NO. 48360-2-II

COURT OF APPEALS, DIVISION II
OF THE STATE OF WASHINGTON

WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES,

Appellant/Cross-Respondent,

v.

ESSES DAMAN FAMILY, LLC,

Respondent/Cross-Appellant,

and

QUINAULT INDIAN NATION and POLLUTION CONTROL HEARINGS BOARD,

Respondents.

DEPARTMENT OF NATURAL RESOURCES' RESPONSE BRIEF TO ESSES DAMAN FAMILY, LLC

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I. INTRODUCTION

Where will the Quinault River be flowing in the vicinity of two parcels in the year 2153? The question affects where timber may be lawfully cut, because the answer determines where the riparian management zone starts on a migrating river like the Quinault. The underlying adjudicative proceeding considered this scientific issue involving the Quinault River's channel migration zone in the context of appealed permits to cut timber under the state Forest Practices Act.

The Pollution Control Hearings Board (PCHB) conducted a site visit, considered the expert testimony of five geologists, a forester, a hydraulic engineer, a roads engineer, and a lands surveyor, and received over 70 exhibits before it found that the Department of Natural Resources (DNR) offered the most persuasive channel migration zone evidence. Using that testimony, the PCHB located the edge of the channel migration zone along a major county road that sits between the Quinault River and the two parcels. This location also fell between the channel migration zone widths urged by landowner, Esses Daman Family, LLC, and the Quinault Indian Nation.

Both Esses Daman Family, LLC (Daman Family), and the Quinault Indian Nation (QIN) pursued judicial review of the PCHB's final order. Daman Family sought a narrower channel migration zone, while

QIN sought a wider one. Daman Family's argument on appeal, which it failed to raise before the PCHB, contends that the PCHB was legally required to use the witnesses' testimonies that produced the smallest width channel migration zone that followed the analytical steps in a guidance document called the Forest Practices Board Manual. But the PCHB expressly determined that Daman Family's witnesses applied those steps in a manner that lacked credibility for the site. QIN, on the other hand, seeks to force a particular reading of the Board Manual's language concerning "disconnected migration areas" to avoid the PCHB's decision limiting the channel migration zone by establishing it along a vital, well-maintained county road. But QIN ignores that the PCHB expressly found the DNR's witnesses' testimonies on that point to be the most credible.

Thus, both Daman Family and QIN want to disregard the PCHB's evaluation of testimony admitted without objection, and to turn factual questions into legal ones. Predicting how a river will behave 140 years into the future involves complex scientific issues. However, resolution of this case only requires this Court to apply basic administrative law concepts to the extensive record before the PCHB. Because the PCHB's decision adhered to all laws and rules and relied upon testimony that was the PCHB's job to weigh, it fell within the bounds of administrative discretion and should be affirmed.

II. COUNTER-STATEMENT OF ISSUES

(1) Does RAP 10.3(h) require a judicial review appellant to assign error and provide argument concerning RCW 34.05.554(1) when the superior court dismissed its case because appellant failed to raise its sole legal issue before the underlying agency.

(2) Does RCW 34.05.554(1) bar judicial review of claims not asserted to the agency in the underlying adjudicative proceeding.

(3) Does any provision of law restrict the PCHB's ability to weigh competing evidence on a disputed factual issue when no party objected to the evidence in question.

III. COUNTER-STATEMENT OF THE CASE

As both the Daman Family and QIN seek review of the PCHB's final decision, and there are some parallels between their arguments, this section addresses the facts pertinent to both appeals and will not be repeated in DNR's brief regarding QIN's appeal.

A. The Regulatory Context.

Washington regulates the harvest of timber under the Forest Practices Act, RCW 76.09, which divides power between three administrative entities. The Forest Practices Board serves a quasi-legislative role and adopts rules that implement the Forest Practices Act.[1] The Forest Practices Board also publishes a technical guidance manual (Board Manual) to facilitate implementation of the rules.[2] DNR implements the rules and manual guidance, which generally requires approved forest practices applications (permits) for all harvests of timber near water.[3] Appeals from DNR's decisions implementing the Forest Practices Act go to a separate, quasi-judicial agency — the PCHB.[4]

This case involves a technical concept under the Forest Practices rules, pertaining to the place on the ground where a landowner must start providing a "riparian management zone." Like it sounds, a "riparian management zone" protects the edge of a stream with a horizontal buffer.[5] For rivers that migrate in their channels, the riparian management zone starts at the outer edge of the channel migration zone (CMZ).[6] This ensures that migrating rivers receive the benefit of the riparian functions from adjacent forest lands for a set period of time in the future.[7]

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[1] RCW 76.09.040(1)(a).

[2] RCW 76.09.040(3)(c); WAC 222-12-090 ("When approved by the board the manual serves as an advisory technical supplement to these forest practices rules.").

[3] RCW 76.09.050(2); WAC 222-20-010(1).

[4] RCW 76.09.205.

[5] WAC 222-16-010 ("Riparian management zone"). Some forest management can occur in riparian management zones, particularly the parts furthest away from streams. *See generally* WAC 222-21-021(1).

[6] WAC 222-16-010 ("Riparian management zone"); WAC 222-30-021.

[7] "The goal of riparian rules is to protect aquatic resources and related habitat to achieve restoration of riparian function . . . ." WAC 222-30-010(2).

No Forest Practices Act statutes address CMZ delineation, and only three rules regulate CMZs. First, as already discussed, riparian management zones on migrating rivers start at the outer edge of a CMZ.[8] Second, the rules generally prohibit timber harvest within CMZs.[9] Third, the rules provide a very general and broad definition of a CMZ:

> 'Channel migration zone (CMZ)' means the area where the active channel of a stream is prone to move and this results in a potential near-term loss of riparian function and associated habitat adjacent to the stream, except as modified by a permanent levee or dike. For this purpose, near-term means the time scale required to grow a mature forest. (See board manual section 2 for descriptions and illustrations of CMZs and delineation guidelines.).[10]

Board Manual Section 2 provides extensive technical guidance and methodologies for locating the CMZ edge.[11] The process requires an estimation of where a river may migrate to in "the near-term," which is 140 years.[12] The Board Manual establishes the steps to follow in delineating a CMZ. A series of PCHB findings describes the general methodology of

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[8] WAC 222-16-010 ("Riparian management zone") and WAC 222-30-021.

[9] WAC 222-30-020(13). The rule contains some exceptions not material here.

[10] WAC 222-16-010 ("channel migration zone"). The forest practices rules regularly cross-reference to applicable manual sections, but no Board Manual section has been adopted as a rule. CP 485 (PCHB Final Order, Finding No. 14). Numerous cross-references between the Forest Practices Board's rules and technical manual exist. *See, e.g.*, WAC 222-12-0401(1) (cross-referencing Board Manual Section 21); WAC 222-24-015 (Board Manual Sections 8 and 9); WAC 222-30-021 (Board Manual Sections 1, 5, 7, and 26); and WAC 222-30-050(1) (Board Manual Sections 4 and 5).

[11] *See* CP 570-638 (Board Manual Section 2). For ease of reference, the Board Manual also appears in the Appendix.

[12] CP 485 (PCHB Final Order, Finding No. 13).

delineating a CMZ, including its various component parts – the Historical Migration Zone, Avulsion Hazard Zones, the Erosion Hazard Area, and Disconnected Migration Areas.[13] Daman Family's appeal involves the Erosion Hazard Area, while QIN's appeal involves Disconnected Migration Areas.

The purpose of Board Manual Section 2 "is to help identify the point along the stream where measurement of the riparian management zone (RMZ) begins."[14] Still, "CMZ delineation is a relatively recent concept, and no one method of analysis has been adopted or prescribed. Various geomorphic, engineering, and modeling methods can be applied to channel migration delineation."[15] All rivers are variable, and each river's characteristics vary throughout its length. As the PCHB observed, "[d]espite the level of detail in the [Board] Manual, there is still no cookie cutter approach to a CMZ delineation."[16]

B. Permitting Background.

Sherman Esses and Esses Daman Family, LLC, jointly submitted forest practices permits for their adjacent 40-acre parcels, located six miles

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[13] CP 486-88 (PCHB Final Order, Finding Nos. 16-19).

[14] CP 570 (first substantive line).

[15] CP 610.

[16] CP 485-86 (PCHB Final Order, Finding No. 14).

northeast of Lake Quinault.[17] The parcels are bounded on their north side by a county road, called the South Shore Road. The Quinault River flows 600-1,000 feet from the parcels, north of the South Shore Road.[18] The parcels sit on a terrace a few feet above the level of the Quinault River channel.[19] The river has not flowed across the terrace for a few thousand years.[20] The site contains old growth stumps from a timber harvest around 1930, and "pit and mound" topography.[21] The presence of those features indicates that the site has not been regularly flooded since the old-growth trees harvested around 1930 began their growth cycle.[22]

DNR approved forest practices applications for Mr. Esses and Daman Family. Based on the evidence above, DNR did not initially believe that the Quinault River would impact the site, even though a comprehensive CMZ analysis had not been prepared during the 30-day application review period.[23]

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[17] CP 480 (PCHB Final Order, Finding No. 1). The families are related; Sherman is Joyce Daman's uncle. *Id.* and CP 1865. Sherman Esses stopped participating in the case due to the stress he felt from it. CP 1854.

[18] CP 480 (PCHB Final Order, Finding No. 1). A color map of the parcels is attached. *See* Appendix. The same map in black and white is CP 955 (PCHB at 765).

[19] CP 481-82 (PCHB Final Order, Finding No. 4).

[20] *Id.*

[21] CP 480-81 (PCHB Final Order, Findings Nos. 1 and 2).

[22] CP 480 (PCHB Final Order, Finding No. 1).

[23] CP 504 (PCHB Final Order, Conclusion No. 3).

C. The QIN Appeal, Temporary Stay Process, and Establishment of the CMZ Issue to Be Litigated.

QIN quickly appealed the approvals, asserting that the Quinault River would affect the parcels. QIN sought a temporary suspension of the permits based upon evidence of channel movement that DNR lacked during the permit review process.[24] DNR does not typically submit evidence or take positions on these motions, and it did not in this case.[25] The PCHB issued the temporary suspension order pending an evidentiary hearing. Based on the new evidence of channel movement towards the parcels, DNR was prepared to issue administrative Stop Work Orders based upon a CMZ that ended at the South Shore Road.[26]

The PCHB issued a prehearing order that established the issues to be litigated in the case after the stay process.[27] The parties agreed on one broadly worded CMZ issue: "Whether the Forest Practices channel migration zone of the Quinault River impacts the forest practices proposed in Application Nos. 2612019 or 2612020, and if so, whether the Act and

[24] CP 197 (PCHB Order on Motion for Temporary Suspension).

[25] CP 205 (PCHB Order on Motion for Temporary Suspension).

[26] CP 504, n.20 (PCHB Final Order, Conclusion No. 3); CP 851-52 (Draft Stop Work Orders). DNR may use Stop Work Orders under RCW 76.09.080 to protect public resources if it later determines it wrongly approved an application.

[27] The PCHB decided one other issue, but Daman Family's and QIN's judicial review appeals only raise CMZ-related issues.

Rules require further conditioning on the applications?"[28] Daman Family never tried to establish any other CMZ-related issue.

D. PCHB Hearing and Decision.

Each party had expert witnesses present testimony about the CMZ and its four component parts, setting up a "battle of the experts." No party made any motions or other legal arguments that any source of law dictated any particular result from the PCHB's hearing.

All parties argued and presented testimony contending that they followed the Board Manual's methodology for predicting future river movement. Each party's CMZ evidence thus focused on the component parts of a CMZ outlined in the Board Manual: the Historical Migration Zone, Avulsion Hazard Zones, the Erosion Hazard Area, and Disconnected Migration Areas.[29] The most divergent testimony focused on avulsions, the erosion calculations, and whether the South Shore Road disconnected (or blocked) where the Quinault River was predicted to go.[30]

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[28] CP 216 (PCHB Prehearing Order). Non-CMZ issues were raised, but the judicial review appellants solely challenge the PCHB's resolution of the CMZ issue.

[29] CP 486-88 (PCHB Final Order, Findings 16-19).

[30] This section provides a very general overview of the evidence submitted to the PCHB. The shortened administrative record for the CMZ issue includes over 1,000 pages of testimonial transcripts spanning eight volumes. CP 1434-2512. The shortened administrative record also includes over 900 pages of PCHB exhibits for the CMZ issue. CP 518-1433.

1. Avulsion Hazard Testimony.

QIN's primary CMZ witness, Mary Ann Reinhart, was the only expert to testify that avulsions would significantly affect the site.[31] Both Daman Family and DNR attacked the credibility of QIN's analysis, since her analysis deviated in many significant ways from the Board Manual. The PCHB ultimately agreed with DNR and Daman Family in its Finding of Fact 24 that Ms. Reinhart's deviations from the Board Manual affected the credibility of her CMZ testimony.[32] Neither QIN nor Daman Family challenged that credibility determination.

Daman Family's appeal focuses exclusively on the language immediately following the PCHB's analysis of QIN's experts' deviations from the Board Manual. Finding of Fact 25 contains four sentences which state:

> Of the remaining three CMZ delineations, one prepared by DNR's geologist, and two prepared by consultants for the Damon [sic] Family, the Board finds that all three ***followed*** the Manual within the bounds of discretion allotted to the practitioner in the manual. None of the other experts found any avulsion hazard area as a significant component of the CMZ that would affect the CMZ for the Esses parcels. This is consistent with the fact that the area north of and including the Esses parcels is on an upper terrace, and not on the floodplain of the river. The dominant river process

[31] CP 490-91 (PCHB Final Order, Finding No. 25).

[32] CP 489-90 (PCHB Final Order, Finding No. 24) ("The Board finds, however, that Ms. Reinhart's analysis does deviate in significant ways from the Manual, and that these deviations affect her CMZ delineation for the Esses parcels.").

> that could have the potential to affect these parcels is erosion, not avulsion.[33]

Daman Family's argument relies exclusively on the first sentence of Finding 25 and the PCHB's use of the word "followed" to describe the Daman Family witnesses' use of the Board Manual.

2. Erosion Hazard Testimony.

As noted above, river erosion was considered the dominant CMZ process potentially affecting the Esses parcels.[34] The forest practices methodology for estimating future river erosion looks back as far as reliably possible and calculates an average rate of river movement per year over that period.[35] The expert witnesses predicted vastly different rates of river erosion near the parcels.[36]

After discounting Ms. Reinhart's opinion as not credible in Findings 24 and 25, the PCHB's Final Order found the analysis of DNR's Leslie Lingley to be the most persuasive in its erosion analysis. The PCHB determined that two specific factors made her analysis more credible than Daman Family's. First, Ms. Lingley based her analysis on a

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[33] CP 490-91 (PCHB Final Order, Finding No. 25) (emphasis added).

[34] CP 490-91 (PCHB Final Order, Finding No. 25).

[35] CP 487-88 and 491-92 (PCHB Final Order, Finding Nos. 17, 19, and 26).

[36] Ms. Reinhart predicted that the river would migrate approximately 2,300 feet to the valley wall over the next 140 years (a rate over 16 feet per year). CP 489-90 (PCHB Final Order, Finding No. 24). Daman Family's experts contended the river would migrate at a rate of 3.1 feet per year, or 434 feet in 140 years. CP 492 (PCHB Final Order, Finding No. 27). DNR contended that the river would migrate at a rate of 10.9 feet per year, or 1,529 feet in 140 years. *Id.*; CP 953.

longer time frame (starting in 1906) than Daman Family's experts (who started their analysis in 1939).[37] Second, Ms. Lingley analyzed a more appropriate segment length of the river.[38] While Daman Family witnesses focused exclusively on one of the two parcels at issue in the appeal,[39] Ms. Lingley's analysis looked at both parcels and, in doing so, she included a portion of the river called a "meander bend" that was closer to Sherman Esses' parcel.[40] Meander bends tend to erode on the outside of the bend, where the water flows faster.[41] Daman Family's witnesses ignored the meander bend in their analysis, which resulted in a smaller average erosion rate.[42] These were the reasons the PCHB gave for following DNR's evidence while discounting Daman Family's.[43]

Daman Family never objected to the admissibility of Ms. Lingley's testimony before the PCHB.

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[37] CP 491 (PCHB Final Order, Finding No. 26).

[38] CP 492 (PCHB Final Order, Finding No. 27).

[39] CP 489 (PCHB Final Order, Finding No. 22).

[40] CP 492 (PCHB Final Order, Finding No. 27).

[41] CP 607 ("A river creates these characteristics through the process of progressive bank cutting on the outside of a meander bend and subsequent deposition on the inside of the bend.").

[42] CP 492 (PCHB Final Order, Finding No. 27).

[43] CP 492 (PCHB Final Order, Finding No. 27) and CP 506 (PCHB Final Order, Conclusion No. 7).

3. Disconnected Migration Areas Testimony.

Once the PCHB determined that the Quinault River was eroding at a rate that could reach the Esses and Daman Family parcels, it needed to resolve whether the South Shore Road would serve as a "permanent dike or levee" deemed to block channel migration.[44] The Board received extensive testimony on this issue, with QIN's witnesses opposing designation of the South Shore Road as a permanent dike or levee, and other witnesses supporting its use in that capacity.

The South Shore Road is owned and maintained by Jefferson County and is part of a popular "loop" that includes the North Shore Road around Lake Quinault and few miles upstream of Lake Quinault.[45] The road also provides access to private and federal lands, including Olympic National Park.[46] All of the parties agreed that while the road is well maintained, the portions of the road near the parcels are not currently armored to withstand the river, which is still hundreds of

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[44] WAC 222-16-010 defines "channel migration zone" to exclude areas "modified by a permanent levee or dike." The South Shore Road sits between the Quinault River and the properties at issue.

[45] CP 494 (PCHB Final Order, Finding No. 31). The road also serves several privately owned parcels.

[46] *Id.* The Colonel Bob Wilderness lies to the south of the two parcels at issue and can also be accessed from the South Shore Road. CP 480 (PCHB Final Order, Finding No. 1).

feet north of the road's location.[47] The parties presented differing testimony about how to consider the fact that the County has armored other sections of the same road as the river approached it. The PCHB agreed with DNR and Daman Family that such armoring was likely to occur.[48]

The role the South Shore Road plays with regard to river movement was studied by QIN when it developed a Salmon Habitat Restoration Plan to address conditions affecting Quinault River salmonids.[49] Road location issues were considered in the Restoration Plan because the North and South Shore Roads have affected salmon habitat. The PCHB quoted a portion of this document in its findings:

> "The North Shore and South Shore roads parallel each side of the Upper Quinault River. *The location of these roads has isolated the river from portions of its floodplain and channel migration zone, resulting in a reduction of total available habitat area throughout the valley. The two roads essentially define the available channel migration zone.*"[50]

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[47] CP 494 (PCHB Final Order, Finding No. 31); CP 510 (PCHB Final Order, Conclusion No. 12).

[48] *Id.*

[49] CP 502 (PCHB Final Order, Finding No. 45).

[50] CP 494 (PCHB Final Order, Finding No. 30) (quoting Quinault Indian Nation 2008 Salmon Habitat Restoration Plan, CP 711) (emphasis added).

This significant passage was consistent with other evidence offered by DNR and the Daman Family, and evidence about how the Board Manual suggests addressing regularly maintained public rights of way.

Among the evidentiary considerations concerning the South Shore Road was the Board Manual's language and the testimony about it.[51] The text of this Board Manual provision follows:

> The disconnected migration area (DMA) is the portion of the CMZ behind a permanently maintained dike or levee. . . . As used here, a permanent dike or levee is a channel limiting structure that is either:
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> 1. A continuous structure from valley wall or other geomorphic structure that acts as a historic or ultimate limit to lateral channel movements to valley wall or other such geomorphic structure and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedence [sic] flow); or
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> 2. A structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity (Figure 19).
>
> A dike or levee is not considered a "permanent dike or levee" if the channel limiting structure is perforated by pipes, culverts, or other drainage structures that allow for the passage of any life stage of anadromous fish and the area behind the dike or levee is below the 100-year flood level.
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> The Washington Department of Fish and Wildlife (WDFW) and the Indian tribes can often provide assistance

[51] The Board Manual was Exhibit A-29 before the PCHB. CP 187 (PCHB Index to Certified Record).

> in evaluating the potential for seasonal fish passage and use of the floodplain, as well as details on dike permitting.[52]

The parties' argument and evidence focused on the public rights of way language in "point 2" and whether that sentence was connected to the sentence which followed it. QIN treated the sentence after "point 2" as an "exception" to "point 2," whereas DNR and other witnesses disagreed with that approach.

DNR's Marc Engel testified about the Board Manual's language and its application at this site. He served as the lead and facilitator for the group that re-wrote Board Manual Section 2's CMZ guidance in 2003-2004.[53] Mr. Engel testified that in order to qualify under the Board Manual's guidance as a "permanent dike or levee" that disconnects a migration area, there are two alternative criteria – those set forth in "point 1" or "point 2" on page M2-30 of the Board Manual.[54] He testified that the sentence after the public right of way language in point 2 was not an exception, as QIN contended. This, he noted, was amplified by the "dike or levee (constructed)" definition in the Board Manual's glossary, which does not

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[52] CP 507 (PCHB Final Order, Conclusion No. 9); CP 599. This is page M2-30 in the Board Manual, which also appears in the Appendix.

[53] CP 493 (PCHB Final Order, Finding No. 29); CP 2352-53 (Tr. Vol. VII, at 161:9–162:6).

[54] CP 2378-79 (Tr. Vol. VII, at 187:15–188:10).

contain any language following the right of way language found in point 2.[55] Daman Family expert Steve Toth agreed with Mr. Engel's testimony regarding the glossary.[56]

Mr. Engel testified that the ***two*** sentences following the public right of way language in point 2 were added near the end of Board Manual drafting. Further, the two sentences were added to the Board Manual ***as a unit*** and related to each other.[57] The sentences addressed tribal concerns that the streams and wetlands behind dikes or levees would continue to be treated as fish-bearing where appropriate. Mr. Engel testified that, contrary to QIN's argument, these sentences did not modify the criteria in points 1 and 2 as to what constitutes a "permanent dike or levee."[58]

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[55] CP 493-94 (PCHB Final Order, Finding No. 29); CP 508-09 (PCHB Conclusion No. 10); and CP 2382-83 (Tr. Vol. VII, at 191:21-192:6). The Board Manual glossary defined "dike or levee (constructed)" with the following language:

> A continuous structure from valley wall to valley wall or other geomorphic feature that acts as an historic or ultimate limit to lateral channel movements and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedence [sic] flow); or a structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity.

CP 630 (Board Manual, page M2-61). This language is identical to that found in points 1 and 2 in the Board Manual, in the Disconnected Migration Areas section, defining "permanent dike or levee."

[56] CP 2174-75 (Tr. Vol. VI, at 134:14-135:2).

[57] CP 2381-82 (Tr. Vol. VII, at 190:9-191:12); CP 2441-43 (Tr. Vol. VIII, at 51:25-53:8); and CP 2460-61 (Tr. VIII, at 70:25-71:24).

[58] CP 2462-63 (Tr. Vol. VIII, at 72:21-73:4) (sentence after point 2 is a "separate thought from either 1 or 2").

The PCHB found that this was "a reasonable explanation . . . as to how this Manual section came to contain the language at issue."[59] QIN argued for a different interpretation of that language but it never objected to the admissibility of Mr. Engel's testimony, however.

The foregoing evidence was consistent with the DNR's proposed CMZ delineation for the permits. Ms. Lingley offered her opinion that the CMZ should be delineated at the South Shore Road.[60] Daman Family's expert, Steve Toth, delineated a CMZ that fell short of the road, but he agreed that if his rate of erosion applied to the Sherman Esses parcel, he would have put the CMZ edge at the road because it would act as a permanent dike or levee.[61] He believed that the South Shore Road as a CMZ delineation line would be an appropriate "worst case analysis" for this site.[62]

The PCHB found Ms. Lingley's (DNR's) CMZ delineation to be the most credible.[63] As a result, the PCHB set the CMZ edge for the Quinault River at the north side of the South Shore Road.[64] The PCHB

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[59] CP 509 (PCHB Final Order, Conclusion No. 11).

[60] CP 493 (PCHB Final Order, Finding No. 28).

[61] CP 2164-65 (Tr. Vol. VI, at 124:20-125:3) and CP 2173-76 (Tr. Vol. VI, at 133:20-136:20).

[62] CP 2176 (Tr. Vol. VI, at 136:12-20).

[63] CP 506.

[64] CP 510-11 (PCHB Final Order, Conclusion No. 13).

remanded the permits to DNR so that a riparian management zone could be applied from the edge of the CMZ.[65]

E. Superior Court Proceedings.

Daman Family sought judicial review of the PCHB's decision in Jefferson County,[66] while QIN sought judicial review in Thurston County.[67] QIN pursued direct review in this Court, but the PCHB refused to certify the case because it was fact-bound and nonprecedential.[68] The PCHB also refused certification in Daman Family's case because Daman Family did not raise its appealed issue before the PCHB.[69] The appeals were then consolidated in the Jefferson County Superior Court.[70]

The superior court first considered Daman Family's appeal and dismissed it, finding that its appeal was barred under RCW 34.05.554(1) as a "new issue" not raised before the PCHB.[71] The superior court then considered QIN's appeal and reversed the PCHB. The superior court applied a de novo review standard to the PCHB's decision to use the South Shore Road for the CMZ edge and ignored the evidentiary record.

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[65] CP 516-517 (PCHB Final Order).

[66] CP 173-177.

[67] CP 1-50.

[68] CP 75-82; CP 164-72; CP 169.

[69] CP 169.

[70] CP 178-81.

[71] CP 2630-32.

The superior court determined that the PCHB misread the Board Manual, which it found was subject to only one possible construction. The superior court ruled that the South Shore Road could not serve as a permanent dike or levee under its and QIN's reading of the Board Manual.

DNR appealed the superior court's ruling on QIN's claim, and Daman Family appealed the rulings on both its claim and QIN's claim.

IV. ARGUMENT SUMMARY

Daman Family's procedural errors prevent this Court from considering the merits of its sole legal issue. The superior court's decision dismissed Daman Family's appeal on a procedural ground not addressed by the PCHB. Daman Family's opening brief needed to address that issue with legal argument, but it did not. Additionally, Daman Family failed to raise its claim that the PCHB could only approve of the "most minimal CMZ" that followed the Board Manual's steps at the administrative level. RCW 34.05.554(1) bars judicial review in this situation.

Even if this Court reaches the merits, Daman Family's claim fails. The PCHB was asked to resolve a "battle of the experts" that disputed how far the CMZ for the Quinault River extended. The PCHB expressly resolved that credibility issue against Daman Family. Daman Family's permit fell short of the minimum forest practices requirements because it lacked a riparian management zone on the Quinault River. No case or statute supports Daman Family's contention that the PCHB overstepped its authority by weighing the disputed CMZ evidence to determine the starting point for the Quinault River's riparian management zone.

V. ARGUMENT

A. Standards of Review.

The underlying PCHB decision is presumptively correct in all judicial review actions. The burden of demonstrating the invalidity of the agency action falls on Daman Family as the judicial review appellant.[72]

Daman Family challenges no findings of fact. Unchallenged findings of fact are verities on appeal.[73] Here, this includes the findings that Daman Family's CMZ delineation was less credible than DNR's.

Daman Family asserts that the PCHB made a legal error, citing RCW 34.05.570(3)(d).[74] Questions of law are reviewed de novo,[75] but this standard implies that there is something to review. The PCHB made no rulings on Daman Family's claim of legal error, so Daman Family's brief identifies no challenged conclusions of law. The de novo standard

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[72] RCW 34.05.570(1); *Bowers v. Pollution Control Hearings Bd.*, 103 Wn. App. 587, 595, 13 P.3d 1076 (2000), *review denied*, 144 Wn.2d 1005 (2001).

[73] *Campbell v. Emp't Sec. Dep't*, 180 Wn.2d 566, 573, 326 P.3d 713 (2014).

[74] Daman Family Opening Brief at 9.

[75] *City of Redmond v. Cent. Puget Sound Growth Mgmt. Hearings Bd.*, 136 Wn.2d 38, 46, 959 P.2d 1091 (1998).

also applies to ancillary rulings such as the superior court's decision to dismiss Daman Family's appeal under RCW 34.05.554(1).[76]

B. Daman Family's Appeal Fails Due to Procedural Errors.

Two procedural problems prevent further review of the Daman Family judicial review appeal. The superior court below dismissed Daman Family's appeal due to the failure to exhaust administrative remedies by raising its legal issue to the PCHB.[77] Daman Family assigned no error and presented no argument in its opening brief regarding this dismissal, in violation of RAP 10.3(h). The superior court properly dismissed Daman Family's appeal under RCW 34.05.554 in any event. Both issues are addressed below.

1. Daman Family Failed to Assign Error and Present Argument Regarding the Superior Court's Dismissal for Failure to Exhaust Administrative Remedies, in Violation of RAP 10.3.

Daman Family appealed the superior court ruling dismissing its judicial review case before reaching the appeal's merits.[78] But its opening brief contains no assignment of error or argument about the superior court's dismissal. Review of the merits of Daman Family's case cannot

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[76] *Herman v. Shorelines Hearings Bd.*, 149 Wn. App. 444, 454, 204 P.3d 928, *review denied*, 166 Wn.2d 1029 (2009) (superior court ruling on decision to receive new evidence received de novo review).

[77] CP 2630-32; RCW 34.05.554(1).

[78] CP 2846 and 2854-56. Daman Family also sought interlocutory review of the superior court order that found its judicial review appeal violated RCW 34.05.554(1). *See* No. 47540-5-II.

occur without reviewing the superior court's order dismissing Daman Family's appeal for the failure to exhaust administrative remedies.

RAP 10.3(h) requires opening briefs in administrative law appeals to identify and argue alleged superior court errors in addition to alleged errors by the administrative agency. It states:

> *In addition to the assignments of error required by rule 10.3(a)(3) and 10.3(g)*, the brief of an appellant or respondent who is challenging an administrative adjudicative order under RCW 34.05 shall set forth a separate concise statement of each error which a party contends was made by the agency issuing the order . . . .[79]

RAP 10.3(a)(4) requires assignments of error and issues statements relating to superior court decisions.[80] RAP 10.3(a)(6) requires legal argument on the issues.

In judicial review proceedings, identification and argument concerning allegedly erroneous superior court rulings matters when a superior court considers ancillary issues beyond the underlying agency's decision. The superior court here found Daman Family's appeal solely asserted a new issue not raised before the PCHB and dismissed Daman Family's appeal under RCW 34.05.554(1). Our Supreme Court

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[79] RAP 10.3(h) (emphasis added).

[80] A 2006 amendment to RAP 10.3 added provision (a)(3) for the introduction section and renumbered the assignment of error provision from (a)(3) to (a)(4). *Adoptions, Amendments, Rescissions, and Renumbering of Rules of Court,* 157 Wn.2d 1345, 1437 (2006). The cross-reference in RAP 10.3(h) to the assignments of error provision was unfortunately not updated. 157 Wn.2d at 1438.

has noted that appellate courts considering Administrative Procedure Act (APA) appeals need to go beyond the administrative record and decision when the superior court examines an issue not raised before the agency under RCW 34.05.554.[81]

While appellate courts have discretion to overlook errors in compliance with the Rules of Appellate Procedure, they do not generally consider issues for which there have been no assignments of error *or* argument.[82] Those errors go to the heart of the appellate process. Opening briefs must raise and address the issues to which respondents respond.

DNR should not have to guess at Daman Family's arguments, and this Court should not be deprived of "symmetrical" briefing on the issues before it. The Rules of Appellate Procedure protect the rights of all litigants, including respondents. Daman Family has apparently attempted an end run around RAPs 10.3(h), 10.3(a)(4), and 10.3(a)(6) for tactical reasons and appears poised to argue about the superior court's dismissal order solely in its reply brief. This Court can and should disregard Daman Family's appeal in its entirety.

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[81] *Waste Mgmt. of Seattle, Inc. v. Util. & Transp. Comm'n*, 123 Wn.2d 621, 633-34, 869 P.2d 1034 (1994) (superior court consideration of new evidence or new issues are exceptions to the rule that appellate courts only review the agency's record).

[82] *State v. Olson*, 126 Wn.2d 315, 321-23, 893 P.2d 629 (1995); *Smith v. Emp't Sec. Dep't*, 155 Wn. App. 24, 33-34, 226 P.3d 263 (2010).

2. The Superior Court Correctly Dismissed Daman Family's Appeal Because Its Legal Issue Was Not Raised Before the PCHB.

Daman Family contends that the PCHB was legally required to first determine which CMZ witnesses "followed" the Board Manual's process for CMZ delineation, and from those, pick the one that provided for the smallest CMZ. The superior court properly applied RCW 34.05.554(1) when it dismissed this "most minimal CMZ" argument because Daman Family failed to raise it before the PCHB.

a. RCW 34.05.554(1) Is a Narrow Application of the Exhaustion Doctrine.

Parties must exhaust their administrative remedies before resorting to the judicial system to resolve their issues. Our state's APA was derived in large part from the 1981 Model State APA.[83] The APA covers general exhaustion principles in RCW 34.05.534 and the litigation of new issues in RCW 34.05.554. The Uniform Law Commissioners expressly recognized that both statutes codified the exhaustion doctrine.[84]

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[83] *Washington Administrative Law Practice Manual*, App. 3 § App.-3.01 (2015). "Washington was one of few states to adopt many provisions of the 1981 Revised Act." *Id.*, App. 3 § App-3.03. For the 1981 Model Act and comments, *see*: http://www.uniformlaws.org/shared/docs/state%20administrative%20procedure/msapa81.pdf (last visited Mar. 26, 2016).

[84] RCW 34.05.534 was derived from 1981 Model APA § 5-107. RCW 34.05.554 was derived from 1981 Model APA § 5-112. The Comment to 1981 Model APA § 5-107 cross-references § 5-112, observing that § 5-112's limitation on new issues "is in effect an elaboration of the doctrine of exhaustion of administrative remedies."

RCW 34.05.554 sets forth a well-established rule of procedure—a party cannot raise an issue on appeal that they fail to assert to the tribunal below. Our Supreme Court has noted that "[t]his rule is more than simply a technical rule of appellate procedure; instead, it serves an important policy purpose in protecting the integrity of administrative decisionmaking."[85] The Court explained that rules like RCW 34.05.554 further the purposes of:

> (1) discouraging the frequent and deliberate flouting of administrative processes; (2) protecting agency autonomy by allowing an agency the first opportunity to apply its expertise, exercise its discretion, and correct its errors; (3) aiding judicial review by promoting the development of facts during the administrative proceeding; and (4) promoting judicial economy by reducing duplication, and perhaps even obviating judicial involvement.[86]

These purposes are nearly identical to those that underlie RCW 34.05.534.[87] Statutorily required exhaustion of administrative remedies can also be thought of more broadly as a separation of powers issue between the three coordinate branches of government.

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[85] *King County v. Wash. State Boundary Review Bd.*, 122 Wn.2d 648, 668, 860 P.2d 1024 (1993).

[86] *Boundary Review Bd.*, 122 Wn.2d at 669, quoting *Fertilizer Inst. v. U.S. Envtl. Protec. Agency*, 935 F.2d 1303, 1312-13 (D.C. Cir. 1991) and *Cutler v. Hayes*, 818 F.2d 879, 890-91 (D.C. Cir. 1987).

[87] *See Harrington v. Spokane Cnty.*, 128 Wn. App. 202, 209-10, 114 P.3d 1233 (2005) (discussing purposes exhaustion under RCW 34.05.534).

RCW 34.05.554(1) is written in clear and absolute terms: "[i]ssues not raised before the agency may not be raised on appeal . . . ." This language absolutely requires a party to raise an issue at the administrative level before asserting it in court. Even if one of the limited statutory exceptions applied, RCW 34.05.554(2) would require a remand to the PCHB to resolve the issue. No statutory exceptions apply, however.[88]

b. Daman Family Did Not Ask the PCHB to Establish a "Most Minimal CMZ" Prehearing Issue, Did Not Provide Argument About It, and Did Not Object to DNR's CMZ Evidence.

Proving a negative can be tricky. However, Daman Family's failures to raise its sole legal issue are multifaceted. All litigation at the PCHB starts with the statement of issues in the Prehearing Order.[89] In this case, there was only one agreed issue relating to CMZs: "Whether the Forest Practices channel migration zone of the Quinault River impacts the forest practices proposed in Application Nos. 2612019 or 2612020, and if so, whether the Act and Rules require further conditioning on the applications?"[90] The evidence presented to the PCHB related to that issue.

[88] RCW 34.05.554(1)'s exceptions relate to a party's ability to raise its issue before the agency. But Daman Family knew all the facts supporting its "most minimal CMZ" theory before the PCHB hearing began. *Pac. Land Partners, LLC v. Dep't of Ecology*, 150 Wn. App. 740, 754, 208 P.3d 586, *review denied*, 167 Wn.2d 1007 (2009).

[89] WAC 371-08-435(2) ("The issues which the prehearing order identifies for the hearing shall control the subsequent course of the appeal, and shall be the only issues to be tried at the hearing, unless modified for good cause by subsequent order . . . .").

[90] CP 216 (PCHB Prehearing Order, Issue #1).

Daman Family never asked the PCHB to decide any other CMZ issue, such as whether the PCHB was legally required to adopt the "most minimal CMZ" that could be created by following the Board Manual's delineation steps. Consequently, the parties did not brief or argue the issue before the PCHB, and the PCHB rendered no decision on it.

Daman Family never argued that the PCHB could not weigh the credibility of the witnesses on the CMZ issue if more than one expert "followed" the Board Manual's guidance. Because the PCHB determined that DNR's evidence was the most credible, Daman Family essentially now challenges that evidence as irrelevant to the PCHB's resolution of the CMZ issue. But Daman Family never objected to the presentation of DNR's CMZ analysis on any ground (let alone relevance). Evidentiary objections at the PCHB must be made at the time evidence is offered, like objections in superior court.[91]

Daman Family's PCHB briefing also completely omits its "most minimal CMZ" argument. The phrase "minimum standard" appeared 28 times in Daman Family's 18-page Opening Brief.[92] However, Daman Family's Motion in Limine and its Prehearing Brief at the PCHB

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[91] WAC 371-08-515; ER 103(a)(1).

[92] Daman Family Opening Brief at 1-4 and 9-17.

are wholly bereft of the same term.[93] Similarly, Daman Family cites little law in support of its argument, relying primarily on RCW 76.09.040(1)(a) and RCW 76.09.050(5) in its brief to this Court.[94] But those authorities were also missing from Daman Family's briefs to the PCHB. Neither Daman Family's Motion in Limine at the PCHB nor its Prehearing Brief contained any citations to *any* statute, let alone RCW 76.09.040 or RCW 76.09.050. RCW 34.05.554(1) bars judicial review of issues when the applicable law and argument was not cited to the agency.[95]

Daman Family never argued that the PCHB was legally required to focus upon the evidence that provided the smallest CMZ. Instead, Daman Family presented its case as a factual battle of the experts. First, it indicated that "[p]redicting the future movement of a river is an uncertain business. A scientist can, by selecting the right data points and

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[93] CP 265-69 (Daman Family Motion In Limine); CP 349-59 (Daman Family Prehearing Brief). Word searches for "minimum" and "smallest" returned no hits.

[94] RCW 76.09.040(1)(a)(i) empowers the Forest Practices Board to adopt rules setting forth minimum standards for forest practices, while RCW 76.09.050(5) applies to DNR's denials of applications to conduct forest practices.

[95] *See, e.g.*, *B&R Sales, Inc. v. Dep't of Labor & Indus.*, 186 Wn. App. 367, 381-82, 344 P.3d 741 (2015) (applicable statute not raised in any filing before the agency, including initial appeal, statement of issues, prehearing brief, or reply brief); and *ZDI Gaming, Inc. v. Wash. State Gambling Comm'n*, 151 Wn. App. 788, 811, 214 P.3d 938 (2009), *aff'd*, 173 Wn.2d 608 (2012) (issue that evaded two levels of administrative review was barred because it was not sufficiently raised).

methodologies, influence the result of the analysis to arrive at a prediction that appears valid but is not in reality likely to come true."[96]

Consistent with that view, Daman Family continued:

> At this hearing, this Board will be presented with at least three different predictions of the future migration of the Quinault River, based on varying methodologies. Some of these methods deviate significantly from the guidance set forth in the Board Manual. *This Board will need to approach the CMZ issue . . . with a critical eye, to determine which analysis is the most accurate in predicting not just where the Quinault River might possibly migrate, but where it is likely to migrate in the next 140 years.*[97]

Daman Family thus argued that the Board needed to use the CMZ analysis that was the most credible and "the most accurate" in predicting where the Quinault River would be in 2153. That is exactly what the PCHB did. Nowhere did Daman Family argue that the PCHB was legally required to ignore the opinion of DNR's geologist because she reached a wider CMZ delineation than Daman Family's witness.[98]

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[96] CP 350. Ironically, this problem plagued Daman Family's CMZ analysis. PCHB Findings of Fact Nos. 26 and 27 expressly discredited Daman Family's analysis because it used a shorter time period for its analysis of river movement, and it used too short a segment of the river that showed very little movement over the time period studied. CP 491-92. The latter error reflected the fact that Daman Family's experts ignored the part of the river closest to Sherman Esses' parcel and only delineated a CMZ for the Daman Family parcel. CP 489 (PCHB Finding No. 22).

[97] CP 350 (emphasis added).

[98] The PCHB ruled against Daman Family's Motion in Limine to exclude all testimony of QIN CMZ witnesses due to their deviations from the Board Manual. CP 431-32. Daman Family's Prehearing Brief sought to *discredit* the CMZ opinions offered by QIN witnesses due to the same deviations. CP 356-58. But Daman Family's briefing never challenged or even questioned DNR's CMZ delineation.

The PCHB's thorough ruling in this case spanned 40 pages. The PCHB would have ruled upon Daman Family's "most minimal CMZ" issue had it been properly raised. When it denied certification for direct review of this case at the court of appeals, the PCHB itself expressly indicated that Daman Family failed to raise its sole issue on judicial review.[99]

c. Neither the Burden of Proof Nor the "Inherent Authority" of Appellate Courts Limit RCW 34.05.554.

Daman Family may contend that the burden of proof somehow affects this issue. No law supports that proposition. RAP 2.5(a) is roughly analogous to RCW 34.05.554(1). However, the RAP is less strict because it is permissive, whereas the statute's wording absolutely bars courts from taking up new issues.[100] RAP 2.5(a) still applies equally to all parties raising an issue on appeal, regardless of who bore the burden of proof in the trial court.[101] Given the less-flexible, absolute nature of RCW 34.05.554's

[99] CP 169 ("The first problem with this [most minimal CMZ] legal issue is that Esses did not raise it before the Board, and therefore, the Board concludes that it is unlikely that a reviewing Court will address the merits of this issue on judicial review.").

[100] The *Washington Appellate Practice Deskbook* notes that the analogy between RAP 2.5(a) and RCW 34.05.554 is limited "because RAP 2.5(a) is permissive, whereas the APA *mandates* that new issues cannot be raised unless one of the statutory exceptions applies." *Washington Appellate Practice Deskbook* § 21.10(3)(b) at 21-94 (Wash. State Bar Assoc. 4th ed. 2016) (emphasis added).

[101] RAP 2.5(a) commonly arises in criminal cases against defendants. Thus, no linkage exists between RAP 2.5(a) and the burden of proof. *See, e.g., State v. O'Hara*, 167 Wn.2d 91, 217 P.3d 756 (2009), and *In re Diamondstone*, 153 Wn.2d 430, 441-44, 105 P.3d 1 (2005) (applying rule against attorney in disciplinary proceedings).

wording, it should apply to all parties aggrieved by an administrative decision who seek judicial review.

As a responding party before the PCHB, Daman Family had no burden to prove that the CMZ did not affect its property. But Daman Family *did* have the burden to raise its "most minimal CMZ" argument *if* it expected the PCHB to base its ruling on the idea that a "most minimal CMZ" standard exists in forest practices law. Alternatively, Daman Family needed to object to Leslie Lingley's CMZ testimony if it contended the PCHB could not legally rely upon that evidence. That would have allowed the PCHB to rule upon the admissibility question.

In the superior court, Daman Family contended that courts could exercise "inherent authority" to address an issue even if a party failed to raise it below.[102] But Daman Family authorities were highly questionable and did not devote any analysis to the issue. The court in *Heidgerken v. DNR*, 99 Wn. App. 380, 387 n.3, 993 P.2d 934 (2000), merely relied upon two prior cases in declaring its inherent authority. One was *Shoreline Community College District No. 7 v. Employment Security Department*, 120 Wn.2d 394, 402, 842 P.2d 938 (1992), which arose out of the previous version of the APA which did not contain a statutory limitation on new

[102] CP 2600-01.

issues.[103] *Shoreline Community College*, in turn, relied upon a prior, non-APA case that resolved the "new issue" question under RAP 12.1(b).[104] The other case cited by Daman Family solely cited the *Shoreline Community College* case.[105]

Before courts conducting judicial review apply the RAPs or other judicial procedures in APA cases, those procedures must be analyzed to see if they directly conflict with the APA's provisions.[106] No case cited to the superior court by Daman Family conducted this important analytical step. RCW 34.05.554(1) expressly and clearly limits the raising of new issues on appeal in a judicial review proceeding. Even if Daman Family called upon this Court to use its inherent authority to address its new issue, that would directly conflict with RCW 34.05.554(1) and would be prohibited by RCW 34.05.510(2).

Daman Family did not ask the PCHB to establish a "most minimal CMZ" issue in the prehearing order. It did not brief the issue, nor did it

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[103] *Shoreline Cmty. College*, 120 Wn.2d at 401 (applying RCW 34.04.130).

[104] *Id.* at 402, citing *Alverado v. WPPSS*, 111 Wn.2d 424, 429-30, 759 P.2d 427 (1988) (Supreme Court addressed federal preemption question pursuant to RAP 12.1(b) in a non-APA drug testing matter).

[105] *Nielson v. Emp't Sec. Dep't*, 93 Wn. App. 21, 43, 966 P.2d 399 (1998), citing *Shoreline Cmty. College*, 120 Wn.2d at 402.

[106] RCW 34.05.510(2); *Diehl v. W. Wash. Growth Mgmt. Hearings Bd.*, 153 Wn.2d 207, 216-17, 103 P.3d 193 (2004) (applying RCW 34.05.510(2) regarding a service of process rule); and *King County v. Cent. Puget Sound Growth Mgmt. Hearings Bd.*, 138 Wn.2d 161, 178-80, 979 P.2d 374 (1999) (applying RCW 34.05.510(2) regarding the timing of APA cross-appeals).

object to the DNR's evidence. In order to effectively raise an issue under RCW 34.05.554(1), the Supreme Court requires "*more than simply a hint or slight reference to the issue in the record.*"[107] The APA establishes a strict, judicial review "no fly zone" for stealthy issues that completely evade detection by the underlying agency. Daman Family's appeal presents such an issue. The superior court's dismissal should be affirmed.

C. The PCHB's Ruling Only Applied the Forest Practices Act's Minimum Standards; It Did Not Exceed Them.

Even if the Court reaches the merits, Daman Family's appeal still lacks merit. Daman Family mischaracterizes the PCHB's evaluation of its evidence, it mischaracterizes the PCHB's ruling, and lacks support in law. These arguments follow below.

1. Daman Family Mischaracterizes the PCHB's Evaluation of Its CMZ Evidence.

Daman Family's entire argument relies upon one word in one finding of fact in the PCHB's 40-page ruling. It claims that the PCHB found its experts "followed" the Board Manual in performing their CMZ delineations.[108] But Daman Family's cramped reading of the PCHB's decision fails to see the forest for the trees.

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[107] *Boundary Review Bd.*, 122 Wn.2d at 670 (emphasis added). *See also B&R Sales, Inc.*, 186 Wn. App. at 381-82, and *ZDI Gaming, Inc.*, 151 Wn. App. at 811.

[108] Opening Brief of Daman Family at 5 (assignment of error).

The word "followed" appears among the many findings of fact that balanced the parties' expert testimony on the CMZ issue. The PCHB's Finding of Fact 24 established that QIN's expert, Ms. Reinhart, deviated from the Board Manual's approach in several ways that affected her credibility.[109] The first line of the next finding, Finding of Fact 25, states:

> [o]f the remaining three CMZ delineations, one prepared by DNR's geologist, and two prepared by consultants for the Damon [sic] Family, the Board finds that all three followed the Manual within the bounds of discretion allotted to the practitioner in the manual.[110]

The rest of Finding of Fact 25 continues distinguishing and separating QIN's CMZ analysis from the others. It focused on the fact that QIN's expert was the only one to opine that river avulsions would be a significant CMZ component on this site. Finding of Fact 25 ended by concluding that the dominant river process to affect the parcels was erosion, not avulsion, and thus explained why the PCHB distanced itself from QIN's CMZ evidence.[111]

The PCHB's opinion then teased out the differences between the remaining experts from DNR and Daman Family. The PCHB needed to assess why Daman Family's witnesses used an average river erosion rate that

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[109] CP 490 (PCHB Final Order, Finding No. 24).

[110] *Id.* (PCHB Final Order, Finding No. 25) (emphasis added).

[111] CP 490-91 (PCHB Final Order, Finding No. 25).

was only *one-third* of the rate that DNR's witness used.[112] Findings of Fact 26 and 27 expressly discuss why the PCHB favored the analysis performed by the DNR's expert, Leslie Lingley: she used a longer time period for her analysis, and she studied a longer segment of the river that included a key meander bend. In the PCHB's words, "The Board has found, based on consideration of the testimony of all of the experts, that *Ms. Lingley's approach to delineation of the CMZ was the most consistent with the rule definition and Manual*."[113] The PCHB's unchallenged, express finding that Daman Family's CMZ analysis was less credible because it was less consistent with the rule definition and the Board Manual is a verity.[114]

Reviewing the PCHB's evaluation of all the CMZ testimony provides context for its general comment that the DNR and Daman Family experts "followed" the Board Manual. Daman Family makes this finding seem as though the PCHB fully embraced Daman Family's analysis and then chose to ignore it. Instead, the PCHB found that Daman Family's CMZ

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[112] CP 492 (PCHB Final Order, Finding No. 27). Daman Family's experts used an average erosion rate of 3.1 feet per year, while DNR's expert used a rate of 10.9 feet per year. *Id.* Multiplying that rate by 140 years provides an estimate how far the river may erode over that period. CP 487-88 (PCHB Final Order, Finding No. 19).

[113] CP 506 (PCHB Final Order, Conclusion No. 7) (emphasis added).

[114] *Tapper v. Emp't Sec. Dep't*, 122 Wn.2d 397, 407, 858 P.2d 494 (1994). Even if the findings were challenged, the PCHB's final order discussed the extensive testimony about these issues, and judicial review courts do not re-weigh the evidence presented at administrative hearings. *Bowers*, 103 Wn. App. at 596.

analysis had serious analytical flaws that made it unreliable for locating the CMZ's edge.

2. The PCHB Weighed Disputed CMZ Evidence so That It Could Determine the Starting Point for a Riparian Management Zone.

Daman Family correctly notes that the Forest Practices Act sets minimum requirements for forestry operations in Washington.[115] But from simple truism, Daman Family makes several leaps of logic unsupported by law and isolated from the Findings of Fact and record in this case.

The minimum forest practices standard at issue in this case concerned the riparian management zone for the Quinault River, and specifically, the point on the ground where the riparian management zone begins. For migrating rivers, the rules set a minimum standard that requires estimating a CMZ. WAC 222-30-021 (one of the three rules governing CMZ issues) requires riparian management zones to be measured from the outer edge of the CMZ on rivers like the Quinault.

The parties' evidence about how far the Quinault River would migrate over the next 140 years was divergent. In other words, different witnesses used similar but different methodological approaches to estimate where that point would fall. This prototypical factual dispute does not

[115] RCW 76.09.040(1)(a)(i).

become a legal issue just because a disgruntled party's evidence was not favored by the trier of fact.[116]

The PCHB read the requirements of the Board Manual, heard five geologists and several other experts testify about channel migration zones, and learned about the physical features present at this site. The PCHB then found that DNR's geologist provided the CMZ location that "was the most consistent with the rule definition and Manual."[117]

The Board Manual itself only provides technical guidance and is not a rule.[118] Daman Family appears to tacitly contend otherwise, by referencing that the title to Board Manual Section 2 contains the word "standards," and by repeatedly bolding that word in its opening brief. WAC 222-12-090, the rule that creates the Board Manual, expressly states that it is "an *advisory* technical supplement to these forest practices rules." The Board Manual rule dates to 1976, shortly after the adoption of the Forest Practices Act in

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[116] *Callecod v. Wash. State Patrol,* 84 Wn. App. 663, 676 n.9, 929 P.2d 510 (1997) (review of findings "is deferential and entails acceptance of fact finder's views regarding credibility of witnesses and weight to be given reasonable but competing inferences").

[117] CP 506 (PCHB Final Order, Conclusion No. 7). This conclusion reviewed Findings of Fact Nos. 26-27 (CP 491-92).

[118] CP 485-86 (PCHB Final Order, Finding No. 14).

1974. That predates the present version of the APA, which introduced some similar forms of non-binding guidance documents.[119]

Board Manual Section 2 itself reiterates several times that it is nonbinding. As it introduces the concept of CMZs, the Board Manual states, "[o]nce it has been determined that channel migration has historically occurred or is occurring along the segment, Part 2.3 provides *technical guidelines and likely scenarios* for CMZ delineation."[120] Part 2.3 then states:

> [t]he following *guidelines* and delineation scenarios contain technical recommendations for CMZ delineation. *It may be reasonable to deviate from these recommendations* based on carefully developed technical analysis of the historical channel and watershed processes that control channel migration.[121]

Later, the Board Manual further clarifies the state of CMZ science:

> *CMZ delineation is a relatively recent concept, and no one method of analysis has been adopted or prescribed.* Various geomorphic, engineering, and modeling methods can be applied to channel migration delineation.[122]

This evidence supports the PCHB's finding that the Board Manual is not a rule and does not present one "cookie-cutter" way to analyze migrating

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[119] *See* RCW 34.05.230(1) (discussing "advisory only" nature of interpretive and policy statements). In contrast, a rule establishes a binding directive of general applicability. *See* RCW 34.05.010(16) and *Failor's Pharmacy v. Dep't of Soc. & Health Servs.*, 125 Wn.2d 488, 495, 886 P.2d 147 (1994).

[120] CP 575 (emphasis added).

[121] CP 590 (emphasis added).

[122] CP 610 (emphasis added).

rivers. The agreed CMZ issue that the PCHB needed to decide necessarily resulted in disparate evidence and opinions on the CMZ's extent. As noted by the PCHB, the experts agreed on several matters, but differed on others.[123] The PCHB exists to resolve such factual disputes.

Here, the PCHB discharged its primary duty and weighed the credibility of the experts, finding Daman Family's experts less credible than DNR's. After doing so, the PCHB recognized that the legal consequence of its factual findings was that the Quinault River's riparian management zone affected the Sherman Esses and Esses Daman Family parcels. Because DNR approved the permits without that rule-based requirement, the PCHB properly found that DNR's approvals needed to be reversed.[124]

Daman Family repeatedly cites RCW 76.09.050(5) for the proposition that a forest practices permit denial needs to explain "the specific manner in which the application fails to comply with . . . the forest practices regulations." But PCHB Conclusion of Law 13 cited WAC 222-30-021 and explained that Daman Family's application lacked a required riparian management zone for the Quinault River.[125] The PCHB's order thus met the requirements of RCW 76.09.050(5).

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[123] CP 489-93 (PCHB Final Order, Finding Nos. 23-28).

[124] CP 510-11 and 516-17 (PCHB Final Order, Conclusion No. 13, and Order).

[125] *Id.*

The parties asked the PCHB to determine if the Quinault River's CMZ impacts the parcels, and if so, whether further conditioning was necessary. The PCHB utilized the most credible evidence to locate the CMZ edge. Nothing in the Forest Practices Act, rules, or Board Manual supports Daman Family's contention that the PCHB was legally required to use the "most minimal CMZ" prediction, when valid scientific evidence pointed to a different location that better met the rules and Board Manual guidance.

3. QIN May Not Have Carried Its Burden of Proof in the Hearing, but That Does Not Void the Evidence Entered by Other Parties.

Daman Family contends that because QIN appealed the forest practices permits to the PCHB, it bore the burden of proof under the PCHB's procedural rules.[126] From that true statement, Daman Family rationalizes that only QIN's evidence mattered and that Daman Family was unequivocally entitled to its permit as a matter of law if QIN failed to meet its burden.[127] Daman Family's arguments miss the mark, because the PCHB's decision rests upon substantial evidence in the record.

Daman Family first asserts that an approved application is "presumed valid" just because an appealing party bears "the initial burden of proof" under WAC 371-08-485(3). No other authority is cited for the

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[126] WAC 371-08-485(3).

[127] Daman Family Opening Brief at 16-18.

"presumption." But Daman Family overlooks that the same rule provides that the PCHB has a de novo scope *and* standard of review. WAC 371-08-485(1). The PCHB's de novo standard of review means that no presumption of validity exists for appealed DNR decisions.[128]

Additionally, the PCHB's de novo "scope of review" means that it is not limited to the scope of evidence DNR had at the time it made a particular decision. Once the PCHB's jurisdiction is secured, it may receive evidence on any disputed facts if relevant to the issues in the prehearing order.[129] The scope of review rule enables DNR to present what it thinks is the best evidence on a particular issue, even if that evidence conflicts with what it initially believed at the time it issued a permit.[130]

The parties agreed that the PCHB should decide one CMZ issue. The PCHB resolved that issue after hearing disputed evidence—evidence

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[128] The PCHB sees the de novo standard of review as part of its independent quasi-judicial role. *See, e.g., Nw. Aquatic Ecosystems v. Dep't of Ecology*, PCHB No. 05-101, Order Denying Summary Judgment, at 5-7 (Dec. 19, 2005); *see also Port of Seattle v. Pollution Control Hearings Bd.*, 151 Wn.2d 568, 591-92, 90 P.3d 659 (2004), and *ASARCO v. Air Quality Coalition*, 92 Wn.2d 685, 695, 601 P.2d 501 (1979). The Forest Practices Appeals Board (FPAB) reviewed DNR's forest practices decisions until its duties were transferred to the PCHB. It employed the same standard. *See* WAC 223-08-177, *repealed*, WSR 10-18-021; *see also* Laws of 2010, ch. 210, §§ 1 and 19-25 (eliminating the FPAB and transferring duties to the PCHB).

[129] *Port of Seattle*, 151 Wn.2d at 595-99, and *Postema v Pollution Control Hearings Bd.*, 142 Wn.2d 68, 121, 11 P.3d 726 (2000) (in permit appeal, WAC 371-08-485 allows issuing agency and all other parties to present relevant evidence).

[130] *Postema*, 142 Wn.2d at 121 ("Ecology was not foreclosed from arguing a changed position based upon the evidence presented, and the Board was authorized to reach a decision based upon that evidence.").

that DNR did not have at the time it made its permitting decision.[131] The PCHB heard all of the disputed evidence and agreed with DNR's position that the Quinault River CMZ affected the proposals and that further conditioning was required. Daman Family did not object or seek to exclude DNR's CMZ evidence; hence the trier of fact could and did consider it.

Whether QIN or DNR presented the best CMZ evidence is irrelevant. What matters is that the PCHB received substantial evidence concerning the proper location of the CMZ, and the PCHB decided the disputed issue based upon the evidence received.[132] Simply no claim of legal error exists in the unremarkable weighing of competing expert testimony and deciding a disputed issue based upon the most credible evidence.

VI. CONCLUSION

Daman Family's procedural errors plague its appeal. Its opening brief failed to assign error and provide argument regarding the superior court's decision dismissing Daman Family's appeal because it failed to exhaust its administrative remedies. The superior court correctly determined that RCW 34.05.554(1) barred Daman Family's appeal because it failed to raise its "most minimal CMZ" issue before the PCHB.

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[131] CP 504, n.20 (PCHB Final Order, Conclusion No. 3).

[132] While Daman Family treated the findings as verities, the substantial evidence standard would apply to any challenged findings of fact. RCW 34.05.570(3)(e); *Motley-Motley, Inc. v. State*, 127 Wn. App. 62, 72, 110 P.3d 812 (2005), *review denied*, 156 Wn.2d 1004 (2006).

On its merits, Daman Family's legal theory eschews the PCHB's role in assessing witness credibility on a disputed factual issue. That is the PCHB's raison d'être. The PCHB did not err by fulfilling its statutory mission.

RESPECTFULLY SUBMITTED this 18th day of April, 2016.

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CERTIFICATE OF SERVICE

I certify that I caused a copy of the foregoing document to be served on all parties or their counsel of record on April 18, 2016, as follows:

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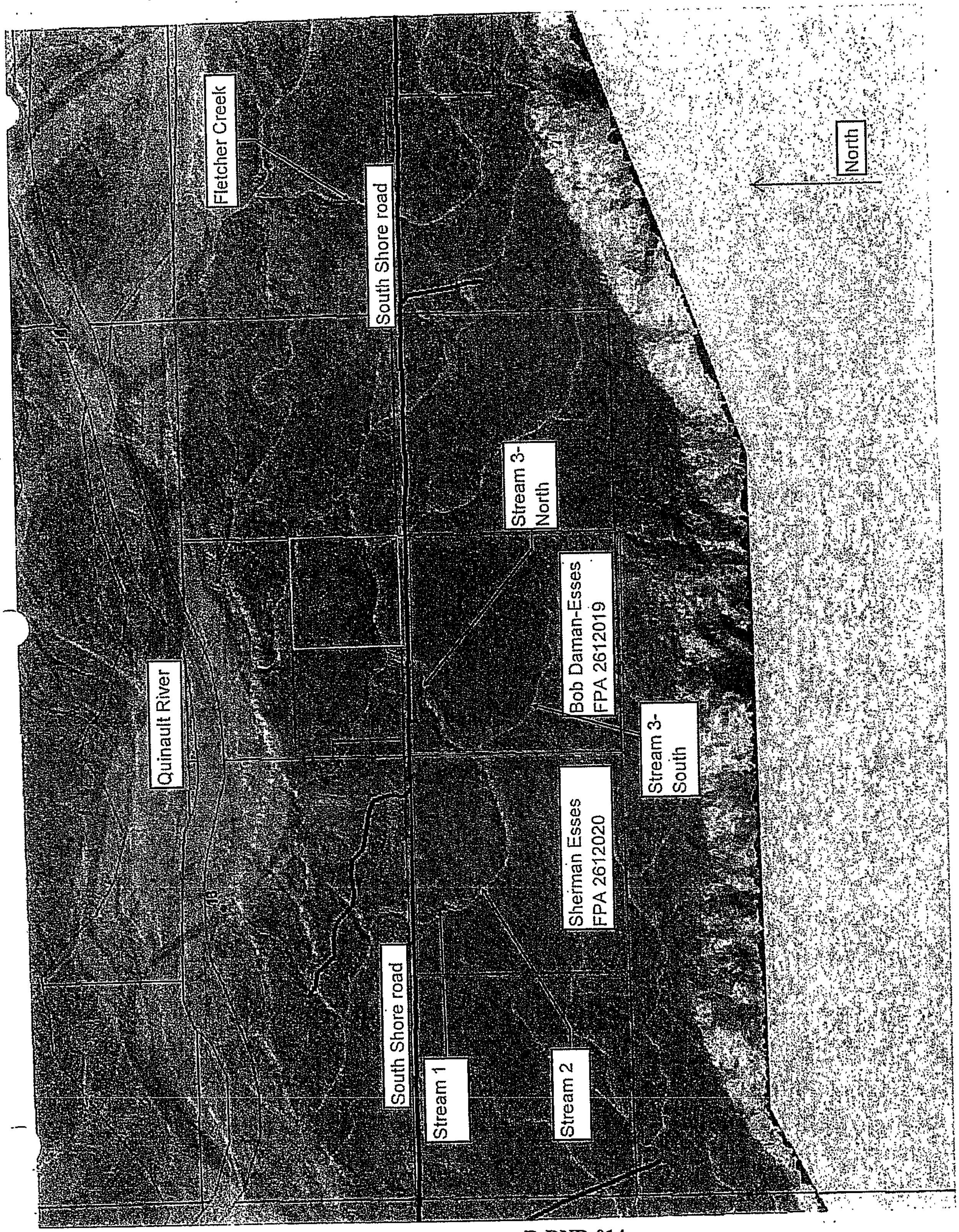
I certify under penalty of perjury, under the laws of the state of Washington, that the foregoing is true and correct.

DATED this 18th day of April, 2016, at Olympia, Washington.

Kim L. Kessler

KIM L. KESSLER
Legal Assistant
Natural Resources Division

APPENDIX



R-DNR-014

COLOR VERSION OF CP 955

ORDER ON CROSS-MOTIONS FOR SUMMARY JUDGMENT, RESOLVING ESSES DAMAN FAMILY'S CLAIMS

FILED

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RUTH GORDON, CLER

STATE OF WASHINGTON
JEFFERSON COUNTY SUPERIOR COURT

ESSES DAMAN FAMILY, LLC, Petitioner, v. POLLUTION CONTROL HEARINGS BOARD; WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES; AND QUINAULT INDIAN NATION, Respondents.	PRIMARY CAUSE NO. 14-2-00078-1 **ORDER ON CROSS-MOTIONS FOR SUMMARY JUDGMENT, RESOLVING ESSES DAMAN FAMILY'S CLAIMS**
QUINAULT INDIAN NATION, Petitioner, v. POLLUTION CONTROL HEARINGS BOARD; WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES; ESSES DAMAN FAMILY, LLC; AND SHERMAN ESSES, Respondents.	CONSOLIDATED CAUSE NO. 14-2-00182-6

THIS MATTER having come on regularly for hearing before the undersigned judge of the above-entitled court upon motion for summary judgment concerning the appeal of Esses Daman Family, LLC, filed by the Respondent, Department of Natural Resources. A cross-motion

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for summary judgment was filed by Esses Daman Family, LLC. The Department of Natural Resources was represented by ROBERT W. FERGUSON, Attorney General, and PHILIP M. FERESTER, Senior Counsel; Esses Daman Family, LLC, was represented by JON E. CUSHMAN and KEVIN HOCHHALTER, of the Cushman Law Offices; and the Quinault Indian Nation, was represented by WYATT GOLDING, of the Washington Forest Law Center, and KAREN ALLSTON and PETER CROCKER, of the Quinault Indian Nation. Respondent SHERMAN ESSES, Pro Se, and Respondent, Pollution Control Hearings Board, being represented by DIANE MCDANIEL, Senior Assistant Attorney General, of the Washington State Attorney General's Office, Licensing and Administrative Law Division, did not appear.

The Court having examined the briefs, the Court's file, the Pollution Control Hearings Board's record from its adjudicative proceeding, and having heard argument of counsel and being fully advised in the matter; now, therefore,

IT IS HEREBY ORDERED:

(1) The Court **DENIES** Esses Daman Family, LLC's motion for summary judgment on the merits of its appeal, because Esses Daman Family, LLC has not demonstrated that the Pollution Control Hearings Board's weighing of disputed evidence violated the law.

(2) The Court **GRANTS** the Department of Natural Resources' summary judgment motion and dismisses the Esses Daman Family, LLC's judicial review appeal pursuant to RCW 34.05.554(1). The only issue raised in the superior court appeal was a new issue not presented to or decided by the Pollution Control Hearings Board, the agency whose order is being reviewed in this Court; hence, the appeal is barred by the statute's terms.

(3) This Order resolves one parties' claims before the Court. The parties shall work cooperatively to prepare a briefing schedule and hearing date for the Quinault Indian Nation's

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claims concerning the same PCHB Final Order. Esses Daman Family, LLC may appeal this order to the Court of Appeals at the conclusion of the consolidated litigation.

(4) Daman Family's motion for certification for immediate appeal under CR 54(b) is denied.

DONE IN OPEN COURT this 3rd day of March, 2015.

JUDGE KEITH C. HARPER

Presented by:

ROBERT W. FERGUSON
Attorney General

PHILIP M. FERESTER, WSBA #21699
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FINDINGS OF FACT, CONCLUSIONS OF LAW, AND ORDER (CORRECTED)

POLLUTION CONTROL HEARINGS BOARD
STATE OF WASHINGTON

QUINAULT INDIAN NATION, Appellant, v. STATE OF WASHINGTON, DEPARTMENT OF NATURAL RESOURCES, ESSES DAMAN FAMILY, LLC and SHERMAN ESSES, Respondents.	PCHB No. 12-118c (PCHB No. 12-118, PCHB No. 12-071c) FINDINGS OF FACT, CONCLUSIONS OF LAW, AND ORDER (CORRECTED)[1]
ESSES DAMAN FAMILY LLC, and SHERMAN ESSES, Appellant, v. STATE OF WASHINGTON, DEPARTMENT OF NATURAL RESOURCES Respondents.	

The Quinault Indian Nation ("QIN" or "the Nation") appealed two forest practices applications approved by the Washington State Department of Natural Resources (DNR) for logging operations on adjacent land owned by the Esses Daman Family LLC (Daman Family) and Sherman Esses (collectively Esses). Esses filed a cross appeal of the conditions DNR had placed on the approved applications.

[1] Technical corrections have been made to this order as identified in the Order Denying Petition for Reconsideration and Correcting Order issued on April 29, 2014.

This case has an extensive history at the Board, involving pre-hearing practice on motions for an emergency suspension order, a temporary suspension order, and the setting of a bond.[2] The prehearing officer conducted a pre-hearing conference and established issues in the case, and the parties filed several procedural motions and partial summary judgment motions. The Board's presiding officer and the Board issued orders on all of these motions. Following the completion of motion practice, three issues remained for hearing. These issues proceeded to an eight-day evidentiary hearing at the Board's office in Tumwater, Washington.

The Board was comprised of Chair Tom McDonald and Member Kathleen D. Mix.[3] The Board heard sworn testimony from 19 witnesses, mostly experts, and admitted multiple exhibits. The Board also spent approximately two hours on a comprehensive site visit on the Esses' properties. The Board observed the physical features at the site including portions of Streams 1, 2 and 3, the culverts under the South Shore Road, the alluvial fan area, the South Shore Road in the vicinity of the parcels, the Wilson Barn, and the Quinault River (River) at several locations. The Board did not take testimony at the site visit.

Having fully considered this record, the Board enters the following:

[2] Esses appealed the suspension orders to Thurston County Superior Court, where Judge Erik D. Price affirmed the orders, and remanded the matter to the Board for completion of the administrative process.
[3] The third board member, Joan M. Marchioro, recused herself.

FINDINGS OF FACT

1. The site

1.

The forest practices at issue in these appeals involve two square, adjacent 40-acre parcels located approximately six miles northeast and upriver of Lake Quinault in Jefferson County. Related families own the parcels. These families are small forest landowners and have lived in the Quinault River Valley for generations. The parcels are bounded on the north by the South Shore Road and on the south by the Colonel Bob Wilderness. The River lies 600 to 1000 feet north of the property. The parcels lie on a generally flat terrace with multiple old-growth stumps on the property. Pit and mound topography[4] and old-growth stumps are visible on some of the site, evidence of a prior old-growth forest on the site. The fact that the pit and mound topography is still identifiable indicates that the site has not been regularly flooded during the time that the old-growth forest developed on the site. S. Esses Testimony, D. Esses Testimony, B. Daman Testimony, J. Damon Testimony, R. Esses Testimony, Lingley Testimony, Exs. DNR 6 and 14, Ex. Esses 20.

2.

The parcels now contain trees, mostly Sitka Spruce and Western Hemlock, which are 70 plus years in age. These trees grew as natural regeneration following a timber harvest on both properties in the 1930's. This natural stand contains "voids" which are open areas that do not

[4] The mounds are the piles created by the fallen decaying old-growth trees, while the pits are the holes left when the falling trees pull out their roots. Ex. DNR 6, p. 3, citing Wikipedia.

contain trees. Lingley Testimony; S. Esses Testimony; Mahan Testimony, Exs. DNR 1, 2, 6; Ex. Esses 20.

3.

The geologic history of an 18-kilometer reach of the Upper River, which includes the River section closest to the Esses parcels, was the subject of a geomorphic evaluation by the U.S. Department of the Interior, Bureau of Reclamation. The Bureau of Reclamation published a report in July 2005, entitled *Reclamation Managing Water in the West, Geomorphic Investigation of Quinault River, Washington* (BOR Report). The BOR undertook this analysis to better understand what opportunities exist to restore sockeye salmon habitat in the Upper Quinault River. All of the scientists that testified in this hearing relied extensively on this report. Lingley Testimony, Einersen Testimony, Toth Testimony, Reinhart Testimony, Embertson Testimony, Ex. DNR 20.

4.

Retreating glaciers originally formed Lake Quinault, which was once much more extensive in size. As Lake Quinault receded, the River incised into the remaining glacial valley, leaving behind a series of terraces. The Esses site is located on a terrace called the Upper Holocene surface. The active channel of the River has not flowed over this terrace for a few thousand years and flood flows from the River do not inundate the terrace. The terrace is at an approximate elevation of 312 feet, roughly six feet above the flood plain of the River to the north.[5] Einersen Testimony; Lingley Testimony; Exs. DNR 6, pp. 4-6; DNR 20, pp. 20, 21; Ex. Esses 20, pp. 3, 4.

5.

The Esses site contains unique, incised, bath-tub or U-shaped channels that are roughly three to eight feet wide, at both the bottom and the top, and four to fifteen feet deep. These channels are ancient features, most likely caused by the drainage of the Colonel Bob Wilderness uplands to the south of the site, and possibly by the drainage of the historic Lake Quinault. The bottoms of these channels are vegetated. While the parcels as a whole are mostly above the flood level for a 100 year flood event[6] based on modeling the Nation had prepared for this appeal, the bottoms of the incised channels are below the 100-year flood event. Embertson Testimony, Mahan Testimony, Lingley Testimony, Mendoza Testimony, Mobbs Testimony, Einersen Testimony, Exs. A-28, DNR 6, Esses 20.

6.

The bottoms of these channels also contain streams labeled 1, 2, and 3 North and South for purposes of the forest practices applications. Streams 1 and 2 are on the Sherman Esses parcel. Streams 3 North and 3 South are on the Daman Family parcel. The forest practices rules require practitioners to measure streams by bankfull width, which is the area where a stream flows regularly when it flows. The majority of the experts that testified placed the bankfull width on these streams at an average of six feet, although it is difficult to determine bankfull

[5] Dr. Einersen concluded that the northern part of the Damon Family parcel lies about eight to nine feet above the active channel of the River north of the site. Einersen Testimony; Ex. Esses 20, p. 11.

[6] The 100-year flood event is the flood level that has a 1 percent chance of occurring every year. Embertson Testimony.

width of these streams because of their low flow and vegetation. Mobbs Testimony; McMurry Testimony; Mahan Testimony; Ex. DNR 14; Ex. A-29, p. M2-3 through M2-6.

7.

Water passes under the South Shore Road at a culvert on Stream 1, located on the Sherman Esses property (West Culvert), and a culvert on Stream 3 North, located on the Daman Family property (East Culvert). These streams connect to the River. There is no barrier to connectivity for fish between Stream 1, Stream 2, and Stream 3 North and South, except the absence of continual water. Embertson Testimony, Mobbs Testimony.

8.

Water flow in Streams 1, 2, and 3 is intermittent. Water flows in parts of Stream 1 during some of the time. Much of the time Streams 2 and 3 are devoid of flow, and are either completely dry or have small isolated puddles. Mr. Mobbs described Streams 2 and 3 in particular as "flashy" because they flow mostly during winter heavy rain or rain-on-snow events and for short durations. Sherman Esses testified that based on his observations, water flows in Streams 1, 2, and 3 for approximately one to four days per year. Bob Daman estimated that water flows in Stream 3 somewhere between 10 and 20 days per year, only during heavy rain combined with rain on snow events, and lasting, at most, several hours. Casey Testimony; Mahan Testimony; S. Esses Testimony; B. Daman Testimony; Mobbs Testimony; Exs. DNR 10, 13, 39, 40.

9.

The direction and source of water in these streams is complicated. One direction of water flow is north and west, originating in the Colonel Bob Wilderness highlands and flowing onto the Damon Family parcel across the alluvial fan[7] feature evident on that property. The water may also flow underground in this area. This flow typically occurs in the winter and as the result of heavy rain or rain-on-snow events. The run-off water flows through the streams, through the culverts, under the South Shore Road, and toward the River, thus functioning as a tributary flow to the River. This is the direction of flow indicated on the DNR water typing maps initially used for these applications. Casey Testimony; Mendoza Testimony; B. Daman Testimony; Exs. DNR 1, 2, and 6.

10.

Water flow may also occur in the opposite direction, from the south side of both the East and West Culverts, flowing under the South Shore Road and into Streams 1 and 3. While no witness that testified had observed flow in this direction, there are pictures in the record of this type of event. Another source of water in these streams may be ground water. R. Esses Testimony, Casey Testimony, Lingley Testimony, Mendoza Testimony, Exs. DNR 10 through 12.

11.

It is undisputed that young fish including salmonids are present in Stream 1; however no one has seen fish in Streams 2 or 3. The majority of the expert testimony at the hearing supports

[7] An alluvial fan is "a fan or cone shaped deposit of sediment crossed and built up by streams." http://en.wikipedia.org/wiki/Alluvial_fan.

the finding that Streams 1, 2, and 3 provide off channel habitat for juvenile salmon during high water events on the River. Coho Salmon, a type of Salmon present in the River, in particular benefit from off channel habitat because Coho over-winter in the River before heading out to the ocean. Off channel habitat allows young fish to remain in slower moving water when the flow in the main river system is moving too fast and would move them too quickly out to the ocean. Mobbs Testimony, Casey Testimony, Mendoza Testimony, Ex. DNR 13.

12.

Because the main stem of the River is moving in a southwardly direction toward the Esses site, in the future it will be closer to the site. As the River gets closer, Streams 1, 2, and 3 will likely carry more water, and therefore become fish habitat for more days out of the year. Lingley Testimony, Mobbs Testimony.

2. The Channel Migration Zone (CMZ)

13.

A Channel Migration Zone (CMZ), for forest practices purposes, is the area where a river is prone to move in the next 140 years. The purpose of the CMZ is to protect the riparian management zone (RMZ) of a river, which is a minimum stream buffer that contributes to stream health by maintaining essential riparian functions. Toth Testimony, Engle Testimony, Ex. A-30.

14.

The Forest Practices Board Manual (Manual), a document approved by the Forest Practices Board[8] but not adopted through formal rulemaking, is a technical supplement to the

[8] The Forest Practices Board is the entity charged with promulgating Forest Practices Rules. RCW 76.09.030, .040.

rules. A group of 12 scientists and foresters developed the Manual. It is a consensus product. It contains a very large section (60-plus pages) devoted to the delineation of CMZs. The section sets out detailed instructions for determining a CMZ, while allowing for some discretion on the part of the practitioner in making the delineation. Despite the level of detail in the Manual, there is still no cookie cutter approach to a CMZ delineation. Engle Testimony, Toth Testimony, Ex. A-29.

15.

As stated in the Manual, "[t]he general methodology in this section defines the CMZ based on valley and floodplain features and channel processes. The outer edge of the CMZ is identified using historical map and photo analysis and/or current field evidence to predict future channel migration." Ex. A-29, p. M2-21.

16.

The Manual breaks down the CMZ analysis into a series of component parts that the practitioner can use collectively to define the boundaries of the CMZ. The manual clarifies that all component parts are not present in every CMZ analysis. The components identified in the Manual for a CMZ include:

> 1. The historical migration zone (HMZ) – The sum of all active channels over the historical period (post 1900).
> 2. The avulsion hazard zone (AHZ) – The area not included in the HMZ where the channel is prone to move by avulsion and if not protected would result in a potential near-term loss of riparian function and associated habitat adjacent to the stream.
> 3. The erosion hazard area (EHA) – The area not included in the HMZ where bank erosion from stream flow can result in a potential near-term loss of riparian function and associated habitat adjacent to the stream.

4. The disconnected migration area (DMA) – The portion of the CMZ behind a permanently maintained dike or levee.

Ex. A-29, p. M2-21.

17.

The Manual devotes several pages to describing how one can identify the component parts. To identify the HMZ the Manual advises the practitioner to look at photos, maps, and field evidence, and go back as far as the year 1900 if possible. The Manual suggests extending the historical period at sites known to have been impacted by timber harvest activities prior to 1900 or where historical information such as General Land Office (GLO) maps and notes are available. Ex. A-29, pp. M2-25 to M2-27.

18.

The next potential component, the AHZ, is an area outside of the HMZ where the river is prone to move. The Manual explains that channel avulsions are either "relatively sudden and major shifts in the position of the channel to a new part of the floodplain (first-order avulsion) or sudden reoccupation of an old channel on the floodplain (second-order avulsion)." Ex. A-29, p. M2-27. The Manual states "avulsion is likely to involve floodplain surfaces, where erosion may involve higher floodplain and terrace edges." *Id.* p. M2-10.

19.

The third component, the EHA, is intended to include "those areas outside of the HMZ and AHZ which are susceptible to bank erosion from stream flow" and which can "result in a potential near-term loss of riparian function and associated habitat adjacent to the stream." Ex.

A-29, p. M2-29. The Manual provides a formula, which utilizes information about past erosion over a studied time period, to produce an average erosion rate per year. The formula then directs the practitioner to multiply the average erosion rate by 140 years in an attempt to predict where the river might erode to in the future. The EHA is added to the area defined by the HMZ and AHZ to delineate the CMZ. *Id.*, pp. M2-28 through M2-30.

20.

The Manual instructs in several places to look for and consider the flood history of a river when delineating a CMZ. *See, e.g.* Ex. A-29, pp. M-22, M-26. Floods have not inundated the Esses parcels at least since the 1900's. Sherman Esses testified that floods have not inundated his parcel in his 80 years of experience. The BOR Report provides data regarding the size of flood events from 1900 to 2002. The largest flood was an estimated 60-year event in 1909. S. Esses Testimony; Embertson Testimony; Ex. DNR 20, p. 26, Figure 7; Ex. DNR 39, p. 6.

21.

Leif Embertson, river engineer, modeled how a 100-year flow would impact the South Shore Road and the Esses parcels. Based on his model, the 100-year flow would result in flooding over the South Shore Road, and on some parts of the Esses parcels, primarily in the channels. His modeling also predicts there would be some shallow flood waters outside of the channels on the Esses parcels. The Federal Emergency Management Agency (FEMA) has not reviewed Mr. Embertson's modeling. Mr. Embertson is not aware of a 100-year flood event ever actually happening in the area. Based on his modeling, Mr. Embertson concludes that portions of the Esses parcels are below the modeled 100-year flood level. Embertson Testimony, Ex. A-28.

22.

The Board heard testimony from five geologists, two of whom had done CMZ delineations specifically for both parcels (Ms. Lingley, a DNR geologist, and Ms. Reinhart, the Nation's consultant), two that had performed CMZ delineations for just the Damon Family parcel (Dr. Einersen and Mr. Toth, consultants on behalf of the Damon Family), and one that reviewed the CMZ delineations prepared by the others (Dr. Abbe, on behalf of the Nation). Ms. Lingley, Ms. Reinhart, and Dr. Einersen provided CMZ delineations drawn on maps. Mr. Toth did not provide a CMZ delineation drawn on a map, but he did testify regarding his own CMZ delineation. Lingley Testimony; Reinhart Testimony; Einersen Testimony; Toth Testimony; Abbe Testimony; Exs. DNR 6, 35; Exs. A-3, 4, 5, 28, 37, 49, 55, 67; Exs. Esses 20, 37.

23.

The experts that performed CMZ delineations had many areas of agreement. All four placed the Esses parcels outside of the HMZ. All four experts agreed that the main channel of the River has moved south over time and is continuing to do so. All four had their final CMZ delineation coming very close to or past the South Shore Road at the Esses parcels. Lingley Testimony; Reinhart Testimony; Einersen Testimony; Toth Testimony; Exs. DNR 6, 35; Exs. A-5, A-37; Ex. Esses 20, 37.

24.

Of the four CMZ delineations presented to the Board, Ms. Reinhart's analysis was the only one that deviated from the approach outlined in the Manual. Ms. Reinhart's delineation identified a much larger AHZ and EHA than the other experts, resulting in a CMZ that extends entirely across the Esses parcels to the valley wall. This delineation was the result of Ms. Reinhart's determination that there were potential avulsion areas in the vicinity of the Esses site that would affect the CMZ in that area. She then applied an erosion setback to the potential avulsion sites she had identified, a step not provided for in the Manual, resulting in an extensive AHZ. Finally, Ms. Reinhart made another adjustment to the "final" CMZ boundary, moving it a few hundred feet south to reach the valley wall, another step not in the Manual but rather based on her professional judgment. Dr. Abbe supported Ms. Reinhart's analysis and explained the adjustments are consistent with the intent and guidelines of the Manual and used good science in determining the CMZ components. The Board finds, however, that Ms. Reinhart's analysis does deviate in significant ways from the Manual, and that these deviations affect her CMZ delineation for the Esses parcels. Reinhart Testimony; Toth Testimony; Engle Testimony; Exs. A-3 through 5, A-29, Section 2, M2-25 through 29, A-55; Ex. DNR 35.

25.

Of the remaining three CMZ delineations, one prepared by DNR's geologist, and two prepared by consultants for the Damon Family, the Board finds that all three followed the Manual within the bounds of discretion allotted to the practitioner in the manual. None of the other experts found any avulsion hazard area as a significant component of the CMZ that would affect the CMZ for the Esses parcels. This is consistent with the fact that the area north of and including the Esses parcels is on an upper terrace, and not on the floodplain of the river. The dominant river process that could have the potential to affect these parcels is erosion, not avulsion.[9] Engle Testimony, Lingley Testimony, Einersen Testimony, Ex. DNR 20.

26.

Overall, the Board finds Ms. Lingley's CMZ analysis more persuasive than that of Dr. Einersen or Mr. Toth for two primary reasons. First, Ms. Lingley based her HMZ on a longer period of analysis. Ms. Lingley started her analysis from 1906, using the 1906 GLO survey information, whereas Dr. Einersen and Mr. Toth started from 1939. The Board finds that the 1906 GLO survey, while it may have contained some inaccuracies, provided sufficiently accurate information to justify its use. This particular GLO survey contained detailed survey notes. The survey encompassed an already populated area, and therefore there was public interest and pressure to perform an accurate survey. The survey occurred in July, a time of generally good weather. The BOR report itself used the 1906 GLO survey when studying the HMZ. Ex. DNR 20, at 55, and Appendix J, p. 3. Here, Ms. Lingley's use of the 1906 information was warranted given that the BOR report notes that the River valley was rapidly settled between 1900 and 1920, and that the River was already responding to human disturbances by the time of the earliest aerial photographs. Ex. DNR 20, p. 46. The Manual suggests extending the historical period at sites known to have been impacted by timber harvest activities prior to 1900 or where historical information such as GLO maps and notes are available. Ex. A-29, p. M2-25. The BOR report also concludes that the time period from 1906 to 1939 represents a period of heavy erosion on the terrace bank, lending further support for the use of the GLO survey material. Ex. DNR 20,

[9] The BOR Report states that in this area "the south side terrace has been experiencing erosion in recent years" and that "the terrace channels in the vicinity of this section [are] at risk for erosion." Ex. DNR 20, p. 131.

pp. 59, 60. Therefore, including this time period in calculating an average erosion setback results in a likely overstatement of the average erosion, and thus constitutes a conservative approach. Holt Testimony; Lingley Testimony; Einersen Testimony; Toth Testimony; Ex. DNR 6; Exs. A-29, pp. M2-25 to M2-27; A-49; Exs. Esses 20, 37.

27.

Second, the Board finds that Ms. Lingley's selection of segment length to calculate an erosion rate was more conservative, and therefore more persuasive, than Dr. Einarsen or Mr. Toth. Ms. Lingley used a long segment (9200 feet) to calculate a historical average erosion rate of six feet per year. She then selected a shorter segment north of the parcel and near the Wilson Barn to calculate the erosion setback area. She selected this segment because she had observed that this area was subject to the most recent aggressive erosion and she concluded that using this segment would be the most conservative approach. Based on this segment, and using data from 105 years, she calculated an erosion setback area of 1529 feet, and an erosion rate of 10.9 feet at this section of the River. This can be compared with Dr. Einarsen's approach in which he selected a 1459 foot segment directly north of the Damon Family parcel, an area with considerably less erosion, to arrive at an erosion rate of 2.3 feet/year, or a longer section going one-quarter mile above and one-quarter below the Damon Family parcel (4,495 foot segment) to arrive at an erosion rate of 3.1 feet/year.[10] Neither of these segments included the meander bend north of the Wilson Barn where there is the most aggressive erosion. Lingley Testimony, Einersen Testimony, Ex. DNR 6, Ex. Esses 20.

[10] Mr. Toth selected a segment location directly north of the Damon Family LLC, evaluated a period from 1939 to the present, and then arrived at an erosion rate of 3.2 feet/year. Toth Testimony.

28.

Based on her analysis, Ms. Lingley concluded that if the South Shore Road were not present, the CMZ for the Quinault River, including the EHA, would reach past the South Shore Road, and encompass over half of the two parcels.[11] Based on her understanding of the Manual, however, she concluded that the South Shore Road limits the CMZ for forest practices regulatory purposes. Lingley Testimony, Engle Testimony, Ex. DNR 6.

29.

The Manual addresses the effect of permanently maintained dikes or levees on the delineation of the CMZ in a section entitled *Disconnected Migration Area (DMA)*. Ex. A-29, p. M2-30. Marc Engle, a DNR Forest Practices Assistant Division Manager, was involved with the committee that developed this chapter of the Manual. In Mr. Engle's opinion, pursuant to the guidance in the Manual, the South Shore Road acts as a channel limiting structure for the River. The Manual also states that "a dike or levee is not considered a 'permanent dike or levee' if the channel limiting structure is perforated by pipes, culverts, or other drainage structures that allow for the passage of any life stage of anadromous fish and the area behind the dike or levee is below the 100-year flood level." *Id.* Mr. Engle testified that a public right-of-way, which has been maintained in the past, should be considered a channel limiting structure regardless of whether it contains culverts and whether the area behind it is below the 100-year flood level. Mr. Engle explained that the paragraph in the Manual that addresses perforation by culverts should be interpreted to address a concern raised by some members of the committee that Type F

[11] Dr. Einersen and Mr. Toth's delineations reach almost to the South Shore Road in the area of the Sherman Esses parcel. Toth Testimony, Einersen Testimony, Ex. Esses 20.

waters passing beneath a public right of way acting as a constructed dike or levee for CMZ purposes might lose their status as fish streams, and therefore their riparian buffers. Mr. Engle explained that the authors did not intend to apply this paragraph to a structure that supports a public right-of-way. Engle Testimony; Lingley Testimony; Ex. DNR-6; Ex. A-29, p. M2-30.

30.

The QIN's *Salmon Habitat Restoration Plan, Upper Quinault River* (Restoration Plan) describes the road system around the upper River. It states:

> The North Shore and South Shore roads parallel each side of the Upper Quinault River. The location of these roads has isolated the river from portions of its floodplain and channel migration zone, resulting in a reduction of total available habitat area throughout the valley. The two roads essentially define the available channel migration zone.

Ex. A-63, p. 24.

31.

The South Shore Road is a major collector road, the highest category of rural highways. The County is able to access FEMA money for repairs to this type of road when the appropriate circumstances are present. The road receives regular maintenance from Jefferson County because it is a popular loop road and provides access to federal lands including the Olympic National Park. The County has armored sections of the road when the River threatens them. There have been sections of the road eroded and relocated in other parts of the River valley. While the South Shore Road has not been constructed in the immediate area of the parcels to withstand the River, it is likely that the County will armor the road if necessary to protect it from erosion caused by the River. Abbe Testimony, R. Esses Testimony, Lingley Testimony, B. Daman Testimony, Ex. DNR 6.

3. The Riparian Management Zone (RMZ)

32.

Sherman Esses and the Damon Family submitted separate forest practices applications, which included alternate plans, on September 6, 2012. To lower overall costs of the regulations for small forest landowners, the law allows the landowners to apply for alternate harvesting plans that allow for less restrictive conditions than prescribed in the forest practices rules, if the public resources will still be protected. See COLs 14-16. Alternate plans must provide protection for the public resources at least equal in overall effectiveness to the protection provided by the rules. Ex. A-30. The applications, numbered FP 2612019 and 2612020, proposed even-aged harvests of 28 acres and 38 acres respectively. Both applications identified Streams 2 and 3 on the parcels as fish streams[12] with bankfull widths of five-plus feet, and proposed harvest within the RMZ on both sides of the streams pursuant to alternate plans. The alternate plans for both applications provide:

> This proposal includes "F" streams based on characteristics that flows only during short duration run-off events. There is very limited fish use due to extreme water velocities during the storm events and dry stream conditions for the remainder of the year. Minimal riparian functions are occurring within these seasonal flowing streams.

[12] For Stream #1 located on the Sherman Esses parcel, the landowner submitted, and DNR approved, an alternate plan which includes a 101-foot no-harvest riparian management zone from the bankfull width on each side of the stream. DNR Ex. 1. No party challenges the RMZ on Stream 1.

Both alternate plans stated that the intent was to "adjust the riparian protection applied to more accurately reflect the amount of riparian function that can be achieved." The proposed management activities are the same for both plans:

> Along type "F" streams #2 and #3 a riparian buffer of 1-tree width will be applied to include all trees directly connected to the terrace "break in slope." A 30' equipment limitation zone will also be applied. WRTs and GRTs will be left in association with their RMZs where possible. RMZ trees will be marked with blue paint. Trees blown down into (or across) the streams shall be bucked 2' outside of the terrace 'break in slope' and the spanning portions shall remain in place. 3-root wads will be placed in the stream channel within stream #1 (fixed width buffer area) to enhance the only fish use areas within these stream systems.

Casey Testimony, Mahan Testimony, Exs. DNR 1, 2.

33.

DNR convened an interdisciplinary (ID) team on September 24, 2012, to review the proposed alternate plans contained in the applications. The landowners, the Nation, Washington State Department of Fish and Wildlife (WDFW), Washington State Department of Ecology (Ecology), United States Fish and Wildlife Service (USFW), and the National Oceanic and Atmospheric Administration (NOAA) were invited to the ID team meeting. Several of the ID team participants expressed concern that the one tree width RMZ was inadequate because it would not provide sufficient shade, sediment filtration, bank protection, large woody debris (LWD), and riparian nutrients, especially given the effects of trees blown down by the wind (blowdown). Ecology suggested that no-cut buffers extending 25 feet per side from bankfull width for both Streams 2 and 3 would be sufficient. Casey Testimony, Mahan Testimony, Exs. DNR 1 through 3.

34.

Based on input from the ID team, DNR modified the proposed RMZs for Streams 2 and 3 prior to approving alternate plans. FPA 2612019, as approved, provides:

1. No harvest within 35 feet of the terrace edge on both sides of creek 3 (from the County Road CMP to the spur road CMP at the south end of the harvest proposal approx. 1,450').[13]
2. Place or directionally fell wood approximately every 100 feet across creek 3. Wood must be at least 10 inches in diameter at the small end and sixteen (16) feet long. Wood must be either felled directionally or placed in the channel at a 45 to 90 degree angle so that at least one-end is located within the bankfull width. See HPA issued by WDFW.

Mahan Testimony; Casey Testimony; Exs. DNR 1, 2.

35.

The functions performed by riparian corridors on streams generally include stream shading, stream bank stability, wood debris availability and recruitment, sediment filtering, and nutrients and leaf litter fall. Ex. A-30, pp. M2-2, M2-3. Due to the unique characteristics of the Esses site, not all of the riparian functions are of equal importance. At this site, all of the witnesses agreed that the most important riparian function for this system, and the one which is most deficient on the site as exists today, is LWD. Because the streams do not flow during the summer months, and because the mountains provide overall shade to the site, shade is not a riparian function of concern. Because the streams are low energy and the banks are wide and stable, bank stability and sediment filtering are not riparian functions of great concern. Further,

[13]FP 2612020 contains identical language except it addresses creek 2 ("from the end of creek 1 to the junction of creek 3 approx. 1,130'"). Ex. DNR 2.

because the area of influence[14] for bank stability on this site is 15 feet from the bankfull width,[15] and the area of influence for sediment filtering is 30 feet from the bankfull width,[16] the 35-foot RMZ from the terrace edge contained in the approved permit more than meets this requirement.[17] There are also sufficient understory plants growing in the channels and on the terrace tops to provide leaf litter and nutrients. Mobbs Testimony, Mahan Testimony, McMurry Testimony, Mendoza Testimony, Ex. A-30.

36.

The Manual explains the importance of LWD as follows:

> LWD provides important habitat diversity by providing structure for stabilizing streambeds, building floodplains, storing sediment, retaining spawning gravels, maintaining flow complexity, storing nutrients, and providing habitat for fish and/or stream-associated amphibians.

Ex. A-30, p. M21-6. It suggests managing for the potential recruitment of LWD for both the short and long term. *Id.* p. M21-7.

37.

The Manual estimates the area of influence for LWD for alternate plans as the distance equal to 75 percent of the 100-year site potential tree height of the tallest trees on site, which on these parcels would be approximately 105 feet. Mendoza Testimony; Ex. A-30, p. M21-6. Trees

[14] The Board Manual explains that the "'area of influence' is the area that may affect a particular riparian function. Site specific conditions determine the size of the area of influence for each riparian function." Ex. A-30, p. M21-3.

[15] The area of influence for bank stability is usually a distance one-half the average crown diameter of the dominant conifer trees closet to the outer edge of the bankfull width. Ex. A-30, p. M21-5.

[16] The area of influence for sediment filtering is usually within 30 feet of the top of the first terrace beyond the outer edge of the bankfull width. Ex. A-30, p. M21-7.

[17] It does not appear that the one tree width RMZ from the terrace break, which was the RMZ proposed in the alternate plan, would adequately protect the area of influence for sediment filtering. Mr. Mendoza provided the only testimony regarding the width of a one tree width buffer when he stated that a 35-foot buffer is about two tree widths.

closest to the stream have the highest potential to fall into the stream. Ninety percent of LWD recruitment comes from trees within the first 50 feet of the bankfull width of a stream. Mahan Testimony. The trees in the outer buffer areas play more of a role in long term LWD recruitment. On Streams 2 and 3, there are generally no trees within the incised channels. The trees closest to the streams start at the top of the terrace break. This means that of the crucial first 50 feet for LWD recruitment, approximately 10 to 20 feet will not provide any LWD because it is devoid of trees. Another factor affecting LWD is blowdown of the trees in the RMZ. These parcels are subject to strong winds, and therefore there is significant blowdown potential. Mobbs Testimony, Mendoza Testimony, Mahan Testimony.

38.

In addition to the lack of trees growing close to the streams in the incised channels, these parcels have other impediments to natural LWD recruitment. One problem is the voids in the surrounding tree stand that leave large gaps with no natural LWD recruitment potential. Another problem is that when trees fall on the site in the riparian areas, they tend to bridge the incised channel, instead of falling into the much smaller streams at the bottom of the channels. This prevents the wood from getting in contact with the water, even during the periods when the streams have water. In addition, because the site is relatively flat up to the terrace break, the trees in the riparian area will not necessarily fall toward the streams. Mahan Testimony; Exs. DNR 1, 2.

39.

The wood placement strategy imposed on the permits will primarily address the lack of LWD on these parcels in the near term. The conditions require the landowners to place LWD in the channel of the stream at regular intervals of 100 feet, and in such a manner that at least one end is located within the bankfull width of the stream. The condition requires that the placed wood be 10 inches in diameter at the small end and sixteen feet long. Pieces meeting this requirement would generally be about 16 inches at the large end. While the conditions do not specify a particular species of wood, the majority of the trees in the area of the streams are conifer, and therefore DNR anticipates that most of the placed LWD will be conifer. Conifer decomposes slower than other wood types, and therefore contributes wood to a stream over a longer period of time. Mahan Testimony; Mendoza testimony; Exs. DNR 1, 2.

40.

The bankfull widths of Streams 2 and 3 are significantly narrower than the incised channels the streams are located in, and therefore a 35-foot buffer from the terrace edge is equivalent to a 40- to 60-foot buffer from the bankfull width. The DNR chose to start the RMZ from the terrace break instead of the bankfull width because on this site the bankfull width is difficult to locate. Mahan Testimony, Mobbs Testimony.

41.

The Board finds that the conditions on these applications requiring a 35-foot buffer from the terrace edge do not provide sufficient LWD recruitment for these parcels, even given the additional LWD placement. Because most of the LWD comes from the first 50 feet of buffer from the bankfull width the Board finds that a full 50 feet of forested buffer is necessary for LWD recruitment on Streams 2 and 3. Therefore, the 35-foot RMZ on these applications does not meet the LWD riparian function. Instead, the Board finds that the condition should require a 50-foot no-cut buffer from the terrace break. A 50-foot no-cut buffer would also help to offset the impacts of blowdown. Mahan Testimony, Mendoza Testimony, Mobbs Testimony.

42.

The original buffer proposed by the landowners (one tree width from the terrace break) is not adequate to meet the riparian functions of LWD recruitment for these parcels for the same reason as the 35 foot no-cut buffer condition. Further, the one-tree-width buffer would suffer even more from the effects of blowdown. Mendoza Testimony, Mahan Testimony.

4. <u>The Nation's Restoration Plan</u>

43.

The Nation has a federally protected treaty right to take fish from the Upper River Valley, which is within their usual and accustomed fishing area. The River and its salmon runs have economic and cultural significance to the Nation. The Blueback sockeye in particular is a cultural icon for the Nation and is unique to the River. Bingaman Testimony, Mobbs Testimony, Ex. A-63.

44.

The sockeye salmon runs in the River have declined dramatically over the last century. Concern regarding these negative changes prompted the Nation to ask the Bureau of Reclamation in 2001 to evaluate the Upper Quinault River sockeye habitat. Ex. DNR 20, p. 1.

The resulting BOR Report concluded that a primary reason for this decline is the clearing of mature forests and large woody debris from the historic floodplain of the River, which has caused the River to lose stability and simplify in shape. This change in the River has reduced its ability to create and maintain habitat for salmon, because as the River moves across the floodplain it destroys productive habitat. A primary limiting factor to salmon production in the River is availability of older side and terrace tributary channels that persist for more than 30 years. Bingaman Testimony; Ex. A-63, p. 17; Ex. DNR-20, pp. 5-9.

45.

Using the information from the BOR Report, the Nation developed a Restoration Plan in 2008. Ex. A-63. The Restoration Plan purposes an ambitious, multi-million dollar, long-term (75 years) framework to restore the stability of the main channel of the River. Ex. A-63, pp. viii, 17. The Nation intends the plan to restore the sockeye runs in the River by reestablishing the River's flood plain, controlling the movement of the River across the floodplain, and reestablishing an anabranching form. If the Nation achieves these goals, and the River returns to an anabranching form, the result will be less migration of the River. The core elements of the Restoration Plan include construction of engineered log jams and application of reforestation methods. The Nation has spent over four million dollars and countless staff hours implementing the plan to date. The Nation has already implemented several projects on the Upper Quinault River, but because of funding issues, it is not known whether the Plan will be fully implemented. Bingaman Testimony, Abbe Testimony, Ex. A-63.

46.

Any Conclusion of Law deemed to properly be considered a Finding of Fact is hereby adopted as such.

Based on the foregoing Findings of Fact, the Board enters the following:

CONCLUSIONS OF LAW

1.

The Board has jurisdiction over the subject matter and the parties pursuant to RCW 43.21B.110(1)(j). The Board reviews the issues raised de novo. WAC 371-08-485(1). These consolidated appeals involve challenges to two approved forest practices permits, and therefore the appealing parties have the burden of proof. WAC 371-08-485 (3). QIN appealed the permits on the CMZ issue, and therefore it has the burden of proof on this issue. Both Esses and QIN challenge the RMZ conditions imposed on the permits, and therefore both have the burden of proof on this issue.

2.

The pre-hearing order identifies the following issues:[18]

1. Whether the Forest Practices channel migration zone of the Quinault River impacts the forest practices proposed in Application Nos. 2612019 or 2612020, and if so, whether the Act and Rules require further conditioning on the applications?

[18] There were originally six issues in this consolidated appeal. The Board dismissed issues 4 and 5 during motion practice. *See Order on Motions for Summary Judgment, Cross Appeal, On-Site ID Team Water Typing Meeting, and Dismissal of PCHB No. 12-071 and 12-078*, issued December 13, 2013 (Summary Judgment Order). Issue 3, which challenges whether the Board can provide effective relief on the RMZ issue, was an issue put forward by Esses. Esses did not address this issue in their pre-hearing brief, opening statements, or closing arguments, nor did they offer any evidence on this issue at the hearing. Therefore, the Board concludes that Esses abandons this issue. *Dep't of Natural Res. v. Browning*, 148 Wn. App. 8, 21, 199 P.3d 430 (2008)(citing *State v. Dennison*, 115 Wn.2d 609, 629, 801 P.2d 193 (1990)).

2. Whether the alternate plans for Application Numbers 2612019 or 2612020 suitably protect the riparian functions of Type F creeks 1, 2, and 3 pursuant to the process and standards set forth in WAC 222-12-040 and WAC 222-12-0401?

6. Whether the Board has jurisdiction to determine damages, and if so what damages were suffered by Esses, if the QIN's Temporary Restraining Order and Temporary Suspension Order were improperly secured?[19]

1. Issue No. 1: The CMZ

3.

DNR approved Application Nos. 2612019 and 2612020 without having completed an analysis of whether any portion of the parcels were within the CMZ or RMZ of the River. After approval, DNR did have Ms. Lingley complete a CMZ analysis. Based on this analysis DNR now contends that the southern edge of the River's CMZ is delineated by the north side of the South Shore Road.[20] QIN, based on Ms. Reinhart's delineation, contends that both parcels are located completely within the River's CMZ. The Damon Family offers two delineations, one from Dr. Einersen and one from Mr. Toth, and based on these delineations argues that the River's CMZ stops further north of the South Shore Road, at least in the vicinity of FP 2612019.

4.

WAC 222-16-010 provides the forest practices regulatory definition of CMZ. The rules define the CMZ as:

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[19] The Board concluded in its Summary Judgment Order that it would not address this issue until after the final hearing. Based on the Board's decision here, the Board now concludes that Issue 6 is moot. Analysis of the basis for this conclusion is in Conclusions of Law, § 3, Infra.

[20] Because DNR approved the applications prior to completing its CMZ delineation, the applications as approved do not reflect the effect of the River's CMZ. DNR prepared two stop work orders to impose the additional restrictions that would result from the DNR's CMZ analysis, but did not issue them because QIN had already appealed the applications and the Board had issued a stay. Mahan Testimony; Exs. A-71, 72.

> [T]he area where the active channel of a stream is prone to move and this results in a potential near-term loss of riparian function and associated habitat adjacent to the stream, except as modified by a permanent levee or dike. For this purpose, near-term means the time scale required to grow a mature forest. (See board manual section 2 for descriptions and illustrations of CMZs and delineation guidelines.)

WAC 222-16-010 ("channel migration zone (CMZ)").

5.

The Board Manual referenced in the rule, while not itself a rule, provides advisory technical guidance on how to apply this definition as a technical matter. WAC 222-12-090. The Manual represents a consensus effort by a group of scientists and foresters to apply the best science to the policy decisions made by the Forest Practices Board. The Forest Practices Board approves the Manual. *Id.*

6.

The regulatory effect of the CMZ, once delineated, is not in dispute. WAC 222-30-020(13) prohibits harvest, construction, or salvage within the CMZ with only limited exceptions for road crossings and yarding corridors. The outer edge of the CMZ provides the starting place for the RMZ, which is also an area of restricted harvest. In this case, the River's RMZ would extend 140 feet from the edge of the CMZ. WAC 222-16-010 ("riparian management zone"); WAC 222-30-021. Therefore, if the Esses parcels are within the River's CMZ, or within the RMZ for the CMZ, DNR's approval of the applications is invalid.

7.

In the face of competing CMZ delineations from qualified experts, the Board concludes that the delineation that is consistent with the rule definition and the technical guidance provided in the Manual is the most reliable, as it is based on well-developed, science-based guidance approved by the Forest Practices Board. The Board has found, based on consideration of the testimony of all of the experts, that Ms. Lingley's approach to delineation of the CMZ was the most consistent with the rule definition and Manual. The Board has also found that it is most credible because it is based on the longest period of analysis for establishment of the HMZ, and because it takes a conservative approach to the erosion calculation while still being consistent with the Manual. Further, the Board concludes that it is appropriate to give deference to DNR's position on a technical matter, given that DNR is the regulatory agency with specialized knowledge and expertise in the area of forest practices, and the agency charged by the Legislature with enforcement of the Forest Practices Act and rules. RCW 76.09.040(1)(c); *Port of Seattle v. Pollution Control Hearings Bd.*, 151 Wn.2d 568, 594-95, 90 P.3d 659, 673 (2004), citing *Department of Ecology v. Public Utility District No. 1 of Jefferson County*, 121 Wn.2d 179, 849 P.2d 646 (1993), *aff'd*, 511 U.S. 700, 114 S.Ct. 1900, 128 L.Ed.2d 716 (1994); *Strahm v. DNR*, PCHB Nos. 11-045 & 11-068, ¶ 14 (Order Granting Summary Judgment, Oct. 29, 2012).

8.

Based on Ms. Lingley's delineation, including her calculation of an erosion rate that results in an extensive EHA in the vicinity of the parcels, the CMZ extends in a southerly direction beyond the South Shore Road and approximately half way into the parcels. This directly raises the question of the effect of the road on the forest practices regulatory CMZ delineation; specifically, whether the road is a channel limiting structure that would limit the River's CMZ to the South Shore Road at the Esses parcels.

9.

The Board Manual addresses the effect of permanently maintained dikes or levees on the delineation of the CMZ. The section in its entirety states:

> Disconnected Migration Area (DMA): The disconnected migration area (DMA) is the portion of the CMZ behind a permanently maintained dike or levee. The CMZ of any stream can be limited to exclude the area behind a permanent dike or levee provided these structures were constructed according to appropriate federal, state, and local requirements. As used here, a permanent dike or levee is a channel limiting structure that is either:
>
> 1. A continuous structure from valley wall or other geomorphic structure that acts as a historic or ultimate limit to lateral channel movements to valley wall or other such geomorphic structure and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedance flow); or
> 2. A structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity (Figure 19).
>
> A dike or levee is not considered a "permanent dike or levee" if the channel limiting structure is perforated by pipes, culverts, or other drainage structures that allow for the passage of any life stage of anadromous fish and the area behind the dike or levee is below the 100-year flood level.
>
> The Washington Department of Fish and Wildlife (WDFW) and the Indian tribes can often provide assistance in evaluating the potential for seasonal fish passage and use of the floodplain, as well as details on dike permitting. Applicants should also contact local, state, federal, and tribal entities to make sure that there are no plans to remove the structure.

Ex. A-29, p. M2-30. This written description is followed by an aerial photograph of a CMZ disconnected by a public right-of-way. *Id.*, Figure 19.

10.

QIN argues, based on this section, that the South Shore Road is not a "permanent dike or levee" that limits the River's CMZ because (1) it contains culverts and (2) the area south of the road is below the 100-year flood level. QIN bases this interpretation on the conclusion that the first unnumbered paragraph after point 2 applies as a limitation to both point 1 and point 2. The structure of this section supports the Nation's interpretation; however it is problematic because it would eliminate virtually all roads from ever constituting channel limiting structures because most roads have culverts. This result does not make sense, given that the authors of the Manual chose to include point 2, and under QIN's interpretation point 2 would be meaningless.[21] It is also inconsistent with the depiction in Figure 19, which shows a road operating to limit a CMZ. There is no reason to think that the road in the Figure, like most roads, would not have culverts. Finally, it is inconsistent with the definition of "dike or levee" found in the glossary section of this Board Manual chapter. This definition states:

> **dike or levee (constructed):** A continuous structure from valley wall to valley wall or other geomorphic feature that acts as an historic or ultimate limit to lateral channel movements and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedance flow); or a structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity.

[21] A principle applied by the Courts when construing an ambiguous statute is that all language within a statute must be given effect so that no portion is rendered meaningless or superfluous. *Muckleshoot Indian Tribe v. Washington Dep't of Ecology*, 112 Wn. App. 712, 720, 50 P.3d 668, 673 (2002), *review denied* 150 Wn.2d 1016, 79 P.3d 446 (2003).

Ex. A-29, p. M2-61. This definition does not include any of the limiting language regarding the presence of culverts or the 100-year flood level in the clause pertaining to roads.

11.

DNR offered a reasonable explanation at the hearing as to how this Manual section came to contain the language at issue. DNR explained that members of the committee added this paragraph after they completed the rest of the Manual chapter to address a concern that Type F waters passing beneath a public right of way that acted as a constructed dike or levee for CMZ purposes, might lose their status as fish streams, and therefore their riparian protections. Engle Testimony. With this explanation in mind, and given all of the reasons why the interpretation advocated by the Nation is not reasonable, the Board concludes that the better interpretation of this section of the Manual is that the paragraph beneath point 2, stating that a dike or levee is not considered a "permanent dike or levee" if the channel limiting structure is perforated by drainage structures, does not apply to limit point 2, which pertains to structures supporting public right of ways. Further, this is the interpretation advocated by DNR, the agency charged by the Legislature with enforcement of the Forest Practices Act and rules, and therefore the Board concludes that DNR's interpretation of this ambiguous section of the Board Manual is entitled to deference. *Friends of the Columbia Gorge, Inc. v. Washington State Forest Practices Appeals Bd.*, 129 Wn. App. 35, 56, 118 P.3d 354, 364 (2005).

12.

QIN further argues that the South Shore Road in the vicinity of the parcels will not function as a permanent dike or levee because the County has not currently built it to withstand the erosive forces of the River. There have been sections of the road eroded and relocated in other parts of the River valley. All parties agree that the South Shore Road in the area of the parcels, while well maintained now, would not hold the River back if it approaches the road. However, the River has not approached the road in this area to date, so Jefferson County has not had to take action to protect the road. The County has protected other sections of the South Shore Road through armoring, however, when those sections were threatened or damaged by the River. DNR argues, and the Board agrees, that based on the history of efforts to protect the road from erosion and the reliance of the residents and the local, state, and the federal governments on the South Shore Road, it is reasonable to conclude that Jefferson County will take similar action in the future to protect the South Shore Road from the River in the vicinity of the parcels. This approach is supported by the language in point 2 of the manual which identifies a road that "receives regular maintenance sufficient to maintain structural integrity" as one that should be considered a permanent dike or levy. Ex. A-29, p. M2-61.

13.

The Board concludes that DNR's CMZ analysis, which ends the CMZ delineation at the north side of the South Shore Road, is scientifically supportable and most consistent with the policy direction identified in the Manual. Based on this CMZ delineation and the forest practices rules, the Quinault River RMZ for FP's 2612019 and 2612020 should begin at the northern side of the South Shore Road, and extend for 140 feet into the Esses parcels. WAC 222-30-021.[22]

2. Issue No. 2: The Alternate plans

14.

RCW 76.09.368 sets out the intent of the Legislature that "small forest landowners have access to alternate plan processes or alternate harvest restrictions, or both if necessary, that meet the public resource protection standard set forth in RCW 76.09.370(3), but which also lowers the overall cost of regulation to small forest landowners . . . ." RCW 76.09.370 clarifies that alternate plans should provide protection to public resources at least equal in overall effectiveness to the forest practices rules by alternate means. RCW 76.09.370(3); WAC 222-12-0401(6).

15.

WAC 222-12-0401 sets out the process for applying for an alternate plan. A plan must include a description of how it provides "public resource protection to meet the approval standard, including a description of the proposed alternate management strategy, prescriptions, and where applicable, aquatic resource enhancements" and "[a] list of the forest practices rules that the alternate management plan is intended to replace." WAC 222-12-0401(3)(b)(c). The rule goes on to provide for an ID team site visit prior to approval. WAC 222-12-0401(5).

[22] The Board notes that based on its conclusion that the South Shore Road limits the CMZ, the CMZ would end in the same place (the north side of the South Shore Road) regardless of whether the Board uses Ms. Reinhart's CMZ delineation or Ms. Lingley's.

16.

For FP No. 2612020, Sherman Esses proposed to use a "template alternate plan" for his alternate plan for Stream 1. A template alternate plan is an alternate plan developed by DNR based on direction from the Legislature, for use by small landowners. RCW 76.13.110(3), WAC 222-12-0403, Ex. A-30, p. M2-8 through M2-16. The specific template alternate plan used on FP No. 2612020, Template 2, provides for a 101-foot no-harvest RMZ from the bankfull width on each side of Stream 1. *Id.*, pp. M21-15, M21-16. Template 2 replaces the RMZ requirements of WAC 222-30-021(1). DNR approved the Template 2 alternate plan for Stream 1 without modification. No party challenges the RMZ on Stream 1. The Board concludes that the RMZ for Stream 1, as stated in the approved FP No. 2612020 satisfies the requirements of WAC 222-12-040 and 0401.

17.

FP Nos. 2612019 and 2612020 also contained proposed alternate plans to replace the RMZs on Streams 2 and 3. Pursuant to the regular forest practices rules, these streams would require a 140 foot buffer from the bankfull width of the streams. See WAC 222-30-021. The proposed alternate plans, which were not template alternate plans, proposed one tree width buffers for Streams 2 and 3. Esses argued at hearing that the one tree width buffer would be at least equal in overall effectiveness for the streams as the rule based RMZ.

18.

Members of the ID team and DNR staff that reviewed these applications concluded that the one tree width buffers were inadequate, primarily because they did not provide adequate

LWD recruitment. This is especially true given the anticipated blowdown on the site. The Board agrees. The Board concludes based on the facts presented at the hearing, that the one-tree width standard does not adequately protect the riparian function of LWD recruitment.

19.

The applications, as approved by DNR, contain 35-foot no-cut buffers from the top of the terrace break on Streams 2 and 3, and a requirement of placement of LWD in Streams 2 and 3. DNR contends that this buffer and LWD placement requirement are equally protective of the riparian functions on this site as the 140-foot RMZ required under WAC 222-30-021(1). QIN contends otherwise, and the Board agrees. The Board concludes that the 35 foot buffer is inadequate to meet the riparian function of LWD recruitment. Instead the Board concludes that a 50 foot buffer from the terrace break, along with the placement of LWD, is necessary to adequately protect the riparian functions on this site.

20.

The Board has found that because of site specific characteristics, the only riparian function on this site not adequately protected by a 35-foot buffer from the terrace break is LWD availability and recruitment. The availability and recruitment of LWD is of primary concern on this site, and most of the LWD recruitment comes from trees located within the first 50 feet of a stream. On this site, due to the large incised channels that contain small streams, there are no trees between the bankfull width of the small streams and the terrace break. Therefore, the Board concludes it is necessary to begin the RMZ from where the trees start at the top of the terrace break and protect a full 50 feet of trees to ensure adequate LWD recruitment.

21.

The Board concludes that the placement of wood in Streams 2 and 3 is necessary to provide short term LWD availability.[23] The Board concludes that the condition as drafted on the approved applications is adequate to satisfy this need, given that the wood will be generally 16 inches at the large end, and primarily conifer, due to the presence of predominantly conifer on the parcels in the vicinity of the streams.

3. Issue No. 6: Damages

22.

After appealing the validity of DNR's approval of FP 2612019 and 2612020, QIN sought an injunction, prohibiting Esses from cutting trees on the parcels pending a full evidentiary hearing on the merits of QIN's appeal. The Board's presiding officer issued an emergency discontinuance order, which was effective for 14 days. *Order Granting Temporary Restraining Order*, issued November 9, 2012. In response to a motion from QIN, the Board subsequently dissolved the emergency discontinuance order and issued a temporary suspension order, and required the posting of a $50,000 bond as security. *Order on Motion for Temporary Suspension*, issued November 21, 2012. The temporary suspension order allowed Esses to remove trees from the site that had been previously cut, but not to do any further cutting of trees. The suspension order was to remain in effect until the Board issued a final decision on the merits.

[23] This remains true even with 50-foot buffers because the standing trees provide long term LWD recruitment potential, but the wood placed in the streams addresses short term LWD availability. *See* FF 37, 39, *supra*.

23.

Esses appealed the emergency and temporary suspension order to the Superior Court, which upheld the orders and remanded to the Board for further proceedings. *Order and Judgment Affirming the Order of the Pollution Control Hearings Board*, Case no. 12-2-02624-3, issued April 3, 2013. Pursuant to this Court direction, the Board acted on pending motions and then conducted this evidentiary hearing. The Board has now concluded its proceedings, and determined that based on the findings and conclusions above, DNR improperly approved FP 2612019 and 2612020, and that the applications as approved were invalid.

24.

On the basis of this final decision, the Board concludes that Esses was not wrongfully restrained from proceeding with harvest under these invalid permits. *See Nintendo of Am., Inc. v. Lewis Galoob Toys, Inc.*, 16 F.3d 1032, 1036 (9th Cir. 1994), *cert denied* 115 S.Ct. 85 (1994)(holding that a party has been wrongfully enjoined[24] within the meaning of Rule 65(c) when it turns out the party enjoined had the right all along to do what it was enjoined from doing).

[24] As the *Nintendo* Court explained, there is a difference between a party being wrongfully enjoined and an injunction being wrongfully issued. As that Court states: "We prefer the wording of Rule 65(c), which speaks in terms of a party who has been 'wrongfully enjoined,' rather than the wording in some cases in other circuits which refers to an injunction as having been 'wrongfully issued.' Fed.R.Civ.P. 65(c). A court that complies with the applicable law in issuing a preliminary injunction does not 'wrongfully' issue it. Indeed, in an earlier appeal in this case we upheld the district court's issuance of the preliminary injunction." Nintendo, 16 F.3d at 1036. Likewise here, the Superior Court has already affirmed the Board's issuance of its emergency and temporary suspension orders.

Here, Esses did not have the right to harvest under these improperly approved permits, and therefore Esses was not wrongfully restrained. Therefore, the Board concludes that Esses cannot recover on the bond.

25.

Since there can be no recovery on the bond, the Board concludes that Issue 6, the question of the Board's authority to determine damages, and the amount of damages, is now moot.[25] *Orwick v. Seattle*, 103 Wn.2d 249, 252-3, 692 P.2d 793 (1984)(An issue is considered moot when a court can no longer provide effective relief.); *In re Cross*, 99 Wn.2d 373, 376-77, 662 P.2d 828(1983); *City of Moses Lake v. Grant Cy. Boundary Review Bd.*, 104 Wn. App. 388, 391 (2001), *rev. denied* 95 P.3d 758 (2004). Based on this analysis, Issue 6 is dismissed.

26.

Any finding of fact deemed to be a conclusion of law is hereby adopted as such.

ORDER

1. DNR's approvals of FP 2612019 and 2612020 are reversed.

2. FP 2612019 and 2612020 are remanded to DNR to reissue with the following modifications:

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[25]Issue 6 states: "Whether the Board has jurisdiction to determine damages, and if so what damages were suffered by Esses, if the QIN's Temporary Restraining Order and Temporary Suspension Order were improperly secured?". *Pre-Hearing Order,* issued December 7, 2012, p. 2 (emphasis added)." The Board understands this issue to raise the question of whether the Board has jurisdiction to determine damages, and if so what damages were suffered by Esses, if Esses had been wrongfully restrained? This is the way Esses, the party that proposed this issue, stated it in their motion briefing filed on June 7, 2013. See *Esses Supplemental Memorandum of Law regarding the Board's Jurisdiction to Award Damages*, pp. 1, 2. In its Summary Judgment Order, the Board deferred ruling on this issue until after the Board's final hearing. *See* footnote 18, supra.

a. conditions that provide for a 140-foot RMZ for the Quinault River, starting from the north side of the South Shore Road.

b. conditions that require a no-harvest RMZ on both sides of Streams 2 and 3 starting from the terrace edge and extending 50 feet.

3. DNR may impose mitigation requirements as necessary to prevent material damages to public resources in those areas that have already been harvested within the 140-foot Quinault River RMZ or the 50 foot RMZ on Streams 2 and 3. If DNR imposes such mitigation requirements, it shall do so through issuance of a Notice to Comply.

4. The Board's Order on Motion for Temporary Suspension, issued November 21, 2012, is hereby lifted.

SO ORDERED this 29th day of April, 2014.

POLLUTION CONTROL HEARINGS BOARD

TOM MCDONALD, Chair

KATHLEEN D. MIX, Member

Kay M. Brown
Administrative Appeals Judge, Presiding

BOARD MANUAL
SECTION 2

Section 2
Standard Methods For Identifying Bankfull Channel Features and Channel Migration Zones

The purpose of this section of the board manual is to help identify the point along the stream where measurement of the riparian management zone (RMZ) begins. The section is divided into two parts that describe how to identify bankfull channel features and channel migration zones (CMZ), respectively. *For streams that show evidence of migration as described in this manual, the RMZ begins at the outer edge of the CMZ. For streams without such migration, the RMZ begins at the outer edge of the bankfull width.*

PART 1. BANKFULL CHANNEL FEATURES

If you determine no channel migration zone (CMZ) is present, the next step is to identify the bankfull width of the stream.

1.1 Background

Forest practices rule, WAC 222-16-010, provides the following definition for bankfull depth and width:

"Bankfull depth" means the average vertical distance between the channel bed and the estimated water surface elevation required to completely fill the channel to a point above which water would enter the floodplain or intersect a terrace or hillslope. In cases where multiple channels exist, the bankfull depth is the average depth of all channels along the cross section.

"Bankfull width" means:

- For streams - the measurement of the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth. In cases where multiple channels exist, bankfull width is the sum of the individual channel widths along the cross section.
- For lakes, ponds, and impoundments – line of mean high water.
- For tidal water – line of mean high tide.
- For periodically inundated areas of associated wetlands – line of periodic inundation, which will be found by examining the edge of inundation to ascertain where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland.

If a CMZ is not present, measurement of the riparian management zone (RMZ) begins at the outer edge of the bankfull width. Guidance for measuring bankfull width and depth in this manual refers to a measurement of channel dimensions at bankfull flow and not for other parts of the bankfull width definition: b) lakes, ponds, and impoundments; c) tidal water (tidally influenced channels); or d) periodically inundated areas of associated wetlands. See Board Manual Section 8 for guidance.

Bankfull Channel Dimensions and Flood Frequencies

The width and depth of a stream channel reflects flow magnitudes and sediment load over time. Channel size is established by the smaller, more frequent flood events that over time accomplish the greatest volume of sediment transport. While a 100-year recurrence interval flood moves more material than a two-year recurrence interval flood, the cumulative sediment movement from fifty two-year floods over 100 years is usually far greater than the one 100-year flood. The bankfull flow typically represents a discharge that is reached in most years.

1.2 Identifying Bankfull Width and Bankfull Depth

The edge of the bankfull channel typically corresponds to the start of the floodplain. A floodplain receives floodwaters in most years, but is generally vegetated by perennial plants and trees. This vegetation often reflects repeated flow-related disturbance and may not support mature trees. The following primary indicators are used to characterize the start of the floodplain:

- **Topography** - A berm or other break in slope from the channel bank to a flat valley bottom, terrace or bench;
- **Vegetation** - A change in vegetation from bare surfaces or annual water-tolerant species to perennial water-tolerant or upland species; and
- **Sediment Texture** - A change in the size distribution of surface sediments (e.g., gravel to fine sand) (Figure 1).

Field determination of the bankfull channel edge generally relies on two or more of the following:

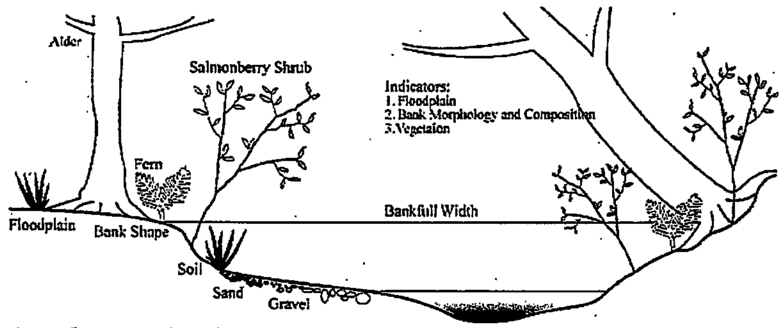


Figure 1. Indicators for determining bankfull width (adapted from Pleus and Schuett-Hames, 1998).

If physical obstructions, such as log jams, or a lack of indicators prevent accurate identification of the bankfull width at a particular point, move to the nearest place where identification is feasible. In cases where the outer edge of the bankfull width is easier to determine on one side of the channel than the other, simply identify the bankfull width on one side and project across at that same elevation to the other bank.

In streams where the substrate is dominated by boulders or bedrock or where the channel is tightly confined, a distinct floodplain may not exist. In these situations, you will have to rely on secondary indicators, such as vegetation or other evidence of flood flows to determine the bankfull width. These indicators may include:

- A change in vegetation from bare surfaces or annual water-tolerant species to perennial upland or water-tolerant shrubs and trees;
- Bare areas associated with scour around woody debris or other obstructions;
- The top of point bars; or
- The lowest elevation at which fine organic debris is caught on brush or trees.

One approach to help identify the bankfull edge is to evaluate the indicators discussed previously from within the bankfull channel looking towards the suspected bankfull edge. Identify the point where the certainty of being within the bankfull channel is less than 100%. Then, repeat this process, but begin on the floodplain and work towards the channel. This exercise should help narrow the focus to the area between the two markings where more subtle indicators of the bankfull edge may be found (Pleus and Schuett-Hames, 1998).

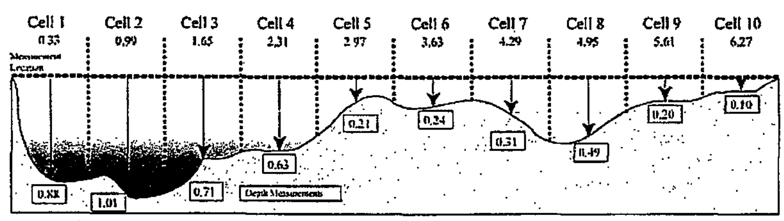
1.3 Measuring Bankfull Width and Depth

Once the edges of the bankfull channel are determined, one can easily measure bankfull width and the average bankfull depth. A tape measure and measuring rod (such as a surveyor's rod) are useful to make these measurements. String wrapped around wooden stakes may also be helpful to more easily mark reference points. The most common situations where these measurements will be helpful are when one needs to:

- Determine a width category for the RMZ rules (see Board Manual Section 7); or
- Determine functional large woody debris size for CMZs in meandering rivers or as part of the LWD placement protocol. See Board Manual Section 26.

To measure bankfull width, attach or have an assistant hold one end of the tape at the bankfull edge and extend the tape to the other edge of the bankfull channel. The outlets of overflow swales, small islands, log jams, backwater eddies or regularly flooded adjacent wetlands may all occur within the bankfull width. In cases where multiple channels exist, such as around a small island, bankfull width is the sum of the individual channel widths along the cross section.

Bankfull depth is the average distance from the channel bed to the estimated water surface elevation at bankfull flow. With the measuring tape extended across the channel, divide the bankfull width into ten evenly spaced sections (Figure 2). Depth measurements are taken at the center of each section. The average bankfull depth is then calculated by dividing the sum of all depth measurements by the number of measurements.



Bankfull Width = 6.6 m
Cell Interval = Bankfull Width * 10% = 0.66 m
Average Bankfull Depth = Sum of depth measurements / 10 = 0.478 m

Figure 2. Measurement of bankfull depth using the 10% cell method (adapted from Pleus and Schuett-Hames, 1998)

When characterizing the average bankfull width or depth for a certain stream length, take enough cross sectional measurements to provide an accurate representation of the general channel size. For channels that are obviously greater or less than 10 feet in width in Western Washington or greater or less than 15 feet in Eastern Washington, bankfull width measurements are not necessary. For channels widths that are not obviously discernible, bankfull width should be measured with at least 10 evenly spaced measurements over a representative section of at least 500 linear feet. Please refer to the TFW monitoring program's "Method Manual for Reference

Point Surveys" for more detailed information on determining bankfull width or depth (Pleus and Schuett-Hames 1998).

PART 2. CHANNEL MIGRATION ZONES

2.1 Introduction

This manual is a technical supplement to the forest practices rules to assist landowners, foresters and others in determining whether a channel migration zone (CMZ) is present in a proposed forest practice activity area and, if so, to assist in the delineation of the CMZ. The forest practices rules define a CMZ as *"the area where the active channel of a stream is prone to move and this results in a potential near-term loss of riparian function and associated habitat adjacent to the stream, except as modified by a permanent levee or dike. For this purpose, near-term means the time scale required to grow a mature forest"* (WAC 222-16-010).

This manual section is organized to first help the user distinguish if the stream segment adjacent to a proposed forest practices activity is prone to migration (Part 2.2). Once it has been determined that channel migration has historically occurred or is occurring along the segment, Part 2.3 provides technical guidelines and likely scenarios for CMZ delineation. Part 2.4 provides possible CMZ review steps and a description of where and what type of additional analyses may be necessary. A glossary of technical terms used in this manual can be found in Part 2.6.

In delineating a CMZ, we attempt to anticipate the type and scale of large channel-changing events that may occur during a 25, 50, or 100-year flood event. The scale of events for which we have some predictive capability. Careful evaluation of field evidence will help the landowner determine the limit of channel migration over the near-term future. An understanding of general river processes may also be helpful to the landowner. To this end, technical background (Part 2.5) is included, and users of this manual are encouraged to become familiar with the concepts offered.

2.2 Determining if Channel Migration Is Present

Prior to delineating a CMZ adjacent to any harvest unit, one first needs to determine if channel migration has historically occurred. Evidence that channel migration is occurring now or has occurred in the past can be observed by viewing topographic maps and aerial photographs and by observing lines of evidence on field inspections. This part describes the two distinct steps to perform this determination; 1) an Office Review and 2) a Field Evaluation.

1. Office Review to Determine Channel Migration: The purpose of the Office Review is to look for obvious indicators of past channel movement, to gather information about channel features, and to facilitate and complement the field evaluation. Use the CMZ Office Review Form in conjunction with historical and current aerial photography and topographic maps to do this review. The text following the form provides technical guidance for questions on the form.

CMZ Office Review Form

Collect appropriate tools, including USGS 7 ½' quadrangle topographic maps, current and historic aerial photographs (oldest and some years in between oldest and most recent is recommended). List the source, year, and scale of all historical information used (for example, DNR aerial photograph, 1995, 1:12000):

Examine upstream and downstream from the harvest unit boundaries as necessary to determine stream behavior. If the stream of interest is not mapped on the USGS topographic map, or if channel features are too small to be visible on the aerial photographs, proceed to the Field Evaluation Form.

Question 1: Do you observe obvious channel movement between aerial photograph years?

No. Go to Question 2.
Yes. Proceed directly to Part 2.3 Delineating the Channel Migration Zone.

Question 2: Using Board Manual guidance, evaluate valley confinement from USGS Topographic Map or aerial photographs.

_______ Valley floor is significantly wider than the channel. Channel migration may be occurring.

_______ Valley floor is very narrow, obviously less than twice as wide as the channel. If you can clearly see this circumstance on the aerial photographs, it is unlikely that channel migration is occurring.

In both cases, proceed to Question 3.

Question 3: On the aerial photographs, do you observe:

Yes	No	
_____	_____	Secondary Channels
_____	_____	Multiple Channels (braiding or anabranching)
_____	_____	Large Gravel Bars
_____	_____	Young Disturbance Vegetation
_____	_____	Eroding Banks
_____	_____	High Sinuosity
_____	_____	Wood Jams

If "yes" to 1 or more channel features, channel migration is likely to be occurring. Proceed to Part 2.2 Field Evaluation to Determine Channel Migration.

If none of these channel features are evident on the aerial photographs, proceed to Field Evaluation to Determine Channel Migration to confirm that no channel migration has historically occurred.

Observations of Channel Migration from Photos and Maps: For larger rivers, active channel migration is often readily observed on a single aerial photograph or by comparing aerial photographs and maps. Where channel migration is apparent, proceed directly from the Office Review Form to Part 2.3 Delineating the Channel Migration Zone.

A lack of channel movement visible on aerial photographs does not mean that channel migration has not occurred. In particular, photos may be of limited value in observing the movement of small streams. If channel migration is not observed in the aerial photographs and topographic maps, proceed to Part 2. Field Evaluation to Determine Channel Migration for final determination.

Determining Valley Confinement from Photos and Maps: Valley width is the area within the comparatively flat valley bottom, measured from the edges of significant changes in topography (typically the base of hills or mountains). In migrating channels, the valleys must be wide enough to accommodate lateral movement of the stream. The Forests and Fish Report (WSDNR et al., 1999) identifies streams potentially associated with a CMZ as those that are moderately confined or unconfined.

Aerial photographs may be useful to estimate valley confinement. However, aerial photographs must be viewed in stereo, otherwise the features of interest may not be apparent. From the photos:

1. Identify valley walls where hillslopes or other significant topographic controls begin. Measure the average valley width along the segment;
2. Identify the width of the active stream channel (this includes areas currently under water, adjacent unvegetated areas, and vegetated islands). Measure the average channel width along the segment; and
3. Determine the ratio of average valley width to average channel width (i.e., approximately less than 2 times valley width or greater than 2 times valley width).

Topographic maps can also be used to estimate valley confinement:

1. Measure the average valley width between the contour lines that define the valley walls. The contour lines of the valley bottom will be broadly spaced, and those of the adjacent hillslopes will be more closely spaced (Figure 3);
2. Observe how sharply angled the contour lines surrounding the channel are. Valleys that are tightly confined will have closely spaced contour lines that form a narrow upstream-pointing V-shape (see the stream labeled "Creek" in Figure 3). Unconfined valleys will have more widely spaced contours that form an open V- or U-shape (Figure 3);
3. Estimate the average channel width from aerial photographs or field knowledge; and
4. Determine the ratio of average valley width to average channel width (i.e., approximately less than 2 times valley width or greater than 2 times valley width).

It can be difficult to measure channel confinement from standard 7.5 minute topographic quadrangle maps (1:24,000 scale), especially for small channels because the channel widths are difficult to discern. Wherever possible, stream channel confinement estimated from topographic maps should be confirmed with aerial photographs and field observations. Where available, high-resolution topography from photogrammetry, Light Distancing And Ranging (LiDAR), and land surveys can be extremely useful in identifying channel features.

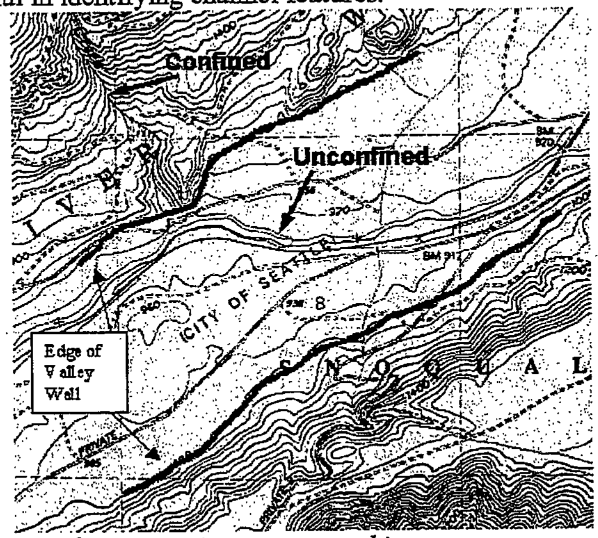
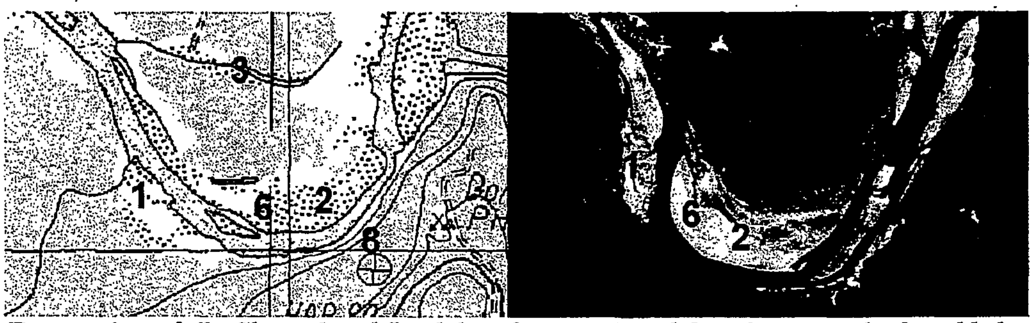


Figure 3. Valley confinement using a topographic map.

Aerial Photograph Observations of Channel and Floodplain Features: The following figures are examples of aerial photographs and a map that display one or more of the channel and floodplain features listed on the Office Review Form.

Figure 4. Channel and floodplain features (floodplain feature codes listed below).

Figure 5. Channel and floodplain features(floodplain feature codes listed below).



Figures 6a and 6b. Channel and floodplain features (floodplain feature codes listed below).

Figures 4, 5, 6a, and 6b. Examples of channel and floodplain features: 1) obvious channel movement; 2) high sinuosity; 3) secondary channels; 4) braiding; 5) anabranching (multiple channels around vegetated islands); 6) large gravel bars; 7) young disturbance vegetation; 8) eroding bank.

Aerial Photographs Observations of Bank Erosion: Observable lateral movement of the channel may be due to avulsion or erosion processes. Avulsion is likely to involve floodplain surfaces, where erosion may involve higher floodplain and terrace edges. It may be possible to distinguish between these processes from examination of aerial photographs. An avulsion may isolate a portion of the floodplain between channels, whereas bank erosion will not. The exposed soils (scarp) of the eroding bank may also be observable in the photos. Bank erosion can be episodic and strongly correlated with flood frequency, so care must be taken to evaluate a sufficiently long period of time to determine if significant bank retreat is occurring within the segment. The office analysis time frame should include the entire length of the aerial photograph record and/or cover at least two decades to account for impacts of larger events (Figure 7a and 7b).

Figures 7a and 7b. Bank erosion between two sets of aerial photographs.

2. Field Evaluation to Determine Channel Migration
The purpose of the field evaluation is to use field observations to determine if historical channel migration has occurred and, therefore, if a CMZ delineation is necessary. This is accomplished by working through observations of evidence in the Field Evaluation Table below. Evidence identified on the Field Evaluation Table is described in detail following the table.

When field evidence indicates channel migration to be occurring, proceed to Part 2.3 Delineating the Channel Migration Zone. If no evidence of historical channel migration is found, then establish a RMZ from the bankfull edge of the stream (see Part 1. Determining Bankfull Width). When experienced with the Field Evaluation Table, a field practitioner may find the Flow Chart for Determining Channel Migration to be a useful field tool.

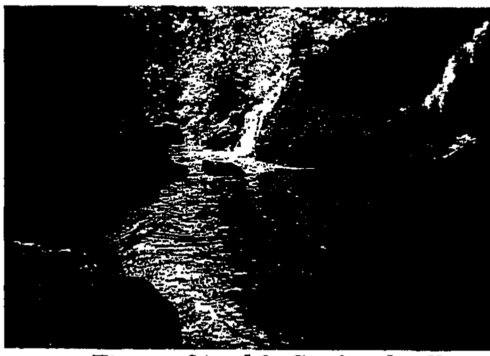
To conduct a field reconnaissance for evidence of channel movement, the entire floodplain within or adjacent to the project and, as necessary, some distance beyond the area of the forest practice should be walked to observe the character of the channel. Evidence of channel migration should be obtained from a homogenous channel segment. To establish a homogenous channel segment, follow the guidance outlined in Part 2.3. Note that permission of adjacent landowners to access their property may be required.

Field Evaluation Form

Evidence Category		Observations	Next Step
Valley Confinement	C1	The width of the valley floor is less than 2 times bankfull width of the channel.	No CMZ; delineate RMZ from bankfull edge.
	C2	The width of the valley floor is equal to or greater than 2 times the bankfull width of the channel.	CMZ may be present; continue to lateral activity category.
Lateral Activity	L1	No lateral movement possible due to presence of bedrock bed and banks or other erosion-resistant material.	No CMZ; delineate RMZ from bankfull edge.
	L2	There is obvious lateral movement of the channel.	Proceed to delineating the CMZ.
	L3	Neither L1 nor L2 is true.	Continue to vegetation category.
Vegetation	V1	Along a representative channel, old growth conifer trees or stumps occur uninterrupted from higher terraces or valley walls down to both stream edges and there are no secondary channels.	No CMZ; delineate RMZ from bankfull edge.
	V2	There are age-progressive bands of trees or other linear vegetative features of channel migration on the floodplain.	The channel is migrating or has historically migrated. Proceed to delineating the CMZ.
	V3	There is no vegetative evidence of channel migration (except, perhaps, interrupted old growth trees or stumps).	Continue to secondary channels category.
Secondary Channels	S1	There are no secondary channels.	No CMZ. Delineate RMZ from bankfull edge.
	S2	There are secondary channels on the floodplain and all bed elevations lie above the bankfull elevation of the main channel.	Historical channel migration may have occurred but was not identified by this evaluation. Proceed to Part 2.3 Delineation of the Historical Migration Zone (HMZ) for further evaluation.
	S3	There is at least one secondary channel on the floodplain with bed elevation at or below bankfull elevation.	The channel is migrating; proceed to delineating the CMZ.

Valley Confinement (Field Evaluation Form C1-C2): Measuring valley confinement is the first step in determining if CMZ delineation is necessary. Measuring valley confinement in the field is accomplished by measuring the width of the entire valley floor from hillslope to hillslope and comparing this value with the bankfull width of the stream. When characterizing the average bankfull width and average valley width for the channel segment, take enough measurements to provide an accurate representation of valley confinement. Where valley confinement is not obviously discernible, bankfull width and valley width should be measured and averaged from at least 10 evenly spaced cross section transects along the channel segment.

If valley width is less than 2 times bankfull width, on average (C1), it is not necessary to delineate a CMZ. If valley width is approximately equal to or exceeds 2 times bankfull width, on average (C2), continue the evaluation (Figures 8 and 9).



Figures 8 and 9. Confined valley and an unconfined valley.

Before proceeding with the rest of the field evaluation, review the definitions of "terrace" and "floodplain". These terms are defined to help with distinguishing between terraces and the floodplain surfaces where most of the field evidence for historical channel migration will be found.

"*Terrace*," as defined here, is a former or relict floodplain no longer inundated by floodwater given the current climate. A non-floodable terrace surface is not considered to have the potential to be re-occupied by the river or stream under the current climate regime and natural wood loads; however, it could be susceptible to erosion by the stream. Some care must be taken when identifying surfaces as terraces because any land-use or management-induced loss of large woody debris may have resulted in the channel incising into its floodplain, temporarily stranding surfaces that are floodplain surfaces during times of natural wood loads.

Evidence of a terrace surface include, but are not limited to:

- No evidence of inundation by floodwaters
  - No evidence of fine sediment deposition on the surface or embedded in tree bark or moss;
  - No flotsam hanging in the brush;
  - No stick or log jams on the surface; and
  - No evidence of flowing water on the surface, such as scour features, flattened grass or secondary channels formed by scour action of the modern river.
- There is soil development (presence of a deep A-Horizon or humus organic layer).
- There are noticeable differences in the geologic materials as compared with lower surfaces (e.g., glacial deposits versus Holocene alluvium).
- Vegetation on the surface is dominated by upland plant species, except where there are perched wetlands.
- The surface lies ABOVE the elevation of the 100-year flood inundation. Usually, this can be reasonably agreed to, taking into account evidence of incision and wood loss. It should be a rare situation where this elevation needs to be quantified.

"*Floodplain*," as defined here, is the area of the valley that can flood given the current climate and natural loads of large woody debris (LWD). The floodplain may contain surfaces at one or many elevations. The floodplain is the area to be evaluated for possible inclusion within the CMZ.

Evidence for a floodplain includes, but is not limited to:

- Flotsam hanging in the brush and log jams on top of the surface.
- Fine sediments are found in the tree moss and there may be abrasions of the lower tree trunks.
- Silt, sand, or gravel are found immediately under the leaf layer.
- The alluvial materials consisting of silt, sand and gravel are uncompacted and unconsolidated.
- A wetter understory plant community with facultative wet and/or wetland obligate species is present. Disturbance species such as willow, cottonwood and alder are likely to be present in the overstory canopy.
- Evidence of flowing water, such as scour features, flattened grass or secondary channels formed by scour action of the modern river.
- The elevation of the surface lies near the elevation of the highest channel features (e.g., log jams and gravel bar surfaces).
- The surface lies WITHIN the elevation of the 100-year flood inundation. Usually, this can be reasonably agreed to, taking into account evidence of incision and wood loss. It should be a rare situation where this elevation needs to be quantified.

If some period of time has lapsed since a large flood event greater than a 20-year event, evidence that relates directly to flooding of a surface may be muted.

Lateral Activity (Field Evaluation Form L1-L3): This category of field evidence is a screen for obvious indicators of lateral channel activity by identifying conditions where channel migration is unlikely and those where channel movement is apparent. Where neither condition described as field evaluation form question L1 or L2 below are true or obvious, proceed with the evaluation (L3) and the vegetative indicators category below.

If the bed and banks of the stream are composed of bedrock or other erosion-resistant material, no lateral movement of the channel is possible (L1), and the RMZ will begin at the bankfull channel edge. Stream banks resistant to erosion are composed of materials such as hard rock or well-cemented alluvial deposits that can form stable vertical banks. These do not experience significant erosion (Figure 10). Cemented alluvial deposits often look similar to unconsolidated and erodible alluvial deposits, but display their resistance to erosion by showing resistance to removal of individual stones by hand and exhibit a non-retreating near-vertical bank (Figure 10). On these banks, tree roots are unlikely to be exposed but may "wrap" around the edge of the bank. Under-cutting of stream banks consisting of cohesive materials such as clay, or partially cemented or well-consolidated deposits may indicate relative stability or very slow erosion.

Stream banks that are re-enforced with tree roots can be quite stable if the roots extend the full height of the bank and are not destabilized by undercutting from the stream channel (Figure 11). This occurs along relatively small channels and where bank materials have some natural erosion resistance (L3).

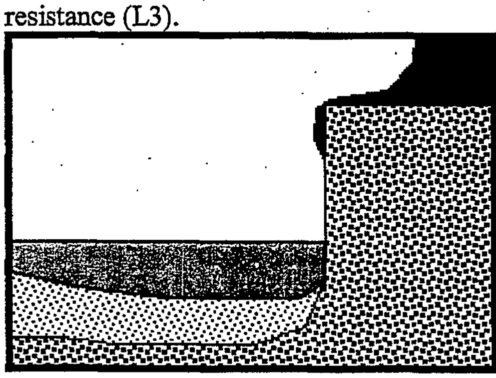
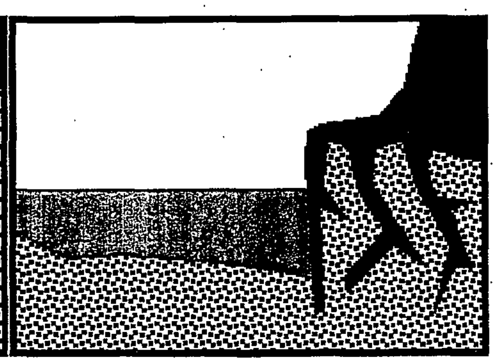



Figure 10. Erosion-resistant bank.
Figure 11. Root-stabilized bank.

Where it is obvious the channel is or has been moving laterally, proceed to delineating the CMZ (L2). Abandoned channels and extensive bank erosion are some obvious indicators. Stream banks susceptible to erosion are usually composed of the same size material currently being transported by the channel, as evidenced in the channel bed and bars. Eroding stream banks can be identified through the observation of frequent overhanging tree roots exposed in the bank above the stream channel, an indication that the bank has retreated a distance equal to the length of root exposure (Figure 12). The eroding bank is typically paired with a bar deposited on the opposite bank or downstream. Fan-like accumulations of the same material that the bank is composed of at the base of the slope can also indicate that the stream channel has eroded into the slope (Figure 13a). These accumulations are typically found in stream banks made of unconsolidated alluvium (sand, gravel, cobble), but can include more consolidated materials (clay, compacted or partially cemented silt or gravel) that accumulate in blocks at the toe (Figure

13b). A stream bank where the toes have been undercut can also indicate active bank erosion, particularly if bank failures are also observed along banks of similar material within the same stream channel segment (Figure 14). All these situations fall under question L2 on the Field Evaluation Form. If it's unclear from field evidence that bank erosion indicates obvious lateral movement, continue with the evaluation starting from question L3.

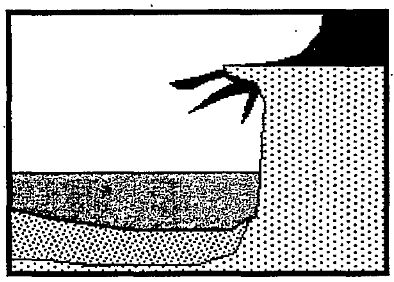


Figure 12. Root exposure as an indication of bank erosion.

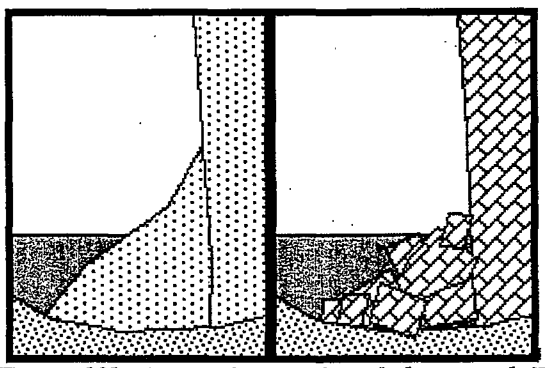


Figure 13a. and Figure 13b. Accumulation of eroded material (Figure 13a) and blocks of material (Figure 13b) at base of bank.

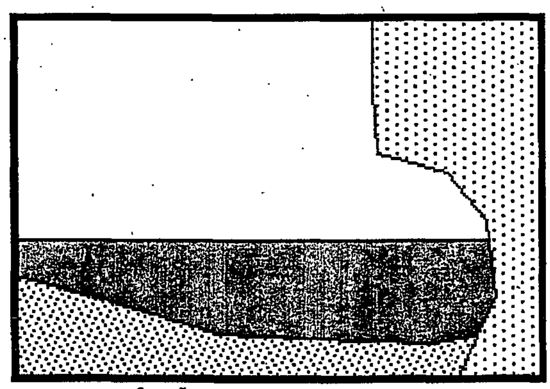


Figure 14. Undercut stream bank.

Vegetative Indicators of Channel Migration (Field Evaluation Form V1-V3): Existing vegetation and historic vegetative features that are still present can provide significant indications of channel history within a given stream reach. Vegetation age is a reflection of the length of time that has passed since disturbance. Vegetation type or plant community can also reflect the type or severity of disturbance that has occurred. When used in conjunction with other channel indicators, vegetation patterns can greatly assist in the identification and delineation of channel migration zones, but are never sufficient evidence alone (i.e., the presence of old trees or stumps is not sufficient evidence to exclude an area from a CMZ).

Much of the land subject to forest practices regulation has been logged at least once. Often old-growth stumps and sometimes trees remain, bearing evidence of pre-settlement stand conditions. Old growth Douglas-fir and Western red cedar stumps are especially persistent within the forested environment. Surfaces that are covered with old-growth trees or stumps have not been disturbed by river influences within the time period reflecting the age of the trees or stumps. In general, stream-adjacent surfaces populated with persistent old-growth trees or stumps from valley wall to bankfull edge, uninterrupted by secondary channels, are considered to be upland terraces or stable floodplain. These surfaces are typically outside the influence of channel migration (V1) if they are not subject to channel migration through erosion or avulsion processes (L2). Where surfaces with old growth trees or stumps contain linear channel features without stumps or trees of the same age, proceed with the evaluation (V3) if there are no other vegetative indicators as described below (V2).

Patterns of vegetation can indicate areas disturbed by past channel activities (V2). Vegetation types often show up in linear patterns on a stream-adjacent surface. Age-progressive bands of vegetation along a stream reach can indicate meander migration that occurs as an active channel moves laterally away from a stream bank over time (Figures 5 and 6). Tree species such as alder can colonize natural linear features such as secondary channels or other deposition/disturbance edges on the floodplain. Caution must be used in this interpretation however, as vegetative bands can also represent non-stream influences such as orphaned road grades, skid trails, or gravel extraction sites.

A stream-adjacent wetland plant community such as red alder with a sedge understory may denote a low floodplain surface subject to frequent inundation (V2). A red alder/sword fern plant community indicates a drier site such as a re-colonized gravel bar, debris fan, or even an upland terrace. Surfaces with this vegetation can still flood, and their presence is inconclusive. Stream bank or terrace edges that have had sufficient time post-disturbance to develop a stable angle of repose are typically covered with timber and/or understory vegetation (V3). Non-bedrock channel features that are devoid of vegetation have been subjected to recent or recurrent scour/deposition (V2). If it's unclear from field evidence that vegetation patterns indicate channel migration, assume there is no vegetative evidence of channel migration and continue with the evaluation starting from question V3.

Secondary Channels (Field Evaluation Form S1-S3): Floodplain river systems often have multiple types of interacting *channels*, which aid in floodplain building processes and the conveyance of water longitudinally and laterally. Secondary channels carry water (intermittently or perennially in time; continuously or interrupted in space) away from, away from and back into, or along the main channel. *Anabranch* channels are the most common form of secondary channel, which are a diverging branch of the main channel that re-enters the main channel some distance downstream. Secondary and anabranch channels can be subdivided into: side channels, wall-based channels, distributary channels, abandoned channels, chutes, and swales (Part 2.5 Technical Background, Floodplain-building Processes and Part 2.7 Glossary).

Presence of secondary channels on floodplain surfaces can convey much information to the field practitioner regarding channel processes and the potential for channel migration through lateral erosion or avulsion processes. Active secondary channels (e.g., side channels or overflow channels) are obvious locations where the active floodplain network has flowed in the recent past. Over time, these channels may be enhanced by the river system through:

- Active enlargement of channel dimensions (i.e., width or depth) through increasing vertical and lateral connectivity with the main channel; and
- Total occupation of the river in that location through avulsion (second- and third-order avulsion).

Secondary channels can also be slowly or abruptly abandoned by the active channel when:

- The main channel migrates away from the channel area;
- The channel becomes cut off at its upstream end due to wood or sediment deposition;
- The channel fills in with sediment or organic material from in-channel aggradation and/or overbank floodplain deposition of sediment (silts and sands); and
- The main channel incises into floodplain deposits resulting in reduced connectivity with the secondary channel.

Thus, secondary channels can be episodically activated and deactivated, either partially or fully through time. Over time, secondary channels can become less defined due to infilling and vegetation growth, which masks their surface distinction and the interpretation of their previous fluvial processes. In certain situations, secondary channels may also stay static in their form and processes. A static secondary channel is rare in Washington state where discharge of water, sediment and wood is often highly variable through time, creating dynamic channel evolution processes.

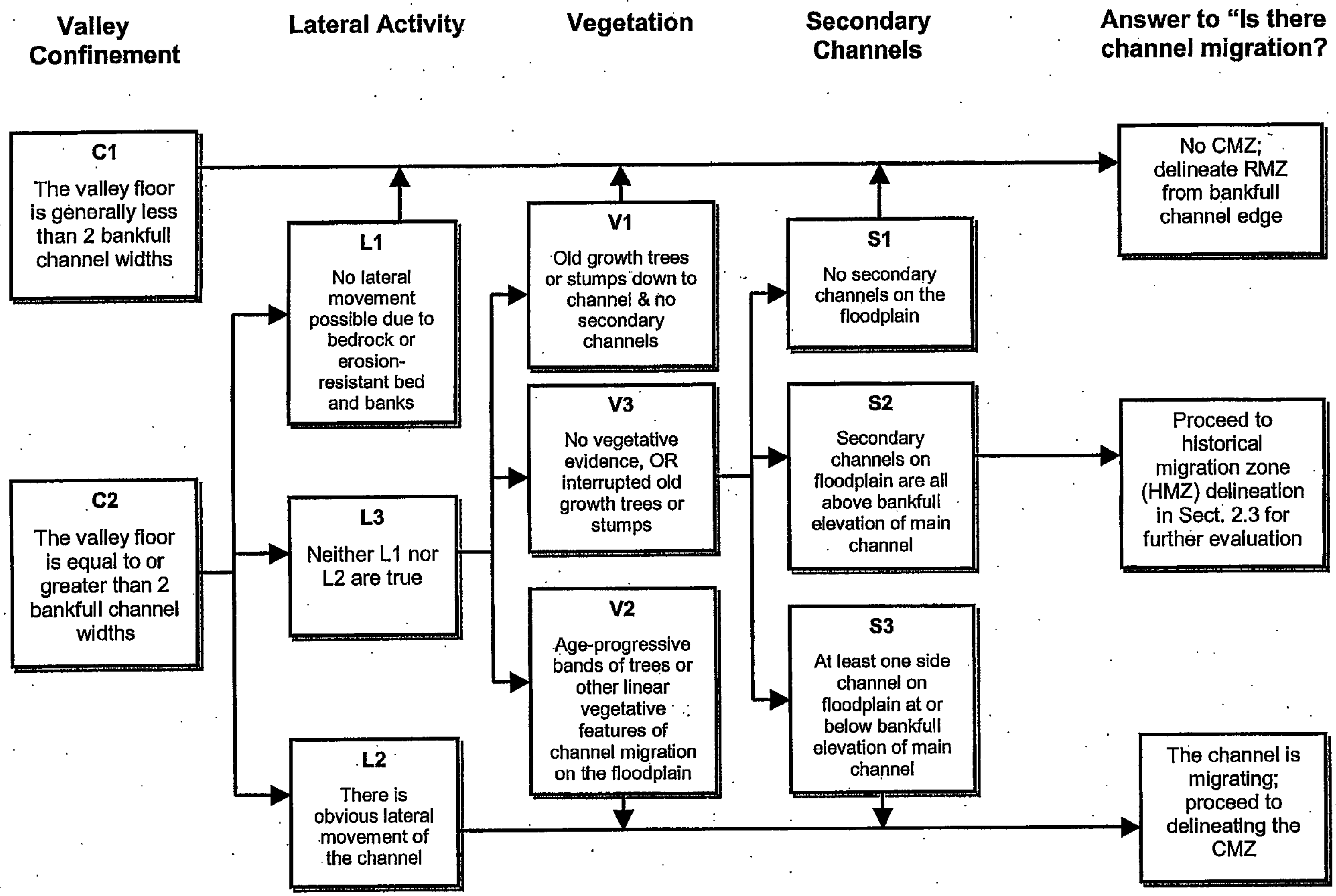
The presence of secondary channels does not alone predict the likelihood of future channel migration, nor does the absence of secondary channels on the floodplain solely indicate that channel migration by avulsion is unlikely. These features need to be assessed individually and in conjunction with other floodplain forms and processes along the segment of interest.

If there are no secondary channels of any sort on the floodplain, channel migration is unlikely. This would mean that there are no other indicators of channel migration described under the L2 or V2 evidence above. Proceed to delineating the RMZ from the bankfull edge (S1).

The channel is migrating if there are any side channels on the floodplain where the bottom of the channel is at or below the bankfull elevation of the main channel, proceed to delineating the CMZ (S3).

If there are secondary channels on the floodplain and all bed elevations of these channels lie above the bankfull elevation of the main channel, then channel migration may have occurred but cannot be determined without further evaluation. Proceed to Part 2.3 and the delineation of the historical migration zone (HMZ) for guidelines to further evaluate if historic channel migration has occurred (S2).

Flow Chart for Determining Channel Migration



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2.3 Delineating the Channel Migration Zone

Once it has been determined that channel migration has historically occurred or is occurring anywhere along the channel segment that includes the proposed forest practice activity, the landowner is required to begin the RMZ at the outer edge of the channel migration zone. In addition, if the evidence for historical migration remained unclear after following the guidelines outlined in Part 2.2, the field practitioner is instructed to use the lines of evidence for delineating the Historical Migration Zone (described below) to determine whether or not a CMZ is present. It is therefore possible to work through the delineation methods and determine that historical channel migration has not occurred and CMZ delineation is not necessary.

The following guidelines and delineation scenarios contain technical recommendations for CMZ delineation. It may be reasonable to deviate from these recommendations based on carefully developed technical analysis of the historical channel and watershed processes that control channel migration. Consulting with the DNR forest practices forester or conducting additional analysis is encouraged whenever or wherever you are confused about how to proceed with the delineation of a CMZ.

Information useful to accompany the forest practices application (FPA) includes a statement describing the lines of evidence used to establish the delineation along with any analyses performed or reports generated (see CMZ Reporting Form).

Methods Overview: The following methods have been developed to guide CMZ delineation. The general methodology in this section defines the CMZ based on valley and floodplain features and channel processes. The outer edge of the CMZ is identified using historical map and photo analysis and/or current field evidence to predict future channel migration.

It is helpful to view the river landscape as a series of the following identifiable components that can be used collectively to define the boundaries of the CMZ (Figure 15). All zones are not necessarily present along all river segments.

1. The historical migration zone (HMZ) – The sum of all active channels over the historical period (post 1900).
2. The avulsion hazard zone (AHZ) – The area not included in the HMZ where the channel is prone to move by avulsion and if not protected would result in a potential near-term loss of riparian function and associated habitat adjacent to the stream.
3. The erosion hazard area (EHA) – The area not included in the HMZ where bank erosion from stream flow can result in a potential near-term loss of riparian function and associated habitat adjacent to the stream.
4. The disconnected migration area (DMA) – The portion of the CMZ behind a permanently maintained dike or levee.

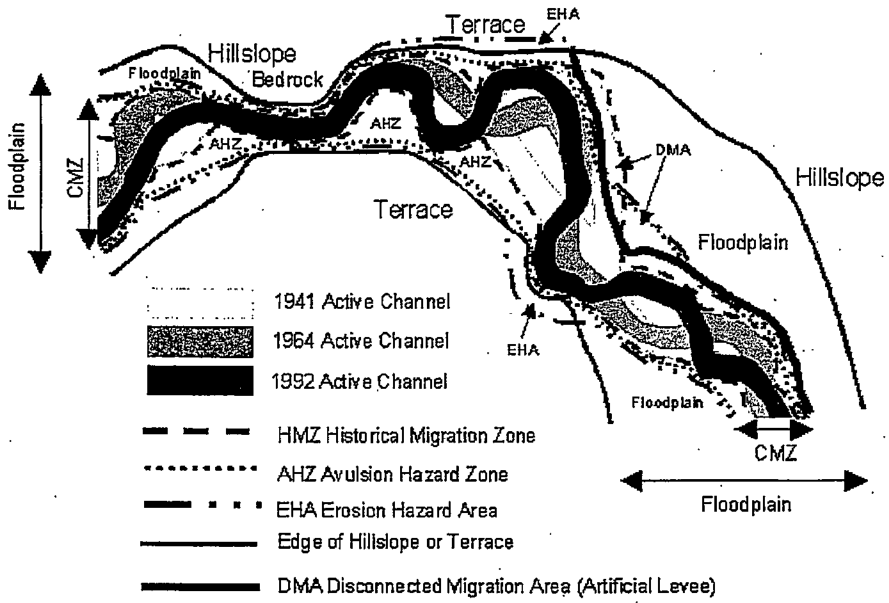


Figure 15. Valley and floodplain features identified and evaluated for inclusion into the CMZ delineation. All zones are not necessarily present along all river segments.

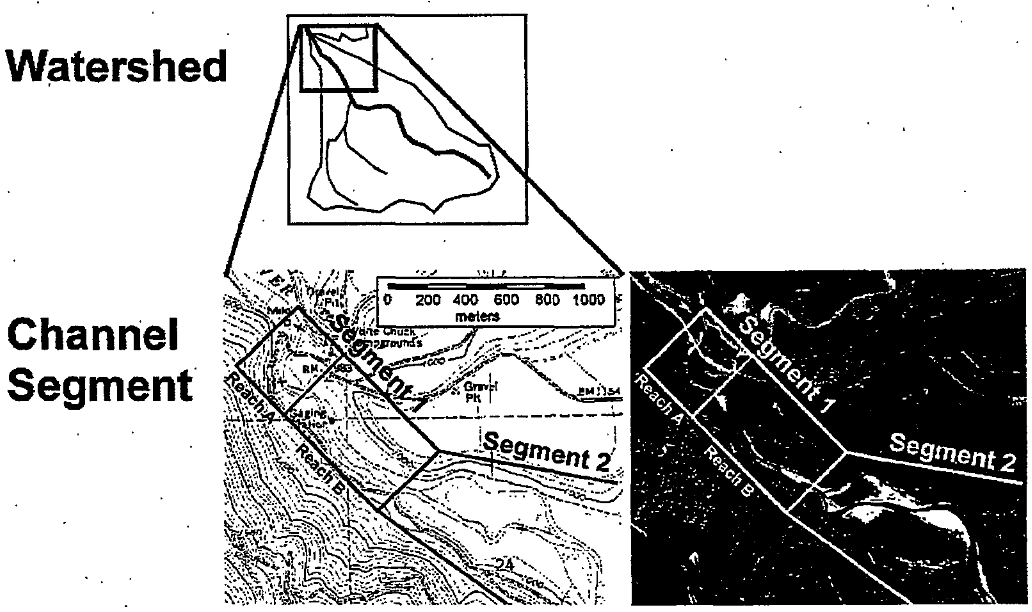
The concept of looking at the channel migration zone as a collection of these components was adapted from Rapp and Abbe, 2003. All river segments with a CMZ necessarily have an HMZ; additionally, some segments have AHZ, EHA and/or DMA.

The remainder of this section presents information on channel segment delineation, delineation of the three major components of the CMZ, and identification of floodplain features outside of the CMZ. Different types or "scenarios" of channel migration situations have also been provided to facilitate CMZ delineation and illustrate the use of appropriate evidence and methods.

In delineating a CMZ, we attempt to anticipate the type and scale of large channel-changing events that may occur such as 25, 50, and 100-year flood events – the scale of events for which we have some predictive capability. Careful evaluation of field evidence will help the landowner determine the limit of channel migration over the near-term future. An understanding of general river processes may also be helpful to the landowner. To this end, technical background (Part 2.5) is included, and users of this manual are encouraged to become familiar with the concepts offered.

Future river channel changes (e.g., channel aggradation, altered LWD load, and channel avulsion) may bring improved understanding of local stream processes. When these changes occur, existing CMZ boundaries can be re-evaluated in the context of an entire stream segment, and the additional information gained can be applied to future forest practices. However, a lack of channel changes within a few decades after the initial delineation does not preclude the potential for channel migration in response to larger flood events or other significant watershed changes in the future. If the nature of river form and processes is well understood during the initial CMZ delineation, future adjustments to the CMZ should be minimal.

Segment-Level Delineation: The lateral extent of the channel migration zone is based on field evidence found at the channel segment scale. Although many CMZ delineations will be specific to those portions of the stream adjacent to individual forest practices activities, some or perhaps much of the evidence for the delineation may exist on the opposite bank or elsewhere in the associated channel segment. Similar to its use in watershed analysis, stream segments are lengths of stream that have similar valley confinement, discharge, channel pattern, and average valley gradient (Figure 16). Segments may vary from a few hundred feet to a couple of miles in length, and are somewhat scale-dependent such that smaller streams may have shorter segments.



Segment 1: plane bed and transitional pool-riffle channel segment moderately confined by glacial moraine

Segment 2: unconfined lower gradient pool riffle segment

Figure 16. Channel hierarchy from watershed to segment to reach scale.

Identifying Segment Breaks

Stream segments are most easily identified initially from topographic maps and aerial photographs, and then field verified. Segment breaks are determined from abrupt or gradual changes in confinement, gradient, channel pattern, streamflow, or other channel or watershed characteristics as listed below:

- Confinement: A change in the valley confinement (i.e., the ratio of bankfull width (w_b) and valley width (w_v)), approximately corresponds to one of three confinement classes from a wide floodplain to a confined canyon.

Confinement class	Floodplain width
Unconfined	$w_v > 4\ w_b$
Moderately confined	$2\ w_b < w_v < 4\ w_b$
Confined	$w_v < 2\ w_b$

- Gradient: A significant change in average channel gradient, corresponding to one of the following gradient classes:
  0-0.9 %   1.0-1.9 %   2.0-3.9 %   4.0-8.0 %   8.0-20 %
- Channel pattern changes (e.g., from a straight to sinuous to braided channel, or a single-thread to anabranched channel)
- Tributary confluences, which can result in:
  - Significant streamflow discharge changes
  - Significant channel width and/or depth changes
  - Significant changes in the type and/or quantity of sediment.
- Streambed or streambank material changes (e.g., bedrock to gravel bed, cohesive to non-cohesive banks).

Advantages to delineating a CMZ for one or more segment lengths rather than a single forest practices application are:

1. At the broader scale, it is easier and more defensible to define segments of varying activity from no migration to small-scale migration to very active migration. In some large river systems, segments of active migration and those of little or no migration may alternate down the length of the river. Careful analysis of the aerial photo record and the field evidence for migration will help define these segments. Observations may lead to hypotheses about the subtle controls causing these changes. It may be difficult to defend the delineation of just two segments, one with no or only small-scale migration and one with very active migration, but this distinction may be quite defensible when alternating segments of different behaviors have been documented. Large-scale analysis of channel migration is most strongly recommended for large rivers.
2. Multiple segment analyses provide a higher level of confidence in channel migration delineation because more is understood about the river's migration behavior.
3. There may be significant cost savings in conducting a large-scale analysis. Cost savings are likely to be very significant if landowners and other cooperators conduct these analyses together.

Channel Migration Zone Components: The CMZ, as defined by forest practice rules, may or may not include all portions of the floodplain. Some floodplain surfaces may be periodically inundated, but lack the risk factors for channel shifting or bank erosion. The following terms are defined and described below for those areas included in the CMZ.
A "surface" of a floodplain is a widely used but poorly defined concept. Conceptually, a "surface" is a constant feature up and down the valley. It lies at a consistent elevation above bankfull. A discrete process at a discrete point in time has formed the surface, resulting in consistent soil development and other age indicators. Unfortunately, these conceptual "surfaces" rarely exist because processes that form floodplain surfaces are complex and often localized. Where contiguous surfaces were formed, they have often been fragmented by erosion and avulsion. Therefore, a "*surface*" is specifically defined as those individual pieces of the floodplain that share the following characteristics:

- The surface lies at a fairly consistent relationship to the bankfull channel elevation, understanding that the relationship between a given surface and bankfull elevation can vary within a segment due to irregularities on the surface and due to local flow patterns and obstructions.
- The surface displays evidence that supports fairly constant flood frequency.
- The surface supports a fairly similar plant community as influenced by water table or flooding (perched wetlands should not be included in this consideration).

It is assumed that a common process as defined above has formed the fragments of a surface.

Historic Migration Zone (HMZ): The historic migration zone (HMZ) is the sum of all active channels over the historical period, and is delineated by the outermost extent of channel locations over that time (Figure 15). This is direct evidence of where the channel has been and may be assumed to reoccupy. The historical period usually includes the time between the year 1900 and the present – the approximate time period sufficient to capture pre-timber harvest channel conditions. This time period is extended for those sites known to have been impacted by timber harvest activities prior to 1900, or where historical information such as Government Land Office maps and notes are available at http://riverhistory.ess.washington.edu/ (Puget Sound Rivers) and http://pnptc.org/t-sheets.htm (Olympic Peninsula Rivers). At a minimum, the CMZ will include the HMZ except where a portion of the HMZ is behind a permanently maintained dike or levee (see Disconnected Migration Area).

The HMZ is identified based on photos, maps, and field evidence (Figure 17). Since few streams have a complete historical map and photo record or the stream may be too small to be adequately assessed from photos or maps, what historical data is available is supplemented with field evidence. When in doubt whether a surface is part of the historic migration zone, evaluate for avulsion hazard potential.

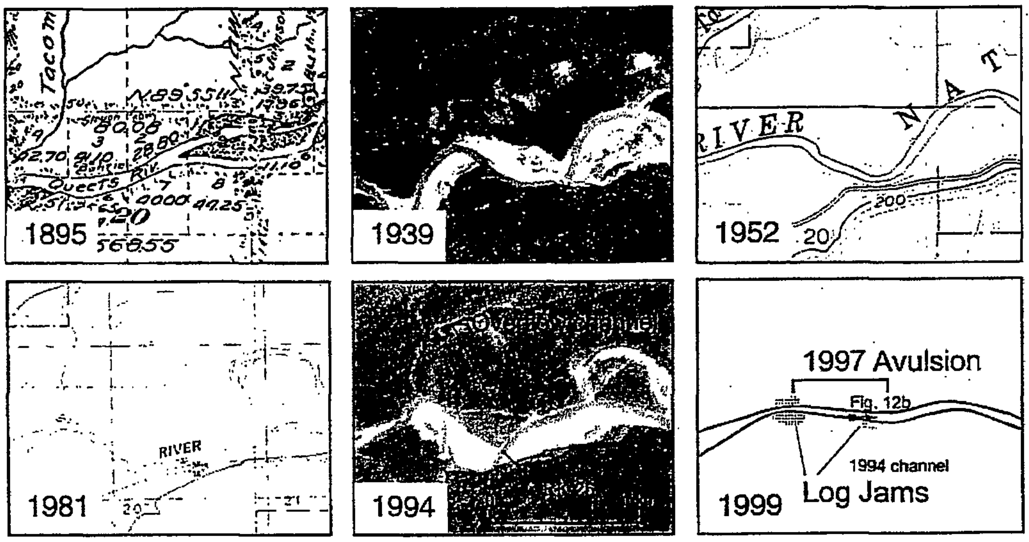


Figure 17. A sequence of historical channel maps and photos: 1895 General Land Office Survey; 1939 USGS aerial photograph; 1952 15' USGS topographic quadrangle map; 1981 7 ½' USGS topographic quadrangle map; 1994 DNR orthophoto; and a field map (modified from O'Connor et al., 2003).

In determining the historic migration zone first, include the area within the active channel and any side channels. Then, if available for the segment, analyze the historic map or aerial photograph record to determine the areas the channel has occupied in the past. Next, examine the floodplain surface(s) for channels abandoned within the historic time frame that may not be evident on the historic map or aerial photograph record. Evidence of historic abandonment may include: lack of stumps; surficial deposits of gravel or cobble, which can be thinly covered by fine, overbank sediments or duff; plant communities that are younger than the surrounding flood plain surface; and surficial evidence of logjams. Finally, examine the surface(s) for age-progressive plant communities that indicate point bar growth during the historic time period.

Evaluating the lines of evidence during the delineation of multiple-surface floodplains requires some understanding of the recent flood history of the river. The longer the period of time since the last disturbance event, the more muted the surficial evidence for channel migration will be. In particular, evidence of bed scour may be covered in leaf litter and humus. Some coring or digging in low or topographic depressions to determine the nature and age of shallow materials may be useful.

Strong field evidence of historic channel migration on a seemingly higher elevation surface may suggest a historic change in wood and/or sediment loading or channel processes that have caused the channel to downcut, and this condition can be confirmed through historical information or analysis. The reintroduction of mature wood to the stream could bring the bed elevation up to that surface in the future.

Smaller and moderately confined segments of a stream are generally closer to sediment sources and may receive large pulses of sediment that are stored for shorter time frames than sediment in large floodplains further downstream. Because these segments may aggrade and degrade rapidly, the resulting deposits may be at an anomalously high elevation above the current channel. Because these surfaces were deposited and abandoned rapidly, they may also lack any surface expression of former channel features. Additional evidence includes the buried stems of trees (no obvious root collar on the tree) on surfaces where tree age may otherwise indicate an older surface. Many hardwoods will tend to survive root collar burial, whereas conifers will not. Buried stems of trees (no obvious rootwad) may indicate an older surface. Much of the other evidence for the HMZ will apply in these locations, even though the surface may not flood, given the current elevation of the channel.

Avulsion Hazard Zone (AHZ): Channel *avulsions* are defined as relatively sudden and major shifts in the position of the channel to a new part of the floodplain (first-order avulsion) or sudden reoccupation of an old channel on the floodplain (second-order avulsion) (Nanson and Knighton 1996) (Figure 40 and Part 2.5). Avulsions into floodplain deposits can occur at a variety of scales and channel sizes. Primary avulsion paths can be guided by log jams or the presence of poorly defined topographic low points along the floodplain, and secondary avulsion paths can follow better defined *secondary* or *abandoned channels* on the floodplain.

The avulsion hazard zone is the area not included in the HMZ where the active channel of a stream is prone to move to (Figures 18a and 18b) and if not protected would result in a potential near-term loss of riparian function and associated habitat adjacent to the stream. The purpose of delineating avulsion hazard zones is to anticipate future shifts in channel location outside the recent historical locations. Predicting channel shifting to a new portion of the floodplain (first-order avulsion) is more challenging than predicting reoccupation of an old channel (second-order avulsion). The time frame for migrating channels to move across their floodplains varies from decades to hundreds of years; therefore, in some river systems, much older floodplain surfaces may still be subject to avulsion. The evidence and situations outlined below will help identify these floodplain areas at risk.

Figures 18a and 18b. Channel avulsion that occurred between two photo years.

The evidence for the avulsion hazard zone includes consideration of several situations:

1. Those floodplain surfaces extending outward from the HMZ that are of similar height to the surfaces within the HMZ, including:
   - If a surface has experienced historical avulsion within the segment, that entire surface is within the AHZ.
   - Floodplain islands stranded by historical channel avulsion.

- The surface within the elevation of the highest channel features (gravel bars, the bulk of wood jams, mid-channel surfaces).
- A surface beyond a flood berm that is at or below bankfull elevation.

2. There may be additional situations where the near-term risk for avulsion is significant. The relationship of a portion of the floodplain, often a meander bend, to the active channel may generate preferential avulsion paths. The possibility of such an avulsion path can be assessed in the context of knowledge of local channel behavior, knowledge of watershed condition and trends, and an assessment of the relationship of the channel to the floodplain surfaces. To assess the potential for preferential paths, the following situations need to be considered:
   - The channel has been systematically moving in one direction towards an obvious path for primary or secondary avulsion.
   - There is a continuous or intermittent linear or curvilinear depression or channel form connecting at the upstream end to the active channel that would be prone to flood in a large event.
   - Streamflow is directed at a portion of the floodplain such that floodwaters have an unimpeded, focused path.
   - The floodplain has a gradient greater than the adjacent channel, and the greater the difference the more likely avulsion will occur (Jones and Schumm, 1999). Avulsions typically occur where the down valley floodplain slope is greater than (>1x) the channel slope (Bridge, 2003). If the floodplain slope is 3 to 5 times greater than the channel slope, avulsion during a large flood event is probable (Bridge 2003).
   - Watershed and segment-scale evidence demonstrates that significant vertical bed aggradation due to increases in LWD or sediment (or both) is occurring or has occurred in the historical past. Evidence of the historic bed elevation should exist on any remaining adjacent surfaces, but can be buried. Specific evidence that supports the likelihood of vertical bed aggradation includes:
     - post-harvest or stream-cleaning channel degradation that has isolated historic floodplain surfaces,
     - channels with multiple floodplain surfaces that are close in elevation indicate that the channel bed elevation fluctuates,
     - in-channel sediment waves, commonly produced by concentrated landsliding, can be observed (through historic aerial photographs or cross sectional survey records such as those at gauging stations) as channel disturbance propagated downstream over time,
     - high variability in the current channel bed elevation, and
     - the presence of islands on higher surfaces.

     For additional information, see Part 2.5 Technical Background for a discussion of how changes in wood and sediment budgets affect channel form and migration processes,

Erosion Hazard Area (EHA): Along some rivers there are lengths of channel where the stream is laterally eroding into a terrace or floodplain surfaces. Although the stream may not continue to erode in the same direction (it could shift back at any time) or at the same rate (the channel could reach equilibrium) over the long term, it may erode over the near term. For these stream segments, erosion rates of bank retreat and the CMZ setback distances can be calculated.

The erosion hazard area includes those areas outside of the HMZ and AHZ which are susceptible to bank erosion from stream flow and this can result in a potential near-term loss of riparian function and associated habitat adjacent to the stream (Figure 7a and 7b). Typically, the EHA will be comprised of portions of floodplain and terrace surfaces other than those within the HMZ and AHZ. Establishing an EHA is necessary for those situations where measurable undercutting or erosion on the order of feet per year or per flood event is currently taking place. In some reaches where channels are now permanently disconnected from their floodplain due to channel degradation, the CMZ may consist solely of the EHA. However, the CMZ will not extend further than the base of the valley hillslope or other such geologic controls to lateral channel movement.

Evidence of measurable or chronic bank erosion includes:

- The channel has visibly eroded into surfaces higher than those in the HMZ and AHZ during the record of historical aerial photography.
- There are meander bends with age progressive vegetation on the point bar, indicating that erosion into the far bank has been occurring.
- There are steep or vertical, unvegetated, non-cohesive banks along higher surfaces. See Part 2.2 Bank Erosion for additional guidance in determining if significant bank erosion is occurring if this situation exists.

The area to be included in the EHA can be calculated by averaging the historical erosion rate along the entire length of the channel segment or by calculating the erosion rate at a specific location where erosion may be concentrated.

To delineate the EHA for erosion into a terrace or non-HMZ/AHZ portion of the floodplain, the actual area(s) lost at each bank location is (are) delineated and measured using all historical aerial photographs. For segment-averaged erosion, these areas are added together. The individual or combined eroded area is divided by the length of terrace edge adjacent to the floodplain and then divided by the number of years of record used to get an average annual erosion rate. The erosion rate is then multiplied by the appropriate length of time to grow functional-size wood to get the average erosion setback along the eroding bank(s). For segment-averaged erosion, the length of eroding channel is measured along both sides of the channel, but does not include any length of channel or floodplain that abuts the valley hillslope.

$$AES = \frac{A \text{ (or } \Sigma A)}{L} \times \frac{1}{\Delta t} \times T$$

Where AES is the average erosion setback, A is the total eroded area or ΣA sum of total eroded areas over some time Δt, L is the length of eroding bank, and T is the length of time to grow functional wood.

Where the stream is eroding into floodplain surfaces or terraces, the EHA portion of the CMZ layout will protect the eroding bank edge. In addition to consideration of a CMZ, stream erosion of hillslopes and very high glacial terraces at the outside of meander bends and at the toes of deep-seated landslides are considered unstable slopes situations and are also evaluated under forest practices rules for unstable slopes (see Board Manual Section 16). As with other situations of overlapping forest practices rules, the harvest unit layout should reflect the greater of the protections.

Disconnected Migration Area (DMA): The disconnected migration area (DMA) is the portion of the CMZ behind a permanently maintained dike or levee. The CMZ of any stream can be limited to exclude the area behind a permanent dike or levee provided these structures were constructed according to appropriate federal, state, and local requirements. As used here, a permanent dike or levee is a channel limiting structure that is either:

1. A continuous structure from valley wall or other geomorphic structure that acts as a historic or ultimate limit to lateral channel movements to valley wall or other such geomorphic structure and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedence flow); or
2. A structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity (Figure 19).

A dike or levee is not considered a "permanent dike or levee" if the channel limiting structure is perforated by pipes, culverts, or other drainage structures that allow for the passage of any life stage of anadromous fish and the area behind the dike or levee is below the 100-year flood level.

The Washington Department of Fish and Wildlife (WDFW) and the Indian tribes can often provide assistance in evaluating the potential for seasonal fish passage and use of the floodplain, as well as details on dike permitting. Applicants should also contact local, state, federal, and tribal entities to make sure that there are no plans to remove the structure.

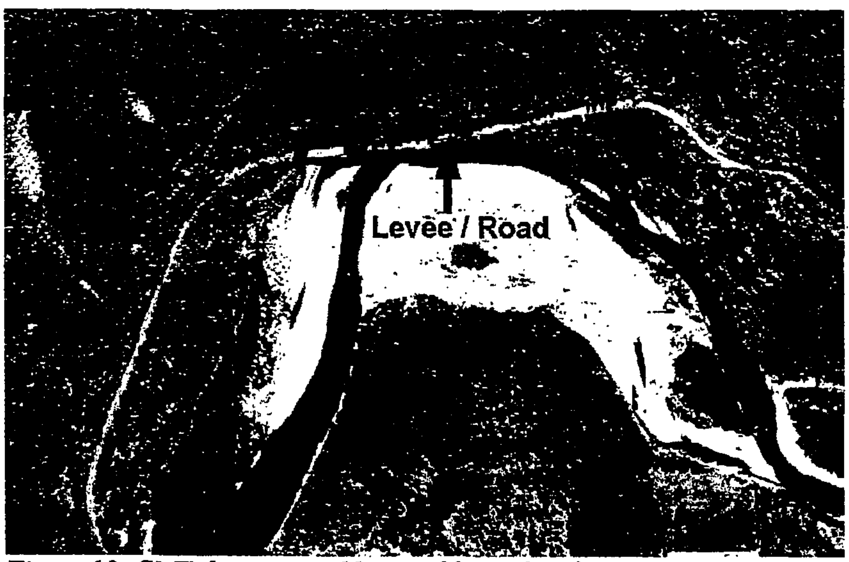


Figure 19. CMZ disconnected by a public right-of-way.

CMZ REPORTING FORM

Forest Practices Application/Notification

To list the evidence and/or methodology used to determine the presence of a channel migration zone within the immediate vicinity of your forest practice activity.

Please enclose completed copies of the CMZ Office Review form, Field Evaluation form, and any other additional information used to determine the presence/absence of a CMZ.

1. Is the forest practice activity adjacent to a channel migration zone?

   [ ] Yes. Continue with form.
   [ ] No. Delineate RMZ.

2. What was the distance of channel walked? What was the length of CMZ boundary delineated?

   ____

3. Please check the component(s) present in your CMZ delineation.

   [ ] Historical migration zone
   [ ] Avulsion hazard zone
   [ ] Erosion hazard area (attach erosion rate calculation sheet)

4. Check the appropriate box(es) that best matches floodplain configuration. For additional details refer to Part 2.3 Delineating the Channel Migration Zone.

   [ ] simple floodplain
   [ ] simple floodplain with terraces
   [ ] complex floodplain, with
      [ ] multiple surfaces
      [ ] multiple terraces
   [ ] alluvial or debris fan
   [ ] braided channel
   [ ] unconfined meandering stream
   [ ] stable sinuous channel

5. Please indicate how you marked the outer edge of the CMZ on the ground.

   ____
   ____

CMZ Delineation Scenarios: The following different types or "scenarios" of channel migration are provided to facilitate CMZ delineation and the use of appropriate evidence and methods. Almost all rivers and streams with historic or active channel migration will fit into one of the following categories. Some of the delineation situations are very straightforward. Others are more complex, and it may take some additional fieldwork to be sure you have correctly identified the situation.

Read the following seven descriptions carefully and decide which situation best fits the stream segment in which you are delineating a CMZ. Each scenario includes the CMZ components likely to be included in the delineation and an example of delineation and field or analysis methods unique to those situations where appropriate.

Scenario 1 - Simple floodplain abuts valley walls: In this situation, one relatively flat floodplain surface, that is approximate in elevation to the bankfull channel, abuts the valley walls (Figures 20 and 21). There are no higher horizontal surfaces that could represent either additional floodplain or terrace. These conditions are most likely to be found where the channel is moderately confined (the valley width is approximately 2 to 4 bankfull widths – (Parts 2.6 and 2.7).

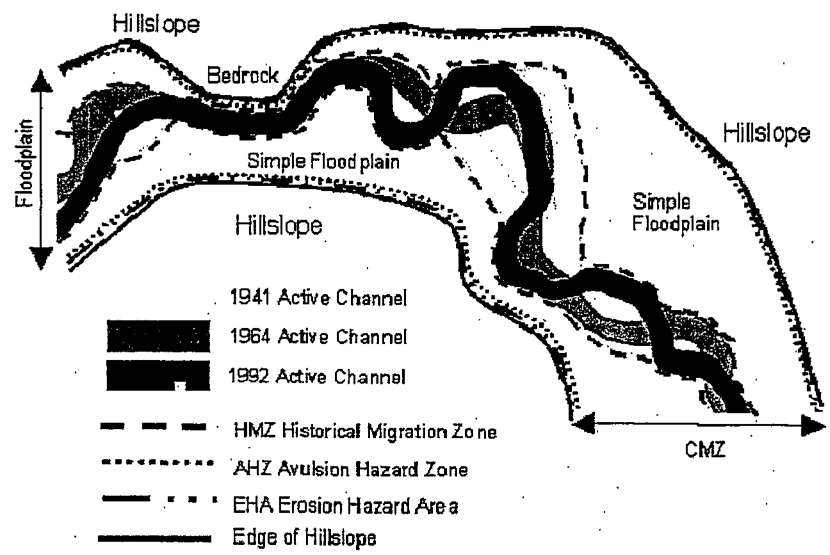


Figure 20. Simple floodplain abuts valley walls CMZ scenario in plan view.

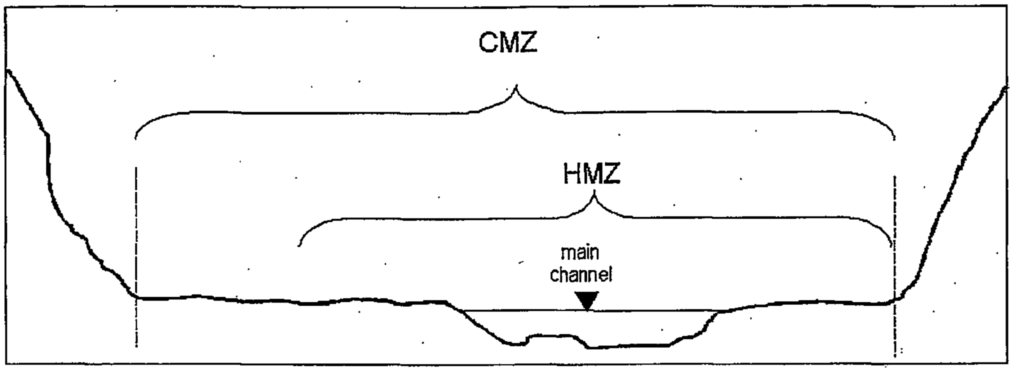


Figure 21. Cross sectional of the simple floodplain CMZ scenario.

In this situation, the simple floodplain is the channel migration zone, and will represent the historical channel locations (HMZ) in addition to any floodplain areas prone to avulsion (AHZ). The CMZ is the valley bottom, and the RMZ starts at the hillslope/valley-floor slope break. The RMZ extends up the valley wall, and its design must also protect any unstable slopes. Where migration is very active, the valley walls may be periodically undercut by the channel, creating over-steepened and unstable slopes (see Board Manual Section 16).

Scenario 2 - Simple floodplain with terraces: This situation is similar to the one above, except that the relatively flat floodplain surface, that is approximately the same elevation as the bankfull channel, abuts a terrace or terraces (Figures 22 and 23). The floodplain surface or the channel itself may intermittently abut a valley wall where there is no remaining terrace. If you are unsure that the higher surfaces are terraces, then work through the "evidence for a terrace surface" in Part 2.2. If you are still not sure that the higher surfaces are terraces, then assume that you have a complex floodplain with multiple surfaces and proceed to the delineation for that scenario below. This situation might be confused with the upper, narrow end of an alluvial fan (Scenario 4) if your designated segment does not extend a sufficient distance down valley.

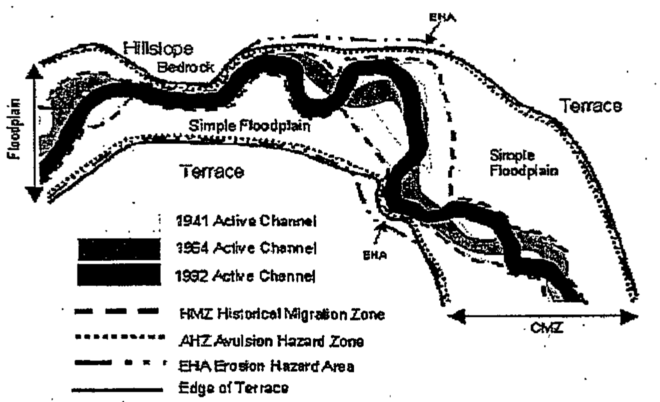


Figure 22. Simple floodplain with terraces CMZ scenario in plan view.

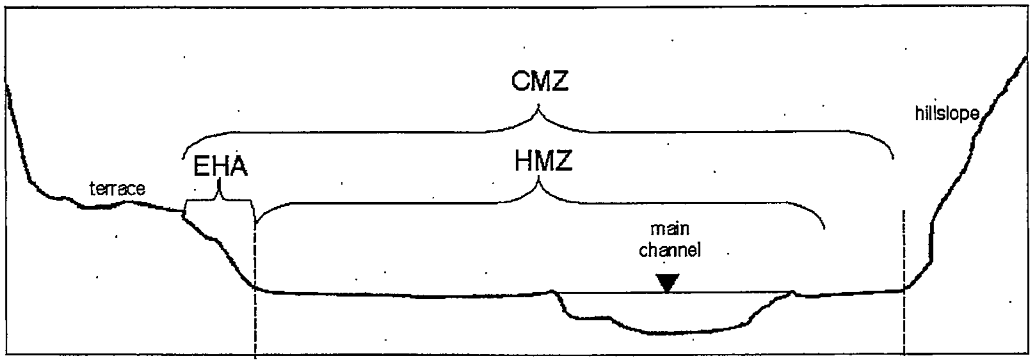


Figure 23. Cross sectional of the simple floodplain with terraces CMZ scenario.

As in the previous delineation, the entire floodplain lies within the channel migration zone, and will include the historical channel locations (HMZ) in addition to any floodplain areas prone to avulsion (AHZ). An erosion hazard area (EHA) may also be identified where rivers are still actively widening their floodplain by eroding the terraces.

Scenario 3 - Complex floodplain with multiple surfaces: In this situation, there are multiple surfaces of varying elevations within the floodplain (Figures 24 and 25). This situation may be caused by the interaction of sediment, debris, and water or variability in sediment and/or wood loading in the historic past, and indicates that the channel bed elevation fluctuates. Multiple floodplain surfaces may be absent where the channel abuts a terrace or valley wall within the segment. Multi-surfaced floodplains can exist for streams of varying sizes and confinements. The processes of channel migration under this scenario are primarily bank erosion and avulsion.

A helpful first step is to identify the surfaces as either terraces or floodplain by working through the "evidence for a terrace surface" and "evidence for a floodplain surface" criteria in Part 2.2. If you are still uncertain, assume you are in this category.

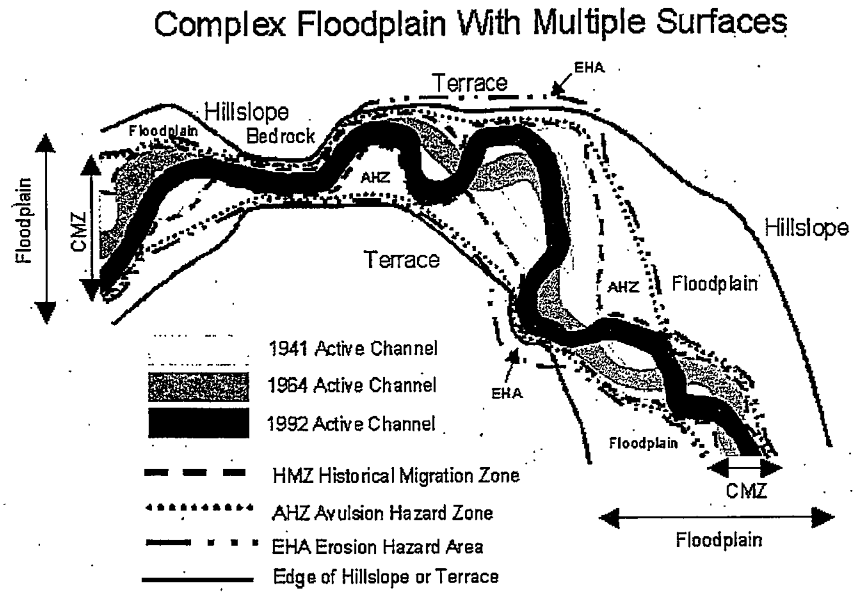


Figure 24. Complex floodplain CMZ scenario in plan view.

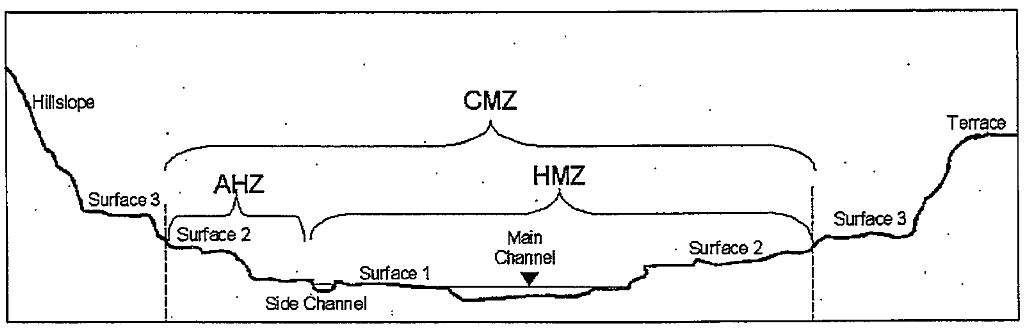


Figure 25. Cross sectional of the complex floodplain CMZ scenario.

Because of the complex floodplain features, this delineation scenario requires historical map and photo work in addition to extensive fieldwork to identify the CMZ components. The situation may require the collection of quality elevation data (e.g., cross sectional traverses or LiDAR data for large rivers). The quality elevation data is needed to link geographically isolated surfaces to each other down the length of the reach and across the river.

Much of the criteria for each of the CMZ components above can be applied to evaluate the channel migration potential where more than one floodplain surface exists. Because multiple surfaces imply fluctuations in channel bed elevation, emphasis should be placed on evaluating evidence for vertical bed elevation changes found at the end of the AHZ Section. Refer to Part 2.5 Technical Background for additional information and discussion of how changes in wood and sediment budgets affect channel form and migration processes.

When you are evaluating a "surface" in order to characterize it by the CMZ criteria listed above, the entire extent of that surface along the segment must also be evaluated for evidence of channel migration potential. The CMZ delineation for these complex floodplain situations may consist solely of the HMZ or any combination of the HMZ plus AHZ and EHA. Additional analysis is encouraged.

Scenario 4 - Alluvial or Debris Fans: Alluvial fans are a unique landform in the river valley. They are cone or fan-shaped deposits of sediment and debris that accumulate immediately below a significant change in channel gradient and/or valley confinement (Figure 26). The fan shape is created as the channel moves back and forth across the gradient transition depositing sediment. It is common for the stream to form distributary channels (channels branch but do not rejoin) as water flows down the fan. On varying time scales, the channel(s) will change location on the fan, seeking a lower elevation away from where it has most recently been depositing sediment. See Part 2.5 River Pattern for more information.

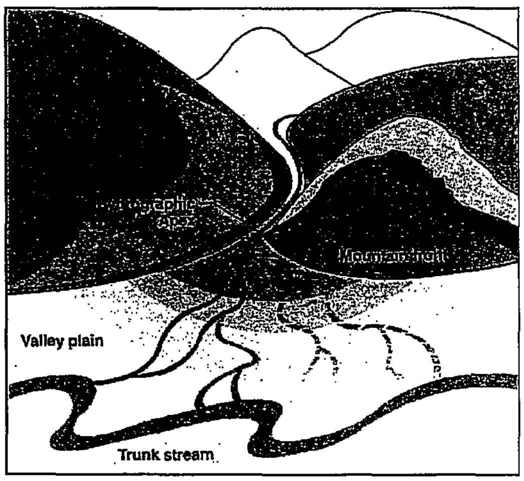


Figure 26. Environment where alluvial fans form (National Research Council, 1996).

Technically, the term "alluvial fan" refers to those features composed of stream-sorted alluvium; however, it is also commonly used to refer to fan features built by debris flow processes or a combination of alluvial and debris flow processes. Debris flow deposits are unsorted, and debris flows will often form a berm next to the channel. Trees on a fan subject to debris flow provide a buttress effect that limits the downstream extent of debris flow deposition, which is important for protecting human life or property inadvertently in the path of such events.

Surface gradients on alluvial fans are generally between 8 and 20%, but a fan built by debris flow or mass wasting processes can have steeper slopes. Both commonly exist:

- Where a smaller channel meets a larger channel;
- Where an abrupt change from narrow to wide valley width occurs; or
- Where an abrupt change from steep to gentle channel gradient occurs.

By definition, the channels on alluvial fans migrate and are therefore subject to CMZ delineation. Alluvial fans are also identified as "sensitive sites" in WAC 222-16-010 and no timber harvest is permitted within an alluvial fan (WAC 222-30-021(2)(b)(vi) and -022(2)(b)(ii)(C)(IV)). An alluvial fan will need CMZ delineation where historical map and aerial photograph and field evidence demonstrate that channel migration has occurred or can occur due to active fan building processes upstream. Channels can be located anywhere on the fan and are best observed starting from the apex or upstream portion of the fan and following them downstream. The CMZ will generally encompass the entire fan surface because of the difficulty in predicting the future channel location.

All or some portions of the fan may no longer be subject to channel shifting if the fan-building processes have ceased or diminished. The degree of channel incision at the fan head is not a reliable indicator of the lack of channel shifting potential, as infrequent but large flood events or debris flows can rapidly fill the channel. A relict fan may have one or more small modern fans building at the downstream margin of the larger feature. In this situation, only the smaller, active fan has a CMZ. Technical expertise may be necessary to evaluate the age and frequency of fan-building processes.

A related landform is the delta, which forms distributary channels as water slows and deposits sediment upon entry into a lake or estuary.

Scenario 5 - Braided Channels: A braided stream is divided into several channels that branch and rejoin around bare or sparsely vegetated sand/gravel/cobble bars (Figure 27). Braided streams are characterized by high sediment loads relative to the transport capacity of the stream, low sinuosity, rapid shifting of bed material, and continuous shifting of the locations of the low-flow channels (Knighton, 1998). The braided channel pattern is partly stage- or water level-dependent. At higher discharges the bars are flooded and the river displays a single channel. A braided stream pattern is common on streams fed by glaciers. See Part 2.5 River Pattern for more information.

Figure 27. Braided river.

Examples of some rivers known to have braided segments include the upper Quinault River, the upper Carbon River, the Mowich River, and part of the upper White River in Western

Washington and the upper Wenatchee River, the north and south forks of the Touchet River, the Entiat River, and Chiwawa River in Eastern Washington.

Braided channels are each unique in their migration behavior and potential, and their delineation may require both extensive fieldwork and detailed aerial photography analysis. Where braided channels extend valley wall to valley wall, or have only small pieces of terrace or low floodplain on the valley floor, the entire valley floor is included in the CMZ and the RMZ extends up the hillslope. As in the first and second delineation scenarios, there may also be unstable slopes that require additional protection or eroding terraces that require an EHA. Braided channels with a floodplain will require the same CMZ evaluation as the complex floodplain in scenario 3 above, and expert delineation is encouraged.

Scenario 6 - Unconfined Meandering Streams: As used here (Forests and Fish Report, 1999), unconfined, meandering streams are 5th order and larger Type S waters with bankfull widths greater than 50 feet and gradients of less than 2% with the following additional characteristics:

- The waters are sinuous, primarily single-thread channels that have a distinct meandering pattern readily observable on aerial photographs.
- Remnant side-channels and oxbow lakes often create wetland complexes within the associated channel migration zone.
- A diverse set of vegetation can grow within the associated channel migration zone including cedar, spruce, hardwoods, and wetland vegetation on wetter sites and Douglas-fir, spruce, hemlock, and true firs on drier surfaces.

A river creates these characteristics through the process of progressive bank cutting on the outside of a meander bend and subsequent deposition on the inside of the bend. A river maintaining its floodplain in this manner is generally considered in a state of dynamic equilibrium with the volume of water and sediment it carries (Knighton, 1998). The elevation and basic pattern and average geometry (width, depth, and cross sectional shape) of the channel do not change (Figure 28); but the channel location migrates across the valley horizontally, and the meander pattern migrates down valley over time (Figure 29). The meander loops or bends are also subject to cut-off by avulsion (Figure 40 and Part 2.5). Both progressive channel migration and avulsion processes create the remnant side-channels and oxbow lakes. The valleys of such rivers are generally wide relative to the size of the channel. The time frame for migrating channels to move across their floodplains varies from decades to hundreds of years. The rate of bank erosion is dependant on the scour energy of the stream (direction and magnitude) and the erodibility of the bank material.

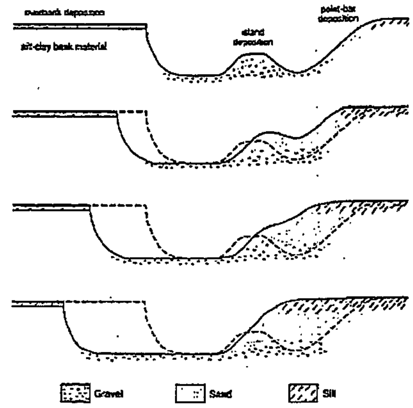


Figure 28. Progressive channel migration shown in cross section (Drawing: Knighton, 1998).

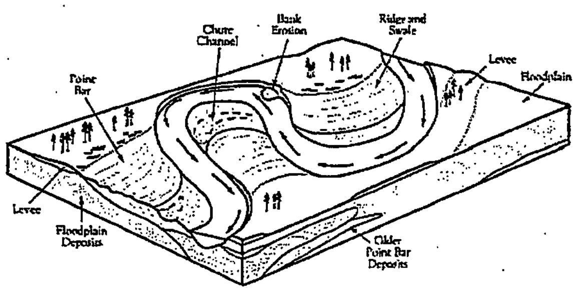


Figure 29. Progressive channel migration shown in plan view (Drawing: Mount, 1995).

Likely locations for rivers exhibiting this behavior include low gradient valleys below the outlets of lakes and those some distance away from primary sediment sources. The size of available sediment for transport is a factor in maintaining a single channel. There may be a few rivers in Washington where aerial photo review and field evidence show that the river migrates primarily in this manner. The methods for CMZ delineation of these stream types are described below.

For large sinuous, or meandering, rivers that are unaffected by permanent dikes or levees and show historical or photographic evidence of the channel migration processes described above, the extent of the CMZ can be determined by one of the following methods:

1. Using aerial photos to determine the amplitude of the meander wavelength described below; or
2. Evaluating the average annual bank erosion rate as described for the Erosion Hazard Area above.

As illustrated in Figure 28, the meander bends of a river have a wave pattern characterized by a general wave-length and amplitude. The amplitude of the meander bends can be used to help delineate the approximate extent of the channel migration zone (Method 1). From aerial photographs, two generally parallel lines are drawn to encompass the maximum amplitude of the meander wave and any meander cutoffs or oxbow lakes in a given stretch of river. These parallel boundaries can be roughly located in the field using landmarks identified from aerial photos to place the CMZ boundary. Changes from riparian to upland vegetation communities, geologic controls, remnant side-channels, oxbow lakes, and associated wetland complexes can be used as field indicators to help identify the extent of the meander belt. The CMZ delineated in this manner is assumed to encompass the historic migration zone, the avulsion hazard zone, and the erosion hazard zone.

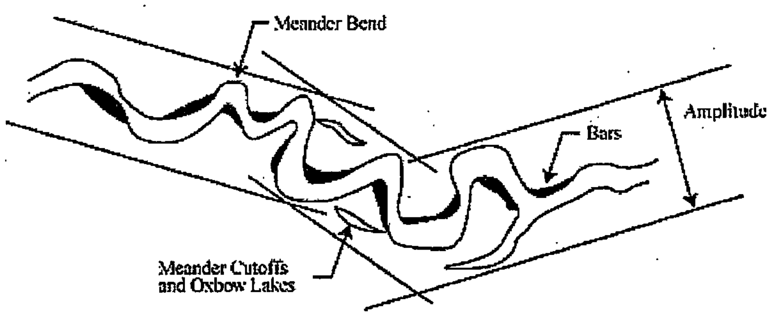


Figure 30. Method 1: CMZ equals area within amplitude of meander bends.

When using Method 1, the segment should also be evaluated for the potential for primary avulsion outside of the meander belt (see avulsion hazard zone). If avulsion outside of the meander belt has occurred historically, using a different scenario and delineation method may be necessary. If it's unclear where to draw these lines to include or exclude some meander pattern floodplain features, an expert analysis is recommended. Method 2, calculating the average annual bank erosion rate, is advised where the river is eroding into a terrace edge or the stream has been eroding laterally across the floodplain in a single direction either throughout the entire segment, a portion of it, or at a single location.

Scenario 7 - Stable, Sinuous Channels: Bare or exposed banks alone are not necessarily an indicator of channel migration. Segments of rivers or streams that are unconfined, low gradient, and sinuous may be stable and may not exhibit active bank retreat or lateral migration over time if erosion or avulsion processes are inactive. Stable sinuous streams or segments have a gradient generally less than 1% and silt or clay banks. In stable stream segments, the bankfull channel position shifts negligibly over the span of the photo record. These stable reaches do not need CMZ delineation.

Included in this category are those wetland channels that have no ability to migrate because they are very low energy and transport low volumes of sediment. These streams have very low gradients (e.g., <.05%) and are narrow and deep (channel width < 3 times channel depth). Their substrate is predominately silt or fine organic particles, banks are stabilized by the roots of wetland vegetation, and >90% of the water surface is smooth. These channels are not common on forested lands except in certain low elevation, coastal plain situations (e.g., Willapa Bay). This does not include distributary channels in deltas or estuaries where the stream meets a larger water body such as a lake, river, or the ocean).

2.4 CMZ Review and Additional Analyses

Pre-application reviews by stakeholder groups can be useful in identifying important processes affecting channel migration and determining additional information necessary to delineate a channel migration zone.

An interdisciplinary team (I.D. team) is recommended for those situations that are complex or potentially controversial. An I.D. team will benefit if members have familiarity with the stream system and/or have an understanding of geomorphic and channel processes.

Additional analyses are recommended for CMZ delineations of large rivers and multiple river segments, alluvial fans, and braided channels. These analyses may include information such as a thorough review of channel behavior over the historical record, a synthesis of the watershed processes driving channel migration, a topographic analysis (channel cross sections, longitudinal profile, or LiDAR), the origin, composition, and erodibility of valley fill and features, and any additional analyses appropriate to the situation. CMZ delineation is a relatively recent concept, and no one method of analysis has been adopted or prescribed. Various geomorphic, engineering, and modeling methods can be applied to channel migration delineation (FEMA 1999).

2.5 Technical Background

River and stream channels are constantly adjusting to changes in flow, sediment, and other debris loads. The tendency for a channel to adjust both vertically and horizontally to these variable inputs of mass can cause it to move laterally across its valley. The concept of delineating the area where the channel is prone to move, or the *channel migration zone* (CMZ), comes from an acknowledgment of these natural processes and the need to alter land use practices to accommodate them.

To aid the field practitioner in understanding and predicting the extent to which a channel may move, an overview of the processes involved in channel movement is provided here. The concepts conveyed below are helpful for understanding the definitions related to channel migration zone contained in the Forests & Fish Report (WSDNR et al., 1999), which provides the original basis for the CMZ rule. This information is also useful as a reference for complex or difficult CMZ delineations. The following technical background draws from several classic texts on river process (Leopold, Wolman, and Miller, 1964; Schumm, 1977; Dunne and Leopold, 1978; Mount, 1995; Knighton, 1998; Wohl, 2000) and from current work in the Pacific Northwest.

River Systems: Rivers are essentially agents of erosion and transportation, removing the water, sediment, and debris supplied to them from the land surface to the oceans or other basins. In performing this work, rivers have evolved over time to their present configuration.

The character and behavior of the stream system at any particular location reflects the net effect of a suite of independent variables that act at the landscape, local basin or channel reach scale and exert control on the dependent channel morphology. At the landscape scale, the combined influences of climate, geology, and land use determine the suite of processes controlling the delivery and rate of water and sediment to a stream (Knighton, 1998) (Figure 31). Climate dictates seasonal precipitation patterns and temperature, thereby influencing the type of vegetation present and general runoff patterns (e.g., snowmelt versus rain-dominated). Regional geology influences topographic relief, valley morphology, types of erosional processes operating (e.g., shallow rapid soil slips, rock fall, earth flows, soil creep, or deep weathering of the rock), as well as stream chemistry.

Within a basin, differences in rock type and relief strongly influence the slope and physical characteristics along the stream channel. Land use within a basin can both directly and indirectly influence channel morphology. Direct land use effects on morphology include dams, river regulation, channelization, gravel mining, and navigation maintenance. Indirect effects on morphology include forest cutting and clearance, road building, upslope mining, agriculture and urbanization (Knighton, 1998; Wohl 2000). The *flow regime*, which is defined as the magnitude, frequency, duration, timing, and rate of change of all flow events through time at a particular location within a basin (Poff et al. 1997), is the cumulative result of climate, geology, topography, and land use. All of these independent variables affect each portion of a river or stream.

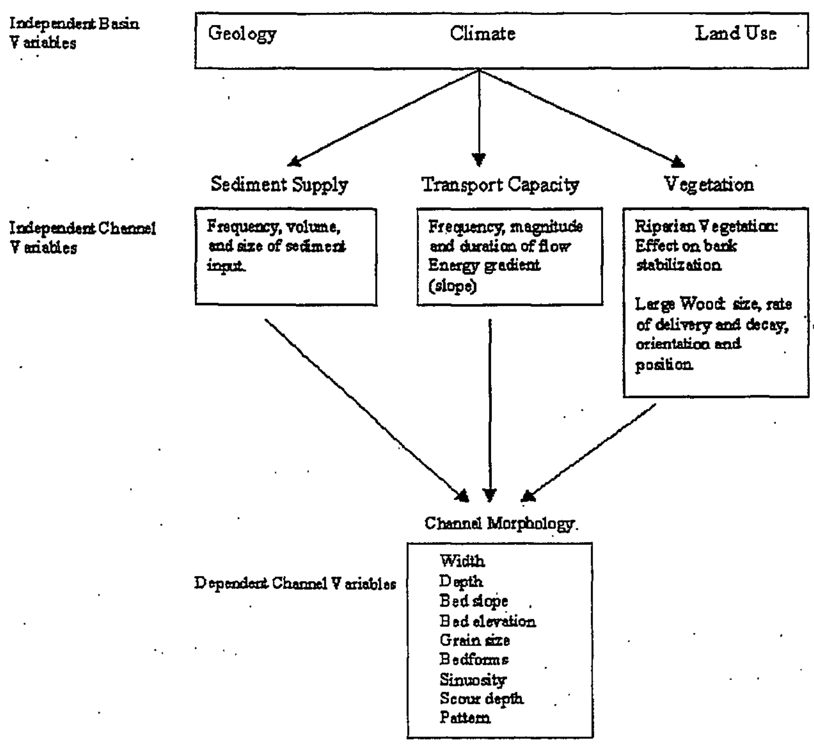


Figure 31. Independent controls on channel morphology and the dependent variables subject to change or adjustment (Diagram: modified from Montgomery and Buffington 1993).

A number of concepts and classification systems have been developed to describe the river system and to help us organize our understanding of river processes. Understanding these ideas will help us predict where channels are prone to migrate within a catchment. Classically, rivers were viewed as lengthwise systems where both physical (Schumm, 1977) and biological (e.g., the River Continuum Concept, Vannote et al., 1980) forms and processes change gradually downstream (e.g., Mackin, 1948). In general terms, a river develops systematic downstream changes in shape and form based on increasing discharge and decreasing gradient as it transitions from the steep sediment source headwaters, through a zone dominated by transportation of sediment, to a zone of long term sediment storage and transport (Figure 32). A downstream change in physical processes also occurs as rivers become less directly coupled with hillslope water and sediment sources (Schumm, 1977; Montgomery, 1999; Church, 2002). Applied on a broad scale, these relationships are generally true, and would suggest that channel migration is likely in floodplain valleys and mainstem rivers located at lower elevations or gradients in the system.

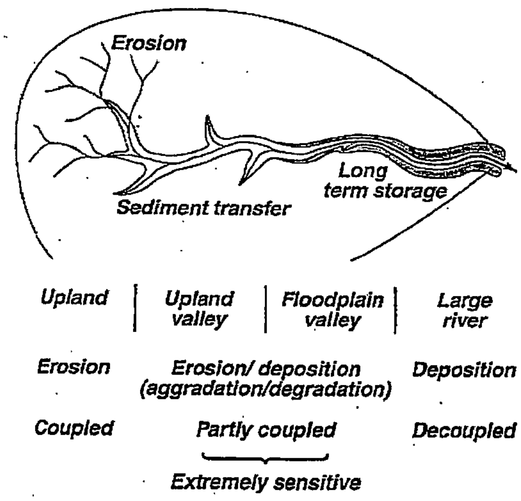


Figure 32. Watershed map showing the principal zones of sediment behavior (Church, 2002).

Given a closer look, however, most rivers will not always transition gradually and continuously downstream. Idealized, smooth, concave-up bed elevation profiles give way to stepped profiles (Figure 33). Local controls such as differences in bedrock type or structure, tributary junctions, landslides, variation in valley width, and storage of sediment and wood all influence the location and scale of these gradient steps (Rice and Church, 2001; Church, 2002). These local controls also interrupt the downstream fining of sediment sizes predicted by the river continuum theory and introduce variability in stream energy (Rice and Church, 1998; Knighton, 1999), which influences the rate of sediment accumulation and transport within a step or channel reach. Termed the "river discontinuum" theory, it predicts a patchy arrangement of channel form and response in the downstream direction (Figure 34) and suggests that channel migration may occur anywhere along the river profile (Ward and Stanford 1983, 1995; Ward et al., 2002; Poole, 2002).

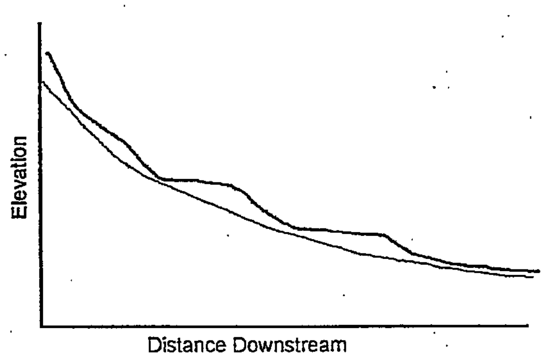


Figure 33. Comparison of an idealized river (gray line) to the more realistic profile (black line) from headwaters to mouth.

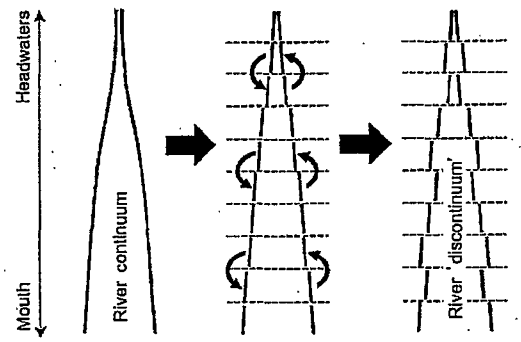


Figure 34. Different conceptual models of how rivers change in the downstream direction (Drawing: Poole, 2002).

Despite their general lower elevation and gradient locations, floodplain reaches containing alluvial deposits of various scales can exist throughout a river system. The river network consists of alternating reaches with variable gradient and valley width (Figure 35). In reaches where gradient diminishes and valley width increases, sediment and organic material deposition can lead to channel adjustment and migration. Lateral channel migration through these valleys provides a mechanism of sediment exchange and serves to create and maintain these floodplain deposits over time.

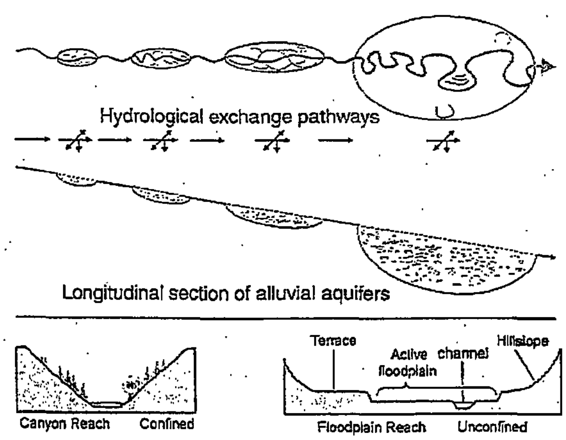


Figure 35. The channel network shown as a series of confined and unconfined reaches. Additionally, hydrologic exchange pathways are shown for the longitudinal, lateral and vertical dimensions (Drawing: Ward et al., 2002).

River systems are described in four dimensions: three spatial planes (cross section, long profile, and planview) and time (Figure 36). Channel geometry (width and depth) and confinement are derived from cross sections and used to evaluate the area through which water and sediment are moving. Channel gradient (potential energy) is illustrated in profile and channel patterns are conveyed in planview. Changes occur in each of these planes with every flow event that alters the channel bed or banks.

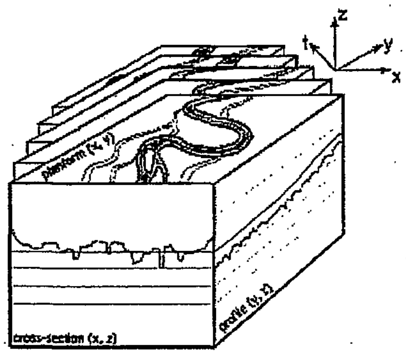


Figure 36. The four dimensions typically used to describe the morphology of a river: Physical space (x, y, z) and time (t). Three two-dimensional planes are: 1) cross section (x, z), 2) long profile (y, z), and 3) planview (x, y). The x-axis extends perpendicular to the river channel and its valley, the y-axis parallels the valley, and the z-axis is vertical.

Schumm (1985) defines three major categories of stream channels: bedrock, semi-controlled, and alluvial. Bedrock channels are composed of and controlled by bedrock. This category of channel is generally stable over time and does not change its position unless there are weak sections of bedrock that allow the channel to shift laterally. A channel may also be non-alluvial when materials that were not transported by the river under current conditions bound it. Such examples include channels that are deeply incised into hillslope or glacial deposits. Semi-controlled channels have local controls that resist channel movement. Local controls can be areas of bedrock, resistant alluvium, or large wood and logjams (Schumm 1985; Abbe and Montgomery 2003). Alluvial channels are formed in and flow through the sediment transported by the river, referred to as alluvium. Since alluvial channels are shaped by the volume of water and debris load they carry, they are also self-adjusting to alterations that change the timing and volume of flow, wood, and sediment load. It is the alluvial channels that have the capacity to build floodplains and migrate laterally.

The relationship between a channel and the valley through which it flows is fundamental to channel migration. The degree to which a channel is deflected by the valley walls or by resistant terraces is known as confinement (Kellerhals et al., 1976). Many applied scientists use some description of valley confinement to define hillslope constraint on channel processes. Although confinement is often reported as the ratio of average valley width to average channel width (e.g. Cupp, 1989), little empirical data exists to support a numerical interpretation of this relationship. However, it remains a useful relative measure. Rivers and streams unconfined by hillslopes can also be artificially constrained by dikes or road grades constructed on the floodplain or in the channel itself.

In contrast to channel confinement, channel *entrenchment* is the relationship between the channel and the relatively flat surfaces on the valley floor that may be prone to flooding at some maximum stream discharge (Galay et al., 1973; Kellerhals et al. 1976). A qualitative definition of entrenchment is the vertical containment of a river and the degree to which it is incised within a valley floor (Kellerhals et al., 1972). Although attempts have been made to quantify entrenchment as the ratio of average *flood-prone width* to the average channel bankfull width within a reach (e.g. Rosgen, 1994), little empirical data exists to support precise numerical classifications. Flood-prone width refers to the width of the stream at some maximum stream discharge (Galay et al., 1973) (Figure 37). Channel entrenchment can occur in response to natural processes (e.g., tectonic uplift) or human disturbance (e.g., channel clearing and straightening, harvest and clearing of floodplain forests, urbanization, upstream impoundments).

The Floodplain: The river floodplain is defined as the relatively flat area or berm adjoining a river channel and actively constructed by the river in the present climate by a combination of progressive lateral migration, channel creation and abandonment, and overbank sediment deposition from periodic inundation. Floodplain inundation can result from any combination of overbank river and tributary water at high discharge, hillslope runoff, groundwater, and direct precipitation. Floodplains may not be uniform or homogeneous flat surfaces, and can consist of irregular or multiple surfaces at different elevations that reflect vertical differences in the channel bed resulting from reach scale scour or fill and changes in flow regime, sediment supply and wood loading.

The height at which the channel overflows its banks is called the bankfull *stage* and corresponds approximately to the discharge at which the channel characteristics are maintained. The floodplain is, by definition, the valley level corresponding to the bankfull stage, or slightly less than bankfull if natural levees exist. Areas outside the bankfull channel (i.e., floodplain) are areas of short- or long-term sediment storage. The relatively flat valley bottom of the floodplain composed of river alluvium is the most direct evidence of lateral migration (Dunne and Leopold, 1978). Because channels are rarely in equilibrium and constantly undergoing adjustment (particularly in areas with historic forest clearing (Wolman and Leopold, 1957, Lisle and Napolitano, 1998; Wohl, 2000), floodplain and bankfull elevations change and are therefore not constant through time.

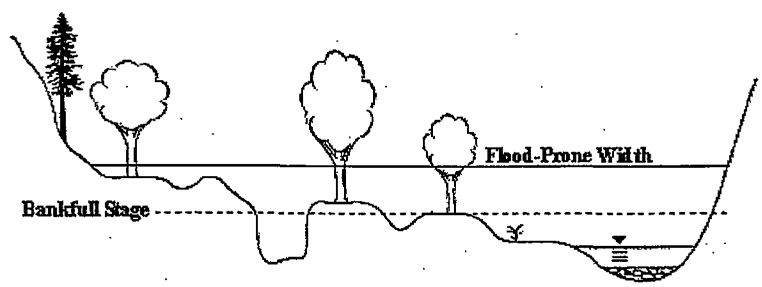


Figure 37. Simplified valley cross section of alluvial valley bottom illustrating the effects of various stages on channel width.

Field determination of bankfull stage is difficult when the floodplain is narrow or not flat or well defined. The difficulty is greater in foothills and mountains (Dunne and Leopold, 1978) because processes in addition to the floodplain building process described below are operating (Part 1 Bankfull Channel Features and Part 2.5 Magnitude and Frequency of Channel-forming Events).

The bankfull concept was developed for alluvial channels and does not apply to bedrock bounded or confined channels.

Floodplain-building Processes: Floodplains represent areas where river borne sediments (both bedload and suspended sediments) are stored, at least temporally, within the valley. Floodplains play an important role in conveying high flows, diffusing flood levels downstream, and exchanging organic and inorganic material. Dominant floodplain building processes include overbank deposition of sediment (both fine or coarse), bar deposits in actively meandering rivers, and residual deposits associated with channel creation and abandonment. The sediment and debris stored in a floodplain are eventually re-introduced to the channel at varying time scales and conveyed further downstream. Floodplain river systems often have multiple types of interacting channels, which aid in floodplain building processes and the conveyance of water longitudinally and laterally. Secondary channels carry water (intermittently or perennially in time; continuously or interrupted in space) away from, away from and back into, or along the main channel. Anabranch channels are the most common form of secondary channel, which are diverging branches of the main channel that reenter the main channel some distance downstream. Secondary and anabranch channels can be subdivided into: side channels, wall-based channels, distributary channels, abandoned channels, overflow channels, chutes, and swales.

A river maintaining a floodplain through the process of progressive bank cutting on the outside of a meander bend and subsequent deposition on the inside of the bend (Figures 38 and 39) is considered in a state of dynamic equilibrium with the volume of water and sediment it carries (Knighton, 1998). The elevation and basic pattern and average geometry (width, depth, and cross sectional shape) of the channel do not change; but the channel location migrates across the valley horizontally, and the meander pattern migrates down valley over time. However, this process can be short circuited by dramatic shifts in the position of the channel through avulsions.

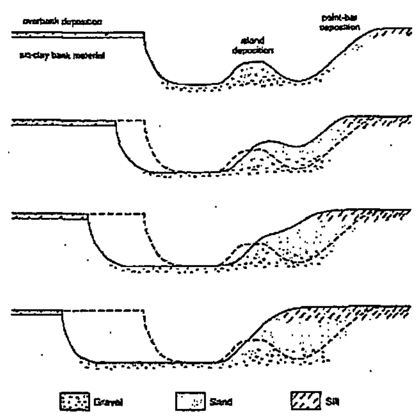


Figure 38. Progressive channel migration shown in cross section (Drawing: Knighton, 1998).

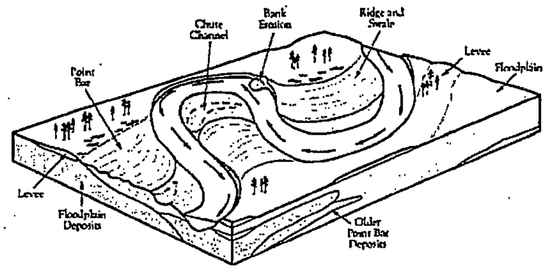


Figure 39. Progressive channel migration shown in planview (Drawing: Mount, 1995).

Channel avulsions are defined as relatively sudden and major shifts in the position of the channel to a new part of the floodplain (first-order avulsion) or sudden reoccupation of an old channel on the floodplain (second-order avulsion) or relatively minor switching of channels within a braid train or other active channels (third-order avulsion) (Nanson and Knighton,1996). Avulsions onto floodplain deposits can occur at a variety of scales and channel sizes. Primary avulsions paths can be guided by the presence of poorly defined topographic low points along the floodplain, and secondary avulsion paths can follow better defined secondary or abandoned channels on the floodplain. The shifting of the main channel into an active side channel or braid (third-order avulsion) is not considered a classic channel avulsion per se, but rather represents the typical channel-switching phenomenon of anabranching rivers as defined by Nanson and Knighton (1996) (Part 2.5 River Pattern).

Avulsions occur when the channel capacity to convey water, sediment, and wood is reduced. Avulsions can be caused by any combination of a downstream decrease in the main channel slope, an increase in slope down-valley along the floodplain as compared to the channel slope, local sediment build up in the channel called aggradation, wood debris jam formations, ice jams in colder climates, vegetation encroachment, hydrologic change in peak discharge, and/or stream capture from adjacent or secondary channels (Jones and Schumm, 1999; Bridge, 2003). Typically, as a channel becomes more sinuous as it actively meanders, the channel length increases (relative to the same down valley distance) and the slope decreases, slowing the water, which favors sediment deposition and higher water surface elevations. This condition increases the potential energy for eroding a new, steeper, shorter, and less resistant course through a floodplain meander deposit, resulting in a meander chute (or neck) cut-off or an avulsion (Figure 40). These processes can be aided by stream capture from the headward erosion of secondary channels draining the floodplain (Thompson, 2003) and large woody debris deposits in the old main channel (Abbe and Montgomery, 2003).

Empirically, avulsions or cut-offs typically occur when the floodplain slope (i.e., potential avulsion path) is greater than the channel slope ($S_f/S_c>1$) (Jones and Schumm, 1999; Bridge 2003), the ratio of the bend radius of curvature to channel bankfull width is less than two ($r_c/w<2$) (Lewis and Lewin, 1983; Knighton, 1998), or the channel sinuosity (channel thalweg length vs. straight-line valley length) is greater than one and a half ($L_c/L_v>1.5$) (Leopold et al., 1964). The occurrence of an avulsion also obviously depends on the prerequisite ratio of a high discharge event above a threshold discharge for avulsion ($Q_{max}/Q_{threshold}$) (Bridge, 2003) or other complicating factors such bed aggradation or wood debris jam formations (Jones and Schumm, 1999; Bridge, 2003).

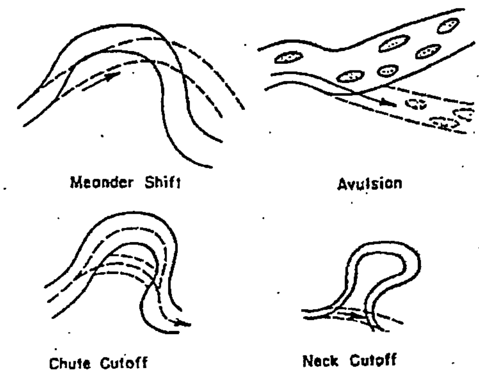


Figure 40. Types of channel changes (modified from Schumm, 1985). Solid lines indicate pre-change channel position. Dashed lines indicate post-change channel position.

Role of Wood in Streams: "Gravel, sand, and silt collect in the dead water, behind the drift piles, strengthening them and preventing the river from returning to its original bed. Evidences of this action are plentiful, and, in the narrow valley of the upper reaches, show that the river has been forced from the hills on one side to those of the other, a distance of ½ mile (0.81 km) or more, and the original bed has become overgrown with very heavy timber." From a description of the White River, near Auburn, Washington in the early 1900s (Wolff 1916).

Wood debris can play a significant role in channel migration throughout a fluvial network from headwater bedrock channels (e.g., Montgomery et al., 1996, Massong and Montgomery, 2000) to large alluvial rivers (Abbe and Montgomery, 2003; Lancaster et al., 2001; O'Connor et al., 2003). The majority of streams and rivers are depleted in wood debris, and historic conditions may not reflect conditions associated with intact, mature riparian forests (e.g., Maser and Sedell, 1994).

Wood debris (i.e., branches, tree trunks with and without root mass) is an important element of the solid material introduced to rivers. Just like the sediment load of a river, wood debris ranges widely in its physical characteristics such as size, shape and density. Generally the larger pieces of wood debris tend to be more stable and become a significant factor increasing the frictional resistance that flow encounters (e.g., Shields and Gippel, 1995, Gippel et al., 1996, Brooks and Brierley, 2003). Wood debris, either as individual snags or accumulations (i.e., logjams), often creates obstructions impeding flow and sediment transport and thereby altering channel morphology. By dissipating energy through a general increase in channel roughness or directly impounding flow, wood effectively reduces the sediment transport capacity of the channel and traps sediment and other wood that would have otherwise passed through the channel. The resulting sediment storage upstream of wood accumulations raises the channel bed elevation and increases the frequency of overbank flow and the probability of a channel avulsion (e.g., Lisle, 1995; Hogan et al., 1998; Lancaster et al., 2001; Abbe et al., 2003). New channels develop where flows find an unobstructed path around the wood obstruction. This process can occur from steep headwater channels (e.g., Massong and Montgomery, 2000) to large rivers (e.g., Sedell and

Luchessa, 1982, Triska, 1984, Abbe and Montgomery, 1996, 2003). Wood accumulations impose a strong influence on vertical (profile) and lateral (planform) migration of streams and rivers. Logjams can raise a channel several meters and move a river from one side of its valley to another, including large rivers (Abbe, 2000; Abbe and Montgomery, 1996, 2003; O'Conner et al., 2003).

Other Valley Forming Processes: In mountain valleys subject to recurrent debris flows, debris flow deposits form the valley floor in many reaches. The defined stream channels carved in these deposits are impermanent, since subsequent floods may dam or divert or greatly enlarge them. Where such debris flows are important, levees, berms, or terraces may be distinguished and even ascribed to particular flood years. However, a floodplain, as defined above and having a constant frequency of overflow, cannot be identified or does not exist (adapted from Dunne and Leopold, 1978).

In the Pacific Northwest, rivers may also occupy valleys formed by quiescent processes from former continental or alpine glaciation or volcanic mudflows (Booth et al., 2003). A river or stream that appears too small to have eroded the valley in which it occupies is called an underfit stream (Knighton, 1998). An example of an underfit stream is the White River, which flows through a valley produced by multiple glaciations combined with periodic deposition of volcanic related mudflows (lahars) and debris flows originating from the Mount Rainier volcano (Collins, et al. 2003).

Alluvial fans are a unique landform in the river valley. They are cone- or fan-shaped deposits of sediment and debris that accumulate immediately below a significant change in channel gradient and/or valley confinement (Figure 41). The fan shape is created as the channel moves back and forth across the gradient transition depositing sediment. Technically, the term refers to those features composed of sediment deposited by running water; however, it is commonly used to refer to those features also built by debris flows that simply overflow the channel and spread out onto the fan surface. Debris flow deposits can be later reworked by the stream and deposited further down the fan surface. Generally, a gently sloping fan will be alluvial, and a fan built by debris flow or mass wasting processes will have steeper sides. Both commonly exist:

- Where a smaller channel meets a larger channel;
- Where an abrupt change from narrow to wide valley width occurs; or
- Where an abrupt change from steep to gentle channel gradient occurs.

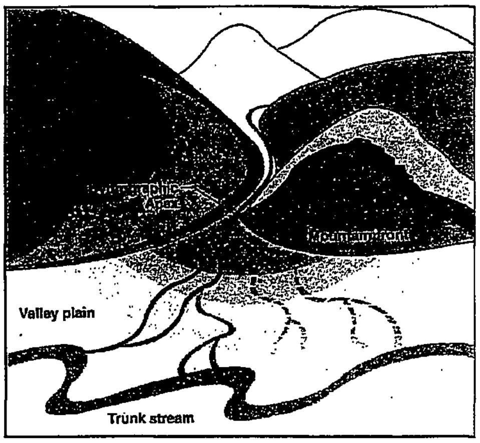


Figure 41. Idealized alluvial fan environment (National Research Council, 1996).

All or some portions of the fan may no longer be subject to channel shifting if the fan-building processes have ceased or diminished. The degree of channel incision at the fan head is not a reliable indicator of the lack of channel shifting potential, as infrequent but large flood events or debris flows can rapidly fill the channel.

Magnitude and Frequency of Channel-forming Events: River channel form is a product of all flow and sediment transporting events and the sequence of those events through time. Fluvial systems also have memory for past events, as partially displayed in the current channel form. Of the total sediment load, bed-load transport has the greatest effect on channel form (Knighton, 1998). While all flow events cumulatively do influence current channel form, not all events produce the same effect or occur at the same flood frequency. This has lead to the theory that a dominant discharge controls the gross channel geometry.

In many alluvial streams, channel size (i.e., width, depth) is established by flood events that occur frequently, which over time accomplish the most work and move the greatest volume of sediment (Wolman and Miller, 1960). While larger flood events, those that occur on average every 50 years, do more work and move more material than small events that occur on average every 2 years, the cumulative work and sediment movement from twenty-five '2-year' floods over fifty years is usually far greater than the one '50-year' flood. Thus, the dominant discharge that may control gross channel form is related to the effective discharge, which over the long term, transports more bed-load sediment than any other flow (Knighton, 1998). The dominant and effective discharges for bedload have been related to flow events that just fill the channel, or the bankfull flow, for alluvial systems in humid climates. The bankfull flow represents a discharge that is reached in most years (e.g., every 1-2 years) in undisturbed watersheds in humid climates (Leopold, Wolman, and Miller, 1964).

However, regionally and world wide, there is great variability among the frequency in flows that just fill the banks of the channel, especially in mountainous or arid terrain and human modified environments. The bankfull discharge may not occur frequently nor be the most effective discharge. In addition, the bankfull channel cannot always be well defined in the field. In streams with highly variable flow regimes or resistant channel boundaries (e.g., smaller, higher elevation drainage basins) (Gustard, 1994), high-magnitude, low frequency events may dominate channel form and have lasting effects (Knighton, 1998).

As land managers, we desire to predict the conditions that will cause specific channel changes. Land use can affect the hydrologic cycle by reducing infiltration capacity, changing the amount and effectiveness of vegetation cover, changing the timing and volume of runoff, and changing channel bed roughness and thus water velocity in channels and in overland flows. These result in changes in the volume of storm runoff and peak discharge. Such changes may be expected to result from a variety of land-use alterations, such as urbanization, grazing, agriculture, forest removal, and others. Increases in the magnitude and frequency of flow and flood pulse events can translate into alterations in the channel morphology and pattern (see Channel Adjustment below). This is especially true for common flood events such as the effective discharge. While land use may change the magnitude and frequency of extreme flood events, data records are of insufficient length to correctly quantify these changes. However, data are sufficient to quantify changes in high frequency flood events such as the effective discharge, which may have the greatest effect on channel form.

Obvious flow regime alterations occur following urbanization (e.g., Hollis, 1975; Booth, 1990; Booth and Jackson, 1997). Impacts in forested regions have also been well studied but are a subject of much debate, especially regarding low frequency extreme events. However, it is clear that the removal of the forested canopy and/or the associated presence of a road network can alter water production. Annual water yield typically increases for some time following the reduction of vegetation cover (Bosch and Hewlett, 1982; Stednick, 1996). Furthermore, common peak flow events within the frequency range of the effective discharge of bedload (i.e., 0.5- to 2-year recurrence interval) increase following forest harvest and road building in small catchments (Jones and Grant, 1996; Thomas and Megahan, 1998; Lewis et al., 2001; Jones and Post, 2004). The cumulative effects of hydrologic alterations within large watersheds are relatively unknown and undocumented.

The same factors affecting surface runoff will also tend to change sediment load. Channel response to large sediment inputs depends on channel size, position of the receiving reach within the drainage network, the quantity and size of sediment, and the characteristics of the riparian zone (Hogan et al., 1998).

Channel Adjustment: Channels are constantly adjusting to changes in the timing and volume of flow and sediment, and to the characteristics and supply of wood. Channels can adjust to changes in the rate of flow, sediment, and wood through changes in channel geometry (width, depth, and slope), channel pattern, and bed texture (grain size and bed form). Table 1 summarizes the general response in channel geometry and pattern based on changes in sediment and/or stream flow and wood debris. The time scale of responses in the dependent factors to changes in independent factors is variable. Width and depth can respond to changes within a year, while adjustment in river slope and meander wavelength may take decades to centuries (Knighton, 1998). Whether the adjustment is small and incremental or episodic depends on the relative size or magnitude of the change.

Abrupt episodes of stream adjustment can occur as significant thresholds are crossed (e.g., Lisle, 1982). An event such as a large flood or disturbance can dramatically reshape the floodplain and increase channel width. Climate change (geologic time scale) or a change in watershed condition by fire, timber harvest, grazing, urbanization, vegetative recovery, or direct channel manipulation (planning level time scale) may cause the river to change bed elevation either downward (degradation) or upward (aggradation). The stream will then build a new level of floodplain appropriate to the new bed elevation. These lateral and vertical adjustments in channel form over time, along with changes in channel pattern are called channel evolution.

Table 1. Generalized adjustment in stream geometry and pattern based on changes in flow and sediment discharge (modified from Kellerhals and Church, 1989, and Chang, 1988) and changes in large woody debris.

Changes in Independent Factors	**Dependent or Adjustable Factors**				
	Channel Geometry			Channel Pattern	
	Width[1]	Depth	Slope	Sinuosity	Meander Wavelength
Water discharge increases alone (e.g., forest harvest)	↑	↑	↓	↓	↑
Water discharge decreases alone (e.g., water supply diversion)	↓	↓	↑	↑	↓
Sediment discharge increases alone (e.g., road building on unstable slopes)	↑	↓	↓	↓	↑
Sediment discharge decreases alone (e.g., road & harvest restrictions)	↓	↑	↑	↑	↓
Water and sediment discharge both increase (e.g., response to large storm event)	↑	?	?	↓	↑
Water and sediment discharge both decrease (e.g., downstream of a reservoir)	↓	?	?	↑	↓
Water increases and sediment decreases (e.g., climate change toward a more humid pattern)	↑↓	↑	↓	↑	?
Water decreases and sediment increases (e.g., water supply diversion plus road building and harvest)	↑↓	?	↑	↓	?
Decreased large wood debris (e.g., riparian harvest)	↑↓	↑↓	↑	↓	↑
Increased large wood debris	↑↓	↑↓	↓	↑	↓

[1] Non-cohesive bank material (↑ = Increase; ↓ = Decrease; ↑↓ = Either increase or decrease or both; ? = Indeterminate)

Conceptual channel evolution models have been created to display typical channel adjustment following channel disturbance. Simon and Hupp (1986) developed a model for channel incision and vertical channel change (Figure 42). Once disturbed, a channel may proceed through a cycle of channel degradation and incision, bank failure and widening, aggradation, and re-creation of a floodplain and quasi-equilibrium channel form (Simon and Hupp, 1987, 1992 and Simon, 1994). Once disturbed, the channel bed and associated floodplain may or may not return to initial bed elevations. However, if disturbed, stream channels will tend to return approximately to their previous state (e.g., pattern and size) once the perturbation is damped down (Knighton, 1984) (Figure 42).

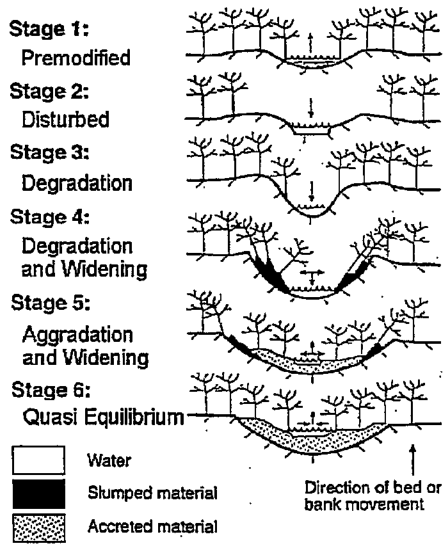


Figure 42. Channel incision and vertical channel change over time (Drawing: modified from Simon and Hupp 1986).

When a stream down-cuts or lowers its bed elevation (i.e., incision), the former floodplain it had been constructing may be abandoned. An abandoned floodplain is called a terrace. Terraces may be at different levels above the floodplain, depending on the past history of the individual river (Figure 43). When a river aggrades, the floodplain may reoccupy or become higher than adjacent terraces. The process of valley scour and redeposition is called "cut and fill." Analysis of alluvial history suggests that valley filling tends to be a much slower process than valley erosion (Leopold, 1994). Many alluvial valleys consist of multiple floodplain and terrace surfaces.

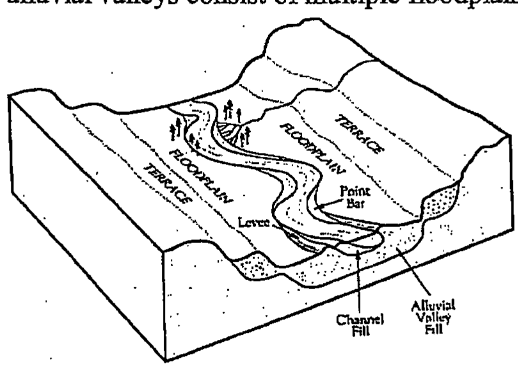


Figure 43. Cross section and planview illustration of terrace development and valley downcutting and subsequent filling (Drawing: adapted from Mount, 1995).

Terraces are susceptible to erosion by migrating channels, particularly when the terrace is composed of unconsolidated alluvium. Unlike the definition of floodplain, there is no consistency among rivers in the recurrence interval of flooding of the terraces that exist (e.g., very extreme flood events) (adapted from Dunne and Leopold, 1978).

As with all natural systems, channels will develop the most stable configuration based on the existing conditions. However, rivers are inherently dynamic systems that constantly respond to variable inputs of water, wood, and sediment through erosion and deposition. For relatively constant conditions of the controlling variables, a natural river may develop characteristic forms, recognizable as statistical averages about which fluctuations occur. A change in discharge and sediment characteristics does not necessarily produce an immediate change in the stream channel but rather initiates a change that may extend over a period of time. Adjustment to changes in watershed conditions may take time and may not be completed before another event disrupts the condition, causing readjustment again. It is therefore not possible to forecast what will be the net effect of a particular or series of alterations. However, there are probable states (Leopold 1994).

River pattern is used to describe the planform geometry of a river reach or segment, as viewed from above as it would appear from an airplane, and implies the processes operating along that river. Channel pattern is used to define these characteristics only within individual channels that make up part of the overall river pattern (Nanson and Knighton, 1996). Two main river patterns are generally recognized: single-channel rivers and anabranching rivers. Anabranching rivers are multi-channel systems characterized by vegetative or otherwise stable alluvial floodplain islands that divide flows at discharges up to nearly bankfull (Schumm, 1985; Nanson and Knighton, 1996). Channel pattern, as applied to individual channels, has been classically divided into straight, meandering and braided channels (Leopold and Wolman, 1957). A simple diagram of these river and channel patterns is displayed in Figure 42, but more detailed analyses of different patterns also exist (Leopold and Wolman, 1957; Brice, 1978; Schumm, 1985; Knighton and Nanson, 1993; Nanson and Knighton, 1996; Thorne, 1998).

Due to hydrodynamics, nearly all natural channels exhibit some tendency to develop curves, or meanders in plan form, which seem to be proportional to the size of the channel. The meandering channel pattern is often illustrated as symmetrical bends, although the meanders can be asymmetrical or quite irregular. The exceptions to the meandering pattern occur where a stream is forced into a more or less straight channel pattern by land use intervention or through geologic controls like fractured bedrock or very cohesive sediment, and where high sediment loads produce a braided channel pattern. Even where the channel is straight it is usual for the thalweg, or line of maximum channel depth, to wander back and forth from near one bank to the other. Rivers are seldom straight through a distance greater than about ten channel widths, and so the designation straight is relative and implies an irregular, sinuous (non-meandering) alignment (Figure 44). Most rivers can also exhibit straight, meandering and braided patterns all within the same reach or valley segment depending on the scale of the observation.

A braided stream is divided into several channels that branch and rejoin around bare or sparsely vegetated sand/gravel/cobble bars. The braided form may range from occasional (widely separated single bars) to fully braided (many channels divided by many low bars). The braided channel pattern is partly stage or water level dependent. Bars exposed at most flows may be inundated at higher discharges to display the overall single-channel river pattern. Braided streams are characterized by high sediment load relative to transport capacity, wide active channels overall, low sinuosity, low threshold of bank erosion, rapid shifting of bed material, and a continuously shifting stream course (Knighton, 1998). Rapidly fluctuating stream flow contributes to bed instability and bank erosion, common on streams fed by glaciers. Braiding involves the positive feedback cycle between sediment supply, bar formation, and bank erosion. Braided channels are also common in locations with a high sediment supply and a rapid reduction in transport capacity, such as alluvial fans when a steep mountain stream drops into a valley.

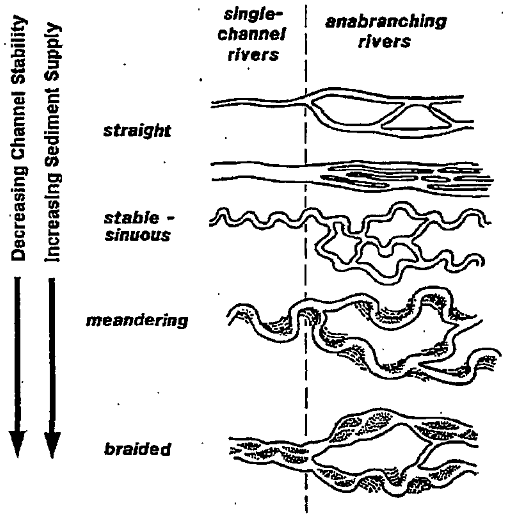


Figure 44. Single and Anabranching River Patterns (Drawing: modified from Nanson and Knighton, 1996)

Anabranching rivers have multiple channels divided by semi-permanent floodplain islands, which are typically vegetated. Individual channels within anabranching rivers can be straight, meandering or braided (Figure 44). Anabranching streams typically retain the appearance of a multiple channel system up to the bankfull discharge, when floodwaters connect across forested island floodplains. As with braided streams, individual channels of an anabranching river are a response to relatively high sediment supply at varying scales. Multiple channels, each with relatively small width-depth ratios as compared to the overall channel, effectively increase the sediment transport capacity to accommodate the sediment load (Schumm, 1985; Nanson and Knighton, 1996). Numerous types of anabranching rivers have been described (Part 2.5 Channel Types and Classifications). Wood debris also plays a role in initiating and sustaining anabranching systems (Abbe and Montgomery, 1996, 2003).

Anastomosing, a word borrowed from a medical term for dividing and rejoining blood vessels is used to describe a specific subset of anabranching rivers with erosion-resistant cohesive banks and relatively low width-depth ratios of individual channels. The lower width-depth ratios of anastomosing channels are partially supported by cohesive bank sediment, island vegetation root strength, and/or large woody debris bank protection (imbedded or instream) (Smith and Smith, 1984; Knighton and Nanson, 1993; Nanson and Knighton, 1996). As with all anabranching rivers, vegetation plays a crucial role in creating anastomosing channels by providing bank cohesion and providing wood debris for channel creation (i.e., avulsion), maintenance, and stability (Nanson and Knighton, 1996; Gurnell and Petts, 2002; Abbe & Montgomery, 2003).

Channel pattern represents a mode of channel form adjustment in the horizontal plane that is linked with other channel adjustments. The available evidence suggests that the sequence of straight, meandering and braided patterns is related to (Knighton, 1984):

- increasing width-depth ratio, which is generally associated with decreasing bank stability/resistance and increasing bed-load transport;
- increasing stream power, which implies increasing discharge at constant slope or increasing slope at constant discharge; and
- increasing sediment load and in particular bed load.

A particular channel shape and pattern is closely related to the quantity and variability of stream flow, the quantity and character of the sediment and wood in movement through the section, and the composition of the materials making up the bed and banks of the channel. Classifying channels based on pattern can tell us something about the current sediment and water regime, but a channel pattern can change from a large change in either of those inputs. For example, a channel may change from a single channel meandering pattern to a braided pattern and back to a meandering pattern in response to a large but temporary increase in sediment or short term reduction of bank resistance through vegetation loss. It is not uncommon for a non-braided channel to develop a side channel forced by the deposition of large wood at the upstream end of a gravel bar. A channel can also be highly sinuous and meandering but entirely confined by bedrock or very cohesive banks.

River pattern is a continuum from one extreme to another. There is no sharp distinction between any of these patterns, but empirical attempts have been made to separate them (Leopold et al. 1964). The current pattern of the channel is only one attribute looked at when attempting to predict future channel movement. Because plan form is a response to a complex array of interactive variables, it is not the sole discriminator for river classification or channel types. Although any classification of distinctive patterns or channel types is somewhat arbitrary, some sweeping statements can be made about the processes forming each general class. These generalities are expanded upon below.

Channel Types and Classification: Because a river channel can be characterized by a particular combination of patterns and attributes, channel classification is possible. Once classified, general statements can be made about the responsiveness of each channel type to changes in the controlling factors described above. Based on a combination of characteristics, we can broadly predict which stream channels will have a tendency to migrate over time and by what processes. However, river channel morphologies do not always neatly fit into discrete compartmental types. Rivers should be viewed as a continuum (or discontinuum) of channel types, where one type blends gradually or abruptly into another depending on different processes and geomorphic thresholds (Kondolf et al., 2003).

A number of classification schemes exist in the literature and are applied at different scales for different purposes. Defining the intended spatial scale of any classification scheme is important. Streams can be viewed as hierarchically organized, interlocked units nested within each other. The variability of the next lower level is constrained by the higher hierarchical level (Frissell et al., 1986; Kondolf et al., 2003). These hierarchical levels range from the river system or catchment scale, to the valley segment scale, to the reach scale, to the habitat scale, to the microhabitat scale (Figure 45) (Frissell et al., 1986). For the purposes of channel migration, the valley segment and reach scales are most appropriate. Fortunately, the majority of channel classification systems have focused at these scales.

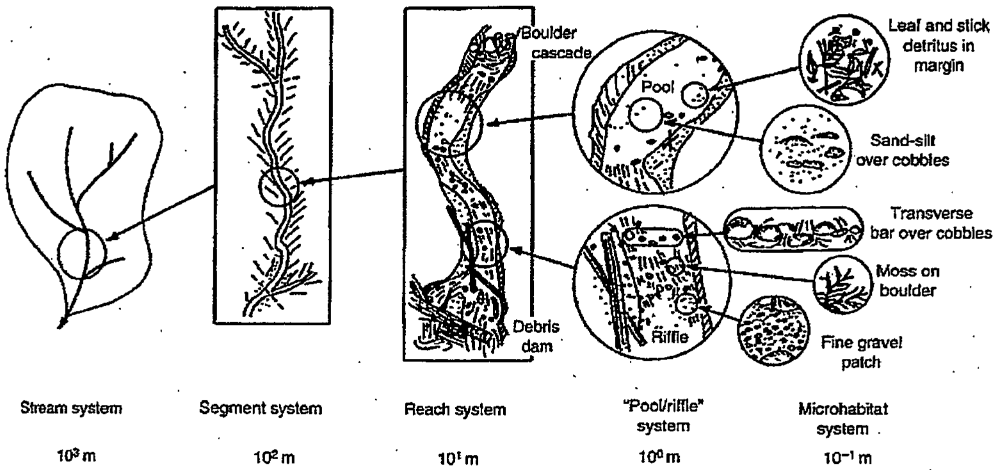


Figure 45. Hierarchical stream classification (Drawing: Frissell et al,. 1986; adapted from Kondolf et al., 2003).

Several basic catchment-to-reach scale classifications of fluvial forms and processes have been reviewed above [i.e., 1) sediment erosion, transfer, and long-term storage zones (Schumm, 1977); 2) bedrock, semi-controlled, and alluvial channels (Schumm, 1985); 3) single-channel rivers and anabranching rivers (Nanson and Knighton, 1996); 5) straight, meandering and braided channels (Leopold and Wolman, 1957)]. While very useful, these classifications are only a few building blocks of more detailed reach and segment scale classifications.

All channel classifications use a combination of attributes to describe general channel types. Basic to many of these are 1) channel slope or gradient, 2) horizontal and vertical confinement of the channel (valley morphology), 3) relative channel size (function of drainage area and dominant discharge), 4) bank and bed material and size, 5) dominant mode of sediment transport, 6) channel pattern, 7) and available stream energy (stream power).

Several mountain drainage basin classifications exist for Washington state. Whiting and Bradley (1993) classify headwater channels based on process interactions between hillslopes and channels. Montgomery and Buffington (1993, 1997) use a process-based channel classification that relates morphological parameters to relative sediment supply and the ratio of sediment supply to transport capacity. While very useful for many streams in a mountain drainage network, these classifications are limited in their applicability to floodplain river systems and the assessment of migration potential through floodplain deposits.

Cupp (1989) developed a valley segment scale classification intended for basin-wide land management planning and research. Cupp's system focuses on six valley bottom and sideslope geomorphic characteristics thought to remain relatively persistent over a planning time scale. Grouped into four broad categories, any valley width to channel width ratio greater than 2 is generally considered "unconstrained" in this system. This type of classification can provide a relative measure of the valley size potentially available to channel migration.

Nanson and Croke (1992) give a genetic classification specific to floodplain morphology and functional processes in alluvial rivers. Their classification is based on a stream's competence and ability to do work. Primary classification variables include specific stream power and the erosional resistance of floodplain alluvium. *Specific stream power* is the potential energy per unit width of stream available to erode and transport sediment. It is a function of stream slope, discharge and channel width. The classification scheme is divided into three major distinct groups based mainly on stream power and sediment size. Sediment size of non-cohesive alluvium ranges from gravel to fine sand, while cohesive alluvium consists of silt and clay.

Class A: High-Energy Non-Cohesive Floodplains
Class B: Medium-Energy Non-Cohesive Floodplains
Class C: Low-Energy Cohesive Floodplains

Within this classification are a total of fifteen subgroups that differ according to specific stream power, sediment size, confinement, erosional and depositional or accretional processes, landforms, channel pattern, and catchment location.

Nanson and Knighton (1996) provide a classification of floodplain anabranching rivers, which are very common in Washington State. Again, their classification is primarily based on stream power (slope-discharge combinations) but also includes classification metrics on bed and bank material size, lateral migration rate, vertical accretion rate, channel sinuosity, and relative floodplain island size. They distinguish six different channel types, within which there are also several sub-types (Figure 46).

Channel type	Channel character	Unit stream power	Bed material	Bank material	Lateral migration rate	Vertical accretion rate	Channel sinuousity	Island length/channel width
1	Anastomosing	A	A	A	A	A	E	F
2	Sand-dominated, island forming	B	B	B	B	F	A	E
3	Mixed load, laterally active	C	C	C	C = /F =	C =	F	D
4	Sand-dominated, ridge forming	D	D	D	C = /D	B	B	C
5	Gravel-dominated, laterally active	E	E	E	F	C =	D	B
6	Gravel-dominated, stable	F	F	F	E/C =	E	C	A

A–F: relative strength of variable, either LOW (A) to HIGH (F) or FINE (A) to COARSE (F).

Figure 46. Summary of variables linked to channel adjustment, morphology and classification in floodplain alluvial rivers (Chart: Nanson and Knighton, 1996; after Gurnell and Petts, 2002).

These two process-based, floodplain classification systems (i.e., Nanson and Crooke 1992; Nanson and Knighton 1996) can be utilized separately or in combination, due to their overlapping attributes. Once classified by these variables, a channel can be assessed for the dominant processes operating to build and erode floodplain deposits and its relative potential to migrate and rework these deposits.

Channel classification is useful for identifying or screening for channels prone to migration and, if assessed correctly, will provide clues to the generalized processes operating within a stream reach or segment. It also provides a technical basis for communication regarding river systems. However, the existing classification systems were not designed to predict delineation lines of channel migration zones on the ground. The dynamic behavior of channels through space and time at a unique location along the river discontinuum cannot be fully captured by channel classification, as it is not an absolute predictive tool.

2.6 Summary

The technical information provided in this background serves as a common language to describe and analyze streams prone to channel migration. While detailed scientific quantification of channel form and process is always possible, in most cases it is not necessary to proceed to this level of detail to generally understand a stream system or delineate a channel migration zone. However, at least a qualitative understanding of forms and processes at work in a given stream reach or segment is essential to guide a CMZ delineator in their attempt to predict future channel locations. This essential understanding of a river system, as defined above, includes: 1) the watershed's landscape location (e.g., climate, geology, land use); 2) segment location in the river discontinuum (e.g., upland valley vs. lowland valley); 3) valley segment four-dimensional configuration (e.g., confined vs. unconfined); 4) general magnitude and frequency of water, sediment and wood inputs and their disturbance effects; 5) floodplain building processes (e.g., combination of avulsion and bank erosion); 6) river pattern and plan form (e.g., inferences of fluvial processes at work); 7) cycles of channel adjustment and evolution through time (e.g., relative changes in bed elevation or channel pattern); and 8) an appreciation of the complex interaction of all these forms and processes over time.

Stream classification systems attempt to incorporate some or all of these variables to describe the responsiveness of a given stream to changes in the controlling factors and predict a stream's tendency to migrate over time. Once a stream is classified and at least qualitatively understood, communication regarding management options will be greatly enhanced.

2.7 Glossary

As used in Part 2, the following terms are defined as:

abandoned channel: Any *channel* feature that was once more active in water and sediment transport than in its current form. Often partially filled in or blocked at the upstream end with sediment, duff, or debris. No reference to time or location. Could be formed from active and recent processes or processes and conditions no longer operating and masked by sediment and organic material infilling. Can either be on a terrace or floodplain.

active channel: That portion of the channel or floodplain network that receives periodic scour and/or fill during sediment transport events.

aggradation: An increase in sediment supply and/or decrease in sediment transport capacity that leads to an increase in the channel bed elevation. An increase in base level can also decrease sediment transport capacity, thereby initiating aggradation.

alluvial fan: A cone or fan-shaped deposit of sediment and debris that accumulate immediately below a significant change in channel gradient and/or valley confinement Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.

alluvium / alluvial: A general term for or pertaining to deposits made by streams on river beds, flood plains, and alluvial fans.

anabranch: A diverging branch or *secondary channel* of a river, which reenters the mainstream some distance downstream.

anabranching: A river pattern with multi-channels characterized by vegetative or otherwise stable alluvial *floodplain islands* that divide flows at discharges up to nearly bankfull. Individual channels may be straight, meandering or braided.

anastomosing channel: A river pattern (subset of anabranching) with multiple, interconnected, coexisting channels separated by *floodplain islands*, with erosion-resistant cohesive banks, and relatively low width-depth ratios of individual channels.

avulsion: Relatively sudden and major shifts in the position of the channel to a new part of the floodplain (first-order avulsion) or sudden reoccupation of an old channel on the floodplain (second-order avulsion) or relatively minor switching of channels within a braid train or other active channels (third-order avulsion) (Nanson and Knighton 1996).

avulsion hazard zone (AHZ): The area not included in the HMZ where the channel is prone to move by avulsion and if not protected would result in a potential near-term loss of riparian function and associated habitat adjacent to the stream.

bankfull stage: The height at which the channel overflows its banks, corresponding approximately to the discharge at which the channel characteristics are maintained.

braided : a channel pattern that is divided into several channels that branch and rejoin around bare or sparsely vegetated sand/gravel/cobble bars.

channel (watercourse): Any open conduit or linear depressional feature either naturally or artificially created or cut by fluvial processes (i.e., erosion plus deposition), which periodically or continuously (i.e., intermittent or perennial) contains moving water, or which forms a connecting link between two bodies of water.

channel evolution: Lateral and vertical adjustments in channel form over time, along with changes in *channel pattern.*

channel pattern: The planform geometry of a river channel, as viewed from above as it would appear from an airplane. Only used to describe individual channels that make up part of the overall *river pattern.*

chutes: Small *secondary channels* used during flow or flood pulses only. Typically chutes flow across the convex side of meander bends through floodplain deposits, between sequential riffles above and below meander bends, and along steeper flow paths than the main river channel.

chute cutoff: A reach scale *avulsion* that erodes a channel behind a point bar deposit either through a *chute* (second-order *avulsion*) or the general floodplain (first-order *avulsion*).

confinement or valley confinement: A measure of the degree to which a channel is bounded by hillslopes or other resistant landform, usually expressed as a ratio of the average channel width to valley bottom width.

debris flow: A moving mass of rock fragments, soil, and mud, more than half of the particles being larger than sand size.

degradation: An decrease in sediment supply and/or increase in sediment transport capacity that leads to an decrease in the channel bed elevation through incision or downcutting. A decrease in base level can also increase sediment transport capacity, thereby initiating degradation or incision.

dike or levee (constructed): A continuous structure from valley wall to valley wall or other geomorphic feature that acts as an historic or ultimate limit to lateral channel movements and is constructed to a continuous elevation exceeding the 100-year flood stage (1% exceedence flow); or a structure that supports a public right-of-way or conveyance route and receives regular maintenance sufficient to maintain structural integrity.

disconnected migration area (DMA): The portion of the CMZ behind a permanently maintained dike or levee.
distributary channel: A *secondary channel* that branches from the main channel but does not rejoin. These typically occur at the mouth or delta of a river where it empties in a lake or ocean or on an alluvial fan.
entrenchment: The vertical containment of a river and the degree to which it is incised within a valley floor, as seen by the relationship between the channel and the relatively flat surfaces on the valley floor that may be prone to flooding at some maximum stream discharge
erosion hazard area (EHA): Those areas outside of the HMZ and AHZ which are susceptible to bank erosion and retreat from stream flow and this can result in a potential near-term loss of riparian function and associated habitat adjacent to the stream
flood frequency: Refers to a flood level that has a specified percent chance of being equaled or exceeded in any given year. For example, a 100-year flood occurs on average once every 100 years and thus has a 1-percent chance of occurring in a given year.
(Recurrence Interval: the average time interval in years in which a flow of a given magnitude will recur)
floodplain: The relatively flat area or berm adjoining a river channel and constructed by the river in the present climate by a combination of progressive lateral migration, channel creation and abandonment, and overbank sediment deposition from periodic inundation. Floodplains may not be uniform or homogeneous flat surfaces, and can consist of irregular or multiple surfaces at different elevations that reflect vertical differences in the channel bed resulting from local scour, changes in flow regime, sediment supply and wood loading. See complete definition in Part 2.2 Determining if Channel Migration Is Present
floodplain island: A body of land located within the active river channel completely surrounded by water during moderate flow or flood pulses, which can be completely inundated during larger floods.
flood-prone width: the width of the stream at some maximum stream discharge.
gradient: The slope of the stream channel, valley, floodplain, or terrace in the downstream direction usually expressed as a ratio of vertical rise to horizontal run. Channel gradient can either be measured as the thalweg slope or water surface slope.
historic migration zone (HMZ): The sum of all active channels over the historical period that usually includes the time between the year 1900 and the present – the approximate time period sufficient to capture pre-timber harvest channel conditions. This time period is extended for those sites known to have been impacted by timber harvest activities prior to 1900, or where historical information such as Government Land Office maps and notes are available.
lahar: A mixture of water and rock debris (mudflow) composed chiefly of pyroclastic material on the flanks of a volcano.
lateral erosion: The wearing down or washing away of the stream bank, soil and land surface by the action of water as the stream swings from side to side, impinging against and undercutting its banks.
levee (natural): A longitudinal (flood) berm of sediment along the channel bank. Results from sediment (silt to boulder) deposition dropped from suspension or movement during floods. Occurs where water passes from a deep channel to shallow flow and where turbulence abruptly drops along channel margins.
main channel: The main stream channel is the dominant channel with the deepest or lowest thalweg, the widest width within defined banks, and the most water during low flow periods. Main channel locations can be transient over time. Braided channels may not have a defined main channel, especially as stages reach bankfull.

meandering: a channel pattern of stream curves in plan form (symmetrical bends, asymmetrical or irregular), which seem to be proportional to the size of the channel. Meandering is a pattern and does not necessarily imply bank erosional processes at work in the channel.
meander belt: The area between the limits of the amplitude of the meander bends. Typically, parallel lines are drawn to encompass the maximum amplitude of the meander wave and any meander cutoffs or oxbow lakes in a given stretch of river. Multiple sets of parallel lines are usually drawn to encompassed meander belts along sinuous valleys.
meander scrolls: Individual *ridge-swale* pairs oriented in a curvilinear fashion along the convex side of meander bends.
neck cutoff: A reach scale *avulsion* that erodes a channel through a floodplain deposit (first- or second-order *avulsion)* connecting two previously separated meander bends.
overflow channel: A *secondary channel* on the floodplain that conveys water away from and/or back into the main channel. These channels can be continuous or interrupted in space in terms of channel dimensions and scour and fill. They often are a response to episodic flood scour and fill during floodplain inundation and drainage. They also can partially fill in between episodic flood events or become *abandoned* completely or be blocked by deposits of sediment or wood at their head. Overflow channels are typically at or above the range of bankfull flow elevations.
oxbow lake: A crescent shaped pond or lake formed in a portion of abandoned stream channel cut off from the rest of the main channel created when meanders are cut off by *avulsions* from the rest of the channel. Once isolated by formation of avulsion channels, oxbow lakes will slowly fill up with sediment, as point bar sands and gravels are buried by silts, clays, and organic material carried in by river floods and by sediment slumping in from sides as rain fills up lake.
point bar: Accumulations of fluvial sediment at the relatively gentle slope of the inside of a *channel* bend or curve.
river pattern: the planform geometry of a river reach or segment, as viewed from above as it would appear from an airplane, and implies the processes operating along that river. The river pattern includes the individual channels patterns with in the reach or segment.
secondary channel: Any *channel* on or in a floodplain that carries water (intermittently or perennially in time; continuously or interrupted in space) away from, away from and back into, or along the main channel. Secondary channels include: *side channels, wall-based channels, distributary channels, anabranch channels, abandoned channels, overflow channels, chutes, and swales.*
segment or channel segment: Lengths of stream that have similar valley confinement, discharge, channel pattern, and average valley gradient.
side channel: A *secondary or anabranch channel* that is at least partially connected to the main river channel with its channel thalweg at or below the range of bankfull flow elevations. Side channel inlets are often blocked by wood jams or large accumulations of gravel and sand.
sinuosity: A measure of the extent of river meandering usually applied to single channels and expressed as the ratio of channel thalweg length to straight-line valley length.
slough: An area of slack (not moving) water formed in a *meander scroll* deposit (*swale*) or an *abandoned channel* still partially connected to the main river at its downstream end. During flood stage, sloughs can become reconnected at their upstream end.
straight: a channel pattern in plan form where a stream is forced into a more or less non-curved channel pattern by land use intervention or through geologic controls like fractured bedrock or very cohesive sediment.
specific stream power: the potential energy per unit width of stream available to erode and transport sediment.

surface or floodplain surface: A constant feature up and down the valley that lies at a relatively consistent elevation above bankfull and was formed by a discrete process at a discrete point in time, resulting in consistent soil development and other age indicators. See Part 2.3 under Channel Migration Zone Components.
swales: Small *secondary channel* or linear depressional features on point bar deposits. Associated with the point bar are a series of arcuate *ridges* and *swales*. The *ridges* are formed by lateral channel movement and are relic lateral bars separated by low-lying *swales*. S*wales* are locations where fine-grained sediments accumulate following original creation. See Figure 37 in background section.
terrace: A former or relict floodplain no longer inundated by flood water given the current climate. See complete definition in Part 2.2 Determining if Channel Migration Is Present
thalweg: The longitudinal line that defines the deepest part of the channel or stream bed.
underfit stream: A river or stream that appears too small to have eroded the valley in which it occupies.
wall-based channel: A *secondary channel* formed on floodplains or terraces that follows linear depressional features created by channel migration or floodplain deposition of the mainstem river near the base of valley walls or terraces. They typically flow parallel to a mainstem river along the floodplain before joining the river. These channels can be *anabranch or secondary channels* of the main river, or tributary channels. Water sources can originate from a combination of hillslope tributary input, hillslope seepage, groundwater input (i.e., springs or diffuse), river water input, and direct local precipitation.

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