Monitoring Strategy to Support Implementation of the Upper Klamath and Lost River Subbasins Temperature Total Maximum Daily Load

1.1 Introduction

Section 303(d) of the Clean Water Act requires states to identify waters where current pollution control technologies alone cannot meet the water quality standards set for that waterbody. Every two years, states are required to submit a list of impaired waters (i.e., 303(d) list) to EPA for approval. Waters that do not meet water quality criteria and fully support beneficial uses are termed water quality limited segments (WQLS). The Total Maximum Daily Load (TMDL) process allocates those allowable loads to pollutant sources necessary to achieve water quality standards within a WQLS. Water temperature data evaluated by DEQ and EPA as part of the 303(d) listing process identified 26 WQLS in the Upper Klamath and Lost River subbasins (Table 1 and Table 2). See sections 2 and 3 of the *Upper Klamath and Lost Subbasin Temperature TMDLs* (DEQ 2019) for more details.

Table 1. Temperature impaired streams in the Upper Klamath subbasin.

Waterbody Name	Watershed (HUC)	Length (River Miles)
Beaver Creek	Jenny Creek (1801020604)	5.5
Grizzly Creek	Jenny Creek (1801020604)	3
Hoxie Creek	Jenny Creek (1801020604)	3.6
Jenny Creek	Jenny Creek (1801020604)	17.8
Johnson Creek	Jenny Creek (1801020604)	9.4
Klamath River	John C Boyle Reservoir (1801020602) Lake Ewauna-Klamath River (1801020412) <u>Upstream Watersheds:</u> Copco Reservoir-Klamath River (1801020603) Iron Gate Reservoir-Klamath River (1801020605) Cottonwood Creek (1801020606) Beaver Creek (1801020609)	24.1
Keene Creek[1]	Jenny Creek (1801020604)	9.4
Mill Creek	Jenny Creek (1801020604)	3.9
South Fork Keene Creek	Jenny Creek (1801020604)	3.1
Spencer Creek	Spencer Creek (1801020601)	18.9

[1] There are two water quality limited segments for Keene Creek, a 7.2-mile segment and a 2.2-mile segment. This TMDL covers the full 9.4-mile segment, which is inclusive of both 303(d) listed segments.

Table 2. Temperature impaired streams in the Lost River subbasin.

Waterbody Name	Watershed (HUC)	Length (River Miles)
Antelope Creek[1]	Rock Creek-Lost River (1801020404)	14.1
Barnes Valley Creek	Gerber Reservoir-Miller Creek (1801020405)	14
Ben Hall Creek	Gerber Reservoir-Miller Creek (1801020405)	8.7
Buck Creek	Yonna Valley-Lost River (1801020407)	11.8
East Branch Lost River	Rock Creek-Lost River (1801020404)	2.4
Klamath Straits Drain	Lower Klamath Lake (1801020414) Lake Ewauna-Klamath River (1801020412)	10.2
Lapham Creek	Gerber Reservoir-Miller Creek (1801020405)	4
Long Branch Creek	Gerber Reservoir-Miller Creek (1801020405)	4.9
Lost River	Rock Creek-Lost River (1801020404) Langell Valley-Lost River (1801020406) Yonna Valley-Lost River (1801020407) Mills Creek-Lost River (1801020409)	60.6
Lost River Diversion Channel	Mills Creek-Lost River (1801020409) Lake Ewauna-Klamath River (1801020412)	7.8
Miller Creek	Gerber Reservoir-Miller Creek (1801020405)	9.6
North Fork Willow Creek	North Fork Willow Creek-Willow Creek (1801020402)	2.3
Rock Creek	Rock Creek-Lost River (1801020404)	4.3
Unnamed (Horse Canyon Creek)	Gerber Reservoir-Miller Creek (1801020405)	2.2

[1] There are two water quality limited segments for Antelope Creek, a 14.1-mile segment and a 1-mile segment. This TMDL covers the full 14.1-mile segment, which is inclusive of the 1-mile segment.

1.2 Purpose and Problem Definition

The purpose of this water monitoring strategy (KLR strategy) is to inform adaptive implementation of the KLR TMDL, assess the effectiveness of best management practices (BMPs), and better understand sources of thermal load to WQLS. The KLR monitoring strategy is a guidance document that identifies monitoring objectives and reporting requirements that DEQ expects to be incorporated into site-specific Quality Assurance Project Plans (QAPPs) developed and implemented by DMAs and responsible persons. Specific sampling designs constructed to meet each applicable monitoring objectives will be included in site-specific QAPPs.

Implementation of the KLR TMDL is oriented toward an adaptive management approach. See the Water Quality Management Plan (WQMP) section (Section 4) of the TMDL document for more details. The adaptive management concept applies scientific methods in the design, implementation, and evaluation of management strategies. The premise of adaptive management is that iterative adjustments to management strategies, based on knowledge gained, are likely needed to effectively and efficiently reach project goals. Such adjustments will be informed by data generated from this KLR strategy, among other sources. Adaptive management is well suited for settings and situations that feature significant scientific complexity. As described in the KLR TMDL (TMDL sections 2.2.6 and 3.2.6, hydrology in the Upper Klamath and Lost subbasins is highly modified to support irrigation agriculture and hydropower. The high degree of hydromodification in the KLR subbasin represents significant scientific complexity in the spatiotemporal heat budget and consequently, uncertainties in thermal restoration potential.

1.3 Monitoring to Support Implementation Assurance

Monitoring, assessment, and analysis actions conducted according to the KLR monitoring strategy provides a key feedback mechanism to support adaptive management. This strategy also organizes reporting requirements, corrective actions, and other accountability elements related to monitoring that improve assurance of implementation. Those KLR monitoring strategy elements that support accountability include, but are not limited to:

- Use of data and analytical frameworks to determine, over time, the type and number of specific implementation actions needed to achieve thermal pollution reductions listed in the WQMP and KLR TMDL.

- Compile and track the type, location, number, and effectiveness of restoration actions, including BMPs, being implemented. Evaluate achievements against timelines and milestones established in the WQMP.

- Identification of persons, including designated management agencies (DMAs) and responsible persons, responsible for developing site-specific QAPPs and completing monitoring or reporting actions.

- Take necessary corrective action(s), including DEQ-led monitoring and reporting, if DMAs or responsible persons fail to develop or effectively implement their site-specific QAPP, monitoring, or reporting requirements.

- Track water quality status and trends concurrently as management actions are implemented.

- Conduct monitoring and analysis actions necessary to identify and reduce sources of unidentified anthropogenic thermal load.

Each DMA and responsible persons listed in Table 4.4 of the WQMP will submit monitoring data and project tracking summary to DEQ on an annual basis. Information generated by each DMA or responsible persons will be pooled and used by DEQ to determine whether management actions are having the desired improvements or if changes in management actions are needed. A BMP performance and effectiveness evaluation report will be submitted by each DMA and responsible persons on a 5-year cycle. If progress is insufficient, then the appropriate DMA and responsible persons will be contacted with a request for corrective action.

In some cases, modeling indicates that even with the removal of known, quantifiable sources, the water quality criteria will not be attained. In these cases, DEQ assigns a heat load reduction to background and unidentified anthropogenic sources in order to meet the criteria. As described in Section 2.5 of the KLR TMDL, additional heat budget and system response information may be needed for three waters (i.e., mainstem of the Klamath River, Jenny Creek, and Miller Creek) to effectively reduce unidentified anthropogenic sources of heat or heat related processes. System response studies will be initiated by DEQ for segments of Miller Creek or Klamath River that do not meet water temperature criteria within 10 years of EPA's approval of the KLR TMDL. If these analyses are initiated, reports documenting results and recommendations will be completed by DEQ within 12 years of EPA's approval of the KLR TMDL.

1.4 Monitoring Objectives

Monitoring objectives are statements that identify the reason(s) for collecting water quality data. Monitoring designs are then constructed to achieve objectives. Objectives relevant to the KLR TMDL reflect the complexities of assessing attainment of water quality standards, characterizing the performance of BMPs, evaluating compliance with TMDL allocations, better understanding unidentified sources of heat, and determining whether the underlying TMDL assumptions are correct or if the TMDL needs to be revised.

1. Collect data of sufficient quality and quantity to assess attainment of applicable Oregon water temperature criteria in each water quality limited segment. (*ambient status monitoring*)

2. Collect data of sufficient quality and quantity to detect changes in water temperature and criteria attainment status in each water quality limited segment. (*ambient trend monitoring*)

3. Collect, maintain, and organize administrative data to describe, enumerate, and locate water temperature management strategies planned or implemented by DMAs, responsible persons, and other responsible parties. (*project tracking, administrative monitoring*)

4. Collect data of sufficient quality and quantity that quantifies individual BMP performance and assess progress by DMAs and responsible persons in implementing water temperature management strategies[1]. Table 4-2 in the WQMP presents potential pollutant management strategies for temperature. (*implementation, performance monitoring*)

5. Collect data of sufficient quality and quantity to determine progress by DMAs, responsible persons, and other responsible parties in meeting applicable load or wasteload allocation(s) including surrogate implementation measures[1]. (*effectiveness and allocation attainment monitoring*)

6. Collect data of sufficient quality and quantity to support system-scale analytical linkages between in-stream water temperatures and management strategies planned or implemented by DMAs, responsible persons, or other responsible parties. These data should be aligned with informational needs specified by DEQ in a separate modeling QAPP for the Klamath River, Jenny Creek, and Miller Creek. (*system response monitoring)*

7. Develop analytical linkages (e.g., heat budget models, stream statistical networks, multiple regression, etc.) capable of predicting or estimating changes in water temperature in response to management strategies. To be implemented by DEQ and further described in a separate modeling QAPP for the Klamath River, Jenny Creek, and Miller Creek. (*system response modeling and assessment*)

8. Apply analytical linkages developed in #7 above to distinguish and quantify natural and anthropogenic heat sources, including those anthropogenic heat loads that may not have been identified in the 2019 TMDL. To be implemented

[1] Monitoring objective 4 may be needed in some situations to effectively achieve monitoring objective 5.

by DEQ and further described in a separate modeling QAPP for Klamath River, Jenny Creek, and Miller Creek. (*heat source characterization monitoring and modeling*)

1.5 Monitoring Design Guidance

Monitoring designs describe how and why data are collected to meet monitoring objectives. More specifically, monitoring designs describe the sampling approach, monitoring site location, measurement frequency, and duration of sampling. The KLR monitoring strategy includes specific designs for ambient status and trend monitoring (objectives 1.4.1 and 1.4.2). General guidance is provided in this strategy for DMAs to develop specific designs to implement objectives 1.4.3. – 5 within site-specific QAPPs.

1.5.1 Ambient Status Monitoring

The purpose of ambient status monitoring is to determine if each WQLS is achieving applicable biologically-based numeric temperature criteria. Table 3 outlines the KLR monitoring design to support status monitoring.

Table 3. Monitoring Design Summary for Status and Trend Assessments in the KLR Water Temperature TMDL

Design: fixed station network to be situated at representative locations within each WQLS listed below (a minimum of one temperature sensor per KLR WQLS).
Location: longitudinal surveys may be needed to install instrumentation at sites representative of the reach average or maximum condition.
Parameters: water temperature
Frequency: continuous (15-30 minute resolution)
Duration: minimum 10 years with preferred focus on summer critical period and sensitive salmonid migration windows as applicable.

Site ID	Waterbody Name	Location	Latitude	Longitude	Lead DMA
	Beaver Creek	Beaver Creek River Mile 0.2 just downstream of Corral Creek confluence	42.1180	-122.3700	
	Grizzly Creek	Near Howard Prairie Dam Outlet	42.2170	-122.3730	
	Grizzly Creek	Grizzly Creek 0.1 mi upstream of Jenny Creek confluence	42.1960	-122.3430	
	Hoxie Creek	Hoxie Creek at Keno Access Road	42.2410	-122.3860	
	Jenny Creek	Jenny Creek 1.1 miles upstream of Stateline at Skookum Creek Road	42.0231	-122.3584	
	Jenny Creek	Upstream of Spring Creek off BLM 40 SE-19 Road	42.0350	-122.3470	
	Jenny Creek	Downstream of Spring Creek off BLM 40 SE-19 Road	42.0310	-122.3460	

	Jenny Creek	Jenny Creek off Green Springs Highway	42.1190	-122.3660	
	Jenny Creek	Jenny Creek near BLM 40S-4E-21	42.0780	-122.3445	
	Jenny Creek	Jenny Creek near BLM 40S-4E-33	42.0408	-122.3518	
	Johnson Creek	Johnson Creek at Moon Prairie Road	42.1580	-122.3080	
	Klamath River	Klamath River near Stateline off Copco Lake Road	42.0090	-122.1840	
	Klamath River	Link River at Klamath Falls, USGS 11507500	42.2236	-121.7930	
	Klamath River	Lake Euwana at Railroad Bridge, USGS 421209121463001	42.2025	-121.7750	
	Klamath River	Klamath River at Miller Island Boat Ramp USGS 420853121505501	42.1480	-121.8490	
	Klamath River	Klamath River above Keno, USGS 420741121554001	42.1280	-121.9270	
	Klamath River	Klamath River below Keno Dam	42.1336	-121.9490	
	Klamath River	Klamath River just below JC Boyle Dam	42.1214	-122.0490	
	Klamath River	Klamath River below JC Boyle, USGS 11510700	42.0840	-121.0700	
	Klamath Strait Drain	Klamath Strait Drain near mouth. USGS 420503121513900	42.0843	-121.8609	
	Lost River Diversion Channel	Lost River Diversion Channel near Klamath River, USGS	42.1708	-121.7883	
	Lost River Diversion Channel	Lost River Diversion Channel at Hwy 39	42.1407	-121.6982	
	Keene Creek	Keene Creek above Hyatt Reservoir at Hyatt Prairie Road	42.1980	-122.4600	
	Keene Creek	Keene Creek below Hyatt Reservoir at Hyatt Prairie Road	42.1710	-122.4700	
	Keene Creek	Upstream of Little Hyatt Reservoir off Old Hyatt Prairie Road	42.1630	-122.4870	
	Keene Creek	Downstream of Little Hyatt Reservoir off Old Hyatt Prairie Road	42.1580	-122.4860	
	Keene Creek	Keene Creek downstream of Lincoln Creek at BLM 40-4E-7 Road	42.0970	-122.3960	

	Keene Creek	Keene Creek Upstream of Keene Creek Reservoir at Green Springs Highway	42.1350	-122.4780	
	Keene Creek	Keene Creek Downstream of Keene Creek Reservoir off Green Springs Highway	42.1280	-122.4780	
	Keene Creek	Keene Creek 0.05 mi upstream from Jenny Creek Confluence	42.0910	-122.3690	
	South Fork Keene Creek	South Fork Keene Creek at BLM 40-3E-2 Road	42.0980	-122.4530	
	Mill Creek	Mill Creek off Mill Creek Road	42.0990	-122.4270	
	Spencer Creek	LASAR 28557 Near River Mile 0.5. at Oatman Lake Road.	42.1560	-122.0270	
	Spencer Creek	Spencer Creek near Maggard Road	42.2630	-122.1670	
	Miller Creek	Miller Creek at Round Valley Road, USGS 421114121080100	42.1870	-121.1340	
	Miller Creek	Miller Creek above Miller Creek Diversion Dam	42.1347	-121.1973	
	Miller Creek	Miller Creek below Miller Creek Diversion Dam	42.1337	-121.2014	
	Miller Creek	Miller Creek 0.1 mi upstream of Lost River confluence	42.1080	-121.2559	
	Antelope Creek	Antelope Creek 3.0 mi upstream of Willow Valley Reservoir	42.0460	-121.0730	
	Antelope Creek	Antelope Creek downstream of Midway Reservoir Confluence	42.0990	-121.0720	
	Barnes Valley Creek	Upper Barnes Valley Creek at Barnes Valley Road	42.1670	-120.9700	
	Barnes Valley Creek	Lower Barnes Valley Creek at RM 0.6	42.1750	-121.0450	
	Ben Hall Creek	Ben Hall Creek 0.1 mi upstream of Gerber Road	42.2230	-121.1510	
	Buck Creek	Buck Creek at Burgdorf Road, RM 0.8	42.1950	-121.4540	
	Buck Creek	Buck Creek at Lakeview Hwy	42.2714	-121.4839	
	East Branch Lost River	East Branch Lost River 0.2 mi upstream of Willow Valley Road	42.0040	-121.1170	
	Lapham Creek	Lapham Creek at Forest Service Road 397	42.1880	-120.8760	
	Long Branch Creek	Long Branch Creek at Barnes Valley Road	42.1890	-121.0110	
	Horse Canyon Creek	Horse Canyon Creek at Keno Springs Road Spur	42.2580	-121.2250	

	Rock Creek	Rock Creek below Groh's Reservoir at Willow Valley Road	42.0106	-120.9650	
	Rock Creek	Rock Creek at Natl Forest Rd 4003.	42.0415	-120.8954	
	North Fork Willow Creek	NF Willow Creek near Forest Road 111	42.0090	-120.7870	
	Lost River	Lost River at Stateline (Hwy 161) Rd.	41.9980	-121.5230	
	Lost River	Lost River above Malone Dam	42.0020	-121.2200	
10761-ORDEQ	Lost River	Lost River at Malone Dam (Langell Valley)	42.0068	-121.2241	
38907-ORDEQ	Lost River	Lost River at Gift Road	42.09316	-121.2438	
	Lost River	Lost River above Anderson-Rose Dam	42.0098	-121.5641	
	Lost River	Lost River below Anderson-Rose Dam	42.0094	-121.5584	
	Lost River	Lost River at N. Poe Valley Spur Rd.	42.1503	-121.4939	
	Lost River	Lost River Pool at Crystal Springs Road	42.1553	-121.6620	
	Lost River	Lost River at Hill Road	42.1408	-121.6787	
	Lost River	Lost River at E. Langell Road	42.1654	-121.3183	

1.5.2 Ambient Trend Monitoring

Please see ambient status monitoring at 1.5.1

1.5.3 Project Tracking and Administrative Monitoring

Each DMA should establish and operate a program for tracking and monitoring the implementation of projects and practices. DMA and responsible persons specific tracking systems should align and communicate with the overall tracking and accountability program described by the WQMP (see WQMP section 4.4.1). Characteristics of a tracking and reporting program should:

- Efficiently compile and report management strategies and actions to assess against interim milestones.
- Be easily accessible to the public and agencies for review and audit.
- Be regularly maintained and updated.
- Facilitate submittal of annual progress reports to DEQ.
- Provide sufficient information to document, itemize, and enumerate the location, type, installation date, maintenance schedules, and performance duration of BMPs or strategies.

- Include sufficient information to document the performance of practices and strategies in reducing thermal loads and evaluating compliance with TMDL allocations.
- Describe changes to design, operation, or maintenance taken by DMAs and responsible persons in response to performance evaluations (i.e., adaptive management and design).
- Include a central filing approach, as applicable, to manage hard copy information (e.g., chain of custody forms, design plans, monitoring field sheets etc.) related to project implementation and evaluation.
- Report compliance with TMDL load allocations and surrogate measures as needed to assess against interim milestones.

1.5.4 Implementation and Performance Monitoring

Each DMA and responsible persons should design a monitoring system that quantifies the implementation and performance of individual BMPs and strategies. Example implementation measurements could include: changes in effective shade, number of unknown discharges removed or consolidated, feet of geomorphic restoration, volume of water infiltrated, increases in groundwater accretion, or number of dams removed. Examples of performance monitoring include changes in water temperature, water balance, and thermal load, at the BMP or practice scale, that result from implementing water quality improvement measures.

Considerations in characterizing the performance of structural, distributed, or practice-based BMPs include but are not limited to:

- Characterizing existing water temperatures and thermal loads prior to implementing BMPs or practices.
- The scale and nature of the proposed BMP along with available control sites will influence the study design and placement of monitoring sites. Designs such as upstream/downstream, input/output, before/after/control, or paired watershed designs may be appropriate. Monitoring location(s) may be situated at project boundaries to isolate effects attributable to BMP performance.
- Where possible, include replicates in study designs to improve statistical power. Avoid pseudoreplication.
- In addition to water temperature and flow, measuring key covariates may be needed to characterize BMP performance. For example, changes in water temperature discharged or influenced by a BMP could partially be caused by changes in air temperature rather than management actions. Effects of covariates may need to be accounted for, as applicable, to effectively characterize BMP performance.
- Certain BMPs and practices may require meteorological data (e.g., air temperature, evapotranspiration, etc.) to effectively characterize BMP performance. Unless meteorological data are available and located near the

study site, a temporary climate station may be needed to obtain representative data.

- Characterizing site conditions may be preferred to transfer or extrapolate BMP performance findings to other spatial or temporal settings. Examples of site conditions include soils, slope, climate, relative weather conditions (e.g., wet year, drought), cultivation or drainage practices, land use, or infield practices already implemented (e.g., upgradient wetlands etc.).
- Identify appropriate sample sizes needed to provide the desired level of statistical effect size and significance. Existing datasets and literature can provide a pilot dataset that can be used to estimate the number of samples, storms, seasons, etc. that should be sampled to achieve desired statistical rigor. Sources of existing water quality data within the KLR basin include but are not limited to:
  - Klamath Basin Monitoring Program (http://kbmp.net/maps-and-data)
  - ODEQ Water Monitoring Program (https://www.oregon.gov/deq/wq/pages/wqdata.aspx)
  - North Coast Water Quality Control Board via California Environmental Data Exchange (http://www.ceden.org/)
  - U.S. Geological Survey (https://waterdata.usgs.gov/nwis/qw)
  - U.S. EPA (https://www.epa.gov/waterdata/water-quality-data-wqx#portal)
  - NorWest water temperature database (https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html)

As requested, DEQ will coordinate with DMAs and responsible persons as part of the site-specific QAPP process to assist with study design.

1.5.5 Effectiveness and Allocation Attainment Monitoring

As described in sections 2.7.3.4 and 3.7.3.3 of the KLR TMDL, implementation of surrogate measures such as riparian effective shade, is considered a minimum improvement measure incumbent on applicable DMAs. In addition to surrogate measures, DMAs are to implement practices necessary to meet TMDL load allocations and surrogate measures. The purpose of effectiveness and allocation monitoring is to estimate the in-stream response of BMPs and other measures necessary to evaluate the progress of each DMA toward meeting load allocations specified in the TMDL. For larger WQLS and multi-jurisdiction settings, it is expected that allocation monitoring results may need to be aggregated prior to comparison with TMDL allocations. For more detail on how the allocations were distributed, see sections 2.7.1 and 3.7.1 of the KLR TMDL.

Considerations in developing effectiveness and allocation monitoring designs include but are not limited to:

- Annual measurement of effective shade and riparian zone characteristics, as applicable, according to DEQ methods and procedures.

- Measurement of critical period surface and groundwater discharge, as applicable, according to DEQ methods and procedures.
- See guidelines for objective 1.5.4
- A mixture of heat budget monitoring and modeling methods may be needed to link or translate DMA and responsible persons' management actions into changes in water temperature within WQLSs. In addition to water temperature and flow, modeling information that may be useful includes but is not limited to: water conveyance geometry, travel time, transient storage zones, specific conductivity, applicable meteorological data, and groundwater accretion.
- For management actions that take longer to implement (e.g., riparian zone restoration), predictions of implementation success needed for 5-year reporting may be needed. Such predictions could be based on a combination of literature and data collected elsewhere in the KLR basin or similar catchments in Oregon.
- Data and/or model(s) developed to assess effectiveness along the Upper Klamath mainstem and Miller Creeks should align with inputs and formats needed by DEQ to assess overall system response to management actions (see objectives 1.5.6 – 8).
- In developing study designs, DEQ, the DMAs and responsible persons may wish to consider how operations and management strategies impact or influence heat budget processes through: increasing effective shade, restoring surface flow regimes, increasing groundwater (baseflow) discharge, reducing surface water detention, restoring channel complexity, and controlling stream channel erosion or other disturbances that increase wetted width.
- Data should be collected at sufficient spatial and temporal resolution to: (1) delineate those times and locations where implementation milestones are being achieved and (2) detect the signature or 'fingerprint' of management actions on ambient temperature or flow timeseries.

For practical reasons, there is not a uniform or 'one-size-fits-all' design for effectiveness monitoring. As requested, DEQ will coordinate with DMAs and responsible persons as part of the site-specific QAPP process to assist with study design.

1.5.6 - 8 System Response and Heat Source Characterization

Simulations of restored water temperatures (see KLR TMDL sections 2.6 and 3.6) in the Klamath River, Jenny Creek, and Miller Creek suggest that background thermal loading may prevent these two WQLS from achieving applicable biologically-based numeric criteria (BBNC) at all times or locations. The purpose of objectives 1.5.6 - 8 is to integrate information provided by DMAs and responsible persons (objectives 1.5.4 and 5) within a broader modeling framework to: (1) simulate system-wide progress toward meeting TMDL allocations and applicable BBNCs, (2) simulate the in-stream effect of removing any substantive source of previously unidentified anthropogenic heat, and (3) update estimates of background water temperatures to inform restoration goals. Updated models that simulate restored temperatures could account for anthropogenic changes to: riparian effective shade, point sources of thermal discharge; surface and groundwater withdrawals; water diversions; dams; channel modifications (i.e., changes to width, depth, slope, sinuosity, or roughness); changes in microclimate; climate change, changes in surface and groundwater flow regime (magnitude, frequency, duration, timing - including occurrence of springs); and changes in groundwater temperatures. As described in section 1.3, DEQ will initiate and lead these analyses for segments of Klamath River, Jenny Creek, or Miller Creek that do not achieve water temperature criteria within 10 years of EPA's approval of the KLR TMDL.

Monitoring and modeling procedures used by DEQ for TMDL development and Heat Source characterization will be implemented to support these objectives. Final monitoring designs and analytical frameworks will be described in QAPP(s).

1.6 Data Management and Analysis

Each DMA and responsible persons are responsible for compiling, managing, and reporting data obtained in the performance of monitoring objectives described above. Data management systems implemented by DMAs and responsible persons should: (1) effectively support project tracking and accountability objectives, (2) facilitate timely reporting, (3) facilitate timely uploads to state (AWQMS) or federal (WQX) databases, and (4) include those meta data necessary to describe and document the quality of stored data. DEQ encourages DMAs and responsible persons to pursue a common database design to facilitate data sharing.

Analysis approaches used to construct experimental designs and evaluate collected data should be described in site-specific QAPPs and structured data analysis plans. Data analysis plans for each objective should be prepared. For example, how will data be compared to applicable water quality standards to assess status? Or, what trend analysis technique(s) will be used to detect breakpoints or monotonic changes in water quality timeseries? Statistical techniques and computer models used to analyze data should comport with applicable DEQ or federal guidance. Important assumptions should be documented.

For practical reasons, there is not a uniform or 'one-size-fits-all' set of analysis techniques. As requested, DEQ will coordinate with DMAs and responsible persons as part of the site-specific QAPP process to assist with design of data analysis plans.

1.7 Timelines and Reporting

The KLR monitoring strategy includes reporting requirements to support adaptive managment, project tracking, and implementation assurance. Reporting requirements are summarized below.

- <u>Annual Progress Report</u>

Each DMA and responsible persons should submit an annual progress report that: (1) tracks progress in implementing strategies and BMPs, (2) transfers monitoring data to

DEQ, (3) interprets and summarizes available data, and (4) documents changes to implementation plans in response to new information or data.

- Five-Year Effectiveness and Performance Monitoring Report

Each DMA and responsible persons should submit a report every five years that: (1) documents the effectiveness and performance of water quality improvement strategies, (2) evaluates progress in achieving allocations and applicable surrogates, and (3) documents any proposed changes to the number and/or type of strategies necessary to achieve allocations based on performance evaluations.

- Biennial Status and Trend Evaluation

In conjunction with the statewide integrated report, DEQ will evaluate status and trend data in the KLR basin collected by DMAs, responsible persons and other parties.

- System Response and Heat Source Characterization Report

As described in section 1.3, DEQ may conduct system response and heat source characterization evaluations in Klamath River, Jenny Creek, or Miller Creek if applicable water temperature criteria are not achieved. If these studies are triggered, DEQ will complete a report documenting these studies and recommendations within 12 years following EPA's approval of the KLR TMDL.

- Site-specific Quality Assurance Project Plans

DMAs and responsible persons will submit a monitoring and analysis QAPP to DEQ within 18 months of TMDL approval by EPA. DEQ will approve QAPPs within six months of submittal by DMAs.

Useful References

DEQ (Oregon Department of Environmental Quality). 2019. *Upper Klamath and Lost Subbasins Temperature TMDLs*.