Chapter 3:

FLOOD HAZARD AREAS

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3.1 INTRODUCTION

The Washington State Growth Management Act (GMA) lists "frequently flooded areas" as a critical area that local jurisdictions must protect under their critical areas regulations. King County defines "frequently flooded areas" as "flood hazard areas" and regulates them to protect members of the public from injury, loss of life, property damage or financial loss due to flooding. King County's river management program and flood hazard regulations are among the most contemporary in the country and are considered by many as the best available science for floodplain management. This chapter is a review of the scientific literature relating to flood hazard areas followed by a list of literature references.

3.2 REVIEW OF LITERATURE

3.2.1 Description of Flood Hazard Areas

A floodplain is the generally flat, low-lying area adjacent to a river or stream that is periodically flooded by overbank flows during storm events. Flood hazard areas are those open-channel and overbank areas in the floodplain that are periodically inundated with floodwaters.

Floods are a natural process that result in inundation and bank erosion. Inundation of the floodplain and bank erosion are not mutually exclusive. Inundation can often create bank erosion, and bank erosion can expand and exacerbate the flood hazard. Floodwaters rise above the natural containment levels in rivers and streams as a result of excessive rainfall or snowmelt or both. Bank erosion is the process whereby river and stream banks are scoured or undermined by high velocity erosive flow. Ongoing bank erosion can result in movement or shifting of the channel, called channel migration. Both flooding and channel migration are natural processes that exacerbate the risk of flooding and damage to developed properties. At the same time, these processes are important for creating and maintaining healthy aquatic and riparian habitats. This chapter will discuss inundation of floodplains, whereas bank erosion will be addressed separately under the Channel Migration Zones chapter in this proposed CAO Best Available Science report.

King County Rivers and Streams

There are six major river systems in King County: the South Fork Skykomish, Snoqualmie (including, North, South and Middle Forks), Cedar, Sammamish, Green, and White. Except for the Sammamish, which is dominated by a large lake and drains low-lying foothills, each of these rivers descend from the crest of the Cascade Mountains to Puget Sound and are heavily influenced by snow and rain patterns in the mountains. The White River is the only glacial system in King County. In addition, flood control and hydropower dams and water supply diversions constructed in these river systems play an important role in regulating river flow. King

County also has numerous mid-sized stream systems, such as Bear, Soos, and Issaquah Creeks that drain low-lying hills. Their flooding is controlled more by storm events than snow patterns. Because they are smaller and have relatively high amounts of development compared to large river systems, their flooding is also heavily influenced by stormwater runoff from developed areas.

Flood Hazard Areas: Delineation and Purpose

Flood hazard areas are delineated by conducting floodplain analyses that use accepted engineering standards and practices (FEMA 2002b.). These floodplain analyses include detailed hydrologic and hydraulic computer modeling as well as computational techniques for shallow and ponded areas of inundation. These models and techniques must be acceptable to the Federal Emergency Management Agency (FEMA) and computations must follow FEMA guidelines and specifications. Observations of flood conditions, stream flow measurements, channel and overbank dimensions, aerial photographs and mathematical computations are the types of base data used in completing a floodplain analysis.

Flood hazard areas are regulated to reduce the risk to people and property. This is achieved by limiting subdivision of land within the floodplain, requiring elevation of structures above the base flood elevation (BFE), safeguarding critical facilities, such as hospitals and fire stations, requiring compensatory storage of floodwater, establishing construction standards and other standards designed to protect people and property.

Flood hazard areas often coincide with other critical areas, such as aquatic areas or wetlands, which are regulated for the protection of critical species and their habitats. Flood hazard areas are not regulated to provide for habitat protection. However, habitat benefits do accrue as a secondary benefit if habitat protection is considered when planning, designing, installing and maintaining flood protection facilities (Bolton and Shellberg 2001). Also, information gathered and developed in a floodplain analysis provides information about flood frequencies, magnitude and timing, flow depths and velocities, channel slope and channel cross-section geometry that is useful in understanding the existing and potential habitat conditions along a river or stream.

3.2.2 FEMA and the NFIP

In 1968 with the passage of the National Flood Insurance Act, the U.S. Congress created the National Flood Insurance Program (NFIP) as part of the Federal Emergency Management Agency (FEMA). FEMA began to formally delineate flood hazard areas along major river and stream corridors to identify areas that are at risk from floodwaters. Under the NFIP, FEMA is required to develop flood hazard information for use in both insurance rating and floodplain management. The NFIP allows property owners to purchase federally backed flood insurance within communities that participate in the Program. In return for insurance protection, participating communities implement floodplain management measures and land-use regulations to prevent and reduce flood hazards to new and existing development (United States 2002).

FEMA's early flood studies relied heavily on expertise from the U.S. Geological Survey, U.S. Army Corps of Engineers, and private engineering firms to estimate the extent of inundation and to prepare flood maps (FEMA 2001b.). It is important to note that the technical approaches utilized by these modern day practitioners are based upon the pioneering efforts over the last two centuries of hydrologic and hydraulic experts, such as Manning, Bazin, Darcy, and Weisbach. These FEMA flood maps, named Flood Insurance Rate Maps (FIRMs), illustrate the extent of the predicted "base flood." The base flood is the flood that has the one-percent chance of occurring in any given year. The base flood is commonly referred to as the 100-year flood. Many of the FIRMs are significantly out of date and do not accurately map and represent the current flood hazard area. In addition, not all portions of King County rivers and streams have flood areas delineated on FIRMs even though any open channel has a floodplain and will periodically flood onto its overbanks.

Flood hazard areas may also be identified through studies related to road and bridge construction, land development proposals and river corridor studies. With the passage of the National Flood Insurance Reform Act of 1994, FEMA identified the need to prepare additional and updated flood studies for those river and stream reaches currently unmapped or for areas with mapping that is not representative of current-day flood hazards due to new mapping techniques or changed conditions (FEMA 2002b.). The King County Flood Hazard Reduction Plan (FHRP) recommends that King County develop new hydrologic and hydraulic models for the major river basins and keep those models updated with regular cross-section surveys and land use information. The models would be used to regularly update FEMA FIRMs and maintain the countywide FIRM inventory on a five-to ten-year update cycle. With improved and additional mapping, more flood hazard areas in King County will be delineated and regulated. New and updated floodplain mapping information can be used to improve efforts to reduce flood damages and the risk to human safety and collaterally provide for the protection of aquatic and riparian habitats.

3.2.3 Flood Hazard Area Functions

Natural Floodplains

Natural floodplains provide aquatic and riparian habitat for a wide variety of fish and wildlife. A natural floodplain is a highly productive, dynamic environment that provides the proper structure, processes and functions for sustaining a viable ecosystem. Please see Chapter 7 – Aquatic Areas for a full discussion of the relationship between natural floodplains and aquatic and terrestrial species. During flood events, large volumes of water and debris move downstream. By definition, floodwaters are those waters that, at some interval, overtop the river or stream bank and flow onto the floodplain and also along smaller-sized side-channels. Flooding therefore acts to provide connectivity between the river or stream, its riparian soils, vegetation, and the hyporheic and perirheic zones. Floodwaters transport sediments and nutrients that replenish floodplain lands. Floodwaters move and distribute large woody debris that builds structure and creates the physical characteristics of the main channel and side-channels. Floodplains also provide for the storage of water during these storm events which, for King County, are most likely to occur from October through March during periods of heavy rainfall and rapid snowmelt. Flooding can also be produced from stormwater runoff draining from developed land areas. Stormwater runoff from impervious surfaces can increase the volume of water and the timing and size of the peak flood (USDA 1998). Stormwater runoff has greater impact on urban streams than major rivers, which are affected more by heavy rainfall events and rapid snowmelt.

Floodplain Alterations and Impacts

Past flood control activities and land development have altered many of the river and stream floodplains in King County. As such, these altered floodplains do not provide the same habitat benefits as a natural floodplain. Floodplain alterations are typically caused by streambank hardening intended to provide erosion protection and flow confinement through the placement of fill materials (e.g., roadway and levee construction), and channel excavation (e.g., gravel bar scalping and dredging). These alterations can result in an increase in water velocities that may exacerbate channel scour, a reduction of floodwater storage that would increase peak flood flows, and the loss of the physical, biological and chemical connectivity between the river or stream and its riparian vegetation, side channels, and floodplain wetlands (Bolton and Shellberg 2001).

If floodplain areas are properly protected or managed, storage of floodwaters can reduce local and downstream peak flood discharges and also decrease highly erosive flood velocities. Protecting, restoring, and managing floodplain areas provides for a more natural flow regime by minimizing floodplain modification and limiting development within floodplains. This not only reduces the potential for flood damages but also provides an improved condition for the fish and wildlife species dependent upon viable riverine corridors (USDA 1998, Poff et al. 1997).

3.2.4 Flood Hazard Area Protection

Flood Hazard Mapping and Regulation

Flood hazard areas are defined by mapping the relatively flat areas adjoining rivers and streams that are inundated by the 100-year flood, that is, the areas subject to a one-percent or greater chance of flooding in any given year. This hazard area mapping establishes the floodplain area over which land-use regulations are applied by local government in order to protect the public health and safety from flooding. For example, a floodplain analysis determines areas of expected deep, high velocity flow. Such areas would be extremely hazardous to public safety and have a greater potential to cause property damage than areas of shallow, slow-moving or ponded water. The shallow flooding areas that have average depths between one and three feet are labeled AO zones by FEMA. The mandatory requirement to purchase flood insurance applies within AO zones as well as other mapped special flood hazard areas (e.g., AE zones) identified on FEMA's published Flood Insurance Rate Maps. AE Zones are areas where base flood elevation has been estimated. Under FEMA regulations, a specific portion of the 100-year floodplain is delineated to allow for the complete conveyance of the base flood. This hazard area is called the FEMA floodway (Figures 1 and 2).

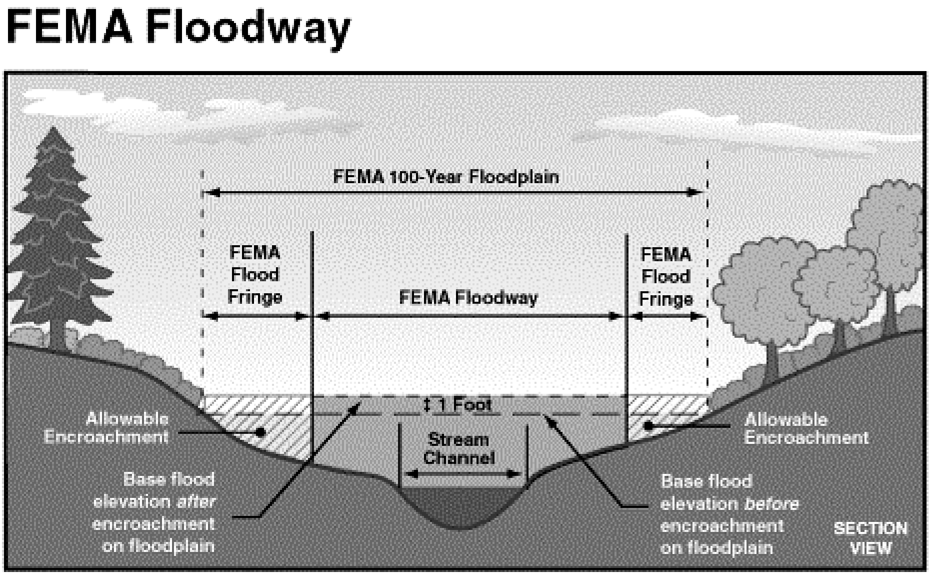

Figure 1

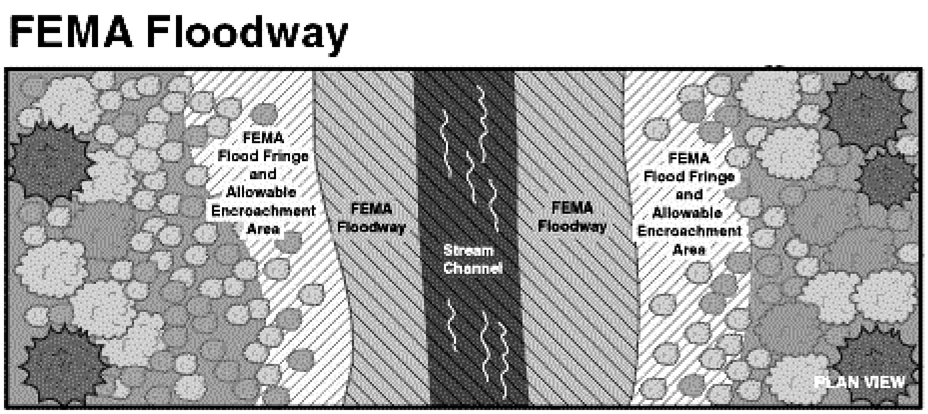

Figure 2

FEMA also identifies shallow flow and ponded areas. The identification of these types of flooded areas is also useful in understanding and protecting valuable riparian habitat for fish and wildlife. Shallow and ponded areas are included in the FEMA flood fringe. The FEMA flood fringe, combined with the FEMA floodway, constitute the regulatory FEMA 100-year floodplain. King County regulates these same areas as zero-rise floodway and zero-rise flood fringe when a specific zero-rise study has not been completed. These areas constitute the regulatory King County 100-year floodplain (Figures 3 and 4). The zero-rise nomenclature relates to County regulations that preclude development and floodplain encroachments that would cause a measurable rise in base flood elevations. For King County, this measurable rise is calculated as an increase that is equal to or greater than 0.01 foot above the BFE.

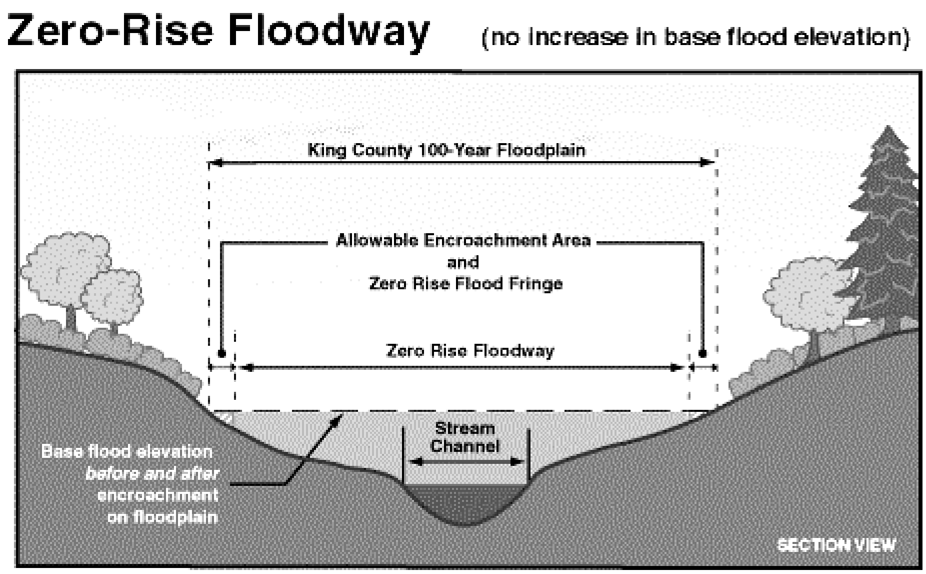

Figure 3

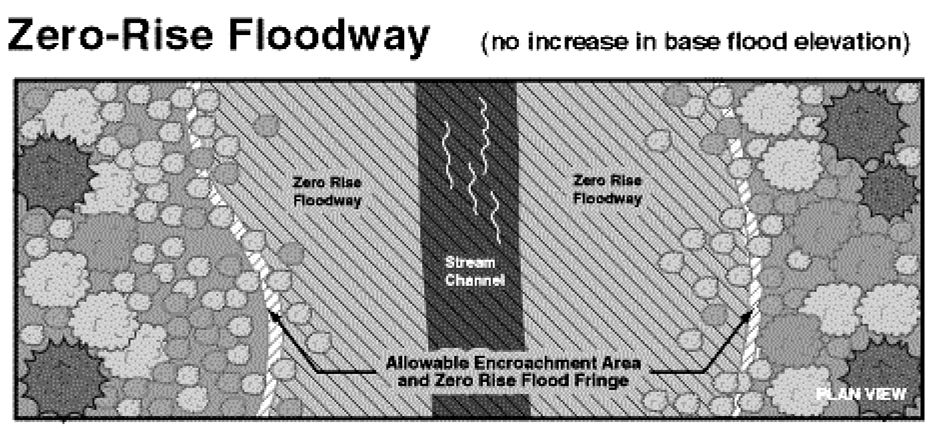

Figure 4

Identifying the extent of flood hazard areas through technically sound analyses provides the basis for protecting these areas from adverse alterations that affect aquatic species and also can identify the flood risk to human safety. However, use of floodplain areas for land development and infrastructure construction has occurred since humans have inhabited the earth. By minimizing the effects of the built environment, the dynamic processes of rivers and streams and their floodplains can more naturally occur. Floodplain encroachments increase flood elevations and flow velocities, change flood flow patterns and increase the area of flood inundation. Encroachments into the floodplain also result in a loss of storage volume of floodwaters which in turn increases the downstream flood peaks that then exacerbates flooding and erosion (Carlton et al. 1989; DeVries 1980). Limitations on placement of fill material and other floodplain alterations; (e.g., the amount of impervious surfaces and the removal of native vegetation) can protect and maintain the natural characteristics and functions of the floodplain, as well as reduce, but not altogether eliminate, the impact to human life and loss of property.

Contemporary Floodplain Management Policy and Regulations

Current-day strategies in floodplain management are focused on "no net impact" (Larson and Plasencia 2001). A "no adverse impact floodplain" is one in which the floodplain action of one property owner or community does not adversely affect the flood risks for other properties or communities as measured by increased flood stages, increased flood velocity, increased flows, or increased potential for erosion and sedimentation, unless the impact is mitigated (Larson and Plasencia 2001). Regulatory approaches to remedy the effects of floodplain alterations include compensating for lost storage volume and requiring no increase in flood elevations. Regulatory requirements serve to prevent the risk to health and human safety by protecting current floodplain conditions. They also preserve existing aquatic and riparian habitat resources.

These types of regulatory remedies are most effective in reducing flood losses and in protecting and preserving the natural resources of the river and stream corridor when combined with structural solutions in a comprehensive flood hazard reduction plan. Structural solutions may include setting back the location of levees or re-connecting side-channels, which re-establishes flood storage areas and restores vital aquatic and riparian areas. Other actions, such as the relocation of flood-prone buildings from the floodplain, reclaim lost floodplain areas while permanently removing the risk to human safety (Conrad et al. 1998).

Watersheds experiencing urban growth, or changes in physical conditions caused by erosion, can benefit from the use of future conditions hydrology to estimate where the boundaries of the floodplain will be after full build-out of the basin (FEMA 2001b.). Depicting a future conditions floodplain would serve to alert the public to potential, future hazards and also further the understanding of potential effects to the natural habitat and aquatic resources. The development of future flow hydrology has been completed in King County stream systems where comprehensive basin planning was conducted.

Past practices for flood control involved containing the flow of water within a defined channel by constructing berms and levees along natural riverbanks and creating hard surfaces using erosion resistant materials, such as concrete slabs and large angular rock. Contemporary science of floodplain management strives to mimic natural floodplains and their flow regimes. Today's floodplain management allows floodwaters to use as much of the natural floodplain as possible during storm events so that the natural processes of river systems can occur largely unimpeded.

Impacts of Traditional Flood Control Facilities

Traditional flood control measures include widening or deepening the channel, straightening the channel, levee construction adjacent to the channel, stream bank stabilization, and clearing living and dead vegetation in and along the river. Levees that constrict the floodplain confine flood flows to the main channel, resulting in higher water velocities and depths, both of which may be harmful to habitat and fish. See Chapter 7 – Aquatic Areas for an additional discussion of the affects of altered floodplains on aquatic and terrestrial wildlife. Over time, the higher velocities and increased potential for erosion along levee faces have resulted in levees evolving into bank stabilization projects in addition to their original containment function (Maddock 1976). The presence of levees disconnects the active channel from its overbank areas, disallowing the periodic interaction of floodwaters and sediment that are necessary for fully functioning floodplain. Levees also have blocked flow and fish access to important side-channel habitats used by fish for spawning and rearing. Blockages to small tributary streams entering rivers also occur due to inoperative flap gates on culverts, perched outlets and pump stations having no fish passage facilities.

Clearing rivers and streams of vegetation and large woody debris increases the capacity to convey floodwaters but may increase bank erosion (Shields and Nunnally 1984). In addition, the removal of large woody debris simplifies the physical structure of the channel and affects the ability for the stream or river to form pools, which are important salmonid habitat (Montgomery and Buffington 1993). The removal of vegetation from within streams and rivers also reduces the ability to trap and store sediment and nutrients important for aquatic life (Bilby and Ward 1991; Culp, Scrimgeour, and Townsend 1996). Gippel et al. (1992, 1996) determined that the re-introduction of large woody debris into streams lacking woody debris does not significantly decrease the flood-carrying capacity nor increase the flood frequency of the stream or river. However, the re-introduction of large woody debris into streams will result in a slight rise locally in the base flood elevation. The habitat benefit derived from large woody debris has been recognized by FEMA as a reasonable compromise for this effect on base flood elevations (FEMA 2002c.). Also, FEMA allows the local floodplain administrator to exempt those encroachments necessary for addition of enhancement elements (i.e., large woody debris) that would result in an increase in base flood elevations.

Contemporary Design and Construction Guidelines for Flood Protection Projects

Bolton and Shellberg (2001), which comprehensively discusses the typical effects of stream channelization, states that channelized rivers tend to have greater fluctuations in water temperatures, less shading from trees, reduced cover for fish, less diverse aquatic habitats, and less organic matter input. These impacts result from traditional flood control techniques. Contemporary floodplain management measures use alternative design and construction practices to more fully mitigate impacts and enhance aquatic and riparian habitats.

Bolton and Shellberg (2001) reviewed the current understanding of effects to aquatic habitat from floodplain development and land management activities. Their review includes a discussion of contemporary floodplain management practices that can be used to mitigate for these effects. Impacts from flood control projects can be minimized by first emulating nature in the design approach. Projects should revegetate or maintain vegetation and have minimal channel alterations to natural channels. Rock riprap, for erosion protection, should be used judiciously and two-stage channels should be considered when addressing control of flood elevations. Channel morphologic features, such as original meander bends, small side-channels and riffle-pool complexity, should be preserved. Alternating construction on opposite sides of stream or riverbanks can minimize disturbances during construction.

In addition to preserving native vegetation, newly planted native vegetation should be installed to create habitat complexity. The re-establishment of a more naturally vegetated floodplain area can occur by creating a vegetated berm as part of a two-stage channel morphology and also by setting back a levee to allow for natural revegetation along the active channel. In-channel placement of large woody debris and the use of bioengineering techniques on stream and riverbanks can address erosion protection while increasing aquatic habitat and riparian habitat diversity. Complete or partial removal of levees and revetments can more readily provide for the restoration of floodplains and channel morphology.

Comprehensive Floodplain Management Plans

Project actions and regulatory approaches are most effective when appropriately guided by a comprehensive floodplain management plan. King County's Flood Hazard Reduction Plan embodies a comprehensive floodplain management program for all King County's rivers and streams and establishes the following goals:

1. The reduction of flood-related hazards and damages.
2. The reduction of environmental impacts of flood control.
3. The reduction of the long-term costs of flood control and floodplain management.

The FHRP policy and direction is moving King County away from past practices of flood control to flood hazard reduction through sound floodplain and watershed management practices (King County 1993). The FHRP includes floodplain management policies, floodplain management regulations, program guidelines and recommendations on floodplain mapping, flood warning, facility maintenance and operations and public outreach and awareness. In addition, it contains a capital improvement program that recommends retrofitting and removing old flood protection projects that are environmentally harmful or are not cost effective to maintain. The FHRP also establishes policy guidance for public buy-out of homes and structures that are persistently flooded and for reclaiming those lands for permanent flood storage, conveyance, and riparian values. The FHRP includes design guidelines for constructing new flood protection facilities with bioengineering and habitat features consistent with watershed management practices. These Guidelines, named Guidelines for Bank Stabilization Projects in the Riverine Environments of King County, were adopted by reference as part of the 1993 FHRP and have been used by King County in the design and construction of major river maintenance and repair projects for the past decade (Johnson and Stypula 1993).

3.2.5 Gaps in the Knowledge and Areas of Uncertainty

In spite of improved analytical techniques, there still remain limitations and inaccuracies of data collection and hydrologic variability that affect the most proficient computer modeler's ability to accurately predict flood elevations. The variations in physical features, changes in surface water run-off rates due to development, seasonal fluctuation in stream flows, and a wide variety of factors limit the exactness in estimating flood elevations. Communities and FEMA have built in a factor of safety to address this level of uncertainty in the regulatory standards by requiring structures to be built above the calculated base flood elevation.

One significant gap in the literature on the relationship between flood protection measures and aquatic and riparian habitat is the quantification of effects of flood protection facility maintenance on fish productivity (Brooks 1988), particularly related to removal of vegetation. The lack of information is primarily related to the scarcity of long-term monitoring projects and the information they provide. A second area of uncertainty is the effect of channelization on amphibians and reptiles (Bolton and Shellberg 2001). See Chapter 7 – Aquatic Areas and Chapter 8, Wildlife Areas for further discussion on the impacts of vegetation removal and wildlife habitat.

There is little scientific information on the effect of channel confinement and channelization on the hyporheic and perirheic zones. The hyporheic zone is generally understood to be that area between the stream channel and the stream banks that is saturated by a mixture of stream channel water and ground water. The perirheic zone is a complex mixing zone of surface water and hyporheic water. These systems are extremely complex and there appears to be little agreement among researchers on exactly how to define and delineate hyporheic and perirheic zones. This uncertainty leaves many unanswered questions about the effects of degraded hyporheic and perirheic zones (Bolton and Shellberg 2001). Finally, local jurisdictions conducting or requiring mitigation and restoration have done little to document the project design, implementation, and monitoring. Because of the lack of documentation, the success and failure of different restoration techniques is unknown.

3.3 CONCLUSION

A review of the literature on flood hazard areas indicates that a key element of floodplain management is accurately identifying and mapping lands that are subject to inundation of flood waters. Mapping is conducted using criteria developed by FEMA, along with standard hydraulic and hydrologic computer modeling and accepted engineering standards and practices. However the accuracy of flood hazard maps varies based on the quality of the mapping techniques used. Alterations to natural floodplains generally result in increasing the flooding risk to people and property and impact fish and wildlife habitat. Traditional flood control practices have been particularly damaging to fish and wildlife habitat, but contemporary methods are striving to provide an acceptable level of flood protection to people and property, while at the same time preserving and enhancing fish and wildlife habitat. Risk to people and property is best achieved by limiting floodplain development and assuring that allowed development does not increase flood elevations and flow velocities, change flood flow patterns, reduce flood storage, increase erosion or increase area of flood inundation.

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