



FINAL
BEST AVAILABLE SCIENCE REPORT

Use of Best Available Science
in Skagit County Critical Areas Ordinance
(Wetlands and Fish & Wildlife Habitat Conservation Areas)

Prepared for:

Skagit County
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25 January 2007

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TABLE OF CONTENTS

TABLE OF CONTENTS

Page No.

List of Tables

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INTRODUCTION

The Washington State Growth Management Act (GMA) mandates that cities and counties adopt policies and regulations to protect the values and functions of critical areas. Critical areas include wetlands, frequently flooded areas, geologically hazardous areas, aquifer recharge areas, and fish and wildlife habitat conservation areas (WAC 365-190-080). The GMA, as amended in 1995, further requires that cities and counties include best available science in the development of such policies and regulations, as well as those measures taken to protect or enhance anadromous fisheries (WAC 365-195-900 *et sec*.). Inclusion of best available science in the development of locally appropriate policies and regulations must be balanced with the many other substantive goals and mandates of the GMA. Use of nonscientific information (e.g., social, legal, cultural, economic, or political) that results in departures from scientifically valid critical areas recommendations must be identified and justified, and potential consequent impacts must also be identified.

This report is intended to document the consideration of best available science in the proposed revisions to Skagit County Critical Area Ordinance (Skagit County Code, Chapter 14.24), and is incorporated by reference. This report will identify existing conditions within Skagit County (County), discuss proposed changes to the Critical Area Ordinance, and examine the anticipated effectiveness of these changes with regard to the protection of the functions and values of critical areas located within the County.

There are two elements to this report: 1) fish and wildlife habitat conservation areas and 2) wetlands.

While proposed stream and wetland buffer widths represent an increase over the existing regulatory buffers, buffer width reductions with enhancement are provided to alleviate increased burden on properties within critical areas and their buffers while promoting improved buffer quality and function. As indicated in the best available science, narrow buffers may be adequate if they are of high quality (May et al. 1997b).

FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Code Review and Comparison

The County’s existing regulations include the designation of Fish and Wildlife Habitat Conservation Areas (FWHCAs) (SCC 14.24.500). Defined in SCC 14.04.020 as:

- areas with which endangered, threatened, and sensitive species have a primary association;
- habitats and species of local importance that have been designated by the County at the time of application;
- all public and private tidelands suitable for shellfish harvest;
- kelp and eelgrass beds, herring and smelt spawning areas;

- naturally occurring ponds under 20 acres with submerged aquatic beds that provide fish or wildlife habitat;
- waters of the State as defined by WAC 222-16;
- lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity;
- areas with which anadromous fish species have a primary association;
- State Natural Area Preserves and Natural Resource Conservation Areas; and
- other aquatic resource areas.

Fish and wildlife habitat conservation is the management of land for maintaining species in suitable habitats within their natural geographic distribution. Habitat conservation areas provide adequate space for fish and wildlife to live and these habitat areas also provide protection for endangered, threatened, and sensitive species so that isolated subpopulations are not created. Cooperative and coordinated land use planning is critically important among counties and cities in a region. However, while the overall protection and preservation of species statewide is an inter-jurisdictional task, it is the responsibility of each city and county to ensure protection within their individual jurisdiction. The Washington State Department of Community, Trade, and Economic Development (CTED) provides guidance for jurisdictions to consider the designation of appropriate fish and wildlife habitat conservation areas (CTED 2003). While the existing designation of FWHCAs by the County meets these guidelines, the following additional designations are also recommended by CTED:

- State Priority Habitats and Areas Associated with State Priority Species.
- Areas of Rare Plant Species and High Quality Ecosystems.
- Land Useful or Essential for Preserving Connections Between Habitat Blocks and Open Spaces.

In addition, CTED suggests considering the following principles in classification and designation of this critical area:

- Creating a system of fish and wildlife habitat with connections between larger habitat blocks and open spaces.
- Providing for some level of human activity in such areas including presence of roads and level of recreation type (passive or active recreation may be appropriate for certain areas and habitats).
- Protecting riparian ecosystems.
- Evaluating land uses surrounding ponds and fish and wildlife habitat areas that may negatively impact these areas.
- Establishing buffer zones around these areas to separate incompatible uses from the habitat areas.
- Restoring lost salmonid habitat.

The GMA requires jurisdictions within the state to address impacts to fish and wildlife habitat, specifically to give special consideration to the protection and enhancement of anadromous fisheries.

Stream typing is currently and appropriately included within the FWHCA code section. Currently, the County follows the Washington Department of Natural Resources (DNR) interim water typing system (WAC 222-16-031) as adopted by reference. This system utilizes a numerical (Types 1-5) system, which can be summarized as follows:

- **Type 1 Water** means all waters, within their ordinary high-water mark, as inventoried as "shorelines of the state" under chapter 90.58 RCW and the rules promulgated pursuant to chapter 90.58 RCW, but not including those waters' associated wetlands as defined in chapter 90.58 RCW.
- **Type 2 Water** means segments of natural waters which are not classified as Type 1 Water and have a high fish, wildlife, or human use.
- **Type 3 Water** means segments of natural waters which are not classified as Type 1 or 2 Waters and have a moderate to slight fish, wildlife, and human use.
- **Type 4 Water** means all segments of natural waters within the bankfull width of defined channels that are perennial non-fish habitat streams. Perennial streams are waters that do not go dry any time of a year of normal rainfall. However, for the purpose of water typing, Type 4 Waters include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.
- **Type 5 Water** means all segments of natural waters within the bankfull width of the defined channels that are not Type 1, 2, 3, or 4 Waters. These are seasonal, non-fish habitat streams in which surface flow is not present for at least some portion of the year and are not located downstream from any stream reach that is a Type 4 Water.

While the descriptions in this classification system are consistent with State recommendations, most jurisdictions have begun to utilize the DNR permanent water typing system (WAC 222-16-030). The permanent water typing system is intended to be adopted by all jurisdictions within the state upon completion of fish habitat water type mapping. The permanent system provides for four stream classes by combining the Type 2 and 3 Waters into one (**F**)ish class. For the purposes of comparison, see Table 1:

Table 1. Water Type Conversion Table

Permanent Water Typing	Interim Water Typing
Type "S"	Type 1 Water
Type "F"	Type 2 and 3 Water
Type "Np"	Type 4 Water
Type "Ns"	Type 5 Water

The County's existing development code applies standard riparian buffer requirements, typically established from a stream's ordinary high water mark (OHWM), to protect the stream and adjoining riparian area. These buffer requirements vary based on the Water Type as shown in Table 2.

Table 2. Existing Riparian Buffers (Chapter 14.24.530)

Water Type	Buffer (ft)
Type 1 and 2	200
Type 3	100
Type 4 and 5	50

Table 3 provides a comparison of the County's existing stream regulations, with regulations from other counties in Western Washington of similar size and geographic context. In addition, this table lists the stream typing and buffers recommended by CTED. Based on Table 3, the County's existing riparian buffers are generally consistent with other jurisdictions, but the water typing system should be updated accordingly.

Table 4 provides information as to how other jurisdictions have approached the protection of FWHCAs.

Existing Conditions

Skagit County overlaps four different Water Resource Inventory Areas (WRIAs): Nooksack (WRIA 1), Lower Skagit (WRIA 3), Upper Skagit (WRIA 4), and Stillaguamish (WRIA 5). The Lower and Upper Skagit WRIAs are located almost entirely within the County boundary. The Skagit River is one of the largest rivers of Western Washington, draining more than 3,000 square miles. It is the only river in the state that supports all five species of native salmon, including one of the largest runs of endangered wild chinook salmon (*Oncorhynchus tshawytscha*). The County encompasses a wide range of habitats and land uses, from high-elevation wilderness areas contained within national park and national forest boundaries down to the Puget Sound lowlands, where 90 percent of the County's human population resides in expansive floodplains and fertile agricultural land. Skagit County currently supports some of the highest levels of wildlife species diversity and population of any county in Washington State.

The Upper Skagit WRIA (WRIA 4) has been identified in the statewide Habitat Limiting Factors report as the only WRIA within the state with overall "good" habitat ratings in all complete (i.e. no data gaps) categories (Smith 2005). Much of this is due to the high percentage of state and federal forest land in the eastern, upland portion of the County. Generally, basins with higher percentages of federal lands were found to have better habitat ratings for access, floodplains, large woody debris (LWD), riparian, high flow, and sedimentation conditions. Additionally, forest-dominated WRIAs usually exhibit better ratings for riparian, water temperature, and pool conditions. Conversely, WRIAs dominated by agricultural lands (e.g. WRIA 3) had generally poor access, floodplain, and LWD conditions. However, agriculture-dominated basins still rated higher than those of more urbanized settings (Smith 2005). Beechie et al. (1994) found that coho salmon (*O. kisutch*) smolt production has been significantly reduced in the Skagit River basin due mainly to the loss of side-channel sloughs[1].

[1] Sloughs were classified as either side channels or distributary channels with more than 90 percent of their areas consisting of pools (Beechie et al. 1994).

Table 3. Jurisdictional Comparison of Stream Classification and Buffer Regulation

Existing Skagit County CAO (SCC 14.24)	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County CAO (urban)	King County CAO (rural)
Stream Classification						
Stream regulations are a subset of the Fish and Wildlife Habitat Conservation Areas chapter Stream categories defined in WAC 222-16-031 (Interim Water Typing System) include 5 types of Waters of the State (1-5).	Stream regulations are a subset of the Fish and Wildlife Habitat Conservation Areas chapter Stream categories defined in WAC 222-16-031 include 5 types of Waters of the State (1-5).	Classification of streams and lakes shall occur pursuant to the water typing rules contained in WAC 222-16-031	F1: All segments of natural waters which provide habitat or support critical fish species. F2: Type F1 water adjacent to a landslide hazard area. N1: Perennial or seasonal non-fish bearing natural waters within ¼ mile of the confluence with a Type F1 or F2 water. N2: Perennial or seasonal non-fish bearing natural waters either located more than ¼ mile upstream from the confluence with a Type F1 or F2 water or are not connected to a Type F1 or F2 water. N3: Lakes or ponds that do not support any critical fish species	Type S: streams inventoried as "shorelines of the state" Type F: all segments of aquatic areas that are not type S waters and that contain fish or fish habitat Type N: all segments of aquatic areas that are not type S or F waters and that are physically connected by an above-ground channel system, stream or wetland to type S or F waters.	Type S: aquatic areas inventoried as "shorelines of the state" under the County's shoreline master program Type F: aquatic areas that contain fish[2] or fish habitat Type N: aquatic areas that are not Type S or F and are physically connected to Type S or F waters by an above-ground channel system, stream, or wetland Type O: not Type S, F, or N	

Existing Skagit County CAO (SCC 14.24)	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County CAO (urban)	King County CAO (rural)
Stream/Riparian Buffers						
Type 1: 200 feet Type 2: 200 feet Type 3: 100 feet Type 4: 50 feet Type 5: 50 feet	Type 1 and 2, shorelines of the state, or shorelines of statewide significance: 250 feet Type 3 and perennial and/or fish bearing streams 5-20 feet wide: 200 feet Type 3 less than 5 feet wide: 150 feet Type 4 and 5 or intermittent with low mass wasting potential: 150 feet Type 4 and 5 or intermittent with high mass wasting potential: 225 feet	Anadromous fish-bearing stream segments and lakes: 150 feet Type 1: 150 feet Type 2: 150 feet Type 3: 100 feet Type 4: 50 feet Type 5: 50 feet	F1: 150 feet F2: 150 feet N1: 115 feet N2: 65 feet N3: 35 feet	Type S: 250 feet Type F: 200-250 feet Type Np: 100-200 feet Type Ns: 100-200 feet	Types S and F: 115 feet Type S and F in a basin or shoreline designated as "high": 165 feet Type N: 65 feet Type O: 25 feet	Types S and F: 165 feet Type N: 65 feet Type N within Bear Creek Drainage and designated regionally significant resource area: 100 feet Type O: 25 feet

[1]CTED = Washington State Department of Community, Trade, and Economic Development
[2] Fish = fish-bearing waters are conservatively defined as streams 2ft or greater in width and with a sustained gradient of less than 22 percent or lakes and ponds connected to a known fish-bearing water by a stream channel of similar dimensions
[3]Special Urban Waters = urban waters (aquatic areas) having high biological and habitat functioning (in such instances, the rural buffer standard would apply).

Table 4. Jurisdictional Comparison of Fish and Wildlife Conservation Areas Designation and Management Regulations

Existing Skagit County CAO (SCC 14.24)	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County CAO
Wildlife Habitat Conservation Areas - Designation					
1. Areas with which endangered, threatened, and sensitive species have a primary association; 2. Habitats and species of local importance that have been designated by the County at the time of application; 3. All public and private tidelands suitable for shellfish harvest; 4. Kelp and eelgrass beds, herring and smelt spawning areas; 5. Naturally occurring ponds under 20 acres with submerged aquatic beds that provide fish or wildlife habitat; 6. Waters of the State as defined by WAC 222-16; 7. Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; 8. Areas with which anadromous fish species have a primary association; 9. State Natural Area Preserves and Natural Resource Conservation Areas; and 10. Other aquatic resource areas.	CTED Example Code Provisions specifically identify 11 types of Fish and Wildlife Habitat Conservation Areas. 1. Areas with which State or Federally designated Endangered, Threatened, and Sensitive Species have a primary association. 2. State Priority Habitats and Areas Associated with State Priority Species. 3. Habitats and Species of Local Importance. 4. Commercial and Recreational Shellfish Areas. 5. Kelps and Eelgrass Beds and Herring and Smelt Spawning Areas. 6. Naturally Occurring Ponds Under 20 Acres. 7. Waters of the State. 8. Lakes, Ponds, Streams, and Rivers Planted with Game Fish by a Government or Tribal Entity. 9. State Natural Area Preserves and Natural Resource Conservation Areas. 10. Areas of Rare Plant Species and High Quality Ecosystems. 11. Land Useful or Essential for Preserving Connections Between Habitat Blocks and Open Spaces.	Changes to the definition of Fish and Wildlife Habitat Conservation Areas have not been proposed in the draft CAO update in 2005 1. Streams and wetlands regulated under SCC 30.62.300 through SCC 30.62.360; 2. Areas with which critical species listed as endangered or threatened under federal law have a primary association; and 3. Saltwater-related habitat including kelp and eelgrass beds, shellfish areas, and herring and smelt spawning areas.	1. Federally- and State-Listed Species and their Associated Habitats. 2. Species of Local Importance and their Associated Habitats. 3. Habitats of Local Importance. 4. Potential Fish and Wildlife Habitat Conservation Areas.	Important Habitats and Species 1. Federally Listed Species and Habitats. 2. State Listed Species and Associated Habitats. Priority species and their habitats of primary association. Priority species identified on the WDFW Priority Habitats and Species List (PHS List) and their habitats of primary association. 3. Habitats and Species of Local Importance.	Wildlife Habitat Conservation Areas: an area for a species whose habitat the King County Comprehensive Plan requires the county to protect that includes an active breeding site and the area surrounding the breeding site that is necessary to protect breeding activity (e.g., bald eagle nests, great blue heron rookeries, osprey nests). Specific guidance on timing restrictions and buffer widths around each of these areas is provided in the CAO. Wildlife Habitat Networks: the official wildlife habitat network defined and mapped in the King County Comprehensive Plan that links wildlife habitat with critical areas, critical area buffers, priority habitats, trails, parks, open space and other areas to provide for wildlife movement and alleviate habitat fragmentation.

Existing Skagit County CAO (SCC 14.24)	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County CAO
[4] King County Inventory = King County Comprehensive Plan, 2004. Chapter 4, Environment [5] Species of Concern = those species listed as state endangered, threatened, sensitive, or candidate, as well as those species listed or proposed for listing by the federal government. [6] State Priority Habitats = those habitat types or elements with unique or significant value to a diverse assemblage of species. They may consist of a unique vegetation type or dominant plant species, a described successional stage, or a specific structural element [7] State Priority Species = those species considered to be priorities for conservation and management and are identified in the Washington Department of Fish and Wildlife Priority Habitat and Species (PHS) List. [8] Habitats and Species of Local Importance = include habitat that supports both vulnerable and recreationally important species. Vulnerable species, such as the great blue heron, are those susceptible to significant population declines because they are uncommon, have a very limited distribution, or have special space or habitat requirements. Recreationally important species include species with high recreational importance or a high public profile, and that are vulnerable to habitat loss or degradation					
Wildlife Habitat Conservation Areas - Management					
Alterations to Fish and Wildlife Habitat Conservation Areas allowed according to an approved Site Assessment/Habitat Management Plan. **Plans to include (1) Impact analysis, (2) Regulatory analysis, (3) Mitigation report establishing buffer zones, preservation areas, and seasonal restrictions, and (4) Management and maintenance practices.**	A habitat conservation area may be altered only if the proposed alteration of the habitat or the mitigation proposed does not degrade the quantitative and qualitative functions and values of the habitat. Mitigation sites shall be located to preserve or achieve contiguous wildlife habitat corridors in accordance with a mitigation plan that is part of an approved critical area report to minimize the isolating effects of development on habitat areas. Approved activities shall be conditioned to minimize or mitigate any potential adverse impacts. Conditions may include timing restrictions, access limitation, preservation of certain vegetation communities, and establishment of buffers consistent with WDFW recommendations, among others. Mitigation of alterations shall achieve equivalent or greater biologic and hydrologic functions and shall include mitigation for adverse impacts upstream or downstream of the development proposal site. Mitigation shall address each function affected by the alteration to achieve functional equivalency or improvement on a per function basis.	Specific management of Wildlife Habitat Conservation Areas are not specifically outlined under the draft CAO. Protection of wildlife and their habitats are provided through the regulation of other critical areas (i.e. streams and riparian habitats, wetlands, lakes, marine shorelines and their buffers).	All regulated development activities in critical fish and/or wildlife habitat areas and associated buffers shall, in the following order, avoid, minimize, or mitigate for the impacts or a combination of these methods. Mitigation of alterations to habitat areas shall achieve equivalent or greater biological functions and shall include mitigation for adverse impacts upstream and downstream of the development proposal site. Mitigation shall be provided on-site, where feasible. When mitigation cannot be provided on-site, it shall be provided in the immediate vicinity of and within the same watershed as the regulated activity.	No net loss of habitat functions. Uses and activities carried out pursuant to this section shall result in equivalent or greater habitat functions, as determined by the approval authority consistent with best available science. All actions and uses shall be designed and constructed to avoid or, where that is not possible, minimize all adverse impacts to the important habitat area and associated buffers. Adverse impacts to important habitats and associated buffers shall be fully mitigated.	The Wildlife Habitat Networks regulations are nearly identical to existing SMC 21A.30.240. Wildlife Habitat Conservation Area standards apply different radii around active nests, rookeries, or other breeding area occupied by designated species. Within these radii, certain activities are prohibited during a specified time period when the species is most sensitive to disturbance. The restrictions are consistent with WDFW management recommendations.

According to the County's Comprehensive Plan (Skagit County 2003), land use throughout the County consists of Public Open Space (47%), Natural Resource Areas (43%, of which 8% is agricultural land), Rural Lands (7%), Commercial/Industrial Lands (0.1%), and Urban Lands (3%).

Extensive work by the Skagit Watershed Council (Skagit Watershed Council 1998; Beamer et al. 2000) has inventoried many areas throughout both the Skagit and Samish River basins, from "pristine" to "impaired," such that habitat restoration and protection strategies can be effectively prioritized to result in appropriate levels of success. Beamer et al. (2000) found that 23 percent and 46 percent of the watersheds have been impaired with respect to hydrology and sediment, respectively. Likewise, 42 percent of riparian corridors which support anadromous fish are in need of restoration. They also identified 164 km of stream channels blocked from anadromous fish use. Overall, they identified over 400 individual restoration and protection projects within the basins, organized into five different categories (sediment reduction, riparian, isolated habitat, protection, and feasibility studies). These projects focus on addressing the *cause* rather than the *effects* of habitat degradation as emphasized by Beechie and Bolton (1999) in assessing habitat-forming processes.

Best Available Science Review: Riparian Areas

While the primary role of streams and rivers is to transport water, riparian areas provide many other fluvial and landscape processes. These processes act in concert to support a wide diversity of aquatic and terrestrial plant and wildlife species. Under natural conditions, a dynamic equilibrium within riparian areas provides for continual environmental change, such as channel migration, but supports the stability of species which rely on those changes for survival. Human impacts upon the landscape have altered this relationship through the modification of water conveyance for flood control, agriculture, and other development, such that the protection and enhancement of both habitat and species is essential to their preservation.

While lakes are hydrologically different from streams and rivers, the riparian functions that relate to lakes have many similarities to the functions provided by fluvial systems. Similar inferences can be made to the impacts which result from development along lakeshores. While site-specific in-water structures and shoreline hardening have been found to have negative impacts to both the aquatic and nearshore environment (Kahler et al. 2000), general observations of cumulative changes to watersheds and riparian zones have been noted with measurable differences in littoral habitat (Jennings et al. 2003). Much of the science discussing riparian functions focuses on fluvial rather than lentic systems. Thus, for the purposes of this best available science review, lake riparian functions are assumed to be analogous to the findings provided below.

The following review provides a background of both natural and anthropogenic-influenced processes to riparian areas. In addition, a review of the available scientific literature is provided, assessing the effectiveness of the various riparian buffer functions.

Natural Processes and Disturbance Events

Natural disturbances (e.g. floods, fire, landslides, channel migration) lead to spatial heterogeneity and temporal variability, which lead to numerous habitat niches in non-equilibrium, leading ultimately to ecological diversity (Naiman et al. 1993; Gregory et al. 1991). Unmodified riparian corridors are characterized by high dynamism and disturbance events, which, in low-order[2] streams, consist primarily of landslides and debris flows. Higher-order streams are typically characterized by floods and channel migration (Naiman et al. 1993). The survival of many plant and animal species is dependent upon such dramatic changes to the environmental landscape.

Stream channel migration is a key environmental disturbance necessary for the sustainability and richness of species along the riparian corridors. Erosional processes which occur during flood events and subsequent changes in channel direction lead to improvements in large woody debris (LWD) recruitment, gravel and sediment transport, and nutrient supply. These structural changes can result in habitat improvements, including generation of salmon spawning areas. These processes can also form off-channel habitat such as oxbows and side channels or even smaller incremental changes such as lateral bank scour and pool/riffle formations (King County 2004).

Effects of Development

A key feature of urban areas, including those developed areas within unincorporated county lands, is impervious surface coverage. Increases in impervious surface coverage, and the consequent reduction in soil infiltration, have been correlated with increased velocity, volume and frequency of surface water flows. This hydrologic shift alters sediment and pollutant delivery to streams (Booth 1998; Arnold and Gibbons 1996). Increased surface water flows associated with impervious surface coverage of suburban areas (20-30%) has been linked to decreased bank stability and increased erosion (May et al. 1997a). Knutson and Naef (1997), in their literature review, concluded that as little as 10 percent impervious surface coverage is sufficient to alter bank stability and erosion. This increased erosion often simplifies stream morphology, leading to wider, straighter stream channels (Arnold and Gibbons 1996), or narrow incised channels (Booth 1998), depending upon position in the watershed. Changes in hydrology and stream morphology brought on by impervious surfaces have also been linked to shifts in macroinvertebrate community composition, which could have profound and far-reaching impacts on the productivity of a watershed (Pederson and Perkins 1986, as cited in Leavitt 1998). Changes in fish assemblages have been correlated with changes in stream temperature and base flow as a result of increased impervious surface coverage (Wang et al. 2003). Increases in flood frequency and volume have been correlated to declining salmon populations in some Puget Sound lowland streams (Moscrip and Montgomery 1997). Riparian areas can protect against these factors by moderating surface water and sediment inputs. However, while riparian quality has been shown to be inversely proportional to the level of urbanization (May et al. 1997b), impervious surface area alone is not the only component to predicting stream biological conditions (Booth et al. 2004).

Many concerns have arisen in recent years over the impacts from the urbanization of predominantly forested areas, especially areas which contain erosion-susceptible geologic

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[2]Stream order refers to a classification system that groups streams based upon their relative size. By convention, first-order streams have no tributaries, as viewed on a map, typically a USGS 7 ½-minute topographic map; second-order streams result from the confluence of two first-order streams; third-order streams are produced when two second-order streams meet; and so on. Recognition that many intermittent and small perennial streams are not represented on USGS 7 ½-minute topographic maps has led some to use the term “zero-order” for such streams. Reliable classification of stream order requires field verification.

substrate and relatively high gradients (Booth and Henshaw 2001). Booth and Henshaw (2001) found that under highly susceptible conditions, post-development channel changes occur so rapidly that remediation efforts could only be successful if implemented prior to development. Booth et al. (2002) conclude that under typical rural land uses, impacts to watershed ecology from reduced forest-cover area can be as great or greater than similar increases in impervious area. Threshold levels of 10 percent impervious coverage and 35 percent deforested area have been found to mark a distinct transition towards severely degraded stream conditions (Booth 2000).

In general, development is known to have detrimental effects on salmonids, particularly with spawning abundance and success. Pess et al. (2002) found that wetland occurrence, local geology, stream gradient, and land use were significantly correlated with adult coho salmon abundance. While positive correlations were found between spawner abundance and forested areas, negative correlations were found between spawner abundance and areas converted to agriculture or urban development. An estimated 115 km of side-channel and distributary sloughs have been eliminated within the Skagit River basin, leading to a 52 percent reduction in slough rearing habitat (Beechie et al. 1994). Fish species diversity has been found to decline with increasing levels of urban development, while cutthroat trout (*O. clarki*) tend to become the dominant salmonid species (Lucchetti and Fuerstenberg 1993; Ludwa et al. 1997). In WRIA 8 (Lake Washington/Cedar/Sammamish), a local steering committee has recently recognized the need to restore coho salmon spawning habitat in order to reduce the population of cutthroat trout, a known predator of juvenile chinook salmon. Similar recommendations may be appropriate in areas throughout Skagit County.

Effects of Agriculture

Agricultural activities can have profound detrimental effects upon riparian areas, especially those activities with concentrated livestock grazing (Platts 1991; Spence et al. 1996; Armour et al. 1991). Livestock are naturally attracted to riparian areas due to available water, generally palatable vegetation, and microclimate conditions which usually represent a cooling effect during hot summer months. Cattle can spend up to 20 to 30 percent more time in riparian areas than elsewhere on their range (Platts 1990). Livestock use of riparian areas can lead to detrimental impacts to fish and wildlife habitat such as the following (excerpted from Thurston County 2005):

- Reduces or eliminates regeneration of woody vegetation.
- Changes plant species composition (e.g., xeric species and highly competitive exotic species invade, perennials are replaced by annuals, and trees/willows/sedges are replaced by brush and bare soil).
- Reduces overall riparian vegetation.
- Reduces overall plant vigor.
- Increases bank and instream deformation and erosion from loss of protective vegetation, and increases soil compaction and churning by hoof action, which lead to reduced water quality and changes in bank and channel integrity.
- Causes stream channel widening, shallowing, trenching, or braiding because of increased stream bank erosion.

- Reduces the ability of riparian habitat to trap and filter sediments and pollutants, leading to increased sedimentation and pollution from fecal matter of livestock.
- Increases stream temperatures as a result of lost cover provided by both woody and herbaceous plants.
- Results in loss of nutrient inputs, especially invertebrate food sources, to streams.
- Lowers the water table, with subsequent loss of riparian vegetation and stream flow.
- Increases the magnitude of high and low stream flow events.
- Reduces shrub and ground-nesting habitat for songbirds and other wildlife.
- Causes declines of amphibians, small mammals, and other ground-dwelling animals that need herbaceous and woody vegetation for food and cover.
- Increases songbird nest predation and brown-headed cowbird parasitism due to loss of shielding vegetation.
- Results in loss of structural and compositional diversity of plant communities, thereby reducing overall wildlife diversity.
- Reduces forage available for wild ungulates and other herbivores.

Fencing to exclude livestock or removal of livestock in heavily impaired riparian areas is recommended to allow these areas to recover. Once the riparian vegetation and streambanks have become stable, livestock use could return to the riparian area under limited duration and intensity (Spence et al. 1996).

Cultivation of croplands can also contribute to the degradation of riparian and instream habitat. Large quantities of fine sediments can be readily transported to streams due to the loss of permanent vegetation, regular tilling of fields, and bank erosion in ditches (Spence et al. 1996). These sediments can also carry a higher quantity of fertilizers and pesticides. Consideration for use of conservation techniques such as cover crops and conservation tillage can protect exposed soil from erosion and protect riparian and stream systems (Terrell and Perfetti 1989).

Importance of Headwater Systems

There have been numerous studies of riparian and wetland buffers, and numerous reviews of those studies. Relatively few of these studies have specifically investigated the functions of buffers on intermittent or small, perennial streams. However, Benda et al. (1992) reported that in typical mountain watersheds of the Northwest, low-order streams (first- and second-order streams) account for more than 70 percent of the cumulative channel length. Similarly, intermittent streams on 13 national forests in the Northwest represented an average of approximately two-thirds of the estimated total channel length (FEMAT 1993). This can be important when assessing potential impacts to anadromous fisheries, as it is noted that populations in lower order streams can show, on a relative basis, greater declines due to environmental changes. Findings from recent modeling studies on the Skagit River and accompanying tributary systems, indicate that changes in low-flow levels show greater relative declines on lower order tributaries than on the main body of the Skagit River (Mobrand - Jones and Stokes 2005).

Functional roles of riparian areas and the width of the riparian corridors are related to the position of the stream in the drainage, the hydrologic regime, and the local geomorphology

(Naiman et al. 1993). Low-order streams typically occupy confined channels whose forms are dominated by hillslope rather than fluvial processes (Montgomery and Buffington 1997).

Riparian plant communities influence aquatic and terrestrial ecology (Gregory et al. 1991). Steep slopes may limit the extent of common riparian vegetation (Knutson and Naef 1997). Low-order streams flowing through unconfined reaches exhibit plant communities distinct from the surrounding uplands (Gregory et al. 1991; Naiman et al. 1998). In contrast, because of the dominance of hillslope process on channel form, riparian areas along confined headwater streams tend to be narrower and less distinct, and have been thought generally to contain vegetation similar to that of upland areas (Gregory et al. 1991). However, recent investigations of confined, intermittent streams and small, perennial streams have found significant differences between riparian and upland vegetation characteristics (Waters et al. 2001). These differences in vegetation characteristics are exhibited primarily in the groundcover and shrub vegetation layers of headwater channels (Waters et al. 2001). Vegetation characteristics are critical factors in the function of the riparian zone, including allocthonous input (litterfall, terrestrial insects) (Piccolo and Wipfli 2002) and wildlife habitat (Waters et al. 2001; O'Connell et al. 2000). Finally, riparian corridors can play an important role in plant dispersal due in large part to microclimate considerations (Gregory et al. 1991).

Hydrologic connectivity is an important consideration in watershed management, and the basis for support of headwater-stream protection (Naiman et al. 1993). Headwater streams serve as important resource bases to subsidize downstream food webs, and much of the material for export originates in the riparian zone (Dodge and Mitas 2001; Piccolo and Wipfli 2002; Wipfli et al. 2002). Headwater streams also govern downstream water temperatures (Mohseni and Stefan 1999). Thus, disregard for headwater streams could have ramifications at multiple scales.

Riparian Functions

Upland changes that impact riparian areas are important in determining overall stream function, degradation and rehabilitation potential (Booth 1998). Buffers less than 10 meters in width (approximately 33 feet) are not generally considered functionally effective (review by May et al. 1997b; Johnson and Ryba 1992). The literature includes a wide range of recommended buffer widths; those with smaller widths may be adequate provided the existing buffer is high-quality forest and/or the surrounding land use has low impact (May et al. 1997b). Riparian forests tend to exhibit higher productivity than upland forests (Naiman and Décamps 1997). Buffer continuity is as important as width (May et al. 1997b). Knutson and Naef (1997) have found that there are few studies that examine the effects of incremental changes in buffer widths. While variable buffer widths may be more effective in protecting sensitive areas while also allowing flexibility (Haberstock et al. 2000; Castelle and Johnson 1998), the criteria to establish such variable widths for streams have not been developed.

Recent updates to critical area regulations within some other jurisdictions (e.g. King County, Thurston County, City of Redmond) have utilized a variable width approach based on best available science in which stream buffers may be larger/smaller depending upon connectivity to special aquatic areas such as Puget Sound or other Shorelines of the State. It is noted that fixed buffer widths are more easily established, require a lesser degree of scientific knowledge to implement, and generally require less time and money to administer (Castelle and Johnson

1998). However, Haberstock et al. (2000) suggests utilizing conservative fixed buffer widths that are larger than the minimum needed for protection.

The best available science looks at the following functions of stream buffers: 1) water quality, 2) bank stabilization, 3) shade and temperature, 4) microclimate, 5) wildlife habitat, 6) in-stream habitat (large woody debris recruitment), and 7) productivity. Most research on these functions is narrowly focused and conducted in rural forested areas. Thus, deriving overall recommended buffer widths for application throughout a county is somewhat subjective. Table 5 notes the ranges of effective buffer widths (as outlined in each subsection) based on each function and some notes on the functions that were studied.

Water Quality

Sediment input to streams is supplied by both bank erosion and upland processes (Naiman and Décamps 1997). Sediment input to confined, low-order streams in unmodified watersheds is typically dominated by hillslope processes while sediment input within higher order streams is typically driven by fluvial processes (Montgomery and Buffington 1997). In unmodified watersheds, aquatic organisms are adapted to the natural rate of sediment input via disturbance and erosion. Changes to that natural rate of sediment input resulting from human activities stress aquatic systems (May et al. 1997b). Large storms and resulting high flows in urbanized watersheds result in elevated sediment and associated turbidity and nutrient concentrations, probably due to erosion, mass-wasting, and the mobilization of water-quality constituents accumulated on roads and other impervious surfaces. Construction sites are also potential sources for sediment (May et al. 1997b).

Table 5. Range of Effective Buffer Widths for Each Applicable Riparian Function

Function	**Range of Effective Buffer Widths**	**Notes on Function**
Water Quality (sediment and pollution removal)	80 to 150 feet	For 80% nutrient and sediment removal
Bank Stabilization (erosion control)	80 to 125 feet	Disproportionately large increases needed beyond 30 meters to improve function
Shade and Temperature	80 to 150 feet	Based on adequate shade
Microclimate	80 to 525 feet	Up to a distance of two to three site-potential tree heights (SPTH)
Wildlife Habitat	100 to 600 feet	Coverage not inclusive
In-stream Habitat (large woody debris – LWD)	33 to 200 feet	Up to 1 site potential tree height (SPTH)
Productivity	80 to 100 feet	Disproportionately large increases needed beyond 30 meters to improve function

Riparian areas have inherent water storage capabilities, which can serve to retain pollutants and nutrients in surface runoff; this is affected by soil permeability and type, surrounding land uses, slope, and drainage installations (Naiman and Décamps 1997). Riparian forests are important for biotic accumulation of nutrients due to high transpiration rates (Naiman and Décamps 1997), but there are variations in the effectiveness of different vegetation types in the removal of specific nutrients (Osborne and Kovacic 1993). Thus, complex buffers with multiple classes of vegetation may be most effective at removing a variety of contaminants. Indeed, Schultz et al. (1995) found that riparian buffers combining trees, shrubs, and groundcover vegetation were effective at significantly reducing a complex mix of agricultural pollutants and nutrients. Riparian buffers along smaller streams have greater potential to reduce pollutant load due to the lower water volumes in small channels, underscoring the importance of protecting such systems (Naiman and Décamps 1997).

The reduction in forest cover and increase in impervious surface coverage typical of urbanized watersheds substantially impairs the storage capabilities of the watershed (Booth 2000; Sorrano et al. 1996). Stormwater systems often bypass riparian buffers, conducting nutrient- and sediment-laden water directly to receiving waters. The result is that urban areas contribute a disproportional amount of nutrients and other contaminants to receiving waters relative to the percentage of urbanized area within the watershed (Sorrano et al. 1996). Provided that they are not bypassed via a stormwater system, forested buffers can significantly reduce nutrient flux to receiving waters, but actual reductions are highly responsive to variations in precipitation (Sorrano et al. 1996). Chemical removal functions increase with buffer width out to 25 to 30 meters (approximately 80 to 100 feet); after this point, disproportionately large increases are needed to improve riparian function (Castelle and Johnson 1998).

Forested buffers of 100 to 150 feet are frequently recommended for sediment removal functions (Johnson and Ryba 1992). However, 50 percent removal efficiency is commonly attained in the first 30 to 100 feet (Daniels and Gilliam 1996, as cited in May et al. 1997b). For sediment reduction and chemical removal, disproportionately large increases in buffer width are needed beyond 80 to 100 feet to markedly improve buffer function; most benefits of riparian vegetation are realized in the first 15 to 80 feet. Palone and Todd (1997) report that buffers of 45 feet or more are effective at reducing pesticide contamination of streams. Most studies indicate that buffer widths of 50 to 100 feet are adequate for phosphorus and sediment removal, and that increasing widths beyond 150 feet does not significantly improve removal efficiencies (Palone and Todd 1997). While vegetative filter strips have been known to be an effective best management practice for controlling non-point source pollution (Dillaha et al. 1989; Magette et al. 1989; Young et al. 1980), Palone and Todd (1997) emphasize that a combination of grass filter strips and forested buffer is especially good at removing phosphorus and sediment.

The extensive agricultural activity within Skagit County requires concentrated attention on potential impacts of varying agricultural uses. Agricultural lands tend to have some of the most disturbed areas of the landscape, often due to the removal of native vegetation and continual tillage of the soil (Spence et al. 1996). Livestock grazing, especially in riparian areas, can have profound impacts to riparian vegetation and soil conditions which can lead to water quality impairment. Platts (1991) found in 20 of 21 studies that stream and riparian habitats were degraded by livestock grazing and that habitat improved when grazing was prohibited.

To achieve improved water quality in the County's streams and rivers, riparian buffer areas should be utilized effectively to provide both biofiltration of stormwater runoff and protection from agricultural activities. Both of these goals can be achieved by providing dense, well-rooted vegetated buffer areas. Forested riparian areas are known to reduce nutrient input into streams (Snyder et al. 1998). Additionally, biofiltration swales, created wetlands, and infiltration opportunities for specific stormwater runoff discharges can be utilized before they reach stream channels. Stormwater runoff that is conveyed through stream buffers in pipes or ditch-like channels and discharged directly to stream channels “short circuits” or bypasses buffer areas and receives little water quality treatment via biofiltration. In areas where stormwater flows untreated through riparian buffer areas, the buffer is underutilized and is prevented from providing the intended or potential biofiltration function. Effective methods to reduce impacts from livestock grazing can include fencing, reduction of grazing intensity near riparian areas, concentrating watering/feeding activities away from riparian areas, and densely planting riparian buffers with native trees, shrubs, and groundcover species.

Bank Stabilization

Riparian vegetation is commonly acknowledged as providing a bank stabilization function. This is accomplished through a complex of tree roots, brush, and soil/rock that protect stream banks from high velocity stream flows by slowing water currents (Spence et al. 1996). These structures create resistance to erosion while allowing moderate levels of dynamic channel change to occur.

In addition to bank vegetation and root structures, large woody debris (LWD) also plays a significant role in streambank stabilization, especially in headwater streams (Naiman and Décamps 1997). Due to a lack of stream power, LWD is relatively stable in small headwater streams, contributing to overall channel stability and the retention of sediment (Montgomery and Buffington 1997), both of which are critical factors in the distribution of salmonids (Montgomery et al. 1999). Ironically, the contribution of LWD to channel form in headwater streams is essential to the reduction in stream power that ultimately impedes the export of LWD from headwater systems. Thus, maintaining sufficient recruitment of LWD to headwater streams provides an effective mechanism for maintaining channel form. However, changes in basin hydrology resulting from land use activities and stormwater conveyance can have a profound negative influence on channel stability (Booth 2000). As with sediment reduction, the streambank stabilization functions of vegetation increase with buffer width out to 25 to 30 meters; after this point, disproportionately large increases are needed to improve riparian function (Castelle and Johnson 1998).

Shade and Temperature

Factors influencing water temperature include shade, relative humidity, ambient air temperature, wind, channel dimensions, groundwater, and overhead cover (Adams and Sullivan 1989; Mohseni and Stefan 1999). The loss of riparian forest cover and stream shading has been found to significantly increase stream temperatures (Brown and Krygier 1970; Beschta et al. 1987). While shade affects stream temperature more than most other factors, it may not play a significant role in short, headwater streams (Poole and Berman 2001). Intermittent streams, for instance, typically contain no flow during the hottest weather when the potential for warming would be the greatest. Thus, the level of shading to intermittent streams is often largely irrelevant with respect to temperature. Additionally, studies of clear-cuts along forested streams in Oregon found incremental yet insignificant increases in stream temperature through short cleared reaches (Zwieniecki and Newton 1999). Ultimately, for short, headwater streams, groundwater temperature and the magnitude of groundwater inputs have the greatest influence on stream temperatures (Mohseni and Stefan 1999).

Overall, sixty to eighty percent shading throughout the day is recommended to maintain water temperature control (Knutson and Naef 1997). Vegetated buffers up to about 25 meters (approximately 80 feet) provide significant shade production (Castelle and Johnson 1998). Besides shading, the next most important factor influencing stream temperatures is ambient air temperature, which is a function of microclimate (Mohseni and Stefan 1999; Poole and Berman 2001; Adams and Sullivan 1989).

Microclimate

Microclimate affects many ecological processes and functions, including plant growth, decomposition, nutrient cycling, succession, productivity, migration and dispersal of flying insects, soil microbe activity, and fish habitat (synthesis provided by Brosofske et al. 1997). With the exception of wildlife habitat, riparian buffer widths necessary for microclimate control are generally much wider than those necessary for other functions. Microclimatic gradients appear in air, soil, and surface water temperatures as well as relative humidity (Naiman and Décamps 1997). Altering riparian vegetation can change microclimate, leading to alterations in riparian functions (Brosofske et al. 1997). Stream temperatures are strongly influenced by riparian soil temperatures (Naiman and Décamps 1997), ambient air temperature, relative humidity, and wind speed (Mohseni and Stefan 1999). Changes to microclimate can effectively fragment riparian areas for those species unable to cope with altered conditions (Brosofske et al. 1997). While studies on small streams (2-5 meters wide) suggest that buffers greater than 45 meters (approximately 150 feet) are appropriate to protect riparian microclimate (Brosofske et al. 1997), buffers greater than 100 meters (approximately 328 feet) are generally required for full microclimate protection (Spence et al. 1996; Brosofske et al. 1997). Microclimate factors are potentially influenced by altered conditions to a distance of two to three site-potential tree heights from the streambank (Reid and Hilton 1998). Ledwith (1996) reported that the rates of change in ambient air temperature and relative humidity in forested buffers decreased beyond 30 meters (approximately 100 feet) from the stream, indicating that the inner 30 meters of buffer were the most critical for maintaining those factors.

Wildlife Habitat

Riparian zones play a critical role as wildlife habitat, and those buffer widths reported to fully protect wildlife habitat functions are exceeded only by those widths necessary to protect microclimate (Pentec 2001a). Most studies report a range of 200 to 300 feet necessary to provide essential habitat for most species (Keller et al. 1993). However, it has been noted that even a narrow buffer will enhance the habitat of most species (Wenger 1999). Wildlife habitat value is determined by structural complexity, ecological connectivity, food and water availability, and moist and moderate microclimate (Knutson and Naef 1997). The wildlife-habitat functions of riparian buffers are intrinsically tied to the other functions discussed previously. Thus, alteration to any buffer function is likely to affect wildlife habitat. Development can fragment riparian connectivity, thereby reducing its value as habitat and travel corridor for wildlife (Armstrong et al. 1983). Based on songbird studies, while wide corridors are optimal, management efforts should focus on restoring or creating riparian areas along streams that lack vegetation, as even narrow buffers have been shown to enhance habitat for most species (Keller et al. 1993).

Riparian corridors can serve as refuges and travel corridors for wildlife (Naiman and Décamps 1997). The number of wildlife species present is directly proportional to buffer width (Dickson 1989, as cited in Keller et al. 1993). Riparian areas provide ready access to drinking water, nesting and foraging sites, and cover. The wildlife communities supported by large rivers can be dramatically different than those associated with small streams. Additionally, wildlife species respond to varying degrees of forest successional stages and are affected by the type, frequency, duration, and severity of disturbance (Naiman et al. 1998).

Riparian habitat along smaller streams is generally insufficient to support large mammals, but it can provide habitat for a number of bird species (Bolton and Shellberg 2001). Natal dispersal of some bird species has been linked to riparian corridors (Machtans et al. 1996). Corridors are used more frequently than clearcuts by certain bird species for movement (Machtans et al. 1996). Frogs and salamanders utilize riparian habitat at various stages of their lives; this use can be either permanent or transient (Brode and Bury 1984). Salamanders range widely from waterbodies, and utilize riparian areas as migration corridors (Maxcy and Richardson 2000; Semlitsch 1998; Brode and Bury 1984). Buffer strips that are inadequate for wildlife could impact the transfer of nutrients from aquatic to terrestrial systems (Willson et al. 1998).

In-Stream Habitat (Large Woody Debris)

As discussed above under "Shoreline Stabilization," LWD exerts a substantial influence on channel morphology for confined headwater streams. LWD and other debris are rarely transported in small streams, and the consequent obstructions formed by LWD alter hydrology and geomorphology (Knutson and Naef 1997). The collection of woody debris and the subsequent entrapment of smaller branches, limbs, leaves and other material has been found to significantly reduce flow conveyance (Dudley et al. 1998). Gregory et al. (1991) reviewed the literature and found that LWD has a greater influence in the development of geomorphic structures in headwater streams, than downstream channels. LWD also retains smaller organic debris and provides substrate for microbes and algae, supplying a resource base for macroinvertebrates (Bolton and Shellberg 2001). LWD results in longer water residence time, shortening the carbon-spiral length (Naiman and Décamps 1997).

In higher order streams, LWD plays an extremely important role in forming complex in-water habitat structures (Bilby and Ward 1991; Montgomery and Buffington 1997; Pollack and Kennard 1998). These structures improve salmonid habitat by providing flow refugia and essential cover from predators as well as improved foraging conditions. LWD also traps smaller woody debris and organic matter which in turn contributes to additional enhancement of habitat conditions. The loss of riparian forest cover has been correlated to declines in salmon populations throughout the Pacific Northwest (Bisson et al. 1987; FEMAT 1993; Naiman and Bilby 1998).

In the riparian zone, LWD facilitates establishment and survival of plants, and provides cover for wildlife (Naiman and Décamps 1997). Recruitment of LWD is largely dependent on stand-age of the riparian forest (May et al. 1997b). Recruitment from alder-dominated stands tends to be faster than coniferous forests, but decomposition rates are higher (Bilby and Ward 1991). The contribution of secondary tree falls (when the falling of one tree leads to the falling of another) reduces the effective width of forested buffer strips surrounded by active harvest (Reid and Hilton 1998). The implications of this study are that buffer strips need to be much greater than one site-potential tree height to maintain pre-harvest recruitment rates (Reid and Hilton 1998). Further investigation would be necessary before applying this concept to an urban environment. However, new developments requiring clearcutting of forested areas should consider the effective reduction in buffer dimensions over time due to windthrow on buffer edges.

Productivity

Small streams receive most of their energy from allocthonous input (litterfall, terrestrial insects) from the riparian zone. Ninety percent of organic matter received by small streams is exported downstream (Kiffney and Richardson *no date*). Small, headwater streams serve as food conduits for downstream, fish-bearing waters, significantly increasing the capacity of those waters to support salmon (Dodge and Mitas 2001; Piccolo and Wipfli 2002; Wipfli et al. 2002). Intermittent streams, which have been ignored in the past, have been found to produce substantial numbers of macroinvertebrates, exceeding those of perennial streams in some cases (Muchow and Richardson 2000). Recent studies around the Puget Sound region have found stream health, as measured with the multimetric benthic index of biological integrity (B-IBI), to be closely associated with urban land cover with a reduction in biological integrity as the percentage of urban cover increases (Morley and Karr 2002). Studies have shown that 30-meter (approximately 100 feet) riparian buffers maintain natural rates of input of organic matter (Kiffney and Richardson *no date*). Other studies have suggested that beyond 80 feet, disproportionately larger buffers are needed to markedly increase allocthonous inputs (Castelle and Johnson 1998).

Best Available Science Review: Marine Areas

Skagit County's western boundary abuts Puget Sound, broadly categorized as an estuary. However, the larger estuary contains numerous sub-habitat types classified based on their physical (e.g., water depth, substrate type, light level), chemical (e.g., salinity, oxygen content), and biological characteristics (e.g., plant and animal communities). These sub-habitat types include sand and mudflats, tidal marshes, beaches, bluffs, and riparian areas, among others. It is estimated that nearly one-third of all outmigrating chinook and chum salmon fry utilize salt marsh habitat rather than migrating directly into Skagit Bay (Congleton et al. 1981), emphasizing the importance of this critical habitat niche. The ecological and structural diversity in the marine environment is the result of complex and highly dynamic physical, chemical, and biological processes, none of which can be altered within a single sub-habitat type without having effects on multiple qualities of that sub-habitat type and adjacent sub-habitat types. For this dynamic system to maintain itself, remain stable (but not static), and continue to support a variety of organisms, the processes must be allowed to operate without interference. Because direct human disturbances primarily occur in or adjacent to beaches, bluffs and riparian areas (collectively the "nearshore"), the following discussion will focus on these areas.

Marine Riparian Processes and Function

According to Brennan and Culverwell (2004), "[o]f the many habitat elements comprising the nearshore, perhaps the least understood and most unappreciated, in terms of critical functions, is the riparian zone." Although research on riparian processes and functions has not been conducted for marine environments to the same level as freshwater environments, it is generally acknowledged that vegetation adjacent to waters of any salinity would likely provide the same basic functions (Desbonnet et al. 1994; Culverwell and Brennan 2004). These basic functions include the following: 1) water quality, 2) wildlife habitat, 3) microclimate, 4) shade and temperature 5) nutrient input, 6) bank stabilization, and 7) large woody debris recruitment (see detailed discussions above). However, the relative importance of each of these functions to the marine nearshore ecosystem is likely different and each of these functions likely has some unique mechanisms and vectors for influencing the ecosystem. The following discussion provides a brief description of each of those functions, focusing on those aspects that are exclusive to the marine environment.

Water Quality

Riparian areas adjacent to marine waters perform the same water quality functions as those adjacent to fresh waters (see discussion above). The bulk of the water inputs to the nearshore, however, are via tributary streams and rivers. These streams and rivers are likely a larger source of pollutants to the marine environment than waters that pass through the adjacent uplands. The nearshore environment acts as a sink (in sediments and organisms) for a variety of contaminants, including metals and hydrocarbons. Many of these contaminants become part of the food chain at the lowest level, and may bioaccumulate in the upper tropic levels. For example, excessively high levels of PCBs have been found in Puget Sound harbor seals (Calambokidis et al. 1999) and in orca whales (Ross et al. 2000).

Wildlife Habitat

The following discussion of the wildlife habitat function of marine riparian areas has been excerpted from *Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9)* (Pentec 2001b).

> Healthy riparian areas along marine shorelines support abundant and diverse assemblages of wildlife. For example, Brennan and Culverwell (in prep.) identified 205 wildlife species (5 amphibians, 4 reptiles, 153 birds, and 43 mammals) in a review of wildlife species known or expected to have a direct association with riparian habitat along the marine shorelines in Central Puget Sound. This represents approximately 70 percent of the 292 wildlife species known to inhabit all of King County. Wildlife species diversity and abundance is greatly influenced by the composition and continuity of vegetation and the proximity of riparian areas to Puget Sound, which offers a moderate climate, greater habitat complexity and increased opportunities for feeding, foraging, cover and migration.
>
> Wildlife habitat requirements in freshwater riparian zones are complex and have received a significant amount of review and analysis. However, few studies have focused on wildlife habitat requirements in marine riparian areas and we must depend upon wildlife studies and studies of riparian support functions elsewhere to begin to understand the potential of marine riparian areas. It is suspected that buffer requirements for freshwater systems may be significantly less than for some marine and estuarine riparian systems because of the

> influences of wind, salt spray, desiccation, and general microclimate effects on vegetation and associated wildlife (Klaus Richter, pers. comm.).

Microclimate

The marine riparian zone is strongly affected by the marine aquatic environment. The plant community that can survive such an environment must be tolerant of sun and wind exposure, and tidal inundations or salt spray. In turn, the resulting marine riparian plant community can ameliorate the effects of sun and wind exposure on organisms inhabiting the marine riparian zone and the adjacent nearshore aquatic habitats. For example, many marine organisms are subject to desiccation and overheating; riparian vegetation that overhangs the environment in which these organisms are found provides the shade and temperature control that makes it possible for these species to survive the harsh conditions. This in turn is one of the environmental factors that affect the "spatial and temporal patterns in intertidal organisms" (Foster et al. 1986, cited in Pentec 2001b). Removal of riparian vegetation results in "increased temperatures, decreased moisture and humidity, increased runoff and elevated water temperatures entering marine systems, desiccation or erosion of soils, and increased stress for organisms dependent upon cool, moist conditions" (Pentec 2001b).

Shade & Temperature

The ability of marine riparian vegetation to have an effect on water temperature is a function of the level of tidal exchange and the percentage of the waterbody that is shaded (immeasurably small in the case of Puget Sound). However, water temperatures in narrow tidal channels and small direct drainages (streams, springs, and seeps) into the nearshore environment may be partially regulated by shade (Pentec 2001b).

Nutrient Input

The following discussion of the nutrient input function of marine riparian areas has been excerpted from *Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9)* (Pentec 2001b).

> Riparian areas act as both sources of organic matter and sinks for trapping and regulating the flow of nutrients. Although the amount of input and level of importance to the marine system have not been quantified, riparian vegetation has the potential of producing significant amounts of organic matter. The organic matter that falls to the forest floor and becomes a part of the soil, or enters the aquatic environment, directly or indirectly, contributes to the detrital food web. Organic detritus is the principal energy source for food webs in estuarine and shallow marine benthic portions of the ecosystem; the principal source of this detrital carbon is debris from macrophytes in the system (Gonor et al. 1988). Nutrients, such as nitrogen, are also fixed by roots of some plants and metered out to the aquatic system through runoff, leaf and stem litter, or large woody debris.
>
> Riparian vegetation also makes indirect contributions of nutrients to the nearshore system in the form of prey resources. The organic debris produced by riparian vegetation often collects on beaches and combines with marine-derived plant material to form beach wrack. The structure and decomposition of beach wrack attracts a diverse array of terrestrial insects and

marine invertebrates. Many riparian plants attract insects that become prey for terrestrial and aquatic consumers. For example, a number of studies have identified terrestrial insects as a significant dietary component of juvenile chinook and chum salmon diets in subestuaries and other nearshore waters throughout Puget Sound (Fresh et al. 1979; Fresh et al. 1981; Pearce et al. 1982; Levings et al. 1991; Shreffler et al. 1992; Levings et al. 1995; Miller and Simenstad 1997; Cordell et al. 1999a,b; Cordell unpublished data). In addition, other invertebrates, such as mysids and amphipods, are connected to vegetation via detritus-based food webs and serve as important prey for salmonids and other fishes, birds, and invertebrates in the nearshore.

Current nearshore food web analysis by the University of Washington has identified important habitats and food web connections for chinook salmon in Puget Sound, including (Cordell et al. unpublished data):

- Intertidal and shallow subtidal areas that produce amphipods and other epibenthic crustaceans. As has been established for juvenile chum salmon, these probably include intertidal flats as well as vegetation and areas of high detritus buildup.
- Nearshore vegetated terrestrial habitats that are the source of terrestrial insects in the diets.
- Feeding on planktonic grazers such as euphausiids, shrimp, and crab larvae, planktonic amphipods, and copepods.
- Feeding on other secondary pelagic consumers such as herring and other fishes.

Due to the limited sampling and dietary analysis of juvenile salmonids and other species in the nearshore environment, additional studies are needed to quantify and understand the contribution of riparian vegetation to nearshore food webs and the impacts of vegetation loss along marine shorelines. However, it is clear that as vegetation is eliminated, the food supply and the thus the carrying capacity of the nearshore ecosystem is reduced (Brennan and Culverwell, in prep.).

Bank Stabilization

The mechanisms of soil and bank stabilization by vegetation are the same for marine and freshwater riparian areas. Removal of shoreline vegetation to allow development and maintain views results in reduced bank stability, increase erosion, and slope failures.

Large Woody Debris

The riparian zone is one contributor of large woody debris to the nearshore environment. Other sources include LWD washed downstream from local freshwater riparian zones and storm-deposited wood (Pentec 2001b). The functions of large woody debris in the nearshore environment are in many ways similar to those in the freshwater environment. For example, LWD in both environments:

- Is a source of nutrients;
- Traps sediments;
- Is a source of cover and refuge from predators;
- Buffers high-energy water movements;

- Provides potential roosting, nesting, and foraging opportunities for wildlife;
- Provides foraging, refuge, and spawning substrate for fishes; and
- Provides foraging, refuge, spawning, and attachment substrate for aquatic invertebrates and plants (Brennan and Culverwell, 2004; Pentec 2001b; Williams and Thom 2001).

The sediment-trapping function of LWD can be particularly important in the development and maintenance of berm and backshore areas. The berm and LWD protect the backshore area so that vegetation can establish and further stabilize the beach. Vegetation establishment is also directly aided by the moisture and nutrients provided by the LWD (Pentec 2001b; Brennan and Culverwell, 2004).

Bluff Processes and Function

Banks and bluffs are "formed and maintained by the dynamics of numerous factors including soils, wind, erosion, hydrology, and vegetative cover" (Pentec 2001b). They are an important transition area between the aquatic and upland portions of the nearshore environment. Functions performed by banks and bluffs include the following:

- Source of sediments to beaches,
- Habitat for bluff-dwelling animals,
- Support of marine riparian vegetation (and associated riparian functions), and
- Source of groundwater seepage into estuarine and marine waters (Pentec 2001b).

Shoreline armoring, vegetation clearing, construction of overwater and in-water structures, development, dredge and fill, and hydrology changes can all affect the maintenance and formation of bluffs through changes in erosion rate (either increases or decreases), either directly or indirectly. These changes would alter performance of the above-listed functions, thereby reducing the ability of bluffs to directly provide habitat and to provide sediments to nearshore habitats at an appropriate rate.

Beach Processes and Function

According to Pentec (2001b), beaches are "boulder, cobble, gravel, sand, and silt areas" and backshore areas are "immediately landward of beaches and are zones inundated only by storm-driven tides." Beaches are formed by accumulations of sediments of varying sizes derived from feeder bluffs or materials that were delivered to the nearshore by fresh-water drainages. The location and composition of accumulated sediments is a function primarily of physical processes and landforms that influence sediment recruitment and transport (Zelo and Shipman 2000). Ecological functions of beaches that have been documented in the region include:

- Primary production,
- Nutrient cycling,
- Refuge for multiple species,
- Prey production for juvenile salmon and other marine fishes,
- Fish habitat, including forage fish spawning, and
- Infaunal and epifaunal production (Pentec 2001b).

Beaches are medium- to low-energy environments, which allow development of numerous habitats along the tidal gradient (Zelo and Shipman 2000). The beach provides a matrix in which or on which a variety of plants, invertebrates and other organisms live. These organisms in turn are fed upon by fish, mammals, birds, and other invertebrates. According to Zelo and Shipman (2000), the vegetation component of the beach environment "dominates the primary productivity and the base of the food web in these nearshore areas, but the flora also provides forage, refuge, and a variety of other habitat functions for many marine species." Several forage fish species, which are a primary prey source for salmonids, also spawn on very specific beach forms. Less is known about backshore areas, although accumulated LWD in the backshore can "help stabilize the shoreline, trap sediments and organic matter, and provide microhabitats for invertebrates and birds" and "[b]ackshore areas also support a unique assemblage of vegetation tolerant of wind, salt spray, and shifting substrate" (Pentec 2001b).

Similar to bluffs, shoreline armoring, vegetation clearing, construction of overwater and in-water structures, development, dredge and fill, and hydrology changes can all affect the maintenance and formation of beaches, either directly or indirectly. These changes would reduce the performance of the above-listed functions.

Best Available Science Review: Wildlife Habitat

The majority of wildlife habitat located within Skagit County can be found within or adjacent to wetlands and/or aquatic areas and thus would be afforded some level of protection through buffer regulation. However, it is recognized that not only are there other wildlife habitats outside of these wetland and riparian areas, but that the need for wildlife habitat protection may extend much farther than any fixed-width stream or wetland buffer. The diversity of species along with variation of habitat types and land uses makes it difficult to create blanket regulations that would apply to all wildlife areas within the County. Therefore, protection of wildlife habitat should be regulated on a more site-specific basis.

Approaches to protecting and conserving species and their habitats have varied from protecting species only within clearly identified ecological reserves (Wright 1998) to protecting species regionally through enhancement of existing habitat and important wildlife needs (Morrison et al. 1998, as cited in King County 2004). Regardless of the approach, it is important to recognize the need to protect not only the existing habitats being utilized, but also alternative habitats which may be necessary for breeding, foraging, and sheltering (Bissonette 1997). In order to maintain viable wildlife populations, alternate habitats and features must be accessible (Marzluff and Ewing 2001).

Several generalizations regarding effective policies for wildlife and habitat conservation can be gleaned from the literature. For example, large habitat patches tend to support greater wildlife diversity than smaller patches (Brown 1985; Donnelly 2002), particularly for interior species. However, small, isolated patches of suitable habitat can both support species throughout critical life stages and provide cover for individuals moving between larger habitat patches (Fahrig and Merriam 1994).

Recent and ongoing research at the University of Washington's College of Forest Resources (Marzluff and Ewing 2001; Marzluff and Donnelly 2002; Rohila and Marzluff 2002) addresses native forest species conservation in developed areas of the Puget Sound region. Recommendations stemming from this work include limiting development at the landscape level to approximately 50 percent, emphasizing preservation of forest stands at least 73 acres in size, maintaining mixed (at least 23% conifer) stands at a minimum tree density of four per acre, and preserving trees of large diameter. Many recommendations in the available literature are species-specific. Thus, as mentioned previously, wildlife habitat is most effectively regulated on a site-specific basis.

In the marine nearshore environment, wildlife habitat and resultant wildlife species composition is the result of the complex interactions of a number of physical, chemical and biological processes. Protection of those processes is the best way to protect marine nearshore habitat. Species of particular interest include forage fish (e.g., surf smelt, sand lance) and shellfish. These species are dependent on specific substrate types, the formation of which are driven by erosion and sediment movement processes. Changes in erosion rates resulting from shoreline hardening or changes in sediment movement from groin installation can result in losses of suitable habitat. Further, losses of marine riparian vegetation can eliminate the microclimate conditions that facilitate survival of those species. For example, Pentilla (1978, as cited in Pentec 2001b) suggests that shade can increase the success of surf smelt spawning by reducing the mortality attributed to thermal stress and desiccation.

In response to growing public interest in wildlife and its protection, as well as changing and expanding federal legislation regarding wildlife, and in order to be competitive for federal grant money, the Washington State Department of Fish and Wildlife (WDFW 2005) produced a conservation strategy for the preservation and enhancement of state and federal threatened or endangered species. The resulting document, *Washington's Comprehensive Wildlife Conservation Strategy*, was created using six "guiding principles" to achieve its goals of healthy, diverse, and sustainable fish and wildlife populations, habitats and recreational opportunities. Table 6 summarizes these principles and how they are useful in the future development and refinement of wildlife habitat regulation in Skagit County.

Table 6. Guiding principles used in development of Washington's Comprehensive Wildlife Conservation Strategy (CWCS)

Guiding Principle	Relevance to Skagit County
Address all species and habitats, identifying those having the greatest need or lacking adequate documentation	This allows for emphasis on species regulated by state and federal government while addressing all wildlife species and habitat, as required by the County's Comprehensive Plan.
Summarize and use information gathered in collaborative conservation planning methods	The Washington GMA mandates the use of best available science in policy decision; the CWCS collates and utilizes recent knowledge gathered specifically for developing wildlife and habitat conservation strategies in Washington State.
Strengthen and expand conservation partnerships	Implementation of wildlife and habitat regulations and policies will be most successful with the cooperation of private, public, and non-government groups and individuals.
Emphasize conservation of biodiversity	In 2002, Washington State passed legislation calling for the development of state guidelines for conserving biodiversity. Best available science also emphasizes the need to address and conserve biodiversity.
Produce an understandable document available to the public	Providing a comprehensive, reader-friendly document will assist in gaining public support for proposed regulatory updates.

Guiding Principle	Relevance to Skagit County
Produce a document that draws attention to important wildlife issues, particularly where decision-makers are concerned	Implementation of wildlife conservation strategies will require the support of both the public and decision-makers. Policy backed by best available science, detailed in a document highlighting wildlife issues, will facilitate acceptance and approval by concerned parties.

As mentioned above in the *Code Review and Comparison Section*, the existing CAO does not include the following three additional elements recommended by CTED in its designation of Fish and Wildlife Habitat Conservation Areas:

- State Priority Habitats and Areas Associated with State Priority Species.
- Areas of Rare Plant Species and High Quality Ecosystems.
- Land Useful or Essential for Preserving Connections Between Habitat Blocks and Open Spaces.

Inclusion of state priority habitats, state priority species, rare plants, and high quality ecosystems would substantially overlap the existing designation of "areas with which endangered, threatened, and sensitive species have a primary association." However, the habitat elements that do not overlap provide key foraging or breeding habitat (e.g., snags), support high species density and diversity (e.g., old-growth or mature forest), are difficult or impossible to replace (e.g., caves), and/or are limited in number (e.g., cliffs). While state or federally listed or sensitive species may not be directly associated with these special habitats or ecosystems, their preservation and protection may be key in preventing the addition of species to those lists. Further, existing and proposed performance standards for FWHCAs require coordination on a site-specific level with the Washington Department of Fish and Wildlife and Washington Department of Natural Resources (among others), the agencies which manage the Priority Habitats and Species program and the Natural Heritage Program (which maps rare plants and high quality ecosystems), respectively.

Maintenance of special habitats across the landscape is important in the short term, but long-term viability requires that species be able to move between patches to maintain genetic diversity, enable dispersal, and allow movement of species that require different habitat types for different life stages. The relative importance of safe corridors connecting patches is somewhat dependent on the particular species and the size and characteristics of the habitat patch. Accordingly, the County should consider including the three elements recommended by CTED in its definition of FWHCAs.

Summary

For most riparian buffer functions, much of the literature indicates that buffer widths of 100 feet (30 meters), and in some cases less, may be adequate to provide for fish and wildlife habitat if the buffer is of high quality (Knutson and Naef 1997). Buffer width reduction with enhancement can be used by landowners to improve the functions of existing, degraded riparian buffers while also making effective use of their land. Both Larry Fisher and Tony Opperman of the Washington Department of Fish and Wildlife (pers. comm., 10 April 2002) concur that buffer averaging and reduction incentives are appropriate to encourage mitigation and enhancement that would improve buffer functioning beyond levels provided by existing buffer conditions. Narrow buffer widths may be adequate if such buffers are of high quality (May et al. 1997b; Castelle and Johnson 1998). Contiguous buffers along streams may be more important than increased width for achieving aquatic and terrestrial habitat goals, and smaller buffers may be adequate to protect small, first-order streams (Palone and Todd 1997). The continuity of the riparian corridor along the stream is at least as important as its width (Horner and May 1998; May et al. 1997a).

The removal of non-point source pollutants, including nutrients, sediment, and metals, is generally regarded as a valuable function of riparian buffers (May et al. 1997b). Chemical contamination of the receiving waterbodies within the watershed consists primarily of hydrocarbon input resulting from urbanization. Wakeham (1977) computed a hydrocarbon budget for Lake Washington and determined that the majority of the hydrocarbons were from stormwater runoff. In general, hydrocarbons are found in road runoff and can reach the County's streams directly through existing stormwater systems. Stormwater systems which circumvent buffers limit the opportunity to filter runoff through adjoining soils and vegetation. Accordingly, stream buffers are typically underutilized for treatment of hydrocarbons and other pollutants found in typical stormwater runoff.

In addition to best available science, the County's unique position in a typically rural setting, including expansive agricultural areas, and the area's hydrologic and geologic processes are to be taken into consideration in the determination of appropriate buffer widths. In establishing the appropriate level of protection for different stream classes throughout the County, various inferences must be drawn. The majority of scientific studies that critically examine the functions and values associated with riparian areas have been conducted in forested environments. As such, fundamental differences between forested, agricultural, and urban areas, including land use and hydrology, are frequently overlooked. Moreover, Knutson and Naef (1997) have found that there is a limited body of literature on the effects of incremental changes in riparian buffer widths. Lastly, riparian studies often fail to account for the contribution of engineering and public works projects, such as surface-water detention facilities, that can supplement natural riparian function in more urban settings.

WETLANDS

Code Review and Comparison

The existing Code requires utilization of DOE *Washington State Wetlands Identification and Delineation Manual* for identifying and delineating wetlands, as required by RCW 36.70A.175. The County's existing regulations call for the classification of wetlands according to the four-tiered *Washington State Wetland Rating System for Western Washington* (DOE 2004). Under this system, wetlands are categorized using the following criteria:

Category I:

1) represent a unique or rare wetland type (e.g., some estuarine wetlands, wetlands in coastal lagoons); or
2) are more sensitive to disturbance than most wetlands (e.g., bogs); or

3) are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime (e.g., Natural Heritage wetlands, some mature and old-growth forested wetlands); or
4) provide a high level of functions (score at least 70 points on DOE's wetland rating form).

Category II:

1) difficult, though not impossible, to replace (e.g., some estuarine wetlands, some interdunal wetlands); and
2) provide high levels of some functions (score between 51 and 69 points on DOE's wetland rating form).

Category III:

1) wetlands with a moderate level of functions (scores between 30 and 50 points on DOE's wetland rating form), and
2) some interdunal wetlands.

Category IV:

1) lowest levels of functions (scores less than 30 points on DOE's wetland rating form).

Protection of wetland functions, values, and uniqueness, as recommended by CTED for compliance with the GMA, are to a large extent addressed under the DOE system. Explicitly, CTED recommends, in addition to use of the DOE rating system, consideration of the following:

- Wetland functions and values,
- Wetland sensitivity to disturbance,
- Rarity of a wetland type, and
- The degree to which degradation or destruction of a wetland can be compensated.

The existing regulations generally meet the CTED recommendations for determining wetland categories through their use of the DOE system. The overall content of the existing wetland regulations do not meet the CTED and other agencies' criteria for classification and use of best available science determining appropriate buffer widths and making variance decisions, however. Current County Code requires 150-, 100-, 50-, and 25-foot fixed-width buffers on Category I, II, III, and IV wetlands, respectively. By comparison, DOE and CTED determined required wetland buffers based on the intensity of proposed land use actions (Table 7). The DOE recommended standard buffer widths have been developed based on DOE's review of the best available science for wetlands throughout the state.

In addition, current County Code exempts from regulatory authority Category II and III wetlands less than 2,500 square feet in size and Category IV wetlands less than 10,000 square feet in size. This is inconsistent with both CTED and DOE recommendations, which require regulation of and appropriate mitigation for all wetland categories, except certain Category III and IV wetlands under 1,000 square feet.

CTED acknowledges that the DOE-recommended standard buffer widths may not be appropriate in non-rural and non-forested settings, and thus advised that local governments tailor them to meet specific needs in their jurisdictions. The degree of development in some areas of western Skagit County may allow for buffer widths to be scaled to account for surrounding land use types and degree of urbanization, while still providing the best protection of wetland functions and values, as well as allowing reasonable and appropriate use of property by landowners. Some cities and counties throughout Western Washington have utilized a similar variable buffer width approach by assessing buffers based on habitat scores or combination of habitat score and land-use intensity.

Buffer averaging and buffer reduction with enhancement can be applied to the revised wetland buffer widths as incentive for landowners to improve buffer conditions. Both are standard practices in many jurisdictions. The existing Code allows for buffer width reduction to a maximum of 50 percent of the standard buffer width or 25 feet, whichever is greater, when no reasonable alternative exists, unless it is determined by the County that no net loss of wetland functional values will occur. CTED guidelines allow for a buffer to be reduced to 75 percent of its width or 35 feet, whichever is larger. All buffer averaging and reduction proposals should be submitted with a critical areas study that uses best available science to demonstrate how functions and values will be preserved.

Current Code requirements for mitigation sequencing, siting, and timing are in compliance with CTED guidance. Mitigation ratios under the current SCC differ from those recommended by CTED (see Table 7). As well, the SCC allows mitigation of Category III and IV wetlands by enhancement of significantly degraded wetlands at a minimum ratio of at least double the standard ratios. CTED recommends enhancement only be used in conjunction with restoration and/or creation, and also at double the ratios given in the CTED guidance. DOE more recently provided additional guidance which allows wetland enhancement as sole compensation for impacts at quadruple the standard ratio (DOE 2006)

Existing Conditions

The County's *Comprehensive Plan* refers to a Supplemental Map Portfolio which includes a general inventory of known and documented wetlands throughout the County. The National Wetland Inventory (NWI) Wetlands Online Mapper identifies many additional wetlands. Innumerable unmapped wetlands representing all wetland categories are also present throughout the County. Specifically, the County's lowland areas throughout the Skagit River estuary contain countless wetlands of varying category ratings.

Existing residential and commercial development within the County, primarily within already populated and susceptible lowlands, has increased impervious surface area and decreased forest cover. Future growth within the County is expected to increase the rate of impervious surface and deforestation, with expected increases in flood frequency, peak flows, and nutrient and chemical loading to the natural environment.

Table 7. Jurisdictional Comparison of Wetland Classification and Management

Existing Skagit County CAO	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County – Rural (2005)	King County—Urban (2005)
Wetland Classification						
Classified according to the 4-tiered Washington State Wetland Rating System for Western Washington (DOE August 2004) Category 1: wetlands scoring >70 points on the DOE rating form Category II: wetlands scoring 51-69 the DOE rating form Category III: wetlands scoring 30-50 the DOE rating form Category IV: wetlands scoring <30 the DOE rating form	Category 1: wetlands with documented habitat for a listed species; or with high quality native wetland communities; or high quality, regionally rare wetlands/wetlands of local significance Category 2: wetlands with State listed priority fish/wildlife or rare plant species; or having ecological functions that may not be adequately replicated; or rating ≥22 habitat points using DOE rating system; or being of documented local significance Category 3: wetlands not satisfying criteria of other categories and scoring ≤21 habitat points on using the DOE rating system Category 4: hydrologically isolated wetlands ≤1 ac with 1 wetland class and , dominated by non-native monotypic vegetation; or ≤2 ac with one class and >90% cover of non-native plants	Classified according to the 4-tiered Washington State Wetland Rating System for Western Washington (DOE August 2004) Category 1: wetlands scoring >70 points on the DOE rating form Category II: wetlands scoring 51-69 the DOE rating form Category III: wetlands scoring 30-50 the DOE rating form Category IV: wetlands scoring <30 the DOE rating form	Category 1: Natural Heritage, DNR high quality, and bog wetlands, and relatively undisturbed estuarine wetlands >1 ac; mature and old growth forest wetlands > 1ac; wetlands in coastal lagoons; and wetlands scoring at least 70 out of 100 on questions related to functions. Category 2: estuarine wetlands <1 ac or >1 ac and disturbed; wetlands containing sensitive plant species confirmed by DNR; wetlands scoring 51-69 out of 100 on questions related to functions. Category 3: wetlands scoring 30-50 out of 100 on questions related to functions. Category 4: wetlands scoring <30 out of 100 on questions related to functions.	Classified according to the 4-tiered Washington State Wetland Rating System for Western Washington (DOE August 2004) Category 1: wetlands scoring >70 points on the DOE rating form Category II: wetlands scoring 51-69 on the DOE rating form Category III: wetlands scoring 30-50 on the DOE rating form Category IV: wetlands scoring <30 the DOE rating form	Classified according to the 4-tiered Washington State Wetland Rating System for Western Washington (DOE August 2004) Category 1: wetlands scoring >70 points on the DOE rating form Category II: wetlands scoring 51-69 on the DOE rating form Category III: wetlands scoring 30-50 on the DOE rating form Category IV: wetlands scoring <30 on the DOE rating form	Classified according to the 4-tiered Washington State Wetland Rating System for Western Washington (DOE August 2004) Category 1: wetlands scoring >70 points on the DOE rating form Category II: wetlands scoring 51-69 on the DOE rating form Category III: wetlands scoring 30-50 on the DOE rating form Category IV: wetlands scoring <30 on the DOE rating form

[1] CTED = Washington State Department of Community, Trade, and Economic Development

Existing Skagit County CAO	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County – Rural (2005)	King County—Urban (2005)
Wetland Buffers						
Category I – 150 ft Category II – 100 ft Category III – 50 ft Category IV – 25 ft	Category 1: High intensity – 300 ft Moderate intensity – 250 ft Low intensity – 200 ft Category 2: High intensity – 200 ft Moderate intensity – 150 ft Low intensity – 100 ft Category 3: High intensity – 100 ft Moderate intensity – 75 ft Low intensity – 50 ft Category 4: High intensity – 50 ft Moderate and low intensity – 35 ft	Category 1: Natural Heritage, DNR high quality, and bog wetlands –190 ft Estuarine (>1 ac) and coastal lagoons – 150 ft Habitat score 29-36 - 225 ft Habitat score 20-28 –110 ft Category 1 not meeting above criteria – 75 ft Category 2: Estuarine (<1 ac) – 110 ft Habitat score 29-36: - 225 ft Habitat score 20-28 –110 ft Habitat score <20 and water quality improvement score 24-32 – 75 ft Category 3: Habitat score 20-28 – 110 ft Category 3 not meeting above criteria –60 ft	Base buffer widths: Category I – 150 ft Category II – 100 ft Category III – 50 ft Category IV – 25 ft Variable buffer widths are provided based on both habitat score and surrounding land-use intensity	Buffer widths are based on function scores in each category. Ranges are: Category I – 100-300 ft Category II – 100 - 300 ft Category III – 100 - 300 ft Category IV – 50 - 100 ft	Category 1: Natural Heritage and Bog wetlands – high impact: 250 ft; moderate impact: 190 ft; low impact: 125 ft Estuarine and coastal lagoon – high: 200 ft; moderate: 150 ft; low: 100 ft Habitat score 29-36: - high: 300 ft; moderate: 225 ft; low: 150 ft Habitat score 20-28 – high: 150 ft; moderate: 110 ft; low: 75 feet Category I not meeting above criteria – high: 100 ft; moderate: 75 ft; low 50 ft. Category II: Estuarine and interdunal, habitat score 20-28 – – high: 150 ft; moderate: 110 ft; low: 75 ft Habitat score 29-36 – high: 300 ft; moderate: 225 ft; low: 150 ft Category II not meeting above criteria – high: 100 ft; moderate: 75 ft; low: 50 ft Category III**:** Habitat score 20-28 – high: 150 ft; moderate: 110 ft; low: 75 ft	Category 1: Natural Heritage and Bog wetlands – 215 ft Estuarine and coastal lagoon – 175 ft Habitat score 29-36 - 225 ft Habitat score 20-28 – 150 ft Category I not meeting above criteria – 125 Category II: Estuarine – 135 ft Habitat score 29-36 – 200 ft Habitat score 20-28 – 125 ft Category II not meeting above criteria – 100 ft Category III**:** Habitat score 20-28 – 125 ft Category III not meeting above criteria – 75 ft Category IV – 50 ft

Existing Skagit County CAO	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County – Rural (2005)	King County—Urban (2005)
		Category 4: Total score <30 – 40 ft Type 1 marine shorelines: 150 ft			Category III not meeting above criterion – high: 80 ft; moderate: 60 ft; low: 40 ft Category IV – high: 50 ft; moderate: 40 ft; low: 25 ft	
Wetland Mitigation						
Mitigation ratios for on-site restoration/creation: Category I - 4:1 Category II or III: Forested – 3:1 Scrub/shrub – 2:1 Emergent – 2:1 Category VI - 1.25:1	Mitigation sequencing is as follows: 1. Avoidance of impacts 2. Minimization of impacts 3. Repair, rehabilitation, restoration 4. Preservation and maintenance to reduce impacts over time 5. Replacing, enhancing, or providing substitute resources as compensation Mitigation ratios apply to in-kind, on-site creation or restoration and are: Category 1 – 6:1 Category 2 – 3:1 Category 4 – 2:1 Category 5 – 1.5:1 Enhancement may be allowed in	Mitigation ratios for wetland creation: Category 1: Forested – 6:1 Based on functions score – 4:1 Natural Heritage, coastal lagoon, bog, and estuarine – case-by-case Category 2: Estuarine – case-by-case All others – 3:1 Category 3: All – 2:1 Category 4: All – 1.5:1	Mitigation ratios for on-site, in-kind restoration/creation: Category I - 6:1 Category II – 3:1 Category III – 2:1 Category VI - 1.5:1 Enhancement of existing or created wetlands may be permitted at twice the standard mitigation ratios.	Maximum mitigation ratios: Category I mature forested: Creation or re-establishment (C/R) – not allowed Rehabilitation - 12:1 R/C+enhancement – 1:1 RC and 10:1 enhancement Enhancement - Not allowed Category I scoring at least 70: C/R - 4:1 Rehabilitation - 8:1 R/C+enhancement – 1:1 RC and 6:1 enhancement Enhancement – 16:1 Category I estuarine, bog, coastal lagoon, natural heritage site: C/R – not allowed (estuarine 12:1) Rehabilitation - 6:1 R/C+enhancement – 12:1 Enhancement – not	Mitigation ratios for permanent alterations: Category I forested: Creation or re-establishment (C/R) - 6:1 Rehabilitation - 12:1 R/C+enhancement – 1:1 RC and 10:1 enhancement Enhancement – case by case Category I based on score: C/R - 4:1 Rehabilitation - 8:1 R/C+enhancement – 1:1 RC and 6:1 enhancement Enhancement – case by case Category I estuarine, bog, coastal lagoon, natural heritage site: C/R – not allowed (estuarine case by case) Rehabilitation - 6:1 R/C+enhancement – case by case	Mitigation ratios for permanent alterations: Category I forested: Creation or re-establishment (C/R) - 6:1 Rehabilitation - 12:1 R/C+enhancement – 1:1 RC and 10:1 enhancement Enhancement – case by case Category I based on score: C/R - 4:1 Rehabilitation - 8:1 R/C+enhancement – 1:1 RC and 6:1 enhancement Enhancement – case by case Category I estuarine, bog, coastal lagoon, natural heritage site: C/R – not allowed (estuarine case by case) Rehabilitation - 6:1 R/C+enhancement –

Existing Skagit County CAO	CTED[1] Example CAO	Snohomish County CAO (draft)	Pierce County CAO	Thurston County CAO (draft)	King County – Rural (2005)	King County—Urban (2005)
	conjunction with creation/ restoration; mitigation bank credits may be approved for unavoidable impacts.			allowed <u>Category II estuarine</u>: C/R – 12:1 Rehabilitation- 4:1 R/C+enhancement – 12:1 Enhancement – not allowed <u>Category II (all other):</u> C/R - 3:1 Rehabilitation- 8:1 R/C+enhancement – 1:1 RC and 4:1 enhancement Enhancement – 12:1 <u>Category III</u>: C/R - 2:1 Rehabilitation- 4:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 8:1 <u>Category IV</u>: C/R – 1.5:1 Restoration - 3:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 6:1	Enhancement – case by case <u>Category II estuarine</u>: C/R – case by case Rehabilitation- 4:1 R/C+enhancement – case by case Enhancement – case by case <u>Category II (all other):</u> C/R - 3:1 Rehabilitation- 8:1 R/C+enhancement – 1:1 RC and 4:1 enhancement Enhancement – 12:1 <u>Category III:</u> C/R - 2:1 Rehabilitation- 4:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 8:1 <u>Category IV</u>: C/R – 1.5:1 Restoration - 3:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 6:1	case by case Enhancement – case by case <u>Category II estuarine</u>: C/R – case by case Rehabilitation- 4:1 R/C+enhancement – case by case Enhancement – case by case <u>Category II (all other):</u> C/R - 3:1 Rehabilitation- 8:1 R/C+enhancement – 1:1 RC and 4:1 enhancement Enhancement – 12:1 <u>Category III:</u> C/R - 2:1 Rehabilitation- 4:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 8:1 <u>Category IV:</u> C/R – 1.5:1 Restoration - 3:1 R/C+enhancement – 1:1 RC and 2:1 enhancement Enhancement – 6:1

Best Available Science Review: Wetlands

Buffers

It is generally acknowledged that wetlands perform the following eight functions: 1) flood/stormwater control, 2) base flow/groundwater support, 3) erosion/shoreline protection, 4) water quality improvement, 5) natural biological support, 6) general habitat functions, 7) specific habitat functions, and 8) cultural and socioeconomic values (Cooke Scientific Services 2000). The performance of each wetland function is affected to varying degrees by the width and/or character of the surrounding buffer. Vegetated areas surrounding wetlands perform four important functions that in turn protect wetland functions: 1) hydrology maintenance (stormwater and erosion control), 2) water quality improvement, 3) fish and wildlife habitat, and 4) human disturbance barrier. Protection of wetland functions from effects of surrounding land uses is most commonly achieved through fixed buffers. The scientific literature identifies three primary factors important in determining buffer width to adequately protect wetlands. These are 1) the type of wetland and the functions it provides, 2) the surrounding land uses, and 3) the characteristics of the buffer itself.

The most recent comprehensive review summarizing effectiveness of various buffer widths in western Washington was completed by McMillan (2000). Water quality is the wetland function that has been studied most comprehensively in the context of adequate buffer width. Water movement and quantity, habitat, and disturbance protection functions have been addressed to a lesser extent. However, general studies on stream buffer widths can be used in discussions of wetland buffer widths because a vegetated buffer often operates independently of the sensitive area it is intended to protect, particularly for "sink" functions such as sediment and pollutant removal. Table 8 lists general recommended buffer widths ranges for protecting wetland buffer functions.

Table 8. Range of Effective Wetland Buffer Widths in Existing Literature for Applicable Functions

Function	Range (ft) of Effective Buffer Widths	Sources Consulted
Stormwater control	50-300 (generally); vegetative structure and impervious surface in basin are more important factors	Wong and McCuen 1982; McMillan 2000; Azous and Horner 2001
Erosion control	Unknown: wetland size and buffer type are more important factors	Cooke Scientific Services 2000; Kleinfelter et al. 1992, in McMillan 2000
Water quality	10-200	Horner and Mar 1982; Lynch et al. 1985; Lee et al. 1999; Shisler et al. 1987, in McMillan 2000; Dillaha and Inamdar 1997; Daniels and Gilliam 1996; Magette et al. 1989
Wildlife habitat	45-300	Castelle et al. 1992b; Desbonnet et al. 1994; Semlitsch 1998; Richter 1997, in McMillan 2000; Cooke 1992
Disturbance barrier	45-200	Cooke 1992; Shisler et al. 1987, in McMillan 2000; Desbonnet et al. 1994

Skagit County's variety of common land uses complicates the issue of effective buffer widths. The literature referenced in Tables 5 and 8 pertain primarily to non-agricultural lands. Effects of agricultural activities on wetlands in Washington State tend to cause a decline in functional values, especially in habitat complexity, species diversity, population support, and wetland special diversity (Spence et al. 1996, [Ritter and Shilohammadi 2001; Mitsch and Gosselink 1992; Forman 1995] in DOE 2005a). Buffer recommendations in agricultural areas focus on revegetating degraded areas.

Other methods of wetland protection include stormwater management and watershed protection. Management of stormwater quality and quantity is being implemented with growing frequency in response to recent findings demonstrating their potential effects on wetlands (Azous and Horner 2001). Stormwater best management practices implemented in King County include landscape-level planning; treatment, storage, and infiltration; volume control; and runoff bypass to avoid aquatic areas. Other recently adopted basin plans take a comprehensive approach to wetland protection by addressing hydrological functions at the watershed level. For example, several basin plans in King County recommend clearing restrictions. Although results have not been published, the available science acknowledges that the value of buffers alone in protecting wetland functions is limited and supports a broader approach. Stormwater management and watershed protection are not addressed further in this document, as they are not immediately managed through wetland regulation. Because buffer preservation is the primary means of protecting wetlands, buffer functions are addressed in detail in the following sections.

Hydrology Maintenance (Stormwater and Erosion Control)

Similar to stream systems, vegetated buffers can affect water quantity and timing in the wetland by moderating the input of precipitation in a number of ways. Vegetation slows the movement of water from above and outside of the buffer, allowing the water to infiltrate into the soil and/or groundwater. Over time, this stored water will slowly be released into the wetland. Leaf and other vegetative litter on and in the soil also capture water and improve the soil's infiltration capacity (Castelle et al. 1992b). Depending on the size of the basin, the type of wetland, and the degree to which stormwater falling on impervious surfaces is routed away from the buffer (either directly to the sensitive area protected by the buffer, to a detention or infiltration pond, or to some other facility), the contribution of a specific buffer to water quantity maintenance in a wetland may be high or low (McMillan 2000). In either case, water quantity maintenance as related to buffer width has not been sufficiently studied. However, buffer characteristics that influence performance of this function are: "vegetation cover, soil infiltration capacity, rainfall intensity and antecedent soil moisture conditions" (Wong and McCuen 1982).

Wetlands extending at least 200 feet from lake shorelines and stream edges provide the best opportunity for erosion control (Cooke Scientific Services 2000). Upland buffers also function to control erosion by slowing water flow and allowing greater time for infiltration. Buffer vegetation can reduce sediment input to the wetland through soil stabilization by roots, and reduction in rain energy by the vegetation canopy and organic material on the soil (Castelle et al. 1992b). The plant species growing in buffers are an important factor in the buffers' ability to perform this function. Plants with fine roots are most effective at preventing erosion by binding the soil (Kleinfelter et al. 1992, in McMillan 2000).

The literature does not recommend a specific buffer size or range of buffer sizes for this function. McMillan (2000), however, summarizes the evidence and concludes that buffers are not likely to protect a wetland's hydroperiod if they are located in a basin with impervious surface exceeding 15 percent.

Water Quality Improvement

Buffers protect water quality in wetlands through removal of sediment and suspended solids, nutrients, and pathogens and toxic substances (Desbonnet et al. 1994; McMillan 2000; Castelle et al. 1992b). Performance of the water quality improvement function depends on a number of variables, including slope, vegetation composition, leaf and wood litter, soil type, and the type of pollutant (Desbonnet et al. 1994). In general, optimum performance could be achieved with a diverse mix of trees, shrubs and groundcovers; poorly drained clay-loam soils with organic content; abundant downed wood and leaf litter; and no slope. Sediment and pollutants can either be prevented from reaching the wetland through physical mechanisms, such as wood or leaf litter holding or binding these materials, or through chemical/biological means, such as breakdown or uptake of certain pollutants by root systems or microorganisms in the soil (Desbonnet et al. 1994; McMillan 2000; Castelle et al. 1992b). Buffer vegetation can reduce sediment input to the wetland through stabilization of soils by roots, and reduction in rain energy by the vegetation canopy and organic material on the soil (Castelle et al. 1992b). Shading and wind reduction by buffer vegetation also influences water quality by maintaining cooler temperatures. Water temperature in wetlands can be critical to survival of aquatic wildlife species, but more importantly from a water quality perspective, it helps maintain sediment-pollutant bonds, increases the water's dissolved oxygen capacity (McMillan 2000), and limits excessive algal growth (Castelle et al. 1992b).

Desbonnet et al.'s (1994) literature summary concluded that approximately 70 percent or greater sediment and pollutant removal was obtained at buffer widths between approximately 65 and 100 feet. Between 60 and 70 percent of sediment and pollutant removal, except for phosphorus, occurs in buffers between 25 and 50 feet (Desbonnet et al. 1994). Phosphorus removal efficiencies of 60 percent or more are found in buffers greater than 40 feet wide (Desbonnet et al. 1994). McMillan's (2000) summary analyzed a range of buffer widths by specific water quality function and identified the following effective buffers: 5 to 100 meters (16-330 feet) for sediment removal; 10 to 100 meters (33-330 feet) for nitrogen removal; 10 to 200 meters (33-656 feet) for phosphorus removal; and 5 to 35 meters (16-100 feet) for bacteria and pesticide removal.

Fish and Wildlife Habitat

Vegetated wetland buffers provide essential habitat for a wide variety of wildlife species, particularly those that are wetland-dependent, but require adjacent upland habitat for some part of their life cycle (e.g., some amphibians, waterfowl, some mammals). They also provide habitat for non-wetland-dependent species that prefer habitat edges, use the wetland as a source of drinking water, or use the protected buffer corridors to travel between different habitats. Studies have been done to determine necessary wetland buffer widths for wildlife in general, for particular species, and for particular life stages of particular species. The recommended buffer widths range widely in the literature, from 50 feet to 650 feet (Desbonnet et al. 1994), with a large number of those studies recommending buffers between 150 and 300 feet (WDW 1992, in Castelle et al. 1992b). For example, a study conducted in urban King County (Milligan 1985) found that bird diversity was positively correlated with vegetated buffers of 50 feet or greater.

Triquet et al. (1990, in Desbonnet et al. 1994) recommend minimum buffer widths of 50 to 75 feet to provide general avian habitat. A minimum recommended wildlife corridor is 98 feet (Shisler et al. 1987, in McMillan 2000), although 490 feet was also recommended as a minimum travel corridor by Richter (1997, in McMillan 2000).

Disturbance Barrier

Dense, vegetated buffers also provide a barrier between a wetland and the various vectors for human encroachment. Those vectors include noise; nighttime light; physical intrusion by equipment, people, or pets; and garbage. Each of these vectors can result in one or more of the following: disruption of essential wildlife activities, damage to native vegetation and invasion of non-native species, erosion, or wetland fill, among others. Shisler et al. (1987, in McMillan 2000) determined that buffers between 98 and 164 feet are needed adjacent to high-intensity land uses, such as the residential development in parts of Skagit County. The buffer itself, and the functions that it provides, is subject to human-related disturbance. Cooke (1992, in Castelle et al. 1992a) found that buffers less than 50 feet wide experienced the most loss of buffer function related to human disturbance, and this loss is related to gradual reduction in buffer width.

Mitigation Ratios

A relatively low success rate of wetland mitigation through both creation of new wetlands and restoration of historic wetlands (Castelle et al. 1992a; Johnson et al. 2000; NRC 2001) is generally acknowledged in the literature. The goal of no net loss of wetland function cannot be achieved through mitigation alone, but may be met through a number of factors, including adequate monitoring and maintenance and appropriate performance standards. NRC (1992) identifies factors that reduce the risk of mitigation failure, such as detailed functional assessment, high success standards, detailed mitigation plans, larger bonds, high replacement ratios, and greater expertise.

Mitigation estimates in the literature are most often based on known failure rates. Because compensatory mitigation implemented in the past has not fully replaced lost wetland area and functions, and because an immediate loss of habitat occurs when mitigation installation is delayed, compensation should never be made in less than a 1:1 ratio (Josselyn et al. 1990). Other research suggests that compensation should be made in substantially larger ratios to account for both the possibility of failure and the lapse of time between mitigation implementation and functionality (Josselyn et al. 1990; Willard and Hiller 1990) (Table 9).

Table 9. Suggested Wetland Mitigation Ratios and Sources

Recommended Ratio	Wetland and/or Mitigation Type	Source
1.5:1	Restoration (1:1 for completion prior to impact)	Kruczynski 1990
2:1	Creation (1:1 for completion prior to impact)	Kruczynski 1990
3:1	Enhancement (1:1 for completion prior to impact)	Kruczynski 1990
2:1	Creation	Kantor and Charette 1986
10:1	Low quality replacement wetlands	Zedler 1991
5:1	Moderate quality replacement wetlands	Zedler 1991
2:1	Compensation for projects needing a Hydraulic Approval Permit	WDW Wetlands Policy (POL-3025)
various	Creation	DOE 2006

DOE (2004b) recommends the following replacement ratios for local governments within Washington State: 6:1 for forested Category I wetlands, 4:1 for most other Category I wetlands, 3:1 for Category II wetlands, 2:1 for Category III wetlands, and 1.5:1 for Category IV wetlands. DOE's *Guidance on Wetland Mitigation in Washington State* (2004b) also suggests criteria to be met in consideration of lowering or raising ratios on a project-specific basis.

Summary

Eight primary functions of wetlands are commonly referred to in the literature. The degree to which these functions are performed partially depends on the type and quality of buffer immediately surrounding the wetland. Preservation of fixed buffers is the most commonly used method of protecting wetland functional values. Existing science recommends buffer widths that vary widely depending on the specific wetland and functions to be protected, the characteristics of the buffer itself, and the proposed use of surrounding area. Buffers perform four major functions in the protection of wetland functions: maintaining hydrology, preserving and improving water quality, providing fish and wildlife habitat, and protecting species from disturbance.

Water quality protection has been studied the most extensively in the context of protecting wetland function and buffer width, and recommended buffers in the literature vary generally from 10 to 200 feet for this function. The specific width at which a buffer is effective in protecting water quality function of wetlands depends on a number of factors, including the type of pollutant or sediment in question and the structure and composition of buffer vegetation.

Hydrologic maintenance, including stormwater and erosion control, is influenced by buffer and wetland vegetation and soil characteristics, rainfall, and soil moisture conditions. However, the literature does not provide a range of effective buffer widths. Of greater importance to a wetland's hydrologic regime is the percentage of development present in the wetland's drainage basin.

Similarly, effective buffer widths for protecting habitat depends upon which species are likely to be present and the life stages in which they use the buffer. Existing literature recommends a range of buffer widths from 45 to 300 feet for protecting habitat functions.

Protection from disturbances such as noise, light, and physical intrusion may be achieved in a wetland by preserving buffers of 45 to 200 feet in width.

Stormwater management and watershed protection are large-scale, effective means of protecting wetlands. Mitigation for wetland impacts can be achieved through wetland creation, restoration, and enhancement, and best available science recommends that it be implemented at greater than 1:1 ratios to compensate for the possibility of failure and any time lapse between wetland loss and functionality of the mitigation site.

STRATEGIES FOR PROTECTION: FIXED VS. VARIABLE BUFFER WIDTHS

While standard fixed-width buffers are relatively simple to regulate and uncomplicated for lay people to employ, they do not always provide the best mechanism to both protect critical areas and offer flexibility in development regulations. Fixed-width buffers can be a viable option for small local municipalities which do not have a high degree of variable land uses or habitat types. In such circumstances, it can be appropriate to apply the largest standard buffer sufficient to protect the critical areas within and adjacent to the jurisdiction with allowances for buffer reduction and buffer averaging. However, for large jurisdictions, such as Skagit County, which have land uses which include unincorporated urban areas, moderate- to high-intensity residential development, and extensive agricultural and forested areas, applying fixed buffer widths may not provide adequate protection for all areas nor allow for the flexibility desired by local residents. As recommended by the Washington Department of Ecology (2005a), and proposed by several counties in Western Washington already undergoing revisions to critical area regulations, variable buffer widths are an appropriate means to protect critical areas and allow flexibility based on land use. The following summary recommendations are excerpted from the compilation of best available science from the Washington Department of Ecology (2005a):

1. Many researchers have recommended using four basic criteria to determine the width of a buffer:
    - The functions and values of the aquatic resource to be protected by the buffer
    - The characteristics of the buffer itself and of the watershed contributing to the aquatic resource
    - The intensity of the adjacent land use (or proposed land use) and the expected impacts that result from that land use
    - The specific functions that the buffer is supposed to provide including the targeted species to be managed and an understanding of their habitat needs
2. Protecting wildlife habitat functions of wetlands generally requires larger buffers than protecting water quality functions of wetlands
3. Effective buffer widths should be based on the above factors. They generally should range from:
    - 25 to 75 feet (8 to 23 m) for wetlands with minimal habitat functions and low-intensity land uses adjacent to the wetland
    - 75 to 150 feet (15 to 46 m) for wetlands with moderate habitat functions and moderate or high-intensity land uses adjacent to the wetland
    - 150 to 300+ feet (46 to 92+ m) for wetlands with high habitat functions, regardless of the intensity of the land uses adjacent to the wetland
4. Fixed-width buffers may not adequately address the issues of habitat fragmentation and population dynamics. Several researchers have recommended a more flexible approach that allows buffer widths to be varied depending on site-specific conditions.

ANALYSIS OF PROPOSED REGULATIONS

Fish and Wildlife Habitat Conservation Areas

The proposed update to Skagit County's Critical Areas Ordinance regarding Fish and Wildlife Habitat Conservation Areas is generally supported by the review of Best Available Science.

The proposed regulations include a change of the Stream Typing system to be in-line with State guidance and other local jurisdictions (Table 10). The proposed system would effectively combine Type 2 and 3 streams into one category ("F"), simplified to mean those waters which contain or have the potential to support salmonids. The other stream types (1, 4 and 5) would be relabeled as S (Shorelines of the State), Np (non-salmonid perennial), and Ns (non-salmonid seasonal), respectively.

Table 10. Current and Proposed Stream Typing System

Current Stream Type	Proposed Stream Type
1	S
2	F
3	
4	Np
5	Ns

The proposed changes to the mitigation standards (SCC 14.24.530) would also include changes to some of the standard riparian buffers (Table 11). Current stream Type 1, which would become Type S under the proposed regulations, would keep a 200-foot riparian buffer. Type 2 and 3 streams, which would be combined under Type F, would have either a 150-foot or 100-foot riparian buffer depending on whether the stream is greater or less than 5 feet wide. Although this change marks a 50-foot decrease to Type 2 streams[3], it also could potentially increase riparian buffers of some Type 3 streams by 50 feet if they are found to be wider than 5 feet. No change is proposed to the standard riparian buffers for Type 4 and 5 streams.

A 200-foot riparian buffer for Type S streams is consistent with the Best Available Science, specifically for the functions of water quality, bank stabilization, shade and temperature, in-stream habitat, and productivity (see Table 5 above). As noted in Table 5, the effective riparian buffer width for microclimate can range well beyond 200 feet. Buffers greater than 100 meters (328 feet) are generally required for full microclimate protection on higher order streams (Spence et al. 1996; Brosofske et al. 1997). Even small streams (2 to 5 meters wide) would need up to a 150-foot buffer to effectively protect the riparian microclimate (Brosofske et al. 1997). However, as noted by Ledwith (1996), the inner 100 feet of riparian buffer is the most critical for

[3] Theoretically, buffers for some Type 2 streams could be reduced by 100 feet if the stream was found to have high fish use. However, based on the water typing definition listed under WAC 222-16-031, Type 2 streams having high fish use are presumed to be 20 feet wide or greater. Therefore, it is highly unlikely that any Type 2 stream would be less than 5 feet wide and consequently have a buffer less than 150 feet.

maintaining ambient air temperature and relative humidity. Thus, a 200-foot riparian buffer on Type S streams is considered acceptable for the protection of microclimate.

Table 11. Current and Proposed Standard Riparian Buffers

Current Stream Type	Current Riparian Buffer	Proposed Water Type	Proposed Riparian Buffer
1	200	S	200 feet
2	200	F	F> 5' wide: 150 feet
3	100		F< 5' wide: 100 feet
4	50	Np	50 feet
5	50	Ns	50 feet

Similar to the buffer width requirements to protect microclimate, buffer widths necessary to protect wildlife habitat functions can be well over 200 feet. While the range of effective buffer widths can differ tremendously due to the variability in species size and distribution, most studies report a range of 200 to 300 feet necessary to provide essential habitat for most species (Keller et al. 1993). Typically, wide buffers are necessary to provide for refuge and travel corridors. However, the connectivity that a continuous buffer provides to other wildlife habitats can be equally important. Based on the best available science, a 200-foot standard riparian buffer is sufficient to provide effective habitat for most wildlife species. Additional protection of wildlife habitat beyond 200 feet may be provided in SCC 14.24.530 (4-7).

The 150- and 100-foot riparian buffers proposed for Type F streams would represent a 50-foot (see previous footnote) reduction in the protection afforded current Type 2 streams. Riparian buffers for Type 3 streams would either increase by 50 feet or remain unchanged. By definition from WAC 222-16-031, Type 2 streams are considered to have "high fish, wildlife, or human use." Similarly, Type 3 streams are considered to have "moderate to slight fish, wildlife, or human use." Given the width and gradient conditions of a Type 2 stream as defined by WAC-222-031, most likely all of the current Type 2 streams within the County would be considered Type F streams greater than 5 feet wide. Thus, the majority of those streams would likely have their riparian buffers reduced by 50 feet but not 100 feet. Similarly, the majority of Type 3 streams would also likely be greater than 5 feet wide. In such cases, the riparian buffers would increase by 50 feet. As discussed above, some riparian buffer functions are optimized within the first 100 feet. However, due to the landscape surrounding most fish bearing waters (i.e. low gradient, connected to larger water bodies, usually adjacent to other habitat features, etc.) the majority of riparian buffer functions would be further optimized if buffers are extended beyond 100 feet. It has been fairly common for most other jurisdictions to propose a 150-foot or greater riparian buffer for Type F streams (see Table 3 above).

The proposed 50-foot riparian buffers for Type Np and Ns streams are considered moderately protective for the seven riparian functions discussed above. While it has been common for other nearby counties to propose similar riparian buffer widths (see Table 3), a 50-foot riparian buffer will only function to a limited extent. As noted in the discussion of riparian functions above, significant improvements to water quality, bank stabilization, shade and temperature, and productivity are observed out to 80 to 100 feet (Castelle and Johnson 1998). Microclimate, in-stream habitat, and wildlife habitat needs often extend well beyond 80 to 100 feet. Given that the Np and Ns streams do not contain salmonids or salmonid habitat, less protection is typically allowed for these streams. However, Type Np and Ns streams are usually short stream segments which flow into Type S and F waters and thus their importance should not be minimized. Since seasonal streams typically are not flowing during warm summer months, some functions such as shade and temperature, bank stabilization, and in-stream habitat do not provide year-round benefit. Thus, seasonal streams are typically given the narrowest standard buffer width. Based on recent water type modeling performed by the Washington Department of Natural Resources, many previously mapped Type 4 (Np) streams would now be considered Type 3 (F) based on width, gradient, and basin size characteristics. In those circumstances, stream buffers would potentially increase by either 50 or 100 feet, depending upon the stream width.

The County may allow the standard buffer widths to be reduced up to 25 percent, based on an approved buffer mitigation or enhancement plan and in accordance with a critical area study and the best available science. Buffer averaging and/or reduction is allowed subject to provisions in the Critical Area Ordinance which require that the overall proposal result in net increases in habitat function and protection compared to those determined using the standard riparian buffer widths without mitigation. Incentive based mitigation options for reducing standard buffer widths are provided such that the cumulative reduction can be up to 25 percent.[4] Ideally, stormwater discharge would be directed to the outer 25 percent of the riparian buffer so as to utilize the buffer in improving water quality, but only in circumstances where it is shown that the discharge would not in itself result in increased erosion, sedimentation, or other loss of function.

Buffer width reduction and buffer averaging, or a combination of the two, are provided in the Critical Area Ordinance as alternatives to landowners to provide incentives for improving the functions of existing, degraded riparian buffers while also making effective use of their land. Through an administrative variance process (SCC 14.24.140), the County may allow reductions of up to 50 percent of the standard buffer width. Narrower buffer widths may be adequate if such buffers are of high quality (May et al. 1997). The buffer reduction regulations are intended to allow a narrower buffer width as long as the applicant substantially increases the buffer quality. Contiguous buffers along streams may be more important than increased width for achieving aquatic and terrestrial habitat goals, and smaller buffers may be adequate to protect small, first-order streams (Palone and Todd 1997). The continuity of the riparian corridor along the stream is at least as important as its width (Horner and May 1998).

Under the proposed regulations and as recommended by the State, the County has decided to specifically include lake (those defined as Shorelines of the State) and marine shorelines as critical areas to be afforded standard riparian buffers (SCC 14.24.530). These proposed buffers for lake and marine shorelines (Table 12) are designed to meet or exceed the existing setbacks from the County's Shoreline Master Program (SMP). Given that these lake and marine

[4] These incentive options and proposed buffer reduction allowances have been developed by qualified professionals at The Watershed Company based on experience with mitigation plans, the effectiveness of various techniques at mitigating impacts, applicability of certain mitigation actions to the impact, and best professional judgment. Similar incentive options and reduction allowances have been incorporated into other Critical Areas Ordinances throughout the region and are being implemented by those jurisdictions. In addition, most natural resource agencies have recognized and encourage incentive based options which may lead to improved ecological functions.

shorelines would qualify as Type S waters, as defined by WAC 222-16-030, consideration has been made to provide protection similar to that proposed under SCC 14.24.530. As proposed shoreline buffers, these widths provide adequate buffer functions for most of these aquatic areas as indicated by the scientific literature. Regardless, future updates to the County's Shoreline Master Program will also require an assessment of the Best Available Science and likely include a site-specific analysis of the areas to which these buffers apply and potentially an increase to some of the existing setbacks.

Table 12. Proposed shoreline buffers to be consistent with existing shoreline setbacks per SMP (SCC14.26)

Shoreline Area Designations	Shoreline Buffer
Natural	200 feet
Conservancy	150 feet
Rural	100 feet
Rural Residential	100 feet
Urban	140 feet

The shoreline and stream buffers may be reduced more than 25 percent of the standard buffer width through an Administrative Variance process. Additionally, the shoreline and stream buffers may be reduced beyond 50 percent of the standard width through a Hearing Examiner Variance process. While most critical areas variance applications do not generally meet the guidelines provided by the Best Available Science, strict variance requirements per SCC 14.24.140 will ensure that impacts are addressed, minimized, and mitigated to the maximum amount feasible.

Skagit County's existing and proposed CAO designates a number of areas as Fish and Wildlife Habitat Conservation Areas, the list of which is consistent with the minimum requirements of WAC 365-190-080(5). Further, the proposed CAO now includes additional FWHCA elements that are recommended by CTED, identified above in the *Code Review and Comparison* section, and discussed in the *Best Available Science Review: Wildlife Habitat* section. The proposed regulations include a requirement for special studies and coordination with applicable agencies to determine appropriate management of habitat conservation areas, including potential application of buffers, timing restrictions, and other practices to minimize and mitigate impacts. Because the regulations lack specificity with respect to particular habitats, it is critically important that the County enforce the special study and coordination requirements, and track implementation of the resultant management and mitigation measures.

Wetlands

The proposed update to the County's Wetlands regulations is generally supported by the review of Best Available Science. The update includes changes to the wetland classification and rating system per Washington Department of Ecology (DOE) guidelines. Specifically, this update identifies that the rating of wetlands would follow the most current DOE rating form. The most recent version of the wetland rating system from DOE (2004) includes a detailed assessment of wetland functions.

The proposed changes to the mitigation standards would include an increase of all standard wetland buffer categories and base each Category's corresponding buffer on the surrounding land use as defined by DOE (2005b) (Table 13). These proposed buffers would be in-line with DOE guidelines.

Table 13. Current and Proposed Standard Wetland Buffers

Wetland Rating	Current Buffer	Proposed Buffer		
		Land Use Intensity		
		Low	Moderate	High
Category I	150 feet	150 feet	225 feet	300 feet
Category II	100 feet	150 feet	225 feet	300 feet
Category III	50 feet	75 feet	110 feet	150 feet
Category IV	25 feet	25 feet	40 feet	50 feet

In addition, the propose code includes an optional buffer system based on a combination of habitat score and surrounding land use intensity to allow increased flexibility to landowners (Table 14). This system could be used in lieu of the standard buffer widths, but must be supported by an evaluation of wetland function by a qualified professional. As shown in Table 14, this option allows for small changes in buffer width based on incremental changes in habitat score. This system would minimize the potentially drastic scenario of large buffer increases based on a one or two point swing in habitat function that is observed in many jurisdictions. DOE has recognized that even among well-trained professionals, the final habitat score for a particular wetland may differ. Thus, one or two point variations could easily occur.

Table 14. Proposed Variable Wetland Buffers Based on Habitat Score

Optional Buffers		
	Land Use Intensity	
Habitat score	Moderate	High
31 or higher	225 feet	300 feet
30	200 feet	270 feet
29	175 feet	240 feet
28	155 feet	210 feet
27	135 feet	180 feet
26	115 feet	150 feet
25	105 feet	136 feet
24	95 feet	124 feet
23	85 feet	112 feet
22 or lower	75 feet	100 feet

In recent years, more attention has been given to studying the effects of differing land-use intensities. At this point, it is widely accepted that impacts to critical areas, specifically streams and wetlands, are typically different depending upon the surrounding land use. Areas with high-intensity land uses usually have the highest level of impacts due to narrower buffers, greater percent deforestation and impervious surface coverage, and loss of habitat, etc. Because the buffer functions in these areas are typically diminished, it is recommended that they be assigned a larger regulatory buffer. Likewise, areas with low land-use intensity (i.e. forested) normally have larger effective buffers. The proposed code properly addresses impacts from varying degrees of land use intensity and habitat value. Overall, the proposed Wetland Protection Standards (SCC 14.24.240) are supported by the Best Available Science.

Similar to the proposed stream regulations, buffer widths can be reduced up to 25 percent based on an approved buffer mitigation or enhancement plan and in accordance with a critical area study and the best available science. Buffer averaging and/or reduction is allowed subject to provisions in the Critical Area Ordinance which require that the overall proposal result in net increases in habitat function and protection compared to those determined using the standard wetland buffer widths without mitigation. The incentive based mitigation options are provided to allow additional flexibility while potentially improving the effectiveness of critical areas and/or their buffers.

As with shoreline and stream buffers, the County is proposing a variance process to allow additional setbacks from the standard buffer already provided through buffer averaging and buffer reduction methods. Under SCC 14.24.140, wetland buffers may be reduced more than 25 percent of the standard buffer width through an Administrative Variance process. Additionally, wetland buffers may be reduced beyond 50 percent of the standard width through a Hearing Examiner Variance process. While most critical areas variance applications do not generally meet the guidelines provided by the Best Available Science, strict variance requirements per SCC 14.24.140 will ensure that impacts are addressed, minimized, and mitigated to the maximum amount feasible.

The County is proposing that development and/or fill can occur within Category III and IV wetlands which are less than 1,000 square feet if they are isolated, are not associated with a riparian area or a wetland mosaic, are of low habitat value, and do not contain habitat identified as essential for local populations of priority species identified by Washington Department of Fish and Wildlife. Additionally, Category III and IV wetlands between 1,000 and 4,000 square feet may be exempt from the avoidance criteria of mitigation sequencing if they meet the criteria listed above *and* provide mitigation for wetland function replacement (presumably surface water impacts mitigated pursuant to an approved mitigation plan or the Storm Water Design Manual, when necessary). However, this allowed activity does not cover state and federal agencies which may have jurisdiction over these wetlands. While there does not appear to be BAS literature in support of such an exemption, DOE recognizes the need to provide some flexibility to wetland regulations as they pertain to small Category III and IV wetlands (McMillan, pers. comm., 28 July 2004; Casey, pers. comm., 3 November 2005).

Wetland creation and restoration ratios are also proposed for increases per recommendations from DOE based on low historical success rates of wetland mitigation projects (Table 15). As indicated in the review of best available science above, the high risk of failure is reduced by increasing mitigation standards such as larger bond quantities, improved mitigation planning (specifically maintenance and monitoring), and higher replacement ratios. The proposed wetland creation and restoration ratios are in-line with the best available science.

Table 15. Existing and Proposed Wetland Restoration/Creation Ratios

	Existing Wetland Created : Area Lost	**Proposed Wetland Created : Area Lost**
Category I	4:1	6:1
Category II or III		
Forested	3:1	3:1
Scrub/shrub	2:1	2:1
Emergent	2:1	2:1
Category IV	1.25:1	1.5:1

Other County regulations, policies and resident education efforts will contribute to increased protection of wetlands beyond what is provided by wetland buffers. These include adoption of the most recent version of the Washington Department of Ecology Stormwater Manual for Western Washington, increased vigilance of construction projects to monitor effectiveness of required erosion-control measures, and education of County residents on the impacts of landscape management and maintenance practices. The proposed increases in buffer width and other anticipated policy changes and education efforts should result in net improvement to the functions and values of County wetlands. In addition, buffer enhancement through buffer averaging and/or reduction proposals will likely provide for improvements in wetland buffer functions while providing flexibility for property owners to reasonably develop and/or redevelop their property.

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