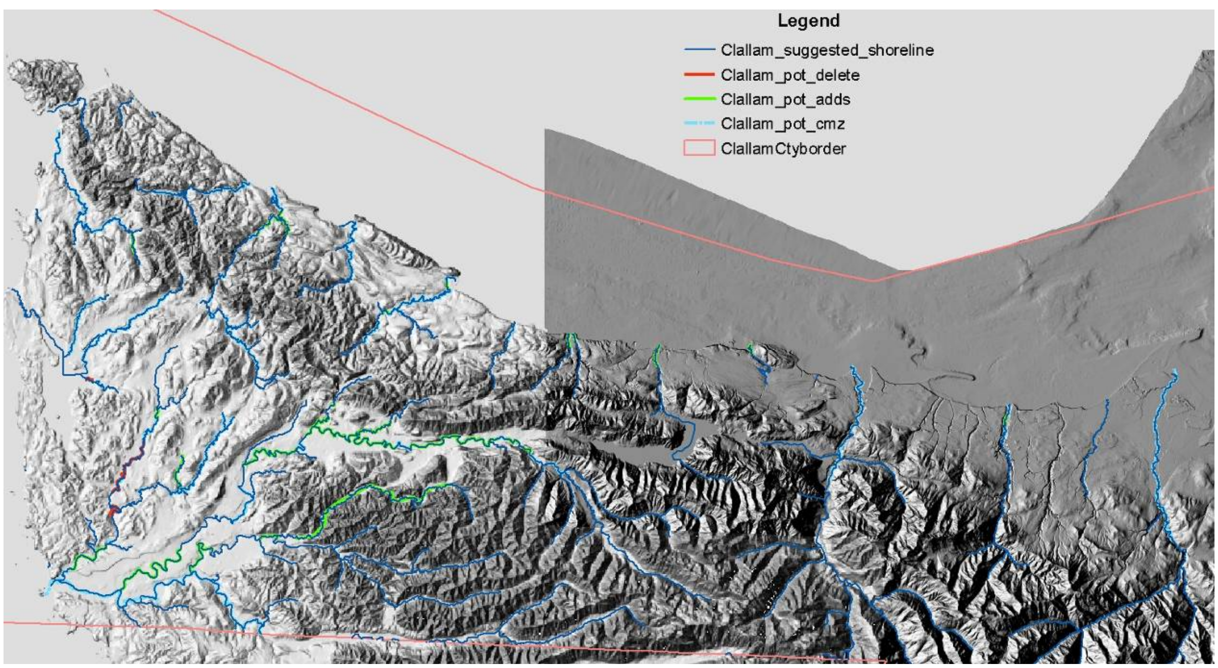
Appendix C Identifying Channel Migration Reaches

DEPARTMENT OF ECOLOGY, SHORELANDS AND ENVIRONMENTAL ASSISTANCE

SMP Master Program Update:
Identifying Potential Channel Migration Reaches



10/9/2009

SMP UPDATE: CHANNEL MIGRATION REQUIREMENTS

Channel migration is a natural process **associated** with streams[1]. Streams may migrate across valleys due to a variety of reasons including channel and bank erosion, meander chute cutoff, avulsion and aggradation. The channel migration zone represents the area within which a given stream may migrate over time.

Channel migration is an ecosystem process supporting a number of ecological functions including the creation of aquatic and riparian habitat. The channel migration process is also an important risk factor for human settlements in that migration may endanger human welfare and can result in property damage, and change flooding dynamics.

Chapter 173-26 WAC requires that channel migration areas be generally identified during the inventory and characterization phase of Shoreline Master Program updates:

WAC 173-26-201(3) (c): Inventory shoreline conditions:

Local governments shall, at a minimum, and to extent information is relevant and reasonably available, collect the following information:

(ii) Information on critical areas

(vii)General location of channel migration zones and flood plains

What does reasonably available data mean for determining channel migration areas?

WAC 173-26-221(3) (b) indicates that the assessment should be based on the historic record, geologic character and evidence of past migration over the past 100 years. Much of this information is collected for other inventory items as well. Existing relevant data include:

Information on channel characteristics such as channel gradient and confinement.

Existing GIS geology and soils data to evaluate erosion potential

2 to 3 time series of aerial photographs, maps, LiDAR or other spatial and temporal data that is available.

Already states that aerial photographs may be necessary to identify cumulative impacts

Since, channel migration areas vary over space; mapping provides a more efficient means to identify their location. Mapping occurs during the communities Shoreline Master Program updates if it hasn't already been done in their Critical Area ordinance updates.

The SMP regulations also address development and other modifications within the channel migration zone (CMZ) (Figure 1, with hyperlinks to appropriate WAC sections)

[1] The term stream encompasses all sizes of flowing water bodies.

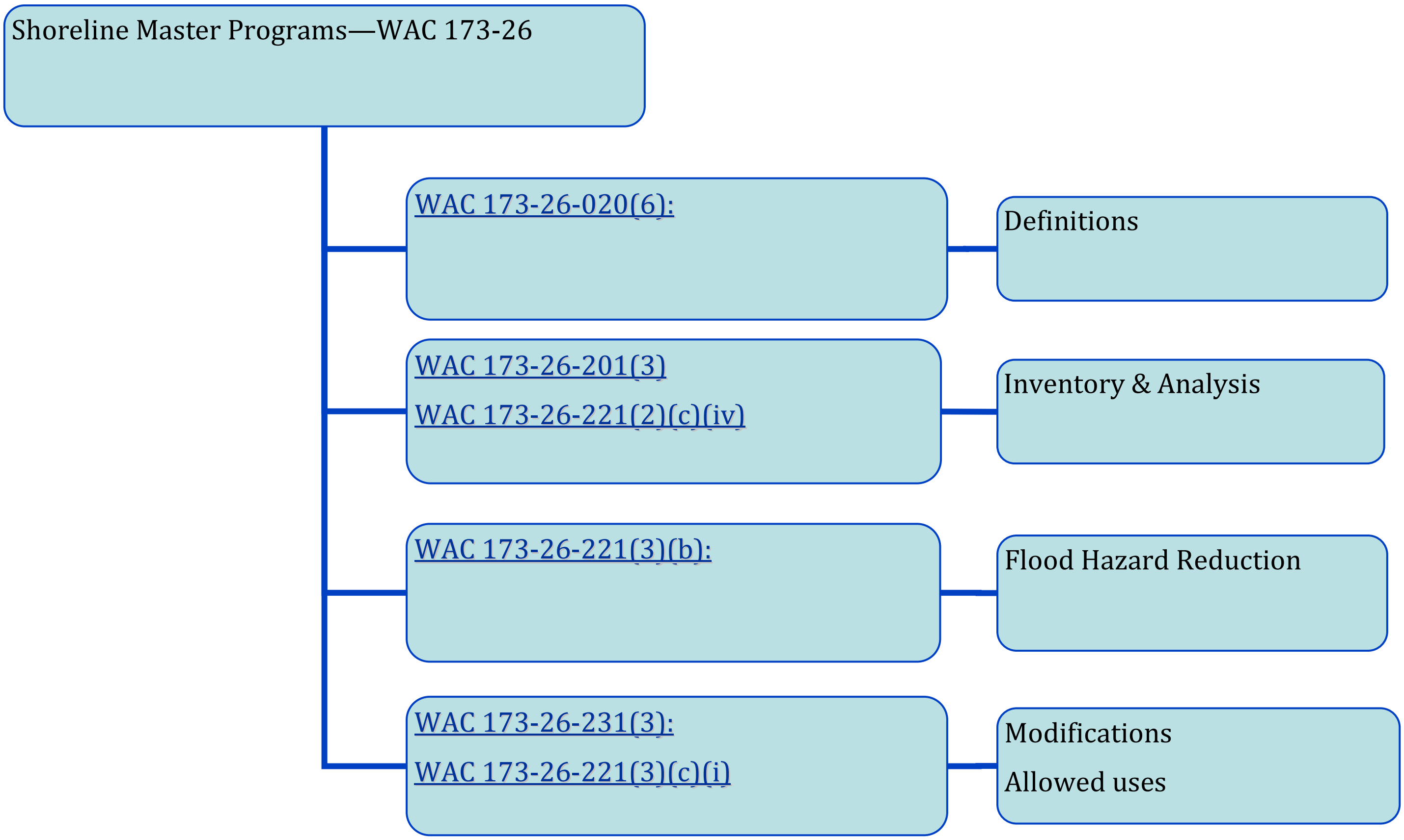


Figure 1: Flow chart provides hyperlinks to SMP regulations that address channel migration.

Introduction

The Washington Department of Ecology, Shorelines and Environmental Assistance Program (SEA) are responsible for managing Shoreline Master Program updates and providing technical and policy assistance and guidance. The SEA program has developed web-based technical guidance for identifying when channel migration assessments are needed as part of the update[2]. The guidance also provides a range of approaches and methods to use depending on management objectives and importance of environment and infrastructure values.

The web guidance uses a decision flow chart to answer the question: "Is a channel migration assessment needed and where?" We followed the decision flow chart for evaluating stream reaches with potential for channel migration. The potential channel migration reaches were identified using the most minimal standard that is only suitable for determining the general location of the channel migration area. The results are preliminary and will require some field verification. The data used is publicly available and mostly free. The GIS steps are described in Appendix B.

[2] The guidance is a draft and a work in progress. http://www.ecy.wa.gov/programs/sea/sma/cma/index.html. Comments are welcome.

Screening indicators used were:

Channel characteristics

Channel confinement, gradient & floodplain

USGS study suggested SMA streams, FEMA maps

Erosion potential

Geology, soil

Evidence of channel movement from air photos, maps, LiDAR

Human alterations (where apparent on air photos, maps, LiDAR): Levees, bridges, roads, revetments

Land Ownership

Data Sources:

Source	Address	Layers
Washington Department of Fish and Wildlife	http://wdfw.wa.gov/mapping/salmonscape/	Channel confinement, gradient
Washington Department of Ecology	http://www.ecy.wa.gov/services/gis/data/data.htm	FEMA Q3 Flood Data Suggested Shoreline Arcs County boundaries
Washington Department of Natural Resources	http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/gis_data.aspx	Geology units[3] Liquefaction susceptibility
Natural Resource Conservation Service	http://soildatamart.nrcs.usda.gov/	Soil data by County
Puget Sound LiDAR Consortium	http://pugetsoundlidar.ess.washington.edu/	LiDAR
University of Washington & Washington State Imagery	http://duff.ess.washington.edu/data/raster/doqs/ http://geography.wa.gov/	orthophotos

[3] USGS geology layers (1:24,000) were also used where these more detailed studies are available. The latter data were found through Internet searches for geology in specific areas.

Portal		
Puget Sound River History	http://riverhistory.ess.washington.edu/index.html	Older orthophotos & GLO maps

Compared channel alignment between 2-3 time series available as GIS raster data sets including USGS 7.5' digital images, 1990-2006 orthophotos, LiDAR. Where LiDAR was available, elevation profiles were also used to add or delete areas in question.

Methods and Results

We used ArcMap (Version 9.3) to evaluate potential channel migration from existing GIS data. No field verifications were done, so the mapped areas are potential only.

Channel confinement and gradient.

Explanation—Channel gradient and confinement influences channel type and migration potential.

Confinement—indicator of space available for channel movement	Channel gradient— influences channel type, migration, bank erosion
Confined: ratio of valley width (vw) to active channel width (bw) <2 Restricts channel movement	>4%--high gradient— Bank erosion, slope failure
Moderate confinement: vw/bw ≥2 and <4 Channel movement and erosion	2-4%--moderate gradient— Avulsions, limited migration & flooding, bank erosion, slope failure
Unconfined: vw/bw ≥4 Channel can move rapidly	<2%--lower gradient— Migration, avulsions, bank erosion, flooding

Gradient	Confinement	Channel type	Associated patterns	Potential to migrate
0-2%	Unconfined, moderate	Pool-riffle	Meander, anabranching, wandering	High
1-2%	Moderate-confined	Pool-riffle, plane-bed	Meander, straight, anabranching, wandering	Moderate-High
2-3%	Unconfined-confined	Plane-bed, step pool, forced pool-riffle	Braided, wandering, straight, alluvial fans	Moderate
3-8%	Moderate-confined	Step-pool	Straight, or low sinuosity angular bends, large radius bends	Low-Moderate (avulsions, bank erosion)
8-20%	Moderate-	Cascade (rock)	Straight, or low	Low lateral

	confined		sinuosity, angular bends	Moderate avulsions, bank erosion
1-12%	Unconfined-moderate	Alluvial fans (granular), deltas	Multiple channel, distributary channels	Moderate-High

The SHIAPP data doesn't include channel confinement for all counties. In those cases the FEMA floodplain maps were used as surrogates for moderate to unconfined conditions. Relative confinement can also be estimated by overlaying the SMA streams on the 7½' USGS Quadrangle digital images (1:24,000 scale) and or the 10 meter DEM or LiDAR. [4]

Geology erosion potential

Surface geology: In this assessment, these geologic features include the Quaternary deposits such as glacial outwash, alluvium, and lahars which have not metamorphosed into rock.

Surface geology deposits	Erosion potential
Holocene alluvial and active alluvial fan deposits; landslides; peat; glacial deposits—recessional outwash, outburst flood, recent volcanic deposits—lahars, ash	High
Glacial—coarse undifferentiated drift and fractured till, terraces (coarse grained), advance outwash such as the Esperance sands, or coarse clasts	Moderate High
Undifferentiated glacial drift with clay matrix (Pleistocene or older alluvium and alluvial/debris fans, landslides), terraces with clay matrix	Moderate
Basal till	Moderate Low

Bedrock: Bedrock along streams is generally considered a geologic control on channel migration. However, coarse sediment during transport can remove weathered bedrock and cause slope instability (e.g., Sklar and Dietrich 2001, 2004; Montgomery 2004). Rock tensile strength was used as a surrogate for rock resistance to fluvial erosion. Less resistant geologic material such as glacial and debris flow deposits, however, can experience significant erosion and be subject to channel migration.

Strength classification	Unconfined fracture strength (MPa)	Typical rock types	Fluvial erosion potential
Very weak	10-20	weathered and weakly-compacted; highly fractured; marine sedimentary rocks	Moderate High
Weak	20-40	weakly-cemented sedimentary rocks; tuffs,	Moderate

[4] GIS models are available to determine channel confinement, for example, the Netmap tool available as a download from Earth System Institute, http://www.netmaptools.org/analysis_tools. The model is only available for areas previously mapped s o this model wasn't used in this assessment.

Medium	40-80	competent sedimentary rocks; tuff breccia	Moderate Low
Strong	80-160	competent igneous rocks; some metamorphic rocks and fine-grained sandstones, schists; some low-density coarse-grained igneous rocks	Low
Very strong	160-320	quartzite; dense fine-grained igneous rocks	Low

Local conditions may alter the potential. For example in Clark County, some volcaniclastic sedimentary rocks (Eocene) are prone to failure.

Liquefaction layer provides additional information on potential bank and hillslope stability during floods and earthquakes. We assume that a reach with high liquefaction potential may be susceptible to bank slumping and landslides. Both processes may force the channel to move (e.g., Hazel Slide on NF Stillaguamish, Nile Valley landslide on the Naches River) and alter channel alignment, upstream migration or add additional sediment leading to increased migration potential. This layer also identifies surface bedrock control. The landslide layer was used to further evaluate hillslope stability adjacent to streams or that feed directly into streams.

Bank and floodplain erosion potential

Alluvial soils comprising floodplain and terrace banks directly influence channel morphology and erosion rates. NRCS SSURGO soil data were used to estimate the bank and floodplain erosion potentials with soil texture as the primary variable. Soil texture was chosen over other factors because knowledge of soil texture provides an indication of cohesive properties of the banks or floodplains. Also considered was the soil rill erodibility factor (kffact). While this erodibility factor typically relates to upland rill erosion, it also applies to sediment detachment associated with the shear stresses induced by stream flow. The kffact rating is relative only because soil textures susceptible to rill erosion may not be as susceptible to bank erosion as coarser grained soils.

For example, silt soils have the highest rill erodibility factor while sands are quite low. However, banks composed of coarser materials are less cohesive and thus more susceptible to fluvial erosion. Using the Bank-toe stability model (Simon and Langendoen 2006) and keeping all things equal except soil texture, model results indicate that clay with silt soils are less likely to erode than sandy soils with silt.

The 2 end point textures were used: clayey soils (lower erosion potential) and sandy soils (higher erosion potential). Many of the clay soils have high silt content also, so while these soils have lower erosion potential than sandy soils they are still erodible. Textural class tables were used to define the two textures where clayey soils were defined as having clay content > 15%. Sandy soils were classified as total sand>35%. There may be some overlap between sandy clay, sandy clay loam, clay loam and loam textures. These soil textures occur more frequently in areas with glacial outburst flood deposits such as in Clark County and in glacio-fluvial terraces and moraines. The underlying geology becomes an important discriminator in those cases. Heavily vegetated soils are significantly more resistant to erosion than areas where the vegetation has been disturbed or cleared.

Two buffer features were created: Floodplain with a buffer and the stream with a buffer. The stream buffer layer was used for evaluating potential bank erosion. The soils data were intersected with each buffer layer to differentiate between bank erosion and overbank or floodplain erosion.

Channel pattern and evidence of channel movement or bank erosion

Orthophotos, maps and LiDAR provided information on channel movement. The most recent orthophotos (NAIP 2006) and LiDAR where available were evaluated for general indicators of channel movement including:

Multiple channels

Multiple bar forms (accretion wedges)

Channel aggradation

Meandering, wandering channel planform including oxbows, chute cutoffs

Secondary channels --

Side channels: persistent secondary channels, typically with vegetated islands or other persistent landforms separating it from the main channel

Relic channels -- those channels that may have flow in them only during very high water. They don't have to be connected to main channel but are still in the floodplain.

Young disturbance vegetation

Wood jams

Bank erosion

Orthophoto time series were compared to identify areas of obvious channel movement. However, channel movement between orthophotos was not the deciding factor for potential channel migration because comparisons were mostly between 1990's and 2006. Channel migration might have occurred outside that time range. So the indicators listed above were given more weight unless movement was observed between 1990s orthophotos and 2006 orthophotos.

Another less evident indicator is change in water depth between orthophoto years with similar discharge. Shallower depths, particularly in straight line sections, may indicate that a medial or shoal bar is forming or aggradation is occurring. These areas will likely migrate unless confined by non-erodible feature.

Land Ownership

Reaches occurring within National Park and Tribal boundaries are not regulated under the SMP. The land ownership layer provided information for removing these reaches.

References

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