Final Report

Whatcom County Critical Areas Ordinance

Best Available Science Review and Recommendations for Code Update

Prepared for

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7.2 OVERVIEW OF AQUATIC HABITAT FUNCTIONS AND VALUES

Productive salmonid habitat is necessarily complex owing to the myriad requirements of various life-stages. Salmonids require cold clean waters, silt-free substrates, natural flow conditions, and structurally complex habitat suitable for spawning, rearing, and migration. The aquatic habitat features important for supporting salmonid populations include riparian condition, LWD recruitment, fish passage, floodplain connectivity, channel migration, bank stability, pools, off-channel habitat, substrate/fines, water quality, and hydrology.

Riparian areas are the zones where aquatic and terrestrial ecosystems interact. Riparian vegetation provides habitat for many species of wildlife, and streamside or shoreline vegetation provides habitat functions for streams, and fish such as shade, bank stability, sediment/nutrient filtering, and organic nutrient input. In addition, riparian vegetation interacts with natural erosional and depositional processes of streams as channels migrate across valley bottoms to form instream habitat. As channels move back and forth through this channel migration zone (CMZ), instream pools and riffles are formed. Channel migration also promotes floodplain connectivity and recruitment of LWD, which can be a primary factor influencing channel form by the creation pools, riffles and off-channel habitats that are essential to support all life stages of anadromous salmonids (May 2000).

Historically, natural riparian corridors in the Pacific Northwest were nearly continuous and the importance of riparian continuity is widely recognized (May et al. 1997; Naiman and Bilby 1998; Wenger 1999). Riparian corridor continuity is particularly important in smaller headwater streams because smaller streams generally make up most of the stream length within a watershed, and the influence of riparian vegetation on some stream habitat functions is greater for small streams (Binford and Bucheneau 1993; Wenger 1999; Beschta et al. 1987). Such areas upstream of fish-bearing waters help determine water quality, the magnitude and timing of flows, stream temperature, sediment, nutrients, and prey production in downstream waters.

Along marine and lake shorelines, riparian vegetation is also a key element of ecological function and has a significant influence on the habitat value of the riparian zone, and in adjacent aquatic and terrestrial areas (Zelo and Shipman 2000). Though not as well defined as for riverine systems, both marine and freshwater shoreline riparian zones serve many of the same functions (e.g. LWD, shading, organic matter production, sediment filtration, microclimate), as well as some additional functions unique to shorelines (Gregory et al. 1991; Naiman et al. 1992).

The following discussion is a review of major riparian functions and the level of functionality afforded by riparian buffers of varying widths as reported in the literature. Tables 7-2, 7-3, and 7-4 summarize the conclusions and recommendations for riparian buffer widths in frequently cited literature reviews of riparian buffer functions. These tables are not intended to be prescriptive, but do serve to illustrate the wide range of effective buffer widths reported in the literature, and also provide recommendations based on providing a reasonable level of habitat functionality under most conditions. However, it must be recognized that a single prescription is not necessarily appropriate or warranted for all situations. Buffer recommendations and functionality is frequently expressed in terms of site-potential tree height (SPTH), which is the height of mature trees that a given site can be expected to support.

Following the tables, further discussion of riparian functionality and considerations for determining buffer effectiveness is provided. In addition, riparian functions for lake and marine shorelines are included in the discussion where appropriate.

Table 7-2. Stream Riparian Functions and Appropriate Widths Identified by May (2000)[20].

Function	Range of Effective Buffer Widths	Minimum Recommended Width	Notes On Function
Large Woody Debris	10 to 100 m (33 to 328 ft)	80 m (262 ft)	1 SPTH based on long-term natural levels
Water Temperature	11 to 43 m (36 to 141 ft)	30 m (98 ft)	Based on adequate shade
Sediment removal and erosion control	8 to 183 m (26 to 600 ft)	30 m (98 ft)	For 80% sediment removal
Pollutant Removal	4 to 262 m (13 to 860 ft)	30 m (98 ft)	For 80% nutrient removal
Microclimate	45 to 200 m (148 to 656 ft)	100 m (328 ft)	Optimum long-term support

Table 7-3. Stream Riparian Functions and Appropriate Widths Identified by Knutson and Naef (1997)

Function	Range of Effective Buffer Widths (ft)
Large Woody Debris	100 to 200
Water Temperature	35 to 151
Erosion Control	100 to 125
Sediment filtration	26 to 300
Pollutant Removal	13 to 600
Microclimate	200 to 525

Table 7-4. Stream Riparian Functions and Appropriate Widths Identified from FEMAT (1993)

Function	Number of SPTH	Equivalent (ft)[21]
Large Woody Debris	1.0	200
Shade	0.75	150
Sediment Control	1.0	200
Bank Stabilization	0.5	100
Organic Litter	0.5	100
Microclimate	up to 3	up to 600

[20] May (2000) recommendation for an overall minimum buffer width is 30 m (98 ft), with the understanding that full effectiveness may not be achieved for some functions such as LWD, wildlife habitat, and microclimate.

[21] Note that this is based on a 200-ft SPTH (or that expected on a Class I site), and that equivalent functionality may be achieved by narrower buffers on sites having a narrower SPTH.

As specified in WDNR Forest and Fish Report (1999, 2003), SPTH has been determined for different stream site classes in western and eastern Washington (Table 7-5)[22]. Site classes are based on soil conditions and range from the most productive to the least productive sites (Goldin 1992). It has been determined that the most productive sites (Site Class I) in Western Washington would have a SPTH of 200 feet and the least productive sites (Site Class V) would have a SPTH of 90 feet. Based on these site potentials and stream size, riparian buffer prescriptions have been developed that are most applicable to forested lands. Differences in stream size for a given site class are used to further modify prescribed buffer dimensions within the overall riparian management zone (RMZ; which is equivalent in width to the SPTH) so that different portions of the buffer (core, inner, and outer areas) have different dimensions to provide appropriate levels of protection (Table 7-5).

Table 7-5. Example of Riparian Buffer Width Prescriptions from WDNR (2003)

Site class	RMZ/SPTH[1] width	Core zone width (measured from outer edge of the bankfull width or CMZ, whichever is greater)	Inner zone width (measured from outer edge of core zone)		Outer zone width (measured from outer edge of inner zone)	
			Stream width ≤10 ft	Stream width >10 ft	Stream width ≤10 ft	Stream width >10 ft
I	200	50	83	100	67	50
II	170	50	63	78	57	42
III	140	50	43	55	47	35
IV	110	50	23	33	37	27
V	90	50	10	18	30	22

1 The RMZ defined in WDNR (1999, 2003) is equivalent to the SPTH that has been determined for different site classes

Riparian functions and concepts covered in the following text include:

- Channel migration zones
- LWD recruitment
- Stream shading/temperature
- Bank stabilization/habitat formation
- Filtering of sediment, nutrients and chemicals
- Organic input and nutrient source
- Microclimate

Though the following discussion is primarily focused on stream habitats, additional discussion of how riparian vegetation influences marine, lake, or estuarine shorelines is included where appropriate.

[22] According to WDNR (1999, 2003), SPTH means the distance represented by the approximate mid-point of one of five site classes projected to a stand age of 100 years. See Table 5. Note also that the SPTHs presented in Table 7-5 were derived from Douglas Fir stands and adjustments to the SPTH values are likely appropriate for stands in which other species are dominant.

7.2.1 Channel Migration Zones (CMZ)

The importance of protecting the CMZ is well-documented, and to protect habitat functions supported by the CMZ, many investigators recommended that riparian buffers be measured laterally from the edge of CMZs where they occur, rather than from the ordinary high water mark (OHWM) as is typically required by existing code regulations (Knutson and Naef 1997; May 2000; WDNR 1999, 2003; Smith 2002). Knutson and Naef (1997) state "the channels of some streams, particularly larger streams and rivers in broad, alluvial valleys, may migrate across the valley as a result of natural erosional and depositional processes; the area over which the channel is expected to migrate is called the channel migration zone". As stream channels migrate across valley bottoms, riparian vegetation interacts with natural erosional and depositional processes, which promotes floodplain connectivity, LWD recruitment potential and the formation of instream habitat (May 2000).

From a regulatory standpoint, the definition of CMZs varies. The Washington Forest Practices Board (WDNR 1999) defined CMZs as "...the area that streams have recently occupied (in the last few years or less often decades), and would reasonably be expected to occupy again in the near future." However, the Forests and Fish Report (WDNR 1999) provided the following guidance for defining CMZs:

"Operationally, the CMZ should be equivalent to the area that a stream is expected to occupy in the time period it takes to grow a tree of sufficient size to provide geomorphic/ecological functions in the channel. On smaller streams, it may be appropriate to be concerned where the stream could move within 100 years or less. However, larger wood is needed to function in larger, high-energy channels. To be functional, recruitment trees must be very large, with root wads attached. As a consequence, on a larger stream, it may be necessary to include areas in the CMZ that the stream could occupy in the next 200 years or more."

Regardless of the time frame used to define a CMZ, what ultimately determines the presence of a CMZ is physical evidence of channel migration such as inactive channels, old meander bends, sloughs, oxbows, or floodplain terraces. By definition, such features only occur within CMZs and any classification system of channel migration potential can only be derived from such evidence of channel migration. In general though, channel migration can be expected to occur in lower gradient streams and rivers having broad valleys (that were often formed by such channel migration processes over long periods of time), which are typical of those reaches designated as "Shorelines of the State" (i.e. having a mean annual flow $\geq$ 20 cfs) in Whatcom County. However, CMZs often occur in smaller streams and reach specific delineations, which are currently ongoing in Whatcom County, must be conducted to determine the presence and extent of CMZs. Additional details and protocols for identifying and delineating CMZs can be found in WDNR (2003).

7.2.2 LWD Recruitment

LWD in streams influences coarse sediment storage, creates hydraulic heterogeneity, moderates flow disturbances, provides cover, and contributes to overall channel complexity. LWD traps and accumulates sediment, small woody debris, and other organic matter (Bilby 1981). The complex, submerged structure formed by LWD and entrapped smaller woody debris provides flow refugia and essential cover in which salmonids conceal themselves from predators and competitors and find profitable feeding positions, as inferred from observations under both natural and laboratory conditions (McMahon and Hartman 1989; Fausch 1984). The removal of riparian forest reduces woody debris in streams, which in turn leads to adverse changes in channel and habitat-forming processes (Bilby 1984; Heifetz et al. 1986; McDade et al. 1990; Van Sickle and Gregory 1990; Bilby and Ward 1991).

Riparian buffer widths of 100 to 200 ft (equal to about 1 site potential tree height or SPTH) generally provide adequate LWD recruitment potential, depending on site conditions such as stream size, channel confinement, gradient, and buffer vegetation characteristics (i.e. type, maturity, and density) (Murphy and Koski 1989; Robison and Beschta 1990; McDade et al. 1990; Thomas et al. 1993). With respect to stream size, the role of LWD varies, with riparian vegetation generally exerting a greater influence on smaller streams (Knutson and Naef 1997). Large woody debris is not easily transported in small streams, regardless of gradient, thus individual pieces (logs, root wads, etc) can greatly influence channel morphology, instream cover, food resources, and sediment transport. As stream size increases, the influence of riparian vegetation and individual pieces of LWD decreases, and more substantial logjams are needed to affect instream structural complexity, which was characteristic of the historic Nooksack River (Collins and Sheikh 2002). Larger buffer widths (>200 ft) may be required for long-term natural recruitment of woody material (FEMAT 1993; May 2000). Humans can "import" woody debris to streams and rivers, but these artificial recruitment efforts provide limited short-term, benefits to stream habitat (e.g., fish cover, localized hydraulic complexity). Therefore, while human installation of LWD is not an adequate substitute for the natural recruitment potential of healthy riparian areas, nor does it provide many other important long-term benefits provided by native vegetation buffers, but artificially introduced LWD can provide some habitat benefits in the absence of riparian buffers and natural recruitment (e.g. highly managed agricultural areas), or as an interim measure while existing or newly established riparian buffers mature.

LWD is a natural component of marine shorelines. LWD accumulates in backshore areas at high tides, and serves to help stabilize the shoreline by absorbing wave energy, and trap sediment as is seen in riverine and freshwater lake shorelines where current and wave action would otherwise cause erosion (Zelo and Shipman 2000). LWD is also a source of organic matter and nutrients as with freshwater systems. LWD along shorelines supports a variety of habitats for aquatic species such as foraging, refuge, and spawning substrate for fishes and invertebrates (Brennan and Culverwell 2004).

7.2.3 Shading and Temperature

As was reviewed in GEI (2002), thermal modeling results indicate that stream temperature in any given location is primarily dependent on the temperature of water directly upstream, or the input water temperature. Riparian vegetation generally serves to reduce solar heating and maintain water temperatures. Under undisturbed conditions, stream temperatures are maintained because the surface and groundwaters than comprise streamflow are thermally protected by upland and riparian vegetation and soils. As forested area in a watershed is removed, thermal protection is removed and the ratio of surface-to-groundwater in a stream increases. Combined with loss of thermal protection, stream temperatures increase. Therefore, actions in upper watersheds can lead to increased water temperatures in lowland areas, but adequate shading is required in lowland areas to prevent further solar heating.

The value of riparian buffers in moderating stream temperatures is well-established, but the effectiveness of different buffer widths varies depending on site conditions. Several authors (Beschta et al. 1987) have concluded that buffer strip widths of 100 feet or more generally provide the same level of shading as that of and old growth forest in the Pacific Northwest while several authors have recommended a minimum buffer width of 30 feet (Davies and Nelson 1994). In forested areas, harvest treatments that leave overstory vegetation buffers adjacent to streams have been shown to have no significant impact on stream temperature (Lee and Samuel 1976; Rishel et al. 1982; Lynch et al. 1984; Sugimoto et al. 1997). In coastal British Columbia, Gomi et al. (2003) conducted a 6-year field experiment to evaluate the effects of riparian buffer widths on stream and riparian ecosystems, including stream temperature response. Treatments included no timber harvesting, harvesting with 33-ft and 100-ft wide riparian buffers, and clear-cut harvesting with no buffer. The results indicated that water temperature in the streams with 33 -ft

and 100-ft wooded buffers did not exhibit statistically significant warming. Todd (2000) examined various buffer functions and found that smaller riparian buffers (as narrow as about 40 feet) are required to protect water temperature and food web functions, and Johnson and Ryba (1992) recommend a similar buffer width of from 30 to 100 feet to effectively protect stream temperature. However, Brown and Kryier (1971) noted that on very small streams, adequate shade may be provided by brush species.

Along lake and marine shorelines, shading from vegetation reduces light levels and helps regulate heating of the nearshore areas or the upper intertidal zone. Shading also reduces mortality and stress to insects, marine invertebrates, as well as fish eggs deposited in intertidal areas, including those of sand lance and surf smelt (Pentilla 2000). Juvenile anadromous salmonids rely upon shallow-water habitats, especially those vegetated with algae and eelgrass, for prey resources and shelter from predation, making shallow nearshore habitats critical for the survival of these species (Healey 1982; Simenstad et al. 1982; Johnson et al. 1997).

7.2.4 Bank Stabilization and Habitat Formation

Streams tend to erode the outer banks of meander bends while depositing sediment as bars on the inside of the meander bends. Through this continual process of erosion and deposition, the location and quality of habitats, and the meander pattern and position within the valley, changes over time. This process acts in response to natural and unnatural disturbances within a watershed and serves to create and recreate salmonid habitat. For any given disturbance, the rate, magnitude, and nature of channel response in part depends on the condition of riparian vegetation.

Vegetation resists shoreline erosion, but often not as effectively as artificial structures. Diverse native vegetation can be expected to moderately resist shoreline erosion allowing channels to physically respond to disturbances, thereby forming and reforming salmonid habitat features over time (Reeves et al. 1995). As reviewed in Spence et al. (1996), roots bind streambank soils and slow water currents, thereby stabilizing stream banks. Stream currents carve the material underneath the root zone creating shelter and structural habitat for salmonids and terrestrial and aquatic macroinvertebrates that support fish populations such as. Other benefits of the natural channel formation and migration process include erosion of gravels from streambanks, which replenishes spawning substrate, and the undercutting of streamside trees, which become a primary source of LWD.

In many areas of the populated and developed lowland areas of Whatcom County, natural channel formation processes have been interrupted by armoring streambanks with artificial structures such as rock-riprap, concrete bulkheads, or steel sheet-piling to protect lives and property. This interruption of channel-forming processes may be necessary and permanent, but it must be acknowledged in such cases that complete resistance to shoreline erosion does not support reliance on natural habitat forming processes, and other means of providing habitat features, if possible, would be necessary.

As concluded in FEMAT (1993), an appropriate width for providing bank stabilization is 0.5 SPTH (Table 3). Based on this criterion, this distance will vary depending on site conditions, but would be expected to range from about 50 to 100 ft. While relatively narrow buffers of immature vegetation may provide adequate bank stabilization, particularly in low-gradient reaches of smaller streams, other studies recommend a width of about 100 ft as generally sufficient to control streambank erosion, even in areas of high mass wasting (Knutson and Naef 1997; May 2000; Cederholm 1994).

7.2.5 Filtering of Sediment, Nutrients and Chemicals

Uptake of dissolved chemicals, and filtration of sediments from overland-runoff and flood water is an important riparian function (Cummins et al. 1994). The chemicals that constitute plant nutrients may be

largely incorporated in the riparian zone's biomass. This combined with the trapping of sediment within the riparian landscape contributes to the building of "new land" involved in channel or shoreline migration. Any action, such as clearing, that degrades the integrity of the riparian zone will hamper to some degree these chemical filtering, uptake and land-building functions.

Literature analysis by FEMAT (1993) indicated that healthy riparian zones greater 200 ft from the edge of a floodplain probably remove most sediment from overland flow. Sufficiency of buffer widths is dependent on slope steepness, with wider buffers required for steeper slopes (Vanderholm and Dickey 1978). Given this, widths of 100 to 300 ft appear to be generally sufficient for filtering substantial proportions of sediment (50 to 90 percent) originating from hill slopes (Karr and Schlosser 1977; Johnson and Ryba 1992; Belt et al. 1992; Lowrance et al. 1986, 1988). While these recommendations are based mainly on short-tem studies, some long-term studies have been conducted that also support a recommended buffer width of 100 to 300 ft for filtering sediment (Lowrance et al. 1986, 1988).

Buffer widths reported for removal of pollutants, nutrients and chemicals can vary widely based on vegetation type, soil type, and slope. Knutson and Naef (1997) report that buffer widths ranging from 13 ft to more than 850 ft are adequate for nutrient reduction or removal depending on site conditions. Though there is a wide range of effective buffer widths reported in the literature, widths of 100 ft are generally sufficient for removing nutrient or bacterial pollution (Lynch et al. 1985; Terrell and Perfetti 1989). Terrell and Perfetti (1989) also report riparian widths of 200 and 600 ft as necessary for removing pesticides and animal waste and nutrients from croplands.

But numerous studies reported in GEI (2002) illustrate that significant sediment filtering and water quality benefits can achieved in agricultural areas (generally low-gradient systems with little side-slope) by buffers or vegetation filter strips ranging from 25 to 50 feet, particularly in combination with suitable BMPs. If buffers are the primary means of protection against input of sediments, nutrients, pesticides and pathogens, then relatively wide buffers may be required. However, by employing appropriate BMPs such as sediment controls, and managing the application of fertilizer and pesticides can markedly reduce the risk of transport into streams, thereby reducing the riparian buffer width required to effectively protect streams from these impacts.

7.2.6 Organic Input and Nutrient Source

Riparian trees and other vegetation furnish fresh and marine waters with a "litter fall" of plant particles (leaves, pollen grains, etc.), and with terrestrial insects. These organic materials compose a major energy source for food webs that sustain production of salmonids, particularly in low- and mid-order streams (Gregory et al. 1991; Naiman et al. 1992; Cummins et al. 1994). Along small stream channels, outside sources of nutrients such as litter fall from healthy stands of riparian vegetation is a greater contributor to the aquatic food web than in-channel algae production, which tends to predominate as the basis in wider, less shaded streams (Vannote et al. 1980) and in standing waters. Clearing riparian vegetation will may reduce or destroy the nutrient-providing function depending on the extent of the action and the relative importance of litter fall in sustaining nutrient input into the system.

7.2.7 Microclimate

Microclimate, defined as the local climate (humidity, wind speed, and air temperature) within the stream-riparian ecosystem, is primarily affected by the quality and extent of riparian vegetation (Pollack and Kennard 1998). Watershed scale microclimate also influences stream temperatures, contributing to lower temperatures in forested watersheds than in urbanized or otherwise cleared watersheds. Brosofske et al. (1997) documented that riparian microclimate is important to consider in management because it affects plant growth, therefore influencing ecosystem processes such as decomposition, nutrient cycling, plant succession, and plant productivity. Thus microclimate alterations can affect structure of the riparian forest, the waters within it, and the well-being of many animals, including fish. Riparian buffer widths

necessary for microclimate control are generally much wider than those necessary for other functions, with the exception of habitat for some species of wildlife. A riparian buffer width of 200 ft may provide minimum or partial microclimate function in some circumstances; however, widths greater than 300 ft are generally required to provide full microclimate protection (Spence et al. 1996; Chen et al. 1990; Brosofke et al. 1997; Franklin and Forman 1987).

7.3 HUMAN ACTIVITY AND AQUATIC HABITAT FUNCTIONS

Puget Sound streams and rivers once flowed through dense forested areas and broad vegetated floodplains. These streams had natural flow regimes, excellent water quality, and complex instream cover. Today, healthy riparian areas are scarce or inadequate, and streams and rivers are frequently confined or controlled, or are realigned to accommodate agricultural or development activities. Human activities have had similar effects on nearshore and estuarine habitats. The effects of human activities on aquatic habitats are summarized in Table 7-6.

Table 7-6. General effects of Different Human Activities on Aquatic Habitats

Activities	Effects
Removing riparian vegetation	Reduced channel complexity, simplified channel morphology, increased stream velocities, loss of pools for holding and rearing, loss of spawning gravel, loss of side channels, loss of wood recruitment, loss of connectivity with floodplain and riparian zone, reduced shade and cover; increased solar radiation; increased erosion and sedimentation, elevated water temperatures and reduced leaf litter.
Introducing invasive non-native vegetation	Altering native riparian habitat functions including associated wildlife refuge, insect litter, replacement of coniferous shade producing trees, etc.
Creating impervious surfaces, filling and draining of wetlands, and increasing water allocations	Altered flow regimes (timing and magnitude of flows), degraded water quality/increased stream temperatures, increased stormwater runoff, and altered instream habitat
Streambank modifications	Loss of natural meander/habitat-forming processes, disconnected floodplains and subsequent loss of floodplain processes
Discharging sewage effluent	Degraded water quality, altered water temperatures, reduced dissolved oxygen concentrations, and increased contaminant levels
Agricultural runoff	Degraded water quality including increased nitrogen and fecal coliform, and reduced dissolved oxygen levels
Livestock access	Degraded water quality, loss of riparian vegetation, streambank instability
Constructing culverts, pipes, and ditches	Obstructed upstream passage of fish and reducing the downstream movement of wood and gravel
Filling/altering estuarine and nearshore habitats	Reduced availability of freshwater to saltwater smolt transition habitat (including cover and food production), and staging and holding habitats for adult salmon
Constructing bulkheads and docks	Increased habitat for predators, altered nearshore currents and gravel movement
Construction activities	Increased erosion, turbidity and inputs of fine sediment during construction and prior to revegetation
Recreational activities	Degraded water quality, and increased contact with listed species

7.3.1 Freshwater Riverine Habitats

As presented in the WRIA 1 Limiting Factors Analysis (Smith 2002), riparian and floodplain conditions have been heavily altered throughout the Nooksack River sub-basin. Riparian impacts include timber harvest, agriculture, residential/commercial/industrial development, and livestock access to stream channels. The Nooksack River and most tributaries have extremely degraded riparian and instream conditions due to lack of stream shading, extensive bank erosion, low large woody debris (LWD) recruitment, and lack of organic inputs (Smith 2002). Alteration of land cover and native vegetation throughout the Nooksack watershed has increased the magnitude and timing of peak streamflows. Such problems are more prevalent in lowland streams where land has been converted to agricultural or urban use, and where stream channelization, water withdrawals, loss of wetlands, invasive plant introductions, and increased impervious surface are most evident.

Perhaps the greatest impact to salmonid habitat in Whatcom County is the loss of floodplain connectivity and associated functions (Smith 2002). The major tributaries of the Nooksack River were historically meandering channels, but these streams have been straightened and diked, and much of the floodplain off-channel and wetland habitat has been lost. Overall, floodplain and riparian functions tend to be more degraded in the lower mainstem (downstream of the forks) and South Fork Nooksack (including tributaries) than in the North and Middle Forks because the watersheds of the North and Middle forks is less developed (greater percentage of forest cover, less impervious surface, etc).

Most of the salmonid spawning habitat in the Nooksack River watershed is located in the three forks of the Nooksack River where sedimentation is a considerable problem (Smith 2002). Landslides and bank erosion are the major sources of sediment. The lack of adequate riparian cover and instream LWD contributes to sedimentation by destabilizing banks and impairing the sediment transport processes. Increased sedimentation also contributes to the lack of adequate pool habitat by filling in pools.

The Middle Fork diversion dam, which channels water from the Middle Fork of the Nooksack River to Lake Whatcom, is the most significant single fish passage barrier in Whatcom County because it prevents access to approximately 17 miles of potential habitat for anadromous salmonids. An inventory of all Whatcom County road crossings began in 2000 and the final report is due to be delivered to Whatcom County by March 2005. To date, the inventory has identified approximately 500 culverts that block fish passage either completely or during high flow events. The main type of potential passage barriers are the numerous culvert and small dam barriers that tend to occur mostly in smaller lowland tributaries, but have been identified in virtually all Nooksack River subbasins and the independent watersheds in the County. The highest numbers of culvert and dam barriers appear to occur in Hutchinson and Tinling Creeks in the South Fork drainage, several small tributaries that drain directly into the North Fork Nooksack, Tenmile/Deer Creeks, Terrell Creek, Dakota Creek, Squalicum Creek, and among the numerous small tributaries that drain directly into Lake Whatcom and Lake Samish. There relatively few passage barriers identified in the South Fork and Middle Fork Nooksack drainages other than those already mentioned.

To effectively address these impacts to aquatic habitats, it is necessary to prioritize management strategies based on habitat needs. Smith (2002) describes the condition of habitat features and limiting factors of streams and rivers throughout WRIA 1, and the analysis of limiting factors is a necessary step in defining management priorities. But it should be stressed that prioritization of habitat and restoration needs is dependent not only on existing habitat conditions and current species use, but also on the expectations and potential for conservation or restoration given the entire suite of existing and anticipated land-uses.

7.3.2 Nearshore and Estuarine Habitats

The primary disturbances to nearshore and estuarine habitats are estuarine habitat loss, shoreline modifications, overhead structures, and impacts on water/sediment quality. The condition of the estuarine and nearshore habitat in Whatcom County varies considerably depending on location. Estuary habitat loss has been documented in Bellingham, Lummi, and Samish Bays (Smith 2002). Shoreline modifications such as bulkheads, rip-rap, and fills are common along Point Roberts, the Peace Arch, Blaine, Birch Bay, Neptune Beach, Sandy Point Shores, Lummi Bay, Bellingham Bay, and Samish Bay (Smith 2002). Areas of shoreline modification typically have poor riparian or shoreline vegetation, which reduces or eliminates the function of shoreline vegetation as described in Section 1.2. In addition, quick spreading invasive non-native plants such as Giant Japanese Knotweed are rapidly replacing native marine and estuarine shore plants in areas such as Blaine, the Nooksack Delta, Bellingham Bay and Whatcom Creek.

Major overwater structures also impact eelgrass beds by shading out sunlight, and can alter salmonid behavior and survival. Such major overwater structures in Whatcom County include Arco Pier, Intalco Pier, British Petroleum Pier, Gooseberry Point Ferry Terminal, Lummi Island Ferry Terminal, inner Bellingham Bay, Point Roberts Marina, Blaine Marina, Birch Bay Marina, Sandy Point Shores Marina, Semiahmoo Marina, and Squalicum Marina. Light is a primary factor limiting the survival and distribution of eelgrass (Dennison et al. 1993). The loss of eelgrass habitat due to overwater structures can reduce prey resources and cover, thereby impacting habitat-use, migration patterns, and survival of juvenile fish species, including salmonids (Weitkamp and Schadt 1982). In addition, direct shading during the day and increased lighting at night (from artificial lighting) can also change fish species assemblages and increase the risk of predation by changing the migration, activity, and location of both predators and prey species (Weitkamp and Schadt 1982; Ratte and Salo 1985; Pentec Environmental 1997).

Inner Bellingham Bay contains numerous contaminated sediment sites. Detected toxins such as mercury, arsenic, and PCBs can cause tumors and suppress immune systems in salmonids, and be lethal for organisms that are food resources for salmonids. Creosote-treated materials and oil spills are also important water quality concerns within nearshore areas of Whatcom County.

7.4 HABITAT MANAGEMENT AND PROTECTION TOOLS

7.4.1 Designation, rating, and classification

WCC does not designate or classify streams according to any stream typing system. New water types have been established in WAC 222-16-030, but this system will not go into effect until fish habitat water type maps have been adopted by the State. Until such time, the interim water typing system established in WAC 222-16-031 will continue to be used by the State. New water types are presented below for informational purposes along with a conversion table for the interim and new water types.

As excerpted from WAC 222-16-030, new water types are as follows:

- **Type S Water -** all waters, within their bankfull width, as inventoried as "shorelines of the state" under chapter 90.58 RCW and the rules promulgated pursuant to chapter 90.58 RCW including periodically inundated areas of their associated wetlands.
- **Type F Water** - segments of natural waters other than Type S Waters, which are within the bankfull widths of defined channels and periodically inundated areas of their associated wetlands, or within lakes, ponds, or impoundments having a surface area of 0.5 acre or greater at seasonal low water and which in any case contain fish habitat.

- **Type Np Water** - means all segments of natural waters within the bankfull width of defined channels that are perennial nonfish 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 Np Waters include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.
- **Type Ns Water** - means all segments of natural waters within the bankfull width of the defined channels that are not Type S, F, or Np Waters. These are seasonal, nonfish habitat streams in which surface flow is not present for at least some portion of a year of normal rainfall and are not located downstream from any stream reach that is a Type Np Water. Ns Waters must be physically connected by an above-ground channel system to Type S, F, or Np Waters.

Conversion between the water types is presented in WAC 222-16-031 as follows:

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

7.4.2 Buffers

WCC buffer designations for rivers and streams are not tiered to current or proposed State water typing classifications. WCC currently requires buffers of 100 ft from the OHWM on all rivers and streams, provided that a standard 50 ft buffer be applied to those streams that do not contain salmonid populations, or to those streams that do not directly flow into such waterways. Where forested buffers do not exist, and agricultural activities are ongoing proximate to these watercourses, WCC further provides that buffer width may be reduced by combining USDA- Natural Resources Conservation Service Field Office Technical Guide vegetative, structural and management practices as expressed in a conservation plan.

For protection of instream salmonid habitat conditions, a wide range of recommended riparian buffer widths is presented in existing studies (see previous discussion of riparian buffer functions). Variation in recommendations or buffer effectiveness is frequently due to variation in site conditions such as side-slope angle, stream type, geology, climate, etc. However, no studies recommend zero width, nor do the studies recommend the equivalent of more than several site potential tree heights. Design of riparian buffers must consider the ecological, cultural, and economic values of the resource, land use characteristics, and existing riparian quality throughout watersheds in order to address the cumulative impacts on stream functions and the resources being protected (Johnson and Ryba 1992; Castelle et al. 1994; Wenger 1999).

Appropriate buffer sizes will depend on the area necessary to maintain the desired riparian or stream functions for the given suite of land-use activities. A wider buffer may be desired to protect streams from impacts resulting from activities such as unpermitted ad hoc trail construction, recreation, pets, garbage, and tree removal for unpermitted view improvements and hazard reduction. These concerns are associated more with areas of high-intensity land use and thus wider buffers, or restrictions (such as building setbacks) that keep a potential hazard from occurring, may be needed, while narrower buffers may suffice in areas of low-intensity land use (May 2000). It should be noted though that opportunities for protection or improvement of buffer conditions in areas of high-intensity land use are often effectively foreclosed by existing development, or the existing habitat conditions are already highly altered. Under such conditions,

establishing buffers wide enough to provide an effective full-range of riparian functions is likely unattainable, and other actions may be required to improve habitat conditions beyond what riparian buffers are able to provide. In addition, buffer vegetation type, diversity, condition, and maturity are equally as important as buffer width, and the best approach to providing high-quality buffers is to strive for establishing and maintaining mature native vegetation communities (May 2000).

Pollack and Kennard (1998) recommended buffer widths of 250 ft on all perennial streams. Buffer widths of one SPTH would reasonably provide for a full range of riparian functions, and therefore, not contribute significantly to the loss of salmonid habitat. May (2000) and other extensive reviews provide detailed summaries of buffer width sizes necessary to achieve stream and riparian functions (Knutson and Naef 1997; FEMAT 1993). The conclusions of those reviews are presented in Tables 7-2, 7-3, and 7-4. However, as was previously discussed, these recommended buffer widths are largely driven by providing adequate long-term LWD recruitment potential, and are not necessarily inclusive of all situations. For example, along highly managed streams such as in agricultural, residential, or commercial areas, some functions normally provided (at least in part) by riparian buffers, such as flow attenuation or filtration of pollutants, can be provided by application of appropriate BMPs in combination with smaller buffers.

In addition, the importance of protecting the CMZ is well documented. Many researchers recommend that buffer widths be measured from the edge of the CMZ on streams with active channel migration zones (Knutson and Naef 1997; May 2000; WDNR 1999; Smith 2002). Incorporating CMZs into County regulations should be provided for, but using CMZs as the basis for buffer determination poses some challenges in a regulatory context because the extent of the channel migration zone will vary from parcel to parcel and has not been determined for most streams and rivers in Whatcom County. However the task of determining CMZs in Whatcom County is underway and the information will be incorporated into determinations of appropriate buffer widths as it becomes available. Nearshore and Estuarine Habitats

7.4.2.1 Nearshore and Estuarine Habitats

Maintaining viable forage fish spawning grounds is a significant challenge to managing nearshore and estuarine habitats for species such as Pacific herring, sand lance, and surf smelt (Bargmann 1998). Present regulatory policies emphasize the protection of all natural nearshore habitats because there is no known mitigation method for replacing destroyed spawning habitats into perpetuity. Additional measures include protecting or establishing natural nearshore buffers in spawning areas.

7.4.3 Timing restrictions

Timing restrictions for conducting in-water work are necessary to protect habitat and life-stage requirements that differ by species and time of year. No timing restrictions for in-water work are specified in the WCC, but windows for conducting work within the OHWM of freshwater and marine systems have been established by state and federal resources agencies. The approved fish work windows for most Whatcom County streams is from July 1 to September 30. For some streams, the work window is extended to begin earlier on June 15. Work windows vary by species of interest in marine or estuarine waters. Marine work windows are established for salmon (July 2 to March 2), bull trout (July 16 to February 15), Pacific herring (from April or June 15 until January 31 depending on location), sand lance (March 2 to October 14), and surf smelt (year-round).

7.5 PROTECTION AND MANAGEMENT OF ANADROMOUS SPECIES

Habitat used by anadromous fish is potentially found in all types of FWHCAs listed in WCC 16.16.710. The WCC does not provide specific guidelines for protecting anadromous salmonid species, but the

protection and management of anadromous salmonids is provided for in regulations potentially applicable to aquatic habitats.

The protection and recovery of anadromous salmonids species is a primary focus in Whatcom County. The County, resource agencies, Tribes, and private interests have coordinated protection and management efforts for anadromous species in Whatcom County. Existing habitat conditions, habitat limiting factors, and proposed protection measures for anadromous salmonids in Whatcom County have been presented in several completed or ongoing management documents (Smith 2002; Nooksack Indian Tribe 2004; Whatcom County 2004a,b). These documents have been developed with the intent of identifying specific habitat issues throughout the Nooksack River watershed and other waters of Whatcom County, and proposing protections and strategies for conserving anadromous salmonid populations. Protection measures and goals that have been identified within and outside of the Nooksack River watershed include:

- Improve riparian conditions throughout Whatcom Country watersheds;
- Reduce bank hardening and investigate areas for dike removal and reconnection of the floodplain. High impact areas include the mainstem Nooksack, the South Fork Nooksack, and the lower reaches of lower river tributaries. These areas are frequently dominated by agricultural, residential, and municipal land-uses;
- Prevent further loss of wetlands, which can contribute to improved water quality, groundwater recharge, instream flows, and other floodplain functions;
- Prevent further loss of native riparian and wetland buffers (freshwater, marine & estuarine) through the aggressive elimination and/or management of non-native invasive plants;
- Reconnect tidal floodplains, marsh, and wetlands;
- Improve passage barriers, particularly at the Middle Fork diversion dam and at identified high-priority culverts;
- Increase LWD by adding to streams, or preferably by improving natural LWD recruitment in the long-term;
- Decommission or treat roads that are of moderate to high risk of mass-wasting, which is a leading source of sediment in throughout the Nooksack watershed;
- Reduce pollution runoff from urban, industrial, and agricultural sources; and
- Reduce water withdrawls, enforce instream flows, increase stream sinuosity, and increase watershed land cover to improve instream flows.

Notwithstanding these efforts, there is a need to strengthen existing regulations at the County level to achieve the goal of no net loss of ecological functions as specified under the GMA. Specific recommendations are provided below.

7.6 FINDINGS AND CODE RECOMMENDATIONS

General Habitat Findings and Recommendations	
Finding #1	1. Fish species are not included in the list of listed species and species of local importance named in WCC Ch 16.16 Appendix C. In lieu of being included in Appendix C, criteria for determining fish species of local importance are unclear. 2. WCC does not specify that special consideration must be provided for anadromous fish species as specified in the GMA 3. In general, WCC does not include detailed performance standards or review and approval process for guiding potential actions within aquatic critical areas. See further description and recommendations under Section 1.8.2 Aquatic Habitat Functions and Values.
Recommendation	1. Identify fish species that are listed or of local importance in WCC Ch 16.16 Appendix C and provide specific implementation provisions to address these species. 2. Include language that special consideration be afforded to anadromous fish species and habitats.
BAS Sources	GMA requirement for special consideration of anadromous species

Aquatic Habitat Functions and Values	
Finding #2	1. Stream buffers are measured from the OHWM with no provision for including channel migration zones (CMZ). Where channel migration occurs or is likely to occur, a buffer measured from the OHWM may not fully protect riparian functions. Of particular concern would be the ability of a stream channel to migrate (thereby recruiting LWD), and to form new instream habitat features such as pools, riffles, and off-channel areas important for several salmonid life-stages. Areas of likely channel migration need to be determined, as does the feasibility of protecting CMZs where they do or should occur. 2. Existing stream buffers are 100 ft for salmon-bearing streams and 50 ft for non salmon-bearing streams. A 100 ft buffer is generally adequate for protecting many riparian habitat functions and features. Where buffers do not provide a full range of habitat functions, other conservation measures and BMPs may be in place to offset some land-use impacts, but some riparian functions, most notably LWD recruitment, generally cannot fully be provided by 50 to 100 ft buffers. 3. WCC does not incorporate a stream typing system for incorporating stream functions into determining appropriate management strategies. 4. Under WCC 16.16.650, adjustments are allowed for standard buffer widths depending on demonstration of the need for increased or reduced buffer width requirements on a given site. No emphasis is placed on continuity of stream buffers, which has been shown to be an important aspect of effective buffers. Standard buffer adjustments establish no minimum buffer widths for cases of buffer width averaging or reduction. Without minimum standards, buffer continuity is jeopardized. 5. There are no provisions for mitigation in instances of when buffer encroachments do occur. 6. No building setbacks from riparian buffers are required, which could result in buffer impacts due to construction activities, or impacts to structures from the riparian buffer (e.g. hazard trees). 7. There are few performance standards established for the list of "activities allowed without a permit" in WCC 16.16.225. As written, many of these allowable activities such as ditch maintenance, gravel extraction, maintenance of utilities, removal of beaver dams, and other potential construction and agricultural activities could adversely affect aquatic habitats and still be in compliance with WCC. 8. WCC states that management of shellfish habitat conservation areas, kelp and eelgrass beds, and surf smelt/sand lance spawning areas are currently primarily implemented through the Shoreline Master Program and HPA process. WCC does include shellfish protection districts with protections strategies, but there are no provisions beyond requiring that all development shall avoid or mitigate impacts to forage fish spawning areas and projects, and that shoreline protection projects should not adversely affect the supply of beach sands and gravels necessary for spawning areas. Additionally, WCC 16.16 does not include a septic system operating and maintenance program to protect shellfish from contamination.