1-1.1 Climate Change Impacts on Stormwater Management

Climate Change Trends and Predictions in Washington State

Climate change and its impact on stormwater management has become a significant topic of discussion and research in recent years.

A growing number of research and repeated model simulation results indicate that changes in global, national, and Washington State climates have cascading impacts on water resources, infrastructure, agriculture, human health, and more. Washington State, local government agencies, businesses, and communities have been preparing for climate change and potential mitigation options. We have already started experiencing climate-related hazards, and more impacts are inevitable. The intensity of the predicted changes and damages from those changes depend on our mitigation actions and preparedness.

The University of Washington's Climate Impacts Group published the State of Knowledge (Climate Impacts Group, 2015) and other reports summarizing the observed and predicted climate trends and their impacts in the Puget Sound region.

Some key climate changes in the Puget Sound region, as highlighted in those reports include:

- **Temperature:** The average air temperature rose 1.3°F from 1895 to 2014, and it is expected to rise more.
- **Precipitation:** Yearly variations in total precipitation will continue to be high. Many models predicted drier summers and wetter winters. Heavy rainfall events, often called "Atmospheric River" events, are projected to be more frequent and more intense (see Table 1-1.1: Future Hydrologic Projections).
- **Sea level rise:** Sea level is projected to be 14-54 inches higher by the year 2100 relative to the sea level in 2000. Coastal inundation and flooding will likely cause coastal habitat and biodiversity losses, and economic and cultural consequences.
- **Ocean acidification:** The North Pacific Ocean and Puget Sound are experiencing a reduction in pH, ocean acidification, as a result of increased carbon dioxide (CO_2) in the atmosphere and water.

These climate changes will likely result in a wide range of impacts in the Puget Sound region. Examples of potential consequences include:

- **Water resources:** Reduced water availability in the summer due to less snowpack, drier summers, and increased water temperatures.
- **Forests:** Higher forest mortality is expected due to increased risks of wildfire, insect outbreaks and diseases, and changes in the distribution and species of trees.
- **Agriculture:** Mixed results on crop production. While some crops may favor elevated CO_2 levels and temperature, others will be more vulnerable due to water and heat stresses.
- **Human health:** Although data is limited, studies suggested more heat-related illnesses, respiratory illnesses, water-borne diseases, and mental stresses as a result of climate change.
- **Infrastructure:** Infrastructure in certain locations (e.g. in the mountains, near or on steep slopes, and low-lying areas subject to flooding) are more vulnerable.

Stormwater Management in a Changing Climate

Climate change impacts on stormwater and receiving water ecosystems

Climate change impacts, especially precipitation pattern changes, pose increasing challenges in stormwater management and receiving water ecosystems (see Table 1-1.1: Future Hydrologic Projections). Wetter winters and more frequent and intense heavy rainfall events mean an increasing possibility for these events to overwhelm existing stormwater facilities that were sized based on historic rainfall data, resulting in more frequent and intense flooding, and more pollutant loads (e.g. particles, toxic chemicals and bacteria) carried with stormwater.

Frequency and intensity of extreme events (i.e. heavy rainfall, or atmospheric river events) are increasing. These events often severely damage infrastructure and receiving water bodies, resulting in costly repairs. The flood damages caused by extreme atmospheric river events cost tens to hundreds of millions of dollars; one atmospheric river event in January 2009 (size 3-8 inches of rainfall) resulted in $125 million in damages.

Table 1-1.1: Future Hydrologic Projections

Category	Variable	Summary messages	Future projections
Precipitation	Annual precipitation	Annual changes vary by models, from drier (negative %) to wetter (positive %)	-4 to +14% [A]
	Seasonal precipitation	Decrease in summer	- 30 to -6% [A]
		Increases in winter, spring and fall	+2 to +7% [A]
	Precipitation	Heavy rainfall	Days with rainfall > 1” : +13% [A]

Category	Variable	Summary messages	Future projections
	extremes	"atmospheric river" events	Days with rainfall > 3": +22% [A]
Receiving water	Streamflow	Increase in winter streamflow	+25 to +34% [B]
		Decrease in summer streamflow	-44 to -34% [B]
	Temperature	Increase in stream temperature	4 to 4.5 °F increase & 16% more locations experiencing stressful temp (> 67 °F) to salmon [B]
	Fish habitat	Decrease in coldwater fish populations	-77 to -33% of trout populations in the western US [B]
Notes: **A**: % change for 2041-2070 relative to 1950-1999 **B**: % change for 2070-2099 relative to 1950-1999 Projections are based on moderate to low mitigation action (RCP 4.5 and RCP 8.5) scenarios			

Challenges to developing regional stormwater management recommendations to mitigate for climate change

Although climate change models generally predict increases in heavy rainfalls and drought in summer, the uniqueness and variability of local conditions limit developing regional recommendations for engineering design. Local agencies also face challenges, such as those listed here, when developing climate change preparation strategies:

- Multiple Global Climate Models (GCMs) paired with different greenhouse gas emission and action scenarios produce a rather wide range of projections with high uncertainty, sometimes conflicting with each other. Additionally, coarse spatial scaled GCM projections would need to be downscaled to the local level, which brings another layer of uncertainty and challenges, especially to medium and small size communities.
- Climate change projections don't necessarily provide information required for management decisions. Stormwater engineers and managers need local hourly rainfall total and flashiness information, not seasonal or annual rainfall data, to select and size stormwater conveyance systems and Runoff Treatment and Flow Control BMPs.

- Stormwater managers need analytical and management tools. For example, stormwater BMPs are not sized to fully capture extreme storm events. Stormwater managers in areas with poorly draining soil (i.e. till soil) will be challenged to adequately quantify the potential effectiveness of low impact development (LID) to mitigate for future stormwater discharges.

Ecology's recommendations for stormwater management to mitigate for climate change

Despite high uncertainties, variations, and limited information and resources at the local level, some actions and planning can be taken based on best available science and tools. Based on the data available, Ecology recommends the following actions to help mitigate the impacts of climate change on stormwater management design:

- **Develop a flexible and multi-objective strategy** allowing cost-effective and adaptive management to handle large uncertainty and variability.
- **Prepare for more extreme events** such as drought and atmospheric river events, which pose more hazardous risks, rather than annual average change.
- **Improve awareness** of how climate change can damage infrastructure, communities, and the economy significantly without proper climate adaptation and preparedness.
- **Apply more LID**, rather than managing the stormwater at the end of pipe or receiving water bodies. Consider the long-term and multiple benefits of low impact development in the decision making process in comparison to the flood damage and recovery cost that may result from extreme storm events.
- **Maintain and increase natural ecosystem areas** by zoning, land acquisition, wetland protection, riparian restoration, and forest restoration.
- **Develop local rebate, credit, fee in lieu, and/or stormwater banking programs** for rainwater mitigation, stormwater reuse, rain gardens, tree planting, reforestation, and land conservation and acquisition.
- **Local agencies should stay current on new research** and recommendations, and consider if increased stormwater regulations should be implemented that would lower the design thresholds to require stormwater management BMPs or expanded retrofit requirements.
- **Place stormwater regional facilities** in more vulnerable locations.
- **Preserve and enhance the capacity of existing BMPs** through regular inspection, maintenance, and retrofits.
- **Perform a critical assessment of existing infrastructure** to understand how many facilities experience flooding, and their anticipated failure to perform with future rainfall intensities.
- **Consider changing Flow Control BMP design requirements** by doing one or more of the following:
    - Sizing Flow Control BMPs based on local future precipitation projections.
    - When local future precipitation projections are not available, historic rainfall data can be still used. Upsize BMPs when possible by changing the Flow Control goals to capture larger storms (e.g. 100 yr peak flow instead of 50 yr) in more vulnerable areas. For example:
        - Upsizing Flow Control BMPs by a factor (set locally)

    - Scaling design storms used to size Flow Control BMPs by a factor (set locally)
    - Designing Flow Control BMPs for larger storm events (e.g. 100 yr peak flow instead of 50 yr peak flow)

Related Information

While there are not yet regulations on how to prepare for climate change impacts to stormwater management by state or federal agencies, many Washington state local agencies and communities have proactively developed and conducted innovative approaches to improve climate resiliency of stormwater systems. More information can be found at the following web addresses:

- UW Climate Impacts Group webpage and publications including State of Knowledge:

  https://cig.uw.edu/

- Washington Stormwater Center Stormwater-Climate Resiliency Workshop webpage:

  https://www.wastormwatercenter.org/stormwater-climate-resiliency/