

# AN OVERVIEW OF THE GEOLOGY AND GEOMORPHOLOGY OF THE SNOQUALMIE RIVER WATERSHED



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**King County**

Department of Natural Resources and Parks  
Water and Land Resources Division

**Capital Projects and**

**Open Space Acquisitions Section**  
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## 1.0 Introduction

### 1.1. Purpose and Scope of this Report

The purpose of this report is to summarize current knowledge on the geology and geomorphology of the Snoqualmie River Watershed, with emphasis on how this information relates to land use and aquatic habitat issues in the watershed. This report was prepared in support of the Snohomish River Basin Salmon Conservation Plan. The report is specifically intended to:

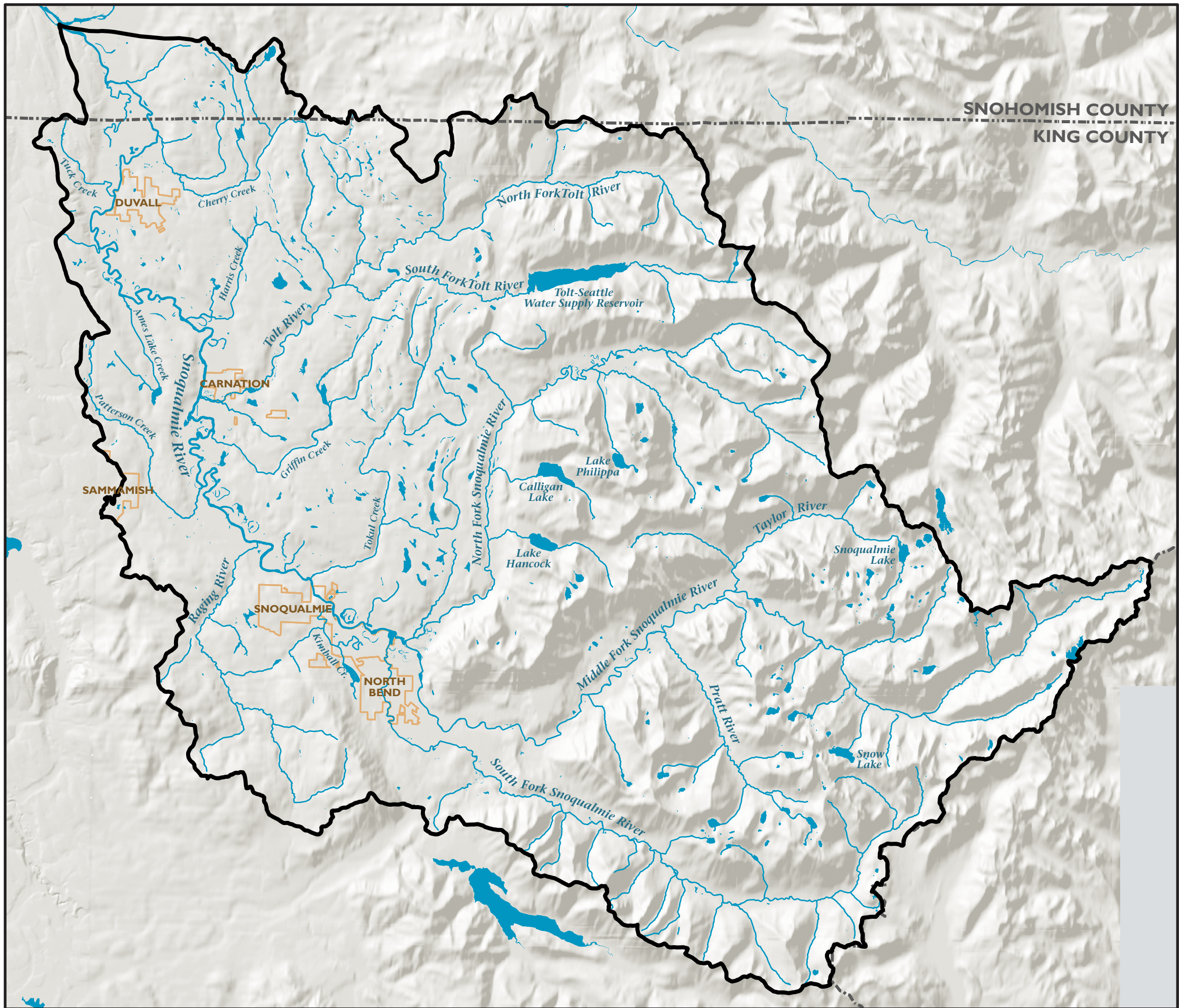
- Characterize the geologic history and active geomorphic processes in the Snoqualmie River valley;
- Provide a basis for assessing the role of active geomorphic processes in development of high-quality aquatic and riparian habitat;
- Identify circumstances in the watershed where geologic conditions or fluvial geomorphic processes pose a risk to existing or likely future land use; and
- Identify gaps in our present understanding of geologic conditions or geomorphic processes in the Snoqualmie River watershed as they relate to development of aquatic habitat or hazards to land use.

### 1.2. Overview of the Snoqualmie River Watershed

The Snoqualmie River originates as west-flowing drainage from the central Washington Cascade Mountains. Its various headwater tributaries join to form the mainstem river in the vicinity of the city of North Bend. The mainstem river continues flowing westward over Snoqualmie Falls. Below the Falls the river turns north into a glacially sculpted trough that it follows for 40 miles (64 kilometers) until reaching the confluence with the Skykomish River near the city of Monroe (Figure 1). The combined discharge of the Snoqualmie and Skykomish Rivers flows generally westward as the Snohomish River, reaching Puget Sound at the city of Everett.





The Snoqualmie River has a drainage area of 693 square miles (1794 square kilometers) at its confluence with the Skykomish River, and ranges in elevation from 7492 feet (2283 meters) on Mount Hinman on the Cascade Crest to 15 feet (4.6 meters) at the confluence with the Skykomish. Rainfall in the watershed ranges from 40 inches (1000 millimeters) in the lower valley up to 160 inches (4000 millimeters) near the Cascade Crest. At Carnation (the lowest gauged station in the watershed), the two-year discharge is 30,200 cubic feet per second (855 cubic meters per second); the one-hundred-year discharge is 79,700 cubic feet per second (2257 cubic meters per second). The Carnation gauge includes flow from 87 percent of the watershed area.

The Snoqualmie River watershed includes parts of two major physiographic provinces, the Puget Lowland and the Middle Cascade Range (Buffington et al., 2003). For the purposes of this report, these will be referred to as the “lowland” and “alpine” portions of the watershed.



# SNOQUALMIE WATERSHED

Figure I  
VICINITY MAP

-  Watershed Boundary
-  Stream
-  Lake/River
-  Incorporated Areas



0 2 4 Miles

April 2004



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In the lowland portion of the watershed, geology and topography are primarily products of repeated continental glaciations. In the alpine area, much of the ground surface (except in valley bottoms) is directly underlain by bedrock, and the topography is primarily a result of erosion and sediment deposition by repeated alpine glaciations.

Land use in the Snoqualmie watershed is strongly related to elevation and topography. The highest portions of the watershed in the high Cascades are set aside in the Alpine Lakes Wilderness Area; 112 square miles (289 square kilometers) or 16 percent of the watershed are inside the Wilderness Area boundaries. With a few minor deviations, all of the land in the watershed starting in Township 10 and east to the Cascade Crest (including the wilderness area) is in the Mount Baker-Snoqualmie National Forest. The lower slopes of the Cascades and the foothills areas are in mixed public/private ownership in many locations, preserving the “checkerboard” ownership pattern reflecting early railroad and public school land grants. Much of this land is in forest production. The alluvial valley bottoms have a long and continuing history of agriculture. Urban land uses and densities characterize communities in the watershed, including the cities of Snoqualmie, North Bend, Carnation, and Duvall, and the unincorporated towns of Preston and Fall City. Suburban residential development is the dominant land use in the portion of the watershed west of the lower valley and is expanding in other areas of low to moderate elevation.

## 2.0 Factors Controlling Fluvial Geomorphology

The physical characteristics of a stream channel result from the integration of a number of controlling factors. The relationship between these factors is complex and in some cases only qualitatively understood. In spite of this uncertainty, it is critical to base stream management actions (whether for habitat enhancement or hazard mitigation) on the clearest possible understanding of active geomorphic processes and relationships in the action area.

Precipitation falling on the landscape is the ultimate source of stream flow. Rain (or snowmelt) can flow a variety of paths between falling to earth and reaching a stream channel. Precipitation that falls on a typical undisturbed Pacific Northwest hillside soaks directly into the ground without flowing on the surface at all. This water, moving as shallow or deep groundwater, flows downslope and emerges as seeps or springs that feed stream flow. This process attenuates discharge from intense precipitation events, decreasing peak flows and increasing stream base flow. In contrast, precipitation that falls on impervious surface (bedrock or asphalt) flows quickly downslope into the receiving channel. This results in much higher peak discharges and lower base flow. From a hydrologic standpoint, the most significant change that occurs with land development is a dramatic increase in the percent area of impervious surface in the developed area.

Upon reaching a channel, water has potential energy related to its height above sea level. This potential energy is converted to kinetic energy as the water flows downhill. This kinetic energy provides the motive force for all fluvial geomorphic processes. The amount of energy available to do fluvial geomorphic work in a watershed is therefore a function of the ground surface topography (elevation), and the climate (precipitation). Geomorphic processes are continually flattening the landscape through erosion. The rate and pattern of this erosion is strongly controlled by the underlying geology. Tectonic movement raises areas of the earth's crust. The interplay between erosion and tectonic uplift ultimately controls the development of watershed topography.

The climate, topography, and substrate geology control the rate and routing of water flow from the land surface and through the drainage network. These drainage characteristics constitute the watershed hydrology. The hydrology in turn is one of the primary factors directly controlling fluvial processes. The character of the vegetative cover is largely controlled by the climate, and to a lesser extent by the substrate geology, hydrology, and topography. Vegetation in turn exerts a strong influence on hydrology by creating soil conditions that allow rapid infiltration. Live vegetation and organic detritus play an important role in many geomorphic processes. Canopy cover and organic soil horizons reduce surface erosion. Roots reinforce hillslopes and streambanks. In most environments the presence of vegetation inherently introduces fire to the landscape. Large woody debris (LWD) can strongly influence stream channel morphology.

Human actions alter geomorphic process in numerous and often dramatic ways. Human innovation creates new ways of modifying natural processes on an almost daily basis. Construction of roads and buildings changes natural runoff patterns. Grading, resource

extraction, and dam construction directly alter topography. Logging, agriculture, and landscaping can dramatically change vegetation patterns over large areas of the landscape. The web of interrelated factors that control fluvial geomorphic processes is summarized in Figure 2.

The physical character of a stream channel (including elements like cross-sectional shape, longitudinal profile, streambed texture, and sinuosity) is a result of integration of the controlling factors described above. Changing any of these factors will generally result in a change in the channel character. It is, however, often difficult to predict exactly how a channel will respond to a given change. For example, if a landslide suddenly introduces a large volume of sediment into a river, the channel may show a variety of responses. It may widen and become shallower, the streambed texture may become finer, the channel may become braided, and the sinuosity may increase. Fluvial geomorphic relationships suggest that any (or all) of these are possible channel responses to increased sediment supply. Predicting which of these responses is most likely and to what extent each will manifest itself is a substantially indeterminate problem. Much of the habitat degradation now seen in Pacific Northwest streams is a result of unanticipated responses to human alteration of the contributing watershed.

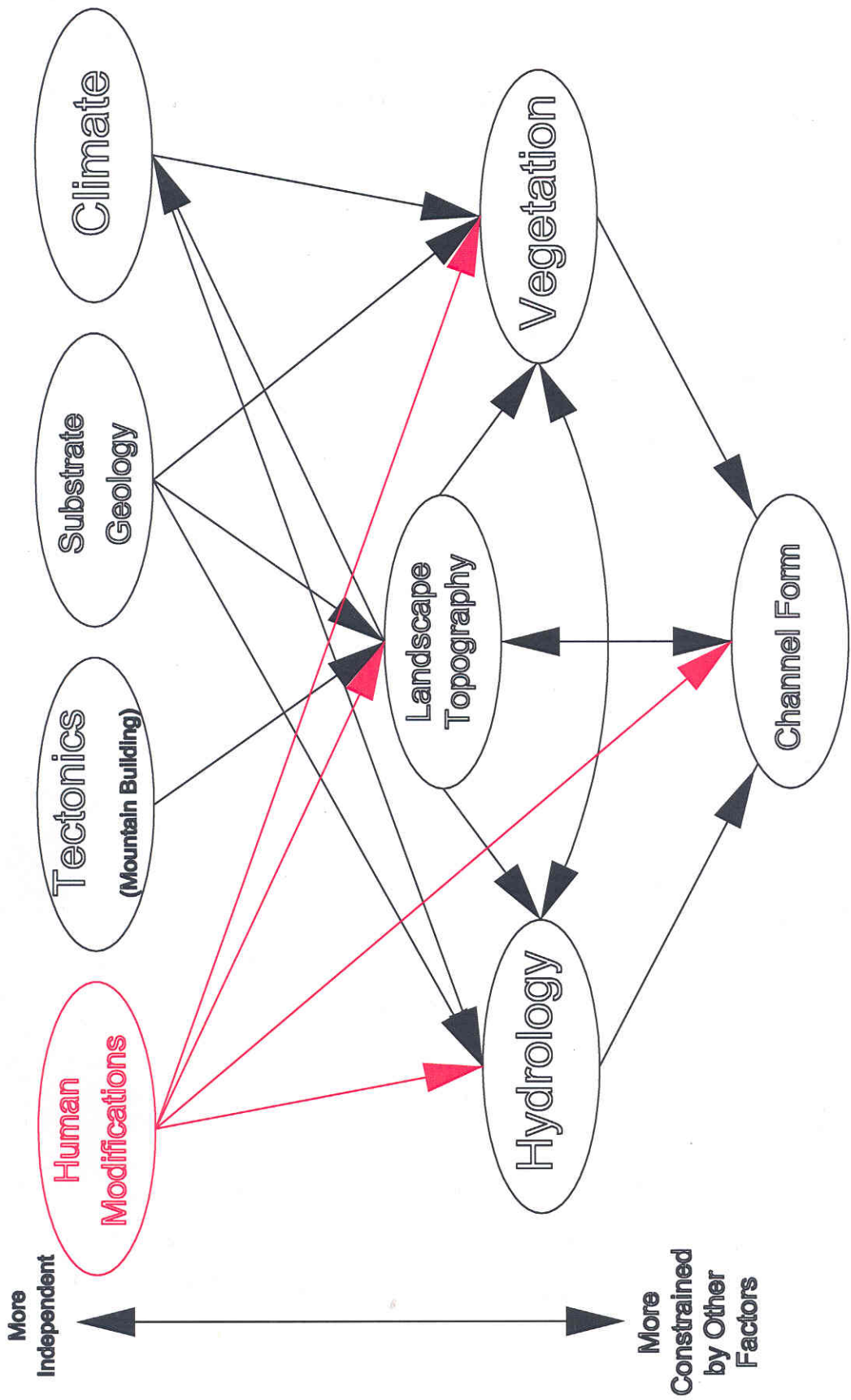


Figure 2: Factors that control the size and shape of stream channels

### 3.0 Bedrock Geology in the Snoqualmie River Watershed

Most of the headwater channels draining from the Cascade Mountains are underlain at shallow depth by bedrock (Figure 3). There are three primary bedrock assemblages exposed in the Snoqualmie River watershed (Tabor et al., 1993; Tabor et al., 2000) that form three irregular bands roughly paralleling the topographic expression of the Cascade Range. Along the core of the Cascade Range, intrusive igneous rocks of Tertiary age are extensively exposed. These consist primarily of light gray granite rocks. Most of the High Cascade peaks in the Snoqualmie River watershed are composed of these erosion-resistant rocks. These rocks are identified as unit Tst and Tsg on Figure 4, the geologic map of the Snoqualmie River watershed.

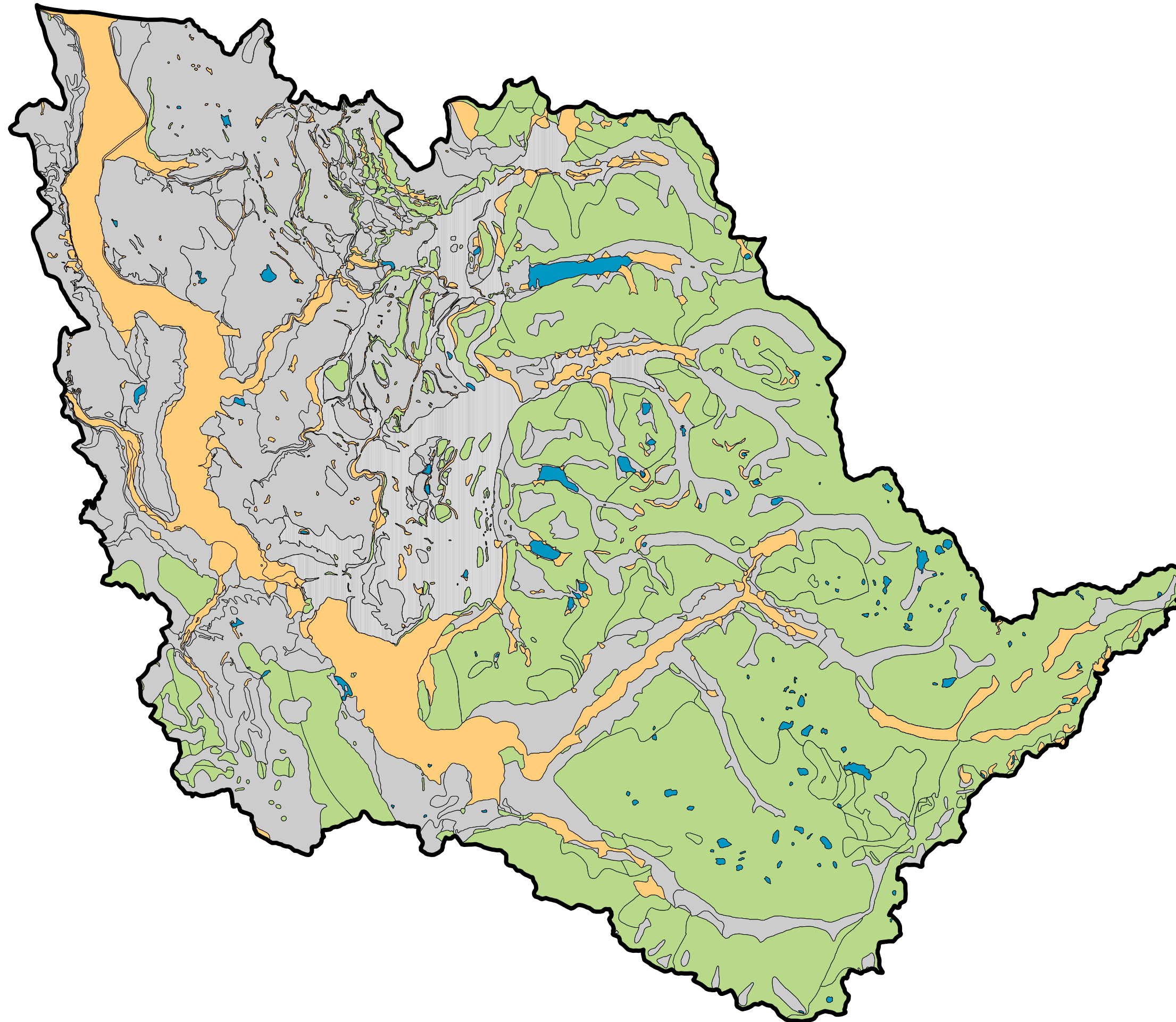
Generally bordering these tertiary rocks to the west is a band of pre-Tertiary rocks known as the western *mélange* belt. *Mélange*, a French word for mixture or medley, refers to a heterogeneous assemblage of rocks that has been intensively sheared and deformed. This deformation occurs as these rocks are “scraped” off the top surface of a crustal plate that is being subducted. These rocks record a period in between the early Cretaceous and middle Eocene (100 to 40 million years ago) when the study area was on the western edge of the North American continent (Tabor et al., 2000). These rocks consist of marine sedimentary and igneous rocks that have been subject to relatively low-grade metamorphic modification. For example, Mount Si is a large block of erosion resistant metamorphosed gabbro of the *mélange* unit. Rocks of this *mélange* unit are generally more friable and more readily weathered than the plutonic rocks to the east. The *mélange* rocks are identified as Tkwa on Figure 4.

Bordering the *mélange* rocks to the west are Eocene Age volcanic and sedimentary rocks (45 to 37 million years ago) (Tabor et al., 1993). Weathered andesite of this unit is widely exposed in the foothills and lower, western peaks of the Cascades. Snoqualmie Falls are located where the Snoqualmie River flows over an outcrop of these rocks. These rocks are identified as Trr and Tmp on Figure 4.

# SNOQUALMIE WATERSHED

Figure 3

## GENERALIZED GEOLOGY



 Watershed Boundary

 Recent

 Glacial

 Bedrock

 Water



0 2 4 Miles

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