creek
170701030603	Lower East Birch Creek
170701030604	Bear Creek-West Birch Creek
170701030605	Jack Canyon
170701030606	West Birch Creek
170701030607	George Canyon
170701030608	Stewart Creek-Birch Creek
170701030609	Coombs Peak-Birch Creek

Publicly available spatial data were acquired for all of the HUC12 level subwatersheds in the Birch Creek watershed. The geologic controls in the Birch Creek Watershed were identified by GIS mapping and description of lithology and surficial geology with data compiled from the Oregon Department of Geology and Mineral Industries (DOGAMI). Soils data were acquired from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) and State Soil Geographic (STATSGO) data sets. Elevation data throughout the watershed were acquired from the 10-meter digital elevation model (DEM) in the National Elevation Database available from the US Geological Survey (USGS). Land use and land cover data from the years 1992 and 2011 were available from the USGS National Land Cover Database (NLCD).

High-resolution elevation data along the primary stream corridors in the watershed were available from a 2013 Light Detection and Ranging (LiDAR) dataset, which also included high resolution orthophotographs. The bare earth digital elevation model (DEM) from the LiDAR dataset was used to create stream thalweg lines within the watershed. The ArcGIS workflow started with the DEM, sinks were filled using the Fill tool (Spatial Analyst—Hydrology), and then flow direction was calculated from the resulting raster using the Flow Direction tool (Spatial Analyst—Hydrology). The resulting flow direction raster was used to calculate flow accumulation for each cell using the Flow Accumulation tool (Spatial Analyst—Hydrology) and the resulting raster was edited to depict cells that drained greater than 0.1 km^2 using the raster calculation tool (Spatial Analyst—Map Algebra). The raster of streams was converted to a feature. This feature was smoothed using Smooth Line (Cartography) tool, the PEAK method with a 2-foot smoothing tolerance. The smoothed polyline was edited to remove small tributaries and to merge thalwegs from the same stream. Finally, the

HEC-GEORAS tool was used to convert the 2-dimensional polyline to a 3-dimensional polyline using the DEM.

The thalweg lines were used to create a linear referencing system throughout the watershed. In ArcGIS, measured routes (in meters) were created for each tributary. All measured routes begin at the mouth of each tributary (0.0) and increase in the upstream direction. Linear event tables were used for correlating data and analysis results to locations along the thalweg of each tributary.

The ODFW Natural Resources Information Management Program was used to acquire the most recent information on the distribution of summer steelhead in streams throughout the Birch Creek Watershed. The existing Birch Creek/Umatilla Ecosystem Diagnosis and Treatment (EDT) model developed during the Subbasin planning process (NPCC, 2005) was used to setup the initial fish-habitat analysis framework. EDT reaches were linked to the thalweg lines (measured routes) through the use of relational tables.

Action Plan Tiered System

The spatial extent for assessment, data analysis and development of restoration strategies was defined using a tiered approach based on summer steelhead distribution, available data, and hydrology in the watershed. Tier 1 streams encompass steelhead distribution, are included in the 2013 LiDAR data extent, and are primary tributaries within the 12-digit Hydrologic Unit Code (HUC12) subwatershed. Tier 2 streams encompass steelhead distribution, are included in the 2013 LiDAR data extent, and are secondary or minor tributaries in the HUC12 subwatershed. Tier 3 streams may encompass steelhead distribution (but not in Tier 1 or Tier 2), or they may not be currently identified in the steelhead distribution, but may be significant contributors to maintaining water quality or quantity to downstream stream reaches. Five Tier 1 streams were identified in the Birch Creek Watershed, with assessments and restoration strategies completed for each of the following: Birch Creek, East Birch Creek, Pearson Creek, West Birch Creek, and Bear Creek.

The three tier system was developed based on the following primary considerations:

- Salmonid presence. Fish distribution should be the most important factor, because salmon recovery is the purpose of the Action Plan. According to the latest available information from ODFW (November 2014; https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=fishdistdata) steelhead have the most extensive distribution in the watershed (historic, current, and potential).
    - Review of Extensive Habitat Assessment (EHA) output from CTUIR (O'Daniel, 2012). The EHA predicted distribution for steelhead is within the extents of ODFW data, therefore no expansion beyond the ODFW data is needed.
- Major tributaries within each of the HUC12 subwatersheds within the Birch Creek Watershed. These tributaries represent the primary physical habitat for multiple life-history stages of steelhead, and are likely to be the primary locations for restoration actions.
- Major tributaries included in the 2013 LiDAR dataset. The availability of high-quality elevation data is critical to understanding the physical processes throughout the major tributaries in the watershed.

These primary considerations were used to define streams within this three-tier system as follows:

- Tier 1
    - Tributaries encompassing steelhead distribution, and

    - Tributaries that are primary tributaries within the HUC12 subwatershed, and
    - Tributaries included in the 2013 LiDAR dataset
- Tier 2
    - Tributaries encompassing steelhead distribution, and
    - Tributaries included in the 2013 LiDAR dataset
    - Secondary or minor tributaries within the HUC12 subwatershed
- Tier 3
    - Tributaries encompassing steelhead distribution, but not in Tier 1 or Tier 2
    - Tributaries not currently identified in the steelhead distribution, but may be significant contributors to maintaining water quality or quantity to downstream river reaches

The following is the final list of Tier 1, Tier 2 and Tier 3 streams within the Birch Creek Watershed for the Action Plan. The list is organized according to tributary structure within the watershed.

- **Tier 1 (primary tributaries within HUC12 subwatersheds) and Tier 2 (secondary tributaries within HUC12 subwatersheds)**
    - **Birch Creek (B)**
        - **Stewart Creek (ST)**
    - **West Birch Creek (WB)**
        - **Bear Creek (BR)**
            - **Lower Owings Cr (O)**
        - **Lower Bridge Creek (BG)**
        - **Lower Stanley Creek (SY)**
    - **East Birch Creek (EB)**
        - **Lower California Gulch (CG)**
        - **Pearson Creek (P)**
            - **Lower Little Pearson Creek (LP)**
- **Tier 3 (steelhead tributaries within HUC12 subwatersheds not included in Tier 1 or 2)**
    - **Willow Spring Canyon (Bear Creek tributary)**
    - **Unnamed tributaries (2) to Pearson Creek**
    - **South Canyon (East Birch tributary)**
    - **Unnamed tributaries (2) to East Birch**

Geomorphic Reaches

The Tier 1 and Tier 2 streams in the Birch Creek Watershed were delineated into distinct reaches based on their geomorphic characteristics. Reaches were delineated based on geomorphic process domains in order to guide the sampling, interpretation and identification of restoration strategies within similar physical-ecological systems at the reach scale (Montgomery, 1999; Fryirs and Brierley, 2013). Reaches were delineated based on valley confinement, geology of the valley floor and walls, slope, and tributary confluence locations. There were 32 geomorphic reaches delineated among the five Tier 1 streams (Table A-2).

TABLE A-2. GEOMORPHIC REACH CHARACTERISTICS

Name	Reach Code	Tier	Slope (%)	Confinement	Geology Channel	Geology Valley Right	Geology Valley Left	Channel Type	Sinuosity
Bear	BR1	1	1.22	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.24
Bear	BR2	1	1.89	Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.19
Bear	BR3	1	2.11	Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Plane-Bed	1.15
Bear	BR4	1	2.23	Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.17
Bear	BR5	1	4.12	Partially Confined	Intrusive Rocks	Intrusive Rocks	Intrusive Rocks	Step-Pool	1.13
Bear	BR6	1	6.32	Confined	Intrusive Rocks	Intrusive Rocks	Intrusive Rocks	Step-Pool	1.09
Birch	B1	1	0.69	Unconfined	Unconsolidated Alluvium	Sedimentary Rocks	Basalt Rocks	Pool-Riffle	1.21
Birch	B2	1	0.64	Unconfined	Unconsolidated Alluvium	Sedimentary Rocks	Sedimentary Rocks	Pool-Riffle	1.33
Birch	B3	1	0.78	Unconfined	Unconsolidated Alluvium	Sedimentary Rocks	Basalt Rocks	Pool-Riffle	1.14
Birch	B4	1	0.87	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.14
Birch	B5	1	0.88	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Sedimentary Rocks	Pool-Riffle	1.20
East Birch	EB1	1	1.30	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.15
East Birch	EB2	1	1.40	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.17
East Birch	EB3	1	1.61	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.10
East Birch	EB4	1	1.66	Partially Confined	Unconsolidated Alluvium	Sedimentary Rocks	Sedimentary Rocks	Plane-Bed	1.21

Name	Reach Code	Tier	Slope (%)	Confinement	Geology Channel	Geology Valley Right	Geology Valley Left	Channel Type	Sinuosity
East Birch	EB5	1	1.80	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.21
East Birch	EB6	1	2.21	Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.17
East Birch	EB7	1	5.23	Partially Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Step-Pool	1.09
East Birch	EB8	1	6.81	Partially Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Cascade	1.06
Pearson	P1	1	2.67	Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Plane-Bed	1.09
Pearson	P2	1	3.59	Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Step-Pool	1.09
Pearson	P3	1	3.48	Partially Confined	Unconsolidated Alluvium	Metamorphic Rocks	Metamorphic Rocks	Step-Pool	1.08
Pearson	P4	1	4.27	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Step-Pool	1.08
Pearson	P5	1	3.64	Partially Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Step-Pool	1.09
West Birch	WB1	1	1.16	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.14
West Birch	WB2	1	1.44	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Pool-Riffle	1.08
West Birch	WB3	1	1.91	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.10
West Birch	WB4	1	2.31	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.16
West Birch	WB5	1	2.78	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.15
West Birch	WB6	1	2.62	Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.05

Name	Reach Code	Tier	Slope (%)	Confinement	Geology Channel	Geology Valley Right	Geology Valley Left	Channel Type	Sinuosity
West Birch	WB7	1	4.15	Unconfined	Unconsolidated Alluvium	Metamorphic Rocks	Metamorphic Rocks	Step-Pool	1.13
West Birch	WB8	1	4.92	Partially Confined	Landslide Rocks	Landslide Rocks	Landslide Rocks	Step-Pool	1.06
Bridge	BG1	2	3.06	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.09
California Gulch	CG1	2	4.41	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Step-Pool	1.00
California Gulch	CG2	2	5.42	Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Step-Pool	1.02
Lower Pearson	LP1	2	8.15	Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Cascade	1.02
Owings	O1	2	2.27	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.03
Stanley	SY1	2	4.40	Confined	Basalt Rocks	Basalt Rocks	Basalt Rocks	Step-Pool	1.07
Stanley	SY2	2	5.78	Partially Confined	Unconsolidated Alluvium	Metamorphic Rocks	Metamorphic Rocks	Step-Pool	1.08
Stanley	SY3	2	6.22	Unconfined	Metamorphic Rocks	Metamorphic Rocks	Metamorphic Rocks	Step-Pool	1.08
Stewart	ST1	2	1.68	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.04
Stewart	ST2	2	2.61	Unconfined	Unconsolidated Alluvium	Basalt Rocks	Sedimentary Rocks	Plane-Bed	1.02
Stewart	ST3	2	2.53	Partially Confined	Unconsolidated Alluvium	Basalt Rocks	Basalt Rocks	Plane-Bed	1.03

FLOODPLAIN DELINEATION

Delineation of the valley bottom and floodplain along the geomorphic reaches was completed using GIS analysis and hydraulic modeling results. We used the Active River Area (ARA) methods described by Smith et al. (2008) and the associated ARA ArcGIS Toolbox. These methods were developed for 30-m DEM, and therefore we adapted the methods for use with the 1-m LiDAR data available in Birch Creek.

The ARA approach uses a DEM and the PathDistance method in ArcGIS to create a surface of the relative costs of traveling upslope from the stream. The cost is a computation of the elevation and distance from the channel, with higher costs for greater elevation and distances. The cost surface is continuous and therefore the technique requires that cost thresholds be identified beyond which the area is no longer likely to be dynamically linked to the channel (Smith et al., 2008). Cost thresholds are identified separately for channels that area defined as “headwater streams”, “mid-elevation streams”, and “lower elevation rivers.” The ARA approach is more appropriate for entrenched streams than other valley confinement methods that use factors of bankfull depth to calculate valley widths; this is because defining the floodplain width along entrenched channels as a function of calculated flow depth will highly underestimate the floodplain width that has been disconnected from the channel.

The ARA approach for the Birch Creek Watershed used the LiDAR DEM and thalweg lines for the geomorphic reaches. The geomorphic reach lines were converted to raster layers and coded as “headwater streams,” “mid-elevation streams,” and “lower elevation rivers.” The slope, flow direction and flow accumulation of each geomorphic reach grid cell was calculated. A cost distance grid was calculated separately for “headwater streams,” “mid-elevation streams,” and “lower elevation rivers,” using slope as the cost raster. Threshold values of the cost grids to delineate the ARA were set at 240, 400 and 400 for the “headwater streams,” “mid-elevation streams,” and “lower elevation rivers,” respectively. These values were set through iteration of threshold values, and comparing interim results to FEMA floodplain boundaries, HEC-RAS model outputs, and visual observations of orthophotos and the hillshaded LiDAR DEM. Output rasters were converted to polygons and split at the geomorphic reach breaks. The ARA processing methods resulted in delineating the floodplain boundary (or active river area for those reaches without a characteristic floodplain) for each geomorphic reach.

The results of the floodplain/valley delineation were used in subsequent analyses of hydrology and hydraulic characteristics. The floodplain/valley area was calculated separately for each geomorphic reach and used in the analysis of specific peak discharge (i.e., discharge divided by floodplain/valley area). The width of the floodplain/valley was sampled at 100-m intervals along the thalweg in order to calculate summary statistics of width by geomorphic reach. These widths were used for metrics of channel confinement (e.g., ratio of valley width to 2-yr discharge top width) and floodplain connectivity (e.g., inundated area ratios of 100-yr discharge top width to valley width).

HYDROLOGY

Birch Creek drains approximately 290 square miles into the Umatilla River. Mean basin precipitation is 22 inches annually and peak discharge events occur in response to rain-on-snow precipitation. Instantaneous peak discharges and daily low flow exceedance discharges were analyzed for Birch Creek and tributaries.

Watershed Scale Hydrologic Analysis

To analyze discharges at the watershed scale we used historic streamflow data from USGS Gage 14025000, at Rieth, Oregon. This gage was initially located 1,200 feet upstream of the confluence of Birch Creek and the Umatilla River and was operated by the USGS between 1928 and 1976. Data collection resumed in 1993 after the gage was moved approximately 300 feet further upstream (1,500 feet above the confluence). The Oregon Water Resources has since maintained the gage and publishes data online. Mean daily flows and peak discharges are available for 68 complete water years.

We estimated peak flow at specific recurrence intervals from 71 annual peak flow values. Of these, 68 were recorded values and three were extrapolated based on a regression of maximum instantaneous discharge and maximum mean daily discharge. Peak flows were analyzed using a Log-Pearson Type III (LP3) Distribution to estimate flood recurrence intervals and discharges. A workbook developed by GeoEngineers uses the methods described in Bulletin 17B from the USGS to estimate discharges at selected exceedance probabilities (USGS 1982). The results of this analysis are presented in Table A-3.

Daily exceedance statistics were also evaluated at the gage using the historic record of mean daily discharges between 1921 and 2014. Results for daily exceedance discharges are presented in Table A-4.

TABLE A-3. PEAK DISCHARGE SUMMARY

Return Period (Years)	Discharge (cfs)
1	155
2	544
5	989
10	1397
25	2070
50	2708
100	3482
200	4417

TABLE A-4. MEAN DAILY EXCEEDANCE DISCHARGE SUMMARY

Daily Exceedance	Discharge (cfs)
5% Exceedance Flow	230.0
50% Exceedance Flow	15.0
95% Exceedance Flow	0.0

Reach Scale Hydrologic Analysis

Peak discharges and low flow statistics were calculated for five Tier 1 streams, six Tier 2 streams and one Tier 3 stream within the Birch Creek Watershed. While an extensive flow record exists near the mouth of the watershed at USGS gage 14025000 (Birch Creek at Rieth), few gages with substantial data records exist for other locations in the watershed. To compensate for limited data, empirical regression equations were used to generate peak discharge and low-flow statistics. These equations were developed specifically for ungaged streams within the region and use watershed characteristics to estimate discharge.

Peak discharges statistics were based on equations developed by the State of Oregon Water Resources Department for eastern Oregon. Birch Creek is classified as being within Flood Region 2, north-central eastern Oregon. The watershed characteristics the regression equations use to estimate peak discharges include drainage area, mean January precipitation, mean July precipitation and soil storage capacity. We derived these variables using the online geospatial tool StreamStats (USGS, 2012). Watershed characteristics are shown in Table A-5. Peak flow statistics for each reach can be seen in Table A-6. All of the discharges listed in Table A-5 were estimated using this regression based method, with the exception of Birch Creek, for which the results of the gage analysis are repeated.

Similar to regression equations developed for peak flows, the USGS has generated regression equations to calculate flow-duration and low-flow frequency statistics in Oregon for each of ten hydrologic regions. Birch Creek is defined as being within Region 5. Input watershed characteristics include drainage area, mean annual precipitation and maximum elevation within the area of interest. These values were also determined using the online StreamStats delineation tool. Low flow statistics for the reaches are presented in Table A-7.

TABLE A-5. REACH-BASED DRAINAGE AREA CHARACTERISTICS

Reach	Drainage Area (square miles)	Mean Annual Precipitation (inches)	Maximum Elevation (feet)	January Mean Precipitation (inches)	July Mean Precipitation (inches)	Soil Storage Capacity (inches)
Birch Creek	285	22.20	5230	2.49	0.57	0.13
East Birch Creek	91.8	26.40	5230	2.92	0.68	0.14
Stewart Creek	14.7	21.90	3890	2.69	0.55	0.10
Pearson Creek	24.1	28.80	5230	3.29	0.78	0.16
Pearson Creek Tributary	2.31	29.10	5210	3.36	0.80	0.17
Little Pearson Creek	2.44	28.90	5230	3.14	0.76	0.16
California Gulch	7.31	28.40	5230	2.92	0.70	0.13
West Birch Creek	122	23.25	5190	2.56	0.59	0.13
Bear Creek	41.7	24.00	5110	2.67	0.61	0.12
Owings Creek	18.4	23.30	4700	2.71	0.59	0.11
Bridge Creek	13.8	25.10	5080	2.89	0.64	0.12
Stanley Creek	6.57	28.40	5190	3.20	0.75	0.13

TABLE A-6. REACH PEAK DISCHARGE SUMMARY (DISCHARGE IN CFS)

Flow Reach	Flood Frequency (Years)					
	2	5	10	25	50	100
Birch Creek	573	1090	1570	2360	3050	3800
East Birch Creek	429	1026	1484	1720	2054	2845
Stewart Creek	64	158	240	296	609	537
Pearson Creek	192	452	640	737	695	1151
Pearson Creek Tributary	33	81	116	139	118	215
Little Pearson Creek	30	75	110	133	123	211
California Gulch	53	130	190	230	293	381
West Birch Creek	454	1140	1701	2030	2691	3530
Bear Creek	178	439	653	784	1174	1358
Owings Creek	85	208	312	380	669	671
Bridge Creek	78	190	280	337	511	575
Stanley Creek	51	121	174	206	268	334

TABLE A-7. REACH MEAN DAILY EXCEEDANCE DISCHARGE SUMMARY (DISCHARGE IN CFS)

Reach	5% Exceedance	50% Exceedance	95% Exceedance
Birch Creek	487	24.3	3.2
East Birch Creek	245	12.5	1.8
Stewart Creek	30	0.8	0.1
Pearson Creek	85	4.3	0.7
Pearson Creek Tributary	10	0.5	0.08
Little Pearson Creek	10	0.5	0.1
California Gulch	27	1.3	0.2
West Birch Creek	244	11.9	1.6
Bear Creek	96	4.4	0.6
Owings Creek	42	1.6	0.2
Bridge Creek	38	1.7	0.2
Stanley Creek	25	1.2	0.2

HYDRAULICS

Hydraulic Model Setup

GeoEngineers applied the US Army Corps of Engineers (USACE) Hydrologic Engineering Center—River Analysis System (HEC-RAS) Version 4.1.0. HEC-RAS is a one-dimension model that solves energy and momentum equations to estimate hydraulic characteristics at user defined cross-sections. Hydraulic results include bankfull discharge, hydraulic radius, hydraulic depth, maximum depth, mean velocity and applied shear stress, among other characteristics. The HEC-RAS model was set-up using HEC-GeoRAS version 10.1. HEC-GeoRAS interfaces with ArcGIS to allow the HEC-RAS model to be created within ArcGIS.

Reach Streamlines

Reaches for the model were defined for all five Tier 1 streams, six Tier 2 streams and one of several Tier 3 streams within the Birch Creek Watershed. Reach centerlines followed the thalweg of each reach and were spatially defined using the LiDAR survey of Birch Creek. We utilized Spatial Analyst tools within ArcGIS to generate the location of each reach centerline. Results were checked using Google Earth imagery and then manually adjusted.

Cross-Sections

Cross-sections within the model are located every 500–1,000 feet along each of the reaches with orientation roughly perpendicular to the anticipated direction of flow. Additional cross-sections were placed within 20 feet of every bridge and several of the larger culverts within the basin. HEC-GeoRAS defined cross-section topography and bathymetry by sampling the LiDAR surface. The LiDAR data was collected between August 22 and August 25, 2013 when mean daily discharge was less than 1 cubic foot per second recorded at the gage at the mouth of Birch Creek. Therefore, the LiDAR survey provided a sufficient representation of channel bathymetry.

Discharge Values

Hydrologic inputs include the steady state values defined under the Reach Hydrologic Analysis above. In addition to these, we added several flow change locations between the reach confluences to model downstream flow accumulation.

Model Calibration

Channel and floodplain roughness values were approximated with a Manning's n-value and were based on field observations of grain size and roughness, references from a FEMA flood insurance study, standard hydraulic reference manuals, channel slope and engineering experience. Ineffective flow areas and banks stations were adjusted manually after running the model.

Hydraulic Model Results

Comparison to FEMA Water Surface Elevations

The FEMA Flood Insurance Study for Umatilla County, Oregon, includes water surface elevation for the 100-year recurrence interval flood at cross sections located near the town of Pilot Rock (FEMA, 2010). The reaches modeled include Birch Creek, East Birch Creek and West Birch Creek. A comparison of FEMA model results and the results from the hydraulic model are presented in Table A-8.

TABLE A-8. PEAK DISCHARGE COMPARISON SUMMARY

Reach	FEMA Cross Section	FEMA Water Surface Elevation (ft)	Model Water Surface Elevation (ft)	Difference (ft)
Birch Creek	A	1622.4	1621.9	0.5
	B	1625.1	1624.5	0.6
	C	1627.6	1624.8	2.8
East Birch Creek	A	1629.7	1629.3	0.4
	B	1631.4	1631.9	-0.5
	C	1633.3	1633.3	0.0
	D	1636.4	1634.9	1.5
	E	1637.4	1637.9	-0.5
	F	1640.8	1640.6	0.2
	G	1642.5	1641.5	1.0
	H	1642.6	1642.8	-0.2
	I	1643.6	1643.7	-0.1
	J	1645.5	1645.0	0.5
	K	1647.1	1646.7	0.4
	L	1647.8	1648.4	-0.6
	M	1650	1650.8	-0.8
	N	1651.9	1652.7	-0.8
	O	1654.7	1654.3	0.4
	P	1661.1	1660.5	0.6
	Q	1665.1	1666.6	-1.5
West Birch Creek	A	1628.9	1628.9	0.0
	B	1630.8	1630.5	0.3
	C	1632.1	1631.4	0.7
	D	1636	1635.1	0.9
	E	1638.8	1641.5	-2.7
	F	1643.8	1645.7	-1.9
	G	1647.1	1647.4	-0.3
	H	1651.5	1651.5	0.0
	I	1656.7	1655.7	1.0
	J	1659.3	1661.2	-1.9
	K	1663.3	1665.2	-1.9

Hydraulic Model Output

Hydraulic characteristics were output at all cross-sections for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr and 100-yr recurrence interval discharges. The model output included hydraulic depth (channel, overbank, average), velocity (channel, overbank, average), shear stress (channel, overbank, average), top width, and unit stream power in the channel. These model outputs were used to calculate additional hydraulic metrics, such as top width ratios that indicate incision/entrenchment (e.g., 5-yr:2-yr), indicators of channel confinement within a valley (e.g., ratio of valley width to 2-yr top width), indicators of hydraulic diversity (e.g., ratio of channel shear stress to average cross-section shear stress) and indicators of sediment mobility (e.g., ratio of the applied shear stress to the critical shear stress for selected grain sizes). Model outputs and hydraulic metrics were summarized by geomorphic reach.

WATERSHED SEDIMENT

Sediment yield within the Birch Creek Watershed was estimated through GIS-based spatial modeling. The primary objective for these analyses was to quantify the relative magnitude of sediment yield among subwatersheds. The sediment yield results are useful for making relative comparisons among subwatersheds, rather than comparisons of absolute magnitude, for reasons that include:

- The uncertainty in modeling the physical processes responsible for sediment erosion
- The uncertainty in the spatial data used for modeling
- The lack of empirical sediment yield data within the Birch Creek Watershed

Potential sediment yield to streams was modeled separately for hillslope erosion and road erosion, as is common practice in watershed sediment modeling (e.g., the U.S. Forest Service (USFS) application of NetMap in the Pacific Northwest) (Benda et al., 2007). The reason for using two separate models is because none of the most common, physically-based, spatially-distributed watershed models (ArcSWAT, GeoWEPP, DHSVM) have the capability to model road erosion. Thus, hillslope and road erosion are modeled separately based on equations and parameters specific to those processes. We used the ArcSWAT model for hillslope erosion and the WEPP:Road model for road erosion. WEPP:Road is one of the road erosion models implemented in the NetMap application used by the USFS (Benda et al., 2007). Road erosion in NetMap can also be estimated with the GRAIP model. The application of GRAIP requires empirical measurements of road surface erosion, and such a sampling program does not exist in the Birch Creek Watershed.

Results of these analyses were used for comparing the relative magnitude of sediment yield among subwatersheds for the same erosion process (i.e., road erosion among subwatersheds, hillslope erosion among subwatersheds). The data are presented in the typical dimensions of sediment yield as mass per unit area per unit time (e.g., ton ha^{-1} y^{-1}), including for road erosion estimates. Road erosion estimates are also presented in units of mass per unit length of road per unit time (e.g., kg km^{-1} y^{-1}).

Hillslope

Watershed sediment yield models were used to estimate the potential sediment delivery from hillslopes to the streams. The ArcGIS version of the Soil and Water Assessment Tool (ArcSWAT, v. 2012.10.18) was used to model hillslope erosion for the land cover and land use represented in the 1992 and 2011 data sets. Other inputs to the model included the elevation, slope and soils data.

Data Sources

National Landover Datasets (NLCD) from the USGS were used for land use inputs for 2011 and 1992. The entire Birch Creek watershed was downloaded from the (NLCD) website (http://www.mrlc.gov/nlcd2011.php), clipped to the National Hydrography Dataset NHD watershed boundary 12th field HUC and resampled to a 10m cell size ESRI grid format. Land use and vegetation cover categories were converted to the best fit category corresponding to the SWAT database.

Soils were obtained from the Soil Survey Geographic Database (SSURGO) and the US General Soil Map Coverage (STATSGO2) (http://websoilsurvey.nrcs.usda.gov/). The Northern portions of the Birch Creek watershed contains SSURGO data while the southern tip contains STATSGO information. The entire Birch Creek watershed was downloaded from the website, clipped to the NHD 12th field HUC and resampled to a 10m cell size ESRI grid format.

Modeling Parameters

All basins were modeled with the following parameters except where noted in Table A-9:

- Approximately 1 % of the watershed area was used as the threshold for stream definition as listed below
- Each basin was divided into 5 slope classes (listed below); breaks for the slope classes were established using the Slope tool in ESRI's Spatial Analyst tool box and classified using the Natural Breaks Classification option
- Hydrologic Response Unit (HRU) definition thresholds of 20% Land use, 10% Soils, 20% Slope
- Weather Station and data from WGEN_US_COOP_1960-2010
- Simulation period of 1/1/1960-12/31/2010
- Skewed normal rainfall distribution

TABLE A-9. ARCSWAT MODEL PARAMETERS EACH HUC12 SUBWATERSHED

HUC12 Code	HUC12 Name	Stream Threshold (ha)	Slope Breaks (%)
170701030601	Pearson Creek	62	16.73, 32.31, 46.15, 61.72
170701030602	Upper East Birch Creek	66	16.75, 33.50, 47.85, 63.00
170701030603	Lower East Birch Creek	110	13.36, 25.5, 37.63, 52.80
170701030604	Bear Creek-West Birch Creek	107	11.38, 22.75, 34.75, 50.55
170701030605	Jack Canyon	75	6.96, 13.92, 22.62, 35.49
170701030606	West Birch Creek	132	12.78, 25.56, 38.95, 54.76
170701030607	George Canyon	107	4.58, 7.96, 12.35, 50.80
170701030608	Stewart Creek-Birch Creek	65	9.34, 21.48, 33.63, 48.58
170701030609	Coombs Peak-Birch Creek	10	7.34, 15.09, 24.05, 37.91

ArcSWAT was run individually for the 9 HUC12 subwatersheds within the Birch Creek watershed. Two different scenarios were run for each subwatershed—1992 land cover and 2011 land cover.

Data Summary

Hillslope sediment yield within a subwatershed was summarized primarily with two metrics:

1. Average annual sediment yield within the subwatershed. This is a standard output summary from SWAT (output.std) of watershed average loading to streams, and does not include any channel routing. These are the weighted sums of HRU loadings.
2. Average annual sediment yield at the subwatershed outlet. This is a calculated value based on data in the "sed" table within each MS Access database.

Roads

Potential sediment delivery from primary and secondary roads was estimated with the road version of the Watershed Erosion Prediction Project model (WEPP:road). Road characteristics were developed from field surveys and elevation data in the GIS database.

The WEPP:road is an interface of the Water Erosion Prediction Project (WEPP) soil erosion model developed by the Rocky Mountain Research Station in 1999 (http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html). The procedure to calculate road runoff follows the WEPP:road Batch input screen provided by Washington State University (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproadbat.pl).

The WEPP:road analysis required a desktop and field study. The study plan was designed to collect the data necessary for the following model input parameters:

- Design (insloped bladed, insloped vegetated, outsloped rutted, outsloped unrutted)
- Road surface (native, gravel, paved)
- Traffic level (high, low, none)
- Road gradient (%)
- Road length (ft)
- Road width (ft)
- Fill gradient (%)
- Fill length (ft)
- Buffer gradient (%)
- Buffer length (ft)
- Rock fragment (%)

Road Data

In ArcGIS, we selected major roads that are likely to influence sediment yield in the Birch Creek Watershed using the Streets feature class provided by Umatilla County. These roads included primary and secondary unpaved roads, but did not include less traveled roads and trails on native soils. Therefore, the road erosion evaluation was not a comprehensive analysis of sediment delivery from all roads and trails in the Birch Creek Watershed.

We used the NHD Flowline and Umatilla Forest Service “reach” feature classes for streams. Road segments were segmented at each stream crossing. The selected roads were exported into a new shapefile, “Roads_Study_RTE” (roads). The horizontal distance between successive stream crossings represents the road segment length. The roads shapefile was exported to GISPro software in order to collect filed data using iPads. Data dictionary templates were developed for the GISPro software, so that the data necessary for the WEPP:road model parameters could be collected.

During August 2015, field data were collected from 159.43 miles of road throughout the Birch Creek Watershed (Table A-10.) Road data were collected with the GISPro data dictionary on GPS-enabled iPads. Road characteristics were observed and measured at multiple observation points along each road segment. Where road conditions changed appreciably within a predefined road segment, the road segment was split into two or more distinct segments. Photographs were acquired at the majority of data collection points.

TABLE A-10. MILES OF ROAD AND ROAD DENSITY IN EACH HUC12 SUBWATERSHED

HUC12 Code	HUC12 Name	Road Length (mi)	Area (sq mi)	Road Density (mi/sq mi)
170701030601	Pearson Creek	11.51	24.07	0.48
170701030602	Upper East Birch Creek	11.87	25.53	0.47
170701030603	Lower East Birch Creek	25.35	42.49	0.60
170701030604	Bear Creek-West Birch Creek	21.03	41.58	0.51
170701030605	Jack Canyon	12.53	29.05	0.43
170701030606	West Birch Creek	25.10	51.06	0.49
170701030607	George Canyon	27.54	29.95	0.92
170701030608	Stewart Creek-Birch Creek	21.34	25.10	0.85
170701030609	Coombs Peak-Birch Creek	3.17	15.64	0.20

Road data were post-processed in ArcGIS. Buffer widths and gradients were measured from a mid-point of the road segment to the nearest stream. Streams that were not parallel to the road segment required estimation for appropriate buffer dimensions. Stream buffers were digitized from the edge of road to nearest stream. Lengths were automatically generated in ArcMap. Gradients to the stream were manually calculated using elevation data (LiDAR or 10 M DEM). Buffer results were added to the RoadWEPP shapefile. Road segment gradients were manually calculated in ArcMap. Manual road slope acquisition was required because of inconsistencies in automatically generated elevation data. Traffic levels were interpreted from field observations, photographs, and historic aerial photography using Google Earth Pro.

Road Sediment Modeling

Spatial data for the road characteristics were delineated into the HUC12 subwatershed boundaries. The data were organized into WEPP:road input tables, with each defined road segment containing data for the model input parameters. These data were used as inputs to the online WEPP:road model at http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproadbat.pl. The models for each HUC12 were run for 50 years of simulated climate, based on data from nearby weather stations, including in Pilot Rock, Oregon.

Data Summary

WEPP:road model results were summarized for each HUC12 subwatershed. The two primary model outputs used in subsequent analyses were the average annual sediment leaving the road, and the average annual sediment leaving the buffer (also known as the "Potential Average Annual Sediment Delivery from Roads to Streams").

The length of road within each subwatershed was used to identify the magnitude of road management needs within each subwatershed. We summed the length of roads within each subwatershed that produced 80% of the average annual sediment leaving the buffer in that subwatershed. These data were summarized as the road length (miles, and percent of road length within each subwatershed) that is responsible for 80% of the average annual sediment leaving the buffer in that subwatershed.

REACH ASSESSMENT

Introduction

The reach assessment methods were designed to be consistent with the Physical Habitat Monitoring Strategy (PHAMS) for Reach-Scale Restoration Effectiveness Monitoring (Jones et al., 2015). The CTUIR habitat restoration efforts have shifted from site scale (1–10 meters) to the reach-scale (100–1,000 meters) in order to emphasize process-based restoration and to support the 2007 Accords Agreement with the Bonneville Power Administration (Jones et al., 2015). The Birch Creek Watershed Action Plan is focused on reach-scale restoration actions.

Prior to 2015, CTUIR habitat restoration project leaders chose metrics and protocols for effectiveness monitoring from site-scale methods, such as those from the Columbia Habitat Monitoring Program (CHaMP), Environmental Monitoring and Assessment Program (EMAP), PACFISH/INFISH Biological Opinion (PIBO), and Monitoring Methods (www.monitoringmethods.org) (Jones et al., 2015). The CTUIR determined that one limitation of these existing site-scale protocols was that none were explicitly designed to consider the scale of restoration projects as a factor in the design, collection and analysis of restoration effectiveness data (Jones et al., 2015). As such, the physical responses to restoration at the reach scale may be missed if only site-scale methods are used for reach assessment and effectiveness monitoring (Jones et al., 2015). For these reasons, the Birch Creek reach assessment methods were not based solely on existing, prescriptive site-scale methods such as CHaMP, EMAP, PIBO or USFS Level II.

The CTUIR developed PHAMS with the goal of filling the gap in available monitoring approaches for reach-scale restoration projects (Jones et al., 2015), like those being identified in the Birch Creek Watershed Action Plan. The PHAMS identifies general approaches to monitoring based on recent scientific literature, rather than prescribed methods in site-scale protocols (Jones et al., 2015). The PHAMS monitoring approaches are selected to emphasize measurements at the reach-scale that will provide metrics for various parameters of hydrology, geomorphology, connectivity and riparian vegetation—the River Vision Touchstones of functioning rivers (Jones et al., 2008). In addition, the PHAMS approach is intended to be flexible, whereby assessment and monitoring protocols can be selected from various site- and reach-scale methods, depending on the goals of the restoration project (Jones et al., 2015).

The PHAMS approach focuses on applying assessment and monitoring methods from the peer reviewed literature for physical features and riparian vegetation (Jones et al., 2015). As such, the Birch Creek reach assessment methods were based on the peer-reviewed literature identified in PHAMS, as well as related and more contemporary methods from the peer-reviewed literature. The Birch Creek reach assessment methods were designed to acquire the data necessary to quantify the Functional Metrics used to evaluate the reach-based Functional Categories of Hydrology, Hydraulic, Geomorphology and Physicochemical (Appendix B).

Data Collection

Geomorphic and habitat surveys of the reaches were completed in July and August of 2015. The surveys focused on Tier 1 and Tier 2 streams where access to the streams was granted by the adjacent landowners. The total field survey distance was approximately 48 miles (Table A-11). Surveys were completed by a team of two scientists consisting of a fluvial geomorphologist and a fish biologist. Prior to completing the surveys, spatial data depicting the delineated geomorphic reaches and linear referencing system were loaded onto ruggedized GPS-enabled iPad tablets. Separate geomorphic and habitat data forms were created in the GISPro software and loaded onto the iPads for data collection.

TABLE A-11. GEOMORPHIC AND HABITAT SURVEY DISTANCES

Tributary	Length (mi)
Birch	15.90
Bear	0.00
California Gulch	0.43
East Birch	11.14
Owings	1.30
Pearson	12.18
Stanley	0.01
Stewart	0.22
West Birch	7.09
Total	**48.28**

Geomorphic Assessment

Within each geomorphic reach, information was collected at every change in bedform type (e.g., head of riffle, head of pool, etc.) and continuously as encountered (Sear et al., 2009). The bedform change locations were identified along the longitudinal profile to delineate distinct, bank-to-bank geomorphic units (Peck et al., 2001; Archer et al., 2014; ODFW, 2014; ISEMP, 2012; Fryirs and Brierley, 2013). The bedform change locations were recorded as GPS points with attributes that included the bedform type (riffle head, riffle tail, pool head, pool tail, run head, run tail, step, cascade head, cascade tail), the physical control of the bedform (elevation, obstruction, bank, artificial), and the dominant and subdominant grain size (bedrock, boulder, cobble, coarse gravel, fine gravel, sand, silt) estimated from visual observations (Buffington and Montgomery, 1999; Bunte and Abt, 2001; ODFW, 2014).

Quantitative estimates of riverbed grain size distributions were derived from digital photographs (Bunte and Abt, 2001; Graham et al., 2005). At every three to five bedform change locations, digital photographs were acquired at two to four randomly selected locations. Digital photographs were post-processed using a C++ implementation of the Graham et al. (2005) routines in the Hydraulic Toolbox software (Aquaveo, 2013).

Depositional bars were identified and recorded as they were encountered continuously throughout each reach. The location of each bar was recorded as a GPS point with attributes that included bar type (lateral, mid-channel, transverse, point, vegetated island, delta), and the dominant and subdominant grain size (bedrock, boulder, cobble, coarse gravel, fine gravel, sand, silt) estimated from visual observations (Buffington and Montgomery, 1999; Bunte and Abt, 2001; ODFW, 2014).

Large wood material (LWM) was identified and recorded as encountered continuously throughout each reach. Individual pieces of large wood (>10 cm diameter and >1.0 m long) and large wood jams (>5 pieces of large wood) were enumerated (Roni et al., 2005; ISEMP, 2012; Archer et al., 2014). All LWM was recorded as GPS point features with attributes that included large wood type (log, log-rootwad, rootwad, jam), diameter category [small (<30 cm diam), medium (> 30 cm diam), large (> 60 cm diam)], length category [small (<3 m), medium (>3 m), large (>6 m)], location along the stream (channel, bank), orientation to flow as tangent to the bank from upstream (acute, perpendicular, obtuse).

Unstable stream bank conditions below the top of bank were identified and recorded as they were encountered continuously throughout each reach (Peck et al., 2001; USFS, 2013; Archer et al., 2014; ODFW, 2014). The locations of bank instability were recorded as GPS points with attributes that included the bank side (right, left), slope measured with a clinometer [undercut, steep (>45 deg), moderate (22–45 deg), shallow (<22 deg)], visual observations of bank materials (bedrock, boulder/cobble, cobble/gravel, gravel/sand, sand/silt/clay), visual observations of bank vegetation (none, herbaceous, shrubs, trees, roots), revetment type (none, riprap, LWD, other), and length of bank instability measured with a laser rangefinder or measuring tape.

Habitat Assessment

As primary controls on stream temperature, estimates of channel shading by the riparian vegetation and topography were completed with field surveys (USFS, 2013; ODFW, 2014) and from analysis of the 2013 orthophotos acquired during the LiDAR survey. At approximately every three to five bedform change locations, or when shading characteristics changed, the shade along both banks was measured with a clinometer from the center of the channel. GPS points were recorded to collect right and left bank attributes that included visual estimates of the dominant and subdominant vegetation (none, herbaceous, shrubs, trees), visual estimates of the dominant and subdominant cover extent [high (>75%), med-high (50–75%), med-low (50-25%), low (<25%)], and the degrees above horizontal to the top of the vegetation or topographic point along the right and left banks.

Quantitative estimates of the percent fines (<2 mm) on the riverbed surface were collected at approximately every three to five bedform change locations. Two to four randomly selected samples at these locations were identified. A 1.0 m metric measuring tape was placed on the riverbed surface and the dominant particle size at every 10 cm increment was recorded (Bain, 1999). GPS point locations were recorded with attributes that included the geomorphic unit type (pool, riffle), and the calculated percent fines.

Within each primary, bank-to-bank geomorphic unit, the number of secondary pool features created by localized structures (large wood, boulders, undercut banks) was enumerated (Stevenson and Bain, 1999; Peck et al., 2001). These local pools were identified and recorded as encountered continuously throughout each reach. GPS points were recorded for each local pool with attributes indicating the pool-forming feature (wood, boulder, bank, other).

Similarly, local habitat cover elements (large wood, vegetation, boulders, undercut banks) were enumerated within primary geomorphic units (Stevenson and Bain, 1999; Peck et al., 2001; ISEMP, 2012; ODFW, 2014). These local cover elements were identified and recorded as encountered continuously throughout each reach. GPS points were recorded for each cover element with attributes indicating the cover type (wood, vegetation, boulder, bank, other).

Fish passage barriers were identified and recorded as encountered continuously throughout each reach (Robison et al., 1999; WDFW, 2009). The locations were recorded as GPS point features with attributes including feature type (culvert, non-culvert crossing, fishway, dam, diversion, natural barrier, other), passage barrier significance (major, moderate, minor), reason (water surface drop, slope, velocity, depth, obstruction, other).

Non-Sampled Reaches

Geomorphic and habitat surveys of all reaches were not possible, due to landowners denying access to the tributaries. The spatial extent of the reach surveys is summarized in Table A-12. In order to include non-sampled reaches in the restoration strategy, it is necessary to develop some data summaries in order to complete the functional scoring for these reaches.

TABLE A-12. SUMMARY OF THE GEOMORPHIC AND HABITAT SURVEY EXTENT FOR EACH REACH

Stream	Reach Code	Tier	Sampled Distance (m)	Total Reach Length (m)	% of Reach Sampled
Birch	B1	1	7800	7800	100
Birch	B2	1	5910	5910	100
Birch	B3	1	4760	5460	87
Birch	B4	1	2120	2120	100
Birch	B5	1	5004	5804	86
Bridge	BG1	2	0	5500	0
Bear	BR1	1	0	6100	0
Bear	BR2	1	0	2900	0
Bear	BR3	1	0	3060	0
Bear	BR4	1	0	4760	0
Bear	BR5	1	0	4500	0
Bear	BR6	1	0	3790	0
California Gulch	CG1	2	700	1650	42
California Gulch	CG2	2	0	2598	0
East Birch	EB1	1	4600	6100	75

Stream	Reach Code	Tier	Sampled Distance (m)	Total Reach Length (m)	% of Reach Sampled
East Birch	EB2	1	2690	4290	63
East Birch	EB3	1	1960	3060	64
East Birch	EB4	1	3220	3220	100
East Birch	EB5	1	50	1450	3
East Birch	EB6	1	1900	7380	26
East Birch	EB7	1	2260	2260	100
East Birch	EB8	1	1140	3100	37
Lower Pearson	LP1	2	0	1536	0
Owings	O1	2	2100	3085	68
Pearson	P1	1	1410	1410	100
Pearson	P2	1	6380	6380	100
Pearson	P3	1	4460	4460	100
Pearson	P4	1	1560	1560	100
Pearson	P5	1	5790	5790	100
Stewart	ST1	2	0	2440	0
Stewart	ST2	2	200	3220	6
Stewart	ST3	2	0	3585	0
Stanley	SY1	2	20	2780	1
Stanley	SY2	2	0	3270	0
Stanley	SY3	2	0	2040	0
West Birch	WB1	1	3350	3350	100
West Birch	WB2	1	0	5060	0
West Birch	WB3	1	2450	3740	66
West Birch	WB4	1	1750	4340	40
West Birch	WB5	1	2800	3160	89
West Birch	WB6	1	30	2030	1
West Birch	WB7	1	1010	4730	21
West Birch	WB8	1	20	1690	1

Notes:

Shaded rows indicate reaches that were not sampled or under sampled (less than 50% of the reach length) because of landowner access denial.

The data for some functional parameters (Appendix B) in the non-sampled reaches are available from the hydrology and hydraulic modeling efforts. These parameters include: flow duration, floodplain connectivity, flow dynamics and sediment transport competency. The methods for estimating these functional parameters are the same for both sampled and non-sampled reaches.

The data for the water quality-temperature parameter (riparian % shade; relative % of dominant vegetation type) in the non-sampled reaches were acquired through aerial photo interpretation in ArcGIS of the 2013 orthophotos. Sampling points (n=584) were established at 100-m intervals along the reaches, and the length of the open riparian canopy was measured at each point. These measurements were used along with the reach-averaged bankfull width (derived from hydraulic modeling) to estimate the percent of the channel covered by riparian shade. The dominant vegetation type (trees, shrubs, herbaceous) in the riparian zone was also recorded.

Based on our review of the 2013 LiDAR data and orthophotos, data for the remaining functional parameters (LWD transport and storage; bank migration/lateral stability; bed form diversity; bed material characterization) in the non-sampled reaches could not be acquired through aerial photo interpretation, modeling or spatial analysis. The following is the approach for developing estimates for the habitat, substrate and wood metrics in Tier 1 non-sampled reaches (Table A-12):

- If the reach was sampled less than 50% but more than 10% of its length, then apply the sampling results to the remainder of the reach. This applies to:
  - East Birch: EB6, EB8
  - West Birch: WB4, WB7
- If the reach was sampled less than 10% of its length, then apply the summary results from the most geomorphically similar reach. This applies to:
  - Bear Creek, all reaches (BR1–BR6)
  - East Birch: EB5
  - West Birch: WB2, WB6, WB8

Based on geology, topography, elevation and vegetation, we identified reaches that are most geomorphically similar to each of the non-sampled reaches (Table A-13). The data summaries from the source reaches were applied to the non-sampled reaches as indicated in Table A-13. The data summaries apply to the following functional parameters:

- LWD transport and storage
- Bank migration/lateral stability
- Bed form diversity
- Bed material characterization

TABLE A-13. SUMMARY OF RECOMMENDED SOURCE REACH DATA FOR NON-SAMPLED REACHES

Non-Sampled Stream	Non-Sampled Reach Code	Source Stream	Source Reach Code
Bear	BR1	West Birch	WB3
Bear	BR2	Owings	O1
Bear	BR3	Pearson	P1
Bea	BR4	Pearson	P2
Bear	BR5	Pearson	P3

Non-Sampled Stream	Non-Sampled Reach Code	Source Stream	Source Reach Code
Bear	BR6	Pearson	P5
East Birch	EB5	East Birch	EB4
West Birch	WB2	East Birch	EB2
West Birch	WB6	West Birch	WB5
West Birch	WB8	West Birch	WB7

Data Summary

Summary data analyses were completed for the reach-based geomorphic and habitat assessments. The spatial data from the field work is contained in an ArcGIS geodatabase. These data were extracted from the geodatabase and summarized in spreadsheet tables and figures specific to each tributary. Data summaries included the metrics in Table A-14.

TABLE A-14. GEOMORPHIC AND HABITAT DATA ANALYSIS BY REACH AND UNIT LENGTHS[1]

Feature Class	Metrics
Bank Condition Below Bankfull Elevation	■ Length of unstable bank ■ Length of bank revetment
Bedform Change Location	■ Number of pools ■ Number of bedforms ■ Length of pools ■ Dominant grain sizes relative frequency from the survey ■ Sub-dominant grain sizes relative frequency from the survey
Depositional Bar	■ Number of bars; total and by type
Large Wood	■ Number of jams, total and by diameter and length categories ■ Number of logs, total and by diameter and length categories ■ Number of log-rootwads, total and by diameter and length categories
Local Pool	■ Number of local pools ■ Pool type relative frequency from the survey
Cover	■ Number; total and by type

Feature Class	Metrics
Substrate Percent Fines	■ Summary statistics (e.g., mean, range, SD) of percent fines ■ Summary statistics (e.g., mean, range, SD) of percent fines by channel unit
Riparian Vegetation	■ Summary statistics (e.g., mean, range, SD) of shade ■ Dominant veg relative frequency from the survey ■ Sub-dominant veg relative frequency from the survey
Passage Barrier	■ Number of passage barriers; total, by type, and by significance

Note:

[1] e.g., per 100 m, per 1000 m

FISHERIES ASSESSMENT

Approach

The Birch Creek Technical Team (BCTT) established and coordinated a Fisheries Workgroup (Workgroup) to conduct data discovery and technical review. The Workgroup convened in Mission Oregon at the initiation of the project, and during four technical review sessions. PFC worked directly with Workgroup participants in between technical review sessions to develop and review data and information needed to conduct the diagnosis.

Birch Creek salmon populations face multiple demographic pressures from multiple sources. The most explicit analyses (Jager et al., 1997) have shown that flow and its influence on temperature are only predictive of performance at their extremes. The remaining variance in restoration potential is associated with the combinations of degraded environmental attributes in the current condition.

The complexities of this problem requires both a multivariate approach, and an ecosystem approach that recognizes the complexity of the system and its history. Patient-Template Analysis (PTA) is an approach to the diagnosis of an ecosystem and focal population(s) that are depleted relative to their potential (Lichatowich et al., 1995). The approach recognizes the relationship between ecosystem health and habitat complexity. Salmon are highly migratory and self-organizing. To be sustained, salmon populations must spawn, rear, and migrate in specific locations during specific periods of time.

For depleted salmon populations, the diagnosis must also be sensitive to the range of life history diversity which directly impacts a population's sensitivity to environmental conditions. The comparison of Patient-Template or Current-Historic performance allows for an Observed/Expected analysis which can be used to identify restoration potential through diagnosis of degraded and lost habitat in specific terms regarding the life history diversity that is impacted.

The diagnosis was conducted using a series of equations and matrices structured based on the life history stage transitions for segments of the population (Caswell, 1978). Recruitment to the spawning population is represented as the final stage transition, estimated for salmon based on the Beverton-Holt stock-recruitment function (Moussalli and Hilborn, 1986). Regional Assessment of Supplementation Project (1992) developed the general implementation of these matrices for supplemented salmon populations in the Columbia Basin, from which numerous assessments and tools have been developed. The matrices include the following elements (taken generally from [Lichatowich et al., 1995] page 14):

- **Geography**—A spatially explicit matrix of the aquatic network and its annual maximum environmental conditions under Patient and Template scenarios
- **Time**—Seasonal (monthly) variance in environmental conditions and habitat connectivity
- **Biology**—Population segment state transitions which quantitatively approximate the life history of the target population and explain the exposure of different segments to conditions which vary in space and time

The matrices are structured based on the following general procedures:

1. **Watershed Examination**—The watershed is broken into sub-watersheds of appropriate size for the management system, within which the tributaries are divided into environmentally distinct reaches. These are identified based on similarities and differences in environmental conditions, the presence of passage obstructions or water withdrawals, and the geography of government and management boundaries. Segments may be as small as one meter or as long as is practical depending on the complexity of the watershed and the resources available for the diagnosis.
2. **Life History Simulation**—The life history is simulated based on the life history stage transitions specific to the population under consideration and the geography of the watershed. This results in a matrix of space-time transitions that describe the timing of segments of the population throughout their life cycle and migration. The transitions can be calculated across the entire life cycle to diagnose adult performance, and at finer scales to diagnose the discrete stages, stream reaches, and time periods.
3. **Patient-Template Assessment**—The environmental matrix describing conditions in reaches at times produced in step 1 is rotated against the matrix describing the biology produced in step 2 for both the Patient and Template conditions. Any number of independent and dependent variables may be then populated for points in time and space for each segment of the population depending upon the information available and the specific models being used.
4. **Patient-Template Analysis**—The Patient and Template matrices are compared by swapping the individual rows of the Patient scenario with the Template scenario, and estimating performance of the new partially swapped matrix. The change in performance represents the sensitivity of the population segment to limiting factors, reaches, and stages.

Watershed Examination

The Birch Creek geography was reviewed for distinct reaches in 2003 during the most recent Subbasin planning effort (NPCC, 2005). The previously developed geographic information was inherited in GIS format—from the Subbasin Planning Data and Document Archive. Spatial information was imported into ArcMap for review and editing by PFC.

The watershed level geography was reviewed by the Workgroup to provide a quality assessment of the watershed boundaries. United States Geological Survey Hydrologic Unit Codes (Seaber et al., 1984), and population structure of Birch Creek salmon and steelhead were overlain on the previously developed geography to determine if the watershed delineation was compatible with best available scientific information. The previously developed geometry was adjusted spatially as needed to conform to the known channel position, and was modified as needed to conform to the Tier 1 and Tier 2 Reach Breaks developed by the BCTT.

Environmental conditions were evaluated for distinct reaches and obstructions to determine conditions under current and historic scenarios. The environmental attribute definitions used in the prior assessment of the Birch Creek Watershed were inherited as straw-man attribute definitions for the current diagnosis (Lestelle, 2004; NPCC, 2005). Environmental attribute values developed during Subbasin planning were inherited as the null hypothesis for each reach, month, and attribute combination. Each of these were reviewed, and then adjusted based on new information for each attribute, reach, and month combination for which new information was discovered. Best available information was expanded to reaches that lacked information by evaluating the nearest neighbor information and adopting based on professional judgment.

Environmental data was inherited from the BCTT, and from the geomorphic and habitat assessment field surveys. Information was summarized for each survey reach, and transformed into an environmental attribute index based on a set of environmental attribute model definitions. Environmental Attribute Definitions were first imported from the prior diagnosis (Lestelle, 2004) and reviewed by the Workgroup. These definitions were adjusted and modified to incorporate the available environmental information conducted during the geomorphic and habitat assessments (Table A-15). The survey specific methods and environmental attributes were reviewed to develop analogues for previously defined attributes. Existing attribute definitions were inherited for each analogue (Lestelle, 2004). Attributes were redefined as needed to integrate existing data collection and data processing methodologies. Summary Statistics (point mean, mode, median, variance, standard deviation, and skewness) of each environmental attribute was calculated for each sampling. These values were used to generate three matrices:

1. **Gradient**—Contains summary statistics for the slope of each diagnostic reach. Gradient is constant in all months
2. **Habitat**—Contains the wetted stream length distance, surface area, volume, and percentage of reach for each habitat type and month
3. **Environmental Attributes**—Contains the point estimate, mean of each environmental attribute for each reach and month

TABLE A-15. ENVIRONMENTAL ATTRIBUTE MODEL DEFINITIONS USED TO CALCULATE ENVIRONMENTAL ATTRIBUTE INDICES BASED ON GEOMORPHIC AND WATER QUALITY SURVEY DATA

Attribute Category	Environmental Attribute	Attribute Definitions	Model
Channel	Bedscour	Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts and others (1983) based on information in Gordon and others (1991): gravel (0.2 to 2.9-inch diameter), small cobble (2.9 to 5-inch diameter), large cobble (5 to 11.9-inch diameter), boulder (>11.9-inch diameter).	If D50 is greater than 1.2, and d50 grain size is greater than 2.5, then y = -0.0035x4 - 0.006x3 + 0.2795x2 - 0.0303x + 0.0053 where x = D85 grain size
Habitat Complexity	Benthos Diversity	Measure of the diversity and production of the benthic macroinvertebrate community	=([@Sediment]*X1+[@BedformDiversity]*X2+[@LogJamsPer1000m]*X3)+B
Sediment	Fine Sediment (intra-gravel)	Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the focus watershed.	y = 0.0056x5 - 0.0688x4 + 0.3075x3 - 0.5906x2 + 0.5411x + 0.0027 where X = percent fines in riffles
Flow High	Flow High	The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad 2000b), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every 2 years (Q2yr).	y = 0.0473x4 - 0.7786x3 + 4.6136x2 - 12.085x + 13.325 where X = 5y:20yr top width ratio
Gradient	Gradient	slope of channel	Gradient
Habitat Type Cascade	Cascade		0.176470588
Habitat Type Riffle	Riffle		0.176470588

Attribute Category	Environmental Attribute	Attribute Definitions	Model
Habitat Type Cobbles	Step		0.411764706
Habitat Type Pool Tailouts	Pool		1
Habitat Type Primary Pools	Run		0.470588235
Passage	Passage	Probability of passage by direction, month, and life stage	Percent Passage by life stage
Riparian Function	Riparian Function	A measure of the percent of the reach within riparian function has been degraded	((Percent unstable plus 0.33 * percent revetted)+(Percent Riparian Shade))/2
Temp	Temperature - Daily Maximum	Maximum water temperatures within the stream reach during a month	(Lestelle 2004)
Habitat Complexity	Wood	The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces > 0.1 m diameter and > 2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson and others (1992), May and others (1997), Hyatt and Naiman (2001), and Collins and others (2002).	y = -0.3328x + 4.6425 where X = log jams/1000m
Key Habitat Quantity	Width	Wetted Widths	Width (meters)
Key Habitat Quantity	Channel Length	Wetted Length of Channel	Length (meters)

Water quality conditions were evaluated quantitatively based on existing routines. The frequency of monthly exceedances in daily maximum temperature was used to estimate the monthly Temperature Maximum attribute from each data set using protocols developed for the US Bureau of Reclamation (Mobrand-Jones & Stokes, 2005). Attribute estimates for specific points along the mainstem were applied to the diagnostic reach they reside on, and were extrapolated to nearest neighbors using metric-based nearest neighbor analysis in linear space (Micó et al., 1992). Temperature estimates for the tributaries to Birch Creek were assigned manually and reviewed by the Workgroup.

Flow data was inherited from the hydrologic analysis for this project. Daily flow data was post processed to estimate the frequency of high and low flows, and then transformed using techniques developed for the US Bureau of Reclamation to provide estimates of Flow High and Flow Low attributes for each sampling location (Watson and Blair, 2005). Attribute estimates were applied to the diagnostic reaches for which they were generated, and were extrapolated to nearest neighbors using metric-based nearest neighbor analysis in linear space (Micó et al., 1992). Flow attributes for tributaries to Birch Creek were developed by hand based on the relative contribution of each subwatershed using Streamstats (Ries III et al., 2008) and previously published regression models for estimating flow frequencies at ungaged streams (Sanborn and Bledsoe, 2006).

Life History Simulation

Life history simulations were inherited from the previous diagnosis to provide life history hypotheses (NPCC, 2005). The range of life stage timing and locations were estimated from the previously produced life history simulations, and evaluated against best available field information. Field based estimates of life stage timing and locations were reviewed by the Workgroup for adult (Contor, 2013, 2014, 2015) and juvenile (Hanson et al., 2009; Hanson and Schultz, 2010, 2011; Hanson and Jewett, 2013; Hanson et al., 2014, 2015) steelhead, and used to revise the life history hypotheses.

Previously generated life history simulations that were outside of the hypothesized ranges of life stage timing and distribution were removed from the Life History matrix. Additional life history simulations were conducted to ensure that one life history simulation was seeded in each linear stream meter of spawning habitat for each spawning week for each life history type. Life histories were simulated using Agent Analyst© (Johnston, 2013) in ArcMap. Agents were generated to simulate life histories across the life cycle for each life history type, spawning reach, spawning week, and linear meter of spawning habitat within the reach using the life history hypotheses similar to the prior analysis (Blair et al., 2009).

Patient Template Assessment

Environmental Sensitivities from the prior analysis were inherited for each Life Stage, Environmental Type, and analogous Environmental Attribute. This matrix was reviewed by the Workgroup, and updated using a modified **Delphi Method** (Helmer and Rescher, 1959; USFWS, 1987; Creswell, 2013). The final set of Environmental Sensitivities was used to estimate instantaneous Performance (Productivity and Capacity) for each record in the Life History matrix under the Patient and Template conditions using Microsoft Excel and the equations that were documented for the prior analysis (Blair et al., 2009). Changes in Capacity and Productivity for life stages in the Columbia River, Columbia Estuary, and ocean were approximated based on published survival studies (Hanson et al., 2009; Hanson and Schultz, 2010, 2011; Hanson and Jewett, 2013; Hanson et al., 2014, 2015).

Obstructions to migration were evaluated independently of the physical or biological condition of the diagnostic reaches. Estimates of the influence of each obstruction on productivity above (for upstream migration) and below (for downstream migration) for each life stage and month were inherited from the prior analysis. Best available information was reviewed for each obstruction against previously published passage criteria for steelhead (Robison et al., 1999). **Inlet Depth**, **Outlet Depth**, **Minimum Channel Depth**, **Outlet Drop**, **Jump Pool**, and **Channel Gradient** were evaluated to determine passage condition based on Adult and Juvenile steelhead and Chinook.

Each passage attribute was estimated based on fish passage requirements based on a review of (Robison et al., 1999) and (Fisheries, 2001). Passage was estimated to be unimpaired (100%), slightly impaired (90%), likely impaired (50%), or impaired (0% passage) (Table A-16). Each Workgroup participant reviewed each obstruction to estimate the passage parameters based across the relative hydrograph for Birch Creek to provide a monthly estimate of each parameter. These were evaluated using the Delphi Method, and a final ranking was selected for each. The variance for each ranking was recording as an index of uncertainty surrounding the professional judgment. A final passage estimate was determined for each life stage and month based on the minimum estimate of the final scores. The influence of each obstruction was estimated in terms of the impacts to the population's overall Productivity and Capacity based on a comparison under Patient and unimpeded conditions: even if a natural barrier historically existed. A total of 72 barriers were identified and shown in Table A-17.

TABLE A-16. PASSAGE CRITERIA FOR ADULT (A) AND JUVENILE SALMON

Parameter	Definition	100% Passage	90% Passage (Some Concern)	50% Passage (Uncertain Passage)	0% Passage (Limited Passage)
Inlet Depth (A)	Depth of water at structure inlet	7 inches or greater	5–7 inches	1–5 inches	dewatering
Juveniles		4 inches or greater	3–4 inches	1–3 inches	1 inch or less
Outlet Depth (A)	Depth of water at outfall	Full backwatering	7–6 inches	6–1 inches	dewatering
Juveniles		Full backwatering	4–3 inches	3–1 inches	1 inch or less
Minimum Channel Depth (A)	Depth of water in structure channel	7 inches or greater	5–7 inches	1–5 inches	dewatering
Juveniles		4 inches or greater	3–4 inches	1–3 inches	1 inch or less
Entrance Jump (A)	Distance of jump relative to pool depth at 20 degrees Celsius	Less than 1 foot	1–3 feet	3–6 feet	6–12 feet
Juveniles		Less than 6 inches	6–12 inches	1–2 feet	2–6 feet

Parameter	Definition	100% Passage	90% Passage (Some Concern)	50% Passage (Uncertain Passage)	0% Passage (Limited Passage)
Channel Gradient (A)	Gradient along wetted channel through structure	Less than 0.5%	0.5–2%	2-4%	4–8%
Juveniles		Less than 0.5%	0.5–1%	1–3%	3–6%
Jump Pool (A)	Pool depth at jump position	1.5 times jump height or 2 ft at 1 foot from Outlet	1.5 times jump height or 2 ft at less than 3 ft from Outlet	Less than 1.5 times jump height or but less than 1.5 times jump height distance from Outlet	Less than 2ft and greater than 1.5 times jump height from Outlet
Juveniles		1.5 times jump height at 6 inches from Outlet	1.5 times jump height at less than 1 ft from Outlet	Less than 1.5 times jump height or 1 ft from Outlet	Less than 1 times jump height and more than 1 times jump height from Outlet

Note:

Based on review of criteria from (Fisheries, 2001), (Agrawal et al., 2005), and (Robison et al., 1999).

Patient Template Analysis

The Patient-Template analysis followed the general approach used for the prior assessment (Lichatowich et al., 1995). Limitations to the performance of each life stage were evaluated by iteratively swapping elements of the Patient and Template matrices, and estimating performance at various levels of aggregation. Performance was calculated for each diagnosis based on the algorithms used in the prior assessment (Mobrand Biometrics, 2005).

The following diagnoses were conducted to determine the limitations of different components of the population on the Productivity, Capacity, Life History Diversity, and Equilibrium Abundance of the population of the population as a whole:

1. **Life Stage Analysis**—The percent change in performance for the population after swapping the elements for a life stage from the Patient Performance matrix with the comparable elements from the Template Performance matrix, and recalculating the performance for the Patient Performance matrix
2. **Population Limiting Factors Analysis**—The percent change in population performance estimated by swapping the elements for an Environmental Attribute in the Patient Environmental Attribute matrix with the comparable elements from the Template Environmental Attribute matrix, recalculating the Patient Performance matrix, and then recalculating the performance of the population
3. **Reach Limiting Factors Analysis**—The percent change in performance of the population's life stages that are exposed to a reach estimated by swapping the elements for an Environmental Attribute and Reach in the Patient Environmental Attribute matrix with the comparable elements from the Template

Environmental Attribute matrix, recalculating the Patient Performance matrix, and then recalculating the performance of the population

4. **Reach Restoration Analysis**—The percent change in performance for the population after swapping the elements for a reach in the Patient Performance matrix with the comparable elements from the Template Performance matrix, and recalculating the performance for the Patient Performance matrix

   Reach Protection Analysis—The percent change in performance for the population after swapping the elements for a reach in the Patient Performance matrix with zeroes and re-calculating performance for the Patient Performance matrix

Table A-17. Fish Passage Barriers Identified in the Birch Creek Watershed

Object ID	Stream Name	Geomorphic Reach	Obstruction Description	Step Height	Pool Depth	Scour Pool Length	River Mile	East	North	Upstream Capacity	Upstream Productivity	Upstream Neq	Weighted Neq	Risk
28	Birch Creek	B1	Whitney Dam. Pool length estimated by GIS measure in 2015 field collection.	2.30	4.8	15	2.78	355884.4523	5054302.993	1024.509498	3.141305528	698.3681887	1396.736377	Major
27	Birch Creek	B1	Dimensions derived from 2015 field survey photos and GIS measure. Rock weir below withdrawal. Notch appears to allow passage.	0.50	1.0	100	3.72	356863.1758	5053504.566	1024.509498	3.141305528	698.3681887	0	Minor
29	Birch Creek	B1	Small rock weir with debris racking.	0.00	0.0	0	2.68	355830.2521	5054404.329	1024.509498	3.141305528	698.3681887	0	Minor
63	Birch Creek	B1	Dimensions estimated from 2015 field survey photos and GIS measure. Boulder grouping with shallow flow in notch.	1.50	2.0	100	1.78	354759.3279	5055323.006	1024.509498	3.141305528	698.3681887	698.3681887	Moderate
26	Birch Creek	B1	Pool length estimated from 2015 field survey GIS measure and aerial photograph.	0.00	0.0	17	4.97	357118.6686	5053277.414	1024.509498	3.141305528	698.3681887	698.3681887	Moderate
80	Birch Creek	B2	Pool length estimated from 2015 field survey photos. Old concrete bridge footing and abutment, 2 meter elevation drop to streambed invert.	1.90	3.4	17	8.65	359517.3480	5047820.735	1024.509498	3.141305528	698.3681887	1396.736377	Major
41	Birch Creek	B2	Hummel/Garton Diversion. Concrete apron extends 15 feet upstream and 20 feet downstream. 3 feet maximum drop over concrete, sloped backside mixed flat concrete and cobble accumulation.	1.25	4.7	75	9.96	359962.4422	5045564.908	1024.509498	3.141305528	698.3681887	1396.736377	Major
19	East Birch Creek	EB5	Channel spanning log weir.	0.80	2.6	UKN	10.16	364175.0011	5028653.006	1024.509498	3.141305528	698.3681887	0	Minor
75	Birch Creek	B5	Two boulder steps of high significance, built as grade control for removal of prior upstream obstruction.	0.00	0.0	UKN	15.85	357011.4479	5038877.001	941.5276877	3.295666339	655.8410948	1311.68219	Major
76	Birch Creek	B5	Boulder weir for irrigation diversion.	0.00	0.0	UKN	15.40	357239.7205	5039516.912	941.5276877	3.295666339	655.8410948	1311.68219	Major
77	Birch Creek	B5	Boulder weir for irrigation diversion.	0.00	0.0	UKN	15.30	357227.8105	5039677.867	941.5276877	3.295666339	655.8410948	1311.68219	Major
78	Birch Creek	B5	Boulder step.	0.00	0.0	UKN	14.92	357391.0851	5040188.786	941.5276877	3.295666339	655.8410948	1311.68219	Major
79	Birch Creek	B5	Gravel pushup in channel.	0.00	0.0	0	13.05	358835.6894	5042237.861	941.5276877	3.295666339	655.8410948	1311.68219	Major
88	Birch Creek	B5	Two boulder steps of moderate significance.	0.00	0.0	UKN	15.81	357034.6048	5038921.239	941.5276877	3.295666339	655.8410948	655.8410948	Moderate
16	Bridge Creek	BG1	Culvert at Yellow Jacket Road.			UKN	3.52	351320.1000	5027700.000	44.65183324	1.637615313	17.38545823	0	Minor
52	California Gulch	CG1	Large rock and steepened riffle.	0.00	0.0	0	0.30	358748.5234	5029485.169	43.07258746	1.354198193	11.26587876	0	Minor
54	East Birch Creek	EB1	Vehicle ford and livestock trail.	0.00	0.0	0	2.13	357098.9301	5035360.087	584.5326796	3.251708564	404.7709734	0	Minor
55	East Birch Creek	EB1	Rock weir.	0.00	0.0	UKN	0.70	356783.7948	5037518.213	584.5326796	3.251708564	404.7709734	0	Minor
56	East Birch Creek	EB1	Four boulder steps. Pool length estimated from GIS data. Elevation difference of 0.6 feet from water surface to crest.	1.50	0.0	0	0.05	356668.8651	5038373.247	584.5326796	3.251708564	404.7709734	0	Minor
57	East Birch Creek	EB1	Irrigation withdrawal. Dimensions estimated using 2015 field survey GIS data.	2.00	3.0	40	3.35	357175.2917	5033624.258	584.5326796	3.251708564	404.7709734	404.7709734	Moderate
58	East Birch Creek	EB1	Bedrock cascade.	0.00	0.0	0	3.24	357205.5255	5033765.997	584.5326796	3.251708564	404.7709734	404.7709734	Moderate
59	East Birch Creek	EB1	Vehicle ford with subsurface flow.	0.00	0.0	0	3.20	357191.5005	5033826.986	584.5326796	3.251708564	404.7709734	404.7709734	Moderate
38	East Birch Creek	EB2	Vehicle ford.	0.00	0.0	0	5.78	358459.5975	5030552.736	543.7092573	3.269592603	377.4165954	0	Minor
53	California Gulch	CG1	Vehicle ford with large rock drop at downstream edge.	0.00	0.0	0	0.01	358951.3764	5029894.139	543.7092573	3.269592603	377.4165954	0	Minor
36	East Birch Creek	EB2	Rock weir. Pool depth and length estimated from 2015 field survey GIS and photo.	1.30	2.0	15	6.23	358872.4737	5030001.313	543.7092573	3.269592603	377.4165954	377.4165954	Moderate
37	East Birch Creek	EB2	Vehicle ford with subsurface flow. Dimensions estimated from 2015 field survey GIS and photos.	1.50	1.0	65	6.03	358666.9135	5030203.426	543.7092573	3.269592603	377.4165954	377.4165954	Moderate
39	East Birch Creek	EB2	Irrigation diversion. Plastic lined pushup dam.	0.80	1.2	30	5.77	358414.9377	5030573.531	543.7092573	3.269592603	377.4165954	377.4165954	Moderate
40	East Birch Creek	EB2	Subsurface flow through large rock substrate.	1.20	1.5	35	4.05	357564.6293	5032645.636	543.7092573	3.269592603	377.4165954	377.4165954	Moderate

Object ID	Stream Name	Geomorphic Reach	Obstruction Description	Step Height	Pool Depth	Scour Pool Length	River Mile	East	North	Upstream Capacity	Upstream Productivity	Upstream Neq	Weighted Neq	Risk
20	East Birch Creek	EB6	Channel spanning log weir.	0.50	1.0	UKN	11.06	365842.0011	5028269.006	176.3739066	3.346829242	123.6751001	0	Minor
21	East Birch Creek	EB6	Log weir across 1/2 the channel width.	0.00	0.0	UKN	11.30	365842.0011	5028269.006	176.3739066	3.346829242	123.6751001	0	Minor
22	East Birch Creek	EB6	Undermined and failing log weir with a majority of water going under log.	1.30	2.1	0	11.30	365477.0011	5028284.006	176.3739066	3.346829242	123.6751001	0	Minor
23	East Birch Creek	EB6	Channel spanning log weir.	1.70	1.2	UKN	14.95	370605.0011	5025929.006	67.80825601	3.005265142	45.24510341	0	Minor
35	East Birch Creek	EB6	Vehicle ford.	1.70	1.2	0	15.08	370771.5143	5025923.256	67.80825601	3.005265142	45.24510341	0	Minor
33	East Birch Creek	EB7	Vehicle ford.	2.00	0.0	0	16.14	372394.7230	5026428.728	30.48315941	2.342443375	17.46975651	0	Minor
34	East Birch Creek	EB7	Channel spanning debris jam with 2 foot drop.	2.00	1.5	30	15.62	371614.8210	5026304.933	30.48315941	2.342443375	17.46975651	0	Minor
31	East Birch Creek	EB8	Subsurface flow.	1.00	0.0	0	16.78	372994.4554	5025706.088	13.27312674	2.342443375	7.606767037	0	Minor
32	East Birch Creek	EB8	Tributary crosses road to the main channel. Dimensions are estimated from 2015 field survey GIS measure.	0.00	0.0	20	16.53	372889.2053	5026089.083	13.27312674	2.342443375	7.606767037	7.606767037	Moderate
83	Pearson Creek	P1	Boulder weir under bridge with notch.	0.00	0.0	UKN	0.30	364999.0820	5027886.917	161.2136189	4.096893072	121.8634049	0	Minor
60	Pearson Creek	P2	Boulder and bedrock pool. Length estimated with 2015 field survey GIS measure and photo. Over 4 foot elevation drop, trapped fish in pool. No flow at outlet.	4.00	1.0	8	4.30	365228.7669	5021887.582	145.7155655	4.807435734	115.4051103	230.8102205	Major
81	Pearson Creek	P2	Rock weir without a plunge pool.	0.30	0.0	0	2.30	364760.8602	5024850.975	145.7155655	4.807435734	115.4051103	0	Minor
82	Pearson Creek	P2	Subsurface flow through large substrate.	0.00	0.0	0	1.90	364509.4170	5025411.478	145.7155655	4.807435734	115.4051103	0	Minor
61	Pearson Creek	P2	Boulder and bedrock pool. Pool length estimated from 2015 field survey GIS measure and photo. Subsurface flow below main drop with water in bottom of pool.	2.00	0.5	3	4.26	365216.7722	5021898.094	145.7155655	4.807435734	115.4051103	115.4051103	Moderate
62	Pearson Creek	P2	Boulder structure dimensions estimated from 2015 field survey photos. Subsurface flow with active side channel.	4.00	0.0	0	4.20	365148.3428	5021965.792	145.7155655	4.807435734	115.4051103	115.4051103	Moderate
89	Pearson Creek	P3	Culvert (CMP) on Pearson Creek Road. Dimensions estimated from 2015 field survey photos.			1.5	6.69	363500.0689	5019544.185	96.76352776	4.768716027	76.47221094	0	Minor
86	Pearson Creek	P3	A set of three large boulder drops that may be a grade control structure. Dimensions estimated from 2015 field survey photos.	2.00	1.2	20	5.48	364708.3367	5020924.180	96.76352776	4.768716027	76.47221094	0	Minor
87	Pearson Creek	P3	Large boulder drop with a 1.5 foot elevation difference. Dimensions estimated from 2015 field survey photos. Deep plunge pool at outfall.			UKN	6.00	364186.0812	5020213.004	96.76352776	4.768716027	76.47221094	76.47221094	Moderate
85	Pearson Creek	P3	Boulder drop with moderate plunge pool. Dimensions estimated from 2015 field survey photos. Estimated 1 foot drop above inlet and perched 1 foot outlet.	1.00	1.2	35	5.51	364621.4541	5020908.640	96.76352776	4.768716027	76.47221094	76.47221094	Moderate
66	Pearson Creek	P5	Culvert, not perched and slope appears low.	0.00	0.0	0	10.90	359502.0630	5016697.694	31.81901837	4.691276615	25.0364257	0	Minor
67	Pearson Creek	P5	Culvert with sediment deposition upstream of pipe. Approximately 0.5 foot drop at inlet.	0.50	0.0	0	10.85	359572.5579	5016681.917	31.81901837	4.691276615	25.0364257	0	Minor
68	Pearson Creek	P5	Boulder and bedrock drop of approximately 1 foot. Fish noted in pool, one approaching 6 inches.	1.00	1.5	12	10.60	359964.4583	5016617.383	31.81901837	4.691276615	25.0364257	0	Minor
69	Pearson Creek	P5	Boulder and bedrock drop of approximately 2 foot drop.	2.00	1.0	6	10.59	359977.8747	5016612.285	31.81901837	4.691276615	25.0364257	0	Minor
70	Pearson Creek	P5	Channel spanning log with approximately 2 foot drop.	1.00	1.0	1	10.59	359986.0677	5016616.600	31.81901837	4.691276615	25.0364257	0	Minor
65	Pearson Creek	P5	Log and rock debris blockage in channel.	0.00	0.0	0	11.20	359102.1174	5016836.572	31.81901837	4.691276615	25.0364257	25.0364257	Moderate

Object ID	Stream Name	Geomorphic Reach	Obstruction Description	Step Height	Pool Depth	Scour Pool Length	River Mile	East	North	Upstream Capacity	Upstream Productivity	Upstream Neq	Weighted Neq	Risk
30	Pearson Creek	P5	Culvert of baffled CMP with debris in the inlet. Potentially slightly undersized, moderate plunge pool at outlet, not perched.	0.00	0.8	20	8.51	362904.9001	5016936.491	31.81901837	4.691276615	25.0364257	25.0364257	Moderate
25	Stanley Creek	SY1	Culvert on County Road 1407.	0.00	1.3	UKN	0.06	353771.0011	5026434.006	45.33468526	2.769339745	28.9644709	0	Minor
47	West Birch Creek	WB1	Drop in channel upstream of gauge. Estimated drop of 2 feet from 2015 field survey photos.	2.00	0.0	UKN	0.10	356544.9250	5038362.100	431.9872943	3.024859855	289.1749608	578.3499216	Major
24	West Birch Creek	WB1	Irrigation diversion with a measured length of 4.3 feet.	0.80	0.8	0	1.20	355529.0011	5036698.006	431.9872943	3.024859855	289.1749608	0	Minor
46	West Birch Creek	WB1	Concrete channel with very shallow flow down left side. Step height estimated from 2015 field survey photo.	1.50	0.0	0	1.12	355536.6284	5037290.581	431.9872943	3.024859855	289.1749608	289.1749608	Moderate
74	Birch Creek	B5	Boulder and wood debris in steep portion of channel.	1.50	2.5	40	16.20	356665.8199	5038484.859	431.9872943	3.024859855	289.1749608	289.1749608	Moderate
48	West Birch Creek	WB1	Concrete weir with notch. Step height estimated from 2015 field survey photo.	1.10	2.3	40	0.05	356580.7320	5038406.120	431.9872943	3.024859855	289.1749608	289.1749608	Moderate
49	West Birch Creek	WB3	Vehicle ford with subsurface flow upstream and downstream.	0.00	0.0	0	7.25	351720.6750	5030018.422	235.4810477	2.493860952	141.0567585	0	Minor
50	West Birch Creek	WB3	Wood and substrate deposition caused by small fence across channel.	0.00	0.0	0	6.61	351955.8076	5030913.055	235.4810477	2.493860952	141.0567585	0	Minor
51	West Birch Creek	WB3	Vehicle ford with subsurface flow upstream and downstream.	0.00	0.0	0	6.38	352061.3128	5031267.996	235.4810477	2.493860952	141.0567585	0	Minor
84	West Birch Creek	WB4	Hascall concrete irrigation diversion at County Road 1407 crossing. Structure and pool dimensions estimated from 2015 field survey GIS and photos. Vertical drop of approximately 3 feet with 1 foot deep pool below.	3.00	1.0	15	8.26	352212.7130	5028783.994	165.9981524	2.886130311	108.482332	108.482332	Moderate
71	West Birch Creek	WB5	Vehicle ford with subsurface flow.	0.00	0.0	0	10.82	353397.9564	5025341.609	101.930582	2.99537647	67.90127613	0	Minor
72	West Birch Creek	WB5	Channel spanning log with approximately 2 foot drop. Large trout stranded in pool below.	0.00	0.0	UKN	10.70	353416.5134	5025517.824	101.930582	2.99537647	67.90127613	0	Minor
44	West Birch Creek	WB5	Subsurface flow with water visible in places through cobbles.	0.00	0.0	0	11.15	353311.9011	5024823.561	101.930582	2.99537647	67.90127613	0	Minor
73	West Birch Creek	WB5	Vehicle ford with subsurface flow that continues downstream.	0.00	0.0	0	10.50	353551.5461	5025849.794	101.930582	2.99537647	67.90127613	67.90127613	Moderate
45	West Birch Creek	WB5	Subsurface flow in large cobble substrate.	0.00	0.0	0	10.98	353358.2212	5025114.419	101.930582	2.99537647	67.90127613	67.90127613	Moderate
42	West Birch Creek	WB7	Vehicle ford with subsurface flow.	0.00	0.0	0	15.30	355235.9949	5019314.192	78.25371565	4.215828334	59.69183185	0	Minor
43	West Birch Creek	WB7	Subsurface flow in gravel and cobble for approximately 10 to 15 feet.	0.00	0.0	0	15.22	355223.6213	5019404.537	78.25371565	4.215828334	59.69183185	0	Minor

APPENDIX B
Functionality Tables

Table B-1. Primary Limiting factors (as stated in 2008 Accords), NOAA Ecological Concerns, River Vision Touchstones, and Reach Functionality Categories and Parameters

Primary Limiting Factors[1]	NOAA Ecological Concerns[2]	River Vision Touchstone[3]	Functional Category	Functional Parameters
In-channel Characteristics	Bed and Channel Form Instream Structural Complexity	Primary: Geomorphology Secondary: Aquatic Biota	Geomorphology Hydraulic	LWD Transport and Storage Bank Migration/Lateral Stability Bed Form Diversity Bed Material Characterization
Passage/Entrainment	Anthropogenic Barriers	Primary: Connectivity Secondary: Aquatic Biota	Biology Hydraulic Geomorphology	Flow Duration Physical Longitudinal Connectivity (Barriers)
Riparian/Floodplain	Riparian Vegetation LWD Recruitment Floodplain Condition	Primary: Riparian Vegetation Secondary: Connectivity Tertiary: Geomorphology	Biology, physicochemical Geomorphology Hydraulics	Riparian Vegetation Floodplain Connectivity Water Quality—Temperature
Sediment	Increased Sediment Quantity	Primary: Geomorphology Secondary: Aquatic Biota	Hydraulic Geomorphology	Bed Material Characterization Bank Migration/Lateral Stability
Water Quality Temperature	Temperature Decreased Water Quantity	Primary: Geomorphology Secondary: Riparian Vegetation Tertiary: Aquatic Biota	Physicochemical Hydrology Geomorphology	Riparian Vegetation Bedform Diversity

Notes:

[1]Primary Limiting Factors as defined in the 2008 Fish Accords

[2]NOAA Ecological Concerns Sub-Category Definitions

[3]Touchstones as defined in the Umatilla River Vision

Table B-2. Functional Assessment Categories and Definitions

Functional Category	Functional Parameter	Function Definition
Hydrology	Flow Duration	Transport of water from the watershed to the channel
Hydraulic	Floodplain Connectivity	Transport of water in the channel, on the floodplain, and through sediments
	Flow Dynamics	
Geomorphology	Sediment Transport Competency	Transport of wood and sediment to create diverse bed forms and dynamic equilibrium
	LWD Transport and Storage	
	Bank Migration/Lateral Stability	
	Bed Form Diversity	
	Bed Material Characterization	
Physicochemical	Water Quality—Temperature	Temperature and oxygen regulation; processing of organic matter and nutrients

Table B-3. Functional Metric Definitions

Functional Category	Functional Parameter	Functional Metric	Functional Metric Definition
Hydrology	Flow Duration	Specific peak discharge	The reach-based specific peak discharge is calculated as selected peak discharges (e.g., 2-yr, 100-yr) divided by the reach valley/floodplain area (an adaptation of specific mean annual max flow; Olden and Poff, 2003).
		Percent of reach dewatered during summer low flow	The percent length of the reach without surface water flow during the field survey period of July-August (Archer et al. 2014).
Hydraulic	Floodplain Connectivity	Top-width ratios	Ratios of the channel top width for selected flood discharges relative to the top width for the 2-yr recurrence interval discharge (e.g., 5-yr:2-yr), and valley width relative to the 2-yr channel top width (Hall et al., 2007; Schenk et al. 2013; Nagel et al. 2014).
		Inundated area ratios (100-yr:valley)	The ratio of the area inundated by selected flood discharges (e.g., 2-yr, 5-yr, etc.) to the valley/floodplain area (Steiger et al. 1998; Benda et al. 2011; Schenk et al. 2013).
	Flow Dynamics	Shear stress ratios (channel:total)	Ratios of the in-channel shear stress to the total cross-section shear stress for selected flood discharges (e.g., 2-yr, 100-yr) (Nanson and Croke, 1992; Knighton, 1998; Fryirs and Brierley, 2013).
Geomorphology	Sediment Transport Competency	Incipient motion (transport stage)	For the 2-yr discharge (approximate effective discharge), ratios of the shear stress applied by the flow relative to the critical shear stress required to mobilize selected grain sizes (e.g., D50, D84) (Pitlick, 1992; Parker, 2008; USFS, 2008).
	LWD Transport and Storage	Jams per 100 m	The number of large wood accumulations (five or more individual pieces of large wood > 10 cm diameter and > 1.0 m length) per 1000 m of channel length (Roni et al., 2005; ISEMP, 2012; Archer et al., 2014).
		Logs/log-rootwads per 100 m	The number of individual pieces of large wood (> 10 cm diameter and > 1.0 m length) per 100 m of channel length (Roni et al., 2005; ISEMP, 2012; Archer et al., 2014).
	Bank Migration/Lateral Stability	Percent of reach with unstable bank	The percent of reach length comprised of actively eroding unstable banks with exposed soils or lack of vegetation (Peck et al., 2001; USFS, 2013; Archer et al., 2014; ODFW, 2014).
		Percent of reach with bank revetment	The percent of reach length containing bank revetments (Peck et al., 2001; USFS, 2013; Archer et al., 2014; ODFW, 2014).
	Bed Form Diversity	Number of geomorphic units per km	The number of primary bank-to-bank geomorphic units (pool, riffle, run, step cascade) along the longitudinal channel profile per km of reach length (Peck et al., 2001; ISEMP, 2012; Fryirs and Brierley, 2013; Archer et al., 2014; ODFW, 2014).

Functional Category	Functional Parameter	Functional Metric	Functional Metric Definition
Geomorphology	Bed Form Diversity	Number of pools per km	The number of primary, bank-to-bank, pool geomorphic units along the longitudinal channel profile per km of reach length (Peck et al., 2001; ISEMP, 2012; Fryirs and Brierley, 2013; Archer et al., 2014; ODFW, 2014).
		Percent of reach length comprised of pools	The percent of reach length comprised of primary, bank-to-bank, pool geomorphic units along the longitudinal channel profile (Peck et al., 2001; ISEMP, 2012; Fryirs and Brierley, 2013; Archer et al., 2014; ODFW, 2014).
		Pool frequency (bankfull channel widths between pools)	The distance (in number of channel widths) along the longitudinal channel profile between primary, bank-to-bank, pool geomorphic units (Peck et al., 2001; ISEMP, 2012; Fryirs and Brierley, 2013; Archer et al., 2014; ODFW, 2014).
		Number of local pools per km	The number of secondary pool features created by localized structures (large wood, boulders, undercut banks) within primary geomorphic units per km of reach length (Stevenson and Bain, 1999; Peck et al., 2001).
		Relative percent of local pool types	The relative percent of the type of secondary pool features created by localized structures (large wood, boulders, undercut banks) within primary geomorphic units (Stevenson and Bain, 1999; Peck et al., 2001).
		Number of local cover elements per km	The number of local habitat cover elements (large wood, vegetation, boulders, undercut banks) within primary geomorphic units per km of reach length (Stevenson and Bain, 1999; Peck et al., 2001; ISEMP, 2012; ODFW, 2014).
		Relative percent of local cover types	The relative percent of the type of local habitat cover elements (large wood, vegetation, boulders, undercut banks) within primary geomorphic units (Stevenson and Bain, 1999; Peck et al., 2001; ISEMP, 2012; ODFW, 2014).
	Bed Material Characterization	Gravel percent in riffles	The percent surface area of riffle geomorphic units comprised of gravel (2 - 62 mm b-axis diameter) (Buffington and Montgomery, 1999; Bunte and Abt, 2001; Graham et al., 2005; USFS, 2013; ODFW, 2014).
		Percent fines in riffles	The percent surface area of riffle geomorphic units comprised of sand and smaller material (< 2 mm b-axis diameter) (Buffington and Montgomery, 1999; Bunte and Abt, 2001; Peck et al., 2001; USFS, 2013; ODFW, 2014).
		Depositional bars per km	The number of geomorphic units formed by deposition of coarse sediment (i.e., depositional bars) per km of reach length (Fryirs and Brierley, 2013).

Functional Category	Functional Parameter	Functional Metric	Functional Metric Definition
Physicochemical	Water Quality Temperature	Riparian percent shade	The percent of channel width shaded by riparian vegetation or topography, measured at > 10% of the geomorphic units in a reach (USFS, 2013; ODFW, 2014).
		Relative percent of dominant vegetation type	The relative percent of dominant vegetation types (tree, shrub, herbaceous) within the riparian zone (USFS, 2013; ODFW, 2014).

Notes:

Functional metrics were calculated from available data, measured in accessible reaches, or modeled within the Birch Creek Watershed during 2015.
Metrics were summarized at the reach scale for all Tier 1 reaches.

Table B-4. Functional Metric Performance Standards for Scoring

	Metrics are scored on a continuous scale from 0.0 to 1.0, using the performance standard as a guide				
Functional Metric	**Absent/Dysfunctional 0.0 - 0.25**	**0.26 - 0.50**	**0.51 - 0.75**	**Abundant/Fully Functional 0.76 - 1.0**	**Notes See also Functional Metric Definitions and References**
Specific peak discharge	<10	10 - 20	20 - 30	>30	akin to specific discharge diversity; high is more diverse (Olden and Poff, 2003)
Percent of reach dewatered during summer low flow	>10%	5% - 10%	>0% and <5%	0% dewatered	All streams are perennial, and should have surface flow year-round.
Top-width ratios (5yr:2yr Entrenchment, by Valley:2yr Confinement)	Confinement (Valley:5yr): Entrenchment (5yr:2yr) Unconfined >6: <2.9 Partially-confined 4-6: <2.6 Confined <4: <1.8	Confinement (Valley:5yr): Entrenchment (5yr:2yr) Unconfined >6: 2.9 - 3.2 Partially-confined 4-6: 2.6 - 2.8 Confined <4: 1.8- 2.0	Confinement (Valley:5yr): Entrenchment (5yr:2yr) Unconfined >6: 3.2 - 3.5 Partially-confined 4-6: 2.8 - 3.0 Confined <4: 2.0 - 2.2	Confinement (Valley:5yr): Entrenchment (5yr:2yr) Unconfined >6: >3.5 Partially-confined 4-6: >3.0 Confined <4: >2.2	5yr:2yr is akin to entrenchment ratio, which varies based on confinement (valley:2yr); adapted from Nagel et al., 2011; Harman et al., 2012
Inundated area ratios (100yr:Valley)	<20%	20% - 50%	50% - 80%	>80%	Use 100-yr Q; Hillman et al., 2002; USBR, 2012; adapted
Shear stress ratios (Channel:Total for 100yr Q)	Confinement (Valley:5yr): Shear Stress (Channel:Total) Unconfined >6: <1.5 Partially-confined 4-6: <1.5 Confined <4: <1.2	Confinement (Valley:5yr): Shear Stress (Channel:Total) Unconfined >6: 1.5 - 2.5 Partially-confined 4-6: 1.5 - 2.0 Confined <4: 1.2 - 1.8	Confinement (Valley:5yr): Shear Stress (Channel:Total) Unconfined >6: 2.5 - 3.0 Partially-confined 4-6: 2.0 - 2.5 Confined <4: 1.8 - 2.0	Confinement (Valley:5yr): Shear Stress (Channel:Total) Unconfined >6: >3.0 Partially-confined 4-6: >2.5 Confined <4: >2.0	Use 100-yr Q; Steiger et al. 1998; Benda et al. 2011; Schenk et al. 2013
Incipient motion (Applied Shear:Critical Shear, D84)	>2.0	1.6 - 2.0	1.2 - 1.5	<1.2	akin to the Transport Stage; Nanson and Croke, 1992; Knighton, 1998; Fryirs and Brierley, 2013
Jams per km	<1	1 - 2	3 - 5	>6	USBR, 2012, adapted
Logs/log-rootwads per 100 m	<10	10 - 14	15 - 20	>20	ODFW benchmark, adapted
Percent of reach with unstable bank	>25%	16% - 25%	10% - 15%	<10%	Peck et al., 2001; USFS, 2013; Archer et al., 2014; ODFW, 2014
Percent of reach with bank revetment	>25%	16% - 25%	10% - 15%	<10%	Peck et al., 2001; USFS, 2013; Archer et al., 2014; ODFW, 2014
Number of geomorphic units per km	0 - 25% of fully functional	26 - 50% of fully functional	51 - 75% of fully functional	channel width: units/km range <3 m: 48 - 220 3 m: 70 - 120 5 m: 60 - 80 6 m: 48 - 70 8 m: 28 - 60 15 m: 12 - 32 23 m: 4 - 28 30 m: 4 - 22	Hillman et al., 2002, adapted
Number of pools per km	0 - 25% of fully functional	26 - 50% of fully functional	51 - 75% of fully functional	channel width: pools/km range <3 m: 24 - 114 3 m: 37 - 60 5 m: 30 - 43 6 m: 24 - 35 8 m: 14 - 29 15 m: 6 - 16 23 m: 2 - 14 30 m: 2 - 11	Hillman et al., 2002; USBR, 2012
Percent of reach length comprised of pools	Pool-Riffle: <10% Step-Pool: <22% Plane-bed: <5%	Pool-Riffle: 10% - 22% Step-Pool: 22% - 34% Plane-bed: 5% - 14%	Pool-Riffle: 22% - 35% Step-Pool: 35% - 50% Plane-bed: 15% - 25%	Pool-Riffle: >35% Step-Pool: >50% Plane-bed: >25%	ODFW 2014 benchmark, adapted; Harman et al., 2012
Pool frequency (bankfull channel widths between pools)	Pool-Riffle: <5 and >20 Step-Pool: <2 and >10 Plane-bed: <4 and >15	Pool-Riffle: 15 - 20 Step-Pool: 8 - 10 Plane-bed: 5 - 7	Pool-Riffle: 9 - 14 Step-Pool: 5 - 7 Plane-bed: 7 - 9	Pool-Riffle: 5 - 8 Step-Pool: 2 - 4 Plane-bed: 10 - 15	ODFW 2014 benchmark, adapted; Harman et al., 2012
Number of local pools per km	<100	100 - 140	141 - 200	>200	assume local pools at the same density as LWD; Stevenson and Bain, 1999; Peck et al., 2001
Relative % of local pool types	100% of one pool type	80% - 100% of one pool type	40% - 80% of one pool type	equal relative % among pool types	e.g., diversity
Number of local cover elements per km	<100	100 - 140	141 - 200	>200	assume local cover at the same density as LWD; Stevenson and Bain, 1999; Peck et al., 2001; ISEMP, 2012; ODFW, 2014
Relative % of local cover types	100% of one cover type	80% - 100% of one cover type	40% - 80% of one cover type	equal relative % among cover types	e.g., diversity
Gravel % in riffles	<15%	15% - 24%	25% - 34%	>35%	ODFW 2014 benchmark, adapted; USBR, 2012
Percent fines in riffles	Pool-Riffle: >25% Step-Pool: >20% Plane-bed: >15%	Pool-Riffle: 20 - 25% Step-Pool: 15 - 20% Plane-bed: 10 - 15%	Pool-Riffle: 12 - 19% Step-Pool: 10 - 14% Plane-bed: 8 - 9%	Pool-Riffle: <12% Step-Pool: <10% Plane-bed: <8%	ODFW 2014 benchmark, adapted; USBR, 2012
Depositional bars per km	0 - 25% of fully functional or signs of significant aggradation caused by excess sediment supply	26 - 50% of fully functional	51 - 75% of fully functional	channel width: bars/km range <5 m: 5 - 20 5 m - 15 m: 10 - 40 15 m - 30 m: 20 - 60	Fryirs and Brierley, 2013
Riparian % shade	channel width: shade% <12 m: <50% >12 m: <40%	channel width: shade% <12 m: 50% - 55% >12 m: 40% - 45%	channel width: shade% <12 m: 55% - 60% >12 m: 45% - 50%	channel width: shade% <12 m: >60% >12 m: >50%	ODFW 2014 benchmark, adapted
Relative % of dominant vegetation type	trees comprise <20% of riparian zone	trees comprise 20% -39% of riparian zone	trees comprise 40% - 80% of riparian zone	trees comprise >80% of riparian zone	USBR 2012, adapted

Table B-5. Functional Metric Scores

Streams and Reaches

			Birch Creek					East Birch Creek								Pearson Creek				
Functional Category	**Functional Parameter**	**Functional Metric**	**B1**	**B2**	**B3**	**B4**	**B5**	**EB1**	**EB2**	**EB3**	**EB4**	**EB5**	**EB6**	**EB7**	**EB8**	**P1**	**P2**	**P3**	**P4**	**P5**
Hydrology	Flow Duration	Specific peak discharge	0.125	0.38	0.125	0.63	0.125	0.125	0.38	0.38	0.38	0.88	0.125	0.125	0.125	0.88	0.125	0.38	0.38	0.125
		Percent of reach dewatered during summer low flow	0.125	0.125	0.125	0.125	0.125	0.125	1.00	0.125	0.125	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)	0.125	0.125	0.125	0.125	0.88	0.38	0.125	0.125	0.63	0.38	0.88	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Inundated area ratios (100-yr:Valley)	0.630	0.380	0.380	0.380	0.630	0.630	0.630	0.380	0.380	0.380	0.380	0.380	0.125	0.630	0.380	0.380	0.380	0.380
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.38	0.38	0.38	0.38	0.63	0.38	0.38	0.38	0.38	0.38	0.63	0.38	0.125	0.38	0.38	0.38	0.38	0.38
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)	0.63	0.88	0.88	0.88	0.88	0.88	0.88	0.63	0.38	0.38	0.88	0.125	0.125	0.38	0.125	0.38	0.38	0.63
	LWD Transport and Storage	Jams per km	0.125	0.38	0.125	0.38	0.125	0.38	0.88	0.38	0.38	0.38	0.88	0.63	0.63	0.38	0.63	0.88	0.125	0.63
		Logs/log-rootwads per 100 m	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	Bank Migration/Lateral Stability	Percent of reach with unstable bank	0.38	0.125	0.63	0.125	0.63	0.125	0.38	0.38	0.88	0.88	0.125	0.63	0.38	0.38	0.38	0.88	0.88	0.63
		Percent of reach with bank revetment	0.88	0.88	0.88	0.38	0.88	0.38	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.63	0.88	0.88	0.88	0.88
	Bed Form Diversity	Number of geomorphic units per km	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.125	0.38	0.63	0.38	0.63	0.125	0.125
		Number of pools per km	0.88	0.88	0.88	0.88	0.63	0.88	0.63	0.88	0.88	0.88	0.63	0.125	0.38	0.38	0.125	0.63	0.125	0.125
		Percent of reach length comprised of pools	0.88	0.88	0.88	0.88	0.63	0.88	0.63	0.63	0.88	0.88	0.38	0.125	0.125	0.38	0.125	0.125	0.125	0.125
		Pool frequency (bankfull channel widths between pools)	0.125	0.125	0.125	0.125	0.88	0.125	0.125	0.38	0.125	0.125	0.63	0.125	0.125	0.88	0.125	0.125	0.125	0.125
		Number of local pools per km	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Relative % of local pool types	0.63	0.125	0.63	0.125	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.88
		Number of local cover elements per km	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Relative % of local cover types	0.88	0.63	0.88	0.63	0.63	0.63	0.63	0.88	0.88	0.88	0.63	0.63	0.63	0.88	0.63	0.38	0.63	0.63
	Bed Material Characterization	Gravel % in riffles	0.88	0.88	0.63	0.38	0.125	0.88	0.88	0.88	0.38	0.38	0.88	0.88	0.88	0.38	0.125	0.88	0.88	0.88
		Percent fines in riffles	0.88	0.88	0.88	0.88	0.88	0.38	0.125	0.38	0.38	0.38	0.38	0.125	0.125	0.125	0.38	0.38	0.38	0.125
		Depositional bars per km	0.125	0.125	0.38	0.63	0.63	0.125	0.38	0.38	0.38	0.38	0.38	0.63	0.63	0.38	0.38	0.38	0.125	0.38
Physicochemical	Water Quality - Temperature	Riparian % shade	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.63	0.125	0.125	0.125	0.125
		Relative % of dominant vegetation type	0.125	0.125	0.63	0.63	0.63	0.63	0.63	0.38	0.63	0.63	0.88	0.63	0.88	0.63	0.88	0.88	0.88	0.63

Streams and Reaches

			West Birch Creek								Bear Creek					
Functional Category	**Functional Parameter**	**Functional Metric**	**WB1**	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**	**WB7**	**WB8**	**BR1**	**BR2**	**BR3**	**BR4**	**BR5**	**BR6**
Hydrology	Flow Duration	Specific peak discharge	0.63	0.38	0.125	0.125	0.38	0.88	0.125	0.63	0.38	0.63	0.63	0.38	0.125	0.125
		Percent of reach dewatered during summer low flow	1.00	1.00	0.125	0.125	0.125	0.125	1.00	1.00	0.125	1.00	1.00	1.00	1.00	1.00
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)	0.38	0.38	0.88	0.125	0.125	0.125	0.125	0.125	0.125	0.88	0.88	0.38	0.125	0.63
		Inundated area ratios (100-yr:Valley)	0.630	0.630	0.380	0.380	0.380	0.630	0.380	0.380	0.630	0.380	0.630	0.630	0.380	0.380
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.38	0.38	0.63	0.38	0.38	0.38	0.38	0.125	0.88	0.63	0.63	0.63	0.38	0.63
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)	0.88	0.88	0.88	0.63	0.63	0.88	0.88	0.63	0.88	0.88	0.63	0.88	0.63	0.125
	LWD Transport and Storage	Jams per km	0.63	0.88	0.63	0.63	0.63	0.63	0.88	0.88	0.63	0.38	0.38	0.63	0.88	0.63
		Logs/log-rootwads per 100 m	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	Bank Migration/Lateral Stability	Percent of reach with unstable bank	0.125	0.38	0.38	0.125	0.125	0.125	0.38	0.38	0.38	0.88	0.38	0.38	0.88	0.63
		Percent of reach with bank revetment	0.63	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.63	0.88	0.88	0.88
	Bed Form Diversity	Number of geomorphic units per km	0.88	0.88	0.63	0.88	0.88	0.88	0.38	0.125	0.63	0.125	0.63	0.38	0.63	0.125
		Number of pools per km	0.88	0.88	0.63	0.88	0.88	0.88	0.38	0.125	0.63	0.125	0.38	0.125	0.63	0.125
		Percent of reach length comprised of pools	0.88	0.63	0.63	0.88	0.63	0.63	0.38	0.38	0.63	0.125	0.38	0.125	0.125	0.125
		Pool frequency (bankfull channel widths between pools)	0.88	0.125	0.88	0.38	0.38	0.38	0.125	0.125	0.88	0.125	0.88	0.125	0.125	0.125
		Number of local pools per km	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Relative % of local pool types	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.125	0.63	0.63	0.63	0.88
		Number of local cover elements per km	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
		Relative % of local cover types	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.38	0.88	0.63	0.38	0.63
	Bed Material Characterization	Gravel % in riffles	0.88	0.88	0.38	0.63	0.38	0.38	0.38	0.38	0.38	0.88	0.38	0.125	0.88	0.88
		Percent fines in riffles	0.63	0.125	0.38	0.125	0.38	0.38	0.63	0.63	0.38	0.125	0.125	0.38	0.38	0.125
		Depositional bars per km	0.125	0.63	0.125	0.125	0.38	0.38	0.38	0.38	0.125	0.125	0.38	0.38	0.38	0.38
Physicochemical	Water Quality - Temperature	Riparian % shade	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.63	0.125	0.125	0.125
		Relative % of dominant vegetation type	0.125	0.63	0.38	0.63	0.63	0.63	0.88	0.88	0.38	0.63	0.63	0.88	0.88	0.63

Table B-6. Functional Parameter Scores

			Streams and Reaches																	
			Birch Creek					East Birch Creek								Pearson Creek				
Functional Category	**Functional Parameter**	**Functional Metric**	**B1**	**B2**	**B3**	**B4**	**B5**	**EB1**	**EB2**	**EB3**	**EB4**	**EB5**	**EB6**	**EB7**	**EB8**	**P1**	**P2**	**P3**	**P4**	**P5**
Hydrology	Flow Duration	Specific peak discharge																		
		Percent of reach dewatered during summer low flow	0.13	0.25	0.13	0.38	0.13	0.13	0.69	0.25	0.25	0.94	0.56	0.56	0.56	0.94	0.56	0.69	0.69	0.56
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)																		
		Inundated area ratios (100-yr:Valley)	0.38	0.25	0.25	0.25	0.76	0.51	0.38	0.25	0.51	0.38	0.63	0.25	0.13	0.38	0.25	0.25	0.25	0.25
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.38	0.38	0.38	0.38	0.63	0.38	0.38	0.38	0.38	0.38	0.63	0.38	0.13	0.38	0.38	0.38	0.38	0.38
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)	0.63	0.88	0.88	0.88	0.88	0.88	0.88	0.63	0.38	0.38	0.88	0.13	0.13	0.38	0.13	0.38	0.38	0.63
	LWD Transport and Storage	Jams per km																		
		Logs/log-rootwads per 100 m	0.13	0.25	0.13	0.25	0.13	0.25	0.50	0.25	0.25	0.25	0.50	0.38	0.38	0.25	0.38	0.50	0.13	0.38
	Bank Migration/Lateral Stability	Percent of reach with unstable bank																		
		Percent of reach with bank revetment	0.63	0.50	0.76	0.25	0.76	0.25	0.63	0.63	0.88	0.88	0.50	0.76	0.63	0.51	0.63	0.88	0.88	0.76
	Bed Form Diversity	Number of geomorphic units per km																		
		Number of pools per km																		
		Percent of reach length comprised of pools																		
		Pool frequency (bankfull channel widths between pools)																		
		Number of local pools per km																		
		Relative % of local pool types																		
		Number of local cover elements per km																		
		Relative % of local cover types	0.57	0.47	0.57	0.47	0.57	0.53	0.47	0.57	0.57	0.57	0.50	0.25	0.32	0.50	0.28	0.35	0.25	0.28
	Bed Material Characterization	Gravel % in riffles																		
		Percent fines in riffles																		
		Depositional bars per km	0.63	0.63	0.63	0.63	0.55	0.46	0.46	0.55	0.38	0.38	0.55	0.55	0.55	0.30	0.30	0.55	0.46	0.46
Physicochemical	Water Quality - Temperature	Riparian % shade																		
		Relative % of dominant vegetation type	0.13	0.13	0.38	0.38	0.38	0.38	0.38	0.25	0.38	0.38	0.50	0.38	0.50	0.63	0.50	0.50	0.50	0.38

			Streams and Reaches													
			West Birch Creek								Bear Creek					
Functional Category	**Functional Parameter**	**Functional Metric**	**WB1**	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**	**WB7**	**WB8**	**BR1**	**BR2**	**BR3**	**BR4**	**BR5**	**BR6**
Hydrology	Flow Duration	Specific peak discharge														
		Percent of reach dewatered during summer low flow	0.82	0.69	0.13	0.13	0.25	0.50	0.56	0.82	0.25	0.82	0.82	0.69	0.56	0.56
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)														
		Inundated area ratios (100-yr:Valley)	0.51	0.51	0.63	0.25	0.25	0.38	0.25	0.25	0.38	0.63	0.76	0.51	0.25	0.51
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.38	0.38	0.63	0.38	0.38	0.38	0.38	0.13	0.88	0.63	0.63	0.63	0.38	0.63
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)	0.88	0.88	0.88	0.63	0.63	0.88	0.88	0.63	0.88	0.88	0.63	0.88	0.63	0.13
	LWD Transport and Storage	Jams per km														
		Logs/log-rootwads per 100 m	0.38	0.50	0.38	0.38	0.38	0.38	0.50	0.50	0.38	0.25	0.25	0.38	0.50	0.38
	Bank Migration/Lateral Stability	Percent of reach with unstable bank														
		Percent of reach with bank revetment	0.38	0.63	0.63	0.50	0.50	0.50	0.63	0.63	0.63	0.88	0.51	0.63	0.88	0.76
	Bed Form Diversity	Number of geomorphic units per km														
		Number of pools per km														
		Percent of reach length comprised of pools														
		Pool frequency (bankfull channel widths between pools)														
		Number of local pools per km														
		Relative % of local pool types														
		Number of local cover elements per km														
		Relative % of local cover types	0.63	0.50	0.54	0.57	0.54	0.54	0.35	0.28	0.54	0.16	0.50	0.28	0.35	0.28
	Bed Material Characterization	Gravel % in riffles														
		Percent fines in riffles														
		Depositional bars per km	0.55	0.55	0.30	0.29	0.38	0.38	0.46	0.46	0.30	0.38	0.30	0.30	0.55	0.46
Physicochemical	Water Quality - Temperature	Riparian % shade														
		Relative % of dominant vegetation type	0.13	0.38	0.25	0.38	0.38	0.38	0.50	0.50	0.25	0.38	0.63	0.50	0.50	0.38

Table B-7. Functional Category Scores

Functional Category	Functional Parameter	Functional Metric	Streams and Reaches: Birch Creek					East Birch Creek								Pearson Creek				
			B1	B2	B3	B4	B5	EB1	EB2	EB3	EB4	EB5	EB6	EB7	EB8	P1	P2	P3	P4	P5
Hydrology	Flow Duration	Specific peak discharge																		
		Percent of reach dewatered during summer low flow	0.13	0.25	0.13	0.38	0.13	0.13	0.69	0.25	0.25	0.94	0.56	0.56	0.56	0.94	0.56	0.69	0.69	0.56
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)																		
		Inundated area ratios (100-yr:Valley)																		
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.38	0.32	0.32	0.32	0.69	0.44	0.38	0.32	0.44	0.38	0.63	0.32	0.13	0.38	0.32	0.32	0.32	0.32
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)																		
	LWD Transport and Storage	Jams per km																		
		Logs/log-rootwads per 100 m																		
	Bank Migration/Lateral Stability	Percent of reach with unstable bank																		
		Percent of reach with bank revetment																		
	Bed Form Diversity	Number of geomorphic units per km																		
		Number of pools per km																		
		Percent of reach length comprised of pools																		
		Pool frequency (bankfull channel widths between pools)																		
		Number of local pools per km																		
		Relative % of local pool types																		
		Number of local cover elements per km																		
		Relative % of local cover types																		
	Bed Material Characterization	Gravel % in riffles																		
		Percent fines in riffles																		
		Depositional bars per km	0.52	0.55	0.59	0.50	0.57	0.48	0.59	0.53	0.49	0.49	0.59	0.41	0.40	0.39	0.34	0.53	0.42	0.50
Physicochemical	Water Quality - Temperature	Riparian % shade																		
		Relative % of dominant vegetation type	0.13	0.13	0.38	0.38	0.38	0.38	0.38	0.25	0.38	0.38	0.50	0.38	0.50	0.63	0.50	0.50	0.50	0.38
		Reach Functionality Scores	**0.29**	**0.31**	**0.35**	**0.39**	**0.44**	**0.36**	**0.51**	**0.34**	**0.39**	**0.55**	**0.57**	**0.42**	**0.40**	**0.58**	**0.43**	**0.51**	**0.48**	**0.44**

Functional Category	Functional Parameter	Functional Metric	Streams and Reaches: West Birch Creek								Bear Creek					
			WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8	BR1	BR2	BR3	BR4	BR5	BR6
Hydrology	Flow Duration	Specific peak discharge														
		Percent of reach dewatered during summer low flow	0.82	0.69	0.13	0.13	0.25	0.50	0.56	0.82	0.25	0.82	0.82	0.69	0.56	0.56
Hydraulic	Floodplain Connectivity	Top-width ratios (5-yr:2-yr, Valley:2-yr)														
		Inundated area ratios (100-yr:Valley)														
	Flow Dynamics	Shear stress ratios (Channel:Total for 100-yr Q)	0.44	0.44	0.63	0.32	0.32	0.38	0.32	0.19	0.63	0.63	0.69	0.57	0.32	0.57
Geomorphology	Sediment Transport Competency	Incipient motion (Applied:Critical shear, D84)														
	LWD Transport and Storage	Jams per km														
		Logs/log-rootwads per 100 m														
	Bank Migration/Lateral Stability	Percent of reach with unstable bank														
		Percent of reach with bank revetment														
	Bed Form Diversity	Number of geomorphic units per km														
		Number of pools per km														
		Percent of reach length comprised of pools														
		Pool frequency (bankfull channel widths between pools)														
		Number of local pools per km														
		Relative % of local pool types														
		Number of local cover elements per km														
		Relative % of local cover types														
	Bed Material Characterization	Gravel % in riffles														
		Percent fines in riffles														
		Depositional bars per km	0.56	0.61	0.54	0.47	0.49	0.54	0.56	0.50	0.54	0.51	0.44	0.49	0.58	0.40
Physicochemical	Water Quality - Temperature	Riparian % shade														
		Relative % of dominant vegetation type	0.13	0.38	0.25	0.38	0.38	0.38	0.50	0.50	0.25	0.38	0.63	0.50	0.50	0.38
		Reach Functionality Scores	**0.49**	**0.53**	**0.39**	**0.32**	**0.36**	**0.45**	**0.49**	**0.50**	**0.42**	**0.58**	**0.64**	**0.56**	**0.49**	**0.48**

APPENDIX C
Restoration Strategy Tables

Table C-1. Birch Creek Reach Prioritization

Selection Criteria	Description	Relative Value of Selection Criteria			Assigned Value of Selection Criteria				
		1	2	3	B1	B2	B3	B4	B5
1	Steelhead Abundance (capacity/productivity)	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	2.0	3.0
2	Steelhead population growth rate (productivity)	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	3.0	3.0
3	Steelhead population spatial structure	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	1.0	3.0
4	Steelhead population diversity	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	3.0	3.0
5	Obstruction to fish passage	low	medium	high	3.0	3.0	3.0	3.0	3.0
6	Hydrologic function	>60%	30% to 60%	<30%	3.0	3.0	3.0	2.0	3.0
7	Hydraulic function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	1.0
8	Geomorphology function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0
9	Physicochemical function - water temperature	>60%	30% to 60%	<30%	3.0	3.0	2.0	2.0	2.0
				Total Score	**25.0**	**25.0**	**24.0**	**20.0**	**23.0**

Note:

Higher scores indicate a greater restoration need

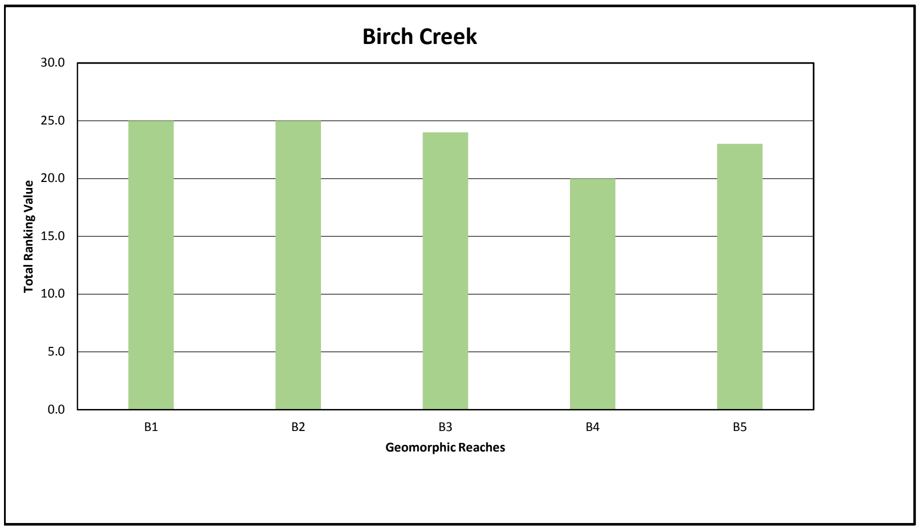

Table C-2. East Birch Creek Reach Prioritization

Selection Criteria	Description	Relative Value of Selection Criteria			Assigned Value of Selection Criteria							
		1	2	3	EB1	EB2	EB3	EB4	EB5	EB6	EB7	EB8
1	Steelhead Abundance (capacity/productivity)	highest third rank	middle third rank	lowest third rank	3.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
2	Steelhead population growth rate (productivity)	highest third rank	middle third rank	lowest third rank	1.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0
3	Steelhead population spatial structure	highest third rank	middle third rank	lowest third rank	3.0	1.0	3.0	3.0	1.0	1.0	2.0	1.0
4	Steelhead population diversity	highest third rank	middle third rank	lowest third rank	2.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0
5	Obstruction to fish passage	low	medium	high	3.0	3.0	0.0	0.0	0.0	2.0	1.0	1.0
6	Hydrologic function	>60%	30% to 60%	<30%	3.0	1.0	3.0	3.0	1.0	2.0	2.0	2.0
7	Hydraulic function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0	1.0	2.0	3.0
8	Geomorphology function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0	2.0	1.0	2.0
9	Physicochemical function - water temperature	>60%	30% to 60%	<30%	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0
				Total Score	21.0	17.0	18.0	16.0	11.0	13.0	16.0	17.0

Note:

Higher scores indicate a greater restoration need

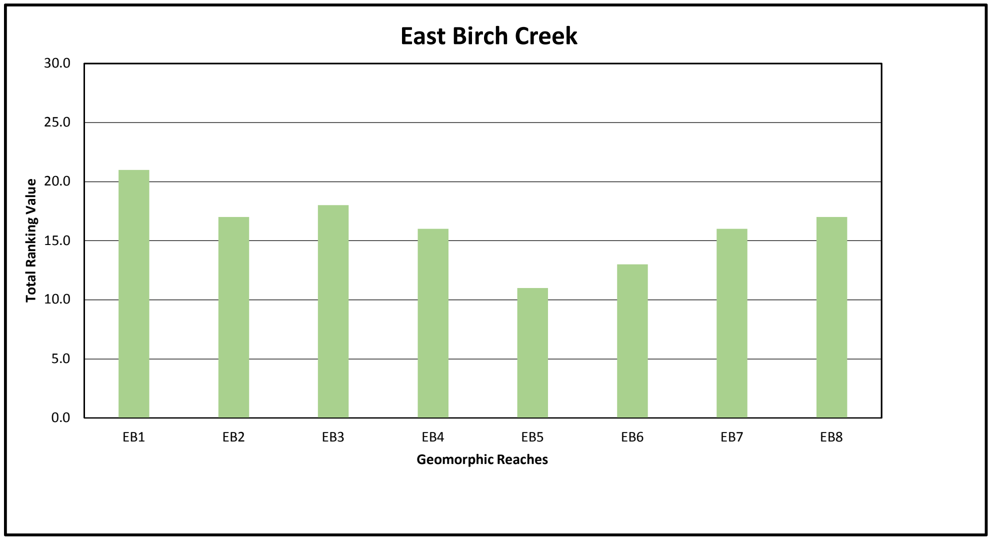

Table C-3. Pearson Creek Reach Prioritization

Selection Criteria	Description	Relative Value of Selection Criteria			Assigned Value of Selection Criteria				
		1	2	3	P1	P2	P3	P4	P5
1	Steelhead Abundance (capacity/productivity)	highest third rank	middle third rank	lowest third rank	2.0	3.0	1.0	1.0	2.0
2	Steelhead population growth rate (productivity)	highest third rank	middle third rank	lowest third rank	3.0	1.0	1.0	1.0	1.0
3	Steelhead population spatial structure	highest third rank	middle third rank	lowest third rank	1.0	3.0	2.0	1.0	3.0
4	Steelhead population diversity	highest third rank	middle third rank	lowest third rank	1.0	1.0	1.0	1.0	1.0
5	Obstruction to fish passage	low	medium	high	2.0	2.0	2.0	0.0	1.0
6	Hydrologic function	>60%	30% to 60%	<30%	1.0	2.0	1.0	1.0	2.0
7	Hydraulic function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0
8	Geomorphology function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0
9	Physicochemical function - water temperature	>60%	30% to 60%	<30%	1.0	2.0	2.0	2.0	2.0
				Total Score	**15.0**	**18.0**	**14.0**	**11.0**	**16.0**

Note:

Higher scores indicate a greater restoration need

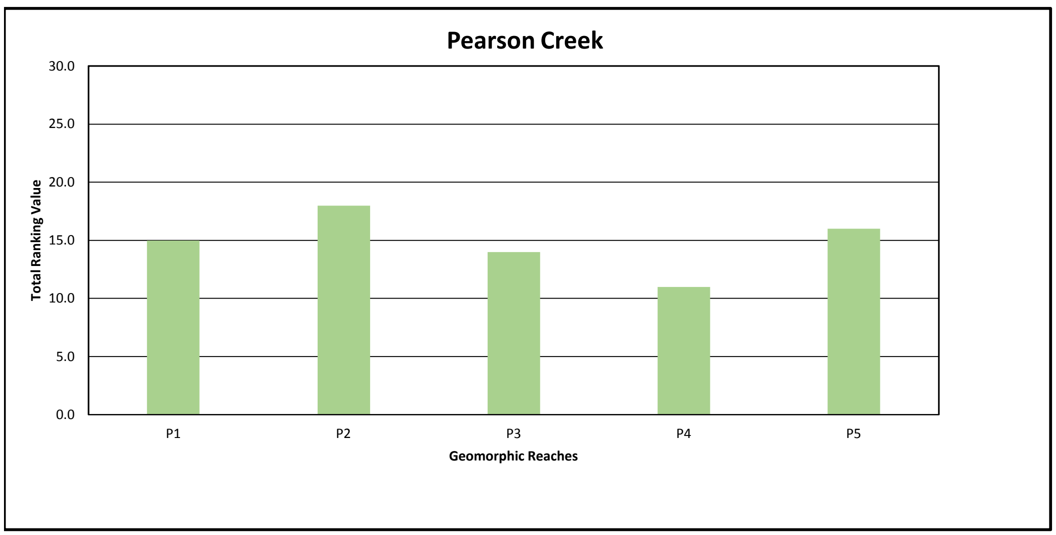

Table C-4. West Birch Creek Reach Prioritization

Selection Criteria	Description	Relative Value of Selection Criteria			Assigned Value of Selection Criteria							
		1	2	3	WB1	WB2	WB3	WB4	WB5	WB6	WB7	WB8
1	Steelhead Abundance (capacity/productivity)	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	3.0	2.0	1.0	2.0	1.0
2	Steelhead population growth rate (productivity)	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	2.0	3.0	1.0	2.0	1.0
3	Steelhead population spatial structure	highest third rank	middle third rank	lowest third rank	3.0	3.0	2.0	3.0	2.0	2.0	2.0	1.0
4	Steelhead population diversity	highest third rank	middle third rank	lowest third rank	3.0	3.0	3.0	2.0	2.0	3.0	2.0	1.0
5	Obstruction to fish passage	low	medium	high	3.0	3.0	2.0	2.0	2.0	0.0	2.0	0.0
6	Hydrologic function	>60%	30% to 60%	<30%	1.0	1.0	3.0	3.0	3.0	2.0	2.0	1.0
7	Hydraulic function	>60%	30% to 60%	<30%	2.0	2.0	1.0	2.0	2.0	2.0	2.0	3.0
8	Geomorphology function	>60%	30% to 60%	<30%	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0
9	Physicochemical function - water temperature	>60%	30% to 60%	<30%	3.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0
				Total Score	23.0	21.0	22.0	21.0	20.0	15.0	18.0	12.0

Note:

Higher scores indicate a greater restoration need

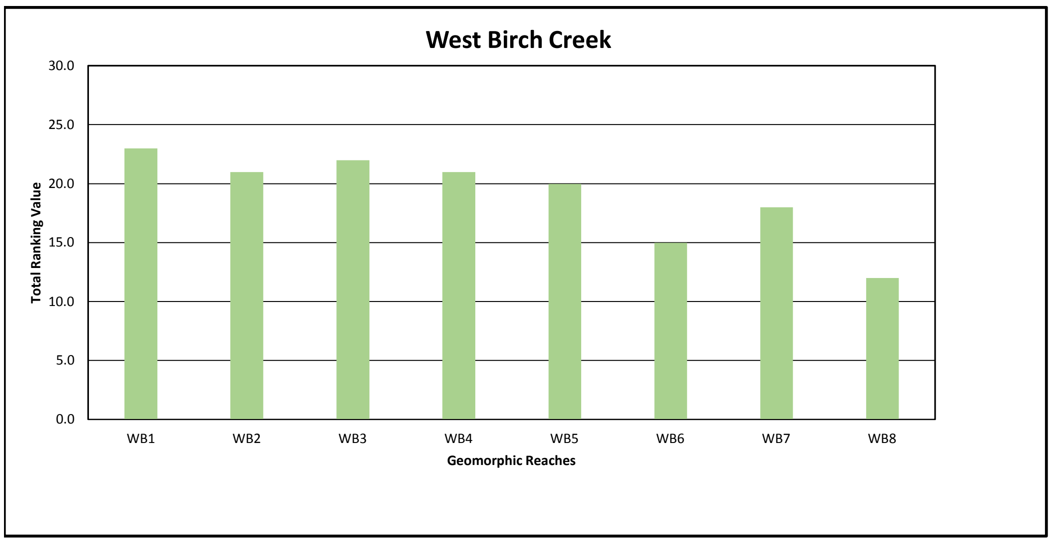

Table C-5. Bear Creek Reach Prioritization

Selection Criteria	Description	Relative Value of Selection Criteria			Assigned Value of Selection Criteria					
		1	2	3	BR1	BR2	BR3	BR4	BR5	BR6
1	Steelhead Abundance (capacity/productivity)	highest third rank	middle third rank	lowest third rank	2.0	1.0	2.0	2.0	1.0	2.0
2	Steelhead population growth rate (productivity)	highest third rank	middle third rank	lowest third rank	3.0	1.0	1.0	1.0	1.0	1.0
3	Steelhead population spatial structure	highest third rank	middle third rank	lowest third rank	2.0	2.0	2.0	3.0	1.0	2.0
4	Steelhead population diversity	highest third rank	middle third rank	lowest third rank	2.0	1.0	2.0	1.0	1.0	1.0
5	Obstruction to fish passage	low	medium	high	0.0	0.0	0.0	0.0	0.0	0.0
6	Hydrologic function	>60%	30% to 60%	<30%	3.0	1.0	1.0	1.0	2.0	2.0
7	Hydraulic function	>60%	30% to 60%	<30%	1.0	1.0	1.0	2.0	2.0	2.0
8	Geomorphology function	>60%	30% to 60%	<30%	2.0	2.0	2.0	2.0	2.0	2.0
9	Physicochemical function - water temperature	>60%	30% to 60%	<30%	3.0	2.0	1.0	2.0	2.0	2.0
				Total Score	**18.0**	**11.0**	**12.0**	**14.0**	**12.0**	**14.0**

Note:

Higher scores indicate a greater restoration need

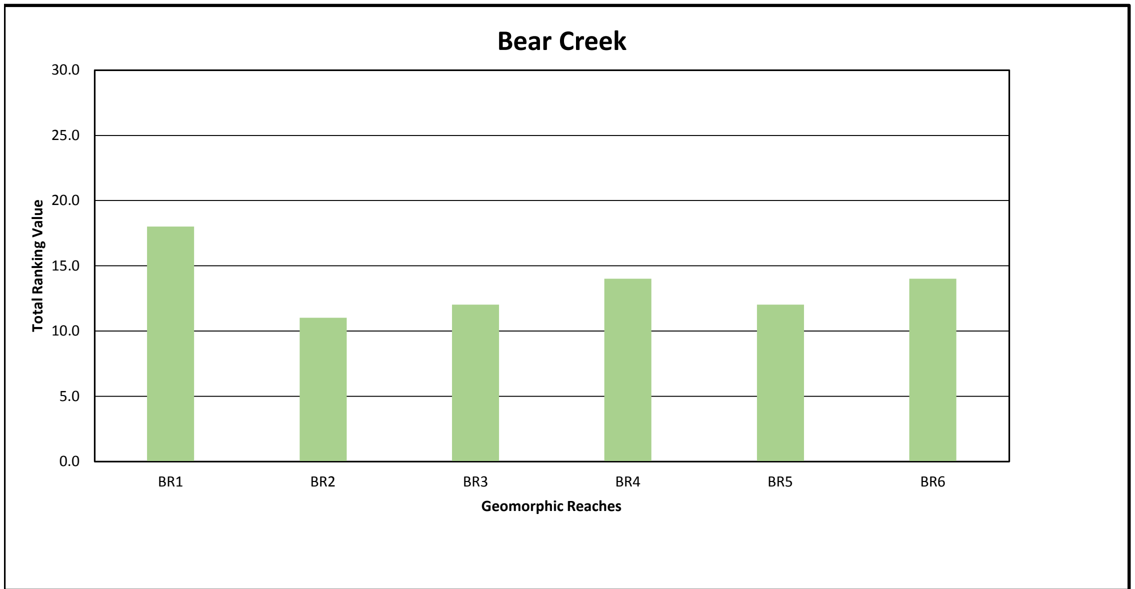

Table C-6. Restoration Activities, Bonneville Power Administration

Restoration Group	Restoration Action
1. Dedicating Land and Water to the Preservation and Restoration of Stream Habitat	1.1. Protect land and water (easement, acquisition)
2. Channel Modification	2.1. Channel Reconstruction
	2.2. Pool Development
	2.3. Riffle Construction
	2.4. Meander (Oxbow) Re-connect - Reconstruction
	2.5. Spawning Gravel Cleaning and Placement
3. Floodplain Reconnection	3.1. Levee Modification: Removal, Setback, Breach
	3.2. Remove - Relocate Floodplain Infrastructure
	3.3. Restoration of Floodplain Topography and Vegetation
	3.4. Floodplain Construction
4. Side Channel / Off-Channel Habitat Restoration	4.1. Perennial Side Channel
	4.2. Secondary (non-perennial) Channel
	4.3. Floodplain Pond - Wetland
	4.4. Alcove
	4.5. Hyporheic Off-Channel Habitat (Groundwater)
	4.6. Beaver Re-introduction
5. Riparian Restoration and Management	5.1. Riparian Fencing
	5.2. Riparian Buffer Strip, Planting
	5.3. Thinning or removal of understory
	5.4. Remove non-native plants
6. Fish Passage Restoration	6.1. Dam removal or breaching
	6.2. Barrier or culvert replacement/removal
	6.3. Structural Passage (Diversions)
7. Nutrient Supplementation	7.1. Addition of organic and inorganic nutrients
8. Instream Structures, Large Wood and Logjams	8.1. Rock Weirs
	8.2. Boulder Placement
	8.3. LWD Placement
9. Bank Restoration, Modification, and Removal	9.1. Modification or Removal of Bank Armoring
	9.2. Restore banklines with LWD - Bioengineering
10. Water Quality and Quantity Impacts	10.1. Acquire Instream Flow (Lease- Purchase)
	10.2. Improve Thermal Refugia (spring reconnect, other)
	10.3. Irrigation System Upgrades -Water Management
	10.4. Reduce - Mitigate Point Source Impacts
	10.5. Upland Vegetation Treatment - Management
	10.6. Road Decommissioning or abandonment
	10.7. Road Grading - Drainage Improvements