

Appendix B- Monitoring Framework

Impairment	Action	Quantifiable effects	Type of effect and scale	Conceptual model category (see Chapter 3 of the UKBWAP)	Monitoring method	References
Channelization	Channel reconstruction, methods to achieve Stage 0 restoration	Sinuosity	Direct, local	Channel morphology	Sinuosity ratio	Fitzpatrick et al. 1998
		Channel profile (width, depth)	Direct, local	Channel morphology	Bankfull width-to-depth ratio, cross sections	Rosgen 1996; Harrelson et al. 1994
		Channel gradient	Direct, local	Channel morphology	Longitudinal channel profile	Harrelson et al. 1994
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Fish habitat types (e.g., pools, riffles, etc.)	Indirect, local	Native fish needs	Cross sections, longitudinal channel profile	Harrelson et al. 1994
		Streambed elevation relative to floodplain	Indirect, local	Riverine process and function	Cross sections	Harrelson et al. 1994
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Nutrient and sediment loads	Indirect, local (and watershed-scale)	Riverine process and function	Discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, Schenk et al. 2016
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, secchi disk measurements	Wetzel and Likens 1991
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009		
Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999		
Channel incision	Actions to aggrade the stream channel	Water surface elevation	Direct, local	Local channel process	Stage measurements	Fitzpatrick et al. 1998
		Stream velocity	Direct (and indirect), local	Local channel process (direct), Riverine process and function (indirect)	Stream velocity measurements	Fitzpatrick et al. 1998
		Sediment deposition	Direct, local	Local channel process	Cross sections	Harrelson et al. 1994
		Streambed elevation relative to floodplain	Indirect, local	Floodplain-river connection, Riverine process and function (indirect)	Cross sections	Harrelson et al. 1994
		Changes in magnitude and duration of floodplain inundation	Direct, local	Floodplain-river connection	Hydraulic modeling, photopoints during high water periods	Opperman et al. 2009
		Riparian plant abundance/density	Indirect, local	Floodplain condition	Riparian canopy closure, dominant riparian land use/land cover, bank vegetative cover, bank erosion	Fitzpatrick et al. 1998
		Size of floodplain	Indirect, local	Floodplain condition	Hydraulic modeling	Opperman et al. 2009
		Number of LWD	Indirect, local	Native fish needs	LWD Survey	Schuett-Hames et al. 1999
		Fish prey abundance and diversity	Indirect, local	Native fish needs	Benthic macroinvertebrate surveys	Hayslip 2007, Brittonand Greeson 1987
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Presence of overhanging vegetation	Indirect, local	Native fish needs	Survey of habitat cover features	Fitzpatrick et al. 1998
		Beaver activity	Indirect, local	Biological response	Presence, survival, density, aerial photography surveys	Pollock et al. 2014, Pollock et al. 2018
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Nutrient and sediment loads	Indirect, local (and watershed-scale)	Riverine process and function	Discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, Schenk et al. 2016
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, secchi disk measurements	Wetzel and Likens 1991
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009		
Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999		

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Levees and berms in the floodplain	Levee removal, breaching, or setback	Changes in magnitude and duration of floodplain inundation	Direct, local	Floodplain-river connection	Hydraulic modeling, photopoints during high water periods	Opperman et al. 2009
		Riparian plant abundance/density	Indirect, local	Floodplain condition	Riparian canopy closure, dominant riparian land use/land cover, bank vegetative cover, bank erosion	Fitzpatrick et al. 1998
		Size of floodplain	Indirect, local	Floodplain condition	Hydraulic modeling	Opperman et al. 2009
		Number of LWD	Indirect, local	Native fish needs	LWD Survey	Schuet-Hames et al. 1999
		Fish prey abundance and diversity	Indirect, local	Native fish needs	Benthic macroinvertebrate surveys	Hayslip 2007, Britton and Greeson 1987
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondoff 1997
		Presence of overhanging vegetation	Indirect, local	Native fish needs	Survey of habitat cover features	Fitzpatrick et al. 1998
		Beaver activity	Indirect, local	Biological response	Presence, survival, density, aerial photography surveys	Pollock et al. 2014, Pollock et al. 2018
		Stream velocity	Indirect, local	Riverine process and function	Velocity measurements	Fitzpatrick et al. 1998
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Streambed elevation relative to floodplain	Indirect, local	Riverine process and function	Cross sections	Harrelson et al. 1994
		Nutrient and sediment loads	Indirect, local (and watershed-scale)	Riverine process and function	Discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, Schenk et al. 2016
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, secchi disk measurements	Wetzel and Likens 1991
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999		
Wetland drainage	Restoration of natural wetlands	Soil moisture	Direct, local	Wetland condition	Soil moisture analyses	NRCS 1998, Schmutz et al. 1980
		Inundation depth	Direct, local	Wetland condition	Depth measurements, hydraulic modeling	Opperman et al. 2009
		Wetland plant abundance/density	Indirect, local	Wetland condition	Aerial surveys, vegetative cover	EPA 2002, adaptation of Fitzpatrick et al. 1998
		Groundwater elevation	Indirect, local	Wetland process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Instream cover	Indirect, local	Native fish needs	Habitat cover features	Fitzpatrick et al. 1998
		Fish prey abundance and diversity	Indirect, local	Native fish needs	Benthic macroinvertebrate surveys	Hayslip 2007, Britton and Greeson 1987
		LRS and SNS rearing habitat	Indirect, local	Native fish needs	Emergent wetland plant surveys	EPA 2002, adaptation of Fitzpatrick et al. 1998
		Sediment nutrient dynamics	Indirect, local	Bacterial response	Laboratory studies	Aldous et al. 2007
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, secchi disk measurements	Wetzel and Likens 1991
		Nutrient and sediment loads	Indirect, local (and watershed-scale)	Water quality	Discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, Schenk et al. 2016
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
		Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999

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Unmanaged (or improperly managed) riparian and floodplain grazing	Riparian and floodplain grazing management, fencing, and planting (if appropriate)	Riparian plant abundance/density	Direct, local	Riparian/floodplain condition	Riparian canopy closure, dominant riparian land use/land cover, bank vegetative cover, bank erosion, utilization (if grazing is occurring)	Fitzpatrick et al. 1998, Winward 2000, Scatena 2010
		Bank cover	Direct, local	Riparian/floodplain condition	Bank vegetative cover	Fitzpatrick et al. 1998
		Soil compaction	Direct, local	Riparian/floodplain condition	Soil compaction analyses	Soil Science Division Staff 2017
		Root strength and abundance	Indirect, local	Riparian/floodplain process	Bank erosion	Fitzpatrick et al. 1998
		Beaver activity	Indirect, local	Biological response	Presence, survival, density, aerial photography surveys	Pollock et al. 2014, Pollock et al. 2018
		Stream shading	Indirect, local	Riparian/floodplain process	Riparian canopy closure	Fitzpatrick et al. 1998
		Number of LWD	Indirect, local	Native fish needs	LWD Survey	Schuet-Hames et al. 1999
		Fish prey abundance and diversity	Indirect, local	Native fish needs	Benthic macroinvertebrate surveys	Hayslip 2007, Britton and Greeson 1987
		Presence of overhanging vegetation	Indirect, local	Native fish needs	Survey of habitat cover features	Fitzpatrick et al. 1998
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Streambed elevation relative to floodplain	Indirect, local	Riverine process and function	Cross sections	Harrelson et al. 1994
		Channel profile (width, depth)	Indirect, local	Riverine process and function	Bankfull width-to-depth ratio, cross sections	Rosgen 1996; Harrelson et al. 1994
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, sechi disk measurements	Wetzel and Likens 1991
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009		
Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999		
Irrigation tailwater returns	Diffuse Source Treatment Wetlands	Hydraulic residence time	Direct, local	Wetland process and function	Before and after comparison using hydraulic modelling	Stillwater Sciences 2020
		Groundwater elevation	Direct, local, site-dependent	Wetland process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and David 2017
		Nutrient and sediment loads	Indirect, local	Water quality	Before and after comparison of nutrient and suspended sediment loads via discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, USGS, Fitzpatrick et al. 1998
		Thermal load	Indirect, local	Water quality	Before and after comparison of water temperature via discrete or continuous sensor measurements; must include discharge measurement	ODEQ 2009, Turk and Water Dipper 2001, Fitzpatrick et al. 1998
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Algal productivity	Indirect, watershed-scale	Algal response	Phytoplankton abundance and presence, chlorophyll-a concentrations, sechi disk measurements	Wetzel and Likens 1991
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
	Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999	
	Irrigation efficiency/modernization	Decreased tailwater returns	Direct, local	N/A	Before and after comparison of discharge measurements	Fitzpatrick et al. 1998
		Nutrient and sediment loads	Indirect, local	Water quality	Before and after comparison of nutrient and suspended sediment loads via discrete point sampling, continuous sensor measurements (for turbidity); must include discharge measurement	ODEQ 2009, USGS, Fitzpatrick et al. 1998
		Thermal load	Indirect, local	Water quality	Before and after comparison of water temperature via discrete or continuous sensor measurements; must include discharge measurement	ODEQ 2009, Turk and Water Dipper 2001, Fitzpatrick et al. 1998
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, local (and watershed-scale)	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
Geomorphology (sediment transport)		Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999	

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Disconnection of off-channel springs from mainstem rivers and tributaries	Restored connection of off-channel springs to mainstem rivers and tributaries	Fish access to coldwater refugia	Direct, local	Native fish needs	Velocity, depth, discharge measurements (fish passage assessment)	ODFW 2006
		Groundwater contribution to streamflow	Direct, local	Riverine process and function	Discharge measurements (of spring contribution)	Fitzpatrick et al. 1998
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
		Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999
Fish passage barriers	Mitigation or removal of fish passage barriers	Fish passage	Direct, local	Native fish needs	Velocity, depth, discharge measurements (fish passage assessment)	ODFW 2006, Ross Taylor and Associates 2015
		Channel gradient	Direct, local	Channel morphology	Longitudinal channel profile	Harrelson et al. 1994
		Channel profile (width, depth)	Direct, local	Channel morphology	Bankfull width-to-depth ratio, cross sections	Rosgen 1996; Harrelson et al. 1994
		Local hydraulics (velocity, water surface elevation, etc.)	Indirect, local	Riverine process and function	Velocity, stage measurements	Fitzpatrick et al. 1998
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, local, watershed-scale	Water quality (local), Ecosystem response (watershed-scale)	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
		Geomorphology (sediment transport)	Indirect, local, watershed-scale	Riverine process and function (local), Ecosystem response (watershed-scale)	Suspended sediment load	Edwards and Glysson 1999
Roads and culverts	Road decommissioning (including removal or replacement of culverts)	Presence of impermeable surfaces, non-native materials (associated with road bed)	Direct, local	Upland condition	Survey extent of impermeable surfaces/non-native materials	N/A
		Soil compaction	Direct, local	Upland condition	Soil compaction analyses	Soil Science Division Staff 2017
		Fish passage	Direct, local	Native fish needs	Velocity, depth, discharge measurements (fish passage assessment)	ODFW 2006
		Channel gradient	Direct, local	Channel morphology	Longitudinal channel profile	Harrelson et al. 1994
		Channel profile (width, depth)	Direct, local	Channel morphology	Bankfull width-to-depth ratio, cross sections	Rosgen 1996; Harrelson et al. 1994
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and David 2017
		Streambed elevation relative to floodplain	Indirect, local	Riverine process and function	Cross sections	Harrelson et al. 1994
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
		Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999

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Unscreened irrigation diversions	Installation of fish screens	Entrained fish	Direct, local	N/A	Electro-fishing, snorkel surveys, netting; occur behind (downstream of) fish screen	Johnson et al. 2007, Simpson and Ostrand 2012
		Fish populations	Indirect, watershed-scale	Ecosystem response	Electro-fishing, snorkel surveys, netting, PIT tags, rotary screw traps	Johnson et al. 2007, Simpson and Ostrand 2012
Lack of LWD	LWD placement, other actions that increase LWD recruitment	Channel profile (width, depth)	Direct, local	Channel morphology	Bankfull width-to-depth ratio, cross sections	Rosgen 1996; Harrelson et al. 1994
		Longitudinal channel profile	Direct, local	Channel morphology	Longitudinal channel profile	Harrelson et al. 1994
		Instream cover/habitat	Direct, local	Native fish needs	Habitat cover features	Fitzpatrick et al. 1998
		Substrate composition	Indirect, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Fish prey abundance and diversity	Indirect, local	Native fish needs	Benthic macroinvertebrate surveys	Hayslip 2007, Britton and Greeson 1987
		Streambed elevation relative to floodplain	Indirect, local	Riverine process and function	Cross sections	Harrelson et al. 1994
		Groundwater elevation	Indirect, local	Riverine process and function	Groundwater elevation survey	Nielsen 1991, USFS 2007, Cooper and Merritt 2012
		Hydrology (baseflow, hydrograph, magnitude of high and low flows)	Indirect, watershed-scale	Ecosystem response	Continuous stream discharge measurements	Turnipseed and Sauer 2010
		Water quality (nutrients, water temperature, DO concentrations, pH, etc.)	Indirect, watershed-scale	Ecosystem response	Discrete point sampling, continuous sensor measurements, load calculations	ODEQ 2009
		Geomorphology (sediment transport)	Indirect, watershed-scale	Ecosystem response	Suspended sediment load	Edwards and Glysson 1999
Lack or loss of spawning substrate	Gravel additions or other actions that affect substrate composition	Substrate composition	Direct, local	Native fish needs	Facies mapping, pebble counts	Buffington and Montgomery 1999, Wolman 1954, Kondolf 1997
		Fish populations	Indirect, watershed-scale	Ecosystem response	Electro-fishing, snorkel surveys, netting, PIT tags, rotary screw traps	Johnson et al. 2007, Simpson and Ostrand 2012