Climate change vulnerability is about more than just impacts: To plan for climate change, we also need to know when consequences are important, and what is our capacity to adapt.

Vulnerability is not just about Impacts

Three factors:

1. How much change?
2. When does it matter?
3. What is our capacity to adapt?

https://www.washingtonpost.com/weather/2021/06/25/pacific-northwest-heat-wave-seattle-portland/

Vulnerability is not just about Impacts

Three factors:

1. Exposure
2. Sensitivity
3. Adaptive Capacity

https://www.washingtonpost.com/weather/2021/06/25/pacific-northwest-heat-wave-seattle-portland/

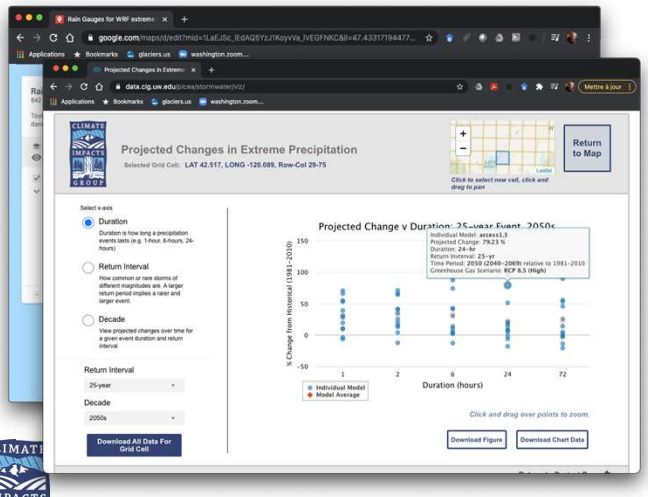
There is more than one way to prepare for climate change: Start simple, then add complexity as you need it.

Anacortes Water Treatment Plant

Start with what you want to know:

By defining the problem, you can better hone in on the information you need.

Impact on Stormwater Design



Evaluation of Potential Climate Change Impacts on Stormwater Facility Size and Cost

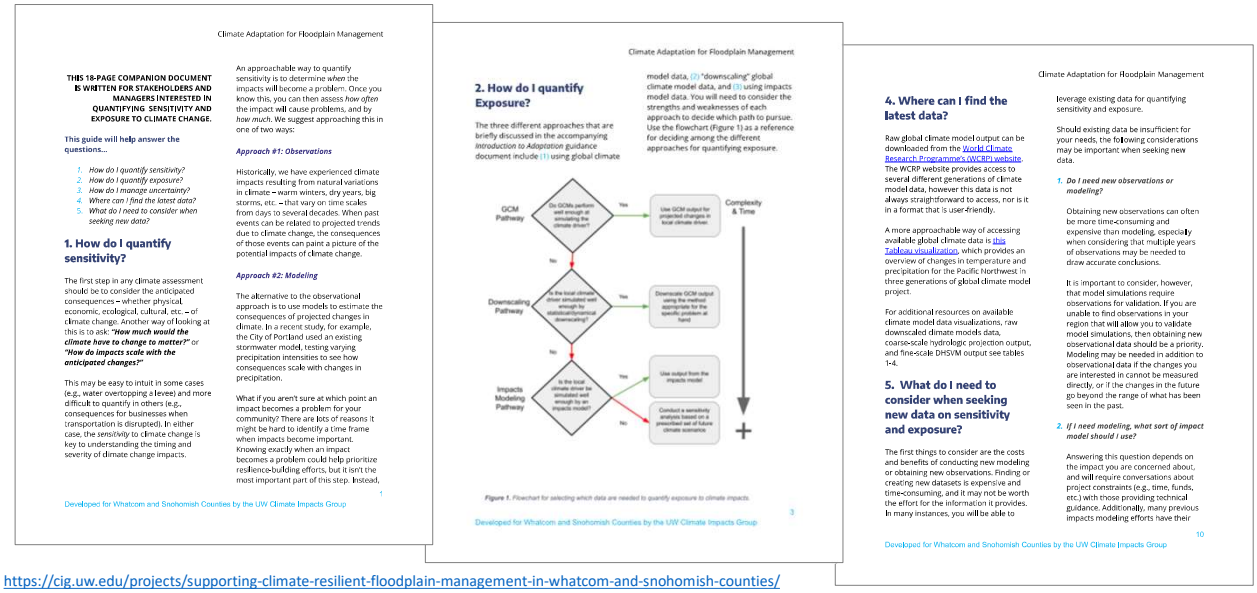
November 2019

King County

https://cig.uw.edu/our-work/applied-research/heavy-precip-and-stormwater/

There are lots of resources available to help you both assess impacts and plan for climate change.

New Data Guide: *"Quantifying Sensitivity + Exposure"*



Climate Adaptation for Floodplain Management

THIS 18-PAGE COMPANION DOCUMENT IS WRITTEN FOR STAKEHOLDERS AND MANAGERS INTERESTED IN QUANTIFYING SENSITIVITY AND EXPOSURE TO CLIMATE CHANGE.

This guide will help answer the questions...

1. *How do I quantify sensitivity?*
2. *How do I quantify exposure?*
3. *How do I manage uncertainty?*
4. *Where can I find the latest data?*
5. *What do I need to consider when seeking new data?*

1. How do I quantify sensitivity?

The first step in any climate assessment should be to consider the anticipated consequences – whether physical, economic, ecological, cultural, etc. – of climate change. Another way of looking at this is to ask: ***"How much would the climate have to change to matter?"*** or ***"How do impacts scale with the anticipated changes?"***

This may be easy to intuit in some cases (e.g., water overtopping a levee) and more difficult to quantify in others (e.g., consequences for businesses when transportation is disrupted). In either case, the *sensitivity* to climate change is key to understanding the timing and severity of climate change impacts.

An approachable way to quantify sensitivity is to determine *when* the impacts will become a problem. Once you know this, you can then assess *how often* the impact will cause problems, and by *how much*. We suggest approaching this in one of two ways:

Approach #1: Observations

Historically, we have experienced climate impacts resulting from natural variations in climate – warm winters, dry years, big storms, etc. – that vary on time scales from days to several decades. When past events can be related to projected trends due to climate change, the consequences of these events can paint a picture of the potential impacts of climate change.

Approach #2: Modeling

The alternative to the observational approach is to use models to estimate the consequences of projected changes in climate. In a recent study, for example, the City of Portland used an existing stormwater model, testing varying precipitation intensities to see how consequences scale with changes in precipitation.

What if you aren't sure at which point an impact becomes a problem for your community? There are lots of reasons it might be hard to identify a time frame when impacts become important. Knowing exactly when an impact becomes a problem could help prioritize resilience-building efforts, but it isn't the most important part of this step. Instead,

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Climate Adaptation for Floodplain Management

2. How do I quantify Exposure?

The three different approaches that are briefly discussed in the accompanying *Introduction to Adaptation* guidance document include (1) using global climate model data, (2) "downscaling" global climate model data, and (3) using impacts model data. You will need to consider the strengths and weaknesses of each approach to decide which path to pursue. Use the flowchart (Figure 1) as a reference for deciding among the different approaches for quantifying exposure.

Figure 1. Flowchart for selecting which data are needed to quantify exposure to climate impacts.

Developed for Whatcom and Snohomish Counties by the UW Climate Impacts Group 3

Climate Adaptation for Floodplain Management

4. Where can I find the latest data?

Raw global climate model output can be downloaded from the World Climate Research Programme's (WCRP) website. The WCRP website provides access to several different generations of climate model data, however this data is not always straightforward to access, nor is it in a format that is user-friendly.

A more approachable way of accessing available global climate data is this Tableau visualization, which provides an overview of changes in temperature and precipitation for the Pacific Northwest in three generations of global climate model project.

For additional resources on available climate model data visualizations, raw downscaled climate models data, coarse-scale hydrologic projection output, and fine-scale DHSVM output see tables 1-4.

5. What do I need to consider when seeking new data on sensitivity and exposure?

The first things to consider are the costs and benefits of conducting new modeling or obtaining new observations. Finding or creating new datasets is expensive and time-consuming, and it may not be worth the effort for the information it provides. In many instances, you will be able to leverage existing data for quantifying sensitivity and exposure.

Should existing data be insufficient for your needs, the following considerations may be important when seeking new data.

1. ***Do I need new observations or modeling?***

   Obtaining new observations can often be more time-consuming and expensive than modeling, especially when considering that multiple years of observations may be needed to draw accurate conclusions.

   It is important to consider, however, that model simulations require observations for validation. If you are unable to find observations in your region that will allow you to validate model simulations, then obtaining new observational data should be a priority. Modeling may be needed in addition to observational data if the changes you are interested in cannot be measured directly, or if the changes in the future go beyond the range of what has been seen in the past.

2. ***If I need modeling, what sort of impact model should I use?***

   Answering this question depends on the impact you are concerned about, and will require conversations about project constraints (e.g., time, funds, etc.) with those providing technical guidance. Additionally, many previous impacts modeling efforts have their

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https://cig.uw.edu/projects/supporting-climate-resilient-floodplain-management-in-whatcom-and-snohomish-counties/

Resources for assessing impacts:

Climate Toolbox

https://climatetoolbox.org/

Water Resources Dashboard

https://toolkit.climate.gov/topics/water/water-resources-dashboard

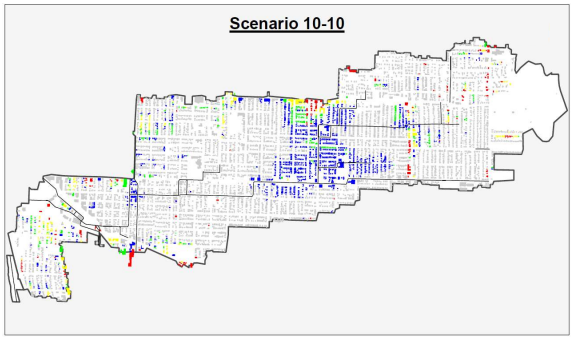
Climate Impacts Group

https://cig.uw.edu/resources/analysis-tools/

Use sensitivity testing to explore impacts:

”What happens if” scenarios are a valuable way to explore vulnerabilities.

Use sensitivity testing to explore impacts



Intensity Increases	Basement Backup Risk Increase					
50%	272%	292%	300%	325%	345%	362%
40%	198%	216%	231%	246%	265%	286%
30%	133%	151%	162%	175%	193%	198%
20%	79%	91%	100%	116%	128%	137%
10%	37%	43%	49%	59%	71%	90%
0%	0%	0%	7%	14%	23%	34%
	0%	10%	20%	30%	40%	50%
	Volume Increases					

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

https://www.wucaonline.org/assets/pdf/awwa2018-portland-resiliency.pdf

Learn from events as they happen: These are "dress rehearsals" for the future, and probably the best way to understand what works / doesn't.

2015: A preview of the future

Warmest year on record for the NW
~5ºF warmer than pre-industrial

7th driest January to June in the Northwest

Lowest snowpack on record for WA
30% of normal (1970-1999 average)

Data: NCA 2018
Figure: Climate Impacts Group

2015:

FISHERIES
Low summer streamflow & warm waters resulted in fishery closures

>250,000 Columbia River sockeye salmon died

RECREATION
Low snowpack led to reductions in winter & summer recreation

42% shorter ski season at Stevens Pass

WILDFIRE
The most severe wildfire season in Washington's recorded history

>1,000,000 acres burned

>$253 million fire supression

AGRICULTURE
Warm temperatures & reduced water availability stressed WA agriculture

17 major crops with reduced yields

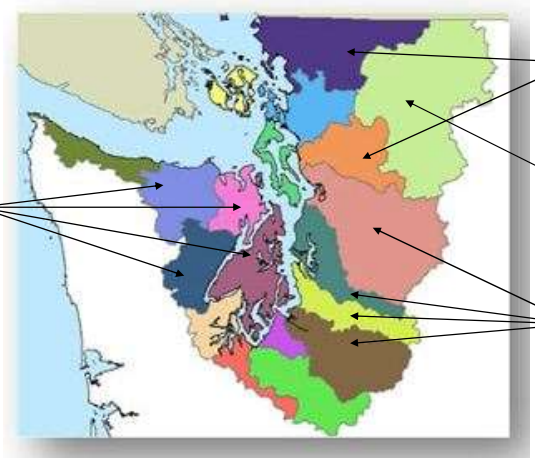
$633-733 million economic losses

Data: NCA 2018
Figure: Climate Impacts Group

Leverage existing science to benefit from economies of scale: Impacts studies can often be conducted over large areas, or at least build on past experience.

Recent Fine-Scale Hydrologic Model Projections

15 West Sound watersheds
Statistical Downscaling
PNPTC, 2019



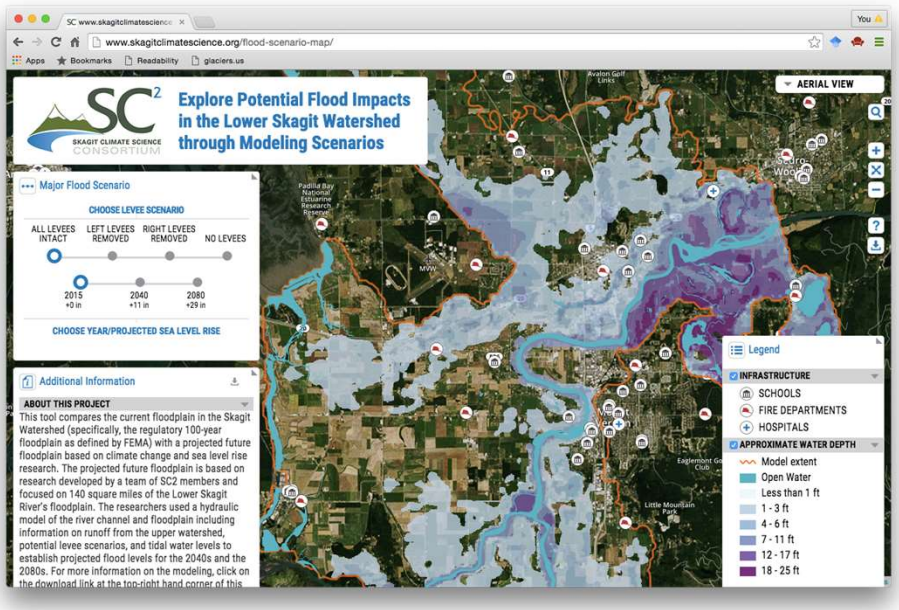
Nooksack, Stillaguamish
Dynamical Downscaling
WWU, 2022

Skagit
Statistical Downscaling
UW CEE, 2018

Snohomish, Cedar, Green, Puyallup
Dynamical Downscaling
UW CIG, in progress

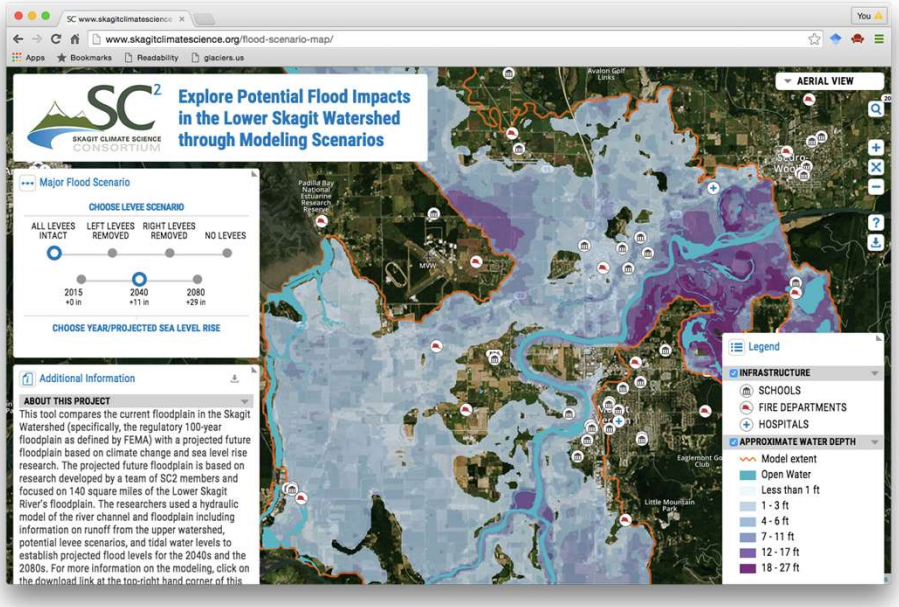
(this list is likely incomplete)

Example: Current v Future Flooding in the Skagit Valley



http://www.skagitclimatescience.org/flood-scenario-map/

Example: Current v Future Flooding in the Skagit Valley



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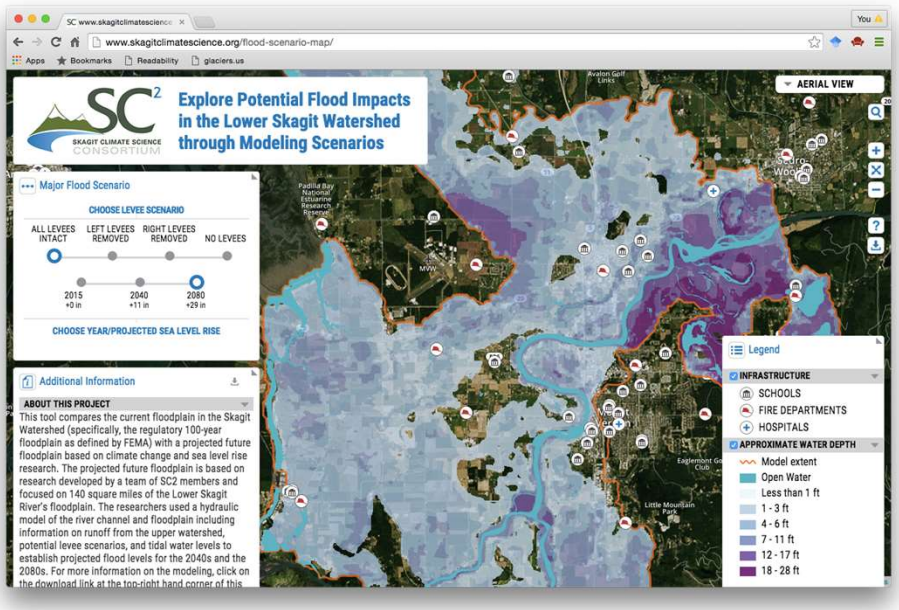

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Research priorities should directly address management needs: This is best done by co-developing an agenda with stakeholders and researchers.

Example: Climate study priorities in Pierce County

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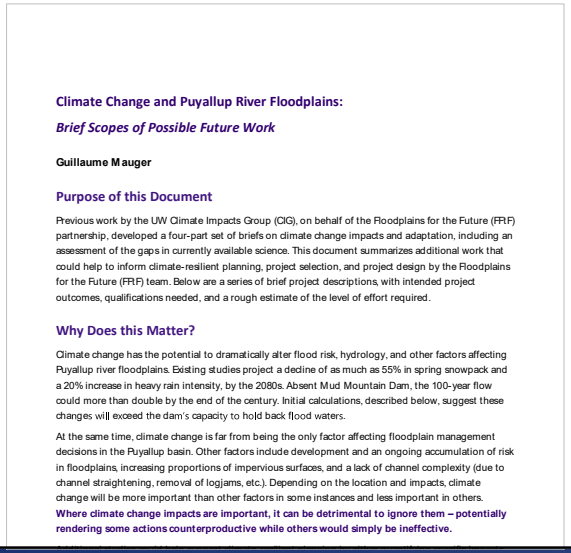

Climate Change and Puyallup River Floodplains:

Brief Scopes of Possible Future Work

Guillaume Mauger

Purpose of this Document

Previous work by the UW Climate Impacts Group (CIG), on behalf of the Floodplains for the Future (FRF) partnership, developed a four-part set of briefs on climate change impacts and adaptation, including an assessment of the gaps in currently available science. This document summarizes additional work that could help to inform climate-resilient planning, project selection, and project design by the Floodplains for the Future (FRF) team. Below are a series of brief project descriptions, with intended project outcomes, qualifications needed, and a rough estimate of the level of effort required.

Why Does this Matter?

Climate change has the potential to dramatically alter flood risk, hydrology, and other factors affecting Puyallup river floodplains. Existing studies project a decline of as much as 55% in spring snowpack and a 20% increase in heavy rain intensity, by the 2080s. Absent Mud Mountain Dam, the 100-year flow could more than double by the end of the century. Initial calculations, described below, suggest these changes will exceed the dam's capacity to hold back flood waters.

At the same time, climate change is far from being the only factor affecting floodplain management decisions in the Puyallup basin. Other factors include development and an ongoing accumulation of risk in floodplains, increasing proportions of impervious surfaces, and a lack of channel complexity (due to channel straightening, removal of logjams, etc.). Depending on the location and impacts, climate change will be more important than other factors in some instances and less important in others. **Where climate change impacts are important, it can be detrimental to ignore them – potentially rendering some actions counterproductive while others would simply be ineffective.**

Example: Climate study priorities in Pierce County

Climate Change and Puyallup River Floodplains:

Brief Scopes of Possible Future Work

Guillaume Mauger

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Table 1. Summary of proposed studies and the utility of each for climate-resilient FRF work. Priority studies are highlighted in bold.

	Study would inform:		
Proposed Study	**Scale**	**Prioritization**	**Design**
Impacts Table (whole watershed)		✓	
Impacts Table (specific reach)		✓	
White R Sensitivity Analysis	✓	✓	
Projected Changes in Streamflow	✓	✓	✓
Future Flood Depth & Extent (whole watershed)	✓	✓	
Future Flood Depth & Extent (specific reach)	✓		✓
Groundwater Depth & Salinity	✓	✓	✓
Sediment	✓	✓	✓
Saltwater Wedge	✓		✓
Retrospective Impacts Analysis	✓	✓	
Will Our Plans Measure Up?		✓	
Vulnerabilities and Adaptive Capacity		✓	
Guidelines: Climate-Resilient Planning & Design		✓	✓
Stream Temperature	✓	✓	

Example: Climate study priorities in Pierce County

Climate Change and Puyallup River Floodplains:

Brief Scopes of Possible Future Work

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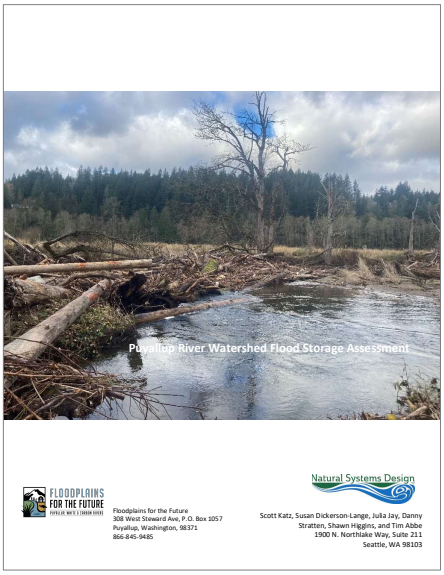
Impacts			
White			
Projected Cha			
Future Flood Depth & Extent			
Future Flood Depth & Ex			
Groundwat			
Retrospecti			
Will Our			
Vulnerabilities and			
Guidelines: Climate-Resilier			
Stream Temperature	✓	✓	

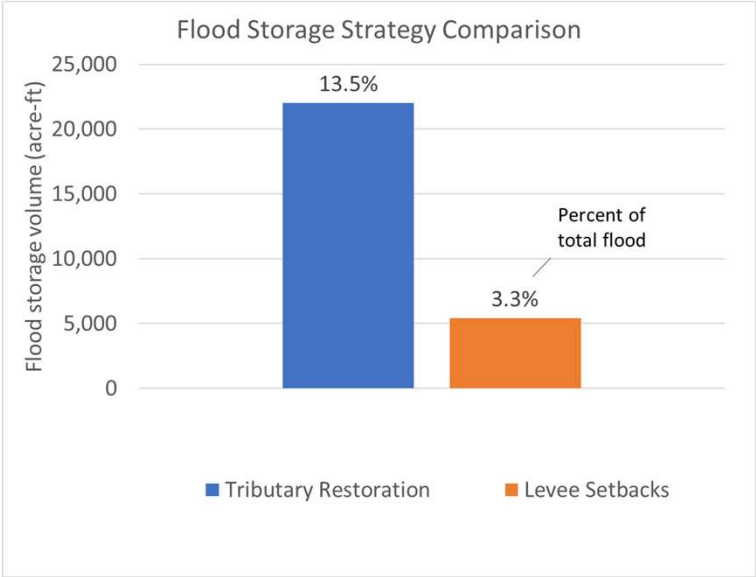
Topic	Project Name	Lead	PM	Approx. Budget	Approx. Timeline	Outcom
Do Our Plans Measure Up?	FFtF: Puyallup Watershed Retoration and Flood Benefits	NSD	PCD?	$30,000	06/2020-11/2020	Flood and sedime potential setbacks development. To flood volume & ag
Salt Wedge	Clear Creek Salinity Intrusion Study	UW CEE	UW CEE	$30,500	10/2020-06/2021	How often salt we and in the future.
Streamflow	Impacts of Climate Change on Peak Flows in the Puyallup River basin	PNNL	UW CIG (Guillaume)	$36,000-$48,000	10/2020-06/2021	Future streamflow Focus is peak flow times/seasons (e.
Flooding	Flood Inundation Mapping	Todd, SWM	Brynne? Guillaume?	???	???	Future flood depth conditions, if all p implemented, and protections remov
Sediment	Phase 1 – Document the scale and extent of recent aggradation	USGS	SPSSEG	$35,000	6 months for results, 3-6 more for report. can't start until 10/2020	Updated aggradat lower basin. Useful trends from transi
Sediment	Phase 2 – Improve understanding of underlying causes of observed aggradation	USGS	SPSSEG	$80,000	~18 months, depending on scope	Causes of aggrada management opti of aggradation.
Sediment Monitoring	Monitoring: Suspended + Bedload sampling	USGS	PC SWM?	Suspended: $20-22k/yr Bedload: $12-24k/yr (cost per site)	n/a	Long-term monito better information the sources of tho accurate sedimen
Sediment Monitoring	Multi-beam survey of lower river	TBD	PC SWM (Dennis Dixon)	$5,000-10,000	TBD	Lidar surveys do n lower river, where between levees. T important to mon of flooding in the

Climate change is better addressed through prioritization than project design: Both are important, but with limited resources we need to be judicious.

Example: Effectiveness studies

Example: Effectiveness studies





The Seattle Times

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TRAFFIC
All lanes blocked at Aurora Ave. N. and N. 96th St. after major crash ›

Weather disasters can teach us how to prepare for the future

Jan. 26, 2022 at 1:57 pm | *Updated Jan. 27, 2022 at 11:37 am*

https://www.seattletimes.com/opinion/weather-disasters-can-teach-us-how-to-prepare-for-the-future/