Visions for Kimball Creek

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University of Washington

Institute for Hazards Mitigation Planning and Research

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A Report to the City of Snoqualmie

Autumn 2002 Floodplain Management and Stream Ecology Studio, University of Washington Institute for Hazards Mitigation Planning and Research, Department of Urban Design and Planning

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EXECUTIVE SUMMARY

Introduction and Background

Kimball Creek, a tributary of the Snoqualmie River, and the Snoqualmie River itself surround the City of Snoqualmie. Kimball Creek, together with its wetlands and tributaries, shapes the physical landscape of the City of Snoqualmie. The stream corridor winds through the community's parks, neighborhoods, and backyards on its path to the Snoqualmie River. While much research has been conducted to determine Snoqualmie River's ecological health and flooding risk, little attention has been focused on Kimball Creek. Despite the fact that the length of the creek is within the city's urban growth area, the creek is not recognized as a community asset; many residents of the city may not even realize that the creek exists. The waters of Kimball Creek have relatively high levels of fecal coliform, are surrounded mostly by blackberries, flood often, and are nearly inaccessible to the residents of the City of Snoqualmie.

This project considers Kimball Creek to be an unexplored opportunity for the City of Snoqualmie. Ideally, this document and the vision within it will serve as a starting point for a broad, community-based planning process focusing on the corridor as an asset.

Responding to ecological, flood risk, and human use aspects of Kimball Creek, this document suggests measures of action that will lead to achieving the vision of the creek as an amenity for the entire community. Specific objectives for the creek include habitat restoration, water quality improvement, and flood safety. Overall, the project objective is to integrate Kimball Creek more deliberately into the community that surrounds it, making it a more visible, accessible, safe, and healthy resource for the people of Snoqualmie.

Work products include stream corridor and ecological maps depicting land cover and vegetation types, riparian buffer and bank conditions, corridor access points; the 10, 100, and 500 year flood event levels; recommendations for risk reduction and stream restoration; identification of restoration and management alternatives/opportunities for the Kimball Creek corridor, including a catalog and description of potential actions.

A Vision for Kimball Creek

The Kimball Creek corridor presents an opportunity for the City of Snoqualmie to think critically about its future. The City will continue to grow and develop in coming years. Without careful planning, this growth could negatively alter the community's sense of identity. The vision described in this document is meant to be the beginning point for a community effort to address the Kimball Corridor as an asset for Snoqualmie's future development. Through a concerted and deliberate planning effort, the Kimball Creek corridor can become an amenity for the entire community. Kimball Creek can be:

- A healthy, diverse ecosystem that provides habitat for wildlife even within a relatively urban setting. Through restoration, the creek would be cleaner, clearer, and colder, improving habitat for trout and other species.
- A focus of community involvement efforts, as volunteers come together to restore stability to the creeks banks and riparian habitat, and maintain trails that provide access to the creek.

Kimball Creek would be an ideal tool for educators, youth and nature enthusiasts seeking an outdoor laboratory in a nearby wetland stream system.

- An accessible, integrated unit of the Snoqualmie community, and a place where residents and tourists can explore the scenic beauty of the area. Loops trails would connect existing trails to the Kimball corridor and the downtown core, creating opportunities for recreation while providing access to the creek's natural habitat.

The following sections summarize some of the more pressing issues surrounding Kimball Creek and its development, providing appropriate actions to address these issues and move toward the achievement of the vision described above.

Stream Ecology

The Kimball Creek corridor has been significantly modified by development. The creek follows a historic meander of the Snoqualmie River, and drains wetlands, seeps, and streams throughout its length. Its history is characterized by flux, as its drainage is subjected to small-scale and large-scale flood events that alter the corridor, vegetation, and flow of the creek. Development has modified the structure and function of the stream corridor and the surrounding landscape.

This report assesses the condition of the Kimball Creek corridor and identifies areas where actions can improve the health of the stream. Restoration work along the stream corridor cannot hope to achieve pre-development conditions. However, restoration of various structural elements and ecological processes can improve the water quality, wildlife habitat, and overall ecological value of the stream corridor. Restoration proposals in this report include improvements to the landscape, to the riparian corridor, and to the active channel of the stream.

Water Quality

Historic water quality conditions in Kimball Creek are difficult to assess due to the lack of data collected on past stream conditions. Interviews with local residents indicate that Kimball Creek has shown a dramatic decrease in perceived water quality over the past 10 to 15 years, with the most noticeable decline in turbidity, or stream clarity. Comparison of aerial photography from 1949, 1971, and 2001 shows that the watershed has been subjected to development pressures and an associated decrease in forest and vegetation cover along the banks of Kimball Creek for at least 50 years. The loss of vegetative buffers along the Creek is often associated with declines in water quality.

Following are current measures of Kimball Creek's water quality:

- Turbidity measures an average of 39.42 Nephelometric Turbidity Units (NTU) along the creek. (A clear flowing mountain stream is generally below 5.)
- Four out of the six test sites show fecal coliform numbers that could be harmful to people. Kimball Creek is in violation of the State Water Quality Standards for fecal coliform.
- Dissolved oxygen levels along Kimball Creek vary from test site to test site, but are generally inadequate to support fish populations.

Septic Systems

Aging septic systems (particularly in the Williams Addition) may be contributing to fecal coliform in Kimball Creek. Prevention of septic system failure should be addressed prior to development to prevent contamination of water sources. Steps that may be taken include: community education, setbacks from surface water and wells, stringent regulations for septic system siting, and large lot zoning. An initial determination of homes contributing directly to the water quality problem of Kimball Creek could be performed by providing dye tests to determine status of home septic systems.

Stormwater Management

While sources of sediment in Kimball Creek remain unidentified, the high turbidity measures are likely a combination of multiple non-point sources. Development practices in the watershed are probably contributing to sediment loads in the creek. Requiring new developments in the watershed to not simply divert storm water, but to treat and release at a rate that mimics natural base flows will increase the amount of water traveling through the system and increase the dilution and flushing rates of the Creek.

New construction in the Kimball Creek watershed should be closely monitored to insure compliance with all existing King County Storm Water Management practices.

Flooding Risk

Kimball Creek does not present a flood hazard on its own; however it does provide a corridor for overbank floodwaters from the Snoqualmie River. This results in a relatively significant risk of flooding for residents, especially those with homes near the confluence of Kimball Creek and the Snoqualmie River. Federal Emergency Management maps of the 100 year floodplain and the floodway do not adequately represent this pattern of flooding along Kimball Creek. Homes in the floodplain that are not elevated have suffered repetitive damages during the frequent floods in the area. Furthermore, floodway regulations, which restrict all new construction and do not allow for substantial improvement or rebuilding of damaged homes, present a hardship to the many Snoqualmie residents who own homes in the floodway overlay zone.

Split Floodway

Consider the feasibility of a split floodway, with the main conveyance channel along the Snoqualmie River, and a narrower channel along Kimball Creek. This land use change could open more land for development in the city's core, most of which is currently zoned as "floodway overlay zone." A split floodway could also limit development in the path of floodwaters as they have been documented, thereby more fully protecting life and property along Kimball Creek. The split floodway would preserve Kimball Creek as a corridor, protecting it permanently from future development, and, over time, opening more of the creek for public access and open space.

Elevation of Homes

Continue to encourage residents to elevate homes to above the base flood level, targeting especially those residents in the most frequently flooded areas along Kimball Creek. This is one of the most effective flood mitigation strategies available to those with homes in the floodplain.

Lot Buyouts

Continue to target repetitive loss homes for purchase. Strategically select those lots that would contribute most to the public good, and to maintenance of a corridor for public access and ecological integrity along Kimball Creek. Those include:

- *Parcels bordering the creek.* Public ownership of these parcels would provide further points of access to Kimball Creek, space for trails, and closer control of bank stability and habitat integrity.
- *Parcels adjacent to existing buyouts.* Contiguous plots would provide larger spaces for public parks and creek access.
- *Parcels served by septic systems.* Many of the septic systems in the area are older and may be in danger of failure. Reducing reliance on septic systems could have a positive effect on groundwater and stream water quality.

First Floor Elevation Database

Update and complete the first floor elevation database (with data usable in a GIS format) to prioritize those homes that should be targeted for future elevations and/or buyouts.

Human Use and Access

Kimball Creek is a community treasure, and should be considered as such. Its entire watercourse, from headwaters to mouth, lies within the city's urban growth area. Wrapping around the city, it is inextricably linked to the biological health of the region. The creek's dynamic relationships with biological and geological processes, combined with its location in the community, present major opportunities for the city of Snoqualmie. Currently, however, most of the creek runs through private property; the public can only access the creek from the few, small home buyout lots, at city and county right of ways, and at two parks (the Kimball Creek Nature Trail and Meadowbrook Park). At all of these locations, blackberries and other foliage make approaching the creek banks a challenge.

The creek could become an important part of the Snoqualmie community. First, the creek can become an important educational tool for communicating information about flooding events and creekside ecology. Second, the creek's location can be used to create pedestrian connections to the various features the Snoqualmie region has to offer.

Citizen Committee

A citizen's panel or committee should be created with the purpose of involving residents, area homeowners and outdoor enthusiasts in planning for the future use of the creek. This group would oversee a wide range of activities, including organizing volunteers, fund raising, outreach to local schools, and educating and gathering input from the public. The group could also take a leadership role in designing creekside trails and parks. The underlying goal of these activities would be for the group to strike a balance between the needs of the public and the neighborhoods surrounding the creek with efforts to preserve and enhance the creek's ecological integrity.

Increase Public Access to Creek

Provide public access to creek, augment existing publicly owned lands, and strengthen positive public awareness for creek. This can be accomplished through strategic lot buyout, as outlined above: target parcels along the watercourse at high flood risk and that could become good locations for future parks or facilitate the expansion of existing parks. Increase positive public awareness for the creek through the creation and expansion of park space. Increase public ownership along creek at strategic points.

Create a Citywide Trail System

Create a citywide pedestrian, bicycle, and possibly equestrian trail system. Use the creek as a pedestrian path connecting the various features of Snoqualmie, and linking existing trails to the Kimball corridor. This would provide further public access, and add to public awareness of the creek as an asset.

The Future of Kimball Creek

All of these actions together could positively affect not just Kimball Creek, but the shape of the City of Snoqualmie in the years to come. The City is projected to grow rapidly; protecting open space and managing development within the urban growth area will help the city to maintain its rural character through the changes in infrastructure necessary to support a growing population. Planning for Kimball Creek as an asset now can be an important step in planning for a livable City of Snoqualmie in the future.

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CHAPTER 1: INTRODUCTION AND BACKGROUND

Kimball Creek, a tributary of the Snoqualmie River, and the Snoqualmie River itself surround the City of Snoqualmie. Kimball Creek, together with its wetlands and tributaries, shapes the physical landscape of the City of Snoqualmie (please see "Locational Map" in Appendix A). The stream corridor winds through the community's parks, neighborhoods, and backyards on its path to the Snoqualmie River. While much research has been conducted to determine Snoqualmie River's ecological health and flooding risk, little attention has been focused on Kimball Creek. The creek is not recognized as a community asset, and many residents of the city may not even realize that the creek exists. The waters of Kimball Creek have relatively high levels of fecal coliform, are surrounded mostly by blackberries, flood often, and are nearly inaccessible to the residents of the City of Snoqualmie.

Document Organization

This document describes Kimball Creek in its current state, focusing on three major components of the corridor: ecological condition, flood risk, and human use patterns. Chapters 2 – 5 describe the condition of the Kimball Creek corridor in regard to each of these topics:

Chapter 2: Stream Ecology

Kimball Creek's current habitat condition is less than ideal. Both its turbidity and its temperature are too high to support a significant fish population. Its banks are vegetated primarily with blackberries, and its riparian zones don't support a wide range of habitat.

Chapter 3: Water Quality

Kimball Creek has high levels of fecal coliform bacteria, turbidity, and elevated water temperatures.

Chapter 4: Flooding Risk

Homes near Kimball Creek's mouth at the Snoqualmie River are among the most frequently flooded homes in King County. Kimball Creek plays a complex role in flooding in the valley; it floods mostly as a result of backup water from the Snoqualmie River near the confluence, but also channels overbank water from the Snoqualmie upstream. Risk along this historic meander channel is significant for property owners, especially those whose homes are not elevated. Many homeowners have experience repetitive loss on their properties.

Chapter 5: Access and Human Use

Kimball Creek flows almost entirely through private property; public access points are currently limited and under advertised. Few people use Kimball Creek for recreational or educational purposes despite the fact that much of it is within the Urban Growth Area of the city.

This final section, Chapter 6, uses the analysis from Chapters 2 – 5 as a basis for further suggested action in the Kimball Creek corridor. Chapter 6 describes a vision for Kimball Creek as a community amenity, focusing on its potential as an integral part of the landscape of the City of Snoqualmie. This chapter suggests first a community planning or visioning process for the corridor, and then presents action items that would be appropriate starting points for groups interested in improving the current state of the area.

Project Purpose and Objectives

This project responds to each of the issues discussed above, forwarding a vision of Kimball Creek as a community asset, and suggesting measures of action that will lead to achieving that vision. Specific objectives for the creek include habitat restoration, water quality improvement, and flood safety. Overall, the project objective is to integrate Kimball Creek more deliberately into the community that surrounds it, making it a more visible, accessible, safe, and healthy resource for the people of Snoqualmie.

While not an explicit objective of the project, several of its components would serve to build community involvement and capacity while raising the visibility of the creek through their implementation. Bank and habitat restoration projects could provide opportunities for community involvement and volunteerism. The loop trail could provide recreational opportunities for residents and enhance existing tourist infrastructure. Habitat restoration and clean water objectives might encourage trout spawning, bringing further opportunities for residents and tourists.

This project has been completed in conjunction with a graduate studio course at the University of Washington Institute for Hazard Mitigation. As such, it fulfills the additional objective of providing learning experiences for graduate students in Urban Planning and Water Resources Engineering. The principal goal of the course is to equip students with the professional and conceptual tools necessary to implement and develop long-term floodplain management policies within the context of sound science. More specific educational outcomes include an understanding of stream science and management principles from an ecology and risk based perspectives, and an ability to translate these principals into long-term sustainable development policy. All course work and research was overseen by University of Washington professors with expertise in hazard mitigation and stream ecology.

Philosophy

The foundation of the analysis in this report is an understanding of Kimball Creek as an ecological unit within an urbanizing human system. The approach is holistic, recognizing that Kimball Creek is a natural resource that has been, and will continue to be impacted by development. Analysis addresses those impacts by integrating biology, hydrology, and risk management into a plan for Kimball Creek that will maximize its potential as part of the larger human habitat of the City of Snoqualmie. To achieve an appropriate balance between the human and natural components of the study area, this study recommends improvements to water quality and natural habitat while reducing the risk to life and property from flooding. In this philosophy, ecological goals are primary; other recommendations address crucial community issues while supporting an overall vision that relies upon the healthy habitat of Kimball Creek.

Methods

After determining project philosophy and goals, researchers assumed analytical lenses including biology, hydrology, policy, and human use. Specific methodology varied somewhat from lens to lens, and further detail will be provided in each chapter. In general, topical research was compiled from existing studies and documents as well as from original sources (including interviews and field visits). Areas of potential correlation and/or conflict were then discussed with the broader goal of determining the most beneficial use for Kimball Creek. The work product includes descriptions of existing conditions, problems and opportunities, and recommendations for each topic area (stream ecology, water quality, flooding, and community use). Map products mostly involve GIS mapping, though some original drawings and Photoshop alterations will also be included. Appendix E describes GIS methodology more thoroughly.

The project study area encompasses the 200 feet on either side of Kimball Creek; if a property parcel falls partially into the 200-foot area, the entire parcel is considered as part of the study area (see "Study Area" map in Appendix A). Within the study area, the project considers natural habitat, water quality, flood risk, and human use (including land use and regulations). A larger unit of analysis extended this corridor back from the creek to surrounding arterial streets. This larger unit was designed to reflect the areas that contribute ecologically and hydrologically to the Kimball Creek corridor, and also to reflect neighborhood relationships with the creek. At an even broader scale, some attention was necessarily given to flooding issues as they affect the entire floodplain within the city and its urban growth area.

Work Products

- Stream corridor ecological maps for Kimball Creek depicting the following Geographic Information Systems (GIS) layers:
    - Study area boundaries
    - Land cover, vegetation types, and land uses
    - Riparian buffer and bank conditions
    - Corridor access points, including visual access
- A map depicting 10, 100, and 500 year flood event levels throughout the Snoqualmie River Valley.
- Assessment of risks attributable to Kimball Creek within the larger floodplain environment of the Snoqualmie River.
- Recommendations for risk reduction and stream restoration.
- Identification of restoration and management alternatives/opportunities for the Kimball Creek corridor, including a catalog and description of potential actions. These include:
    - Land use options for the corridor
    - Consideration of development density issues
    - Septic system versus sewerage issues
    - Cooperative programs to involve landowners in stream restoration.

Location

Kimball Creek is located largely outside of the City of Snoqualmie limits yet inside the City's Urban Growth Area (UGA). The creek's headwaters are in the south end of the city in Meadowbrook Park. From there it flows westward into an undeveloped area of the city that has been zoned as constrained residential because it is situated on a large expanse of wetlands. As the creek flows towards the west it travels out of city limits and starts to flow northward. This section of the creek flows through unincorporated King County in the area referred to by the comprehensive plan as the Snoqualmie Hills Planning area. The neighborhoods of Johnson Heights and the Williams Addition are included in this planning area.

Two unnaturally straight segments of the creek in this planning area indicate that the region has had a long history of managing the Kimball Creek's periodic flooding. Documentation exists of historic channel manipulation. In this section as well as others the course and drainage of Kimball Creek may have been affected by dredging to drain wetlands through the Kimball/Coal Creek corridor. Further along the northward stretch of the watercourse, the creek reenters the city in the Johnson Slough neighborhood. At this point natural meanders reoccur and the creek starts flowing in an eastward direction where it crosses under State Route 202 and then enters into the Snoqualmie River.

Along its length, Kimball Creek receives tributary flow from the streams, seeps and wetlands to the south and west of Snoqualmie, including Rattlesnake Ridge and the Coal Creek drainage.

Community Context

The City of Snoqualmie is proud of its rural identity; numerous hobby farms, working farms, green spaces and a wealth of natural beauty surround the city's downtown core. The city's vision statement in the Snoqualmie Vicinity Comprehensive Plan (SVCP) calls for the preservation of this small-town feel, and the policies found in the SVCP offer strategies and implementation plans to achieve this goal. Additionally, the city has used its location on the 100-year floodplain as a tool to preserve its rural identity, restricting development to 1 unit per 5 acres throughout the 100-year floodplain. This policy not only reduces the number of homes exposed to flood risk but preserves more open space and large lots within the city. Outside of the city limits, the King County Snoqualmie Valley Community Plan (KCSVCP) supports these goals by setting a one unit per five-acre restriction as well. The result is a dense network of small pre-1937 parcels closer to the downtown and larger five acre parcels further away. Residents use these five-acre parcels mainly for residential uses, as well as for farming and livestock operations.

Like the rest of the Central Puget Sound Region, Snoqualmie is expected to grow quite dramatically in the next twenty years. The 2000 census reported 1,631 people living in 656 housing units at a density of 317.2 people per square mile and 127.6 housing units per square mile for the city of Snoqualmie. Population projections for the city of Snoqualmie in the year 2014 range from 8,415 at the low end to 10,040.

The majority of this new growth is being planned for the Snoqualmie Ridge. The Ridge is a new Weyerhauser development project three miles to the west of historic/downtown Snoqualmie that has sprung up quite rapidly. Just two years after the 2000 census, the Snoqualmie Ridge development has already caused the city's population to double. Although most of the construction is single-family homes, there is a mixture of condominiums and townhouses. The ridge was also zoned for mixed use and has burgeoning retail center. Other amenities include the city's wide range of recreational, outdoor, and tourist opportunities in its open spaces and parks, its golf courses and trails, and such tourist opportunities as Snoqualmie Falls and the Historic District.

Even with the large population projections for the Snoqualmie Ridge, the rest of Snoqualmie is still expected to absorb between 1700 and 3500 more citizens. Clearly, rapid growth and the attendant threats to rural identity are issues that have begun and will continue to face the Snoqualmie Valley.

CHAPTER 2: STREAM ECOLOGY

Ecological Function of Kimball Creek

Creeks and rivers are those portions of the landscape that are shaped by ongoing fluvial processes and also by flooding[1]. They include both active channels and surrounding landscape.

The Kimball Creek corridor has been significantly modified by development. The creek follows a historic meander of the Snoqualmie River,[2] and drains wetlands, seeps, and streams throughout its length. Its history is characterized by flux, as its drainage is subjected to small-scale and large-scale flood events that alter the corridor, vegetation, and flow of the creek. With this disturbance regime and its location in the alluvial floodplain of the Snoqualmie, the creek's corridor would be expected to support an early to mid-successional stage of vegetation characterized by native shrubs and deciduous trees such as red alder and black cottonwood; if there is extended time between disturbance events, later-successional vegetation such as coniferous trees would be expected to develop along the creek. Historic conditions have been altered along the creek and throughout the landscape by development. This has impacted the structure and function of the riparian corridor, with impacts to such functions as shading and temperature regulation, wildlife habitat, nutrient contribution, and water filtration and storage capacity.

To comprehensively assess the current ecological function of Kimball Creek and the surrounding landscape, extensive field inventories and analysis are necessary. Our evaluation of the ecology of the creek and its surrounding landscape was based on aerial photographs taken in 2001, and a single field survey conducted on November 15, 2002. The purpose of the recommendations is to suggest a specific management *direction* to maintain and enhance the ecological function of the creek and its surrounding landscape.

Unlike many terrestrial ecosystems, creeks, streams, and rivers are linked along a network[3]. Evaluation of the ecological function of the creek must include the active channel and account for physical and biological processes that shape the landscape. As witnessed by channelization of a section of the creek and clearing of large forest patches, we assume that the creek and surrounding landscape have to some extent diverged from natural presettlement conditions (please refer to "Generalized Landscape Surrounding Kimball Creek" map in Appendix E). The extent of this divergence is unknown at this time. We define the following objectives for the creek and its surrounding landscape:

> -*Maintain and enhance creek structure and function*
>
> -*Maintain and enhance native diversity of plant and animal habitats and communities within the active creek channel, adjacent riparian area and surrounding landscape.*

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[1] Hulse and Gregory 2001.
[2] Perkins, S. J. 1996. Channel Migration in the Three Forks Area of the Snoqualmie River. King County Department of Natural Resources, Surface Water Management Division, Seattle, WA.
[3] Hulse and Gregory 2001.

Assessment and Discussion

Surrounding Landscape

Landscape-wide approaches to environmental resource management are rare, however this context is increasingly seen as important. In forested landscapes, forest patch size is important in reducing edge effects, which impact species such as birds (please refer to "Additional Information" in Appendix F). From field observations we determined that the landscape surrounding the creek probably contains viable wildlife habitat in the largest patches of undisturbed forest (refer to "Streamside Conditions" and "Land Cover" maps in Appendix E). Our cursory observation of approximately 3 km^2 of pasture/agriculture landscape found it to be species poor in regards to wildlife and flowering plants.

Riparian Area

Riparian areas are complex ecosystems vital to the protection of creeks, streams, and rivers. One of the guiding principles used to assess creek function and its riparian area as well as the surrounding landscape was the construction of ecological maps and the use of a management indicator species (MIS).

We constructed ecological maps from aerial photography to facilitate in the determination of vegetation and habitat along the creek, as well as aid in understanding its landscape context (please refer to "Land Cover" and "Streamside Conditions" map in Appendix E). The land cover map delineates separate land cover classes along the creek . Land cover classification was developed from aerial photography and the use of a stereoscope. Once a classification was constructed, digital photography in conjunction with a Geographic Information System (GIS) database (Arcview: ESRI, Redlands, CA) with layers provided by the City of Snoqualmie was used for representation and spatial analysis. These data were augmented via ground-truthing to enhance accuracy (see Appendix E for additional GIS methodology). The landscape ecological map delineates the main components of the landscape (e.g., urban, suburban, pasture, large patches of native vegetation).

Ideally, a MIS is a species whose presence, abundance and breeding success is sensitive to changes in a landscape, as well as being easy, cost effective and statistically appropriate to monitor.[4] MIS candidates usually include sensitive species because it is thought that the sign of stress to an ecosystem will occur at the population level, affecting especially sensitive species.[5] In addition, keystone species or umbrella species are often chosen as MIS. Often in larger landscapes a suite of MIS is monitored, each reflecting a different spatial scale. This is important because smaller organisms and processes may act independently of larger habitat elements.[6] We chose salmonids (trout) as an indicator for the health of the creek and its riparian area. Cutthroat and rainbow trout, mountain white fish and sculpins probably occupy the creek, and reaches above city boundaries may support spawning habitat.[7]

It is often desirable to measure the habitat itself, either as an alternative to or to supplement to an MIS. For example, key habitat and vegetation features are relevant to mid and large size wildlife

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[4] Walsh et al. 2001.
[5] Odum 1992.
[6] Opperman, pers. comm.
[7] Opperman pers. comm.

species and play a role in structuring the ecosystem (e.g., large trees, snags).[8] At the landscape scale, structure-based indicators such as complexity and composition, connectivity and heterogeneity can be used to reflect landscape biodiversity or health.[9,10] This strategy can be desirable because structural features are static and can be remotely sensed.

In general, salmonids including trout require cold, clear and clean water[11]. Because of the small size of the creek, and its low flow, adjacent land use dominates its function [12]. Given this context, a well functioning riparian area is probably the most important factor in maintaining cold, clean, and clear conditions [13][14][15] (For further information please refer to "Additional Information" in Appendix F). Riparian buffers should consist of, "predevelopment riparian plant community – usually mature forest."[16] Buffer width should be a minimum of 30 m.[17] In their review of 38 buffer width investigations, Johnson and Ryba (1992) of King County Surface Water Management Division found that, "buffers less than 10 m provide little if any [ecological] functions…buffers of 15 to 30 m provide minimal maintenance for most functions, [and] buffers greater than 30 m appear adequate for most functions." A buffer width of 30 m is necessary for maintenance of salmonids and 200 m for maintenance of terrestrial wildlife that depend on the riparian area.[18] Riparian buffer widths were documented at indicated locations (please refer to "Widening the Riparian Buffer" map in Appendix E).

Shading and Creek Temperature

Temperatures of 10.0 - 13.9 C are the preferred temperature range for salmonids.[19] Temperatures are regulated by factors such as creek flow, width and depth and vegetative shade. Living trees provide shade that keeps water temperatures cool.[20] Large woody debris can also function for cover and shade including shade for juvenile and adult salmonids.[21]

Management of creek temperature through manipulation of riparian vegetation is a cost-effective solution. Riparian vegetation is effective in shading if it blocks sunlight before it reaches the stream surface. We used height of vegetation adjacent to the creek as a criteria based on stream width and summer sun angles. Although variable depending on the creek section in question, a minimum vegetation height of 15 m is needed to provide adequate shading. Vegetation height was documented at indicated locations (refer to "Land Cover" Map in Appendix E).

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[8] Simberloff, 1998.
[9] Noon et al 1997.
[10] Lindenmayor et al. 2000.
[11] C. McGrath pers. comm.
[12] Bolton and Shelborn.
[13] Lynch et al. 1985.
[14] Steinblums et al. 1984
[15] Plum Creek Timber Company Habitat Conservation Plan.
[16] The Federal interagency Stream Restoration Working Group 1998, pg. 8-12.
[17] Johnson and Ryba 1992.
[18] Johnson and Ryba 1992.
[19] Snohomish River Basin Salmonid Recovery Technical Committee 2002.
[20] Bolton and Shelborn
[21] Bisson et al. 1987.

Vegetation along the creek bank is important for stability and erosion control (please refer to “Additional Information” in Appendix F). Existence of bank vegetation was documented at indicated locations (refer to “Land Cover” and “Streamside Conditions” maps in Appendix E).

Active Channel

Riffles and pools with a stone substrate (creek bottom), and large woody debris are important habitat elements for the maintenance of salmonid populations and were observed at these locations (please refer to “Land Cover” and “Streamside Conditions” maps in Appendix E). Riffles and pools were uncommon along the creek however, due to its low flow. Natural creeks have meanders and development has eliminated meanders along a section of the creek as indicated.

Standout examples of clear running tributaries of the creek were Coal Creek and the waterway associated with the casino. Coal Creek was observed to have abundant riffles, a freestone bottom, and riparian vegetation comprised of dense alder at this location.

Options for Stream Ecology Improvement

The following suggestions define different areas of the landscape that may require different types of management.

Knowledge of pre-disturbance conditions is important for any ecological management project because they help define what future trajectory is needed. In the case of our study, it is difficult, if not impossible, to reconstruct past function due to the paucity of data. However, analysis of early aerial photography indicated that modification of Kimball Creek occurred prior to 1944 and some clearing of surrounding forest had occurred. Old meander-scars were observed for the Snoqualmie River, but not for the creek.

Although we have limited baseline data important for assessing past creek function, we tentatively suggest the following management interventions (Please refer to “Management Interventions,” “Widening the Riparian Buffer,” and “Non-Native Vegetation” maps in Appendix E for the following suggestions). Management projects should be part of an environmental education effort that involves the local community especially young students.

Surrounding Landscape

- Increase native biodiversity in the surrounding landscape.

  -Agricultural lands should be managed to increase biological diversity by planting strips of native plants along property and field boundaries and controlling weeds. Wildlife surveys are needed to determine what bird species nest on these lands such that specific management strategies can be designed to mitigate associated human impacts.

  -Increase the interior area and reduce edge of small forest patches as indicated.

Riparian Area

- Widen the riparian buffer at indicated locations.
- Decrease exotic vegetation, increase native vegetation within the riparian area at indicated locations.

- Increase stream shade by establishing mature conifer and deciduous at least 15 m in height at these locations.

Active Channel

- Modify the linear section of the creek and reestablish some degree of historic creek morphology by placing large woody debris in stream at indicated locations.
- Enhance in-creek habitat structure by placing large woody debris at indicated locations and place rocks to create pools.
- Revegetate and stabilize bank with native plants and rootwads at indicated locations.
- Protect Coal Creek and the waterway associated with the casino (particularly Coal Creek as an outstanding examples of a clear running tributary with abundant riffles, a freestone bottom, and buffer comprised of dense alder). This creek should be protected from negative impacts such as recreation and development.

CHAPTER 3: WATER QUALITY

This section will summarize historic, existing and potential future water quality trends in Kimball Creek, and suggest community responses for water quality improvement.

Past Conditions

Historic water quality conditions in Kimball Creek are difficult to assess due to the lack of data collected on past stream conditions. The earliest available data is from a University of Washington study in 1993. Significant anecdotal evidence of stream conditions exists, and can be acquired from community members; however the extent to which quantitative analysis can be made from this evidence is also limited.

Interviews with local residents indicate that Kimball Creek has shown a dramatic decrease in perceived water quality over the past 10 to 15 years.[22] The most noticeable decline in water quality has been with regard to turbidity. Improvements in the clarity of Kimball Creek waters would have the greatest effect on the public's perception of the water quality in the creek.

Aerial photography of the Kimball Creek area provides the best sense of the stream conditions over the history of the town. Comparison of aerial photography from 1949, 1971, and 2001 shows that the watershed has been subjected to development pressures and the associated decrease in forest and vegetation cover along the banks of Kimball Creek for at least 50 years. The loss of vegetative buffers along the Creek is often associated with declines in water quality[23] (Please refer to "Land Use" map in Appendix A.)

Present Conditions Overview

Water quality conditions in Kimball Creek have been monitored sporadically since 1993. Four different studies of water quality have been performed and were reviewed for this report:

1. Lane, C.M., 1993. Snoqualmie River water quality model: A predictive tool linking land use changes to water quality. University of Washington, Department of Civil and Environmental Engineering, Seattle, WA.
2. Peterson Consulting Engineers, Inc. 1998. Draft Master Drainage Plan for the Falls Crossing Master Planned Community. Puget Western Inc, 1998.
3. Associated Earth Sciences, 1999. Unpublished water quality monitoring data. October 6, 1999.
4. City of Snoqualmie, 2001. Unpublished water quality data by Vern Allamond, City of Snoqualmie.

The four studies above utilized the same sampling locations (refer to "Water Quality Test Points" map in Appendix A). The results from the multiple studies are averages in Table 1 below for six sampling stations during base flow conditions.

[22] Johnson, Colleen. Interview. 30 October, 2002. Fletcher, Randy "Fuzzy", Mayor, City of Snoqualmie. Interview. 20 October, 2002.
[23] Dunne and Leopold, p704

Metric / Site	A	D	E	F	H	J
Turbidity (NTU)	11.6	61.7	3.9	19.9	45.3	94.1
Fecal Coliforms (# / 100ml)	>63	>3113	>89	>338	>178	>157
Dissolved Oxygen (mg/L)	7.8	2.0	9.7	7.5	4.1	3.3
Temperature (°C)	10.7	10.7	9.8	10.6	11.2	11.3
pH	6.9	6.5	7.0	6.9	6.5	6.4
From: *Kimball Creek Water Quality Inventory and Assessment and Habitat Restoration Project*, Final Report, City of Snoqualmie, Dec 28.2001						

Table 1: Water quality measurements along Kimball Creek

Analysis of Water Quality

The state of Washington has established water quality standards for surface waters in order to maintain satisfactory public health and public enjoyment. Additionally, standards are intended to assist in the propagation and protection of fish, shellfish, and wildlife. These rules, set forth in the Washington Administrative Code (WAC173-201A) are summarized in Table 2 below.

The different classes of surface waters are ascribed certain characteristic uses that are typically associated with waters of a said class. Most notable of these characteristics for Kimball Creek is recreational contact. Classes AA and A are typically associated with primary contact recreation, while Classes B and C are associated with only secondary contact recreation. This metric, while seemingly subjective, is useful for determining a stream's water quality as perceived by the community. The more technical definitions of water quality standards in Table 1 can be explained in terms that are more reflective of the perception one would get when encountering these conditions in an urban stream such as Kimball Creek.

Turbidity is a measure of the clarity of the water and is measured in Nephelometric Turbidity Units (or NTU). A clear flowing mountain stream will typically have a turbidity below 5 NTU, whereas a stream that looks like coffee with cream will have a turbidity of greater than 100. As described in Table 1 above, the average of water samples taken at six locations along Kimball Creek is 39.42 NTU.

Fecal coliforms are indicator organisms used to monitor the presence of harmful pathogens in a stream. While the coliform bacteria themselves are not harmful, their presence is taken to imply that a stream has been contaminated by some sort of animal wastes. Levels of contamination are measured by growing a lab culture and counting the number of bacteria present in 1000 ml of stream water. Numbers below 50 are considered pristine, while values greater than 200 are considered harmful. People are generally warned to avoid contact with waters having coliform levels greater than 200. Measurements of fecal coliform presence in Kimball Creek show levels that, at one tested location, exceeded 3000; this is drastically higher than safe levels. Four out of the six test sites on Kimball Creek show numbers that could be harmful to people. Kimball Creek is in violation of the State Water Quality Standards for fecal coliform as outlined in Table 2 below.

Dissolved oxygen is literally the amount of oxygen present in the waters. Fish and other aquatic vertebrates require high dissolved oxygen levels to survive. Trout will thrive in water with oxygen levels above 9 parts per million (ppm). Excessive nutrients flowing into a body of water, (from lawn fertilizer or septic effluent) can cause algae blooms that deplete the water of oxygen.[24] Dissolved oxygen levels below 2 ppm are lethal to trout, while levels below 5 will typically cause to fish to move elsewhere in the stream seeking better water quality. As described in Table 1 above, dissolved oxygen levels along Kimball Creek vary from test site to test site, but are generally inadequate to support fish populations.

Selected Washington State Water Quality Standards (additional standards also apply)

Water Body Class	Turbidity	Fecal Coliform levels	Dissolved Oxygen	Temperature	pH
Lake	Shall not exceed 5 NTU over background	Geometric mean value shall not exceed 50 org/100 mL, with not more than 10 percent of the samples exceeding 100 org/100 mL.	No measurable change from natural conditions	No measurable change from natural conditions	No measurable change from natural conditions
AA "Extraordinary"	Shall not exceed 5 NTU over background when background is less than 50 NTU, or have >10% increase	Geometric mean value shall not exceed 50 org/100mL, with not more than 10 percent of the samples exceeding 100 org/100 mL	Shall exceed 9.5 mg/L	Shall not exceed 16 ° C	Shall be between 6.5 and 8.5
A "Excellent"	Shall not exceed 5 NTU over background when background is less than 50 NTU, or have >10% increase	Geometric mean value shall not exceed 100 org/100 mL, with not more than 10 percent of the samples exceeding 200 org/100 mL.	Shall exceed 8.0 mg/L	Shall not exceed 18 ° C	Shall be between 6.5 and 8.5
B "Good"	Shall not exceed 10 NTU over background when background is less than 50 NTU, or have >20% increase	Geometric mean value shall not exceed 200 org/100 mL, with not more than 10 percent of the samples exceeding 400 org/100 mL.	Shall exceed 6.5 mg/L	Shall not exceed 21 ° C	Shall be between 6.5 and 8.5
C "Fair"	Shall not exceed 10 NTU over background when background is less than 50 NTU, or have >20% increase	Geometric mean value shall not exceed 200 org/100 mL, with not more than 10 percent of the samples exceeding 400 org/100 mL.	Shall exceed 4.0 mg/L	Shall not exceed 22 ° C	Shall be between 6.5 and 8.5
Source: WAC 173-201a, 11/18/97					

Table 2: State surface water quality standards

From a comparison of the water quality data in Table 1 and the state water quality classification guidelines in Table 2, a map of the water quality classifications of the reaches of Kimball Creek has been derived (refer to "Water Quality" Map in Appendix A). It should be noted again that the State defines Kimball Creek as a Class A water body. The water quality classification map,

[24] Welch, p304.

however, clearly chows that sections of Kimball creek fall well below the standards set for this designation. The reach from the confluence with the Snoqualmie river to a point near the intersection of 77th and 380th streets and the entire length of Coal Creek are the only sections that actually contain Class A water quality. From 77th and 380th to and including the wetlands immediately east of 384th street are of such a low quality that they should be designated Class C waters. This implies water not fit for human contact, with only secondary contact recreation (such as boating or "aesthetic enjoyment") recommended.[25] Upstream from the wetlands along 384th to the headwaters in the Meadowbrook area the water quality further declines to a level below the Class C designation. There is no officially defined class for waters of this poor quality, meaning it falls below the state standards for "Fair" water quality. This is noted as Class "D" on the water quality map, a designation meant to imply any waters below the Class C standard.

Septic Systems

Preliminary analysis of the sanitary systems in the Kimball Creek basin demonstrates that public sewers serve the majority of the homes in the area (see "Sewer Types" map in Appendix A). However, a cluster of homes along Kimball Creek in the area known as the Williams Addition is served by private septic systems. Due to the age of these systems (installed in the 1950s) and the density of the houses, these systems may not be performing optimally.

Septic system failure may be attributable a number of causes: poor siting with regard to soil characteristics, too many closely-spaced systems, systems located too close to surface water (less than 100 feet), poor installation and maintenance, disposal of improper chemicals, or under-capacity of system.[26] Poor siting and inappropriate density of septic systems are among the leading causes of septic system failure. Failing septic systems pose a public and environmental health risk. Effluent from failing systems contributes nitrogen, phosphorus, and coliform bacteria to ground and surface water.[27] A discussion of causes of septic system failure follows.

Factors Limiting Septic System Performance

<u>Density</u>

The density of septic tanks is limited by the soil's capacity to treat sewage effluent. The U.S. Environmental Protection Agency indicates that densities of more than one system per sixteen acres (or 40 per square mile) present a potential for groundwater contamination.[28] Typical minimum lot size for septic system for one household is one acre, which should account for soil variation, unsuitable areas, and setbacks in most areas.[29] By comparison, the average lot size of the homes within septic systems in the Williams Addition along Kimball Creek is approximately 0.25 acres, far more dense than the level recommended by the EPA.

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[25] WAC 173-201a, 11/18/97
[26] MSU 1997
[27] MSU 1997
[28] Jaffe and DiNovo 1987 p. 113
[29] Cotteral and Norris 1969 in Canter and Knox 1985 p.21

Soil Characteristics

Drainfield performance is related to the following three soil characteristics:[30]

Percolative Capacity	The rate at which effluent is transmitted through the pores of the soil. This should be high enough to transport effluent away from the system at a rate equal to or greater than the rate at which liquid enters the soil. The purified liquid moves away from the drainfield by gravity, percolation, evaporation, and plant uptake and transpiration.[31]
Infiltrative Capacity	The rate at which effluent can enter the soil through the surface where it is applied. This capacity influences the long-term capacity of the drainfield system.
Particle Size and Soil Type	Both of these factors influence percolative and infiltrative capacities. Soil and soil bacteria act as a filter to digest and remove most of the pollutants and bacteria from effluent.[32] Soil texture affects the biological activity in the area of discharge; certain soil types and textures may contribute to the formation of a clogging mat and reduced infiltration.[33]

Table 3 Soil characteristics limiting drainfield performance

The neighborhoods within the 100-year floodplain of the Snoqualmie River are located primarily on young alluvial soils from the Holocene, formed by the meandering of the Snoqualmie River. The soil types mapped in the area of the Williams Addition are the Seattle and the Si soil complexes.[34] The drainage properties of the two soil types are described in Table 4; percolation is mapped on “Soil Percolation Map” in Appendix A.

Property	Si	Seattle
Classification (USDA texture)[35]	Silt Loam	Mucky Peat
Limitations for Septic Tank Filter Fields[36]	Moderate. Flood hazard. Depth to seasonal high water table is usually 2-4 feet for Si soils.	Severe. Flood hazard. Depth to seasonal high water table is usually 0-1 foot for Seattle soils.
Drainage[37]	Moderately well drained	Very poorly drained
Percolation rate	Moderate Water Percolation (0.6 – 2 in/hr)	Slow water percolation (0.06 – 0.2 in/hr)
Water Capacity	High Water Capacity	High Water Capacity

Table 4: Properties of soil types in the Williams Addition

The properties immediately adjacent to Kimball Creek lie in the Seattle Soil complex (including along 381st Street in Williams Addition). The combined effects of slow percolation, a very high seasonal water table, and the proximity to the creek indicate an increased likelihood of a lateral

30 Cotteral and Norris 1969 in Canter and Knox 1985 p. 27
31 Chomowicz, 1991, p. 30.
32 Clackamas County 2002 p. 2
33 Jaffe and DiNovo 1987, p. 112
34 King County GIS database, SOILS layer.
35 Snyder et al., 1973, p.40
36 Snyder et al., 1973, Soil Survey: King County Area, Washington, p. 40 and p. 60-62.
37 The following 3 rows from King County GIS database, SOILS layer

transfer of effluent towards the stream, rather than vertical infiltration to the deeper groundwater. The implication to this situation is that septic effluent is likely to enter Kimball Creek.

Topography, High Seasonal Water Table, and Proximity to Water

Additional topographic and geological considerations for septic system placement include: slope, groundwater level, depth of the soil mantle, location in relation to surface water and streams. Slope and setback distance from natural and built features of the site are key considerations for septic system placement on a site.[38] The King County Soil Survey notes that the percolation rate alone "does not necessarily indicate an acceptable site. Adjoining soils that have a very low percolation rate or proximity to streams or ponds can make the installation of a septic tank inadvisable. Filter fields should be placed where they cannot contaminate water supplies."[39]

Inundation and a high water table (particularly in wet winter months) can reduce the infiltrative capacity of the soil. Shallow water tables are often located near a point of groundwater discharge (where water leaves an aquifer at streams or wetland areas).[40] Winter wet conditions may increase the level of the shallow water tables to inundate septic system drainfields. This impairs the ability of the soil and soil bacteria to process the effluent. Instead, waste-borne bacteria and leachate from the effluent enter the water table. The water table typically follows a hydraulic gradient down towards the point of discharge, facilitating the movement of effluent from a failing system to these discharge points. Bacterial movement in sub-surface water is influenced by local groundwater movement rates and direction.[41]

As noted above, in the Williams Addition not only are homes located in proximity to the creek, but they are located in the Seattle Soil Series where high seasonal water table is within 0-1 feet of the surface. This presents a high risk of water table contamination.

Sediment Loading

Snoqualmie Ridge and Falls Creek developments claim no significant impact to pollution load of Kimball Creek because the majority of the storm water is piped directly to the Snoqualmie River. However this practice, while reducing overall pollutant loading and maintaining a reasonable storm surge flow, also reduces the base flow rate by removing a significant portion of water that might otherwise serve to flush pollutants from the stream. The overall reduction in flow results in a similar or reduced pollutant load, but increased pollutant concentrations.

County ordinances require that "all surface and storm water runoff from a project must be discharged at the natural location so as not to be diverted onto or away from downstream properties."[42] Clearly exceptions from this rule can be made for purposes of mitigating environmental impacts, but the intent of the rule is to minimize the disruption of the natural hydrology of a basin that is normally caused by development.

Occasional periods of high flow in natural streams serve to remove accumulated fine-grained sediments.[43] The diversion of storm waters from the Kimball Creek basin may be responsible for

[38] Canter and Knox 1985 p.21
[39] Snyder et al, 1973, p. 62.
[40] Waller 1989 p. 9
[41] Hagedorn, Hanson and Simonson 1978 in Canter and Knox 1985 p. 66
[42] King County Surface Water Design Manual, section 1.2.1
[43] Dunn and Leopold, p661

a reduction in peak flows and an accompanying accumulation of sediments. The accumulation of fine sediments and lack of regular flushing leads to an overall increase in water turbidity.

Potential sources of sediment to Kimball Creek are illustrated in the "Sediment Issues" map in Appendix A. These sites were identified as parcels within 100 feet of a direct tributary to Kimball Creek, zoned either commercial or residential, and not currently containing a structure. These parcels are likely sites of future construction and should be monitored for compliance with the county's Surface Water Design Manual.

Because the ultimate source of sediment in Kimball Creek remains unidentified, and is likely a combination of multiple non-point sources, non-point source mitigation efforts can be employed to improve water quality. Visual inspection of tributaries during rain events can provide a qualitative analysis of which tributaries are importing high sediment loads. Once identified, these tributaries can be fitted with small sediment traps to prevent sediments from entering the main channel. [44]

Opportunities for Water Quality Improvement

Responding to Septic System Failure

When development occurs in an area with a density exceeding the soil's capacity, there are three alternatives: improve septic system technology, if possible; limit density in the area; or to convert municipal sewer system.

There are various types of on-site sewage systems that have different levels of effectiveness in treating sewage, reducing TSS or BOD, reducing nitrogen, etc. The choice of system varies according to the lot size, topography, climate, and proximity to water sources (groundwater and surface water).[45] Some areas may be so environmentally sensitive that no alternative systems will mitigate risk acceptably.[46]

Sewering is costly to homeowners and to a municipality, but effectively reduce the contribution of effluent to the water table and groundwater. The issue of extending sewer infrastructure is an important growth management concern: the introduction of sewer infrastructure contributes to increased density in these areas because of the high cost of constructing municipal sewer systems.[47] However, in areas where dense settlement and septic failure has already occurred, sewer infrastructure may not induce increased densities. Zoning and existing development can limit density increases in these areas. Extension of municipal infrastructure occurs with incorporation of an urban growth area into a city. In these areas, it is proper under growth management regulations to increase density within a growth boundary.

Prevention of septic system failure should be addressed prior to development to prevent contamination of water sources. Steps that may be taken include:[48]

- Education of community

[44] Riley, A.L. 1998.
[45] Chomowicz, 1991, p. 22-23.
[46] MSU 1997.
[47] Chomowicz, 1991, p. 105.
[48] MSU 1997.

- Establish setback distances from surface water (100 feet or more) and wells (50 feet or more)
- Require connections to sewer where available
- Establish septic system management districts (special assessment, use, or drainage districts) where residents follow pumpout and maintenance schedule
- Develop stringent regulations for septic system siting with regard to environmental constraints
- Institute large lot zoning to ensure enough land for the drainage field
- Establish an aquifer protection area

An initial determination of homes contributing directly to the water quality problem of Kimball Creek could be performed by providing dye tests to determine status of home septic systems. The dye test is easy and low cost. Materials to test 15 homes will cost less than $800.

The City and local residents may investigate partnerships to subsidize testing, repair of septic systems, or extension of sewer services to areas that are experiencing possible septic system failure. Contribution of septic system failure to Kimball Creek may be identified through upcoming water quality testing to analyze sources of fecal coliform bacteria.

Opportunities for Other Actions

Requiring new developments in the watershed to not simply divert storm water, but to treat and release at a rate that mimics natural base flows will increase the amount of water traveling through the system and increase the dilution and flushing rates of the creek. In this case the solution to pollution is dilution; however storm water diversion has reduced the quantity of water available for diluting the pollutants.

New construction in the Kimball Creek watershed should be closely monitored to ensure compliance with all existing King County Storm Water Management practices.

CHAPTER 4: FLOODING RISK

Kimball Creek does not present a flood hazard on its own, however it does provide a corridor for floodwaters from the Snoqualmie River. This results in a relatively significant risk of flooding for residents, especially those with homes near the confluence of Kimball Creek and the Snoqualmie River. Several maps describing general flood patterns along the Snoqualmie are included in this report. The three maps listed below are included in Appendix A:

- "Authorization and Jurisdiction" depicts the Base Flood Elevation and the floodway as determined by the Federal Emergency Management Agency (FEMA). Most of the regulations designed to protect inhabitants from flood damages are based on this map.
- "10, 100, and 500 Year Flood Zones" depicts potential flood levels during 500, 100, and 10 year events. This map was created using flood profile elevations at the confluence of Kimball Creek and the Snoqualmie River.[49] As can be seen in both maps above, the entire length of Kimball Creek is located within the 100 year flood plain of the Snoqualmie River, and much of it would also flood in a 10 year event. Flood observers and residents confirm this fact.[50]
- "1990 Flood Flow" depicts flood flow patterns during the 1990 flood.

To understand Kimball Creek's role in flooding, it is important to first understand its role in the larger floodplain. Aerial photos suggest that the creek occupies a historic meander channel of the Snoqualmie River (as depicted in Figure 2 below). It constitutes a natural low point within the floodplain that draws overflow from the main channel of the Snoqualmie River. The map depicting 10-year flood event levels supports this theory. Much of Kimball Creek as well as the Snoqualmie River would flood in a 10-year event, while the area between the two remains within the 100 year flood level and would be dry in a 10 year event. It is further supported by the observations described in the 1990 Flood Flow Map, which show heavier flows along the Kimball Creek and Snoqualmie River corridors, with lighter flows between the two. In short, Kimball Creek carries much of the flood overflow water during flood events in the Snoqualmie Valley.

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[49] These elevations were determined by FEMA for King County. Using their records of flood elevations at the confluence of Kimball Creek and the Snoqualmie River and GIS modeling, the contour lines were filled throughout the valley to determine the most likely flood patterns at different event levels. Though the valley is relatively flat (with just over 3 feet of elevation difference from river mile 41 to river mile 43), this method creates a map that is less accurate upstream from the confluence than it is near the confluence where measurements were taken. See Appendix A for the FEMA flood profile for the Snoqualmie River. See Appendix E for GIS modeling methodology.

[50] Johnson, Colleen. Personal Interview. 30 October, 2002. AND, The K. McCarty Study, as described in *Snoqualmie River Flood Control Project, Pre-feasibility Investigation Final Report*, Northwest Hydraulic Consultants, Inc. 3 March, 1996.

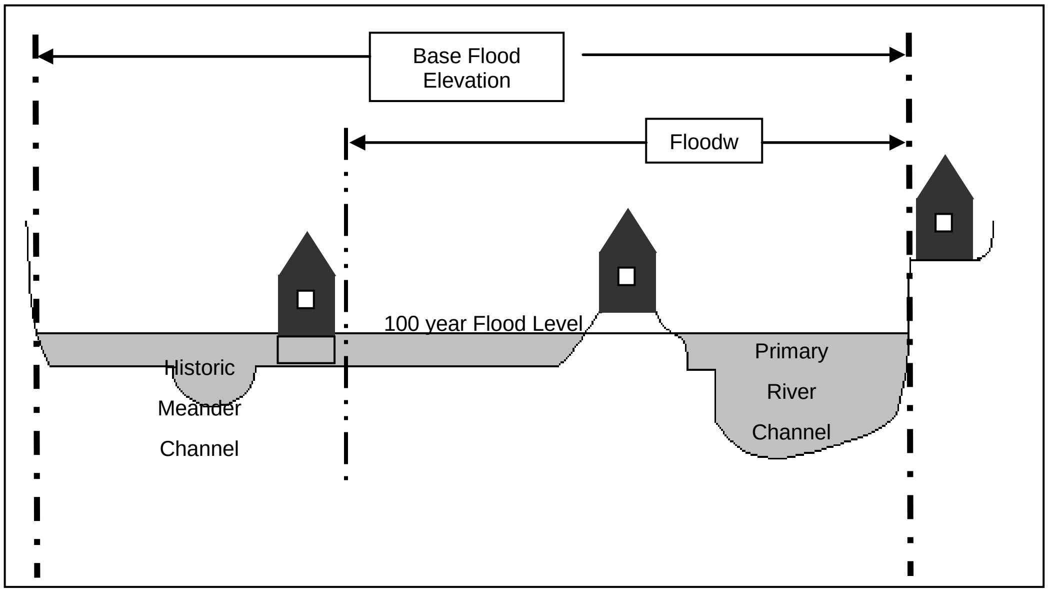

Figure 2: Kimball Creek in Historic Meander Channel of Snoqualmie River

The following section will address Kimball Creek as a risk, describing in detail flood events and the policies that guide development along the banks of the creek. Additionally, it will address one of a series of issues for further study recommended for Kimball Creek in King County's Flood Hazard Reduction Plan: "The first-floor-elevation database developed by the U.W. Army Corps of Engineers should be used to study the effectiveness of reductions in Kimball Creek flood stages in preventing first-floor inundation."[51]

Flood Character

Location

Observers of the 1990 flood event described water entering Kimball Creek from two directions.[52] First, as water backs up in the main channel of the Snoqualmie River behind the constriction above the falls, it flows into the mouth of the creek and upstream. Second, as the Snoqualmie overbanks downstream from the Kimball confluence, water flows over land to meet up with

[51] *King County Flood Hazard Reduction Plan, Executive Proposal*, Appendix B. January, 1993, p. B-76. Additional recommendations for Kimball Creek which are outside of the scope of this project but would further define the nature of flooding along the Creek include:

a. An overall flood reduction strategy for the area in and around the City of Snoqualmie must be decided before this project can be pursued.
b. Hydraulic studies must be conducted in sufficient detail to determine the depth and extent of any project backwaters for compliance with the Sensitive Areas Ordinance. Under that code, easements will be required for any flood hazards either created or increased by the project.

[52] Johnson, Colleen. Personal Interview. 30 October, 2002. AND, The K. McCarty Study, as described in *Snoqualmie River Flood Control Project, Pre-feasibility Investigation Final Report*, Northwest Hydraulic Consultants, Inc. 3 March, 1996.

Kimball and flow downstream. "The train tracks, state highway (SR 202) and other high ground of downtown Snoqualmie partially confined water in the Kimball Creek system, keeping most flows from returning to the river. Consequently, flood stages were greater… north of Delta and west of the train tracks than at the nearest riverfront property." [53] (See flow maps from *Snoqualmie River Flood Control Project.)* Videotape of the flood events confirms this at the SR 202 bridge. Water from the Snoqualmie River reached the shoulder of the road while Kimball Creek overtopped the bridge and flowed into the river.[54]

It is important to note that this complex flow pattern is not represented in FEMA flood maps of the 100-year flood plain and floodway. Since their modeling systems "describe whole-valley cross sections, which assume that flows are free to alternate between Kimball Creek and Snoqualmie River channels,"[55] the maps actually represent a shallower flood than has been experienced. As a result, residents experience relatively high-volume floods along Kimball Creek even though it is outside of the FEMA floodway and its accompanying development restrictions. Actual flood pattern are probably most accurately described in the McCarty Study ("1990 Flood Flow" Map in Appendix A).

This is not a contradiction, as areas designated as floodways are not necessarily intended to carry the fastest moving flow, nor to represent the most frequently flooded area. The floodway is a corridor within the 100-year floodplain that the community has set aside for the sole purpose of conveying water, so that as development occurs within the floodplain, sufficient area will remain to drain the land during a flood. FEMA hydrologists have determined that the amount of space a community has set aside can sufficiently drain the land during a flood event. Some floodways coincide with the most frequently flooded areas; others do not, making them highly political boundaries.

Both of the observations described above and watershed analysis calculations (see Appendix B) suggest that Kimball Creek does not flood on its own; floodwaters in the creek result almost entirely as a result of backup and overflow from Snoqualmie floods.

Frequency

Kimball floods in conjunction with the Snoqualmie, and major flood events are relatively frequent. The Snoqualmie River also overtopped its banks in 1959, 1960, 1976, 1977, 1981, 1986, 1995 and 1996. Each of these events was accompanied by flooding along Kimball Creek. Homes and roads along the creek are among the most frequently flooded in King County. [56] Flooding will continue to be an issue throughout the valley.

Severity

In the past, residents of Snoqualmie have had adequate notice of flood arrival to either prepare or evacuate; floodwaters tend to rise relatively slowly and without great increases in flow velocity. Damage to property, however, has been extensive.

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[53] *King County Flood Hazard Reduction Plan, Executive Proposal*, Appendix B. January, 1993
[54] ibid.
[55] ibid.
[56] ibid.

Vulnerability

Since much of Kimball Creek corridor is within the 10 year floodplain and the entire creek is within the 100 year floodplain of the Snoqualmie River, homes along the creek will continue to be prone to flood damages (See "10, 100, and 500 Year Flood Flow Map," Appendix A). As noted by King County in their Flood Hazard Reduction plan, "In the most commonly-flooded parts of the basin, a number of homes have been elevated to reduce their susceptibility to rising waters. These elevated homes were relatively undamaged by the Thanksgiving 1990 flood, and provide good examples of perhaps the best opportunity for flood hazard reduction in this area."[57] However, a number of houses remain flood-prone, especially in the Williams Addition neighborhood. These houses will continue to experience damages in years to come. Currently elevated homes are depicted in the "Williams Addition First Floor Elevation" Map in Appendix A. Additionally, Snoqualmie (in collaboration with FEMA) has bought out two homes that have experienced repetitive loss. These lots are located in the Williams Addition.

Past Flood Control Efforts

King County dredged and straightened Kimball Creek in the late 1960's; at the same time, they rip rapped some stretches of the creek. The project seems to have had little effect on flooding in the area; much of the water in the channel during flood events is overflow from the Snoqualmie, so dredging/riprap on Kimball provides little mitigation benefit. Further dredging is not advised as sediment from the creek would likely infill the dredge quickly.[58]

Other projects have been considered along Kimball Creek, including floodgates and pump stations at the mouth, and the re-routing of a maintenance road that flanks the right bank of the creek and may constrict flood flows. However, these projects lack cost effectiveness, and have therefore not been implemented.

Current Projects

The following is a discussion of current projects that have the potential to change the character of flooding in Snoqualmie. Taken together, these projects will necessitate a new look at policies affecting floodplain development in Snoqualmie, and may present opportunities to re-map the floodplain and floodway.

Section 205 Project

The Section 205 project proposes to remove key portions of the constriction below the City of Snoqualmie, speeding the flow of water through the town. This $3.6 million project would widen the bank at two points (one on the right bank and one on the left) and remove a railroad bridge that currently slows floodwaters. The project is projected to lower the 100 year flood level by 1.2 feet.

[57] *Final King County Flood Hazard Reduction Plan,* November, 1993, p. 194.
[58] *King County Flood Hazard Reduction Plan, Executive Proposal*, Appendix B. January, 1993

FERC Hydropower Relicensing

The City is currently working with Puget Sound Energy in the relicensing of power generating facilities at Snoqualmie Falls to ensure that flood damage reduction measures are included in conditions of approval for relicensing.[59] One proposal that is currently part of this project is an inflatable weir, which, in the event of a flood, could be deflated to allow greater conveyance of floodwater.

Kimball Bank Grading

The City of Snoqualmie is currently considering grading the bank area near SR 202 to provide an outlet for water backed into Kimball Creek in Snoqualmie flood events.[60] Water would circumvent the backup at the confluence and meet back up with the Snoqualmie downstream. It is not known how much effect this may have on flooding.

Policy Options

This section describes current policy defining development in the Snoqualmie River Valley, and suggests several options for change.

Current Development Policy and Code

The "Authorization and Jurisdictions" map in Appendix A depicts policies that currently guide new and existing development in Snoqualmie. The entire floodplain is governed by the Revised Code of Washington as a critical area and by FEMA through the National Flood Insurance Program; the map provides further information describing which body of code governs which areas of the creek. A thorough description of these codes can be found in Appendix C.

Most importantly, all new development and substantial improvement in the floodway is prohibited, while less severe restrictions are placed on development in the floodplain. Additionally, densities within the floodplain are limited to 1 unit per 5 acres to minimize loss to human life and property. FEMA minimum standards call for 1 unit per 1 acre.[61]

Density Fringe Areas

Floodways are designed to provide conveyance of floodwaters on the assumption that the entire remaining floodplain will be developed to a maximum. Some jurisdictions in the State of Washington have taken a slightly different approach, adopting policies that limit development in flood prone areas without the use of a floodway. These policies, sometimes called "density fringe areas" limit development in the entire floodplain by allowing only a percentage of each lot to be developed. Snohomish County, Washington, for example, allows development of 2 percent of each lot within the floodplain, assuming that conveyance of floodwaters will be provided around the developed areas. See Appendix D for a sample of density fringe code.

There are several reasons that this option is probably not an appropriate one for Snoqualmie. First, this type of policy works best in very rural areas that have not already been developed at higher densities. It would be difficult to implement a policy like this throughout the floodplain,

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[59] City of Snoqualmie, *2002 Annual Community Rating System Progress Report*, p. 5
[60] Fletcher, Randy "Fuzzy", Mayor, City of Snoqualmie. Interview. 20 October, 2002.
[61] *NFIP/CRS Coordinator's Manual.* Jan, 1999.

given the fact that nearly the entire city (including its downtown core) is already developed in the floodplain. Only very small percentages of new lots could be developed if conveyance is to be preserved. Flooding in the Snoqualmie Valley primarily results from the ponding of water behind the constriction just upstream from the falls; this water conveyance pattern would not be affected by limiting the amount of developed land allowed on a given parcel. Additionally, a density flood fringe would not effectively limit development in the areas along Kimball and the Snoqualmie River that are most prone to flooding. There is little reason to create hardship on landowners unless the effect will be reduced exposure to risk or elimination of the hazard itself.

Channel Migration Zones/High Hazard Areas

Some jurisdictions have also adopted “Channel Migration Zones” or “High Hazard Areas” as a means of guiding development in flood prone areas. As is the case in Snoqualmie, the FEMA mapped floodways don’t always represent the areas where flood damages are most likely; channel migration zone and/or high hazard area ordinances are designed to protect life and property which is outside of the floodway but nonetheless in danger of flood hazard. Pierce County, for example, regulated “deep and/or fast moving waters,” restricting development along their banks in addition to FEMA floodways.[62]

While these ordinances can be very effective in some areas, they would probably not be an appropriate option for the City of Snoqualmie. High hazard codes generally refer to areas where structures would be at risk of substantial damage or complete destruction due to rapid erosion rates, high velocities, or debris swept onto the banks. As described above, the floods in Snoqualmie result from a ponding effect as water backs up behind upstream river constrictions. Therefore, Snoqualmie floods don’t usually experience the kind of high velocity, high erosion capacity floods that the aforementioned codes are designed to address.

The “Split Floodway” Concept

As described above, much of the City of Snoqualmie’s developable land lies within the floodway, and all new construction is restricted in that area. Furthermore, the floodway as it is currently mapped does not represent the true path of floodwaters. One option available to address these problems is the adoption of a “split floodway” in the Snoqualmie Valley. A hypothetical description of a split floodway is depicted in the “Split Floodway Concept” map in Appendix A, and in cross section in Figure 3 below.

Note especially the differences between the “Authorization and Jurisdictions” map, which shows the current regulatory patterns, and the “Split Floodway Concept” map. Much of the core of Snoqualmie is currently regulated as “floodway” and no new development is allowed. This presents a significant hardship to homeowners in the floodway; they cannot substantially improve their existing residences, nor can the rebuild them in the event of a disaster. Using a split floodway, much of the central part of the city would remain a “special flood hazard area,” but would be removed from the floodway. This would give homeowners the freedom to rebuild or improve their properties, and would also allow for new development. As is evident, such changes would free some of the area between Kimball Creek and the Snoqualmie River for new development and protect life and property in the areas most prone to flood damages. Figure 3 below describes a split floodway in cross section, explaining how development patterns in the

[62] Pierce County Code, 17A.50.110

Snoqualmie Valley might change. As is currently the case, pre-existing houses above the base flood elevation in the floodway could be permitted as non-conforming uses; new homes in the floodway would not be permitted.

In addition to removing the current hardship homeowners in the floodway experience regarding improvement of their properties, there are several other reasons that a split floodway would be useful for flood reduction in the area:

1. A split floodway would eliminate the need for the 1 unit per 5 acre requirement currently used to protect flood prone property in the Kimball Creek corridor. If the area adjacent to the creek were designated "floodway" rather than "Special Flood Hazard Area" (as it currently is zoned), densities in the area would be kept low through existing floodway regulations. The split floodway would eliminate the possibility of sprawl, and maintain the rural character of the city edges without the 1 per 5 restriction.

2. Splitting the floodway could allow for denser development while growth in the Kimball corridor is completely restricted. Under current code, all development within the 100 year floodplain is limited to 1 unit per 5 acres; this applies, therefore, to the entire downtown core of the city (most of which was grandfathered in at its current density because it existed prior to implementation of the 1 per 5 code). It would be possible to lessen that restriction in the area nearest the current city core, since the floodway on the Kimball Corridor would achieve the goal of limiting denser developments at the city fringe. Figure 1 below describes that concept in cross-section.

   The City, however, will want to evaluate this option with the recognition that the 1 unit per 5 acre restriction currently in place is as much about maintaining community character as it is about reducing exposure to risk. There are other development restrictions designed specifically to address flooding issues: the "zero rise" floodway, for example, doesn't allow any development that will cause a rise in the base flood levels. Any development in the floodplain must also be built at least one foot above the base flood level. These other codes would remain in place, protecting any new and existing development from increased flood damage. Allowing for denser development in the floodplain near the city core will not affect flood levels, but the City may wish to maintain current development restrictions for other reasons.

3. A split floodway would be relatively easy to implement. The principal channel of the floodway (carrying the greatest flood discharge) would probably remain along the Snoqualmie River, with a much narrower band along Kimball Creek. Relatively few homes would be affected by the new designation. Furthermore, city code dictates that most of the homes that would be in the new floodway along the corridor are on large lots (at least 5 acres) with the homes themselves set back at least 100 feet from Kimball Creek. Therefore, though the floodway would cross their property, the homes might actually be outside of the floodway, allowing property owners to make substantial improvements to or rebuild their homes in the event of a disaster. The split floodway would not simply remove the hardships associated with a home in the floodway from one set of homeowners and place it on another.

   One notable exception to this would be homes nearest the creek in the Williams Addition. These homes are likely to lie in the path of the new floodway. Importantly, though, they are also the most likely candidates for FEMA buyout lots; several of them, in fact, have already been purchased through the buyout program. This concept will be more thoroughly addressed in Chapter 6.

4. The split floodway comes closer to representing the actual path of floodwaters. As described above, Kimball Creek carries much of the overflow from the Snoqualmie River during major flood events, and homes in the corridor are among the first to flood. Disallowing new development in the corridor will further reduce risk to flooding.

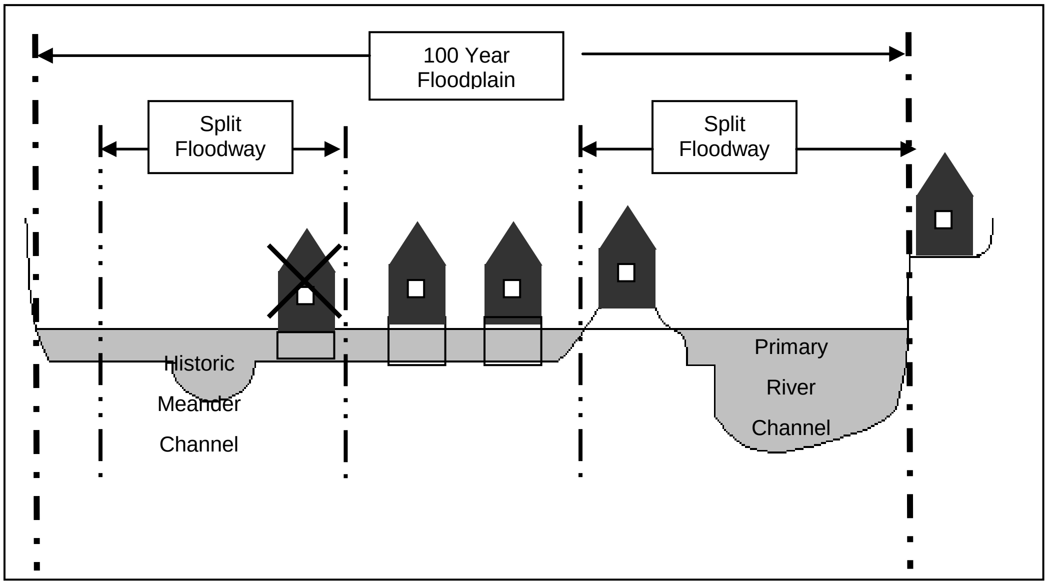

Figure 3: Split Floodway Concept

The “Split Floodway” map and Figure 3 split floodway descriptions are conceptual only; hydrogeologists (most likely from FEMA) would need to model potential flood flows to determine the most appropriate locations for the floodway boundaries. Furthermore, the City of Snoqualmie would have to work with both FEMA and King County to make these changes to their current policy; since some of the floodway would be outside the jurisdictional boundaries of Snoqualmie, King County would have to recognize the new changes in order to make them effective. However, given the fact that the changes would free developable land for the City of Snoqualmie and protect key properties, it is an option worth studying further. This change could alter development patterns in the City of Snoqualmie substantially, encouraging denser development in the city core, and limiting development on the city’s fringe.

Options for Flood Mitigation

This section introduces and analyzes several possible options available to reduce the risk from flooding along Kimball Creek. It addresses both structural and nonstructural methods for mitigating flood losses.

Structural Measures and Dredging

Several studies have already considered the option of structural measures to address flooding on Kimball Creek and discounted them as feasible options. King County’s 1993 Flood Hazard Reduction Plan evaluated the option of floodgates, which would keep the Snoqualmie River backwaters from filling the Kimball Creek floodplain. The final assessment of this option states that, "…gating the mouth of the creek would not substantially reduce flood stages."[63] Furthermore, as described earlier in this chapter, the city is currently creating an overflow channel to relieve some of the backup. While floodgates are not currently an option, after completion of the 205 Project, it might be worth reassessment.

King County also considered the option of dredging the channel to allow more water to flow along it, and determined that this action would not likely produce any long-term reduction in flood stages. This is most likely because flooding along Kimball is related to back up from the Snoqualmie River rather than the carrying capacity of the creek itself. Furthermore, dredging can be harmful to in-stream and riparian habitat.

In general, Kimball Creek will probably continue to flood whenever the Snoqualmie River floods, and structural measures and/or dredging will not address the problem of rising waters. Therefore, the most appropriate remaining solutions will address the vulnerabilities (which, within the project study area, are mostly homes) rather than the reduction of the flood hazard.

Relocate Residences

Another option is to move residences away from the creek, removing them from the path of damage from rising water. While this could reduce the potential for destruction of the homes and structures, it is a viable option for very few residents. Relocating a home on the same lot would not be an option for most of the residents along Kimball, as their entire lot is in the floodplain. And, though there may be empty lots nearby, for the most part those would also remain in the floodplain. Furthermore, though costs vary greatly depending upon lot size, they type of septic system in place, or the construction method of the structure, they can be prohibitive. (For example, homes with concrete floors would cost much more to move than homes with a crawl-space.) Structures elevated on crawl-spaces would cost between $5,000 and $10,000 to move.

Elevation of Homes

Another particularly viable option for removing homes from harm's way is to elevate them (discussed in general above). Since 1997, the City has obtained three Federal Emergency Management Agency Hazard Mitigation Grants to elevate and purchase homes in the floodplain and one Flood Mitigation Assistance Grant to elevate and/or purchase homes in the floodplain. Thirty-nine homes have been elevated through this program. There are six additional homes that have been elevated since 1997 without using grant funds. Three additional repetitive loss homes using grant funds are scheduled to be elevated in 2002. The City has purchased one additional repetitive loss property.[64]

As stated in their annual CRS Progress Report, the Planning and Building Departments will "continue to encourage residents, through [their] outreach program, to elevate their homes by providing the Corps elevation survey information, requiring houses that are being substantially improved to be elevated, and seeking additional funding assistance for elevations."[65]

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[63] King County Surface Water Management, *King County Flood Hazard Reduction Plan, Executive Proposal,* "Appendix B: Problem Sites and Project Recommendations." January, 1993.
[64] City of Snoqualmie. *Annual CRS Progress Report,* 2002.
[65] City of Snoqualmie. *Annual CRS Progress Report,* 2002.

The National Flood Insurance Program for new and substantially improved structures requires elevating a home above the base flood elevation. Elevation through retrofitting is a common practice in the City of Snoqualmie, and has received financial support initially through the Small Business Administration, and later through the Hazard Mitigation Grant Program (HMGP) and the Flood Mitigation Programs (FMA). These latter two programs have required participating homeowners to contribute between 12.5% and 25% of the cost of retrofitting.

A recent study conducted at the University of Washington[66] suggests that retrofitting is a more sustainable option than other studies have indicated. That the market price of elevated homes within the City was higher than non-elevated homes, with the difference in price ranging 25% to 75% of the cost of the retrofit. The fact that market values are improved through elevation further supports continued participation in home elevation programs.

Elevation of homes is clearly already a goal of the City of Snoqualmie, and a precedent has been set for finding funding and encouraging residents along these lines. However, available data is not sufficient to determine which specific homes should be targeted for elevation first. A map of relative first floor elevation heights exists for the Eastern side of Kimball Creek. The Army Corps of Engineers developed this map in the early 1980s.[67] It describes high, medium, and low flood risk based on the first floor elevation, but first floor elevation is not recorded on this map. Army Corps files include detailed surveys of houses and first floor elevations at the time of study, but this information is not complete. New buildings have been built since that information was compiled.

A completed database of first floor elevations could be useful – and easily completed by touring the area, measuring first floor elevations of the buildings that are currently missing data, and filling this information into the GIS layer. This database could help the City decide which houses are most vulnerable to flooding (based on where they are located and whether they have been elevated). This could lead to a prioritization of which houses should be elevated or purchased.

Public Purchase of Residences

Federal, State, County, and local funds could also be used to purchase and remove the residences to eliminate the threat and provide open space for recreational access. The National Flood Insurance Program, adopted in 1994, created the Flood Mitigation Assistance Fund, a program within the FEMA. This Act provides $20 million annually for plans and projects nationwide. Under this Act, state or local jurisdictions, or private parties, must provide 25 percent of an approved project's cost, and the remaining 75% will be funded through FEMA. Funding is available to complete projects prior to their being damaged in a flood, provided the structure has flood insurance. Eligible projects include acquisition, relocation, or elevation of structures.

The Annual CRS Report again shows that the City of Snoqualmie has been thinking along these lines. Since 1997 the city has obtained grant funds to purchase repetitive loss properties or homes that have been damaged from previous floods, and has purchased more than ten homes

[66] Thourpe, R., & Freitag, B., & Montgomery, R. May 2002. "A Reconnaissance Study on the Market Impacts on Elevated Homes in Known Flooplains: City of Snoqualmie Case Study."
[67] *Snohomish Mediated Agreement Feasibility Study;* Non-Structural Studies for City of Snoqualmie: First Floor Elevations – Existing Conditions. Year Unknown

that meet these criteria. Both local, Hazard Mitigation Grant Program and Flood Mitigation Assistance funding sources have been utilized.[68]

Again, however, available data is inadequate to determine which houses the city should target for purchase. Chapter 6 later in this document will build upon strategies for selecting homes for purchase.

Opportunities for Flood Hazard Reduction

Split Floodway

Consider the feasibility of a split floodway, which could open more land for development in the city's core. This change could also limit development in the path of floodwaters as they have been documented, thereby more fully protecting life and property. Channel Migration Zones and Density Fringe Areas will probably be less effective guides for flood mitigation in the Snoqualmie Valley.

Elevation of Homes

Continue to encourage residents to elevate homes, targeting especially those residents in the most frequently flooded areas along Kimball Creek.

Lot Buyouts

Continue to target repetitive loss homes for purchase. Update and complete the first floor elevation database (with data usable in a GIS format) to prioritize homes for purchase.

First Floor Elevation Database

Update and complete the first floor elevation database (with data usable in a GIS format) to prioritize those homes that should be targeted for future elevations and/or lot buyouts.

[68] City of Snoqualmie. *Annual CRS Progress Report,* 2002.

CHAPTER 5: HUMAN USE OF KIMBALL CREEK

Land Use in Vicinity

Land use in the vicinity of Kimball Creek is composed largely of single-family housing. The housing stock, density and quality in the area around the creek are comparable to the rest of the Snoqualmie community. More than half of these housing units were constructed prior to 1950. Most of these one to two bedroom homes are well maintained and in good condition. At present most of this housing exists outside the city limits but within the city's urban growth boundary (UGB). This area includes the neighborhoods of Johnson Heights and the Williams Addition. (Please refer to “Locational Map,” “Study Area” map, and “Land Use” map in Appendix A).

The creek travels through four distinct planning areas with different zoning codes. The headwaters of the creek are in the Meadowbrook Planning Area. Most of this area is open space. From the Meadowbrook Planning Area the creek runs through the Historic Snoqualmie Planning Area. This area is zoned as constrained residential. The Snoqualmie Vicinity Comprehensive Plan (SVCP) defines constrained residential as large lot single-family residences in areas constrained by the 100-year floodplain, wetlands or other sensitive areas. As the creek leaves the Historic Snoqualmie Planning Area it flows into the Snoqualmie Hills Planning Area. The largest stretch of the creek flows through this area that is also home to the Williams Addition Neighborhood, the Johnson Heights Neighborhood, and the proposed Snoqualmie Tribe Gaming Facility. This planning area is zoned for single-family residential housing. To the north of the Snoqualmie Hills Planning Area the creek flows through the Snoqualmie Falls Planning Area. This area is zoned for mixed-use development however at this time it is relatively undeveloped. Finally, for a few hundred feet at the mouth of the creek is the Kimball Creek Nature Trail. This part of the creek is a city-operated park and is zoned as green space.

Due to its location in the floodplain the city has zoned the areas around the creek at one unit per five acres. This zoning policy was implemented after most of neighborhoods in the region had already been built to much higher densities. The result is that some neighborhoods, such as the Williams Addition are pockets of relatively high density in the middle of a rural atmosphere created by the five acres per unit zoning policy.

Community Character

The city of Snoqualmie prides itself on having a "rural small town feel." The vision statement of the SVCP calls for the city to preserve its small town identity while taking actions to mitigate the hazards caused by its location within the Snoqualmie River floodplain.

The SVCP outlines numerous strategies to achieve the goals of the vision statement. These strategies include enhancing pedestrian activity throughout the city, maintaining and obtaining new open space, restricting development in sensitive areas and concentrating new growth in the Snoqualmie Ridge area.

The various outdoor recreation opportunities available in Snoqualmie further add to the rural character of the town. The SVCP notes,

> "Some of the many recreation activities which are possible without a large investment in capital improvements include berry picking, bicycling, camping, canoeing and kayaking, horseback riding, hiking, hunting, fishing, nature study, picnicking, sightseeing, photography, pleasure driving and swimming." (SVCP p 9-1)

In addition to these recreational attractions, the city is also home to Snoqualmie Falls, which receives more than 1.5 million visitors a year.[69] Other attractions include the Northwest Railway Museum, the Snoqualmie Historic District, numerous parks (see section below), the Snoqualmie Tribes' proposed gaming facility and two golf courses (the Mt. Si Golf Course and the Tournament Players Course at Snoqualmie Ridge).

Parks, Open Space, and Recreation in the Vicinity

The City of Snoqualmie, and the upper Snoqualmie Valley as a whole, has a large number of parks and open spaces. The historic area of Snoqualmie is surrounded by green space that provides a valuable community resource. Tollgate Farm, Meadowbrook Farm and the Three Forks Natural Area form a network of open space that connects the cities of North Bend and Snoqualmie. Together these three areas comprise more than 1,000 acres of open space between the two cities. Regional trail systems and a landscape of protected land in the region further connect Snoqualmie to the surrounding landscape.

Snoqualmie Vicinity Parks and Land Protection

The following list includes descriptions of significant parks and open spaces in the Snoqualmie vicinity:

- Meadowbrook Park is 500 acres in size and is jointly operated by the cities of North Bend and Snoqualmie. Large portions of the park are wetlands and it is these wetlands that serve as part of the headwaters for Kimball Creek.
- To the east of Meadowbrook Park is the 418-acre Three Forks Natural Area. This King County park is predominantly riverine and riparian habitat as it encompasses over five miles of riverfront along the Snoqualmie River.
- Tollgate Farm preserves additional open space between North Bend and Snoqualmie, protecting historic farm and pasture in the area. Tollgate Farm, Three Forks Natural Area, and Meadowbrook Farm collectively preserve an open space corridor between these two cities with significant wildlife habitat and recreational opportunities.
- The city is also home to two golf courses: The Mt. Si Golf Course located between Meadowbrook Park and the Three Forks Natural Area, and the Tournament Players' Course at Snoqualmie Ridge designed by Jack Niklaus.
- The Snoqualmie Tribe Gaming Facility is the early planning stages. The planned location will be near Kimball Creek. Once constructed this facility will be a 100,000 square foot building designed to resemble a "great lodge" similar to those used by various Native American peoples. The facility's proximity to the creek, its size, and its potential as a major regional attraction make this an important planning element for this area.

[69] http://www.snoqualmiefalls.com 2002

- To the north of the city of Snoqualmie is the Falls Crossing Park. This part was established in coordination with the Cascade Land Conservancy.[70] This park is less than a mile away from the Kimball Creek Nature Trail and downtown Snoqualmie. The park can be accessed by car along Route 202 or pedestrians and cyclists can use the Centennial Trail, which was designed for the purpose of connecting pedestrians from downtown Snoqualmie to the Falls.
- The Snoqualmie Preservation Initiative planning continues with the Cascade Land Conservancy. This may provide up to 9,800 additional acres of land protection in this area.[71] Most of this will occur in the Rattlesnake Ridge corridor south of SR 90, but acquisitions will also include enhancements of regional trails in Snoqualmie, and Snoqualmie Ridge mitigation and planning area improvements.

Regional Trails

The King County Regional Trails system connects Snoqualmie to other parts of the region. Two major trail systems pass through the city of Snoqualmie: the Preston Snoqualmie Trail and the Snoqualmie Valley Trail. The Preston-Snoqualmie Trail connects with the city's Centennial Trail that travels north down North Railroad Avenue through the City of Snoqualmie to Snoqualmie Falls. The Centennial Trail also connects with the Kimball Creek Nature Trail.

Parks and Open Space in the Kimball Creek Corridor

Despite the number of parks in the region, there are very few parks in the vicinity of Kimball Creek. Only two formal parks can be found on the creek. The Kimball Creek Nature Trail is a short trail that starts at both Route 202 and the Centennial Trail, and follows Kimball Creek to the Snoqualmie River. Green space surrounds the trail. This park is quite undeveloped and there are no signs or other amenities along the trail. The trail itself is rather informal and follows along a grass covered unpaved road. Accessing this trail is somewhat problematic. There is no parking near the trail and no signs alerting people as to the trail's existence. Approaching the trail from the Centennial Trail is also challenging. To reach the trail one must step off the Centennial Trail and walk under the Route 202 bridge.

The SVCP targets the home buyout lots as potential pocket parks. Currently the lots are not being used and sit vacant. At the opposite end of Kimball Creek is Meadowbrook Park, described above.

Policy Considerations

Density Limits

Because the entire creek is within the 100-year floodplain most of the residential areas near the creek are zoned for one unit per five acres (SVCP Policy 3.C.3.1). This zoning gives the region a rural feel. Most of these lots contain hobby farms where horses and other livestock are visible from the street. The comparatively high density of the Williams Addition is out of character with the rest of the area. The differing densities make way-finding a little challenging because the intuitive assumption that density will decrease the further one gets from downtown is being

[70] Cascade Land Conservancy, 2002, at: http://www.cascadeland.org/protland/spi.htm

[71] Cascade Land Conservancy, 2002, at: http://www.cascadeland.org/protland/spi.htm. Further information may be found at: http://www.metrokc.gov/exec/news/2001/021401slides1.htm slideshow

thwarted. Any changes to zoning density should take this assumption into consideration. It is possible that the creation of dense areas away from downtown Snoqualmie may detract from the central city attraction in the historic district.

Regulatory Restrictions on Land Use

Its location in a 100-year floodplain has greatly influenced the form of Snoqualmie's residential areas. Although the state prohibits new residential construction within the floodway and the city limits residential density to five acres per unit within the floodplain, the SVCP allows for contiguous pre-1937 lots to be reconfigured through a lot-line adjustment and developed at a density of approximately 10 units per acre.

The King County guidelines for creek-side trails are designed to minimize human interference biological functioning of the creek while allowing for some proximity to the creek. The guidelines state that trails adjacent to a stream must not contribute to bank collapse and that trees, shrubs and understory vegetation that shades or shelters the creek or prevents erosion by anchoring the bank should not be removed. The guidelines further state that trails should not be located close to creek and that there should only be creek access points at areas that can tolerate the human traffic.

King County Sensitive Areas Ordinance (KCC 21.A.24-26) governs buffer size in the unincoporated area; the City of Snoqualmie Development Regulations govern buffer size in the incorporated area. These provide similar protections for wetlands and streams. These include respective 100, 100, 50, and 25 foot buffers on Class 1, 2 with salmonids, 2 without salmonids, and 3 streams. Kimball Creek is a Class 2 stream without salmonids, requiring 50-foot buffers. Wetland types vary along Kimball Creek; King County requires 100, 50, or 25 foot buffers on Class 1, 2, and 3 wetlands, respectively.

Community Stewardship of Kimball Creek

One long time resident[72] describes the creek as surrounding the city, both literally and figuratively. It is difficult for the residents of Snoqualmie to forget about the creek because of its periodic flooding. Up to the late 1980s and until a serious flooding event in 1990, residents viewed the creek as a positive aspect of the area's rural character. The creek was home to a yearly trout fishing derby sponsored by the Mt Si Fish and Game Club. The fishing derby was moved to the Snoqualmie Ridge after concerns about water quality started to arise.

At present the creek in not considered in a positive light. Low flows, bad odors, mosquitoes and rumors failing septic systems have residents concerned about the health of the creek. The creek is considered quite dirty and children are not allowed to play in it. Citizen awareness for it seems to center on its perceived unhealthy state and its propensity for flooding.

Most of the creek is on private property with very little public access. Currently the public can only access the creek from the home buyout lots, at city and county right of ways and at two parks (the Kimball Creek Nature Trail and Meadowbrook Park). At all of these locations blackberries and other foliage make approaching the creek banks a challenge.

[72] Colleen Johnson, interview, October 2002

Relationship With Community's Plan and Vision

Residents of Snoqualmie[73] believe that the community would like to see the creek made healthy, with clearer water and a regular flow. They would also like to return it to the point where an annual fishing derby is possible again. Both informants agree that property owners around the creek may be amenable to easements or stewardship that improve the health of the creek.

The community's plan and vision calls for the maintenance and enhancement of Snoqualmie's small town and rural character feel. In addition, the vision statement calls for "effective stewardship of its outstanding scenic and natural features," "taking every action possible to alleviate the impacts of flooding," and "a community where residents' various physical, education, economic and social activities can be pursued in a safe, attractive and healthy environment." The actions called for in the vision statement take on an important meaning when applied to Kimball Creek.

Kimball Creek is a community treasure. Its entire watercourse, from headwaters to mouth, is within the city's urban growth area. It wraps around the city and is linked to the biological health of the region. The creek's dynamic relationships with biological and geological processes combined with its location in the community present major opportunities for the city of Snoqualmie. First, the creek can become an important educational tool for communicating information about flooding events and creekside ecology (see "Educational Opportunities" below). Second, the creek's location can be used to create pedestrian connections to the various features the Snoqualmie region has to offer (see "Scenarios for Use of Kimball Creek" below).

Educational Opportunities

Kimball Creek potential as an educational tool. The creek can become a living laboratory for Snoqualmie school children. High school student involvement in water quality sampling in 2002-2003 is an example of the type of research that may provide the community a chance to interact directly with the creek. The creek can provide a forum for general education as well as direct research. Students can investigate topics such as pollution, riparian habits, groundwater, and stream and wetland ecology.

These same issues could be communicated to the public in a less intensive manner through interpretive signs and trails. One of the main educational functions of the creek could be its ability to communicate the issues and challenges of managing the environment in a flood prone region. A series of strategically placed signs throughout the city and along the Kimball Creek watercourse, could discuss the history and dynamics of Snoqualmie area floods. These signs could help reinforce good flood management practices (such as maintaining riparian zones, elevating houses, keeping pollutants from running off into creeks) as well as to provide an interesting and educational tourist experience.

Opportunities for Community Stewardship of Kimball Creek

The following proposals for Kimball Creek take into consideration the natural beauty of the creek, and its spatial relationships to the features and attractions of the Snoqualmie vicinity. The proposals range from low action/short term strategies to high investment/long term strategies.

[73] Colleen Johnson and Mayor Randy "Fuzzy" Fletcher, interviews October and November 2002

The one theme and objective shared by all the proposals is an emphasis to create a strong, positive public awareness for the creek and its beneficial nature for the Snoqualmie region.

Citizen Committee

To this end a citizen's panel or committee should be created with the purpose of giving residents, homeowners and admirers of the creek the power to shape future human uses of the creek. This group would be responsible for a wide range of activities including organizing volunteers, fund raising, outreach to local schools, educating and gathering input from the public. The group could also take a leadership role in designing creekside trails and parks. The underlying goal behind all these activities would be for the group to strike a balance between the needs of the public, the neighborhoods surrounding the creek and efforts to preserve and enhance the creek's ecological integrity.

An important connection for this panel is the Meadowbrook Farm Preservation Assoctiation, which has responsibility for planning for Meadowbrook Farm at Kimball Creek's headwaters. Given their existing presence in the protection of a portion of this system, they may be able to provide guidance over more of the creek's management. The management policies of the Meadowbrook Farm Preservation Association include encouraging efforts to "Provide and enhance wildlife habitat and corridors; Provide and enhance wetlands; Provide active stewardship of ecosystems…"[74] all of which are of key importance to Kimball Creek and to Meadowbrook Farm habitat.

Creek Concept Scenarios

The following scenarios are presented as examples of ways Kimball Creek can be further integrated into Snoqualmie's urban character. They do not represent existing plans, nor are they product of public participation. Rather, they are meant to show the creek's potential as an urban amenity. The main goal of each of these scenarios is to increase public awareness and respect for the creek.

<u>Scenario 1:</u> Provide public access to creek by improving existing publicly owned lands.

Objectives: Provide public access to creek, augment existing publicly owned lands, and strengthen positive public awareness for creek.

Map: "Creek Access Points" map in Appendix A

At present, access to the creek is limited to the Kimball Creek Nature Trail, Meadowbrook Park and the home buyout lots in the Williams Addition (please refer to "Creek Access Points" map in Appendix A). Viewpoints to the creek are available wherever the creek passes under a street or public right of way. Because access is limited to these points, attempts to increase awareness for and access to the creek can only take place at these same points. The addition of parkscape amenities such as signage, lighting, benches and parking spaces combined with the removal of blackberries and the restoration of native species could go a long way in highlighting the benefits the creek brings to the area.

[74] Meadowbrook Farm Master Plan Report. 1998. Prepared by RCA/Huitt-Zollars. Page A-1.

As mentioned earlier the creek presents a major opportunity for educating community members and tourists alike about the biological and geological forces guiding creek ecology. The creek signage suggested in this proposal could consist of a series of interpretive signs placed throughout the Kimball Creek watercourse explaining the dynamic flooding behaviors of the creek as well as the detailing the biological richness sustained by the creek.

Snoqualmie Vicinity Comprehensive Plan Policies 2.H.6.1 through 2.H.6.5 call for the transformation of Maskrod's corner into a pedestrian friendly gateway commercial center. Located at the intersection of State Route 202 and Meadowbrook Way S.E. Maskrod's corner is a gateway to the City of Snoqualmie, Kimball Creek and Meadowbrook Park. These actions in conjunction with the actions described in Proposal 1 could be a powerful means of enhancing the area's relationship with Kimball Creek.

Scenario 2***: Increase public ownership along creek at strategic points to improve public access.***

Objective: Target parcels along the watercourse at high flood risk and that could become good locations for future parks or facilitate the expansion of existing parks. Increase positive public awareness for the creek through the creation and expansion of park space.

Map: "Park Expansion Map" in Appendix A

This scenario builds on Scenario 1, furthering the public access and ownership along the creek through additional public buyouts (please refer to "Park Expansion" map in Appendix A). The removal of houses from land near the creek would increase the health of the creek as well as increase the amount of public access available. This scenario could be advanced by identifying high flood risk parcels along the watercourse as well as parcels that could become good locations for future parks or facilitate the expansion of existing parks

For example, there are some very large parcels of land between 384th Avenue Southeast and State Route 202 that could make excellent green spaces and creek access points. These parcels have been zoned as constrained residential and are mostly wetlands. A series of elevated boardwalk style walkways could lead people around the area with minimal impact on the natural wetland functions. This area is near the Honey Farm Inn. A partnership with the Honey Farm Inn could also increase public access to the creek.

Scenario 3: ***Create a citywide trail system utilizing surface streets, existing trails, and, where possible, parts of the Kimball Creek corridor.***

Objectives: The creation of a citywide trail, bicycle, equestrian, pedestrian path system. Use creek as a pedestrian path connecting the various features and amenities of Snoqualmie together. Provide public access to creek. Strengthen positive awareness for creek.

Map: "Proposed Trail System Map" in Appendix A.

The trail system could span the course of Kimball Creek from the Kimball Creek Trail to Meadowbrook Park. Meadowbrook Park's trails would then connect Kimball Creek to the Snoqualmie Valley Trail (refer to "Proposed Trail System Map" in Appendix A).

This Loop Trail could connect to the elementary, middle and high schools located to the north of Meadowbrook Park. The trail system would also connect to the Centennial Trail that could lead people to the Snoqualmie Preston Trail or the Snoqualmie Falls. At present there is a disruption along the Snoqualmie Valley Trail. The trail ends at Meadowbrook Way SE and then starts up again further north at Tokul Road. Road improvements such as sidewalks and bike lanes and signage could minimize the impact of this disruption as well as guide trail users to the Snoqualmie Falls.

The scope of this scenario could be broadened into a larger, comprehensive plan for Snoqualmie. The city's low traffic levels, large number of attractions, and its mostly flat terrain are all features that make this area a great place for bicycling. Bicycle tour maps could guide day-tripping bicyclers to all the features Snoqualmie has to offer. Snoqualmie Falls would be a starting point for a day of bicycling in Snoqualmie. People could park their cars at the falls, then rent bikes to carry them into the city. Strategically placed bike rental kiosks and courtesy shuttles back to the bikers' cars would also help to improve circulation. The city of Davis, California provides an example of what a small city (population 62,200) can do when it makes a commitment to bicycle transport.[75] The bicycle plan could include links to regional trails and public access points along the Kimball Creek corridor.

Resources

There are a number of potential tools and strategies available to those with an interest in pursuing the proposal described here or for those who have other ideas about the future of Kimball Creek and the Snoqualmie vicinity. The proposed citizen's Kimball Creek committee should examine these tools carefully and create a portfolio of strategies to implement their goals.

One of the strongest tools for this portfolio should be the King County Public Benefit Rating System (PBRS). Using a point based system, the PBRS assesses land based on its various open space resources. Open space resources are enumerated and defined in great detail on King County's website.[76] Open space resources include aquifer protection area, active or passive recreation area, shoreline "Conservancy" environment, and trail linkage. Reductions in taxable value on the portion of property in the PBRS ranges from 50% to 90%. There are certain restrictions to the PBRS which may limit participation within the PBRS program. Parcels along Kimball Creek that are developed to allowable densities may qualify for a property tax reduction if public benefit is provided. Public actions taken on a citywide level and in conjunction with a community-wide plan for the creek and the parcels surrounding it could create some beneficial synergistic effects for landowners.

For larger properties, there may be opportunities to participate a program such as King County's Transfer of Development Rights, or to qualify for density bonuses with development. These types of programs allow density bonuses for land dedication, and may be an opportunity for preservation of some of the large constrained wetland parcels on the south side of Kimball Creek.

King County's Small Habitat Restoration Program (SHRP) is another countywide program that will be of interest to those concerned about the health of Kimball Creek. SHRP provides funding

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[75] http://www.city.davis.ca.us/pw/pdfs/01bikeplan-images.pdf
[76] http://dnr.metrokc.gov/wlr/lands/incentiv.htm

and assistance in the construction of low-cost projects that enhance and restore streams and wetland.[77]

Chapter 8 of the Near Term Action Agenda for Salmon Habitat Conservation WRIA 8 provides information on a number of funding sources aimed at improving environmental quality.[78] Many of these sources identify useful grant applications for the City of Snoqualmie or private residents interested in improving the quality of the Kimball Creek corridor.

[77] Information is available through their website at http://dnr.metrokc.gov/WTD/shrp/
[78] This document is available online at http://dnr.metrokc.gov/wrias/8/near-term-action-agenda.htm

Chapter 6: Recommended Strategies

The Kimball Creek corridor presents an opportunity for the City of Snoqualmie to think critically about its future. The City will continue to grow and develop in coming years. Without careful planning, this growth could negatively alter the community's sense of identity. This document suggests a vision that seeks to maintain the rural character and scenic beauty of the city while allowing for increased development. The vision supports and builds upon the vision statement forwarded in the Snoqualmie Vicinity Comprehensive Plan, and presents the Kimball Creek corridor as a recreational and educational refuge for the future of the city.

Ideally, this document and the vision within it will serve as a starting point for a broad, community-based planning process focusing on the corridor as an asset. As is evident in previous chapters, improvement of the water quality, accessibility, and ecology of the Kimball Corridor could benefit the entire community; the entire community should therefore be involved in designing and implementing a vision for the area.

This section will link discussion from previous chapters to the vision outlined below. The suggested approaches for achieving the vision (also outlined in this chapter) are meant to provide concrete projects that would be appropriate to incorporate into a community visioning and/or planning process. These suggested approaches are meant to operate in conjunction with suggestions and recommendations from previous chapters, which will also play an important role in improving the corridor.

A Vision for the Kimball Creek Corridor

Through a concerted and deliberate planning effort, the Kimball Creek corridor can become an amenity for the entire community. Kimball Creek can be:

- A healthy, diverse ecosystem that provides habitat for wildlife even within a relatively urban setting. Through restoration, the creek would be cleaner, clearer, and colder, improving habitat for trout and other species.
- A focus of community involvement efforts, as volunteers come together to restore stability to the creeks banks and riparian habitat, and maintain trails that provide access to the creek. Kimball Creek would be an ideal tool for educators, youth and nature enthusiasts seeking an outdoor laboratory in a nearby wetland stream system.
- An accessible, integrated unit of the Snoqualmie community, and a place where residents and tourists can explore the scenic beauty of the area. Loops trails would connect existing trails to the Kimball corridor and the downtown core, creating opportunities for recreation while providing access to the creek's natural habitat.

Suggested Approaches

1. Restore Creek and Improve Habitat

Restoration of Kimball Creek to encourage a healthier habitat is a critical first step in the implementation of the vision described above. The creek cannot be a community asset until it can contain the habitat necessary to support a viable, functioning ecosystem. Increased human use and improved habitat are both dependent upon cleaner, clearer, and colder water in Kimball Creek. Community involvement could be fostered through restoration and habitat improvement projects. The following actions will help to achieve those goals:

a. Improve Septic Systems

Both the water quality in Kimball Creek and the health of the overall ecosystem would benefit from septic system improvements. Reductions in the quantity of septic effluent reaching the creek will improve habitat conditions in the stream, reducing the nutrient loads that can lead to high algal biomass and low dissolved oxygen levels. While it has not been clearly established that septic systems are the sole source of contamination to the creek, they are an easily identifiable point source, whose removal will clearly contribute to an overall reduction in stream pollution.

The secondary benefits of addressing the effects of old septic systems depend on the approach taken to remedy this problem. Providing sewerage to the parcels identified as potential septic effluent sources (see "Sewer Types" map in Appendix A) could, in addition to the water quality and ecological health improvement described above, provide an opportunity for additional habitat restoration along the riparian buffer zone of Kimball Creek. The decommissioning of leach fields adjacent to the stream can be linked with a revegetation program to improve the corridor and in-stream habitat.

If sewerage is not an option, buyout of the offending parcels may also provide opportunities to increase open space and public access near the creek. Public ownership of lots would not be a reasonable option if a failing septic system is the only criterion, but when considered in conjunction with the other issues addressed in this document, such as repeated flood damage and recreational access, the presence of a failing septic system can lend additional weight to the decision to implement a buyout program rather than the provision of sewerage.

b. Improve Storm Water Management

Another water quality issue facing Kimball Creek is a heavy sediment load. Such loads result from both natural and human-caused actions. For example, the erosion that occurs during large storms and the erosion that is caused by unmitigated development can both cause excess sediment in the waterway. While the requirements associated with storm runoff from development projects are clearly defined by the King County Surface Water Manual,[79] enforcement of these requirements is not always consistently applied, and can be heavily influenced by the efforts of local citizens.

Sources of sediment entering Kimball Creek are difficult to identify due to the temporary nature of the disturbances. Heavy rainfall events that cause the erosion and deposition of sediment into Kimball creek coincide with the times the citizens are least likely to be observing creek conditions. Observation, in conjunction with a sense stewardship on the part of the creeks neighbors is the best way to identify and rectify the sediment sources that are contributing to the poor water quality of Kimball Creek.

Another contributor to water quality degradation in Kimball Creek is the practice of storm water diversion. Past developments in the Kimball Creek Basin have relied on the re-routing of storm

[79] King County Surface Water Design Manual, 1998 update, 2002 update in progress. (see previous foot notes)

waters directly to the Snoqualmie River to reduce the adverse impacts associated with urban runoff. While this approach has some merit for its ability to reduce pollutant loads, continued use of this practice will gradually reduce the flows in Kimball Creek, further increasing the likelihood of stagnation and the associated water quality issues. Periodic storm surges are essential for flushing accumulating sediments and pollutants out of Kimball Creek.

Given the above discussion, the following suggested actions would further improve the health of the Kimball Creek ecosystem and address the vision in this document:

- Cease storm water diversion.
- Instead, focus on the use of on-site storm water impoundments, treatment, and subsequent release to the natural drainage paths. Better replication of the natural, historic flows in the basin is critical to restoring the creek basin to a state in which it can be regarded as a community asset rather than a liability.
- City of Snoqualmie citizens, in the form of a stewardship association or stakeholder committee, can monitor water quality, report developer violations, and act as a watchdog group for the overall health of the Kimball corridor ecosystem.

c. Specific Restoration Projects

The maintenance of local surface water quality is a challenge in all urban settings. As a shared resource, urban streams belong to each member of the community. To that extent, most citizens feel it is within their rights to use the stream as they would use any piece of their property; this feeling of personal ownership is magnified when an urban stream flows through private lands. It is not uncommon for an individual to feel that their contribution to stream degradation is minimal in comparison to the impacts of the entire community. Little motivation exists for the individual to take responsibility for the degradation of a streams water quality, when it is clearly the responsibility of the entire community. If everyone in the community shares this view, the degradation of the resource is bound to continue. This phenomenon, often referred to as the ‘tragedy of the commons’, is the cause of water quality degradation in urban streams around the world.

Instilling a sense of community stewardship, of pride in ownership of the shared resource, is one method of reversing the ‘tragedy of the commons’ trend. Converting the image of an urban stream from a community problem to an important resource to be enjoyed by all community members is a challenge, particularly when the existing conditions of the stream are poor.

The restoration projects listed here, in addition to the septic tank and storm water retention improvements above, will clearly improve the overall ecological health of the Kimball corridor. Additionally, the results of these actions represent an important first step toward creating an environment conducive to activities suggested in the vision.

Restoration steps to improve the structure and function of Kimball Creek are explained in more detail in Chapter 2, and in the maps in Appendix F. These restoration steps include:

- Improve the surrounding landscape (increasing diversity, wildlife habitat, and forest complexity);
- Improve the riparian buffer (widening riparian buffer, decreasing invasive vegetation, and increasing shade)

- Improve the active channel (enhancing in-stream habitat features, revegetate and stabilize banks)
- Protect healthy elements of nearby hydrologic systems.

Stream restoration contributes directly to the three visions for Kimball Creek. The restoration of habitat quality of Kimball Creek is a primary vision of this report. Restoration activities can be an opportunity for convergence of the City, for volunteers, local landowners, community groups, and student groups. As described above, these groups each play important roles to identify problem areas, monitor conditions, and contribute to habitat improvements. The creek can be a laboratory for student projects and monitoring work. Existing publicly owned lands and access points represent initial locations on which habitat improvements may be made; further work with landowners can contribute to the stewardship of the creek on private parcels. Improving the ecological condition of Kimball Creek strengthens the place of the creek in the community. The creek can provide recreational opportunity to further the third vision – through public access points and potential trails described below.

2. Buy Out Strategic Lots

In addition to creek restoration and habitat improvement, public ownership of targeted lots in the Kimball corridor can present an important opportunity to implement the vision described in this document. Property buyouts and home elevations remain the most effective strategies available to residents in the Kimball Creek corridor to reduce their vulnerability to flooding. Home elevation has an obvious and immediate flood mitigation result for those property owners who elevate. Benefits from public buyout, however, can have a community wide effect that goes well beyond flood mitigation if lots are strategically chosen for purchase. City strategies for implementing these options should include considerations of the public benefits that come along with city ownership of lots.

Homes must have experienced repetitive flood loss to be eligible for the buyout program. Many of the homes in the Kimball corridor already meet eligibility requirements. The following are additional criteria that will help the City prioritize homes to target for buyouts should owners decide to sell:[80]

- *Parcels bordering the creek.* Ownership of these parcels would provide further points of access to Kimball Creek, space for trails, and closer control of bank stability and habitat integrity.
- *Parcels adjacent to existing buyouts.* Contiguous plots would provide larger spaces for public parks and creek access.
- *Parcels served by septic systems.* Many of the septic systems in the area are older and may be in danger of failure. Reducing reliance on septic systems could have a positive effect on groundwater and stream water quality.

Buyouts could further serve the public good by increasing the number of Community Rating System (CRS) points that the City of Snoqualmie earns. A higher number of points can lead to

[80] Owners of homes that meet none or few of these criteria should be encouraged to elevate their homes to reduce damages in future floods.

lower flood insurance rates for the entire community. FEMA provides up to 375 points for preserving open space in the floodplain, and an additional 100 points for preserving "natural and beneficial functions" (leaving open space in an undeveloped and natural space).[81]

Strategic selection of lots for purchase can maintain a corridor that fulfills each of the vision statements described above.

To advance this recommendation, the City should extend and maintain their database of information regarding Kimball Creek. From this study it is clear that the City would benefit from having a complete set of current GIS layers regarding land use, land ownership, septic usage, flooding and political jurisdiction. The City may look at different scales to solve different problems regarding the creek.

This recommendation contributes to the vision of this plan in several ways. Maps and associated information can be used for educational purposes. Maps of floodplains and floodways can help to show which community residents are affected under various strategies of flood control. A priority in this instance is to complete the first-floor elevation database, which reveals the more vulnerable homes. A database describing the riparian zone land use and land ownership along Kimball Creek will help the city to prioritize which actions will be most effective in revitalizing a clear, cold stream. A new database of potential trails for walking, biking, and horseback riding is being compiled through this report. These trails and parks will be used by community residents as well as tourists, and should be updated and maintained for those community members who are interested in helping with these projects or using the trails upon completion.

3. Create a Split Floodway

The "split floodway" concept could be a very powerful tool in the implementation of a vision for Kimball Creek. The split floodway would:

- Permanently preserve very low-density development on the fringes of the City of Snoqualmie, and disallow any new building in that area. The Kimball Creek corridor would be protected from over development through city and county code.
- Allow for improved public access to the recreational and educational resource of Kimball Creek as development patterns change to create new open space in the corridor.
- Give city decision makers greater control of the ecological health of the stream. The split floodway supports the FEMA buyout option described above, strengthening the argument for public ownership of lots in the corridor.

In addition to supporting the vision as described above, the split floodway would benefit the public good in other ways. Perhaps most importantly, it will more closely represent the goals of a floodway overlay zone by disallowing new building in the most frequently flooded areas of the Kimball corridor. The split floodway might better protect life and property than the existing code. It will also narrow significantly the existing floodway overlay zone, thereby relieving many Snoqualmie residents of the hardship of homeownership in a floodway. Residents whose homes would now be outside of the zone would be allowed to significantly improve their properties and/or rebuild following disasters.

[81] Federal Emergency Management Agency, National Flood Insurance Program, *CRS Coordinator's Manual,* January, 1999.

The new floodway will not immediately change development patterns in the Snoqualmie Valley, but will take more meaning over time. As development occurs and homes are bought and sold, the code would begin to manifest itself in the physical landscape of the Kimball corridor, helping to further the vision describe above.

4. Increase Human Use and Community Involvement

The goal of all of the actions suggested above is to create an environment in the Kimball corridor that will be more conducive to human use. This section will address actions that, together, describe the form that that human use might take.

The most important suggestions in this section involve community involvement in the implementation of any vision for the area. Without citizen ownership, large-scale visions like the one suggested here have a much higher likelihood of failure.

a. A Visioning Process and Stakeholders Committee

Before Kimball Creek can become a community amenity, citizens must become aware of the corridor's potential. Two important actions for raising the visibility of the Kimball corridor include: 1) citizen awareness of the corridor's current state, and, 2) sustained community involvement in the vicinity.

Notably absent from Snoqualmie's civic infrastructure is a group of people who share the goal of improving the state of the creek. One option for addressing this is the formation of a group of stakeholders who would be involved in long-term planning and visioning processes for the creek. Many people in the City of Snoqualmie could potentially benefit from improved conditions in the area. Among them are:

- Homeowners along the creek
- Citizens interested in preserving and enhancing the environmental integrity of the creek
- Outdoor enthusiasts, who would enjoy the trails and open space near their homes
- Educators and the school district
- Business owners, especially those who might benefit from increased tourism in the area
- Civic groups, which might be interested providing volunteers for restoration projects
- Naturalist organizations (such as the Audubon Society) who would be interested in improved habitat
- Decision makers and planners

As is evident from the list above, the vision suggested in this document could affect nearly the entire community. Without their involvement, any vision for the area would be meaningless. Using this document as a starting point, a stakeholders committee comprised of the people described above could begin the process of planning for the long-term health of the corridor, and could additionally act as caretakers for the creek's health. Their involvement would help to ensure successful implementation of a more community-based vision.

b. Suggested Activities for Human Use

The following are ideas and suggestions that might be incorporated into the planning process for the Kimball Corridor.

- *Educational Opportunity.* The creek provides a powerful educational opportunity for those who live near or visit the creek. Local schools should be encouraged to bring their students to creek and use it as a living laboratory. However, the educational value of the creek need not be limited to the more formal educational system. A series of signs throughout the watercourse of the creek could inform readers of the geological and biological forces at work in the corridor.
- *Public Amenities.* Create more public amenities such as signage, park furniture, landscaping and adequate parking at existing publicly owned lands. At present, park amenities are nonexistent on all public lands bordering Kimball Creek. This is a relatively inexpensive and simple action that has the potential to greatly increase human use on existing publicly owned parcels.
- *Strategic Acquisition.* Identify lots that through future buyouts could expand and enhance existing publicly owned lands.
- *Trail System.* Use the creek corridor as the basis for an extensive trail system connecting the city together. This trail could connect with the Centennial Trail, the Snoqualmie Valley Trail, the Snoqualmie Preston Trail, Meadowbrook Park. Signs and pedestrian routes along sidewalks and street shoulders could further link city attractions that do not directly border the trail. Please refer to the "Proposed Trail System" map in Appendix A, and Scenario 3 in Chapter 5 for further description.

Conclusion

The Kimball Creek corridor stands to benefit from a community planning process; the creek's water quality and ecological health, flood risk, and accessibility could each be improved through targeted attention from the community surrounding it. The community would also benefit from participation in such a process; the visioning process itself can bring community members together around the important issue of considering the shape of future development in the Snoqualmie Valley.

All of the above actions, taken together, could positively affect not just Kimball Creek, but the shape of the City of Snoqualmie in the years to come. The City is projected to grow rapidly; protecting open space and managing development within the urban growth area will help the city to maintain its rural character through the changes in infrastructure necessary to support a growing population. Planning for Kimball Creek as an asset now can be an important step in planning for a livable City of Snoqualmie in the future.

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APPENDIX A: MAPS

List of Maps in Appendix A:

APPENDIX B: STATISTICAL AND EMPIRICAL ANALYSIS FOR MAXIMUM PROBABLE FLOWS IN KIMBALL CREEK

Approximate maximum stream flow volumes for Kimball creek are calculated using the Soil Conservation Services (SCS) method[82]. Flow volume for a given rainfall intensity is determined as a function of the water shed area *A* (mi^2), the total volume of potential runoff *M* (inches), the duration of the rainfall event *D* (hours) and the tome of concentration t_C (hours). The formula is expressed as:

$$Q_T = \frac{484 \cdot A \cdot M}{0.5 \cdot D + 0.6 \cdot t_C}$$

The result Q_T is a flow in cubic feet per second (cfs) that corresponds to the return interval T from which the rainfall intensity is determined.

Rainfall intensities for selected return intervals were calculated from 70 years of rainfall measurements. The National Climatic Data Center (NCDC) and the National Oceanographic and Atmospheric Administration (NOAA) operate a meteorological station at Snoqualmie Falls. The station is located at approximately at 47°33' north latitude and 121°50' west longitude. The cooperative station ID# is 457773. Daily precipitation measurements covering the period from January of 1931 to July of 2002 that were used to develop the probability distribution of rainfall intensity were downloaded from the NCDC's data distribution center at: http://lwf.ncdc.noaa.gov/oa/climate/stationlocator.html

The 71 maximum annual 24-hour precipitation values were fitted to a Gumbell Extreme Value Type I distribution. The selected return intervals were then read from this fitted distribution.

Time of concentration t_{c+} is calculated with the Kirpitch formula[83]:

$$t_C = 0.0078 \cdot L^{0.77} \cdot S^{-0.385}$$

With L being the length of the stream channel in miles and A being the average slope of the channel in ft/ft.

The area, channel length, and channel slope of the Kimball Creek watershed were determined by analysis of stream flow channels and elevations using an ArcInfo geographic information system. The 10 meter resolution digital elevation model (DEM) for the region provided on-line by the USGS. Other geographic data for the area was provided by the City of Snoqualmie planning department, and the Washington Geospatial Data Archive.

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[82] Handbook of Hydrology, editor David Maidment, McGraw Hill, New York, 1993. p. 9.25

[83] Ramser, C.E., "Run-off from Small Agricultural Areas," *J. Agric. Res.*Vol. 34, 1927.

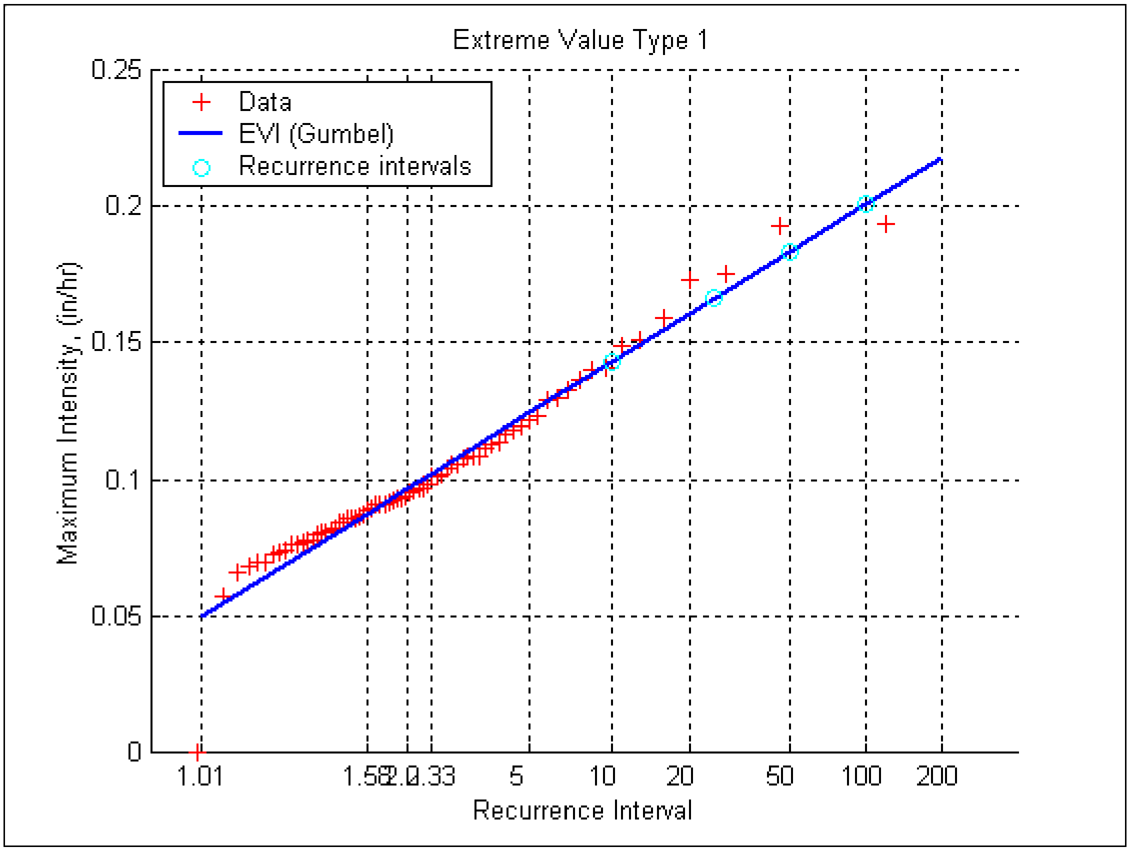

Figure 4 - Recurrent distribution for 24hr rainfall event at Snoqualmie Falls

Recurrence interval (years)	Rainfall intensity (in/hr for a 24 hour period)	Rainfall volume (in)
10	0.143	3.432
25	0.166	3.984
50	0.183	4.392
100	0.201	4.824
500	0.240	5.76

Table 5 - Summary of design rainfall intensities

The total volume of potential runoff *M* is related to the land use and soil characteristics of the basin. The value of *M* is essentially the total volume of rainfall minus the volume infiltrated and intercepted in the basin. Precipitation falling on heavily forested areas with thick soils leads to very little run-off while impervious surfaces convert nearly 100% of rainfall to runoff. The land use patterns of the Kimball Creek water shed where determining by GIS analysis (see map supplement X for land use cover map). Runoff coefficients for each land use type were calculated using the Soil Conservation service's Curve Number (CN) method.[84] An aggregate CN value was determined by using an areal weighted average.

The land use area and CN values are summarized in Table 6. The CN values selected assume a high antecedent moisture condition. The times of year when high flows are likely to occur are typical the wettest periods with several days of extended rainfall. Soils in the watershed are likely to be already near saturation when a storm event occurs.

Land_use	Acres	% cover	CN	CN%	
Dense Shrub	22.5810426	0.436%	45	0.196379	
Cultivated	117.787	2.276%	81	1.843827	
Heavily Forested	3274.530	63.283%	25	15.82076	
High Density Development	264.085	5.104%	85	4.338114	
Impermeable	350.495	6.774%	98	6.638134	
Low Density Development	325.197	6.285%	51	3.205197	
Open Grass/Shrub	97.529	1.885%	39	0.735081	
Partial Forest	325.398	6.289%	30	1.886579	
Turf	109.722	2.120%	39	0.826982	
Riparian/Wetland	287	5.548%	20	1.109675	
	5174.41984	100.000%		36.60	Areal avg CN

Table 6 – Land Use percentages and CN values

Using the average CN value and the precipitation values from the selected storm events in Table 6, the Peak flow volumes for the 10, 25, 50, 100, and 500 year, 24 hour storm events for the current land cover conditions in the watershed are given in Table 7.

Recurrence Interval	10	25	50	100	500
Peak Flow (cfs)	**58**	**96**	**132**	**176**	**289**

Table 7 - Summary of Peak Flow Results

The peak flow for the 100 year event shown in Table 7 illustrates that there is little likelihood of flooding when the Kimball Creek watershed is considered in isolation. It should be noted however that the flood conditions of Kimball Creek are highly influence by the effects of hyporheic flow entering the stream channel from the alluvial plain that covers the entire Snoqualmie valley floor. Additionally the water levels in Kimball Creek are highly influenced by water levels in the Snoqualmie River itself that often "backs up" into the Kimball Creek channel during flood events.

The flow volumes in Kimball Creek are highly influenced by the land cover patterns seen in the basin. Continued development of the basin will undoubtedly lead to alterations in the frequency of high flows in Kimball Creek. Heavily forested areas absorb the majority of the rainfall even

[84] U.S Soil Conservation Service, *National Engineering Handbook, Sec 4, hydrology*, U.S. Department of Agriculture, Washington D.C. 1985

during extreme events, as forested areas are removed this absorptive capacity is lost. The progression of increased flood events as a function of forest cover is demonstrated in Table 8 and Figure 5. It is assumed in this progression that as forest cover is lost the areas are converted to other land uses in an equal proportion to those that already exist.

Percent Forest Cover	Return Period(years)				
	10	25	50	100	500
Pristine(100%)	**24**	**39**	**57**	**82**	**154**
Current (63%)	**58**	**96**	**132**	**176**	**289**
50%	**78**	**125**	**167**	**217**	**345**
25%	**124**	**187**	**241**	**304**	**458**
10%	**157**	**231**	**292**	**362**	**531**
0%	**174**	**250**	**313**	**386**	**559**

Table 8 – Increase in Peak flow volumes with loss of forest cover

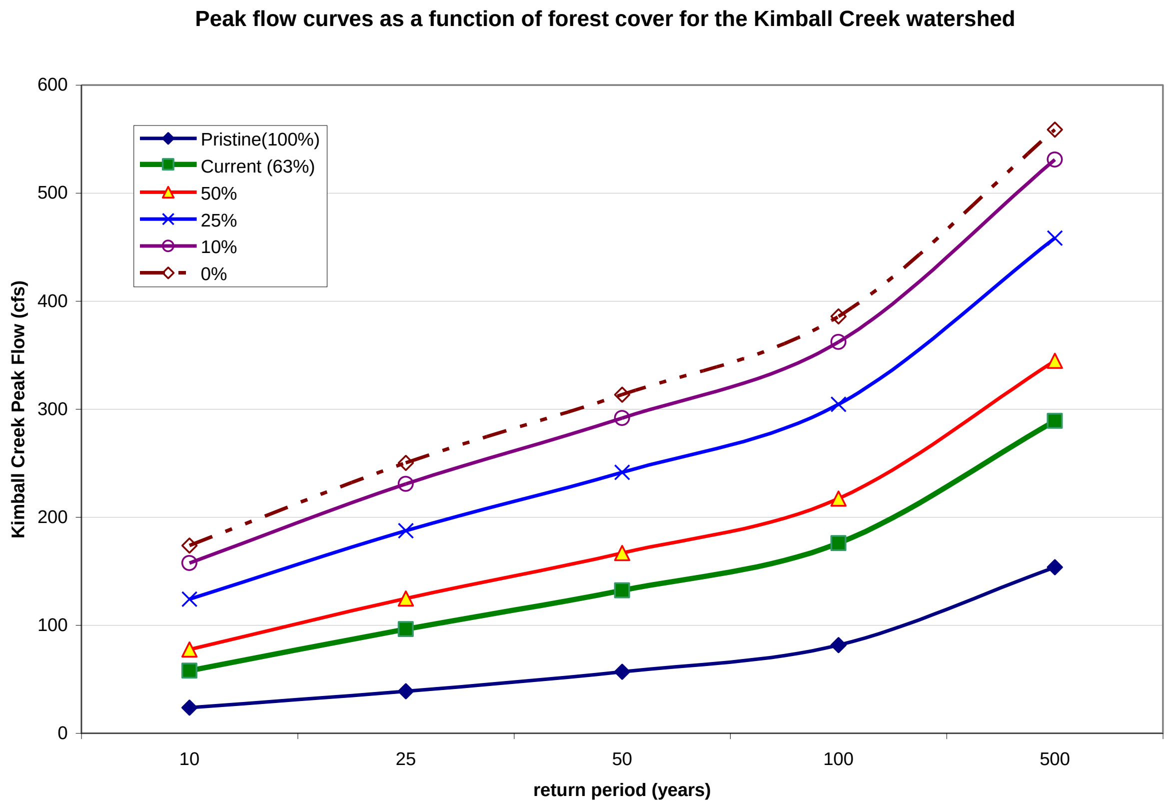

Figure 5 – Peak Flow as a function of forest cover in Kimball Creek watershed

It is clear that floodwaters originating within the Kimball Creek watershed are not of significant concern; however as more changes to land cover occur both inside and outside the Kimball Creek watershed, the likelihood of flooding will increase.

APPENDIX C: CODE AND REGULATIONS GOVERNING DEVELOPMENT

This appendix further explains the code governing development in the Snoqualmie River Valley. It is divided into sections by jurisdiction (Federal, State, etc.), and corresponds to the "Authorization and Jurisdictions" map in Appendix A that delineates jurisdictions and describes flood policies in the area surrounding the study area.

Federal

The entire 100 year flood plain is governed by the following legislation:

1. Most important among Federal programs affecting development along Kimball Creek is the National Flood Insurance Program (NFIP). The National Flood Insurance Program (NFIP) is a federal insurance program that makes affordable flood insurance available to property owners in selected communities. The eligible communities must have adopted floodplain management regulations at least as stringent as the federal minimum standards as established by FEMA. Minimum standards include:

    - Communities must review subdivision proposals and other proposed new development, including manufactured home parks or subdivisions to ensure that these development proposals are reasonably safe from flooding and that utilities and facilities servicing these subdivisions or other development are constructed to minimize or eliminate flood damage.
    - The lowest floor must be raised (on fill or on extended foundation walls or other enclosure walls, on piles, or on columns) to or above FEMA base flood elevation for all residential development.
    - All new construction and substantial improvements of non-residential buildings must either have the lowest floor (including basement) elevated to or above the BFE or dry-floodproofed to the BFE. Dry floodproofing means that the building must be designed and constructed to be watertight, substantially impermeable to floodwaters. [85]

    Residents of the City of Snoqualmie and King County are eligible for FEMA flood insurance; as of September 2001, 499 residents of the City of Snoqualmie had active NFIP insurance.[86]

2. The Community Rating System (CRS) is a NFIP sponsored incentive program designed to reward communities that go beyond the minimum standards to reduce or eliminate flood damages by lowering their flood insurance premiums. There are 18 activities recognized as measures for eliminating exposure to floods. Credit points are assigned to each activity. The activities are organized under four main categories: Public Information, Mapping and Regulation, Flood Damage Reduction, and Flood Preparedness.

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[85] *National Flood Insurance Program Description,* Federal Emergency Management Agency, Federal Insurance and Mitigation Agency, 8/1/2001, p. 13.

[86] FEMA flood insurance statistics, http://www.fema.gov/nfip/pcstat.htm, 11/2002.

King County's current CRS rating, 4 on a scale of 10, is one of the best in the nation. (The best score on the scale is a 1). The City of Snoqualmie scores 5, qualifying its residents for a 25 percent discount on flood insurance.

Washington State

The entire 100 year floodplain is also governed by Washington State statutes and laws as follows:

1. The principal state statutes that address flood hazard management activities are Flood Control by Counties (RCW 86.12) and Floodplain Management (RCW 86.16). The former (86.12) gives counties the authority to levy taxes and exercise eminent domain to control and prevent flood damage. RCW 86.16 integrates local and state regulatory programs in a comprehensive effort to reduce flood damage and protect human health and safety. The state program requires local flood-prone jurisdictions to adopt flood damage prevention ordinances based on the federal standards establish by FEMA through the NFIP. Washington State codes go beyond the NFIP minimums in restricting new residential construction in floodways.

   Since most of Kimball Creek is inside of the FEMA floodplain and/or floodway, this code applies to development along its banks. The City of Snoqualmie accomplishes state goals through its own city code.

2. The Washington State Shoreline Management Act (SMA) (RCW 90.58) also applies to portions of Kimball Creek; its mission is broader than flood damage reduction, including protection of public resources (water, wildlife, habitat) and regulation of development in shoreline areas. In addition to oceanfront shorelines, reservoirs, wetlands, and lakes of certain sizes, the SMA applies to all streams where the mean annual flow is 20 cfs or less. Kimball Creek is under SMA jurisdiction from its confluence with Coal Creek to its mouth at the Snoqualmie River.

   In addition to underlying zoning each jurisdiction might enact, state policy requires that overlay zoning designed to establish allowable shoreline uses within each environment designation be codified and implemented. In most cases, the SMA is now incorporated at the local level as a component of the comprehensive plan. Applicable code is discussed below in the section regarding Snoqualmie's Comprehensive Plan.

3. RCW, though the Growth Management Act (House Bill 2929), also requires special planning and permitting processes for development occurring in "critical areas," which include floodplains. These processes are detailed in Part I of the GMA.

King County Code

The area surrounding Kimball Creek that is outside of the city limit but inside the floodplain is governed by King County Code 21A.24 "Flood Hazard Areas." The City of Snoqualmie has incorporated these regulations into their city code. King County Code is more restrictive than the minimum guidelines set by FEMA.

The most important codes are summarized below:

- King County does not allow any new development or subdivisions that would cause a rise in 100 year flood levels.[87] This is referred to as a "Zero-rise Floodway," considered one of the strictest restrictions on development designed to protect human life and property.
- New residential or nonresidential structures are prohibited in the FEMA floodway.[88]
- All new structures permitted within the flood hazard area require certification by a professional engineer or land surveyor of lowest floor elevation. This must be at least one foot higher than the 100 year flood level.[89]

Snoqualmie City Code

The all areas within the city limit (Urban Growth Area) are governed by City of Snoqualmie Code. Snoqualmie's Comprehensive Plan[90] regulates all development within the city's growth management area. The Comprehensive Plan takes into consideration state GMA and SMA requirements, as well as FEMA floodplain and floodway definitions, requiring all development proposals within the floodplain to be reviewed for, and conditioned or denied based upon their effect upon the storage and conveyance of floodwaters.

Below is a brief discussion policy that governs development along the banks of Kimball Creek:

The City of Snoqualmie has responded to a state objective to "Restrict the opportunity for further inappropriate high density residential development within the floodplain" by limiting density to one dwelling unit per five acres within residential districts in the flooplain (10.C.2.1.1).

Residential development within the Shorelines of the City of Snoqualmie is limited and highly regulated due to flood hazard considerations. In accordance with requirements for participation in the FEMA National Flood Insurance Program, new residential development within the 100-year floodway of the Snoqualmie River is prohibited, and all residential development within the 100-year floodplain must be built with the first floor at or higher than one foot above the 100-year flood elevation. While individual single family residences are exempt from shoreline substantial development permits, the subdivision of land requires such a permit and is subject to Shoreline Master Program regulations.

Development within 200 feet of the ordinary high water mark is limited to uses that are compatible with the ecological function of the shoreline, public safety, and flood hazard constraint (10.C.1.2.1).

Snoqualmie's Comprehensive Plan also specifically addressed the issue of flood control measures, and lays out relatively restrictive allowable uses for in-stream and stream bank mitigation tactics. In fact, most structural measures would not be consistent with the Comprehensive Plan without exhaustive research proving its necessity. A brief summary of applicable code follows:

Do not allow structural flood control measures unless a need is demonstrated and it can be demonstrated by a scientific and engineering analysis that nonstructural measures are not

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[87] King County Code, 21A.24.260B.
[88] King County Code, 21A.24.260C.
[89] King County Code, 21A.24.270.
[90] City of Snoqualmie, *Snoqualmie Vicinity Comprehensive Plan, 2000,* Shoreline Master Program

feasible, impacts to the existing shoreline conditions can be successfully mitigated, and appropriate vegetation management actions are undertaken (10.E.1.1).

Prevent structural flood control measures, vegetation removal, and gravel removal within a channel migration zone unless necessary to protect existing improvements and no other option is feasible (10.E.1.2).

Require that gravel removal for flood management purposes be consistent with the King County Flood Hazard Reduction Plan and allowed only after a hydrogeologic study shows that extraction has a long-term benefit to flood hazard reduction and will not intensify downstream flooding (10.E.1.3).

Design flood control projects to maximize open space elements which are not subject to extensive flood damage, such as parks and agriculture (10.E.1.4).

Design flood control works to minimize negative and maximize positive impacts on the natural environment and wildlife habitat. Require all new flood control works to include environmental enhancement measures whenever feasible (10.E.1.5).

Require that dredging and channel excavation be carefully controlled to minimize damage to the ecological values and natural resources of both the area to be dredged and the area for the deposit of dredged materials (10.E.6.3).

Appendix D: Example of Density Fringe Code, Snohomish County, Washington

This appendix provides excerpts from Snohomish County, Washington county code, which describes development restrictions in the "density fringe area." Snohomish County has adopted "Density Fringe Area" code for some sections of rivers in the county. This type of code is appropriate for areas where floodways are difficult to establish.

27.08.010 Density fringe area.

"Density fringe area" means that portion of the special flood hazard area of the lower Snohomish and Stillaguamish rivers in which floodway areas cannot reasonably be established and in which development is regulated by maximum development density criteria.

27.36.010 Applicability.

This chapter provides specific criteria to be used in regulating development in areas of high flood damage potential where conventional floodway areas cannot be established. In order to foster the continued agricultural use of prime farmlands in these flood plain areas, and maintain an acceptable level of flood hazard protection, the development criteria outlined by this chapter shall apply to all development in the density fringe areas. The development criteria contained in SCC 27.36.030 and 27.36.040 shall be utilized to prevent a cumulative increase in the base flood elevation of more than one foot.

(Added Ord. 84-014, § 1, Feb. 27, 1984).

27.36.020 Area of coverage.

The density fringe area shall consist of that portion of the special flood hazard area (100-year flood plain) identified by the U.S. Army Corps of Engineers river studies as modified by Snohomish county and as incorporated herein by SCC 27.12.020, as follows:

(1) Snohomish River special flood hazard area (100-year flood plain) located between the mouth of said river and river mile 16.61; also corresponding to the Corps of Engineers study E-2-6-497 as modified by Snohomish county, sheets 1 through 15.

(2) Stillaguamish River special flood hazard area (100-year flood plain) located between the mouth of said river and river mile 11.1; also corresponding to the Corps of Engineers study E-2-10-138 as modified by Snohomish county, sheets 1 through 8.

(Added Ord. 84-014, § 1, Feb. 27, 1984).

27.36.030 Maximum allowable density.

The land area occupied by any use or development permitted by this chapter that will displace floodwaters shall not exceed two percent of the land area of that portion of the lot located in the density fringe area. The limitations of this section shall not apply to those uses listed in SCC 27.36.050.

(Added Ord. 84-014, § 1, Feb. 27, 1984).

27.36.040 Maximum allowable obstruction.

The maximum width (sum of widths) of all new construction, substantial improvements or other development shall not exceed 15 percent of the length of a line drawn perpendicular to the known floodwater flow direction at the point where the development(s) is located. The length of said line shall not extend beyond the property boundary or the edge of the density fringe area, whichever is less. The limitations of this section shall not apply to those uses listed in SCC 27.36.050.

27.36.070 Permitted uses.

The following uses are permitted in the density fringe area:

(1) Agriculture, including:

(2) Forestry, including processing of forest products with portable equipment;

(3) Preserves and reservations;

(4) Parks and recreational activities;

(5) Removal of rock, sand and gravel providing that the applicant can provide clear and convincing evidence that such a use will not divert flood flows causing channel shift or erosion, accelerate or amplify the flooding of downstream flood hazard areas, increase the flood threat to upstream flood hazard areas, or in any other way threaten public or private properties. When allowed, such removal shall comply with the provisions of chapter 18.54 SCC, mineral conservation zone and the Snohomish county shoreline management master program;

(6) Utility transmission lines, under the same terms and conditions of SCC 27.28.010(2);

27.36.080 Prohibited uses.

The following uses shall be prohibited in the density fringe area:

(1) Any structure, including mobile homes, designed for, or to be used for human habitation of a permanent nature (including temporary dwellings authorized by SCC 18.32.040), except as provided by SCC 27.36.070 (8) and (9);

(2) The construction or storage of any object subject to flotation or movement during flooding;

(3) The filling of marshlands;

(4) Solid waste landfills, dumps, junkyards, outdoor storage of vehicles and/or materials;

(5) Damming or relocation on any watercourse that will result in any downstream increase in flood levels during the base flood;

(6) Critical facilities;

(7) The listing of prohibited uses in this section shall not be construed to alter the general rule of statutory construction that any use not permitted is prohibited.

(Added Ord. 84-014, § 1, Feb. 27, 1984; Amended Ord. 86-092, § 12, September 10, 1986; Amended Ord. 89-023, § 9, Apr. 26, 1989).

Appendix E: GIS Methodology

Software: We have used mainly Arc GIS 8.2 for projection, management and mapping tools. ArcView 3.2 was used for some minor analyses and file management purposes.

Sources:

Most maps were obtained from the City of Snoqualmie.

- Building shapes
- Parcels
- Lakes and Rivers
- Hill shade and topo map

Some maps were obtained from the County.

- Rivers and tributaries
- Snoqualmie watershed

Some maps were obtained from WAGDA (http://wagda.lib.washington.edu/)

- FEMA floodplain
- Roads and street system

Aerial Photographs were obtained from University of Washington Library (hard copy) and from the City of Snoqualmie's most recent digital aerial photography (ca. 2000).

Projections:

- Maps from the City of Snoqualmie were created from the most recent data layers available from the City. They arrived in the projection: State Plane (feet), Washington State North, NAD83
- Maps from the County were created from the most recent data layers available from King County Department of Natural Resources and Parks GIS. They arrived in the projection: State Plane (feet), Washington State North, NAD83
- Maps from WAGDA are in the projection: State Plane (feet), Washington State North, NAD83

All maps were reprojected in Arc Toolbox, into the projection: UTM (meters), Zone 10, NAD27

New Maps – Creation Process

Kimball Creek and Buffer: Kimball Creek was drawn from a series of aerial photographs. The buffer was created through the Geoprocessing Wizard in Arc – a buffer of 200ft, which is supposed to be a standard riparian buffer width.

Study Area: Parcels were selected if they intersected the 200ft buffer of Kimball Creek. The study area was then expanded to include parcels up to an arterial road. This delineation is supposed to capture a local set of parcels from the creek, and show those that would easily associate themselves within a community.

10, 100, 500 Year Floodplains: We took flood heights at 10, 100, and 500 year flood events from a 1990 flood profile, from a point at the confluence of Kimball Creek and Snoqualmie River. These heights were 415ft, 421ft, and 426ft respectively. Areas below 415ft were designated 10yr flood areas; areas between 415ft and 421ft were designated 100yr flood areas; areas between 421ft and 426ft were designated 500yr flood areas. Error associated with this map is not quantified; some must be expected away from the point of measurement because slope of land is not taken into account, and because the heights are based on only one point on the map, where Kimball meets Snoqualmie.

Land Cover and Land Use: Vegetation on either side of Kimball Creek was classified as follows for these maps, analyzing digital and hard copy aerial photographs on the computer and with a stereoscope to determine land cover on the ground. ArcGIS was used to delineate polygons of land cover.

For "Land Use" a coarse-grained analysis included the following classes:

Mixed Forest
Coniferous Forest
Deciduous Forest
Shrub
Wet Shrub
Grass
Building
Road

Further analysis of land cover classes was performed for the Stream Ecology analysis, producing the "Land Cover" map in Appendix E. Vegetation on either side of Kimball Creek was classified into 22 vegetation and other classes. Aerial photographs were used (digital and hard copy), looked at with a stereoscope, to determine what landcover was on the ground. Field trips were taken in order to ground truth the classification.

Land cover categories delineated from aerial photography. Measurements are relative to each other. For example, small patch, low and high refer to vegetation patches and height that deviate substantially from the average. Cover classes in the "Land Cover" map include:

Alder
Bare soil
Building
Emergent wetland
Forest, conifer
Forest, coniferous-small patch
Forest, deciduous
Forest, deciduous/shrub
Forest, deciduous-small patch
Forest, mixed

Forest, mixed/shrub
Forest, mixed-small patch
Grass
Grass, high
Grass, low
Other
Road
Shrub
Shrub, high
Shrub, low
Shrub wet

Trail System: Trails were hand drawn as new shapefiles.

Park Expansion: Existing parks were evaluated and appropriate parcels of nearby land were chosen based on (i) their land cover and (ii) their ownership.

Split Floodway: The split floodway arrows were drawn by hand on top of FEMA's floodway and floodplain to show the concept of where a split floodway would go and which property would be affected by this change in zoning.

First Floor Elevation Map: A study conducted by the Army Corps of Engineers ca. 1981 (data provided by Paul Cooke, US Army Corps of Engineers) resulted in a map of relative first floor elevations for residences on the West side of Kimball Creek. The buildings are coded according to whether they are susceptible to 10, 50, or 100 year flood events. The same study recorded first floor elevations for many houses in the City. These were not recorded in a GIS, but by combining locational identifications to the County's map, we have created an incomplete GIS layer of first floor elevations for the 200 ft buffer around Kimball Creek.

APPENDIX F: STREAM ECOLOGY APPENDIX

Additional Information

Remote Sensing

Using remotely sensed data to characterize habitats can over-generalize microhabitats. As such, these data were augmented via ground-truthing. Natural vegetation communities form continuous eco-tones that creates technical problems of polygon border determination. The use of multiple scales to capture patch characteristics helped to improve accuracy and resolution of the ecological map.

Management Indicator Species

MIS candidates usually include sensitive species because it is thought that the sign of stress to an ecosystem will occur at the population level, affecting especially sensitive species (Odum 1992). In addition, keystone species or umbrella species are often chosen as MIS. Often in larger landscapes a suite of MIS is monitored, each reflecting a different spatial scale. This is important because smaller organisms and processes may act independently of larger habitat elements (Simberloff 1998). It is often desirable to measure the habitat itself, either as an alternative to or to supplement to an MIS. For example, key habitat and vegetation features are relevant to mid and large size wildlife species and play a role in structuring the ecosystem (e.g., large trees, snags) (Simberloff 1988). At the landscape scale, structure-based indicators such as complexity and composition, connectivity and heterogeneity can be used to reflect landscape biodiversity or health (Noon 1997, Lindenmayor et al. 2000). This strategy can be desirable because structural features are static and can be remotely sensed (Simberloff 1998).

Avian Breeding Conditions

"Avian breeding success reflects stand condition at the microsite (i.e., fine scale). Breeding, not necessarily abundance, sensitive to spatial relations such as distance to canopy openings and urban edge. These landscape features can create "ecological traps" whereby species experience lower reproductive success due to inadequate food supply or increase in predation and / or parasitism. [91][92][93] For example in Boulder, Colorado, Plumbeous vireos nesting near canopy openings and urban edges experience a relatively low reproductive success".[94]

Riparian Habitat Conditions

Riparian and bank vegetation protects streams in a variety of ways:

Filtering and catching of sediment before it reached stream. Too much sediment blocks sunlight, impacting growth and reproduction of aquatic plants, clogs interstitial spaces in gravel which impacts incubating fish eggs by not allowing oxygen to get to eggs, scratches fish gills.

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[91] Chace and Cruz 1999.
[92] Hutto and Young 2000.
[93] Chace et al. 2002.
[94] Walsh et al 2001.

Nutrient, pesticide removal - Nitrogen and phosphorus can spur algal growth which impacts photosynthesis, depletes oxygen needed for fish especially. Riparian vegetation transforms nitrogen (e.g., NO3) in runoff to a gas or can use it in growth processes, nitrogen can be stored as woody tissue, forested soils retain (NO3) through assimilation, nitrification and denitrification.

Nutrient Input – Dissolve organic carbon and particulate organic detritus from riparian vegetation are an energy source for benthic detritivores (e.g., grazers) which are the basis (including algae, diatoms which detritovores will feed on as well) of the aquatic food chain that ends with fish.

Shading - Riparian vegetation can lower stream temperature via shading. This is important in regulating stream oxygen levels important for fish.

Structural input, bank stabilization – Streamside forest contributes large stable debris to the streambed which holds detritus long enough to be processed by the invertebrate community. This instream structure can also contain and store sediment. Tree roots will stabilize stream banks.