**Washington State**
**Cooperative Monitoring, Evaluation, and Research Committee (CMER)**
**Report**

Commented [HB1]: Nice work especially the BAS. All my comments are for clarifications and should be considered yellow.

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

# Draft Scoping Document


**Prepared by**
**Welles Bretherton, A.J. Kroll, Aimee McIntyre, Mark Meleason, Reed Ojala-Barbour**


**Project Manager**
**Jenny Schofield**

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


**Washington State Forest Practices Board**
**Adaptive Management Program**
**Washington State Department of Natural Resources**
**Olympia, Washington**

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

**Scoping Paper**

**Project Team:** Welles Bretherton, A.J. Kroll, Aimee McIntyre, Mark Meleason, Reed Ojala-Barbour, Jenny Schofield (Project Manager)

# Contents

# 1. CONTEXT

Commented [OBRA(2]: Dear CMER Reviewers, we substantially revised the context section which led to the loss of some comment bubbles. They are retained below in deleted track changes.

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 and Type N Amphibian Response (Effectiveness) Rule Groups.

~~Washington's Forest Practice (FP) Rules for private forestlands are described in the Forest Practices Habitat Conservation Plan (WADNR, 2006) and define Riparian Management Zones (RMZs) for streams in Washington State. Washington Administrative code (WAC) 222-30 *Timber Harvesting* defines regulations for the removal of timber from forestlands. WAC 222-30-021 and WAC 222-30-022 define rules for RMZs for western and eastern Washington, respectively.~~

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~~. These intermittent dry reaches disconnect the flowing portions of the Type Np network. Since the focus of this study is on the areas with surface flow, it was important to emphasize that the area of inquiry is on the discontinuous flowing portions of the network instead of the intermittent dry reaches. At the time of negotiations that lead to the development of the Forests and Fish Report (USFWS, 1999), almost no published studies addressed the efficacy of riparian buffers for Type N Waters or provided clear guidance addressing riparian buffer design, most notably for stream-associated amphibians~~." This study primarily focuses on stream temperature and FP-covered amphibians in reaches with surface flow and how intermittent 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 waters with discontinuous flows.

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~~This project will evaluate the potential influence of perennial headwater streams with discontinuous surface flow on stream temperature and stream-associated amphibians. Reach-scale study sites will be sampled with the objective of making inference about other stream reaches on FP managed lands across western Washington. Results may inform the placement of riparian buffers on Type Np Waters as it pertains to the buffering of the "intermittent dry portions of the perennial channel below the uppermost point of perennial flow" (i.e., reaches with discontinuously flowing Np reaches). This project will provide insights on buffer placement relative to the Overall Performance Goals to meet water quality standards and maintain the long-term viability of "other covered species", which includes the Columbia torrent salamander (*Rhyacotriton kezeri*), the Cascade torrent salamander (*R. cascadae*), the Olympic torrent salamander (*R. olympicus*), the Dunn's salamander (*Plethodon dunni*), the Van Dyke's salamander (*P. vandykei*), Coastal Tailed Frog (*Ascaphus truei*) and Rocky Mountain Tailed~~

Frog (*A. montanus*). Results can also be used to inform potential future efforts to evaluate the effectiveness of the current rule in protecting resources, if desired.

Type Np Waters are defined under current FP rules for the state of Washington (WADNR, 2006) as "all segments of natural waters within the bankfull width of defined channels… 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[1]" (WAC 222-16-030). The scope of the proposed research is on the intermittently flowing portions of non-fish-bearing perennial waters (Figure 1). Due to the understandable confusion between perennial waters with discontinuous surface flow and seasonal waters (i.e., Type Ns Waters)[2], we refer to reaches of Type Np Waters with discontinuous surface flow as "*discontinuous perennial reaches*". Seasonal Type N waters (Type Ns Waters), which are typically upstream of perenniality, are outside the scope of this proposal, as are Type F waters with periods of intermittent flows. Discontinuous perennial reaches are well-defined stream channels that support surface flow at certain stream discharge levels such as during high flow events.

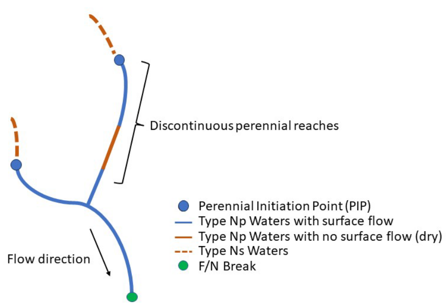


Figure 1. Schematic of a headwater stream network illustrating non-fish-bearing perennial stream reaches (Type Np Waters) with discontinuous or intermittent surface flow (i.e., discontinuous perennial reaches) and seasonal non-fish-bearing channels (Type Ns Waters). The black arrow shows the direction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

With the adoption of the Forests and Fish Law, timber harvest guidelines prescribed under current FP rules expanded riparian protections beyond those of the Timber, Fish and Wildlife agreement (TFW; WFPB, 1987) to include Type Np Waters. FP rules specify requirements for forest management activities around Type Np Waters, including the minimum riparian buffer width, length and configuration required in the RMZ (see WAC 222-30-021).Discontinuous surface flow

[1] The uppermost point of perennial flow, also referred to as the perennial initiation point (PIP), is the uppermost extent of the Type Np Water, or the point at which a Type Np Water becomes a Type Ns (seasonal) Water.
[2] Seasonal waters (Type Ns Waters) include all segments of natural waters within the bankfull width of defined channels that are seasonal, non-fish habitat streams in which surface flow is not present for at least some portion of a year of normal rainfall and are not located downstream from any stream reach that is a Type Np Water.

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**Formatted:** Space After: 0 pt, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers is a common occurrence ~~(approximately 20% of the total Type Np stream length, see BAS section 1.0)~~ in Type Np stream networks (approximately 20% of the total Type Np stream length) ~~th~~, as demonstrated~~at has been addressed~~ in previous CMER studies and in peer-reviewed literature (see ~~BAS~~Appendix A, section 1.0). However, ~~U~~uncertainty exists about ~~these reaches (prevalence and characteristics), their~~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)~~ have been discussed by researchers with CMER~~.

~~Surface water expression has an obvious linkage~~~~Preliminary CMER efforts to inform this topic through evaluations as a part of the DNR Forest Practices AMP began in the early 2000's.~~

This effort was formerly proposed as the *Amphibians in Intermittent Streams Project* by the Type N Amphibian Response Program, LWAG and CMER in 2007. LWAG proposed waiting until the Type N Experimental Buffer Treatment in Hard Rock Lithologies (Hard Rock Study) project was complete to determine how that study could inform critical questions and project development for the current proposed effort. To date, several CMER studies have included data collection components that inform surface water discontinuities, including the Hard Rock Study, Type N Experimental Buffer Treatment in Incompetent Lithologies project (Soft Rock Study) ~~project~~, Eastside Forest Hydrology Study, and the PIP Demarcation Studies. We include a comprehensive description of those efforts in the Best Available Science (BAS) document that we developed to support scoping for this project (Appendix A). These efforts focused on parameters and features associated with discontinuous flow (temperature, hydrology, PIP locations, etc.) but were not focused exclusively on the characterization and effects of discontinuity. The exceptions are the Forest Hydrology Studies which did characterize hydrologic aspects of discontinuity across the landscape on the eastside of the state (~~BAS~~Appendix A, section 1.3.1). This proposed study would characterize discontinuity on the westside while also investigating influences on stream temperature and the FP-covered amphibians of discontinuous reaches.

Surface water expression is linked to adaptive management considerations because of its effect on water quality and aquatic habitat availability and condition. It is also a defining characteristic ~~in stream~~of instream classification and has a direct impact on the delineation of RMZs. ~~Identifying the spatial and temporal expression of surface water is a key element in classifying streams.~~ Water typing in Washington State involves the classification of streams based on two broad criteria: fish use and perennial surface flow. Water type dictates timber harvest prescriptions under FP rules, including the locations and extent of RMZs~~ and the subsequent configuration and placement of riparian buffers. Under current~~. The FP rules~~,~~ apply to all Type Np Waters~~ are protected equally throughout their entirety~~, regardless of whether they exhibit continuous surface water expression.  These regulations, which apply to state and private landowners lacking an individual HCP, are outlined in Title 222 WAC – *Forest Practices Rules* and in the Forest Practices Rules, Board Manual and Act (WFPB, 2001).

~~Discontinuous surface flow is a common characteristic of perennial streams that has been addressed in previous CMER studies and in peer-reviewed literature. Uncertainty about these reaches (prevalence and characteristics), their influence on stream resources (water quality and habitat), and their potential influence on the resource objectives outlined by the Forests and Fish~~

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agreementAgreement (USFWS, 1999) have been previously discussed by researchers with CMER.

Presently, there is a rule making effort that may result in updated buffering requirements on Np streams under the Washington State Forest Practices Habitat Conservation Plan (FPHCP). That effort is in response to several previous CMER studies and is currently being evaluated through a formal process by the Washington Department of Natural Resources. Note that the proposed effort is not an effectiveness study, and as such it does not propose to address or evaluate a specific rule. As such, the potential for rule change does not impact the Problem Statement or the potential for discontinuous reaches to affect the natural resources of concern (namely, stream temperature and stream-associated amphibians). The current rule making effort does not affect study design considerations for this research as proposed herein.

Preliminary CMER efforts to inform this topic through evaluations as a part of the DNR Forest Practices AMP began in the early 2000's. Though it is generally recognized that these features appear on the forested landscape throughout Washington, questions remain about the importance of considering these features relative to Forest Practices rules (hereafter, FP rules) and resource protection.

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The current Master Project Schedule (MPS) has Study Design development budgeted for FY2025 and implementation beginning in FY2026, and budget placeholders for implementation and reporting across five fiscal years to FY2030. The proposed alternatives outlined below include a shorter option that includes one year of site selection, two years of field data collection, and one year for data analysis and reporting, or four years total. Two longer options both include one additional year of field data collection, for five years total. The current approved MPS suggests the research would be conducted FY26-30. Ultimately, the timing and length of project implementation will depend on study design approval, FPAMP priorities, and funding availability/allocation.

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This project informs Overall Performance Goals to meet or exceed water quality standards and to support the long-term viability of other covered species. The project will inform the Heat/Water Temperature Functional Objective for stream temperature (Schedule L-1). Results from the Discontinuous Surface Flow Project may inform TFW Policy deliberations, including the identification of the PIP. However, depending on the specific study design and sampling program utilized by the project, results may also provide insight into modifying riparian buffers. For example, evaluating how discontinuous and perennial small streams differ within the same harvest setting may reveal patterns of seasonal flow and temperature that suggest different numbers and placement of green trees retained in buffers than what is prescribed currently within the Np network. Information about the relative influence of discontinuous perennial reaches on stream temperature and amphibian occupancy is essential for assessing ecological outcomes and the relative costs and/or benefits of the Forest Practices Habitat Conservation Plan (FPHCP)'s riparian strategy.

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**Commented [JD3]:** Can't seem to correct or even attach a comment to the Table of Contents, so I've put it here: 8. Alternatives Analysis needs the "A" in "analysis" capitalized. 2.3.1 title needs three words capitalized (Influence Surface Expression).

**Commented [JD4]:** This paragraph doesn't really fit right here - seems glitchy like it doesn't flow logically either from the paragraph above or to the paragraph below. I wasn't sure what to say about it until I saw the paragraph just below Figure 1: Please combine these two paragraphs into 1, and have it be just below Figure 1.

**Commented [JD5]:** "led"? I'm not sure.

**Commented [CM6]:** Red - This statement does not align with Well's presentation to CMER- the slide that states the discontinuous flow is "highly variable" and "highly unpredictable" across the FPHCP landscape. Given that, how can you infer to FP managed lands?

**Commented [MAP(7R6]:** Welles' presentation stated that the expression of discontinuous flow is highly variable, but we can still make inferences about the implications of discontinuous Np reaches on resources of interest (water temperature and amphibians). We are not trying to model or predict discontinuous reaches. We are investigating their potential to influence FP AMP resources of interest (water temp and amphibians). The Project Team also recommends alternative 3 in part due to the increased sample size and strength of inference.

**Commented [CM8]:** Red - See above comment. How can the results be used to "inform the placement of riparian buffers" over a FP HCP landscape when, according to Well's CMER presentation, discontinuous flow is both highly variable and highly unpredictable across FP HCP lands?

Moreover, Type Np buffers are not solely based on amphibian presence. The FP HCP Alternatives Analysis explains that Type Np buffers also serve other key riparian functions like LWD recruitment which acts as a sediment retention mechanism that prevents sediment / debris torrents that can directly deliver to receiving Type F waters. Discontinuous flow below the PIP has no bearing on LWD's functional role or how other key riparian functions are provided by Type Np riparian buffers. That's the very reason these dry reaches below the PIP are also projected. See the FP HCP EIS Alternatives Analysis and Appendix A (Equal Area Buffer Index).

**Commented [MAP(9R8]:** We've addressed uncertainty in a previous comment. We've modified the way we talk about "placement". We agree that buffers have multiple resource objectives that include resources such as LWD. However, the stated resources of interest are stream temperature and amphibians because these were the resources that were identified as most likely to be influenced by discontinuous flow. Discontinuous flow is not likely to affect wood loading. If folks are interested in response of resources other than those clearly identified, that is not how the current study was scoped, but the current scoping is consistent with the charter as previously reviewed and approved by LWAG and CMER.

torrent salamander (*R. olympicus*), the Dunn's salamander (*Plethodon dunni*), the Van Dyke's salamander (*P. vandykei*), Coastal Tailed Frog (*Ascaphus truei*) and Rocky Mountain Tailed Frog (*A. montanus*). Results can also be used to inform potential future efforts to evaluate the effectiveness of the current rule in protecting resources, if desired.

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Commented [JD10]: Good, strong, clear sentence. I get tired of the ID Team dog fights about what a stream is.

Commented [MAP(11R10]: Thanks Julie!

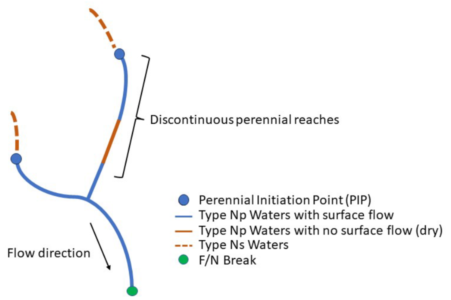


Figure 1. Schematic of a headwater stream network illustrating non-fish-bearing perennial stream reaches (Type Np Waters) with discontinuous or intermittent surface flow (i.e., discontinuous perennial reaches) and seasonal non-fish-bearing channels (Type Ns Waters). The black arrow shows the direction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

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Surface water expression has an obvious linkage to adaptive management considerations because of its effect on water quality and aquatic habitat availability and condition. It is also a defining characteristic in stream classification and has a direct impact on the delineation of RMZs. Identifying the spatial and temporal expression of surface water is a key element in classifying streams. Water typing in Washington State involves the classification of streams based on two broad criteria: fish use and perennial surface flow. Water type dictates timber harvest prescriptions under FP rules, including the locations and extent of RMZs and the subsequent configuration and placement of riparian buffers. The FP rules apply to all Under current rules, Type Np Waters, are protected equally throughout their entirety regardless of whether they exhibit continuous surface water expression. Washington State FP rules apply to state and private forest landowners lacking their own Habitat Conservation Plan (HCP). These regulations, which apply to state and private landowners lacking an individual HCP, are outlined in Title 222 WAC – *Forest Practices Rules* and in the Forest Practices Rules, Board Manual and Act (WFPB, 2001).

Discontinuous surface flow is a common occurrence (approximately 20% of the total Type Np stream length, see BAS section xxx) characteristic inof perennial streamType Np stream networkss that has been addressed in previous CMER studies and in peer-reviewed literature. Uncertainty about these reaches (prevalence and characteristics), their influence on stream resources (water quality and habitat), and their potential influence on the resource objectives outlined by the Forests and Fish agreementaAgreement (USFWS, 1999) have been previously discussed by researchers with CMER. Preliminary CMER efforts to inform this topic through evaluations as a part of the DNR Forest Practices AMPFPAMP began in the early 2000's. Though it is generally recognized that these features appear on the forested landscape throughout Washington, questions remain about the importance of considering these features relative to Forest Practices rules (hereafter, FP rules) and resource protection.

This effort was formerly proposed as the Amphibians in Intermittent Streams Project by the Type N Amphibian Response Program, LWAG and CMER in 2007. LWAG proposed waiting until the *Type N Experimental Buffer Treatment in Hard Rock Lithologies* (Hard Rock Study) projectpProject was complete to determine how that study could inform critical questions and project development. To date, several CMER Studies have included data collection components that inform surface water discontinuities, including the Hard Rock Study, *Type N Experimental Buffer Treatment in Incompetent Lithologies* (Soft Rock Study) projectpProject, Eastside Forest Hydrology Study, and the PIP Demarcation StudiesyStudy. We include a comprehensive description of those efforts in the Best Available Science (BAS) document that we developed to support scoping for this project (Appendix A).

**Commented [CM12]:** Red - Type Np streams are not "protected equally throughout their entirety" under the current rules. Depending on Np length, # of Np confluences, etc. - see the WAC you cited. Also, the clearcut portions of Np streams allowed under current rules do not receive any protection, an ELZ requirement only, no buffer. Please rephrase clarifying this distinction as laid out in the WA FP rule.

**Commented [WB13R12]:** Rephrased. We were trying to point out that the FP rules apply to the wet and dry reaches below the PiP. Basically placing the "including intermittent dry channels" part of the Type Np WAC into the FP rules context.

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**Commented [CM14]:** Red - Not so. CMER reports actually show the opposite - that discontinuous flow is uncommon not "common" on both the westside (Palmquist 2005) and eastside (Plues and Goodman 2003), Miller eastside Forest Hydrology study 2009). Those CMER study results indicate that approx. 80% of the Type Np network is perennial wet and that only ~20% of the network is "intermittent" below the PIP. Also, Also, Eastside Forest Hydrology study showed intermittent reaches were accounted for by a small proportion of streams with long dry reaches. By definition that 's an uncommon "characteristic of perennial streams" not "common". Rephrase - Discontinuous surface flow is an "uncommon" characteristic of perennial streams accounting for approx. 20% of channel length, with approx. 80% perennial wet based on CMER Type N Demarcation studies (east and west)

**Commented [WB15R14]:** Rephrased. We were trying to say that most Np stream networks have some dry reaches, like you state, approximately 20% of the Np network, which we cite in the BAS.

The current Master Project Schedule (MPSMPS) has Study Design development budgeted for FY2025 and implementation beginning in FY2026, and budget placeholders for implementation and reporting across five fiscal years to FY2030. The proposed alternatives outlined below include a shorter option that includes one year of site selection, two years of field data collection, and one year for data analysis and reporting, or four years total. Two longer options both include one additional year of field data collection, for five years total. The current approved MPS suggests the research would be conducted FY26-30. Ultimately, the timing and length of project implementation will depend on study design approval, FPAMP priorities, and funding availability/allocation.

This project informs Overall Performance Goals to meet or exceed water quality standards and to support the long-term viability of other covered species. The project will inform the Heat/Water Temperature Functional Objective for stream temperature (Schedule L-1). Results from the Discontinuous Surface Flow Project may inform TFW Policy deliberations, including the identification of the PIP. However, depending on the specific study design and sampling program utilized by the project, results may also provide insight into modifying riparian buffers. For example, evaluating how discontinuous and perennial small streams differ within the same harvest setting may reveal patterns of seasonal flow and temperature that suggest different numbers and placement of green trees retained in buffers than what is prescribed currently within the Np network. Information about the relative influence of discontinuous perennial reaches on stream temperature and amphibian occupancy is essential for to inform assessments ofing ecological outcomes and the relative costs and/or benefits of the Forest Practices Habitat Conservation Plan (FPHCP)'s riparian strategy.

The FPHCP riparian strategy for Type Np Waters outlines prescriptions that are intended to protect the most ecologically sensitive segments of Type Np streams and associated aquatic resources. High priority areas for RMZ protection include the lower reaches of Type Np Waters immediately above the confluence with Type S (i.e., shorelines of the state) or Type F (i.e., fish-bearing) Waters and designated sensitive sites including side-slope seeps, headwall seeps, headwater springs, Type Np intersections, and alluvial fans. However, at the time of FPHCP negotiations, data and/or published literature supporting the designation of high priority areas were limited. Both the Hard Rock Study and Soft Rock Study evaluated the overall basin-wide effectiveness of current FP rules for Type Np streams to meet resource objectives as intended. Although both included study sites with variable length riparian buffers, neither study examined buffer effectiveness at the reach scale, specific to the placement of riparian buffers in high priority areas. Further, the distribution and length of discontinuous perennial reaches varied among Type Np study basins. Information about the effectiveness of retaining buffers in achieving resource objectives on discontinuous perennial reaches is informative for assessing ecological outcomes and the relative costs and/or benefits of the FPHCP riparian strategy.

As a part of study scoping, we developed a synthesis of the BAS from existing CMER studies and findings from published literature (see Appendix A – Best Available Sciences Review) and used the BAS synthesis to support the development of proposed research alternatives outlined in this Scoping Paper. CMER and Timber, Fish and Wildlife Policy (Policy) can use the Scoping Paper to identify needs and priorities for the potential support of a field study to evaluate the effects of discontinuous perennial reaches on stream temperature and FP-covered amphibians on

**Commented [JD16]:** Need a space here; and as it may be a formatting thing, I'm not gonna try.

**Commented [CM17]:** Red - Again, I don not believe the results of this study can be inferred to buffer placement across the FP HCP landscape when intermittent reaches are high variable and highly unpredictable. Needs to be clearly stated in the introduction based on slide show given to CMER. Moreover, The FP Board is currently in the process of adopting new Type Np rules (CR 102) so the Type Np buffers are going to change substantiually. Nowhere in the introduction is this mentioned, or the potential affect it will have on this current study approach, i.e. your claim that the results of this study will help with Np buffer configuration and placement, when the buffers will be changing in width and length. While I disagree with that claim as stated above, the new Type Np rules the Board adopts, based not the Dept. of Ecology proposal before them, will make this a moot point. This study approach will need to be postponed until the new Type Np rule is adopted by the Board. Need to acknowledge here in the introduction so the reader nows CMER is aware of the Board's current Type Np rule making process.

**Commented [MAP(18R17]:** This research addresses the influence of these reaches on the resources of interest, regardless of the current or future potential rule.

**Commented [CM19]:** Red - The Board is responsible for doing cost benefit analysis (CBA) when adopting new rules / riparian strategies, not CMER. Second, my previous comment makes this a moot point - acknowledge the Board's current phase of rule making for new Type Np buffers on westside FP HCP lands. Not doing so will send a signal to TFW Policy, who approves CMER's scoping documents, that we /CMER have not considered such implications on our studies and prioritization of AMP resources. Same for the Board since that's who were all work for. As a Board-approved CMER member, It would be irresponsible to promote advancing a study on a current rule that the Board is about to change. I cannot accept failing to acknowledge such implications before sending to TFW Policy.

**Commented [MAP(20R19]:** We agree. We did not mean that kind of cost and benefit, we meant more pros and cons. Deleted. This is not an effectiveness study. We are not testing the effectiveness of the current (or future potential rule), we are characterizing the resources. It is still useful to characterize these reaches. We have toned down the language around informing buffer placement.

**Commented [DM21]:** Yellow
"effectiveness" to do what?

**Commented [MAP(22R21]:** Revised.

**Commented [DM23]:** Yellow,
To do what or for what?

**Commented [MAP(24R23]:** revised

the FPHCP landscape. The Type Np Discontinuous research project is a Clean Water Act Assurances Milestone project that was prioritized by Policy.

## 2. PROBLEM STATEMENT

The FPHCP riparian strategy for Type Np Waters outlines prescriptions that are intended to protect the most ecologically sensitive segments of Type Np streams and associated aquatic resources. High priority areas for RMZ protection include the lower reaches of Type Np Waters immediately above the confluence with Type S (i.e., shorelines of the state) or Type F (i.e., fish-bearing) Waters and designated sensitive sites including side-slope seeps, headwall seeps, headwater springs, Type Np intersections, and alluvial fans. However, at the time of FPHCP negotiations, data and/or published literature supporting the designation of high priority areas were limited. Both the Hard Rock Study and Soft Rock Study evaluated the overall basin-wide effectiveness ofof current FP rules for Type Np streams. Although both included study sites with variable length riparian buffers, neither study examined buffer effectiveness at the reach scale, specific to the placement of riparian buffers in high priority areas. Further, the distribution and length of discontinuous perennial reaches varied among Type Np study basins. Information about the effectiveness of retaining buffers on discontinuous perennial reaches is informative for assessing ecological outcomes and the relative costs and/or benefits of the FPHCP riparian strategy.

Previous CMER and other efforts have demonstrated that discontinuous Np reaches are a frequent occurrence in Washington streams, however, little is understood about their spatial and temporal patterns and the potential of these reaches to effect aquatic resources of interest to the FPAMP. .... This project will help inform the likelihood of discontinuous Np reaches to affect resources outlined by the Overall Performance Goals, which are to meet or exceed water quality standards and to support the long-term viability of other covered species, includes i.e., FP-covered stream-associated amphibians,. The proposed study will by evaluating evaluate water stream temperature in, and amphibian use of, discontinuous perennial reaches of Type Np streams. Type Np Waters are perennial streams that do not go dry at 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 222-16-010). In an investigation of perennial initiation point (PIP) expression, Hunter et al. (2005) found that discontinuous perennial reaches frequently occurred near the origin of headwater streams during periods of low flow, and that they exhibited one of two spatial patterns of surface flow, i.e., a single dry reach located adjacent to the PIP or flowing sections interspersed with dry sections. The frequency and distribution of discontinuous perennial reaches of Type Np streams may affect stream physical characteristicstemperature and biota. Under future climate change scenarios the frequency and distribution of these reaches may change (see BAS Appendix A, section 2.5), with potential implications for , increased stream drying throughout western Washington may pose a risk to aquatic resources. While some Previous CMER research studies documented informationhave informed relative to the occurrence of and spatial patterns of dry stream surface expression in discontinuous perennial reaches across the FP managed landscape. However, as well as amphibian detections in these reaches in one study, these these previous efforts cannot support ando not fully inform evaluation of the influence of the occurrence of or patterns of surface expression these reaches on stream temperature or amphibians in or downstream of these reaches. Furthermore, the incidence, timing, and

**Commented [CM25]:** Red - see above comments. This will no longer be a CWA milestone once the Board adopts new Type Np rules, which are based primarily on meeting CWA standards throughout the entire Type Np network on westside Type Np streams. Also, if you read the CWA milestone documents that Mark Hicks used to give to the Board annually, this study was put on hold pending the results of the Hard Rock study (since you're citing CWA Milestones, you no doubt read them). Hard Rock, Soft Rock and BCIF, have resulted in the Board adopt new Type Np rules. I suggest you talk to Brandon A. (prior Policy rep for Ecology, now WDFW) who gave the last CWA update to the Board - I gave him all the CWA Milestone Board update documents from Mark Hicks. That or Chris Briggs (Ecology's new Policy rep) who is next in line to give the Board CWA milestone updates. I'd venture to guess that Ecology would agree that this project as currently scoped is no longer a CWA milestone priority. given the Board is about to change the Type Np rule that will bring DNR into compliance with CWA standards. Y ...

**Commented [WB26R25]:** The most recent CWA milestones states that this project is underway, which is also the update that ...

**Commented [CM27]:** Red - This section looks like it was cut n pasted from the Introduction. Needs to be rewritten based on my ...

**Commented [MAP(28R27]:** Deleted here and incorporated anything missing in Context above.

**Commented [DM29]:** Yellow "effectiveness" to do what?

**Commented [MAP(30R29]:** Revised.

**Commented [DM31]:** Yellow, To do what or for what?

**Commented [MAP(32R31]:** revised

**Commented [CM33]:** Yellow - Not just Mark Hunter et al. Need to cite other CMER studies, with much larger sample sizes ...

**Commented [MAP(34R33]:** We cover this in the BAS. Here, we are specifically referring to the two spatial patterns identified ...

**Commented [HB35]:** I can see biota but don't see how these "relatively" low flow reaches can affect physical characteristics.

**Commented [JD36R35]:** I'm gonna agree with Harry here; stream physical characteristics may influence discontinuity, and r ...

**Commented [MAP(37R35]:** Agreed. We are focused on stream temperature. We want to identify how discontinuous strea ...

**Commented [DM38]:** Yellow, ...

**Commented [MAP(39R38]:** Edited. Climate change is going to change the frequency and distribution of these reaches, and her ...

**Commented [HB40]:** Confusing. This seems to say that you cannot evaluate the influence of the patterns of surface expressio ...

**Commented [MAP(41R40]:** Revised.

**Commented [DM42]:** Yellow ...

**Commented [MAP(43R42]:** See critical questions outlined in section 4.

**Commented [HB44]:** What supports this conclusion? What is lacking in these studies?

**Commented [MAP(45R44]:** Revised to be more clear. See BAS for a full description of the scope of previous CMER work.

**Commented [DM46]:** Yellow Too long, suggest put subject first and shorten. Confusing to reader

**Commented [MAP(47R46]:** Agreed. Statement revised.

~~locations of discontinuously dry proportion of perennial reaches in relation to the placement of riparian buffers has not been evaluated.~~ These uncertainties motivated a synthesis of ~~Best Available Science (~~BAS~~)~~ from CMER-supported studies and other published literature (Appendix A). ~~This synthesis is limited in its inference largely to thethose study sites included in the cited research.~~

## 3. PURPOSE STATEMENT

The purpose of t~~T~~his study ~~will~~ is to inform the ~~likelihood of~~potential for discontinuous Np reaches to affect resources outlined by the Overall Performance Goals, including their influence on stream temperature and FP-designated amphibians, as well as how ~~including the provide information to support the Overall Performance Goals of meeting water quality standards and supporting the long-term viability of other FPHCP covered species, and better inform occurrence and~~ variability in spatial and temporal expression ~~of discontinuous surface flow and~~may affect the resources of interest~~ their influence on stream temperature and FP-designated amphibians~~. This subject is of particular interest due to the potential for ~~U~~upslope harvest activities and/or global climate change ~~may~~to influence the f~~F~~requency and~~,~~ distribution~~, and influence~~ of discontinuous perennial reaches, which ~~, in turn,~~ may impact ~~on~~ stream temperature and amphibian habitat in turn (see ~~BAS~~Appendix A, section 2.4).~~s By examining these reaches, in detail, across the FFR landscape we may be able to inform on the hydrologic conditions at varying stages of the harvest rotation. may be of interest to those considering the ecological benefits and economic costs of riparian buffer prescriptionprescriptions for Type N streams.. In addition to these insights, the information gained from this proposed study could inform a potential future effectiveness study or provide information on discontinuity to the Extensive Monitoring stream modeling efforts (see BAS section 2.3) to evaluate the value of including discontinuous perennial reaches in the placement of riparian buffers along Type Np Waters. This study will provide information to support the Overall Performance Goals of meeting water quality standards and supporting the long-term viability of other covered species, and better inform occurrence and variability in spatial and temporal expression of discontinuous surface flow. As a part of study scoping, we developed a synthesis of the BAS from existing CMER studies and findings from published literature (see Appendix A – Best Available Sciences Review) and used the BAS synthesis to support the development of proposed research alternatives outlined in this Scoping Paper. CMER and Timber, Fish and Wildlife Policy (Policy) can use the Scoping Paper to identify needs and priorities for the potential support of a field study to evaluate the effects of discontinuous perennial reaches on stream temperature and FP-covered amphibians on the FPHCP landscape. The Type Np Discontinuous research project is a Clean Water Act Assurances Milestone project that was prioritized by Policy. CMER and Policy can use this Scoping Paper with alternatives analysis to assess the value of a field study.~~

An effectiveness study could be designed, but our ~~synthesis of BAS~~review of previous efforts and peer-reviewed literature, (see ~~BAS section xxx~~Appendix A) highlighted a need to characterize discontinuous perennial reaches and investigate their potential to influence ~~on~~ stream temperature and amphibians prior to proposing or developing a more extensive effort. However, the investigation proposed herein would certainly inform the value of a more expensive and time-consuming investigation of buffer effectiveness, if desired. ~~It is~~A possible ~~that~~outcome could be that a future effectiveness study ~~could be informed by this current effort~~

**Commented [CM48]:** Red - see prior comment. This is a moot point given the Board's current rule making process for wider, full length Type Np buffers based on findings from the CMER Westside Hard Rock and Soft Rock studies and Westsdie BCIF (Shuett-Hames and Stewart 2019).

**Commented [OBRA(49R48]:** We address the current rule-making process above.

**Commented [DM50]:** Red,
So what? You are implying that buffers influence discontinuous flows, yet you present nothing in BAS to substantiate this assumption????

**Commented [BW(51R50]:** deleted

**Commented [DM52]:** Yellow,
Yes, so why not link/reference science with proposed problem to establish basis/reason for issue?

**Commented [BW(53R52]:** Deleted sentance

**Commented [DM54]:** Yellow
Confusing to reader when say BAS covers both CMER and other lit

**Commented [MAP(55R54]:** Deleted.

**Commented [HB56]:** HPHCP covered species.

**Commented [CM57]:** Red - see prior comment. "may be of interest" is not very likely given the Board is going through their CBA (cost benefit analysis) as part of Type Np rule making right now making this a moot point. Again, need to acknowledge the Board's active rule making process and how it affects this scoping document. There's a draft CBA available via DNR on their website. I recommend reading and referencing it. This scooping should be postponed until the Board adopts the New Type Np rule.

**Commented [OBRA(58R57]:** We address the current rule-making process above.

**Commented [DM59]:** Red
Need to clearly state the purpose. E.G., The purpose of this study is to…….
Reader is confused about purpose of this study vs statements about potential future studies.

**Commented [BW(60R59]:** Thanks, moved sentence to the top to better clarify overall purpose.

**Commented [CM61]:** Red - The reason intermittent reaches below the PIP are included as part of the Type Np riparian buffer rule you cite in WAC is not solely due to amphibians, which is why buffers are required on Type Np waters where amphibians are not present. Again, the role LWD plays as a key sediment retention mechanism preventing debris torrents in steep Type Np waters delivering to receiving Type F waters. This was a critical component of the FFR negotiations promulgated into the FP HCP Alternatives Analysis EABI (Appendix A - Equal Area Buffer Index). The Board also funded several CMER studies on the role of LWD in steep non-fish bearing channels (OConnar and Harr 1997, Montgomery and Buffington, 1998?). This is mentioned nowhere in your Introduction which omits key functional roles those buffers serve on ...

**Commented [BW(62R61]:** Scaled back on buffer implications and focused on the characterization of discontinuous reaches and ...

**Commented [HB63]:** HPHCP covered species.

**Commented [O(64R63]:** Added.

**Commented [DM65]:** Yellow, ...

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~~and scoped~~is recommended, based on the results of this effort, which could be timed for after the current rule making process is complete, if desired. The proposed effort c

~~If interest exists, a Study Design could be developed, for which funding has been allocated in the CMER Master Project Schedule (MPS) for FY25.~~ ould also provide information on discontinuous surface flow that may also prove of use to the to the current Board-directed CMER Extensive Monitoring efforts ~~(see Appendix A, section 2.3)~~.

## 4. PROJECT OBJECTIVES AND CRITICAL QUESTIONS

The objective of the proposed study is to inform critical questions relative to the influence of discontinuous perennial reaches on stream temperature and stream-associated amphibian populations. The study will evaluate patterns in~~to the~~ spatial and temporal intermittency of discontinuous perennial reaches~~,~~ and, importantly, will explore factors (i.e., stream and stand characteristics) that may influence intermittency. ~~The study will evaluate the influence of intermittent surface flow on stream temperature and stream-associated amphibian populations in discontinuous perennial reaches. The study will also include an evaluation of the incidence of discontinuous perennial reaches relative to riparian buffer placements under current FP rules~~~~stand characteristics.~~

The critical questions related to the issue of discontinuous perennial reaches are described in the 2023-2025 Biennium CMER Work Plan under the Type N Amphibian Response and Type N Riparian Effectiveness Programs (Table 1). As a part of the scoping process, the Project Team proposes some modifications to the critical questions outlined in the current Work Plan so that ~~the questions~~they more clearly articulate ~~the questions as they relate to~~ the questions relative to the proposed research. Our investigation into the peer reviewed literature and previous CMER studies revealed that there are still basic aspects of discontinuous Np reaches that 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 buffers adjacent to discontinuous Np reaches and predicting the spatial occurrence could be addressed through future phases. In addition to the proposed modifications to the current Work Plan critical questions ~~as outlined in the current Work Plan~~, the Project Team identified two additional critical questions based on the scoping process that will be addressed under the proposed alternatives (Table 1).

**Commented [DM66]:** Yellow
Not purpose? Move elsewhere

**Commented [MAP(67R66]:** Deleted.

**Commented [CM68]:** Red - The reason intermittent reaches below the PIP are included as part of the Type Np riparian buffer rule you cite in WAC is not solely due to amphibians, which is why buffers are required on Type Np waters where amphibians are not present. Again, the role LWD plays as a key sediment retention mechanism preventing debris torrents in steep Type Np waters delivering to receiving Type F waters. This was a critical component of the FFR negotiations promulgated into the FP HCP Alternatives Analysis EABI (Appendix A - Equal Area Buffer Index). The Board also funded several CMER studies on the role of LWD in steep non-fish bearing channels (OConnar and Harr 1997, Montgomery and Buffington, 1998?). This is mentioned nowhere in your Introduction which omits key functional roles those buffers serve on "intermittent" reaches beyond simply providing for amphibian habitat. This currently reads like amphibs are the sole reason for requiring Type Np buffers in rule and, that you can make recommendations for buffer placement based solely on their presence, which is not the case..

**Commented [BW(69R68]:** Scaled back on buffer implications and focused on the characterization of discontinuous reaches and harvest rotation (see BAS section 2.4).

**Commented [HB70]:** Are you hypothesizing that the placement of riparian buffers influences the expression of discontinuous reaches? What critical question will this answer?

**Commented [O(71R70]:** That question is not the focus of this stage of the study, but information will be collected that could inform a future investigation. The critical question that could be investigated in the future is "What is the effect of buffering or not buffering spatially intermittent stream reaches in Type Np streams? ".

**Commented [DM72]:** Yellow,
Suggest this be presented in Purpose for context

**Commented [OBRA(73R72]:** Agreed, we moved this to the purpose section.

Table 1. Type N Riparian Prescriptions Rule Group: Project-~~r~~Related Programs and Rule Group Critical Questions from the 2023-2025 Biennium CMER Work Plan, modifications proposed in response to the review of BAS and Scoping development, and whether the question is addressed in the current proposed study alternatives.

| **Program** | **Rule Group Critical Questions from CMER 2023-2025 Work Plan** | **Proposed Modifications to Critical ~~Project-specific Research~~ Questions[5] ~~Relative to the Study~~** | **Addressed in Current Study Alternatives?** |
|---|---|---|---|
| Type N Amphibian Response | What is the frequency of occurrence of discontinuous surface flow in streams across the landscape? | What is the frequency of occurrence of discontinuous perennial reaches in Type Np Waters throughout FPHCP lands in Washington? | Yes, ~~Informed by~~clarified in the BAS Section 12.2 |
| | How do stream-associated amphibians utilize intermittent stream reaches at or near the origins of Type N (headwater) streams? | Do stream-associated amphibians utilize discontinuous perennial reaches of Type Np Waters and, if so, do occupancy and abundance differ from reaches with continuous surface flow? | Yes |
| | ~~How do stream-associated amphibians utilize intermittent stream reaches at or near the origins of Type N (headwater) streams?~~ | ~~Do stream-associated amphibians utilize discontinuous perennial reaches of Type Np Waters and, if so, do occupancy and abundance differ from reaches with continuous surface flow?~~ | ~~Yes~~ |
| | How do site-specific factors (e.g., streams dominated by groundwater) affect abundance and condition of amphibian populations? | Do FP-covered amphibians ~~respond~~ utilize discontinuous Np reaches differentially ~~to discontinuous Np reaches~~ based on site specific factors (e.g., lithology, gradient)? | Yes |
| Type N Riparian Effectiveness | What is the effect of buffering or not buffering spatially intermittent stream reaches in Type Np | The proposed study does not inform this critical question. However, ~~I~~implementation of the scoped study may support refinement of this critical question and | |

[5] If approved, these would replace the Rule Group Critical Questions from CMER 2023-2025 Work Plan



**Commented [CM74]:** Red - This Table should be updated based on the Board's Type Np rule making process. As should the CMER project prioritization Table that is currently under review by CMER. This project as currently proposed should read "delayed" pending the Type Np Rule making by the FP Board at which point LWAG could rescope this project based on the new rules, if needed pending the Board's rule adoption.

**Commented [OBRA(75R74]:** These questions are not tied to explicity to current or future rules. We propose to characterize and better understand how discontinuous flow relates to water temperature and amphibians. The fourth question is related to buffering and we propose addressing that in a future investigation, if prioritized.

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**Commented [HB76]:** Do you plan to look at regional differences?

**Commented [BW(77R76]:** Likely, but will addressed in study design.

**Commented [HB78]:** Should this be limited to only the FFR landscape?

**Commented [O(79R78]:** Yes, added text.

**Commented [DM80]:** Yellow
Confusing? Clarify with either Yes or No.

**Commented [BW(81R80]:** clarified

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**Commented [DM82]:** Red
Clarify what you mean by "respond" (e.g., Occupancy, Abundance). Suggest this be a follow-on to next Q. E.G., what factors (litholólgy, gradient) influence…..

**Commented [OBRA(83R82]:** We agree that it would flow more naturally if the order was switched. Occupancy and abundance are both potentially useful metrics that could be used here and they have trade-offs. Those trade-offs are presented in the alternatives analysis. The detailed implementation of this will depend on the alternative selected and ultimately the study design. For these reasons, we prefer not to be overly prescriptive in the question.

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| | | | |
|---|---|---|---|
| | streams*?* | inform a future investigation. ~~Is maintaining a riparian buffer in the RMZ of discontinuous perennial reaches of Type Np streams important for meeting resource objectives related to stream temperature and FP-covered amphibians?~~<br><br>~~No, but information will be collected that could inform a future investigation~~ | |
| | *[new Project Team proposed critical question based on Scoping]* | How do discontinuous perennial reaches influence stream temperature across a range of stream and stand characteristics? | Yes |
| | *[new Project Team proposed critical question based on Scoping]* | What is the ~~relative~~ influence of discontinuous perennial reaches (spatial and temporal pattern of surface water expression) on stream temperature and FP-covered amphibian populations in Type Np reaches? | Yes |

**Commented [JD84]:** Yellow (and you may assume unlabeled editorial suggestions are Green). I don't think "across" is making your point - maybe "in the context of?" Something clearer please.

**Commented [OBRA(85R84]:** Added "a range of" so it reads better.

**Formatted:** Normal, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers

**Commented [HB86]:** Does "relative influence" mean relative to topographic shade, ground flow, etc.?

**Commented [OBRA(87R86]:** Good catch, the word relative here is unnecessary. We are really just trying to understand the influence of discontinuous flow on stream temp and amphibians.

**Commented [DM88]:** Red
Clarify the spatial scale of this and previous Q. Is previous Q a landscape scale Q and this Q a stream-scale Q? Note, doing both scales is a huge undertaking! Also, difficult to separate temperature from flow influences on amphibian metric?

**Commented [OBRA(89R88]:** This a stream-scale question. The unit of analysis would be the reach/harvest unit. Some stratification by geographic region may be used in the study design that could help facilitate understanding if regional or other patterns exist.

Results from the alternatives proposed in this scoping can be used to inform the need for and value of a future, more costly effectiveness study to address the Type N Riparian Effectiveness Program (Table 1)critical question. "*Is maintaining a riparian buffer in the RMZ of discontinuous perennial reaches of Type Np streams important for meeting resource objectives related to stream temperature*[6] *and FP-covered amphibians*[7]??" (CMER Work Plan, 2023), but aA more robust characterization of discontinuous perennial reaches, such as those proposed herein, and their nexus with Schedule L-1 resources objectives (waterstream temperature and FP-covered amphibians) is warranted prior to investment in a more costly manipulative study.

Though not scoped or addressed as a part of the proposed effort, Ppredicting the prevalence of flow permanence across the FP managed landscape is a current issue of interest to CMER and others (e.g., stream mapping for other current CMER efforts, such as Extensive Monitoring and Potential Habitat Breaks). The proposed study would include collection of data that is another direction of future research not addressed by the study alternatives. This could help inform or validate current and future stream modeling efforts, such as the prevalence of dry reaches, PIP locations and by extension the presence of aquatic resources. *PROSPER*, A future project critical question could be "*Can a spatial model such as FLOwPER PROSPER accurately predict flow permanence?*". A future spatial modeling effort could develop a new hydrography layer such as FLOwPER PROSPER that is based on high-resolution LiDAR digital elevation models and returns probabilistic estimates describing flow permanence (See Appendix A, section 2.3). However, the Project Teams recommends undertaking a deeper characterization of the Schedule L-1 resources in discontinuous perennial reaches, as proposed under the various alternatives discussed below, before developing a spatial modeling and validation effort. Data collected as a part of any of the alternatives discussed below could be incorporated into a future modeling effort.

## 5. TESTABLE RESEARCH HYPOTHESES

The proposed alternatives are intended to describe the characteristics of discontinuous perennial reaches, factors influencing these reaches, and their influence on water temperature and amphibians Overall Performance Goals in Schedule L-1. This study seeks to characterize discontinuous perennial reaches and the influence of covariates, including stream and stand characteristics, on stream flow surface expression in Type Np Waters. As such, the research objectives cannot be reduced to a specific research hypothesis.

[6] The functional objective for the Heat/Water Temperature resource objective is to "Provide cool water by maintaining shade, groundwater temperature, flow, and other watershed processes controlling stream temperature."
[7] While there is no specific resource or functional objective for FP-covered amphibians, an Overall Performance Goal for Forest Practices in Washington is to "Support the long-term viability of other covered species" (i.e., the suite of stream-associated species covered under the rules).

**Commented [CM90]:** Red - See prior comments. No longer relevant. Note this is the fourth time I've read this exact phrase up to this point in the document.

**Commented [OBRA(91R90]:** Modified.

**Commented [DM92]:** Red
You refer to the future study in several places, but have not provided the context and justification for a 2 phase, etc process. Please provide the basis/reason for this study and for a follow-on in the problem statement. Why is this study first and how does it inform or set the stage for the future potential study

**Commented [JD93R92]:** I've got a comment further down, making the case that you really hit the nail on the head in the second sentence of the limitations section of Alternative 3, which seems like a strange place to bury such an important point.

**Commented [OBRA(94R92]:** We moved the reference to a potential future phase to the Purpose section. We moved the language that Julie requested so it is no longer buried.

**Commented [HB95]:** Make this a separate sentence for clarity.

**Commented [CM96]:** Red - again, the Boards new Type Np rule as currently proposed could influence the occurrence (frequency) and length of dry segments below the PIP based on how substantially different that proposed rule is from the current rule, e.g. your statement about climate change impacting intermittently under the current Type Np would also apply to the newly proposed full length buffers.

If a "prevalence of flow permanence" study is conducted on the westside at some point AFTER the new Type Np rule is formally adopted by the Board, It would be prudent to mimic the Eastside Forest Hydrology Study (Miller 2009). Recall that study stratified by geology, hypothesizing that the level of intermittency may vary with local geology. The westside has a highly varied geology/ lithology like the WA eastside so there would be no reason not to consider a similarly type stratification.

**Commented [OBRA(97R96]:** I am having trouble discerning the actionable part of this red comment. See our broader revision that acknowledges the current rule-making process. ...

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**Commented [DM98]:** Red ...

**Commented [MAP(99R98]:** Agreed. This was confusing. We toned this way down to simply highlight the value of understandi ...

**Commented [DM100]:** Green ...

**Commented [OBRA(101R100]:** Thanks!

**Commented [HB102]:** Contributing to or sufficient for ?

**Commented [OBRA(103R102]:** Our observations from these studies are not sufficient to stand alone and develop a model, but ...

**Commented [DM104]:** Red ...

**Commented [JD105R104]:** My comment on hardcopy says "Was this okay with others?" - I think some real hypotheses are i ...

**Commented [OBRA(106R104]:** We removed this optional section.

**Commented [CM107]:** And they're premature given the Board's current Type Np rule making process.

**Commented [OBRA(108R107]:** We address current rule-making above.

## ~~6.~~5. DATA REQUIREMENTS

Field surveys, continuous data loggers, and GIS data sources will be used to address the critical questions. Field surveys will be conducted to record amphibian observations and stream habitat characteristics including surface water expression (wet versus dry channels). Continuous data loggers will be deployed to monitor stream temperature and assist in the determination of the spatial and temporal extent of dry stream conditions. Additional data such as topographic characteristics will be gathered from GIS data sources.

## ~~7.~~6. BEST AVAILABLE SCIENCE

We reviewed the BAS to inform the prevalence and characteristics of discontinuous perennial reaches in Washington State, and their potential to influence instream water quality (i.e., stream temperature) and stream-associated amphibians. We reviewed previous CMER efforts, peer-reviewed literature, and other data sources to provide a summary of relevant information. As a part of that effort we ~~A detailed review of relevant CMER studies and peer reviewed literature is provided in **Appendix A**. . We~~ identified ~~16 9~~a number of TFW, CMER and related studies that included monitoring data with the ability to inform surface water expression in discontinuous perennial reaches of Type Np Waters. The earliest CMER studies associated with Type Np Waters focused on PIP identification, since accurate application of the riparian buffer strategy for Type Np Waters relies on accurately identifying the PIP. More recent Effectiveness Monitoring research has tested how upland timber harvest may influence surface water expression. A summary of select lessons learned from these CMER studies is presented in ~~Table 6.~~Table 2. A detailed review of relevant CMER studies and peer reviewed literature is provided in **Appendix A**.

Table ~~6~~2. Select-lesson learned from CMER studies with implications for discontinuous perennial reaches. BACI refers to a study with a Before-After Control-Impact study design.

| **Theme** | **Lesson Learned** | **Citation** |
|---|---|---|
| | **Technical** | |
| PIP Movement | Some~~Most~~ PIP locations appear to be stable, others have been shown to move ~~across years~~seasonally and annually (see Appendix A, Table 7). | Pleus and Goodman 2003<br>Veldhuisen 2004<br>Palmquist 2005<br>Ehinger 2021 |
| Frequency of Occurrence | East of the Cascades, 21% of the Np channel network was dry. | Miller and Peterson 2009 |
| | West of the Cascades, approximately 15-20% of the Np channel network was dry. | McIntyre et al. 2018<br>Ehinger et al. 2021 |
| | Discontinuous perennial reaches are very common both West and East of the Cascade Mountains. | TFW Policy Type N Technical Subgroup 2012<br>Palmquist 2005 |

**Commented [DM109]:** Yellow,
Understanding the factors driving discontinuous flow and temperature is complex
E.G.., see
Leach, J. A., and R. D. Moore. 2011. Stream temperature dynamics in two hydrogeomorphically distinct reaches. Hydrological Processes 25:679-690.

Story, A., R. D. Moore, and J. S. Macdonald. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research 33:1383-1396.

**Commented [OBRA(110R109]:** Thanks. We will consider this in our BAS and study design. Our project team and CMER have had conversations about the complexity of these reaches.

**Commented [CM111]:** I will review and provide comments to this section

**Commented [OBRA(112R111]:** Thanks.

**Commented [HB113]:** Could be seen as being outside the scope of this study.

**Commented [OBRA(114R113]:** It is also a pretty wordy statement so we agree that simplifying it is a good idea.

**Commented [CM115]:** Red - Both studies you cite clearly show that the vast majority of the PIP locations surveyed do NOT "move" and are "stable". Very few actually "moved" and of those that did, most moved during an unusually dry year falling outside "a year of normal rainfall" as defined by the FP Rules for identifying Type Np waters. Therefore, most of those that moved should be depicted as atypical and outside the definition of the rule. Also, need to restructure this table using the actual data from those reports showing 1) the proportion % of PIPs that were stable vs.moved, for all CMER studies covering FP HCP lands, 2) the precipitation data for those years and whether they met the Type Np rule definition of a "year of normal rainfall".

**Commented [BW(116R115]:** Thank you for the suggestion, Chris. I went back and did a deep dive into these studies and it appears that only a small subsample of sites were re-visited. These do show annual PIP stability, but the n is lower than the studies as a whole. I added in the some Soft Rock data because we did see quite a bit of movement of the PIPs and with all of the tributaries that were in the basins we ended up having a lot of PIPs that were captured.

**Commented [CM117]:** Yellow - are these the correct dates: Palmquist Type N Demarcation Study was completed before Plues and Goodman that focused on the Eastside based on Palmquist study. Palmquist did produce a "Summary Report:" for east and western WA using the Eastside data so maybe that's what you're citing?

**Commented [OBRA(118R117]:** I agree with your chronology of the fieldwork, but we base this on the dates of the report approval/finalization. The final version of Palmquist is dated Feb 14, 2005 (Version 7.5) and is based on 2001 fieldwork.

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**Commented [CM119]:** Red - They only occur approx. 20% of the channel network in CMER studies however, they occurred most often on long dry reaches in specific areas so not uniform and distribution or length. You need to show that breakdown by frequency of occurrence, length of channel, and location. That w ...

**Commented [OBRA(120R119]:** This is a summary table, the information you are requesting is reported below in the sections for the respective studies where possible. We moved the table to the BAS section of the main body of the scoping based on your ...

| Theme | Lesson Learned | Citation |
|---|---|---|
| Patterns of Discontinuity | Lower order reaches tend to have the greatest proportion of dry streambed in the Np channel network. | Ehinger et al. 2021 |
| | Underlying lithology can affect the extent to which surface flows are expressed in headwater streams over the summer season (increased length in unconsolidated lithologies). | TFW Policy Type N Technical Subgroup 2012 |
| Stream Temperature | BACI studies showed that reaches with discontinuous perennial flow may have reduced the warming effect of harvest. | McIntyre et al. 2018<br>Ehinger et al. 2021 |
| Stream-associated Amphibian Use | Torrent salamanders have been observed occupying small reaches of surface water in otherwise dry channels. | McIntyre et al. 2018 |
| **Implementation and Study Design** | | |
| Site Selection – Population | Be cautious about relying on DNR Hydrography or national hydrography dataset (NHD) with random site selection as it may lead to many sites lacking channels and surface water. CMER studies suggest much of the Ns network is represented as Np. | CMER Work Plan 2023, pg. 46 |
| Site Selection - Access | Gaining landowner permission to conduct studies can lead to delays and denials, especially with larger pools and random selection of sites. This has been especially true of small forest landowners and select industrial landowners. | Ecology 2019 |
| Implementation | Quality ~~water~~stream temperature data requires maintaining temperature sensors fully in shallow streams. | McIntyre et al. 2018<br>Ehinger et al. 2021 |

# ~~8.~~7. ALTERNATIVES A~~A~~NALYSIS

This section provides potential research approaches for the Discontinuous Np S~~s~~tudy including the benefits and limitations of each approach for meeting objectives and addressing critical questions. Once CMER and TFW Policy select and approve a preferred alternative for further development, a detailed study design will be developed that describes specific data collection and analysis methods following the CMER Protocols and Standards Manual (Chapter 7).

The Project Team proposes consideration of three potential alternatives to address research objectives and address critical questions. All three study alternatives propose using GIS and field verification ~~reconnaissance~~ for site selection of first-order streams with discontinuous perennial reaches. First order streams provide a natural reach break at the confluence, simplifying the amphibian protoco~~ecoo~~ls and analysis. This approach also provides an opportunity to have multiple first-order reaches within a larger Type Np watershed. Under each alternative, the design includes field data collection to support characterization of surface water expression, stream temperature, and FP-covered amphibians. Each alternative proposes the collection of stream and stand characteristics, and other environmental variables to enable identification of

**Commented [HB121]:** On the Np, the wetted portion of Ns or F?

**Commented [BW(122R121]:** On the wetted portion of the Np, see the Soft Rock section of the BAS.

**Commented [JD123]:** Yellow. Please finish the thought.

**Commented [OBRA(124R123]:** Added period. Thanks.

**Commented [CM125]:** Red - See priori comments, no longer relevant given the Board's actively, ongoing Westside Type Np rule making process. Need to wait until that's over, then rescope based on the new Type Np rule if needed.

**Commented [OBRA(126R125]:** We address current rule-making above.

**Commented [DM127]:** Yellow,
Using stream order is problematic given the variability of channel network mapping? In many cases, especially DNR Hydro, the 1st orders often are 2nd order. Recent Np flow surveys by NCASI found coarse substrate and BFW correlated with discontinuous flows. E.G. For discontinuous flow, 55% of observations were found for bankfull widths of <1 m, 34% for 1-2 m, 9% for 2-5m (see A. Coble referenced above)

**Commented [OBRA(128R127]:** We mean field-verified first order streams. We agree that DNR Hydro and NHD flowlines have major limitations associated with stream order. The site selection aspect of this will be further developed in the study design. We are giving the reader context that we are focused on the uppermost extent of the headwater network. We changed reconnaissance to verification to help clarify this.

**Commented [HB129]:** ?

**Commented [JD130R129]:** I wondered if you meant "protocols?"

their associations with the presence of discontinuous perennial reaches and to investigate the relative influence of discontinuous perennial reaches on stream temperature and amphibians. The alternatives vary in the number of study sites proposed for sample, study duration, and the scope of the field data collection effort (~~Table 2~~Table 3). The details of sampling will be further developed in the study design.

All three alternatives proposed by the Project T~~t~~eam include study design development in year one. All alternatives include one year for site selection, including landowner outreach, GIS screening and field reconnaissance. Site selection could proceed in year 2, immediately following study design development and approval. All alternatives propose field data collection beginning the year following site selection. A second year of data collection is proposed for all alternatives. It is at this point that the alternatives begin to vary in terms of their timeline (

Table 3). Alternatives, their differences, and benefits and considerations for each are discussed in greater detail below. All ~~alternatives pose~~alternatives ~~pose~~have the same potential environmental and landowner limitations, requiring identification of study sites with a range of wet vs. dry stream lengths across a range of stand ages and other covariates. It may be difficult to identify enough sites that meet the selection criteria and are located where there is landowner willingness to participate in the study.

Table ~~2~~3. Summary of alternatives proposed for consideration to address critical questions as a part of the Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow Project.

| | **Alternative 1** | **Alternative 2** | **Alternative 3** |
|---|---|---|---|
| **Sample size** | 30-45 | 45-60 | 60-75 |
| **Time** | 1 year site selection + 2 years data collection = **3 year study** | 1 year site selection + 3 years data collection = **4 year study** | 1 year site selection + 3 years data collection = **4 year study** |
| **FP-covered Amphibian** | Presence | Abundance adjusted for imperfect detection | Abundance adjusted for imperfect detection |



Commented [JD131]: Delete space.

| | | | |
|---|---|---|---|
| **~~Water~~ Stream Temperature**[8] | 3 sensors arrayed across 1st-order reach | 4 sensors arrayed across 1st-order reach | 4 sensors arrayed across 1st-order reach and Thermal heterogeneity surveys at a subset of sites. |
| **Surface water expression** | Annual survey during low flow~~.~~ | Annual survey during low flow~~.~~ | Repeat surveys at a subset of sites to document intra-annual variation~~.~~ |
| **Hard and Soft Rock Wetted Extent** | N/A | Revisit a subset of sites with greatest discontinuous Np | Revisit all sites with discontinuous Np |

Table ~~3~~4. Timeline of proposed alternatives across fiscal years for the Water Temperature and Amphibian Use in Type Np Waters with Discontinuous Surface Flow Project. Proposed fiscal years, consistent with the current approved MPS for the 23-25 biennium, are presented in italics.

| **Study Phase** | **FY1** *(FY25)* | **FY2** *(FY26)* | **FY3** *(FY27)* | **FY4** *(FY28)* | **FY5** *(FY29)* | **FY6** *(FY30)* |
|---|---|---|---|---|---|---|
| | Study design development | Site selection | Field data collection | | Reporting | |
| **Alt 1** | Study design development | Site selection | Field data collection | Field data collection | Reporting | |
| **Alt 2** | Study design development | Site selection | Field data collection | Field data collection | Field data collection | Reporting |
| **Alt 3** | Study design development | Site selection | Field data collection | Field data collection | Field data collection | Reporting |

### ~~8.1.~~7.1. *Alternative 1*

Alternative 1 proposes the shortest timeline and the smallest budget in exchange for being less representative of the temporal and spatial variability of discontinuous perennial reaches across the broader landscape (i.e., smallest sample size and shorter study timeline.). This alternative also will ~~also~~ not evaluate continued patterns in surface flow expression in what were previously identified as discontinuous perennial reaches at study sites included in the Hard and Soft Rock Studies.

**Timeline**

[8] air sensors will be deployed near sites to inform drying of instream water sensors.

**Commented [DM132]:** Strongly suggest camera and/or pressure sensors at each temp location to document when sensors dewater

**Commented [OBRA(133R132]:** Water sensors when deployed with air sensors give a clear signal of dryness. Added footnote to help clarify this. Pressure transducers are costly and unreliable in very shallow streams. Our project team has considered cameras similar to Eastside Forest Hydrology Study Extension, but determined that using loggers is a more efficient way to address this.

This alternative proposes the shortest timeline, with implementation in four years. The first year would include site selection and field reconnaissance to verify site conditions (currently proposed for FY26 in the MPS). The next two years would include field data collection July-September (currently proposed in FY27 and FY28). A final year would be required for data analysis and reporting. Under the current proposed timeline reflected in the approved MPS, data analysis and reporting could begin in October 2027 (FY28) upon completion of field sampling and would continue through development, review, and revisions through June 2029 (FY29).

**Cost**

This alternative presents the lowest cost option, estimated at $650,000 over four years of implementation (Table 4).

**Benefits**

This alternative would provide a coarse assessment that informs the critical questions with the lowest cost and in the shortest amount of time.

**Limitations**

While this alternative presents the shortest timeframe and lowest cost, with only two years of data collection, extreme summer conditions (i.e., extreme wet or dry years~~)~~) could have a stronger influence on the study results than the longer-term efforts proposed in Alternatives 2 and 3. Additionally, a shorter two year study period also risks missing or minimizing important annual variation in the timing and spatial expression of discontinuous Np reaches. This is an especially important consideration relative to our changing environment in response to climate change (e.g., changes to timing and duration of precipitation, increased summer high temperatures), and in consideration of the environmental sensitivity of focal FP-covered amphibians. Amphibian survey effort will be limited and focus on an assessment of presence based on observations during a single visit rather than abundance adjusted for imperfect detection, which risks missing important variation in population size. This alternative may be more limited in its ability to allow inference across differing stand ages and stream and stand characteristics, as well as in its ability to understand the relative influence of discontinuous perennial reaches on stream temperature and amphibians.

**Commented [HB134]:** I think that the ENREP study is tracking weather patterns and precip in order to inform interpretation of study results and inference ability. Are you planning this?

**Commented [OBRA(135R134]:** We are not planning on doing precip monitoring at the site scale, that gets very expensive and complex for so many sites. ENREP has a limited number of sites making it more feasible. We could use regional precip information to inform this.

**Commented [HB136]:** Two years is likely not enough to sample precipitation/flow variability. But, since policy may want results sooner than later, you might be ready to discuss increasing the sample size to address these limitations. Going to 60-75 sites looks like it will add about $300K.

**Commented [OBRA(137R136]:** We agree and these considerations are largely why we recommend Alt. 3.

### ~~8.2.~~7.2. *ALTERNATIVE 2*

**Timeline**

Alternatives 2 and 3 expand upon the timeline proposed in Alternative 1 with one additional year of field data collection. Implementation under these alternatives would be five years. As with Alternative 1, the first year would include site selection and field reconnaissance (proposed in current MPS in FY26). However, in these alternatives, this would be followed by three years of field data collection July-September (currently proposed for FY27, FY28 and FY29). A final year would be required for data analysis and reporting. Under the current proposed timeline reflected in the approved MPS, data analysis and reporting could begin in October 2028 (FY29) upon completion of field sampling and would continue through development, review, and revisions through June 2030 (FY30).

**Costs**

~~This alternative presentsa~~Alternative 2 presents a moderate cost option with a total estimated budget of $1,150,000 (Table 4). Implementation of this alternative relies on a larger field crew, additional equipment, and additional travel costs to cover the additional sites along with the additional year of data collection.

**Benefits**

More sites across an additional year of data collection with more robust methods will increase the reliability and generalizability of the study results over Alternative 1. Field data collection across an additional year will increase the chance of capturing the annual variation in weather and site conditions across the area of interest. The increased sample size will allow for increased replication across covariates such as stand age and allow for more reliable inference about the influence of environmental covariates on ~~water~~ stream temperature, amphibians, and surface water expression. The addition of one more stream temperature sensor (increased from three in Alternative 1 to four in Alternatives 2 and 3) better captures the temporal and spatial variation in stream temperature within study sites. The addition of multi-pass sampling to our amphibian methodology will allow us to estimate abundance adjusted for detection, giving a more reliable and accurate evaluation of amphibian populations in and near discontinuous Np reaches. Finally, Alternative 2 proposes including a reassessment of the spatial pattern of wetted extent in discontinuous perennial reaches at a subset of Hard and Soft Rock Study sites. This effort will allow evaluation of changes in surface flow over an extended period, as well as before and after timber harvest. Due to the lack of experimental manipulation, a~~A~~ny effort to draw linkages between timber harvest and variation in surface water expression in discontinuous perennial reaches based on this effort would be limited in scope~~.~~. However, repeat surveys at these sites will provide valuable information relative to the temporal variation of surface water expression over a period that would not be achievable without the prior years of data that these sites provide (Hard Rock 2006-2017, Soft Rock 2012-2020). In addition, by including these sites and using the same methods and time of data collection, comparisons could be made between the two studies that were not available during the writing of the original reports (e.g., Lithology).~~.~~ Under this alternative we would focus selection of a subset of Hard and Soft Rock study sites on those with the most potential to inform the project critical questions.

**Limitations**

This alternative does not have as large of a sample size as Alternative 3, so while being more robust than Alternative 1, it will have less opportunity to detect spatial and temporal variation relative to stand and stream covariates and be less generalizable across the landscape. ~~.~~Unlike Alternative 3, it will also not inform inter-annual variation in surface water expression or within stream thermal heterogeneity.

### ~~8.3.~~7.3. *ALTERNATIVE 3*

**Timeline**

**Commented [JD138]:** I decided that I was okay with the paragraph above, so long as there's a hard transition to "Now we're only talking about Alternative 2."

**Commented [OBRA(139R138]:** Thanks. We accept your track changes.

**Commented [HB140]:** Is there some understanding the that can be derived now from these sites to support selecting the longer alternatives? Just the variation in precip and stream flows measured at these sites, even down stream flow variability suggesting upstream variability, would auger for the longer alternatives.

**Commented [OBRA(141R140]:** Yes! See the BAS section, especially in the Soft Rock data that highlights variability.

**Commented [HB142]:** This is important enough to say why? What does limited in scope mean here?

**Commented [OBRA(143R142]:** Good idea. We are studying associations on the landscape, not an experimental manipulation.

**Commented [HB144]:** What about reduced inference confidence to other landscapes/conditions?

**Commented [OBRA(145R144]:** That is a reasonable limitation to add.

Alternative 3 proposes the same timeline as Alternative 2, with one year for site selection (FY26), followed by three years of field data collection (FY27, FY28 and FY29, with report development, review, and revisions through June 2030 (FY30).

**Costs**

This alternative presents the most expensive cost option with a total estimated budget of $1,400,000 (Table 4). The increased cost is due primarily to the increased field staff needed to implement sampling at more sites in combination with more intensive monitoring efforts related to censusing more Hard and Soft Rock sites in addition to repeat surveys at a subset of study sites to inform inter-annual variation in surface water expression and thermal heterogeneity.

**Benefits**

In addition to the benefits mentioned in Alternative 2, this alternative has the added component of multiple surface water expression surveys across the low flow period allowing for a better understanding of intra-annual variation in low flow expression. This will help inform how variable patterns of drying impact ~~water~~ stream temperature and amphibians. In addition to using continuous ~~water~~ stream temperature sensors, this alternative also includes a survey of thermal heterogeneity across reaches to identify and characterize thermally differentiated patches. This higher-resolution assessment of ~~water~~ stream temperature will contribute to a richer understanding of how hyporheic exchange and groundwater inputs may affect stream temperature within the Np network. Adding all the Hard and Soft Rock sites will have the same benefits as Alternative 2, with the addition of an increased spatial scale.

**Limitations**

Alternative 3 requires the largest sample size and depends on successfully identifying an adequate pool of sites across covariates. Consistent with all alternatives, this approach would not directly evaluate the effect of timber harvest of discontinuous perennial reaches on stream temperature or amphibians. ~~An effectiveness study could be designed, but our synthesis of BAS highlighted a need to characterize discontinuous perennial reaches and investigate their influence on stream temperature and amphibians to inform the value of a more expensive and time-consuming investigation of buffer effectiveness.~~

## ~~9.~~8. RECOMMENDED APPROACH

The Project Team recommends Alternative 3 (Figure 2). This alternative provides the greatest opportunity to address the project critical questions and to evaluate how stream and stand characteristics inform the pattern of surface water extent and the influence of discontinuous perennial reaches on stream temperature and amphibians (Table 5). The larger sample size and more robust sampling methods ensure greater statistical power to reduce the risk of Type II errors (false negatives, i.e., the likelihood of not detecting a difference when one exists). It also allows for enhanced generalizability ensuring the findings are applicable to a broader range of contexts across western Washington. Alternative 3 also allows for greater power to analyze covariates. Additionally, Alternative 3 would leverage existing wetted extent datasets from the

**Commented [JD146]:** This is the sentence mentioned above; great sentence, buried here and not clearly stated anywhere else.

**Commented [OBRA(147R146]:** Thanks for the idea! We moved this up so it is not buried.

**Commented [CM148]:** Red - See priori comments, no longer relevant given the Board's active, ongoing Westside Type Np rule making process. Need to wait until that's over, then rescope based on the new Type Np rule only if needed.

**Commented [OBRA(149R148]:** We address the current rule-making process above. Thank you for your concern.

Hard Rock and Soft Rock study sites to inform the temporal variation in surface water expression through a good portion of the harvest rotation (~ 20 years after harvest at most sites).

Table 45. Overview of how alternatives address critical questions.

| **Critical Questions** | **Alternative 1** | **Alternative 2** | **Alternative 3** |
|---|---|---|---|
| How do discontinuous perennial reaches influence stream temperature across stream and stand characteristics? | Limited ability to address co-variates | Moderate ability to address co-variates | Greater ability to address co-variates |
| What is the relative influence of discontinuous perennial reaches (spatial and temporal pattern of surface water expression) on stream temperature and FP-covered amphibian populations in Type Np reaches? | Limited ability to address inter-annual variability and no ability to address intra-annual variability | Moderate ability to address inter-annual variability and no ability to address intra-annual variability | Greater ability to address both inter-annual and intra-annual variability in spatial and temporal patterns |
| How do FP-covered amphibians respond differentially to discontinuous Np reaches based on site specific factors (e.g., lithology, gradient)? | Limited ability to address co-variates | Moderate ability to address co-variates | Greater ability to address co-variates |
| Do stream-associated amphibians utilize discontinuous perennial reaches of Type Np Waters and, if so, do occupancy and abundance differ from reaches with continuous surface flow? | Yes, occupancy only | Yes, occupancy and abundance | Yes, occupancy and abundance |

**Commented [DM150]:** Alternative 4: Given difficulties in estimating abundance, and huge variability in Np flow regimes. Why not do occupancy surveys at a larger number of sites (e.g., 100).

**Commented [OBRA(151R150]:** We anticipate even evaluating occupancy will require accounting for detection probability (and associated bias). This means that even occupancy surveys require repeat visits to sites. The main expense is getting to the sites, not so much the time spent surveying. The advantage of occupancy surveys would be that you could stop your search when all species are detected, but we anticipate this to be a relatively small time saver. Abundance offers more resolution when it comes to informing the importance of discontinuous Np reaches for FP-covered amphibians. We will continue to consider this if we move toward study design, but prefer to keep abundance as a option.

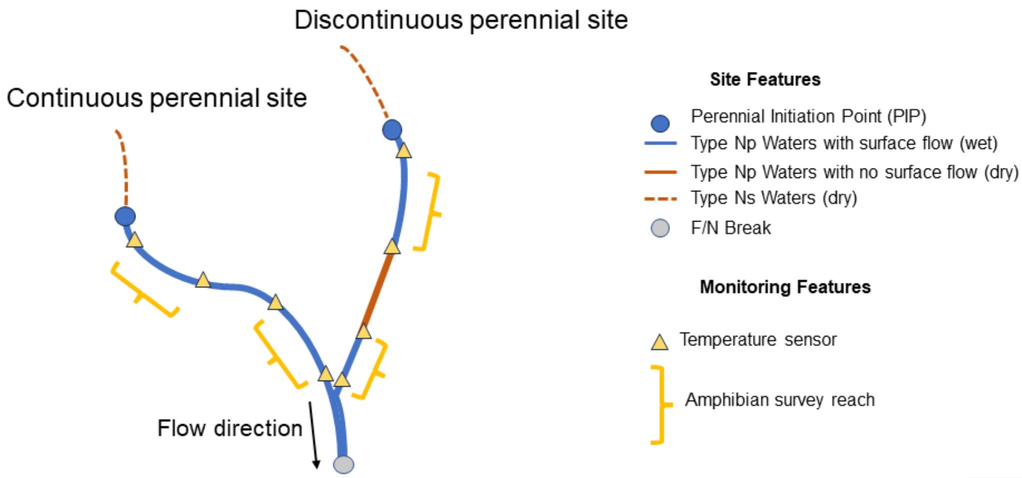


Figure 2. Study site schematic of showing layout of two study sites with varying flow patterns. ~~recommended Alternative 3~~. The different alternatives propose similar study site layouts, however Alternative 1 would employ ~~less~~fewer ~~water~~stream temperature sensors.

## ~~10.~~9. BUDGET

We developed budget estimates for each of the three proposed alternatives (Table 6).

Table ~~5~~6. Estimated budgets for each of three proposed alternatives evaluated during scoping of the proposed study. Colors indicate site selection (green), field data collection (blue), and reporting (orange).

| Alternative | FY2 (FY26) | FY3 (FY27) | FY4 (FY28) | FY5 (FY29) | FY6 (FY30) | Project Total |
|---|---|---|---|---|---|---|
| Alternative 1 | $151,564 | $197,231 | $169,434 | $114,500 | | $650,000 |
| Alternative 2 | $219,734 | $295,185 | $245,546 | $245,546 | $114,500 | $1,150,000 |
| Alternative 3 | $272,682 | $367,989 | $305,113 | $305,113 | $114,500 | $1,400,000 |

If interest exists, a Study Design could be developed, for which funding has been allocated in the CMER Master Project Schedule (MPS) for FY25.

**Commented [JD152]:** Yellow. Yep, yep, great figure. However, without a comparison to efforts for Alternatives 1 and 2, it seems a bit pointless. Did you mean for it to be compared to something else? Could we have that graphic?

**Commented [OBRA(153R152]:** The primary ways that the different alternatives vary is in the number of sites, the duration of the study, and the addition of resampling at the hard and soft/rock studies. We explored creating different study site schematic figures across the different alternatives, but found that they didn't do a good job of capturing the range of alternatives being proposed because of the similarity in study site lay out. Instead of creating fairly redundant comparison figures, we revised the caption.

**Commented [CM154]:** Red - See priori comments, no longer relevant given the Board's active, ongoing Westside Type Np rule making process. Need to wait until that's over, then rescope based on the new Type Np rule only if needed.

**Commented [OBRA(155R154]:** We address current rule-making above.

**Commented [HB156]:** of the what?

**Commented [OBRA(157R156]:** Proposed study. Good catch.

**Commented [HB158]:** Seems like Alt 1 is technically inadequate and the small cost difference between 2 and 3 argues for 3.

**Commented [OBRA(159R158]:** We generally agree. Alt. 1 would be a simplified characterization, but we felt it was important to offer a low-cost option that would still yield useful information.

**Commented [DM160]:** Yellow
Not purpose? Move elsewhere

**Commented [BW(161R160]:** Moved to the end.

## Appendix A. Best Available Sciences Review

In this synthesis, we review the BAS to inform the prevalence and characteristics of discontinuous perennial reaches in Washington State, and their potential influence on instream water quality (i.e., stream temperature) and stream-associated amphibians-. We review previous CMER efforts, peer-reviewed literature, and other data sources and, provide a summary of relevant information, and sources of variability and uncertainty., and identify areas where additional information relevant to FP rules and consideration of discontinuous perennial reaches could be useful..

## 1. CMER AND TFW RESEARCH INFORMING THE TOPIC OF DISCONTINUOUS PERENNIAL REACHES

FP rules first required the protection of Type Np Waters in 2001. At the time of FPHCP negotiations, limited research was available to inform rule negotiations for Type Np Waters and the anticipated effectiveness of the various protections under consideration. Also, uncertainty existed about accurate and consistent delineation of Type Np Waters, including for the demarcation of F/N breaks and the PIP. As a result of scientific uncertainties and operational challenges specific to Type Np Waters, CMER has dedicated time and resources to evaluating surface water expression in Type Np Waters in a variety of studies. The earliest CMER studies associated with Type Np Waters focused on PIP identification, since accurate application of the riparian buffer strategy for Type Np Waters relies on accurately identifying the PIP. Early Rule Implementation Tool Projects were implemented to better understand PIP expression. More recent Effectiveness Monitoring research has tested how upland timber harvest may influence surface water expression. We identified 16 TFW, CMER and related studies that included monitoring data with the ability to inform surface water expression in discontinuous perennial reaches of Type Np Waters. A summary of select lessons learned from these CMER studies is presented in Table 6.

Table 6. Select lesson learned from CMER studies with implications for discontinuous perennial reaches. BACI refers to a study with a Before-After Control-Impact study design.

| .Theme | Lesson Learned | Citation |
|---|---|---|
| | **Technical** | |
| PIP Movement | While some PIP locations appear to be stable, others have been shown to move across years. | Palmquist 2005; Pleus and Goodman 2003 |
| Frequency of Occurrence | East of the Cascades, 21% of the Np channel network was dry | Miller and Peterson 2009 |
| | West of the Cascades, approximately 15-20% of the Np channel network was dry in | McIntyre et al. 2018<br>Ehinger et al. 2021 |
| | Discontinuous perennial reaches are very common both West and East of the Cascade Mountains | TFW Policy Subgroup 2012 |
| Patterns of Discontinuity | Lower order reaches tend to have the greatest proportion of dry streambed in the Np channel network. | Ehinger et al. 2021 |

**Commented [HB162]:** Could be seen as being outside the scope of this study.

**Commented [OBRA(163R162]:** It is also a pretty wordy statement so we agree that simplifying it is a good idea.

**Commented [CM164]:** Red - You left out a major part of the history and fate of the CMER Type N Demarcation Reports (Palmquist 2004?, Plues and Goodman 2005?) relevant to the AMP under the FP HCP.

The Board struck the Type Np Basin area defaults in rule for eastern and western WA based on those two studies (Palmquist 2004, Plues and Goodman 2004?), The Board directed TFW Policy to develop new seasonal defaults to replace basin area (using distance from channel head), and develop new BM language for identifying and locating PIPs in the field (the Type Np/Ns break).

The latter two were completed, however TFW Policy could not agree on approval of the new seasonal defaults or BM guidance. As a member of the PIP Board Manual technical committee tasked with drafting this language, and the Type N technical committee tasked with drafting new seasonal defaults. we completed both tasks and they have been collecting dust on DNR's shelves / files because the Board never adopted either of them - which were based on CMER's Rule tool studies. All TFW Policy members, save WFPA / WFFA, approved of the new PIP seasonal defaults and BM guidance. However, the Board never adopted them. There's documentation outlining all of this. I strongly suggest you add this to your "story" on the history of CMER rule tool studies as they relate to the AMP as they have implications for any future studies. I'm glad to assist if you need help with this when the time oomes.

**Commented [OBRA(165R164]:** Your dates don't match the final reports. You will see these are incorporated in the table and sections below. Here we just provide a high level introduction to CMER data gather efforts relevant to surface water expression in the upper extent of the headwater network.

We removed the sentence. We are tellingl the technical science story about studies that collected data that inform discontinuos reaches. We are not trying to tell the story of TFW Policy and the Boards action related to that work.

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**Commented [CM166]:** Yellow - are these the correct dates: Palmquist Type N Demarcation Study was completed before Plues and Goodman that focused on the Eastside based on Palmquist study. Palmquist did produce a "Summary Report:" for east and western WA using the Eastside data so maybe that's what you're citing?

**Commented [OBRA(167R166]:** I agree with your chronology of the fieldwork, but we base this on the dates of the report approval/finalization. The final version of Palmquist is dated Feb 14, 2005 (Version 7.5) and is based on 2001 fieldwork.

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**Commented [HB168]:** In what?

**Commented [OBRA(169R168]:** Deleted extra word.

| .Theme | Lesson Learned | Citation |
|---|---|---|
| | | |
| | Underlying lithology can affect the extent to which surface flows are expressed in headwater streams over the summer season (increased length in unconsolidated lithologies). | TFW Policy Type N Technical Subgroup 2012 |
| Stream Temperature | BACI studies showed that reaches with discontinuous perennial flow may have reduced the warming effect of harvest. | McIntyre et al. 2018<br>Ehinger et al. 2021 |
| Stream-associated Amphibian Use | Torrent salamanders have been observed occupying small reaches of surface water in otherwise dry channels. | McIntyre et al. 2018 |
| **Implementation and Study Design** | | |
| Site Selection – Population | Be cautious about relying on DNR Hydrography or national hydrography dataset (NHD) with random site selection as it may lead to many sites lacking channels and surface water. CMER studies suggest much of the Ns network is represented as Np. | CMER Work Plan 2023, pg. 46 |
| Site Selection - Access | Gaining landowner permission to conduct studies can lead to delays and denials, especially with larger pools and random selection of sites. This has been especially true of small forest landowners and select industrial landowners. | Ecology 2019 |
| Implementation | Quality water temperature data requires maintaining temperature sensors fully in shallow streams. | McIntyre et al. 2018<br>Ehinger et al. 2021 |

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Commented [HB170]: On the Np, the wetted portion of Ns or F?

Commented [BW(171R170]: On the wetted portion of the Np, see the Soft Rock section of the BAS.

Commented [JD172]: Yellow. Please finish the thought.

Commented [OBRA(173R172]: Added period. Thanks.

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### 1.1. PERENNIAL INITIATION POINT (PIP) DEMARCATION

One of the earliest CMER-supported adaptive management studies evaluated surface water expression in Type Np Waters as a part of PIP demarcation. Since Type Np streams require riparian buffers in the RMZ along at least 50% of their length, and Type Ns streams do not (WAC 222-30-021 WAC 222-30-023), the location of the Np/Ns break (i.e., PIP) is important for rule implementation and resource protection. We identified five TFW, CMER, and related studies that investigated PIP characteristics and movement to inform the FPAMP (Table 7). In an early effort, the Type N Stream Demarcation Study (Palmquist, 2005) sought to refine the delineation of PIP locations in Type Np basins throughout Washington State through topographic modeling and field validation. One intent was to test the adequacy and replicability of a pilot field protocol for identifying PIPs based on contributing basin area for accurate implementation of the new FP rules. A series of companion studies, not all of which were formally part of CMER, were conducted by multiple TFW stakeholders and other researchers during the same period. For example, Pleus and Goodman (2003) expanded on the work started by Palmquist (2005) by revisiting a subset of the sites evaluated in the previous effort, and new sites, using the same field protocols. Though this research is not formally a CMER study, the report went

Commented [CM174]: Red - Misleading. Type Np buffers only require riparian buffers along at least 50% of their length with the remaining being clearcut to their stream banks just like Type Ns stream. For those reaches the only difference is an ELZ requirement on Type Np vs. Type Ns. Suggest you read and cite the rule,

Commented [OBRA(175R174]: Read the rule and cited the WAC as requested.

Commented [CM176]: Red - All CMER Type N Demarcation study results (Palmquist 2004, Plues and Goodman, 2005, Miller and Peterson 2009?) indicate that the PIP is located near the Channel Head the majority of the time. The Type Np Technical committee for TFW Policy lists those distances for the Westside. The Stewart summary (2012?) does the same for Eastside PIPs. My prior comments on rewriting the BAS table above should capture this. The history of the Board not taking action based on those studies should also be part of this narrative. CMER generated enough data (eastern and western) to develop seasonal defaults and the Board Manual tech. committee wrote guidance for locating the Type Np/Ns break. The problem was TFW Policy didn't agree on them. That's a Policy not a science problem. CMER;s Type Np demarcation reports were reviewed and approved by ISPR.

Commented [OBRA(177R176]: We are trying to provide a history of CMER science, not Policy/Board action on the topic. We did add more of the summary findings from the PIP Tech Memo including your point about PIPs and Channel Heads a couple paragraphs below this.

Commented [WB178R176]: Added a separate table for PIP movement. We also added some findings directly from the study reports that deal specifically with the discontinuous portion of the Np streams.

Commented [CM179]: Yellow - what others besides Plues and Goodman are you speaking to? That Tribal study used the same methods as Palmquist and was approved by ISPR.

Commented [OBRA(180R179]: See Table 7. We are refering to Jaeger 2007, Veldhuisen et al 2004 and Hunter 2005..

through the TFW peer-review process. In an additional effort, recategorized data from the Type N Stream Demarcation Study was used to address supplemental information requests from TFW Policy (TFW Policy Type N Technical Subgroup 2012).

Field validation ~~consistently~~ revealed limited variation in PIP ~~expression~~ location across the landscape and found that PIPs ~~they~~ are located very near the channel head (Hunter et al., 2005; Palmquist, 2005; Pleus & Goodman, 2003; Veldhuisen, 2004). These efforts also found that the basin areas above PIPs were smaller than the default basin size criteria defined in the pilot protocol. Notably, these evaluations ultimately led to the first adaptive management rule change, resulting in a policy shift away from using default basin size criteria as a predictor of PIP location and instead relying on field ~~evaluations~~indicators to locate PIPs. ~~The~~Our synthesis of PIP studies found that discontinuous reaches are very common both West and East of the Cascades and the PIP is commonly co-located near the channel head. It also highlighted that dry channels may increase in frequency and length in unconsolidated materials (TFW Policy Type N Technical Subgroup 2012).

A subsample of PIP demarcation study sites were evaluated for PIP stability seasonally or annually. In an evaluation of intra-annual variation, Palmquist (2005) found that 56% of PIPs remained stable throughout the summer months ~~(Figure 3)~~. In evaluations of inter-annual variation, Veldhuisen (2004) and Pleus and Goodman (2003) reported that 83% and 100% of PIPs remained stab~~ility~~le, respectively, across multiple years. However, these are contrasted with data ~~pulled~~ from the Soft Rock Study ~~(~~Ehinger et al. ~~(~~2021) which ~~showed~~found that only 26% of PIPs were stable throughout the study period (Table 7).

Table 7. Data from the PIP demarcation (Palmquist, 2005; Pleus & Goodman, 2003; Veldhuisen, 2004) and Soft Rock (Ehinger et al., 2021) studies related to PIP movement.

| **Study** | **Inter/Intra annual** | **n** | **Spatial Resolution** | **Percent PIP stability** |
|---|---|---|---|---|
| Ple~~us~~us and Goodman 2003~~2~~ | inter | 8 | Unk | 100% |
| Palmquist 2005 | intra | 9 | 5m | 56% |
| Veldhuisen 2004 | inter | 17 | 60m | 82% |
| Ehinger et al. 2021 | inter | 47 | 2m | 26% |



**Commented [CM181]:** Yellow - needs citation(s). There are only a handful.

**Commented [OBRA(182R181]:** Added reference.

**Commented [CM183]:** Yellow PIP "Location" is what all the reports call the upper most points of perennial flow not "expression" . Recommend rewording to make consistent with CMER reports. e

**Commented [OBRA(184R183]:** Done.

**Commented [CM185]:** Red - They were "smaller" by an oder of magnitude (10x) which is why the Board eliminated them from the FP rules. Again, need to Insert the history of the Board's rule change based on these CMER studies. They weren't just "defined in the pilot protocol" which was the point of these "rule tool" studies - to validate the rules, just like the DFC Validation study.

**Commented [OBRA(186R185]:** Thanks for the input, but we are trying to stick to the science. This is a BAS, not a detailed historical account of board actions.

**Commented [BW(187R185]:** Thanks, Chris. This is also broken down by region, so instead of going into extensive detail about the differences in basin areas from the previous rule, we wanted to focus the BAS on the studies that more directly inform this current effort (Hard Rock, Soft Rock and the Forest Hydrology studies).

**Commented [CM188]:** Red - See above comments about the history of the Board directing TFW Policy to develop new seasonal defaults based on the CMER Reports. The Type Np Technical report summarizes contains a lot of that information so you don't have to reinvent. This is important context that helps explain why field evaluation are the only option available to landowners with no new seasonal defaults as directed by the Board. Again, need to add this to your narrative.

**Commented [OBRA(189R188]:** We incorporated more specifics from the PIP memo.

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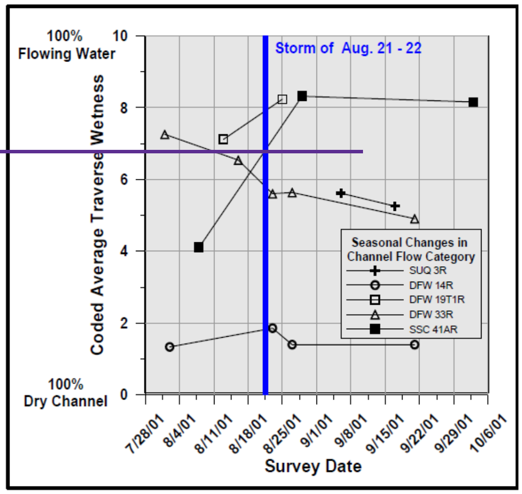


~~Figure 3. Coded dryness of repeated surveys downstream from Channel head showing intra-annual (seasonal) variation in the amount of perennial water in Type Np channels.~~

In addition to evaluating the locations and ~~consistency~~ stability in~~of~~ PIP ~~expression~~ locations across the landscape, these studies examined additional characteristics of discontinuous perennial reaches. ~~This was characterized in~~ Palmquist (2005) ~~as~~evaluated the ~~area~~distance between the start of~~n~~ discontinuous water (Pd) and the start of continuous perennial water (Pc; Figure ~~3~~43). Across five sites evaluated with repeat dry season surveys, ~~In this area of discontinuity,~~ Palmquist (2005) did not find a pattern of drying i~~,~~n discontinuous Np reaches~~in the five sites with repeat dry season surveys~~; however, they did observe a ~~, except for an increase~~decrease in ~~wetness~~the stream distance between Pd and Pc ~~due to an~~in response to rain inputs from an August storm (Figure 4~~4~~5). ~~Collectively, these efforts contributed to CMER's appreciation of the variability in surface water expression and the need for field verification, rather than GIS models or a standard basin area rule, to predict surface water expression.~~

**Commented [CM190]:** Red - you're missing the key points of what those "collective efforts" actually resulted in that were forwarded to TFW Policy as per the Board's request, 1) that the majority of PIPs are located very near the channel head (CH), 2) That lineal distance from CH is a better metric than basin area for identifying and locating PIPs, 3) Technical recommendations were made to the TFW Policy and the Board based on the results of CMER/ Tribal ISPR reviewed studies, but nothing was done due to disagreements at TFW Policy.

**Commented [OBRA(191R190]:** These are good points and I added the technical ones to the previous paragraph. Policy disagreements feel outside the scope of the BAS section.

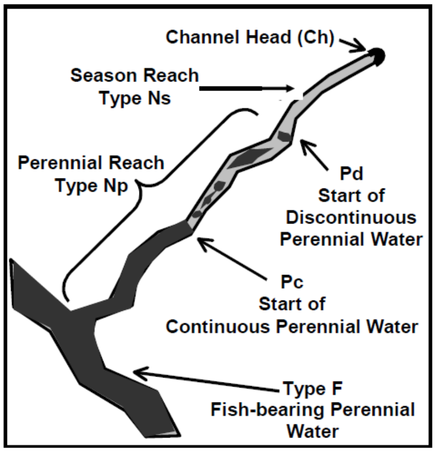


Figure 43. The location and definition of the hydrologic points that define the limits of the seasonal and perennial water types (Palmquist, 2005).

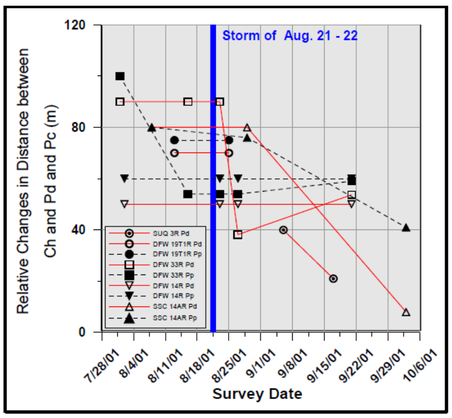


Figure 4~~5~~. Seasonal changes in PIP location (Palmquist, 2005).

~~Veldhuisen (2004) and Plueus and Goodman (2003) did not formally analyze data between Pd and Pc (discontinuous Np). However,~~ Though not part of a formal analysis, Veldhuisen (2004) ~~did~~ noted that of the sites that were resurveyed in 2003, 37% the segment-scale flow categories were drier than in 2001. Sites resurveyed in 2002 were also drier than in 2001 even though annual precipitation was higher. This was likely due to lower-than-normal precipitation in the summer months, which is consistent with results from Hunter (2005).

Collectively, the~~se~~ efforts of the PIP demarcation studies contributed to CMER's appreciation of the variability in surface water expression and the need for field verification, rather than GIS models or a standard basin area rule, to predict surface water expression.

Table ~~7~~8. Adaptive Management Program and related studies evaluating PIP demarcation in Washington State. Study type is Before-After Control-Impact (BACI) or observational (OBS).

| Citation | Study Name | Geographic Area/Region | Study Duration (Timing) | Sample Size and Unit |
|---|---|---|---|---|
| Pleus and Goodman 2003 | Type N Demarcation Study | Statewide | 2 years (2001-2002) | 86 study sites in the 300 dba and 152 study sites in the 52 dba |
| Veldhuisen et al. 2004 | Summary of Headwater Perennial Stream Surveys in the Skagit and Neighboring Basins | Skagit and adjacent watersheds | 3 years (2001-2003) | 25 headwater basins |
| Jaeger et al. 2007 | Channel and perennial flow initiation in headwater streams: management implications of variability in source-area size. | Southwest WA (Black and Willapa Hills) | | 81 channel heads across 4 headwater basins |
| Hunter et al. 2005 | Low flow spatial characteristics in forested headwater channels of southwest Washington | Southwest WA (Stillman Creek in Willapa Hills) | 2 years (2001, 2002) | 23 stream reaches |
| Palmquist 2005 | Type N Demarcation Study | Statewide (Cascades, Northern Rockies, Coast Range, Puget Lowland) | 1 year (2001) | 224 streams |

## 1.2. STUDIES WEST OF CASCADE CREST

We identified five additional studies specific to western Washington that inform the prevalence and characteristics of discontinuous perennial reaches across the landscape in western Washington (Table 9).

Table ~~8~~9. Adaptive Management Program studies conducted west of the Cascade crest that inform prevalence and characteristics of discontinuous perennial reaches in western Washington State. Study type is Before-After Control-Impact (BACI) or observational (OBS).

| Citation | Study Name | Geographic Area/Region | Study Duration (Timing) | Sample Size and Unit | Study Type |
|---|---|---|---|---|---|



**Commented [CM192]:** Red - you're missing the key points of what those "collective efforts" actually resulted in that were forwarded to TFW Policy as per the Board's request, 1) that the majority of PIPs are located very near the channel head (CH), 2) That lineal distance from CH is a better metric than basin area for identifying and locating PIPs, 3) Technical recommendations were made to the TFW Policy and the Board based on the results of CMER/ Tribal ISPR reviewed studies, but nothing was done due to disagreements at TFW Policy.

**Commented [OBRA(193R192]:** These are good points and I added the technical ones to the previous paragraph. Policy disagreements feel outside the scope of the BAS section.

**Commented [CM194]:** yellow - Plues and Goodman focused on the Eastside following up on Palmquist work that primarily focused on the westside.

**Commented [OBRA(195R194]:** That isn't quite my understanding. Plues and Goodman "provides inter-annual (repeat) data using a subset of the Palmquist sites" and adds Eastside sites, so Statewide is correct.

| | | | | | |
|---|---|---|---|---|---|
| Hayes et al. 2002 | Amphibian Use of Seeps and Stream Reaches in Non-fish Bearing Stream Basins in Southwest Washington | Willapa Hills | 1 year (2000) | 16 sub-basins | OBS |
| Jackson et al. 2003 | Integrated Headwater Stream Riparian Management Study (i.e., Amphibian Recovery Project) | Willapa Hills | 4 years (1998-2001) | 15 Type N streams within 5 logging sites | BACI* |
| McIntyre et al. 2018 & McIntyre et al. 2021 | Hard Rock Study – Phase I Hard Rock Study – Phase II | Olympics, Willapa Hills, South Cascades | 12 years (2006-2017) | 17 Type N basins | BACI |
| Ecology 2019 | Westside Extensive Riparian Status & Trends– Stream Temperature | Western Washington | 2 years (2008-2009) | 55 Type F/S and Type Np streams | OBS |
| Ehinger et al. 2021 | Soft Rock Study | Willapa Hills | 9 years (2012-2020) | 10 Type N basins | BACI |

* Funded by the National Council for Air and Stream Improvement (NCASI)

### *1.2.1. Type N Westside Riparian Effectiveness Studies*

The Type N Westside Riparian Effectiveness Studies, including both the Hard and Soft Rock Studies, evaluated the effectiveness of riparian forest management prescriptions for Type N stream basins on hard rock (i.e., competent) and soft rock (i.e., incompetent) lithologies, respectively, in western Washington. These studies evaluated the magnitude, direction (positive or negative), and duration of change for riparian-related inputs and response of instream and downstream components, including an evaluation of basin-wide perennial surface water expression. Both studies were a Before-After Control-Impact (BACI) design that included a pre- and post-harvest period of data collection, and both control (i.e., reference) and treatment sites. Treatments for both studies included Type N basins receiving the current Forest Practices rules prescription in the RMZ. The Hard Rock Study further evaluated the effectiveness of riparian forest management prescriptions by comparing the current FP prescription to alternatives with full-length two-sided 50-foot no-cut riparian leave-tree buffers (100% treatment) and no buffers (0% treatment). Both studies had temperature sensors deployed throughout the stream network and surveys of surface water expression. However, only the Hard Rock Study included surveys of stream associated amphibians. Summaries of the relevant parts of the individual studies are listed below as well as a brief comparison of the studies reported by Ehinger et al. (2021).

#### 1.2.1.a. Effectiveness of Experimental Riparian Buffers on Perennial Non-fish-bearing Streams on Competent Lithologies in Western Washington (Hard Rock Study)

In the Hard Rock Study, McIntyre et al. (2018) evaluated the length of dry channel throughout the entire study basin at 17 study sites during summer low flow. These surveys were conducted concurrent with amphibian sampling in 2006 (pre-harvest year), and 2010, 2015 and 2016 (post-harvest years). Most sites had some portion of dry length in the perennial reach, but the absolute number of dry perennial reaches, lengths of those reaches, and proportion of the basin stream length lacking surface flow differed among sample years (~~Table 9~~Table 10).

Table ~~9~~10. Numbers of Hard Rock Study sites with at least one dry reach ≥ 1 m in length, and the ranges (min, max, mean) in the number of dry perennial reaches, cumulative dry basin length (m), and proportion (%) of dry basin across sites by year. Sample period is Pre (pre-harvest) or post (post-harvest).

| Sample Year | Sample Period | Number of sites with dry (N=17) | Number of Dry Perennial Reaches | | | Cumulative Dry Basin Length (m) | | | Proportion of Basin | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean |
| 2006 | Pre | 15 | 1 | 17 | 6 | 14 | 1132 | 233 | 1% | 51% | 21% |
| 2010 | Post | 14 | 1 | 30 | 8 | 9 | 807 | 174 | 1% | 46% | 13% |
| 2015 | Post | 16 | 1 | 40 | 16 | 5 | 1074 | 227 | <1% | 63% | 22% |
| 2016 | Post | 15 | 1 | 41 | 16 | 4 | 1088 | 210 | <1% | 42% | 17% |

McIntyre et al. (2018) statistically evaluated the response of mean annual proportion of dry channel length to variable length riparian buffers. They did not find clear evidence that dry channel length varied among treatments (P = 0.25). However, when examined by harvest treatment, the post-harvest change in stream temperature increased with greater length of contiguous surface flow above the monitoring location in all three treatments and decreased with increasing proportion of dry channels in the summer months (Ehinger et al., 2021). The length of surface flow above the monitoring station provides an index of the stream area that could be exposed to increased solar radiation after harvest. The finding may have been influence by relatively large effects of groundwater inputs and hyporheic exchange on stream temperature relative to surface flow (Johnson & Jones, 2000; Story et al., 2003; Wondzell, 2006).

The influence of discontinuous Np reaches on amphibians has received very little consideration. Although not a focus of the Hard Rock Study, we do have limited data on the use of discontinuous Np reaches by amphibians. To put amphibian use of these reaches in context, we summarize amphibian observations in dry stream reaches for a single sample year. In 2006 (pre-treatment), only 3.5% of Coastal Tailed Frog (*Ascaphus truei*), torrent salamander (*Rhyacotriton* spp.) and giant salamander (*Dicamptodon* spp.) observations (71 of 2029) were in dry reaches of a perennial stream. Alternatively, 34 of 45 observations (76%) of Western Red-backed (*Plethodon vehiculum*) and Van Dyke's (*P. vandykei*) Salamanders were observed in dry reaches. Coastal Tailed Frog and the three Washington species of torrent salamanders (Cascade *R. cascadae*, Columbia *R. kezeri*, and Olympic *R. olympicus*) are designated as species of focus under Washington FP rules.

#### 1.2.1.b. Effectiveness of Forest Practices Buffer Prescriptions on Perennial Non-fish-bearing Streams on Marine Sedimentary Lithologies in Western Washington (Soft Rock)

Data were collected on surface water expression during the summer low-flow period (mid-August) from 2013-2020 in 10 study sites as a part of the Soft Rock Study. Start and end points for dry sections (> 2m) of perennial reaches were identified and mapped relative to flagging placed at 10m intervals. Discontinuous Np reaches were present in all 10 study sites, including all the 46 individual tributaries present across those sites.

Substantial portions of Type Np streams were without surface water during the summer low-flow, however the absolute proportion varied annually and by harvest treatment. Due to an unusually dry spring and summer, the lowest overall percentage of stream channel with surface flow was observed in post-harvest year 1 (2015), when only 59% of the total stream length in reference sites had visible surface flowing water, down from an average of 91% and 85% in the previous two years. A pair-wise comparison of post-harvest change showed an increase in percent wetted channel at the harvest treatment sites, relative to the references, in post-harvest years 1 and 2 (2015 and 2016; Table 10Table 11). This was considered an increase in surface water expression since the decrease in percent wetted channel at the references in 2015 (Post 1) and 2016 (Post 2) were not reflected at the harvest treatment sites (Table 11Table 12). Starting in post-harvest year 3 (2017) there were no differences in percent wetted channel observed between the reference and treatments for the remainder of the study period (2018-2020). There was also a slight positive correlation between the Mean Monthly Temperature Response (MMTR) and the amount of visible flowing water at the treatment sites in the first two years post-harvest (Table 12Table 13).

Table 1011. Post-harvest change in percentage of stream channel with surface flow in the treatment sites relative to the reference sites by year. Estimates and confidence intervals are in Beta-space. P-values were not adjusted for multiple comparisons. SE = standard error; DF = degrees of freedom; C.I. = confidence intervals (Ehinger et al., 2021).

| Year | Estimate | SE | DF | t-value | P-value | 95% | C.I. |
|---|---|---|---|---|---|---|---|
| Post 1 | 1.20 | 0.32 | 34 | 3.81 | 0.0006 | 0.56 | 1.84 |
| Post 2 | 1.40 | 0.34 | 34 | 4.16 | 0.0002 | 0.72 | 2.08 |
| Post 3 | 0.18 | 0.37 | 34 | 0.50 | 0.6183 | -0.56 | 0.93 |

Table 1112**.** Least squares means by treatment and period expressed in percentage of stream channel with surface flow. Treatment is reference (REF) or harvest treatment (TRT); Period = Pre- or Post-harvest year; SE = standard error; LCL = lower 95% confidence limit; UCL = upper 95% confidence limit (Ehinger et al., 2021).

| Treatment | Period | Mean | SE | LCL | UCL |
|---|---|---|---|---|---|
| REF | Pre | 88 | 4.44 | 76 | 94 |
| | Post 1 | 59 | 9.90 | 39 | 76 |
| | Post 2 | 71 | 8.56 | 52 | 85 |
| | Post 3 | 86 | 5.58 | 71 | 94 |
| TRT | Pre | 82 | 3.79 | 73 | 88 |
| | Post 1 | 75 | 4.81 | 65 | 84 |
| | Post 2 | 86 | 3.37 | 78 | 91 |
| | Post 3 | 82 | 3.99 | 73 | 89 |

**Commented [CM196]:** Red- link this part to the definition of the Type Np rule "in a year of normal rainfall" .if is was an "unusually dry year, " The point needs to be made if they were outside the definition of the Type Np rule. I think Ehinger did this in his Extensive monitoring reports as did Palmquist (compared to precipitation data available from NOAA and other WA weather data sources).

**Commented [BW(197R196]:** That analysis was not done as part of the report (Only included what was reported on). The reason this explanation was included was to illustrate that the drying in the reference sites did not occur in the treatments and that this showed an overall increase in the wetted channel when compared to the drier reference sites. A precipitation analysis was included in my thesis, see below.

**Commented [CM198]:** Red - This is exactly why this study in premature given that the FP Board is in the rule making process now, and poised to changed the Type Np rules. Newly proposed buffers may have an effect on the frequency, magnitude (length), and distribution of discontinuous dry reaches below the PIP. This study as proposed, would become obsolete one a new Type Np rule is adopted.

**Commented [BW(199R198]:** This will not be an effectiveness study, clarified in the introduction.

**Field Code Changed**

Table ~~12~~13. Pearson correlation coefficients and P-values for Pearson correlations with July Mean Monthly Temperature Response (MMTR; Ehinger et al., 2021).

| Year | % Wetted Channel | Wetted Channel Length |
|---|---|---|
| Post 1 | 0.726/0.056 | 0.742/0.065 |
| Post 2 | 0.510/0.243 | 0.763/0.046 |

**1.2.1.c. Hard Rock and Soft Rock Comparison**

Ehinger et al. (2021) and McIntyre et al. (2018) both reported that the main factor influencing the stream temperature response (post-harvest increases in temperature) was the loss of riparian cover. It is possible that the degree of hyporheic exchange had an influence on stream temperature response. An analysis of the MMTR in the Soft Rock study indicates that less surface water expression may have reduced the warming effect of harvest. Temperature change in both studies may have also been influenced by the proportion of wetted channel or the length of wetted stream (Figure 6). However, a formal analysis comparing studies has not been completed. It is also possible that the loss of riparian cover and increase in surface water expression interacted to affect stream temperature. Although not examined, this possibility could be an area of future research.

Commented [CM200]: Riparian cover will change with the Board's adoption of a new Type Np rule. All the more reason to wait until the new rule is adopted.

Commented [BW(201R200]: Potential for a later effectiveness study.

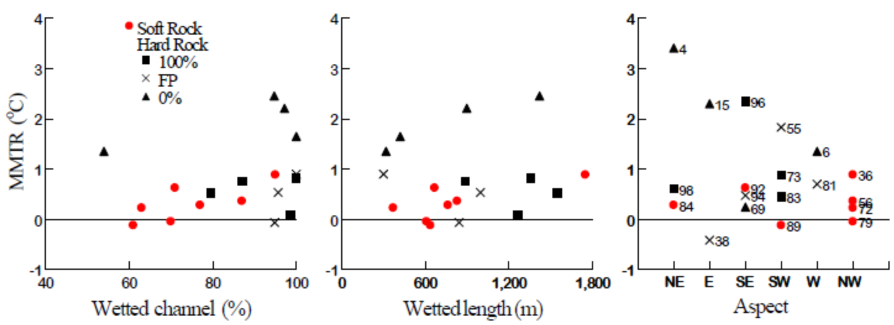


Figure ~~3~~6. July mean monthly temperature response (MMTR) vs. percent of stream channel with surface water (wetted channel), total wetted channel length, and aspect for the Soft (red) and Hard Rock (black) Studies. Values are from the first-year post-harvest except for the Hard Rock Study values for wetted channel and wetted length, which were measured in 2010, the second-year post-harvest at most sites. Numbers in the Aspect plot are mean canopy closure.

In both studies there was some indirect evidence of groundwater influence on the temperature response near the downstream outlet of the basin at some sites. One FP treatment from the Hard Rock Study and one harvest treatment from the Soft Rock Study had persistent dry reaches within a dense canopy located downstream of unbuffered reaches. Both saw an increase in the

Commented [CM202]: Red - "evidence" suggests that you measured ground water which you did not. You can hypothesize, speculate, that ground water may have played a role based on the "evidence" you collected in your study, But you have no empirical evidence of ground water influence. Need to restate.

Commented [BW(203R202]: Temperature sensors, including air, were right below a long persistent dry section which can be used to get an indirect measurement of groundwater influence. Added "indirect".

summer temperature response upstream of the dense canopy and dry reach and little to no temperature increase downstream, near the F/N break. Ehinger et al. (2021) and McIntyre et al. (2018) reported that this could be, in part, a result of hyporheic influence on stream temperature.

The underlying lithology of marine sediment may have played a role in the amount of channel that dried up during the summer low flow period for sites included in the Soft Rock Study. However, it is difficult to make a direct comparison with the basalt lithology of the Hard Rock Study. Data for these two studies were collected in different years so it is possible that prevalent weather played a larger role than lithology.

A more in-depth look into the surface water expression data for the Soft Rock P~~p~~roject was conducted as part of an unpublished thesis ~~(~~Bretherton, 2020*)~~by W. Bretherton (unpublished thesis)~~. The same survey methods, data, and harvest treatment effect analysis were used in both studies (see Soft Rock section for details). However, the extended post-harvest period (post 4-6) was described in more detail in (Bretherton, 2020*)~~W. Bretherton (unpublished thesis)~~ and is included below. This study also included analysis of the topographic and precipitation effects on surface water expression.

As noted in the Soft Rock section, the percentage of surface water present in the treatment basins increased in the first two years post-harvest (Figure 7).~~).~~ No treatment effect was detected in post-harvest years 3-6.

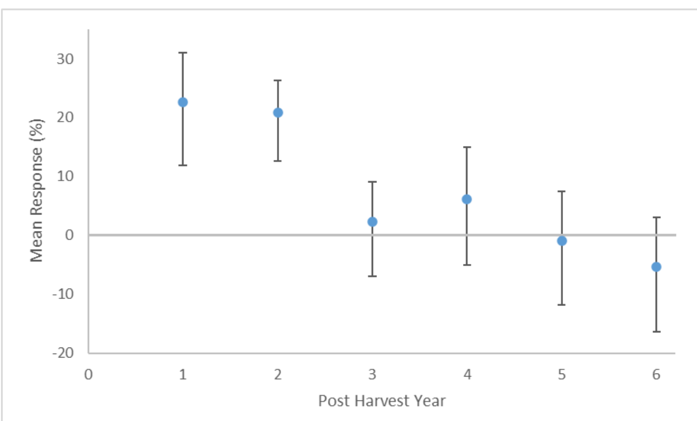


Figure 4~~7~~. The mean response in the extent of the wetted channels, at the treatment sites, for each year after harvest, relative to a static reference represented as the 0 line.

This increase in surface water expression is consistent with other research that has shown that discharge increases after a timber harvest within a watershed (Harr, 1983, 1986; Harr et al., 1975; Jones & Post, 2004). Specifically, McIntyre et al. (2018) found that in the Hard Rock study, with similar basins and similar harvest treatments, mean daily discharge increased by an average of 59%. It seems reasonable to conclude that an increase in discharge at the outlet of a Type Np basin would correspond to greater presence of surface flow throughout the watershed.

**Commented [CM204]:** Yellow - this is why if and when a westside forest hydrology study is conducted, we may want to stratify by lithology / geology like the Eastside Forest Hydrology Study.

**Commented [BW(205R204]:** We are essentially proposing a Westside Forest Hydrology Study with a amphibian and temperature component. We have discussed using the FHS as a guide during study design.

**Commented [JD206]:** Yellow. It still was written in a particular year. And you still need to put it in the references.

**Commented [BW(207R206]:** Changed throughout, added citation.

**Commented [CM208]:** yellow - this also supports waiting until after the Board adopts new Type Np rules - this influence of the Board's newly proposed buffers on discontinuous flow.

**Commented [BW(209R208]:** Might be helpful for a future extensive study.

Like McIntyre et al. (2018), Bretherton (~~unpublished thesis~~2020*) also found this increase to be temporary and only last through the first 2 years after harvest.

Annual precipitation was not correlated with surface water expression (likely due to the flashiness of these rain-~~-~~dominated headwater systems), however precipitation rates closer to the time of the surveys do seem to be correlated (Table 14). This was a loose correlation possibly because a single precipitation gage was used instead of a local rain gage at each of the sites. More precise measurements of precipitation could provide a better understanding of the relationship between summer precipitation and surface flow expression.

Table ~~13~~14. Correlation values (R) of each of the reference sites for the amount of rain in the proceeding x number of days by the percent wetted extent of the network in that water year (Bretherton, 2020*~~unpublished thesis~~).

| TRT ID | Precipitation x Percent Wet (R value) | | | | |
|---|---|---|---|---|---|
| | 7 Days Prior | 14 Days Prior | 30 Days Prior | Water Year | 30+14+7 Days |
| REF 1 | 0.76 | 0.85 | 0.54 | 0.20 | 0.74 |
| REF 2 | 0.59 | 0.39 | 0.47 | 0.30 | 0.53 |
| REF 3 | 0.63 | 0.56 | 0.73 | 0.24 | 0.73 |

A random forest model was also used to analyze the surface water expression at the reach scale. There were three main topographic features that seemed to be important to whether a reach would be dry or wet. The drainage area (flow accumulation), valley slope and stream slope were found to be the most important variables in the model (Figure 8). However, the random forest model had an "error rate of 0.0875 for the wet segments and a 0.4953 rate for the dry segments, making this model more accurate at predicting whether a segment will be wet (92% of the time) than predicting dry segments (50% accuracy)" (Bretherton, ~~unpublished thesis~~2020*).

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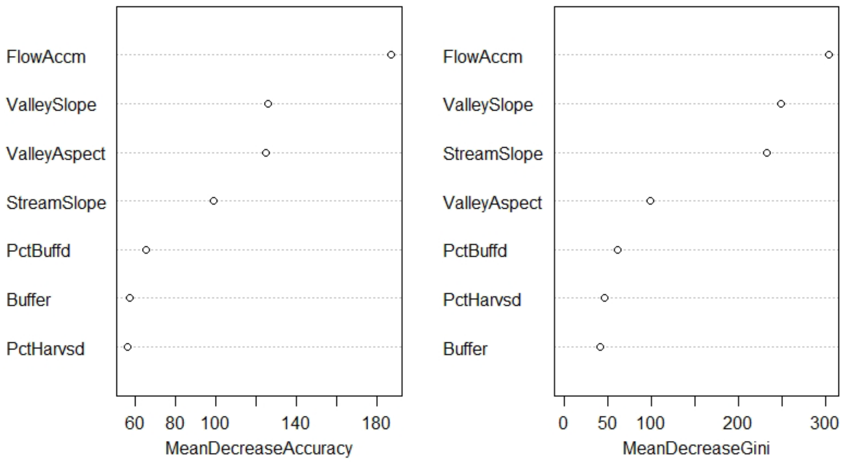


Figure ~~5~~8. Variable importance plot for random forest model for wet vs dry segments for each year of the study in the treatment sites. The scale is relative to indicate the importance of each variable (Bretherton, ~~unpublished thesis~~2020*).

The random forest models confirmed that higher stream slopes, lower valley slopes and smaller drainage areas were associated with reaches that had a higher percent of years dry. All these features are more likely to be higher up in the watershed, so it is difficult to conclude what role stream and valley slope play apart from the location in the watershed. Miller et al. (2015) also found that drainage area was predictive in determining the likelihood of discontinuous channels (Bretherton, 2020*~~as referenced in Bretherton, unpublished thesis~~).

#### 1.2.1.d. Westside Extensive Riparian Status and Trends – Stream Temperature

Two hundred twenty-eight Type Np sites were evaluated and 55 were sampled.
Objectives included:

- Describe the frequency distribution of stream temperature (maximum summer stream temperature and seven-day average maximum stream temperature) and canopy closure in Type F/S and Type Np streams on forest lands managed under the FPR in western Washington.
- Estimate frequency distributions of several descriptive non-temperature variables.

Air and ~~water~~ stream temperature were collected. The focus was on maximum ~~water~~ stream temperature and periods of drying were removed and not reported: “data loggers at several monitoring stations were exposed to air as stream water levels dropped. These data were identified and excluded from analysis.” The data from the 55 Np sites could be re-analyzed to show the temporal frequency of drying at those randomly selected points.

This was Phase 1 of Extensive Monitoring. The intent was to repeat the monitoring but there was no appetite for doing so given the cost and products associated with Phase 1. Also, of the 228 "Type Np" sites that were evaluated, 22.4% were rejected as not being Type Np or having no-channel and 40% were not sampled for other reasons including not having enough water to submerge a temperature logger. Also, landowner permission was a big issue in this study. The intent was to monitor at least 50 sites in each stream type and to install all temperature loggers by 30 June 2008 to record each stream's annual thermal peak; but by mid-July 2008 only one half that number of sites were installed due to delays in locating and obtaining permission to access private property.

This project provides an estimate of status of stream condition across the landscape and was intended to be the baseline for future trend monitoring of stream temperature, riparian cover, and channel metrics. Thalweg depth was measured at 5 transects along 300 m reaches. Very few instances of dry channels were measured, likely due to the rejection of sites without sufficient flowing water. The practice of excluding sites without sufficient water limits the use of this study to inform discontinuous surface flow.

### *1.2.2. TFW ~~Studies~~Reports*

Commented [CM212]: Yellow - TFW Studies implies that they were funded by the FP Board and part of DNR's Adaptive Management Program. I don' believe Jackson et al. (2003) fits that definition. Need to clarify which studies are TFW / AMP and which are not.

Commented [OBRA(213R212]: I believe Jackson does fit that definition based on the CMER IMS. It has a TFW Report number: TFW-LWAG9-01-001. NCASI also funded it, but the report we are referencing is a TFW report. They are all AMP studies.

#### 1.2.2.a. Recovery of Amphibian and Invertebrate Communities in Recently Logged Coastal Headwater Streams

Jackson et al. (2003) evaluated abiotic and biotic responses to timber harvest in non-fish-bearing headwater channels. The study was funded by National Council for Air and Stream Improvement (NACSI) and the WA DNR AMP. The study included an investigation of geomorphology, and macroinvertebrate and amphibian communities in 15 study streams within and near four timber harvest sites in the Coast Ranges of Washington State. This BACI study included one year of pre-harvest (1998) and up to three years of post-harvest data collection (1999, 2000, 2001). In each of the four timber harvest sites, one stream served as a reference (4), and the remaining streams were buffered or partially buffered (4), or clearcut to the channel (7). Surveys of stream flow found that subsurface habitat, where dense alluvial material accumulated on the valley floor and stream flow was below and/or through this alluvial material, comprised 6% of the channel length in these small perennial streams. Note that this finding likely underestimated this occurrence more broadly, as streams with large amounts of subsurface flow were intentionally excluded from the study. The authors speculate about the potential influence of subsurface and/or dry perennial reaches on larval stream-associated amphibians, concluding that since larval movement requires a continuous aquatic environment, movement in their harvested study streams was likely inhibited by post-harvest slash accumulations and changes to channel morphology. The raw data from this effort were unavailable.

#### 1.2.2.b. Amphibian Use of Seeps and Stream Reaches in Non-~~fish~~Ffish-Bearing Stream Basins in Southwest Washington: A Preliminary Analysis

This observational study evaluated 16 randomly selected headwater basins in hard rock lithologies in the Stillman Basin of SW Washington to evaluate stream-associated amphibian distribution and use of seeps and stream reaches. Sampling was conducted from August- early

November 2000 and included collection of data on surface water intermittency. Due to the small sample sizes representing only a single year of data, results should be viewed as preliminary. The overall emphasis of the study was on seeps and there is relatively little evaluation or discussion of surface water expression in the sampled stream reaches. The study highlighted that reaches near PIPs seemed to be important for Columbia Torrent Salamander and had spatially discontinuous surface flow.

## *1.3. Studies East of Cascade Crest*

In eastern Washington, more recent evaluations included observational and modeling efforts to quantify the spatial variability of hydrologic condition relative to basin characteristics in four studies (Table 15). Eastside Type N Riparian Effectiveness Project (ENREP), an on-going CMER effectiveness study, also informs buffering effects on intermittency in eastern Washington. Due to climatic, geophysical, and regulatory differences this geographic region is summarized separately.

Table ~~14~~15. Adaptive Management Program studies conducted east of the Cascade crest that inform prevalence and characteristics of discontinuous perennial reaches in western Washington State. Study type is Before-After Control-Impact (BACI) or observational (OBS).

| Citation | Study Name | Study Duration (Timing) | Sample Size and Unit | Study Type |
|---|---|---|---|---|
| Miller and Peterson 2009 | Eastside Forest Hydrology Study | 1 year (2012) | 146 headwater basins | OBS |
| Stewart 2014* ~~(unpublished)~~ | Eastside Forest Hydrology Study Extension* | 1 year (2014) | 40 Type Np basins | OBS |
| Ehinger 2013** | Eastside Extensive Riparian Status & Trends– Stream Temperature | 2 years (2007 and 2008) | 73 Type Np streams | OBS |
| Link (in progress) | ENREP | Ongoing (2018 to present) | 10 paired streams | BACI |

* Not in CMER W~~w~~ork Plan, name taken from WA DNR Project Plan – no final report was submitted to CMER.
** Only 10% of the Type Np sites included had surface flow during the summer. The TFW Policy committee deprioritized the Eastside Type N strata.

### *1.3.1. Eastside Forest Hydrology Study (FHS)*

The purpose of this study was to characterize hydrologic attributes and their patterns of occurrence across the landscape. Study objectives included:

1. Determine the spatial and temporal characteristics of surface water discharge in Type N streams across eastern Washington FFR (Forests and Fish Report) lands.



**Commented [CM214]:** Yellow - The Plues and Goodman Type Np demarcation study focused on the Eastside and should be included.
**Commented [OBRA(215R214]:** It is included up in the PIP section 1.1 and Table 7.
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2. Investigate process relationships between stream hydrology, landforms, and management activity.
3. Develop criteria for characterizing and mapping streams with similar characteristics across the FFR landscape.

The effort included data collection from one field survey in each basin, sampled during the driest time of year. Study authors used logistic regression to relate a wet channel to geologic, climatic, landcover, and topographic variables.

Of the 146 basins identified for inclusion, 14 were found not to have channels and 12 were determined not to have perennial flow (i.e., Type Ns). Of the remaining 101 basins, 78 were found to have dry reaches during the period of examination while the remaining 23 had continuous flow from the uppermost point of perennial flow (PIP). Seventy-nine percent (79%) of the Np channel network had flowing water while the remaining 21% was dry.

Factors distinguishing whether a channel was wet or dry include planform curvature, slope, topographic position, and geology. Divergent or planar planforms, steeper slopes, and higher relative topographic position (e.g., sites closer to the ridge line) were all associated with a greater proportion of dry channel. The relationship to geology is more complicated and varies with contributing area, but in general more porous lithologies (e.g., volcanic, sedimentary) are more likely to have dry channels than competent lithologies.

### *1.3.2. Eastside Forest Hydrology Study Extension*

The Eastside Forest Hydrology Study Extension built on knowledge gained from the Forest Hydrology Study (FHS) to inform the ENREP study design. Thirty-nine FHS Type Np basins were selected to determine how the length, proportion, and configuration of dry Np reaches vary seasonally. The FHS Extension included data collected during four surveys from late May through early October 2014. Sites were selected based on the known occurrence of dry perennial reaches as determined during the 2012 field survey for the FHS. To investigate change in hydrologic condition occurring between field surveys, presence or absence of stream water was monitored using temperature sensors and time-lapse photography.

Survey of 39 Np basins was conducted to determine the:

- Spatial and temporal variability of flow.
- Spatial and temporal variability of channel continuity.
- Temporal variability of connectivity to fish-bearing waters.

Field surveys indicated that the length of wetted Np channel decreased, and length of dry channel increased, from late spring through early fall. Length of dry Np channel increased from approximately 7% in the first early-season survey to 21% in late summer. The pattern of drying was progressive and there was spatial consistency in dry reaches observed between years, though this observation was not quantified. Detailed maps were produced. Data showed that only 11% of the total Np RMZ was associated with reaches that were dry all summer. ~~In~~ However, the~~se~~ "dry" Np basins ~~(i.e., basins~~ known to have at least 500' of dry channel in late summer 2012~~)~~

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~~that~~ increased to 29% of the Np buffer associated with dry reach by late summer. Despite substantial channel drying over the field season, most of the monitored drying at instrumented sites occurred as a discrete event, rather than a prolonged process of alternating drying and re-wetting. In addition, the locations of many wet channel to dry channel transition points were largely stationary throughout the FHS Extension.

### *1.3.3. Eastside Extensive Riparian Status and Trends – Stream Temperature*

This project was intended to develop estimates of stream temperature in Type Np streams across eastern Washington but was never completed. Sites were selected for the study via a random draw of sampling locations using the DNR Hydrography GIS data. Sixty-six out of 73 of the selected sites were dry, preventing further implementation of the study (W. Ehinger, personal communication). Importantly, this highlights the challenges of using DNR Hydrography GIS data to randomize site selection and predict surface flow for studies in eastern Washington.

### *1.3.4. Eastside Type N Riparian Effectiveness Project (ENREP)*

The ENREP Project is currently in implementation, and its study objectives and pre-harvest site conditions suggest that the study will yield useful information on the occurrence of dry reaches and the effect of dry reaches on stream temperature change after harvest in eastern Washington. Policy expressed interest in "*What is the effect of buffering or not buffering spatially intermittent stream reaches in Type Np streams"* (CMER Work Plan, 2023). The objective is to inform Policy of the quantitative changes in FPHCP covered resources, water quality, and aquatic life coincident with forest harvest activities in eastern Washington, and to determine if and how observed changes are related to activities associated with forest management.

ENREP follows a paired-BACI design with five watershed pairs. The study is designed with at least two-years of pre-treatment monitoring and at least two-years of post-treatment monitoring. The basin-scale treatment that will be applied represents the most common application of riparian protection under Forest Practices rules for Type Np streams in eastern Washington (WAC 222-30-022(2)). Two of the paired sites were selected in part because they have dry Np reaches in most years. The spatial extent of dry and flowing reaches is being determined near the start of the late spring drying period and end of the summer dry periods (McNamara et al., 2005) by direct observations.

Harvest treatment recommendations in 2020 were driven in part by dry stream reaches. The project team secured a variance from the FP Board to deviate from FP rules to clearcut harvest dry reaches of the stream network, including within 500ft of the Type Np/Type F break. The harvest at one study site included an approximately 300ft reach with the first 500ft of the Type Np stream, with many wet-dry sections. Continuous stage/flow measurements are being collected in this section, so detailed hydrologic conditions will be recorded. ENREP is ongoing and will provide some limited insights into discontinuous perennial reaches in eastern Washington.

# 2. BEST AVAILABLE SCIENCE SYNTHESIS

## *2.1. Perennial Initiation Point (PIP) Location and Variation*

PIP locations associated with stable groundwater sources such as seeps and springs can be relatively stationary even with differing amounts of precipitation from year to year (See Table 7;Veldhuisen, 2004; Whiting & Godsey, 2016; Winter, 2007). However, other PIPs have been observed to migrate up and down stream channels across years, highlighting interannual variation in surface water expression (Bretherton, 2020; Winter, 2007). The seasonal migration of PIPs may be in response to precipitation patterns with upstream movement in response to the wetter season and downstream movement in response to the dryer season (Winter, 2007). Other factors that influence PIP migration include changes to and depth of the bedload that may influence surface expression (Edwards et al., 2015; Winter, 2007). These patterns have been associated with lithology as an important control on PIP locations (Jaeger et al., 2007; Montgomery & Dietrich, 1988). Basalt lithologies have bedrock springs that may provide for a more stable PIP, while marine sedimentary lithologies may follow drainage area-slope relationships. In addition, the location of PIPs was influenced by the fractured nature of the local bedrock and were independent of slope and area (Montgomery & Dietrich, 1988).

## *2.2. Frequency of Occurrence*

Approximately 50% of all streams by length in the continental US are headwater streams (defined as 1st order streams in a watershed) and approximately half of these are perennial (Nadeau & Rains, 2007), while the other half are seasonal. These classifications are for a “normal year” (i.e., based on 30-year average for precipitation) and can vary depending on the source of stream flow such as groundwater, subsurface flow through the soil, precipitation over the surface, or overland flow (Brooks et al., 2012).

In several studies of flow permanence in Washington, stream reaches with discontinuous perennial flow were found to be relatively common in eastern and western Washington during summer low flow conditions (Ehinger et al., 2021; Jaeger et al., 2007; McIntyre et al., 2018; Veldhuisen, 2004). Fifty to 75 percent of Type Np Waters in western Washington are estimated to have discontinuous perennial reaches (Palmquist, 2005). We note that inter- and intra-annual variation complicate efforts to identify discontinuous perennial reaches across the landscape.

The extent and distribution of stream flow permanence across the landscape is complicated for several reasons:~~, especially in~~ In mountainous terrain where the groundwater expression can be influenced by fracture pattern from stress in the Earth’s crust (Domenico & Schwartz, 1997; Sophocleous, 2002). Dry reaches may also occur in areas with porous substrates, potentially due to unconsolidated glacial lithology, when the stream is captured by the hyporheic zone (Hunter et al., 2005). ~~For example, subsurfaces~~Subsurface flow can cross watershed boundaries by following flow paths along folded or tilted relatively impermeable bedrock layers (Edwards et al., 2015). Classical understanding of surface flow patterns in headwater systems is that seasonal streams transition into perennial streams in the downstream direction (Edwards et al., 2015). However, this pattern can vary depending on the climate and the hydrogeology of the watershed

**Commented [JD218]:** You need a geologist to help a little with the data collection protocol during the study design writing. I'm not correcting your synthesis, because I know you're correctly stating what these sources said, but there's a driver versus symptom problem, and your study needs to collect data that links/fixes those relationships. Aimee, let's talk about some of these things (offline) someday.

**Commented [MAP(219R218]:** Julie, thanks for your engagement and offer. I would love to take you up on your offer to chat. We did also provide some edits that help better clearly articulate the overall objectives of the research which is to evaluate the potential for stream reaches with discontinuous surface flow to affect resources of interest (namely, stream temp and amphibians), and not an effort to model or predict these reaches across the landscape. That said, our proposed study would be designed such that we could understand the potential influence of site specific characteristics on discontinuous flow. A geologists perspective would be most welcome.

**Commented [CM220]:** Red - again, you fail to recognize that all CMER Type Type Np Demarcation report results showed that the vast majority of PIPs do not "migrate up or down" stream channels (Palmquist 2004, Plues and Goodman 2004, Miller and Peterson 2009). Need to provide all these CMER citations here and state those facts. And, most of those that did migrate, did so during unusually dry years outside " a year of normal rainfall" as defined by The Type Np rule (WAC 222-16-010).

**Commented [co221R220]:** Indeed, they have been observed as relatively stationary as well as been observed to migrate as well. The intent here is to provide an overview of the fundamental principles as described in the broader scientific community. Please see Section 3: CMER Research in the main body of the report where we address CMER you mentioned studies in detail.

**Commented [OBRA(222R220]:** We also added a reference to Table 7 so the reader can take a deeper dive into the CMER studies, if desired.

**Commented [CM223]:** Red - Need to add all of CMER's studies on Type N Demarcation for eastern and western WA. (Palmquist, Plues and Goodman, Miller and Peterson).

**Commented [co224R223]:** Please see Section 3 in the main body devoted to CMER research.

**Commented [JD225]:** This "For example" when it is not an example of the prior sentence, is what started this cascade of edits in the paragraph.

**Commented [co226R225]:** Thank you - we accept all of your edits.

(Winter, 2007; Winter et al., 1999). In addition, the transition between seasonal and perennial streams may include spatially discontinuous segments of surface flow and dry channels, especially in the drier months (Dohman et al., 2021). The source for both perennial and seasonal streams is groundwater but the inputs to seasonal streams may be more reliant on seasonal aquifers that expand during seasons where precipitation is high and /or evapotranspiration is low (Edwards et al., 2015).

An effort initiated in 2023 to map stream flow permanence in Oregon, Washington, and Idaho has been initiated by a joint effort between USDA Forest Service, U.S. Geological Survey, and USDI Bureau of Land Management ([Western Oregon Streamflow Permanence | US Forest Service Research and Development (usda.gov)]). A mobile field application, FLOwPER, was developed to record field observations of surface flow permeance, which is then uploaded to a centralized database. These data will be incorporated in the USGS 3D Hydrography Program and used in the predictive model, Western Oregon Wet Dry model, which is currently being tested in western Oregon and may provide more clarity around the frequency and distribution of discontinuous portions of headwater streams.

### *2.3. Patterns of Surface Flow Discontinuity in Perennial Streams*

The spatial pattern of surface flow discontinuity reflects locations along a perennial stream where subsurface flow capacity at a given time and location is less than the flow necessary for surface expression (Dohman et al., 2021; Winter et al., 1999). A stream reach is considered a gaining reach when the groundwater flows into the streambed or a losing reach when the reach loses water to groundwater (Winter et al., 1999). In general, gaining reaches are more likely to have perennial flow and losing reaches are more likely to have seasonal flow only. Whether a reach is gaining or loosing depends on the relative contribution among lateral, vertical, and longitudinal subsurface flow paths into a given reach at a given time (Dohman et al., 2021). For example, a reach has a high likelihood for surface flow if it is a gaining reach, such as when the longitudinal hydrologic gains and persistent lateral subsurface flow from the hillslopes outweigh the vertical losses as well as transpiration from riparian vegetation (Dohman et al., 2021).

The complex interaction of the various flow paths that contribute to the expression of surface flow can result in a discontinuously perennial flow pattern where surface flow and subsurface flow (e.g., dry portions of the channel) can vary over short longitudinal distances (Dohman et al., 2021). Investigations have revealed high variation in the lengths of discontinuous perennial reaches across Type Np Waters in western and eastern Washington. Some efforts have concluded that the length of discontinuous perennial flow at a site is generally less than 100 m (Palmquist, 2005); others documented examples of much longer discontinuous reaches across multiple study sites (Ehinger et al., 2021; McIntyre et al., 2018; Pleus & Goodman, 2003). Also, expression of discontinuous perennial reaches was related to dry years (Pleus & Goodman, 2003; Veldhuisen, 2004), and the first expression of dry presented itself lower in the stream during drier summers (Veldhuisen, 2004).

**Commented [DM227]:** Yellow
Maybe.
Suggest you contact A Coble regarding her recent study which findings question FLOWPER.

Coble AA, Heaston E, Dunham J, Classifying flow permanence (FLOwPER) of non-fish-bearing streams on privately managed forests in an above-average low flow year. ICRW8, Corvallis, Oregon June 2023.

**Commented [co228R227]:** Thank you. I sent her an email and waiting for a response. I really like Ashley's work. I would suggest that in terms of editing here, no further action is needed because we have recognized this effort and its potential usefulness. I prefer not to cite grey literature such as presentations and company updates.

**Commented [CM229]:** Red - you need to provide the number of streams sampled (N) between studies. Palmquist sampled hundreds of sites precisely because it was a Validation "rule too" study. Hard rock was a BACI effectiveness study so had a fraction of the number of sites. Provide the N for each study you cite when comparing results. Same for Plues and Goodman, Veldhuisen.

**Commented [co230R229]:** Please see table 7

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 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).

Numerous simulation models have explored the surface water-groundwater interactions (see reviews in ~~(~~Barthel & Banzhaf, 2016; Ntona et al., 2022). Recent research has focused on predicting streamflow permanence in headwater streams (see review, Mahoney et al., 2023). For example, a model has recently been developed to predict spatial and temporal patterns of stream connectivity in the Pacific Northwest. Probability of Streamflow Permanence Model (PROSPER) was designed to predict the probability of annual stream flow for free-flowing streams without dams or diversions stream channel in the Pacific Northwest (Jaeger et al., 2019). PROSPER is a GIS raster-based empirical model with a 30-m spatial resolution. A Random Forest classification was applied to an extensive dataset of streamflow permanence observations using 257 climatic and 35 physical predictor variables. The final models (a global model and three subregion models) consisted of 29 predictor variables where the top 3 variables (excluding basin elevation and drainage area) were total annual precipitation, percent forest cover, and mean monthly minimum temperature. An application of the PROSPER model to the Mount Rainier National Park found drainage area, covariates describing geology, topography, and land cover as the top predictors of stream flow permanence(Jaeger et al., 2023). For the global and sub-model applications applied to the Pacific Northwest region, PROSPER had a classification accuracy of ~80%, and a classification accuracy of ~75% for the application to Mount Rainier National Park. This error rate reflects the challenge in predicting stream permanence.

### *2.3.1. Factors that I~~i~~nfluence S~~s~~urface E~~e~~xpression*

Headwater streams exhibit surface flow discontinuity resulting from a complex interaction between groundwater and surface water, which are influenced by climate, landform, geology, and biotic factors in a hydrogeology framework (Sophocleous, 2002; ~~Table 15~~). 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).

Several efforts, including the model PROSPER discussed above, have been conducted to classify streams by flow permanence at the landscape scale for Pacific Northwest streams (Hafen et al., 2022; Liermann et al., 2012; Nadeau et al., 2015). Although these efforts are not specifically designed to predict discontinuous flow section in perennial streams, we assume that these factors also control the discontinuous surface flow. Other studies have explored various aspects of the complex interactions within the hydrogeology framework (Hancock et al., 2009; Sophocleous, 2002) and together, are summarized in ~~Table 15~~Table 16.

Table ~~15~~16: Factors in the hydrogeology framework with example metrics that influence surface flow expression.

| Factor | Example Metrics | Reference |
|---|---|---|
| Climate | Annual and seasonal precipitation (including snow vs. rain)<br><br>Temperature (snow melt) | Kormos et al. 2016; Jaeger et al. 2019; Hafen et al. 2022<br><br>Kormos et al. 2016; Hafen et al. 2022 |
| Landform | Headwater basin area<br><br>Slope, gradient, aspect, and elevation<br><br>Channel metrics such as entrenchment ratio | Fritz et al. 2008; Olson and Burton 2019; Jaeger et al. 2023<br><br>McGuire et al. 2005; Jaeger et al. 2019, 2023<br><br>Fritz et al. 2008 |
| Geology | Soil water holding capacity and catchment storage capacity<br><br>Bedrock composition and permeability | Whiting and Godsey 2016; Hafen et al. 2022; Jaeger et al. 2019, 2022<br><br>Hale 2011; Hale and McDonnell 2016; Hale et al. 2016; Pfister et al. 2016; Jaeger et al. 2019, 2023 |
| Biotic | Percent forest cover<br><br>Evapotranspiration | Jaeger et al. 2019, 2023<br><br>Jaeger et al. 2019, 2023 |

### *2.3.2. 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 perennial reaches. Existing efforts suggest substantial spatial variation exists in temperature in headwater streams, similar to observations from larger non-fish-bearing waters, that cannot be attributed reliably to shading (Dent et al., 2008; Martin et al., 2021).

Potential explanations of spatial variation in these studies beyond the effects of shading include groundwater and hyporheic exchange and stream surface area. For example, Janisch et al. (2012)

reported an average daily maximum temperature increase in clearcut catchments (~2-5 ha headwater basins) of ~ 1.5 °C in the first year post-harvest and observed a maximum change in one basin of 3.6 °C. In contrast, Gomi et al. (2006) reported post-harvest increases in clearcut catchments ranging from 2 to 8 °C. Janisch et al. (2012) cited the amount of exposed surface water above the stream temperature monitoring station as a potential explanation of temperature variation in their results as wetland extent was not similar across their study basins.

Substrate influences 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 (K) that facilitates groundwater exchange (which contributes to cooling) while fine-textured sediments will have lower K and be less able to buffer warmer stream temperatures (Moore et al., 2005). As a result, discontinuous perennial reaches can support patches of cold water or deliver cooler 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).

Finally, a reasonable prediction for basins <100 ha is that stream temperature is associated with the percent of the basin that has been harvested, regardless of whether stream shading is present ~~(~~although the mechanisms responsible for this variation may vary~~;~~ (Martin et al., 2021; McIntyre et al., 2018). For example, increases in ambient air temperature may be sufficient to raise the temperature of small streams even when understory and overstory shading is present. Small streams with high surface area/volume ratios may be especially prone to this influence, given equivalent substrates and other physical controls. As a result, the expectation that riparian buffers are sufficient to maintain stream temperatures within desired ranges may not be reasonable in all settings.

### *2.3.3. Amphibian Use*

Generally, most stream-associated amphibians are low order stream obligates (e.g., first, second, and third order streams) that use the wetted channel width and associated riparian area for important aspects of their life history. Seven stream-associated amphibians (~~Table 16~~Table 17) are designated as "other covered species" in the Forests and Fish Report (USFWS, 1999), and an Overall Performance Goal is to support their long-term viability and persistence.

Associations of these species with wetted channels var~~ies~~y based on desiccation tolerance across life stages. For example, tailed frogs and torrent salamanders use wetted surface or flowing water habitats for egg laying and larval development. Post-metamorphic tailed frogs migrate overland and along stream channels~~ while~~, but torrent salamander post-metamorphs are more reliant on surface moisture throughout all stages of their life history, using upland habitats primarily during periods of high precipitation (e.g., the winter). As a result, all of these species may be less likely to use discontinuous perennial reaches where surface flow is irregular and more prone to drying than perennial reaches downstream. However, we note the common observation of adult tailed frogs in first order perennial and discontinuous reaches during the late summer months, a pattern

**Formatted:** Line spacing: Multiple 1.08 li of seasonal use thought to be associated with increased food availability (Hayes et al., 2006). In contrast, Plethodon *spp.* use of the riparian area may not be dependent on continuous stream flow per se. Also, Plethodon *spp.* will use the riparian area regardless of streamflow depending on whether other factors maintain the hydrology/conditions necessary, such as wetted surface, saturated gravel and soils, and/or the presence of suitable cover ~~objects~~ within the bankfull width of a stream.

Generally, potential benefits of discontinuous perennial hydrology for these species are anecdotal. For example, although some studies report high abundance of torrent salamanders near the upper extent of perennial surface flow (Hayes et al., 2002; Hunter, 1998; Wilkins & Peterson, 2000), available data are insufficient to support an explanation for these observations. Discontinuous reaches may support fewer predators of amphibian larval stages (Welsh Jr et al., 2005). Stable, low volume flows of cool groundwater into unconsolidated gravels may provide oviposition sites for torrent salamanders (Thompson et al., 2018) similar to those that may persist at PIPs in stream networks with discontinuous perennial reaches. (Hayes et al., 2002; Hunter, 1998; Wilkins & Peterson, 2000)

Finally, vertical movement of amphibians into the hyporheic zone is poorly understood, but some observations suggest that as surface flow recedes, amphibians can occupy the wet interstitial spaces maintained by subsurface flow. For example, Feral et al. (2005) incidentally captured Pacific Giant Salamander (*Dicamptodon tenebrosus*) larvae in the hyporheic zone of two seasonally discontinuous perennial reaches while sampling for macroinvertebrates in Humboldt County, California. Out of 22 observations, 15 were captured in PVC traps placed 0 to 30 cm below the streambed and seven were captured in traps buried 30 to 60 cm below the stream bed. Captures occurred throughout the year and did not appear to vary with season, although most captures occurred when surface flow was absent. How torrent salamanders use hyporheic habitats seasonally is not well-documented.

Table ~~16~~17. Stream-associated amphibians designated under the Washington State Forest Practices Habitat Conservation Plan (FPHCP), reliance of the species on permanent surface streamflow for some portion of their life history (Surface Flow Reliant), and known or anticipated use of discontinuous perennial reaches (Discontinuous Np Use).

| **Taxa** | **Species** | **Surface Flow Reliant** | **Discontinuous Np Use** |
|---|---|---|---|
| Torrent Salamanders (*Rhyacotriton* spp.) | Cascade (*R. cascadae*)<br>Columbia (*R. kezeri*)<br>Olympic (*R. olympicus*) | Yes | Yes |
| Tailed Frogs (*Ascaphus* spp.) | Coastal (*A. truei*)<br>Rocky Mountain (*A. montanus*) | Yes | Less frequent |
| Lungless Salamanders (*Plethodon* spp.) | Dunn's (*P. dunni*)<br>Van Dyke's (*P. vandykei*) | No | Yes |

## 2.4. POTENTIAL FOREST MANAGEMENT IMPACTS

Forest management, including harvesting, silviculture, and infrastructure (roads, bridges, and culverts) can modify the hydrology and ecology of discontinuous stream reaches. Potential modifications include altered base flows; increased rates and severity of debris flows and upslope failures; accumulation of slash during and after harvesting in discontinuous perennial reaches; and increased rates of sedimentation during harvest, from poorly routed or orphaned roads, or from bank erosion if green tree buffers fail (Jackson et al., 2007; Moore & Wondzell, 2005; Turner et al., 2010). We note that existing engineering controls, including culvert and bridge upgrades, increased regulation of road construction standards and management (e.g., ~~T~~he Road Maintenance and Abandonment Plans (RMAP) process; https://www.dnr.wa.gov/publications/fp_form_rmap_infoinstructions.pdf~~https://www.dnr.wa.gov/publications/fp_form_rmap_infoinstructions.pdf~~), and slope stability buffers, have been implemented in the current forest practices rules in response to these issues.

In contrast, modification to basin hydrology due to variation in forest cover is a more difficult challenge to resolve (Jaeger et al., 2019; Perry & Jones, 2017). For example, a reduction in overall tree cover can increase water yield due to reduced evapotranspiration rates (Bosch & Hewlett, 1982; Hibbert, 1965; Keppeler & Ziemer, 1990). However, reduction in forest cover may increase insolation rates (Moore et al., 2005). How these factors may interact to influence temperature changes is difficult to determine because of site-specific conditions (e.g., upstream cool inflow) and the duration of the summer drought period (Moore et al., 2023; Naman et al., 2024)~~7}(Moore et al 2023; Naman et al 2023)~~. ~~Also, we note that some studies determined that sl~~Slash (Kibler et al., 2013) and/or understory vegetation (Gravelle & Link, 2007) provided sufficient shading to maintain stream temperatures post-harvest~~t~~ ~~but the generality of this conclusion has not been evaluated~~ (Jackson et al., 2001; Janisch et al., 2012) Importantly, increased baseflows during summer may reduce insolation effects due to increased water volume subsurface versus increased exposure to insolation (Harr & McCorison, 1979). Additional research suggests that increases in flow may be of short duration in some basins;~~,~~ however, ~~as~~ high evapotranspiration rates of densely stocked and fast-growing plantations may decrease summer low flows (Perry & Jones, 2017). Finally, relatively little information is available to describe how longitudinal expression of flow in discontinuous Np reaches may be modified by forest management activities (Coble et al., 2020). ~~As a result, a mismatch may occur between the placement of riparian buffers pre- and post-harvest.~~

## 2.5. IMPLICATIONS OF CLIMATE CHANGE

Realized and potential future climatic variation has consequences for the physical structure, hydrology, and ecology of small, discontinuous perennial forest streams (Creed et al., 2014). Higher peak flows in winter could result in physical modification of stream channels including wood inputs and sorting of fine and coarse substrates. In turn, pool formation and retention could differ from historic patterns and lead to alterations to water storage and hyporheic exchange. In contrast, decreased summer precipitation rates are likely to exacerbate summer low flows that characterize many headwater basins and may result in historically perennial streams becoming seasonally dry or spatially intermittent (Coble et al., 2020; Hunter et al., 2005) However, broad

**Commented [CM231]:** This section supports waiting for the newly proposed Westside Type Np Forest Practices rules to be adopted by the Board before scoping a study on discontinuous flow - the proposed buffers will be substantially wider and longer than the current rule.

**Commented [co232R231]:** This section is intended to be an overview of forest management impact and not specific to the rules.

**Commented [DM233]:** Yellow
See
Moore, R. D., S. M. Guenther, T. Gomi, and J. A. Leach. 2023. Headwater stream temperature response to forest harvesting: Do lower flows cause greater warming? Hydrological Processes 37:e15025.

**Commented [co234R233]:** I added some text to capture Morre et al.'s findings; I also added the synthesis paper on this by Naman et al 2023

**Commented [DM235]:** Yellow
Also see
Kibler, K. M., A. Skaugset, L. M. Ganio, and M. M. Huso. 2013. Effect of contemporary forest harvesting practices on headwater stream temperatures: Initial response of the Hinkle Creek catchment, Pacific Northwest, USA. Forest Ecology and Management 310:680-691.

**Commented [co236R235]:** They specifically address the influence of slash so the citation was inserted to provide support within the sentence

**Commented [DM237]:** Yellow
Maybe, but lots of evidence to support slash and understory (in particular) temp influence. Also, physics, indicates that anything that obstructs direct beam radiation will reduce insolation

**Commented [co238R237]:** I agree with you - seems that adding additional narrative on that point might be getting too detailed for our purposes here

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spatial changes are likely to vary in snow vs. ~~rainr~~Rain-~~-~~dominated systems, with the former likely to be more susceptible to summer droughts (Abatzoglou et al., 2014; Stewart et al., 2004).

Importantly, general predictions of more variable precipitation rates annually, with events of higher intensity and lower frequency becoming more common, suggest that stream networks may “migrate” downstream in response (Olson & Burton, 2019). That is, PIP locations may occur further down in basins, discontinuous perennial reaches become dry, Np reaches become discontinuous, and so forth. General models to predict streamflow may be formulated based on lithology, aspect, and geography. However, the consequences of these changes for stream biota are more challenging to evaluate. Discontinuous perennial and perennial streams play complimentary and unique functions in lotic ecosystems (Richardson & Danehy, 2007) but the relative capacity of these functions to migrate downstream with flowing water has not been evaluated.

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