

## Appendix F

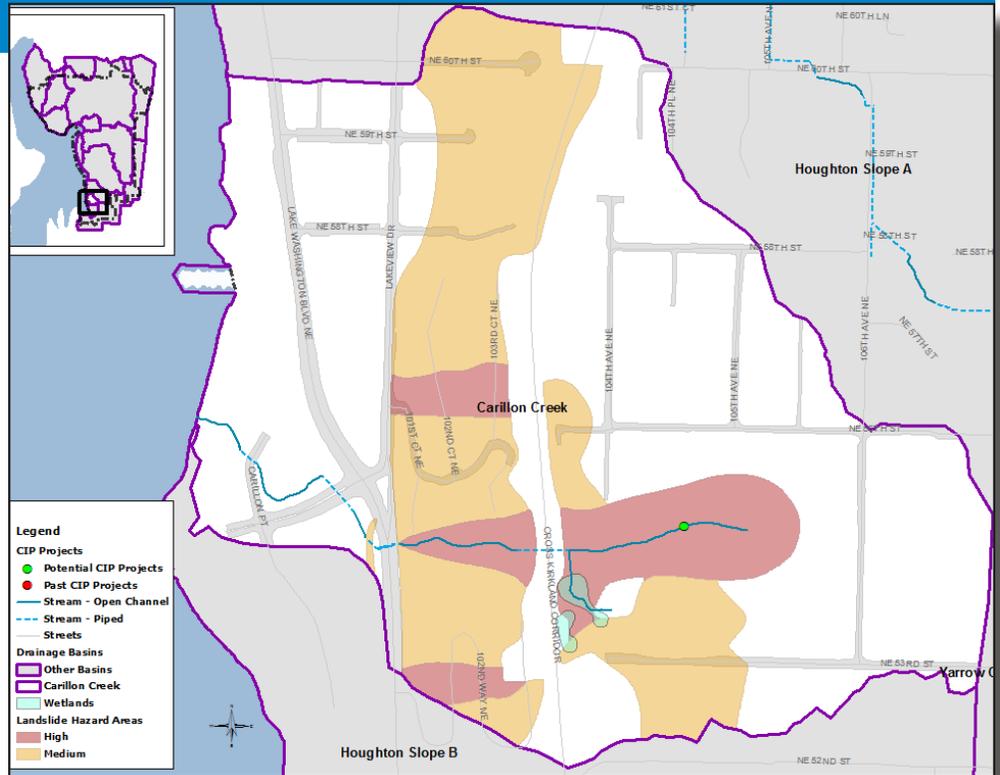
# Basin Characterization Summaries

Carillon Creek  
Champagne Creek  
Denny Creek  
Forbes Creek  
Holmes Point  
Houghton Slope A  
Houghton Slope B  
Juanita  
Kingsgate Slope  
Kirkland Slope  
Moss Bay  
South Juanita Slope  
To Redmond  
Yarrow

# Carillon Creek Basin Report Card

The Carillon Basin is 105.7 acres, with 70% of the basin developed for residential use. The next highest land use in the basin is open space, such as parks, where green space is typically more prevalent than other areas.

In comparison to other basins within Kirkland, the Carillon Creek basin ranks lower on impervious surface coverage and even lower for the potential increase of impervious surfaces within the next 20 years. This can help mitigate volume runoff within the basin and prevent flooding and impact to the natural drainage system.



## Water Quality

As a part of King County Water District 1, Carillon Creek served as the water supply to Yarrow Point until approximately 2003.

Invasive species within the stream channel can cause concern for aquatic habitat. Carillon Creek is on the annual monitoring cycle for the New Zealand mud snail, an invasive species that has recently entered the Puget Sound region and has been found in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and, in turn, the food supply for fish and wildlife. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Land/Streamside Conditions

Approximately 20 to 30% of the Carillon Creek basin contains sandy soils which help filter runoff as it percolates back into the ground. This helps reduce the speed and volume of runoff entering a stream channel as well as helps cool the water to provide a nice base flow for stream channels.

However, the majority of the soils within the basin are fine-textured soil - clay, which impedes infiltration. Less infiltration results in higher runoff volumes and flows

### LAND CHARACTERISTICS

Basin Area	105.7 acres
Highest Elevation	304 feet
Lowest Elevation	18 feet

### STREAM CHARACTERISTICS

Total Length of Channel	0.51 miles
Length of Channel in Pipe	0.13 miles
Length of Open Channel	0.38 miles

### LAND COVER

Existing Impervious	38.3%
Built-out Impervious	40.4%
Forest Cover	35.1%

### LAND USE

Single Family Residential	50.1%
Multifamily Residential	21.3%
Open Space	11.6%

in the creek, potentially leading to erosion and flooding.

There is a significant and sudden elevation change between the upstream portion Carillon Creek basin and the downstream portion at Lake Washington Boulevard. Approximately 30% of the basin is within a landslide hazard area.

There are very minimal wetlands in this basin, approximately 0.44 acres, located along the Cross Kirkland Corridor portion of the stream channel. These are small in size and generally rated low quality.

## In-Stream Conditions

Although this basin has fewer total miles of stream channel than most other basins in Kirkland, it has one of the higher percentages of open stream channel. Development downstream of Lake Washington Boulevard led to the reopening of channel that was previously piped. Although this section of the channel is manicured, the open channel and planted native vegetation such as birch, hemlock, fir, cedar, vine maple, dogwood, hardhack, salal, sword fern, snowberry and cattail provide better fish and wildlife habitat than piped channel.

Like other smaller, developed basins within Kirkland, there are detached greenbelts within the Carillon Creek basin. Two smaller greenbelts are located within the basin - one was previously owned by the King County Water District 1 and supplied water to Yarrow Point. It is now Carillon Woods Park, owned by City of Kirkland. Greenbelts provide refuge for wildlife; however, the Cross Kirkland Corridor and Lake Washington Boulevard are significant barriers to wildlife movement between the greenbelts.

## Fish and Wildlife

In a stream and wildlife study completed by Watershed Company in 1998, cutthroat trout and coho salmon were found in the lower section of Carillon Creek (downstream of Lake Washington Boulevard). However, sedimentation was found to cause problems in the creek, such as braided channel sections, which hinder upstream fish migration. Upstream of Lake

Washington Boulevard, where the stream channel is significantly steeper, electrofishing was conducted and no fish were found.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Carillon Creek basin. Currently, 38% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creek. This increased volume of runoff has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Potential Projects

As part of the *2014 Surface Water Master Plan*, one project has been proposed and was carried over from the *2005 Surface Water Master Plan* to address the sedimentation at the downstream end of the creek. As mentioned earlier in the profile, sedimentation in the creek has caused problems for aquatic habitat and flooding. If sedimentation takes up volume within the channel and there is no clear path for the water, fish can't migrate upstream and the runoff volume needs to find another path to go around the blockage (which can lead to flooding). This project would include monitoring the stream channel to determine how much sedimentation is occurring and designing a proper fix.

*Updated 11/614*

# Champagne Creek Basin Report Card

The Champagne Creek basin, a mid-sized basin for Kirkland, is 627 acres. The basin is primarily developed for single family use while the second largest land use within the basin is open space, including parks like Juanita Woodland Park and Juanita Triangle Park.

Because this basin has large open space areas and is primarily developed for single family use, this basin ranks lower on existing impervious coverage. However, in an analysis looking at what sites are likely to develop or redevelop, this basin was identified as having high potential for development and, in turn, the second largest potential for an increase in built-out impervious coverage over the next twenty years. Without proper mitigation, the increase in impervious surface can cause detrimental impacts to the streams in the basin and to Lake Washington.

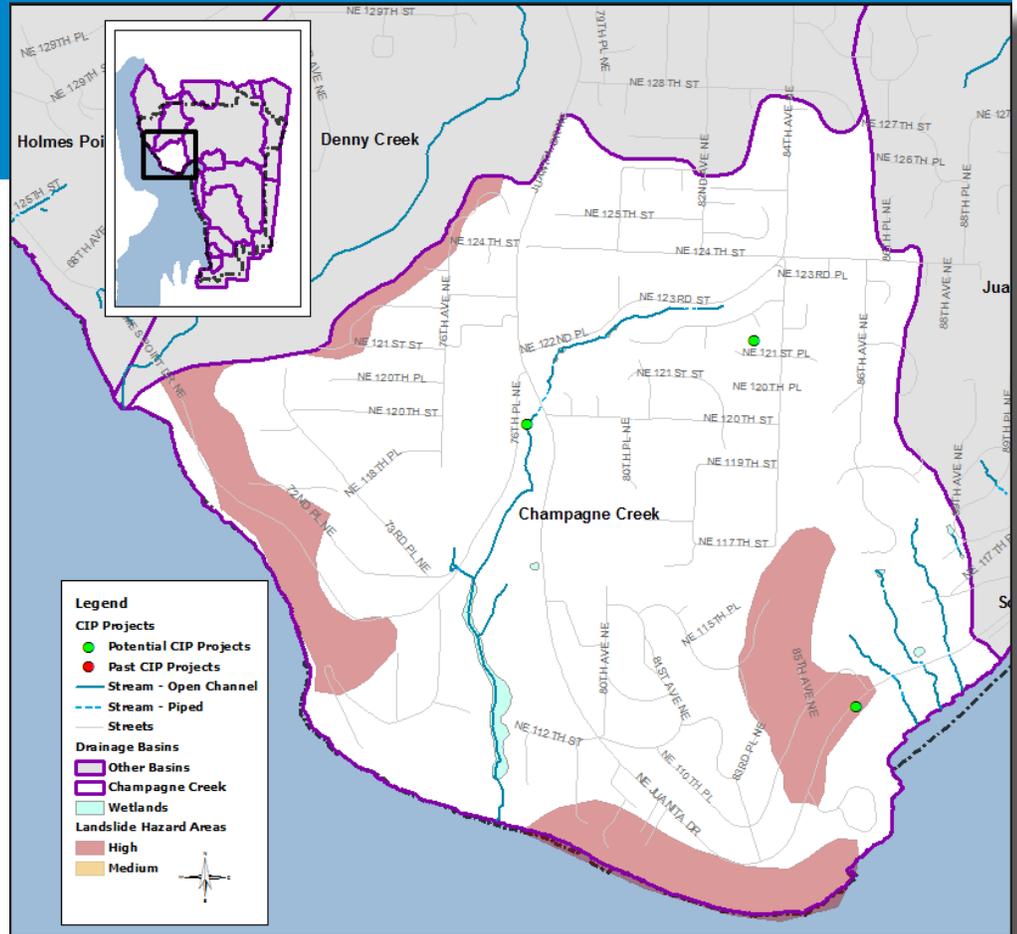
## Land/Streamside Conditions

The primary soil throughout this basin is fine to fine textured sediment, otherwise known as clay. This type of soil is tough to infiltrate, resulting in higher runoff volume and velocity to the stormwater system.

The general slope of this basin is quite steep, averaging around 10%. There are also three sections within this basin that are considered high landslide hazard areas, meaning the slopes are greater than 40% or have been subject to previous landslides or emergent groundwater.

Of the 627 acres within the basin, 3.3 acres are classified as wetland. Within this basin, all the wetlands are located along streams, with the largest one along Champagne Creek. Wetlands are an important part of the natural system, providing water natural quality treatment and attenuation of flows.

At 43%, Champagne Creek basin has the fourth highest forest cover percentage in the City. Studies have found



## LAND CHARACTERISTICS

Basin Area	626.9 acres
Highest Elevation	468 feet
Lowest Elevation	20 feet

## STREAM CHARACTERISTICS

Total Length of Channel	2.0 miles
Length of Channel in Pipe	0.2 miles
Length of Open Channel	1.8 miles

## LAND COVER

Existing Impervious	30.0%
Built-out Impervious	36.1%
Forest Cover	43.0%

## LAND USE

Single Family Residential	88.5%
Multifamily Residential	2.0%
Open Space	8.6%

that higher forest cover can help decrease contaminants from runoff to streams and to Lake Washington.

## In-Stream Conditions

The Champagne Creek basin has 2 miles of stream channel, with 90% of the channel open. However, the majority of the open channel is in poor condition. A recent stream walk for the 2014 Surface Water Master Plan revealed a large sediment deposition in the downstream section of the creek which has formed braided channels and a barrier to stream flow. The sediment is coming from the incision occurring through the middle section of the creek, while the upper reach has ditch-like conditions from urbanization.

Although the stream is in poor condition, the lower and middle sections of the creek have large buffers, creating a nice greenbelt for the creek. Vegetation such as western red cedar, big leaf maple, alder, sword fern and salmonberry were identified during the stream walk. Juanita Woodland Park also serves as a green belt and restriction for development along the creek.

## Fish and Wildlife

In 1998, a Fish and Wildlife study was conducted by the Watershed Company to identify habitat along the creeks within the City and potential annexation areas. Electrofishing was conducted and cutthroat trout were found in the downstream section of Champagne Creek.

Invasive species within the stream channel can cause concern for aquatic habitat. Champagne Creek is on the annual monitoring cycle for the New Zealand mud snail. The New Zealand mud snail is an invasive species that has recently entered the Puget Sound region and have been located in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and food to the fish and wildlife population. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Champagne Creek basin. Currently, 30% of the basin is covered in impervious surface. Although this percentage is one of the lowest in the city, most of the development in this basin occurred before regulations required flow control and water quality treatment, causing Champagne Creek to be “flashy” and leading to erosion and sedimentation problems along the creek. Not only does this cause impacts to habitat, but can also lead to flooding problems within the basin.

### Past Projects

Surface water management for the Champagne Creek basin fell under the jurisdiction of King County until this area was annexed by the City of Kirkland in June 2011.

### Potential Projects

Within the 2014 Surface Water Master Plan, projects are identified to alleviate and prevent flooding, water quality, and habitat issues. Three projects are proposed within the Champagne Creek basin, varying from larger projects such as channel reconstruction to help with the erosion occurring along the creek and a stormwater retrofit option to help mitigate for the lack of water quality and flow control within the basin to a smaller project to assist with groundwater seepage from a landslide hazard area.

*Updated 8/25/14*

# Denny Creek Basin Report Card

The Denny Creek basin, in northwest Kirkland, is 803.8 acres in size. The primary land use in this basin is single family residential housing while the second largest land use in the basin is open space, including parks like Big Finn Hill Park and O. O. Denny Park.

Of all the basins in Kirkland, this basin has the third lowest amount of existing impervious coverage. In an analysis of what sites are likely to develop or redevelop, this basin was identified as having the potential for an increase in built-out impervious coverage of approximately 2.6% in the next twenty years.

## Land/Streamside Conditions

Soils in the Denny Creek basin consist primarily of clay, fine-textured sediment that is tough to infiltrate and can result in higher runoff volume and velocity to the stormwater system.

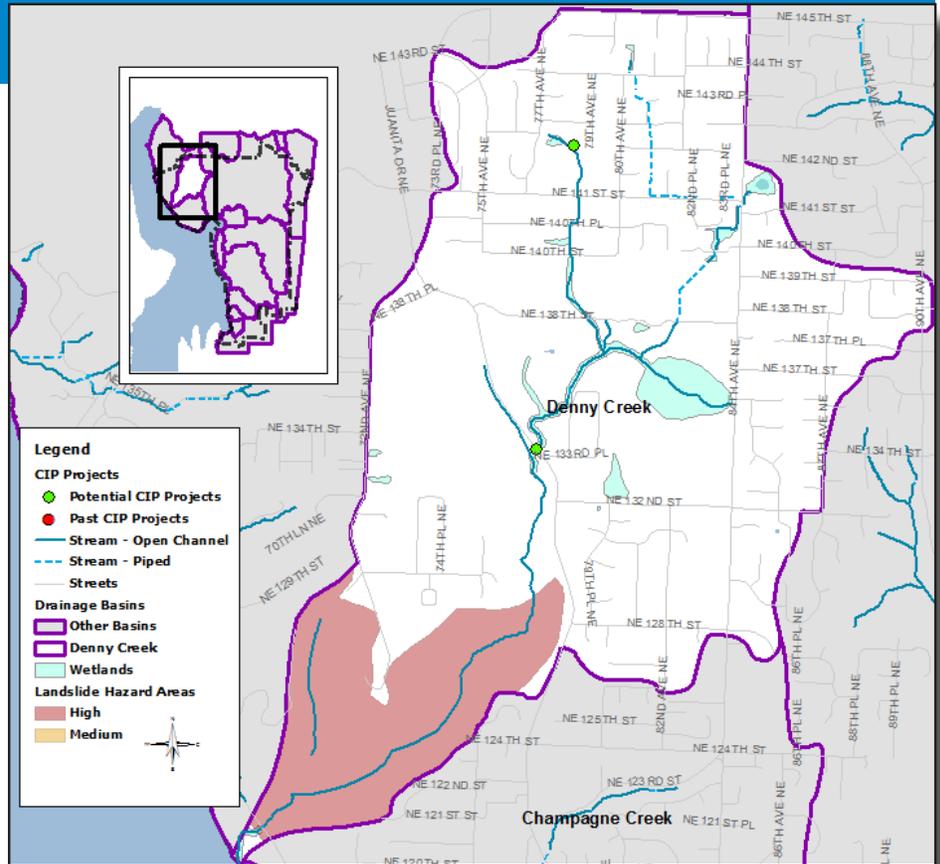
The area from the mouth of the creek to approximately Juanita Drive NE is considered a high landslide hazard area, meaning the slope is greater than 40% or has been subject to previous landslides or emergent groundwater.

Of the 803.8 acres within the basin, 36 acres are classified as wetland. The largest area of wetland, approximately 12.9 acres in size, is located in Big Finn Hill Park. This area is rated as moderate to moderate/high for wetland functions. The remaining wetlands are located along the Denny Creek corridor.

The Denny Creek basin has the second highest forest cover of any basin in Kirkland. This forest coverage provides quality wildlife habitat and, through infiltration, can help decrease the volume of water and contaminants entering Denny Creek and Lake Washington.

## In-Stream Conditions

Denny Creek shows moderate signs of erosion; it is common to find 3 to 4 foot vertical banks along the creek. Large woody debris is found along the length of the creek.



## LAND CHARACTERISTICS

Basin Area	803.8 acres
Highest Elevation	480 feet
Lowest Elevation	20 feet

## STREAM CHARACTERISTICS

Total Length of Channel	3.9 miles
Length of Channel in Pipe	0.7 miles
Length of Open Channel	3.2 miles

## LAND COVER

Existing Impervious	24.4%
Built-out Impervious	27.0%
Forest Cover	55.9%

## LAND USE

Single Family Residential	65.6%
Multifamily Residential	1.9%
Commercial	0.0%

The creek runs through Big Finn Hill Park and O. O. Denny Park just before it empties into Lake Washington. This large greenbelt provides a well-vegetated buffer for the creek, with a variety of trees including black cottonwood, western red cedar, Douglas fir and big leaf maple.

## Fish and Wildlife

In 1998, a Fish and Wildlife study was conducted by the Watershed Company to identify habitat along the creeks within the City and potential annexation areas. Electrofishing was conducted and cutthroat trout, juvenile coho salmon and sculpins were found in the downstream section of the creek. Further upstream, near Juanita Drive NE, no fish were found. However, a salmon population that extended upstream of Juanita Drive was recorded on a King County sensitive areas map from 1990. Other wildlife identified in this basin include great blue heron, mallards and other ducks, bald eagles, beaver, deer, Pacific chorus frogs and other amphibians, and belted kingfisher.

Invasive species within the stream channel can cause concern for aquatic habitat. Denny Creek is on an annual monitoring cycle for the New Zealand mud snail. The New Zealand mud snail is an invasive species that has recently entered the Puget Sound region and has been located in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and food to the fish and wildlife population. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Problems and Opportunities

### Problems

Development and urbanization of the upstream section of Denny Creek has led to erosion in the channel.

### Past Projects

This area was recently annexed in June 2011 from King County. There have been projects within the basin that has been completed or identified by King County such as restoration

work at the mouth of Denny Creek and removal of the bulkhead at O. O. Denny Park. However, no surface water projects have been completed since annexation.

### Potential Projects

Within the 2014 Surface Water Master Plan, projects are identified to alleviate and prevent flooding, water quality, and habitat issues. Three projects for Denny Creek have been proposed in the plan. The highest priority project is to replace the current culvert under Juanita Drive with a fish-passable culvert. The other project addresses sedimentation issues in the creek, restores habitat and removes potential flooding issues.

*Updated 11/5/14*

# Forbes Creek Basin Report Card

At 1,836.8 acres, the Forbes Creek basin is the second largest basin in Kirkland. Over 60% of this area is developed for single family residential. In comparison to other basins, the Forbes Creek basin has one of the lowest levels of impervious surface coverage. This can help mitigate volume runoff within the basin and prevent flooding and impact to the natural drainage system.

## Land/Streamside Conditions

Soils in this basin are typically classified as Type C (sandy clay loam), which is the predominant soil type in Kirkland. The moderately fine to fine soils of the basin can hinder the infiltration of water and can cause higher runoff volumes.

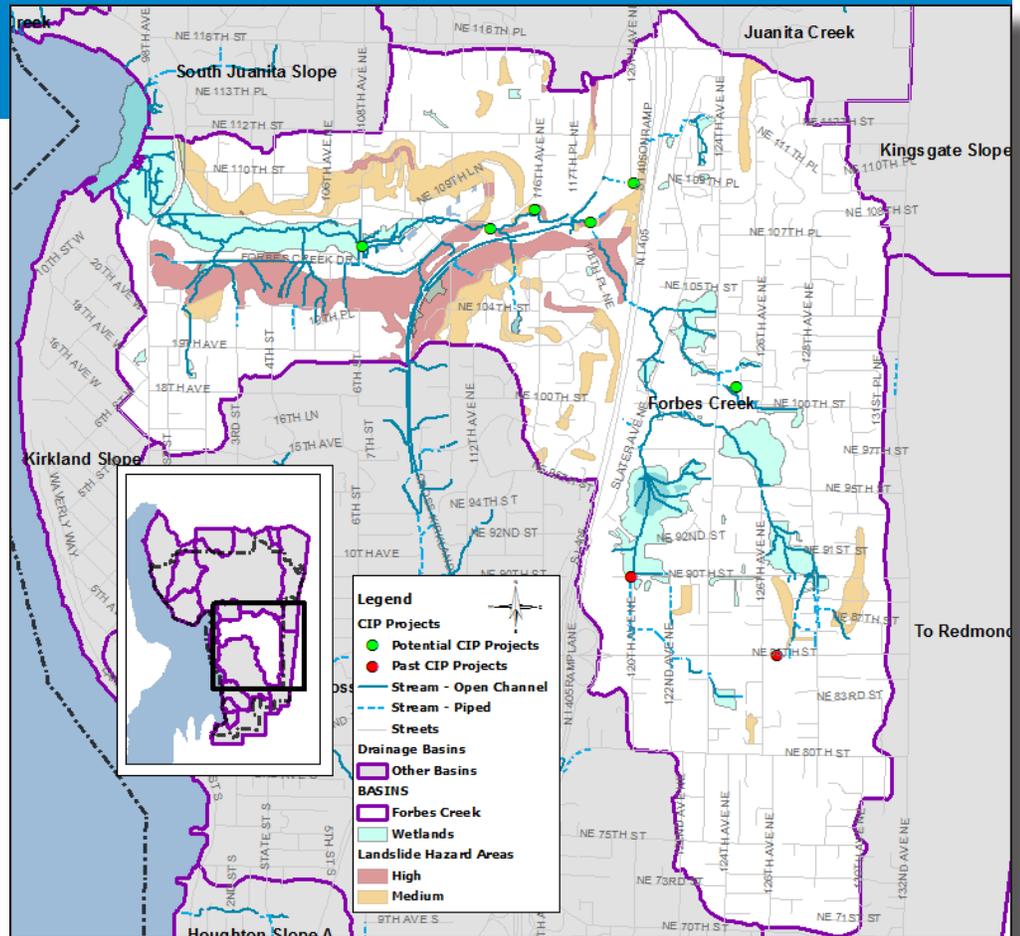
The Forbes Creek basin has the greatest total coverage and number of wetlands of any basin in Kirkland, ranging from low to high quality for wetland functions. Extensive wetland can be found at the mouth of the creek and extending upstream. This wetland complex is rated as the highest quality in the basin. Wetlands located in the upper Forbes basin are also highly rated.

Almost 40% of the Forbes Creek basin is forested, ranking 6<sup>th</sup> out of the 15 basins within the City. Red alder, black cottonwood, and willow are the most common trees along lower Forbes Creek, while invasive plants, reed canary grass and Himalayan blackberry are the most common understory species.

## In-Stream Conditions

The main stem of Forbes Creek flows out of Forbes Lake. The lake collects runoff from surrounding residential and business developments. Higher and more frequent flows, due to less infiltration, have led to active channel down-cutting and bank erosion in many reaches of the creek.

Wetlands and open space line the sides of Forbes Creek from its mouth to about halfway to I-405. This significant



## LAND CHARACTERISTICS

Basin Area	1,836.78 acres
Highest Elevation	492 feet
Lowest Elevation	18 feet

## STREAM CHARACTERISTICS

Total Length of Channel	14.2 miles
Length of Channel in Pipe	2.9 miles
Length of Open Channel	11.2 miles

## LAND COVER

Existing Impervious	36.9%
Built-out Impervious	39.8%
Forest Cover	39.5%

## LAND USE

Single Family Residential	66.8%
Multifamily Residential	8.2%
Open Space	9.8%

area of open space facilitates the movement of fish and wildlife. I-405 creates a barrier to fish and wildlife movement, but significant open space exists upstream of the highway as well.

## Water Quality

Forbes Creek is listed on the Environmental Protection Agency's (EPA) water quality assessment and 303(d) list of impaired water bodies for temperature, dissolved oxygen, pH, ammonia nitrogen, mercury and bacteria. The City and King County have been monitoring water quality indicators and found the following:

- Temperature typically remains below the maximum threshold of 60°F
- Dissolved Oxygen levels typically fall below the threshold of >9.5mg/L
- Fecal Coliform Bacteria ranges between 0-2,000 colonies per 100 mL while the maximum threshold is 100 colonies per 100 mL
- pH falls within allowable ranges from 6.5 to 8.5

Water quality in Forbes Lake has been monitored by volunteers since 2006. Data indicate that the lake has distinctly colored water with medium to high primary productivity (threshold eutrophic) with fair water quality.

Invasive species within the stream channel can cause concern for aquatic habitat. Forbes Creek is on the annual monitoring cycle for the New Zealand mud snail, an invasive species that has recently entered the Puget Sound region and has been found in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and, in turn, the food supply for fish and wildlife. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Fish and Wildlife

In 1998, a Fish and Wildlife study was conducted by the Watershed Company to identify habitat along the creeks within the City. Electrofishing was conducted in Forbes Creek. Cutthroat were found in all of the creek area downstream of I-405. Coho, stickleback and dace were found

upstream of 108<sup>th</sup> Ave NE.

Beaver populations have been found at Forbes Lake. The lower Forbes valley is the longest connected open space in Kirkland, forming a nearly continuous corridor for wildlife movement.

The City also collects aquatic bug samples from various locations along Forbes Creek. Samples are assessed on a B-IBI scales from 50 (excellent) to 10 (poor) to indicate water quality. Typical scores for Forbes Creek range from 14 to 18.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout the City and has significantly increased the impervious coverage in the Forbes basin, resulting in increased stormwater runoff volume to the creek. The stormwater runoff has implications for flooding, water quality, and aquatic habitat concerns, as well as requires operations and maintenance of the storm conveyance system to protect property and our streams and lakes.

The piped section of Forbes Creek that is located downstream of I-405 is a fish passage barrier, not allowing for migration and movement of fish from the lower part of the creek to the upper reaches.

### Past Projects

Two projects have been completed over the years at the upstream end of the basin. Both projects focused on water quality and added treatment to newly added pavement and to capture existing sedimentation issues.

### Potential Projects

Six projects are proposed in the Forbes Creek drainage basin. These projects cover all aspects of the surface water master plan goals. One project focuses on reducing flooding at 116<sup>th</sup> Avenue and improving habitat by reducing flows to Forbes Creek, while multiple projects address habitat and fish barrier issues along Forbes Creek. An LID pilot project is proposed to address all goals by infiltrating runoff at the source.

*Updated 11/6/14*

# Holmes Point Basin Report Card

The Holmes Point basin is located in northwest Kirkland, on Lake Washington and on the border with Kenmore. The basin is 457.6 acres, with 85% of the basin developed for single family residential.

A unique zoning code, the Holmes Point Overlay Zone, restricts the development allowed in this basin in order to help reduce stormwater flow and to retain natural assets of the area. Requirements of this code include retaining significant trees and native vegetation, restricting lot coverage and landscaped areas and setting aside undisturbed areas of native vegetation.

In comparison to other basins within Kirkland, the Holmes Point basin has the second lowest level of impervious surface coverage (21.7%). However, in an analysis looking at what sites are likely to develop or redevelop in Kirkland, this basin was identified as having high potential for development and, in turn, the third largest potential for an increase in built-out impervious coverage over the next twenty years. Even with this potential increase, this basin would still have the second lowest level of impervious surface coverage in Kirkland.

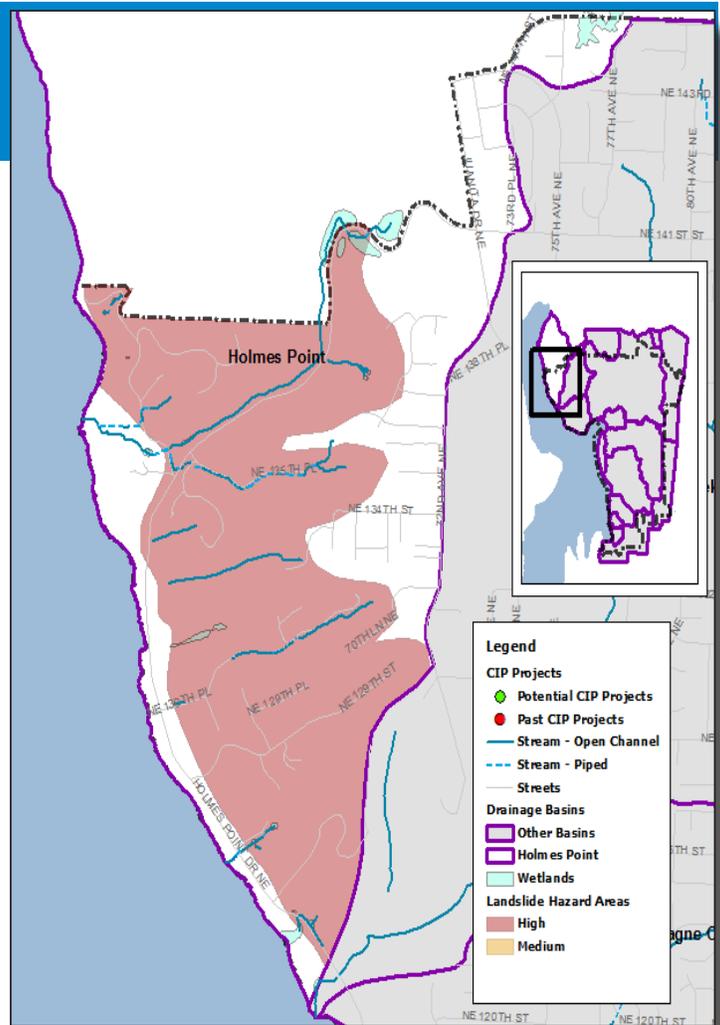
## Land/Streamside Conditions

Soils in this basin are predominantly till soils that can impede the infiltration of water into the ground. This lack of infiltration capacity can contribute to higher runoff volumes and high flows in creeks which can typically lead to erosion and flooding.

Almost all of the Holmes Point basin within Kirkland city limits is a high landslide hazard area. This means that there are areas where the slope is 40% or greater, areas subject to previous landslides, and areas sloping between 15% and 40% with zones of emergent groundwater or underlain by or embedded with impermeable silts or clays.

Approximately 10 acres of wetlands can be found in this basin; most of this acreage is outside of Kirkland city limits.

At 63.3%, the Holmes Point basin has the highest forest coverage of any basin in the city. Studies have shown that higher percentages of tree cover and other vegetation within watersheds correlate directly to quality creek,



## LAND CHARACTERISTICS

Basin Area	457.6 acres
Highest Elevation	466 feet
Lowest Elevation	20 feet

## STREAM CHARACTERISTICS

Total Length of Channel	2.9 miles
Length of Channel in Pipe	0.5 miles
Length of Open Channel	2.4 miles

## LAND COVER

Existing Impervious	21.7%
Built-out Impervious	26.8%
Forest Cover	63.3%

## LAND USE

Single Family Residential	85.1%
Multifamily Residential	2.6%
Commercial	2.0%

wetland and lake habitat, reduced runoff and improved surface water quality (*Kirkland 2011 Urban Tree Canopy Assessment, AMEC*).

## In-Stream Conditions

There are almost three miles of stream channel in the Holmes Point basin with 83% of the channel open. Most of the lower section of Holmes Point Creek, the primary channel within the basin, is armored and weaves through a number of yards with lawn extending to the edge of the creek. Steep ravines and slopes and channel instability have contributed to erosion and significant sediment deposition in the creek. Many fish passage barriers are also present in the creek. Large man-made debris such as tires, cars and appliances can also be found in the stream channel.

Significant green space can be found in the basin due to high forest coverage and development restrictions that are required through the Holmes Point Overlay.

## Fish and Wildlife

No electrofishing has been conducted in Holmes Point Creek, but significant fish use is unlikely due to large barriers downstream and the small size of the stream channel.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the city. Currently, 21.7% of the Holmes Point basin is covered in impervious surface. Although the low impervious coverage can contribute to stormwater infiltration, the high landslide risk and an unstable stream channel leads to erosion and sedimentation problems along the creek. Not only does this cause impacts to habitat but can also lead to flooding problems within the basin.

### Past Projects

Surface water management for the Holmes Point basin fell under the jurisdiction of King County until this area was annexed by the City of Kirkland in June 2011.

### Potential Projects

Within the 2014 Surface Water Master Plan, projects are identified to alleviate and prevent flooding, water quality and habitat issues. Two projects are identified for Holmes Point Creek; however, they are currently unfunded due to a low prioritization in comparison with all projects within the city. The first identified project is to evaluate the removal of a large private dam that is a fish passage barrier. The second is to restore areas of the stream and improve habitat in the vicinity of water diversion structures located downstream of Saint Edwards Park.

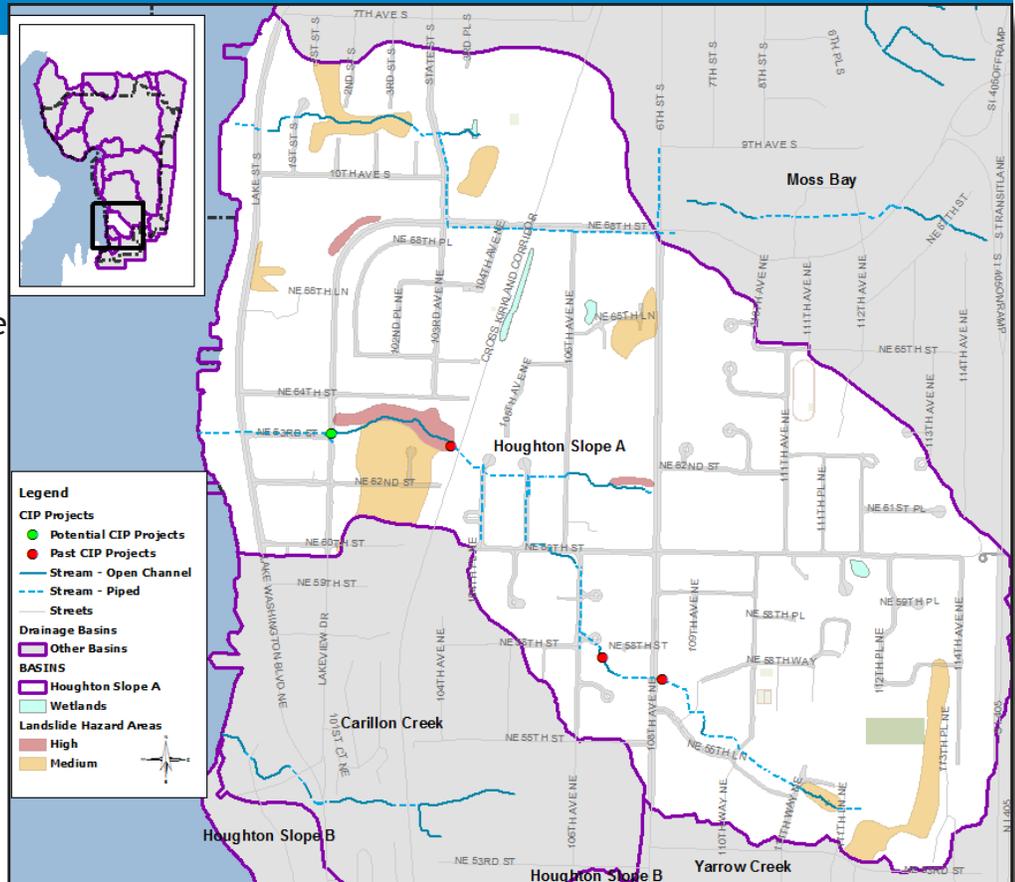
*Updated 8/19/14*

# Houghton Slope A Basin Report Card

The Houghton Slope A basin is 376.6 acres in size and half of the slope is developed for single family residential.

This basin has one of the highest percentages of impervious surface coverage in comparison to other basins. If unmitigated, this can lead to higher runoff volumes, durations, and frequency into the natural and constructed drainage systems.

The Houghton Slope A basin has the lowest amount of forest cover of any basin in Kirkland. Studies have shown that higher percentages of tree cover and other vegetation within basins correlate directly to quality creek, stream and lake habitat, reduced runoff and improved surface water quality (*Kirkland 2011 Urban Tree Canopy Assessment*, AMEC).



## Land/Streamside Conditions

The predominant soils in this basin are type C soils, which are moderately fine to fine textured soils that impede infiltration. There are a few patches of area that are classified as either Type A or B soils which promote infiltration. Infiltration of runoff can help regulate the flow into the natural channels, preventing high flows which typically can cause erosion and flooding. The general slope of the basin is between 5 and 10%, however, there are a few locations that are steeper and classified as a landslide hazard area, near the open channel east of Lakeview Drive.

## In-Stream Conditions

71% of the stream channel in this basin is piped, and 29% is in an open channel. Piped flow is typically more prevalent in more developed areas of the city, especially in this basin where 97% of the area is either single family residential or commercial centers. Sometimes piped conditions are necessary because of steep topography and erosion problems; however, it is ideal to keep stream channels

## LAND CHARACTERISTICS

Basin Area	376.6 acres
Highest Elevation	416 feet
Lowest Elevation	18 feet

## STREAM CHARACTERISTICS

Total Length of Channel	2.75 miles
In Pipe	1.94 miles
Open Channel	0.81 miles

## LAND COVER

Existing Impervious	46.0%
Built-out Impervious	47.5%
Forest Cover	27.1%

## LAND USE

Single Family Residential	55.3%
Commercial	1.7%
Open Space/Park	1.7%

or reestablish stream channels where feasible because they provide better fish and wildlife habitat.

## Fish and Wildlife

In a stream and wildlife study completed in 1998 by the Watershed Company, all streams, wetlands and wildlife corridors were evaluated to create an updated inventory. Test electrofishing was conducted in the small streams within the Houghton Slope A basin and no fish were detected.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Houghton Slope A basin. Currently, 46% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creek. This increased volume of runoff has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

Due to the steep slopes in this basin, erosion is a common problem along the open stream channels. Erosion can cause instability in slopes as well as increase the potential for flooding because sediment will clog the storm system further downstream. Three projects have been implemented in this basin to address both flooding and erosion. One of the projects increased the size of a detention facility to prevent flooding downstream while the other two projects stabilized channels to help with flooding and reduce erosion.

### Potential Projects

As part of the *2014 Surface Water Master Plan*, an additional project has been recommended to continue addressing the problems within the

Houghton Slope A basin. As mentioned before, the Houghton Slope A basin is primarily a piped basin due to steeper slopes and the large amounts of development within the basin. A project has been proposed to address a flooding concern along Lakeview Drive.

*Updated 10/23/14*

# Houghton Slope B Basin Report Card

The Houghton Slope B drainage basin is the second smallest basin in the city at 134.4 acres. This basin is primarily zoned as single family residential.

It is currently one of the most developed basins and has one of the largest potential increases in impervious within the basin at an increase of 4.1% over the next 20 years. If unmitigated, this can lead to a higher volume of stormwater runoff into natural and constructed drainage systems.

## Land/Streamside Conditions

The soil conditions in the Houghton Slope B drainage basin are primarily moderately fine to fine soils which are poor for infiltration.

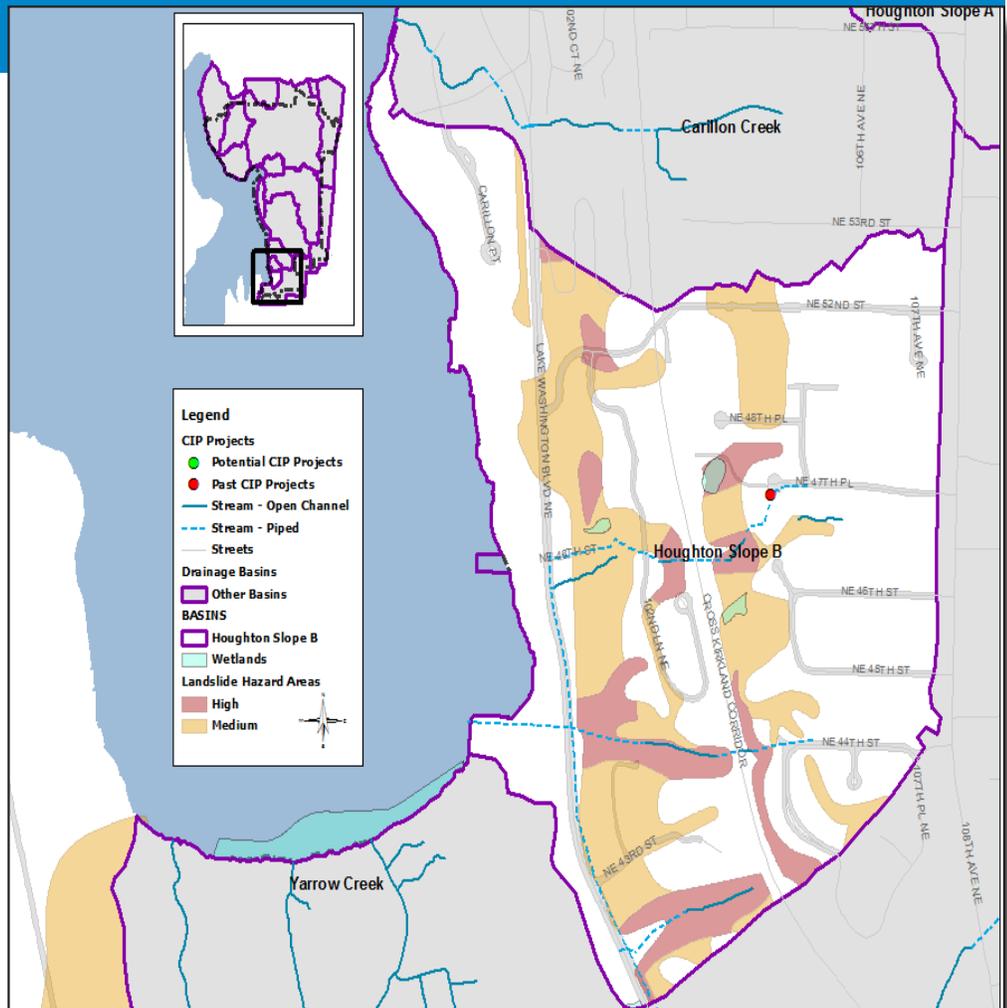
The average slope for the basin is 15%, with approximately 30 to 40% of the area located within a landslide area. There are also seismic concerns along the waterfront because of the type of soils and high groundwater typically located along the shoreline.

Wetlands are few and far between in this basin. There is approximately one acre of low quality wetlands, meaning they don't provide much function for water quality, habitat, or flow control.

The forest cover for this basin is 35.9% which is average for a basin located within the City of Kirkland.

## In-Stream Conditions

The Houghton Slope B basin has a total of 1.2 miles of stream channel within the basin, but only 25% of the stream channel is open and located within 3 small channels through steep ravines. The rest of the stream is piped. Piped stream flow is primarily due to the high average slope and erosion problems within the basin. However, where feasible, it is ideal to keep open stream channels or reestablish stream channels because they



## LAND CHARACTERISTICS

Basin Area	134.4 acres
Highest Elevation	300 feet
Lowest Elevation	18 feet

## STREAM CHARACTERISTICS

Total Length of Channel	1.2 miles
Length of Channel in Pipe	0.9 miles
Length of Open Channel	0.3 mi

## LAND COVER

Existing Impervious	40.8%
Built-out Impervious	44.9%
Forest Cover	35.9%

## LAND USE

Single Family Residential	77.7%
Multifamily Residential	10.6%
Commercial	10.1%

provide better fish and wildlife habitat.

## Fish and Wildlife

Due to the high percentage of piped stream channels and the steep grade of the channels, fish and wildlife habitat is hard to establish in this basin. Piped stream channels eliminate fish habitat and typically create barriers for migration of fish upstream.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Houghton Slope B basin. Currently, 41% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creek. This increased volume of runoff has implications for flooding, water quality, aquatic habitat and infrastructure concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

This is a naturally steep basin which increases the speed of the surface water flow. Erosion is a common issue in this type of basin. A project has been completed to help mitigate erosion occurring along a steep slope. The project piped the flows down the steep ravine and discharged the water at the bottom, and restoring the slope, to prevent future erosion.

### Potential Projects

There are no projects proposed for this basin in the *2014 Surface Water Master Plan*.

*Updated 11/6/14*

# Juanita Creek Basin Report Card

The Juanita Creek basin, at 3,623.6 acres, is the largest basin in Kirkland. More than 60% of this area is developed for single family residential.

In comparison to other stream in Kirkland, the Juanita basin has the fourth highest level of impervious surface coverage. If unmitigated, this can lead to a higher volume of stormwater running off into Juanita Creek.

## Land/Streamside Conditions

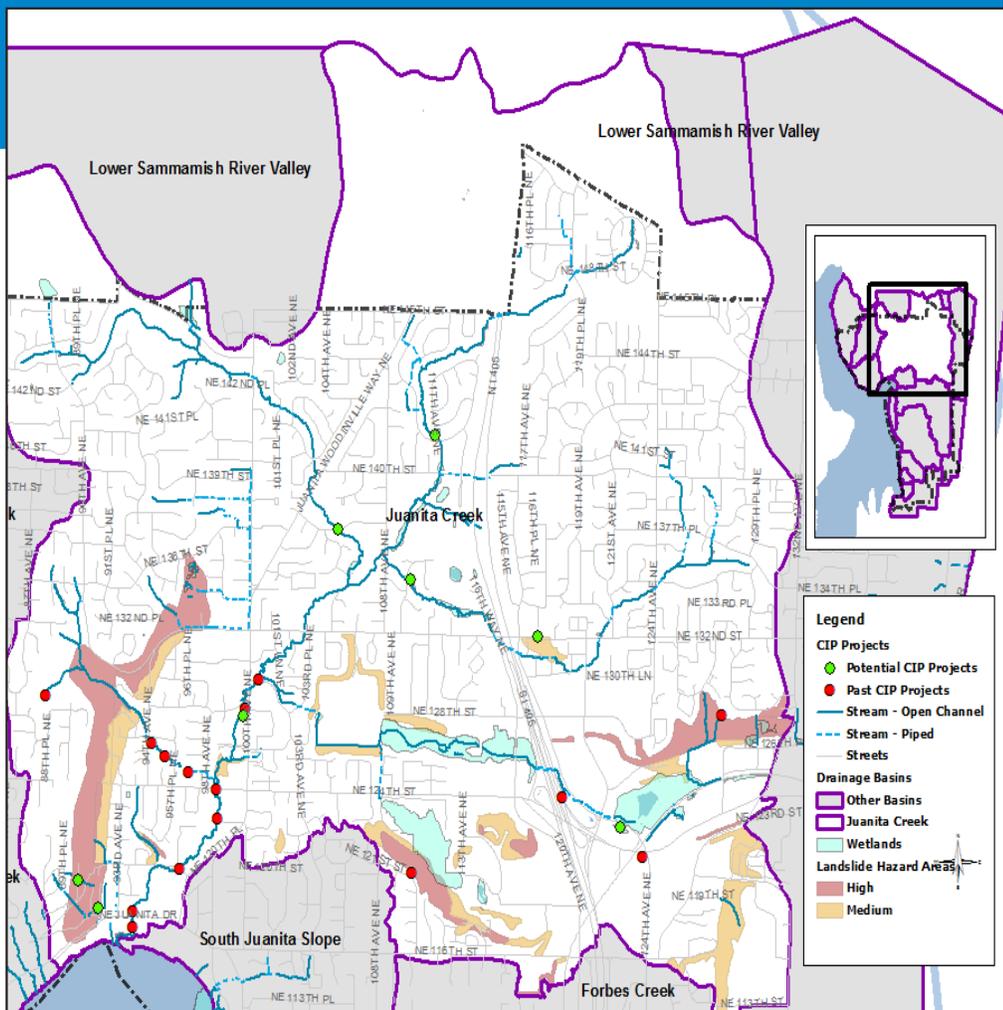
The Juanita Creek basin is the largest basin in Kirkland. It is also, however, one of the most confined streams due to residential development along its banks. Vegetation along the creek is primarily landscaped areas, grass, shrubs, and invasive species such as Himalayan blackberries and Japanese knotweed.

Due to the urbanization of this basin and loss of native vegetation, erosion and instability of the stream bank is common.

The slope through this basin ranges from as steep as 50-60% to low, flat areas that typically contain moderately fine to fine soils that hinder infiltration and can cause higher runoff volumes. There are multiple locations in this basin that are categorized as seismic and landslide hazard areas. Almost 40% of the basin has forested cover, ranking 8<sup>th</sup> out of the 15 basins within the City.

## In-Stream Conditions

Almost 43% of the Juanita basin is covered in impervious surface; it also lacks detention to reduce flows. This makes Juanita Creek very “flashy,” meaning that water levels rise very quickly during rain events and can cause flooding of surrounding areas and erosion of the stream banks. Juanita Creek’s streambed consists primarily of large amounts of sand and fines from erosion. This causes the stream to lose volume from sedimentation and can smother eggs and young fish.



## LAND CHARACTERISTICS

Basin Area	3,623.6 acres
Highest Elevation	468 feet
Lowest Elevation	18 feet

## STREAM CHARACTERISTICS

Total Length of Channel	19.7 miles
Length of Channel in Pipe	5.6 miles
Length of Open Channel	14.1 miles

## LAND COVER

Existing Impervious	42.6%
Built-out Impervious	43.6%
Forest Cover	38.6%

## LAND USE

Single Family Residential	62.6%
Multifamily Residential	13.6%
Commercial	7.3%

## Water Quality

Juanita Creek is listed on the Environmental Protection Agency's (EPA) water quality assessment and 303(d) list of impaired water bodies for dissolved oxygen, temperature, and bacteria. The City and King County have been monitoring water quality indicators and found the following:

- Temperature typically remains below the maximum threshold of 60° F
- Dissolved Oxygen levels typically fall below threshold of >9.5mg/L in the summer
- Fecal Coliform Bacteria ranges between 0-2,000 colonies per 100 mL while the maximum threshold is 100 colonies per 100 mL
- pH falls within allowable ranges from 6.5 to 8.5
- Metals and toxic pollutants should not exceed natural background levels but 24 pesticides were detected in Juanita over the course of a year of study.

The City also collects aquatic bug samples from various locations along Juanita Creek. Samples are assessed on a B-IBI scale from 50 (excellent) to 10 (poor) to indicate water quality. Typical scores for Juanita Creek range from 19 to 16.

## Fish and Wildlife

Juanita Creek has a large variety of fish and wildlife present throughout the corridor. Small numbers of cutthroat trout, coho, sockeye, and kokanee salmon have been observed. Beavers are at work throughout the creek and its tributaries. Ducks and other waterfowl are present in the creek.

Invasive species within the stream channel can cause concern for aquatic habitat. Juanita Creek is on the annual monitoring cycle for the New Zealand mud snail, an invasive species that has recently entered the Puget Sound region and has been found in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and, in turn, the food supply for fish and wildlife. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout the City and has significantly increased the impervious coverage in the Juanita basin. Currently, 43% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creek. The stormwater runoff has implications for flooding, water quality, and aquatic habitat concerns, as well as requires operations and maintenance of the storm conveyance system to protect property and our streams and lakes.

### Past Projects

Since Kirkland's stormwater utility started in 1998, projects have been implemented to help address the problems within the Juanita Basin. Undersized culverts have been replaced under roadways to reduce roadway flooding and to create fish-passable culverts. The utility has also installed a number of bank stabilization projects in the Juanita basin to help prevent undercutting and erosion caused by the movement of the creek. These projects used natural elements such as bioengineered walls, large woody debris and grading to stabilize the stream banks. An element of these projects has also been to remove invasive species and to plant native vegetation within the work area.

### Potential Projects

As part of the 2014 Surface Water Master Plan, additional projects that would continue to address the problems within the Juanita Basin have been recommended for the City's capital improvements project list. Recommended projects include replacing undersized culverts to make them fish-passable, enlarging stormwater facilities to help with flooding issues, and reestablishing Juanita Creek's floodplain to allow the stream to have more room which not only improves habitat but also decrease erosion and undercutting downstream.

*Updated 8/19/14*

# Kingsgate Slope Basin Report Card

The Kingsgate Slope basin is partially located within Kirkland while the rest of the basin is located in other jurisdictions. 562.8 acres of the 1,616.3-acre basin is located within the City of Kirkland. Of the area located within the city, 66.8% of the basin is developed for single family residential.

In comparison to other basins, the Kingsgate Slope basin has the fourth lowest impervious coverage at 29.7%. However, this basin has the highest potential for new development or redevelopment with a potential increase of 8.3% over the next 20 years. If unmitigated, this can lead to a higher volume of stormwater running off into natural and constructed drainage systems.

## Land/Streamside Conditions

The soil classification in this basin is type A soil, which is typically sandy and drains very well. There are pockets of type D soils, peat, that are considered impermeable. Although this area has lots of sandy soils, most of the basin is located within a landslide hazard area and projects to encourage infiltration would need to be strategically placed to ensure the infiltration does not impact the stability of the slope.

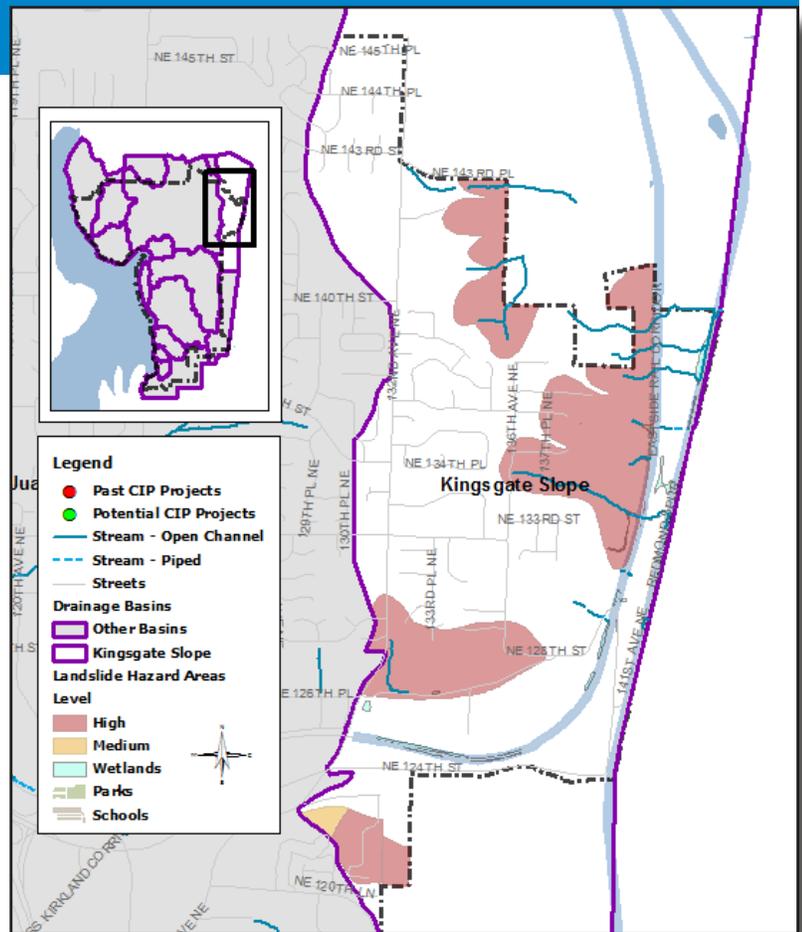
There are multiple small, low quality wetlands along streams and ditches within this basin.

At 42.5% forest coverage, this basin currently has the fifth highest forest cover of all the basins in Kirkland, but, with this basin also having the highest potential for redevelopment, this number may decrease as parcels develop. However, tree retention is a high priority in the development review process.

## In-Stream Conditions

There are 2.5 miles of stream channel within the Kingsgate Slope basin and 96% of the stream channels are open. Many are in steep ravines or along the Cross Kirkland Corridor, and all drain to the Sammamish River.

There are many large private greenbelts within this drainage basin, some located around stream channels. Zoning code restrictions along stream channel buffers help protect the greenbelts from development. Greenbelts



## LAND CHARACTERISTICS

Basin Area	562.8 acres
Highest Elevation	420 feet
Lowest Elevation	32 feet

## STREAM CHARACTERISTICS

Total Length of Channel	2.5 miles
In Pipe	0.1 miles
Open Channel	2.4 miles

## LAND COVER

Existing Impervious	29.7%
Built-out Impervious	38.0%
Forest Cover	42.5%

## LAND USE

Single Family Residential	66.8%
Commercial	1.1%
Open Space/Park	1.5%

November 2014

provide shade in the stream channel for aquatic habitat and provide a place for wildlife to live.

## **Fish and Wildlife**

This basin was located outside of the limits of the Stream and Wildlife Study by the Watershed Company. No fish are known to be present within this basin's streams. The steep slopes of this basin above the Sammamish River probably limited historic fish use.

## **Problems and Opportunities**

### **Problems**

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Kingsgate Slope Basin. Currently, 29.7% of the basin is covered in impervious surface. Although this percentage is one of the lowest in the city, most of the development in this basin occurred before regulations required flow control and water quality treatment. This basin also has the highest potential for development or redevelopment, and, if new flows are not properly mitigated, this will impact habitat and lead to flooding problems within the basin.

### **Past Projects**

This area was annexed from King County on June 1, 2011 and no projects have been completed in this basin.

### **Potential Projects**

No projects are proposed for this basin. There are no flooding issues that need to be addressed and no potential habitat projects at this time.

*Updated 11/6/14*

# Kirkland Slope Basin Report Card

The Kirkland Slope basin is one of the smallest basins in Kirkland at 210.5 acres and is primarily zoned as single family residential, at 86.1% of the basin. This basin has the lowest potential for development over the next 20 years, meaning an increase in impervious area in this basin is likely very minimal.

## Land/Streamside Conditions

The primary soil type throughout this basin is moderately fine to fine textured sediment, otherwise known as clay. This type of soil is tough to infiltrate, resulting in higher runoff volume and velocity to the stormwater system.

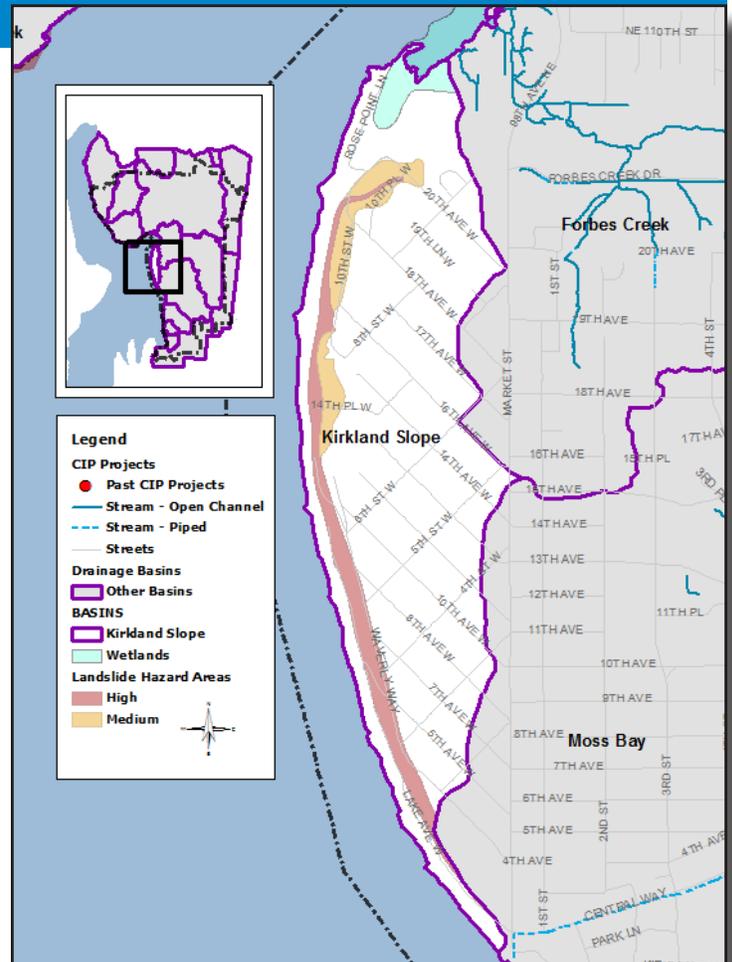
The average slope across this basin is between 5 and 8%, all sloping towards Lake Washington with multiple outfalls to the lake. There is a strip of a high landslide hazard area near the shoreline of the lake, meaning the slopes in this area are greater than 40% or have been subject to previous landslides or emergent groundwater.

Of the 210.5 acres within the basin, approximately 5 acres are classified as wetland. This wetland is part of a larger wetland that also extends into the Forbes Creek basin and is classified as a high quality wetland. Wetlands are an important part of the natural system, providing natural water quality treatment and attenuation of flows.

At 31.2%, the Kirkland Slope basin has one of the lowest forest covers of any basin in the city. The amount of tree coverage and other vegetation within basins correlates directly to quality creek, stream and lake habitat, runoff volume and surface water quality (*Kirkland 2011 Urban Tree Canopy Assessment*, AMEC).

## In-Stream Conditions

There are no stream channels, piped or open, located within this drainage basin. This basin drains directly to Lake Washington through multiple outfalls to the lake. There are multiple greenbelts located within city parks such as Waverly Park and Kiwanis Park. Greenbelts are important for wildlife habitat.



## LAND CHARACTERISTICS

Basin Area	210.5 acres
Highest Elevation	210 feet
Lowest Elevation	20 feet

## STREAM CHARACTERISTICS

Total Length of Channel	0 miles
In Pipe	0 miles
Open Channel	0 miles

## LAND COVER

Existing Impervious	39.1%
Built-out Impervious	40.0%
Forest Cover	31.2%

## LAND USE

Single Family Residential	86.1%
Commercial	0.5%
Open Space/Park	12.7%

## Fish and Wildlife

No fish studies conducted within the basin since there are no streams.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Kirkland Slope basin. Currently, 39.1% of the basin is covered in impervious surface. Most of the development in this basin occurred before regulations required flow control and water quality treatment. If not handled properly, this can lead to flooding problems within the basin.

### Past Projects

There are no records of past projects within this basin.

### Potential Projects

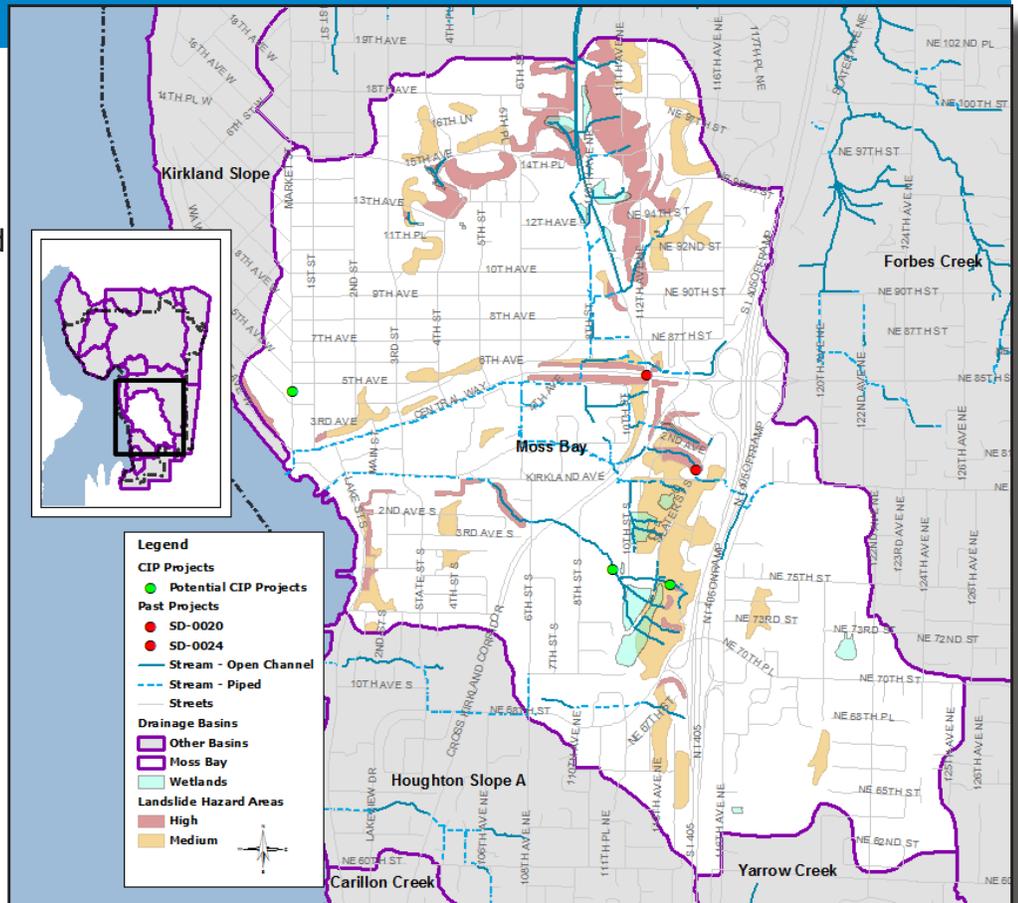
No projects are proposed for this basin.

*Updated 11/3/14*

# Moss Bay Basin Report Card

At 1,487 acres, the Moss Bay Basin is the third largest basin within the City of Kirkland. The majority of the basin is developed for single family use. This basin has the most existing impervious surface coverage within the city at 46.2%.

Although the chance for redevelopment is lower since so much of the basin has already been developed, after built out conditions, it will still be the most developed basin within the City with an impervious coverage of 48.3%. Since a lot of this basin was developed prior to stormwater regulations, this basin will have to rely on redevelopment and retrofit opportunities to reduce impacts to the streams in the basin and to Lake Washington.



## Land/Streamside Conditions

The primary soil type throughout this basin is moderately fine to fine textured sediment, otherwise known as clay. This type of soil is tough to infiltrate, resulting in higher runoff volume and velocity to the stormwater system.

Approximately 15% of the upstream area of this basin has both moderate and high landslide hazard areas. This means that this area has a higher probability to slide due to steep slopes, previous slides in the area, or emergent groundwater is present.

Of the 1,487 acres within the basin, 20 acres are classified as wetland. The wetlands are primarily located next to open channel streams and most are designated as low quality wetlands. Nevertheless, wetlands provide natural water quality and attenuation of flows which help protect downstream. Of the wetlands located in this basin, the highest quality wetlands are located in Everest Park.

The forest cover within the Moss Bay basin is the fourth lowest in the city at 31.9% and is reflective of the high

### LAND CHARACTERISTICS

Basin Area	1,487.4 acres
Highest Elevation	520 feet
Lowest Elevation	18 feet

### STREAM CHARACTERISTICS

Total Length of Channel	9.3 miles
In Pipe	4.5 miles
Open Channel	4.8 miles

### LAND COVER

Existing Impervious	46.2%
Built-out Impervious	48.3%
Forest Cover	31.9%

### LAND USE

Single Family Residential	55.7%
Commercial	6.3%
Open Space/Park	6.9%

impervious coverage within this basin. Forest cover is important because studies have shown that higher levels of forest cover can help decrease contaminants from runoff to streams and to Lake Washington.

## In-Stream Conditions

The Moss Bay basin has 9.3 miles of stream channel, and 52% of the stream channel is open. The upper reaches in this basin tend to be open channel. Due to the high amount of development in this basin, the stream channels have been manipulated and are either straightened, ditched, or piped through the lower reaches prior to entering Lake Washington. Where possible, stream channels should be reestablished and opened because they help provide better fish and wildlife habitat.

## Fish and Wildlife

Since the streams are primarily piped through the lower reaches of the basin, there is no viable habitat for fish to enter from Lake Washington. In a stream and wildlife study completed in 1998 by the Watershed Company, electrofishing was conducted in the upper reaches and no fish were detected.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the Moss Bay basin. Currently, 46.2% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the stream channel. This increased volume of runoff has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

Two projects were completed over the past years in the Moss Bay basin. One project focused on

the stabilization of a stream channel to help with flooding, water quality, and habitat. The other project improved infrastructure by upsizing the pipe system along Central Way to prevent flooding.

### Potential Projects

Three projects are proposed for this basin. Two focus more on water quality and flooding by stabilizing Everest Creek and an upstream tributary. The other project focuses on upgrading stormwater infrastructure that is needed on Market Street due to old, undersized pipes.

*Updated 11/6/14*

# South Juanita Slope Basin Report Card

The South Juanita Slope Basin is the third smallest basin in the City of Kirkland at 287.3 acres. Approximately 66% of this basin is developed for single family residential, followed by 23% of the basin developed for commercial and multi-family residential.

This basin is the third most developed basin in Kirkland with 43.7% of the area covered by impervious area. However, due to the high level of existing development within this basin, the prediction for the change in impervious area over the next 20 years is one of the lowest in the city at 1.5%.

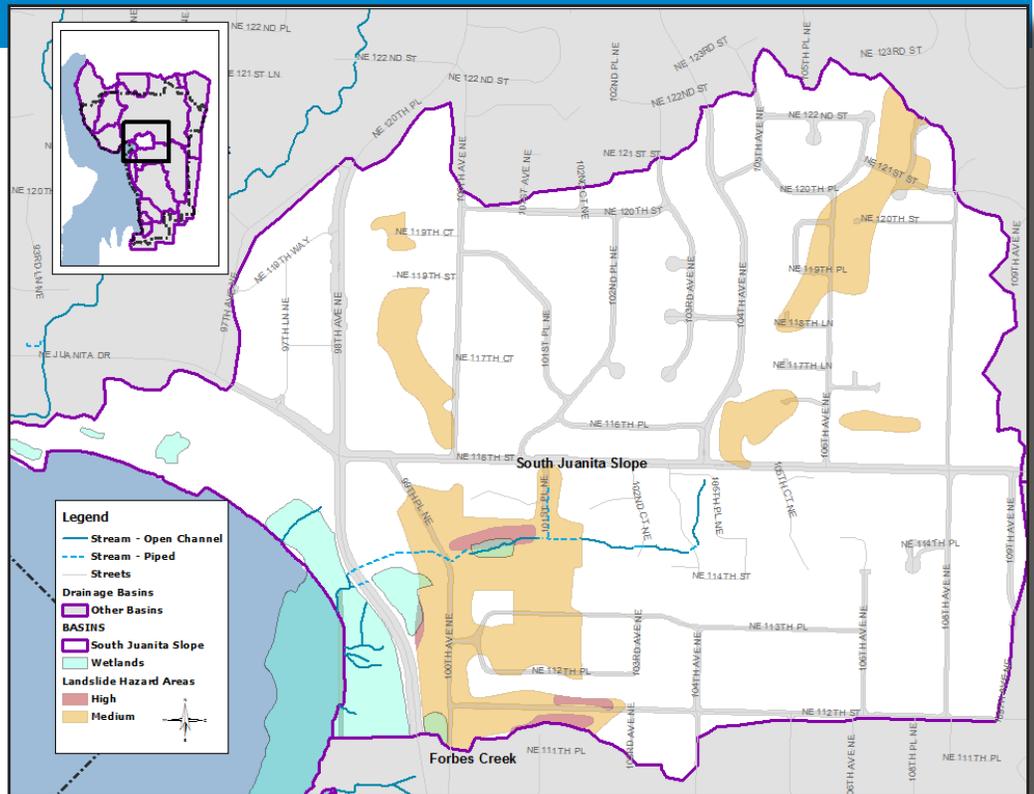
A lot of this basin was developed prior to stormwater regulations. The South Juanita Slope basin will have to rely on redevelopment and retrofit opportunities to reduce impacts to its streams and to Lake Washington.

## Land/Streamside Conditions

The primary soil type throughout this basin is moderately fine to fine textured sediment, otherwise known as clay. This type of soil is tough to infiltrate, resulting in higher runoff volume and velocity to the stormwater system. Approximately 20% of the basin is located within a moderate landslide hazard area, meaning areas sloping between 15 and 40% and underlain by relatively permeable soils consisting largely of sand and gravel or highly competent glacial till.

Within this 287 acre basin, 9.5 acres are designated as wetlands. There are multiple smaller low quality wetlands scattered across the basin, as well as one larger high quality wetland (an extension of the Forbes Creek wetland) along the shoreline of Lake Washington. Wetlands are important because they are a natural way of providing water quality improvement and flow reduction while also providing habitat for wildlife.

Due to the higher level of impervious coverage in the basin, the prediction for the change in impervious area over the next 20 years is one of the lowest in the city at 1.5%.



## LAND CHARACTERISTICS

Basin Area	287.3 acres
Highest Elevation	282 feet
Lowest Elevation	20 feet

## STREAM CHARACTERISTICS

Total Length of Channel	0.8 miles
In Pipe	0.3 miles
Open Channel	0.5 miles

## LAND COVER

Existing Impervious	43.7%
Built-out Impervious	45.2%
Forest Cover	36.4%

## LAND USE

Single Family Residential	66.0%
Commercial	12.2%
Open Space/Park	8.9%

coverage within the city. Studies have shown the high forest cover can help decrease contaminants from runoff to streams and to Lake Washington. The City of Kirkland's urban forestry plan includes strategies to improve the forest cover within Kirkland.

## In-Stream Conditions

There is a total of 0.8 miles of stream channel identified within the basin. 0.5 miles of the stream channel is open and 0.3 miles is piped. There is one main stream channel in the basin, and multiple smaller channels located within the Forbes Creek wetland.

Approximately 9 acres of this basin are zoned as open space. There are 3 main open space areas located within the South Juanita Slope Basin: part of Juanita Beach Park, Juanita Bay Park, and McAuliffe Park. These open spaces are identified green belts in this basin which provide much-needed riparian habitat and refuge for wildlife.

## Fish and Wildlife

Salmon have been identified within the smaller open channels in the Forbes Creek wetland up to 98th Avenue NE. The salmon have not been able to migrate further upstream due to fish barriers and lack of habitat.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the South Juanita Slope basin. Currently, 43.7% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creek. This increased volume of runoff has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

No past projects have been completed within this basin.

### Potential Projects

No projects have been proposed within this basin.

*Updated 11/6/14*



## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious coverage in the To Redmond basin. Currently, 37.7% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the stream channel. This has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

No past projects have been completed within this basin.

### Potential Projects

A project is proposed to prevent system back-up of an existing infiltration facility, reduce future flooding, and potentially provide additional water quality

*Updated 11/6/14*

# Yarrow Creek Basin Report Card

The Yarrow Creek basin is a large basin that spans over both Kirkland and Bellevue. The area within the City of Kirkland is 579.2 acres and contains the mouth of Yarrow Creek. The majority of the basin is developed for single family use. The existing amount of impervious within this basin is the lowest in the City at 20.8%. This is in part due to large areas of open space, such as Yarrow Bay wetland and Watershed Park, where limited or no development is allowed.

## Land/Streamside Conditions

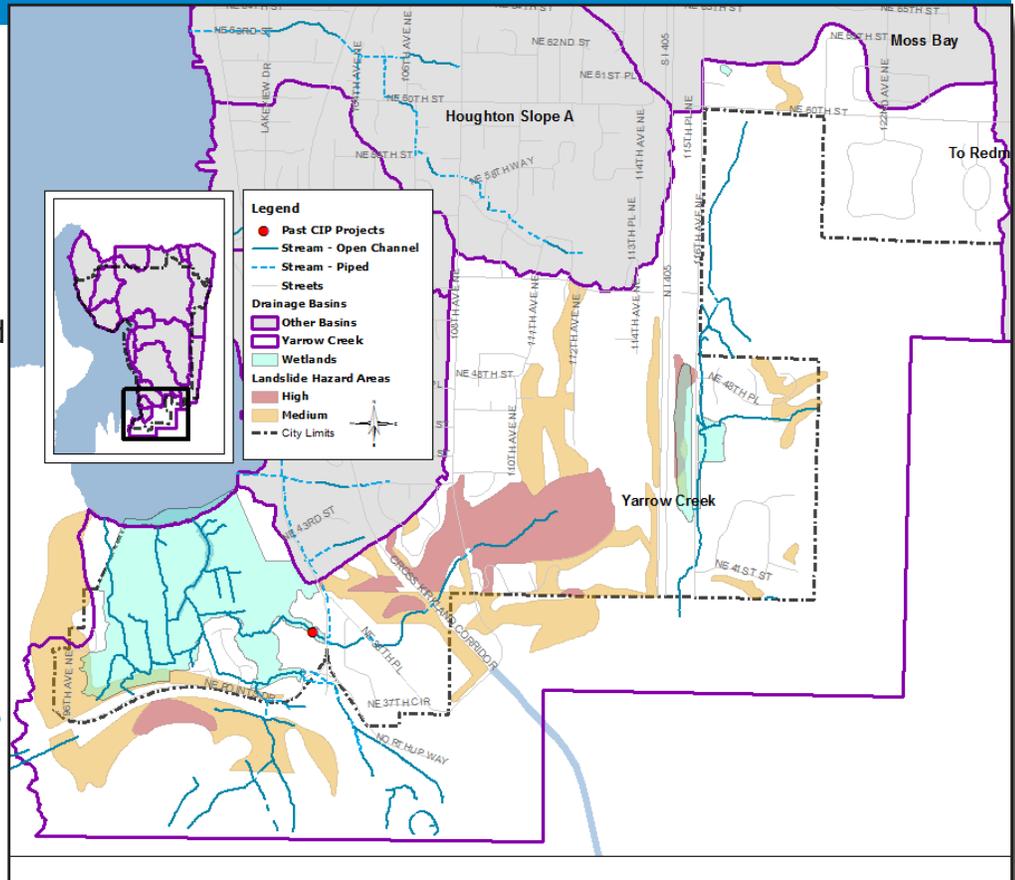
The primary soil type is classified as Type D soil, which is a low infiltrating soil including clay and soils with a permanently high water table or hard pan. This type of soil does not infiltrate, which can lead to larger runoff volumes in storm events.

Approximately 15 to 20% of the basin is covered in both moderate and high landslide hazard areas. These areas slope greater than 15% and likely have groundwater near the surface underlain with impermeable surfaces.

A large wetland complex is located at the mouth of Yarrow Creek. This wetland is 83 acres and rated as highest quality for all wetland functions. This wetland is a critical filter of contaminants prior to discharging into Lake Washington, a storage area for flood waters during storm events, and a home to many fish and wildlife species. There are additional smaller, medium quality wetlands located east of I-405.

50.7% of the Yarrow Creek basin is covered in forest, which is the third highest level of coverage in the city. Forest coverage is important because it reduces the amount of flow and pollutants discharged to streams and lakes. The City is working on an urban forestry plan to improve forest coverage citywide.

There is a nearly continuous greenbelt that connects Yarrow Creek with Cochran Springs Creek and Watershed Park. This enables wildlife to move freely between a variety of upland



## LAND CHARACTERISTICS

Basin Area	579.2 acres
Highest Elevation	534 feet
Lowest Elevation	18 feet

## STREAM CHARACTERISTICS

Total Length of Channel	7.7 miles
In Pipe	0.9 miles
Open Channel	6.8 miles

## LAND COVER

Existing Impervious	20.8%
Built-out Impervious	22.9%
Forest Cover	50.7%

## LAND USE

Single Family Residential	51.4%
Commercial	8.0%
Open Space/Park	29.0%

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stream and wildlife habitat.

## In-Stream Conditions

Yarrow Creek basin contains 7.7 miles of stream channel, with 88.3% of the channel open. Two main stream channels are located within the basin, Cochran Springs Creek and Yarrow Creek.

The headwaters of Yarrow Creek begin in and around Bridle Trails Park, passes under and along roads and railroads for most of its length, including SR-520 and I-405. Cochran Springs Creek begins at Watershed Park and runs between office buildings through stabilized banks and buffers. These two stream channels primarily differ in slope. Cochran Springs Creek is much steeper than Yarrow Creek and flattens out and deposits large amounts of sandy sediment to Yarrow Bay Wetlands. Both creeks drain to Yarrow Bay Wetlands where vegetation such as alders, cottonwoods, willow line stream banks as well as non-native plants such as Himalayan blackberry, Scot's broom, iris, nightshade, and watercress.

## Fish and Wildlife

Biannual maintenance is conducted on Cochran Springs Creek to remove the sandy sediment that deposits where the stream channel flattens out. Electrofishing occurs each time maintenance is conducted and cutthroat trout, juvenile coho salmon, and lamprey have been caught within the past year (2014). Electrofishing conducted in Yarrow Creek has found cutthroat trout along the entire length of the creek. The fish identified in these locations are members of isolated populations due to the migration barriers found at one or more locations in the upper reaches of Yarrow Creek.

The City also collects aquatic bug samples from various locations along Cochran Springs Creek. Samples are assessed on a B-IBI scale from 50 (excellent) to 10 (poor) to indicate water quality. Typical scores for Cochran Springs Creek range between 16 and 14.

Invasive species within the stream channel can cause concern for aquatic habitat. Cochran Springs Creek is on the annual monitoring cycle

for the New Zealand mud snail. The New Zealand mud snail is an invasive species that has recently entered the Puget Sound region and have been found in streams as close as Bellevue. This mud snail has no natural predator and will eat the same food as the native snails and water insects, leading to decline of these species and food to the fish and wildlife population. Fortunately, no New Zealand mud snails have been detected in Kirkland streams.

## Problems and Opportunities

### Problems

Development over the past 20 years has caused dramatic changes to the landscape throughout Kirkland and has significantly increased the impervious surface coverage in the Yarrow Creek basin. Currently, 20.8% of the basin is covered in impervious surface, resulting in increased stormwater runoff volume to the creeks. This increased volume of runoff has implications for flooding, water quality and aquatic habitat concerns; it also requires increased operations and maintenance of the stormwater conveyance system to protect property and our streams and lakes.

### Past Projects

The only project completed within the Yarrow Creek basin was a stream restoration project that reestablished Cochran Springs Creek from Lake Washington Boulevard to Lake Washington. Sedimentation over the past years have caused the channel to fill in and created a fish barrier for fish to migrate upstream. After this project was completed, juvenile coho salmon, cutthroat trout, and lamprey have been found in the channel up to Lake Washington Boulevard.

### Potential Projects

No projects have been proposed for this basin.

A project is currently in design to address sedimentation occurring in the lower reaches of Cochran Springs Creek. Construction is projected for summer 2015.

*Updated 11/6/14*