City of Bellevue Watershed Management Plan – Characterization of Future Conditions

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1. Introduction and Purpose

Urban development in the lowland regions of the Puget Sound over the past 150 years has resulted in the conversion of large tracts of forested area to residential, industrial, and commercial land uses. Changing environmental conditions that resulted from this land conversion have dramatically impacted the health of the region's streams, lakes, and marine water bodies. Common symptoms of water resource degradation from urbanization include poor water quality, loss of riparian and aquatic habitat, and stream channel erosion. In combination, these impacts have resulted in widespread disruption in the ecological function of water bodies causing sensitive aquatic life to decline in abundance or disappear completely. To address this problem, state and local jurisdictions are making a concerted effort to rehabilitate these water bodies through coordinated planning efforts that direct new storm and surface water management practices to existing urban development that was built without stormwater detention or water quality controls that do not meet current requirements and standards.

Commensurate with these regional efforts, the City of Bellevue (City) is committed to improving and protecting the aquatic health of water bodies within its boundaries. To that end, the City is developing a Watershed Management Plan (WMP) that will focus on improving the health and condition of the City's streams using a toolbox of holistic storm and surface water management practices. The WMP will direct investments to high-priority watersheds providing measurable environmental benefits to stream health within a shorter timeframe than past or current approaches. The WMP will also help prevent further degradation in non-priority watersheds. The WMP will include an implementation plan with recommended projects, policies, programs, and operational plans to meet performance goals for Bellevue's streams and provide multiple benefits that help advance City objectives across departments and programs.

The purpose of this memorandum is to characterize potential future conditions within the City to inform the WMP. Assessing future conditions with regards to population growth and associated urban development, climate change, and emerging social and regulatory issues are important for the WMP. The investments proposed in the WMP for stream health will need to address both current needs as well as the change in those needs as a result of climate change and/or population growth and urban development as well as other important factors. The WMP will have a 20-year planning horizon (2023-2043) but some of the investments recommended by the plan will include built infrastructure with a 50-year or longer design life. The information in this memo will help shape those and other future investments.

This memorandum summarizes characterizations of climate change impacts and population growth and urban development, including a characterization of the relative sensitivity of each subbasin to the effects of climate change and growth and development. In addition, this memorandum also provides a narrative characterization of emerging issues, including COVID-19, emerging contaminants, and potential future regulatory requirements. A discussion on the watershed management tools applicable to addressing

climate change and growth and development is also included. Lastly, this memorandum outlines how this information will be used in WMP development.

This memorandum is organized into the following sections:

- Characterization of Potential Future Conditions
- Future Watershed Conditions to be used in Watershed Planning
- Tools Best Suited for Adaptation to Changing Conditions
- Utilizing this Future Conditions Characterization in the Watershed Improvement Plan and in the WMP

2. Characterization of Potential Future Conditions

2.1 Characterization of Future Conditions Across the City

Characterizing future conditions within the City is necessary for WMP development. Impacts from population growth and urban development as well as climate change need to be incorporated into current watershed planning efforts so that proposed investments not only address current conditions, but also those of the future. In addition, emerging issues including COVID-19, emerging contaminants, and potential future regulatory requirements are considered in this discussion to help develop a WMP that is resilient to potential changes over the planning horizon of the WMP.

2.1.1 Population Growth and Urban Development

King County is expected to grow by 660,850 people by 2044, with the City of Bellevue expecting to see an increase of 112,000 people (King County, 2021). For watershed planning, it is important to consider different levels of population growth and have plans to adapt to a growing population and increased urbanization pressures. Table 1 summarizes the impacts on land use/cover, utilities, transportation, environment, parks/open space, and shorelines as a result of anticipated population growth and urban development. City-specific estimates of population growth and development are discussed later in this memorandum.

It is anticipated that the City will continue to attract residents and a workforce from all over the globe. Environmental values and behavior related to streams and stream health may shift with an influx of people from different places. Depending on the direction of value shifts the community could become more or less environmentally conscious resulting in an effect on the support and willingness of the community to sustain and protect watersheds within the City.

2.1.2 Climate Change

The effects of climate change have already been felt in the City including increased storm intensity and changes in stream flows due to changes in precipitation patterns (COB & UW, 2019). Record-setting temperatures experienced in the summer of 2021 also may be an indicator of climate change. Climate change may also result in climate change driven tree mortality and an increase in invasive species (COB & UW, 2019).

Table 1 summarizes the impacts to land use / land cover, utilities, transportation, environment, parks/open space, and shorelines as a result of anticipated climate change. Characterizations of what climate change might look like within the City are discussed later in this memorandum.

2.1.3 Emerging Issues

The topics discussed in the emerging issues section are less quantifiable and less certain than those of population growth and development and climate change discussed in the previous section. A narrative is

provided here, with specific details on how these issues and opportunities may be addressed in the WMP provided in the last section of this Memorandum.

2.1.3.1 COVID-19 Pandemic

The COVID-19 pandemic has resulted in regional and worldwide changes in social structure and human behavior patterns. These changes may be temporary or may be permanent. While COVID-19 is ongoing as of the date of this memorandum, the full impact is unknown at this time. Potential long-term changes due to COVID-19, such as the effect of remote work on transportation/housing patterns, should be considered in the WMP.

Table 1 summarizes the impacts to land use / land cover, utilities, transportation, environment, parks/open space, and shorelines as a result of the COVID-19 pandemic. Note that because the long-term impacts of the COVID-19 pandemic are not yet known, Table 1 summarizes anecdotal and other observations made during the pandemic.

2.1.3.2 Emerging Contaminants

As water quality monitoring efforts increase and laboratory detection limits improve, more is known about what contaminants are present in surface waters of the Puget Sound region. Emerging contaminants of concern including Per- and Polyfluoroalkyl Substances (PFAS) and 6PPD-quinone with known impacts to people and animals have been detected in surface water (WSDOT 2021; Tian Z., et al., 2021).

Per- and Polyfluoroalkyl Substances (PFAS) is a group of over 4000 compounds that are considered persistent, toxic, and bioaccumulate, leading to negative health effects for people and animals.

6PPD-quinone is a compound used in tire manufacturing that has been tied to Coho Salmon deaths.

2.1.3.3 Climate Change Impacts on Vegetation

The primary driver of climate change driven tree mortality is heat, with drought increasing impact. Heat and drought combined result in greater evapotranspiration rates leading to less available water. Without enough water trees lose the ability to transport water to their leaves which prevents them from photosynthesizing (McDowell et al. 2008).

Another factor expecting to increase climate change driven tree mortality are pest and pathogen infestations. Mild to moderate pest and pathogen infestations are normal. However, when trees are already stressed due to heat and/or drought they are more susceptible to severe infestations that tree populations cannot recover from (Raffa, et al. 2008).

One way to mitigate the effects of climate-driven tree mortality is through assisted migration. Assisted migration involves identifying and introducing trees that grow in areas with climates similar to expected future conditions. Examples of more drought tolerant conifer species are Giant Sequoia (Sequoiadendron giganteum) or subspecies of Douglas Fir (Pseudotsuga menziesii) found in Southern California and Mexico that are more drought tolerant than our native Douglas Fir subspecies. The theory behind this practice is these species would be capable of withstanding or thriving in expected future climate conditions in the City because the City is expected to see future climate conditions similar to the species' native ranges. Assisted migration of trees in particular is currently being implemented in some planting projects in parks around the City. Introduced species can impact and even disrupt ecological systems so it is important that the City continues to work with experts to manage the introduction of new species (COB & UW, 2019).

2.1.3.4 Invasive Species

Invasive species are either plant or animal species that have been introduced to an environment outside of their native range often due to human activities such as global shipping and escape of aquatic and plant

species from homes and gardens. Some invasive species can cause environmental and economic harm, while the impact of other invasive species is lesser known (WDFW 2021). Invasive plant and aquatic animal species are already present within the City's watersheds. Climate change will likely increase native plant mortality, increasing susceptibility and disruption of native ecosystems resulting in easier invasion and greater success of invasive species (Weiskopf, S., et al., 2020).

Invasive Aquatic Species

Documented occurrences of invasive aquatic species within the City's waters include the New Zealand Mudsnail (NZMS; Potamopyrgus antipodarum) and Chinese Mystery Snail (CMS; Cipangopaludina chinesis). Other detrimental invasive species that could arrive at any time within the City waters include Zebra Mussels (Dreissena polymorpha) and the African Clawed Frog (Xenopus laevis) (Bellevue 2021b).

The New Zealand Mudsnail (Potamopyrgus antipodarum) has been observed within City limits. NZMS reproduce rapidly by cloning and crowd out and outcompete native invertebrates for food and habitat. This reduces the abundance of native invertebrates that fish and other aquatic species feed on. While fish can consume NZMS, they are not an effective food source in comparison to other fish species food sources (such as terrestrial and aquatic insects, fish, amphipods, crustaceans, and other invertebrates) due to their low nutritional value. Once NZMS have infested an ecosystem, there is no effective method to remove them. Prevention of further infestation in areas of the City without NZMS will help mitigate the damaging impact of NZMS. Preventative action includes keeping pets out of infested streams and lakes, scrubbing debris/mud off any materials that have come in contact with streams, lakes or mud, and draining stream or lake water collected in gear or equipment before leaving a site (Bellevue 2021b).

Chinese Mystery Snails (Cipangopaludina chinesis) Chinese Mystery Snails are a relatively large snail species which are commonly used in aquariums. It is likely that CMS were introduced to Washington State waters through the illegal release of aquarium pets. CMS can reach high densities, compete with native invertebrates for food and habitat resources, host parasites and carry diseases known to infect humans, clog water intake pipes, and interact with other invasives to negatively impact native species. According to the City of Bellevue, CMS have been documented at a very high density within Larsen Lake in the nearby Greater Kelsey Creek Watershed. To prevent further infestation of CMS, aquarium waters and specimens should not be released into the wild and care should be taken to prevent the spread of CMS through cleaning, draining, and drying boats and equipment between water bodies (Bellevue 2021b).

Invasive Plant Species

Invasive plant species are present in watersheds across the City. Invasive plant species often thrive in areas of sparse canopy cover and low species diversity. Some of the most frequently encountered invasive plant species within the City's watersheds are Himalayan blackberry (Rubus armeniacus), English ivy (Hedera helix), Reed canarygrass (Phalaris arundinacea), Bittersweet nightshade (Solanum dulcamara), and Field bindweed (Convolvulus arvensis). These invasive species can become very dense in areas of low canopy cover and crowd out smaller native shrubs. Invasive vegetation infestations can be decreased with species removal and installation of native plants to increase native species and habitat diversity (Bellevue 2022).

In addition, various Knotweed species (Persicaria wallichii or Fallopia spp.) have been found along Kelsey Creek and Richards Creek (Bellevue 2021a). Knotweed forms dense monoculture stands along stream and riverbanks providing little soil stability which results in large amounts of streambank erosion (Colleran et al. 2020). In King County, Knotweed is listed as a Class B noxious weed meaning immediate control is recommended because Knotweed is a rapidly spreading noxious weed that is detrimental to stream health (Bellevue 2021a).

2.1.3.5 Potential Future Regulatory Requirements

Currently, the City is covered under the Western Washington Phase II Municipal Stormwater Permit issued by the Department of Ecology (Ecology). This permit includes the Federal Phase II National Pollutant Discharge Elimination System (NPDES) stormwater requirements plus state requirements that regulate activities within the City that have the potential to impact stormwater and therefore stream health. While

future regulatory requirements are unknown at this time, it is possible that future regulations from Ecology or other regulatory agencies might include requirements to address the following:

- **City-owned Barriers to Fish Passage**: Currently, the State of Washington is required to remove over 800 fish passage barriers on state land to restore access to habitat for salmon. Future regulatory requirements may include requiring cities to address City-owned barriers.
- **Retrofit requirements** in future NPDES stormwater permits
- Pollutant discharge to receiving waters via stormwater, in terms of **Total Maximum Daily Loads (TMDLs)** (nutrients, bacteria, or other)
- **Emerging Contaminants in Stormwater:** Emerging contaminants of concern such PFAS or 6PPD-quinone may be the subject of future stormwater regulatory requirements

In addition to potential future requirements listed above, it is also possible that wording and definitions in existing regulations may change (for example, 'wetlands' or 'Waters of the U.S.') that may impact requirements. While future regulatory requirements are unknown, it will be important in WMP development to include investments that can be implemented to rapidly address changing regulatory conditions.

2.1.3.6 Potential Future Policy and Behavioral Changes

The impacts of future policy and behavioral changes are difficult to quantify. Some examples of future policy changes and potential impacts in Washington State are:

- **Move Ahead Washington Bill**: The bill is a $16.9 billion transportation package over 16 years. It includes historic investments in climate mitigation, preservation and maintenance, public transportation, and pedestrian safety. Part of the bill is Clean Cars 2030 which is a bill stating all vehicles of the model year 2030 or later that are sold, purchased, or registered in the state must be electric. In addition to the EV requirement, there will be large expansions in multimodal transportation options. Potential impacts of the Move Ahead Washington bill are an increase in public transportation and electric vehicle use which could result in a decrease of carbon emissions and decrease of amount of oil and gas and total petroleum hydrocarbons on the roads that can be washed into streams in stormwater (WA House Democrats, 2022).

- **Copper Free Brake Pad Initiative:** On January 21, 2015, EPA, states, and the automotive industry signed an agreement to reduce the use of copper and other materials in motor vehicle brake pads. The agreement calls for reducing copper in brake pads to < 5 percent by weight in 2021 and 0.5 percent by 2025. In addition to reduction of copper, the initiative also aims to reduce mercury, lead, cadmium, asbestiform fibers, and chromium in brake pads. The initiative will result in a decrease of copper and other metals on roadways, resulting in less metals being transported via stormwater to fish bearing waterbodies causing harm (EPA, 2021)

Future policy changes may result in a change in public behavior and a shift toward more environmentally friendly modes of transportation**.** Sound Transit's East Link Light Rail is set to open Summer 2023 and the City is focusing on increasing multimodal transportation through the Mobility Implementation Plan (Bellevue Transportation Commission, 2022). Both plans will likely increase the use of public transportation which could result in less transportation related impacts on watersheds.

2.1.3.7 Aging Infrastructure

The City of Bellevue, similar to all other municipalities, is faced with aging infrastructure and limited budgets to keep up with increasing demands for repairs and replacements. Moreover, maintenance is more expensive for older infrastructure requiring more employees at a time when it is challenging to fill open positions. Therefore, the backlog of needed repairs and replacements of aging infrastructure increases faster than the ability to address that backlog of needs. The investments towards stream health in the WMP may include investments to address aging infrastructure (such as stormwater facility maintenance and retrofits) to maintain or improve the current level of stream health.

Table 1. Characterization of the Potential Effects of Population Growth/Urban Development, Climate Change, and Emerging Issues/Opportunities on the City of Bellevue's Land Use / Land Cover, Utilities, Transportation, Environment, Parks/Open Space, and Shorelines over the WMP Planning Period

Changes in:	As a Result of Population Growth / Development	As a Result of Climate Change	As a Result of Emerging Issues[1] *(COVID-19, emerging contaminants, changing regulatory requirements, climate change impacts on vegetation, invasive species, behavioral changes, aging infrastructure)*
Land Use and Land Cover	• As more open space is developed, pervious surfaces (including native vegetation) are converted to impervious surfaces causing stormwater runoff volumes and peaks to increase. This is partially mitigated by current stormwater regulations. All watersheds will need to go further to mitigate this growth to protect or improve stream health (Minton, 2011). • Older developments can be retrofitted providing both challenges and opportunities to retrofit stormwater infrastructure to current standards (Minton, 2011). • Transit oriented development resulting in land use changes from industrial or commercial use to multifamily/residential use (Sound Transit, 2022).	• Economic impacts from climate change may result in direct and indirect population flows into and out of the region (Saperstein, 2015). • Climate change may impact vegetation, including tree canopy, resulting in further habitat degradation (UW CIG, 2019). • Increased impervious surface and temperatures will increase urban heat island effects (COB & UW, 2019).	• Remote work patterns may alter spatial distribution of re-development. • Areas away from the City's Central Business District (CBD) may see more housing and commercial development.

Changes in:	As a Result of Population Growth / Development	As a Result of Climate Change	As a Result of Emerging Issues[1] *(COVID-19, emerging contaminants, changing regulatory requirements, climate change impacts on vegetation, invasive species, behavioral changes, aging infrastructure)*
Utilities	• Increased stormwater maintenance requirements (as more facilities are built, and existing facilities are used more) (Minton, 2011). • Increase in water demand will increase need for innovative uses of potable/non-potable water (Minton, 2011). • More impervious area can be captured/treated during redevelopment with appropriate retrofitting incentives (Minton, 2011). • Increased land cost commensurate with growth may limit opportunities for open space/public use acquisitions.	• More frequent high intensity storm events may overwhelm City's stormwater infrastructure and may put other utility infrastructure (sewer, drinking water) at risk (UW CIG, 2019). • Stormwater detention facilities may increase stream temperatures (infiltration facilities may be heat sinks). An increase in severe rain events may increase stormwater runoff and flow rates of often warm/hot and turbid road run-off (Minton, 2011).	• Short-term impact during COVID-19 pandemic: Less water use (fewer restaurant/hotel visits). • Utility rates may increase to fund aging infrastructure and additional regulatory requirements.
Transportation	• Increasing demand on existing transportation assets increases need for updated traffic planning and multi-modal transportation. • Potential shift in transportation modes and conversion to alternative fuels. • The scheduled opening in 2023 of approximately 8 miles of light rail track through Bellevue and associated transit oriented development. Also a future light rail route from Kirkland to Issaquah though Bellevue is planned.	• An increase in severe rain events may lead to urban flooding, culvert blockages, and sinkholes causing road closures and transit service disruptions (COB & UW, 2019).	• Short-term impact during COVID-19 pandemic: Decrease in all types of travel; longer-term impact: Shift to remote work may impact transportation demand • Similar to climate change impacts, culvert blockages and sinkholes develop as a result of aging infrastructure

Changes in:	As a Result of Population Growth / Development	As a Result of Climate Change	As a Result of Emerging Issues[1] *(COVID-19, emerging contaminants, changing regulatory requirements, climate change impacts on vegetation, invasive species, behavioral changes, aging infrastructure)*
Environment	• An influx of people from other places who may have different values for environmental preservation. • Redevelopment of large residential lots with small houses to build larger houses or multiple homes, potentially decreasing overall watershed tree canopy.	• Precipitation patterns and stream flows will change (UW CIG, 2019). • Vegetation not tolerant of dry conditions will die (UW CIG, 2019). • There will be higher wildfire potential and higher ambient temperatures (UW CIG, 2019). • Lower groundwater levels (elevations), decrease in stream baseflow, increase in stream temperature (UW CIG, 2019). • An increase in severe rain events may increase stormwater runoff and flow rates and may increase erosion and water quality/sedimentation issues (UW CIG, 2019).	• Economic downturn increased risk of homelessness and camping in riparian areas. • Short-term impact during COVID-19 pandemic: Decrease in vehicular traffic reduced associated stormwater pollutants (heavy oils, 6PPD-quinone, etc.).
Parks, Recreation, and Open Space	• Densification and demand for open space increases (City within a Park). • Increased land cost commensurate with growth may limit opportunities for open space/public use acquisitions. • New parks and trails may present opportunities to increase education and outreach (e.g., awareness and knowledge of tools used by the City to improve stream health).	• Urban flooding may impact parks and open spaces proximate to stream corridors.	• Short-term impact during COVID-19 pandemic: Increase in use of outside public areas, outdoor recreation areas, and pedestrian zones/trails (expected to continue beyond pandemic).

Changes in:	As a Result of Population Growth / Development	As a Result of Climate Change	As a Result of Emerging Issues[1] *(COVID-19, emerging contaminants, changing regulatory requirements, climate change impacts on vegetation, invasive species, behavioral changes, aging infrastructure)*
Shoreline Management	• Increased demand for shoreline/stream side amenities in Bellevue.	• Higher water temperatures may impact lake shoreline water quality and circulation patterns (e.g., stratification).	• None known

[1]Long-term impacts due to emerging issues including the COVID-19 pandemic are unknown at this time. Identified impacts are speculative and based on limited anecdotal information. Note that emerging issues can also be emerging opportunities, such as more people aware of streams and stream health because of additional parks and open space use experienced during the COVID-19 pandemic.

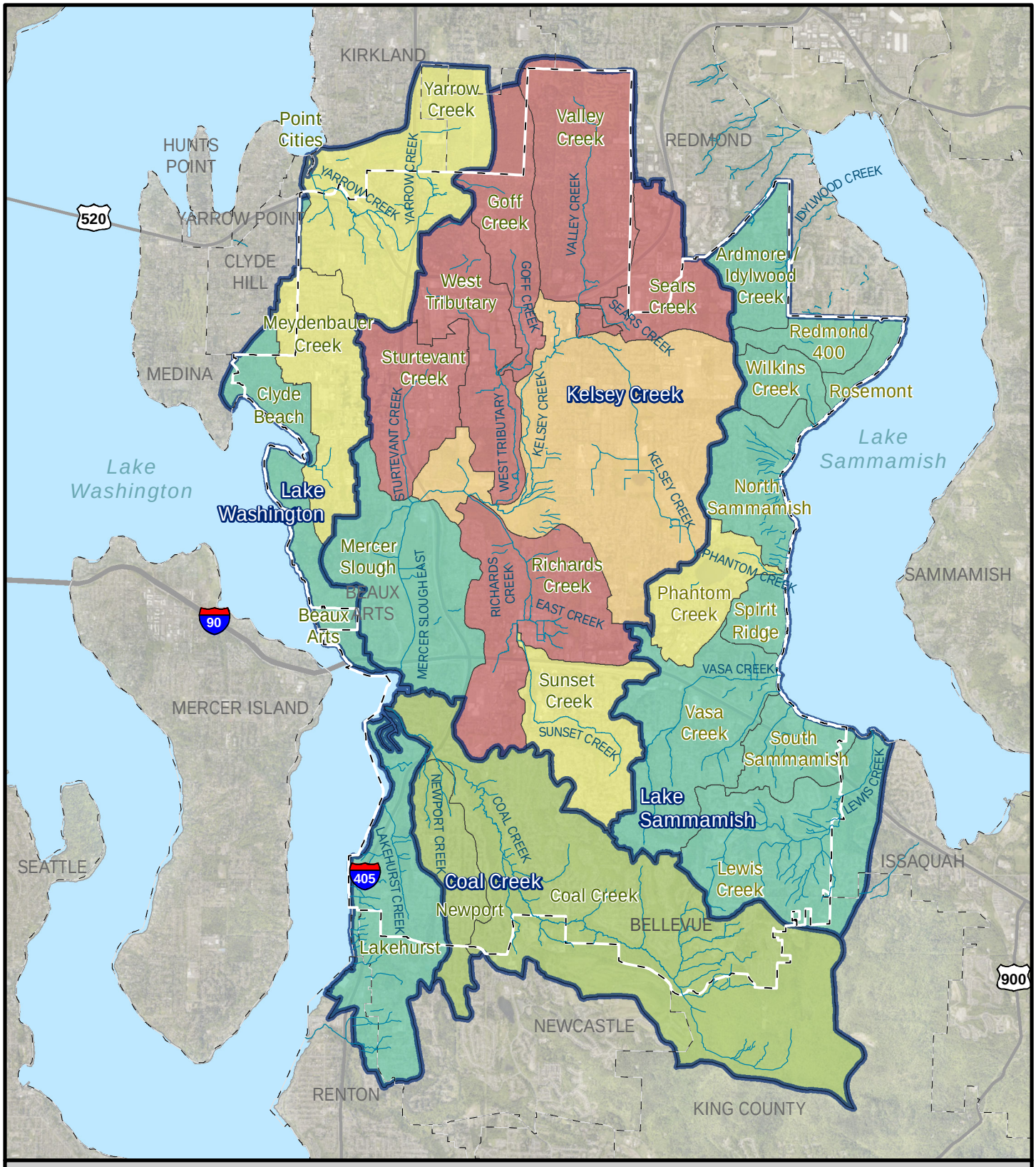
2.2 Sensitivity to Future Conditions

Population growth/development (Figure 1) and climate change (Figure 2) are expected to affect certain areas of the City differently. Areas with steeper slopes will be more sensitive to changes in precipitation patterns as more stormwater volume will run off at higher speeds, causing erosion. Similarly, areas with fewer trees will have less rain interception and greater impact from increases in precipitation, as well as higher ambient temperatures during summer heat waves than areas with more canopy coverage. Areas slated for new and/or re-development will experience the effects of growth/development (such as an increase in impervious surface) much more than areas that are fully developed. To help in WMP development, this relative sensitivity to future conditions has been characterized by subbasin (Table 2).

Population growth/development sensitivity was determined by subbasin according to current land use and potential opportunities for development or redevelopment. For example, if a subbasin is mostly residential there is little chance of large changes in land use. A subbasin was categorized as low sensitivity if the subbasin is built out to existing zoning. The subbasins with a high percentage of residential land use fall into this category. In contrast, subbasins with higher percentages of commercial and/or industrial or multi-family land use were categorized as moderate or high sensitivity.

Climate change sensitivity was determined for each subbasin according to the subbasin's topography, impervious surface coverage, and age of development (as a surrogate for presence of stormwater flow control). For example, if a subbasin is generally steeper, it is more sensitive to projected increases in flooding and erosion than a flatter subbasin. Similarly, a subbasin with limited stormwater controls will experience a greater hydrologic response (higher flow rates).

These relative sensitivity characterizations by subbasin will be used in the Watershed Improvement Plan to identify where investments need to be made (in which subbasin) to maintain the current level of stream degradation, preventing things from getting worse. These investments would be in addition to those made to improve or protect any individual subbasin. As shown in Table 2, many of the City's 27 subbasins will require investments just to maintain current stream condition because of the effects of growth and/or climate change.



Legend

- Main Watershed boundaries
- Bellevue City Limit
- Other Jurisdictions
- Streams
- Highway

Sensitivity to Population Growth

- High
- Moderate/High
- Moderate
- Low/Moderate
- Low

*Note all data from City of Bellevue 2020

Figure 1. Future Conditions - Relative Sensitivity to Population Growth / Urban Development.

0 3,500 7,000 14,000 Feet

King County Aerial (2019)

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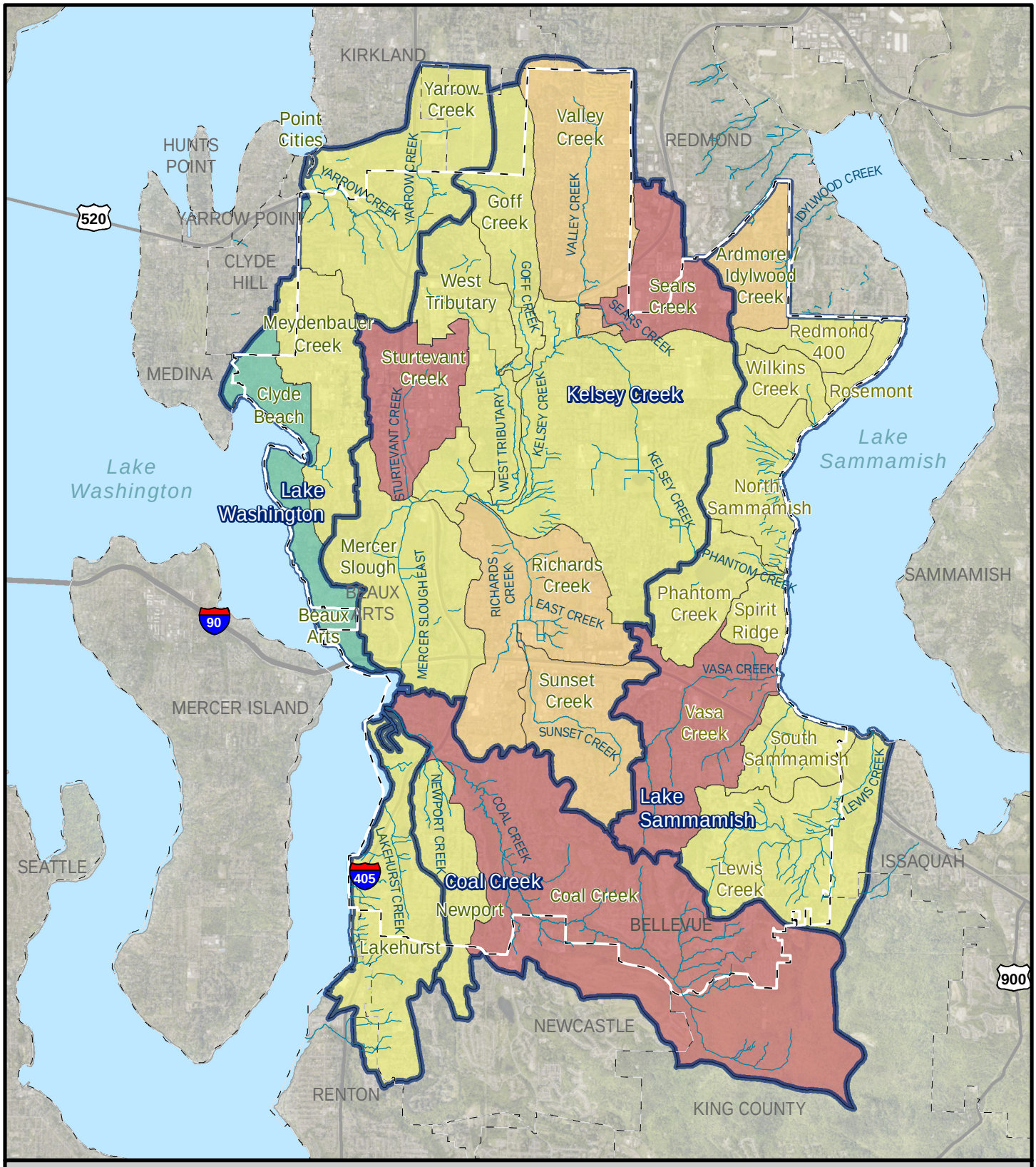

Legend

- Main Watershed boundaries
- Bellevue City Limit
- Other Jurisdictions
- Streams
- Highway

Sensitivity to Climate Change

- High
- Moderate/High
- Moderate
- Low/Moderate
- Low

*Note all data from City of Bellevue 2020

Figure 2. Future Conditions - Relative Sensitivity to Climate Change.

0 3,500 7,000 14,000 Feet

King County Aerial (2019)

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Table 2. Relative Sensitivity of Each Subbasin to the Impacts of Growth/Development and Climate Change

Subbasin*	Watershed	Relative Sensitivity to Population Growth / Urban Development *(considerations: where is re-development going to occur? Where are people moving to? Current land use)*	Relative Sensitivity to Climate Change *(considerations: topography, steepness, relative precipitation amounts, canopy coverage)*
Coal Creek	Coal	Low/Moderate (mainly residential, possible redevelopment of small houses on large lots)	High (steep topography, unstable streambed/banks and hillsides (from mining impacts), yet fair/good canopy coverage (primarily aging deciduous trees, acknowledging this may be declining over time due to climate change) and low impervious surface percentage; potential for wildfire on Cougar Mountain)
Newport Creek	Coal	Low/Moderate (mainly residential, possible redevelopment of small houses on large lots)	Moderate (steep topography; upper portion has very limited stormwater controls, yet good canopy coverage)
Mercer Slough	Kelsey	Low (large tracts of publicly-owned open space with limited opportunities for redevelopment)	Moderate (relatively low impervious surface percentage, flat topography; majority of development has occurred since stormwater controls were put in place; may see higher temperatures due to increase in Lake Washington temperatures)
Kelsey Creek	Kelsey	Moderate/High (commercial/industrial land use and also residential land use with opportunities for re-development; moderate/high will depend on extent of redevelopment actually occurs)	Moderate (high impervious surface percentage (42%) will exacerbate high ambient temperatures, yet not steep and with wetland complexes and connected floodplains to attenuate peak flows)
Sturtevant Creek	Kelsey	High (significant opportunities for re-development)	High (high impervious surface percentage (70%) will exacerbate high ambient temperatures, yet not steep and mainly conveyed in a pipe rather than an open channel which would experience erosion; large portion developed without stormwater controls)

Subbasin*	Watershed	Relative Sensitivity to Population Growth / Urban Development *(considerations: where is re-development going to occur? Where are people moving to? Current land use)*	Relative Sensitivity to Climate Change *(considerations: topography, steepness, relative precipitation amounts, canopy coverage)*
Richards Creek	Kelsey	High (opportunities for re-development in and around Factoria and Eastgate)	Moderate/High (high impervious surface percentage (46%) and significantly degraded habitat will exacerbate high ambient temperatures and sensitivity to climate change, yet not steep; large portion developed without stormwater controls; recently observed dry streams in upstream reaches)
Sunset Creek	Kelsey	Moderate (opportunities for re-development in and around Somerset and Eastgate)	Moderate/High (high impervious surface percentage (42%) will exacerbate high ambient temperatures, yet not steep; large portion developed without stormwater controls; steep in upper reaches)
West Tributary	Kelsey	High (commercial/industrial in upstream portion)	Moderate (high impervious surface percentage (44%) will exacerbate high ambient temperatures, yet not steep; large portion developed without stormwater controls)
Goff Creek	Kelsey	High (mainly residential in upstream portion, but commercial/residential in downstream portion)	Moderate (relatively low impervious surface percentage, yet large portion developed without stormwater controls)
Valley Creek	Kelsey	High (mainly residential, though possible redevelopment of small houses on large lots; downstream-most parts of subbasin do have commercial/industrial land use)	Moderate/High (relatively low impervious surface coverage overall, but impervious surface is in centralized area; large portion developed without stormwater controls; temperature increase in creek)
Sears Creek	Kelsey	High (commercial/industrial is dominant land use)	High (high impervious surface percentage (57%) will exacerbate high ambient temperatures and large portion developed without stormwater controls; yet not steep)
Lewis Creek	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain, yet good canopy coverage and relatively low impervious surface and a majority of development occurred since stormwater regulations were put in place)

Subbasin*	Watershed	Relative Sensitivity to Population Growth / Urban Development *(considerations: where is re-development going to occur? Where are people moving to? Current land use)*	Relative Sensitivity to Climate Change *(considerations: topography, steepness, relative precipitation amounts, canopy coverage)*
Vasa Creek	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	High (steep topography and limited floodplain, yet good canopy coverage; large portion developed without stormwater controls)
Ardmore Area (Idylwood Creek)	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate/High (steep topography and limited floodplain with higher impervious surface (45%) and low tree canopy (31%) that exacerbate ambient temperatures; large portion developed without stormwater controls)
Redmond 400	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain with higher impervious surface (42%) and low tree canopy (26%) that exacerbate ambient temperatures, no fish bearing stream channel)
Rosemont	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography; majority of development occurred before stormwater controls were put in place; no fish bearing stream channel)
Wilkins Creek	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain with higher impervious surface (44%) and low tree canopy (29%) that exacerbate ambient temperatures; large portion developed without stormwater controls, no fish bearing stream channel)
North Sammamish	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain, yet good canopy coverage; no fish bearing stream channel)
Phantom Creek	Lake Sammamish	Moderate (limited opportunities for redevelopment of residential area, yet opportunities for redevelopment near former airfield)	Moderate (steep topography and limited floodplain, and low tree canopy (30%); large portion developed without stormwater controls)

Subbasin*	Watershed	Relative Sensitivity to Population Growth / Urban Development *(considerations: where is re-development going to occur? Where are people moving to? Current land use)*	Relative Sensitivity to Climate Change *(considerations: topography, steepness, relative precipitation amounts, canopy coverage)*
Spirit Ridge	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain with higher impervious surface (44%) and low tree canopy (33%) that exacerbate ambient temperatures; large portion developed without stormwater controls; no fish bearing stream channel)
South Sammamish	Lake Sammamish	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography and limited floodplain, yet good canopy coverage)
Lakehurst	Lake Washington	Low (mainly residential, limited opportunities for redevelopment)	Moderate (steep topography with limited floodplain, yet good tree canopy and majority of development has occurred since stormwater regulations were put into place)
Meydenbauer Creek	Lake Washington	Moderate (may be opportunities for re-development in Central Business District (CBD))	Moderate (high impervious surface percentage will exacerbate high ambient temperatures, though mostly in a pipe so no channel erosion/scour; large portion developed without stormwater controls)
Beaux Arts	Lake Washington	Low (mainly residential, limited opportunities for redevelopment)	Low (no fish bearing stream channel)
Clyde Beach	Lake Washington	Low (mainly residential, limited opportunities for redevelopment)	Low (no fish bearing stream channel)
Yarrow Creek	Lake Washington	Moderate (may be opportunities for re-development commercial/industrial areas near SR-520)	Moderate (high impervious surface percentage will exacerbate high ambient temperatures, though mostly in a pipe so no channel erosion/scour)
Point Cities	Lake Washington	Low (mainly residential, limited opportunities for redevelopment)	Low (no fish bearing stream channel)

*Subbasins are assessed individually, compounding effects from connecting subbasins are not addressed.

2.3 Concurrent City Planning Efforts and other Planned Investments that Influence Future Conditions

On-going City planning efforts will influence future conditions within the City of Bellevue. In addition to the on-going Comprehensive Plan update, the City's Mobility Implementation Plan (MIP) will guide investments in transportation including an increase in bike and pedestrian facilities. The City's on-going Parks and Open Space Master Plan calls for land acquisition to enlarge the open space within the City. The City is opportunistically acquiring parcels in locations including the shores of Lake Sammamish. The City is moving forward on the Bel-Red Lookback Plan and on planning efforts in the Wilburton and East Main neighborhoods. In addition, the City's Transportation Department is conducting a curb management plan that will guide competing transportation and mobility uses of that space.

In addition to the planning efforts underway, the City also has capital projects in various stages of planning and development including roadway and corridor projects, utility projects, and the Grand Connection, an opportunity to connect Lake Washington and Meydenbauer Bay with the neighborhoods east of I-405. In addition to City investments, Sound Transit, the Washington State Department of Transportation (WSDOT) and Puget Sound Energy (PSE) all have investments planned within City boundaries. Transit oriented development (TOD) will result in land use changes from commercial and industrial use to multifamily/residential once construction is completed on transportation related projects, such as East Link Light Rail (Sound Transit, 2022).

There are also areas within the City, such as in City Parks or along creeks, undergoing habitat restoration. Multiple organizations and habitat stewards are working within the City to restore habitat to increase native tree canopy and decrease invasive plant coverage.

These planning efforts and investments will become part of the future conditions within the City. An understanding of these planning efforts and City and non-City investments will be key during Watershed Improvement Plan development to identify specific opportunities to site investments for stream health in the City either around these other investments or as part of them to maximize benefits towards multiple objectives.

3 Future Watershed Conditions for Watershed Planning

By 2044, the City is expected to see an increase of 112,000 people, 35,000 new housing units, and 75,000 new jobs (King County, 2021). Because of current zoning and development patterns, much of this growth will be accommodated via re-development (and densification) in the City's CBD, Bel-Red, and Wilburton/East Main neighborhoods.

With this influx of people from other places, the City may see a shift in community values that are either more or less aligned with the City's values. The community may become more or less environmentally conscious and more or less willing to use alternate transportation methods such as biking and/or public transportation. This potential shift in either direction should be considered when developing the WMP.

In addition to population growth and urbanization, the City is also expected to experience the effects of climate change. Global average warming is likely to reach 1.5 ^{o}C (approximately 3 ^{o}F) between 2030-2052. Assuming Bellevue will experience 3 ^{o}F warming by mid-century, the City will experience changes in ambient temperature, stream flow, and precipitation patterns (UW CIG, 2019).

Table 3 shows the anticipated future conditions in terms of climate change and also population growth and urban development. The possible effects on streams and riparian areas within the City for each of those anticipated future conditions are also shown. The applicable watershed management tools to adapt to these changing conditions are shown in the final column of Table 3 and are discussed in the next Section of this Memorandum.

Table 3. Anticipated Future Conditions Within the City of Bellevue and Applicable Watershed Management Tools

Anticipated Future Condition		Possible Effects on Streams and Riparian Areas within the City of Bellevue	Applicable Watershed Management Tools for Future Conditions Adaptation
Population Growth / Development	Increased Population Density	• Increase in impervious surface leads to higher flowrates and stormwater volumes. • Redevelopment brings additional areas into compliance with modern stormwater standards (flow control and water quality).	• Concentrate growth in high density areas. • Increase stormwater controls (both quantity and quality). • Non-vehicular commuting and/or public transportation incentives .
	Daytime (employment/jobs) population growth	• More vehicular traffic causes increase in pollutant loading.	• Education and commute incentives.
	Changing behaviors/values	• An increase/decrease in environmental consciousness, an increase/decrease in willingness to bike commute or use public transportation will increase/decrease stresses on streams .	• Education and commute incentives. • Code enforcement (ex: pet waste).
Climate Change	Warmer ambient and stream temperatures (67% Increase in number of days over 90 ^{o}F ; may vary based on location within Bellevue)* (UW Climate Impacts Group, 2019)	• Warmer streams increasing stress on fish, more frequent algal blooms. • Native vegetation drought-stressed; invasive species take over. • Aquatic species diversity may change from native dominated to non-native assemblage.	• Tree planting and tree retention (including incentives on private property) citywide and especially in riparian areas, emphasizing the importance of conifers. • Increase shading and use cool pavement types to address heat island effect and to reduce temperature of stormwater runoff. • Invasive species awareness/control/removal. • Promote infiltration and vegetation practices that promote evapotranspiration and cooling. • Rainfall harvesting to irrigate vegetation during summer months. • Replace vegetation with more drought-tolerant species.

Anticipated Future Condition		Possible Effects on Streams and Riparian Areas within the City of Bellevue	Applicable Watershed Management Tools for Future Conditions Adaptation
			• In-stream habitat enhancement including the placement of large woody material to provide cover and create and maintain pool habitat which is a thermal refuge.
	Reduction in snowpack (38% Reduction in snowpack)* (UW Climate Impacts Group, 2019)	• Potentially minimal, as only perhaps Coal and Newport Creeks have snowpack at higher elevations.	• Not applicable.
	Increase in winter stream flowrates (16% Increase in winter stream flowrates)* (UW Climate Impacts Group, 2019)	• Creek flooding, costly stormwater management and flood protection, negative effects on salmon populations and fish passage; more channel scour and erosion.	• Retrofit aging development, low impact development, park redesign, onsite detention in up-zoned areas. • Increase stream habitat complexity to reduce flow velocities and promote streambed and streambank stability.
	Decrease in summer stream baseflow (23% Decrease in summer stream baseflow)* (UW Climate Impacts Group, 2019)	• Negative effects on native aquatic species, including salmon populations and fish passage complications. • Streams may become ephemeral and thus unable to sustain resident fish populations.	• Re-connect natural hillside springs to streams (currently may flow into sewer systems); promote shallow infiltration that would re-surface as creek baseflow. • Floodplain and off-channel reconnection and restoration (including connection to associated wetlands). • Riparian enhancement including planting with drought tolerate species (potentially even non-native species). • Increase stream habitat complexity, particularly pools which provide low flow refugia.

* Values are moderate predictions for 2050.

4 Watershed Management Tools Best Suited for Adaptation to Changing Conditions

A watershed management toolbox was developed early in the WMP planning process in order to identify feasible and beneficial actions to address stream health in the City. Table 3 shows the applicability of some of these tools in addressing the effects of, or adapting to, changing conditions due to climate change and/or population growth and development. 'Green' or 'green/grey' tools mimic natural hydrology and are therefore better suited to adapt to changing conditions than stand-alone 'grey' tools. Tools that provide more than one benefit (for example, reduce peak flows and remove nitrogen) will be most helpful as conditions change in the future.

It is the implementation of many of these tools in different places across the City that will work together to address the effects of changing conditions. Implementing many different tool types in a 'diverse portfolio' will add resiliency as change continues into the future. This diverse set of tools implemented across the City will also provide the flexibility as regulatory requirements evolve over time and as more is learned about emerging contaminates and the long-term impacts of the COVID-19 pandemic. The Watershed Improvement Plan will recommend specific tools targeting limiting factors and sensitivity to future conditions specific to each subbasin. Table 3 represents the beginnings of that effort.

5 Utilizing this Future Conditions Characterization in the Watershed Improvement Plan and in the WMP

In the Watershed Improvement Plan, suites of investments will be developed that address identified limiting factors. These investments will also consider current conditions, potential future conditions (considering sensitivity to change), and emerging issues including potential future regulatory requirements. The investment strategy will include a variety of tools from the toolbox so that it is flexible and the City can add investments to their planned efforts as things change. Investments will be determined according to where they would provide the most benefit.

The characterization of sensitivity to future conditions by subbasin (see Section 2.2 of this memorandum) will be used in the Watershed Improvement Plan to determine how much must be done to maintain the current stream condition in each subbasin, preventing further degradation as that change continues. This level of investment will be added to the level of investment needed to 'Improve', 'Protect', or 'Sustain' the condition in each subbasin according to the Management Strategy assigned for each subbasin. The performance goals set for each subbasin within the Watershed Improvement Plan will reflect sensitivity to future conditions.

Expanding on investments recommended in the Watershed Improvement Plan, the WMP will further explore opportunities to partner with other City Departments making stream health investments and assess where stream health investments will result in maximum community benefits. The WMP will also use scenarios to develop investment strategies to inform willingness to pay and level-of-service discussions. The WMP will include numerical performance targets aligning to each performance goal for each subbasin. The data and information for these numerical performance targets will be gathered and analyzed by the City through the City's planned monitoring program and/or through desktop analyses.

One of the last phases of the WMP development effort is development of an adaptive management plan. That adaptive management plan will identify actions to be taken if numerical performance targets are not met, and/or if the rate of change in population growth / urban development and/or climate change is faster than or different than what was anticipated. Similarly, the adaptive management plan will identify actions to be taken should emerging issues be experienced faster than anticipated, for example policies or regulations going into effect and/or if the long-term effects of the COVID-19 pandemic are more severe than anticipated.

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