STUDY DESIGN

Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow in Western Washington Project

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Prepared for the
Landscape and Wildlife Scientific Advisory Group (LWAG)
of the
Cooperative Monitoring, Evaluation, and Research (CMER) Committee

Contents

INTRODUCTION

The *Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow in Western Washington Project* (hereafter, Discontinuous Np Project) is being developed by the Landscape and Wildlife Scientific Advisory Group (LWAG) as a part of Washington's Department of Natural Resources (DNR) Forest Practices Adaptive Management Program (FPAMP). The Discontinuous Np Project is a part of the Type N Riparian Prescriptions Rule Group, Extensive Riparian Status and Trends Monitoring Program[1]. This project is a complement to the Extensive Riparian Status and Trends Monitoring Project that is currently under development by the Riparian Scientific Advisory Group (RSAG).

For the purposes of this study discontinuous surface flow refers to the areas of the Type Np (perennial non-fish habitat) stream network with intermittent dry reaches. Under WAC 222-16-30 (3) Type N perennial streams are "flowing waters that do not go dry any time of a year of normal rainfall and *include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow*" (Figure 1). This study primarily focuses on stream temperature and Forest Practices (FP)-designated amphibians (i.e., Coastal Tailed Frog *Ascaphus truei*, and Cascade, Columbia and Olympic torrent salamanders *Rhyacotriton cascadae*, *R. kezeri*, and *R. olympicus*) in Np reaches with surface flow and how intermittently surface dry reaches affect these resources. Seasonal Type N waters (Type Ns Waters), which are typically upstream of the Type Np streams, are outside the scope of this proposal, as are Type F (fish-bearing) waters.

[1] This project is currently organized under the Type N Amphibian Response Program in the 2025-2027 CMER Work Plan. Placement in the Extensive Riparian Status and Trends Monitoring Program is pending approval of the TFW Policy Committee.

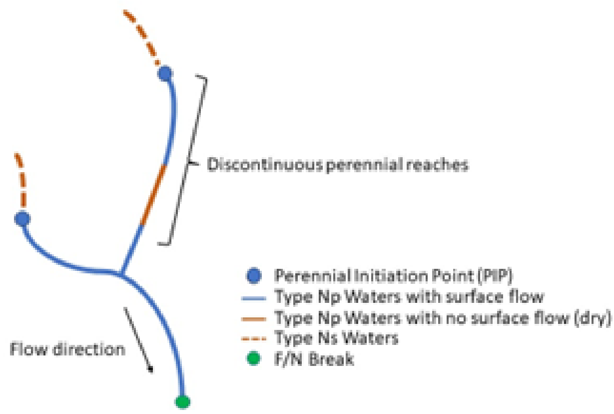

Figure 1. Schematic of a headwater stream network illustrating non-fish-bearing perennial stream reaches (Type Np Waters) with discontinuous or intermittent surface flow (i.e., discontinuous perennial reaches) and seasonal non-fish-bearing channels (Type Ns Waters). The black arrow shows the direction of surface water flow.

Discontinuous surface flow is a common occurrence in Type Np stream networks (approximately 20% of the total Type Np stream length), as demonstrated in previous CMER studies and in peer-reviewed literature (see Scoping Document, Appendix A - Best Available Science, section 1.0). However, uncertainty exists about the potential influence of these reaches on stream resources (water quality and habitat), and their potential influence on the resource objectives outlined by the Forests and Fish agreement (USFWS, 1999).

PROJECT PURPOSE

The purpose of this study is to evaluate how variation in stream temperature and FP-designated amphibians may be associated with discontinuous surface flow and other site specific factors in stream reaches of the Type Np (perennial non-fish-bearing) stream network (hereafter, discontinuous Np reaches) . This effort is intended to inform the potential influence of these reaches on resources of interest to the FPAMP, but is not an effectiveness study that will address or evaluate specific harvest or riparian buffer prescriptions. Also, the study will evaluate how variability in spatial and temporal surface water expression (i.e., wet versus dry channels) may be associated with these resources of interest. This subject is of particular interest to the FPAMP due to their occurrence across the FP-managed landscape (see Scoping Document, Appendix A, section 2.2) and their potential effect on the resources of interest. In addition to physical factors like geology, upslope timber harvest activities and/or global climate change have the potential to influence the frequency and distribution of discontinuous Np reaches and, in turn, modify stream temperature and amphibian habitat (see Scoping Document, Appendix A, section 2.4).

Our review of previous efforts and peer-reviewed literature that evaluated discontinuous Np reaches highlighted a need to characterize discontinuous Np reaches and investigate their potential to influence stream temperature and stream-associated amphibians as a logical next step for FPAMP investigation (see Scoping Document, Appendix A). The investigation proposed herein will also inform other Adaptive Management studies and priorities including Extensive

Monitoring. Findings of this study are intended to characterize stream temperatures farther up the channel network than what will be accomplished by the Extensive Riparian Status and Trends Monitoring Project (Berge et al., 2025, Extensive Riparian Status and Trends Monitoring Project, Scoping Document). Collecting these foundational data will establish status, future trends monitoring could continue at these sites, should the AMP be interested.

PROJECT CRITICAL QUESTIONS

The critical questions related to the issue of discontinuous Np reaches are described in the 2025-2027 Biennium CMER Work Plan under the Type N (i.e., non-fish-bearing waters) Amphibian Response and Type N Riparian Effectiveness Programs. As a part of the scoping process, the Project Team proposes some modifications and additions to the critical questions outlined in the current Work Plan so that they more clearly articulate the questions relative to the proposed research. Our investigation into the peer reviewed literature and previous CMER studies revealed that basic aspects of discontinuous Np reaches have yet to be investigated and as such it is necessary to address a subset of critical questions prior to evaluating the need for a future effectiveness project. Additional critical questions informing effectiveness of riparian buffers adjacent to discontinuous Np reaches and addressing predictions of their occurrence could be addressed through future phases, if desired. The focus of this effort is 1st-order streams, which provide a natural reach break at the confluence, simplifying the study approach and statistical analysis. First-order reaches are generally more prone to seasonal drying and are more likely to have both continuous and dry reaches during summer low flow.

Critical Questions:

- How are stream temperature and FP-covered amphibians (e.g., torrent salamanders) associated with spatial and temporal patterns of surface water expression in discontinuous Np reaches?
- How does stream temperature in discontinuous Np reaches vary across a range of stream and stand characteristics?
- Do stream-associated amphibians utilize discontinuous Np reaches and, if so, do occupancy and/or abundance differ from reaches with continuous surface flow?
- How does FP-covered amphibians use of discontinuous Np reaches vary based on site-specific factors (e.g., lithology, topographic variables, temperature, etc.)?

Predicting the prevalence of flow permanence across the FP-managed landscape is an issue of current interest to CMER, including for the purpose of stream mapping for other CMER efforts such as the Extensive Monitoring and Potential Habitat Breaks (PHB) Projects. The proposed study would collect data that can inform current and future stream modeling efforts, such as *PROSPER*, a new hydrography layer that is based on high-resolution LiDAR digital elevation models and returns probabilistic estimates of streamflow permanence.

PROJECT OBJECTIVES

The objective of the proposed study is to inform critical questions relative to the influence of discontinuous Np reaches on stream temperature and stream-associated amphibian populations (e.g., torrent salamanders). The study will evaluate patterns in spatial and temporal intermittency of discontinuous Np reaches and, importantly, explore factors (i.e., terrestrial and vegetative characteristics) that may influence intermittency. We will evaluate inter- and intra-annual variability in stream temperature. Amphibian response will focus on variation among sites across the three years of the study. Stream surface expression in these first-order reaches is highly variable among years and we anticipate that we will detect variation in amphibian use of reaches as their surface expression changes across year. Data collected as a part of this effort may also be used to inform other areas of FPAMP interest, including expanding on previous efforts to describe the permanence/stability of perennial initiation points (PIPs, i.e., uppermost point of perennial flow) and the potential for the location of PIPs to move under various circumstances, as well as small streams less than 3-ft bank full width (BFW, which are less studied than larger streams.

LITERATURE SUMMARY

Below is a short summary of Best Available Science Review section (Appendix A) of the Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow in Western Washington Project – Scoping Document. See Appendix A for the full literature review.

Stream Temperature

Although associations between temperature responses in larger non-fish-bearing streams and forest management practices have been evaluated frequently, relatively little work has been conducted on small headwater streams including discontinuous Np reaches. Similar to observations from larger non-fish-bearing waters, existing efforts suggest substantial spatial variation exists in stream temperature in headwater streams that cannot be attributed entirely to shading (Dent et al., 2008; Johnson, 2004; Martin et al., 2021; Pollock et al., 2009).

Substrate influences stream temperature variation in small streams by moderating stream-groundwater interactions and hyporheic exchange (Brown, 1969; Johnson, 2004; Moore & Wondzell, 2005). Coarse stream substrates are more likely to have high saturated hydraulic conductivity that facilitates groundwater exchange, contributing to stream cooling. Conversely, fine-textured sediments will have lower saturated hydraulic conductivity and be less able to moderate stream temperature (Moore et al., 2005). As a result, discontinuous Np reaches can support patches of cold water and contribute to the export of cool water downstream because subsurface flow reduces the effects of solar radiation (Ebersole et al., 2014). Guenther et al. (2014) reported that reaches with greater upwelling tended to be cooler than those with downwelling, a result consistent with other reports (Curry et al., 2002; Malcolm et al., 2002; Moore et al., 2005).

Surface Water Expression

Some headwater streams exhibit surface flow discontinuity resulting from a complex interaction between groundwater and surface water, which are influenced by weather/climate, landform, geology, and biotic factors in a hydrogeology framework (Sophocleous, 2002). Because the movement and storage of water varies both spatially and temporally, predicting the longitudinal expression of surface flow can be difficult (Hafen et al., 2022).

Investigations have revealed high variation in the lengths of discontinuous Np reaches across Type Np Waters in western and eastern Washington. Some efforts have concluded that the length of discontinuous Np flow at a site is generally less than 100 m (Palmquist, 2005); others documented examples of much longer discontinuous reaches across multiple study sites {McIntyre, 2018 #53;Ehinger, 2021 #122;Pleus, 2003 #49;Miller, 2015 #2760}. Also, expression of discontinuous Np reaches was related to dry years (Pleus & Goodman, 2003; Veldhuisen, 2004), and the first expression of dry reaches presented itself lower in the stream during drier summers (Veldhuisen, 2004).

Although PIP locations typically associated with seeps and springs can be relatively stable in some sites across years, research has consistently supported the conclusion that the location of highest continuous surface flow (Figure 2) in Type Np Waters varied more from year to year than the location of the PIP (Hunter et al., 2005; Palmquist, 2005; Veldhuisen, 2004). These findings suggest a higher incidence of variation (both between and within sample years) in the surface water expression within discontinuous perennial reaches (Hunter et al., 2005). Note under current rules, definitions for perennial streams apply to flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow (WAC 222-16-031).

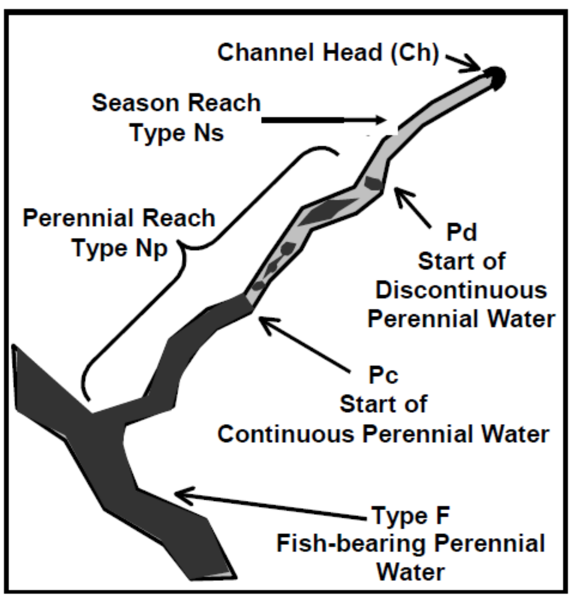

Figure 2. The location and definition of the hydrologic points that define the limits of the seasonal and perennial water types (Palmquist, 2005).

Stream-associated Amphibians

The influence of discontinuous Np reaches on stream-associated amphibians has received very little consideration, at least as reflected in the published literature. Although not a focus of the Hard Rock Study, we do have a limited amount of data on the use of discontinuous Np reaches by amphibians. To put amphibian use of these reaches in context, we summarized amphibian observations (counts) in dry Np stream reaches for a single sample year (2006, pre-treatment). In that effort, only 3.5% of Coastal Tailed Frog, torrent salamander and giant salamander (*Dicamptodon* spp.) observations (71 of 2029) were in dry reaches of a Np stream. Alternatively, 34 of 45 observations (76%) of Western Red-backed (*Plethodon vehiculum*) and Van Dyke's (*P. vandykei*) Salamanders (the latter which is also a FP-designated species) were observed in dry reaches.

RESEARCH/MONITORING APPROACH

Field surveys, continuous temperature loggers, and GIS data sources will be collected over a 3-year period and used to address the critical questions. Field surveys will be conducted to record amphibian observations and stream habitat characteristics including surface water expression and stream temperature to inform thermal heterogeneity. Continuous loggers will be deployed to monitor stream temperature and assist in the determination of the spatial and temporal extent of dry surface stream conditions. Additional data such as topographic characteristics (gradient) and recent harvest history will be gathered from GIS data sources (see Table 4 for a full list). Collectively, these data will be used to inform the critical questions and the potential for discontinuous Np reaches to influence stream temperature and stream-associated amphibian populations.

STUDY POPULATION

The population of interest for the proposed investigation are 1st-order Type Np streams on timber managed lands in western Washington. Including both stream temperature and stream-associated amphibian components in a single effort allows us to address the complexity of these dynamic and variable systems on both resources in a single study, resulting in substantial savings in cost and effort. However, since our goal is to not limit our scope of inference for the stream temperature component to only those sites with verified amphibian presence, we have developed a site selection process that will allow us to draw inference to both by minimizing the potential for unintended bias in site selection.

Site Selection

We will perform a stratified spatially balanced random site selection using a Generalized Random Tessellation Stratified (GRTS; Stevens & Olsen, 2004) approach to identify 1st-order Type Np stream reaches in western Washington for potential inclusion in the study (Figure 3). Each step is detailed below.

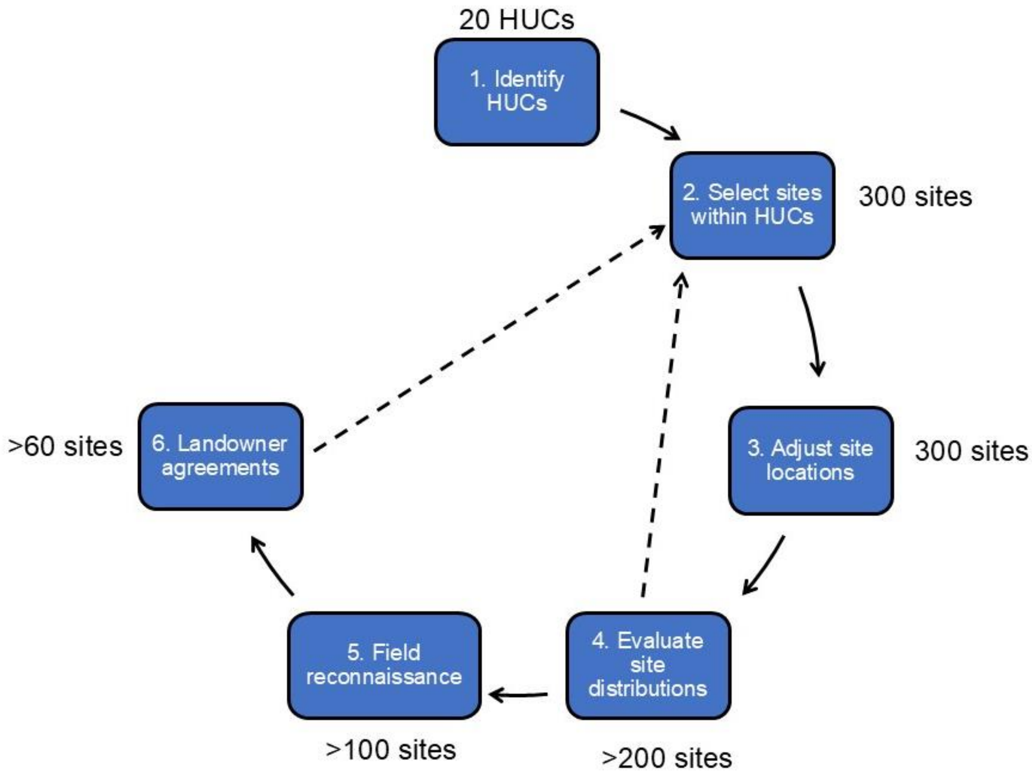

Figure 3. Flow chart of the site selection process, including six distinct steps, to support identification of potential study sites for inclusion in the Discontinuous Np Project.

Step 1. Identify HUCs: Randomly select 20 HUC12 watersheds for inclusion in the Discontinuous Np Project that are within the geographic scope of interest (i.e., west of the crest of the Cascade Mountains) and that meet the criteria/distribution considerations outlined in Table 1 and shown in Figure 4. We will use a stratified sample design, like that described in Miller et al. (2015), to evaluate discontinuous Np reaches on the timber-managed landscape in western Washington. Miller et al. (2015) noted that by not proportionally stratifying sample basins, some basins were unevenly distributed across the stratum. To avoid this issue, we will stratify the HUC12s in proportion to the percentage of private forestlands in each of the geologic provinces. In addition, we will only select HUC12s that have a minimum of 40% of the total watershed area managed for timber production (i.e., state, federal timber managed, and private industrial timber forests). Watersheds dominated by other uses (e.g., wilderness, national parks, urban areas) will not be included in this effort, and only state and federal lands adjacent to private lands will be included (see Figure 4). Lastly, we will ensure a spatially balanced sample using a GRTS approach to select streams within the selected HUCs (Stevens and Olsen 2004).

Table 1. HUC12 watershed site selection criteria of interests.

Criterion of Interest	Data Source	Criterion Target
Regions	WADNR geologic provinces	West of the Cascade Crest and distributed[2] as follows: • Willapa Hills ~ 7 • South Cascade Range ~ 6 • Olympic Mountains ~ 3 • North Cascade Range ~ 2 • Puget Lowlands ~ 2
Forest Land Management	Landowner	>40% of the watershed area is managed for timber production

[2] The number of HUCs distributed across the regions is based on a preliminary estimate of the precent of managed forestland in each of the regions. A full analysis will be conducted during site selection that is described in Step 1.

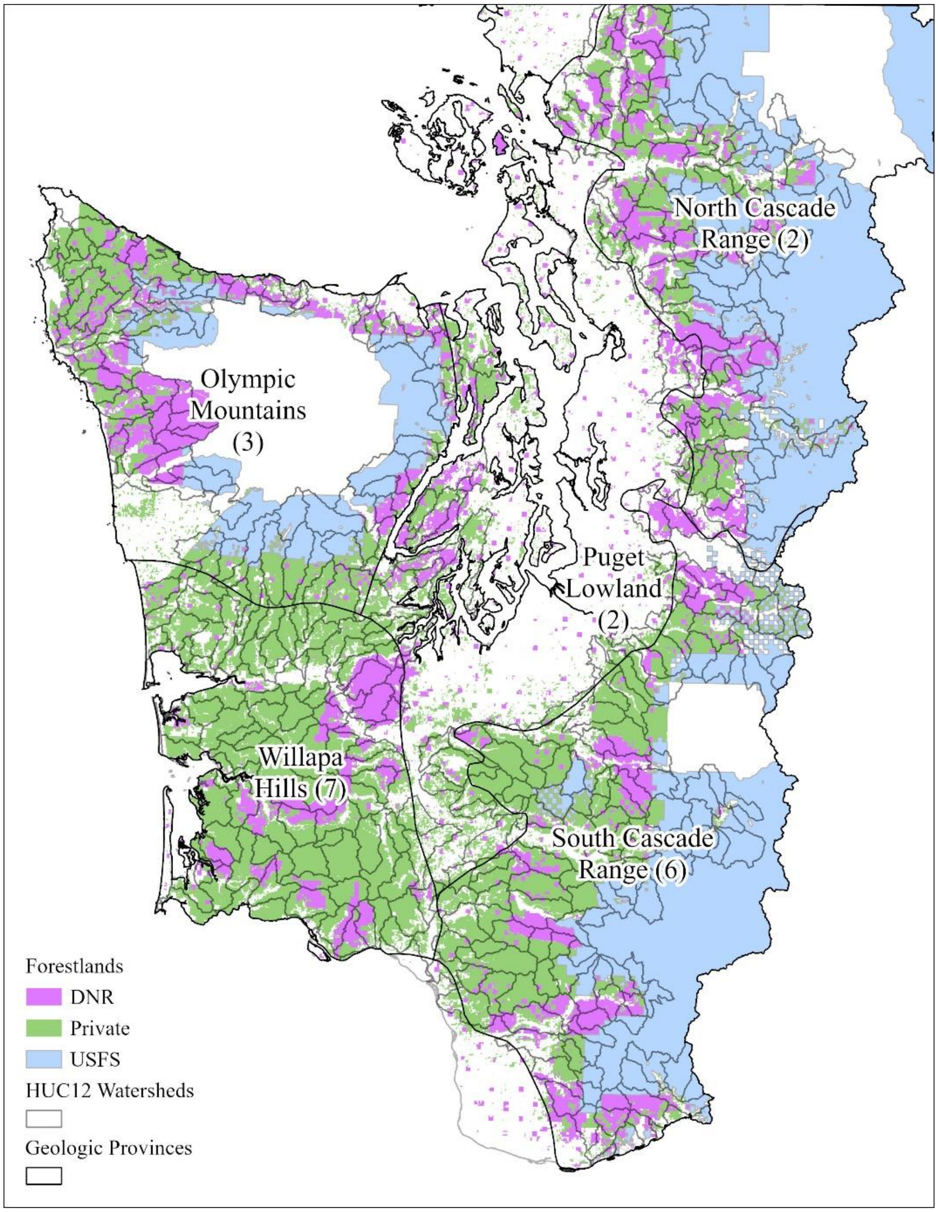

Figure 4. Map of candidate HUC12s in western Washington (>40% timber-managed forestlands). Showing the geologic provinces used to stratify selection and ownership coverage. The number of HUCs to be selected per region are in parentheses.

Step 2. Select sites within HUCs: Randomly select 15 spatially balanced 1st-order stream reaches (completely within timber managed forestland) from the 20 selected HUC12s (n = 300 potential sites). Multiple sites nested in the same HUC12 provide a stronger basis for comparison across predictor variables because they have more similar physical and historical management contexts, allowing for stronger inference related to specific covariates of interest. Incorporating a random effect in the analysis will allow us to account for potential spatial autocorrelation. This approach will also allow for logistical efficiencies since spatial clustering of sites will reduce travel time and cost. We anticipate that not all of these sites will be selected for inclusion in the study due to landowner rejection and stratification targets.

Step 3. Adjust site locations: Use aerial imagery, LiDAR hillshade, and Forest Practices Applications (FPAs) as available to adjust selected 1st-order stream locations to the nearest probable 1st-order stream based on available information. Useable reaches will include 1st-order non-fish-bearing stream reaches that appear to be at least 60-m in total length. Figure 5 highlights the potential error inherent in National Hydrography Dataset (NHD)-modeled 1st-order stream reaches, many of which are in reality non-fish-bearing seasonal (Type Ns) waters or lack a defined channel. The target sample size at the end of this step is 200 sites (out of the 300 that were initially drawn in step 2). If the 200 site criteria is not met, we will repeat steps 2 and 3 until 200 potentially useable sites are identified.

Step 4. Evaluate site distributions: Evaluate if selected sites are representatively distributed across the stratification criteria, namely lithology and upland stand characteristics (Table 2). If target stratification criteria are not met, we will randomly remove sites from the overpopulated strata and randomly select new 1st-order streams from within the underrepresented strata until the stratification targets are met (Miller et al., 2015). The intent of the stratification targets is to ensure that we are representative while minimizing the possibility that our site selection process will unintentionally introduce bias in the sites selected. As such, the sum of the stratification targets do not sum to 100%. This will reduce the need to redraw randomly selected sites while still ensuring representation across strata. The target sample size at this step remains the same as that of step 3, i.e., 200 sites.

Table 2. Stratification criteria and targets for selection of 1st-order streams for potential inclusion in the Study. Targets would will be assessed based on at least 70% of the basin area above the 1st-order confluence.

Stratification Criteria	Data source	Stratification Target
Lithology	WADNR 100k surface geology (hard vs. soft rock classifications)	• Hard rock (basaltic) >30% • Soft rock (marine sedimentary) >30%
Upland stand characteristics	Aerial imagery, WADNR FPA layer for years since harvest where possible (landowner to confirm age if needed)	• Younger stands (less than 20 years old) >30%. • Older stands (equal to or greater than 20 years old) >30%.

Step 5. Field reconnaissance: We will contact landowners to evaluate their willingness to participate in the research effort. If after confirming landowner willingness we have fewer than 100 sites remaining, we will repeat previous steps until representative sites are identified and landowner willingness confirmed at the target number of sites. Once landowner permission is confirmed, we will conduct field reconnaissance at all remaining sites (*Table 3*) to verify that a 1st-order stream reach of at least 60 meters exists for each proposed survey location

Table 3. Target criteria that require field-verification as part of the site selection process.

Parameter of interest	Target
1st-order Np stream length	>60 m

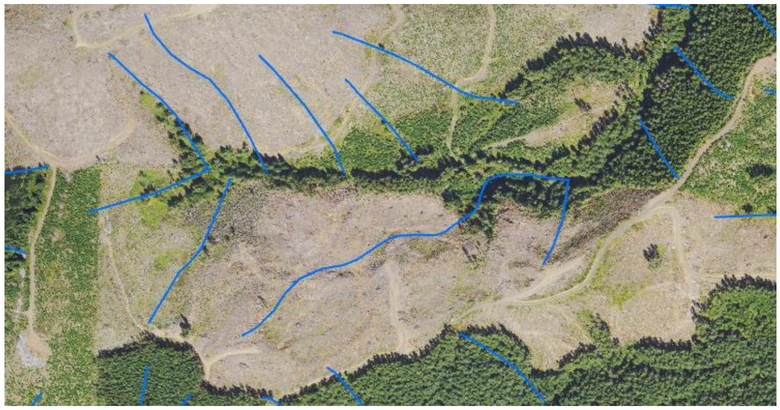

Figure 5. National Hydrography Dataset (NHD)-identified 1st-order (i.e., Type Np) streams (blue line segments) overlaid on aerial imagery in recent clearcut highlight stream segments that are likely seasonal (Type Ns Waters).

Step 6. Landowner agreements: The final step will be to acquire landowner agreements for inclusion of sites in the study. Our intent is to identify a pool of candidate sites greater than our target sample size of 60-75 sites. As a part of this step, we will also verify that we have enough sites in each of the criteria listed in Tables 1, 2, and 3. Steps will be repeated to supplement sample size as needed until 60-75 sites are verified for inclusion in the study. If more than 60-75 candidate sites remain, sites will be randomly selected for removal, while retaining a balance across all criteria.

Observational Unit

The observational unit of interest will vary at each 1st-order stream study site based on the metric of interest, i.e., stream temperature, amphibians, surface expression (see Table 4 for specific units). Stream temperature and surface water expression data will be collected throughout each study site. Four temperature sensors will be placed throughout each study site. Amphibian data will be collected in two 30m stream reaches (Figure 6), one at the bottom of the study site reach, just upstream from the junction with the downstream tributary (hereafter, tributary junction, or TJ plot), and one at the top of the study site reach, just downstream of the PIP (hereafter, PIP plot). Plot placement will be consistent across sites regardless of the current surface water expression (see Table 6). Temperature sensors will be placed with one at the upstream end of each PIP plot, a second at the downstream end of each TJ plot, and the remaining two spaced somewhat evenly along the stream channel.

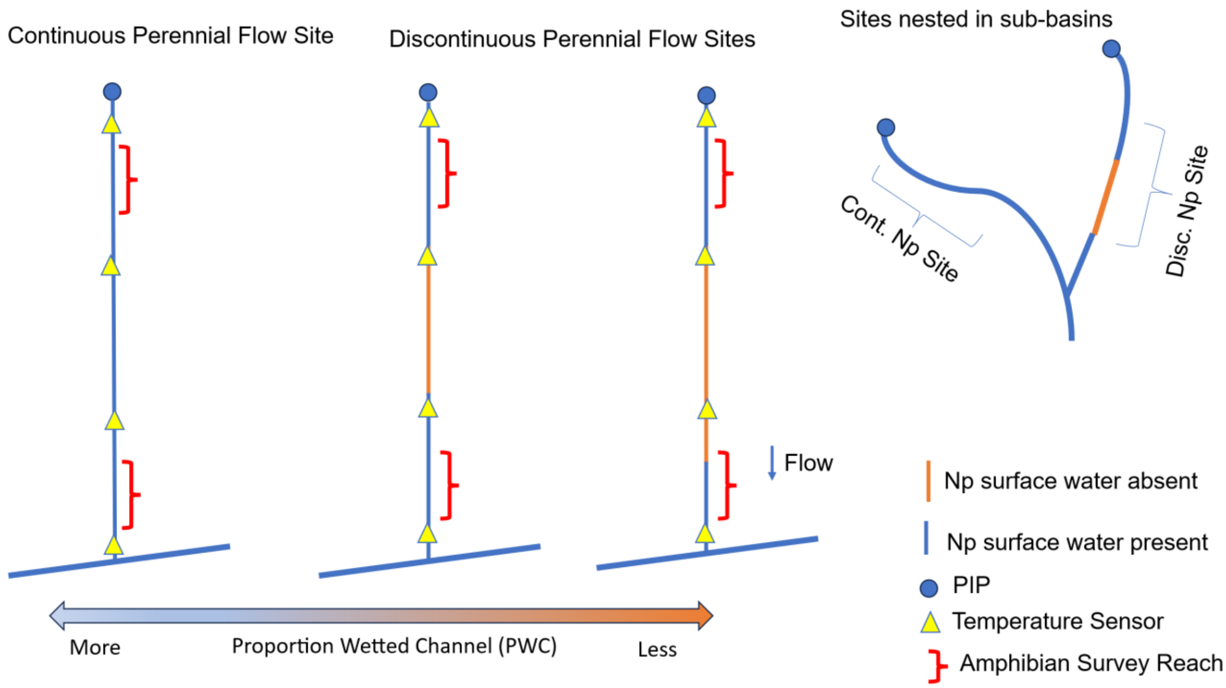

Figure 6. Schematic of three 1st-order stream reach study sites: one with continuous perennial flow and two with discontinuous flow along a gradient of decreasing proportion wetted channel to the right.

Sample Size

The target number of study sites identified during scoping was 60-75 1st-order streams. To determine whether this target sample size was sufficient to estimate quantities of interest, we conducted a power analysis to inform Project Critical Questions (Appendix A). The results of this power analysis indicated that a sample size of 61 was required to estimate stream temperature within two degrees of the true value even with a large amount of variability in the sample data. As a result, we are confident that a sample size between 60-75 should be sufficient.

Data Parameters

Variables of interest include those associated with stream temperature, stream-associated amphibians and surface water expression. Additional habitat data will be used as covariates in select models. See Table 4 for details.

Table 4. Data collection specifics for variables of interest in each variable group: stream temperature, stream-associated amphibians, surface water expression and basin, stream, and riparian characteristics.

Variable group	**Variable**	**Methods**	**Sites**	**Sampling interval**	**Observational unit (per year)**
Stream Temperature	Water	Continuous logger	All	30-minute	4 sensors
	Air	Continuous logger	All	30-minute	Minimum 1 sensor
	Thermal heterogeneity	Field survey	Subset (n = 16)	One time annually	1 survey
Stream-associated Amphibians	Occupancy	Field survey	All	One time annually	2 plots
	Abundance	Field survey	All	One time annually	2 plots
Surface Water Expression	Proportion wetted channel (low flow)	Field survey	All	One time annually	1 survey
	Proportion wetted channel (intra-annual)	Field survey	Subset, 1 site per HUC12 (n = 20)	One time annually	1 survey
	Hydrologic condition	Continuous temperature logger	All	30-minute	4 loggers
	Type N site revisit	Field survey	Subset of possible 28	Years 2 and 3	Np network
Basin Characteristics	Lithology	GIS	All	Once	Np watershed
	Elevation	GIS	All	Once	Np watershed
	Valley aspect	GIS	All	Once	Np network
Stream Characteristics	Substrate	Field survey	All	Once	10m flag locations
	BFW/WW	Field survey	All	One time annually	10m flag locations
	Gradient	GIS	All	Once	Np network
Riparian Characteristics	Canopy cover	Field survey	All	Once	Temperature stations and 30m plots
	Understory composition	Field survey	All	Once	10m flag locations
Upland Stand Characteristics	Stand age	Landowner/ GIS	All	Once	Upland Np watershed

DATA COLLECTION PROCEDURES

Establish Study Sites

We will monument the downstream TJ and PIP at each site with wooden stakes, PVC or capped rebar, and record their locations using a GPS. We will delineate and monument the up- and downstream extent of each study site reach with flagging. We will flag up- and downstream extent of each PIP and TJ plot for amphibian monitoring. We will flag both sides of the stream every 10 m using a string box (string will be pulled upon completion of survey) to follow the sinuosity of the stream channel. We will refresh flags annually as needed during temperature logger downloads in the spring.

Sampling Sequence
The sequence of sampling across sites will be established in the first year by randomly establishing the order of visit of sites within each HUC12 and repeated in the same order in subsequent years.

Stream Temperature Monitoring

Continuous Temperature
We will measure stream temperature continuously at 30-minute intervals at all study sites using Hobo TidbiT MX2205 temperature loggers, with external sensors (Onset Computer Corporation, Bourne, Massachusetts), or similar instruments. Four loggers will be arrayed across each study site with one placed near the downstream tributary junction, one placed upstream near the PIP, and the other two placed opportunistically, approximately equidistant between the upper- and lower-most sensors with a focus on placing them in reaches that are wetted during placement. We will place the external sensor where there is sufficient water depth and flow such that it is submerged during summer installation, but with the expectation that some sensors will go dry. The loggers with an internal temperature sensor, will be used to measure ambient air temperature. The TJ logger will be attached to a T-post on the stream bank (1m above ground). The other 3 station loggers will be placed as close to the stream bed as possible. This will allow some standardization of the ambient air sensors, at the TJ stations, but also make it easier to detect a dry sensor in the upstream locations that are more likely to dewater. Both the bankside loggers and water sensors will be deployed with solar shields (Ehinger et al., 2011). Temperature logger downloads will occur in the field each spring and fall.

Thermal Heterogeneity

We will conduct thermal heterogeneity surveys at a minimum of 2 randomly selected sites per geologic province to identify and characterize thermally differentiated patches and longitudinal patterns in stream temperature (Ebersole et al., 2014). This higher-resolution assessment of stream temperature will contribute to a richer understanding of how hyporheic exchange, groundwater inputs, subsurface flow, and incoming solar radiation may affect stream temperature within the Type Np stream network. We will survey each stream reach using a handheld digital thermometer (Model 35200K ±0.1 °C, response rate < 1 s; Cooper-Atkins Corp.) with a 1m probe walking the reach longitudinally while sweeping the thermometer probe laterally across the stream bed approximately 2 cm from the stream channel bottom. Sweeps will occur every longitudinal meter in which surface water is present until the entirety of the study site has been surveyed. Stream Temperature will be recorded every 5 meters or when there is a change of 0.5 °C. Survey will coincide with the annual low-flow survey.

Steam-associated Amphibian Monitoring

We will conduct light-touch surveys along two 30-m stream reaches (hereafter, plots) at each study site, an upstream PIP and one downstream TJ plot. Researchers commonly use light-touch (Lowe & Bolger, 2002) for headwater amphibians in the Pacific Northwest to establish occupancy or abundance (Quinn et al., 2007; Russell et al., 2004; Steele et al., 2003). Samplers will actively search for amphibians from down- to upstream, turning all moveable surface substrates small cobble-sized or larger (≥64 mm) and within the ordinary high-water mark (WFPB, 2001) during daylight hours. We will randomly select one site from within each HUC included in the study to identify a subset of study sites within which to sample plots three times to allow us to estimate and adjust for variable detection probability at the 30-m detection plot level (Royle, 2004). Our goal is to conduct repeat surveys such that we avoid violating the closed population assumption and with different samplers conducting surveys for each plot pass to reduce sampler bias. Stream temperature and surface water expression (wet or dry) will be collected at the time of each survey for use in the detection model as covariates.

Amphibian count data will be recorded for each taxa (Table 5) and life stage for all focal stream-associated amphibians observed during light-touch surveys. As FP-designated species, Coastal Tailed Frog and the three species of torrent salamanders are the focal species of this effort. However, torrent salamanders are most likely to be encountered in 1st-order study sites due to their predominant occurrence in the uppermost extent of headwater basins. While Coastal Tailed frogs will be documented, they occur in greatest densities farther down in the Type Np stream network (Hayes et al., 2006) and it is possible that occurrence and sample size may not be sufficient for a robust analysis. Two giant salamander species, Coastal and Cope's Giant Salamanders (*D. tenebrosus* and *D. copei*), occur within the geographic scope of interest. While not FP-designated species, we will record all observations due to their occurrence in headwater streams and their inclusion in other CMER efforts. However, giant salamanders are known to occur more frequently farther downstream in the headwater system, thus whether we can conduct a robust statistical analysis for this taxon will depend on our sample size.

Table 5. Stream-associated amphibians included, and their role in, the proposed study. FP-designated stream-associated amphibian are indicated with an asterisk (*).

Taxa	Species	Role in study
Torrent Salamanders *(Rhyacotriton* spp.)	Cascade (*R. cascadae*) * Columbia (*R. kezeri*) * Olympic (*R. olympicus*) *	Focal, primary response variable
Tailed Frogs *(Ascaphus* spp.)	Coastal (*A. truei*) *	Peripheral, anecdotal observations expected but not in analysis
Giant Salamanders (*Dicamptodon* spp.)	Coastal (*D. tenebrosus*) Cope's (*D. copei*)	Peripheral, may be included in the analysis, dependent on sample sizes

Surface Water Expression

We will census the entire stream length of each study site to map surface water expression, at a minimum, once annually during summer low flow (~July-September).

Annual Low-flow Surveys

To estimate the proportion wetted channel, samplers will walk upstream from the downstream extent of each study site, recording changes in surface water expression as defined by the categories in Table 6. For each site, we will summarize these data into a single value that reflects the proportion of the wetted channel for each year/sample period as the sum length of all wet categories divided by the total stream length. To justify a break in surface water expression type there must be a change in surface water expression that is more than one meter in length. Distinct surface water expression categories will be noted for the entire study site stream length between the TJ and the PIP points established during site layout. Using the 10m flagging locations as a guide, we will record the approximate start and end distances for each stream reach that has a change in surface water expression. If we identify a movement in a previously defined PIP location, we will record the distance from the monumented PIP location to the current location and the direction of the move (up- or downstream). We will not conduct low-flow surface water expression surveys within 1-day of a rain event (>1/8 of an inch) as documented at the nearest weather station. Sites will be sampled in the same sequence each year, but this does not guarantee that sites will be at their peak dryness during sampling. A randomized sequence would not allow for strong between year comparisons.

Table 6. Classification scheme for surface water expression surveys, adapted from Miller et al. (2015).

Channel Condition	Current Hydrological Condition	Classification
Presence of distinct banks formed by the removal of material, often with clearly visible substrate	Visible flowing surface water	Wet Channel – Flowing
	Stream reaches with visible pools or surface water that is disconnected from the flowing portions of the stream	Wet Channel – Standing
	No visible surface water, only wet/moist substrate (e.g. muddy stream channels)	Wet Channel – Saturated
	No evidence of surface water or moisture	Dry Channel
Exposed bedrock within the channel reach (>1m) with or without the presence of water.	Visible flowing surface water	Wet Bedrock Channel
	No current surface water or moisture	Dry Bedrock Channel
Unchanneled locations within the valley corridor with signs of persistently saturated soils and evidence of wetland plant species.	Visible surface water	Wet Wetland
	No current surface water or moisture	Dry Wetland
A hollow that is a transitional feature between hillslopes and channels. No channel is present and would likely take an extreme event (e.g. debris flow) to connect channeled locations. Only classify if 10m or greater in length.		Unchanneled Swale
Stream channel obstructed from view such that hydrological condition cannot be accurately evaluated.		Channel Obstruction

During the surface water expression survey, surveyors will check on each of the in-stream temperature sensors and record if it is wet (i.e., fully submerged), partially wet, dry (i.e., not in water), or buried (i.e., covered with fines or other substrate). If the sensor is categorized as "dry" but is adjacent to a continuous flowing part of the stream (within 1 m of the current sensor location) the surveyor will move the rebar and associated sensor to the wetted channel and record the distance moved. For example, if there is a channel shift (e.g., a tree falls into and modifies the channel) samplers may use their discretion to find a new suitable location, moving the sensor as little as possible, and recording the reason for and distance and direction (up- or downstream) of the move. If buried, we will unearth the sensor, record the depth of sediment accrual above the sensor, record the dominant substrate type, fill in the hole, and place the sensor back in the water column. If the relocation of the sensor to a wetted reach would require greater than 1-m longitudinal move upstream or downstream, the sensor will be left in place, and hence available to inform the timing of seasonal drying of that sensor location in that year.

Intra-annual Variation

To describe intra-annual variation in surface water expression we will conduct surface water expression surveys at a minimum of 1 randomly selected site per HUC12 (n = 20) during each of the spring temperature logger downloads. We can also use data from the continuous temperature loggers to infer the timing of any drying associated with instream sensor locations when considered in combination with bankside air sensors.

Hard and Soft Rock Revisit

This study component is not contributing to the sample for the annual and intra-annual surface water expression. This is a separate evaluation of annual variability that allows us the opportunity to expand on existing data over a longer period which included data collected pre- and post- timber harvest. Study sites with documented discontinuous surface water expression will be revisited opportunistically as access, and ability to re-establish sites, allows. For these sites, we will census the stream length, identifying and recording surface water expression consistent with the methodology from the original surveys. Our goal is to revisit all 28 sites as time and landowner willingness permits.

Basin-wide Characteristics

Landscape-level data will be collected from existing shapefiles, rasters and LiDAR that is publicly available. Precipitation data will be collected from nearby sources, similar to the Hard and Soft Rock studies. Data describing lithology, elevation, buffer configuration, gradient, and aspect will be collected and processed in ArcGIS Pro at the watershed and sub-watershed scale.

Stream Characteristics

Substrate will be measured one time over the course of the study at the 10m flagging locations. We will measure wetted width and bankfull width annually one time per site during summer low flow.

Riparian Characteristics

Establish riparian plots every 30m by randomly selecting the initial 10m flag location (between 10 and 40), then designating plot locations every 30m from TJ to PIP.

Overstory
Using a concave spherical densiometer record canopy cover measurements upstream, downstream, right bank, and left bank at 1m above the stream in the center of the channel at a 30m interval, starting from a randomly selected 10m flag location above TJ (follow Ecology's

Standard Operating Procedure for Determining Canopy Closure using a Concave Spherical Densiometer). Canopy cover measurements will also be recorded at the temperature station locations at the time of installation. Record the dominant overstory species within field of vision.

Understory

Using the riparian plots as the center, visually inspect 1m upstream and downstream and over the bankfull channel, and record the percentage of the channel covered, the average height, and the dominant understory species of the plant community.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Quality assurance and control (QA/QC) will be built into the study at multiple levels, from design to implementation. First and foremost, careful consideration of study design elements will ensure that a defensible study design has been developed. As such, the study design will be reviewed and approved by CMER and through an Independent Science Panel Review (ISPR) process to ensure that the study as designed will address the critical questions of interest and that sites are selected in such a way as to minimize bias.

Field crews will undergo a sampling method review and calibration each year under the supervision of the Principal Investigator and/or the Field Lead to ensure consistency in protocol interpretation and application and to minimize data collection errors. A singular Field Lead will implement site selection, conduct site reconnaissance, establish study sites, transects and equipment, and to participate in hiring and overseeing seasonal staff for data collection. Ideally the Field Lead will have experience working in headwater stream ecosystems on the forest managed landscape, be familiar with stream temperature and amphibian monitoring, and have experience leading and organizing staff in a field setting. Data collection will be conducted most frequently in two person teams, and partners will rotate to minimize the potential for observer drift or bias in the interpretation of protocols and definitions and application of data collection methods.

Data stewardship is an important consideration relative to QA/QC. Field data will be primarily recorded electronically, either with dataloggers that are deployed and downloaded in the field, or as data forms in ArcGIS Survey123or similar mobile data collection forms. Dataloggers will be regularly downloaded and data transferred to a database housed on a server that is regularly backed up. Forms will be developed with dropdown lists to minimize mistypes and ensure consistent terminology for species, personnel, and other categorical data. Necessary fields will be designated as required such that staff cannot move onto the next field without fist filling in the previous field. This helps to ensure data are complete before moving on from a sample or site. Constraints will be put on select data fields to reject impossible data values. The date and time are automatically populated every time a record is created. ArcGIS Survey123has the added benefit of being GPS enabled so all data will be spatially georeferenced. Data will be screened for outlier values and field notes indicating sampling issues.

Stream Temperature

Temperature logger downloads will occur in the field each spring and fall. Data will be inspected visually using HOBOware Pro software. Air temperature data will be used for ambient site characterization, data quality assurance, and troubleshooting. If a sensor appears inoperable or damaged, it will be immediately replaced with a reserve sensor and the exchange will be recorded. At the time of download, each sensor's serial number, physical condition and status (e.g. wet, buried, dry) will be recorded. We will identify and flag poor quality data based on the presence of outliers. Field observations (during other surveys, e.g., surface water expression) will be used to identify periods when sensors are exposed to air. Air temperature data will be compared to stream temperature data to discern periods when sensors may have been exposed to the air. Poor quality data may result from sensor exposure to air, burial in silt or mud, freezing, or sensor damage. Anomalous outliers or large segments of missing or erroneous data will be flagged. All raw field data will be permanently retained as downloaded and any edited data files will be saved as new files.

Steam-associated Amphibians

Field crews will be trained to identify focal amphibians to species and life stage. Training and calibration will ensure that individuals are applying amphibian sample protocols in a consistent and repeatable way.

Surface Water Expression

We will cross reference stream layer attributes with field collected data to verify and document study stream locations within a watershed. We will identify the TJ and PIP associated with each study site and clearly flag locations in the field and record locations with GIS. The stream length from TJ to PIP will be verified with LiDAR and other GIS tools and layers. After the first several weeks of the first field season, we will verify that the channel categorizations are representative of conditions on the ground and adjust as needed.

Riparian Characteristics

Create individual buffer polygons with stand attributes within the first year of the study. Record any anomalies or data gaps, then field verify during the subsequent field seasons.

ANALYSIS PROCEDURES

This observational study will address Project Critical Questions by identifying potential associations between stream temperature, stream-associated amphibians, surface water expression, and other site characteristics. This study cannot identify post-harvest changes to specific Forest Practices prescriptions (e.g., an effectiveness study) or identify causal relationships (e.g., an experiment).

Statistical models will be specified to estimate mean stream temperature and stream-associated amphibian demographic responses across a range of discontinuous flow conditions as well as to explore differences across site specific factors. Analysis procedures for each topic and associated critical project question are detailed below. We will focus on:

1. Inter-site Comparisons: Evaluate the associations between stream temperature and amphibian populations across various sites. For each analysis, we will use the proportion of wetted channel as a covariate, while also exploring the influence of site characteristics on stream temperature and amphibian populations (Figure 7).

2. Intra-site Comparisons: Analyze the same associations at a finer reach scale by contrasting conditions within each study site. Specifically, compare upstream PIP plots and associated sensors with downstream TJ plots and sensors to evaluate variation in stream temperature and amphibian populations (Figure 7).

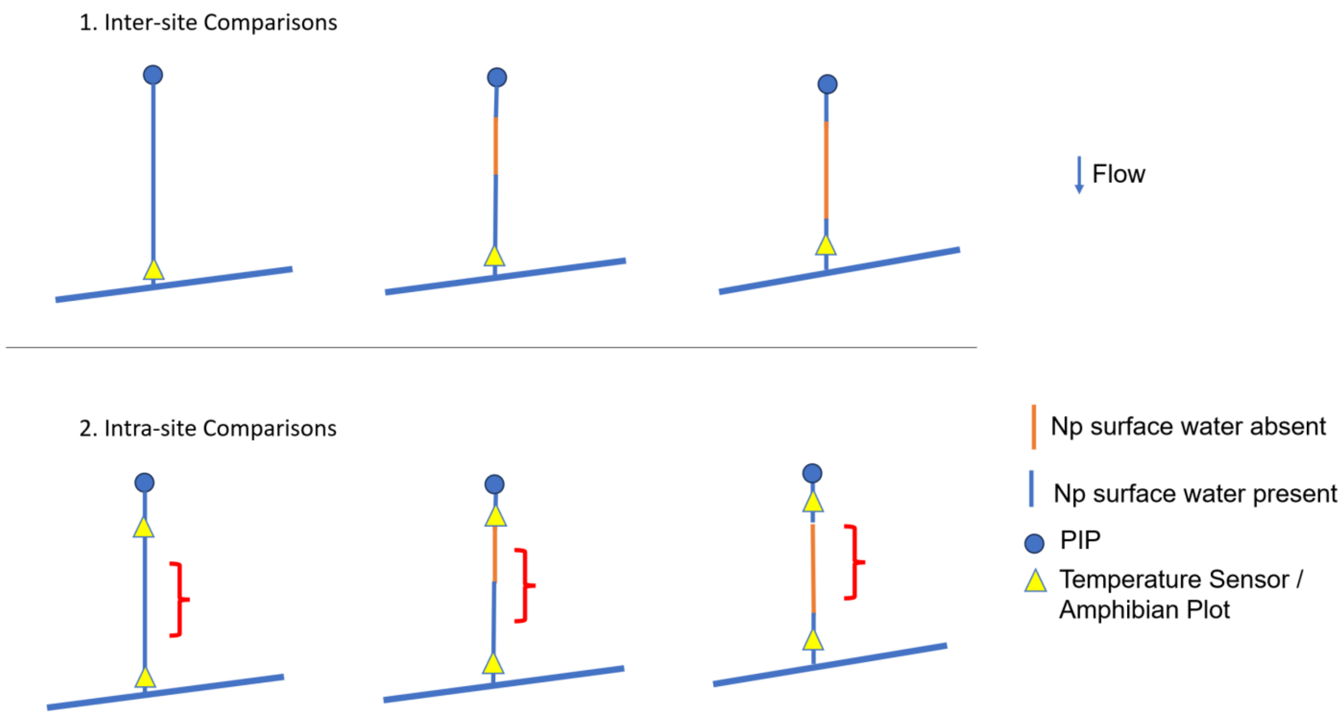

Figure 7. Schemtaic of inter- and intra-site comparisons.

Stream Temperature

We will evaluate how multiple stream temperature metrics vary among and within sites across a suite of covariates including proportion of wetted channel, or categorical continuous versus discontinuous states, and other site characteristics (Table 7) to address the following Project Critical Questions:

Project Critical Question: *How does stream temperature vary in discontinuous perennial reaches (related to spatial and temporal pattern of surface water expression)?*

Project Critical Question: *How does stream temperature in discontinuous perennial reaches vary across a range of stream and stand characteristics?*

Continuous Data Collection

We will summarize data collected from Hobo TidbiT MX2205 loggers at 30-minute interval as the following responses for analysis:

1. 7-day average of the daily maximum (7DADM) – We will evaluate 7DADM as a metric for stream temperature both because of its relevance to state water quality standards (WAC 173-201A-020) and because it likely represents peak thermal stress for cold-adapted stream-associated amphibians (Bury, 2008; Friele et al., 2016).

2. Mean Monthly Diel Range (MMDR) - Summarized as the difference between the maximum and minimum temperatures recorded within a 24-hour period. This can be used to assess groundwater influence on a reach (narrower diel ranges show less of an effect of ambient air temperature on stream temperature).

3. Daily minimum, mean, and maximum daily temperatures summarizes the time series by day for the study period, which provides a finer resolution to explore temporal patterns. We will also evaluate the potential for a duration analysis. This will only be used for an inter-basin comparison conducted at the TJ sensor.

4. Mean Monthly Maximums (MMMs) – We will use MMMs to investigate broader seasonal trends across the year.

Inter-site Comparisons

We will use the data collected from sensors located at the downstream end of the TJ plot to evaluate potential relationships between stream temperature and site wide characteristics (e.g., Proportion Wetted Channel, Lithology, upland stand age). Data from these sensors will be summarized into the above metrics (e.g., 7DADM, MMDR, MMMs). These summarized datasets can then be analyzed using multiple regression models, with site characteristics as explanatory variables (Mayer, 2012).

Intra-site Comparisons

As with the site-wide analysis, data from all sensors will be summarized into the above metrics when feasible. We will then use this summarized data to evaluate reach-scale characteristics (e.g. dry channel length, BFW, canopy cover[3]). The four continuous sensors will allow us to analyze longitudinal patterns throughout the site. For example:

[3] Canopy cover can be used as a surrogate for effective shade. McIntyre and colleagues (2021) compared densiometer reading with hemispherical photography taken at the same site location and found a 0.95 correlation (Table 4-5 of McIntyre et al. 2021). Other studies have also found that similar results when comparing desiometer

- Differences between probe nearest PIP and nearest TJ as it relates to the proportion of discontinuous reaches. TJ-PIP/Stream Length = Change per unit length.
- Longitudinal changes between all 4 sensors.
- Proportion of dry reaches above each sensor location.
- Total length of dry channel above sensor.
- Nearest dry reach.

Table 7. Summary of stream temperature analyses.

Parameter	Error distribution	Potential covariates	Random effects
Stream temperature	Gaussian	• Proportion wetted channel • Riparian/upland stand characteristics • Gradient (stream and valley) • Lithology/substrate • Aspect	HUC12

Thermal Heterogeneity

The purpose of this study component is to evaluate warming and cooling patterns across sites at a higher resolution than is available from continuous temperature loggers. Due to the greater time requirement to collect this data it will only be gathered at a subset of sites and will be a case study rather than a statistical analysis. Data will be mapped as a longitudinal thermal profile to show warming and cooling patterns across a range of site conditions.

This data may also be useful in explaining longitudinal patterns of temperature from the continuous sensors (i.e. to identify cold patches that may fall between data loggers which may alter a general trend of downstream warming).

Steam-associated Amphibians

We will evaluate how stream-associated amphibian occupancy and/or abundance varies among and within sites across a suite of covariates including proportion of wetted channel and other site characteristics (Table 8) to address the following Project Critical Questions:

Project Critical Question: *How does FP-covered amphibian occupancy and/or abundance vary in discontinuous perennial reaches (spatial and temporal pattern of surface water expression)?*

Project Critical Question: *Do stream-associated amphibians utilize discontinuous perennial reaches of Type Np Waters and, if so, do occupancy and/or abundance differ from reaches with continuous surface flow?*

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and hemispherical photos and concluded that densiometer is an effective cheap alternative, especially when high precision is not necessary (Russavage et al. 2021, Paletto and Tosi 2009).

Project Critical Question: *Do FP-covered amphibians utilize discontinuous Np reaches differentially based on site specific factors (e.g., lithology, topographic variables, temperature, etc.)?*

To evaluate amphibian-related questions of interest within our observational design, we will consider various statistical models including occupancy and abundance models. We will estimate parameters to account for variation in detection. We will use data collected during amphibian sampling in the Type N Hard Rock study to identify covariates that explain heterogeneity in detection to inform the number and distribution of detection plots across sites in this study (Table 8). Detection probability adjustments will be applied to count data collected in sample plots to estimate densities by species. Hierarchical model structures may be required to accommodate multiple sample plots (e.g., PIP and TJ plots) within each primary unit of inference (e.g., a study site).

We will compare amphibian mean densities between study sites, as well as between PIP and TJ plots within a site. Our study design approach will allow us to evaluate amphibian metrics as they relate to site-wide surface water expression (Table 6). Statistical models will generate mean estimates and confidence intervals, enabling contrasts for comparisons across these groups. The inclusion of covariates, as summarized in Table 8, will facilitate the evaluation of associations with site-specific factors, including how amphibian densities may be related to the proportion wetted channel and stream temperatures.

Table 8. Summary of stream-associated amphibian analyses.

Parameter	Potential covariates	Random effects
Abundance / Occupancy	• Stream temperature • Proportion wetted channel • Riparian stand characteristics • Gradient • Lithology	HUC12 Year
Detection	• Stream temperature • Dry length • Wetted width	

Surface Water Expression

The primary purpose of the surface water expression effort, as reflected by the proportion wetted channel, or continuous versus discontinuous, is to include this value as an explanatory variable in our stream temperature and stream-associated amphibian analyses. However, during scoping the Project Team highlighted a secondary purpose for which these data could be used, to support a better understanding to the intra- and inter-annual variability in surface water expression throughout western Washington. CMER and TFW Policy demonstrated their interest in this investigation by supporting the proposed revisit to existing Type N Hard and Soft Rock Study sites in the current effort. As such, we will evaluate how surface water expression varies among and within sites across a suite of covariates including site characteristics and climatic variables (Table 9).

Hard and Soft Rock Revisit

We will evaluate long-term annual variation in surface water expression by visiting *existing study sites in a parallel effort* to the proposed study. Data on surface water expression exists for study sites included in both the Type N Hard and Soft Rock Studies, including data collected both before and after timber harvest. We will revisit Hard and Soft Rock study sites to evaluate the current surface water expression consistent with the protocols used in the original studies. With these data, we will re-run surface flow analyses to evaluate potential temporal patterns, including changes in surface water expression and PIP movement.

PIP movement/stability

We will summarize PIP movement distance metrics (e.g. mean, max, distribution). We will calculate the percent of PIPs that move more than 5 meters up- or downstream between years. If significant PIP movement is detected across the study, a GLMM will be used to evaluate potential relationships between explanatory variables (e.g. gradient, lithology, etc.) and PIP movement.

Annual Low-flow Surveys

We will investigate the potential influence of site characteristics and climatic variables on the proportion wetted channel. We will be able to evaluate potential site and climatic influences on proportion wetted channel in both an inter- and intra-site comparison.

- Inter-site comparisons – Use proportion wetted channel metric to test which regional and landscape scale variables impact the proportion of wetted channel.
- Intra-site comparisons – Use reach scale segments to evaluate site characteristic influences on patterns of drying throughout the site.

Intra-annual variation

Mapping surface water expression to visualize the difference between different seasonal patterns of surface flow. Exploratory analysis to see if it would be possible to estimate the probability of summer low flow percentage based on surface water expression in other seasons.

Contribute to New Mapping Tools

Though not specifically a part of the study design as described above, PIs note that the data collected in this effort can supplement other regional efforts. Specifically, data could be used to support the development of models to predict the probability of dry reaches in perennial streams (e.g., USGS Probability of Streamflow Permanence (PROSPER) | U.S. Geological Survey). Currently, these modelling efforts do not fully encompass or accurately reflect 1st-order streams (which are innately difficult to model). Data from this project can support improved modeling to help fill knowledge gaps.

Table 9. Summary of surface water expression analyses.

Parameter	Potential covariates
Percent Wetted Channel (Basin level) / Percent Years Dry (Reach level)	• Lithology • Riparian stand characteristics • Stream characteristics • GIS derived topographic • Climatic variables • Water year

PROJECT RISK ANALYSIS

Project risks are primarily associated with the collection of field data and access to study sites. The study design has a large sample size of 60-75 sites and is intended to accommodate some loss of sample sites and still provide valuable inference.

Adverse Conditions: Adverse environmental conditions pose a potential risk to the timely completion of fieldwork. High wildfire danger may limit access to study sites during periods of extreme fire weather. Staff may encounter blocked roads due to downed trees and washouts when attempting access of remote sites in the spring. Such conditions may prevent staff from conducting essential activities efficiently or accessing some sites at all during certain periods. To mitigate this risk, the project schedule includes flexibility to adjust data collection timelines based on conditions.

Drought as an Outlier Year: Drought conditions may introduce variability into the dataset, creating an outlier year that will be reflected in study results and interpretation. While extreme conditions such as these can be challenging, they also offer an opportunity to capture critical data that can represent a broader range of potential environmental conditions. To account for this possibility, the study's design includes three years of field data collection and statistical approaches to assess and account for outlier data intended to support inference across varying environmental conditions.

Theft or Tampering: Field instrumentation and study infrastructure risks theft, vandalization or tampering. We anticipate these risks to be low, however some sites may carry more risk than others. Equipment will be hidden from plain view, camouflaged, and secured to the extent possible to minimize risk.

Landowner Access: The study design relies on securing access to a variety of sites across multiple landowners. Delays or challenges in obtaining permissions could impede site availability and data collection. To address this, the project will employ proactive engagement with landowners, clear communication about study objectives, and flexible scheduling to accommodate access constraints.

Allocation of sites across target stratification criteria: Though we've outlined a reiterative site selection process above whereby we can circle back and select more sites in an attempt to fill target sample sizes across the various target strata (e.g., region, lithology), there is some risk that we may not achieve desired sample sizes within each combination of strata. If this occurs, we will work with a statistician to identify opportunities for ensuring we are maintaining generalizability of study findings and maximizing statistical power. This consideration may be exacerbated by landowner willingness, which will also play a large role in success of meeting sample sizes across strata (as mentioned above).

Low Sample Sizes: Low amphibian counts and/or dry sensors may impact our ability to conduct a robust statistical analysis. By deploying multiple sensors arrayed along the stream reach and deploying them during summer low flow, we will help reduce the risk of sensors going dry.

BUDGET

The proposed budget for the Discontinuous Np Project for the 2025-2027 Biennium was in the Master Project Schedule (MPS) and has been approved by the Forest Practices Adaptive Management Program. Beyond this biennium, budget estimates for the project timeline (FY26-FY30) as estimated in the MPS total $1,580,000 (Table 10).

Table 10. Budget estimates for the Discontinuous Np Project, FY26-FY30, as currently reflected in the approved Master Project Schedule (MPS). Final budget will be adjusted based on Scoping and finalization and approval of the Study Design, the timing and specifics of which have implications for the overall budget and timeline.

Budget/Cost Items	**Estimated Budget by Fiscal Year**					**Total**
	FY26 (Jul 2025-Jun 2026)	**FY27** (Jul 2026-Jun 2027)	**FY28** (Jul 2027-Jun 2028)	**FY29** (Jul 2028-Jun 2029)	**FY30** (Jul 2029-Jun 2030)	
Finalize Study Design and Conduct Site Selection	$ 202,697					$202,697
Field Work, Data Collection, QA/QC and Analysis		$407,303	$360,000	$360,000	$140,000	$1267,303
Final Report writing and review					$80,000	$80,000
Final Report revisions					$30,000	$30,000
Total FY Estimated Budget	$250,000	$360,000	$360,000	$360,000	$250,000	$1,580,000

Study Timeline

The study timeline (Table 11) begins in Fiscal Year (FY) 26 and concludes in FY30. FY26 work includes finalization of Study Design and initiation of site selection in winter of 2025/2026. Field verification of study site selection criteria will be conducted in the summer of 2026. FY27 will include completion of site selection, study implementation planning and initiation of the first year of study data collection (summer 2027). FY28 will include completion of the first year (summer 2027) and initiation of the second year (summer 2028) of study data collection. FY29 will include the completion of the second year (summer 2028) and initiation of the third year (summer 2029) of study data collection. FY30 will include completion of the third year of study data collection (summer 2029), analysis, reporting, and review. Review and approval are likely to extend into FY31.

Table 11. Timeline for implementation of the Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow in Western Washington Project.

Fiscal Year	**Task**
FY26	- Study Design development, review, and approval - Site selection: GIS screening, landowner outreach, and field validation
FY27	- Finalize study sites, study site layout in field - Field work - Data collection - QA/QC
FY28	- Field work - Data collection - QA/QC
FY29	- Field work - Data collection - QA/QC
FY30	- Field work completion - Data collection - QA/QC - Final Report writing and review

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Appendix A: Sample size calculations to estimate stream temperature within 2, 3, or 4 degrees of the true value (the "difference") and for amounts of variation (standard deviation). For each difference, two confidence levels (0.05 and 0.10) were evaluated.

Estimated sample size (n.0)	Confidence level (z) of 0.05	Standard deviation (s)	Difference between estimate and true value
4	1.96	2	2
6	1.96	2.5	2
9	1.96	3	2
12	1.96	3.5	2
15	1.96	4	2
19	1.96	4.5	2
24	1.96	5	2
29	1.96	5.5	2
35	1.96	6	2
41	1.96	6.5	2
47	1.96	7	2
54	1.96	7.5	2
61	1.96	8	2
2	1.96	2	3
3	1.96	2.5	3
4	1.96	3	3
5	1.96	3.5	3
7	1.96	4	3
9	1.96	4.5	3
11	1.96	5	3
13	1.96	5.5	3
15	1.96	6	3
18	1.96	6.5	3
21	1.96	7	3
24	1.96	7.5	3
27	1.96	8	3
1	1.96	2	4
2	1.96	2.5	4
2	1.96	3	4
3	1.96	3.5	4
4	1.96	4	4
5	1.96	4.5	4
6	1.96	5	4
7	1.96	5.5	4
9	1.96	6	4

Estimated sample size (n.0)	Confidence level (z) of 0.05	Standard deviation (s)	Difference between estimate and true value
10	1.96	6.5	4
12	1.96	7	4
14	1.96	7.5	4
15	1.96	8	4
3	1.645	2	2
4	1.645	2.5	2
6	1.645	3	2
8	1.645	3.5	2
11	1.645	4	2
14	1.645	4.5	2
17	1.645	5	2
20	1.645	5.5	2
24	1.645	6	2
29	1.645	6.5	2
33	1.645	7	2
38	1.645	7.5	2
43	1.645	8	2
1	1.645	2	3
2	1.645	2.5	3
3	1.645	3	3
4	1.645	3.5	3
5	1.645	4	3
6	1.645	4.5	3
8	1.645	5	3
9	1.645	5.5	3
11	1.645	6	3
13	1.645	6.5	3
15	1.645	7	3
17	1.645	7.5	3
19	1.645	8	3
1	1.645	2	4
1	1.645	2.5	4
2	1.645	3	4
2	1.645	3.5	4
3	1.645	4	4
3	1.645	4.5	4
4	1.645	5	4
5	1.645	5.5	4
6	1.645	6	4

Estimated sample size (n.0)	**Confidence level (z) of 0.05**	**Standard deviation (s)**	**Difference between estimate and true value**
7	1.645	6.5	4
8	1.645	7	4
10	1.645	7.5	4
11	1.645	8	4